

UNIVERSIDADE DE SÃO PAULO  
ESCOLA DE ENGENHARIA DE SÃO CARLOS  
DEPARTAMENTO DE ESTRUTURAS

ALGUNS ASPECTOS RELATIVOS À INSPEÇÃO E  
RECUPERAÇÃO DE PONTES DE AÇO  
— ÊNFASE EM PONTES FERROVIÁRIAS —

ANEXO I

DEDALUS - Acervo - EESC



31100017938

Tese apresentada à Escola de Engenharia de São Carlos da Universidade de São Paulo como parte dos requisitos para obtenção do título de "Doutor em Engenharia", área: Estruturas.



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ORIENTADOR: PROF. DR. WALTER ABRAHÃO NIMIR

São Carlos, Maio de 1992

## ANEXO

Este Anexo tem como objetivo permitir ao leitor uma análise complementar dos resultados obtidos nos ensaios das vigas rebitadas, caso seja de seu interesse. A sinopse dos resultados, apresentada no Capítulo sete, é ilustrativa e resume as principais informações sobre os resultados dos ensaios.

Apresentam-se, primeiramente os resultados de corpos de prova, ensaiados à tração, dos aços e rebites utilizados nas vigas rebitadas. Apresenta-se também a caracterização micro-estrutural dos rebites, comparando-os com parafusos A-325.

A seguir, estão apresentados todos os resultados de deslocamentos e deformações, medidas nos vários ensaios das vigas modelos 1 a 4.

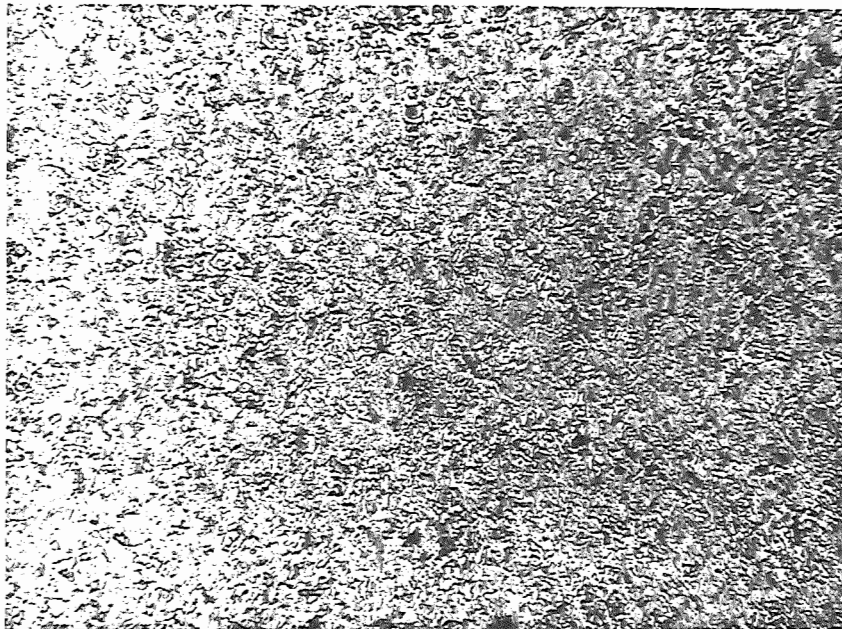
Os pontos instrumentados de cada modelo, deslocamentos e deformações, estão ilustrados no início de cada série das vigas, seguidos das Tabelas e Gráficos com os valores obtidos nos ensaios.

Resultados dos Corpos de Prova dos Aços

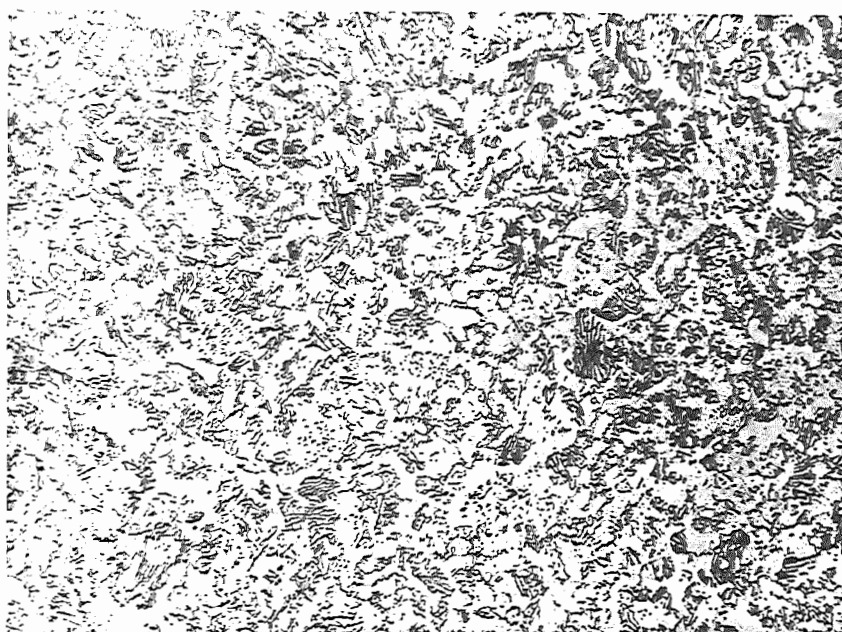
| DADOS SOBRE OS CORPOS DE PROVA   |             |                      |                      |                   |           |                |                |        |
|--|-------------|----------------------|----------------------|-------------------|-----------|----------------|----------------|--------|
| MATERIAL   | C.P.<br>NRO | $\phi_{ext}$<br>(mm) | $\phi_{int}$<br>(mm) | $L_{tot}$<br>(mm) | L<br>(mm) | $f_y$<br>(MPa) | $f_u$<br>(MPa) | A<br>% |
| Chapa de<br>e= 9.5mm<br>ASTM-A36<br>f =250MPa<br>f <sup>y</sup> =400MPa<br>f <sup>u</sup>        | 1           | 3.9                  | 2.2                  | 22.0              | 16.0      | 326            | 498            | 37.5   |
|  | 2           | 3.9                  | 2.2                  | 22.8              | 16.0      | 325            | 490            | 42.5   |
|  | 3           | 3.9                  | 2.2                  | 22.8              | 16.0      | 335            | 502            | 42.5   |
| Chapa de<br>e= 4.8mm<br>ASTM-A36<br>f =250MPa<br>f <sup>y</sup> =400MPa<br>f <sup>u</sup>        | 1           | 1.9                  | 1.08                 | 37.5              | 29.9      | 380            | 431            | 25.4   |
|  | 2           | 1.9                  | 1.10                 | 37.2              | 29.9      | 345            | 431            | 24.4   |
|  | 3           | 1.9                  | 1.08                 | 38.4              | 29.9      | 352            | 422            | 28.4   |
| Rebite<br>$\phi$ =12.5mm<br>SAE-1010<br>f =183MPa<br>f <sup>y</sup> =330MPa<br>f <sup>u</sup>    | 1           | 3.9                  | 2.1                  | 42.0              | 33.7      | 363            | 474            | 24.6   |
|  | 2           | 3.9                  | 2.1                  | 36.1              | 30.0      | 294            | 425            | 20.3   |
|  | 3           | 3.9                  | 2.3                  | 37.4              | 29.8      | 359            | 441            | 25.5   |
| Parafuso<br>$\phi$ =12.5mm<br>A-325<br>f =183MPa<br>f <sup>y</sup> =330MPa<br>f <sup>u</sup>     | 1           | 3.9                  | 2.6                  | 33.3              | 29.9      | 1009           | 1103           | 11.4   |
|  | 2           | 3.9                  | 2.8                  | 33.0              | 29.9      | 809            | 1013           | 10.4   |
|  | 3           | 3.9                  | 2.3                  | 33.0              | 30.0      | 792            | 984            | 10.0   |
| Bar. Red.<br>$\phi$ =16.0mm<br>SAE-1060<br>f =450MPa<br>f <sup>y</sup> =700MPa<br>f <sup>u</sup> | 1           | 3.9                  | 3.1                  | 18.1              | 16.0      | 874            | 931            | 13.1   |
|  | 2           | 3.9                  | 3.1                  | 18.0              | 16.0      | 833            | 916            | 12.5   |
|  | 3           | 3.9                  | 3.0                  | 18.5              | 16.0      | 849            | 935            | 15.6   |
| Bar. Red.<br>$\phi$ =20.0mm<br>SAE-1040<br>f =290MPa<br>f <sup>y</sup> =500MPa<br>f <sup>u</sup> | 1           | 3.9                  | 2.8                  | 21.0              | 16.0      | 457            | 743            | 31.3   |
|  | 2           | 3.9                  | 2.8                  | 21.1              | 16.0      | 453            | 735            | 31.9   |
|  | 3           | 3.9                  | 2.8                  | 21.0              | 16.0      | 457            | 737            | 31.3   |

Nas Fotos, apresentadas abaixo, encontram-se os resultados da metalografia de uma amostra retirada de um rebite e de um parafuso(A-325). Pode-se observar que a granulometria dos cristais são diferentes.

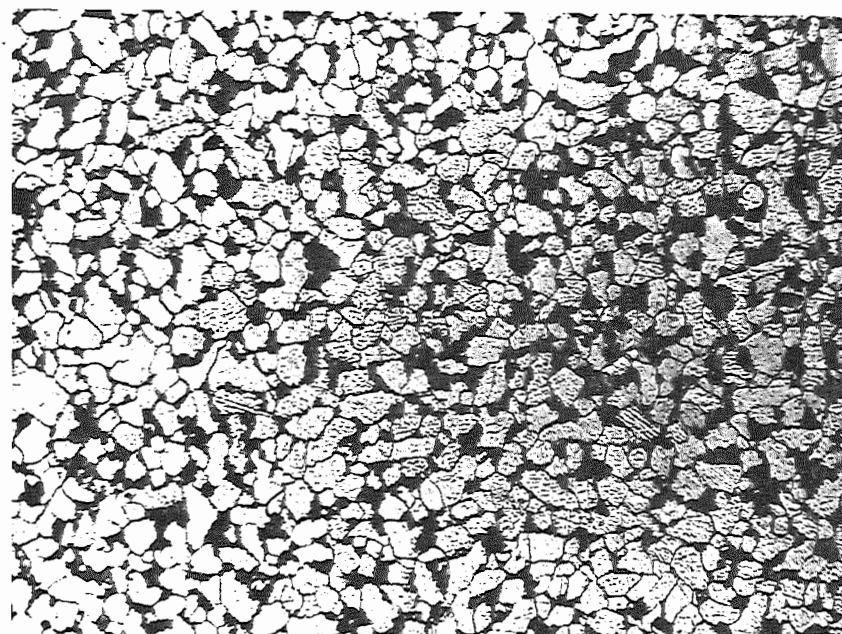
A análise micro-estrutural destes materiais foi realizada pelo Prof. Luis Marino, Departamento de Materiais da EESC-USP, que não constatou nenhuma anomalia nestes aços.



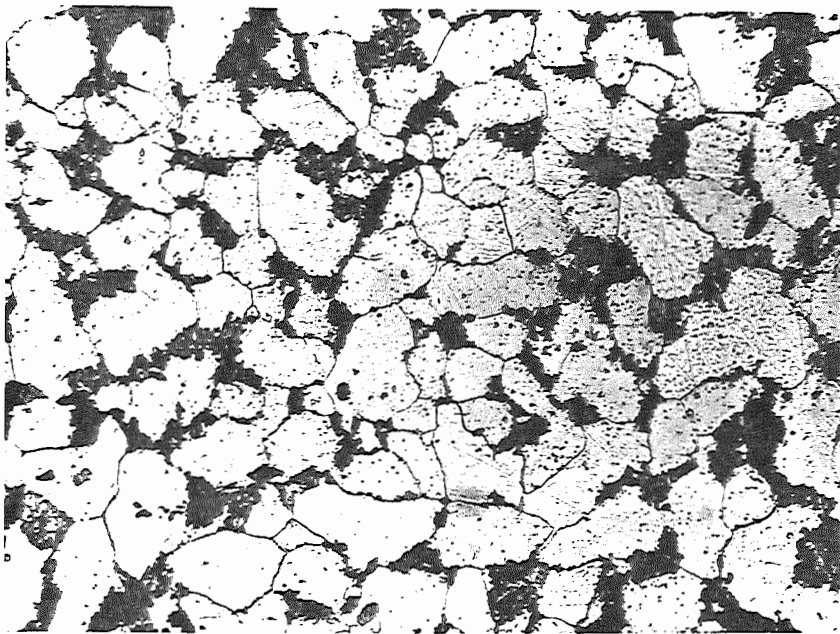
*Foto A-1 Micro-estrutura do rebite.  
Fator de ampliação igual a 160 vezes.*



*Foto A-2 Micro-estrutura do rebite.  
Fator de ampliação igual a 400 vezes.*



*Foto A-3 Micro-estrutura do parafuso.  
Fator de ampliação igual a 160 vezes.*



*Foto A-4 Micro-estrutura do parafuso.  
Fator de ampliação igual a 400 vezes.*

## RESULTADOS DOS ENSAIOS

### TABELAS E GRÁFICOS

#### . VIGAS REBITADAS

DEFORMAÇÕES

DESLOCAMENTOS

## MODELO - VIGA I

### RESULTADOS DOS ENSAIOS

- . ENSAIO 1
- . ENSAIO 2
- . ENSAIO 3

- DESLOCAMENTOS

- DEFORMAÇÕES



MODELO - VIGA I

RESULTADOS DOS ENSAJOS

. ENSAIO 1

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA I

ENSAIO Nro:1

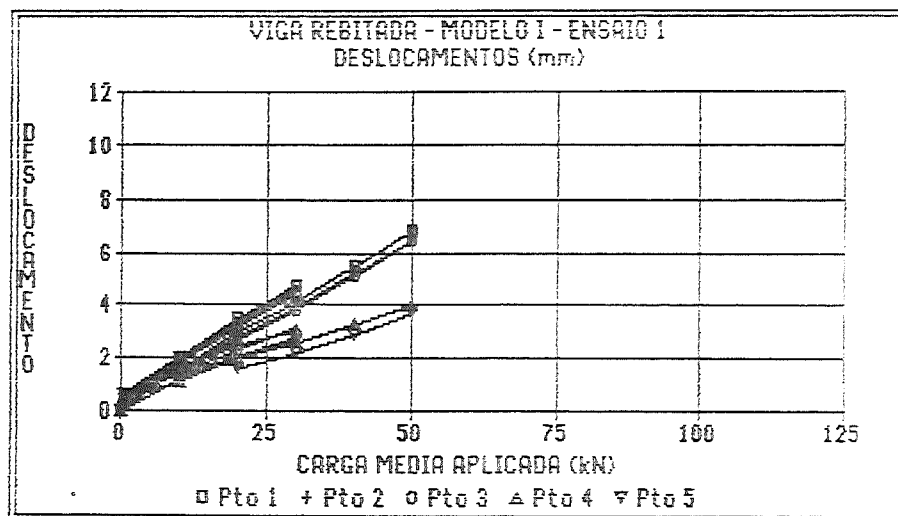
DATA: 4 DE FEVEREIRO DE 1991

HORARIO: 10:30 Hs

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| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |      |       |
|-------|----------------------------|-----------------------|-------|-------|------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00 | 0.00  |
| 1     | 9.95                       | 2.04                  | 1.97  | 1.83  | 1.61 | 1.24  |
| 2     | 19.95                      | 3.46                  | 3.35  | 3.19  | 2.46 | 2.06  |
| 3     | 30.00                      | 4.69                  | 4.50  | 4.38  | 3.07 | 2.70  |
| 4     | .50                        | .62                   | .64   | .64   | .53  | .57   |
| 5     | 10.10                      | 1.54                  | 1.48  | 1.38  | 1.14 | 1.79  |
| 6     | 20.05                      | 2.96                  | 2.81  | 2.71  | 1.96 | 1.59  |
| 7     | 30.00                      | 4.12                  | 3.90  | 3.81  | 2.56 | 2.17  |
| 8     | 39.90                      | 5.47                  | 5.16  | 5.06  | 3.26 | 2.87  |
| 9     | 50.00                      | 6.93                  | 6.54  | 6.47  | 4.04 | 3.66  |
| 10    | 59.95                      | 8.55                  | 8.06  | 8.02  | 4.94 | 4.61  |

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MODELO - VIGA I

RESULTADOS DOS ENSAIOS

. ENSAIO 1

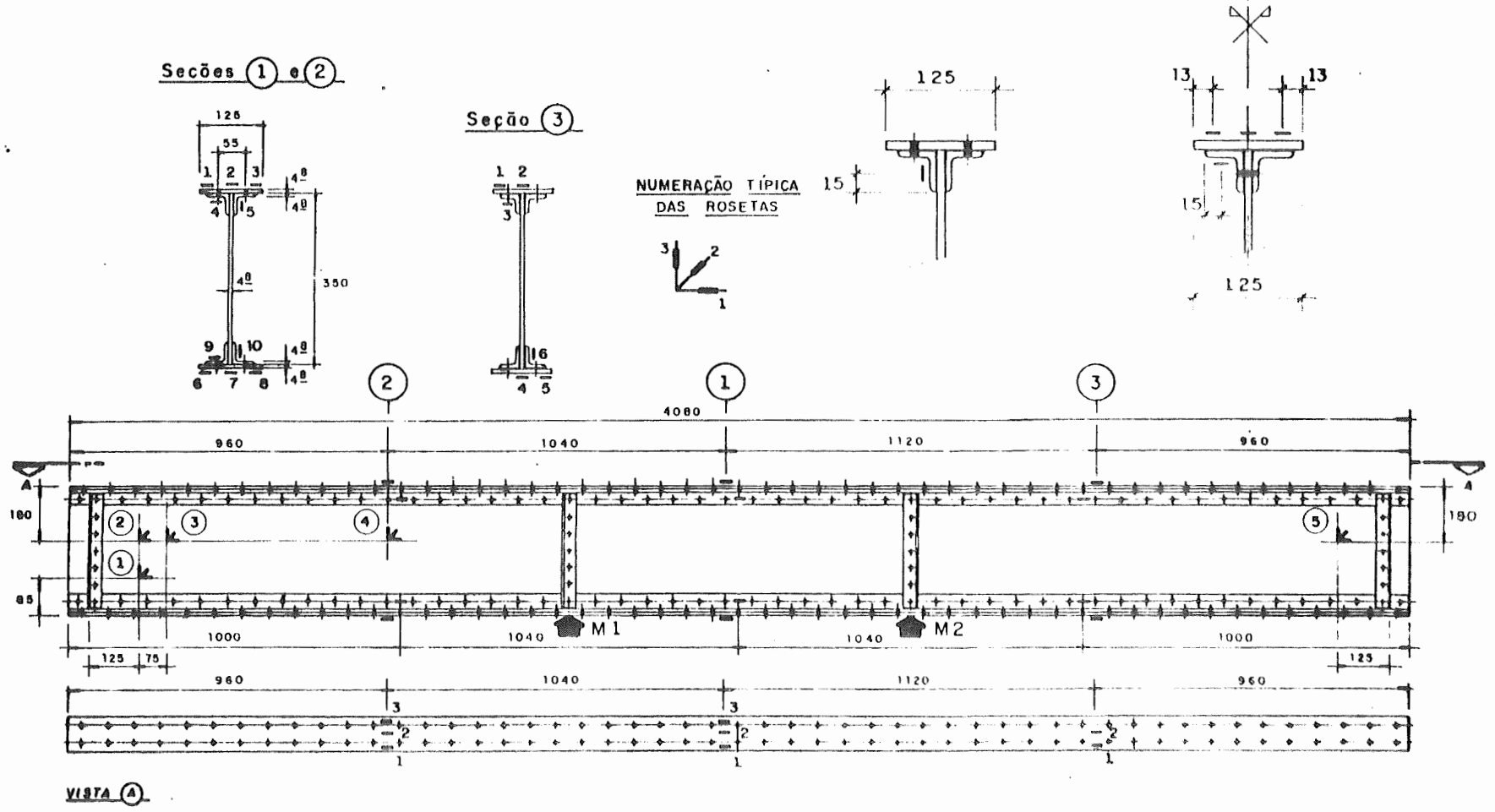
- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

**POSICIONAMENTO TÍPICO DOS EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA PARA TODOS OS MODELOS**



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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.1 DATA: 04/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| $F_s$<br>(KN) | $F_c$<br>(KN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) | 7<br>( $\mu E$ ) | 8<br>( $\mu E$ ) | 9<br>( $\mu E$ ) | 10<br>( $\mu E$ ) |
|---------------|---------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| 0.00          | 0.00          | +1.              | +0.              | +1.              | -1.              | +0.              | +1.              | +0.              | +1.              | +0.              | +1.               |
| 10.32         | 9.64          | +134.            | +120.            | +122.            | +112.            | +93.             | -102.            | -111.            | -149.            | -91.             | -124.             |
| 20.63         | 19.28         | +263.            | +238.            | +253.            | +214.            | +186.            | -228.            | -246.            | -278.            | -187.            | -228.             |
| 30.83         | 29.15         | +395.            | +356.            | +380.            | +308.            | +289.            | -368.            | -377.            | -406.            | -285.            | -330.             |
| 0.59          | 0.46          | +22.             | +6.              | +14.             | -16.             | +13.             | -1.              | -10.             | -32.             | -7.              | -3.               |
| 10.43         | 9.76          | +145.            | +121.            | +133.            | +93.             | +103.            | -107.            | -128.            | -162.            | -95.             | -114.             |
| 20.63         | 19.63         | +275.            | +240.            | +263.            | +202.            | +197.            | -237.            | -250.            | -284.            | -190.            | -223.             |
| 30.63         | 29.27         | +399.            | +359.            | +394.            | +309.            | +292.            | -370.            | -373.            | -404.            | -284.            | -328.             |
| 41.15         | 38.79         | +533.            | +471.            | +537.            | +408.            | +366.            | -517.            | -507.            | -515.            | -387.            | -423.             |
| 51.35         | 48.55         | +669.            | +581.            | +698.            | +503.            | +443.            | -655.            | -652.            | -620.            | -491.            | -515.             |
| 61.31         | 58.42         | +805.            | +693.            | +875.            | +601.            | +524.            | -895.            | -764.            | -677.            | -601.            | -584.             |
| 0.23          | 0.00          | +69.             | -47.             | +82.             | -40.             | -37.             | -21.             | -24.             | -30.             | -17.             | -10.              |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 2

| $F_1$<br>(KN) | $F_2$<br>(KN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00          | 0.00          | +0.                    | +1.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +1.                    | +0.                    | +1.                     |
| 10.32         | 9.64          | +91.                   | +83.                   | +73.                   | +84.                   | +61.                   | -69.                   | -82.                   | -96.                   | -58.                   | -81.                    |
| 20.63         | 19.28         | +175.                  | +163.                  | +153.                  | +161.                  | +124.                  | -150.                  | -163.                  | -182.                  | -119.                  | -157.                   |
| 30.83         | 29.15         | +257.                  | +244.                  | +237.                  | +235.                  | +185.                  | -234.                  | -246.                  | -268.                  | -179.                  | -201.                   |
| 0.59          | 0.46          | +9.                    | +7.                    | +7.                    | +7.                    | +7.                    | +2.                    | -4.                    | -8.                    | -2.                    | -1.                     |
| 10.43         | 9.76          | +94.                   | +85.                   | +79.                   | +85.                   | +67.                   | -65.                   | -81.                   | -97.                   | -58.                   | -77.                    |
| 20.83         | 19.63         | +177.                  | +166.                  | +159.                  | +162.                  | +129.                  | -158.                  | -163.                  | -183.                  | -118.                  | -154.                   |
| 30.83         | 29.27         | +261.                  | +248.                  | +240.                  | +238.                  | +191.                  | -230.                  | -245.                  | -268.                  | -178.                  | -219.                   |
| 41.15         | 38.79         | +347.                  | +336.                  | +323.                  | +309.                  | +252.                  | -315.                  | -327.                  | -352.                  | -241.                  | -301.                   |
| 51.35         | 48.55         | +436.                  | +410.                  | +408.                  | +380.                  | +320.                  | -407.                  | -412.                  | -431.                  | -307.                  | -370.                   |
| 61.31         | 58.42         | +528.                  | +492.                  | +491.                  | +450.                  | +377.                  | -521.                  | -496.                  | -488.                  | -380.                  | -430.                   |
| 0.23          | 0.00          | +25.                   | +5.                    | +17.                   | -5.                    | +3.                    | +5.                    | -1.                    | -8.                    | -19.                   | +6.                     |

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VIGA I            ENSAIO No.1            DATA: 04/02/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | -1.                    | -1.                    | -1.                    | +0.                    | +0.                    | -1.                    |
| 10.32                  | 9.64                   | +80.                   | +62.                   | +74.                   | -83.                   | -104.                  | -69.                   |
| 20.63                  | 19.28                  | +157.                  | +164.                  | +146.                  | -167.                  | -191.                  | -135.                  |
| 30.85                  | 29.15                  | +236.                  | +251.                  | +217.                  | -253.                  | -274.                  | -265.                  |
| 0.59                   | 0.46                   | +8.                    | +10.                   | +3.                    | -6.                    | -19.                   | -8.                    |
| 10.43                  | 9.76                   | +85.                   | +88.                   | +75.                   | -84.                   | -105.                  | -71.                   |
| 20.63                  | 19.63                  | +163.                  | +172.                  | +147.                  | -170.                  | -191.                  | -137.                  |
| 30.83                  | 29.27                  | +240.                  | +256.                  | +219.                  | -253.                  | -270.                  | -201.                  |
| 41.15                  | 38.79                  | +324.                  | +342.                  | +288.                  | -341.                  | -345.                  | -267.                  |
| 51.35                  | 48.55                  | +409.                  | +431.                  | +357.                  | -429.                  | -415.                  | -325.                  |
| 61.31                  | 58.42                  | +497.                  | +524.                  | +430.                  | -520.                  | -473.                  | -384.                  |
| 0.23                   | 0.00                   | +24.                   | +28.                   | -9.                    | -11.                   | -17.                   | +6.                    |



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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>d</sub><br>(με) | ε <sub>e</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | g<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.32                  | 9.64                   | -4.                    | +39.                   | -4.                    | +39.                   | -46.                   | +5.6                    | -7.9                    | +45.0    |
| 20.63                  | 19.28                  | -8.                    | +67.                   | -8.                    | +67.                   | -82.                   | +9.6                    | -14.0                   | +45.0    |
| 30.83                  | 29.15                  | -9.                    | +95.                   | -9.                    | +95.                   | -113.                  | +13.6                   | -19.2                   | +45.0    |
| 0.59                   | 0.48                   | +5.                    | +8.                    | +3.                    | +8.                    | -0.                    | +1.7                    | +0.5                    | U/C      |
| 10.43                  | 9.76                   | +2.                    | +43.                   | -1.                    | +43.                   | -42.                   | +6.8                    | -6.5                    | +44.0    |
| 20.63                  | 19.63                  | -3.                    | +70.                   | -4.                    | +70.                   | -77.                   | +10.6                   | -12.5                   | +44.8    |
| 30.83                  | 29.27                  | -6.                    | +97.                   | -6.                    | +97.                   | -109.                  | +14.6                   | -17.9                   | +45.0    |
| 41.15                  | 38.79                  | -7.                    | +124.                  | -8.                    | +124.                  | -138.                  | +18.6                   | -22.7                   | +44.9    |
| 51.35                  | 48.55                  | -8.                    | +147.                  | -9.                    | +147.                  | -164.                  | +22.0                   | -26.9                   | +44.8    |
| 61.31                  | 58.42                  | -7.                    | +159.                  | -10.                   | +159.                  | -176.                  | +23.9                   | -28.9                   | +44.7    |
| 0.23                   | 0.00                   | +27.                   | +15.                   | -2.                    | +27.                   | -2.                    | +5.9                    | +1.3                    | U/C      |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/D                      |
| 10.32         | 9.64          | -6.                               | +40.                              | -8.                               | +40.                              | -53.                              | +5.4                | -9.3                | +44.4                    |
| 20.63         | 19.28         | -6.                               | +75.                              | -13.                              | +75.                              | -94.                              | +10.5               | -16.1               | +43.7                    |
| 30.83         | 29.15         | -5.                               | +110.                             | -16.                              | +110.                             | -131.                             | +15.5               | -22.0               | +43.6                    |
| 0.59          | 0.46          | +2.                               | +8.                               | +3.                               | +8.                               | -3.                               | +1.5                | -0.1                | U/D                      |
| 10.43         | 9.76          | -1.                               | +44.                              | -4.                               | +44.                              | -45.                              | +6.7                | -8.1                | +44.1                    |
| 20.63         | 19.63         | -2.                               | +79.                              | -9.                               | +79.                              | -89.                              | +11.7               | -14.7               | +43.9                    |
| 30.83         | 29.27         | -1.                               | +113.                             | -12.                              | +113.                             | -126.                             | +16.9               | -20.8               | +43.6                    |
| 41.15         | 38.79         | +1.                               | +148.                             | -15.                              | +148.                             | -162.                             | +22.3               | -26.5               | +43.5                    |
| 51.35         | 48.55         | +2.                               | +180.                             | -17.                              | +180.                             | -195.                             | +27.4               | -31.8               | +43.6                    |
| 61.31         | 58.42         | +4.                               | +206.                             | -16.                              | +206.                             | -219.                             | +31.7               | -35.3               | +43.7                    |
| 0.23          | 0.00          | +10.                              | +5.                               | +6.                               | +10.                              | +6.                               | +2.7                | +2.0                | -5.7                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.1 DATA: 04/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +1.                               | +0.                               | +1.                               | +2.                               | -0.                               | +0.4                | +0.1                | U/C                      |
| 10.32         | 9.64          | -6.                               | +32.                              | -12.                              | +32.                              | -52.                              | +3.7                | -9.6                | +43.4                    |
| 20.63         | 19.28         | -6.                               | +71.                              | -14.                              | +71.                              | -91.                              | +9.9                | -15.7               | +43.5                    |
| 30.83         | 29.15         | -4.                               | +112.                             | -13.                              | +112.                             | -129.                             | +16.5               | -21.5               | +43.9                    |
| 0.59          | 0.46          | +1.                               | +5.                               | +2.                               | +5.                               | -2.                               | +0.9                | -0.1                | U/C                      |
| 10.43         | 9.76          | -3.                               | +37.                              | -8.                               | +37.                              | -47.                              | +5.1                | -8.2                | +43.4                    |
| 20.63         | 19.63         | -3.                               | +76.                              | -9.                               | +76.                              | -85.                              | +11.1               | -14.7               | +43.8                    |
| 30.83         | 29.27         | -1.                               | +115.                             | -9.                               | +116.                             | -126.                             | +17.5               | -20.6               | +44.0                    |
| 41.15         | 38.79         | +2.                               | +155.                             | -8.                               | +155.                             | -161.                             | +24.1               | -25.8               | +44.1                    |
| 51.35         | 48.55         | +5.                               | +196.                             | -3.                               | +196.                             | -194.                             | +31.0               | -30.5               | +44.4                    |
| 61.31         | 58.42         | +9.                               | +234.                             | +10.                              | +234.                             | -214.                             | +38.2               | -32.4               | +45.1                    |
| 0.23          | 0.00          | -6.                               | +9.                               | +9.                               | +9.                               | +7.                               | +2.5                | +2.3                | +67.6                    |

UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

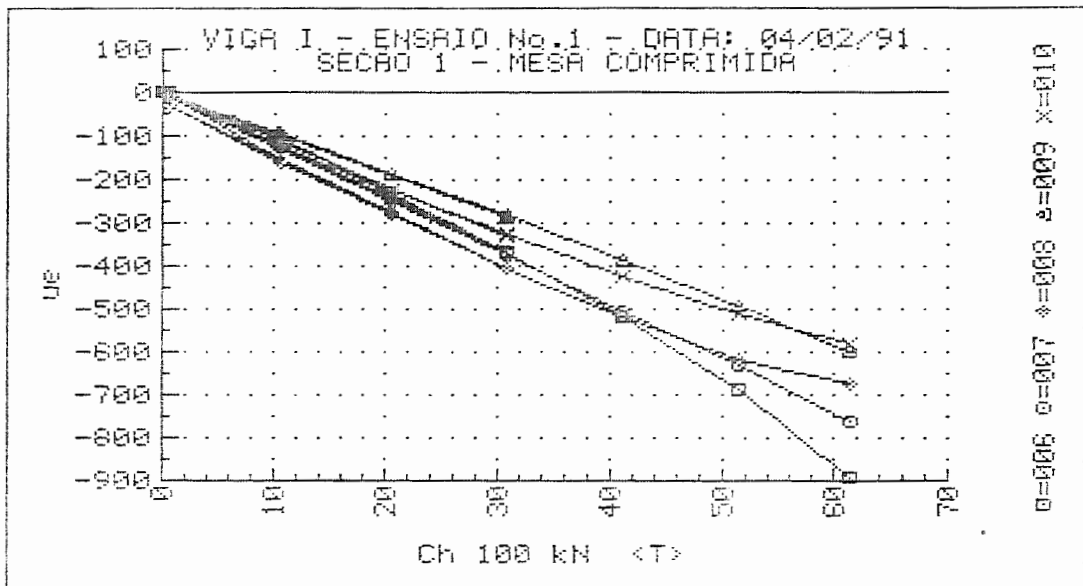
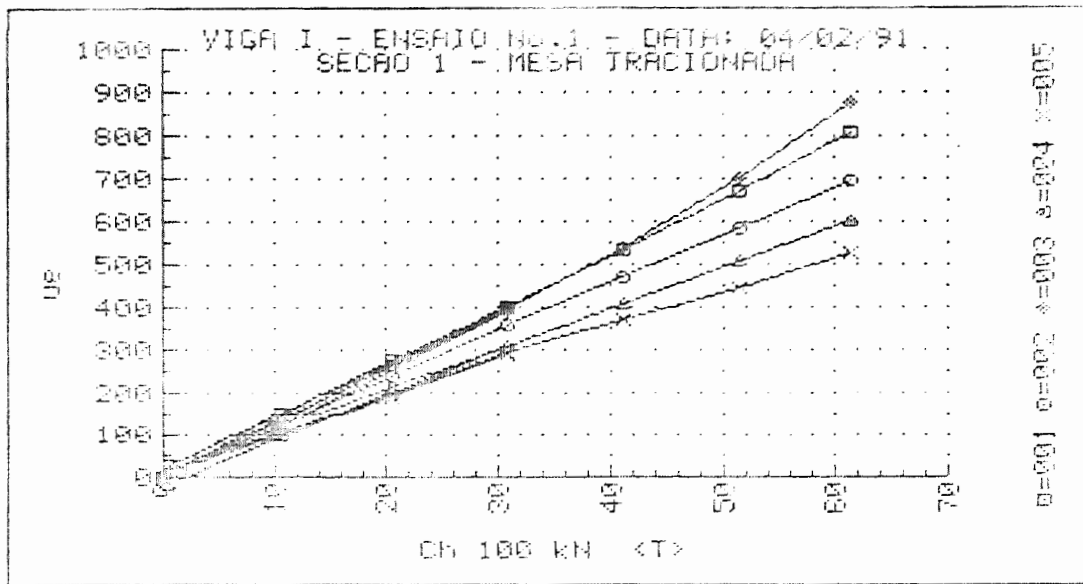
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.1 DATA: 04/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

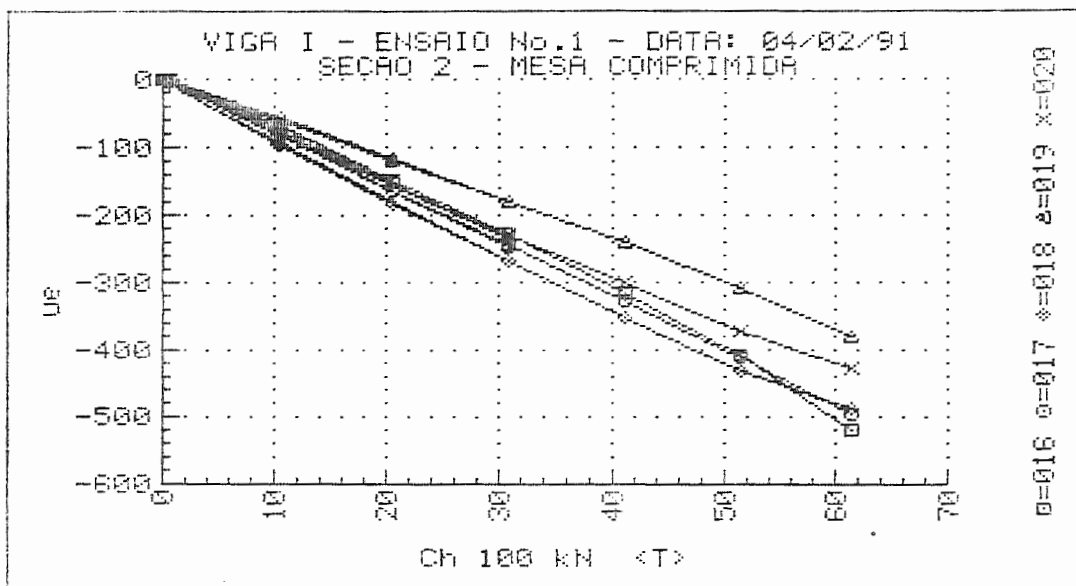
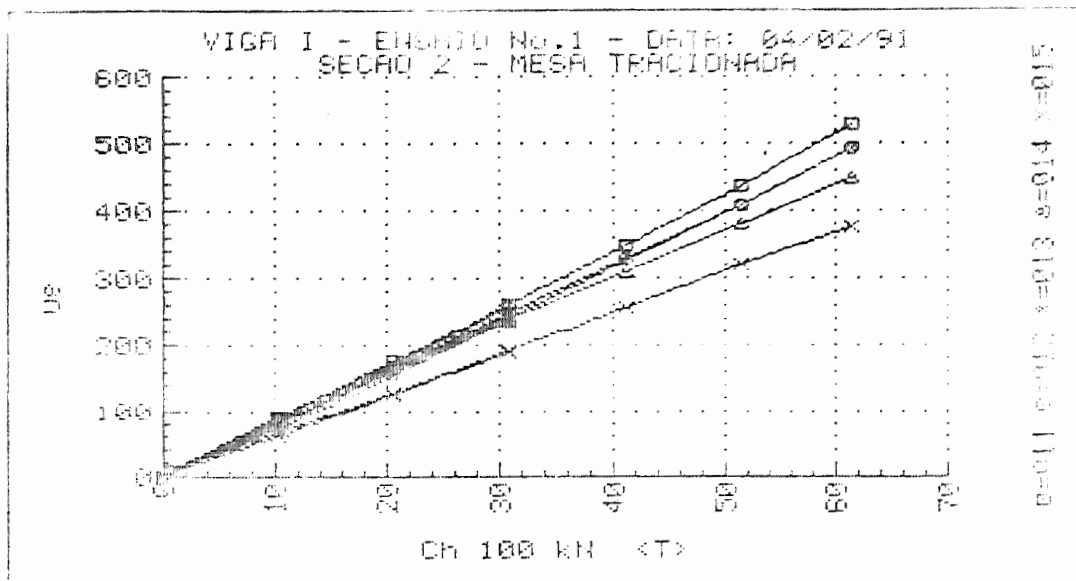
| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_d$<br>( $\mu\epsilon$ ) | $\epsilon_e$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | -1.                               | +0.                               | +1.                               | -1.                               | +0.1                | -0.1                | U/C                      |
| 10.33         | 9.64          | -1.                               | +40.                              | -5.                               | +40.                              | -45.                              | +5.9                | -7.5                | +43.7                    |
| 20.63         | 19.28         | -2.                               | +77.                              | -7.                               | +77.                              | -85.                              | +11.5               | -14.0               | +44.2                    |
| 30.83         | 29.15         | -3.                               | +114.                             | -8.                               | +114.                             | -125.                             | +17.3               | -20.4               | +44.4                    |
| 0.59          | 0.46          | +3.                               | +6.                               | +1.                               | +6.                               | -2.                               | +1.2                | -0.1                | U/C                      |
| 10.43         | 9.76          | +3.                               | +43.                              | -2.                               | +43.                              | -42.                              | +6.8                | -6.5                | +43.4                    |
| 20.63         | 19.63         | +1.                               | +80.                              | -4.                               | +80.                              | -83.                              | +12.5               | -13.3               | +44.2                    |
| 30.83         | 29.27         | +0.                               | +117.                             | -5.                               | +117.                             | -122.                             | +18.2               | -19.6               | +44.4                    |
| 41.15         | 39.79         | +2.                               | +155.                             | -4.                               | +155.                             | -157.                             | +24.3               | -24.9               | +44.5                    |
| 51.35         | 48.55         | +5.                               | +195.                             | -1.                               | +195.                             | -191.                             | +31.0               | -29.9               | +44.6                    |
| 61.31         | 58.42         | +9.                               | +234.                             | +11.                              | +234.                             | -214.                             | +38.4               | -32.3               | +45.1                    |
| 0.23          | 0.00          | +16.                              | +11.                              | +1.                               | +17.                              | +0.                               | +3.8                | +1.2                | U/C                      |

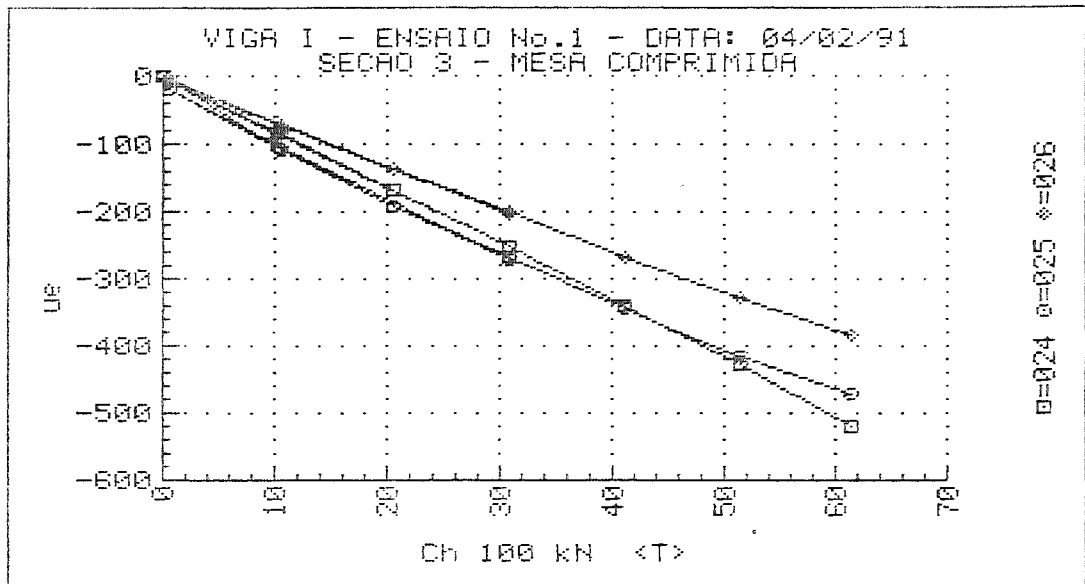
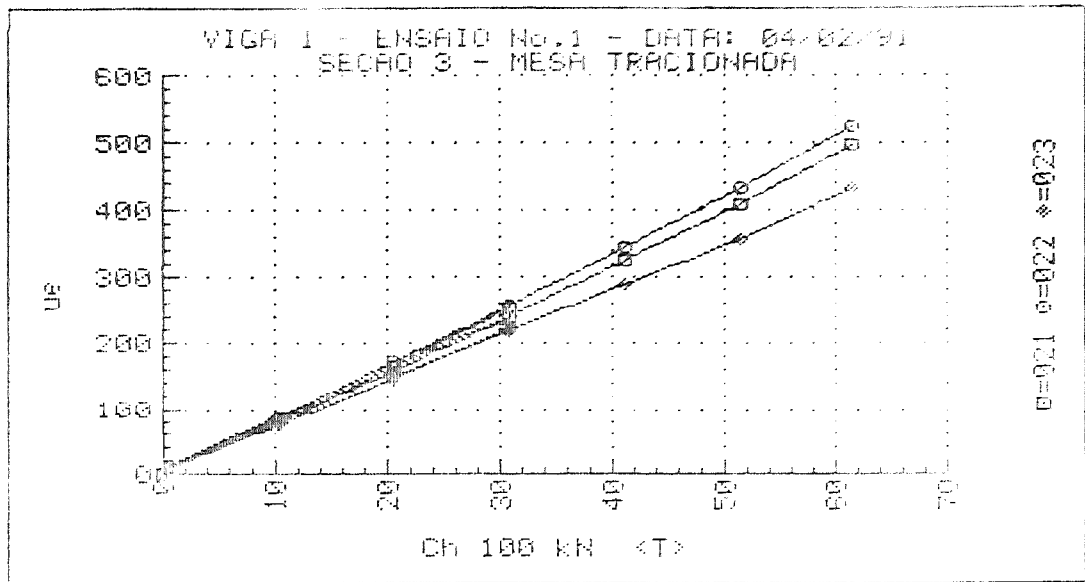
UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I            ENSAIO No.1            DATA: 04/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

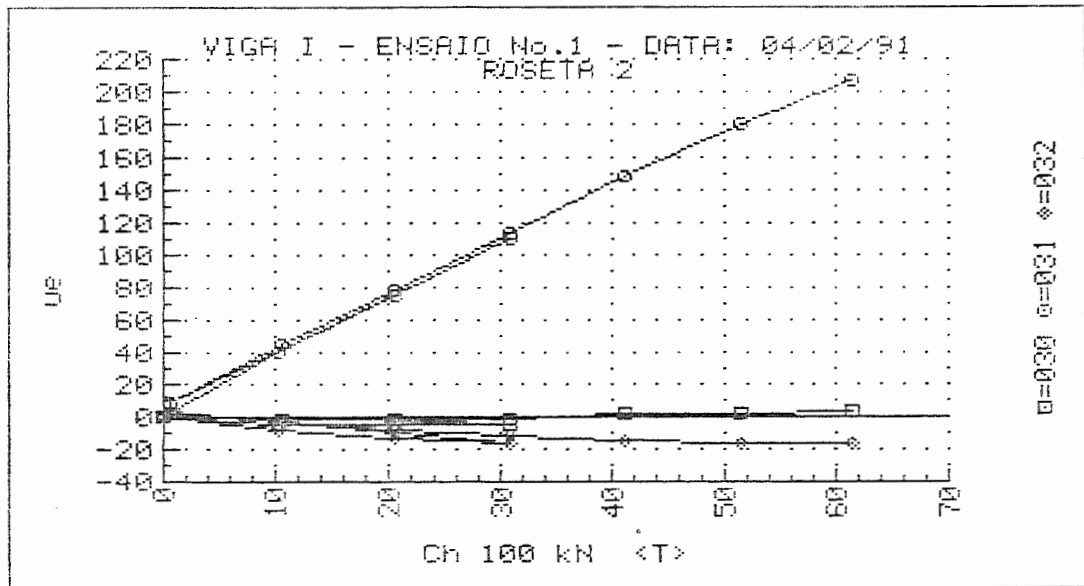
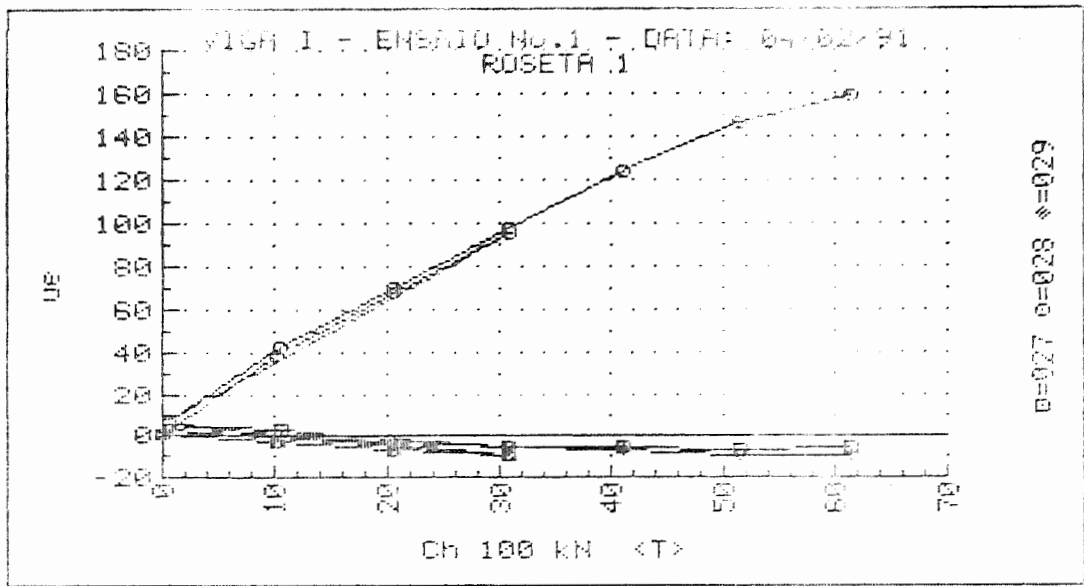
| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.00         | 9.64          | +1.                               | -44.                              | -9.                               | +36.                              | -44.                              | +5.2                | -7.4                | -41.6                    |
| 20.63         | 19.28         | +9.                               | -78.                              | -14.                              | +73.                              | -78.                              | +11.1               | -12.8               | -40.7                    |
| 30.60         | 29.15         | +15.                              | -111.                             | -19.                              | +108.                             | -112.                             | +16.8               | -17.9               | -40.6                    |
| 0.59          | 0.46          | +3.                               | -2.                               | +0.                               | +8.                               | -2.                               | +1.6                | +0.1                | U/C                      |
| 10.43         | 9.76          | +7.                               | -40.                              | -5.                               | +42.                              | -40.                              | +6.8                | -6.2                | -41.0                    |
| 20.63         | 19.63         | +12.                              | -73.                              | -10.                              | +76.                              | -74.                              | +12.0               | -11.5               | -40.6                    |
| 30.80         | 29.27         | +18.                              | -107.                             | -16.                              | +110.                             | -108.                             | +17.5               | -16.9               | -40.5                    |
| 41.15         | 38.79         | +26.                              | -138.                             | -21.                              | +145.                             | -140.                             | +23.1               | -21.8               | -40.3                    |
| 51.35         | 48.55         | +32.                              | -167.                             | -25.                              | +177.                             | -170.                             | +28.5               | -26.3               | -40.3                    |
| 61.31         | 58.42         | +40.                              | -190.                             | -26.                              | +206.                             | -193.                             | +33.4               | -29.5               | -40.2                    |
| 0.23          | 0.00          | +9.                               | +4.                               | +2.                               | +10.                              | +1.                               | +2.3                | +1.0                | U/C                      |

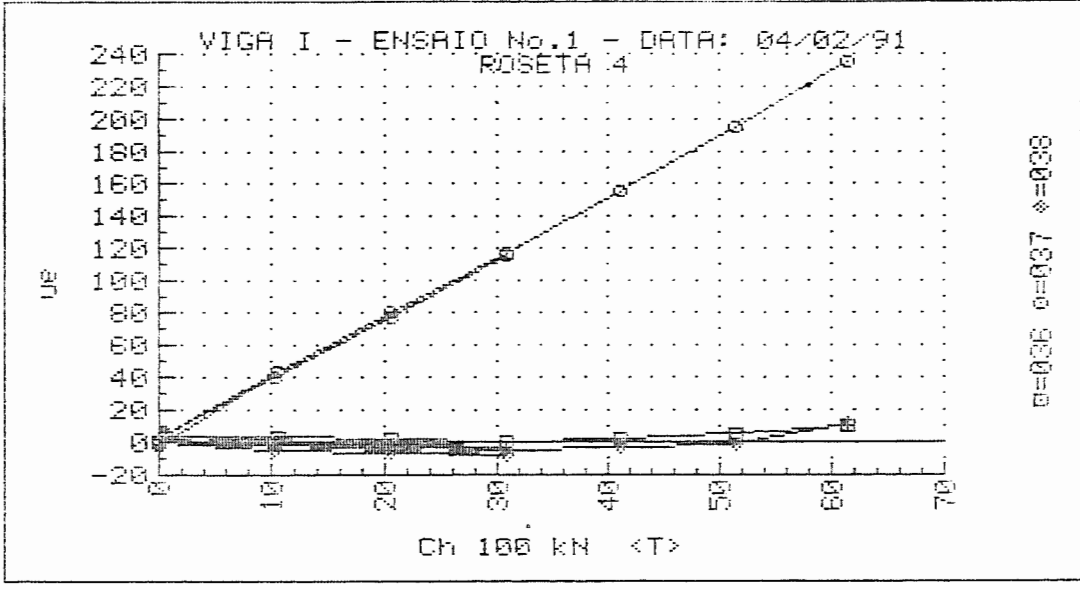
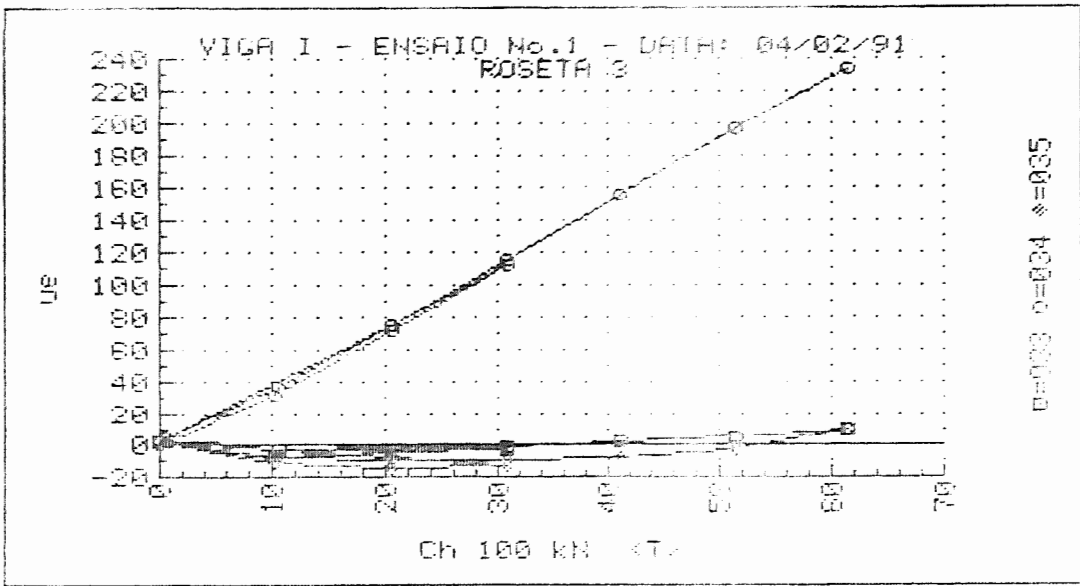


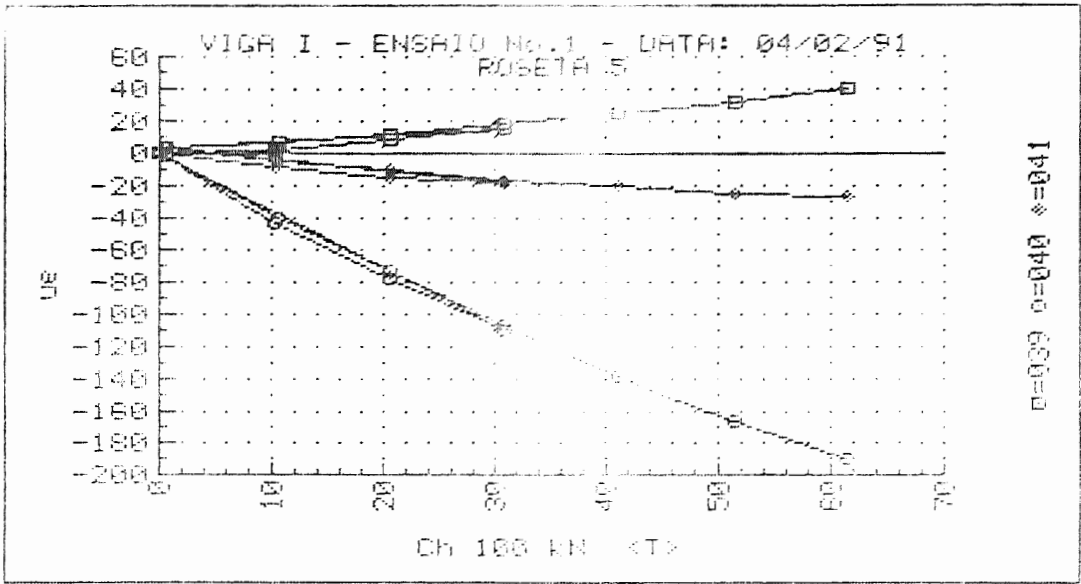












MODELO - VIGA I

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA I

ENSAIO Nro:2

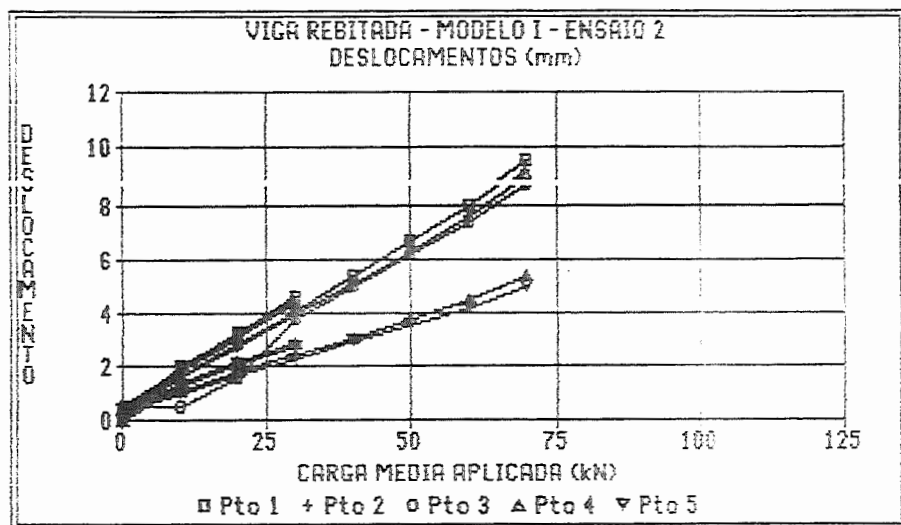
DATA: 8 DE FEVEREIRO DE 1990

HORARIO: 10:30 Hs

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| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |      |       |
|-------|----------------------------|-----------------------|-------|-------|------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00 | 0.00  |
| 1     | 9.95                       | 2.02                  | 2.00  | 1.89  | 1.50 | 1.26  |
| 2     | 20.00                      | 3.32                  | 3.25  | 3.17  | 2.24 | 2.01  |
| 3     | 30.05                      | 4.61                  | 4.45  | 4.35  | 2.91 | 2.75  |
| 4     | .10                        | .42                   | .46   | .49   | .42  | .34   |
| 5     | 10.10                      | 1.64                  | 1.57  | 1.48  | 1.09 | .96   |
| 6     | 19.95                      | 2.90                  | 2.77  | 2.65  | 1.77 | 1.67  |
| 7     | 30.00                      | 4.14                  | 3.94  | 3.81  | 2.42 | 2.38  |
| 8     | 39.95                      | 5.38                  | 5.12  | 5.01  | 3.06 | 3.04  |
| 9     | 50.00                      | 6.65                  | 6.31  | 6.19  | 3.71 | 3.70  |
| 10    | 59.95                      | 7.96                  | 7.54  | 7.43  | 4.41 | 4.36  |
| 11    | 69.85                      | 9.54                  | 9.04  | 8.88  | 5.21 | 5.17  |

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MODELO - VIGA I

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I            ENSAIO No.2            DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 1

| F <sub>1</sub><br>(KG.) | F <sub>2</sub><br>(KG.) | 1<br>(µE) | 2<br>(µE) | 3<br>(µE) | 4<br>(µE) | 5<br>(µE) | 6<br>(µE) | 7<br>(µE) | 8<br>(µE) | 9<br>(µE) | 10<br>(µE) |
|-------------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 0.00                    | 0.00                    | +0.       | +0.       | +0.       | +0.       | +0.       | +1.       | +1.       | +1.       | +1.       | +1.        |
| 10.32                   | 9.64                    | +118.     | +122.     | +140.     | +107.     | +97.      | -112.     | -121.     | -130.     | -92.      | -116.      |
| 20.63                   | 19.40                   | +242.     | +245.     | +275.     | +216.     | +193.     | -232.     | -244.     | -270.     | -185.     | -229.      |
| 30.83                   | 29.27                   | +371.     | +368.     | +406.     | +327.     | +288.     | -348.     | -355.     | -410.     | -278.     | -343.      |
| 0.12                    | 0.12                    | +1.       | +0.       | +9.       | +1.       | +5.       | +5.       | +0.       | -8.       | +1.       | -3.        |
| 10.43                   | 9.76                    | +123.     | +126.     | +146.     | +110.     | +101.     | -109.     | -122.     | -143.     | -90.      | -110.      |
| 20.63                   | 19.28                   | +244.     | +247.     | +278.     | +217.     | +195.     | -228.     | -243.     | -273.     | -183.     | -229.      |
| 30.83                   | 29.38                   | +373.     | +370.     | +410.     | +328.     | +290.     | -347.     | -365.     | -410.     | -279.     | -342.      |
| 40.91                   | 39.02                   | +497.     | +492.     | +542.     | +434.     | +383.     | -468.     | -450.     | -545.     | -373.     | -450.      |
| 51.11                   | 48.90                   | +623.     | +618.     | +678.     | +538.     | +476.     | -590.     | -618.     | -680.     | -468.     | -562.      |
| 61.20                   | 58.65                   | +749.     | +741.     | +811.     | +644.     | +565.     | -690.     | -745.     | -803.     | -561.     | -687.      |
| 71.40                   | 68.29                   | +897.     | +812.     | +976.     | +747.     | +649.     | -754.     | -877.     | -913.     | -651.     | -869.      |
| 0.12                    | 0.00                    | +89.      | -118.     | +64.      | +19.      | +6.       | +176.     | -91.      | +488.     | -24.      | -153.      |



UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.2 DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 2

| $F_1$<br>(KN) | $F_2$<br>(KN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00          | 0.00          | +0.                    | -1.                    | +0.                    | +0.                    | +0.                    | +1.                    | +1.                    | +1.                    | +1.                    | +0.                     |
| 10.32         | 9.64          | +70.                   | +82.                   | +89.                   | +80.                   | +66.                   | -64.                   | -82.                   | -101.                  | -57.                   | -82.                    |
| 20.63         | 19.40         | +150.                  | +164.                  | +176.                  | +157.                  | +130.                  | -135.                  | -163.                  | -198.                  | -116.                  | -163.                   |
| 30.83         | 29.27         | +230.                  | +247.                  | +260.                  | +234.                  | +194.                  | -207.                  | -246.                  | -293.                  | -176.                  | -244.                   |
| 0.12          | 0.12          | +1.                    | +3.                    | +6.                    | +7.                    | +5.                    | +6.                    | +0.                    | -5.                    | +2.                    | -1.                     |
| 10.43         | 9.76          | +81.                   | +85.                   | +91.                   | +85.                   | +69.                   | -59.                   | -82.                   | -106.                  | -56.                   | -84.                    |
| 20.63         | 19.28         | +160.                  | +166.                  | +176.                  | +160.                  | +132.                  | -130.                  | -163.                  | -200.                  | -115.                  | -164.                   |
| 30.83         | 29.38         | +239.                  | +249.                  | +261.                  | +236.                  | +196.                  | -204.                  | -245.                  | -295.                  | -176.                  | -245.                   |
| 40.91         | 39.02         | +316.                  | +331.                  | +347.                  | +309.                  | +260.                  | -279.                  | -327.                  | -388.                  | -236.                  | -324.                   |
| 51.11         | 48.90         | +392.                  | +414.                  | +437.                  | +381.                  | +325.                  | -353.                  | -411.                  | -482.                  | -298.                  | -404.                   |
| 61.20         | 58.65         | +467.                  | +495.                  | +530.                  | +449.                  | +350.                  | -420.                  | -492.                  | -574.                  | -359.                  | -480.                   |
| 71.40         | 68.29         | +539.                  | +578.                  | +642.                  | +515.                  | +451.                  | -488.                  | -575.                  | -672.                  | -419.                  | -563.                   |
| 0.12          | 0.00          | +31.                   | +18.                   | +22.                   | -9.                    | -4.                    | +15.                   | -3.                    | +27.                   | -3.                    | -8.                     |

UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I            ENSAIO No.2            DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 3

| F <sub>1</sub><br>(KN) | F <sub>2</sub><br>(KN) | 1<br>(µε) | 2<br>(µε) | 3<br>(µε) | 4<br>(µε) | 5<br>(µε) | 6<br>(µε) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.00                   | 0.00                   | +0.       | -1.       | +0.       | -1.       | +0.       | +0.       |
| 10.32                  | 9.64                   | +76.      | +83.      | +74.      | -84.      | -87.      | -67.      |
| 20.63                  | 19.40                  | +154.     | +167.     | +147.     | -166.     | -173.     | -132.     |
| 30.83                  | 29.27                  | +237.     | +251.     | +223.     | -257.     | -263.     | -198.     |
| 0.12                   | 0.12                   | +1.       | +4.       | +3.       | -2.       | -4.       | -2.       |
| 10.43                  | 9.76                   | +78.      | +86.      | +76.      | -84.      | -86.      | -67.      |
| 20.63                  | 19.28                  | +154.     | +169.     | +147.     | -167.     | -172.     | -131.     |
| 30.83                  | 29.38                  | +236.     | +253.     | +223.     | -254.     | -261.     | -198.     |
| 40.91                  | 39.02                  | +313.     | +337.     | +295.     | -346.     | -346.     | -264.     |
| 51.11                  | 48.90                  | +390.     | +422.     | +367.     | -427.     | -431.     | -330.     |
| 61.20                  | 58.65                  | +467.     | +508.     | +436.     | -512.     | -520.     | -395.     |
| 71.40                  | 68.29                  | +541.     | +599.     | +499.     | -599.     | -629.     | -459.     |
| 0.12                   | 0.00                   | +30.      | +21.      | +4.       | -3.       | -23.      | +3.       |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.2 DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | 0/0                      |
| 10.32         | 9.64          | -2.                               | +44.                              | -5.                               | +44.                              | -51.                              | +6.6                | -8.5                | +44.1                    |
| 20.63         | 19.40         | -6.                               | +78.                              | -8.                               | +78.                              | -91.                              | +11.3               | -15.2               | +44.7                    |
| 30.83         | 25.27         | -8.                               | +110.                             | -11.                              | +110.                             | -129.                             | +16.0               | -21.6               | +44.5                    |
| 0.12          | 0.12          | +4.                               | +10.                              | +1.                               | +11.                              | -6.                               | +2.0                | -0.0                | +40.0                    |
| 10.43         | 9.76          | +0.                               | +48.                              | -3.                               | +48.                              | -51.                              | +7.4                | -8.2                | +44.2                    |
| 20.63         | 19.28         | -3.                               | +79.                              | -7.                               | +79.                              | -89.                              | +11.9               | -14.7               | +44.4                    |
| 30.83         | 29.38         | -6.                               | +112.                             | -10.                              | +112.                             | -128.                             | +16.5               | -21.2               | +44.4                    |
| 40.91         | 39.02         | -8.                               | +143.                             | -15.                              | +143.                             | -166.                             | +21.0               | -27.6               | +44.3                    |
| 51.11         | 48.90         | -9.                               | +177.                             | -20.                              | +177.                             | -205.                             | +26.0               | -34.3               | +44.1                    |
| 61.20         | 58.65         | -8.                               | +215.                             | -26.                              | +215.                             | -248.                             | +31.6               | -41.3               | +43.9                    |
| 71.40         | 68.29         | -2.                               | +266.                             | -35.                              | +266.                             | -306.                             | +39.3               | -50.9               | +43.2                    |
| 0.12          | 0.00          | +26.                              | +40.                              | -7.                               | +44.                              | -25.                              | +8.2                | -2.6                | +31.0                    |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.2 DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.32                  | 9.64                   | -4.                    | +45.                   | -7.                    | +45.                   | -56.                   | +8.5                    | -5.5                    | +44.2    |
| 20.63                  | 19.40                  | -4.                    | +83.                   | -11.                   | +83.                   | -98.                   | +13.1                   | -16.5                   | +43.8    |
| 30.83                  | 29.27                  | -4.                    | +126.                  | -17.                   | +126.                  | -141.                  | +17.6                   | -23.7                   | +43.5    |
| 0.12                   | 0.12                   | +2.                    | +9.                    | +2.                    | +9.                    | -6.                    | +1.7                    | -0.6                    | +45.0    |
| 10.43                  | 9.76                   | -1.                    | +49.                   | -5.                    | +49.                   | -55.                   | +7.4                    | -9.0                    | +44.0    |
| 20.63                  | 19.28                  | -2.                    | +85.                   | -10.                   | +85.                   | -98.                   | +12.6                   | -16.2                   | +43.7    |
| 30.83                  | 29.38                  | -2.                    | +122.                  | -16.                   | +122.                  | -140.                  | +18.1                   | -23.3                   | +43.5    |
| 40.91                  | 39.02                  | -2.                    | +158.                  | -22.                   | +158.                  | -182.                  | +23.4                   | -30.3                   | +43.3    |
| 51.11                  | 48.90                  | -1.                    | +195.                  | -28.                   | +195.                  | -225.                  | +28.8                   | -37.4                   | +43.1    |
| 61.20                  | 58.65                  | +0.                    | +234.                  | -36.                   | +234.                  | -270.                  | +34.5                   | -45.0                   | +43.0    |
| 71.40                  | 68.29                  | +3.                    | +279.                  | -48.                   | +280.                  | -326.                  | +41.1                   | -54.4                   | +42.6    |
| 0.12                   | 0.00                   | +9.                    | +31.                   | +3.                    | +31.                   | -19.                   | +5.8                    | -2.2                    | +41.2    |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.2 DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | E <sub>A</sub><br>( $\mu\epsilon$ ) | E <sub>B</sub><br>( $\mu\epsilon$ ) | E <sub>C</sub><br>( $\mu\epsilon$ ) | E <sub>1</sub><br>( $\mu\epsilon$ ) | E <sub>2</sub><br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|------------------------|------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------------|---------------------|--------------------------|
| 0.00                   | 0.00                   | +0.                                 | +0.                                 | +0.                                 | +0.                                 | +0.                                 | +0.0                | +0.0                | U/C                      |
| 10.32                  | 9.64                   | -4.                                 | +41.                                | -10.                                | +41.                                | -55.                                | +5.5                | -9.6                | +43.0                    |
| 20.63                  | 19.40                  | -4.                                 | +82.                                | -13.                                | +82.                                | -100.                               | +11.9               | -16.8               | +43.5                    |
| 30.83                  | 29.27                  | -3.                                 | +122.                               | -17.                                | +122.                               | -142.                               | +17.9               | -23.8               | +43.5                    |
| 0.12                   | 0.12                   | +2.                                 | +9.                                 | +1.                                 | -7.                                 | -6.                                 | +1.5                | -0.7                | +43.1                    |
| 10.43                  | 9.76                   | -2.                                 | +44.                                | -6.                                 | +45.                                | -54.                                | +6.4                | -9.2                | +43.3                    |
| 20.63                  | 19.28                  | -2.                                 | +85.                                | -11.                                | +85.                                | -99.                                | +12.6               | -16.4               | +43.5                    |
| 30.83                  | 29.38                  | -1.                                 | +125.                               | -15.                                | +125.                               | -141.                               | +18.6               | -23.4               | +43.5                    |
| 40.91                  | 39.02                  | -1.                                 | +164.                               | -19.                                | +164.                               | -184.                               | +24.5               | -30.3               | +43.5                    |
| 51.11                  | 48.90                  | +0.                                 | +204.                               | -24.                                | +205.                               | -228.                               | +30.7               | -37.6               | +43.4                    |
| 61.20                  | 58.65                  | +0.                                 | +246.                               | -31.                                | +247.                               | -278.                               | +36.8               | -45.9               | +43.3                    |
| 71.40                  | 68.29                  | -1.                                 | +290.                               | -40.                                | +291.                               | -340.                               | +42.5               | -56.9               | +42.8                    |
| 0.12                   | 0.00                   | +6.                                 | +28.                                | -1.                                 | +29.                                | -24.                                | +4.8                | -3.4                | +41.4                    |

