Danmarks Tekniske Højskole · Technical University of Denma

A Theoretical and Experimental Study of Concrete Beams - Especially Over-Reinforced Beams - Subjected to Torsion

Part II. Experiments

John Sander Nielsen

Serie R No 171 198

A Theoretical and Experimental Study of Concrete Beams - Especially Over-Reinforced Beams - Subjected to Torsion

PART II

Experiments

John Sander Nielsen

Afdelingen for Bærende Konstruktioner, Danmarks Tekniske Højskole

Department of Structural Engineering, Technical University of Denmark

Preface

This report has been prepared as one of the conditions for acquiring a licentiate degree in engineering.

The study has been carried out at the Department of Structural Engineering, Technical University of Denmark, under the guidance of Professor, dr.techn. Troels Brøndum-Nielsen. M.W. Bræstrup and E. Skettrup have acted as advisers. In addition, I have received valuable assistance from a large number of the laboratory's employees in connection with the tests.

The tests have been carried out with financial support from the Danish Council for Scientific and Industrial Research.

Lyngby, September 1983.

John Sander Nielsen

CONTENTS

NOTATION

T = Torsional moment

n_l = The force in the reinforcement per unit length (in the stirrup direction)

n_{ly} = n_l at yield in the reinforcement

n_s = The force in the reinforcement per unit length (in the longitudinal direction)

n_{sy} = n_s at yield in the reinforcement

n_b = The compression force in the concrete per unit length (in the direction perpendicular to the compression)

n = The shear force per unit length of the rectangle formed by the corner bars

n_x = Normal force in the x-direction (per unit length)

n_y = Normal force in the y-direction (per unit length)

σ_c = The compression strength of the concrete

σ_t = The split tensile strength of the concrete

σ_f = The pressure per square unit just below the corner bars

σ_{Fl} = The yield stress in the longitudinal reinforcement

σ_{Fb} = The yield stress in the stirrup reinforcement

ν_c = Efficiency factor for concrete compression strength

ν_t = Efficiency factor for tensile strength in the concrete

a, b = The side length of the rectangle formed by the longitudinal reinforcement

d = The diameter of the longitudinal reinforcing bar located at the corner of the cross section

S = Spacing of hoops

$\emptyset$ = Angle of diagonal compression

φ = Angle of friction

β = Half the apex of the wedge just below the corner bars

Summary

This report describes the results of 19 tests on reinforced concrete beams subjected to pure torsion. The beams all had a square cross section and were reinforced with axial reinforcement and with stirrups at an angle of 90° to the beam axis.

The purpose of the project was to determine the dependence of the ultimate carrying capacity on the design of the reinforcement and on the concrete cover over the axial reinforcement (primarily for over-reinforced beams). In addition, I wished to clarify the crack development inside the beams, for which reason, four of the test specimens were cut through after failure.

The report contains photos of these four sections together with photos of the crack pattern on the surfaces of all the beams. In addition, diagrams are given for each beam showing:

the course of loading
the distribution of rotations
the stress-strain curve of the beam
the strain in the reinforcement
the stresses in the reinforcement

Summary in Danish (Dansk Resumé)

I rapporten refereres resultaterne fra 19 forsøg med armerede betonbjælker påvirket til ren vridning. Bjælkerne havde alle kvadratisk tværsnit og var armerede med aksialarmering og med bøjler under 90° med bjælkeaksen.

Projektets formål var at klarlægge brudbæreevnens afhængighed af armeringsarrangementets udformning og af aksialarmeringens dæklag (primært for overarmerede bjælker). Endvidere ønskedes en klarlægning af revneforløbet i bjælkens indre, hvorfor fire af prøvelegemerne efter brud blev skåret over.

Rapporten indeholder fotos af disse fire snit, ligesom den indeholder fotos af revnebilledet på overfladen for samtlige bjælker. Endvidere findes for hver bjælke kurver, der viser:

Belastningsforløbet
Rotationsfordelingen
Bjælkens arbejdskurve
Armeringstøjninger
Armeringsspændinger.

1. Test programme

1.1 Introduction

For normally reinforced beams, the problems relating to determination of the carrying capacity of reinforced concrete beams can be regarded as having been thoroughly investigated and the theories developed have been substantiated by exhaustive test material.

However, a different situation exists in the case of beams in which the reinforcement does not yield at rupture: over-reinforced beams. Here, both theories and tests to illuminate the problems are lacking. Therefore, with the intention of remedying this deficiency, a series of tests on 19 reinforced concrete beams subjected to pure torsion were carried out at the Structural Research Laboratory of the Technical University of Denmark in the autumn of 1975 and the spring of 1976.

1.2 Purpose of the tests

The purpose of the tests carried out was to investigate the carrying capacity of over-reinforced concrete beams subjected to pure torsion. The following parameters were chosen as variables:

1: diameter of axial reinforcing bars
2: design of the arrangement of the reinforcement
3: proof stress of the reinforcing bars
4: thickness of the concrete cover

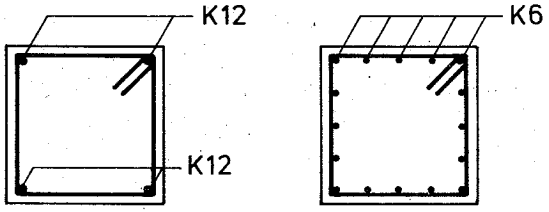
The tests were carried out in two series. Series I was intended to clarify the influence of the design of the reinforcement for different qualities of reinforcement, while series II was intended to clarify the dependence of the carrying capacity on the thickness of the concrete cover.

1.3 Description of test specimens

Series I contained 8 beams, and series II 13 beams. Two of the beams were common to series I and series II (II-2 and I-3), and three of the beams in series II were substitutes for poorly made beams (II-6*, II-5* and II-6*).

All the beams had a length of 280 cm and there was a distance of 200 cm between the loading devices (see fig. 11a). The longitudinal reinforcing bars were 283 cm long and extended 15 mm beyond the concrete at each end. The stirrup spacing (see table 1) was chosen to give identical reinforcing force in the direction of the stirrups and the longitudinal direction (defined as yield force per unit length). A concrete strength of 30 MPa was aimed at. The actual strengths are given in table 2. In series I, the cross-sectional dimensions of all beams were 30 x 30 cm. The longitudinal reinforcement was arranged in two different ways*, using different grades of steel (see table 1).

* (see fig. 1, 2 and 3)



Bjælke nr.:		
	IA1	IA2
	IB1	IA3
	IC0	IB2
	IC1	IB3

Fig. 1.

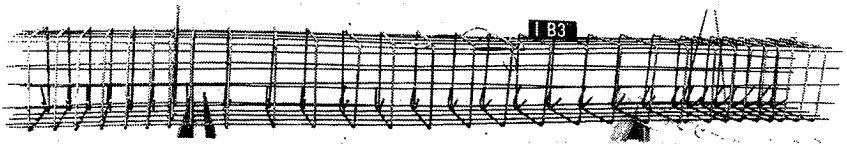


Fig. 2.

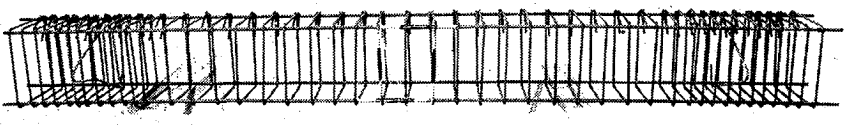


Fig. 3.

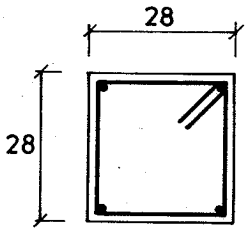
In series II, the arrangement of the reinforcement was kept constant (shown in fig. 3), while the cross section was varied as shown in fig. 4.

Beams II-4*, II-5* and II-6* were replacements for II-4, II-5 and II-6, the concrete properties of which tended to make them act as sandwich structures (see section 2.1.2).

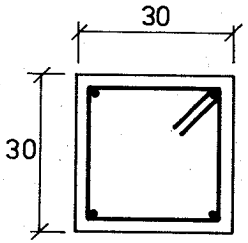
TABLE 1

Arrangement of reinforcement.