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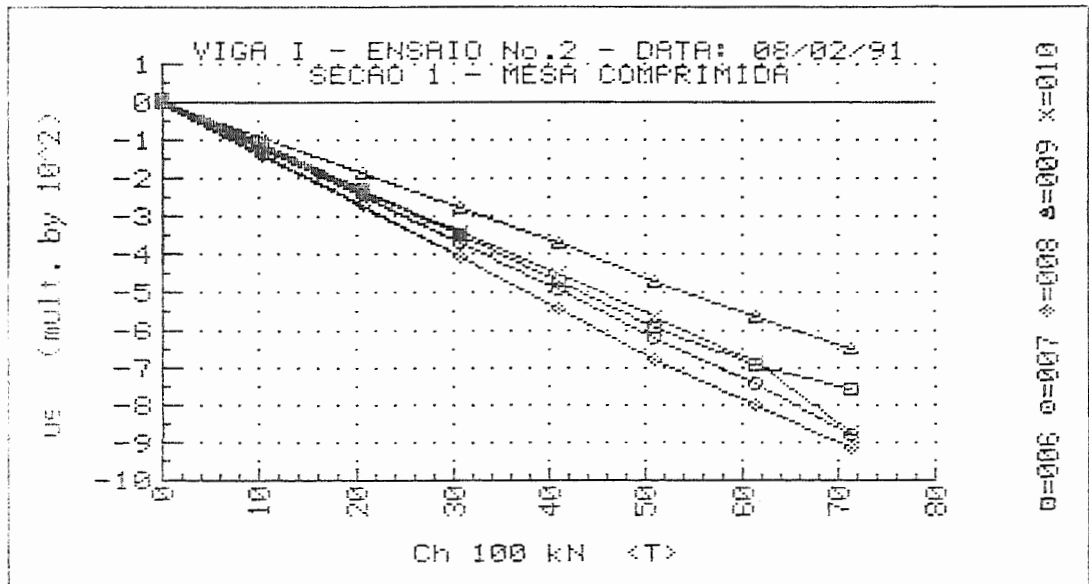
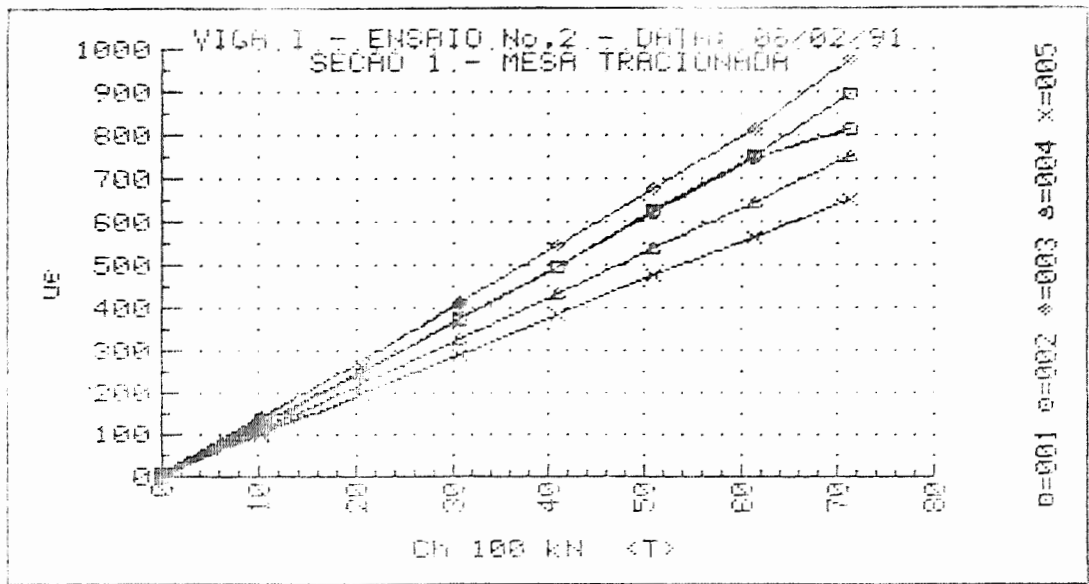
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I            ENSAIO No.2            DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/D                      |
| 10.32         | 9.64          | -1.                               | +40.                              | -7.                               | +44.                              | -51.                              | +6.4                | -8.6                | +43.3                    |
| 20.67         | 19.40         | -2.                               | +82.                              | -10.                              | +82.                              | -95.                              | +12.2               | -15.8               | +43.6                    |
| 30.67         | 29.27         | -3.                               | +119.                             | -14.                              | +119.                             | -136.                             | +17.7               | -22.6               | +43.7                    |
| 0.12          | 0.12          | +2.                               | +9.                               | +1.                               | +9.                               | -6.                               | +1.5                | -0.7                | +43.1                    |
| 10.43         | 9.76          | +1.                               | +46.                              | -5.                               | +46.                              | -50.                              | +7.1                | -8.2                | +43.3                    |
| 20.63         | 19.28         | +0.                               | +83.                              | -9.                               | +83.                              | -93.                              | +12.5               | -15.3               | +43.5                    |
| 30.83         | 29.38         | -2.                               | +121.                             | -13.                              | +121.                             | -136.                             | +18.1               | -22.5               | +43.7                    |
| 40.91         | 39.02         | -4.                               | +158.                             | -18.                              | +158.                             | -180.                             | +23.5               | -29.8               | +43.8                    |
| 51.11         | 48.90         | -5.                               | +195.                             | -25.                              | +195.                             | -224.                             | +28.8               | -37.4               | +43.6                    |
| 61.20         | 58.65         | -7.                               | +231.                             | -36.                              | +231.                             | -274.                             | +33.6               | -46.0               | +43.3                    |
| 71.41         | 68.29         | -7.                               | +268.                             | -66.                              | +269.                             | -342.                             | +37.5               | -58.8               | +42.2                    |
| 0.12          | 0.00          | +9.                               | +27.                              | -12.                              | +29.                              | -33.                              | +4.4                | -5.5                | +35.2                    |

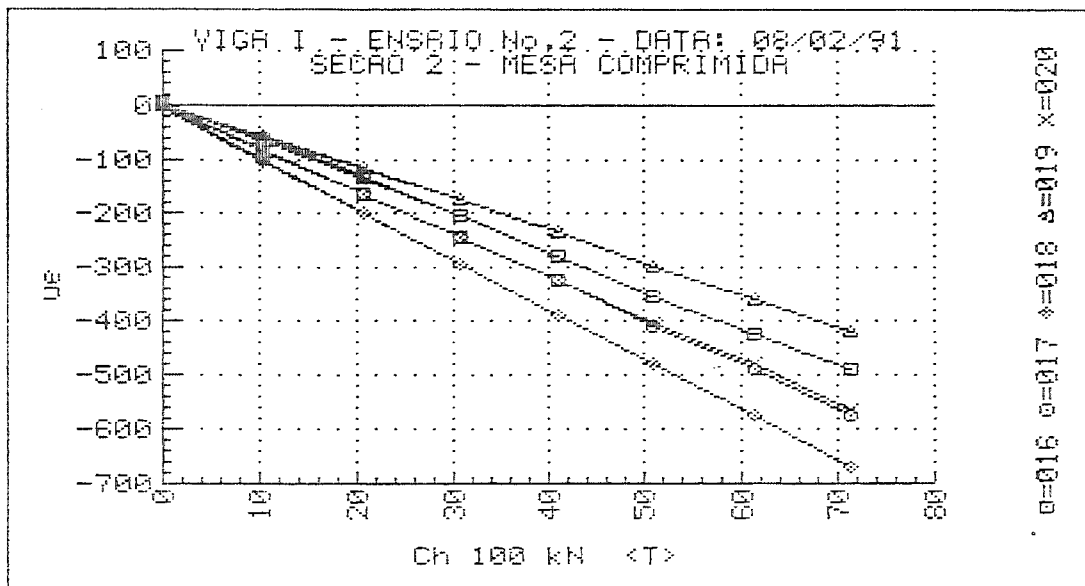
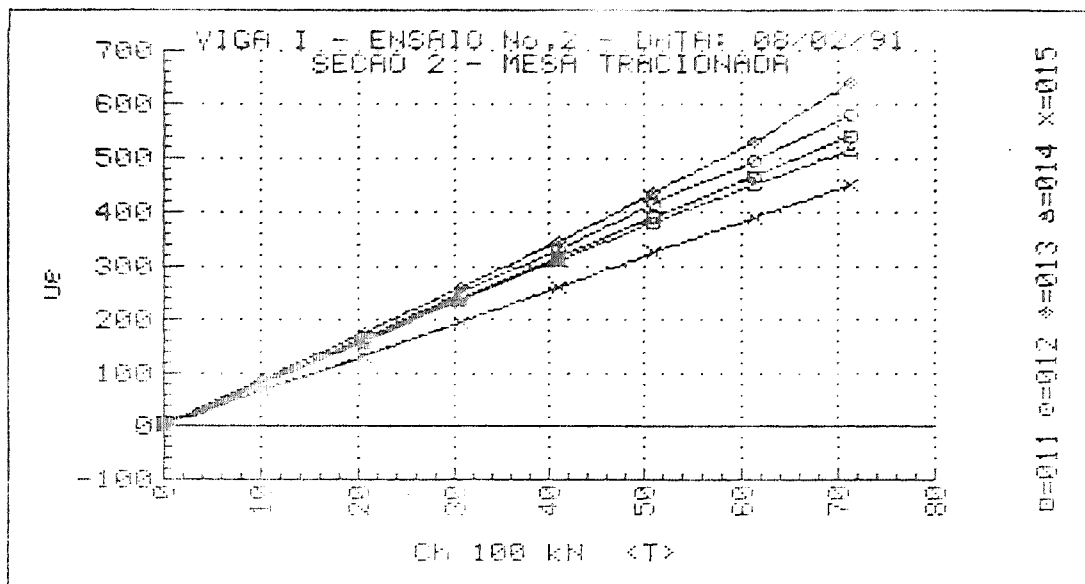
UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

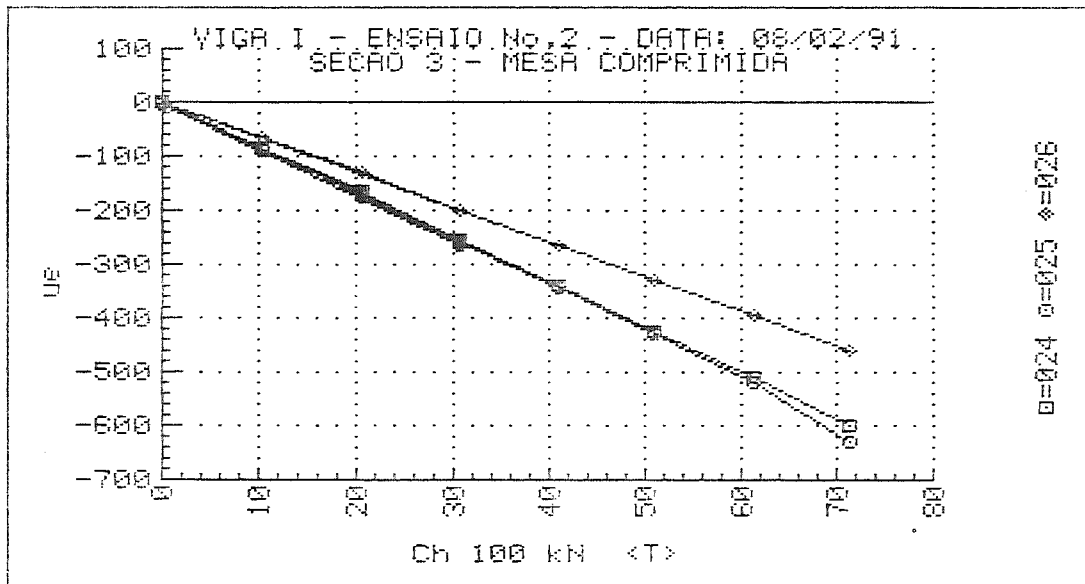
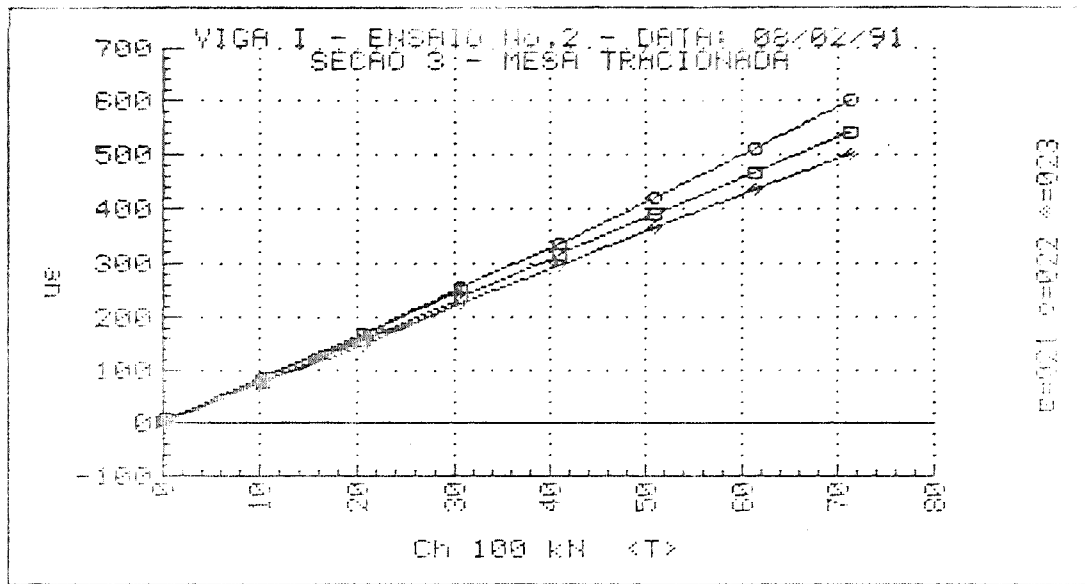
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.2 DATA: 08/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

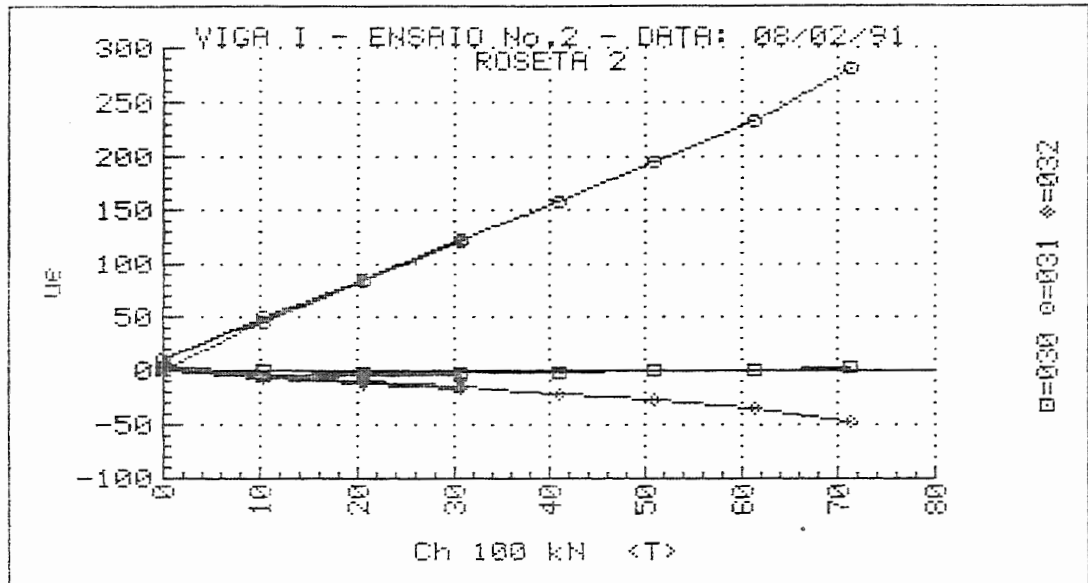
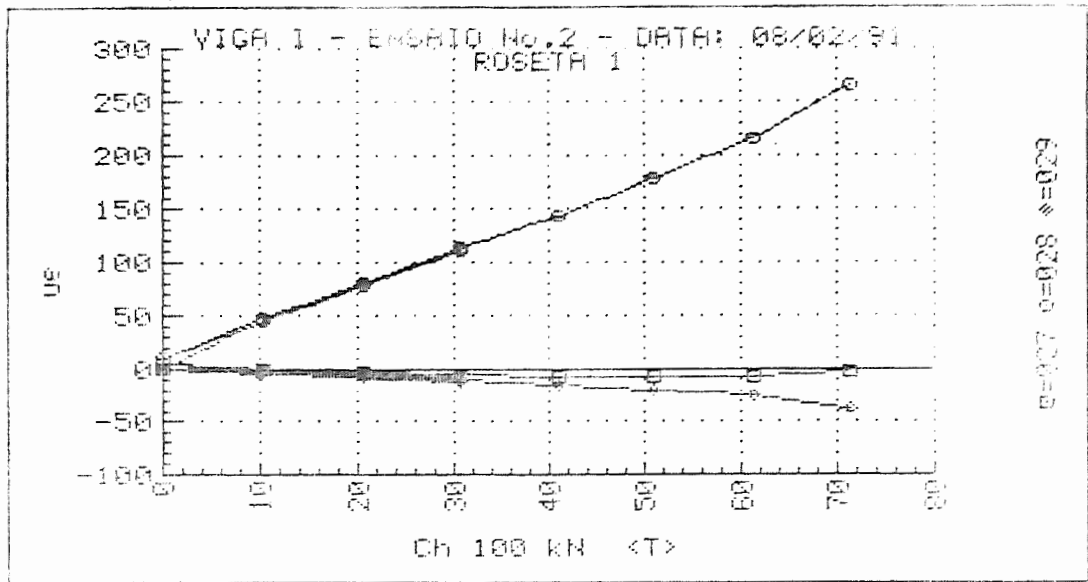
| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.32                  | 9.64                   | +0.                    | -42.                   | -9.                    | +33.                   | -42.                   | +4.7                    | -7.2                    | -41.8    |
| 20.63                  | 19.40                  | +6.                    | -79.                   | -14.                   | +71.                   | -79.                   | +10.6                   | -13.1                   | -41.2    |
| 30.83                  | 29.27                  | +10.                   | -115.                  | -20.                   | +107.                  | -116.                  | +16.2                   | -19.0                   | -41.1    |
| 0.12                   | 0.12                   | +2.                    | +3.                    | +2.                    | +2.                    | +1.                    | +0.7                    | +0.4                    | U/C      |
| 10.43                  | 9.76                   | +3.                    | -40.                   | -6.                    | +37.                   | -40.                   | +5.7                    | -6.5                    | -41.8    |
| 20.63                  | 19.28                  | +9.                    | -76.                   | -12.                   | +73.                   | -76.                   | +11.2                   | -12.3                   | -41.0    |
| 30.83                  | 29.38                  | +14.                   | -114.                  | -18.                   | +111.                  | -115.                  | +17.2                   | -18.3                   | -40.9    |
| 40.91                  | 39.02                  | +19.                   | -150.                  | -25.                   | +146.                  | -152.                  | +22.7                   | -24.4                   | -40.8    |
| 51.11                  | 48.90                  | +24.                   | -190.                  | -31.                   | +185.                  | -192.                  | +28.6                   | -30.8                   | -40.8    |
| 61.20                  | 58.65                  | +27.                   | -232.                  | -40.                   | +222.                  | -234.                  | +34.2                   | -37.8                   | -40.8    |
| 71.40                  | 68.29                  | +32.                   | -286.                  | -53.                   | +268.                  | -289.                  | +40.9                   | -47.0                   | -40.6    |
| 0.12                   | 0.00                   | +7.                    | -25.                   | +0.                    | +31.                   | -25.                   | +5.4                    | -3.5                    | -41.6    |

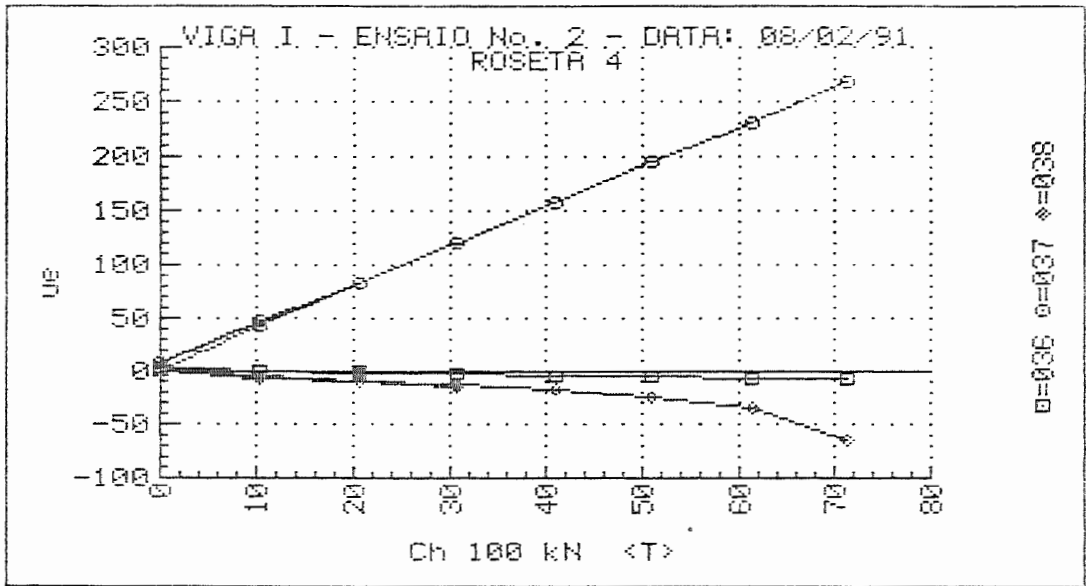
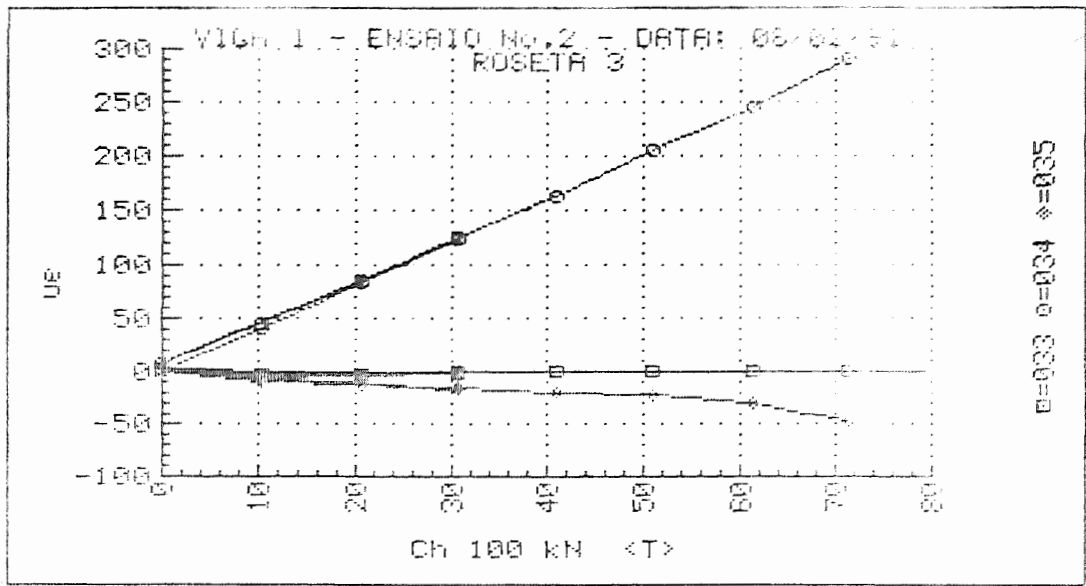


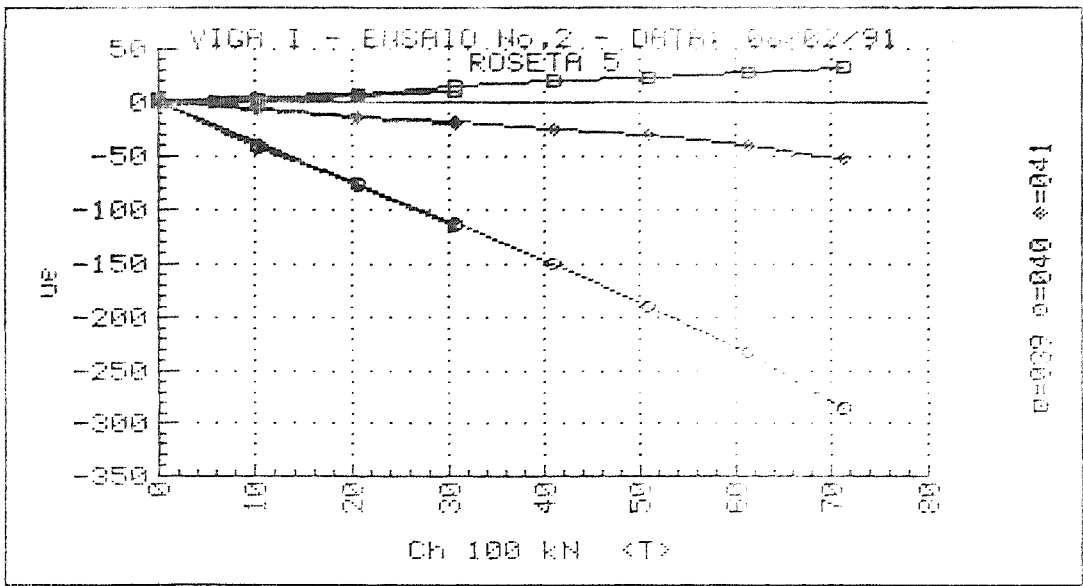












MODELO - VIGA J

RESULTADOS DOS ENSAIOS

. ENSAIO 3

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA I

ENSAIO Nro:3

DATA:15 DE FEVEREIRO DE 1991

HORARIO: 8:45 Hs

| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |      |       |
|-------|----------------------------|-----------------------|-------|-------|------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00 | 0.00  |
| 1     | 10.00                      | 1.62                  | 1.48  | 1.47  | 1.04 | 1.03  |
| 2     | 20.00                      | 2.87                  | 2.65  | 2.66  | 1.70 | 1.64  |
| 3     | 30.05                      | 4.24                  | 3.99  | 3.95  | 2.49 | 2.38  |
| 4     | 0.00                       | -.04                  | .01   | -.01  | .03  | -.04  |
| 5     | 10.00                      | 1.68                  | 1.48  | 1.54  | 1.05 | 1.05  |
| 6     | 20.05                      | 2.95                  | 2.71  | 2.73  | 1.74 | 1.69  |
| 7     | 30.00                      | 4.32                  | 4.00  | 4.00  | 2.49 | 2.49  |
| 8     | 40.05                      | 5.54                  | 5.20  | 5.15  | 3.12 | 3.13  |
| 9     | 50.00                      | 6.79                  | 6.42  | 6.35  | 3.83 | 3.71  |
| 10    | 59.95                      | 8.09                  | 7.65  | 7.54  | 4.49 | 4.41  |
| 11    | 70.00                      | 9.38                  | 8.89  | 8.77  | 5.20 | 5.00  |
| 12    | 80.05                      | 10.77                 | 10.22 | 10.07 | 5.90 | 5.74  |
| 13    | 90.05                      | 12.74                 | 12.06 | 11.95 | 6.86 | 6.77  |
| 14    | 99.95                      | 15.22                 | 14.37 | 14.29 | 8.07 | 7.97  |
| 15    | 106.45                     | 17.82                 | 16.82 | 16.63 | 9.25 | 9.16  |
| 16    | 105.40                     | 18.34                 | 17.33 | 17.15 | 9.47 | 9.42  |

MODELO - VIGA I

RESULTADOS DOS ENSAIOS

. ENSAIO 3

- DEFORMAÇÕES

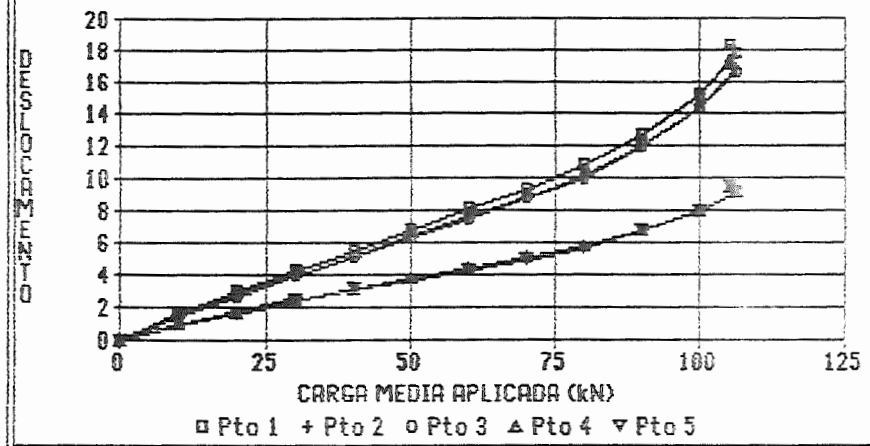
EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS



VIGA REBITADA - MODELO 1 - ENSAIO 3  
DESLOCAMENTOS (mm)



UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.3 DATA: 15/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECao 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µε) | 2<br>(µε) | 3<br>(µε) | 4<br>(µε) | 5<br>(µε) | 6<br>(µε) | 7<br>(µε) | 8<br>(µε) | 9<br>(µε) | 10<br>(µε) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 0.00                   | 0.00                   | +0.       | +0.       | +0.       | +0.       | +0.       | +0.       | +1.       | +1.       | +0.       | +0.        |
| 10.08                  | 9.87                   | +110.     | +123.     | +146.     | +103.     | +97.      | -106.     | -121.     | -142.     | -91.      | -123.      |
| 20.40                  | 19.51                  | +229.     | +246.     | +287.     | +208.     | +194.     | -220.     | -243.     | -279.     | -183.     | -240.      |
| 30.72                  | 29.38                  | +349.     | +369.     | +425.     | +314.     | +290.     | -336.     | -369.     | -416.     | -277.     | -354.      |
| 0.00                   | 0.00                   | +2.       | +3.       | +3.       | +2.       | +3.       | +3.       | +3.       | +0.       | +2.       | +1.        |
| 10.20                  | 9.76                   | +109.     | +124.     | +151.     | +101.     | +99.      | -100.     | -119.     | -145.     | -88.      | -123.      |
| 20.52                  | 19.63                  | +229.     | +248.     | +291.     | +209.     | +195.     | -216.     | -242.     | -279.     | -181.     | -239.      |
| 30.72                  | 29.38                  | +351.     | +371.     | +426.     | +316.     | +292.     | -334.     | -367.     | -415.     | -275.     | -353.      |
| 40.80                  | 39.26                  | +471.     | +493.     | +560.     | +419.     | +384.     | -450.     | -489.     | -554.     | -368.     | -464.      |
| 50.88                  | 49.13                  | +593.     | +618.     | +698.     | +524.     | +477.     | -566.     | -614.     | -694.     | -462.     | -578.      |
| 61.08                  | 58.77                  | +717.     | +740.     | +832.     | +629.     | +565.     | -678.     | -737.     | -855.     | -556.     | -688.      |
| 71.04                  | 69.11                  | +843.     | +864.     | +969.     | +735.     | +655.     | -793.     | -862.     | -978.     | -650.     | -805.      |
| 81.01                  | 78.98                  | +972.     | +960.     | +1113.    | +847.     | +749.     | -910.     | -981.     | -1126.    | -743.     | -931.      |
| 91.09                  | 88.85                  | +1123.    | +949.     | +1329.    | +936.     | +842.     | -1046.    | -1089.    | -1308.    | -846.     | -1090.     |
| 100.94                 | 98.84                  | +1295.    | +927.     | +1589.    | +1037.    | +970.     | -1178.    | -1193.    | -1500.    | -972.     | -1263.     |
| 107.74                 | 105.23                 | +1390.    | +913.     | +1697.    | +1095.    | +1067.    | -1181.    | -1297.    | -1620.    | -1083.    | -1412.     |
| 105.98                 | 104.76                 | +1406.    | +891.     | +1696.    | +1089.    | +1098.    | -1131.    | -1303.    | -1450.    | -1089.    | -1441.     |
| 0.12                   | 0.12                   | +131.     | -391.     | +211.     | -10.      | +119.     | -65.      | -2.       | +66.      | -136.     | -79.       |

UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I            ENSAIO No.3            DATA: 15/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +1.                    | +0.                     |
| 10.08                  | 9.87                   | +68.                   | +82.                   | +97.                   | +72.                   | +65.                   | -65.                   | -80.                   | -98.                   | -57.                   | -81.                    |
| 20.40                  | 19.51                  | +141.                  | +164.                  | +189.                  | +147.                  | +131.                  | -141.                  | -161.                  | -186.                  | -116.                  | -158.                   |
| 30.72                  | 29.38                  | +213.                  | +247.                  | +281.                  | +220.                  | +197.                  | -221.                  | -242.                  | -273.                  | -177.                  | -235.                   |
| 0.00                   | 0.00                   | +3.                    | +3.                    | +4.                    | +4.                    | +3.                    | +4.                    | +3.                    | +2.                    | +3.                    | +2.                     |
| 10.20                  | 9.76                   | +68.                   | +84.                   | +101.                  | +72.                   | +68.                   | -60.                   | -78.                   | -97.                   | -55.                   | -80.                    |
| 20.52                  | 19.63                  | +140.                  | +166.                  | +193.                  | +147.                  | +133.                  | -139.                  | -160.                  | -186.                  | -115.                  | -158.                   |
| 30.72                  | 29.38                  | +214.                  | +248.                  | +283.                  | +221.                  | +198.                  | -220.                  | -241.                  | -271.                  | -176.                  | -234.                   |
| 40.80                  | 39.26                  | +284.                  | +328.                  | +373.                  | +294.                  | +262.                  | -299.                  | -323.                  | -357.                  | -238.                  | -308.                   |
| 50.88                  | 49.13                  | +355.                  | +411.                  | +469.                  | +367.                  | +328.                  | -380.                  | -405.                  | -442.                  | -299.                  | -383.                   |
| 61.08                  | 58.77                  | +426.                  | +492.                  | +563.                  | +439.                  | +394.                  | -461.                  | -487.                  | -527.                  | -361.                  | -457.                   |
| 71.04                  | 69.11                  | +497.                  | +574.                  | +661.                  | +510.                  | +460.                  | -543.                  | -568.                  | -611.                  | -424.                  | -532.                   |
| 81.01                  | 78.98                  | +569.                  | +658.                  | +759.                  | +583.                  | +519.                  | -623.                  | -651.                  | -699.                  | -486.                  | -607.                   |
| 91.09                  | 88.85                  | +644.                  | +743.                  | +887.                  | +647.                  | +573.                  | -704.                  | -734.                  | -799.                  | -546.                  | -690.                   |
| 100.94                 | 98.84                  | +703.                  | +824.                  | +1141.                 | +705.                  | +636.                  | -791.                  | -817.                  | -881.                  | -606.                  | -779.                   |
| 107.74                 | 105.23                 | +717.                  | +856.                  | +1477.                 | +735.                  | +689.                  | -887.                  | -875.                  | -898.                  | -652.                  | -824.                   |
| 105.98                 | 104.76                 | +696.                  | +838.                  | +1575.                 | +725.                  | +687.                  | -875.                  | -867.                  | -882.                  | -645.                  | -817.                   |
| 0.12                   | 0.12                   | +17.                   | -35.                   | +471.                  | -5.                    | -15.                   | -66.                   | -7.                    | +57.                   | -15.                   | -13.                    |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.3 DATA: 15/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00          | 0.00          | +1.                    | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    |
| 10.00         | 9.87          | +68.                   | +83.                   | +66.                   | -82.                   | -85.                   | -65.                   |
| 20.40         | 19.51         | +137.                  | +166.                  | +136.                  | -166.                  | -166.                  | -129.                  |
| 30.72         | 29.38         | +209.                  | +250.                  | +206.                  | -252.                  | -246.                  | -195.                  |
| 0.00          | 0.00          | +2.                    | +2.                    | +2.                    | +2.                    | +1.                    | +2.                    |
| 10.20         | 9.76          | +66.                   | +84.                   | +67.                   | -81.                   | -88.                   | -64.                   |
| 20.52         | 19.63         | +138.                  | +167.                  | +138.                  | -165.                  | -166.                  | -128.                  |
| 30.72         | 29.38         | +211.                  | +251.                  | +208.                  | -251.                  | -246.                  | -193.                  |
| 40.80         | 39.26         | +282.                  | +335.                  | +276.                  | -336.                  | -324.                  | -258.                  |
| 50.88         | 49.13         | +354.                  | +421.                  | +347.                  | -423.                  | -402.                  | -323.                  |
| 61.00         | 58.77         | +425.                  | +506.                  | +415.                  | -508.                  | -477.                  | -387.                  |
| 71.04         | 69.11         | +499.                  | +594.                  | +486.                  | -596.                  | -553.                  | -449.                  |
| 81.01         | 78.98         | +577.                  | +686.                  | +558.                  | -682.                  | -623.                  | -505.                  |
| 91.09         | 88.85         | +657.                  | +786.                  | +620.                  | -769.                  | -693.                  | -561.                  |
| 100.94        | 98.84         | +730.                  | +869.                  | +683.                  | -858.                  | -724.                  | -615.                  |
| 107.74        | 105.23        | +765.                  | +906.                  | +718.                  | -931.                  | -668.                  | -649.                  |
| 105.98        | 104.76        | +751.                  | +893.                  | +709.                  | -932.                  | -605.                  | -642.                  |
| 0.12          | 0.12          | +18.                   | -12.                   | -6.                    | -33.                   | +45.                   | -11.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +1.                               | +0.                               | +1.                               | -1.                               | +0.1                | -0.1                | U/C                      |
| 10.08         | 9.87          | -1.                               | +36.                              | -5.                               | +36.                              | -42.                              | +5.3                | -7.0                | +43.6                    |
| 20.40         | 19.51         | -3.                               | +70.                              | -9.                               | +70.                              | -82.                              | +10.2               | -13.8               | +43.8                    |
| 30.72         | 29.38         | -4.                               | +103.                             | -15.                              | +103.                             | -122.                             | +15.0               | -20.5               | +43.6                    |
| 0.00          | 0.00          | +3.                               | +4.                               | +3.                               | +4.                               | +2.                               | +1.0                | +0.7                | U/C                      |
| 10.20         | 9.76          | +2.                               | +39.                              | -3.                               | +39.                              | -40.                              | +6.1                | -6.3                | +43.3                    |
| 20.52         | 19.63         | +0.                               | +73.                              | -8.                               | +73.                              | -80.                              | +11.0               | -13.2               | +43.6                    |
| 30.72         | 29.38         | -2.                               | +105.                             | -13.                              | +105.                             | -120.                             | +15.5               | -20.6               | +43.6                    |
| 40.80         | 39.26         | -3.                               | +138.                             | -20.                              | +138.                             | -161.                             | +20.3               | -26.5               | +43.4                    |
| 50.88         | 49.13         | -2.                               | +173.                             | -26.                              | +173.                             | -201.                             | +25.5               | -33.5               | +43.2                    |
| 61.08         | 58.77         | +0.                               | +208.                             | -33.                              | +208.                             | -242.                             | +30.7               | -40.4               | +42.9                    |
| 71.04         | 69.11         | +3.                               | +245.                             | -44.                              | +246.                             | -287.                             | +36.0               | -47.9               | +42.5                    |
| 81.01         | 78.98         | +9.                               | +284.                             | -56.                              | +285.                             | -333.                             | +41.8               | -55.6               | +42.0                    |
| 91.09         | 88.85         | +16.                              | +326.                             | -71.                              | +329.                             | -384.                             | +48.2               | -64.2               | +41.5                    |
| 100.94        | 98.84         | +29.                              | +382.                             | -96.                              | +387.                             | -454.                             | +56.4               | -76.1               | +40.7                    |
| 107.74        | 105.23        | +38.                              | +436.                             | -129.                             | +445.                             | -534.                             | +63.7               | -90.3               | +40.1                    |
| 105.98        | 104.76        | +44.                              | +451.                             | -140.                             | +459.                             | -556.                             | +65.9               | -94.2               | +39.8                    |
| 0.12          | 0.12          | +44.                              | +40.                              | -17.                              | +54.                              | -27.                              | +10.4               | -2.3                | +20.1                    |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +1.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 10.00         | 9.87          | +3.                               | +40.                              | -6.                               | +40.                              | -43.                              | +6.1                | -6.9                | +42.0                    |
| 20.40         | 19.51         | +4.                               | +77.                              | -13.                              | +77.                              | -87.                              | +11.5               | -14.3               | +42.0                    |
| 30.72         | 29.38         | +5.                               | +113.                             | -22.                              | +113.                             | -130.                             | +16.7               | -21.7               | +41.9                    |
| 0.00          | 0.00          | +2.                               | +3.                               | +3.                               | +3.                               | +2.                               | +0.8                | +0.6                | U/C                      |
| 10.20         | 9.76          | +4.                               | +43.                              | -4.                               | +43.                              | -43.                              | +6.7                | -6.7                | +42.5                    |
| 20.52         | 19.63         | +5.                               | +79.                              | -12.                              | +80.                              | -87.                              | +12.1               | -14.3               | +42.1                    |
| 30.72         | 29.38         | +6.                               | +114.                             | -21.                              | +114.                             | -129.                             | +17.0               | -21.4               | +41.9                    |
| 40.80         | 39.26         | +8.                               | +149.                             | -29.                              | +150.                             | -171.                             | +22.1               | -26.5               | +41.7                    |
| 50.88         | 49.13         | +10.                              | +184.                             | -39.                              | +186.                             | -214.                             | +27.4               | -35.7               | +41.5                    |
| 61.00         | 58.77         | +12.                              | +219.                             | -49.                              | +221.                             | -257.                             | +32.3               | -43.1               | +41.3                    |
| 71.04         | 69.11         | +15.                              | +254.                             | -61.                              | +257.                             | -302.                             | +37.5               | -50.8               | +41.1                    |
| 81.01         | 78.98         | +18.                              | +289.                             | -73.                              | +293.                             | -348.                             | +42.4               | -58.5               | +40.9                    |
| 91.09         | 88.85         | +21.                              | +324.                             | -89.                              | +328.                             | -396.                             | +47.1               | -67.0               | +40.6                    |
| 100.94        | 98.84         | +24.                              | +362.                             | -111.                             | +368.                             | -455.                             | +52.1               | -77.6               | +40.3                    |
| 107.74        | 105.23        | +26.                              | +391.                             | -138.                             | +398.                             | -510.                             | +55.3               | -87.9               | +39.8                    |
| 105.98        | 104.76        | +26.                              | +393.                             | -147.                             | +401.                             | -521.                             | +55.1               | -90.3               | +39.6                    |
| 0.12          | 0.12          | +6.                               | +26.                              | -5.                               | +27.                              | -26.                              | +4.3                | -4.0                | +39.3                    |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +1.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 10.00         | 9.87          | +4.                               | +46.                              | -2.                               | +46.                              | -45.                              | +7.5                | -6.9                | +43.2                    |
| 20.40         | 19.51         | +4.                               | +86.                              | -9.                               | +86.                              | -91.                              | +13.3               | -14.7               | +43.0                    |
| 30.72         | 29.38         | +5.                               | +125.                             | -16.                              | +125.                             | -137.                             | +19.6               | -22.3               | +42.7                    |
| 0.00          | 0.00          | +2.                               | +0.                               | +3.                               | +3.                               | +2.                               | +0.8                | +0.6                | U/C                      |
| 10.20         | 9.76          | +5.                               | +49.                              | +0.                               | +49.                              | -45.                              | +8.1                | -6.7                | +43.6                    |
| 20.52         | 19.63         | +6.                               | +89.                              | -8.                               | +89.                              | -91.                              | +13.9               | -14.5               | +42.9                    |
| 30.72         | 29.38         | +6.                               | +127.                             | -15.                              | +127.                             | -137.                             | +19.4               | -22.2               | +42.7                    |
| 40.00         | 39.26         | +6.                               | +164.                             | -23.                              | +164.                             | -181.                             | +24.8               | -29.8               | +42.6                    |
| 50.88         | 49.13         | +8.                               | +203.                             | -31.                              | +204.                             | -228.                             | +30.6               | -37.6               | +42.4                    |
| 61.00         | 58.77         | +8.                               | +240.                             | -42.                              | +242.                             | -276.                             | +35.8               | -45.8               | +42.3                    |
| 71.04         | 69.11         | +7.                               | +277.                             | -54.                              | +279.                             | -326.                             | +40.8               | -54.6               | +42.1                    |
| 81.01         | 78.98         | +6.                               | +314.                             | -68.                              | +316.                             | -379.                             | +45.6               | -63.9               | +41.9                    |
| 91.09         | 88.85         | +4.                               | +350.                             | -86.                              | +353.                             | -435.                             | +50.1               | -74.2               | +41.7                    |
| 100.94        | 98.84         | -1.                               | +384.                             | -118.                             | +388.                             | -507.                             | +53.1               | -88.1               | +41.2                    |
| 107.74        | 105.23        | -9.                               | +462.                             | -163.                             | +400.                             | -581.                             | +52.7               | -103.2              | +40.5                    |
| 105.98        | 104.76        | -13.                              | +598.                             | -180.                             | +404.                             | -598.                             | +50.7               | -107.3              | +40.2                    |
| 0.12          | 0.12          | +8.                               | +0.                               | +0.                               | +31.                              | -24.                              | +5.5                | -3.3                | +41.1                    |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

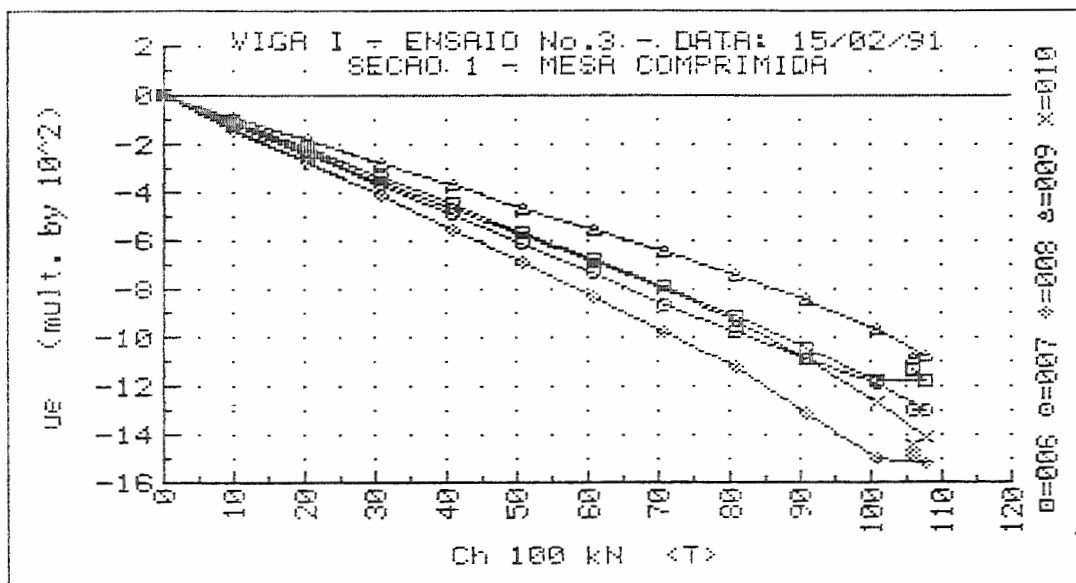
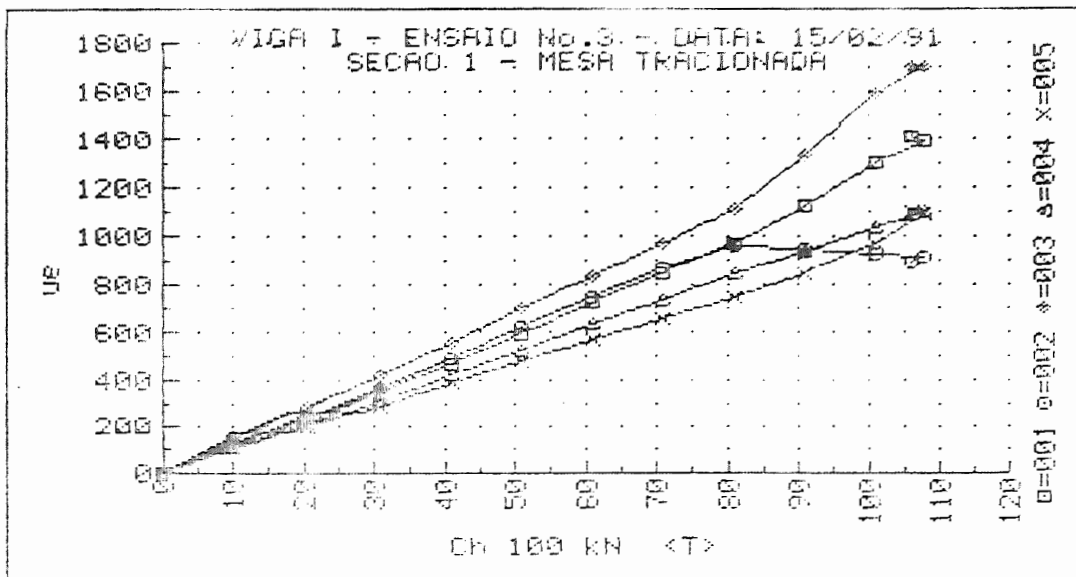
| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.08         | 9.87          | -2.                               | +37.                              | -9.                               | +37.                              | -47.                              | +5.1                | -8.2                | +42.8                    |
| 20.40         | 19.51         | -5.                               | +73.                              | -18.                              | +73.                              | -96.                              | +10.0               | -16.6               | +42.8                    |
| 30.72         | 29.38         | -7.                               | +107.                             | -29.                              | +107.                             | -143.                             | +14.5               | -25.0               | +42.4                    |
| 0.00          | 0.00          | +2.                               | +2.                               | +2.                               | +2.                               | +2.                               | +0.6                | +0.6                | U/C                      |
| 10.20         | 9.76          | -1.                               | +40.                              | -8.                               | +40.                              | -48.                              | +5.7                | -8.2                | +42.8                    |
| 20.52         | 19.63         | -3.                               | +75.                              | -18.                              | +75.                              | -96.                              | +10.4               | -16.5               | +42.5                    |
| 30.72         | 29.38         | -6.                               | +109.                             | -28.                              | +109.                             | -143.                             | +14.9               | -24.9               | +42.4                    |
| 40.80         | 39.26         | -9.                               | +142.                             | -41.                              | +143.                             | -192.                             | +19.2               | -33.6               | +42.2                    |
| 50.88         | 49.13         | -11.                              | +175.                             | -55.                              | +176.                             | -242.                             | +23.3               | -42.7               | +42.0                    |
| 61.08         | 58.77         | -14.                              | +207.                             | -71.                              | +209.                             | -294.                             | +27.2               | -52.1               | +41.8                    |
| 71.04         | 69.11         | -17.                              | +239.                             | -91.                              | +242.                             | -349.                             | +30.8               | -62.4               | +41.4                    |
| 81.01         | 78.98         | -20.                              | +270.                             | -113.                             | +274.                             | -406.                             | +34.2               | -73.0               | +41.1                    |
| 91.09         | 88.85         | -11.                              | +304.                             | -145.                             | +310.                             | -466.                             | +38.4               | -84.1               | +40.1                    |
| 100.94        | 98.84         | -7.                               | +334.                             | -201.                             | +344.                             | -553.                             | +40.3               | -101.2              | +38.7                    |
| 107.74        | 105.23        | -10.                              | +338.                             | -290.                             | +358.                             | -659.                             | +36.1               | -124.2              | +37.0                    |
| 105.98        | 104.76        | -10.                              | +330.                             | -322.                             | +353.                             | -688.                             | +33.1               | -131.2              | +36.4                    |
| 0.12          | 0.12          | +31.                              | +37.                              | -29.                              | +46.                              | -46.                              | +7.7                | -7.1                | +24.9                    |

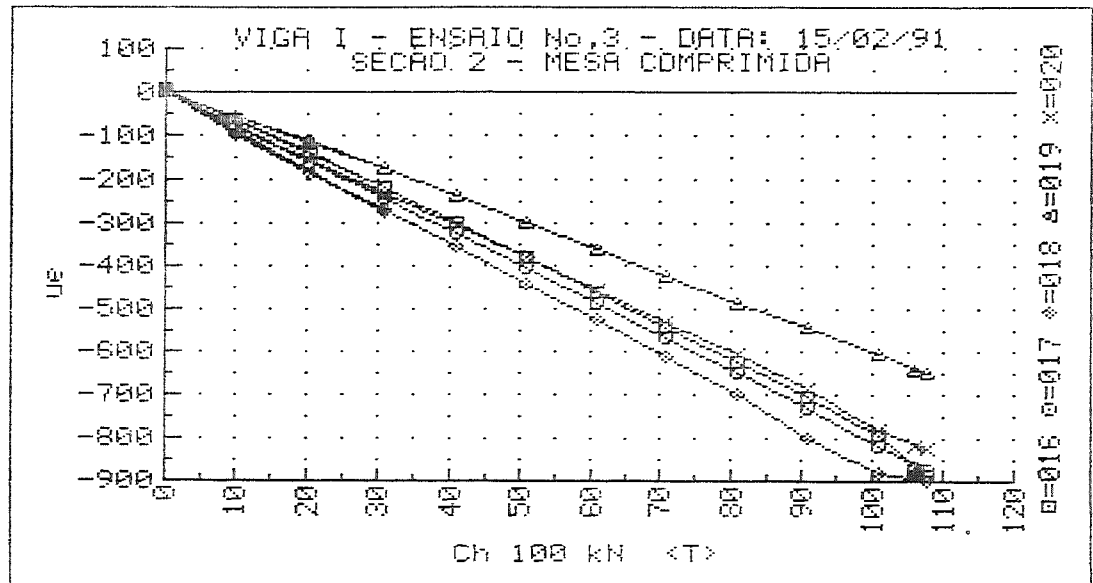
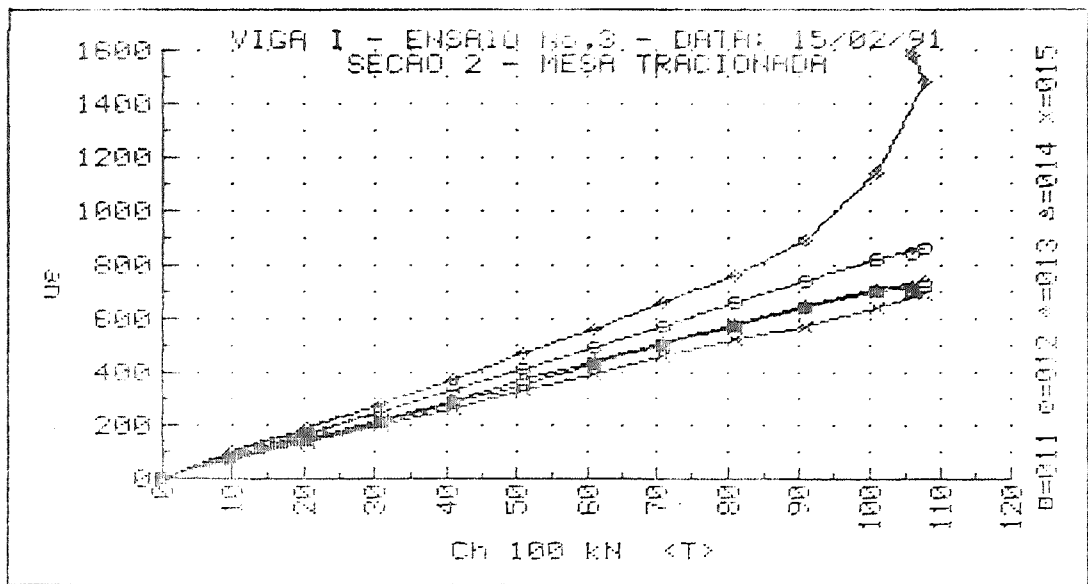


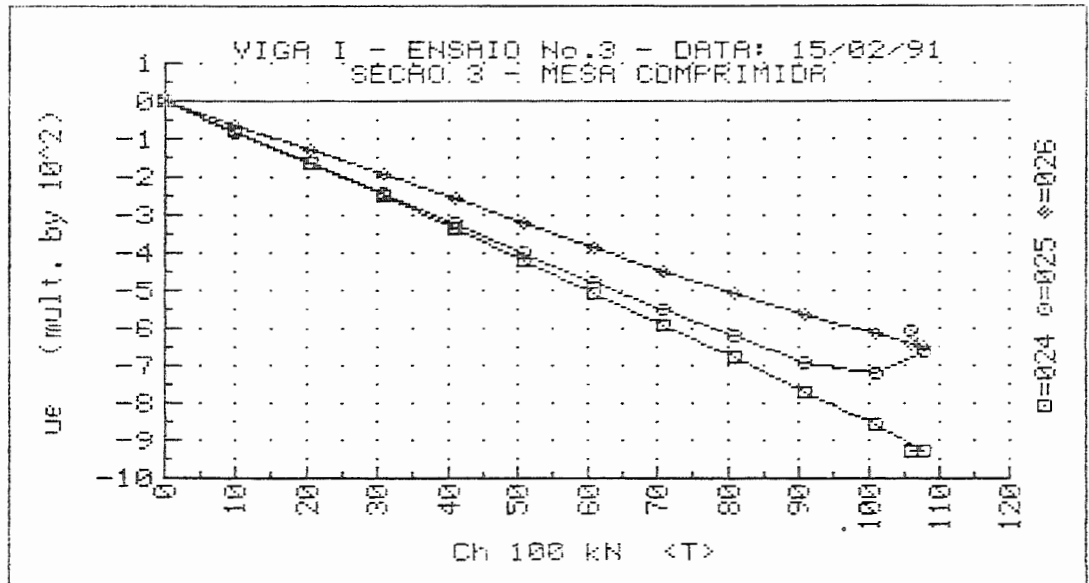
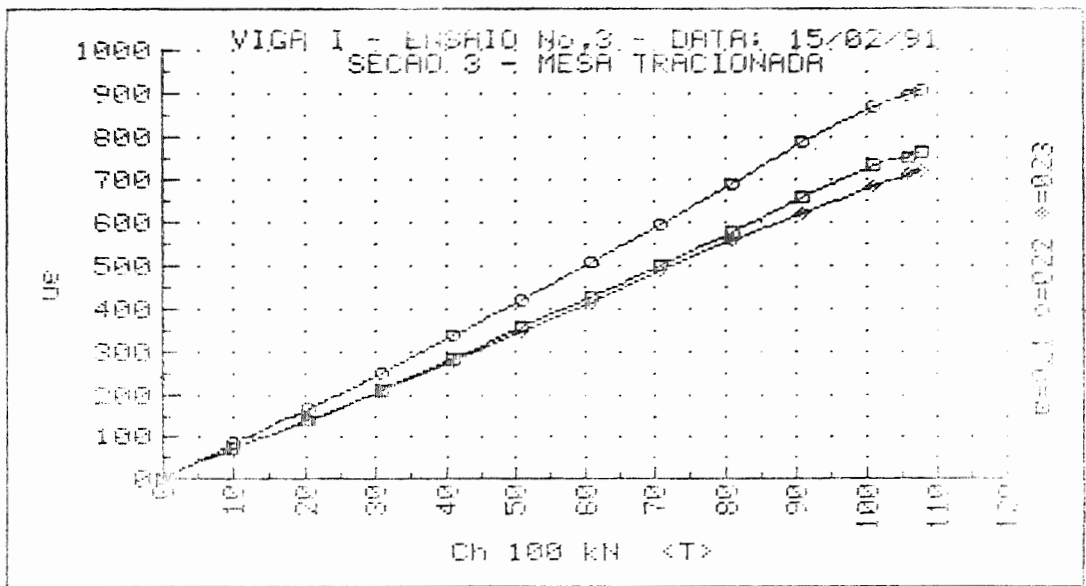
UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

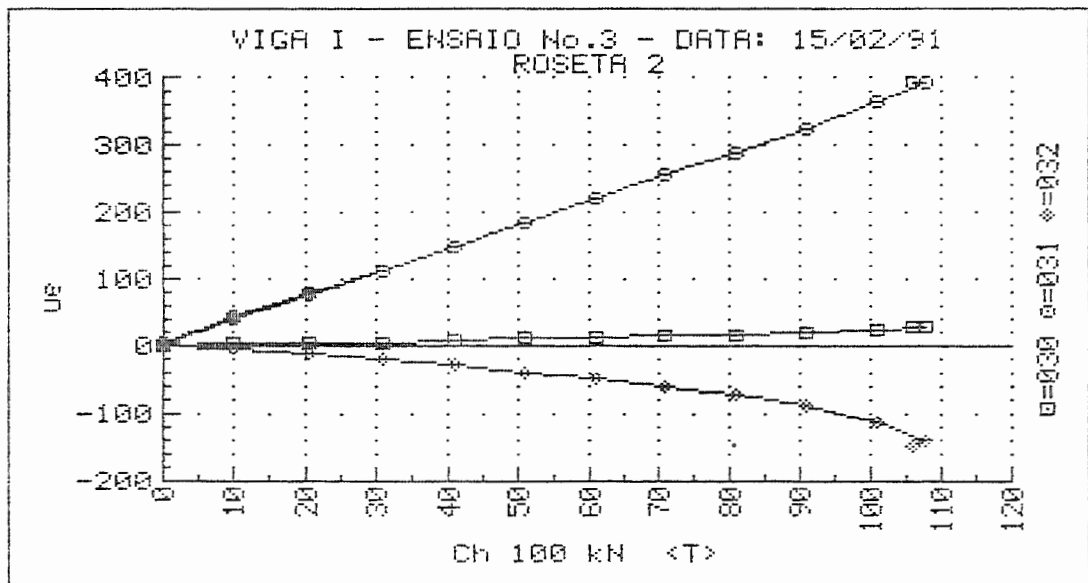
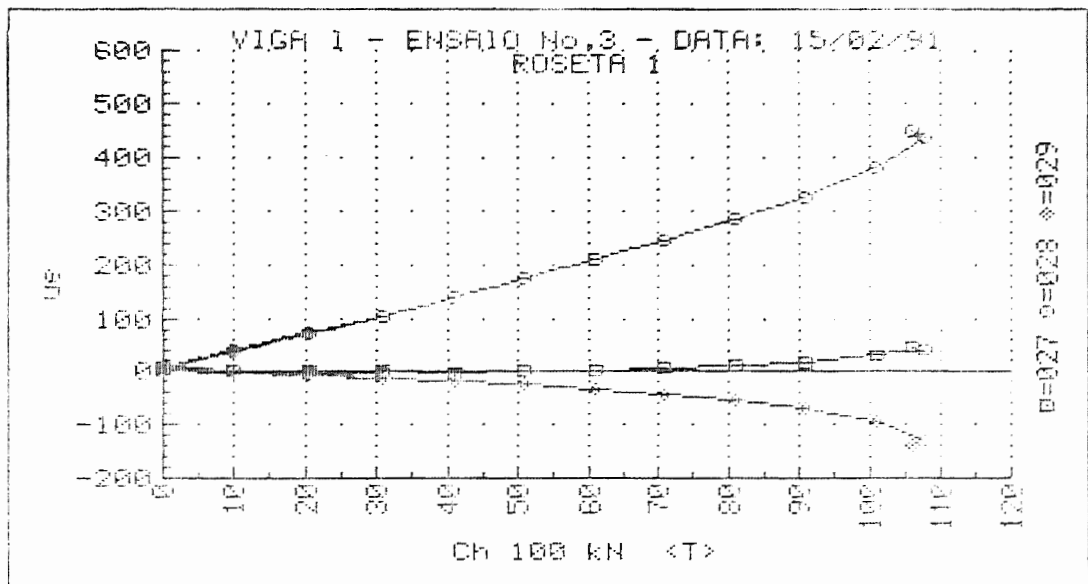
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA I ENSAIO No.3 DATA: 15/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

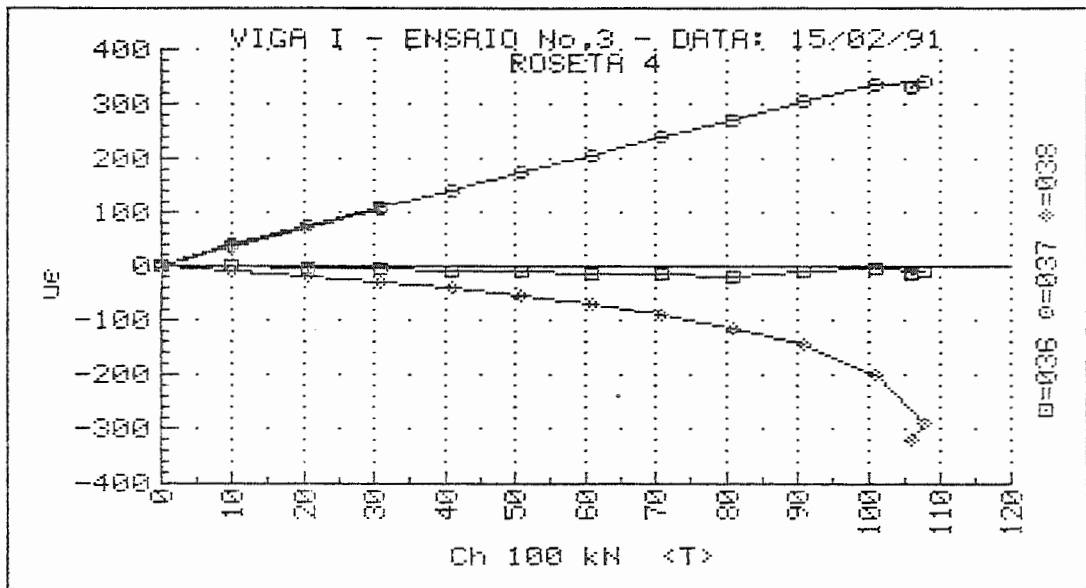
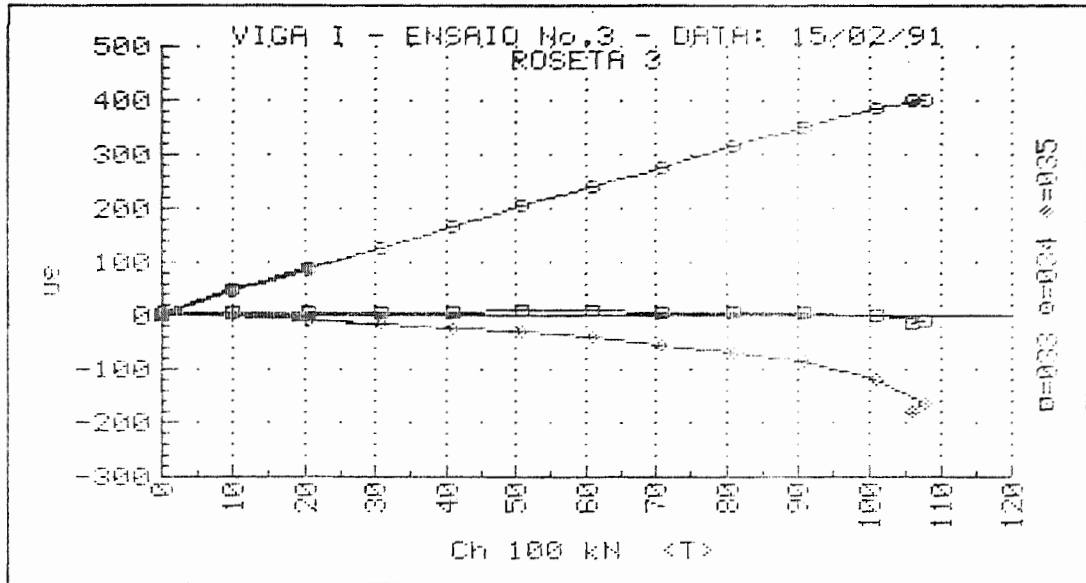
| $F_1$<br>(KN) | $F_2$<br>(KN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.08         | 9.87          | +7.                               | -40.                              | -8.                               | +39.                              | -40.                              | +6.2                | -6.4                | -39.9                    |
| 20.40         | 19.51         | +13.                              | -78.                              | -15.                              | +77.                              | -79.                              | +12.0               | -12.6               | -39.8                    |
| 30.72         | 29.38         | +20.                              | -115.                             | -23.                              | +115.                             | -117.                             | +17.9               | -18.7               | -39.7                    |
| 0.00          | 0.00          | +3.                               | +3.                               | +2.                               | +3.                               | +2.                               | +0.8                | +0.6                | U/C                      |
| 10.20         | 9.76          | +9.                               | -39.                              | -6.                               | +42.                              | -39.                              | +6.9                | -6.0                | -40.0                    |
| 20.52         | 19.63         | +15.                              | -77.                              | -13.                              | +80.                              | -78.                              | +12.7               | -12.2               | -39.8                    |
| 30.72         | 29.38         | +21.                              | -114.                             | -22.                              | +115.                             | -116.                             | +18.1               | -18.4               | -39.7                    |
| 40.80         | 39.26         | +26.                              | -152.                             | -30.                              | +150.                             | -155.                             | +23.4               | -24.7               | -39.7                    |
| 50.88         | 49.13         | +31.                              | -191.                             | -39.                              | +187.                             | -194.                             | +28.9               | -31.2               | -39.7                    |
| 61.08         | 58.77         | +36.                              | -231.                             | -48.                              | +222.                             | -235.                             | +34.2               | -37.8               | -39.7                    |
| 71.04         | 69.11         | +42.                              | -272.                             | -60.                              | +259.                             | -277.                             | +39.7               | -44.9               | -39.6                    |
| 81.01         | 78.98         | +46.                              | -312.                             | -70.                              | +294.                             | -318.                             | +44.8               | -51.7               | -39.5                    |
| 91.09         | 88.85         | +50.                              | -354.                             | -83.                              | +327.                             | -360.                             | +49.4               | -59.1               | -39.4                    |
| 100.94        | 98.84         | +55.                              | -396.                             | -97.                              | +361.                             | -404.                             | +54.1               | -66.6               | -39.3                    |
| 107.74        | 105.23        | +60.                              | -426.                             | -110.                             | +384.                             | -435.                             | +57.2               | -71.9               | -39.0                    |
| 105.98        | 104.76        | +60.                              | -425.                             | -113.                             | +381.                             | -434.                             | +56.5               | -72.0               | -38.9                    |
| 0.12          | 0.12          | +6.                               | -5.                               | -2.                               | +10.                              | -6.                               | +1.8                | -0.6                | -30.1                    |



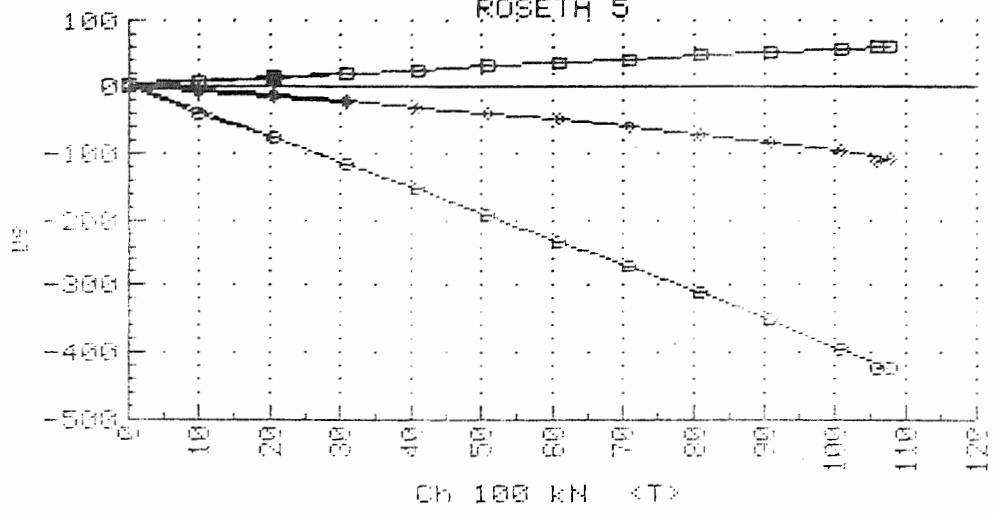








VIGA I - ENSAIO No.3 - DATA: 15/02/91  
ROSETA 5



178=0.040 620=0

## MODELO - VIGA II

### RESULTADOS DOS ENSAIOS

- . ENSAIO 1
- . ENSAIO 2

- DESLOCAMENTOS

- DEFORMAÇÕES



MODELO - VIGA II

RESULTADOS DOS ENSAIOS

. ENSAIO 1

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA II

ENSAIO Nro:1

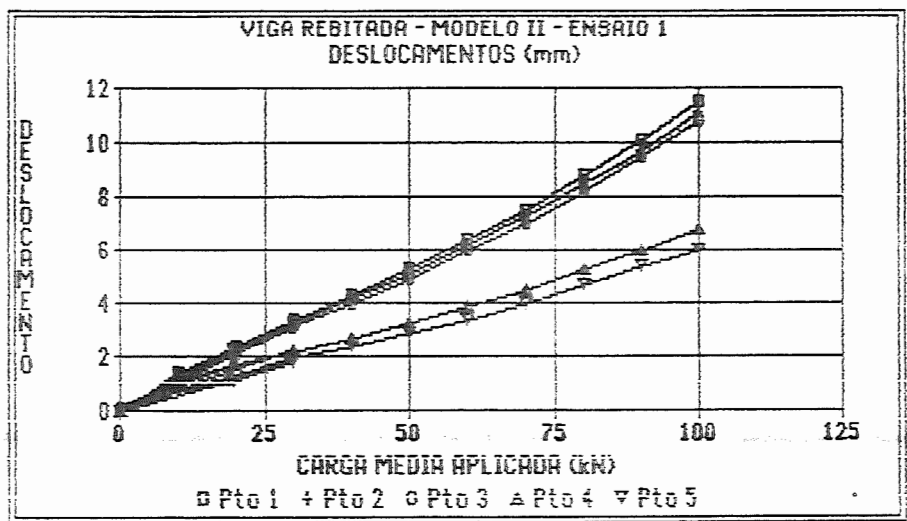
DATA:19 DE FEVEREIRO DE 1991

HORARIO: 8:45 Hs

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| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |      |       |
|-------|----------------------------|-----------------------|-------|-------|------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00 | 0.00  |
| 1     | 9.90                       | 1.35                  | 1.29  | 1.28  | 1.07 | .78   |
| 2     | 19.45                      | 2.25                  | 2.18  | 2.06  | 1.67 | 1.12  |
| 3     | 29.85                      | 3.29                  | 3.16  | 3.08  | 2.18 | 1.79  |
| 4     | .05                        | -.02                  | -.03  | .06   | .05  | -.11  |
| 5     | 9.95                       | 1.29                  | 1.26  | 1.15  | .96  | .76   |
| 6     | 20.00                      | 2.35                  | 2.29  | 2.10  | 1.66 | 1.31  |
| 7     | 30.00                      | 3.42                  | 3.28  | 3.15  | 2.20 | 2.03  |
| 8     | 40.05                      | 4.35                  | 4.20  | 4.02  | 2.73 | 2.43  |
| 9     | 49.95                      | 5.29                  | 5.13  | 4.91  | 3.27 | 2.86  |
| 10    | 59.95                      | 6.39                  | 6.17  | 5.97  | 3.91 | 3.40  |
| 11    | 70.05                      | 7.52                  | 7.26  | 7.02  | 4.53 | 3.99  |
| 12    | 80.05                      | 8.79                  | 8.49  | 8.23  | 5.27 | 4.67  |
| 13    | 89.95                      | 10.07                 | 9.72  | 9.45  | 6.00 | 5.35  |
| 14    | 100.05                     | 11.48                 | 11.08 | 10.79 | 6.78 | 6.04  |

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MODELO - VIGA II

RESULTADOS DOS ENSAIOS

. ENSAIO 1

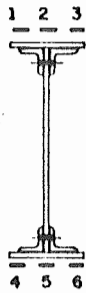
- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

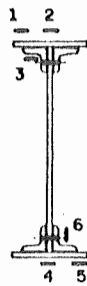
.UNIAXIAIS

.ROSETAS

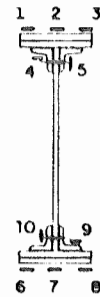
Seção 4



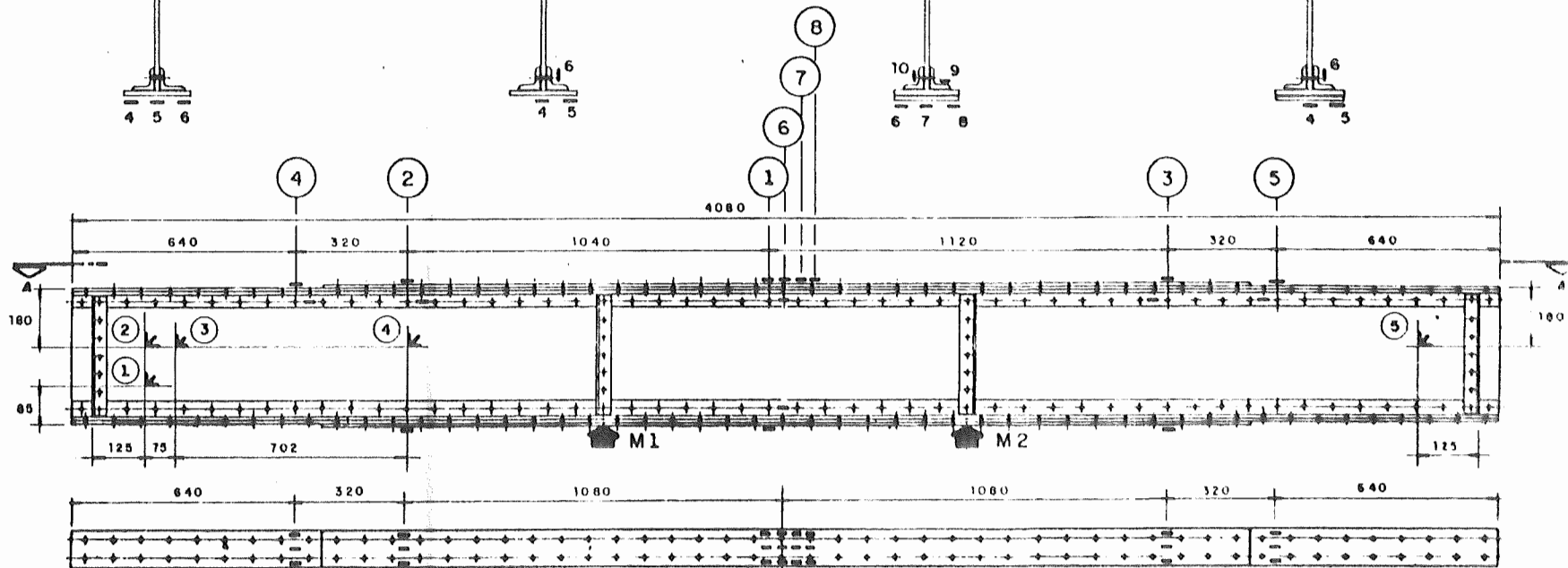
Seção 5



Seções 1 e 2



Seção 3



VISTA A

NOTA: AS SEÇÕES 6, 7 E 8 EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA SOMENTE NA MESA TRACIONADA E NUMERADOS DE MANEIRA IGUAL A SEÇÃO 1

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(μE) | 2<br>(μE) | 3<br>(μE) | 4<br>(μE) | 5<br>(μE) | 6<br>(μE) | 7<br>(μE) | 8<br>(μE) | 9<br>(μE) | 10<br>(μE) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 20.28                  | 19.28                  | +200.     | +185.     | +174.     | +161.     | +134.     | -189.     | -180.     | -183.     | -147.     | -133.      |
| 30.72                  | 29.15                  | +303.     | +280.     | +263.     | +243.     | +202.     | -287.     | -274.     | -280.     | -219.     | -202.      |
| 0.00                   | 0.00                   | +6.       | +4.       | +4.       | +3.       | +5.       | +0.       | +1.       | +0.       | +5.       | +1.        |
| 0.12                   | 0.00                   | +6.       | +4.       | +4.       | +3.       | +5.       | +0.       | +1.       | +0.       | +5.       | +1.        |
| 10.32                  | 9.76                   | +104.     | +97.      | +91.      | +83.      | +71.      | -96.      | -90.      | -92.      | -69.      | -66.       |
| 20.52                  | 19.40                  | +203.     | +189.     | +178.     | +164.     | +138.     | -191.     | -181.     | -184.     | -143.     | -132.      |
| 30.72                  | 29.15                  | +304.     | +282.     | +265.     | +244.     | +204.     | -286.     | -272.     | -278.     | -217.     | -200.      |
| 41.27                  | 38.79                  | +408.     | +378.     | +358.     | +324.     | +272.     | -381.     | -364.     | -372.     | -287.     | -264.      |
| 51.58                  | 48.32                  | +511.     | +471.     | +448.     | +401.     | +333.     | -476.     | -454.     | -465.     | -358.     | -327.      |
| 61.66                  | 58.19                  | +616.     | +564.     | +544.     | +480.     | +392.     | -572.     | -542.     | -563.     | -428.     | -391.      |
| 71.86                  | 68.18                  | +720.     | +659.     | +646.     | +562.     | +452.     | -671.     | -627.     | -662.     | -503.     | -455.      |
| 81.83                  | 78.28                  | +822.     | +755.     | +751.     | +652.     | +513.     | -772.     | -707.     | -765.     | -578.     | -521.      |
| 91.68                  | 88.04                  | +914.     | +849.     | +851.     | +743.     | +573.     | -870.     | -782.     | -869.     | -652.     | -586.      |
| 101.76                 | 98.14                  | +1002.    | +946.     | +956.     | +846.     | +637.     | -972.     | -850.     | -988.     | -736.     | -658.      |
| 0.12                   | 0.00                   | +39.      | +21.      | +55.      | +55.      | -29.      | -16.      | +70.      | -52.      | -11.      | +7.        |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 20.28                  | 19.28                  | +118.                  | +119.                  | +121.                  | +102.                  | +98.                   | -131.                  | -118.                  | -111.                  | -92.                   | -90.                    |
| 30.72                  | 29.15                  | +179.                  | +180.                  | +183.                  | +154.                  | +151.                  | -201.                  | -186.                  | -166.                  | -139.                  | -137.                   |
| 0.00                   | 0.00                   | +4.                    | +3.                    | +4.                    | +3.                    | +7.                    | +0.                    | +2.                    | +2.                    | +2.                    | -1.                     |
| 0.12                   | 0.00                   | +4.                    | +3.                    | +4.                    | +4.                    | +7.                    | +0.                    | +2.                    | +2.                    | +2.                    | -1.                     |
| 10.32                  | 9.76                   | +60.                   | +62.                   | +65.                   | +53.                   | +56.                   | -67.                   | -55.                   | -53.                   | -44.                   | -46.                    |
| 20.52                  | 19.40                  | +119.                  | +122.                  | +127.                  | +104.                  | +105.                  | -134.                  | -118.                  | -108.                  | -89.                   | -91.                    |
| 30.72                  | 29.15                  | +177.                  | +181.                  | +188.                  | +154.                  | +154.                  | -200.                  | -178.                  | -165.                  | -137.                  | -137.                   |
| 41.27                  | 38.79                  | +240.                  | +244.                  | +249.                  | +207.                  | +209.                  | -267.                  | -238.                  | -221.                  | -183.                  | -185.                   |
| 51.58                  | 48.32                  | +296.                  | +304.                  | +308.                  | +255.                  | +264.                  | -333.                  | -298.                  | -278.                  | -230.                  | -233.                   |
| 61.66                  | 58.19                  | +355.                  | +366.                  | +368.                  | +304.                  | +322.                  | -401.                  | -358.                  | -337.                  | -281.                  | -288.                   |
| 71.86                  | 68.18                  | +414.                  | +427.                  | +432.                  | +354.                  | +384.                  | -468.                  | -419.                  | -395.                  | -331.                  | -330.                   |
| 81.83                  | 78.28                  | +473.                  | +487.                  | +498.                  | +407.                  | +447.                  | -534.                  | -479.                  | -453.                  | -377.                  | -362.                   |
| 91.68                  | 88.04                  | +532.                  | +546.                  | +568.                  | +458.                  | +505.                  | -597.                  | -539.                  | -511.                  | -423.                  | -394.                   |
| 101.76                 | 98.14                  | +595.                  | +603.                  | +637.                  | +514.                  | +562.                  | -664.                  | -598.                  | -570.                  | -471.                  | -423.                   |
| 0.12                   | 0.00                   | +15.                   | +4.                    | +21.                   | +5.                    | +55.                   | +5.                    | +1.                    | -7.                    | +1.                    | +37.                    |

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 VIGA II            ENSAIO No.1            DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECao 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 20.28         | 19.28         | +119.                  | +122.                  | +102.                  | -116.                  | -130.                  | -92.                   |
| 30.72         | 29.15         | +179.                  | +162.                  | +155.                  | -176.                  | -196.                  | -142.                  |
| 0.00          | 0.00          | +0.                    | +0.                    | +2.                    | +2.                    | +2.                    | -1.                    |
| 0.12          | 0.00          | +1.                    | +0.                    | +2.                    | +2.                    | +1.                    | +0.                    |
| 10.32         | 9.76          | +59.                   | +61.                   | +52.                   | -56.                   | -65.                   | -46.                   |
| 20.52         | 19.40         | +119.                  | +122.                  | +104.                  | -116.                  | -130.                  | -93.                   |
| 30.72         | 29.15         | +180.                  | +183.                  | +156.                  | -175.                  | -194.                  | -141.                  |
| 41.27         | 38.79         | +242.                  | +244.                  | +200.                  | -233.                  | -250.                  | -189.                  |
| 51.58         | 48.32         | +300.                  | +302.                  | +257.                  | -292.                  | -322.                  | -238.                  |
| 61.66         | 58.19         | +359.                  | +359.                  | +300.                  | -349.                  | -386.                  | -286.                  |
| 71.86         | 68.18         | +417.                  | +417.                  | +360.                  | -408.                  | -450.                  | -333.                  |
| 81.83         | 78.28         | +476.                  | +472.                  | +408.                  | -466.                  | -516.                  | -373.                  |
| 91.68         | 88.04         | +535.                  | +528.                  | +453.                  | -525.                  | -581.                  | -412.                  |
| 101.76        | 98.14         | +599.                  | +585.                  | +500.                  | -581.                  | -644.                  | -437.                  |
| 0.12          | 0.00          | +12.                   | -15.                   | -12.                   | +4.                    | +1.                    | +32.                   |



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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 4

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µε) | 2<br>(µε) | 3<br>(µε) | 4<br>(µε) | 5<br>(µε) | 6<br>(µε) | 7<br>(µε) | 8<br>(µε) | 9<br>(µε) | 10<br>(µε) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 20.28                  | 19.28                  | +90.      | +98.      | +109.     | +74.      | +83.      | -76.      | -92.      | -117.     | -101.     | -64.       |
| 30.72                  | 29.15                  | +140.     | +149.     | +164.     | +115.     | +125.     | -120.     | -142.     | -176.     | -152.     | -99.       |
| 0.00                   | 0.00                   | +2.       | +4.       | +7.       | +7.       | +1.       | +1.       | +0.       | +0.       | +1.       | +1.        |
| 0.12                   | 0.00                   | +2.       | +4.       | +7.       | +7.       | +1.       | +1.       | -1.       | +0.       | +1.       | +1.        |
| 10.32                  | 9.76                   | +46.      | +51.      | +63.      | +45.      | +41.      | -35.      | -47.      | -61.      | -51.      | -32.       |
| 20.52                  | 19.40                  | +93.      | +100.     | +115.     | +82.      | +83.      | -77.      | -94.      | -118.     | -101.     | -64.       |
| 30.72                  | 29.15                  | +142.     | +150.     | +166.     | +118.     | +125.     | -119.     | -141.     | -175.     | -150.     | -98.       |
| 41.27                  | 38.79                  | +192.     | +202.     | +228.     | +161.     | +165.     | -161.     | -190.     | -230.     | -199.     | -130.      |
| 51.58                  | 48.32                  | +240.     | +252.     | +288.     | +205.     | +201.     | -204.     | -238.     | -287.     | -249.     | -164.      |
| 61.66                  | 58.19                  | +285.     | +300.     | +350.     | +253.     | +235.     | -251.     | -281.     | -346.     | -300.     | -198.      |
| 71.86                  | 68.18                  | +331.     | +349.     | +412.     | +296.     | +269.     | -299.     | -322.     | -405.     | -352.     | -230.      |
| 81.83                  | 78.28                  | +374.     | +398.     | +477.     | +340.     | +303.     | -348.     | -361.     | -467.     | -404.     | -262.      |
| 91.68                  | 88.04                  | +421.     | +449.     | +546.     | +390.     | +339.     | -396.     | -400.     | -528.     | -456.     | -297.      |
| 101.76                 | 98.14                  | +473.     | +502.     | +625.     | +450.     | +378.     | -447.     | -439.     | -594.     | -514.     | -332.      |
| 0.12                   | 0.00                   | +8.       | +7.       | +86.      | +80.      | -25.      | -37.      | +40.      | -27.      | -22.      | +6.        |

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DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 5

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µε) | 2<br>(µε) | 3<br>(µε) | 4<br>(µε) | 5<br>(µε) | 6<br>(µε) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 20.28                  | 19.28                  | +91.      | +95.      | +94.      | -98.      | -91.      | -64.      |
| 30.72                  | 29.15                  | +144.     | +136.     | +145.     | -145.     | -136.     | -97.      |
| 0.00                   | 0.00                   | +9.       | -7.       | +7.       | +3.       | +4.       | +4.       |
| 0.12                   | 0.00                   | +9.       | -7.       | +7.       | +2.       | +3.       | +4.       |
| 10.32                  | 9.76                   | +50.      | +40.      | +52.      | -46.      | -43.      | -29.      |
| 20.52                  | 19.40                  | +95.      | +88.      | +98.      | -97.      | -86.      | -61.      |
| 30.72                  | 29.15                  | +141.     | +137.     | +145.     | -147.     | -133.     | -95.      |
| 41.27                  | 38.79                  | +192.     | +185.     | +196.     | -195.     | -176.     | -125.     |
| 51.58                  | 48.32                  | +241.     | +229.     | +247.     | -245.     | -221.     | -156.     |
| 61.66                  | 58.19                  | +297.     | +275.     | +302.     | -296.     | -266.     | -185.     |
| 71.86                  | 68.18                  | +351.     | +322.     | +355.     | -350.     | -314.     | -210.     |
| 81.83                  | 78.28                  | +409.     | +371.     | +410.     | -402.     | -365.     | -224.     |
| 91.68                  | 88.04                  | +461.     | +417.     | +461.     | -454.     | -415.     | -245.     |
| 101.76                 | 98.14                  | +516.     | +462.     | +512.     | -502.     | -469.     | -268.     |
| 0.12                   | 0.00                   | +57.      | -30.      | +41.      | +2.       | -9.       | +58.      |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.1 DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 20.28                  | 19.28                  | -4.                    | +54.                   | -8.                    | +54.                   | -65.                   | +7.7                    | -11.1                   | +44.1    |
| 30.72                  | 29.15                  | -6.                    | +84.                   | -12.                   | +84.                   | -102.                  | +12.1                   | -17.3                   | +44.0    |
| 0.00                   | 0.00                   | +3.                    | +3.                    | +2.                    | +3.                    | +2.                    | +0.8                    | +0.6                    | U/C      |
| 0.12                   | 0.00                   | +3.                    | +3.                    | +2.                    | +3.                    | +2.                    | +0.8                    | +0.6                    | U/C      |
| 10.32                  | 9.76                   | +1.                    | +28.                   | -1.                    | +28.                   | -28.                   | +4.5                    | -4.5                    | +44.0    |
| 20.52                  | 19.40                  | -2.                    | +56.                   | -6.                    | +56.                   | -65.                   | +8.6                    | -10.8                   | +44.1    |
| 30.72                  | 29.15                  | -5.                    | +87.                   | -10.                   | +87.                   | -102.                  | +12.7                   | -17.1                   | +44.1    |
| 41.27                  | 38.79                  | -4.                    | +119.                  | -13.                   | +119.                  | -136.                  | +17.7                   | -22.7                   | +43.9    |
| 51.58                  | 48.32                  | -6.                    | +151.                  | -19.                   | +152.                  | -176.                  | +22.2                   | -29.4                   | +43.8    |
| 61.66                  | 58.19                  | -4.                    | +186.                  | -25.                   | +186.                  | -214.                  | +27.4                   | -35.7                   | +43.5    |
| 71.86                  | 68.18                  | -1.                    | +220.                  | -31.                   | +220.                  | -252.                  | +32.5                   | -41.9                   | +43.2    |
| 81.83                  | 78.28                  | +5.                    | +254.                  | -40.                   | +255.                  | -290.                  | +37.8                   | -48.0                   | +42.7    |
| 91.68                  | 88.04                  | +9.                    | +286.                  | -48.                   | +287.                  | -326.                  | +42.7                   | -54.0                   | +42.3    |
| 101.76                 | 98.14                  | +22.                   | +325.                  | -58.                   | +327.                  | -363.                  | +49.1                   | -59.6                   | +41.7    |
| 0.12                   | 0.00                   | +42.                   | +29.                   | +8.                    | +42.                   | +7.                    | +10.0                   | +4.4                    | +7.8     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.1 DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>ax</sub><br>(με) | ε <sub>bx</sub><br>(με) | ε <sub>cx</sub><br>(με) | ε <sub>1s</sub><br>(με) | ε <sub>2s</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|----------|
| 20.28                  | 19.28                  | +18.                    | +71.                    | -10.                    | +73.                    | -65.                    | +11.9                   | -9.7                    | +39.0    |
| 30.72                  | 29.15                  | +24.                    | +105.                   | -20.                    | +107.                   | -104.                   | +17.2                   | -15.1                   | +39.0    |
| 0.00                   | 0.00                   | +5.                     | +3.                     | +3.                     | +5.                     | +2.                     | +1.3                    | +0.9                    | U/C      |
| 0.12                   | 0.00                   | +5.                     | +4.                     | +3.                     | +5.                     | +3.                     | +1.3                    | +1.0                    | U/C      |
| 10.32                  | 9.76                   | +14.                    | +40.                    | -1.                     | +41.                    | -27.                    | +7.3                    | -3.4                    | +38.6    |
| 20.52                  | 19.40                  | +20.                    | +74.                    | -9.                     | +75.                    | -64.                    | +12.6                   | -9.3                    | +39.1    |
| 30.72                  | 29.15                  | +26.                    | +107.                   | -17.                    | +109.                   | -101.                   | +17.8                   | -15.3                   | +39.1    |
| 41.27                  | 38.79                  | +33.                    | +144.                   | -25.                    | +147.                   | -138.                   | +23.7                   | -21.2                   | +39.2    |
| 51.58                  | 48.32                  | +41.                    | +179.                   | -33.                    | +183.                   | -175.                   | +29.3                   | -27.1                   | +39.1    |
| 61.66                  | 58.19                  | +51.                    | +217.                   | -41.                    | +222.                   | -211.                   | +35.7                   | -32.6                   | +38.9    |
| 71.86                  | 68.18                  | +61.                    | +256.                   | -51.                    | +262.                   | -252.                   | +41.9                   | -39.2                   | +38.7    |
| 81.83                  | 78.28                  | +69.                    | +292.                   | -65.                    | +299.                   | -296.                   | +47.5                   | -46.4                   | +38.5    |
| 91.68                  | 88.04                  | +74.                    | +325.                   | -79.                    | +334.                   | -338.                   | +52.3                   | -53.7                   | +38.4    |
| 101.76                 | 98.14                  | +82.                    | +363.                   | -93.                    | +373.                   | -383.                   | +58.1                   | -61.2                   | +38.3    |
| 0.12                   | 0.00                   | +29.                    | +16.                    | +3.                     | +29.                    | +3.                     | +6.8                    | +2.6                    | U/C      |

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 VIGA II ENSAIO No.1 DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 20.28         | 19.28         | +12.                              | +93.                              | +8.                               | +93.                              | -73.                              | +16.0               | -16.2               | +44.2                    |
| 30.72         | 29.15         | +13.                              | +133.                             | +4.                               | +133.                             | -116.                             | +22.1               | -17.1               | +43.9                    |
| 0.00          | 0.00          | +7.                               | +7.                               | +4.                               | +7.                               | +3.                               | +1.8                | +1.2                | U/C                      |
| 0.12          | 0.00          | +6.                               | +7.                               | +4.                               | +7.                               | +3.                               | +1.7                | -1.1                | U/C                      |
| 10.32         | 9.76          | +14.                              | +57.                              | +10.                              | +57.                              | -32.                              | +10.5               | -7.4                | +43.8                    |
| 20.52         | 19.40         | +15.                              | +97.                              | +9.                               | +97.                              | -73.                              | +16.8               | -9.9                | +43.9                    |
| 30.72         | 29.15         | +16.                              | +134.                             | +5.                               | +135.                             | -114.                             | +22.6               | -16.5               | +43.7                    |
| 41.27         | 38.79         | +19.                              | +177.                             | +2.                               | +177.                             | -156.                             | +29.4               | -23.3               | +43.5                    |
| 51.58         | 48.32         | +22.                              | +217.                             | -3.                               | +217.                             | -198.                             | +35.5               | -30.0               | +43.3                    |
| 61.66         | 58.19         | +29.                              | +261.                             | -8.                               | +262.                             | -240.                             | +42.8               | -36.4               | +42.9                    |
| 71.86         | 68.18         | +33.                              | +304.                             | -13.                              | +305.                             | -285.                             | +49.4               | -43.6               | +42.7                    |
| 81.83         | 78.28         | +33.                              | +345.                             | -22.                              | +346.                             | -334.                             | +55.3               | -51.5               | +42.7                    |
| 91.68         | 88.04         | +30.                              | +382.                             | -30.                              | +384.                             | -384.                             | +60.5               | -60.5               | +42.7                    |
| 101.76        | 98.14         | +30.                              | +424.                             | -38.                              | +425.                             | -433.                             | +66.6               | -66.8               | +42.7                    |
| 0.12          | 0.00          | +38.                              | +36.                              | +5.                               | +43.                              | -1.                               | +9.7                | +2.8                | U/C                      |

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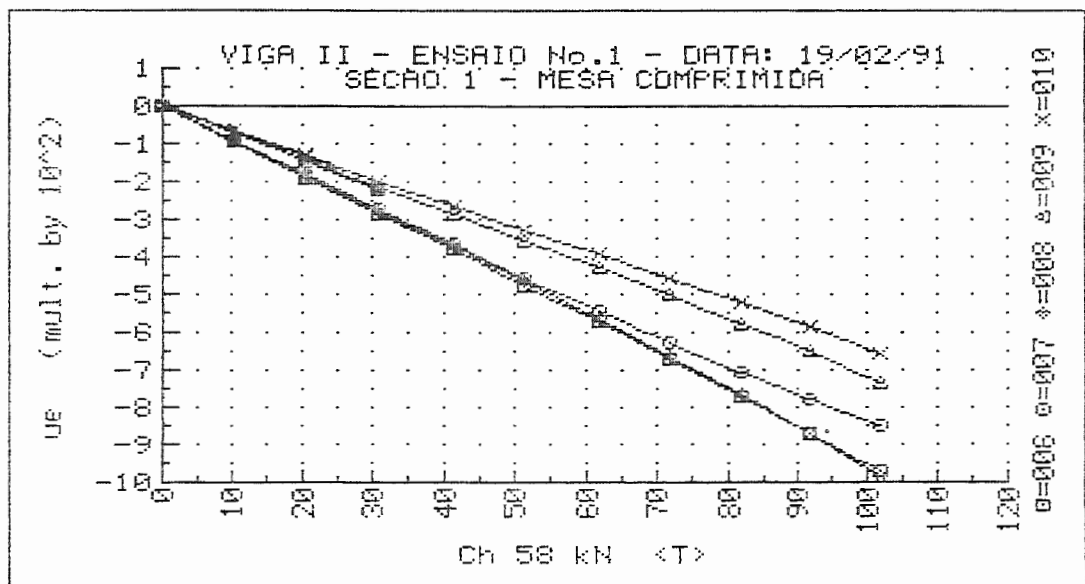
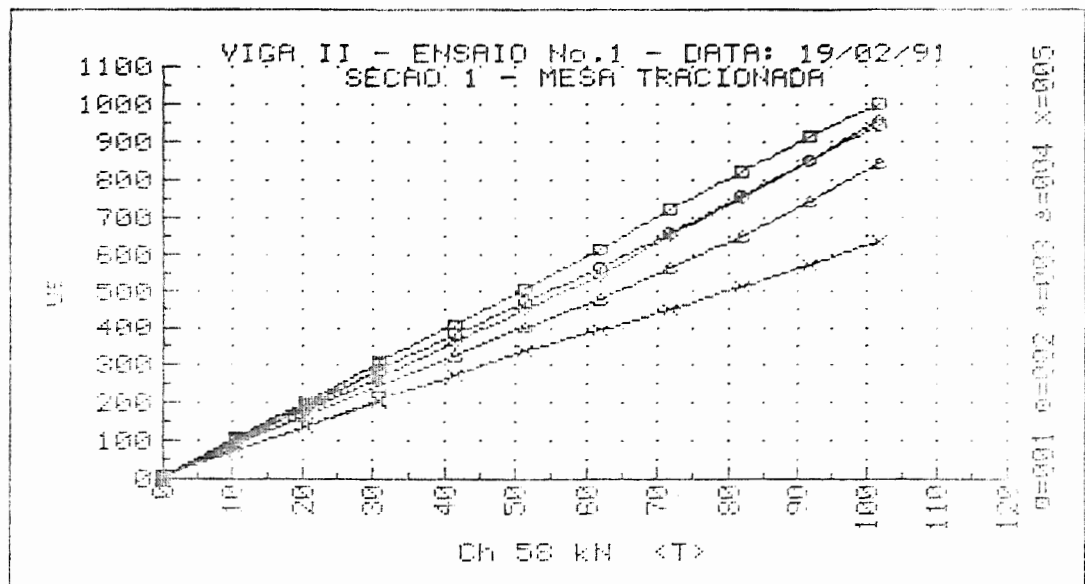
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II            ENSAIO No.1            DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

| $F_1$<br>(KN) | $F_2$<br>(KN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\sigma$<br>( $\sigma$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 20.28         | 19.28         | -2.                               | +73.                              | -4.                               | +73.                              | -79.                              | +11.1               | -12.0               | +44.6                    |
| 36.72         | 29.15         | -1.                               | +110.                             | -9.                               | +110.                             | -119.                             | +16.7               | -19.5               | +44.1                    |
| 0.00          | 0.00          | +5.                               | +5.                               | +2.                               | +5.                               | +1.                               | +1.3                | +0.7                | U/C                      |
| 0.12          | 0.00          | +5.                               | +4.                               | +2.                               | +5.                               | +2.                               | +1.2                | +0.7                | U/C                      |
| 10.32         | 9.76          | +3.                               | +41.                              | -1.                               | +41.                              | -39.                              | +5.6                | -5.0                | +43.6                    |
| 20.52         | 19.40         | +2.                               | +77.                              | -4.                               | +77.                              | -79.                              | +12.0               | -12.5               | +44.0                    |
| 36.72         | 29.15         | +1.                               | +112.                             | -7.                               | +112.                             | -117.                             | +17.2               | -18.9               | +44.1                    |
| 41.27         | 38.79         | +4.                               | +150.                             | -9.                               | +151.                             | -156.                             | +23.4               | -25.0               | +43.8                    |
| 51.58         | 48.32         | +7.                               | +187.                             | -15.                              | +188.                             | -196.                             | +29.0               | -31.5               | +43.4                    |
| 61.66         | 58.19         | +11.                              | +224.                             | -21.                              | +225.                             | -234.                             | +34.0               | -37.6               | +43.0                    |
| 71.86         | 68.18         | +17.                              | +263.                             | -27.                              | +264.                             | -274.                             | +40.9               | -44.0               | +42.6                    |
| 81.83         | 78.28         | +27.                              | +303.                             | -34.                              | +304.                             | -311.                             | +47.6               | -49.5               | +42.1                    |
| 91.68         | 88.04         | +37.                              | +342.                             | -40.                              | +344.                             | -347.                             | +54.0               | -54.8               | +41.8                    |
| 101.76        | 98.14         | +46.                              | +380.                             | -48.                              | +383.                             | -385.                             | +60.3               | -60.9               | +41.5                    |
| 0.12          | 0.00          | +60.                              | +27.                              | -16.                              | +60.                              | -17.                              | +12.4               | +0.3                | +4.3                     |

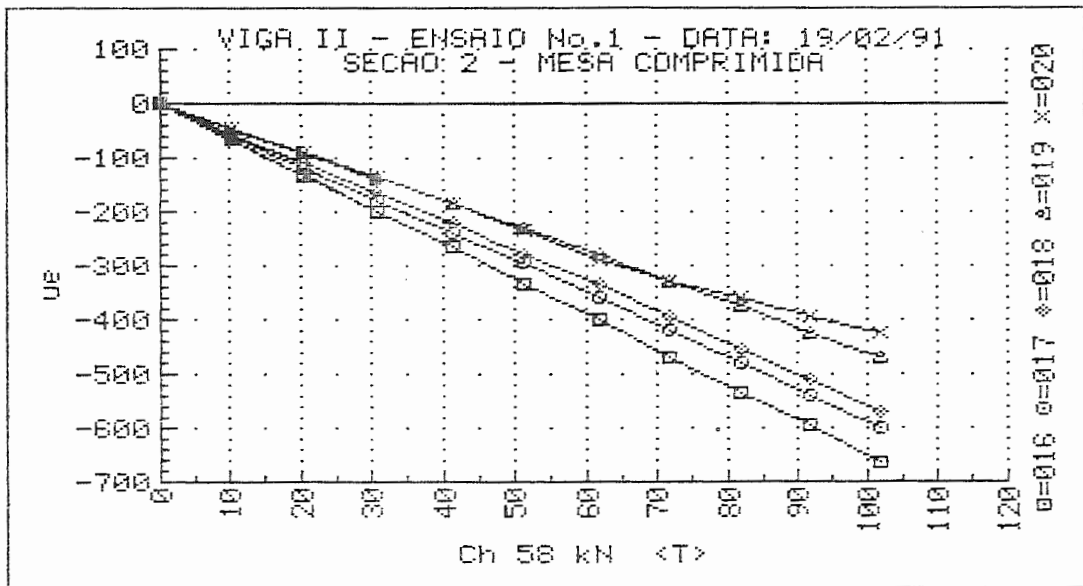
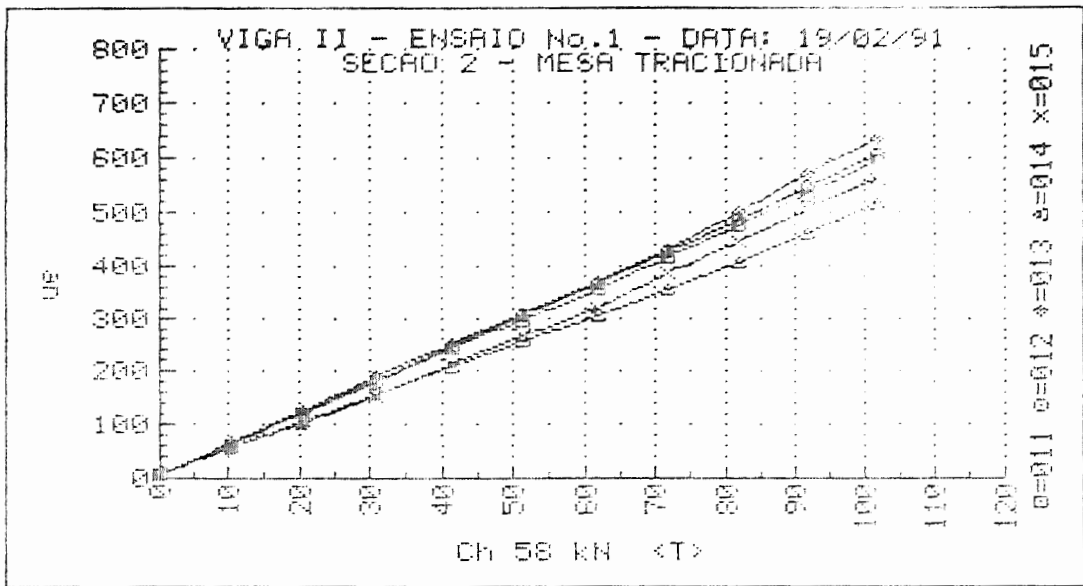
UNIVERSIDADE DE SAO PAULO  
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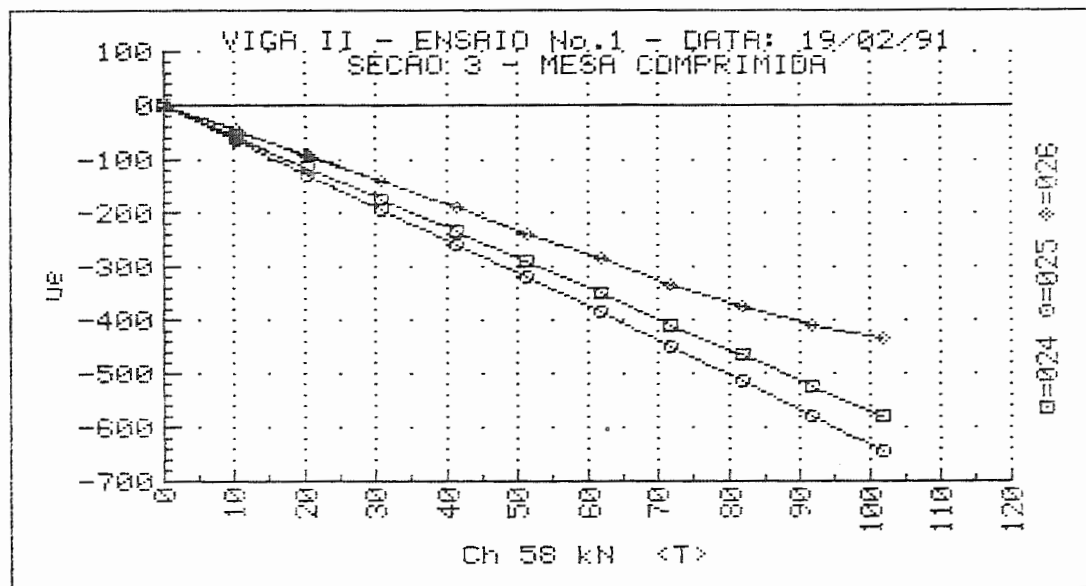
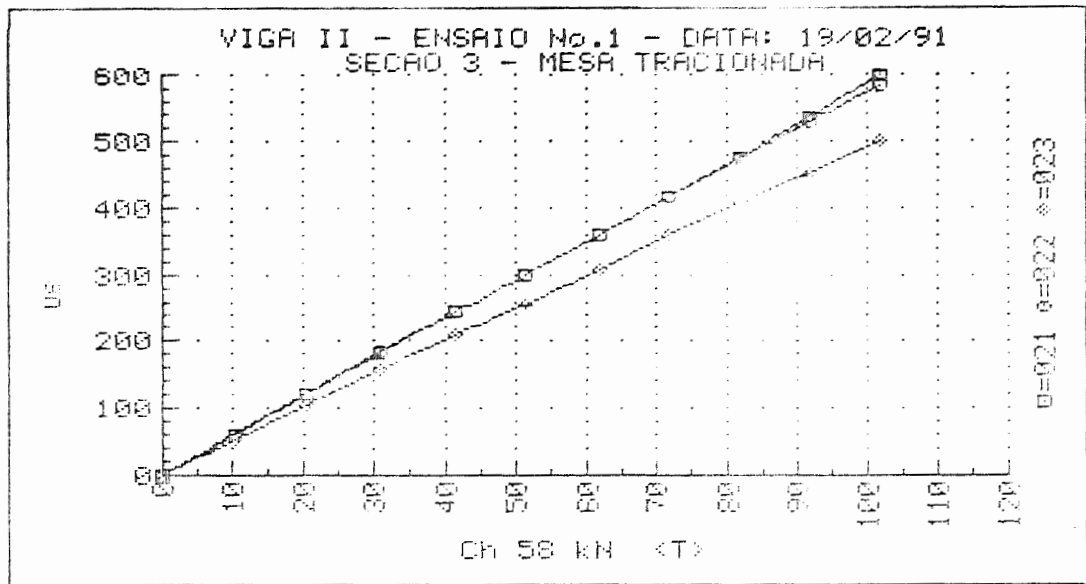
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.1 DATA: 19/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

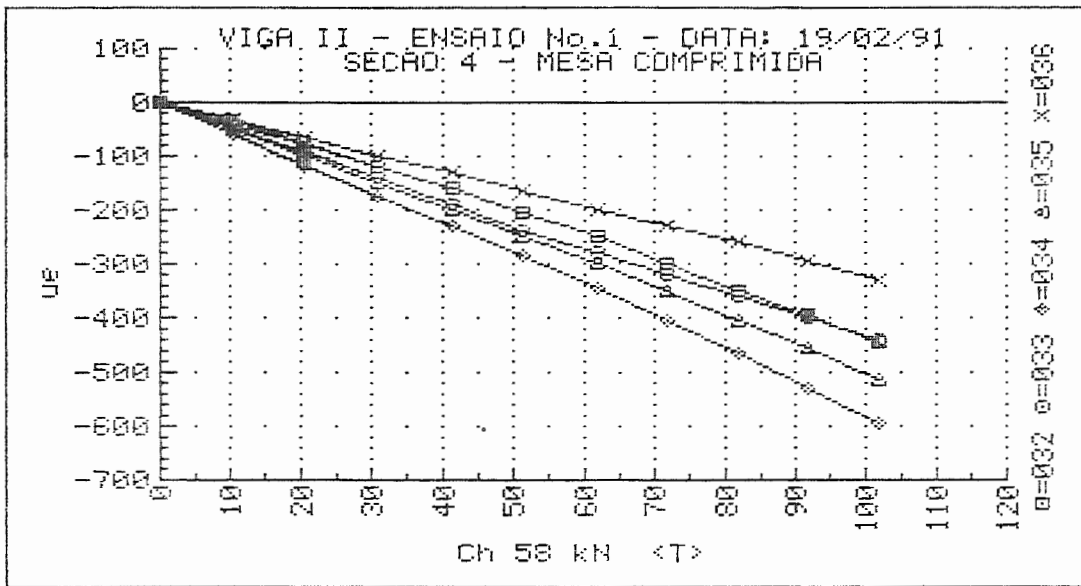
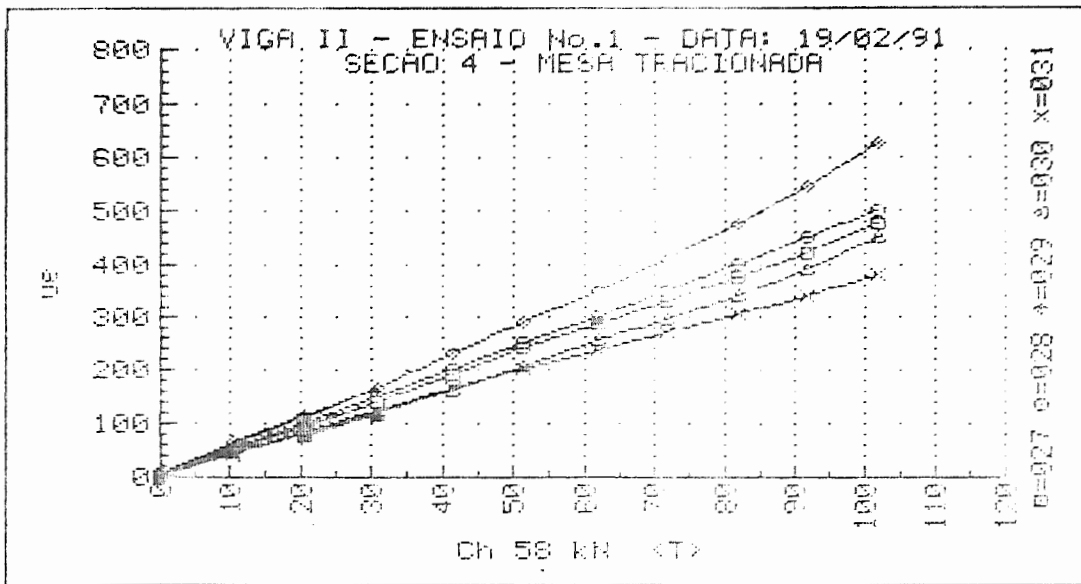
| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 20.28         | 19.28         | +7.                               | -69.                              | -9.                               | +67.                              | -70.                              | +10.3               | -11.2               | -41.6                    |
| 30.72         | 29.15         | +5.                               | -106.                             | -14.                              | +101.                             | -107.                             | +15.5               | -17.2               | -41.9                    |
| 0.00          | 0.00          | +4.                               | +4.                               | +3.                               | +4.                               | +3.                               | +1.1                | +0.9                | U/C                      |
| 0.12          | 0.00          | +4.                               | +4.                               | +4.                               | +4.                               | +4.                               | +1.1                | +1.1                | U/C                      |
| 10.32         | 9.76          | +8.                               | -30.                              | -2.                               | +36.                              | -31.                              | +6.1                | -4.4                | -40.9                    |
| 20.52         | 19.40         | +9.                               | -67.                              | -6.                               | +69.                              | -68.                              | +10.9               | -10.6               | -41.6                    |
| 30.72         | 29.15         | +9.                               | -105.                             | -12.                              | +103.                             | -106.                             | +16.0               | -16.8               | -42.0                    |
| 41.27         | 38.79         | +14.                              | -140.                             | -14.                              | +141.                             | -141.                             | +22.2               | -22.2               | -42.1                    |
| 51.58         | 48.32         | +17.                              | -176.                             | -19.                              | +175.                             | -177.                             | +27.5               | -28.0               | -42.1                    |
| 61.66         | 58.19         | +20.                              | -214.                             | -21.                              | +214.                             | -215.                             | +33.7               | -33.9               | -42.3                    |
| 71.86         | 68.18         | +24.                              | -252.                             | -25.                              | +252.                             | -253.                             | +39.7               | -39.9               | -42.3                    |
| 81.83         | 78.28         | +27.                              | -290.                             | -27.                              | +290.                             | -291.                             | +45.7               | -45.9               | -42.3                    |
| 91.68         | 88.04         | +28.                              | -327.                             | -30.                              | +327.                             | -329.                             | +51.4               | -52.0               | -42.4                    |
| 101.76        | 98.14         | +30.                              | -366.                             | -34.                              | +364.                             | -368.                             | +57.1               | -58.2               | -42.5                    |
| 0.12          | 0.00          | +26.                              | +10.                              | +15.                              | +26.                              | +15.                              | +6.9                | +5.1                | -12.2                    |

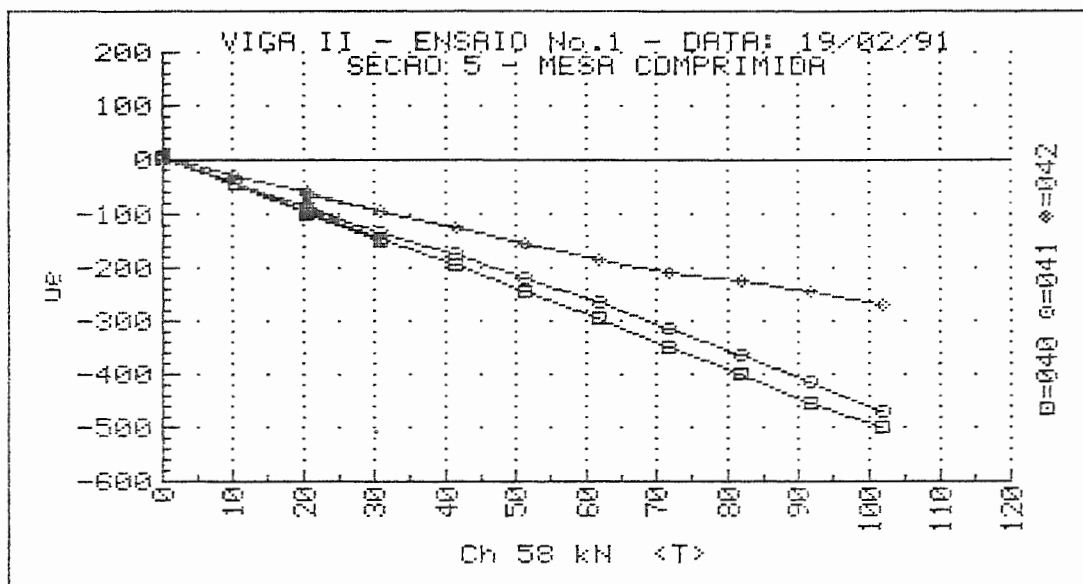
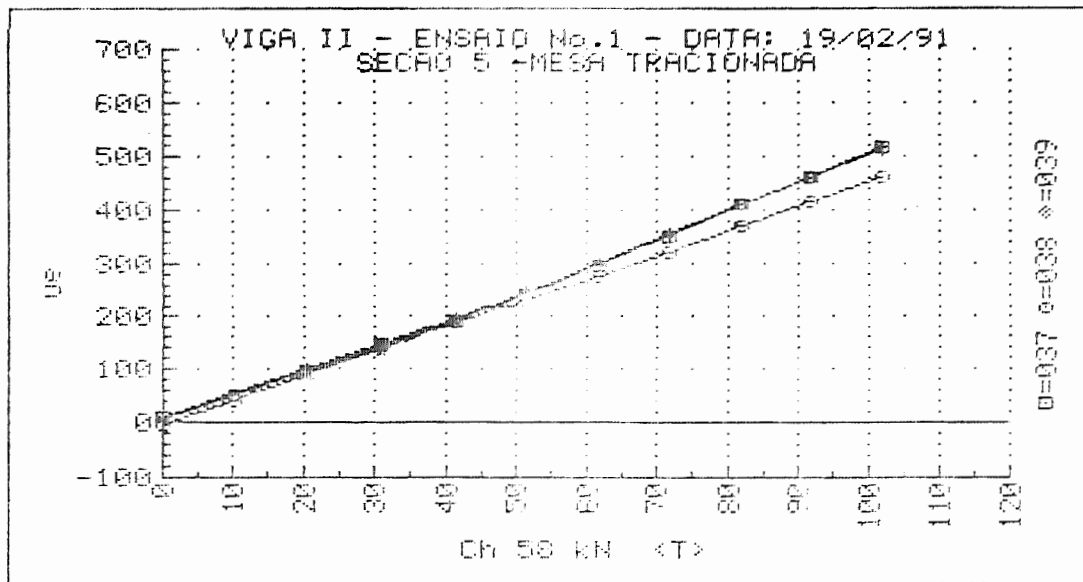


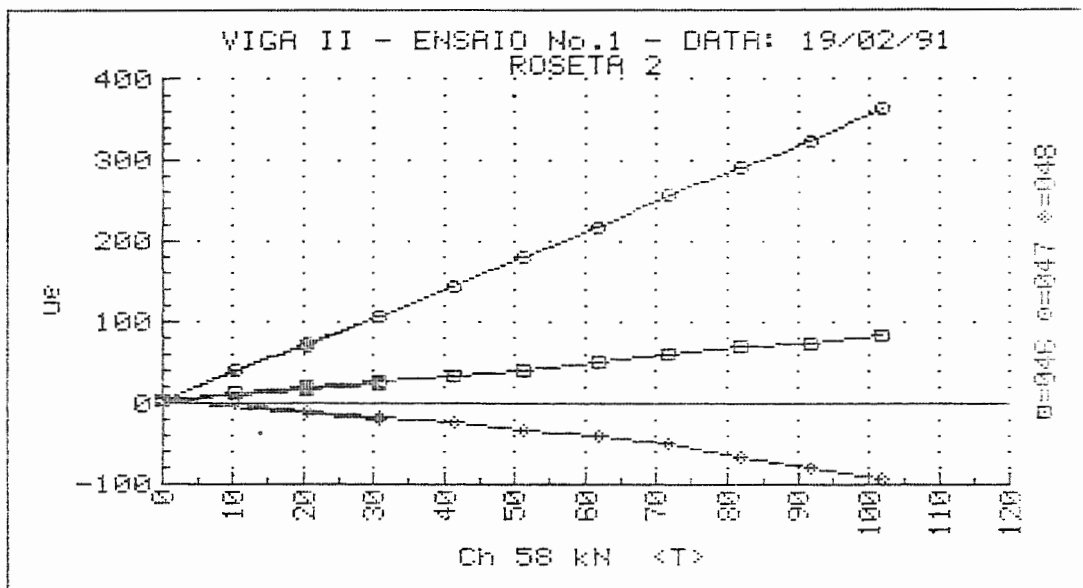
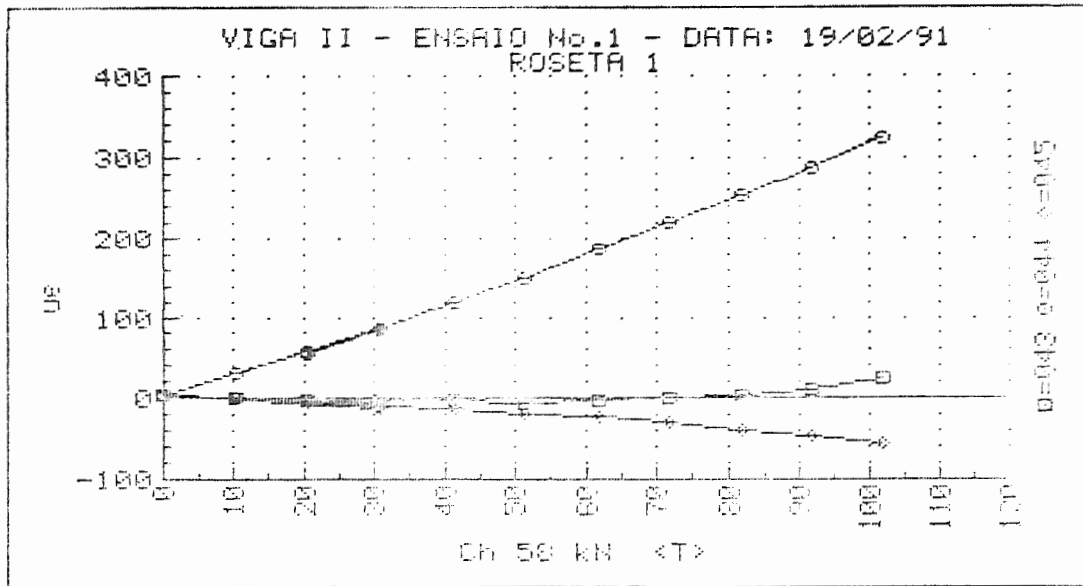


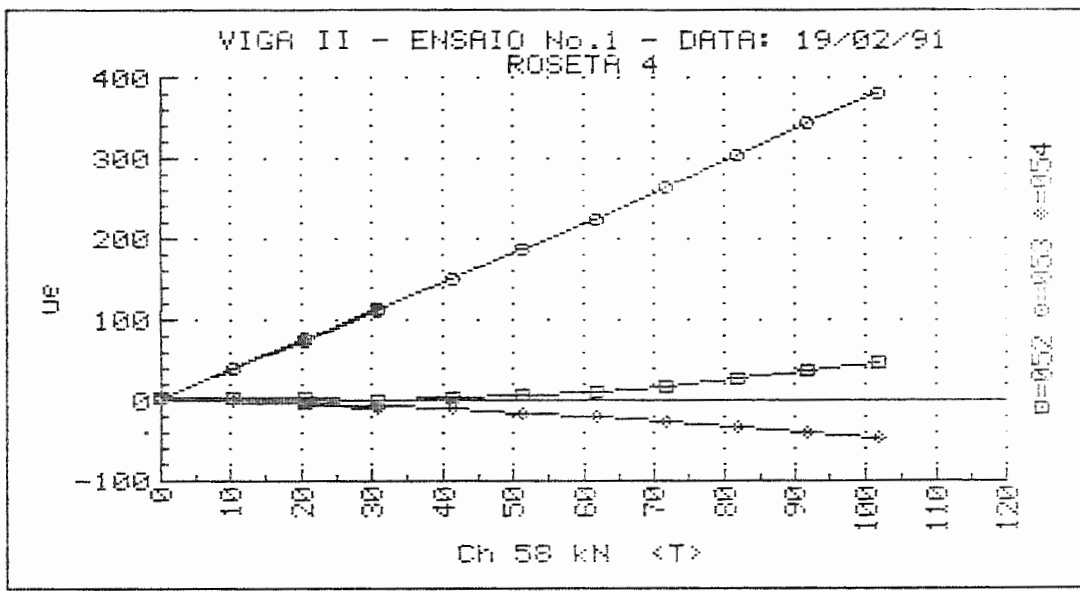
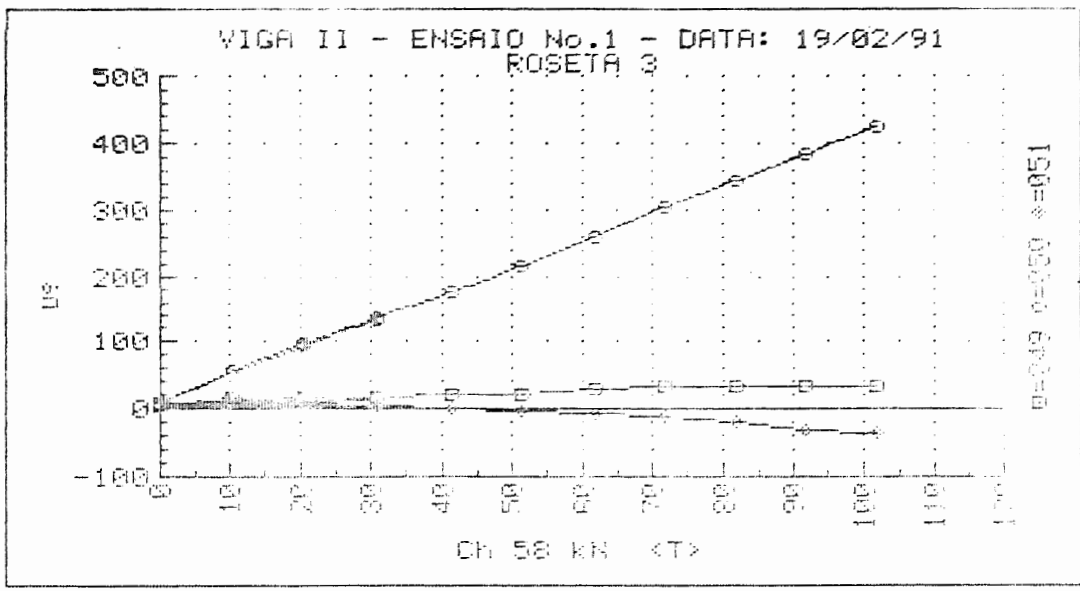


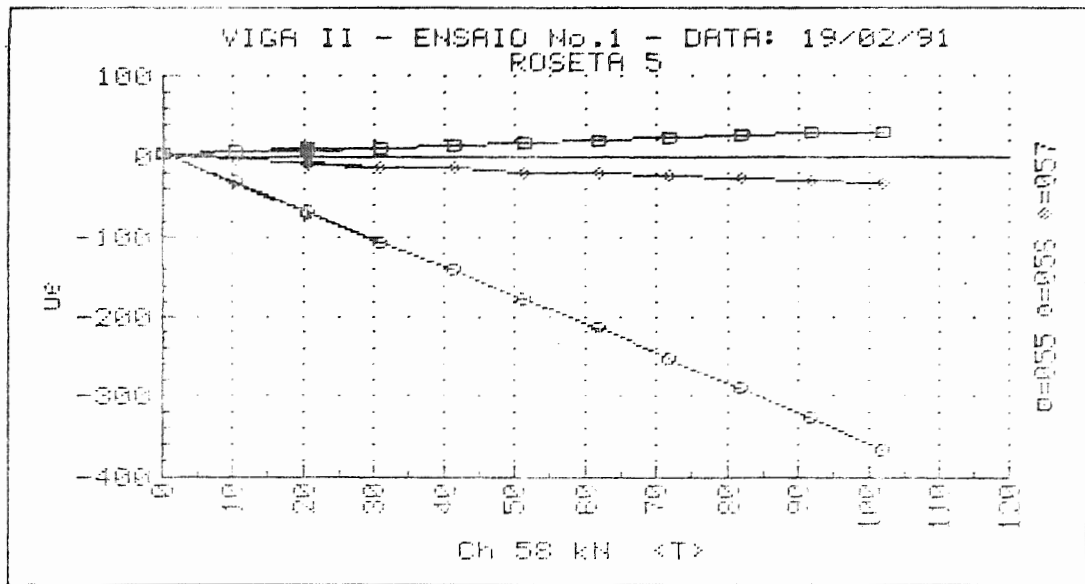












MODELO - VIGA II

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS



MODELO: VIGA REBITADA II

ENSAIO Nro:2

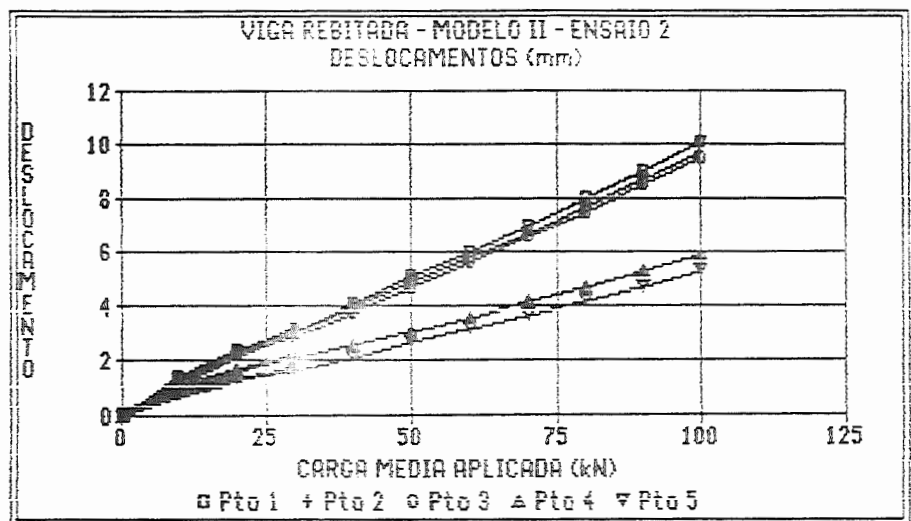
DATA:20 DE FEVEREIRO DE 1991

HORARIO: 8:45 Hs

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| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |       |       |
|-------|----------------------------|-----------------------|-------|-------|-------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto 4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00  | 0.00  |
| 1     | 9.85                       | 1.38                  | 1.33  | 1.24  | 1.11  | .78   |
| 2     | 19.90                      | 2.38                  | 2.28  | 2.19  | 1.66  | 1.35  |
| 3     | 29.95                      | 3.22                  | 3.13  | 2.95  | 2.15  | 1.67  |
| 4     | .25                        | .12                   | .09   | .08   | .11   | .07   |
| 5     | 9.90                       | 1.27                  | 1.24  | 1.21  | 1.00  | .70   |
| 6     | 20.00                      | 2.30                  | 2.21  | 2.15  | 1.55  | 1.32  |
| 7     | 30.00                      | 3.12                  | 3.06  | 2.89  | 2.08  | 1.60  |
| 8     | 39.95                      | 4.06                  | 3.95  | 3.80  | 2.56  | 2.14  |
| 9     | 50.00                      | 5.05                  | 4.89  | 4.74  | 3.10  | 2.65  |
| 10    | 60.00                      | 6.00                  | 5.80  | 5.65  | 3.62  | 3.18  |
| 11    | 69.95                      | 6.98                  | 6.74  | 6.57  | 4.16  | 3.70  |
| 12    | 80.00                      | 7.99                  | 7.69  | 7.53  | 4.73  | 4.21  |
| 13    | 89.95                      | 9.00                  | 8.67  | 8.49  | 5.30  | 4.75  |
| 14    | 99.95                      | 10.08                 | 9.71  | 9.51  | 5.93  | 5.34  |

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MODELO - VIGA II

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.2 DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00          | 0.00          | -1.                    | +0.                    | -1.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                     |
| 10.43         | 9.41          | +96.                   | +91.                   | +87.                   | +79.                   | +66.                   | -91.                   | -96.                   | -95.                   | -75.                   | -65.                    |
| 20.83         | 19.16         | +196.                  | +184.                  | +175.                  | +162.                  | +134.                  | -185.                  | -182.                  | -190.                  | -150.                  | -132.                   |
| 30.95         | 29.04         | +296.                  | +279.                  | +264.                  | +244.                  | +202.                  | -279.                  | -274.                  | -285.                  | -223.                  | -200.                   |
| 0.47          | 0.00          | +3.                    | +4.                    | +5.                    | +3.                    | +4.                    | -3.                    | -1.                    | +0.                    | +0.                    | -1.                     |
| 10.43         | 9.41          | +97.                   | +93.                   | +89.                   | +81.                   | +68.                   | -92.                   | -89.                   | -94.                   | -73.                   | -65.                    |
| 20.83         | 19.40         | +197.                  | +187.                  | +177.                  | +163.                  | +136.                  | -186.                  | -182.                  | -189.                  | -149.                  | -132.                   |
| 30.83         | 29.15         | +296.                  | +279.                  | +266.                  | +244.                  | +202.                  | -279.                  | -273.                  | -283.                  | -222.                  | -199.                   |
| 41.15         | 38.79         | +394.                  | +370.                  | +354.                  | +327.                  | +269.                  | -374.                  | -364.                  | -377.                  | -295.                  | -266.                   |
| 51.58         | 48.43         | +493.                  | +465.                  | +444.                  | +412.                  | +339.                  | -465.                  | -455.                  | -470.                  | -367.                  | -334.                   |
| 61.90         | 58.07         | +589.                  | +558.                  | +533.                  | +493.                  | +407.                  | -564.                  | -547.                  | -562.                  | -438.                  | -401.                   |
| 72.10         | 67.71         | +687.                  | +651.                  | +623.                  | +574.                  | +474.                  | -655.                  | -636.                  | -652.                  | -509.                  | -467.                   |
| 81.83         | 78.16         | +786.                  | +745.                  | +714.                  | +656.                  | +541.                  | -758.                  | -729.                  | -746.                  | -580.                  | -533.                   |
| 92.61         | 87.22         | +883.                  | +837.                  | +804.                  | +735.                  | +607.                  | -854.                  | -820.                  | -838.                  | -648.                  | -598.                   |
| 101.99        | 97.91         | +982.                  | +932.                  | +896.                  | +816.                  | +673.                  | -954.                  | -910.                  | -932.                  | -718.                  | -664.                   |
| 0.59          | 0.00          | +10.                   | +11.                   | +13.                   | +12.                   | +10.                   | -5.                    | +4.                    | +1.                    | +5.                    | +0.                     |