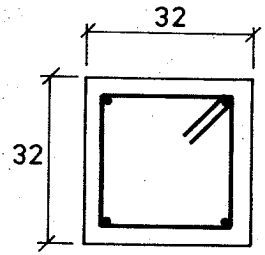
	Axial reinforcement			Stirrup reinforcement		
beam No.	dimension mm	number	grade	dimension mm	spacing mm	grade
Ia1	12	4	KS42S	8	111	KS42S
Ia2	6	16	KS42S	8	128	KS42S
Ia3	6	16	KS42S	8	128	KS42S
Ib1	12	4	KS60S	8	111	KS60S
Ib2	6	16	KS60S	8	101	KS60S
Ib3	6	16	KS60S	8	101	KS60S
II-0	12	4	KS90S	8	81	KS60S
II-1	12	4	KS90S	8	81	KS60S
II-2	12	4	KS90S	8	81	KS60S
II-3	12	4	KS90S	8	81	KS60S
II-4	12	4	KS90S	8	81	KS60S
II-4*	12	4	KS90S	8	81	KS60S
II-5	12	4	KS90S	8	81	KS60S
II-5*	12	4	KS90S	8	81	KS60S
II-6	12	4	KS90S	8	81	KS60S
II-6*	12	4	KS90S	8	81	KS60S
II-7	12	4	KS90S	8	81	KS60S
II-8	12	4	KS90S	8	81	KS60S
II-9	12	4	KS90S	8	81	KS60S



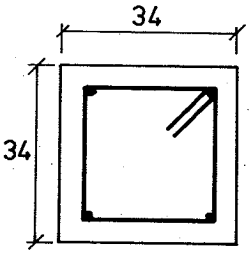
II 0
II 1



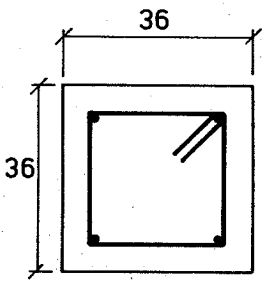
II 2
II 3



II 4
II 5



II 6
II 7



II 8
II 9

Fig. 4.

2. Description of tests

2.1 Beams

2.1.1 Fabrication of beams

The beams were cast in a steel form with a wooden insert the size of which could be varied. After 24 hours the beams were covered with wet sacks, and after 48 hours, the sides of the form were removed. The beams were cured under wet sacks until the fifth day. The tests were carried out 14 days after casting, and for the last 10 days before testing, the beams were stored in the Laboratory' test room at a temperature of about 20°C and about 50% R.H. Each beam was cast in two charges, and at the same time 9 concrete cylinders were cast - 6 from charge 1 and 3 from charge 2. Both cylinders and beams were vibrated by means of pneumatic poker vibrators.

2.1.2 Production of concrete

The same recipe was used for the concrete for all beams:

water	175	l/m3
concrete	246.6	kg/m3
gravel	868	kg/m3
stone	1047	kg/m3

The cement was "rapid" portland cement, purchased in one consignment. The aggregates were marine materials, and fig. 5 shows typical grading curves for the gravel (0-8 mm) and stone (8-32mm).

It proved difficult to arrive at the proper dosing because the gravel contained varying quantities of water (1-10%). Efforts were made to determine the water content by evaporation on 3 specimens extracted immediately before casting.

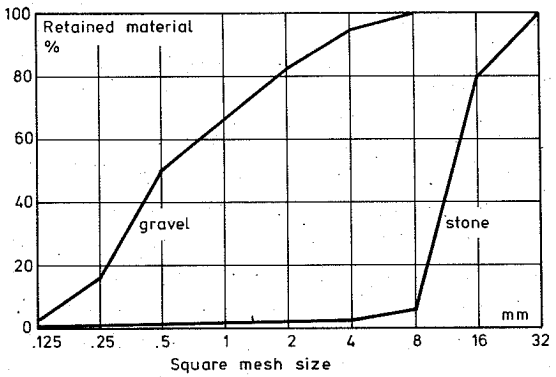


Fig. 5.

The measured values of the compression and tensile stress of the concrete are given in table 2, together with the variation factors. There was a considerably bigger deviation on the compression strength than is often found in other test series. However, this was not due to a poorer quality of concrete, but to a more accurate strength determination.

The normal procedure for producing the concrete beams is to cast the beams in 2 (or more) charges immediately after each other - on account of limited mixing capacity. The moisture content of the gravel is only determined once. The appurtenant cylinders are cast by filling the forms half way up with concrete from the first charge and then to the top with concrete from the second charge. If there is a big difference between the strengths of the two mixes, the measured value will be very close to the strength of the weakest mix, and the variation will be close to the variation for this. Owing to this, the concrete strengths determined in this way and the relevant variations are sometimes lower than actually applying to the beam (for this test series a difference of up to 50% was ascertained in the compression strength between the 2 charges, see also table 2, page 16).

In order to avoid these sources of error, only whole cylinders were cast from each charge (in table 2, page 16 , the mean compression strength and standard deviation are given both for the weakest charge and for both charges). The differences in strength for beams II-4, II-5 and II-6 were so great that, after improving the method of determining the water content of the gravel, it was found reasonable to recast these beams (indicated by *).

2.1.3 Reinforcement

The type of reinforcement used was Swedish deformed steel (weldable) throughout. This steel has a linear elastic - perfectly plastic stress-strain curve (see fig. 10) and is therefore suitable for tests. The following dimensions were used:

6, 8 and 12 mm

and the grades:

ST 42 S
ST 60 S
ST 90 S

A small part of the steel (ST 42 S, d = 6 mm and ST 60 S, d = 6 mm) had been subjected to unintentional cold working, and was therefore normalized at 860 - 880°C with subsequent air cooling. The reinforcing mesh was all tied with binding wire.

2.2 Testing

2.2.1 Testing the concrete

The test cylinders, with a height of 30 cm and a diameter of 15 cm, were tested in the compression press shown in fig. 6.

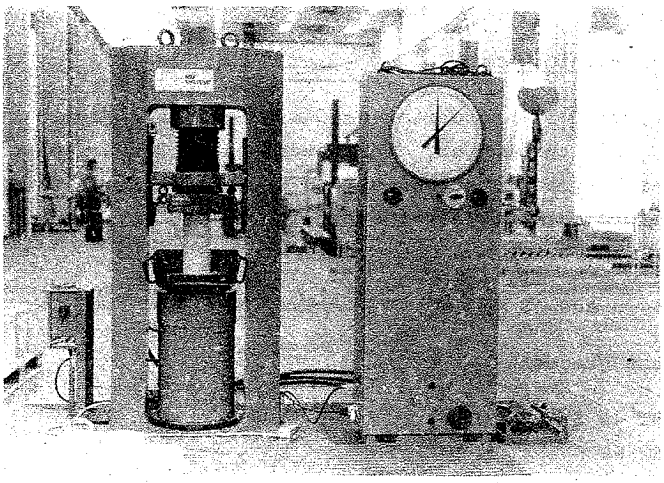


Fig. 6.

A padding of 10 mm soft fibre board was used, and the loading weight was about 4 MPa per min. 3 cylinders from each batch were tested (6 cylinders per beam). Table 2 shows the mean value and standard deviation of all 6 cylinders, together with the mean value and standard deviation for the 3 cylinders from the weakest batch.

Up to 3 cylinders from batch 1 were used for split tests in the arrangement shown in fig. 7.

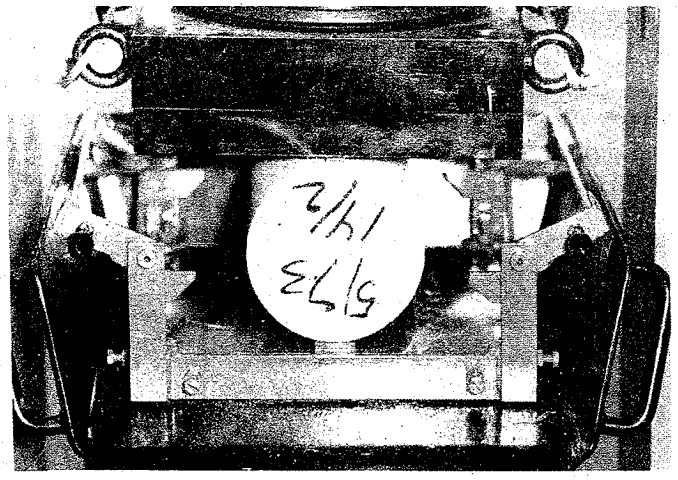


Fig. 7.

The mean value and standard deviation of the tensile strength calculated on this basis ($\sigma_t = \frac{2P}{\pi HD}$) is also given in table 2. The loading rate was here 04 MPa per min.

TABLE 2

Concrete strengths.