UNIVERSIDADE DE SAO PAULO  
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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.2 DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | -1.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                     |
| 10.43                  | 9.41                   | +56.                   | +59.                   | +60.                   | +49.                   | +49.                   | -59.                   | -59.                   | -62.                   | -49.                   | -45.                    |
| 20.63                  | 19.16                  | +116.                  | +110.                  | +120.                  | +101.                  | +99.                   | -122.                  | -121.                  | -123.                  | -98.                   | -90.                    |
| 30.95                  | 29.04                  | +176.                  | +170.                  | +180.                  | +153.                  | +151.                  | -186.                  | -182.                  | -182.                  | -147.                  | -137.                   |
| 0.47                   | 0.00                   | +2.                    | +3.                    | +3.                    | +2.                    | +4.                    | -3.                    | -1.                    | +1.                    | +0.                    | -1.                     |
| 10.43                  | 9.41                   | +57.                   | +59.                   | +61.                   | +50.                   | +51.                   | -60.                   | -59.                   | -59.                   | -47.                   | -45.                    |
| 20.63                  | 19.40                  | +117.                  | +120.                  | +122.                  | +102.                  | +101.                  | -124.                  | -121.                  | -121.                  | -98.                   | -91.                    |
| 30.83                  | 29.15                  | +176.                  | +179.                  | +181.                  | +154.                  | +151.                  | -186.                  | -182.                  | -181.                  | -147.                  | -137.                   |
| 41.15                  | 38.79                  | +236.                  | +239.                  | +241.                  | +206.                  | +203.                  | -251.                  | -242.                  | -240.                  | -196.                  | -184.                   |
| 51.56                  | 48.43                  | +297.                  | +301.                  | +302.                  | +260.                  | +254.                  | -315.                  | -301.                  | -296.                  | -244.                  | -231.                   |
| 61.90                  | 58.07                  | +357.                  | +360.                  | +362.                  | +311.                  | +304.                  | -380.                  | -360.                  | -354.                  | -294.                  | -278.                   |
| 72.16                  | 67.71                  | +417.                  | +421.                  | +422.                  | +364.                  | +354.                  | -446.                  | -418.                  | -411.                  | -341.                  | -325.                   |
| 81.83                  | 78.16                  | +480.                  | +483.                  | +484.                  | +418.                  | +407.                  | -514.                  | -479.                  | -467.                  | -389.                  | -372.                   |
| 92.61                  | 87.22                  | +540.                  | +542.                  | +543.                  | +470.                  | +457.                  | -579.                  | -537.                  | -521.                  | -437.                  | -415.                   |
| 101.99                 | 97.91                  | +604.                  | +605.                  | +605.                  | +524.                  | +509.                  | -647.                  | -596.                  | -578.                  | -485.                  | -457.                   |
| 0.59                   | 0.00                   | +7.                    | +7.                    | +6.                    | +9.                    | +7.                    | -3.                    | +3.                    | +6.                    | +1.                    | +2.                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.2 DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 3

| F <sub>1</sub><br>(KN) | F <sub>2</sub><br>(KN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) |
|------------------------|------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0.00                   | 0.00                   | -1.              | -1.              | -1.              | +0.              | -1.              | +0.              |
| 10.43                  | 9.41                   | +55.             | +59.             | +50.             | -55.             | -65.             | -46.             |
| 20.63                  | 19.16                  | +121.            | +121.            | +103.            | -118.            | -128.            | -92.             |
| 30.95                  | 29.04                  | +184.            | +182.            | +156.            | -177.            | -191.            | -138.            |
| 0.47                   | 0.00                   | +2.              | +3.              | +2.              | -1.              | +1.              | -1.              |
| 10.43                  | 9.41                   | +55.             | +61.             | +51.             | -58.             | -63.             | -45.             |
| 20.63                  | 19.40                  | +121.            | +121.            | +104.            | -117.            | -126.            | -92.             |
| 30.83                  | 29.15                  | +184.            | +182.            | +157.            | -175.            | -187.            | -136.            |
| 41.15                  | 38.79                  | +244.            | +242.            | +208.            | -234.            | -250.            | -184.            |
| 51.58                  | 48.43                  | +300.            | +304.            | +262.            | -291.            | -312.            | -228.            |
| 61.90                  | 58.07                  | +365.            | +364.            | +313.            | -349.            | -373.            | -275.            |
| 72.10                  | 67.71                  | +425.            | +422.            | +364.            | -405.            | -435.            | -320.            |
| 81.83                  | 78.16                  | +484.            | +481.            | +415.            | -463.            | -498.            | -365.            |
| 92.61                  | 87.22                  | +543.            | +542.            | +467.            | -521.            | -560.            | -409.            |
| 101.99                 | 97.91                  | +604.            | +600.            | +518.            | -577.            | -622.            | -448.            |
| 0.59                   | 0.00                   | +6.              | +4.              | +5.              | +5.              | +6.              | +10.             |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 4

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00          | 0.00          | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    | +1.                    | +1.                    | +0.                    | +1.                     |
| 10.43         | 9.41          | +43.                   | +49.                   | +55.                   | +37.                   | +40.                   | -36.                   | -46.                   | -60.                   | -51.                   | -32.                    |
| 20.87         | 19.16         | +94.                   | +100.                  | +106.                  | +74.                   | +84.                   | -80.                   | -95.                   | -116.                  | -100.                  | -65.                    |
| 30.35         | 29.04         | +145.                  | +150.                  | +156.                  | +111.                  | +127.                  | -124.                  | -145.                  | -172.                  | -150.                  | -98.                    |
| 0.47          | 0.00          | +2.                    | +3.                    | +4.                    | +2.                    | +1.                    | +1.                    | -1.                    | -1.                    | -1.                    | +0.                     |
| 10.43         | 9.41          | +45.                   | +50.                   | +56.                   | +39.                   | +41.                   | -34.                   | -46.                   | -60.                   | -51.                   | -32.                    |
| 20.87         | 19.40         | +95.                   | +100.                  | +108.                  | +76.                   | +84.                   | -79.                   | -95.                   | -117.                  | -100.                  | -65.                    |
| 30.83         | 29.15         | +145.                  | +150.                  | +156.                  | +112.                  | +128.                  | -123.                  | -143.                  | -171.                  | -148.                  | -97.                    |
| 41.15         | 38.79         | +193.                  | +200.                  | +209.                  | +149.                  | +169.                  | -167.                  | -193.                  | -227.                  | -196.                  | -133.                   |
| 51.52         | 48.43         | +243.                  | +251.                  | +264.                  | +186.                  | +213.                  | -210.                  | -240.                  | -281.                  | -243.                  | -165.                   |
| 61.90         | 58.07         | +292.                  | +301.                  | +316.                  | +227.                  | +253.                  | -254.                  | -288.                  | -336.                  | -292.                  | -201.                   |
| 72.10         | 67.71         | +339.                  | +350.                  | +370.                  | +265.                  | +294.                  | -296.                  | -336.                  | -390.                  | -340.                  | -234.                   |
| 81.83         | 78.16         | +386.                  | +400.                  | +423.                  | +305.                  | +335.                  | -339.                  | -383.                  | -446.                  | -389.                  | -268.                   |
| 92.61         | 87.22         | +436.                  | +451.                  | +478.                  | +346.                  | +376.                  | -381.                  | -432.                  | -503.                  | -440.                  | -302.                   |
| 101.99        | 97.91         | +483.                  | +501.                  | +533.                  | +382.                  | +416.                  | -423.                  | -481.                  | -561.                  | -491.                  | -333.                   |
| 0.59          | 0.00          | +7.                    | +6.                    | +11.                   | +9.                    | +6.                    | -1.                    | +2.                    | -3.                    | -1.                    | +4.                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II      ENSAIO No.2      DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 5

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µE) | 2<br>(µE) | 3<br>(µE) | 4<br>(µE) | 5<br>(µE) | 6<br>(µE) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.00                   | 0.00                   | -1.       | +0.       | +0.       | +0.       | +0.       | -1.       |
| 10.43                  | 9.41                   | +41.      | +46.      | +45.      | -48.      | -54.      | -35.      |
| 20.87                  | 19.16                  | +87.      | +96.      | +93.      | -96.      | -103.     | -69.      |
| 30.95                  | 29.04                  | +135.     | +145.     | +141.     | -148.     | -152.     | -102.     |
| 0.47                   | 0.00                   | +2.       | +3.       | +1.       | +0.       | +1.       | +1.       |
| 10.43                  | 9.41                   | +43.      | +48.      | +45.      | -48.      | -50.      | -33.      |
| 20.83                  | 19.40                  | +89.      | +97.      | +94.      | -97.      | -101.     | -68.      |
| 30.83                  | 29.15                  | +136.     | +147.     | +142.     | -147.     | -150.     | -102.     |
| 41.15                  | 38.79                  | +184.     | +195.     | +189.     | -197.     | -198.     | -134.     |
| 51.58                  | 48.43                  | +234.     | +247.     | +240.     | -246.     | -245.     | -166.     |
| 61.90                  | 58.07                  | +283.     | +298.     | +290.     | -294.     | -290.     | -197.     |
| 72.10                  | 67.71                  | +333.     | +348.     | +339.     | -343.     | -336.     | -229.     |
| 81.83                  | 78.16                  | +384.     | +401.     | +389.     | -395.     | -383.     | -260.     |
| 92.61                  | 87.22                  | +434.     | +451.     | +437.     | -444.     | -428.     | -291.     |
| 101.99                 | 97.91                  | +486.     | +503.     | +486.     | -497.     | -476.     | -317.     |
| 6.59                   | 0.00                   | +12.      | +12.      | +6.       | +3.       | +8.       | +12.      |



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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II ENSAIO No.2 DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.43         | 9.41          | -2.                               | +24.                              | -5.                               | +24.                              | -30.                              | +3.3                | -5.2                | +43.5                    |
| 20.63         | 19.16         | -4.                               | +52.                              | -9.                               | +52.                              | -65.                              | +7.3                | -11.2               | +43.6                    |
| 30.95         | 29.04         | -6.                               | +81.                              | -15.                              | +81.                              | -102.                             | +11.4               | -17.5               | +43.5                    |
| 0.47          | 0.00          | +1.                               | +1.                               | +1.                               | +1.                               | +1.                               | +0.3                | +0.3                | U/C                      |
| 10.43         | 9.41          | -1.                               | +25.                              | -4.                               | +25.                              | -29.                              | +3.6                | -4.9                | +43.5                    |
| 20.63         | 19.40         | -3.                               | +53.                              | -9.                               | +53.                              | -64.                              | +7.6                | -10.9               | +43.6                    |
| 30.83         | 29.15         | -5.                               | +82.                              | -14.                              | +82.                              | -101.                             | +11.7               | -17.2               | +43.5                    |
| 41.15         | 38.79         | -7.                               | +111.                             | -20.                              | +111.                             | -137.                             | +15.7               | -23.4               | +43.5                    |
| 51.58         | 48.43         | -6.                               | +142.                             | -25.                              | +142.                             | -172.                             | +20.4               | -29.2               | +43.3                    |
| 61.90         | 58.07         | -7.                               | +172.                             | -30.                              | +172.                             | -209.                             | +24.7               | -35.5               | +43.2                    |
| 72.10         | 67.71         | -7.                               | +202.                             | -37.                              | +203.                             | -246.                             | +29.0               | -41.8               | +43.1                    |
| 81.83         | 78.16         | -7.                               | +233.                             | -43.                              | +234.                             | -284.                             | +33.5               | -48.2               | +43.0                    |
| 92.61         | 87.22         | -7.                               | +265.                             | -50.                              | +265.                             | -322.                             | +38.0               | -54.6               | +42.9                    |
| 101.99        | 97.91         | -4.                               | +297.                             | -57.                              | +298.                             | -358.                             | +42.9               | -60.6               | +42.7                    |
| 0.59          | 0.00          | +14.                              | +9.                               | +5.                               | +14.                              | +5.                               | +3.5                | +2.0                | U/C                      |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.43                  | 9.41                   | +12.                   | +36.                   | -2.                    | +37.                   | -26.                   | +6.5                    | -3.4                    | +38.5    |
| 20.63                  | 19.16                  | +19.                   | +71.                   | -10.                   | +72.                   | -64.                   | +12.0                   | -9.5                    | +38.8    |
| 30.95                  | 29.04                  | +25.                   | +105.                  | -20.                   | +107.                  | -103.                  | +17.2                   | -15.9                   | +38.9    |
| 0.47                   | 0.00                   | +3.                    | +2.                    | +2.                    | +3.                    | +2.                    | +0.8                    | +0.6                    | U/C      |
| 10.43                  | 9.41                   | +14.                   | +38.                   | -1.                    | +39.                   | -25.                   | +7.0                    | -3.1                    | +38.2    |
| 20.63                  | 19.40                  | +20.                   | +72.                   | -9.                    | +73.                   | -63.                   | +12.3                   | -9.2                    | +38.8    |
| 30.83                  | 29.15                  | +26.                   | +106.                  | -18.                   | +108.                  | -101.                  | +17.6                   | -15.3                   | +39.0    |
| 41.15                  | 38.79                  | +31.                   | +141.                  | -28.                   | +144.                  | -141.                  | +22.9                   | -22.1                   | +39.0    |
| 51.58                  | 48.43                  | +39.                   | +178.                  | -36.                   | +182.                  | -179.                  | +28.8                   | -28.0                   | +39.6    |
| 61.90                  | 58.07                  | +43.                   | +213.                  | -45.                   | +217.                  | -219.                  | +34.1                   | -34.7                   | +39.1    |
| 72.10                  | 67.71                  | +49.                   | +247.                  | -56.                   | +252.                  | -259.                  | +39.3                   | -41.2                   | +39.1    |
| 81.83                  | 78.16                  | +55.                   | +282.                  | -65.                   | +288.                  | -298.                  | +44.7                   | -47.7                   | +39.1    |
| 92.61                  | 87.22                  | +60.                   | +318.                  | -76.                   | +324.                  | -341.                  | +50.1                   | -54.8                   | +39.1    |
| 101.99                 | 97.91                  | +65.                   | +352.                  | -85.                   | +360.                  | -380.                  | +55.5                   | -61.3                   | +39.1    |
| 0.59                   | 0.00                   | +11.                   | +9.                    | +5.                    | +12.                   | +4.                    | +2.9                    | +1.8                    | U/C      |

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II            ENSAIO No.2            DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.43                  | 9.41                   | +10.                   | +53.                   | +10.                   | +53.                   | -32.                   | +9.8                    | -3.7                    | +43.0    |
| 20.63                  | 19.16                  | +11.                   | +94.                   | +9.                    | +94.                   | -74.                   | +16.1                   | -10.3                   | +44.5    |
| 30.95                  | 29.04                  | +12.                   | +133.                  | +6.                    | +133.                  | -115.                  | +22.3                   | -17.0                   | +44.2    |
| 0.47                   | 0.00                   | +3.                    | +5.                    | +3.                    | +5.                    | +1.                    | +1.1                    | +0.5                    | U/C      |
| 10.43                  | 9.41                   | +12.                   | +55.                   | +11.                   | +55.                   | -31.                   | +10.2                   | -3.3                    | +44.7    |
| 20.63                  | 19.40                  | +13.                   | +95.                   | +9.                    | +95.                   | -73.                   | +16.4                   | -10.0                   | +44.2    |
| 30.83                  | 29.15                  | +13.                   | +134.                  | +6.                    | +134.                  | -115.                  | +22.5                   | -16.9                   | +44.1    |
| 41.15                  | 38.79                  | +13.                   | +172.                  | +2.                    | +172.                  | -157.                  | +28.2                   | -23.0                   | +44.0    |
| 51.58                  | 48.43                  | +14.                   | +214.                  | -2.                    | +214.                  | -202.                  | +34.6                   | -31.0                   | +43.9    |
| 61.90                  | 58.07                  | +13.                   | +253.                  | -7.                    | +253.                  | -246.                  | +40.3                   | -38.4                   | +43.9    |
| 72.10                  | 67.71                  | +12.                   | +290.                  | -11.                   | +291.                  | -290.                  | +45.9                   | -45.6                   | +43.8    |
| 81.83                  | 78.16                  | +10.                   | +329.                  | -15.                   | +329.                  | -334.                  | +51.6                   | -53.0                   | +43.9    |
| 92.61                  | 87.22                  | +9.                    | +368.                  | -21.                   | +368.                  | -381.                  | +57.2                   | -60.8                   | +43.9    |
| 101.99                 | 97.91                  | +9.                    | +407.                  | -26.                   | +407.                  | -424.                  | +63.0                   | -68.0                   | +43.8    |
| 0.59                   | 0.00                   | +10.                   | +15.                   | +7.                    | +15.                   | +2.                    | +3.6                    | +1.4                    | U/C      |

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

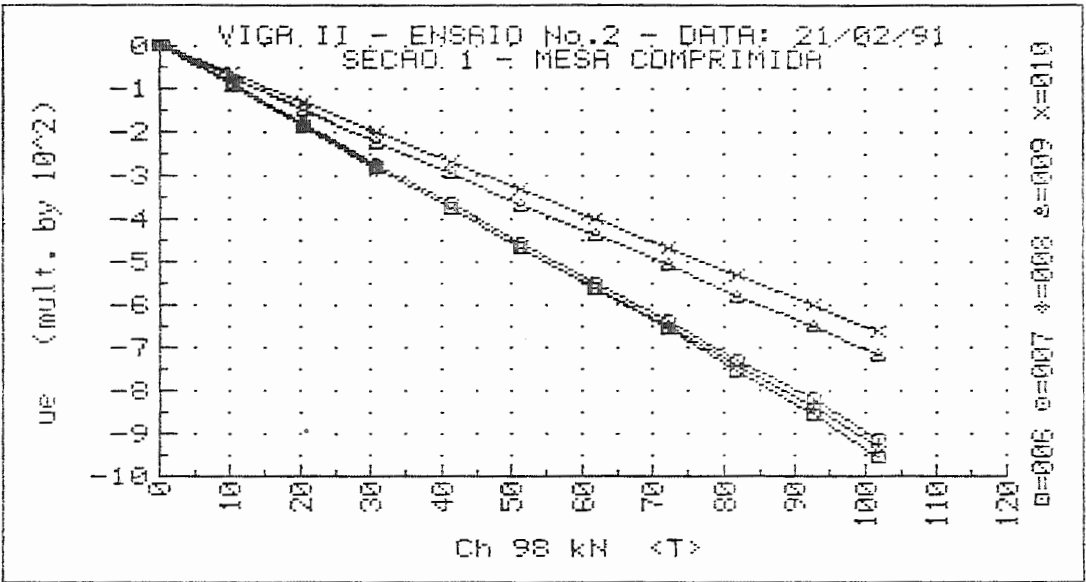
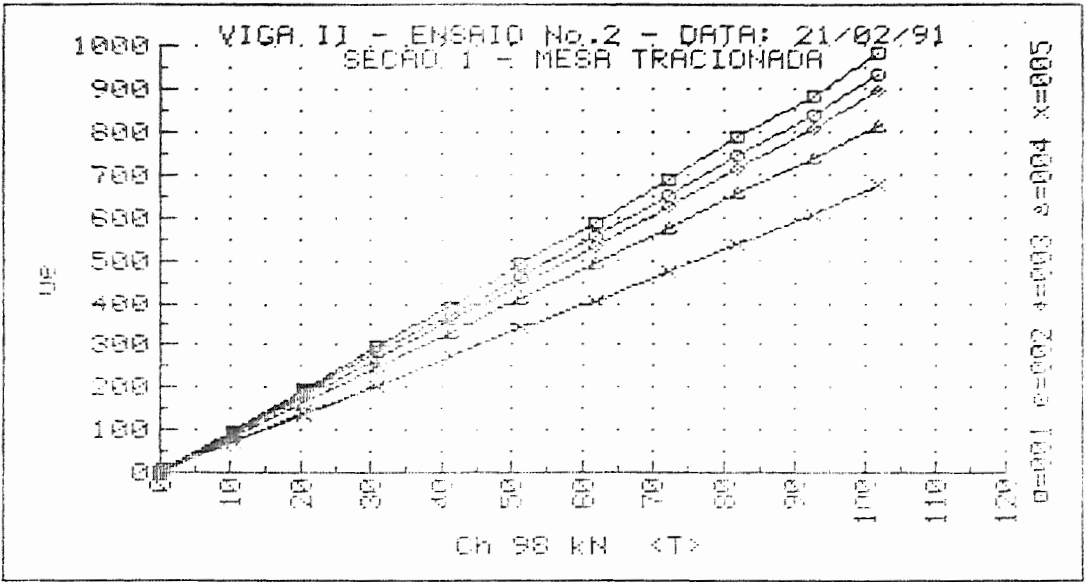
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II            ENSAIO No.2            DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

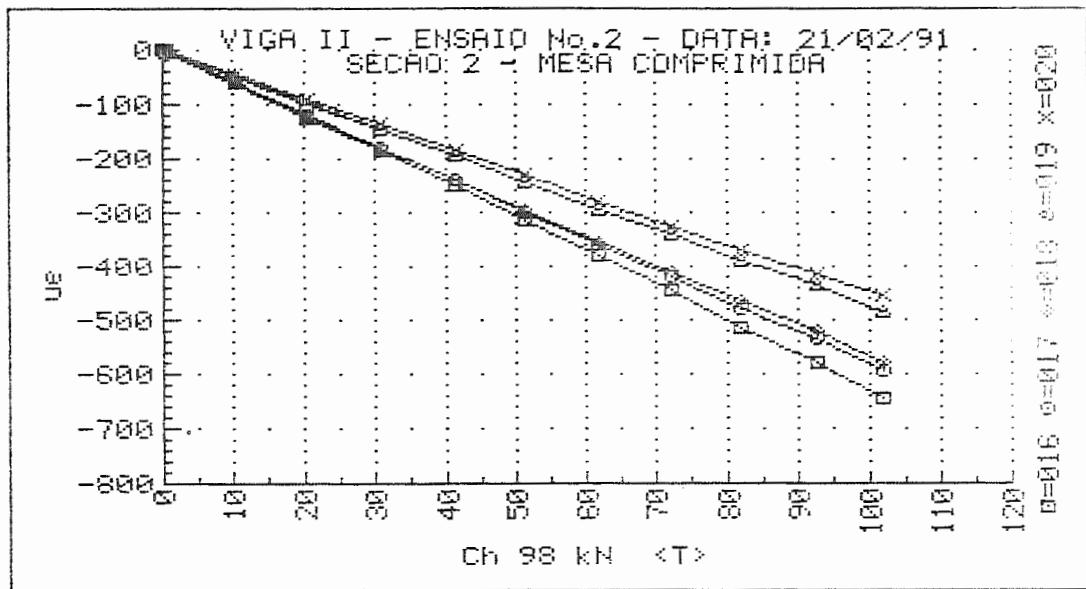
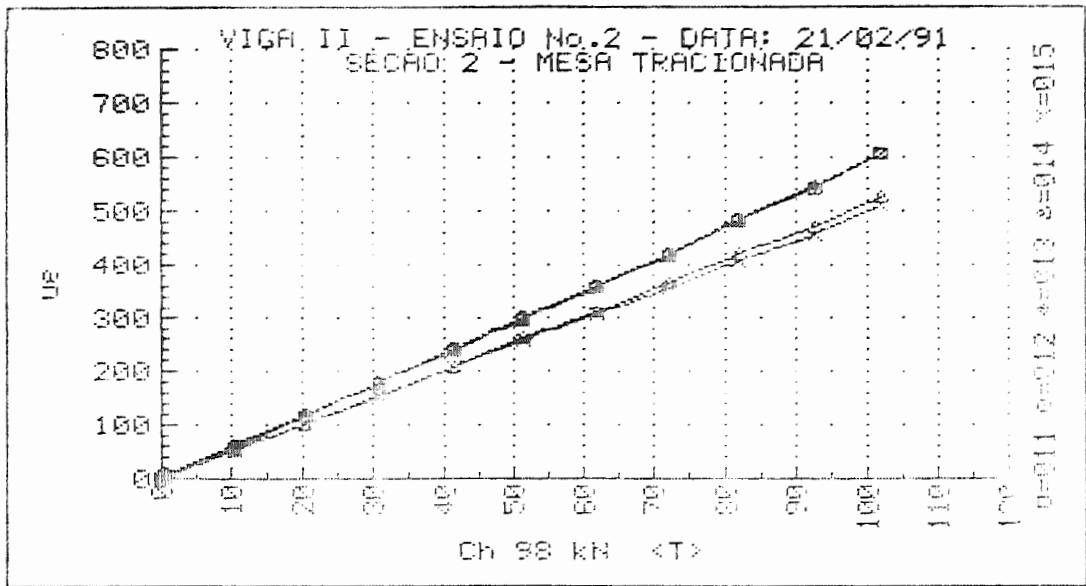
| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.43                  | 9.41                   | -1.                    | +37.                   | +0.                    | +37.                   | -38.                   | +5.8                    | -6.0                    | +45.4    |
| 20.63                  | 19.16                  | -3.                    | +74.                   | -1.                    | +74.                   | -78.                   | +11.4                   | -12.5                   | +45.4    |
| 30.95                  | 29.04                  | -4.                    | +111.                  | -3.                    | +111.                  | -117.                  | +17.0                   | -19.0                   | +45.1    |
| 0.47                   | 0.00                   | +1.                    | +2.                    | +3.                    | +3.                    | +1.                    | +0.7                    | +0.4                    | U/C      |
| 10.43                  | 9.41                   | -1.                    | +38.                   | +2.                    | +38.                   | -37.                   | +6.0                    | -5.6                    | +46.1    |
| 20.63                  | 19.40                  | -2.                    | +75.                   | +0.                    | +75.                   | -77.                   | +11.7                   | -12.2                   | +45.4    |
| 30.63                  | 29.15                  | -3.                    | +112.                  | -2.                    | +112.                  | -116.                  | +17.3                   | -18.7                   | +45.1    |
| 41.15                  | 38.79                  | -5.                    | +147.                  | -5.                    | +147.                  | -156.                  | +22.5                   | -25.3                   | +45.0    |
| 51.58                  | 48.43                  | -5.                    | +184.                  | -6.                    | +184.                  | -194.                  | +28.3                   | -31.3                   | +44.9    |
| 61.90                  | 58.07                  | -6.                    | +219.                  | -9.                    | +219.                  | -233.                  | +33.5                   | -37.7                   | +44.8    |
| 72.10                  | 67.71                  | -8.                    | +253.                  | -11.                   | +253.                  | -272.                  | +38.6                   | -44.1                   | +44.8    |
| 81.83                  | 78.16                  | -9.                    | +288.                  | -15.                   | +288.                  | -312.                  | +43.8                   | -50.7                   | +44.7    |
| 92.61                  | 87.22                  | -9.                    | +322.                  | -18.                   | +322.                  | -348.                  | +49.0                   | -56.7                   | +44.6    |
| 101.99                 | 97.91                  | -9.                    | +357.                  | -22.                   | +357.                  | -388.                  | +54.2                   | -63.3                   | +44.5    |
| 0.59                   | 0.00                   | +5.                    | +4.                    | +4.                    | +5.                    | +4.                    | +1.4                    | +1.1                    | U/C      |

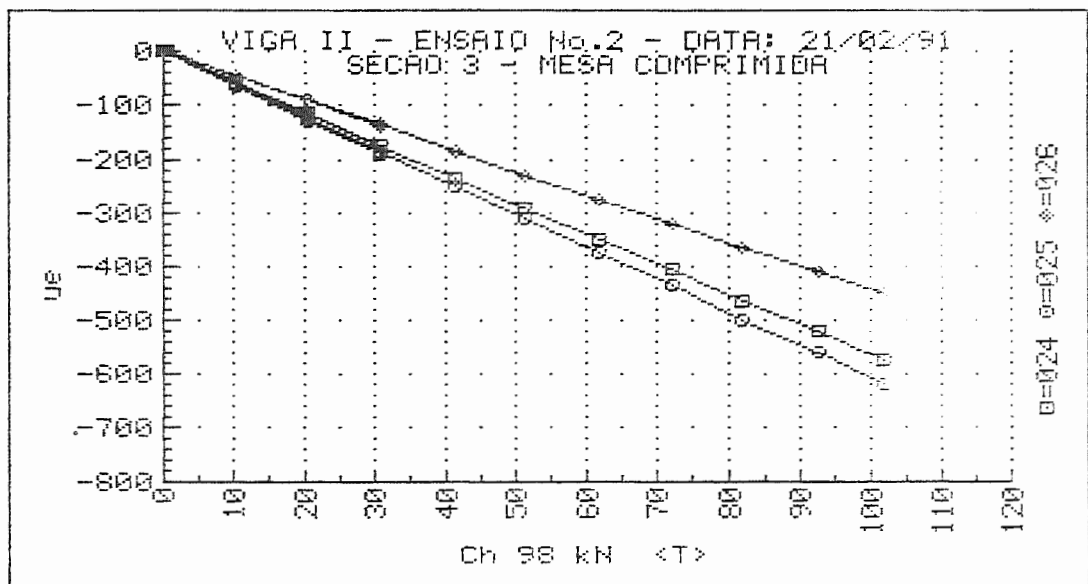
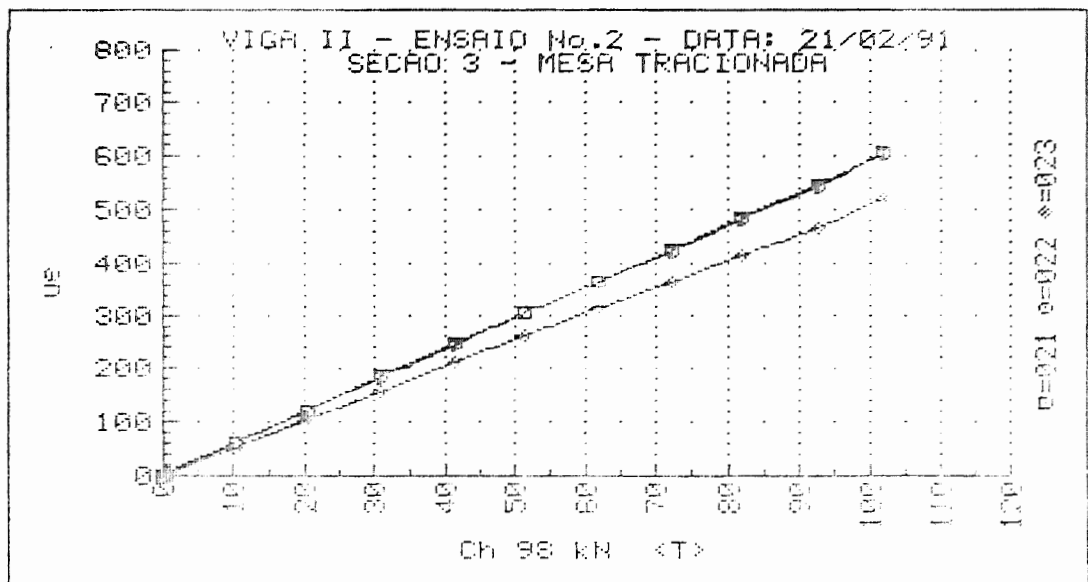
UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA II            ENSAIO No.2            DATA: 21/02/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

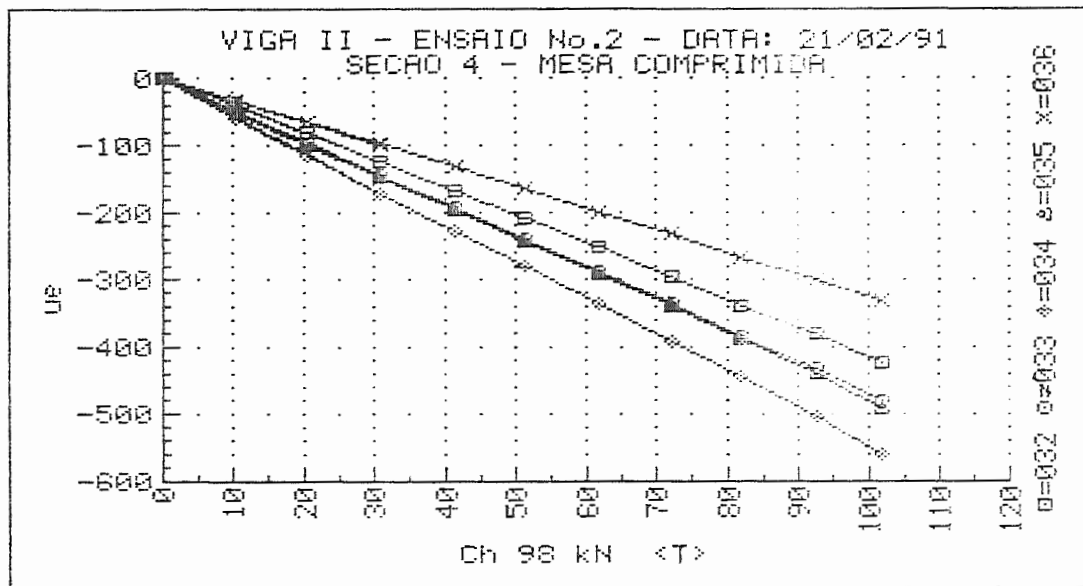
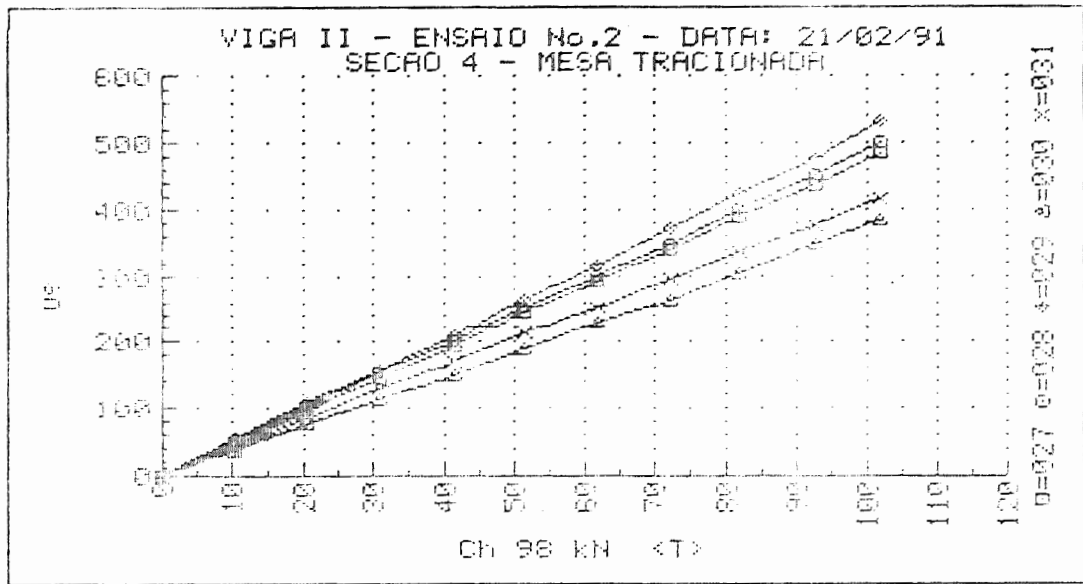
| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(σ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 10.43                  | 9.41                   | +4.                    | -37.                   | -6.                    | +35.                   | -37.                   | +5.4                    | -6.0                    | -41.3    |
| 20.63                  | 19.16                  | +5.                    | -76.                   | -11.                   | +70.                   | -76.                   | +10.5                   | -12.5                   | -41.8    |
| 30.95                  | 29.04                  | +6.                    | -114.                  | -16.                   | +104.                  | -114.                  | +15.6                   | -18.7                   | -42.1    |
| 0.47                   | 0.00                   | +2.                    | +0.                    | +1.                    | +3.                    | -0.                    | +0.7                    | +0.2                    | U/C      |
| 10.43                  | 9.41                   | +5.                    | -36.                   | -5.                    | +36.                   | -36.                   | +5.7                    | -5.7                    | -41.3    |
| 20.63                  | 19.40                  | +6.                    | -75.                   | -10.                   | +70.                   | -75.                   | +10.8                   | -12.2                   | -41.8    |
| 30.83                  | 29.15                  | +7.                    | -114.                  | -15.                   | +106.                  | -114.                  | +16.1                   | -18.6                   | -42.2    |
| 41.15                  | 38.79                  | +7.                    | -152.                  | -20.                   | +140.                  | -153.                  | +21.1                   | -25.0                   | -42.4    |
| 51.58                  | 48.43                  | +9.                    | -189.                  | -23.                   | +176.                  | -190.                  | +26.7                   | -30.9                   | -42.6    |
| 61.90                  | 58.07                  | +9.                    | -227.                  | -25.                   | +212.                  | -228.                  | +32.3                   | -37.0                   | -42.8    |
| 72.10                  | 67.71                  | +9.                    | -264.                  | -28.                   | +246.                  | -265.                  | +37.5                   | -43.0                   | -42.9    |
| 81.83                  | 78.16                  | +10.                   | -303.                  | -31.                   | +283.                  | -303.                  | +43.2                   | -49.3                   | -43.0    |
| 92.61                  | 87.22                  | +10.                   | -340.                  | -34.                   | +317.                  | -340.                  | +48.3                   | -55.3                   | -43.1    |
| 101.99                 | 97.91                  | +13.                   | -378.                  | -38.                   | +355.                  | -379.                  | +54.3                   | -61.5                   | -43.0    |
| 0.59                   | 0.00                   | +8.                    | +3.                    | +8.                    | +12.                   | +3.                    | +3.0                    | +1.5                    | U/C      |

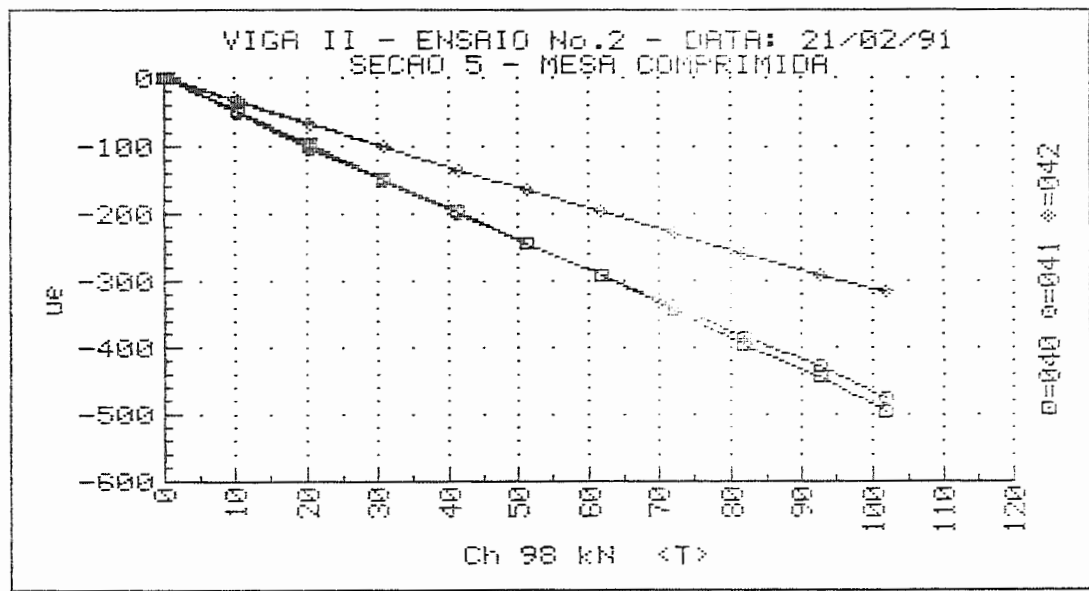
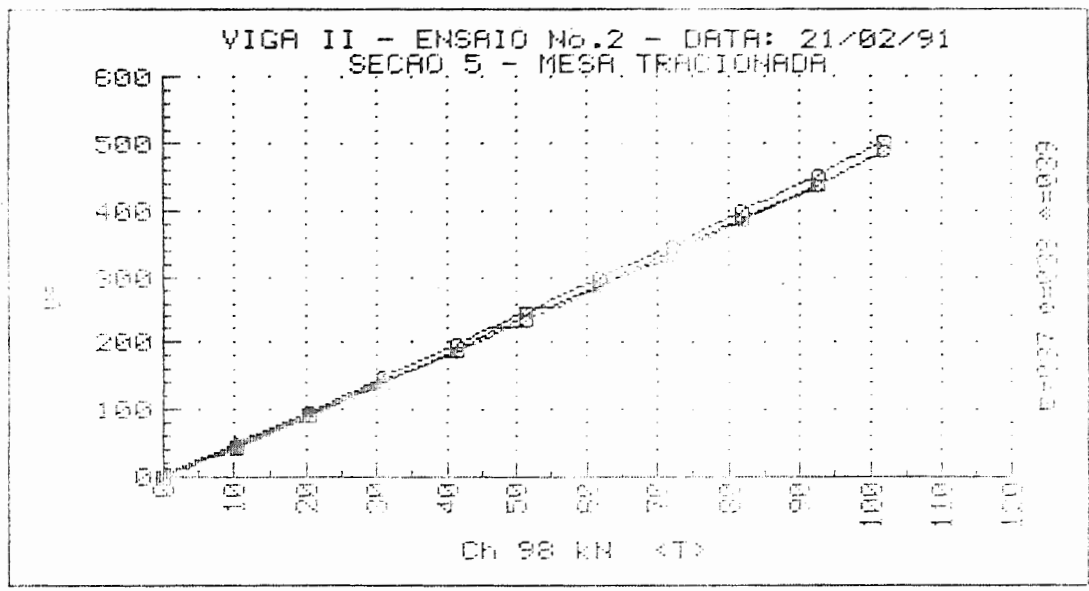


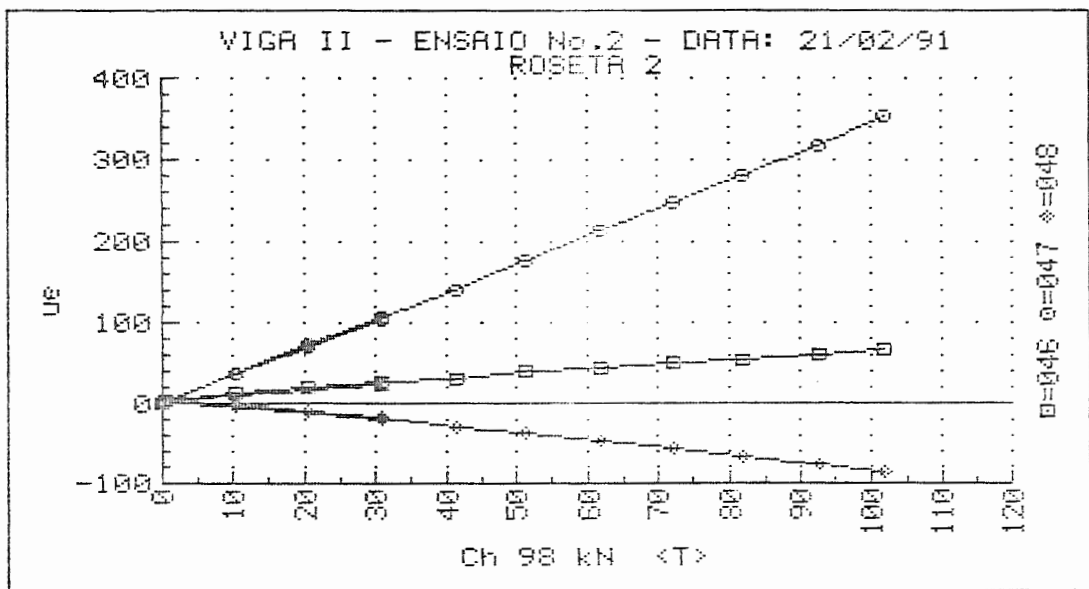
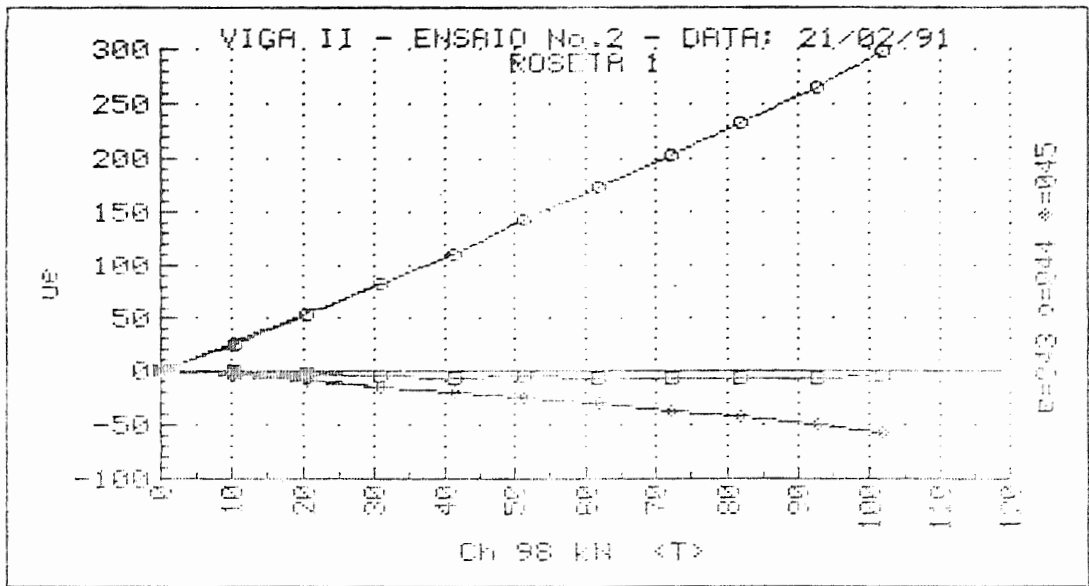


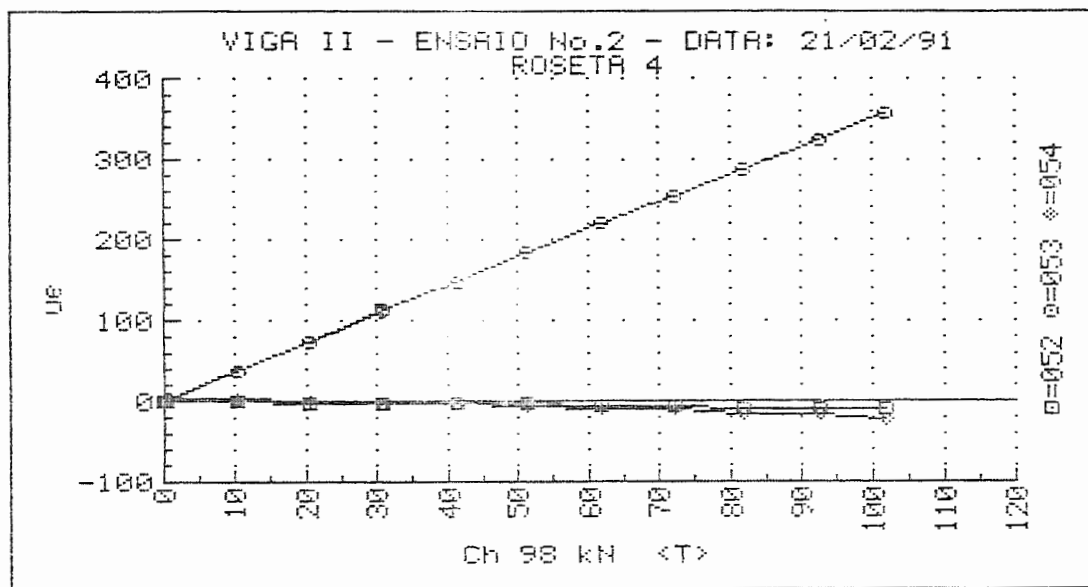
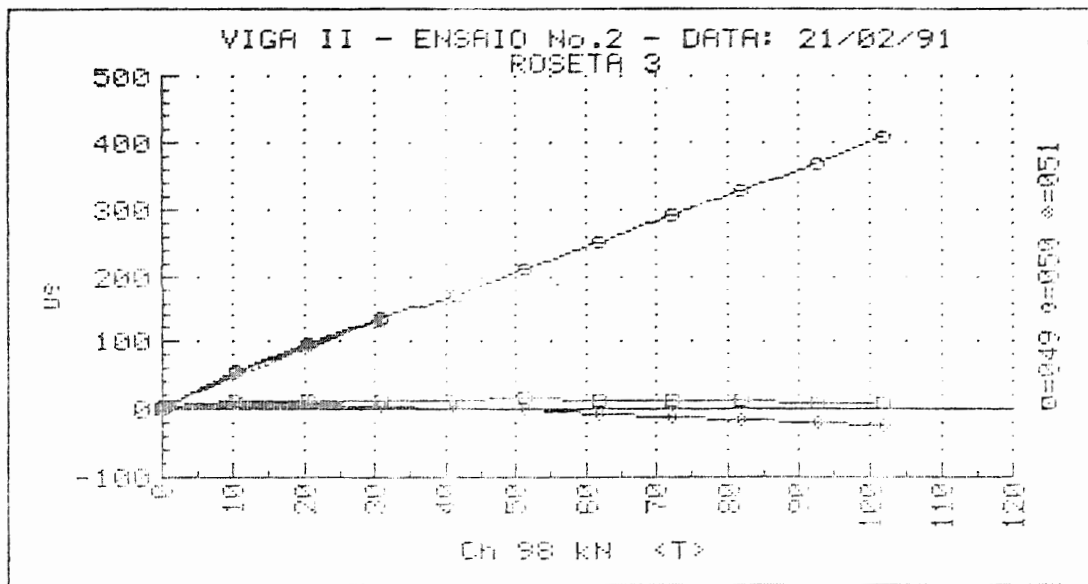




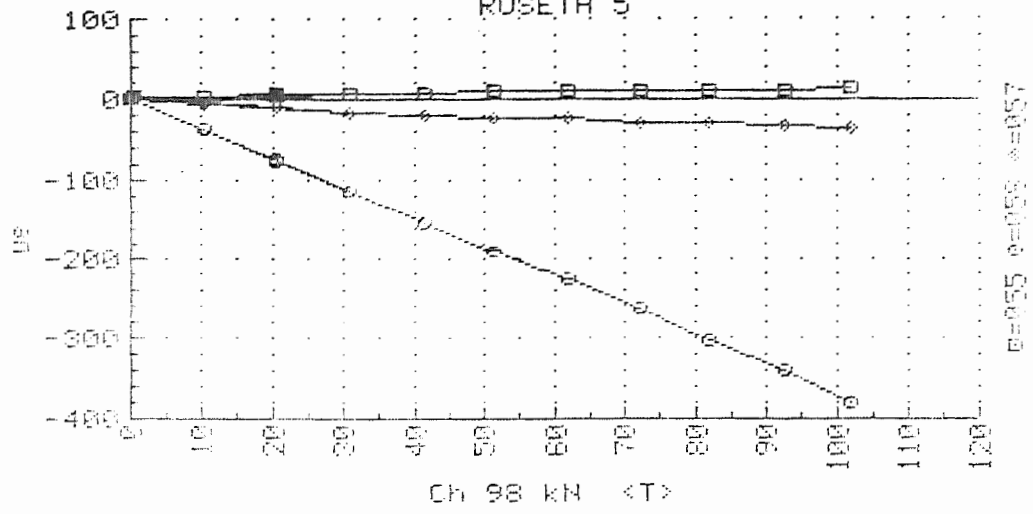








VIGA II - ENSAIO No.2 - DATA: 21/02/91  
ROSETA 5



MODELO - VIGA III

RESULTADOS DOS ENSAIOS

- . ENSAIO 1
- . ENSAIO 2

- DESLOCAMENTOS

- DEFORMAÇÕES

MODELO - VIGA III

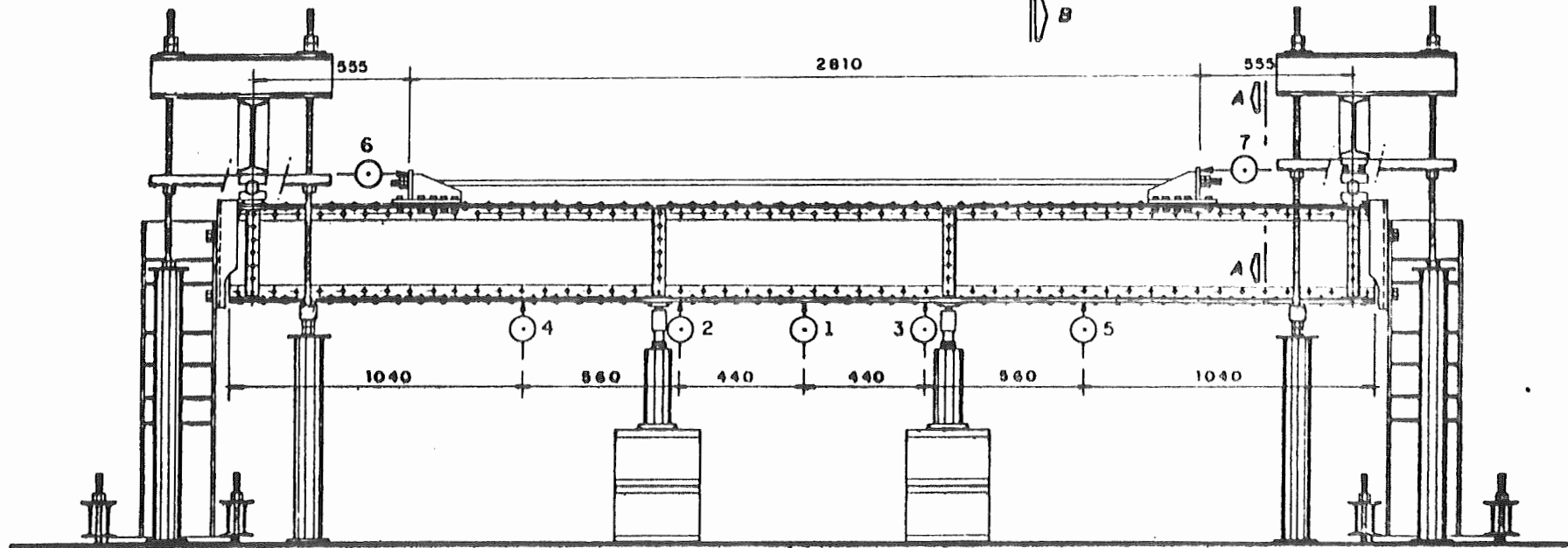
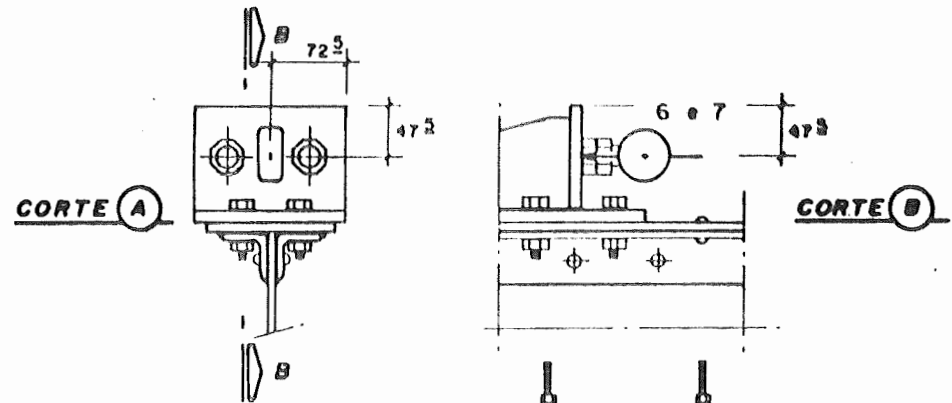
RESULTADOS DOS ENSAIOS

. ENSAIO 1

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS





MODELO: VIGA REBITADA III

ENSAIO Nro:1

PROTENSÃO

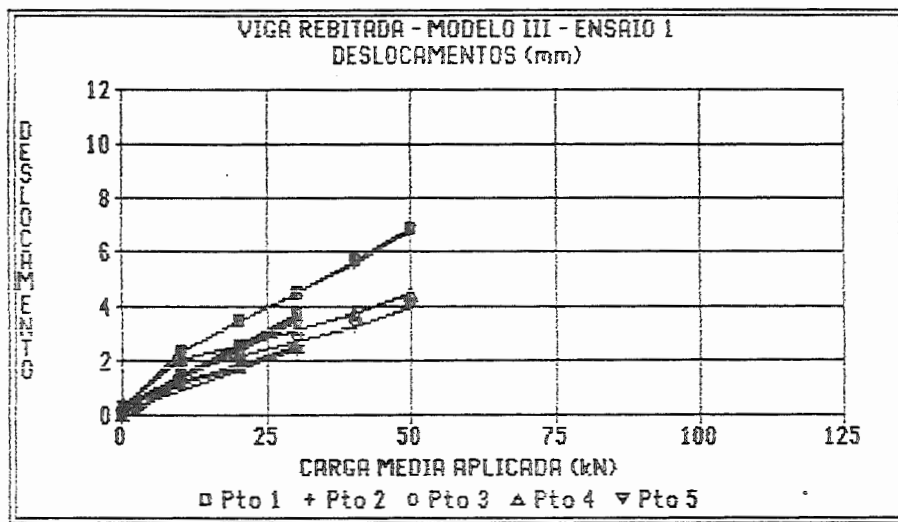
DATA: 13 DE MARÇO DE 1991

HORARIO: 8:45 Hs VIGA ARMADA

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| ETAPA | CARGA APL<br>MEDIA<br>(KN) | DESLACAMENTOS<br>(mm) |       |       |       |       |
|-------|----------------------------|-----------------------|-------|-------|-------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto 4 | Pto 5 |
|       | 0,00                       | 0,00                  | 0,00  | 0,00  | 0,00  | 0,00  |
| 1     | ,35                        | -,23                  | -,28  | -,13  | -,12  | ,28   |
| 2     | 9,98                       | 1,46                  | 1,40  | 1,40  | 1,24  | 1,26  |
| 3     | 20,02                      | 2,58                  | 2,49  | 2,42  | 1,85  | 1,86  |
| 4     | 29,93                      | 3,69                  | 3,60  | 3,47  | 2,48  | 2,42  |
| 5     | ,29                        | ,26                   | ,31   | ,23   | ,39   | ,13   |
| 6     | 10,04                      | 2,40                  | 2,39  | 2,20  | 2,06  | 1,62  |
| 7     | 20,02                      | 3,49                  | 3,46  | 3,23  | 2,65  | 2,21  |
| 8     | 29,93                      | 4,54                  | 4,51  | 4,24  | 3,21  | 2,76  |
| 9     | 40,03                      | 5,66                  | 5,59  | 5,27  | 3,82  | 3,29  |
| 10    | 50,00                      | 6,90                  | 6,80  | 6,44  | 4,51  | 3,98  |
| 11    | ,29                        | 1,16                  | 1,16  | 1,10  | 1,12  | ,97   |

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MODELO - VIGA III

RESULTADOS DOS ENSAIOS

. ENSAIO 1

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

Seções ① e ②

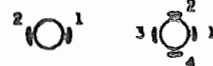


Seção ③



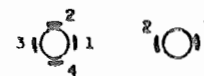
Seção ④

TIRANTE 2      TIRANTE 1

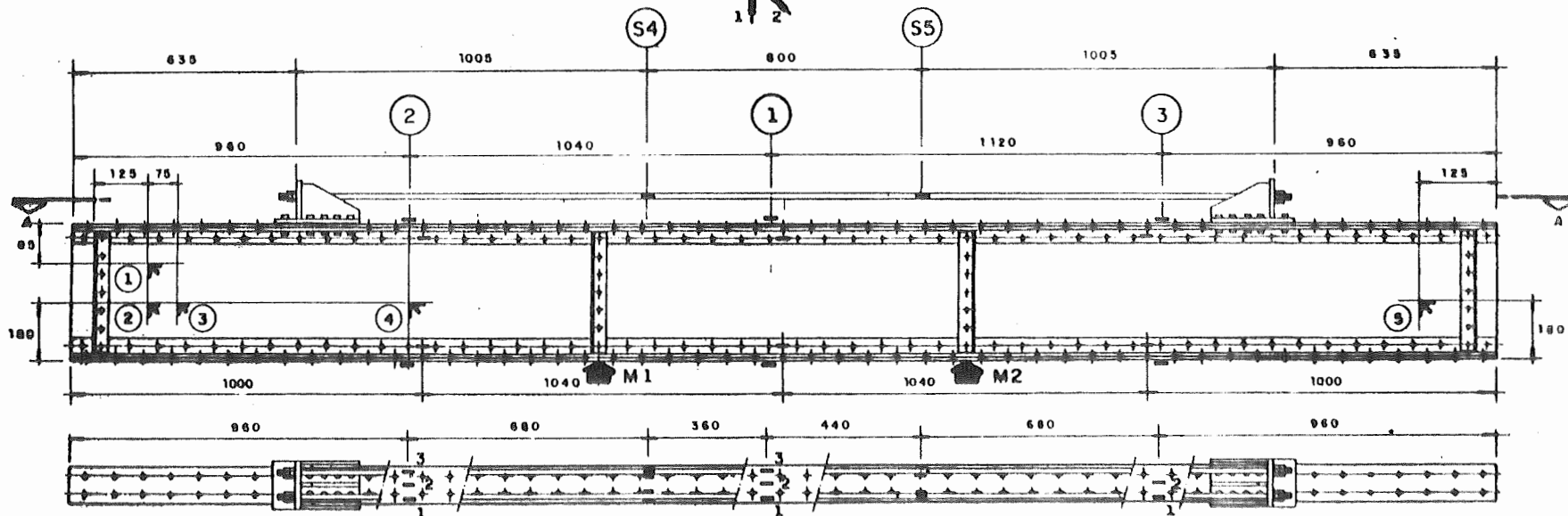


Seção ⑤

TIRANTE 2      TIRANTE 1



NUMERAÇÃO TÍPICA  
DAS ROSETAS



VISTA ④

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.1 DATA: 13/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.12                   | +0.                    | +0.                    | +0.                    | +0.                    | -1.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                     |
| 0.12                   | 0.12                   | -111.                  | -119.                  | -122.                  | -94.                   | -116.                  | +45.                   | +42.                   | +42.                   | +41.                   | +25.                    |
| 0.12                   | 0.12                   | +1.                    | +3.                    | +7.                    | +2.                    | +4.                    | -2.                    | +0.                    | +3.                    | -1.                    | +1.                     |
| 0.12                   | 0.12                   | -132.                  | -147.                  | -155.                  | -114.                  | -145.                  | +57.                   | +51.                   | +49.                   | +51.                   | +32.                    |
| 0.12                   | 0.12                   | +0.                    | +3.                    | +9.                    | +2.                    | +6.                    | -1.                    | +1.                    | +4.                    | +0.                    | +2.                     |
| 0.12                   | 0.12                   | -129.                  | -150.                  | -164.                  | -116.                  | -150.                  | +59.                   | +54.                   | +54.                   | +53.                   | +33.                    |
| 0.12                   | 0.12                   | +2.                    | +6.                    | +12.                   | +4.                    | +8.                    | +0.                    | +3.                    | +6.                    | +1.                    | +4.                     |
| 0.23                   | 0.23                   | -104.                  | -134.                  | -157.                  | -102.                  | -140.                  | +57.                   | +50.                   | +48.                   | +51.                   | +32.                    |
| 0.23                   | 0.12                   | +3.                    | +7.                    | +12.                   | +5.                    | +8.                    | +0.                    | +4.                    | +7.                    | +1.                    | +5.                     |
| 0.23                   | 0.23                   | +4.                    | +7.                    | +12.                   | +6.                    | +9.                    | +1.                    | +4.                    | +7.                    | +2.                    | +5.                     |
| 0.23                   | 0.23                   | -136.                  | -147.                  | -151.                  | -115.                  | -142.                  | +61.                   | +60.                   | +64.                   | +57.                   | +40.                    |
| 0.35                   | 0.23                   | -136.                  | -148.                  | -151.                  | -115.                  | -141.                  | +61.                   | +60.                   | +64.                   | +57.                   | +40.                    |
| 0.35                   | 0.23                   | -138.                  | -150.                  | -156.                  | -117.                  | -144.                  | +65.                   | +63.                   | +67.                   | +60.                   | +43.                    |
| 0.35                   | 0.23                   | -142.                  | -154.                  | -163.                  | -120.                  | -149.                  | +68.                   | +66.                   | +70.                   | +63.                   | +46.                    |
| 0.35                   | 0.23                   | -148.                  | -161.                  | -167.                  | -124.                  | -154.                  | +72.                   | +70.                   | +73.                   | +67.                   | +47.                    |
| 0.35                   | 0.23                   | -154.                  | -168.                  | -174.                  | -130.                  | -162.                  | +75.                   | +72.                   | +76.                   | +70.                   | +50.                    |
| 0.47                   | 0.23                   | -164.                  | -179.                  | -187.                  | -139.                  | -172.                  | +80.                   | +78.                   | +81.                   | +74.                   | +53.                    |
| 0.35                   | 0.23                   | -174.                  | -189.                  | -198.                  | -148.                  | -182.                  | +85.                   | +82.                   | +85.                   | +78.                   | +56.                    |
| 0.35                   | 0.23                   | -127.                  | -137.                  | -141.                  | -107.                  | -129.                  | +66.                   | +65.                   | +70.                   | +61.                   | +46.                    |
| 0.35                   | 0.12                   | +11.                   | +17.                   | +23.                   | +13.                   | +21.                   | +8.                    | +13.                   | +20.                   | +10.                   | +15.                    |
| -0.12                  | 0.00                   | +1.                    | +1.                    | +1.                    | +1.                    | +1.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                     |
| 0.35                   | 0.35                   | -96.                   | -107.                  | -116.                  | -85.                   | -108.                  | +36.                   | +35.                   | +34.                   | +33.                   | +20.                    |
| 10.20                  | 9.76                   | +18.                   | -9.                    | -34.                   | -10.                   | -27.                   | -93.                   | -72.                   | -56.                   | -85.                   | -61.                    |
| 20.52                  | 19.51                  | +127.                  | +96.                   | +60.                   | +67.                   | +61.                   | -217.                  | -185.                  | -164.                  | -200.                  | -149.                   |
| 30.72                  | 29.15                  | +235.                  | +201.                  | +159.                  | +144.                  | +148.                  | -340.                  | -297.                  | -273.                  | -308.                  | -234.                   |
| 0.35                   | 0.23                   | -89.                   | -101.                  | -110.                  | -80.                   | -103.                  | +30.                   | +32.                   | +37.                   | +39.                   | +20.                    |
| 10.43                  | 9.64                   | +25.                   | -2.                    | -29.                   | -5.                    | -22.                   | -102.                  | -75.                   | -54.                   | -82.                   | -61.                    |
| 20.63                  | 19.40                  | +131.                  | +99.                   | +65.                   | +70.                   | +63.                   | -222.                  | -187.                  | -164.                  | -195.                  | -148.                   |
| 30.72                  | 29.15                  | +236.                  | +204.                  | +163.                  | +146.                  | +150.                  | -340.                  | -297.                  | -274.                  | -307.                  | -235.                   |
| 41.03                  | 39.02                  | +348.                  | +319.                  | +269.                  | +215.                  | +242.                  | -464.                  | -412.                  | -387.                  | -417.                  | -321.                   |
| 51.11                  | 48.90                  | +463.                  | +440.                  | +375.                  | +280.                  | +332.                  | -592.                  | -526.                  | -497.                  | -528.                  | -404.                   |
| 0.35                   | 0.23                   | -68.                   | -67.                   | -94.                   | -97.                   | -88.                   | +18.                   | +28.                   | +36.                   | +39.                   | +24.                    |
| -0.23                  | -0.35                  | +24.                   | +32.                   | +8.                    | -19.                   | +8.                    | -7.                    | -1.                    | +0.                    | +14.                   | +8.                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.1 DATA: 13/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(μE) | 2<br>(μE) | 3<br>(μE) | 4<br>(μE) | 5<br>(μE) | 6<br>(μE) | 7<br>(μE) | 8<br>(μE) | 9<br>(μE) | 10<br>(μE) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 0.00                   | 0.12                   | -1.       | +0.       | +0.       | +0.       | +0.       | +0.       | +0.       | +0.       | +0.       | +0.        |
| 0.12                   | 0.12                   | -115.     | -117.     | -120.     | -98.      | -105.     | +56.      | +47.      | +50.      | +33.      | +27.       |
| 0.12                   | 0.12                   | +2.       | +1.       | +6.       | +3.       | +5.       | +0.       | +1.       | +2.       | +0.       | +1.        |
| 0.12                   | 0.12                   | -135.     | -144.     | -154.     | -120.     | -130.     | +43.      | +54.      | +65.      | +41.      | +33.       |
| 0.12                   | 0.12                   | +2.       | +1.       | +7.       | +4.       | +7.       | +1.       | +2.       | +3.       | +1.       | +3.        |
| 0.12                   | 0.12                   | -126.     | -147.     | -168.     | -120.     | -137.     | +43.      | +52.      | +72.      | +42.      | +37.       |
| 0.12                   | 0.12                   | +5.       | +2.       | +9.       | +6.       | +8.       | +3.       | +3.       | +5.       | +3.       | +5.        |
| 0.23                   | 0.23                   | -101.     | -132.     | -160.     | -106.     | -126.     | +42.      | +54.      | +65.      | +40.      | +34.       |
| 0.23                   | 0.12                   | +6.       | +3.       | +10.      | +7.       | +9.       | +3.       | +4.       | +6.       | +3.       | +5.        |
| 0.23                   | 0.23                   | +7.       | +4.       | +10.      | +7.       | +9.       | +5.       | +6.       | +7.       | +5.       | +7.        |
| 0.23                   | 0.23                   | -137.     | -146.     | -151.     | -118.     | -127.     | +49.      | +63.      | +78.      | +47.      | +43.       |
| 0.35                   | 0.23                   | -137.     | -145.     | -151.     | -118.     | -126.     | +49.      | +63.      | +78.      | +47.      | +43.       |
| 0.35                   | 0.23                   | -143.     | -148.     | -150.     | -121.     | -127.     | +55.      | +66.      | +80.      | +52.      | +46.       |
| 0.35                   | 0.23                   | -148.     | -152.     | -153.     | -124.     | -131.     | +58.      | +69.      | +83.      | +54.      | +47.       |
| 0.35                   | 0.23                   | -153.     | -160.     | -161.     | -129.     | -138.     | +61.      | +73.      | +86.      | +58.      | +50.       |
| 0.35                   | 0.23                   | -163.     | -166.     | -166.     | -136.     | -143.     | +65.      | +76.      | +90.      | +60.      | +52.       |
| 0.47                   | 0.23                   | -175.     | -178.     | -176.     | -145.     | -153.     | +70.      | +80.      | +94.      | +64.      | +55.       |
| 0.35                   | 0.23                   | -185.     | -189.     | -188.     | -153.     | -163.     | +73.      | +85.      | +99.      | +69.      | +58.       |
| 0.35                   | 0.23                   | -132.     | -137.     | -137.     | -111.     | -115.     | +57.      | +68.      | +82.      | +53.      | +48.       |
| 0.35                   | 0.12                   | +16.      | +13.      | +21.      | +17.      | +20.      | +13.      | +15.      | +19.      | +12.      | +16.       |
| -0.12                  | 0.00                   | +0.       | +0.       | +1.       | +0.       | +0.       | +0.       | +0.       | +1.       | +0.       | +1.        |
| 0.35                   | 0.35                   | -104.     | -108.     | -113.     | -91.      | -96.      | +27.      | +36.      | +47.      | +26.      | +23.       |
| 10.20                  | 9.76                   | -45.      | -50.      | -56.      | -52.      | -50.      | -58.      | -34.      | -12.      | -50.      | -30.       |
| 20.52                  | 19.51                  | +16.      | +12.      | +7.       | -10.      | -1.       | -136.     | -109.     | -84.      | -123.     | -87.       |
| 30.72                  | 29.15                  | +77.      | +73.      | +68.      | +33.      | +47.      | -215.     | -182.     | -155.     | -194.     | -143.      |
| 0.35                   | 0.23                   | -101.     | -103.     | -109.     | -86.      | -91.      | +21.      | +34.      | +48.      | +24.      | +20.       |
| 10.43                  | 9.64                   | -40.      | -46.      | -52.      | -46.      | -46.      | -62.      | -35.      | -10.      | -52.      | -32.       |
| 20.63                  | 19.40                  | +20.      | +14.      | +8.       | -7.       | +1.       | -138.     | -109.     | -83.      | -124.     | -87.       |
| 30.72                  | 29.15                  | +79.      | +75.      | +70.      | +33.      | +50.      | -216.     | -183.     | -154.     | -196.     | -144.      |
| 41.03                  | 39.02                  | +142.     | +136.     | +130.     | +74.      | +99.      | -298.     | -260.     | -226.     | -269.     | -201.      |
| 51.11                  | 48.90                  | +205.     | +197.     | +189.     | +111.     | +148.     | -381.     | -336.     | -296.     | -342.     | -255.      |
| 0.35                   | 0.23                   | -96.      | -99.      | -108.     | -89.      | -86.      | +12.      | +27.      | +46.      | +20.      | +20.       |
| -0.23                  | -0.35                  | +7.       | +1.       | -4.       | -6.       | +3.       | -5.       | -5.       | +0.       | +1.       | +1.        |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) |
|---------------|---------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0.00          | 0.12          | +0.              | +1.              | +0.              | +0.              | +0.              | +0.              |
| 0.12          | 0.12          | -110.            | -119.            | -94.             | +43.             | +53.             | +43.             |
| 0.12          | 0.12          | +3.              | +6.              | +3.              | -1.              | -3.              | +0.              |
| 0.12          | 0.12          | -145.            | -150.            | -115.            | +56.             | +71.             | +54.             |
| 0.12          | 0.12          | +3.              | +8.              | +4.              | +0.              | -4.              | +1.              |
| 0.12          | 0.12          | -146.            | -156.            | -118.            | +59.             | +75.             | +56.             |
| 0.12          | 0.12          | +6.              | +10.             | +7.              | +2.              | -3.              | +2.              |
| 0.23          | 0.23          | -133.            | -152.            | -107.            | +57.             | +70.             | +52.             |
| 0.23          | 0.12          | +6.              | +10.             | +7.              | +3.              | -4.              | +2.              |
| 0.23          | 0.23          | +7.              | +10.             | +7.              | +3.              | -4.              | +3.              |
| 0.23          | 0.23          | -146.            | -149.            | -114.            | +62.             | +72.             | +61.             |
| 0.35          | 0.23          | -146.            | -148.            | -114.            | +62.             | +72.             | +61.             |
| 0.35          | 0.23          | -149.            | -153.            | -117.            | +64.             | +73.             | +64.             |
| 0.35          | 0.23          | -153.            | -159.            | -121.            | +68.             | +76.             | +67.             |
| 0.35          | 0.23          | -160.            | -167.            | -126.            | +71.             | +81.             | +71.             |
| 0.35          | 0.23          | -167.            | -176.            | -132.            | +74.             | +85.             | +74.             |
| 0.47          | 0.23          | -178.            | -189.            | -141.            | +78.             | +89.             | +79.             |
| 0.35          | 0.23          | -189.            | -201.            | -150.            | +82.             | +94.             | +83.             |
| 0.35          | 0.23          | -137.            | -140.            | -107.            | +66.             | +74.             | +65.             |
| 0.35          | 0.12          | +16.             | +21.             | +17.             | +12.             | +3.              | +12.             |
| -0.12         | 0.00          | +0.              | +0.              | +0.              | +0.              | +0.              | +1.              |
| 0.35          | 0.35          | -109.            | -116.            | -88.             | +37.             | +44.             | +37.             |
| 10.20         | 9.76          | -54.             | -76.             | -47.             | -33.             | -35.             | -33.             |
| 20.52         | 19.51         | +6.              | -31.             | -4.              | -100.            | -111.            | -106.            |
| 30.72         | 29.15         | +64.             | +16.             | +41.             | -164.            | -184.            | -180.            |
| 0.35          | 0.23          | -107.            | -111.            | -86.             | +36.             | +44.             | +35.             |
| 10.43         | 9.64          | -51.             | -73.             | -46.             | -34.             | -39.             | -35.             |
| 20.63         | 19.40         | +7.              | -28.             | -2.              | -100.            | -113.            | -108.            |
| 30.72         | 29.15         | +65.             | +20.             | +42.             | -164.            | -185.            | -181.            |
| 41.03         | 39.02         | +125.            | +71.             | +87.             | -228.            | -257.            | -256.            |
| 51.11         | 48.90         | +186.            | +118.            | +129.            | -292.            | -331.            | -333.            |
| 0.35          | 0.23          | -103.            | -109.            | -86.             | +33.             | +35.             | +30.             |
| -0.23         | -0.35         | -1.              | -2.              | -7.              | +1.              | -9.              | -4.              |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 TIRANTE 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µE) | S1.2<br>(µE) | S1.3<br>(µE) | S1.4<br>(µE) | S2.1<br>(µE) | S2.2<br>(µE) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | 0.12                   | +1.          | +0.          | +0.          | +0.          | +0.          | +0.          |
| 0.12                   | 0.12                   | +366.        | +530.        | +485.        | +342.        | +503.        | +374.        |
| 0.12                   | 0.12                   | +5.          | -5.          | -11.         | -2.          | -6.          | +0.          |
| 0.12                   | 0.12                   | +458.        | +640.        | +578.        | +419.        | +613.        | +454.        |
| 0.12                   | 0.12                   | +58.         | +85.         | -70.         | -84.         | +92.         | -85.         |
| 0.12                   | 0.12                   | +433.        | +638.        | +605.        | +424.        | +625.        | +445.        |
| 0.12                   | 0.12                   | +43.         | +160.        | -70.         | -162.        | +167.        | -164.        |
| 0.23                   | 0.23                   | +378.        | +580.        | +526.        | +348.        | +555.        | +381.        |
| 0.23                   | 0.12                   | +37.         | +178.        | -66.         | -179.        | +187.        | -181.        |
| 0.23                   | 0.23                   | +51.         | +102.        | -68.         | -102.        | +99.         | -96.         |
| 0.23                   | 0.23                   | +5450.       | +688.        | +631.        | +459.        | +662.        | +493.        |
| 0.35                   | 0.23                   | +492.        | +686.        | +631.        | +459.        | +662.        | +493.        |
| 0.35                   | 0.23                   | +529.        | +711.        | +626.        | +469.        | +688.        | +501.        |
| 0.35                   | 0.23                   | +565.        | +737.        | +633.        | +485.        | +718.        | +513.        |
| 0.35                   | 0.23                   | +606.        | +772.        | +651.        | +509.        | +758.        | +533.        |
| 0.35                   | 0.23                   | +642.        | +805.        | +672.        | +534.        | +792.        | +555.        |
| 0.47                   | 0.23                   | +696.        | +854.        | +710.        | +577.        | +842.        | +592.        |
| 0.35                   | 0.23                   | +738.        | +896.        | +745.        | +615.        | +892.        | +632.        |
| 0.35                   | 0.23                   | +487.        | +685.        | +633.        | +459.        | +661.        | +491.        |
| 0.35                   | 0.12                   | -58.         | +210.        | +54.         | -182.        | +200.        | -173.        |
| -0.12                  | 0.00                   | +0.          | +0.          | +1.          | +0.          | +0.          | +0.          |
| 0.35                   | 0.35                   | +207.        | +333.        | +619.        | +482.        | +295.        | +527.        |
| 10.20                  | 9.76                   | +302.        | +425.        | +711.        | +578.        | +388.        | +624.        |
| 20.52                  | 19.51                  | +398.        | +518.        | +805.        | +675.        | +482.        | +720.        |
| 30.72                  | 29.15                  | +489.        | +610.        | +898.        | +769.        | +574.        | +813.        |
| 0.35                   | 0.23                   | +199.        | +327.        | +610.        | +473.        | +288.        | +520.        |
| 10.43                  | 9.64                   | +298.        | +421.        | +707.        | +573.        | +384.        | +620.        |
| 20.63                  | 19.40                  | +394.        | +515.        | +802.        | +672.        | +478.        | +716.        |
| 30.72                  | 29.15                  | +489.        | +608.        | +895.        | +767.        | +572.        | +811.        |
| 41.03                  | 39.02                  | +581.        | +699.        | +989.        | +861.        | +666.        | +906.        |
| 51.11                  | 48.90                  | +676.        | +792.        | +1084.       | +956.        | +760.        | +1001.       |
| 0.35                   | 0.23                   | +193.        | +321.        | +604.        | +467.        | +282.        | +515.        |
| -0.23                  | -0.35                  | +19.         | -17.         | -3.          | +29.         | -17.         | +33.         |



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 TIRANTE 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µE) | S1.2<br>(µE) | S2.1<br>(µE) | S2.2<br>(µE) | S2.3<br>(µE) | S2.4<br>(µE) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | 0.12                   | +1.          | +0.          | -1.          | +0.          | +1.          | +1.          |
| 0.12                   | 0.12                   | +314.        | +556.        | +325.        | +419.        | +544.        | +451.        |
| 0.12                   | 0.12                   | -31.         | +26.         | -71.         | +87.         | +59.         | -92.         |
| 0.12                   | 0.12                   | +419.        | +675.        | +432.        | +527.        | +661.        | +575.        |
| 0.12                   | 0.12                   | +7.          | -13.         | -20.         | +57.         | +11.         | -63.         |
| 0.12                   | 0.12                   | +458.        | +710.        | +497.        | +550.        | +673.        | +624.        |
| 0.12                   | 0.12                   | -32.         | +36.         | -69.         | +92.         | +68.         | -86.         |
| 0.23                   | 0.23                   | +421.        | +685.        | +440.        | +525.        | +665.        | +587.        |
| 0.23                   | 0.12                   | -162.        | +169.        | -196.        | +74.         | +198.        | -50.         |
| 0.23                   | 0.23                   | -112.        | +123.        | -161.        | +94.         | +163.        | -73.         |
| 0.23                   | 0.23                   | +449.        | +707.        | +463.        | +556.        | +692.        | +607.        |
| 0.35                   | 0.23                   | +449.        | +710.        | +463.        | +556.        | +692.        | +607.        |
| 0.35                   | 0.23                   | +449.        | +741.        | +464.        | +558.        | +726.        | +643.        |
| 0.35                   | 0.23                   | +456.        | +775.        | +469.        | +566.        | +763.        | +678.        |
| 0.35                   | 0.23                   | +476.        | +820.        | +485.        | +588.        | +811.        | +721.        |
| 0.35                   | 0.23                   | +497.        | +855.        | +504.        | +611.        | +849.        | +759.        |
| 0.47                   | 0.23                   | +533.        | +907.        | +542.        | +650.        | +904.        | +814.        |
| 0.35                   | 0.23                   | +573.        | +955.        | +576.        | +683.        | +949.        | +861.        |
| 0.35                   | 0.23                   | +453.        | +698.        | +466.        | +553.        | +685.        | +605.        |
| 0.35                   | 0.12                   | -153.        | +186.        | -171.        | +21.         | +200.        | +28.         |
| -0.12                  | 0.00                   | +1.          | +0.          | +0.          | +0.          | +0.          | +0.          |
| 0.35                   | 0.35                   | +461.        | +363.        | +516.        | +317.        | +314.        | +499.        |
| 10.20                  | 9.76                   | +543.        | +442.        | +600.        | +399.        | +394.        | +579.        |
| 20.52                  | 19.51                  | +633.        | +529.        | +688.        | +487.        | +479.        | +665.        |
| 30.72                  | 29.15                  | +720.        | +614.        | +776.        | +574.        | +565.        | +751.        |
| 0.35                   | 0.23                   | +453.        | +356.        | +509.        | +309.        | +306.        | +490.        |
| 10.43                  | 9.64                   | +538.        | +437.        | +594.        | +393.        | +387.        | +572.        |
| 20.63                  | 19.40                  | +630.        | +525.        | +685.        | +483.        | +476.        | +662.        |
| 30.72                  | 29.15                  | +721.        | +615.        | +776.        | +574.        | +565.        | +752.        |
| 41.03                  | 39.02                  | +812.        | +703.        | +867.        | +666.        | +655.        | +840.        |
| 51.11                  | 48.90                  | +902.        | +792.        | +957.        | +756.        | +744.        | +929.        |
| 0.35                   | 0.23                   | +449.        | +350.        | +504.        | +305.        | +301.        | +485.        |
| -0.23                  | -0.35                  | +114.        | -96.         | +107.        | +55.         | -89.         | -51.         |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.12                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | +2.                    | +3.                    | -6.                    | +4.                    | -0.                    | +0.4                    | -1.5                    | U/C      |
| 0.12                   | 0.12                   | +0.                    | -1.                    | +1.                    | +2.                    | -1.                    | +0.4                    | -0.1                    | U/C      |
| 0.12                   | 0.12                   | +4.                    | +6.                    | -10.                   | +8.                    | -15.                   | +0.8                    | -2.8                    | +25.9    |
| 0.12                   | 0.12                   | +1.                    | -1.                    | +2.                    | +4.                    | -1.                    | +0.8                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | +7.                    | +9.                    | -13.                   | +13.                   | -19.                   | +1.6                    | -3.5                    | +26.1    |
| 0.12                   | 0.12                   | +2.                    | +0.                    | +4.                    | +6.                    | -0.                    | +1.3                    | +0.4                    | U/C      |
| 0.23                   | 0.23                   | +8.                    | +11.                   | -10.                   | +14.                   | -17.                   | +2.0                    | -2.9                    | +27.4    |
| 0.23                   | 0.12                   | +3.                    | +2.                    | +5.                    | +6.                    | +2.                    | +1.4                    | +0.8                    | U/C      |
| 0.23                   | 0.23                   | +5.                    | +3.                    | +7.                    | +9.                    | +3.                    | +2.1                    | +1.2                    | U/C      |
| 0.23                   | 0.23                   | +10.                   | +12.                   | -3.                    | +15.                   | -7.                    | +2.8                    | -0.6                    | +26.1    |
| 0.35                   | 0.23                   | +10.                   | +12.                   | -3.                    | +15.                   | -7.                    | +2.8                    | -0.6                    | +26.1    |
| 0.35                   | 0.23                   | +12.                   | +14.                   | +2.                    | +16.                   | -2.                    | +3.5                    | +0.7                    | U/C      |
| 0.35                   | 0.23                   | +13.                   | +15.                   | +3.                    | +17.                   | -1.                    | +3.7                    | +1.0                    | U/C      |
| 0.35                   | 0.23                   | +14.                   | +16.                   | +4.                    | +18.                   | +0.                    | +4.0                    | +1.2                    | U/C      |
| 0.35                   | 0.23                   | +15.                   | +16.                   | +5.                    | +18.                   | +2.                    | +4.2                    | +1.6                    | U/C      |
| 0.47                   | 0.23                   | +15.                   | +17.                   | +6.                    | +19.                   | +2.                    | +4.3                    | +1.8                    | U/C      |
| 0.35                   | 0.23                   | +16.                   | +18.                   | +6.                    | +20.                   | +2.                    | +4.6                    | +1.8                    | U/C      |
| 0.35                   | 0.23                   | +17.                   | +18.                   | +7.                    | +20.                   | +4.                    | +4.7                    | +2.2                    | U/C      |
| 0.35                   | 0.12                   | +14.                   | +13.                   | +19.                   | +21.                   | +12.                   | +5.5                    | +4.2                    | -62.6    |
| -0.12                  | 0.00                   | +1.                    | +0.                    | +0.                    | +1.                    | -0.                    | +0.2                    | +0.0                    | U/C      |
| 0.35                   | 0.35                   | +2.                    | +2.                    | -10.                   | +4.                    | -13.                   | +0.1                    | -2.6                    | U/C      |
| 10.20                  | 9.76                   | +1.                    | -39.                   | -41.                   | +8.                    | -48.                   | -1.4                    | -10.3                   | -21.1    |
| 20.52                  | 19.51                  | +18.                   | -75.                   | -37.                   | +61.                   | -80.                   | +8.4                    | -13.9                   | -33.6    |
| 30.72                  | 29.15                  | +31.                   | -114.                  | -41.                   | +110.                  | -119.                  | +16.7                   | -19.5                   | -35.9    |
| 0.35                   | 0.23                   | +5.                    | +4.                    | -5.                    | +6.                    | -6.                    | +1.0                    | -1.0                    | +19.3    |
| 10.43                  | 9.64                   | +19.                   | -29.                   | -12.                   | +40.                   | -33.                   | +6.7                    | -4.7                    | -32.2    |
| 20.63                  | 19.40                  | +26.                   | -70.                   | -26.                   | +75.                   | -75.                   | +11.8                   | -11.8                   | -35.0    |
| 30.72                  | 29.15                  | +31.                   | -113.                  | -39.                   | +111.                  | -118.                  | +16.9                   | -19.1                   | -36.1    |
| 41.03                  | 39.02                  | +35.                   | -157.                  | -57.                   | +142.                  | -164.                  | +21.0                   | -27.4                   | -36.3    |
| 51.11                  | 48.90                  | +35.                   | -200.                  | -71.                   | +171.                  | -207.                  | +24.6                   | -35.1                   | -36.9    |
| 0.35                   | 0.23                   | -7.                    | +5.                    | -12.                   | +5.                    | -24.                   | -0.5                    | -5.1                    | +39.3    |
| -0.23                  | -0.35                  | -10.                   | +2.                    | -7.                    | +2.                    | -19.                   | -0.8                    | -4.2                    | U/C      |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.12          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 0.12          | 0.12          | +3.                               | -1.                               | +0.                               | +4.                               | -1.                               | +0.9                | -0.0                | U/C                      |
| 0.12          | 0.12          | +1.                               | +0.                               | +1.                               | +2.                               | +0.                               | +0.4                | +0.1                | U/C                      |
| 0.12          | 0.12          | +5.                               | +0.                               | -1.                               | +5.                               | -2.                               | +1.1                | +0.0                | U/C                      |
| 0.12          | 0.12          | +2.                               | +0.                               | +2.                               | +4.                               | +0.                               | +0.9                | +0.3                | U/C                      |
| 0.12          | 0.12          | +7.                               | +2.                               | +0.                               | +7.                               | -0.                               | +1.5                | +0.4                | U/C                      |
| 0.12          | 0.12          | +4.                               | +2.                               | +4.                               | +6.                               | +2.                               | +1.4                | +0.8                | U/C                      |
| 0.23          | 0.23          | +8.                               | +5.                               | +2.                               | +8.                               | +2.                               | +1.8                | +0.9                | U/C                      |
| 0.23          | 0.12          | +4.                               | +3.                               | +5.                               | +6.                               | +3.                               | +1.5                | +1.0                | U/C                      |
| 0.23          | 0.23          | +6.                               | +5.                               | +7.                               | +8.                               | +5.                               | +2.0                | +1.6                | U/C                      |
| 0.23          | 0.23          | +12.                              | +8.                               | +7.                               | +13.                              | +6.                               | +3.3                | +2.2                | -16.8                    |
| 0.35          | 0.23          | +12.                              | +7.                               | +7.                               | +13.                              | +5.                               | +3.4                | +2.1                | -22.5                    |
| 0.35          | 0.23          | +13.                              | +9.                               | +9.                               | +14.                              | +8.                               | +3.6                | +2.8                | -15.5                    |
| 0.35          | 0.23          | +14.                              | +10.                              | +9.                               | +15.                              | +9.                               | +3.9                | +3.0                | -15.4                    |
| 0.35          | 0.23          | +15.                              | +11.                              | +10.                              | +16.                              | +10.                              | +4.2                | +3.3                | -15.4                    |
| 0.35          | 0.23          | +16.                              | +11.                              | +10.                              | +17.                              | +10.                              | +4.4                | +3.7                | -16.8                    |
| 0.47          | 0.23          | +17.                              | +12.                              | +11.                              | +18.                              | +11.                              | +4.7                | +3.6                | -16.8                    |
| 0.35          | 0.23          | +17.                              | +12.                              | +12.                              | +18.                              | +11.                              | +4.8                | +3.8                | -22.5                    |
| 0.35          | 0.23          | +18.                              | +13.                              | +13.                              | +19.                              | +12.                              | +5.1                | +4.0                | -22.5                    |
| 0.35          | 0.12          | +16.                              | +14.                              | +17.                              | +19.                              | +14.                              | +5.2                | +4.5                | -56.6                    |
| -0.12         | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 0.35          | 0.35          | +3.                               | -3.                               | -3.                               | +4.                               | -4.                               | +0.6                | -0.6                | U/C                      |
| 10.20         | 9.76          | +3.                               | -39.                              | -11.                              | +31.                              | -40.                              | +4.3                | -6.8                | -39.2                    |
| 20.52         | 19.51         | +10.                              | -72.                              | -17.                              | +67.                              | -73.                              | +10.1               | -12.0               | -39.3                    |
| 30.72         | 29.15         | +16.                              | -105.                             | -23.                              | +100.                             | -107.                             | +15.4               | -17.3               | -39.6                    |
| 0.35          | 0.23          | +6.                               | +1.                               | +1.                               | +7.                               | -0.                               | +1.5                | +0.4                | U/C                      |
| 10.43         | 9.64          | +10.                              | -29.                              | -7.                               | +34.                              | -30.                              | +5.7                | -4.6                | -37.4                    |
| 20.63         | 19.40         | +14.                              | -66.                              | -13.                              | +69.                              | -68.                              | +10.9               | -10.6               | -39.2                    |
| 30.72         | 29.15         | +17.                              | -105.                             | -22.                              | +102.                             | -107.                             | +15.8               | -17.2               | -39.7                    |
| 41.03         | 39.02         | +21.                              | -143.                             | -27.                              | +138.                             | -145.                             | +21.4               | -23.3               | -40.1                    |
| 51.11         | 48.90         | +24.                              | -180.                             | -33.                              | +173.                             | -182.                             | +26.6               | -29.4               | -40.4                    |
| 0.35          | 0.23          | +7.                               | +2.                               | +5.                               | +10.                              | +2.                               | +2.3                | +1.0                | U/C                      |
| -0.23         | -0.35         | +3.                               | +3.                               | +6.                               | +6.                               | +2.                               | +1.6                | +0.9                | U/C                      |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| F <sub>1</sub><br>(KN) | F <sub>2</sub><br>(KN) | ε <sub>A</sub><br>(με) | ε <sub>B</sub><br>(με) | ε <sub>C</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.12                   | +1.                    | +1.                    | +0.                    | +1.                    | -0.                    | +0.2                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | +3.                    | -1.                    | -3.                    | +3.                    | -3.                    | +0.5                    | -0.5                    | U/C      |
| 0.12                   | 0.12                   | +2.                    | +2.                    | +2.                    | +2.                    | +2.                    | +0.6                    | +0.6                    | U/C      |
| 0.12                   | 0.12                   | +4.                    | -2.                    | -5.                    | +4.                    | -5.                    | +0.6                    | -0.8                    | U/C      |
| 0.12                   | 0.12                   | +4.                    | +3.                    | +4.                    | +5.                    | +3.                    | +1.3                    | +1.0                    | U/C      |
| 0.12                   | 0.12                   | +6.                    | +0.                    | -6.                    | +6.                    | -6.                    | +0.5                    | -0.9                    | -0.0     |
| 0.12                   | 0.12                   | +6.                    | +6.                    | +6.                    | +6.                    | +6.                    | +1.7                    | +1.7                    | -22.5    |
| 0.23                   | 0.23                   | +8.                    | +3.                    | -4.                    | +8.                    | -4.                    | +1.5                    | -0.4                    | U/C      |
| 0.23                   | 0.12                   | +7.                    | +7.                    | +7.                    | +7.                    | +7.                    | +1.9                    | +1.9                    | -22.5    |
| 0.23                   | 0.23                   | +9.                    | +9.                    | +8.                    | +9.                    | +7.                    | +2.5                    | +2.3                    | +22.4    |
| 0.23                   | 0.23                   | +11.                   | +6.                    | +2.                    | +11.                   | +2.                    | +2.7                    | +1.2                    | U/C      |
| 0.35                   | 0.23                   | +11.                   | +6.                    | +2.                    | +11.                   | +2.                    | +2.7                    | +1.2                    | U/C      |
| 0.35                   | 0.23                   | +13.                   | +9.                    | +5.                    | +13.                   | +5.                    | +3.3                    | +2.0                    | U/C      |
| 0.35                   | 0.23                   | +14.                   | +9.                    | +6.                    | +14.                   | +6.                    | +3.6                    | +2.2                    | -3.2     |
| 0.35                   | 0.23                   | +15.                   | +10.                   | +7.                    | +15.                   | +7.                    | +3.9                    | +2.5                    | -3.2     |
| 0.35                   | 0.23                   | +16.                   | +10.                   | +7.                    | +16.                   | +7.                    | +4.1                    | +2.6                    | -5.7     |
| 0.47                   | 0.23                   | +17.                   | +11.                   | +8.                    | +17.                   | +7.                    | +4.4                    | +2.8                    | -5.7     |
| 0.35                   | 0.23                   | +18.                   | +12.                   | +9.                    | +18.                   | +8.                    | +4.5                    | +3.1                    | -5.7     |
| 0.35                   | 0.23                   | +18.                   | +12.                   | +9.                    | +18.                   | +8.                    | +4.6                    | +3.1                    | -5.7     |
| 0.35                   | 0.12                   | +18.                   | +18.                   | +17.                   | +18.                   | +17.                   | +5.2                    | +5.0                    | +22.2    |
| -0.12                  | 0.00                   | +0.                    | +0.                    | +1.                    | +1.                    | -0.                    | +0.2                    | +0.0                    | U/C      |
| 0.35                   | 0.35                   | +0.                    | -7.                    | -6.                    | +2.                    | -8.                    | -0.1                    | -1.6                    | U/C      |
| 10.20                  | 9.76                   | -4.                    | -43.                   | -10.                   | +29.                   | -43.                   | +3.5                    | -7.7                    | -42.3    |
| 20.52                  | 19.51                  | +0.                    | -78.                   | -6.                    | +72.                   | -78.                   | +11.0                   | -12.6                   | -43.9    |
| 30.72                  | 29.15                  | +1.                    | -114.                  | -3.                    | +112.                  | -114.                  | +17.5                   | -18.0                   | -44.5    |
| 0.35                   | 0.23                   | +1.                    | -5.                    | -3.                    | +3.                    | -5.                    | +0.4                    | -0.9                    | U/C      |
| 10.43                  | 9.64                   | +3.                    | -37.                   | -2.                    | +38.                   | -37.                   | +6.0                    | -5.8                    | -43.2    |
| 20.63                  | 19.40                  | +3.                    | -74.                   | -2.                    | +75.                   | -74.                   | +11.9                   | -11.6                   | -44.1    |
| 30.72                  | 29.15                  | +2.                    | -113.                  | -2.                    | +113.                  | -113.                  | +17.8                   | -17.8                   | -44.5    |
| 41.03                  | 39.02                  | +2.                    | -150.                  | -1.                    | +151.                  | -150.                  | +23.9                   | -23.7                   | -44.7    |
| 51.11                  | 48.90                  | +2.                    | -187.                  | +1.                    | +190.                  | -187.                  | +30.2                   | -29.4                   | -44.9    |
| 0.35                   | 0.23                   | +0.                    | -5.                    | -2.                    | +3.                    | -5.                    | +0.3                    | -0.9                    | U/C      |
| -0.23                  | -0.35                  | -1.                    | +0.                    | +2.                    | +2.                    | -1.                    | +0.4                    | -0.1                    | U/C      |

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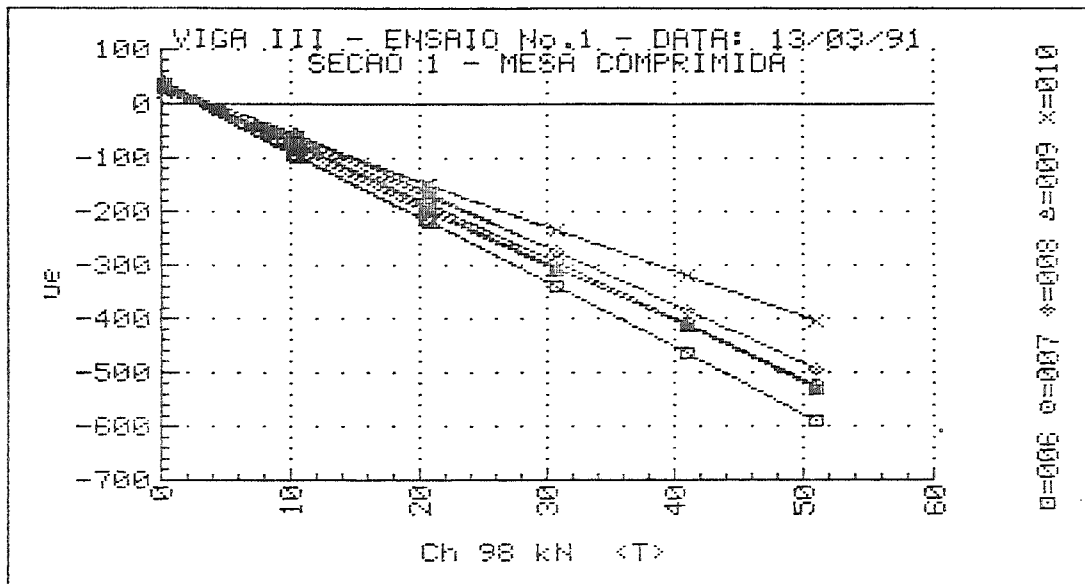
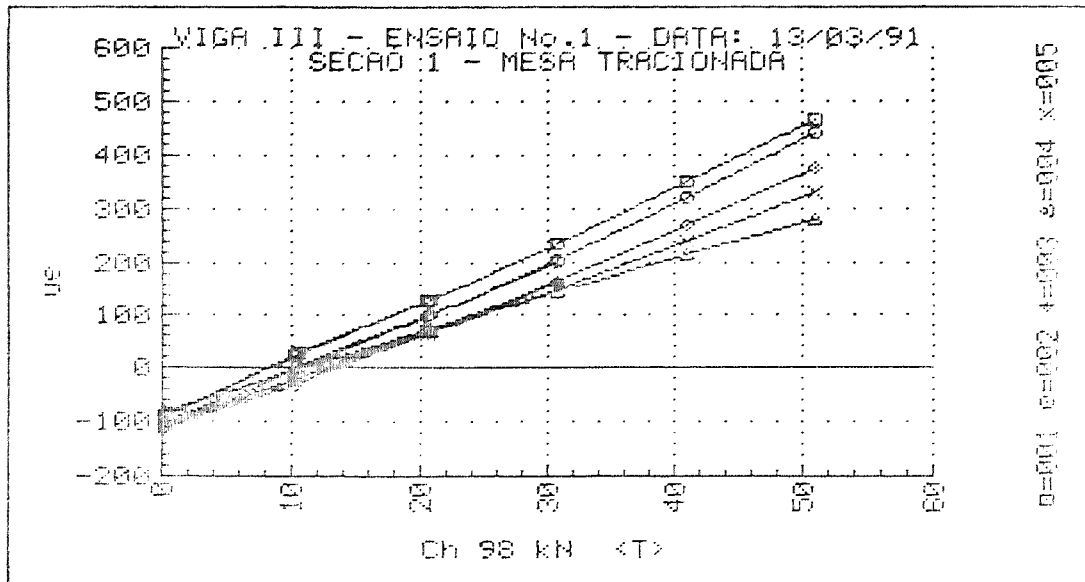
ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

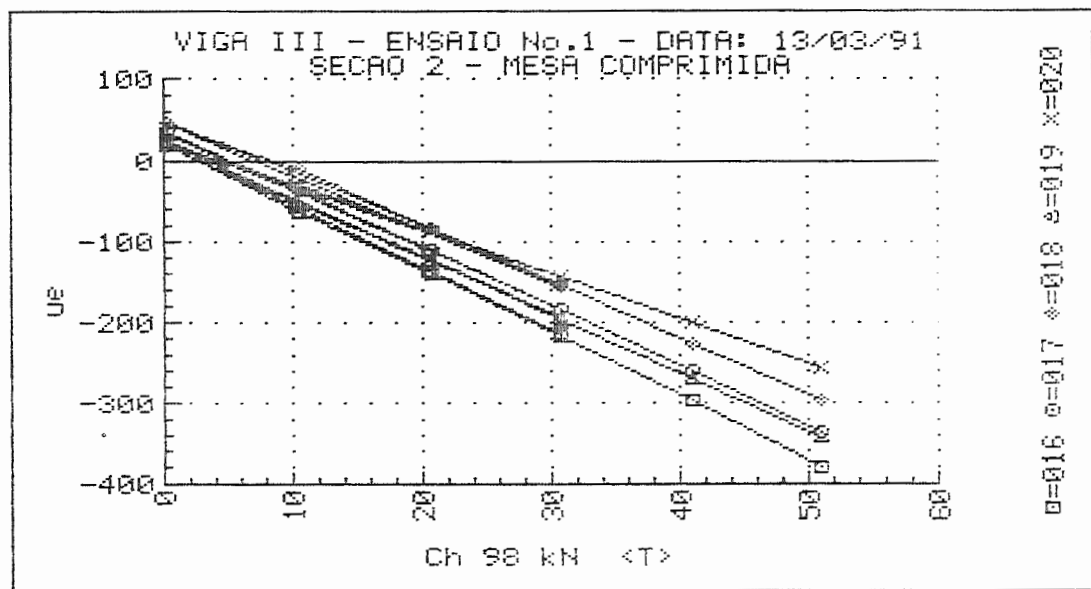
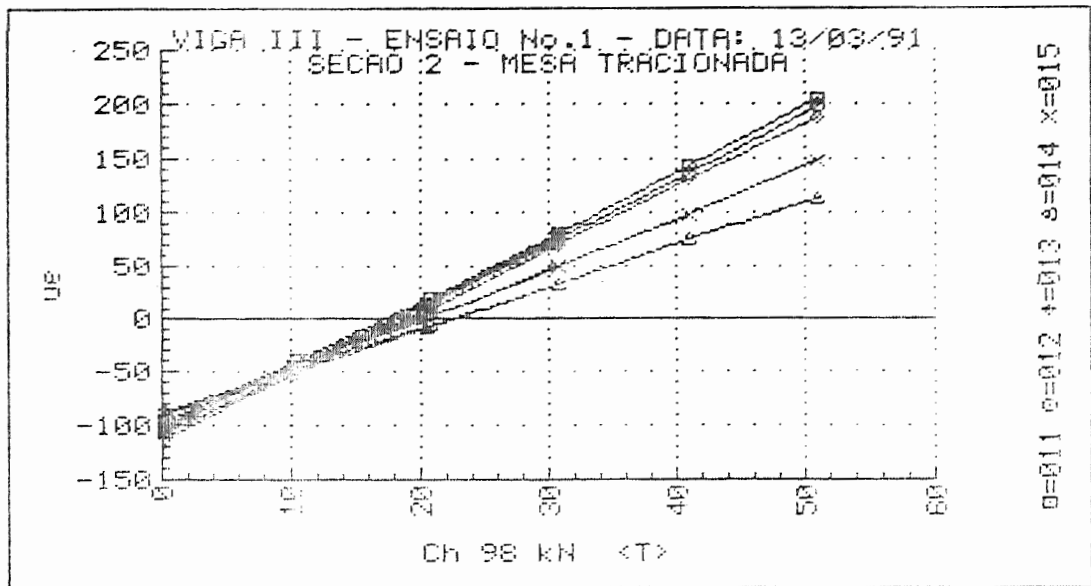
| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.12                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | -39.                   | -22.                   | -3.                    | -3.                    | -39.                   | -3.3                    | -8.9                    | U/C      |
| 0.12                   | 0.12                   | +0.                    | +0.                    | +1.                    | +1.                    | -0.                    | +0.2                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | -47.                   | -28.                   | -9.                    | -9.                    | -47.                   | -5.1                    | -11.2                   | -89.3    |
| 0.12                   | 0.12                   | +1.                    | +1.                    | +2.                    | +2.                    | +1.                    | +0.5                    | +0.3                    | U/C      |
| 0.12                   | 0.12                   | -47.                   | -28.                   | -12.                   | -12.                   | -47.                   | -6.0                    | -11.5                   | +87.7    |
| 0.12                   | 0.12                   | +2.                    | +2.                    | +4.                    | +4.                    | +2.                    | +1.0                    | +0.6                    | U/C      |
| 0.23                   | 0.23                   | -42.                   | -23.                   | -9.                    | -8.                    | -42.                   | -4.7                    | -10.0                   | +85.9    |
| 0.23                   | 0.12                   | +3.                    | +3.                    | +4.                    | +4.                    | +3.                    | +1.1                    | +0.9                    | U/C      |
| 0.23                   | 0.23                   | +4.                    | +4.                    | +4.                    | +4.                    | +4.                    | +1.1                    | +1.1                    | U/C      |
| 0.23                   | 0.23                   | -44.                   | -25.                   | -5.                    | -5.                    | -44.                   | -4.1                    | -10.3                   | U/C      |
| 0.35                   | 0.23                   | -44.                   | -25.                   | -5.                    | -5.                    | -44.                   | -4.1                    | -10.3                   | U/C      |
| 0.35                   | 0.23                   | -44.                   | -22.                   | +1.                    | +1.                    | -44.                   | -2.8                    | -10.0                   | U/C      |
| 0.35                   | 0.23                   | -46.                   | -22.                   | +3.                    | +3.                    | -46.                   | -2.5                    | -10.3                   | U/C      |
| 0.35                   | 0.23                   | -47.                   | -22.                   | +4.                    | +4.                    | -47.                   | -2.3                    | -10.4                   | U/C      |
| 0.35                   | 0.23                   | -50.                   | -23.                   | +5.                    | +5.                    | -50.                   | -2.3                    | -11.0                   | U/C      |
| 0.47                   | 0.23                   | -53.                   | -24.                   | +7.                    | +7.                    | -53.                   | -2.1                    | -11.5                   | -89.5    |
| 0.35                   | 0.23                   | -57.                   | -24.                   | +8.                    | +8.                    | -57.                   | -2.1                    | -12.3                   | +89.2    |
| 0.35                   | 0.23                   | -40.                   | -16.                   | +7.                    | +7.                    | -40.                   | -1.2                    | -8.5                    | +89.4    |
| 0.35                   | 0.12                   | +10.                   | +13.                   | +14.                   | +14.                   | +10.                   | +3.9                    | +3.3                    | +76.7    |
| -0.12                  | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 0.35                   | 0.35                   | -38.                   | -25.                   | -8.                    | -7.                    | -38.                   | -4.2                    | -9.1                    | -86.4    |
| 10.20                  | 9.76                   | -48.                   | -63.                   | -8.                    | +13.                   | -69.                   | -1.7                    | -14.6                   | -59.9    |
| 20.52                  | 19.51                  | -59.                   | -103.                  | -5.                    | +45.                   | -108.                  | +2.8                    | -21.3                   | -55.3    |
| 30.72                  | 29.15                  | -68.                   | -144.                  | -2.                    | +79.                   | -149.                  | +7.7                    | -28.2                   | -53.5    |
| 0.35                   | 0.23                   | -34.                   | -23.                   | -9.                    | -8.                    | -34.                   | -4.2                    | -8.3                    | -86.8    |
| 10.43                  | 9.64                   | -45.                   | -61.                   | -6.                    | +15.                   | -66.                   | -1.1                    | -13.8                   | -59.8    |
| 20.63                  | 19.40                  | -57.                   | -102.                  | -4.                    | +46.                   | -107.                  | +3.2                    | -21.0                   | -55.1    |
| 30.72                  | 29.15                  | -68.                   | -144.                  | -3.                    | +78.                   | -149.                  | +7.5                    | -28.2                   | -53.4    |
| 41.03                  | 39.02                  | -78.                   | -186.                  | -2.                    | +111.                  | -190.                  | +12.1                   | -35.4                   | -52.3    |
| 51.11                  | 48.90                  | -84.                   | -225.                  | -1.                    | +145.                  | -230.                  | +17.1                   | -42.0                   | -51.4    |
| 0.35                   | 0.23                   | -27.                   | -21.                   | -11.                   | -11.                   | -27.                   | -4.3                    | -6.8                    | -83.0    |
| -0.23                  | -0.35                  | +6.                    | +0.                    | -4.                    | +6.                    | -4.                    | +1.0                    | -0.5                    | U/C      |

UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

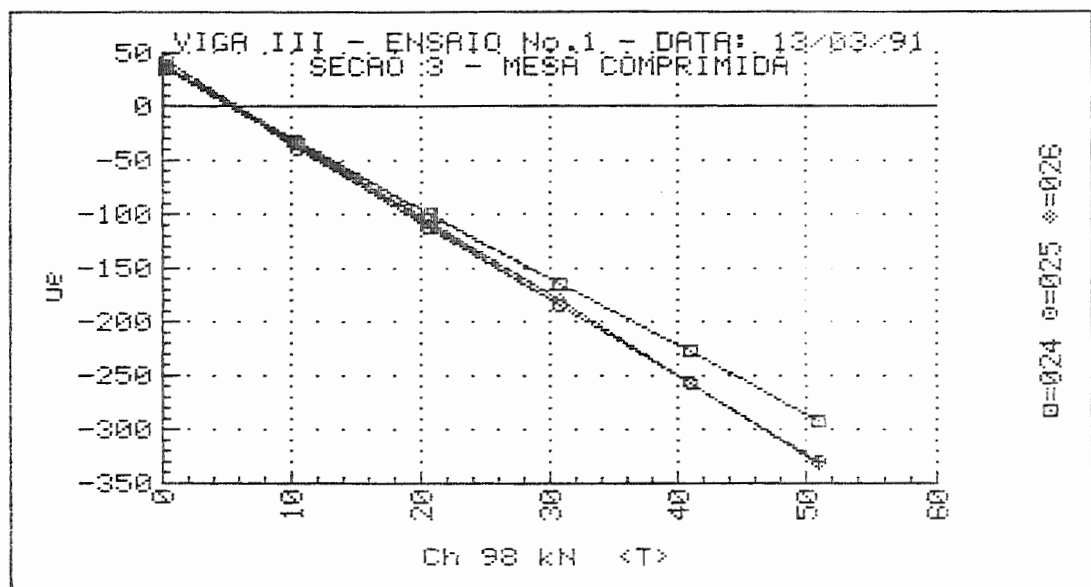
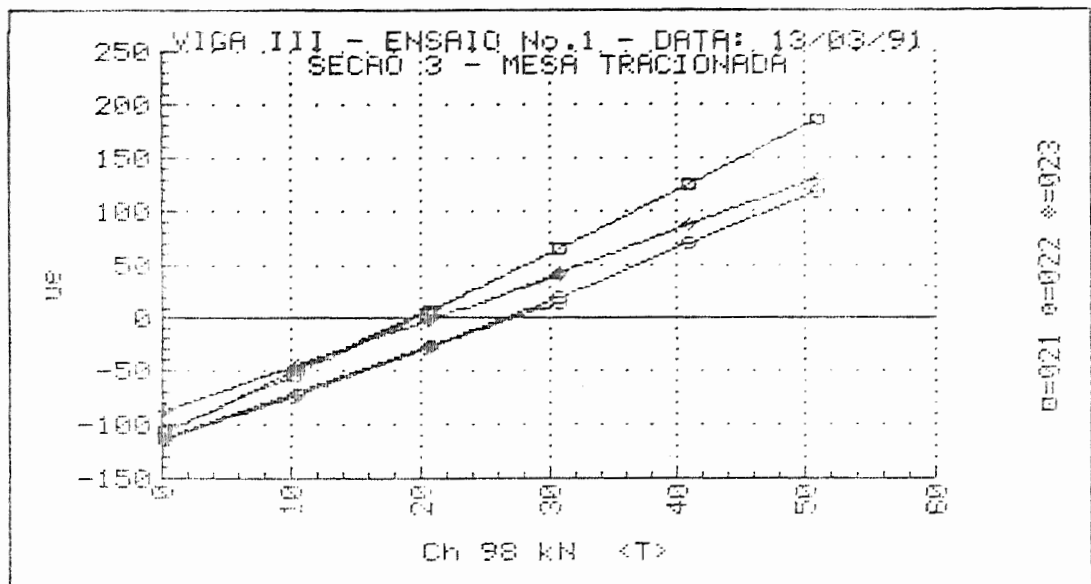
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.1 DATA: 13/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

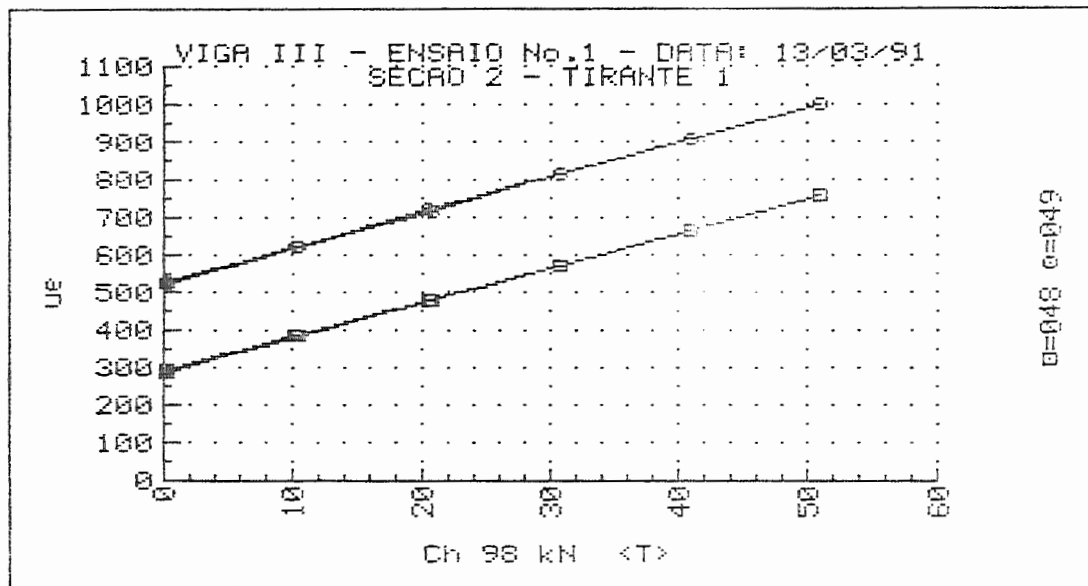
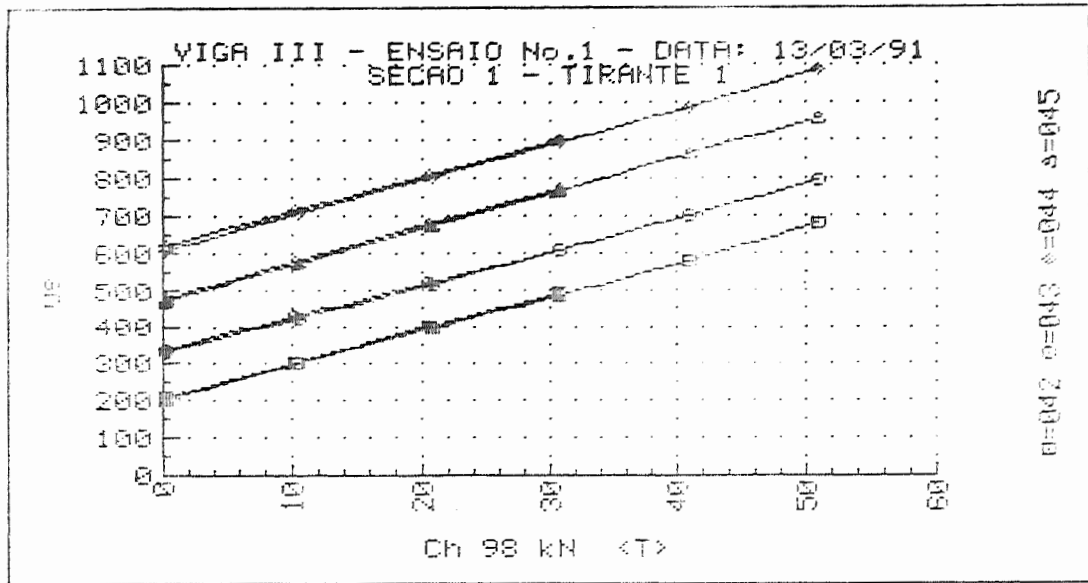
| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | α<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.12                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 0.12                   | 0.12                   | -1.                    | +1.                    | +3.                    | +3.                    | -1.                    | +0.6                    | -0.0                    | U/C      |
| 0.12                   | 0.12                   | +0.                    | +2.                    | +1.                    | +2.                    | -1.                    | +0.4                    | -0.1                    | U/C      |
| 0.12                   | 0.12                   | -2.                    | +1.                    | +6.                    | +6.                    | -2.                    | +1.2                    | -0.1                    | U/C      |
| 0.12                   | 0.12                   | +1.                    | +3.                    | +3.                    | +3.                    | +1.                    | +0.8                    | +0.3                    | U/C      |
| 0.12                   | 0.12                   | -1.                    | +2.                    | +9.                    | +9.                    | -1.                    | +1.9                    | +0.3                    | U/C      |
| 0.12                   | 0.12                   | +3.                    | +5.                    | +5.                    | +5.                    | +2.                    | +1.3                    | +0.9                    | U/C      |
| 0.23                   | 0.23                   | +0.                    | +2.                    | +9.                    | +10.                   | -1.                    | +2.3                    | +0.5                    | U/C      |
| 0.23                   | 0.12                   | +3.                    | +5.                    | +6.                    | +6.                    | +3.                    | +1.5                    | +1.0                    | U/C      |
| 0.23                   | 0.23                   | +4.                    | +6.                    | +6.                    | +6.                    | +3.                    | +1.6                    | +1.2                    | U/C      |
| 0.23                   | 0.23                   | +4.                    | +7.                    | +8.                    | +8.                    | +4.                    | +2.0                    | +1.3                    | U/C      |
| 0.35                   | 0.23                   | +4.                    | +9.                    | +14.                   | +14.                   | +4.                    | +3.5                    | +1.8                    | U/C      |
| 0.35                   | 0.23                   | +6.                    | +10.                   | +15.                   | +15.                   | +6.                    | +3.8                    | +2.3                    | +90.0    |
| 0.35                   | 0.23                   | +7.                    | +10.                   | +16.                   | +16.                   | +7.                    | +4.1                    | +2.6                    | -84.3    |
| 0.35                   | 0.23                   | +8.                    | +12.                   | +17.                   | +17.                   | +8.                    | +4.3                    | +2.9                    | +90.0    |
| 0.35                   | 0.23                   | +9.                    | +12.                   | +18.                   | +18.                   | +8.                    | +4.6                    | +3.1                    | -84.3    |
| 0.47                   | 0.23                   | +9.                    | +12.                   | +18.                   | +18.                   | +8.                    | +4.6                    | +3.1                    | -84.3    |
| 0.35                   | 0.23                   | +9.                    | +13.                   | +19.                   | +19.                   | +9.                    | +4.9                    | +3.4                    | -84.3    |
| 0.35                   | 0.23                   | +9.                    | +14.                   | +19.                   | +19.                   | +9.                    | +4.9                    | +3.4                    | +90.0    |
| 0.35                   | 0.12                   | +12.                   | +15.                   | +16.                   | +16.                   | +12.                   | +4.5                    | +3.8                    | +76.7    |
| -0.12                  | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 0.35                   | 0.35                   | -2.                    | -2.                    | +2.                    | +3.                    | -3.                    | +0.4                    | -0.4                    | U/C      |
| 10.20                  | 9.76                   | +12.                   | +27.                   | -3.                    | +28.                   | -18.                   | +5.0                    | -2.2                    | +35.4    |
| 20.52                  | 19.51                  | +22.                   | +61.                   | -11.                   | +63.                   | -53.                   | +10.6                   | -7.6                    | +36.7    |
| 30.72                  | 29.15                  | +28.                   | +93.                   | -21.                   | +96.                   | -89.                   | +15.7                   | -13.4                   | +37.3    |
| 0.35                   | 0.23                   | -2.                    | -4.                    | +3.                    | +5.                    | -4.                    | +0.9                    | -0.6                    | U/C      |
| 10.43                  | 9.64                   | +10.                   | +25.                   | -4.                    | +26.                   | -19.                   | +4.5                    | -2.6                    | +35.8    |
| 20.63                  | 19.40                  | +20.                   | +59.                   | -12.                   | +61.                   | -53.                   | +10.1                   | -7.9                    | +36.8    |
| 30.72                  | 29.15                  | +27.                   | +93.                   | -22.                   | +96.                   | -91.                   | +15.4                   | -14.1                   | +37.5    |
| 41.03                  | 39.02                  | +32.                   | +126.                  | -32.                   | +130.                  | -130.                  | +20.5                   | -20.5                   | +37.8    |
| 51.11                  | 48.90                  | +35.                   | +155.                  | -44.                   | +160.                  | -169.                  | +24.7                   | -27.1                   | +38.1    |
| 0.35                   | 0.23                   | -5.                    | -14.                   | +0.                    | +10.                   | -14.                   | +1.2                    | -2.6                    | -50.7    |
| -0.23                  | -0.35                  | -4.                    | -13.                   | -4.                    | +6.                    | -13.                   | +0.4                    | -2.6                    | +45.0    |

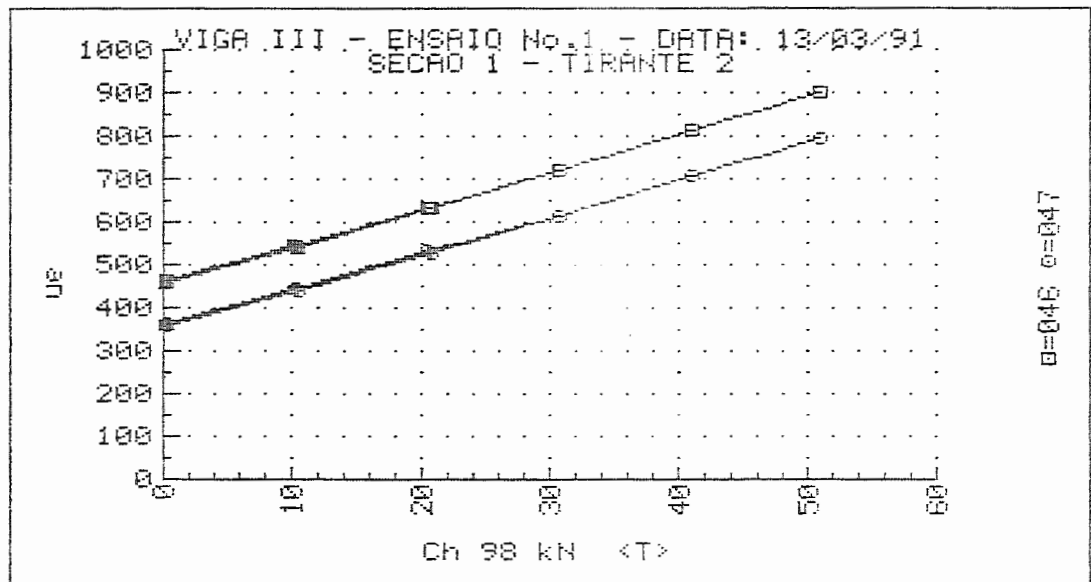
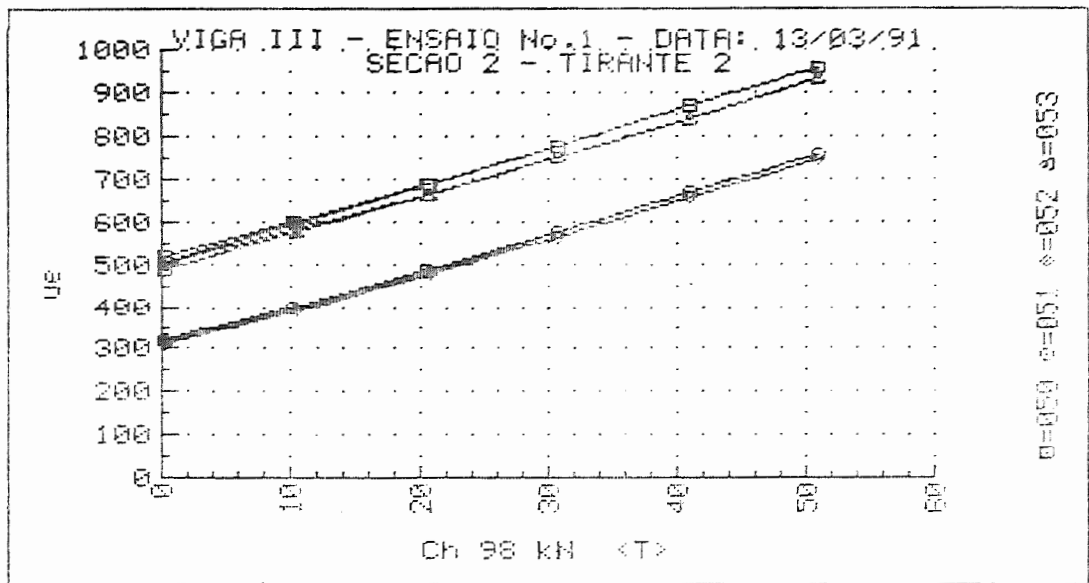


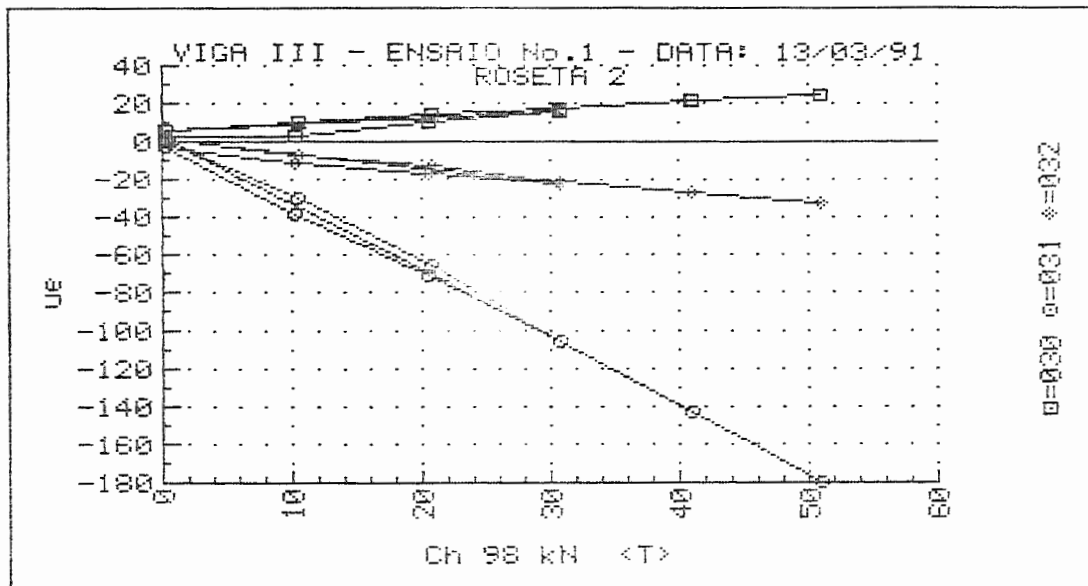
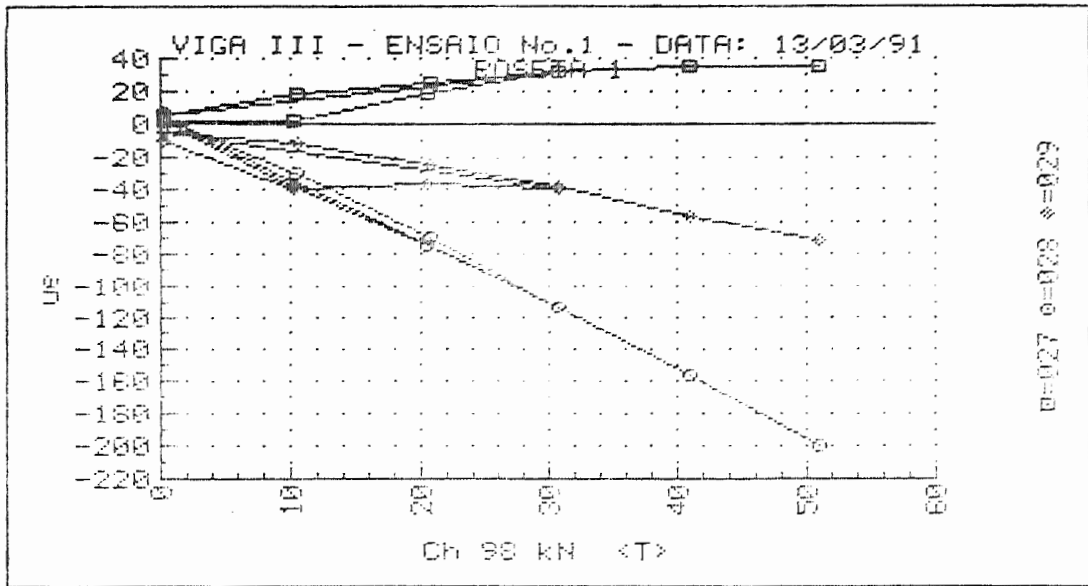


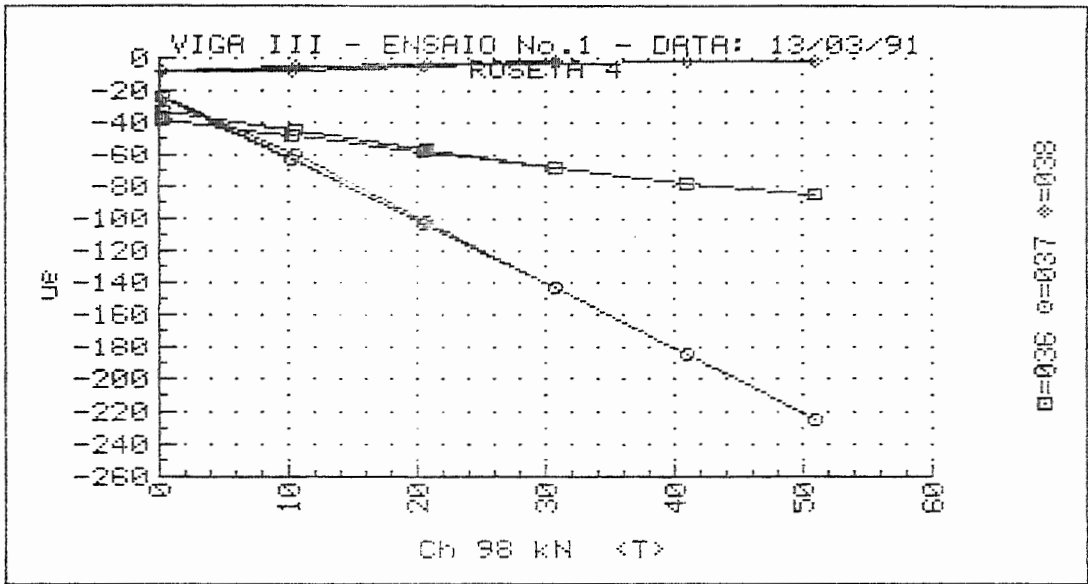
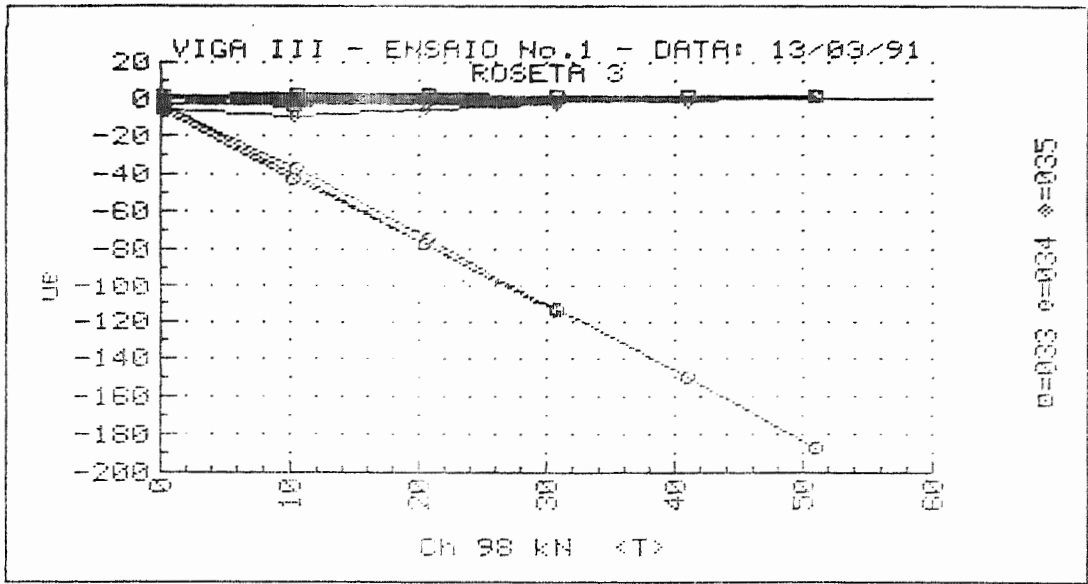


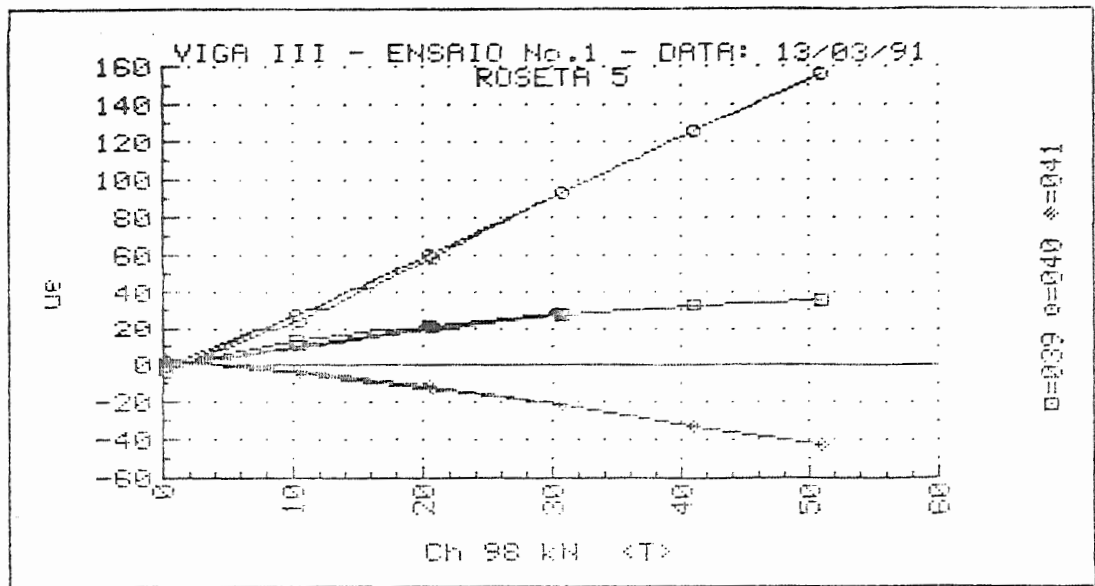












MODELO - VIGA III

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA III

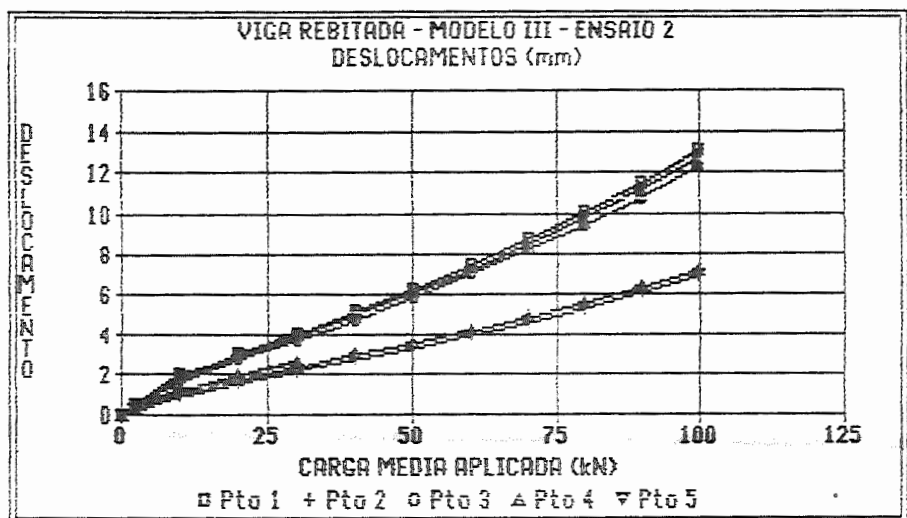
ENSAIO Nro:2

DATA:20 DE MARÇO DE 1991

HORARIO: 8:45 Hs

| ETAPA     | CARGA APL<br>MÉDIA<br>(KN) | DESLOCAMENTOS<br>(mm) |       |       |       |       |       |       |
|-----------|----------------------------|-----------------------|-------|-------|-------|-------|-------|-------|
|           |                            | Pto 1                 | Pto 2 | Pto 3 | Pto 4 | Pto 5 | Pto 6 | Pto 7 |
| TENS. TIR | 0.00                       | - .72                 | - .71 | - .69 | - .46 | - .36 |       |       |
|           | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
| 1         | 9.95                       | 1.81                  | 1.77  | 1.68  | 1.24  | .98   | 0.00  | .29   |
| 2         | 19.95                      | 3.02                  | 2.98  | 2.79  | 2.05  | 1.58  | - .07 | .59   |
| 3         | 29.90                      | 4.14                  | 4.07  | 3.84  | 2.63  | 2.18  | .01   | .76   |
| 4         | 2.10                       | .57                   | .56   | .58   | .34   | .26   | - .05 | .09   |
| 5         | 9.95                       | 1.99                  | 1.95  | 1.82  | 1.38  | 1.09  | - .01 | .21   |
| 6         | 19.95                      | 2.98                  | 2.87  | 2.75  | 1.79  | 1.64  | - .06 | .50   |
| 7         | 29.95                      | 4.08                  | 3.95  | 3.77  | 2.39  | 2.21  | .04   | .68   |
| 8         | 39.95                      | 5.20                  | 5.04  | 4.86  | 3.00  | 2.81  | .20   | .93   |
| 9         | 49.90                      | 6.29                  | 6.10  | 5.89  | 3.59  | 3.37  | .38   | .95   |
| 10        | 59.95                      | 7.49                  | 7.26  | 7.01  | 4.23  | 4.01  | .58   | 1.02  |
| 11        | 69.95                      | 8.78                  | 8.53  | 8.24  | 4.91  | 4.70  | .77   | 1.12  |
| 12        | 79.85                      | 10.09                 | 9.80  | 9.46  | 5.61  | 5.34  | 1.01  | 1.17  |
| 13        | 89.80                      | 11.53                 | 11.19 | 10.85 | 6.35  | 6.19  | 1.27  | 1.22  |
| 14        | 99.85                      | 13.05                 | 12.69 | 12.30 | 7.15  | 6.94  | 1.58  | 1.18  |
| 15        | 2.30                       | 2.02                  | 2.01  | 1.93  | 1.28  | .99   | .23   | - .11 |