	Compression strengths mean value MPa		Compression strengths Weakest batch MPa		Split strengths MPa	
beam No.	mean value	st. deviation	mean value	st. deviation	mean value	st. deviation
Ia1	29.08	0.38	28.76	0.14	3.41	0.12
Ia2	25.55	0.62	25.10	0.57	2.63	0.24
Ia3	23.63	1.50	22.33	0.41	2.75	0.18
Ib1	28.24	0.71	27.71	0.50	3.34	0.01
Ib2	24.54	0.54	24.24	0.52	2.95	0.12
Ib3	25.39	0.61	25.01	0.73	2.99	0.17
II-0	23.79	2.16	21.98	1.33	3.09	0.23
II-1	26.17	1.47	25.00	0.84	3.02	0.04
II-2	27.26	0.86	26.92	1.05	3.31	0.17
II-3	21.61	0.35	21.57	0.43	-	-
II-4	23.20	2.82	20.69	0.71	-	-
II-4*	23.53	1.91	21.87	0.19	3.05	0.16
II-5	22.68	3.95	19.18	0.29	-	-
II-5*	26.41	1.15	25.54	0.36	3.12	0.03
II-6	25.10	5.32	20.25	0.35	-	-
II-6*	27.67	1.26	26.57	0.57	3.40$^{\Delta}$	0.40
II-7	27.55	1.01	26.71	0.41	-	-
II-8	21.80	1.80	20.49	0.77	2.96$^{\Delta}$	0.14
II-9	21.95	1.30	20.78	0.17	-	-

$^{\Delta}$ These split strengths relate to the charge with the highest compression strength.

2.2.2 Testing the reinforcement

The strength of the reinforcing bars was tested by means of the Mohr-Federhaff 60 Mp tensile testing machine shown in fig. 8.

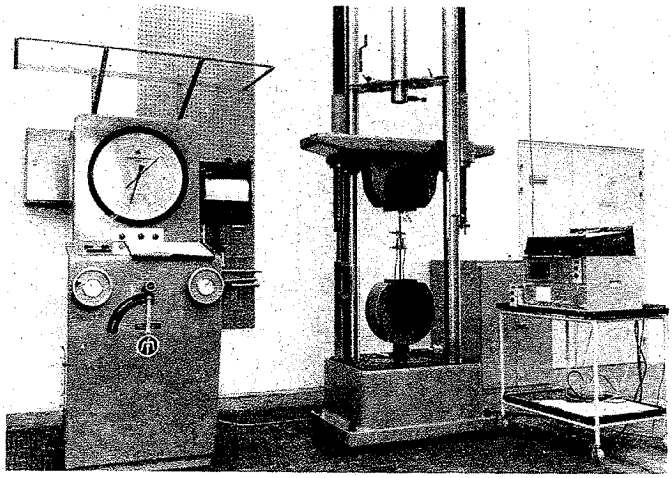


Fig. 8.

The loading rate up to yielding was about 4 Mp per second. The load was read on a manometer on the machine, while the strains were measured with the extensiometer shown in fig. 9, which consists of 2 times 2 jaws that grip the test bar. The jaws are connected in pairs by means of shear potentiometers, and a measure of the strain in the test bar was obtained by measuring the average of the relative change in resistance.

During the test, an automatic printer drew up a stress-strain curve for the reinforcing bar investigated. In principle, the stress-strain curves, one of which is shown in fig. 10, followed the same course.

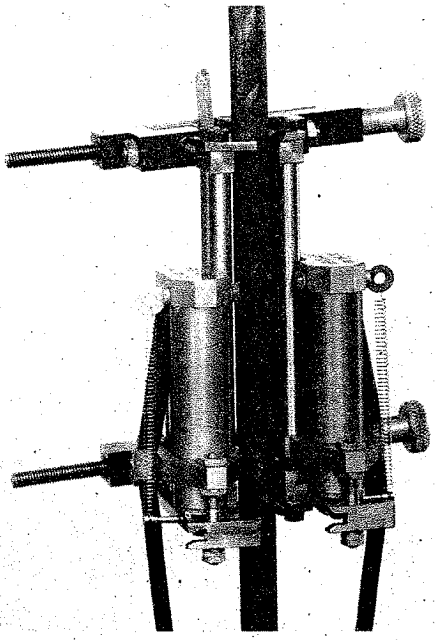


Fig. 9.

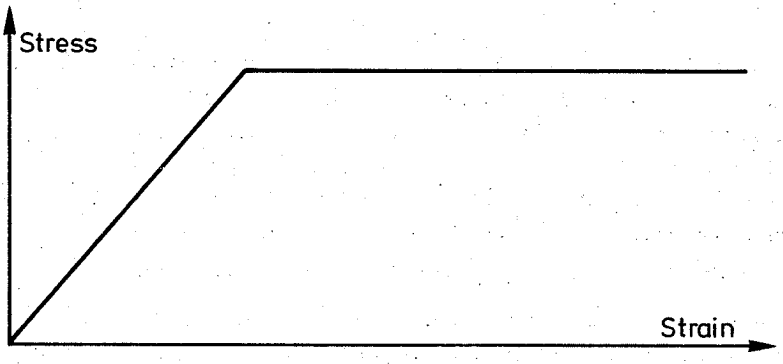


Fig. 10.

Table 3 gives:

yield force
rupture force
strain at yielding

As the fluctuations in strength properties for the same grade and dimension proved to be insignificant, only the mean values for each type of reinforcement are given.

TABLE 3

Steel strengths.

Grade	Dimension mm	P_{yield} kN	ε_{yield} o/oo	$P_{ult.}$ kN
ST42S	6	12.9	2.01	17.3
	8	26.5	2.44	32.0
	12	61.0	2.65	73.1
ST60S	6	19.7	3.05	22.1
	8	32.3	3.03	38.3
	12	71.5	2.98	87.2
ST90S	12	10.43	4.50	11.23

2.2.3 Testing the beam

The beams were tested in the test arrangement shown in fig. 11.

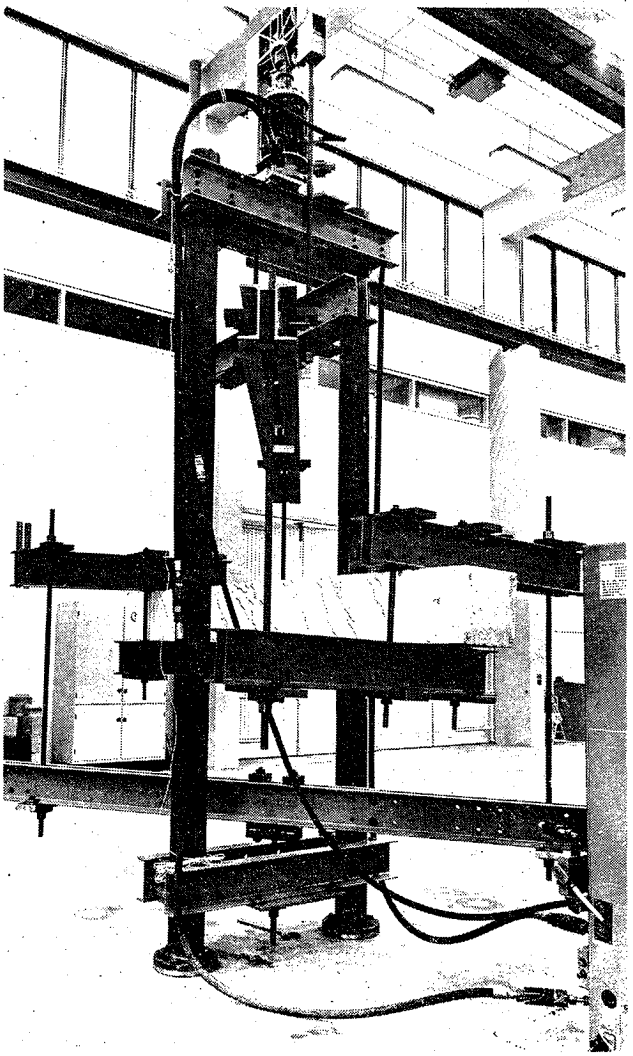


Fig. 11.

The test arrangement was designed with a view to getting as high a degree of pure torsion as possible.

Fig. 11a shows the principle of the mode of operation of the test arrangement.

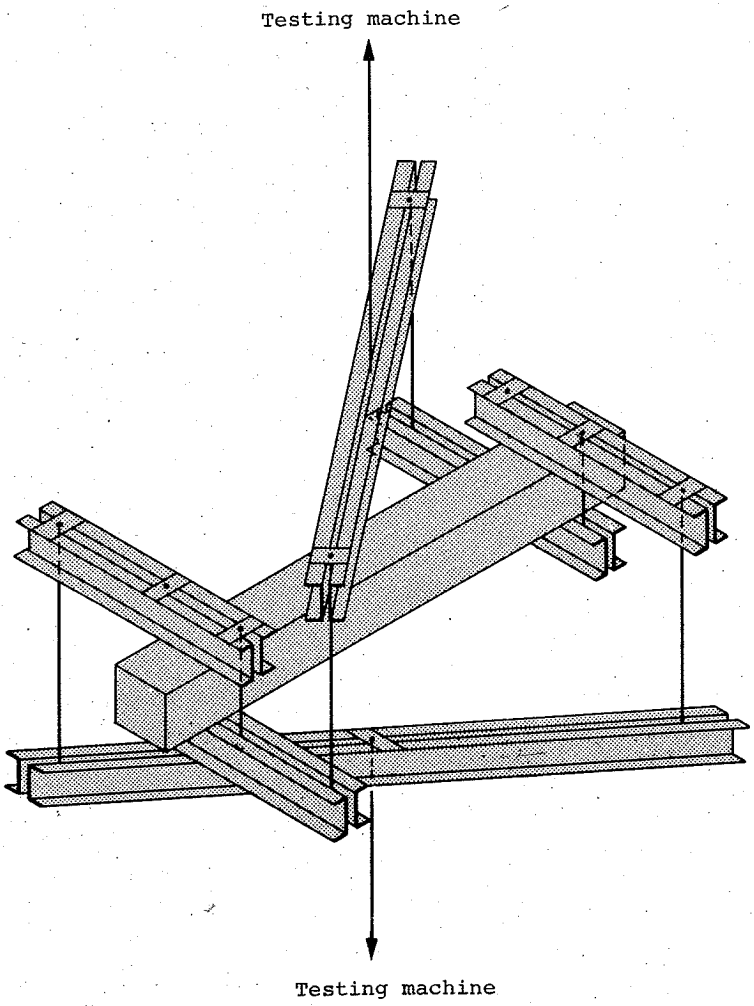


Fig. 11a.

The load was applied by means of a 20 Mp hydraulic Amsler press, and fig. 12 shows a characteristic loading diagram.

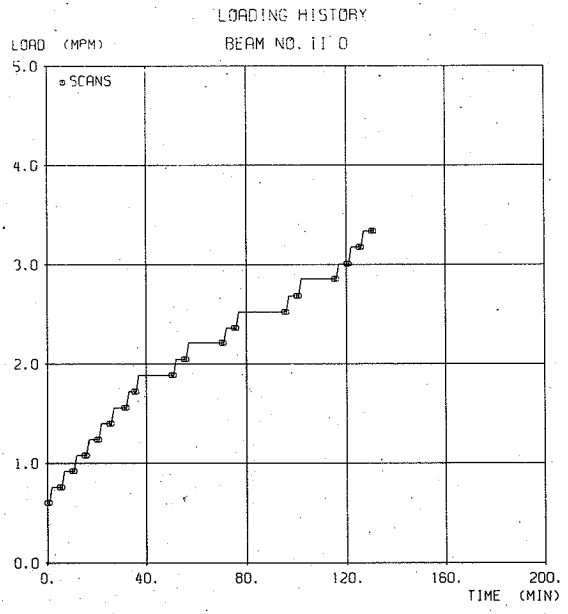


Fig. 12.

The load, which was read on an Amsler spring manometer with pressostat (see fig. 13), was increased in steps of 0.2 Mp (0.16 Mpm).

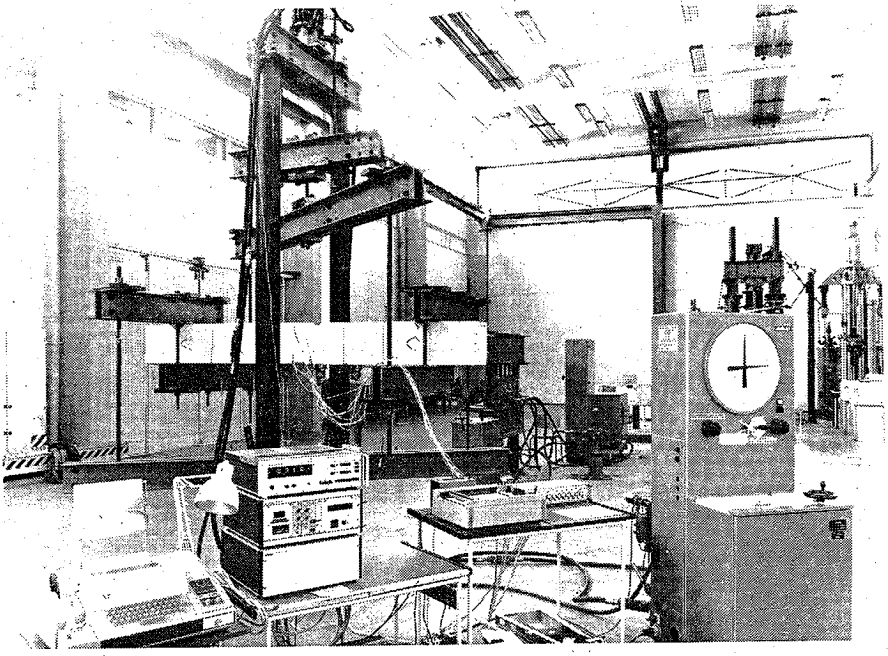


Fig. 13.

Up to the cracking load, the load was increased at intervals of 5 minutes. Thereafter, the load was increased when the beam had stopped reacting (although not until after 5 minutes). The actual loading took about 30 seconds. All readings were taken electrically immediately prior to each loading step, and for control reasons, two readings were taken directly after each other.

Each time the load was relieved, the reinforcing bars projecting from the ends of the beam were examined for anchorage failure. However, none of the beams showed signs of failing anchorage of the axial reinforcement.

2.3 Results

2.3.1 Cracking load

The cracking load was defined as the load at which the stress-strain curve (O-V diagram) plotted during the test had a horizontal section, i.e. the load at which the rotations increased rapidly without a concurrent increase in the moment applied (see fig. 16).

The cracking occurred suddenly and was accompanied by a loud crack from the concrete. On all four sides, the cracks formed at an angle of about 45° with the axis of the beam (visual evaluation). The width of the biggest crack at any time in beams II-2 and II-3 is shown in fig. 14.

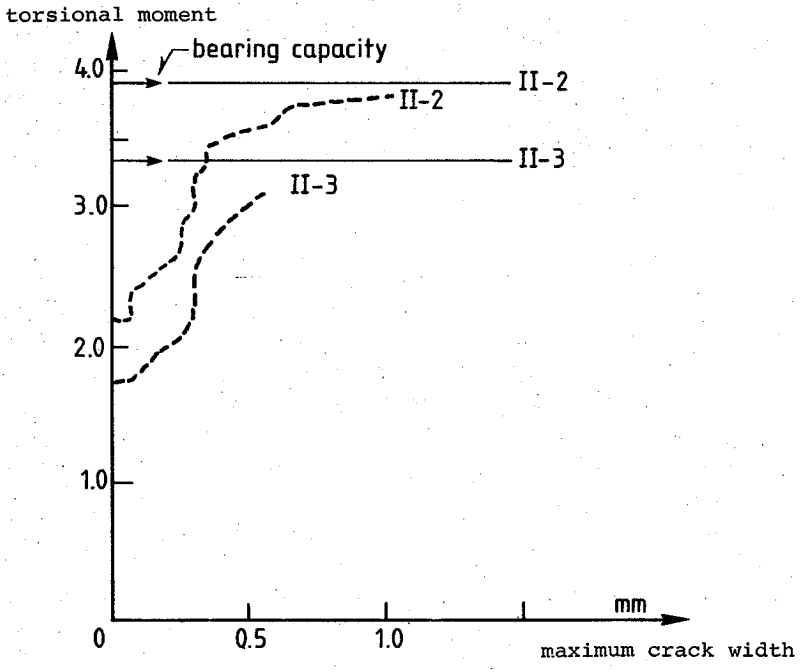


Fig. 14.

The crack widths were measured by means of a comparison with the scale shown in fig. 15.