MODELO - VIGA III

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.2 DATA: 20/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | -0.12                  | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                    | +0.                    | +1.                     |
| 2.23                   | 2.21                   | -144.                  | -155.                  | -163.                  | -124.                  | -149.                  | +31.                   | +36.                   | +46.                   | +28.                   | +20.                    |
| 10.43                  | 9.52                   | -60.                   | -77.                   | -91.                   | -66.                   | -82.                   | -70.                   | -49.                   | -31.                   | -63.                   | -46.                    |
| 20.63                  | 19.16                  | +43.                   | +26.                   | +8.                    | +8.                    | +9.                    | -189.                  | -161.                  | -141.                  | -175.                  | -132.                   |
| 30.83                  | 29.04                  | +145.                  | +131.                  | +111.                  | +85.                   | +99.                   | -307.                  | -273.                  | -256.                  | -286.                  | -220.                   |
| 2.23                   | 1.97                   | -141.                  | -151.                  | -159.                  | -121.                  | -147.                  | +32.                   | +37.                   | +46.                   | +31.                   | +20.                    |
| 10.43                  | 9.52                   | -57.                   | -72.                   | -87.                   | -63.                   | -78.                   | -70.                   | -50.                   | -33.                   | -63.                   | -46.                    |
| 20.63                  | 19.28                  | +45.                   | +29.                   | +13.                   | +11.                   | +13.                   | -189.                  | -161.                  | -143.                  | -175.                  | -133.                   |
| 30.83                  | 29.04                  | +145.                  | +133.                  | +115.                  | +86.                   | +102.                  | -306.                  | -272.                  | -256.                  | -285.                  | -220.                   |
| 41.15                  | 38.79                  | +248.                  | +239.                  | +219.                  | +163.                  | +190.                  | -424.                  | -384.                  | -369.                  | -396.                  | -309.                   |
| 51.11                  | 48.66                  | +352.                  | +346.                  | +324.                  | +241.                  | +279.                  | -543.                  | -498.                  | -482.                  | -505.                  | -396.                   |
| 61.08                  | 58.77                  | +459.                  | +458.                  | +430.                  | +318.                  | +367.                  | -661.                  | -607.                  | -599.                  | -614.                  | -482.                   |
| 71.28                  | 68.64                  | +577.                  | +593.                  | +540.                  | +385.                  | +454.                  | -784.                  | -714.                  | -722.                  | -725.                  | -570.                   |
| 81.95                  | 77.93                  | +695.                  | +725.                  | +651.                  | +457.                  | +539.                  | -906.                  | -812.                  | -848.                  | -838.                  | -659.                   |
| 91.56                  | 88.04                  | +815.                  | +853.                  | +764.                  | +528.                  | +621.                  | -1023.                 | -892.                  | -980.                  | -951.                  | -753.                   |
| 101.88                 | 97.91                  | +952.                  | +978.                  | +885.                  | +606.                  | +709.                  | -1132.                 | -961.                  | -1130.                 | -1072.                 | -858.                   |
| 2.34                   | 2.09                   | -62.                   | -46.                   | -97.                   | -139.                  | -125.                  | +20.                   | +126.                  | -20.                   | -4.                    | -15.                    |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.2 DATA: 20/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | -0.12                  | +0.                    | +0.                    | +0.                    | +1.                    | +1.                    | +0.                    | +1.                    | +0.                    | +0.                    | +1.                     |
| 2.23                   | 2.21                   | -160.                  | -163.                  | -159.                  | -137.                  | -145.                  | +33.                   | +47.                   | +61.                   | +32.                   | +27.                    |
| 10.43                  | 9.52                   | -123.                  | -117.                  | -111.                  | -106.                  | -107.                  | -32.                   | -9.                    | +10.                   | -28.                   | -15.                    |
| 20.63                  | 19.16                  | -64.                   | -56.                   | -48.                   | -65.                   | -57.                   | -110.                  | -84.                   | -59.                   | -100.                  | -71.                    |
| 30.83                  | 29.04                  | -4.                    | +6.                    | +15.                   | -24.                   | -7.                    | -189.                  | -158.                  | -131.                  | -174.                  | -126.                   |
| 2.23                   | 1.97                   | -166.                  | -161.                  | -156.                  | -135.                  | -143.                  | +32.                   | +46.                   | +61.                   | +31.                   | +26.                    |
| 10.43                  | 9.52                   | -120.                  | -114.                  | -108.                  | -103.                  | -104.                  | -34.                   | -11.                   | +11.                   | -30.                   | -16.                    |
| 20.63                  | 19.28                  | -61.                   | -54.                   | -46.                   | -63.                   | -55.                   | -112.                  | -84.                   | -59.                   | -102.                  | -71.                    |
| 30.83                  | 29.04                  | -3.                    | +7.                    | +17.                   | -22.                   | -5.                    | -190.                  | -158.                  | -130.                  | -175.                  | -126.                   |
| 41.15                  | 38.79                  | +58.                   | +68.                   | +79.                   | +20.                   | +46.                   | -271.                  | -232.                  | -200.                  | -248.                  | -183.                   |
| 51.11                  | 48.66                  | +118.                  | +128.                  | +139.                  | +60.                   | +95.                   | -352.                  | -308.                  | -269.                  | -321.                  | -239.                   |
| 61.08                  | 58.77                  | +177.                  | +189.                  | +199.                  | +98.                   | +144.                  | -438.                  | -384.                  | -336.                  | -396.                  | -294.                   |
| 71.28                  | 68.64                  | +241.                  | +251.                  | +258.                  | +139.                  | +191.                  | -529.                  | -462.                  | -404.                  | -471.                  | -349.                   |
| 81.95                  | 77.93                  | +307.                  | +315.                  | +320.                  | +189.                  | +243.                  | -620.                  | -540.                  | -470.                  | -548.                  | -403.                   |
| 91.56                  | 88.04                  | +374.                  | +379.                  | +379.                  | +238.                  | +293.                  | -715.                  | -616.                  | -530.                  | -623.                  | -453.                   |
| 101.88                 | 97.91                  | +447.                  | +463.                  | +447.                  | +286.                  | +348.                  | -819.                  | -695.                  | -589.                  | -709.                  | -507.                   |
| 2.34                   | 2.09                   | -140.                  | -119.                  | -142.                  | -115.                  | -123.                  | +4.                    | +26.                   | +37.                   | +13.                   | +22.                    |

UNIVERSIDADE DE SAO PAULO  
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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.2 DATA: 20/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | -0.12                  | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    |
| 2.23                   | 2.21                   | -164.                  | -173.                  | -133.                  | +40.                   | +42.                   | +46.                   |
| 10.43                  | 9.52                   | -122.                  | -137.                  | -100.                  | -14.                   | -15.                   | -9.                    |
| 20.63                  | 19.16                  | -63.                   | -87.                   | -56.                   | -78.                   | -84.                   | -82.                   |
| 30.83                  | 29.04                  | -4.                    | -34.                   | -10.                   | -141.                  | -155.                  | -156.                  |
| 2.23                   | 1.97                   | -163.                  | -170.                  | -130.                  | +42.                   | +51.                   | +46.                   |
| 10.43                  | 9.52                   | -118.                  | -134.                  | -97.                   | -12.                   | -14.                   | -11.                   |
| 20.63                  | 19.28                  | -60.                   | -83.                   | -53.                   | -77.                   | -87.                   | -83.                   |
| 30.83                  | 29.04                  | -2.                    | -32.                   | -8.                    | -140.                  | -158.                  | -156.                  |
| 41.15                  | 38.79                  | +58.                   | +21.                   | +37.                   | -204.                  | -228.                  | -231.                  |
| 51.11                  | 48.66                  | +117.                  | +74.                   | +84.                   | -268.                  | -297.                  | -306.                  |
| 61.08                  | 58.77                  | +177.                  | +127.                  | +128.                  | -328.                  | -367.                  | -383.                  |
| 71.28                  | 68.64                  | +241.                  | +178.                  | +172.                  | -387.                  | -435.                  | -453.                  |
| 81.95                  | 77.93                  | +302.                  | +228.                  | +215.                  | -444.                  | -500.                  | -516.                  |
| 91.56                  | 88.04                  | +365.                  | +283.                  | +258.                  | -500.                  | -560.                  | -574.                  |
| 101.88                 | 97.91                  | +433.                  | +342.                  | +299.                  | -552.                  | -613.                  | -626.                  |
| 2.34                   | 2.09                   | -141.                  | -157.                  | -133.                  | +25.                   | +26.                   | +99.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 TIRANTE 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µε) | S1.2<br>(µε) | S1.3<br>(µε) | S1.4<br>(µε) | S2.1<br>(µε) | S2.2<br>(µε) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | -0.12                  | +0.          | +0.          | +0.          | +0.          | +0.          | +0.          |
| 2.23                   | 2.21                   | +420.        | +672.        | +888.        | +648.        | +635.        | +688.        |
| 10.43                  | 9.52                   | +493.        | +744.        | +961.        | +723.        | +708.        | +761.        |
| 20.63                  | 19.16                  | +584.        | +834.        | +1053.       | +815.        | +799.        | +853.        |
| 30.83                  | 29.04                  | +676.        | +925.        | +1145.       | +907.        | +890.        | +946.        |
| 2.23                   | 1.97                   | +411.        | +666.        | +879.        | +639.        | +628.        | +679.        |
| 10.43                  | 9.52                   | +487.        | +740.        | +955.        | +716.        | +703.        | +756.        |
| 20.63                  | 19.28                  | +580.        | +831.        | +1050.       | +811.        | +795.        | +850.        |
| 30.83                  | 29.04                  | +673.        | +923.        | +1142.       | +905.        | +888.        | +944.        |
| 41.15                  | 38.79                  | +764.        | +1012.       | +1233.       | +996.        | +978.        | +1035.       |
| 51.11                  | 48.66                  | +852.        | +1101.       | +1321.       | +1085.       | +1068.       | +1124.       |
| 61.08                  | 58.77                  | +938.        | +1187.       | +1409.       | +1172.       | +1155.       | +1213.       |
| 71.28                  | 68.64                  | +1033.       | +1281.       | +1504.       | +1267.       | +1250.       | +1308.       |
| 81.95                  | 77.93                  | +1129.       | +1377.       | +1600.       | +1364.       | +1349.       | +1405.       |
| 91.56                  | 88.04                  | +1224.       | +1472.       | +1696.       | +1460.       | +1445.       | +1503.       |
| 101.88                 | 97.91                  | +1320.       | +1568.       | +1793.       | +1555.       | +1542.       | +1599.       |
| 2.34                   | 2.09                   | +386.        | +644.        | +852.        | +611.        | +607.        | +657.        |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 TIRANTE 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µε) | S1.2<br>(µε) | S2.1<br>(µε) | S2.2<br>(µε) | S2.3<br>(µε) | S2.4<br>(µε) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | -0.12                  | +0.          | +0.          | +0.          | +1.          | +0.          | +0.          |
| 2.23                   | 2.21                   | +672.        | +662.        | +735.        | +545.        | +667.        | +794.        |
| 10.43                  | 9.52                   | +740.        | +731.        | +803.        | +615.        | +675.        | +861.        |
| 20.63                  | 19.16                  | +830.        | +821.        | +894.        | +706.        | +765.        | +951.        |
| 30.83                  | 29.04                  | +921.        | +912.        | +985.        | +798.        | +856.        | +1042.       |
| 2.23                   | 1.97                   | +662.        | +654.        | +725.        | +535.        | +598.        | +785.        |
| 10.43                  | 9.52                   | +734.        | +724.        | +797.        | +609.        | +669.        | +855.        |
| 20.63                  | 19.28                  | +828.        | +818.        | +891.        | +703.        | +763.        | +948.        |
| 30.83                  | 29.04                  | +921.        | +912.        | +985.        | +798.        | +856.        | +1042.       |
| 41.15                  | 38.79                  | +1012.       | +1001.       | +1075.       | +889.        | +946.        | +1131.       |
| 51.11                  | 48.66                  | +1101.       | +1091.       | +1163.       | +978.        | +1036.       | +1218.       |
| 61.08                  | 58.77                  | +1189.       | +1180.       | +1251.       | +1067.       | +1123.       | +1306.       |
| 71.28                  | 68.64                  | +1285.       | +1275.       | +1347.       | +1163.       | +1218.       | +1401.       |
| 81.95                  | 77.93                  | +1381.       | +1372.       | +1442.       | +1258.       | +1314.       | +1496.       |
| 91.56                  | 88.04                  | +1477.       | +1467.       | +1537.       | +1354.       | +1409.       | +1591.       |
| 101.88                 | 97.91                  | +1572.       | +1561.       | +1633.       | +1450.       | +1503.       | +1685.       |
| 2.34                   | 2.09                   | +648.        | +642.        | +711.        | +520.        | +582.        | +771.        |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | -0.12         | +1.                               | +1.                               | +0.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 2.23          | 2.21          | +5.                               | -5.                               | -4.                               | +7.                               | -6.                               | +1.2                | -0.9                | -25.4                    |
| 10.43         | 9.52          | +9.                               | -30.                              | -9.                               | +31.                              | -32.                              | +4.8                | -5.1                | -36.6                    |
| 20.63         | 19.16         | +13.                              | -67.                              | -15.                              | +66.                              | -69.                              | +10.2               | -11.0               | -38.7                    |
| 30.83         | 29.04         | +16.                              | -106.                             | -24.                              | +100.                             | -108.                             | +15.3               | -17.5               | -39.5                    |
| 2.23          | 1.97          | +6.                               | -4.                               | -2.                               | +9.                               | -5.                               | +1.6                | -0.5                | U/C                      |
| 10.43         | 9.52          | +10.                              | -29.                              | -8.                               | +33.                              | -31.                              | +5.5                | -4.6                | -36.9                    |
| 20.63         | 19.28         | +14.                              | -67.                              | -15.                              | +68.                              | -69.                              | +10.6               | -10.9               | -38.8                    |
| 30.83         | 29.04         | +17.                              | -106.                             | -24.                              | +101.                             | -108.                             | +15.5               | -17.5               | -39.4                    |
| 41.15         | 38.79         | +19.                              | -146.                             | -31.                              | +136.                             | -148.                             | +20.6               | -24.2               | -39.9                    |
| 51.11         | 48.66         | +21.                              | -185.                             | -39.                              | +169.                             | -187.                             | +25.5               | -30.7               | -40.2                    |
| 61.08         | 58.77         | +24.                              | -223.                             | -44.                              | +205.                             | -226.                             | +31.0               | -37.1               | -40.5                    |
| 71.28         | 68.64         | +27.                              | -263.                             | -53.                              | +240.                             | -266.                             | +36.0               | -43.8               | -40.5                    |
| 81.95         | 77.93         | +29.                              | -302.                             | -62.                              | +273.                             | -306.                             | +40.8               | -50.4               | -40.4                    |
| 91.56         | 88.04         | +32.                              | -338.                             | -69.                              | +305.                             | -342.                             | +45.6               | -56.4               | -40.5                    |
| 101.88        | 97.91         | +36.                              | -373.                             | -74.                              | +339.                             | -377.                             | +51.0               | -62.1               | -40.6                    |
| 2.34          | 2.09          | +8.                               | -5.                               | -1.                               | +12.                              | -6.                               | +2.4                | -0.5                | -31.1                    |



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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\sigma$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | -0.12         | +0.                               | +1.                               | +0.                               | +1.                               | -1.                               | +0.1                | -0.1                | U/C                      |
| 2.23          | 2.21          | +8.                               | -2.                               | -6.                               | +8.                               | -6.                               | +1.4                | -0.9                | -11.6                    |
| 10.43         | 9.52          | +20.                              | -29.                              | -8.                               | +44.                              | -32.                              | +7.8                | -4.2                | -34.4                    |
| 20.63         | 19.16         | +28.                              | -70.                              | -17.                              | +85.                              | -73.                              | +14.1               | -10.8               | -36.7                    |
| 30.83         | 29.04         | +33.                              | -113.                             | -31.                              | +119.                             | -117.                             | +18.9               | -18.3               | -37.1                    |
| 2.23          | 1.97          | +9.                               | +0.                               | -1.                               | +10.                              | -2.                               | +2.1                | +0.2                | U/C                      |
| 10.43         | 9.52          | +20.                              | -28.                              | -5.                               | +46.                              | -30.                              | +8.2                | -3.8                | -35.6                    |
| 20.63         | 19.28         | +28.                              | -70.                              | -17.                              | +85.                              | -73.                              | +14.1               | -10.8               | -36.7                    |
| 30.83         | 29.04         | +33.                              | -113.                             | -31.                              | +119.                             | -117.                             | +18.9               | -18.3               | -37.1                    |
| 41.15         | 38.79         | +36.                              | -157.                             | -46.                              | +152.                             | -163.                             | +23.3               | -26.3               | -37.4                    |
| 51.11         | 48.66         | +39.                              | -201.                             | -61.                              | +185.                             | -207.                             | +27.7               | -34.1               | -37.7                    |
| 61.08         | 58.77         | +36.                              | -246.                             | -77.                              | +212.                             | -253.                             | +30.7               | -42.6               | -38.0                    |
| 71.28         | 68.64         | +20.                              | -293.                             | -88.                              | +231.                             | -299.                             | +31.8               | -51.7               | -39.1                    |
| 81.95         | 77.93         | +3.                               | -342.                             | -102.                             | +247.                             | -346.                             | +32.2               | -61.3               | -39.9                    |
| 91.56         | 88.04         | -7.                               | -389.                             | -121.                             | +266.                             | -394.                             | +33.3               | -70.8               | -40.0                    |
| 101.88        | 97.91         | -9.                               | -435.                             | -141.                             | +292.                             | -441.                             | +35.9               | -79.7               | -39.8                    |
| 2.34          | 2.09          | -58.                              | -13.                              | -7.                               | -0.                               | -64.                              | -4.4                | -14.4               | U/C                      |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | θ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | -0.12                  | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.0                    | +0.0                    | U/C      |
| 2.23                   | 2.21                   | +2.                    | -9.                    | -4.                    | +7.                    | -9.                    | +1.0                    | -1.6                    | -34.7    |
| 10.43                  | 9.52                   | +4.                    | -36.                   | -3.                    | +37.                   | -36.                   | +5.9                    | -5.6                    | -42.4    |
| 20.63                  | 19.16                  | +4.                    | -75.                   | -2.                    | +77.                   | -75.                   | +12.2                   | -11.7                   | -43.9    |
| 30.83                  | 29.04                  | +4.                    | -114.                  | -3.                    | +115.                  | -114.                  | +18.1                   | -17.9                   | -44.2    |
| 2.23                   | 1.97                   | +3.                    | -8.                    | -2.                    | +9.                    | -8.                    | +1.5                    | -1.2                    | -36.8    |
| 10.43                  | 9.52                   | +5.                    | -35.                   | -1.                    | +39.                   | -35.                   | +6.4                    | -5.3                    | -42.8    |
| 20.63                  | 19.28                  | +5.                    | -74.                   | -1.                    | +78.                   | -74.                   | +12.5                   | -11.4                   | -43.9    |
| 30.83                  | 29.04                  | +4.                    | -114.                  | -2.                    | +116.                  | -114.                  | +18.3                   | -17.8                   | -44.3    |
| 41.15                  | 38.79                  | +4.                    | -153.                  | -3.                    | +154.                  | -153.                  | +24.4                   | -24.1                   | -44.4    |
| 51.11                  | 48.66                  | +2.                    | -192.                  | -3.                    | +191.                  | -192.                  | +30.1                   | -30.4                   | -44.6    |
| 61.08                  | 58.77                  | +1.                    | -230.                  | -3.                    | +226.                  | -230.                  | +35.8                   | -36.4                   | -44.8    |
| 71.28                  | 68.64                  | +2.                    | -271.                  | -4.                    | +269.                  | -271.                  | +42.3                   | -42.8                   | -44.7    |
| 81.95                  | 77.93                  | +3.                    | -310.                  | -5.                    | +309.                  | -310.                  | +48.5                   | -49.1                   | -44.6    |
| 91.56                  | 88.04                  | +5.                    | -347.                  | -5.                    | +347.                  | -347.                  | +54.8                   | -54.8                   | -44.6    |
| 101.88                 | 97.91                  | +8.                    | -382.                  | -2.                    | +388.                  | -382.                  | +61.6                   | -59.9                   | -44.6    |
| 2.34                   | 2.09                   | +7.                    | -13.                   | -7.                    | +15.                   | -15.                   | +2.3                    | -2.3                    | -31.7    |

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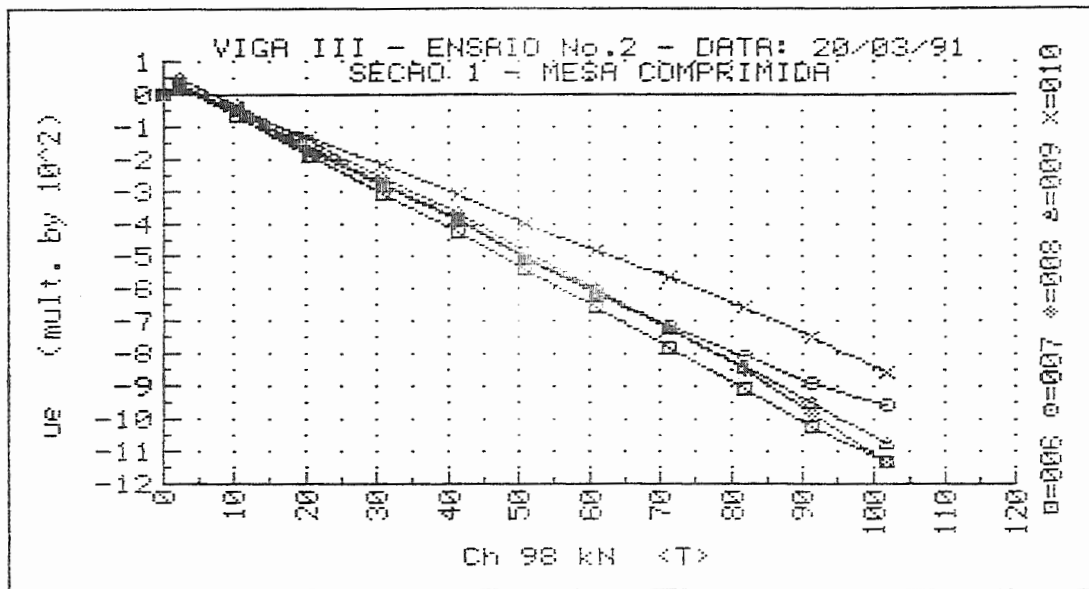
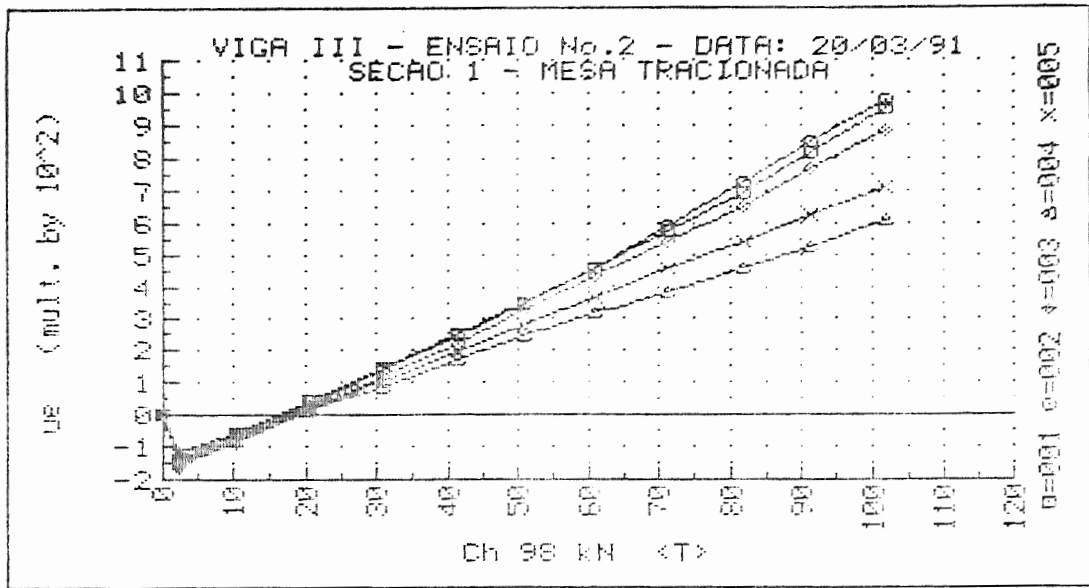
ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

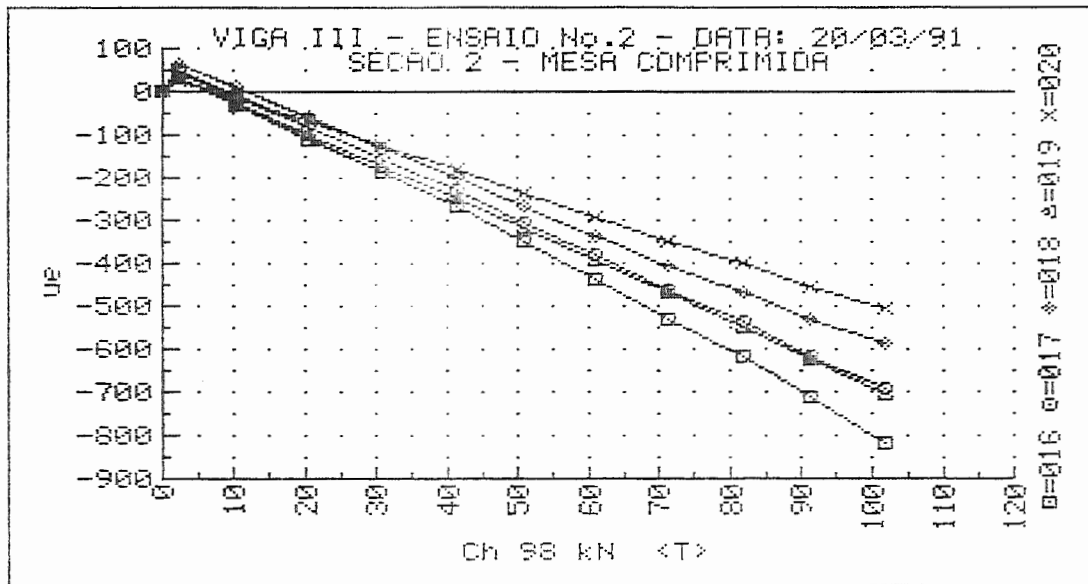
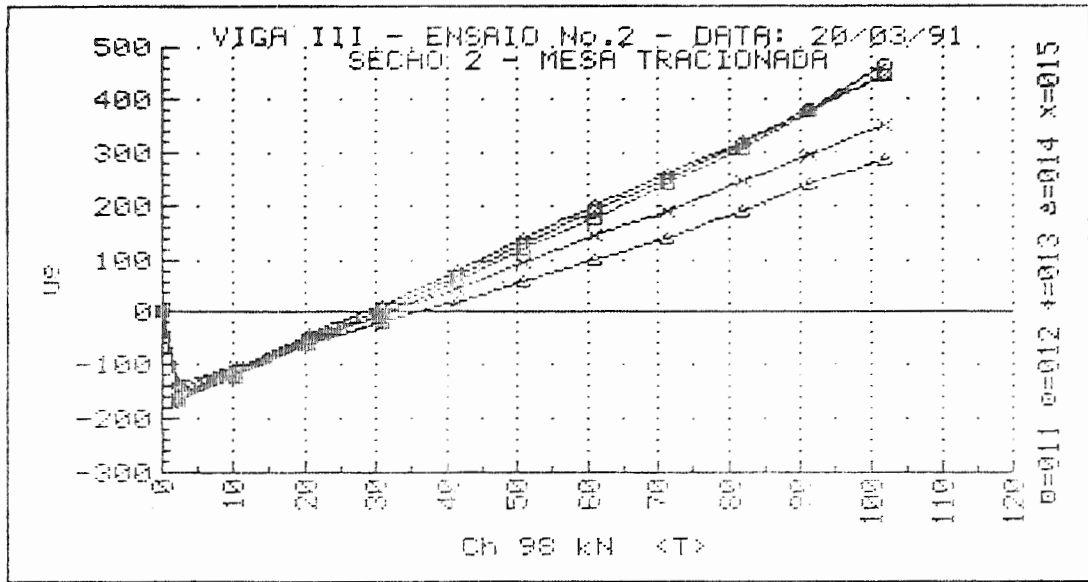
| $F_1$<br>(KN) | $F_2$<br>(KN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | -0.12         | +0.                               | +0.                               | +1.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 2.23          | 2.21          | -61.                              | -38.                              | +1.                               | +2.                               | -62.                              | -3.7                | -10.7               | U/C                      |
| 10.43         | 9.52          | -70.                              | -69.                              | +2.                               | +16.                              | -84.                              | -2.1                | -17.9               | -67.9                    |
| 20.63         | 19.16         | -81.                              | -112.                             | +2.                               | +43.                              | -123.                             | +1.5                | -24.7               | -60.0                    |
| 30.83         | 29.04         | -92.                              | -155.                             | +3.                               | +76.                              | -165.                             | +6.0                | -32.0               | -56.6                    |
| 2.23          | 1.97          | -58.                              | -36.                              | -1.                               | -0.                               | -58.                              | -4.0                | -13.2               | U/C                      |
| 10.43         | 9.52          | -67.                              | -68.                              | +1.                               | +16.                              | -82.                              | -2.0                | -17.4               | -67.1                    |
| 20.63         | 19.28         | -80.                              | -111.                             | +2.                               | +44.                              | -121.                             | +1.7                | -24.4               | -59.8                    |
| 30.83         | 29.04         | -91.                              | -154.                             | +3.                               | +76.                              | -164.                             | +6.0                | -31.8               | -56.5                    |
| 41.15         | 38.79         | -101.                             | -198.                             | +3.                               | +108.                             | -207.                             | +10.4               | -39.2               | -54.7                    |
| 51.11         | 48.66         | -111.                             | -240.                             | +2.                               | +140.                             | -249.                             | +14.7               | -46.6               | -53.4                    |
| 61.08         | 58.77         | -116.                             | -282.                             | +2.                               | +174.                             | -290.                             | +19.5               | -53.6               | -52.5                    |
| 71.28         | 68.64         | -125.                             | -327.                             | +0.                               | +210.                             | -335.                             | +24.6               | -61.2               | -51.6                    |
| 81.95         | 77.93         | -132.                             | -374.                             | -3.                               | +246.                             | -381.                             | +29.7               | -69.1               | -50.9                    |
| 91.56         | 88.04         | -136.                             | -418.                             | -6.                               | +282.                             | -424.                             | +34.9               | -76.5               | -50.3                    |
| 101.88        | 97.91         | -140.                             | -465.                             | -9.                               | +322.                             | -470.                             | +40.7               | -84.2               | -49.8                    |
| 2.34          | 2.09          | -24.                              | -37.                              | -9.                               | +6.                               | -38.                              | -1.2                | -8.2                | -55.0                    |

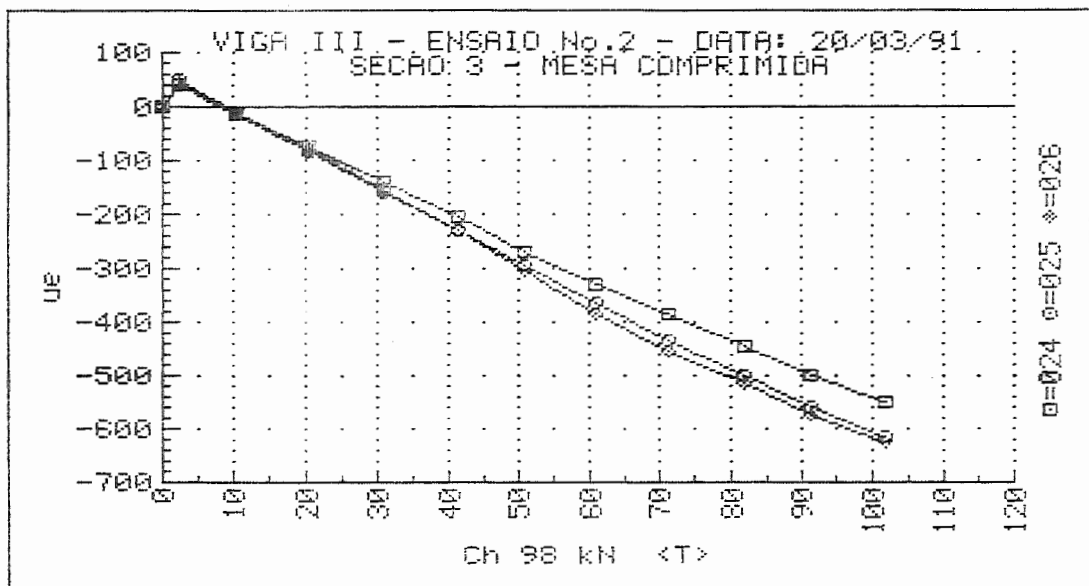
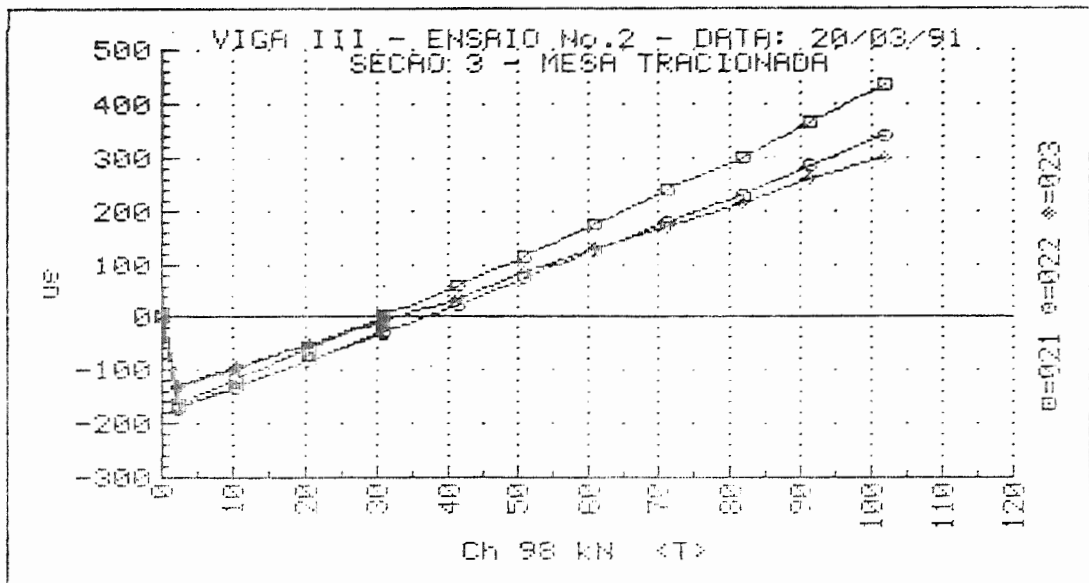
UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

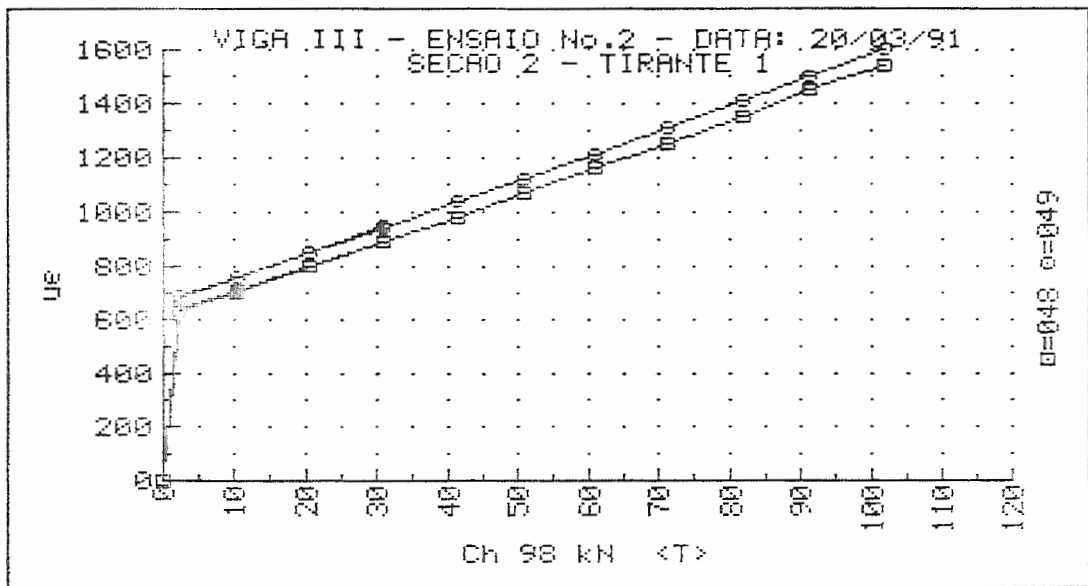
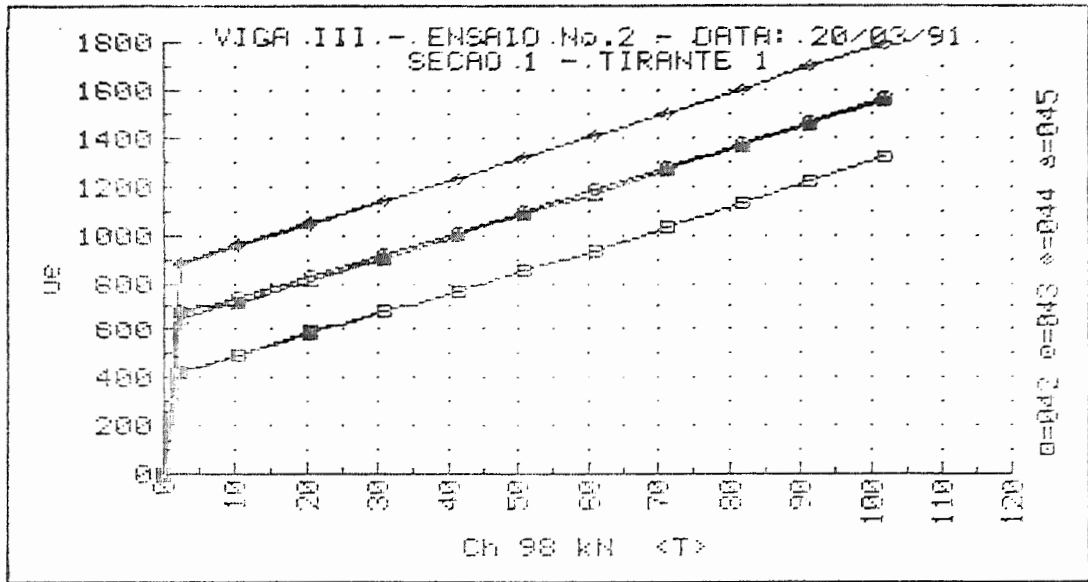
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA III ENSAIO No.2 DATA: 20/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | -0.12         | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 2.23          | 2.21          | +3.                               | +5.                               | +1.                               | +5.                               | -1.                               | +1.0                | +0.1                | U/C                      |
| 10.43         | 9.52          | +9.                               | +20.                              | -6.                               | +29.                              | -26.                              | +4.9                | -3.0                | +37.0                    |
| 20.63         | 19.16         | +19.                              | +62.                              | -14.                              | +65.                              | -60.                              | +10.5               | -9.1                | +37.3                    |
| 30.83         | 29.04         | +27.                              | +98.                              | -24.                              | +102.                             | -99.                              | +16.2               | -15.4               | +37.8                    |
| 2.23          | 1.97          | +2.                               | +5.                               | +2.                               | +5.                               | -1.                               | +1.0                | +0.1                | U/C                      |
| 10.43         | 9.52          | +10.                              | +29.                              | -5.                               | +30.                              | -25.                              | +5.2                | -3.5                | +37.0                    |
| 20.63         | 19.28         | +19.                              | +64.                              | -14.                              | +67.                              | -62.                              | +10.8               | -9.4                | +37.5                    |
| 30.83         | 29.04         | +27.                              | +99.                              | -23.                              | +103.                             | -98.                              | +16.5               | -15.1               | +37.8                    |
| 41.15         | 38.79         | +33.                              | +134.                             | -33.                              | +138.                             | -138.                             | +21.8               | -21.8               | +38.1                    |
| 51.11         | 48.66         | +39.                              | +169.                             | -44.                              | +174.                             | -179.                             | +27.2               | -28.5               | +38.3                    |
| 61.08         | 58.77         | +43.                              | +203.                             | -56.                              | +208.                             | -222.                             | +31.5               | -35.8               | +38.4                    |
| 71.28         | 68.64         | +48.                              | +233.                             | -71.                              | +240.                             | -263.                             | +36.3               | -43.0               | +38.1                    |
| 81.95         | 77.93         | +53.                              | +263.                             | -87.                              | +272.                             | -306.                             | +40.5               | -50.5               | +38.0                    |
| 91.56         | 88.04         | +59.                              | +294.                             | -102.                             | +304.                             | -348.                             | +45.1               | -57.8               | +37.9                    |
| 101.88        | 97.91         | +63.                              | +327.                             | -117.                             | +339.                             | -393.                             | +49.8               | -65.6               | +37.8                    |
| 2.34          | 2.09          | +9.                               | -8.                               | -9.                               | +11.                              | -11.                              | +1.8                | -1.8                | -20.8                    |

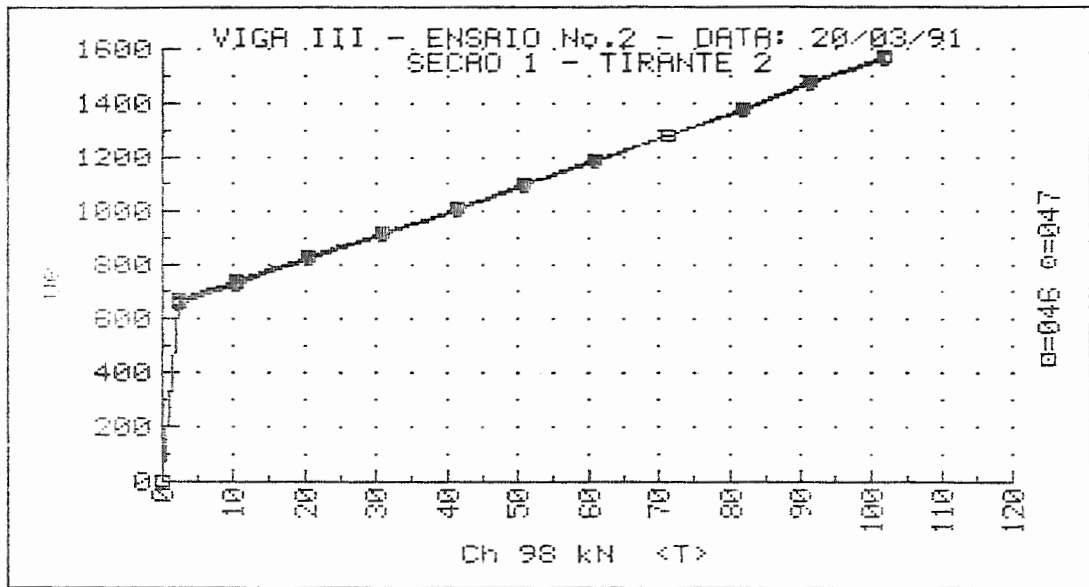
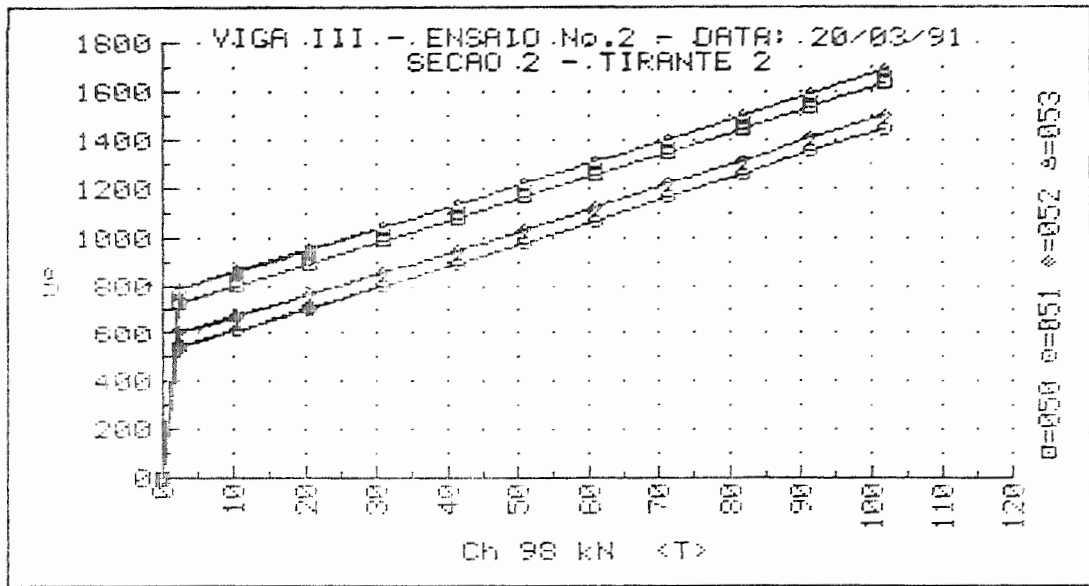


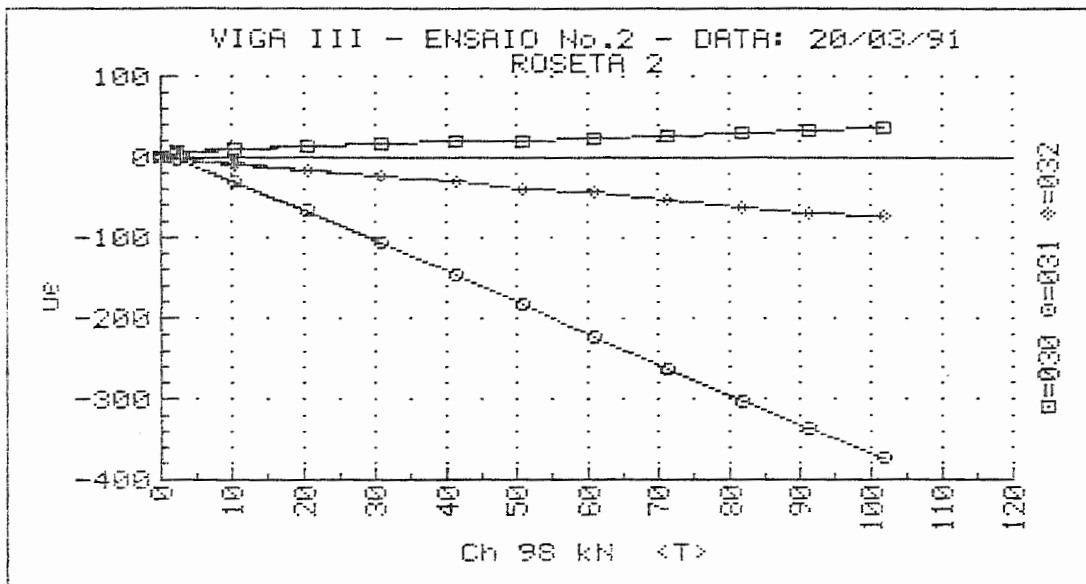
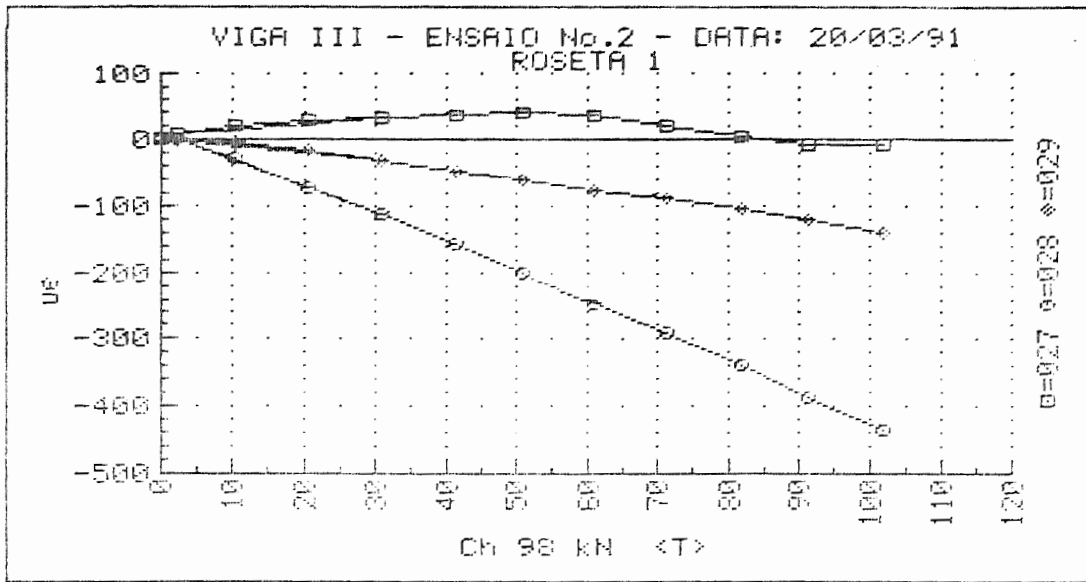


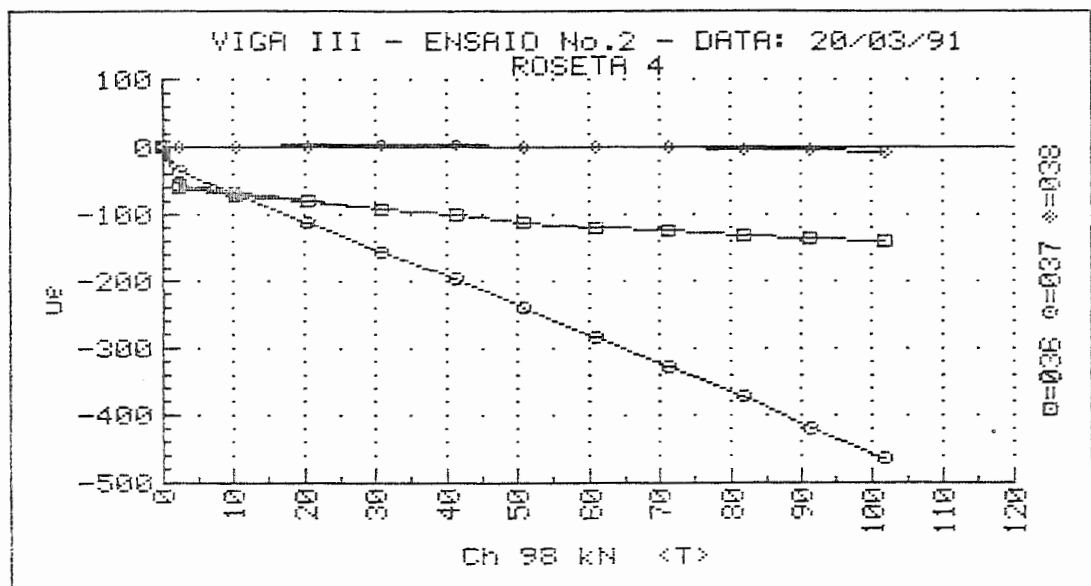
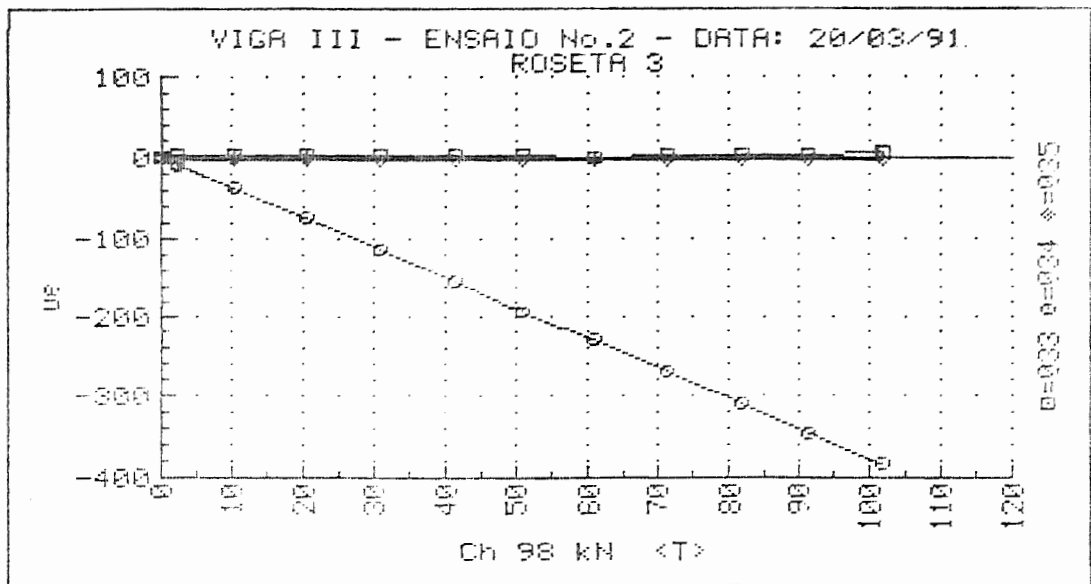




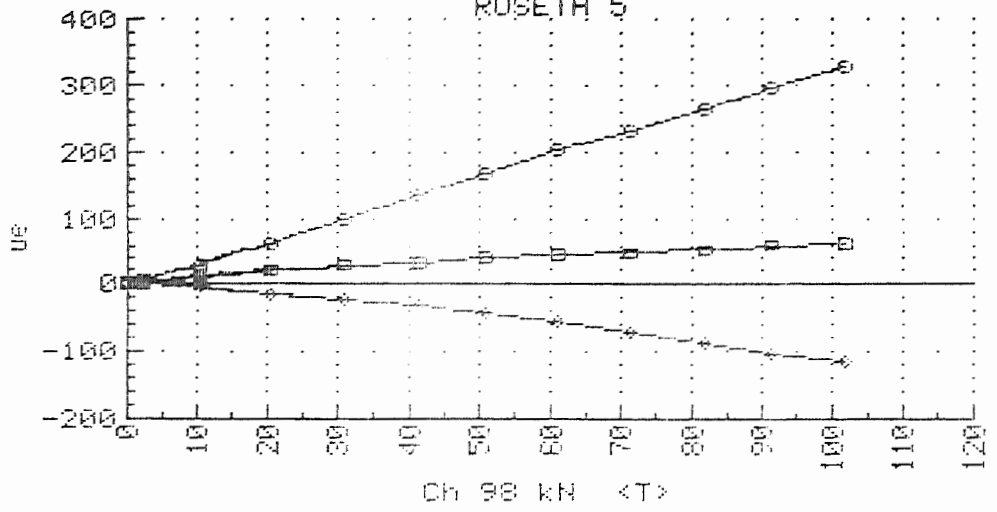








VIGA III - ENSAIO No.2 - DATA: 20/03/91  
ROSETA 5



## MODELO - VIGA IV

### RESULTADOS DOS ENSAIOS

- . ENSAIO 1
- . ENSAIO 2

- DESLOCAMENTOS

- DEFORMAÇÕES

MODELO - VIGA IV

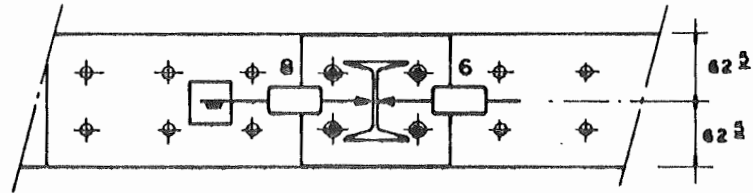
RESULTADOS DOS ENSAIOS

. ENSAIO 1

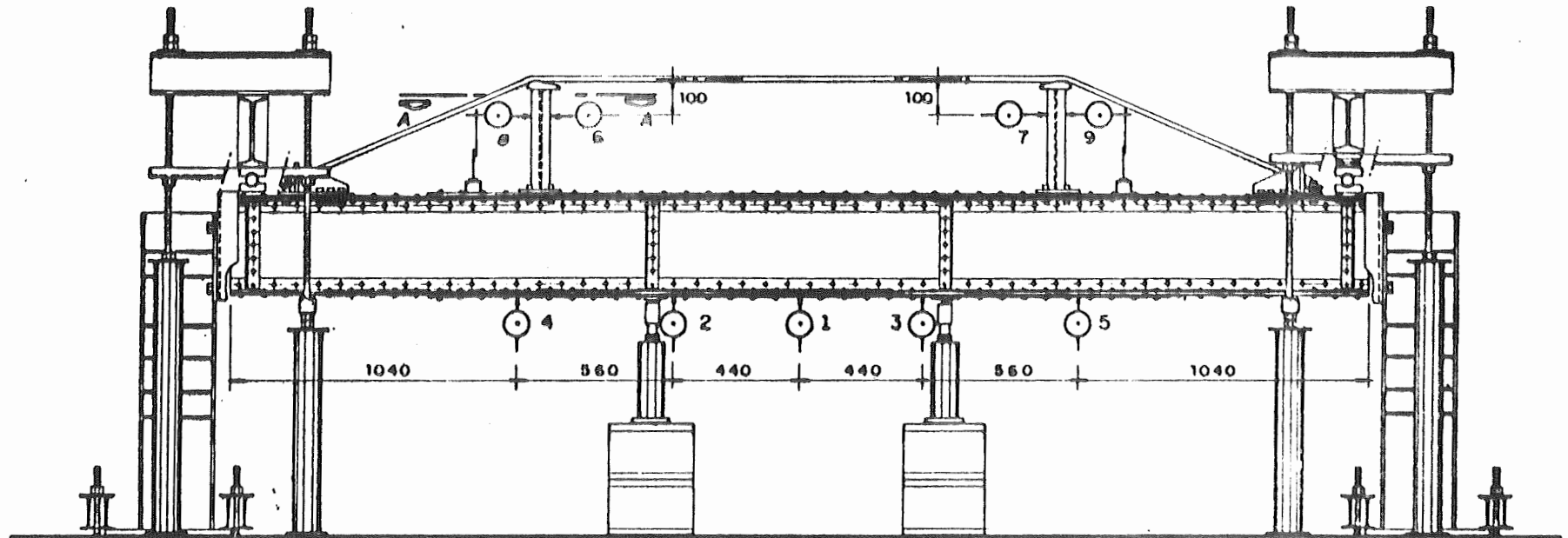
- DESLOCAMENTOS

.TABELAS

.GRÁFICOS



**CORTE A**



MODELO: VIGA REBITADA IV

ENSAIO Nro:1

DATA:26 DE MARCO DE 1991

HORARIO: 8:45 Hs

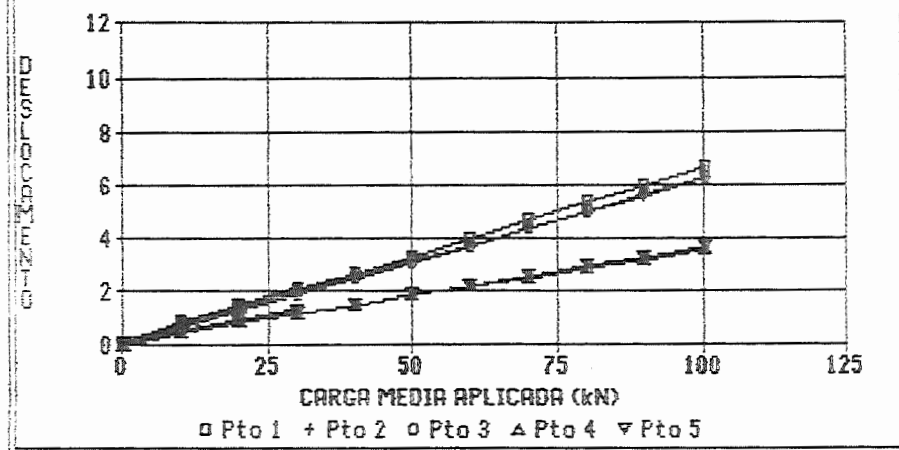
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| ETAPA | CARGA APL<br>MEDIA<br>(KN) | DESLOCAMENTOS<br>(mm) |       |       |       |       |
|-------|----------------------------|-----------------------|-------|-------|-------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto 4 | Pto 5 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00  | 0.00  |
| 1     | 10.00                      | .84                   | .74   | .74   | .52   | .58   |
| 2     | 20.05                      | 1.52                  | 1.38  | 1.38  | .90   | .96   |
| 3     | 30.00                      | 2.13                  | 1.98  | 1.98  | 1.22  | 1.31  |
| 4     | .30                        | .07                   | .00   | .11   | .04   | .06   |
| 5     | 10.05                      | .85                   | .78   | .73   | .54   | .59   |
| 6     | 19.80                      | 1.50                  | 1.40  | 1.33  | .92   | .92   |
| 7     | 30.00                      | 2.06                  | 1.96  | 1.87  | 1.19  | 1.23  |
| 8     | 39.95                      | 2.69                  | 2.56  | 2.47  | 1.54  | 1.52  |
| 9     | 50.00                      | 3.33                  | 3.19  | 3.10  | 1.89  | 1.86  |
| 10    | 60.00                      | 3.96                  | 3.75  | 3.71  | 2.17  | 2.20  |
| 11    | 69.95                      | 4.67                  | 4.41  | 4.36  | 2.55  | 2.60  |
| 12    | 79.90                      | 5.36                  | 5.02  | 5.02  | 2.88  | 3.00  |
| 13    | 89.85                      | 6.01                  | 5.65  | 5.66  | 3.23  | 3.32  |
| 14    | 100.15                     | 6.71                  | 6.31  | 6.30  | 3.60  | 3.65  |

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VIGA REBITADA - MODELO IV - ENSAIO I  
DESLOCAMENTOS (mm)



MODELO - VIGA IV

RESULTADOS DOS ENSAIOS

. ENSAIO 1

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

Seção 4



Seção 5



Seções 1 e 2

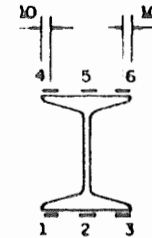
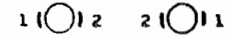


Seção 3

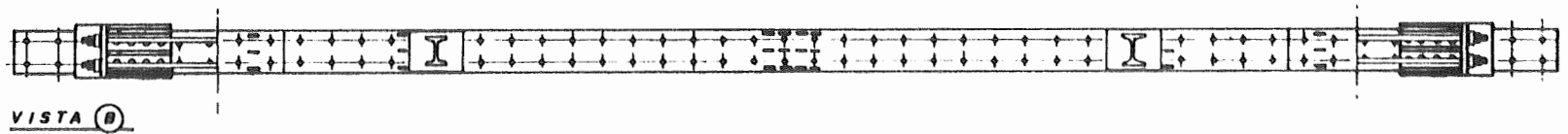
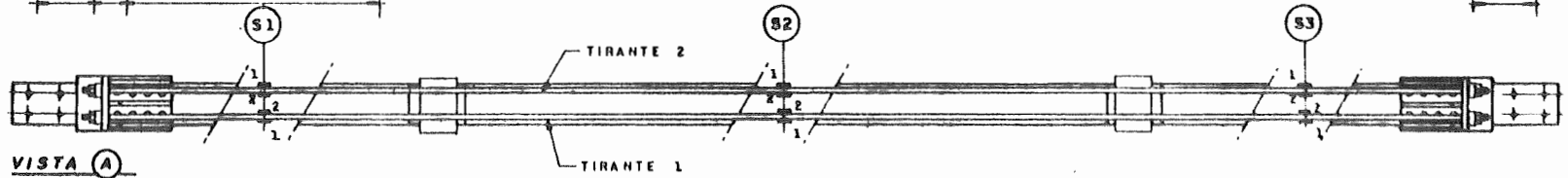
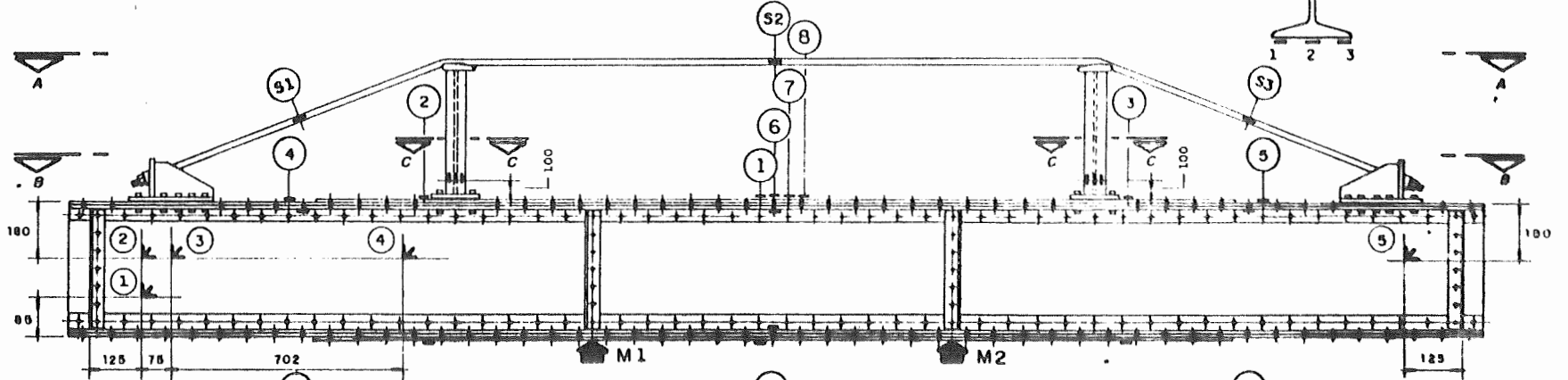


Seções S1, S2 e S3

TIRANTE 1 TIRANTE 2



CORTE C  
(MONTANTES 1 e 2)



UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +0.                     |
| 10.55                  | 9.41                   | +48.                   | +52.                   | +57.                   | +40.                   | +37.                   | -64.                   | -66.                   | -71.                   | -57.                   | -48.                    |
| 20.75                  | 19.28                  | +97.                   | +107.                  | +116.                  | +82.                   | +76.                   | -134.                  | -133.                  | -139.                  | -112.                  | -99.                    |
| 30.95                  | 29.15                  | +149.                  | +162.                  | +175.                  | +124.                  | +116.                  | -203.                  | -201.                  | -208.                  | -166.                  | -150.                   |
| 0.59                   | 0.00                   | +9.                    | +9.                    | +9.                    | +7.                    | +7.                    | +1.                    | -7.                    | -14.                   | -9.                    | -4.                     |
| 10.55                  | 9.52                   | +54.                   | +59.                   | +65.                   | +46.                   | +44.                   | -65.                   | -70.                   | -77.                   | -60.                   | -51.                    |
| 20.63                  | 19.05                  | +101.                  | +110.                  | +120.                  | +85.                   | +79.                   | -134.                  | -134.                  | -141.                  | -112.                  | -99.                    |
| 30.95                  | 29.15                  | +150.                  | +163.                  | +177.                  | +125.                  | +117.                  | -204.                  | -201.                  | -209.                  | -166.                  | -151.                   |
| 41.15                  | 38.79                  | +202.                  | +217.                  | +236.                  | +169.                  | +156.                  | -273.                  | -268.                  | -278.                  | -221.                  | -201.                   |
| 51.35                  | 48.78                  | +257.                  | +275.                  | +296.                  | +215.                  | +198.                  | -343.                  | -337.                  | -350.                  | -278.                  | -253.                   |
| 61.43                  | 58.42                  | +314.                  | +333.                  | +358.                  | +263.                  | +240.                  | -412.                  | -406.                  | -423.                  | -335.                  | -305.                   |
| 71.40                  | 68.52                  | +373.                  | +394.                  | +421.                  | +313.                  | +283.                  | -482.                  | -477.                  | -499.                  | -394.                  | -359.                   |
| 81.36                  | 78.40                  | +431.                  | +453.                  | +484.                  | +362.                  | +326.                  | -548.                  | -547.                  | -575.                  | -453.                  | -409.                   |
| 91.79                  | 88.04                  | +488.                  | +514.                  | +548.                  | +412.                  | +370.                  | -612.                  | -618.                  | -657.                  | -515.                  | -461.                   |
| 101.64                 | 98.84                  | +548.                  | +578.                  | +617.                  | +464.                  | +417.                  | -674.                  | -692.                  | -748.                  | -581.                  | -513.                   |