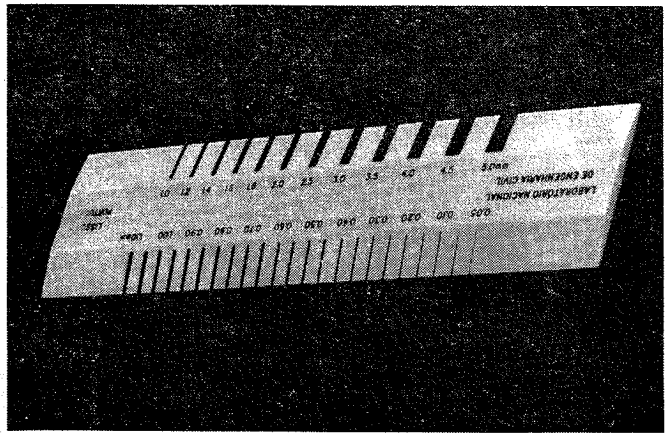


Fig. 15.

The cracking loads for all beams are given in table 4, page 27. The angle of the crack with the beam axis remained 45° up to rupture (visual evaluation).

2.3.2 Ultimate load

The rupture moment is defined as the moment at which the rotations can be increased arbitrarily without an increase in the moment applied. The shape of the stress-strain curves plotted during the test depended on whether the beam was over-reinforced or not (see fig. 16, 17 and 18).

A representative stress-strain curve for a normally reinforced beam is shown in fig. 16. This is characterized by flattening out before actual rupture occurs and it indicates that the beam is not in possession of very much plasticity. The stress-strain curve for an over-reinforced beam (fig. 17), on the other hand, shows that this has a rather high degree of plasticity. Rupture occurred suddenly, without any increased cracking or prior reduction of stiffness. It is also noteworthy that a greater plasticity was observed in over-reinforced beams with a big concrete cover (see fig. 17) than in beams with a smaller cover (see fig. 18).

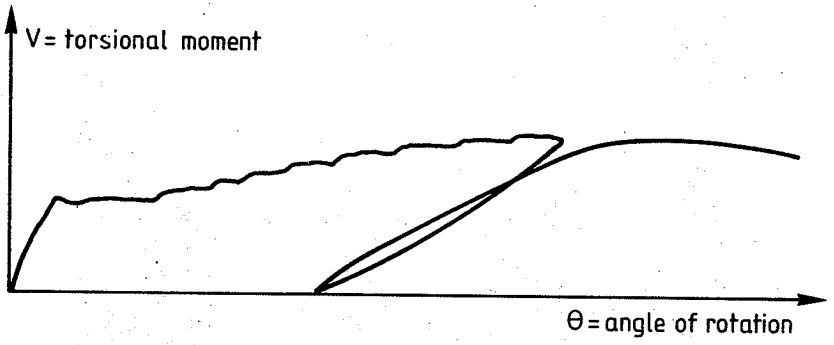


Fig. 16.

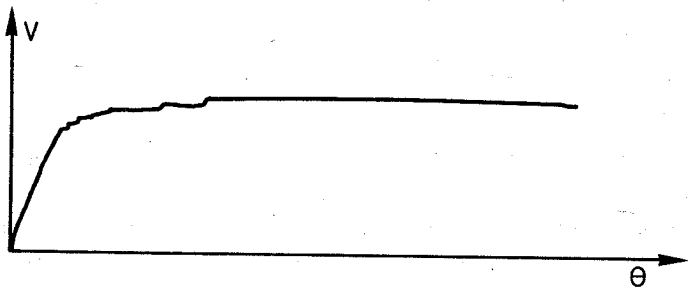


Fig. 17.

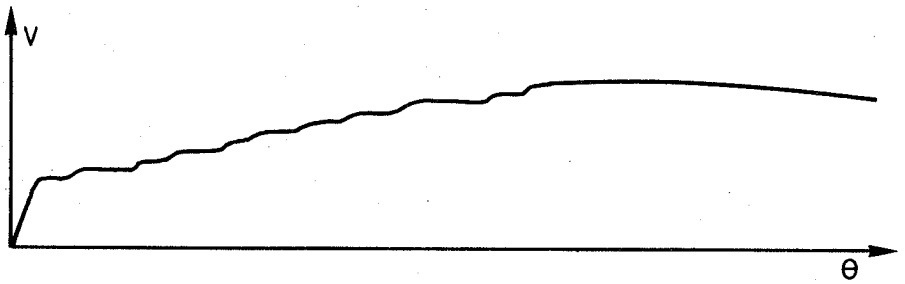


Fig. 18.

TABLE 4

Test results

Beam No.	Cracking load kNm	Rupture load kNm
Ia1	20.68	29.32
Ia2	19.08	26.40
Ia3	19.08	24.68
Ib1	23.88	35.08
Ib2	20.68	29.80
Ib3	19.08	30.28
II-0	15.64	34.68
II-1	17.24	34.84
II-2	22.28	39.16
II-3	17.48	33.57
II-4	24.24	33.76
II-4*	24.24	35.36
II-5	24.24	34.04
II-5*	25.84	38.04
II-6	27.78	33.54
II-6*	29.38	37.38
II-7	30.98	34.20
II-8	28.08	32.88
II-9	32.08	34.28

2.3.3 Rotations

The rotations were measured at 6 points using angle meters of the type: Penny and Giles, model apt 25.

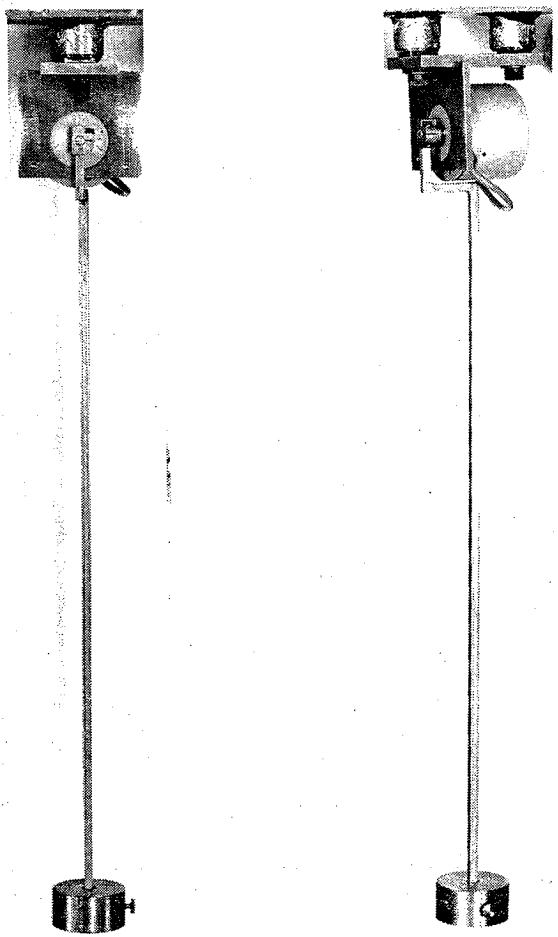


Fig. 19

The angle meter, which is shown in fig. 19, measures the angle formed by the contact face with the plumb line. Fig. 20 shows the six measuring points, and fig. 21 shows the angle meters during the test itself.

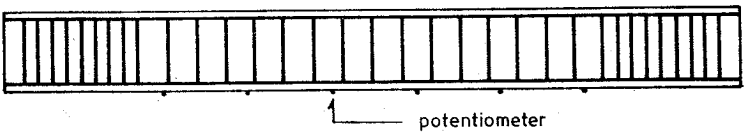


Fig. 20.

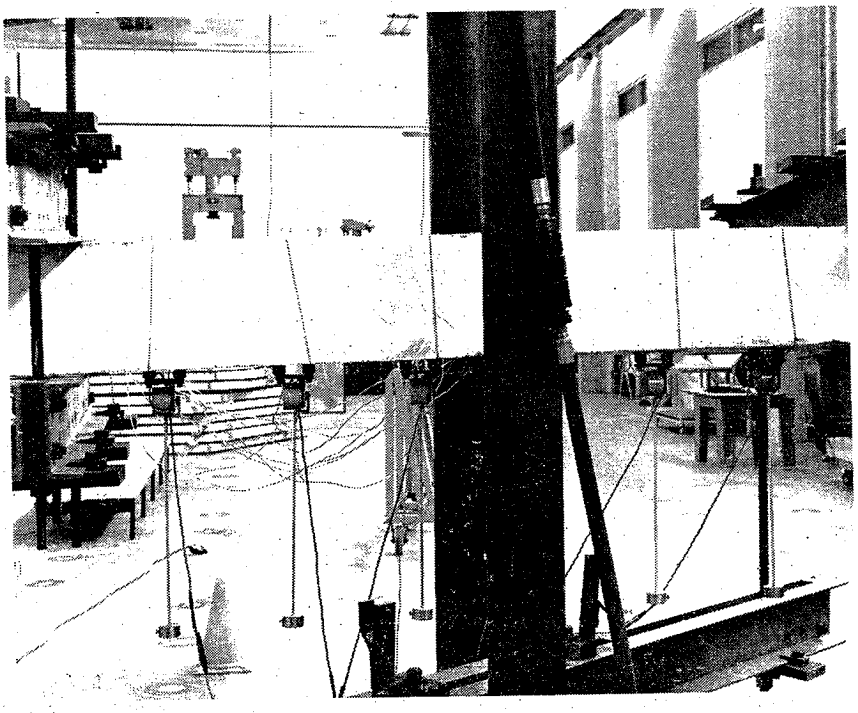


Fig. 21.

In addition to giving the rotation of the beam, the measurements, which are shown in the appendix, were to have been used for estimating within how large an area it could be assumed that there were undisturbed conditions.

It was found that, until cracking occurred, measuring point 1 rotated in the opposite direction than that anticipated. This was interpreted to mean that there had been disturbing effects from the application of the force, and the curves for the course of the moment - rotations (see appendix) therefore cover only the rotation measurements from measuring points 2 and 5.

2.3.4 Strains in the reinforcement

The strains in the reinforcement were measured by strain gauges (made at the Laboratory) placed in pairs, diametrically opposite each other. A mean value therefore gave the mean strain, while the difference between the readings of each pair of gauges gave an expression of the magnitude of the bending stress (curvature of the bar). The force in the reinforcing bar was found by multiplying the mean value by the modulus of elasticity (see appendix). On all beams, the two stirrups closest to the stirrup at the mid-point of the beam were equipped with gauges along one side of the beam. The strains in longitudinal reinforcement were measured by means of gauges mounted on two of the corner bars. All these measurements are shown in the appendix.

On beam IB3, the strains were also measured for all axial reinforcing bars along one side of the beam.

By means of these measurements, which are shown in fig. 22, an impression can be obtained of the distribution of the strains (in the longitudinal direction) along the side of a beam.

The figures on the abscissa give the numbering of the longitudinal bars along the side of a beam. The ordinate shows a constant times the strain. Each curve in the diagram thus

shows the strain distribution for a loading step ending with the rupture load (broken line).

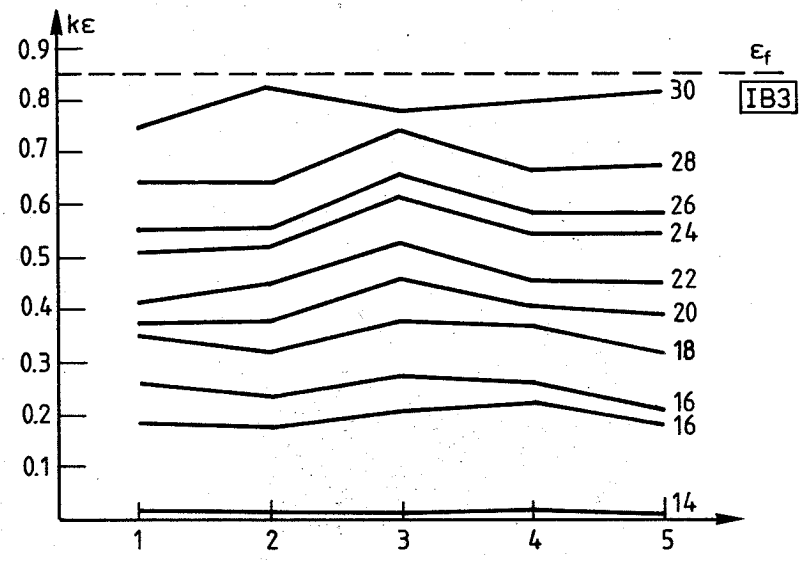


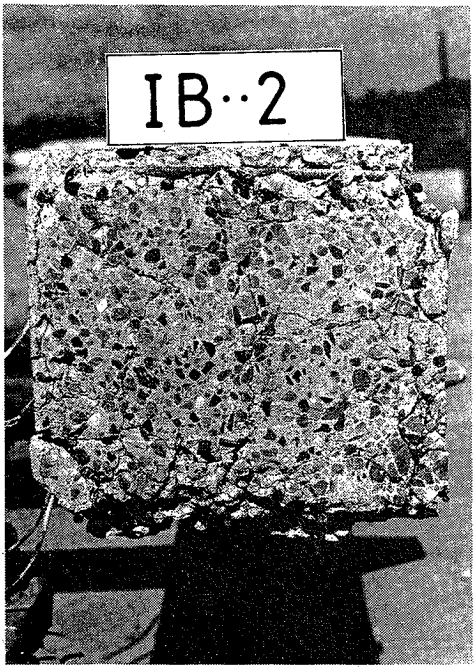
Fig. 22.

2.4 Cutting the beams

In order to establish the development of the cracking inside the beams, 4 beams were cut through using a diamond saw.

The bottom cm of each beam cross section is broken off. This was not due to cracks occurring during the test, but to incorrect use of the saw.

Beams Ia3 and Ib2 had the same arrangement of the reinforcement but were reinforced with steel of different grades. And whereas Ia3 was normally reinforced, Ib2 failed through concrete failure (the crack development is shown in fig. 23 and 24). The arrangement of the reinforcement for beams II-0 and II-8 was also identical, while their concrete cover differed (for the crack development here, see fig. 25 and 26). Details are given in fig. 4 and tables 2 and 3.



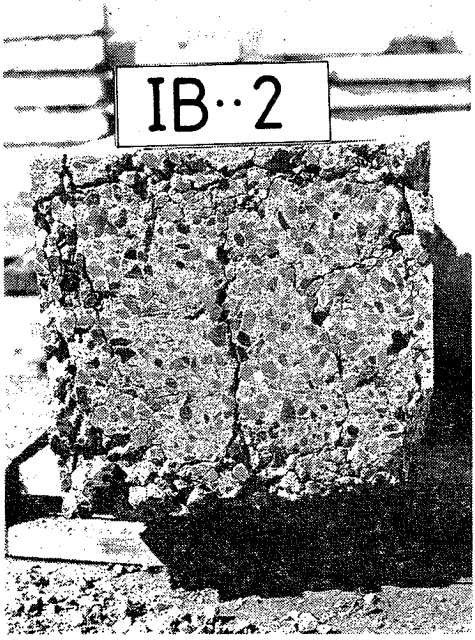


Fig. 23.

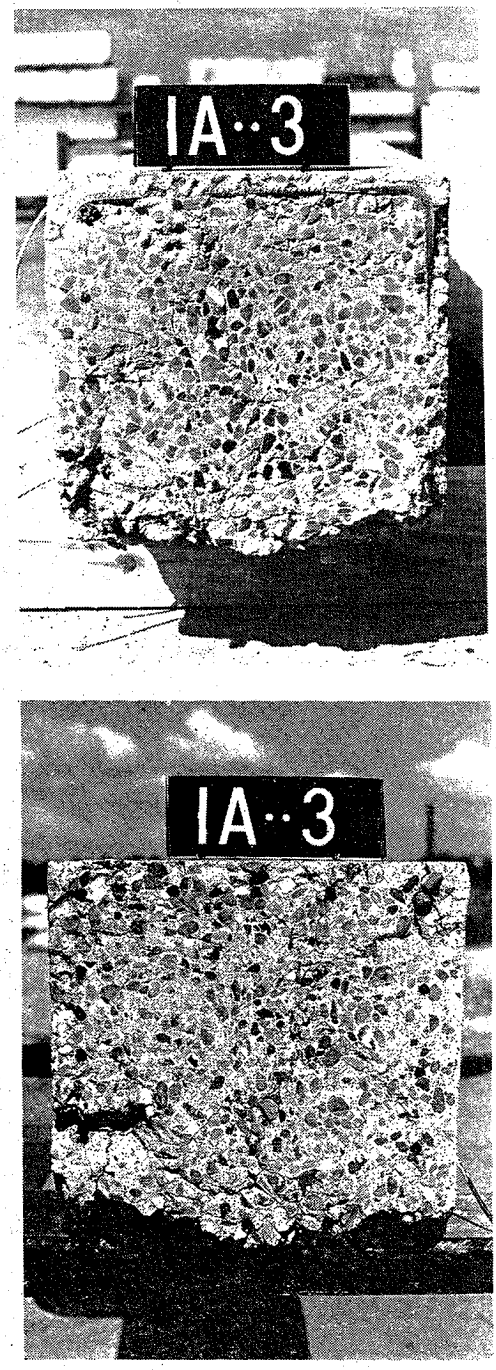


Fig. 24.