UNIVERSIDADE DE SAO PAULO  
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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    | +0.                     |
| 10.55                  | 9.41                   | +24.                   | +27.                   | +39.                   | +7.                    | +17.                   | -37.                   | -36.                   | -36.                   | -29.                   | -26.                    |
| 20.75                  | 19.28                  | +50.                   | +55.                   | +79.                   | +14.                   | +37.                   | -63.                   | -74.                   | -68.                   | -59.                   | -59.                    |
| 30.95                  | 29.15                  | +77.                   | +85.                   | +120.                  | +21.                   | +60.                   | -128.                  | -112.                  | -100.                  | -86.                   | -91.                    |
| 0.59                   | 0.00                   | +10.                   | +9.                    | +11.                   | +2.                    | +0.                    | -7.                    | -6.                    | -6.                    | -5.                    | -4.                     |
| 10.55                  | 9.52                   | +33.                   | +34.                   | +49.                   | +9.                    | +26.                   | -46.                   | -40.                   | -35.                   | -31.                   | -32.                    |
| 20.63                  | 19.05                  | +55.                   | +59.                   | +85.                   | +16.                   | +43.                   | -86.                   | -75.                   | -67.                   | -58.                   | -61.                    |
| 30.95                  | 29.15                  | +79.                   | +86.                   | +123.                  | +22.                   | +60.                   | -129.                  | -113.                  | -101.                  | -86.                   | -92.                    |
| 41.15                  | 38.79                  | +105.                  | +116.                  | +163.                  | +31.                   | +85.                   | -174.                  | -151.                  | -134.                  | -115.                  | -123.                   |
| 51.35                  | 48.78                  | +136.                  | +148.                  | +206.                  | +41.                   | +110.                  | -219.                  | -191.                  | -168.                  | -146.                  | -155.                   |
| 61.43                  | 58.42                  | +166.                  | +182.                  | +252.                  | +53.                   | +137.                  | -267.                  | -230.                  | -202.                  | -177.                  | -187.                   |
| 71.40                  | 68.52                  | +202.                  | +218.                  | +297.                  | +67.                   | +163.                  | -315.                  | -271.                  | -240.                  | -211.                  | -221.                   |
| 81.36                  | 78.40                  | +235.                  | +255.                  | +343.                  | +79.                   | +189.                  | -361.                  | -311.                  | -276.                  | -244.                  | -253.                   |
| 91.79                  | 88.04                  | +269.                  | +292.                  | +389.                  | +89.                   | +213.                  | -409.                  | -353.                  | -314.                  | -280.                  | -283.                   |
| 101.64                 | 98.84                  | +307.                  | +333.                  | +442.                  | +100.                  | +241.                  | -458.                  | -397.                  | -356.                  | -317.                  | -316.                   |

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UNIVERSIDADE DE SAO PAULO  
ESCOLA DE ENGENHARIA DE SAO CARLOS  
DEPARTAMENTO DE ESTRUTURAS

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV            ENSAIO No.1            DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 3

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| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    |
| 10.55                  | 9.41                   | +19.                   | +27.                   | +6.                    | -35.                   | -45.                   | -31.                   |
| 20.75                  | 19.28                  | +38.                   | +56.                   | +13.                   | -72.                   | -88.                   | -61.                   |
| 30.95                  | 29.15                  | +59.                   | +85.                   | +20.                   | -109.                  | -131.                  | -92.                   |
| 0.59                   | 0.00                   | +10.                   | +13.                   | +1.                    | -6.                    | -18.                   | -6.                    |
| 10.55                  | 9.52                   | +26.                   | +37.                   | +6.                    | -39.                   | -58.                   | -34.                   |
| 20.63                  | 19.05                  | +43.                   | +62.                   | +14.                   | -73.                   | -94.                   | -62.                   |
| 30.95                  | 29.15                  | +60.                   | +87.                   | +21.                   | -110.                  | -131.                  | -93.                   |
| 41.15                  | 38.79                  | +83.                   | +116.                  | +31.                   | -146.                  | -172.                  | -123.                  |
| 51.35                  | 48.78                  | +106.                  | +147.                  | +40.                   | -185.                  | -214.                  | -155.                  |
| 61.43                  | 58.42                  | +130.                  | +180.                  | +51.                   | -223.                  | -256.                  | -188.                  |
| 71.40                  | 68.52                  | +158.                  | +214.                  | +66.                   | -262.                  | -302.                  | -223.                  |
| 81.36                  | 78.40                  | +181.                  | +246.                  | +75.                   | -301.                  | -345.                  | -255.                  |
| 91.79                  | 88.04                  | +204.                  | +281.                  | +84.                   | -341.                  | -392.                  | -290.                  |
| 101.64                 | 98.84                  | +227.                  | +316.                  | +93.                   | -381.                  | -440.                  | -324.                  |

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UNIVERSIDADE DE SAO PAULO  
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 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAD 4

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +1.                    | +1.                    | +0.                    | +0.                    | +0.                    | +0.                    | +1.                     |
| 10.55                  | 9.41                   | -1.                    | +10.                   | +23.                   | +7.                    | +3.                    | -14.                   | -25.                   | -46.                   | -33.                   | -19.                    |
| 20.75                  | 19.28                  | +1.                    | +22.                   | +46.                   | +12.                   | +7.                    | -35.                   | -52.                   | -76.                   | -62.                   | -40.                    |
| 30.95                  | 29.15                  | +5.                    | +34.                   | +70.                   | +19.                   | +11.                   | -59.                   | -80.                   | -110.                  | -92.                   | -61.                    |
| 0.59                   | 0.00                   | +7.                    | +8.                    | +11.                   | +7.                    | +7.                    | +10.                   | -5.                    | -20.                   | -12.                   | -2.                     |
| 10.55                  | 9.52                   | +4.                    | +17.                   | +33.                   | +11.                   | +7.                    | -7.                    | -29.                   | -53.                   | -40.                   | -20.                    |
| 20.63                  | 19.05                  | +5.                    | +26.                   | +52.                   | +16.                   | +10.                   | -33.                   | -54.                   | -81.                   | -66.                   | -40.                    |
| 30.95                  | 29.15                  | +5.                    | +35.                   | +72.                   | +20.                   | +12.                   | -59.                   | -80.                   | -110.                  | -92.                   | -61.                    |
| 41.15                  | 38.79                  | +8.                    | +47.                   | +95.                   | +27.                   | +17.                   | -85.                   | -109.                  | -141.                  | -121.                  | -83.                    |
| 51.35                  | 48.78                  | +13.                   | +61.                   | +120.                  | +35.                   | +22.                   | -112.                  | -139.                  | -176.                  | -151.                  | -105.                   |
| 61.43                  | 58.42                  | +18.                   | +77.                   | +150.                  | +46.                   | +29.                   | -139.                  | -169.                  | -209.                  | -180.                  | -126.                   |
| 71.40                  | 68.52                  | +29.                   | +95.                   | +175.                  | +58.                   | +40.                   | -166.                  | -201.                  | -246.                  | -213.                  | -150.                   |
| 81.36                  | 78.40                  | +33.                   | +110.                  | +205.                  | +70.                   | +46.                   | -194.                  | -230.                  | -281.                  | -243.                  | -173.                   |
| 91.79                  | 88.04                  | +35.                   | +127.                  | +241.                  | +84.                   | +51.                   | -224.                  | -261.                  | -316.                  | -275.                  | -197.                   |
| 101.64                 | 98.84                  | +37.                   | +146.                  | +279.                  | +98.                   | +55.                   | -254.                  | -292.                  | -352.                  | -308.                  | -221.                   |

UNIVERSIDADE DE SAO PAULO  
ESCOLA DE ENGENHARIA DE SAO CARLOS  
DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV ENSAIO No.1 DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 5

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +1.                    |
| 10.55                  | 9.41                   | +1.                    | +9.                    | +5.                    | -26.                   | -29.                   | -20.                   |
| 20.75                  | 19.28                  | +4.                    | +26.                   | +11.                   | -56.                   | -51.                   | -40.                   |
| 30.95                  | 29.15                  | +7.                    | +32.                   | +19.                   | -85.                   | -72.                   | -60.                   |
| 0.59                   | 0.00                   | +3.                    | +6.                    | +5.                    | -5.                    | -5.                    | -3.                    |
| 10.55                  | 9.52                   | +5.                    | +14.                   | +9.                    | -30.                   | -28.                   | -21.                   |
| 20.63                  | 19.05                  | +7.                    | +23.                   | +15.                   | -58.                   | -49.                   | -40.                   |
| 30.95                  | 29.15                  | +9.                    | +33.                   | +20.                   | -85.                   | -72.                   | -61.                   |
| 41.15                  | 38.79                  | +14.                   | +44.                   | +27.                   | -114.                  | -95.                   | -80.                   |
| 51.35                  | 48.78                  | +20.                   | +59.                   | +37.                   | -146.                  | -119.                  | -100.                  |
| 61.43                  | 58.42                  | +29.                   | +74.                   | +48.                   | -176.                  | -141.                  | -120.                  |
| 71.40                  | 68.52                  | +41.                   | +93.                   | +63.                   | -210.                  | -166.                  | -140.                  |
| 81.36                  | 78.40                  | +53.                   | +112.                  | +77.                   | -241.                  | -189.                  | -158.                  |
| 91.79                  | 88.04                  | +63.                   | +131.                  | +91.                   | -274.                  | -214.                  | -176.                  |
| 101.64                 | 98.84                  | +75.                   | +153.                  | +108.                  | -309.                  | -239.                  | -194.                  |



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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV            ENSAIO No.1            DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 6

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| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +1.                    | +0.                    | +0.                    |
| 10.55                  | 9.41                   | +49.                   | +50.                   | +55.                   |
| 20.75                  | 19.28                  | +99.                   | +103.                  | +112.                  |
| 30.95                  | 29.15                  | +151.                  | +156.                  | +169.                  |
| 0.59                   | 0.00                   | +9.                    | +9.                    | +8.                    |
| 10.55                  | 9.52                   | +55.                   | +50.                   | +62.                   |
| 20.63                  | 19.05                  | +103.                  | +106.                  | +116.                  |
| 30.95                  | 29.15                  | +152.                  | +157.                  | +171.                  |
| 41.15                  | 38.79                  | +205.                  | +210.                  | +227.                  |
| 51.35                  | 48.78                  | +263.                  | +266.                  | +285.                  |
| 61.43                  | 58.42                  | +323.                  | +325.                  | +345.                  |
| 71.40                  | 68.52                  | +389.                  | +386.                  | +406.                  |
| 81.36                  | 78.40                  | +452.                  | +446.                  | +466.                  |
| 91.79                  | 88.04                  | +516.                  | +507.                  | +528.                  |
| 101.64                 | 98.84                  | +583.                  | +572.                  | +596.                  |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV      ENSAIO No.1      DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 7

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µE) | 2<br>(µE) | 3<br>(µE) |
|------------------------|------------------------|-----------|-----------|-----------|
| 0.00                   | 0.00                   | +0.       | +0.       | +0.       |
| 10.55                  | 9.41                   | +49.      | +52.      | +57.      |
| 20.75                  | 19.28                  | +99.      | +104.     | +117.     |
| 30.95                  | 29.15                  | +151.     | +158.     | +176.     |
| 0.59                   | 0.00                   | +10.      | +10.      | +10.      |
| 10.55                  | 9.52                   | +55.      | +58.      | +66.      |
| 20.63                  | 19.05                  | +102.     | +108.     | +120.     |
| 30.95                  | 29.15                  | +151.     | +160.     | +178.     |
| 41.15                  | 38.79                  | +203.     | +213.     | +235.     |
| 51.35                  | 48.78                  | +258.     | +270.     | +295.     |
| 61.43                  | 58.42                  | +314.     | +327.     | +357.     |
| 71.40                  | 68.52                  | +374.     | +387.     | +420.     |
| 81.36                  | 78.40                  | +433.     | +447.     | +482.     |
| 91.79                  | 88.04                  | +490.     | +506.     | +546.     |
| 101.64                 | 98.64                  | +551.     | +570.     | +616.     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV      ENSAIO No.1      DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 8

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    |
| 10.55                  | 9.41                   | +46.                   | +51.                   | +57.                   |
| 20.75                  | 19.28                  | +95.                   | +105.                  | +117.                  |
| 30.95                  | 29.15                  | +144.                  | +159.                  | +177.                  |
| 0.59                   | 0.00                   | +8.                    | +9.                    | +9.                    |
| 10.55                  | 9.52                   | +52.                   | +58.                   | +66.                   |
| 20.63                  | 19.05                  | +97.                   | +108.                  | +121.                  |
| 30.95                  | 29.15                  | +145.                  | +160.                  | +179.                  |
| 41.15                  | 38.79                  | +195.                  | +213.                  | +237.                  |
| 51.35                  | 48.78                  | +248.                  | +270.                  | +298.                  |
| 61.43                  | 58.42                  | +304.                  | +328.                  | +362.                  |
| 71.40                  | 68.52                  | +364.                  | +390.                  | +427.                  |
| 81.36                  | 78.40                  | +425.                  | +452.                  | +492.                  |
| 91.79                  | 88.04                  | +488.                  | +515.                  | +561.                  |
| 101.64                 | 98.84                  | +555.                  | +582.                  | +635.                  |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV ENSAIO No.1 DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
TIRANTE 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>( $\mu\epsilon$ ) | S1.2<br>( $\mu\epsilon$ ) | S2.1<br>( $\mu\epsilon$ ) | S2.2<br>( $\mu\epsilon$ ) | S3.1<br>( $\mu\epsilon$ ) | S3.2<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 0.00                   | 0.00                   | +0.                       | +0.                       | +0.                       | +0.                       | +0.                       | +0.                       |
| 10.55                  | 9.41                   | +64.                      | +72.                      | +60.                      | +65.                      | +71.                      | +73.                      |
| 20.75                  | 19.28                  | +129.                     | +143.                     | +136.                     | +129.                     | +141.                     | +148.                     |
| 30.95                  | 29.15                  | +193.                     | +212.                     | +203.                     | +193.                     | +211.                     | +221.                     |
| 0.59                   | 0.00                   | -12.                      | -6.                       | -8.                       | -9.                       | -8.                       | -5.                       |
| 10.55                  | 9.52                   | +54.                      | +66.                      | +60.                      | +57.                      | +62.                      | +68.                      |
| 20.63                  | 19.05                  | +121.                     | +139.                     | +130.                     | +124.                     | +135.                     | +141.                     |
| 30.95                  | 29.15                  | +191.                     | +212.                     | +202.                     | +192.                     | +209.                     | +218.                     |
| 41.15                  | 38.79                  | +256.                     | +280.                     | +268.                     | +256.                     | +278.                     | +292.                     |
| 51.35                  | 48.78                  | +319.                     | +348.                     | +333.                     | +319.                     | +346.                     | +362.                     |
| 61.43                  | 58.42                  | +379.                     | +413.                     | +395.                     | +378.                     | +409.                     | +430.                     |
| 71.40                  | 68.52                  | +425.                     | +469.                     | +448.                     | +430.                     | +467.                     | +490.                     |
| 81.36                  | 78.40                  | +481.                     | +529.                     | +505.                     | +486.                     | +526.                     | +553.                     |
| 91.79                  | 88.04                  | +536.                     | +588.                     | +562.                     | +540.                     | +584.                     | +616.                     |
| 101.64                 | 98.84                  | +591.                     | +649.                     | +617.                     | +593.                     | +641.                     | +677.                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV      ENSAIO No.1      DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
MONTANTE 2

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| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +1.                    | +0.                    | +0.                    |
| 10.55                  | 9.41                   | -34.                   | -14.                   | +9.                    | -36.                   | -17.                   | +4.                    |
| 20.75                  | 19.28                  | -70.                   | -30.                   | +18.                   | -72.                   | -32.                   | +9.                    |
| 30.95                  | 29.15                  | -105.                  | -45.                   | +25.                   | -108.                  | -46.                   | +17.                   |
| 0.59                   | 0.00                   | -7.                    | +0.                    | +7.                    | -5.                    | +3.                    | +10.                   |
| 10.55                  | 9.52                   | -37.                   | -14.                   | +14.                   | -38.                   | -13.                   | +11.                   |
| 20.63                  | 19.05                  | -71.                   | -29.                   | +20.                   | -72.                   | -29.                   | +14.                   |
| 30.95                  | 29.15                  | -105.                  | -45.                   | +25.                   | -107.                  | -45.                   | +17.                   |
| 41.15                  | 38.79                  | -141.                  | -60.                   | +33.                   | -143.                  | -59.                   | +24.                   |
| 51.35                  | 48.78                  | -176.                  | -76.                   | +43.                   | -179.                  | -72.                   | +34.                   |
| 61.43                  | 58.42                  | -215.                  | -91.                   | +54.                   | -212.                  | -84.                   | +44.                   |
| 71.40                  | 68.52                  | -247.                  | -104.                  | +62.                   | -243.                  | -96.                   | +50.                   |
| 81.36                  | 78.40                  | -285.                  | -119.                  | +75.                   | -273.                  | -107.                  | +56.                   |
| 91.79                  | 88.04                  | -325.                  | -134.                  | +87.                   | -302.                  | -118.                  | +64.                   |
| 101.64                 | 98.84                  | -366.                  | -150.                  | +101.                  | -330.                  | -128.                  | +71.                   |

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UNIVERSIDADE DE SAO PAULO  
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DEPARTAMENTO DE ESTRUTURAS

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV            ENSAIO No.1            DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
MONTANTE 1

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| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) |
|---------------|---------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0.00          | 0.00          | +0.              | +0.              | +0.              | +0.              | +1.              | +0.              |
| 10.55         | 9.41          | +7.              | -16.             | -34.             | +10.             | -14.             | -36.             |
| 20.75         | 19.26         | +17.             | -32.             | -72.             | +23.             | -27.             | -73.             |
| 30.95         | 29.15         | +28.             | -48.             | -112.            | +38.             | -41.             | -110.            |
| 0.59          | 0.00          | +7.              | +2.              | -3.              | +7.              | +3.              | -3.              |
| 10.55         | 9.52          | +13.             | -14.             | -37.             | +18.             | -11.             | -37.             |
| 20.63         | 19.05         | +20.             | -30.             | -73.             | +28.             | -26.             | -73.             |
| 30.95         | 29.15         | +30.             | -47.             | -113.            | +39.             | -41.             | -111.            |
| 41.15         | 38.79         | +41.             | -63.             | -151.            | +54.             | -54.             | -148.            |
| 51.35         | 48.78         | +53.             | -80.             | -193.            | +71.             | -66.             | -187.            |
| 61.43         | 58.42         | +69.             | -95.             | -234.            | +92.             | -77.             | -226.            |
| 71.40         | 68.52         | +91.             | -108.            | -278.            | +113.            | -90.             | -269.            |
| 81.36         | 78.40         | +103.            | -123.            | -316.            | +136.            | -101.            | -309.            |
| 91.79         | 88.04         | +115.            | -138.            | -355.            | +161.            | -111.            | -350.            |
| 101.64        | 98.84         | +130.            | -153.            | -396.            | +188.            | -122.            | -395.            |

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DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV ENSAIO No.1 DATA: 26/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
TIRANTE 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>( $\mu\epsilon$ ) | S1.2<br>( $\mu\epsilon$ ) | S2.1<br>( $\mu\epsilon$ ) | S2.2<br>( $\mu\epsilon$ ) | S3.1<br>( $\mu\epsilon$ ) | S3.2<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| 0.00                   | 0.00                   | +0.                       | +0.                       | +0.                       | +0.                       | +0.                       | +0.                       |
| 10.55                  | 9.41                   | +77.                      | +72.                      | +67.                      | +74.                      | +83.                      | +61.                      |
| 20.75                  | 19.28                  | +151.                     | +142.                     | +133.                     | +145.                     | +158.                     | +123.                     |
| 30.95                  | 29.15                  | +221.                     | +210.                     | +196.                     | +212.                     | +233.                     | +178.                     |
| 0.59                   | 0.00                   | -11.                      | -11.                      | -8.                       | -14.                      | -38.                      | +8.                       |
| 10.55                  | 9.52                   | +65.                      | +61.                      | +58.                      | +62.                      | +57.                      | +61.                      |
| 20.63                  | 19.05                  | +142.                     | +134.                     | +125.                     | +137.                     | +146.                     | +117.                     |
| 30.95                  | 29.15                  | +218.                     | +208.                     | +194.                     | +210.                     | +232.                     | +176.                     |
| 41.15                  | 38.79                  | +288.                     | +277.                     | +258.                     | +276.                     | +307.                     | +231.                     |
| 51.35                  | 48.78                  | +354.                     | +343.                     | +318.                     | +338.                     | +372.                     | +285.                     |
| 61.43                  | 58.42                  | +416.                     | +405.                     | +377.                     | +398.                     | +443.                     | +338.                     |
| 71.40                  | 68.52                  | +482.                     | +469.                     | +435.                     | +458.                     | +508.                     | +391.                     |
| 81.36                  | 78.40                  | +541.                     | +529.                     | +492.                     | +516.                     | +572.                     | +442.                     |
| 91.79                  | 88.04                  | +600.                     | +589.                     | +548.                     | +572.                     | +637.                     | +493.                     |
| 101.64                 | 98.84                  | +657.                     | +646.                     | +603.                     | +629.                     | +692.                     | +544.                     |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\sigma$<br>( $\sigma$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.55         | 9.41          | -4.                               | +23.                              | +0.                               | +23.                              | -27.                              | +3.3                | -4.4                | +47.2                    |
| 20.75         | 19.28         | -9.                               | +46.                              | -2.                               | +46.                              | -57.                              | +6.6                | -9.7                | +46.8                    |
| 30.95         | 29.15         | -12.                              | +70.                              | -5.                               | +70.                              | -87.                              | +9.9                | -14.9               | +46.4                    |
| 0.59          | 0.00          | +2.                               | +2.                               | -3.                               | +3.                               | -4.                               | +0.4                | -0.7                | U/C                      |
| 10.55         | 9.52          | -3.                               | +25.                              | -3.                               | +25.                              | -30.                              | +3.5                | -5.2                | +45.0                    |
| 20.63         | 19.05         | -7.                               | +47.                              | -3.                               | +47.                              | -57.                              | +6.8                | -9.6                | +46.0                    |
| 30.95         | 29.15         | -11.                              | +70.                              | -5.                               | +70.                              | -86.                              | +10.0               | -14.7               | +46.2                    |
| 41.15         | 38.79         | -15.                              | +95.                              | -8.                               | +95.                              | -117.                             | +13.4               | -20.0               | +46.0                    |
| 51.35         | 48.78         | -19.                              | +119.                             | -11.                              | +119.                             | -150.                             | +16.8               | -25.6               | +45.8                    |
| 61.43         | 58.42         | -22.                              | +146.                             | -16.                              | +146.                             | -184.                             | +20.4               | -31.5               | +45.5                    |
| 71.40         | 68.52         | -24.                              | +174.                             | -21.                              | +174.                             | -219.                             | +24.4               | -37.5               | +45.2                    |
| 81.36         | 78.40         | -27.                              | +201.                             | -27.                              | +201.                             | -255.                             | +28.1               | -43.9               | +44.9                    |
| 91.79         | 88.04         | -28.                              | +232.                             | -34.                              | +232.                             | -294.                             | +32.3               | -50.6               | +44.7                    |
| 101.64        | 98.84         | -30.                              | +265.                             | -44.                              | +265.                             | -339.                             | +36.8               | -58.4               | +44.4                    |



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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/D                      |
| 10.55         | 9.41          | +0.                               | +35.                              | +7.                               | +35.                              | -29.                              | +6.0                | -4.1                | +45.0                    |
| 20.75         | 19.20         | -1.                               | +68.                              | +9.                               | +68.                              | -61.                              | +11.3               | -9.1                | +47.1                    |
| 30.95         | 29.15         | -1.                               | +100.                             | +9.                               | +100.                             | -93.                              | +16.3               | -14.1               | +46.4                    |
| 0.59          | 0.00          | +7.                               | +4.                               | -6.                               | +7.                               | -7.                               | +1.2                | -1.0                | +14.2                    |
| 10.55         | 9.52          | +5.                               | +37.                              | +2.                               | +37.                              | -30.                              | +6.3                | -4.3                | +43.8                    |
| 20.63         | 19.05         | +2.                               | +69.                              | +6.                               | +69.                              | -62.                              | +11.4               | -9.2                | +45.8                    |
| 30.95         | 29.15         | -1.                               | +100.                             | +9.                               | +100.                             | -93.                              | +16.3               | -14.1               | +46.4                    |
| 41.15         | 38.79         | -2.                               | +132.                             | +9.                               | +133.                             | -126.                             | +21.3               | -19.4               | +46.2                    |
| 51.35         | 48.78         | -1.                               | +166.                             | +8.                               | +166.                             | -159.                             | +26.6               | -24.6               | +45.8                    |
| 61.43         | 58.42         | -1.                               | +199.                             | +7.                               | +199.                             | -193.                             | +31.7               | -30.1               | +45.6                    |
| 71.40         | 68.52         | -1.                               | +232.                             | +2.                               | +232.                             | -231.                             | +36.6               | -36.3               | +45.2                    |
| 81.36         | 78.40         | -1.                               | +265.                             | -2.                               | +265.                             | -268.                             | +41.6               | -42.4               | +44.9                    |
| 91.79         | 88.04         | +0.                               | +300.                             | -6.                               | +300.                             | -306.                             | +46.9               | -48.6               | +44.7                    |
| 101.64        | 98.84         | +0.                               | +337.                             | -12.                              | +337.                             | -349.                             | +52.3               | -55.9               | +44.5                    |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\sigma$<br>( $\sigma$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | -1.                               | +0.                               | -1.                               | -0.0                | -0.2                | U/D                      |
| 10.55         | 9.41          | -7.                               | +33.                              | +18.                              | +36.                              | -24.                              | +6.4                | -3.1                | +57.1                    |
| 20.75         | 19.26         | -15.                              | +63.                              | +30.                              | +66.                              | -53.                              | +11.7               | -7.3                | +56.1                    |
| 30.95         | 29.15         | -25.                              | +92.                              | +40.                              | +98.                              | -83.                              | +16.4               | -12.0               | +55.5                    |
| 0.59          | 0.00          | +8.                               | +15.                              | +2.                               | +16.                              | -6.                               | +3.1                | -0.3                | +37.4                    |
| 10.55         | 9.52          | -2.                               | +43.                              | +17.                              | +44.                              | -29.                              | +7.9                | -3.5                | +52.6                    |
| 20.63         | 19.05         | -12.                              | +68.                              | +28.                              | +71.                              | -55.                              | +12.4               | -7.6                | +54.4                    |
| 30.95         | 29.15         | -23.                              | +93.                              | +39.                              | +98.                              | -82.                              | +16.6               | -11.8               | +55.0                    |
| 41.15         | 38.79         | -31.                              | +121.                             | +48.                              | +128.                             | -111.                             | +21.3               | -16.3               | +54.7                    |
| 51.35         | 48.78         | -39.                              | +151.                             | +55.                              | +159.                             | -143.                             | +26.1               | -21.4               | +54.1                    |
| 61.43         | 58.42         | -44.                              | +182.                             | +61.                              | +189.                             | -173.                             | +31.0               | -26.2               | +53.4                    |
| 71.40         | 68.52         | -53.                              | +212.                             | +62.                              | +220.                             | -210.                             | +35.3               | -32.5               | +52.8                    |
| 81.36         | 78.40         | -60.                              | +242.                             | +65.                              | +250.                             | -245.                             | +39.8               | -38.2               | +52.3                    |
| 91.79         | 88.04         | -66.                              | +273.                             | +67.                              | +281.                             | -280.                             | +44.4               | -44.2               | +51.9                    |
| 101.64        | 98.84         | -74.                              | +306.                             | +66.                              | +314.                             | -322.                             | +49.1               | -51.3               | +51.4                    |

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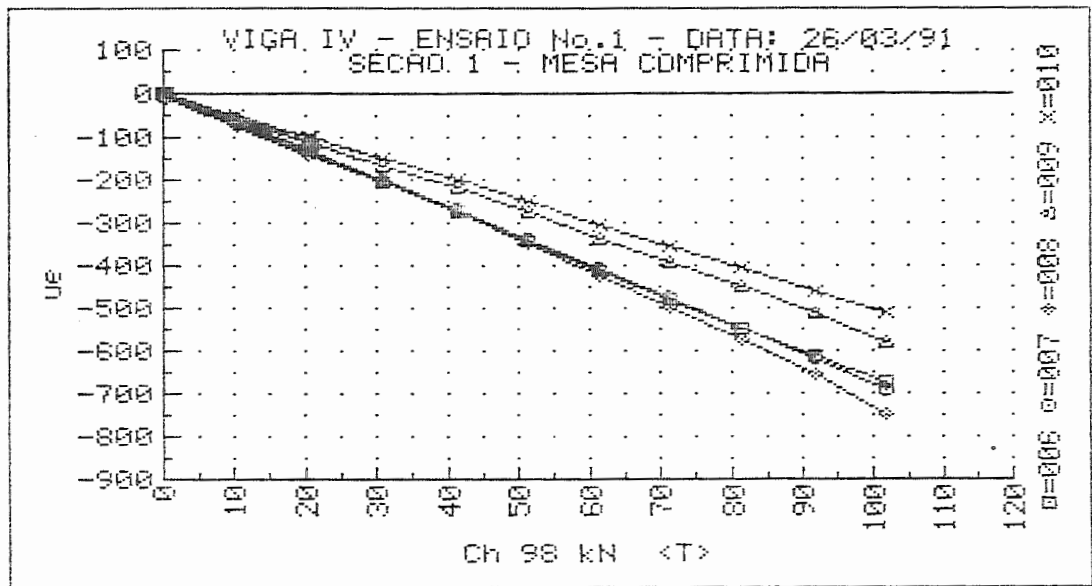
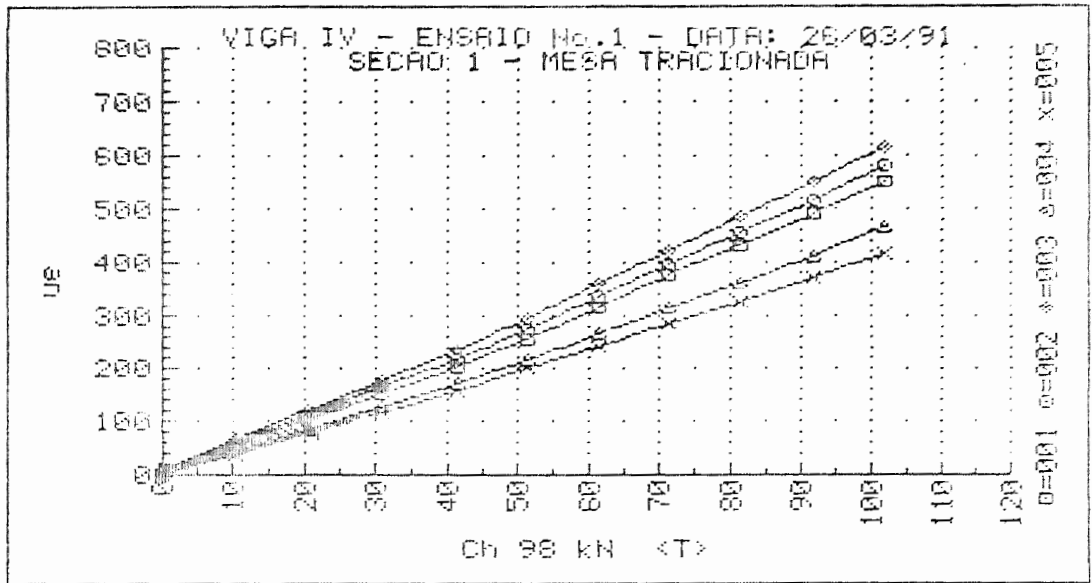
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 4

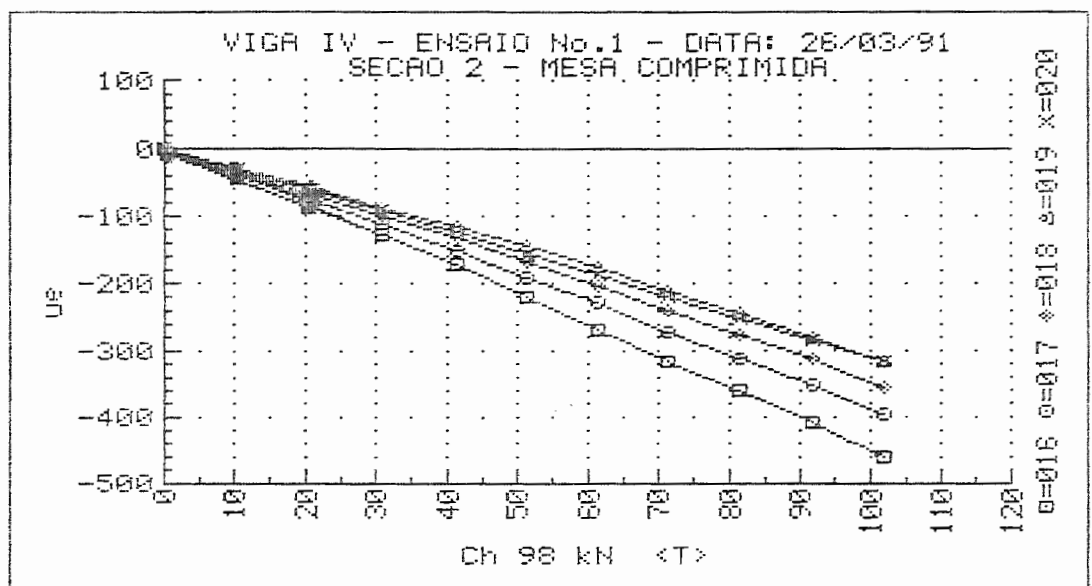
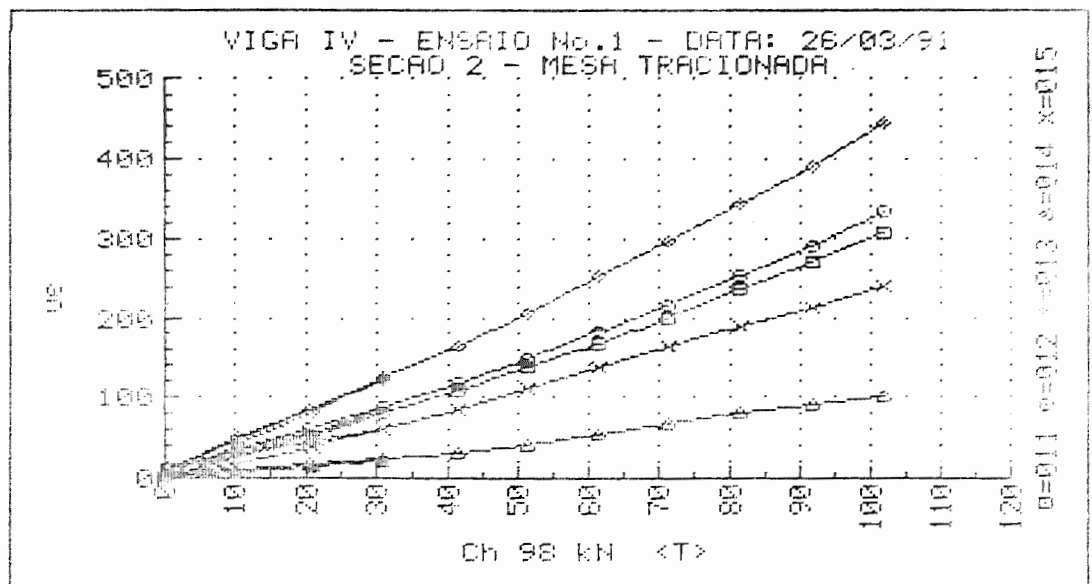
| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.55         | 9.41          | -7.                               | +22.                              | -7.                               | +22.                              | -35.                              | +2.5                | -6.4                | +45.0                    |
| 20.75         | 19.28         | -14.                              | +42.                              | -17.                              | +42.                              | -73.                              | +4.5                | -13.6               | +44.3                    |
| 30.95         | 29.15         | -22.                              | +62.                              | -28.                              | +62.                              | -112.                             | +6.3                | -21.0               | +43.9                    |
| 0.59          | 0.00          | +2.                               | +8.                               | +0.                               | +8.                               | -6.                               | +1.3                | -0.8                | +40.9                    |
| 10.55         | 9.52          | -6.                               | +26.                              | -9.                               | +26.                              | -40.                              | +3.1                | -7.2                | +43.8                    |
| 20.63         | 19.05         | -13.                              | +44.                              | -18.                              | +44.                              | -75.                              | +4.8                | -13.9               | +43.9                    |
| 30.95         | 29.15         | -22.                              | +62.                              | -28.                              | +62.                              | -112.                             | +6.3                | -21.0               | +43.9                    |
| 41.15         | 38.79         | -29.                              | +80.                              | -40.                              | +81.                              | -150.                             | +8.0                | -28.3               | +43.7                    |
| 51.35         | 48.78         | -37.                              | +98.                              | -54.                              | +99.                              | -190.                             | +9.4                | -36.0               | +43.3                    |
| 61.43         | 58.42         | -44.                              | +116.                             | -70.                              | +117.                             | -231.                             | +10.7               | -44.2               | +42.9                    |
| 71.40         | 68.52         | -52.                              | +135.                             | -83.                              | +136.                             | -271.                             | +12.3               | -51.9               | +42.8                    |
| 81.36         | 78.40         | -60.                              | +151.                             | -103.                             | +152.                             | -315.                             | +13.0               | -60.7               | +42.3                    |
| 91.79         | 88.04         | -68.                              | +167.                             | -129.                             | +168.                             | -365.                             | +13.2               | -70.9               | +41.7                    |
| 101.64        | 98.84         | -78.                              | +180.                             | -162.                             | +183.                             | -422.                             | +12.6               | -82.7               | +41.0                    |

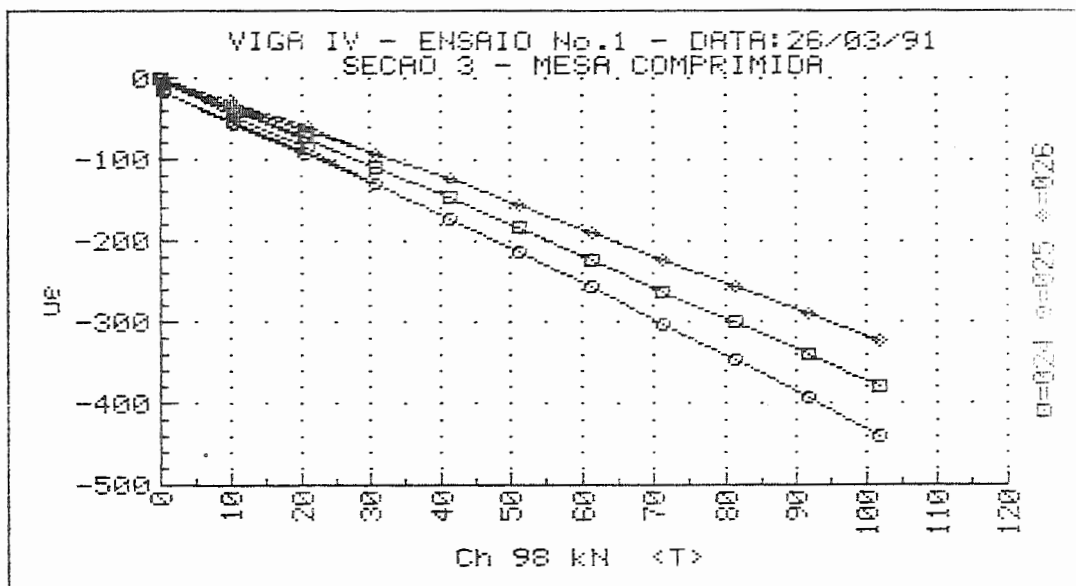
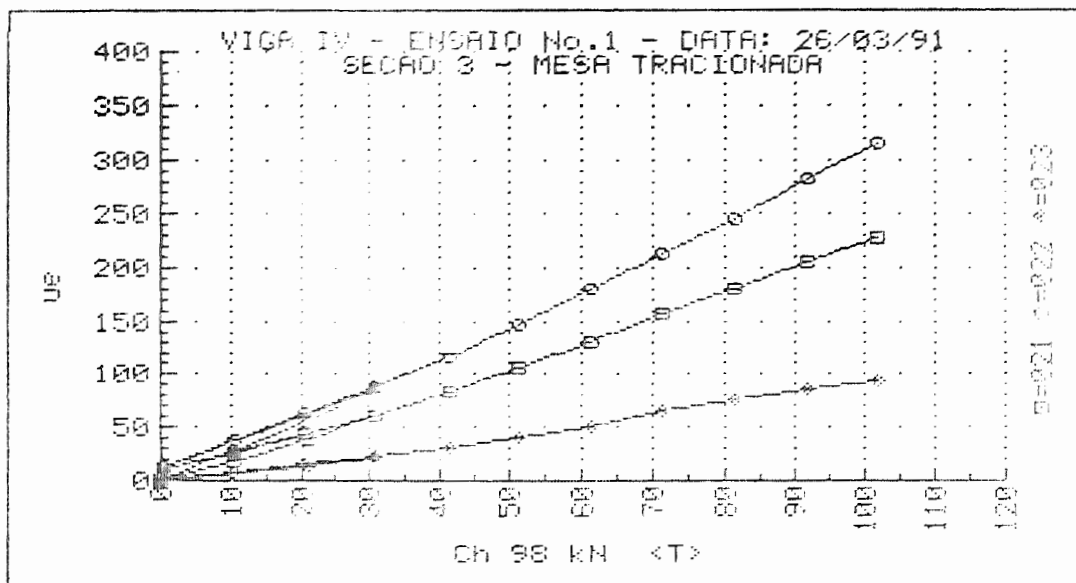
UNIVERSIDADE DE SAO PAULO  
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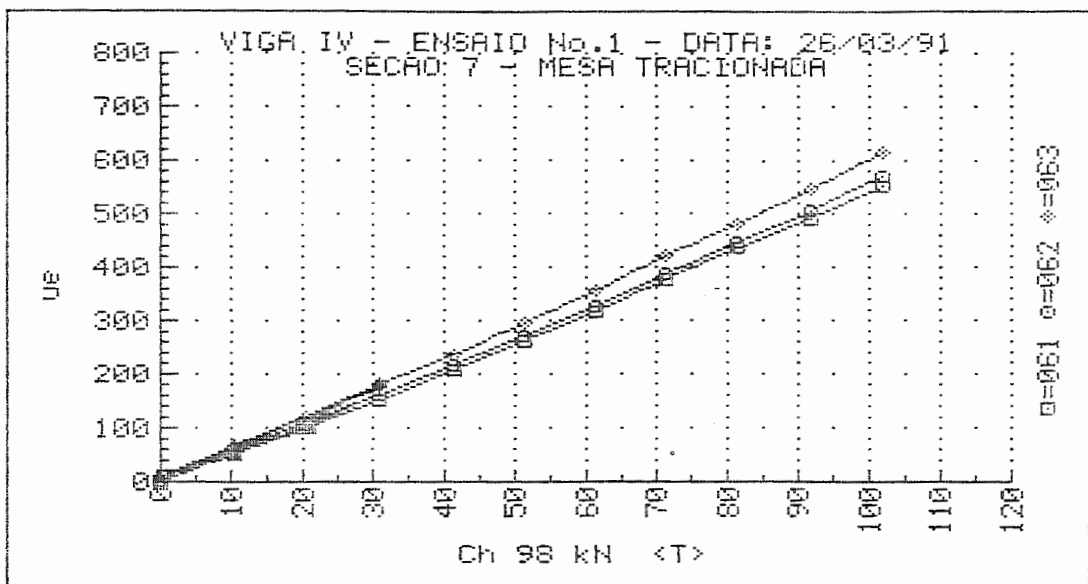
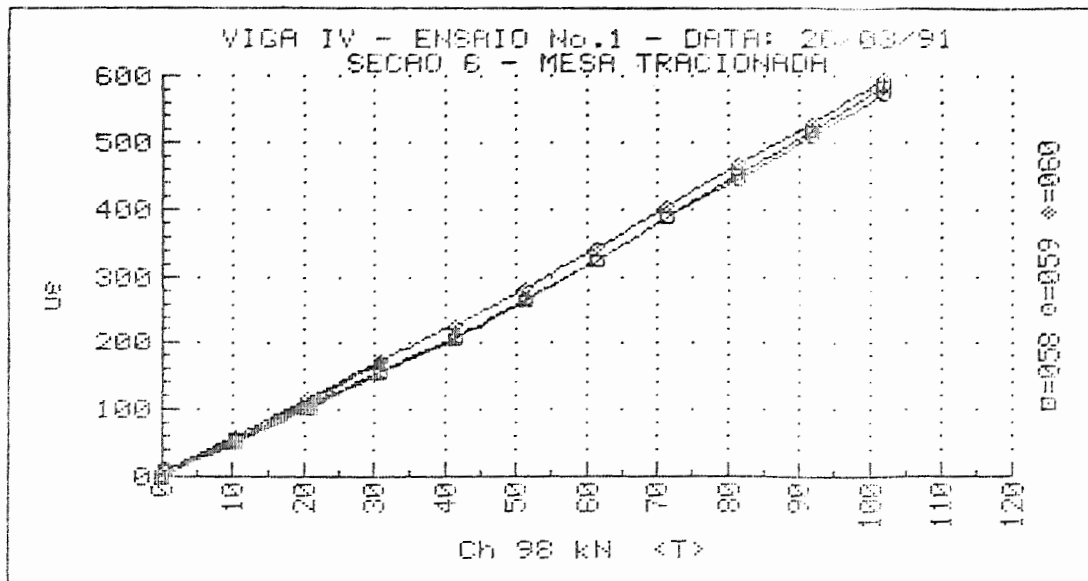
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.1 DATA: 26/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 5

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/C                      |
| 10.55         | 9.41          | -5.                               | -28.                              | +9.                               | +33.                              | -29.                              | +5.4                | -4.3                | -51.2                    |
| 20.75         | 19.28         | -12.                              | -63.                              | +14.                              | +67.                              | -65.                              | +10.6               | -10.1               | -50.8                    |
| 30.95         | 29.15         | -19.                              | -99.                              | +18.                              | +100.                             | -101.                             | +15.7               | -16.0               | -50.3                    |
| 0.59          | 0.00          | +4.                               | -4.                               | -3.                               | +6.                               | -5.                               | +1.0                | -0.7                | U/C                      |
| 10.55         | 9.52          | -2.                               | -30.                              | +6.                               | +34.                              | -31.                              | +5.7                | -4.6                | -48.4                    |
| 20.63         | 19.05         | -9.                               | -63.                              | +12.                              | +67.                              | -64.                              | +10.8               | -10.0               | -49.8                    |
| 30.95         | 29.15         | -18.                              | -99.                              | +17.                              | +100.                             | -101.                             | +15.7               | -16.0               | -50.0                    |
| 41.15         | 38.79         | -24.                              | -134.                             | +21.                              | +133.                             | -136.                             | +20.8               | -21.7               | -49.7                    |
| 51.35         | 48.78         | -29.                              | -171.                             | +23.                              | +167.                             | -173.                             | +25.8               | -27.8               | -49.4                    |
| 61.43         | 58.42         | -33.                              | -208.                             | +23.                              | +200.                             | -210.                             | +30.8               | -33.8               | -48.9                    |
| 71.40         | 68.52         | -37.                              | -248.                             | +21.                              | +234.                             | -250.                             | +35.8               | -40.5               | -48.4                    |
| 81.36         | 78.40         | -40.                              | -288.                             | +20.                              | +269.                             | -289.                             | +41.1               | -47.0               | -48.1                    |
| 91.79         | 88.04         | -44.                              | -328.                             | +17.                              | +303.                             | -330.                             | +46.1               | -53.8               | -47.7                    |
| 101.64        | 98.84         | -46.                              | -372.                             | +13.                              | +340.                             | -373.                             | +51.4               | -61.1               | -47.4                    |

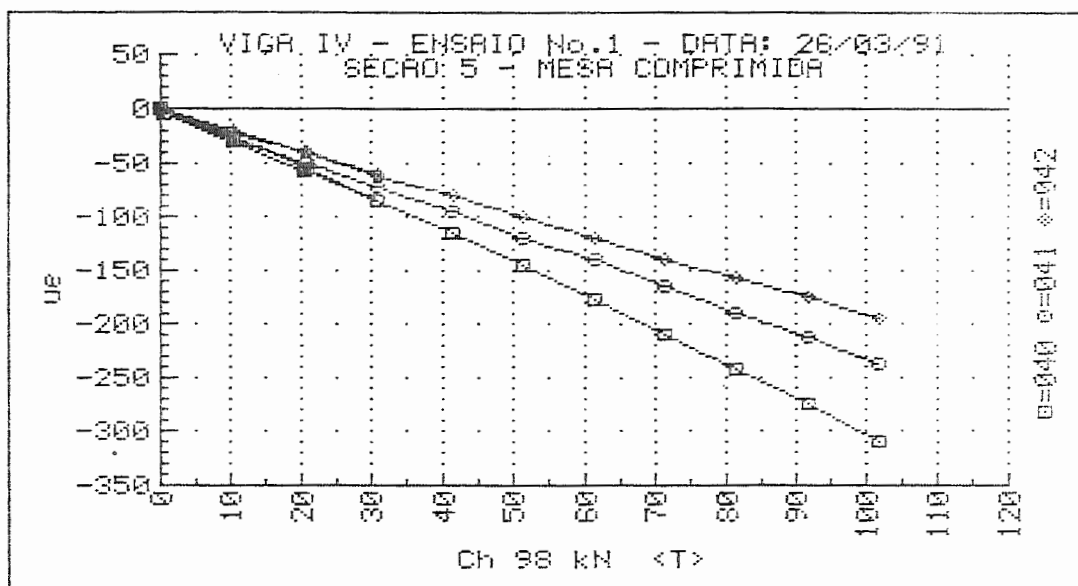
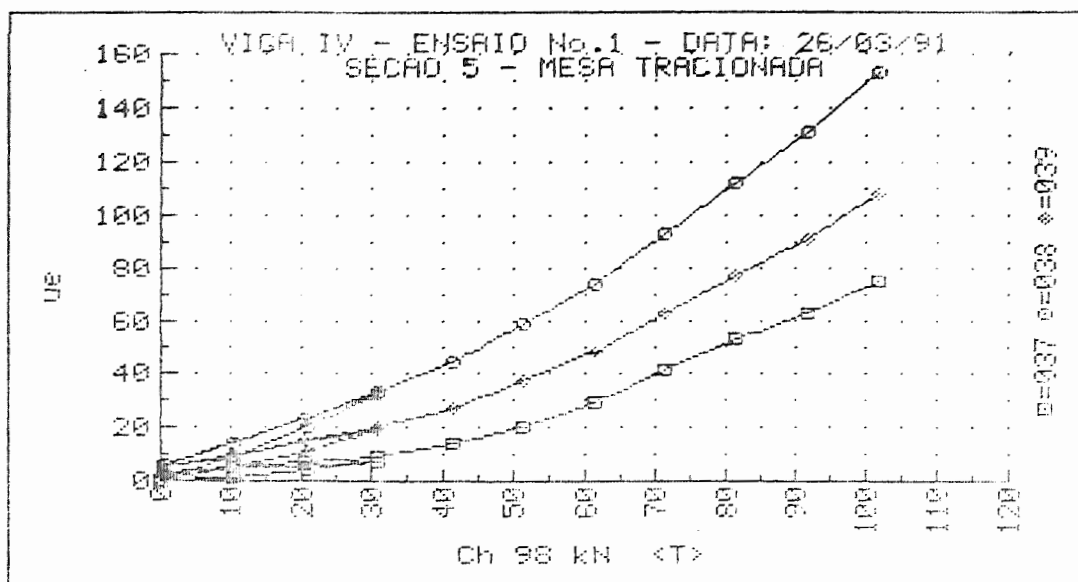


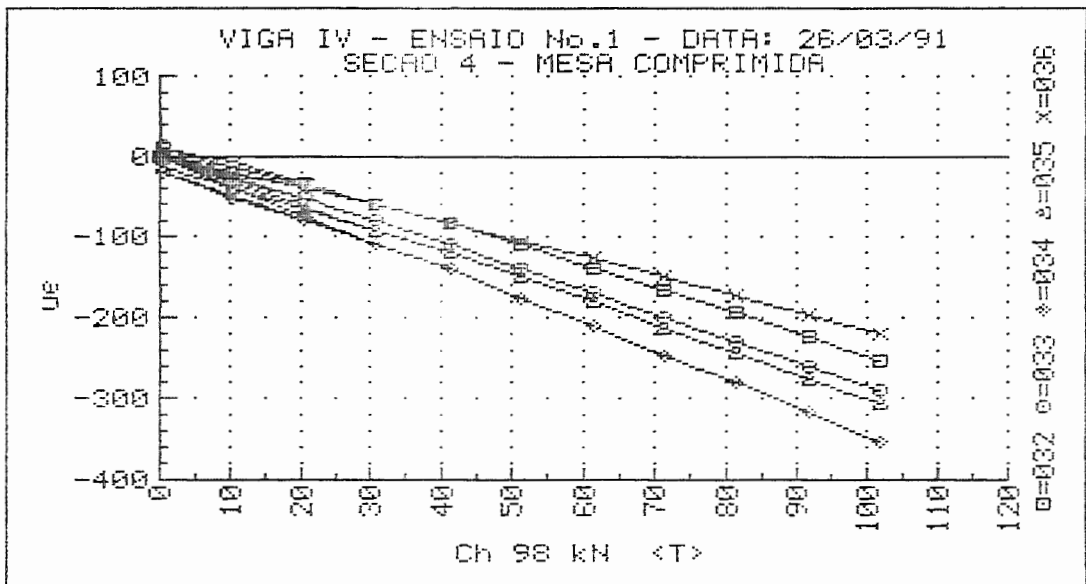
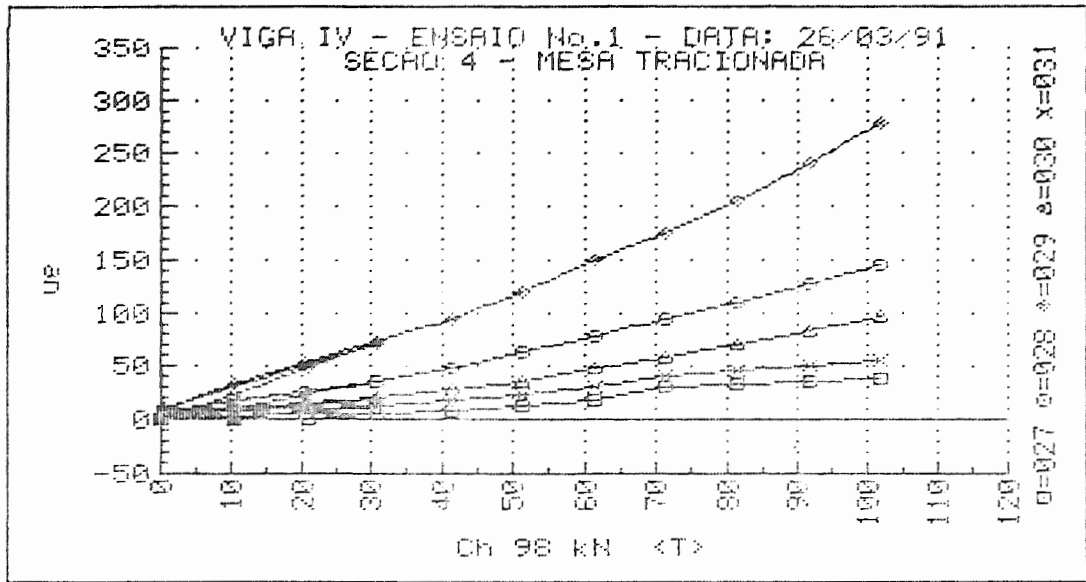


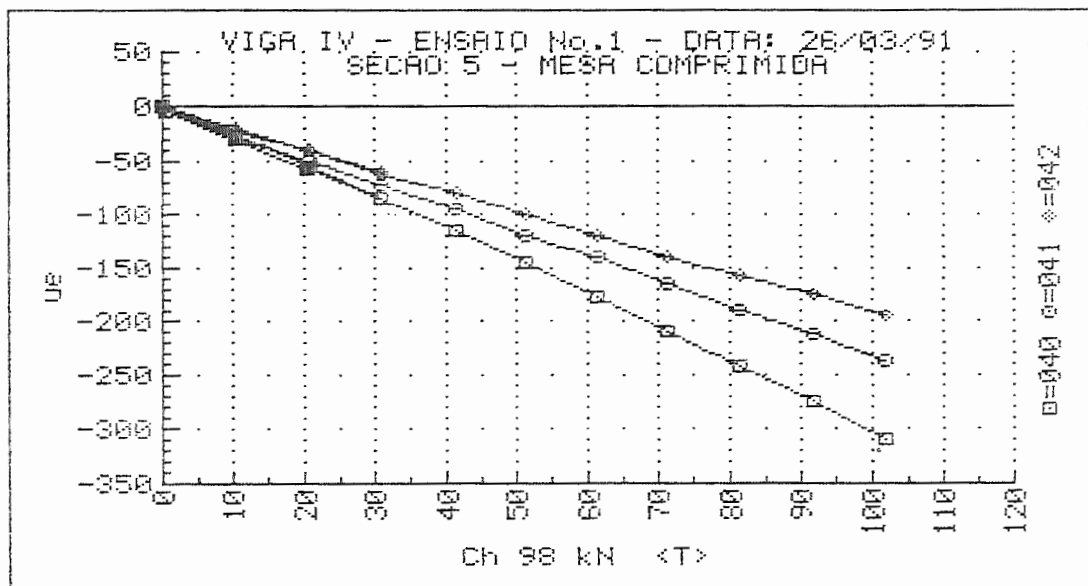
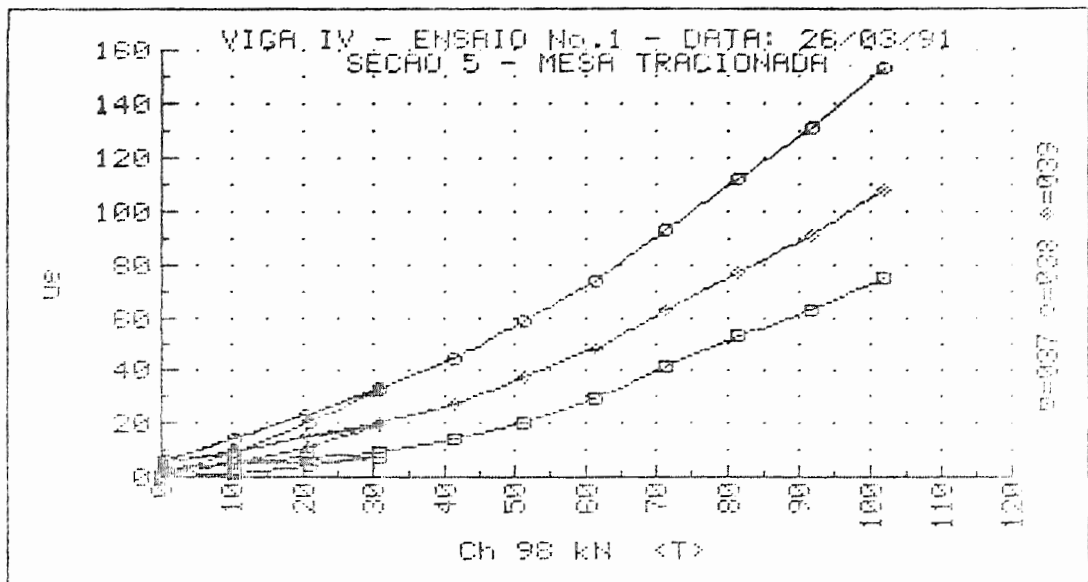


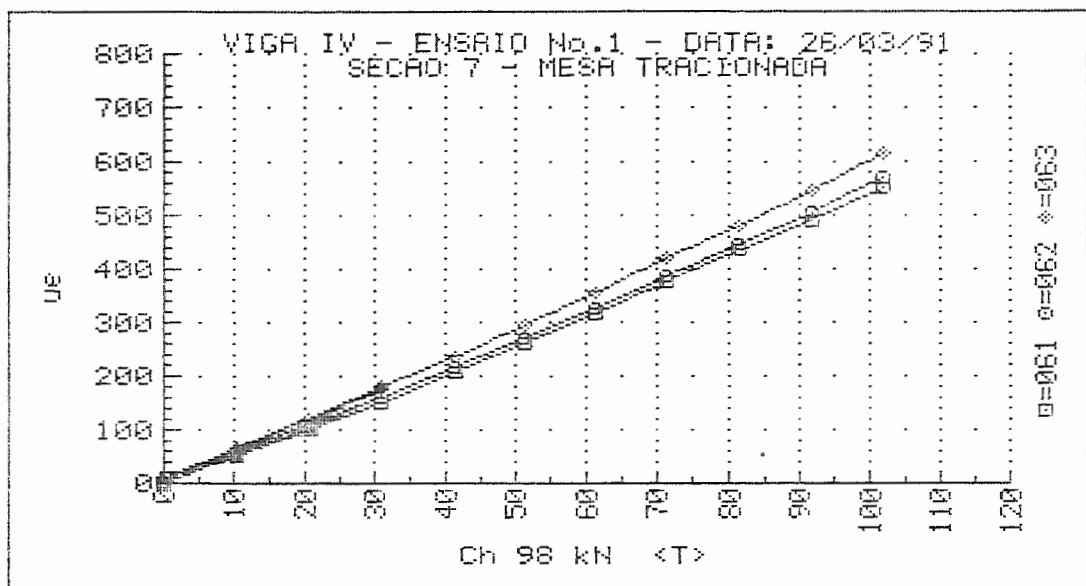
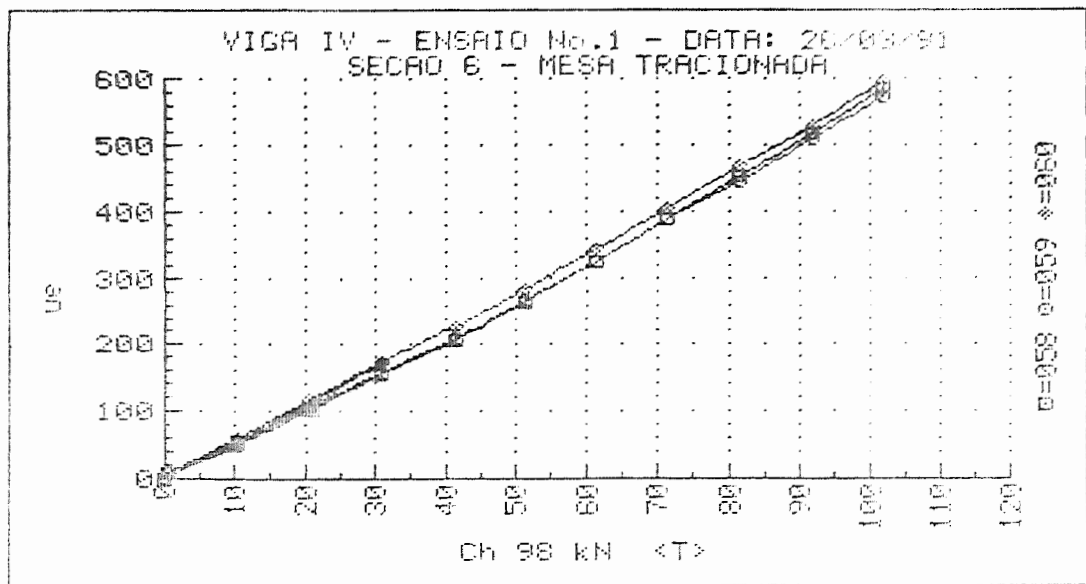


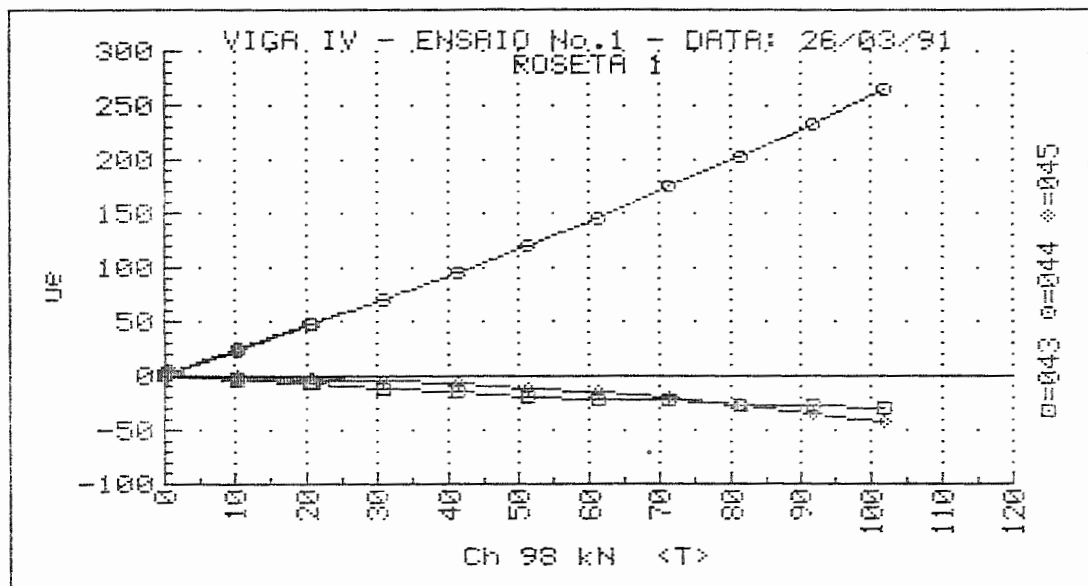
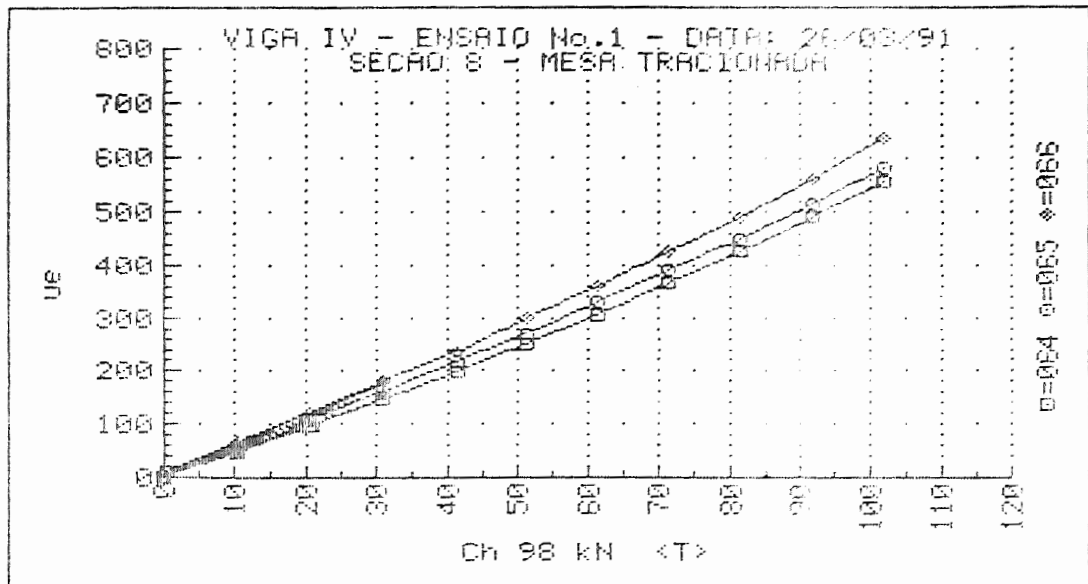


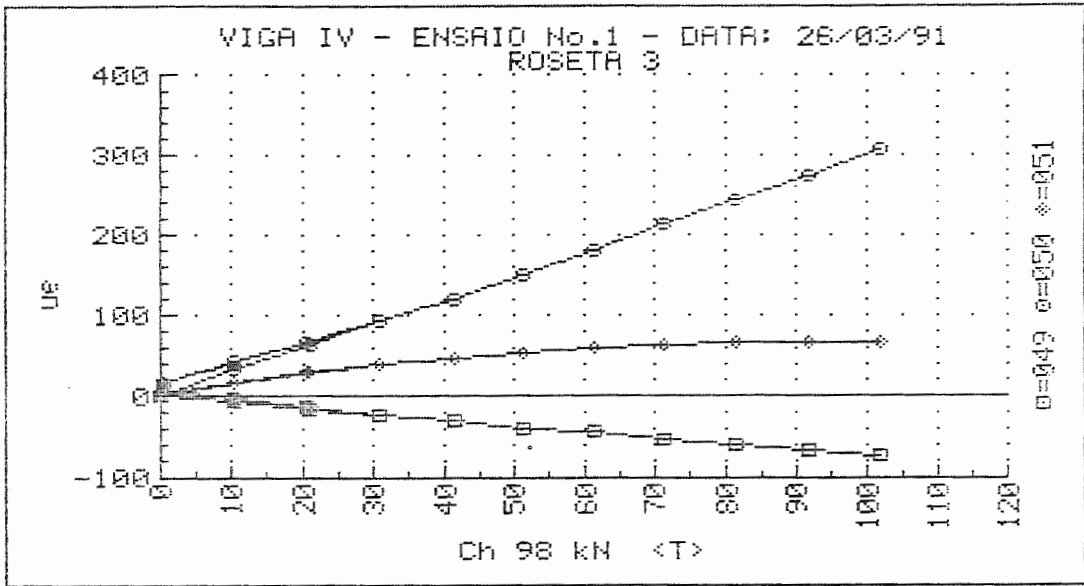
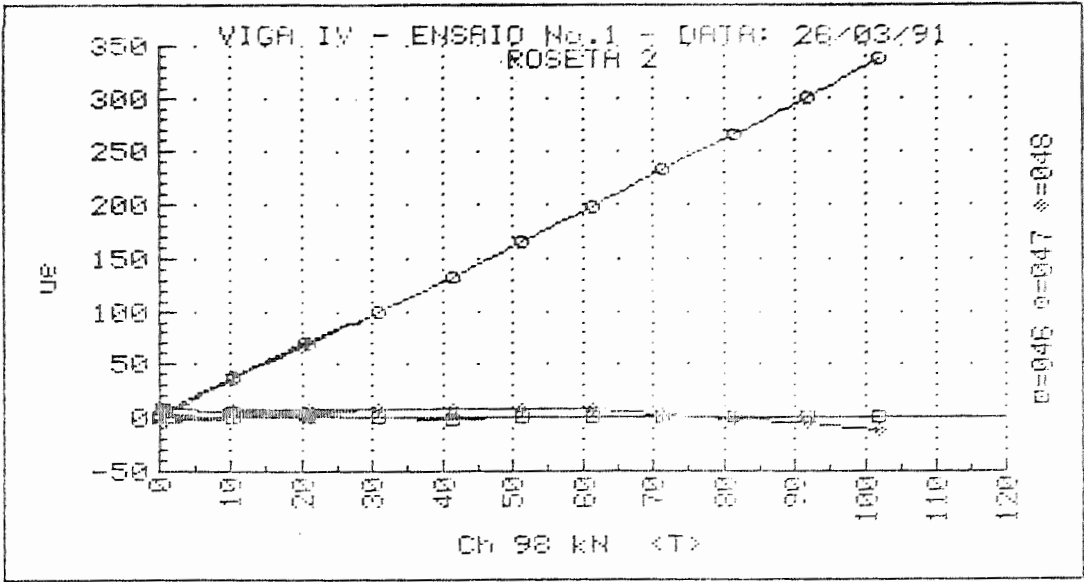


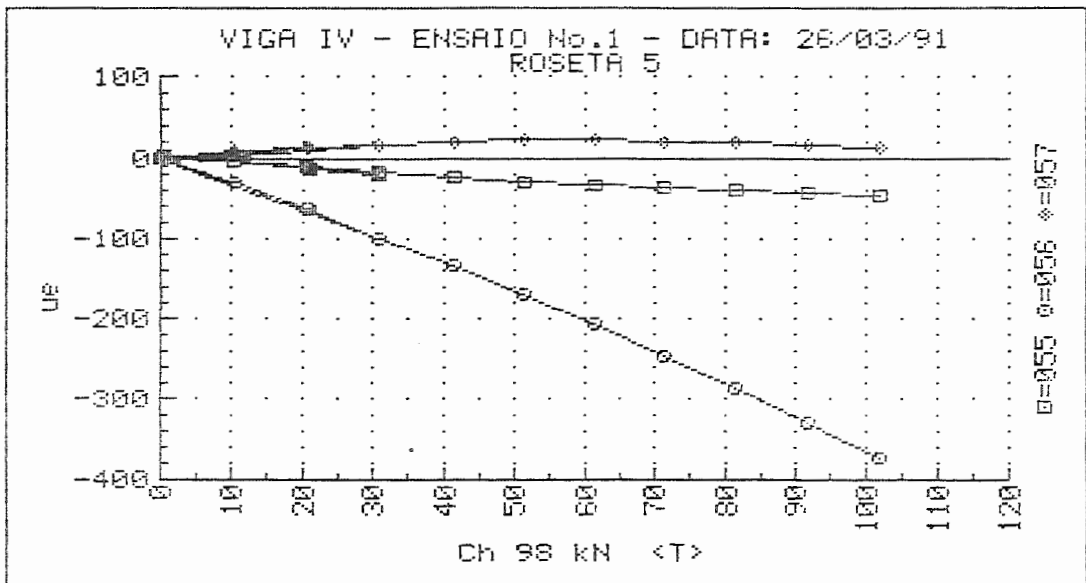
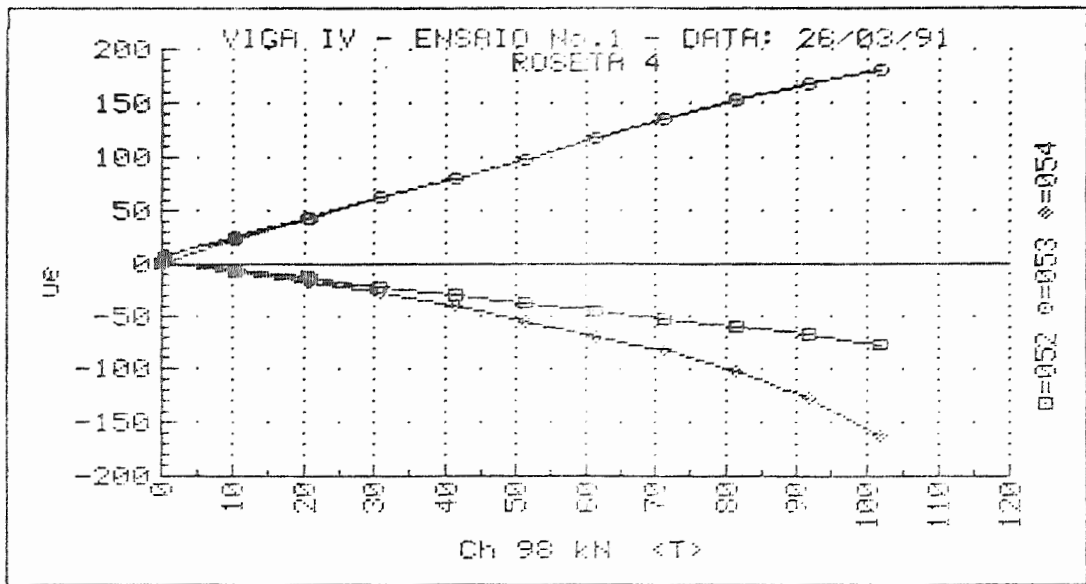


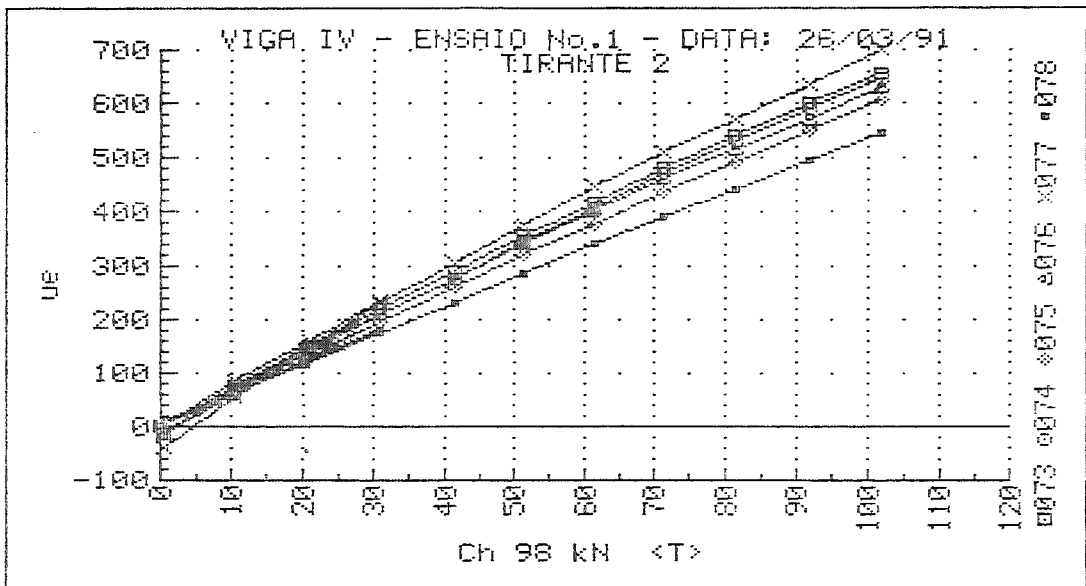
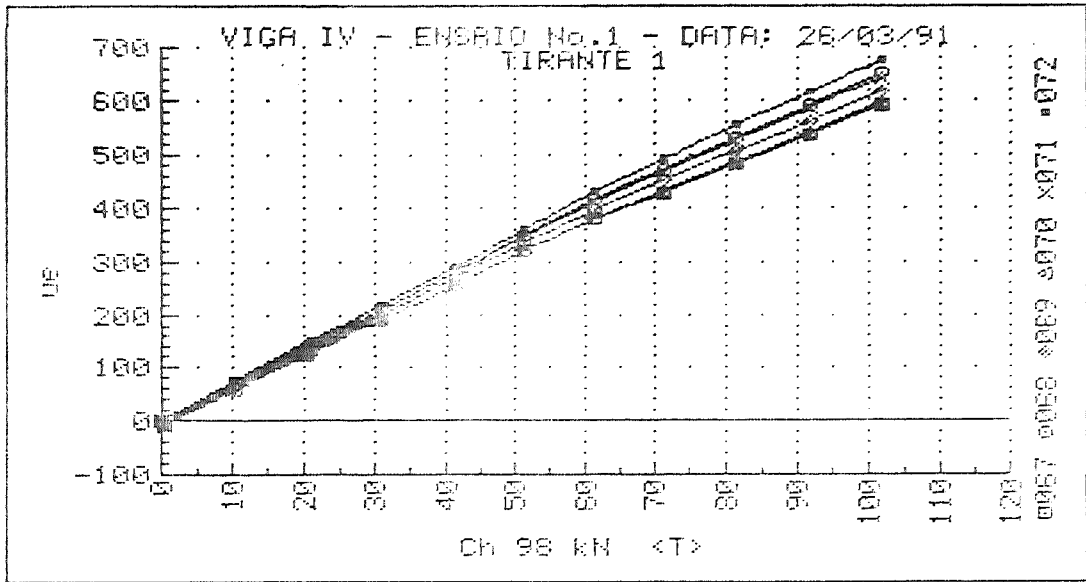




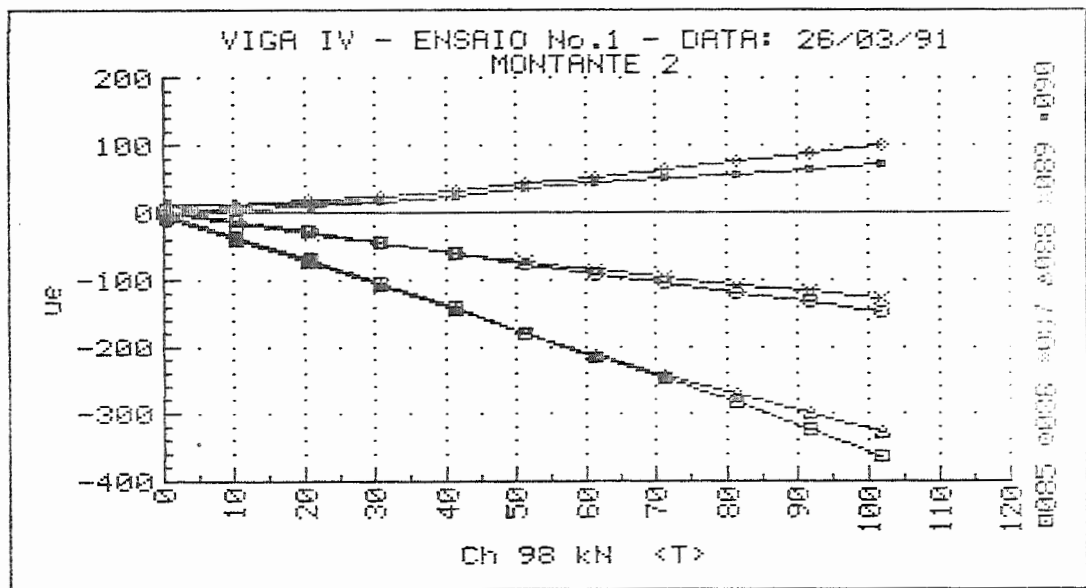
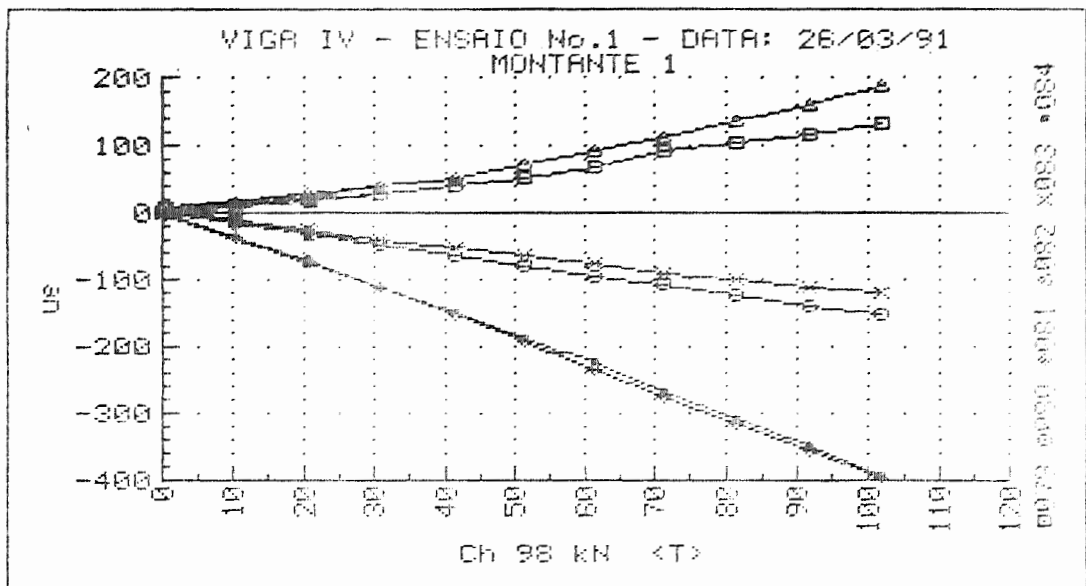












MODELO - VIGA IV

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DESLOCAMENTOS

.TABELAS

.GRÁFICOS

MODELO: VIGA REBITADA IV

ENSAIO Nro:2

DATA:27 DE MARÇO DE 1991

HORARIO: 14:15 Hs

| ETAPA | CARGA APL<br>MEDIA<br>(kN) | DESLOCAMENTOS<br>(mm) |       |       |       |       |       |       |       |       |
|-------|----------------------------|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|
|       |                            | Pto 1                 | Pto 2 | Pto 3 | Pto 4 | Pto 5 | Pto 6 | Pto 7 | Pto 8 | Pto 9 |
|       | 0.00                       | 0.00                  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |
| 1     | 9.70                       | .84                   | .74   | .83   | .47   | .61   | .04   | -.14  | -.11  | -.10  |
| 2     | 19.90                      | 1.50                  | 1.38  | 1.45  | .86   | .99   | .02   | -.22  | -.22  | -.23  |
| 3     | 29.90                      | 2.17                  | 2.01  | 2.08  | 1.23  | 1.38  | .04   | -.33  | -.34  | -.36  |
| 4     | 39.95                      | .12                   | .10   | .14   | .14   | .12   | .11   | -.16  | -.03  | -.12  |
| 5     | 49.90                      | .77                   | .68   | .73   | .37   | .51   | -.02  | -.02  | -.10  | -.05  |
| 6     | 59.95                      | 1.41                  | 1.31  | 1.33  | .74   | .85   | -.06  | -.08  | -.20  | -.15  |
| 7     | 69.95                      | 2.02                  | 1.88  | 1.89  | 1.08  | 1.18  | -.07  | -.17  | -.31  | -.26  |
| 8     | 79.95                      | 2.67                  | 2.49  | 2.51  | 1.44  | 1.55  | -.10  | -.26  | -.42  | -.38  |
| 9     | 89.90                      | 3.32                  | 3.14  | 3.15  | 1.79  | 1.99  | -.14  | -.36  | -.54  | -.50  |
| 10    | 99.95                      | 3.94                  | 3.73  | 3.73  | 2.15  | 2.26  | -.16  | -.45  | -.66  | -.62  |
| 11    | 109.95                     | 4.58                  | 4.31  | 4.32  | 2.47  | 2.59  | -.20  | -.50  | -.77  | -.74  |
| 12    | 119.90                     | 5.16                  | 4.87  | 4.87  | 2.76  | 2.87  | -.25  | -.62  | -.88  | -.86  |
| 13    | 129.95                     | 5.79                  | 5.46  | 5.47  | 3.08  | 3.19  | -.26  | -.75  | -1.07 | -.97  |
| 14    | 139.85                     | 6.41                  | 6.08  | 6.04  | 3.51  | 3.45  | -.27  | -.84  | -1.21 | -1.11 |
| 15    | 149.90                     | 7.09                  | 6.70  | 6.70  | 3.77  | 3.84  | -.28  | -.94  | -1.34 | -1.28 |
| 16    | 159.90                     | 7.89                  | 7.43  | 7.49  | 4.19  | 4.31  | -.30  | -1.07 | -1.54 | -1.47 |
| 17    | 169.90                     | 8.64                  | 8.13  | 8.22  | 4.51  | 4.74  | -.33  | -1.09 | -1.69 | -1.67 |
| 18    | 179.85                     | 9.49                  | 8.94  | 9.06  | 4.96  | 5.21  | -.34  | -1.11 | -1.85 | -1.89 |
| 19    | 189.60                     | 10.40                 | 9.84  | 9.95  | 5.43  | 5.77  | -.37  | -1.13 | -1.93 | -2.07 |

Nota: Os relógios comparadores Pto 6 e Pto 7 referencial externo a viga  
 Os relógios comparadores Pto 8 e Pto 9 tem a viga como referencial  
 Sinais ver Figura do posicionamento dos relógios comparadores

MODELO - VIGA IV

RESULTADOS DOS ENSAIOS

. ENSAIO 2

- DEFORMAÇÕES

EXTENSÔMETROS ELÉTRICOS DE RESISTÊNCIA

.UNIAXIAIS

.ROSETAS

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(KN) | F <sub>2</sub><br>(KN) | 1<br>(µE) | 2<br>(µE) | 3<br>(µE) | 4<br>(µE) | 5<br>(µE) | 6<br>(µE) | 7<br>(µE) | 8<br>(µE) | 9<br>(µE) | 10<br>(µE) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| 0.00                   | 0.00                   | +0.       | +0.       | +0.       | +0.       | +1.       | +1.       | +1.       | +0.       | +1.       | +1.        |
| 10.43                  | 9.41                   | +52.      | +54.      | +55.      | +44.      | +38.      | -67.      | -66.      | -69.      | -54.      | -48.       |
| 20.63                  | 19.16                  | +105.     | +108.     | +111.     | +87.      | +76.      | -136.     | -133.     | -136.     | -109.     | -99.       |
| 30.83                  | 29.15                  | +159.     | +163.     | +167.     | +131.     | +115.     | -206.     | -200.     | -205.     | -164.     | -150.      |
| 0.59                   | 0.00                   | +9.       | +8.       | +7.       | +7.       | +7.       | -3.       | -4.       | -6.       | -4.       | -3.        |
| 10.55                  | 9.64                   | +58.      | +59.      | +60.      | +47.      | +42.      | -76.      | -69.      | -72.      | -57.      | -51.       |
| 20.63                  | 19.40                  | +109.     | +111.     | +114.     | +89.      | +78.      | -137.     | -134.     | -138.     | -110.     | -100.      |
| 30.83                  | 29.15                  | +160.     | +163.     | +169.     | +132.     | +115.     | -206.     | -200.     | -205.     | -164.     | -150.      |
| 41.27                  | 38.79                  | +212.     | +216.     | +224.     | +175.     | +153.     | -274.     | -267.     | -274.     | -218.     | -200.      |
| 51.35                  | 48.55                  | +264.     | +270.     | +279.     | +218.     | +191.     | -342.     | -333.     | -343.     | -272.     | -250.      |
| 61.43                  | 58.54                  | +316.     | +324.     | +336.     | +263.     | +229.     | -409.     | -400.     | -414.     | -328.     | -301.      |
| 71.75                  | 68.06                  | +369.     | +377.     | +392.     | +307.     | +268.     | -475.     | -467.     | -484.     | -383.     | -351.      |
| 82.30                  | 77.58                  | +421.     | +431.     | +448.     | +352.     | +307.     | -539.     | -533.     | -557.     | -440.     | -401.      |
| 91.68                  | 88.04                  | +476.     | +489.     | +510.     | +400.     | +349.     | -607.     | -603.     | -630.     | -497.     | -453.      |
| 102.34                 | 97.44                  | +533.     | +548.     | +571.     | +450.     | +391.     | -673.     | -672.     | -707.     | -555.     | -502.      |
| 111.84                 | 107.67                 | +592.     | +610.     | +635.     | +500.     | +436.     | -739.     | -744.     | -788.     | -615.     | -553.      |
| 121.92                 | 118.00                 | +662.     | +680.     | +707.     | +557.     | +485.     | -805.     | -822.     | -884.     | -683.     | -606.      |
| 132.36                 | 127.41                 | +726.     | +746.     | +778.     | +611.     | +532.     | -862.     | -896.     | -982.     | -752.     | -656.      |
| 142.32                 | 137.40                 | +793.     | +816.     | +853.     | +666.     | +581.     | -907.     | -975.     | -1099.    | -832.     | -707.      |
| 153.11                 | 146.46                 | +855.     | +887.     | +935.     | +716.     | +632.     | -918.     | -1045.    | -1269.    | -936.     | -754.      |

UNIVERSIDADE DE SAO PAULO  
 ESCOLA DE ENGENHARIA DE SAO CARLOS  
 DEPARTAMENTO DE ESTRUTURAS

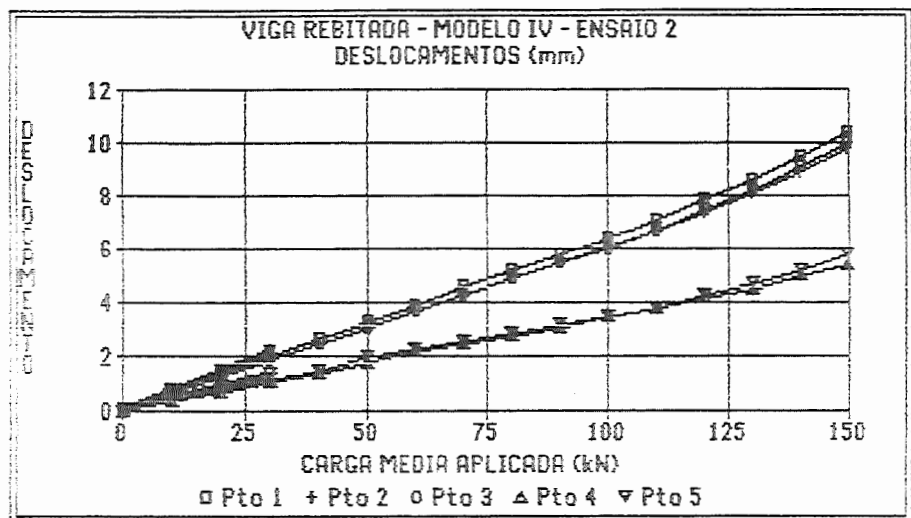
ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00                   | 0.00                   | +0.                    | +0.                    | +0.                    | +0.                    | +1.                    | +1.                    | +1.                    | +0.                    | +1.                    | +1.                     |
| 10.43                  | 9.41                   | +52.                   | +54.                   | +55.                   | +44.                   | +30.                   | -67.                   | -66.                   | -68.                   | -54.                   | -48.                    |
| 20.63                  | 19.16                  | +105.                  | +108.                  | +111.                  | +87.                   | +76.                   | -136.                  | -133.                  | -136.                  | -109.                  | -99.                    |
| 30.83                  | 29.15                  | +159.                  | +163.                  | +167.                  | +131.                  | +115.                  | -206.                  | -200.                  | -205.                  | -164.                  | -150.                   |
| 0.59                   | 0.00                   | +9.                    | +8.                    | +7.                    | +7.                    | +7.                    | -3.                    | -4.                    | -6.                    | -4.                    | -3.                     |
| 10.55                  | 9.64                   | +58.                   | +59.                   | +60.                   | +47.                   | +42.                   | -70.                   | -69.                   | -72.                   | -57.                   | -51.                    |
| 20.63                  | 19.40                  | +109.                  | +111.                  | +114.                  | +89.                   | +78.                   | -137.                  | -134.                  | -138.                  | -110.                  | -100.                   |
| 30.83                  | 29.15                  | +160.                  | +163.                  | +169.                  | +132.                  | +115.                  | -206.                  | -200.                  | -205.                  | -164.                  | -150.                   |
| 41.27                  | 38.79                  | +212.                  | +216.                  | +224.                  | +175.                  | +153.                  | -274.                  | -267.                  | -274.                  | -218.                  | -200.                   |
| 51.35                  | 48.55                  | +264.                  | +270.                  | +279.                  | +218.                  | +191.                  | -342.                  | -333.                  | -343.                  | -272.                  | -250.                   |
| 61.43                  | 58.54                  | +316.                  | +324.                  | +336.                  | +263.                  | +229.                  | -409.                  | -400.                  | -414.                  | -328.                  | -301.                   |
| 71.75                  | 68.06                  | +369.                  | +377.                  | +392.                  | +307.                  | +260.                  | -475.                  | -467.                  | -484.                  | -383.                  | -351.                   |
| 82.30                  | 77.58                  | +421.                  | +431.                  | +448.                  | +352.                  | +307.                  | -539.                  | -533.                  | -557.                  | -440.                  | -401.                   |
| 91.68                  | 88.04                  | +476.                  | +489.                  | +510.                  | +400.                  | +349.                  | -607.                  | -603.                  | -630.                  | -497.                  | -453.                   |
| 102.34                 | 97.44                  | +533.                  | +548.                  | +571.                  | +450.                  | +391.                  | -673.                  | -672.                  | -707.                  | -555.                  | -502.                   |
| 111.84                 | 107.67                 | +592.                  | +610.                  | +635.                  | +500.                  | +436.                  | -739.                  | -744.                  | -788.                  | -615.                  | -553.                   |
| 121.92                 | 118.00                 | +662.                  | +680.                  | +707.                  | +557.                  | +485.                  | -805.                  | -822.                  | -884.                  | -683.                  | -606.                   |
| 132.36                 | 127.41                 | +726.                  | +746.                  | +778.                  | +611.                  | +532.                  | -862.                  | -896.                  | -982.                  | -752.                  | -656.                   |
| 142.32                 | 137.40                 | +793.                  | +816.                  | +853.                  | +666.                  | +581.                  | -907.                  | -975.                  | -1099.                 | -832.                  | -707.                   |
| 153.11                 | 146.46                 | +855.                  | +887.                  | +935.                  | +716.                  | +632.                  | -918.                  | -1045.                 | -1269.                 | -936.                  | -754.                   |
| 0.94                   | 0.23                   | +104.                  | +92.                   | +81.                   | +86.                   | +68.                   | -31.                   | -46.                   | -118.                  | -69.                   | -38.                    |

UNIVERSIDADE DE SAO PAULO  
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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV      ENSAIO No.2      DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) | 7<br>( $\mu\epsilon$ ) | 8<br>( $\mu\epsilon$ ) | 9<br>( $\mu\epsilon$ ) | 10<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|
| 0.00          | 0.00          | +1.                    | +0.                    | +1.                    | +1.                    | +0.                    | +0.                    | +1.                    | +1.                    | +1.                    | +1.                     |
| 10.43         | 9.41          | +26.                   | +27.                   | +38.                   | +12.                   | +19.                   | -34.                   | -36.                   | -39.                   | -31.                   | -28.                    |
| 20.63         | 19.16         | +53.                   | +56.                   | +77.                   | +22.                   | +38.                   | -72.                   | -74.                   | -77.                   | -61.                   | -58.                    |
| 30.83         | 29.15         | +80.                   | +84.                   | +116.                  | +33.                   | +50.                   | -111.                  | -112.                  | -115.                  | -93.                   | -87.                    |
| 0.59          | 0.00          | +8.                    | +7.                    | +7.                    | +7.                    | +4.                    | -3.                    | -3.                    | -3.                    | -3.                    | -2.                     |
| 10.55         | 9.64          | +32.                   | +32.                   | +44.                   | +16.                   | +20.                   | -37.                   | -40.                   | -42.                   | -33.                   | -31.                    |
| 20.63         | 19.40         | +56.                   | +57.                   | +80.                   | +24.                   | +38.                   | -74.                   | -76.                   | -79.                   | -63.                   | -59.                    |
| 30.83         | 29.15         | +80.                   | +84.                   | +116.                  | +33.                   | +57.                   | -112.                  | -113.                  | -116.                  | -94.                   | -88.                    |
| 41.27         | 38.79         | +105.                  | +111.                  | +153.                  | +42.                   | +76.                   | -150.                  | -151.                  | -154.                  | -125.                  | -118.                   |
| 51.35         | 48.55         | +131.                  | +138.                  | +190.                  | +51.                   | +96.                   | -188.                  | -188.                  | -192.                  | -156.                  | -148.                   |
| 61.43         | 58.54         | +157.                  | +166.                  | +228.                  | +60.                   | +115.                  | -227.                  | -226.                  | -230.                  | -189.                  | -179.                   |
| 71.75         | 68.06         | +182.                  | +195.                  | +267.                  | +70.                   | +135.                  | -265.                  | -263.                  | -268.                  | -221.                  | -209.                   |
| 82.30         | 77.58         | +208.                  | +224.                  | +305.                  | +78.                   | +155.                  | -302.                  | -300.                  | -307.                  | -253.                  | -240.                   |
| 91.68         | 88.04         | +237.                  | +257.                  | +350.                  | +91.                   | +181.                  | -348.                  | -341.                  | -346.                  | -287.                  | -274.                   |
| 102.34        | 97.44         | +268.                  | +291.                  | +393.                  | +102.                  | +206.                  | -392.                  | -380.                  | -381.                  | -319.                  | -305.                   |
| 111.84        | 107.67        | +302.                  | +328.                  | +440.                  | +118.                  | +234.                  | -440.                  | -423.                  | -421.                  | -355.                  | -338.                   |
| 121.92        | 118.00        | +347.                  | +373.                  | +495.                  | +137.                  | +263.                  | -490.                  | -470.                  | -469.                  | -394.                  | -369.                   |
| 132.36        | 127.41        | +385.                  | +416.                  | +551.                  | +151.                  | +291.                  | -535.                  | -515.                  | -515.                  | -432.                  | -396.                   |
| 142.32        | 137.40        | +426.                  | +462.                  | +615.                  | +165.                  | +321.                  | -581.                  | -563.                  | -568.                  | -477.                  | -425.                   |
| 153.11        | 146.46        | +457.                  | +507.                  | +685.                  | +168.                  | +354.                  | -625.                  | -611.                  | -620.                  | -525.                  | -448.                   |
| 0.94          | 0.23          | +122.                  | +92.                   | +97.                   | +70.                   | +52.                   | -58.                   | -54.                   | -56.                   | -49.                   | -12.                    |





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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 3

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>(µε) | 2<br>(µε) | 3<br>(µε) | 4<br>(µε) | 5<br>(µε) | 6<br>(µε) |
|------------------------|------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.00                   | 0.00                   | +0.       | +0.       | +0.       | +1.       | +1.       | +1.       |
| 10.43                  | 9.41                   | +19.      | +27.      | +11.      | -35.      | -37.      | -29.      |
| 20.63                  | 19.16                  | +42.      | +54.      | +22.      | -71.      | -71.      | -58.      |
| 30.83                  | 29.15                  | +63.      | +81.      | +33.      | -108.     | -107.     | -87.      |
| 0.59                   | 0.00                   | +7.       | +8.       | +5.       | -4.       | -5.       | -2.       |
| 10.55                  | 9.64                   | +24.      | +32.      | +13.      | -37.      | -39.      | -30.      |
| 20.63                  | 19.40                  | +44.      | +57.      | +23.      | -73.      | -73.      | -58.      |
| 30.83                  | 29.15                  | +63.      | +82.      | +33.      | -109.     | -107.     | -88.      |
| 41.27                  | 38.79                  | +84.      | +108.     | +44.      | -145.     | -142.     | -117.     |
| 51.35                  | 48.55                  | +104.     | +135.     | +53.      | -181.     | -177.     | -147.     |
| 61.43                  | 58.54                  | +124.     | +162.     | +62.      | -217.     | -212.     | -177.     |
| 71.75                  | 68.06                  | +146.     | +190.     | +71.      | -253.     | -248.     | -207.     |
| 82.30                  | 77.58                  | +166.     | +218.     | +80.      | -290.     | -285.     | -238.     |
| 91.68                  | 88.04                  | +186.     | +249.     | +90.      | -328.     | -322.     | -268.     |
| 102.34                 | 97.44                  | +210.     | +280.     | +102.     | -366.     | -364.     | -300.     |
| 111.84                 | 107.67                 | +233.     | +313.     | +116.     | -406.     | -400.     | -332.     |
| 121.92                 | 118.00                 | +266.     | +352.     | +140.     | -450.     | -460.     | -369.     |
| 132.36                 | 127.41                 | +291.     | +391.     | +154.     | -494.     | -512.     | -403.     |
| 142.32                 | 137.40                 | +313.     | +432.     | +166.     | -538.     | -565.     | -437.     |
| 153.11                 | 146.46                 | +321.     | +474.     | +166.     | -583.     | -621.     | -474.     |
| 0.94                   | 0.23                   | +87.      | +83.      | +77.      | -49.      | -60.      | -35.      |

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 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 4

| $F_x$<br>(kN) | $F_z$<br>(kN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) | 7<br>( $\mu E$ ) | 8<br>( $\mu E$ ) | 9<br>( $\mu E$ ) | 10<br>( $\mu E$ ) |
|---------------|---------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| 0.00          | 0.00          | +1.              | +0.              | +0.              | +0.              | +1.              | +0.              | +1.              | +1.              | +1.              | +1.               |
| 10.43         | 9.41          | +3.              | +12.             | +23.             | +7.              | +6.              | -24.             | -26.             | -32.             | -27.             | -20.              |
| 20.63         | 19.16         | +7.              | +24.             | +45.             | +14.             | +11.             | -55.             | -53.             | -58.             | -52.             | -42.              |
| 30.83         | 29.15         | +12.             | +36.             | +65.             | +20.             | +16.             | -85.             | -81.             | -85.             | -77.             | -63.              |
| 0.59          | 0.00          | +7.              | +7.              | +7.              | +6.              | +7.              | -2.              | -3.              | -4.              | -3.              | -2.               |
| 10.55         | 9.64          | +7.              | +17.             | +29.             | +10.             | +8.              | -26.             | -28.             | -33.             | -28.             | -21.              |
| 20.63         | 19.40         | +9.              | +26.             | +46.             | +15.             | +12.             | -56.             | -54.             | -59.             | -53.             | -43.              |
| 30.83         | 29.15         | +12.             | +36.             | +66.             | +20.             | +16.             | -86.             | -81.             | -85.             | -78.             | -64.              |
| 41.27         | 38.79         | +16.             | +47.             | +86.             | +26.             | +20.             | -117.            | -109.            | -111.            | -103.            | -85.              |
| 51.35         | 48.55         | +20.             | +58.             | +107.            | +33.             | +25.             | -148.            | -137.            | -137.            | -128.            | -107.             |
| 61.43         | 58.54         | +21.             | +69.             | +128.            | +39.             | +29.             | -179.            | -165.            | -163.            | -153.            | -129.             |
| 71.75         | 68.06         | +25.             | +81.             | +150.            | +46.             | +33.             | -211.            | -194.            | -190.            | -179.            | -151.             |
| 82.30         | 77.58         | +27.             | +92.             | +174.            | +54.             | +36.             | -242.            | -222.            | -218.            | -205.            | -172.             |
| 91.68         | 88.04         | +25.             | +108.            | +210.            | +66.             | +39.             | -275.            | -252.            | -246.            | -232.            | -195.             |
| 102.34        | 97.44         | +31.             | +123.            | +239.            | +77.             | +46.             | -306.            | -281.            | -277.            | -261.            | -217.             |
| 111.84        | 107.67        | +37.             | +141.            | +268.            | +91.             | +54.             | -337.            | -313.            | -310.            | -292.            | -241.             |
| 121.92        | 118.00        | +56.             | +166.            | +305.            | +111.            | +69.             | -372.            | -348.            | -349.            | -327.            | -268.             |
| 132.30        | 127.41        | +59.             | +188.            | +351.            | +132.            | +75.             | -408.            | -382.            | -385.            | -360.            | -294.             |
| 142.02        | 137.40        | +57.             | +213.            | +408.            | +154.            | +80.             | -448.            | -416.            | -417.            | -391.            | -321.             |
| 153.11        | 146.46        | +28.             | +238.            | +496.            | +178.            | +72.             | -497.            | -450.            | -443.            | -417.            | -344.             |
| 0.94          | 0.23          | +75.             | +75.             | +83.             | +74.             | +65.             | -41.             | -52.             | -72.             | -57.             | -17.              |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 SECAO 5

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu E$ ) | 2<br>( $\mu E$ ) | 3<br>( $\mu E$ ) | 4<br>( $\mu E$ ) | 5<br>( $\mu E$ ) | 6<br>( $\mu E$ ) |
|---------------|---------------|------------------|------------------|------------------|------------------|------------------|------------------|
| 0.00          | 0.00          | +0.              | +0.              | +1.              | +1.              | +1.              | +0.              |
| 10.43         | 9.41          | +7.              | +10.             | +8.              | -27.             | -32.             | -21.             |
| 20.63         | 19.16         | +12.             | +21.             | +17.             | -56.             | -61.             | -42.             |
| 30.83         | 29.15         | +18.             | +33.             | +25.             | -85.             | -90.             | -62.             |
| 0.59          | 0.00          | +5.              | +5.              | +5.              | -2.              | -3.              | +0.              |
| 10.55         | 9.64          | +9.              | +13.             | +11.             | -30.             | -35.             | -22.             |
| 20.63         | 19.40         | +13.             | +22.             | +17.             | -58.             | -63.             | -43.             |
| 30.83         | 29.15         | +18.             | +33.             | +23.             | -86.             | -90.             | -63.             |
| 41.27         | 38.79         | +21.             | +43.             | +31.             | -114.            | -118.            | -84.             |
| 51.35         | 48.55         | +28.             | +55.             | +38.             | -143.            | -146.            | -103.            |
| 61.43         | 58.54         | +34.             | +66.             | +46.             | -173.            | -174.            | -123.            |
| 71.75         | 68.06         | +39.             | +78.             | +54.             | -201.            | -201.            | -142.            |
| 82.30         | 77.58         | +45.             | +90.             | +62.             | -229.            | -227.            | -161.            |
| 91.68         | 88.04         | +53.             | +108.            | +73.             | -261.            | -253.            | -180.            |
| 102.34        | 97.44         | +62.             | +125.            | +84.             | -292.            | -276.            | -198.            |
| 111.84        | 107.67        | +73.             | +145.            | +100.            | -325.            | -302.            | -218.            |
| 121.92        | 118.00        | +91.             | +172.            | +124.            | -364.            | -334.            | -241.            |
| 132.36        | 127.41        | +102.            | +195.            | +143.            | -399.            | -361.            | -260.            |
| 142.32        | 137.40        | +112.            | +222.            | +161.            | -437.            | -392.            | -281.            |
| 153.11        | 146.46        | +110.            | +247.            | +170.            | -474.            | -411.            | -299.            |
| 0.94          | 0.23          | +88.             | +83.             | +96.             | -49.             | -48.             | +5.              |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV            ENSAIO No.2            DATA: 27/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 6

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| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) |
|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00                   | 0.00                   | +0.                    | +1.                    | +0.                    |
| 10.43                  | 9.41                   | +53.                   | +52.                   | +53.                   |
| 20.63                  | 19.16                  | +100.                  | +104.                  | +106.                  |
| 30.83                  | 29.15                  | +163.                  | +157.                  | +160.                  |
| 0.59                   | 0.00                   | +8.                    | +8.                    | +6.                    |
| 10.55                  | 9.64                   | +58.                   | +57.                   | +57.                   |
| 20.63                  | 19.40                  | +110.                  | +106.                  | +108.                  |
| 30.83                  | 29.15                  | +162.                  | +157.                  | +161.                  |
| 41.27                  | 38.79                  | +215.                  | +209.                  | +214.                  |
| 51.35                  | 48.55                  | +271.                  | +261.                  | +267.                  |
| 61.43                  | 58.54                  | +326.                  | +315.                  | +321.                  |
| 71.75                  | 68.06                  | +386.                  | +369.                  | +375.                  |
| 82.30                  | 77.58                  | +445.                  | +423.                  | +430.                  |
| 91.68                  | 88.04                  | +507.                  | +483.                  | +490.                  |
| 102.34                 | 97.44                  | +569.                  | +541.                  | +549.                  |
| 111.84                 | 107.67                 | +636.                  | +604.                  | +611.                  |
| 121.92                 | 118.00                 | +712.                  | +675.                  | +681.                  |
| 132.36                 | 127.41                 | +782.                  | +744.                  | +750.                  |
| 142.32                 | 137.40                 | +855.                  | +815.                  | +824.                  |
| 153.11                 | 146.46                 | +922.                  | +890.                  | +905.                  |
| 0.94                   | 0.23                   | +113.                  | +95.                   | +74.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
VIGA IV            ENSAIO No.2            DATA: 27/03/91  
DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 7

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|
| 0.00          | 0.00          | +0.                    | +0.                    | +0.                    |
| 10.43         | 9.41          | +53.                   | +52.                   | +55.                   |
| 20.63         | 19.16         | +106.                  | +105.                  | +111.                  |
| 30.83         | 29.15         | +160.                  | +158.                  | +166.                  |
| 0.59          | 0.00          | +9.                    | +8.                    | +7.                    |
| 10.55         | 9.64          | +58.                   | +56.                   | +60.                   |
| 20.63         | 19.40         | +109.                  | +107.                  | +113.                  |
| 30.83         | 29.15         | +160.                  | +159.                  | +166.                  |
| 41.27         | 38.79         | +213.                  | +211.                  | +222.                  |
| 51.35         | 48.55         | +265.                  | +264.                  | +276.                  |
| 61.43         | 58.54         | +318.                  | +316.                  | +332.                  |
| 71.75         | 68.06         | +371.                  | +370.                  | +387.                  |
| 82.30         | 77.58         | +424.                  | +424.                  | +444.                  |
| 91.68         | 88.04         | +480.                  | +481.                  | +506.                  |
| 102.34        | 97.44         | +537.                  | +539.                  | +566.                  |
| 111.84        | 107.67        | +599.                  | +600.                  | +631.                  |
| 121.92        | 118.00        | +668.                  | +669.                  | +702.                  |
| 132.36        | 127.41        | +733.                  | +733.                  | +773.                  |
| 142.32        | 137.40        | +800.                  | +802.                  | +849.                  |
| 153.11        | 146.46        | +862.                  | +870.                  | +933.                  |
| 0.94          | 0.23          | +104.                  | +88.                   | +80.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
SECAO 8

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|
| 0.00          | 0.00          | +0.                    | +0.                    | +1.                    |
| 10.43         | 9.41          | +51.                   | +52.                   | +56.                   |
| 20.63         | 19.16         | +103.                  | +106.                  | +113.                  |
| 30.83         | 29.15         | +155.                  | +159.                  | +168.                  |
| 0.59          | 0.00          | +8.                    | +8.                    | +8.                    |
| 10.55         | 9.64          | +56.                   | +58.                   | +61.                   |
| 20.63         | 19.40         | +105.                  | +108.                  | +115.                  |
| 30.83         | 29.15         | +155.                  | +160.                  | +168.                  |
| 41.27         | 38.79         | +206.                  | +211.                  | +225.                  |
| 51.35         | 48.55         | +257.                  | +264.                  | +280.                  |
| 61.43         | 58.54         | +309.                  | +318.                  | +338.                  |
| 71.75         | 68.06         | +362.                  | +373.                  | +396.                  |
| 82.30         | 77.58         | +419.                  | +428.                  | +454.                  |
| 91.68         | 88.04         | +480.                  | +490.                  | +520.                  |
| 102.34        | 97.44         | +543.                  | +550.                  | +585.                  |
| 111.84        | 107.67        | +609.                  | +615.                  | +652.                  |
| 121.92        | 118.00        | +686.                  | +687.                  | +727.                  |
| 132.36        | 127.41        | +756.                  | +757.                  | +801.                  |
| 142.32        | 137.40        | +829.                  | +831.                  | +880.                  |
| 153.11        | 146.46        | +897.                  | +906.                  | +966.                  |
| 0.94          | 0.23          | +111.                  | +95.                   | +85.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 MONTANTE 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00          | 0.00          | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    | +0.                    |
| 10.43         | 9.41          | +8.                    | -14.                   | -33.                   | +14.                   | -14.                   | -39.                   |
| 20.63         | 19.16         | +18.                   | -29.                   | -70.                   | +31.                   | -28.                   | -78.                   |
| 30.83         | 29.15         | +28.                   | -45.                   | -107.                  | +46.                   | -41.                   | -118.                  |
| 0.59          | 0.00          | +7.                    | +3.                    | -2.                    | +10.                   | +2.                    | -5.                    |
| 10.55         | 9.64          | +13.                   | -13.                   | -35.                   | +20.                   | -13.                   | -42.                   |
| 20.63         | 19.40         | +20.                   | -29.                   | -71.                   | +33.                   | -27.                   | -80.                   |
| 30.83         | 29.15         | +29.                   | -45.                   | -108.                  | +46.                   | -41.                   | -119.                  |
| 41.27         | 38.79         | +38.                   | -60.                   | -146.                  | +61.                   | -56.                   | -158.                  |
| 51.35         | 48.55         | +48.                   | -76.                   | -184.                  | +77.                   | -69.                   | -198.                  |
| 61.43         | 58.54         | +60.                   | -93.                   | -224.                  | +92.                   | -83.                   | -237.                  |
| 71.75         | 68.06         | +71.                   | -109.                  | -263.                  | +107.                  | -97.                   | -277.                  |
| 82.30         | 77.58         | +83.                   | -124.                  | -303.                  | +123.                  | -110.                  | -316.                  |
| 91.68         | 88.04         | +99.                   | -142.                  | -350.                  | +163.                  | -119.                  | -369.                  |
| 102.34        | 97.44         | +115.                  | -158.                  | -393.                  | +183.                  | -130.                  | -408.                  |
| 111.84        | 107.67        | +132.                  | -173.                  | -436.                  | +203.                  | -140.                  | -446.                  |
| 121.92        | 118.00        | +165.                  | -184.                  | -486.                  | +230.                  | -151.                  | -489.                  |
| 132.36        | 127.41        | +177.                  | -197.                  | -520.                  | +253.                  | -159.                  | -524.                  |
| 142.32        | 137.40        | +189.                  | -211.                  | -555.                  | +279.                  | -165.                  | -558.                  |
| 153.11        | 146.46        | +201.                  | -227.                  | -594.                  | +312.                  | -169.                  | -592.                  |
| 0.94          | 0.23          | +64.                   | +29.                   | -4.                    | +93.                   | +30.                   | -24.                   |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 MONTANTE 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | 1<br>( $\mu\epsilon$ ) | 2<br>( $\mu\epsilon$ ) | 3<br>( $\mu\epsilon$ ) | 4<br>( $\mu\epsilon$ ) | 5<br>( $\mu\epsilon$ ) | 6<br>( $\mu\epsilon$ ) |
|---------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 0.00          | 0.00          | +1.                    | +0.                    | +1.                    | +1.                    | +0.                    | +0.                    |
| 10.43         | 9.41          | -34.                   | -13.                   | +13.                   | -35.                   | -16.                   | +4.                    |
| 20.63         | 19.16         | -71.                   | -28.                   | +23.                   | -70.                   | -31.                   | +8.                    |
| 30.83         | 29.15         | -107.                  | -43.                   | +33.                   | -103.                  | -45.                   | +13.                   |
| 0.59          | 0.00          | -1.                    | +2.                    | +6.                    | +2.                    | +3.                    | +4.                    |
| 10.55         | 9.64          | -35.                   | -12.                   | +15.                   | -34.                   | -14.                   | +6.                    |
| 20.63         | 19.40         | -72.                   | -28.                   | +23.                   | -69.                   | -30.                   | +9.                    |
| 30.83         | 29.15         | -107.                  | -44.                   | +32.                   | -103.                  | -45.                   | +13.                   |
| 41.27         | 38.79         | -143.                  | -59.                   | +39.                   | -137.                  | -59.                   | +17.                   |
| 51.35         | 48.55         | -179.                  | -75.                   | +46.                   | -171.                  | -73.                   | +22.                   |
| 61.43         | 58.54         | -215.                  | -91.                   | +55.                   | -204.                  | -87.                   | +27.                   |
| 71.75         | 68.06         | -253.                  | -108.                  | +62.                   | -238.                  | -101.                  | +32.                   |
| 82.30         | 77.58         | -290.                  | -124.                  | +71.                   | -271.                  | -115.                  | +38.                   |
| 91.68         | 88.04         | -326.                  | -140.                  | +77.                   | -294.                  | -124.                  | +42.                   |
| 102.34        | 97.44         | -363.                  | -155.                  | +87.                   | -323.                  | -136.                  | +48.                   |
| 111.84        | 107.67        | -404.                  | -171.                  | +102.                  | -352.                  | -147.                  | +56.                   |
| 121.92        | 118.00        | -441.                  | -183.                  | +119.                  | -380.                  | -156.                  | +65.                   |
| 132.36        | 127.41        | -489.                  | -198.                  | +143.                  | -410.                  | -164.                  | +79.                   |
| 142.32        | 137.40        | -542.                  | -214.                  | +168.                  | -439.                  | -170.                  | +96.                   |
| 153.11        | 146.46        | -596.                  | -232.                  | +191.                  | -465.                  | -173.                  | +117.                  |
| 0.94          | 0.23          | -21.                   | +19.                   | +69.                   | +53.                   | +37.                   | +27.                   |



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ENSAIO DE VIGAS DE ACO REBITADAS  
 VIGA IV ENSAIO No.2 DATA: 27/03/91  
 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 TIRANTE 1

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µε) | S1.2<br>(µε) | S2.1<br>(µε) | S2.2<br>(µε) | S3.1<br>(µε) | S3.2<br>(µε) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | 0.00                   | +0.          | +0.          | +0.          | +0.          | +0.          | -1.          |
| 10.43                  | 9.41                   | +62.         | +71.         | +67.         | +61.         | +68.         | +68.         |
| 20.63                  | 19.16                  | +126.        | +144.        | +135.        | +126.        | +141.        | +137.        |
| 30.83                  | 29.15                  | +191.        | +216.        | +204.        | +191.        | +216.        | +204.        |
| 0.59                   | 0.00                   | -5.          | -6.          | -5.          | -6.          | -12.         | +6.          |
| 10.55                  | 9.64                   | +57.         | +70.         | +65.         | +59.         | +61.         | +69.         |
| 20.63                  | 19.40                  | +123.        | +143.        | +134.        | +125.        | +138.        | +137.        |
| 30.83                  | 29.15                  | +190.        | +217.        | +204.        | +191.        | +214.        | +205.        |
| 41.27                  | 38.79                  | +256.        | +290.        | +271.        | +256.        | +288.        | +274.        |
| 51.35                  | 48.55                  | +323.        | +360.        | +339.        | +321.        | +361.        | +343.        |
| 61.43                  | 58.54                  | +388.        | +430.        | +405.        | +386.        | +433.        | +412.        |
| 71.75                  | 68.06                  | +454.        | +500.        | +472.        | +450.        | +506.        | +480.        |
| 82.30                  | 77.58                  | +520.        | +568.        | +538.        | +514.        | +576.        | +548.        |
| 91.68                  | 88.04                  | +589.        | +649.        | +606.        | +579.        | +646.        | +616.        |
| 102.34                 | 97.44                  | +649.        | +709.        | +665.        | +637.        | +711.        | +678.        |
| 111.84                 | 107.67                 | +702.        | +763.        | +719.        | +689.        | +768.        | +734.        |
| 121.92                 | 118.00                 | +731.        | +794.        | +753.        | +722.        | +808.        | +774.        |
| 132.36                 | 127.41                 | +776.        | +841.        | +797.        | +765.        | +853.        | +819.        |
| 142.32                 | 137.40                 | +816.        | +883.        | +835.        | +803.        | +894.        | +859.        |
| 153.11                 | 146.46                 | +853.        | +922.        | +871.        | +838.        | +932.        | +898.        |
| 0.94                   | 0.23                   | -138.        | -114.        | -126.        | -121.        | -137.        | -138.        |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS UNIAXIAIS  
 TIRANTE 2

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | S1.1<br>(µε) | S1.2<br>(µε) | S2.1<br>(µε) | S2.2<br>(µε) | S3.1<br>(µε) | S3.2<br>(µε) |
|------------------------|------------------------|--------------|--------------|--------------|--------------|--------------|--------------|
| 0.00                   | 0.00                   | -1.          | +0.          | -1.          | +0.          | -1.          | +0.          |
| 10.43                  | 9.41                   | +72.         | +70.         | +71.         | +65.         | +77.         | +64.         |
| 20.63                  | 19.16                  | +141.        | +136.        | +138.        | +128.        | +152.        | +122.        |
| 30.83                  | 29.15                  | +210.        | +203.        | +204.        | +193.        | +232.        | +177.        |
| 0.59                   | 0.00                   | -4.          | -7.          | -5.          | -7.          | -24.         | +7.          |
| 10.55                  | 9.64                   | +69.         | +63.         | +66.         | +60.         | +68.         | +62.         |
| 20.63                  | 19.40                  | +139.        | +132.        | +135.        | +125.        | +149.        | +119.        |
| 30.83                  | 29.15                  | +211.        | +202.        | +204.        | +192.        | +231.        | +176.        |
| 41.27                  | 38.79                  | +281.        | +271.        | +271.        | +257.        | +310.        | +234.        |
| 51.35                  | 48.55                  | +349.        | +340.        | +337.        | +322.        | +388.        | +292.        |
| 61.43                  | 58.54                  | +418.        | +410.        | +403.        | +388.        | +464.        | +351.        |
| 71.75                  | 68.06                  | +487.        | +479.        | +469.        | +454.        | +539.        | +413.        |
| 82.30                  | 77.58                  | +555.        | +550.        | +535.        | +519.        | +616.        | +473.        |
| 91.68                  | 88.04                  | +596.        | +603.        | +583.        | +568.        | +675.        | +520.        |
| 102.34                 | 97.44                  | +659.        | +665.        | +643.        | +627.        | +742.        | +575.        |
| 111.84                 | 107.67                 | +716.        | +721.        | +696.        | +681.        | +801.        | +625.        |
| 121.92                 | 118.00                 | +773.        | +776.        | +746.        | +730.        | +850.        | +670.        |
| 132.36                 | 127.41                 | +819.        | +822.        | +792.        | +776.        | +902.        | +713.        |
| 142.32                 | 137.40                 | +861.        | +865.        | +835.        | +820.        | +949.        | +754.        |
| 153.11                 | 146.46                 | +903.        | +907.        | +879.        | +862.        | +996.        | +794.        |
| 0.94                   | 0.23                   | -152.        | -150.        | -140.        | -138.        | -125.        | -164.        |

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ENSAIO DE VIGAS DE ACO REBITADAS  
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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 1

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +1.                               | +0.                               | +0.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 10.43         | 9.41          | -2.                               | +24.                              | +0.                               | +24.                              | -26.                              | +3.6                | -4.2                | +46.1                    |
| 20.63         | 19.16         | -7.                               | +46.                              | +0.                               | +46.                              | -53.                              | +6.9                | -8.0                | +46.9                    |
| 30.83         | 29.15         | -10.                              | +68.                              | -2.                               | +68.                              | -81.                              | +9.9                | -13.5               | +46.6                    |
| 0.59          | 0.00          | +3.                               | +2.                               | -1.                               | +3.                               | -1.                               | +0.6                | -0.1                | U/C                      |
| 10.55         | 9.64          | -2.                               | +25.                              | +0.                               | +25.                              | -27.                              | +3.8                | -4.3                | +46.1                    |
| 20.63         | 19.40         | -7.                               | +46.                              | -1.                               | +46.                              | -54.                              | +6.8                | -9.0                | +46.6                    |
| 30.83         | 29.15         | -10.                              | +69.                              | -3.                               | +69.                              | -82.                              | +10.0               | -13.9               | +46.4                    |
| 41.27         | 38.79         | -14.                              | +91.                              | -5.                               | +91.                              | -110.                             | +13.1               | -18.6               | +46.4                    |
| 51.35         | 48.55         | -19.                              | +114.                             | -8.                               | +114.                             | -140.                             | +16.1               | -23.9               | +46.3                    |
| 61.43         | 58.54         | -23.                              | +135.                             | -11.                              | +135.                             | -169.                             | +19.0               | -29.0               | +46.1                    |
| 71.75         | 68.06         | -26.                              | +159.                             | -15.                              | +159.                             | -200.                             | +22.3               | -34.2               | +45.8                    |
| 82.30         | 77.58         | -29.                              | +183.                             | -19.                              | +183.                             | -231.                             | +25.5               | -39.7               | +45.7                    |
| 91.68         | 88.04         | -31.                              | +206.                             | -26.                              | +206.                             | -263.                             | +28.7               | -45.3               | +45.3                    |
| 102.34        | 97.44         | -34.                              | +234.                             | -31.                              | +234.                             | -299.                             | +32.4               | -51.6               | +45.2                    |
| 111.84        | 107.67        | -36.                              | +263.                             | -38.                              | +263.                             | -337.                             | +36.5               | -58.1               | +44.9                    |
| 121.92        | 118.00        | -38.                              | +299.                             | -48.                              | +299.                             | -385.                             | +41.3               | -66.5               | +44.6                    |
| 132.36        | 127.41        | -39.                              | +335.                             | -61.                              | +335.                             | -434.                             | +46.1               | -75.2               | +44.2                    |
| 142.32        | 137.40        | -39.                              | +375.                             | -78.                              | +375.                             | -491.                             | +51.3               | -85.4               | +43.7                    |
| 153.11        | 146.46        | -39.                              | +429.                             | -105.                             | +430.                             | -573.                             | +58.0               | -100.1              | +43.1                    |
| 0.94          | 0.23          | +20.                              | +50.                              | -9.                               | +52.                              | -41.                              | +9.0                | -5.7                | +36.1                    |

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 DEFORMACOES DOS EXTENSOMETROS ELETRICOS DAS ROSETAS  
 ROSETA 2

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\delta$<br>(%) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|-----------------|
| 0.00          | 0.00          | +0.                               | +0.                               | +0.                               | +0.                               | +0.                               | +0.0                | +0.0                | U/D             |
| 10.43         | 9.41          | +1.                               | +36.                              | +6.                               | +36.                              | -29.                              | +6.1                | -4.2                | +47.1           |
| 20.63         | 19.16         | +0.                               | +67.                              | +9.                               | +67.                              | -59.                              | +11.2               | -8.7                | +46.9           |
| 30.83         | 29.15         | -1.                               | +96.                              | +9.                               | +97.                              | -89.                              | +15.7               | -13.5               | +46.5           |
| 0.59          | 0.00          | +5.                               | +3.                               | -3.                               | +5.                               | -3.                               | +0.9                | -0.4                | U/D             |
| 10.55         | 9.64          | +4.                               | +36.                              | +4.                               | +36.                              | -28.                              | +6.2                | -4.6                | +45.0           |
| 20.63         | 19.40         | +1.                               | +66.                              | +7.                               | +66.                              | -59.                              | +11.0               | -8.7                | +46.3           |
| 30.83         | 29.15         | -1.                               | +96.                              | +9.                               | +97.                              | -89.                              | +15.7               | -13.5               | +46.5           |
| 41.27         | 38.79         | -3.                               | +128.                             | +9.                               | +128.                             | -121.                             | +20.6               | -18.7               | +46.4           |
| 51.35         | 48.55         | -4.                               | +158.                             | +9.                               | +158.                             | -152.                             | +25.3               | -23.7               | +46.2           |
| 61.43         | 58.54         | -5.                               | +188.                             | +9.                               | +188.                             | -184.                             | +30.0               | -28.6               | +46.1           |
| 71.75         | 68.06         | -6.                               | +219.                             | +9.                               | +219.                             | -215.                             | +34.7               | -33.6               | +46.0           |
| 82.30         | 77.58         | -8.                               | +249.                             | +9.                               | +249.                             | -248.                             | +39.3               | -39.0               | +45.9           |
| 91.68         | 88.04         | -7.                               | +279.                             | +7.                               | +279.                             | -279.                             | +44.0               | -44.0               | +45.7           |
| 102.34        | 97.44         | -6.                               | +312.                             | +3.                               | +312.                             | -315.                             | +49.0               | -49.9               | +45.4           |
| 111.84        | 107.67        | -4.                               | +347.                             | -2.                               | +347.                             | -353.                             | +54.4               | -56.0               | +45.1           |
| 121.92        | 118.00        | -1.                               | +384.                             | -13.                              | +384.                             | -398.                             | +59.6               | -63.8               | +44.5           |
| 132.36        | 127.41        | +1.                               | +420.                             | -23.                              | +420.                             | -442.                             | +64.8               | -71.2               | +44.2           |
| 142.32        | 137.40        | +4.                               | +457.                             | -36.                              | +457.                             | -489.                             | +69.9               | -79.4               | +43.8           |
| 153.11        | 146.46        | +5.                               | +497.                             | -59.                              | +498.                             | -552.                             | +74.8               | -90.6               | +43.3           |
| 0.94          | 0.23          | +35.                              | +44.                              | -34.                              | +56.                              | -55.                              | +8.8                | -8.6                | +25.6           |

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 ROSETA 3

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +1.                               | -1.                               | +0.                               | +2.                               | -1.                               | +0.4                | -0.1                | U/C                      |
| 10.43         | 9.41          | -6.                               | +32.                              | +16.                              | +34.                              | -24.                              | +6.1                | -3.1                | +56.6                    |
| 20.63         | 19.16         | -14.                              | +60.                              | +27.                              | +64.                              | -50.                              | +10.9               | -7.0                | +55.7                    |
| 30.83         | 29.15         | -23.                              | +87.                              | +35.                              | +92.                              | -80.                              | +15.3               | -11.7               | +54.8                    |
| 0.59          | 0.00          | +5.                               | +7.                               | -1.                               | +7.                               | -4.                               | +1.4                | -0.3                | U/C                      |
| 10.55         | 9.64          | -4.                               | +36.                              | +15.                              | +37.                              | -26.                              | +6.7                | -3.3                | +53.7                    |
| 20.63         | 19.40         | -13.                              | +61.                              | +26.                              | +65.                              | -52.                              | +11.0               | -7.4                | +54.7                    |
| 30.83         | 29.15         | -23.                              | +87.                              | +35.                              | +92.                              | -80.                              | +15.3               | -11.7               | +54.8                    |
| 41.27         | 38.79         | -31.                              | +114.                             | +44.                              | +120.                             | -108.                             | +19.7               | -16.1               | +54.6                    |
| 51.35         | 48.55         | -40.                              | +140.                             | +52.                              | +148.                             | -135.                             | +24.1               | -20.5               | +54.5                    |
| 61.43         | 58.54         | -47.                              | +166.                             | +59.                              | +175.                             | -164.                             | +28.4               | -25.0               | +54.1                    |
| 71.75         | 68.06         | -56.                              | +193.                             | +65.                              | +202.                             | -193.                             | +32.6               | -29.8               | +53.9                    |
| 82.30         | 77.58         | -64.                              | +219.                             | +71.                              | +229.                             | -222.                             | +36.5               | -34.6               | +53.7                    |
| 91.68         | 88.04         | -71.                              | +248.                             | +75.                              | +258.                             | -255.                             | +41.0               | -39.9               | +53.3                    |
| 102.34        | 97.44         | -79.                              | +277.                             | +78.                              | +288.                             | -289.                             | +45.3               | -45.6               | +52.9                    |
| 111.84        | 107.67        | -85.                              | +309.                             | +80.                              | +320.                             | -325.                             | +50.2               | -51.6               | +52.4                    |
| 121.92        | 118.00        | -93.                              | +342.                             | +74.                              | +352.                             | -371.                             | +54.3               | -59.8               | +51.7                    |
| 132.36        | 127.41        | -99.                              | +376.                             | +68.                              | +385.                             | -417.                             | +58.7               | -67.8               | +51.0                    |
| 142.32        | 137.40        | -107.                             | +410.                             | +56.                              | +417.                             | -468.                             | +62.3               | -77.3               | +50.3                    |
| 153.11        | 146.46        | -118.                             | +443.                             | +29.                              | +448.                             | -537.                             | +64.7               | -90.7               | +49.3                    |
| 0.94          | 0.23          | +38.                              | +71.                              | -20.                              | +77.                              | -59.                              | +13.4               | -8.1                | +32.5                    |

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 ROSETA 4

| $F_1$<br>(kN) | $F_2$<br>(kN) | $\epsilon_a$<br>( $\mu\epsilon$ ) | $\epsilon_b$<br>( $\mu\epsilon$ ) | $\epsilon_c$<br>( $\mu\epsilon$ ) | $\epsilon_1$<br>( $\mu\epsilon$ ) | $\epsilon_2$<br>( $\mu\epsilon$ ) | $\sigma_1$<br>(MPa) | $\sigma_2$<br>(MPa) | $\theta$<br>( $^\circ$ ) |
|---------------|---------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------|---------------------|--------------------------|
| 0.00          | 0.00          | +1.                               | +0.                               | +0.                               | +1.                               | -0.                               | +0.2                | +0.0                | U/C                      |
| 10.45         | 9.41          | -7.                               | +23.                              | -4.                               | +23.                              | -33.                              | +2.9                | -5.9                | +46.5                    |
| 20.63         | 19.16         | -14.                              | +44.                              | -9.                               | +44.                              | -67.                              | +5.3                | -12.2               | +46.2                    |
| 30.83         | 29.15         | -22.                              | +62.                              | -17.                              | +62.                              | -101.                             | +7.2                | -18.6               | +45.8                    |
| 0.59          | 0.00          | +2.                               | +5.                               | +3.                               | +5.                               | -0.                               | +1.1                | +0.3                | U/C                      |
| 10.55         | 9.64          | -6.                               | +25.                              | -3.                               | +25.                              | -33.                              | +3.3                | -5.8                | +46.4                    |
| 20.63         | 19.40         | -14.                              | +44.                              | -9.                               | +45.                              | -68.                              | +5.4                | -12.4               | +46.2                    |
| 30.83         | 29.15         | -22.                              | +63.                              | -17.                              | +63.                              | -102.                             | +7.4                | -18.7               | +45.8                    |
| 41.27         | 38.79         | -30.                              | +81.                              | -26.                              | +81.                              | -138.                             | +9.0                | -25.6               | +45.5                    |
| 51.35         | 48.55         | -38.                              | +100.                             | -36.                              | +100.                             | -174.                             | +10.8               | -32.4               | +45.2                    |
| 61.43         | 58.54         | -46.                              | +118.                             | -47.                              | +118.                             | -212.                             | +12.3               | -39.8               | +44.9                    |
| 71.75         | 68.06         | -54.                              | +135.                             | -61.                              | +135.                             | -250.                             | +13.6               | -47.1               | +44.5                    |
| 82.30         | 77.58         | -62.                              | +151.                             | -75.                              | +152.                             | -289.                             | +14.6               | -54.8               | +44.2                    |
| 91.68         | 88.04         | -72.                              | +166.                             | -96.                              | +166.                             | -333.                             | +14.8               | -63.9               | +43.6                    |
| 102.34        | 97.44         | -80.                              | +181.                             | -117.                             | +181.                             | -379.                             | +15.2               | -73.1               | +43.1                    |
| 111.84        | 107.67        | -89.                              | +195.                             | -141.                             | +196.                             | -426.                             | +15.4               | -82.7               | +42.6                    |
| 121.92        | 118.00        | -95.                              | +214.                             | -165.                             | +216.                             | -475.                             | +16.5               | -92.4               | +42.1                    |
| 132.36        | 127.41        | -102.                             | +226.                             | -204.                             | +230.                             | -536.                             | +16.5               | -105.3              | +41.2                    |
| 142.32        | 137.40        | -110.                             | +234.                             | -260.                             | +240.                             | -610.                             | +12.9               | -121.3              | +39.9                    |
| 153.11        | 146.46        | -120.                             | +230.                             | -362.                             | +245.                             | -728.                             | +6.1                | -147.4              | +37.8                    |
| 0.94          | 0.23          | +13.                              | +27.                              | -15.                              | +30.                              | -32.                              | +4.6                | -5.1                | +31.3                    |

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 ROSETA 5

| F <sub>1</sub><br>(kN) | F <sub>2</sub><br>(kN) | ε <sub>a</sub><br>(με) | ε <sub>b</sub><br>(με) | ε <sub>c</sub><br>(με) | ε <sub>1</sub><br>(με) | ε <sub>2</sub><br>(με) | σ <sub>1</sub><br>(MPa) | σ <sub>2</sub><br>(MPa) | σ<br>(°) |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|----------|
| 0.00                   | 0.00                   | +1.                    | +1.                    | +0.                    | +1.                    | -0.                    | +0.2                    | +0.0                    | U/C      |
| 10.43                  | 9.41                   | -3.                    | -27.                   | +7.                    | +32.                   | -20.                   | +5.2                    | -4.1                    | -49.6    |
| 20.63                  | 19.16                  | -9.                    | -62.                   | +11.                   | +65.                   | -63.                   | +10.4                   | -9.9                    | -49.7    |
| 30.83                  | 29.15                  | -16.                   | -98.                   | +14.                   | +98.                   | -100.                  | +15.3                   | -15.0                   | -49.4    |
| 0.59                   | 0.00                   | +2.                    | -2.                    | -1.                    | +3.                    | -2.                    | +0.6                    | -0.3                    | U/C      |
| 10.55                  | 9.64                   | -3.                    | -30.                   | +6.                    | +33.                   | -31.                   | +5.5                    | -4.6                    | -48.8    |
| 20.63                  | 19.40                  | -9.                    | -64.                   | +9.                    | +65.                   | -65.                   | +10.3                   | -10.3                   | -49.2    |
| 30.83                  | 29.15                  | -17.                   | -99.                   | +13.                   | +97.                   | -101.                  | +15.0                   | -16.1                   | -49.4    |
| 41.27                  | 38.79                  | -24.                   | -135.                  | +15.                   | +128.                  | -137.                  | +19.6                   | -22.1                   | -49.2    |
| 51.35                  | 48.55                  | -30.                   | -170.                  | +18.                   | +160.                  | -172.                  | +24.4                   | -28.0                   | -49.2    |
| 61.43                  | 58.54                  | -38.                   | -207.                  | +19.                   | +190.                  | -209.                  | +28.7                   | -34.3                   | -49.1    |
| 71.75                  | 68.06                  | -44.                   | -243.                  | +21.                   | +222.                  | -246.                  | +33.4                   | -40.3                   | -49.0    |
| 82.30                  | 77.58                  | -51.                   | -279.                  | +22.                   | +252.                  | -282.                  | +37.8                   | -46.4                   | -48.9    |
| 91.68                  | 88.04                  | -57.                   | -316.                  | +22.                   | +284.                  | -319.                  | +42.4                   | -52.6                   | -48.7    |
| 102.34                 | 97.44                  | -60.                   | -351.                  | +21.                   | +315.                  | -354.                  | +47.0                   | -58.4                   | -48.5    |
| 111.84                 | 107.67                 | -61.                   | -389.                  | +18.                   | +346.                  | -391.                  | +51.9                   | -64.6                   | -48.1    |
| 121.92                 | 118.00                 | -61.                   | -429.                  | +13.                   | +380.                  | -430.                  | +57.0                   | -71.1                   | -47.6    |
| 132.36                 | 127.41                 | -61.                   | -467.                  | +10.                   | +417.                  | -468.                  | +62.3                   | -77.3                   | -47.3    |
| 142.32                 | 137.40                 | -61.                   | -508.                  | +6.                    | +454.                  | -509.                  | +67.8                   | -84.1                   | -47.0    |
| 153.11                 | 146.46                 | -62.                   | -554.                  | -2.                    | +490.                  | -555.                  | +73.0                   | -91.8                   | -46.7    |
| 0.94                   | 0.23                   | +42.                   | -9.                    | -9.                    | +52.                   | -20.                   | +10.4                   | -1.0                    | -22.5    |