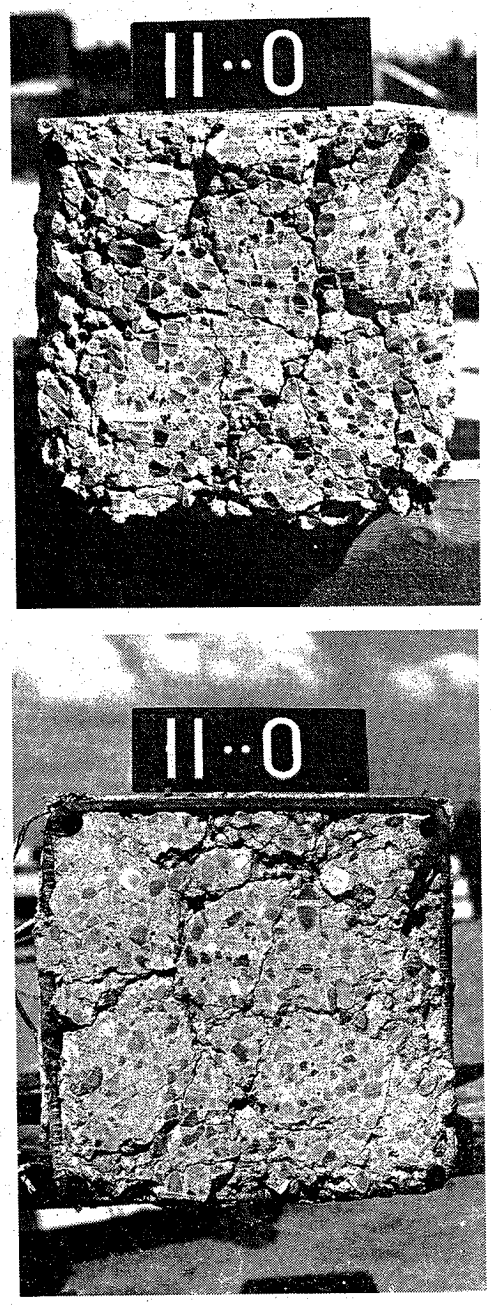


Fig. 25.

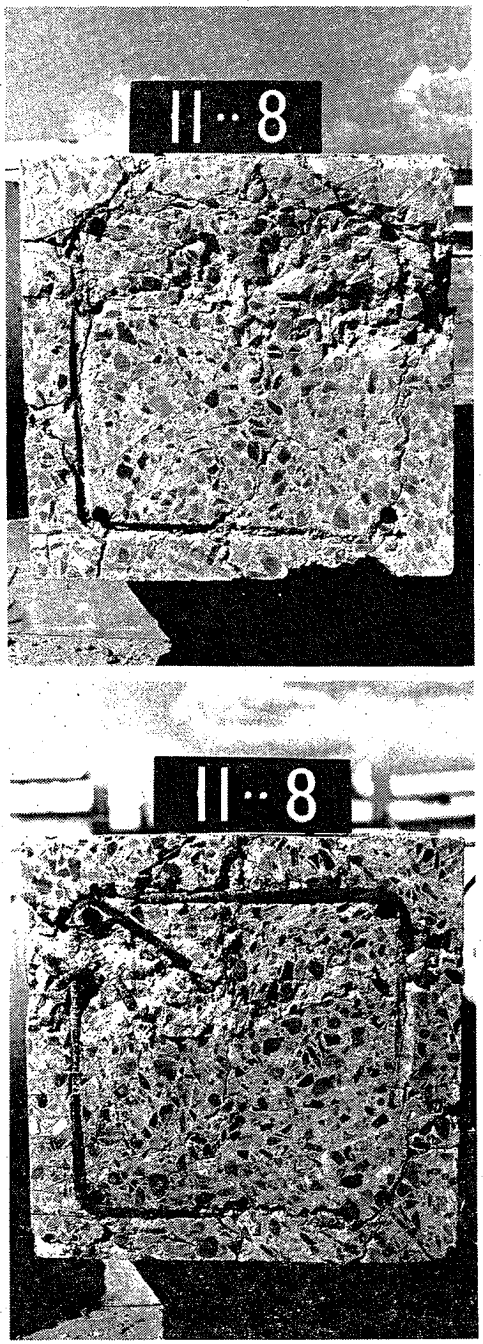


Fig. 26.

3. Numerical analysis

All the test results were written out on punch tape and were then transferred to punch cards for processing by means of a computer program developed for this purpose. The results from the material tests were coded on punch cards and included in the program.

The following were computed for each loading step:

- Rotations
- The mean rotation
- Strains in reinforcement
- Mean strains in reinforcement
- Differential strains
- Forces in reinforcement

In addition, the material constants and the standard deviations on these were computered.

The following diagrams (see appendix) were plotted:

- Loading diagram
- Rotations
- Stress-strain curve of beam
- Strains in reinforcement (mean and differential)
- Forces in reinforcement

Appendix

The appendix contains photographs of the crack pattern together with 6 diagrams for each beam.

1: Loading diagram

abscissa: the time in minutes from start of test.
ordinate: the torsional moment.

The curve does not start at (0,0) because the dead weight of the beam and the weight of the testing machine make a contribution to the load.

2: Rotations

abscissa: the mutual placing of the rotation meters (indicated by vertical lines)

ordinate: the angle of rotation in relation to the first measuring point.

Each curve corresponds to one loading step (torsional moment) the magnitude of which in Mpm is given on the right of the curve.

3: Stress-strain diagram

abscissa: relative rotation between measuring points 2 and 5.

ordinate: torsional moment.

4: Strains in reinforcement

abscissa: torsional moment.
ordinate: mean strain of pair of gauges.

5: Differential strains

abscissa: torsional moment.
ordinate: difference between one pair of gauges.

6: Forces in reinforcement

abscissa: torsional moment.
ordinate: force in a reinforcing bar.

The yield forces for the bars are given on the left of the diagrams.

The sides of the beams are numbered as follows:

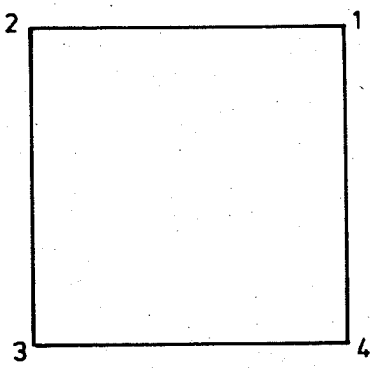


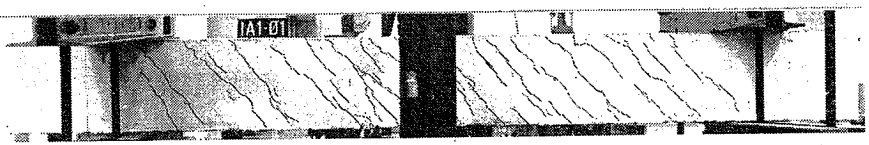
fig. 27 : beam seen from one end.

The relevant number of the side face is given on the right of each photo.

I A1

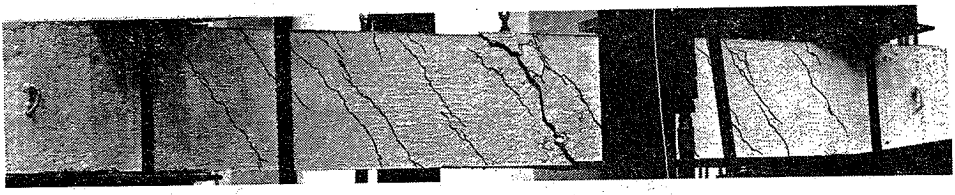
1

2



2

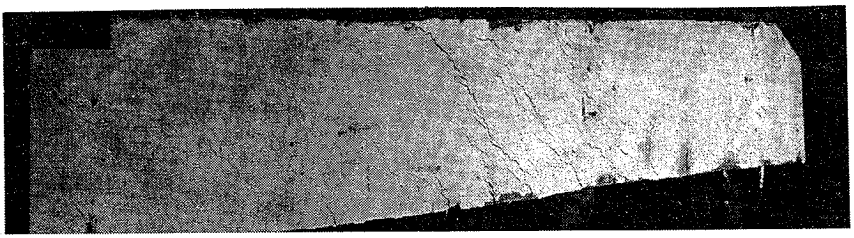
3

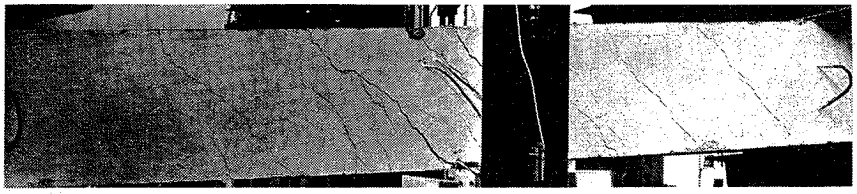


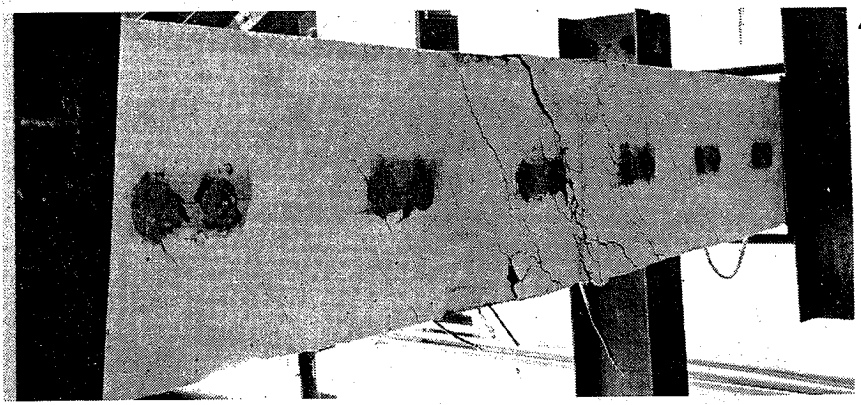
1

4

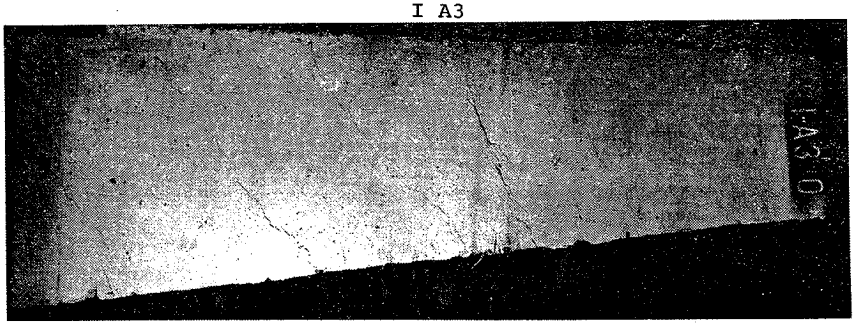
I A2



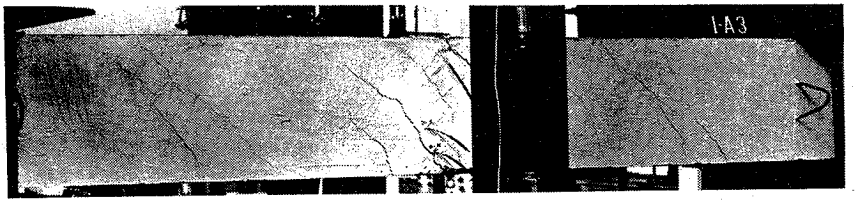




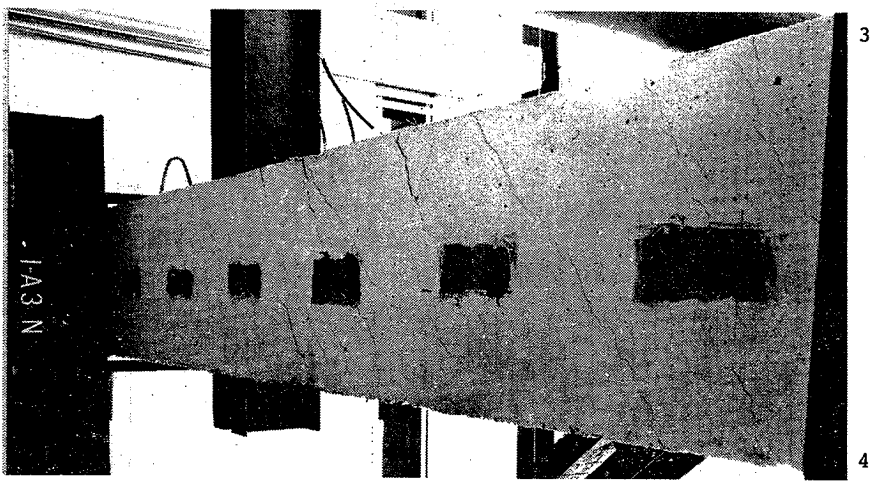
I A3



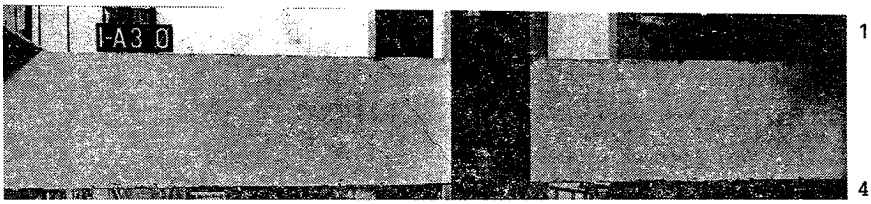
1 2



2 3

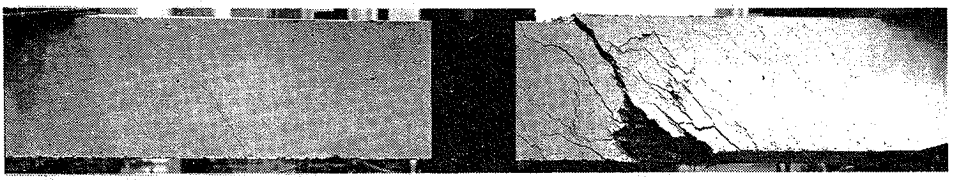


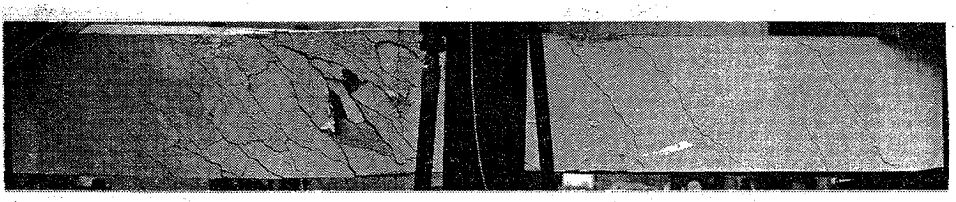
3 4



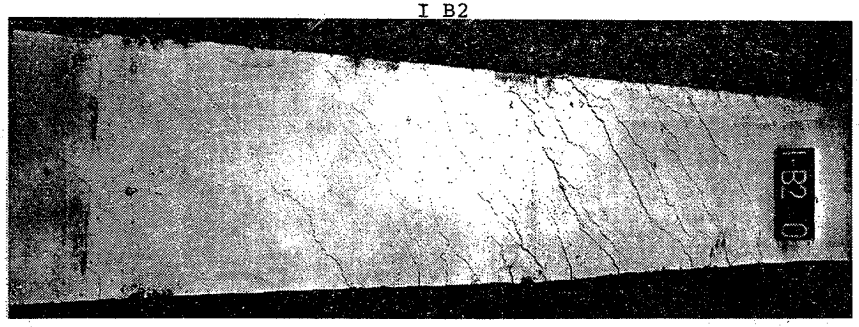
1 4

I B1



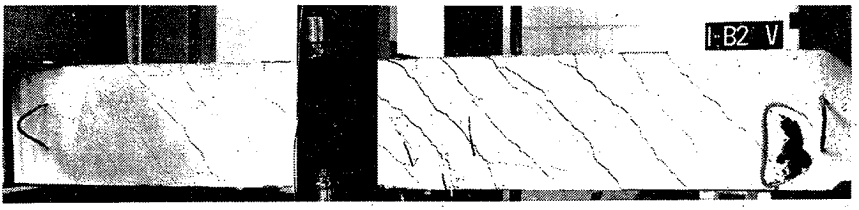


I B2



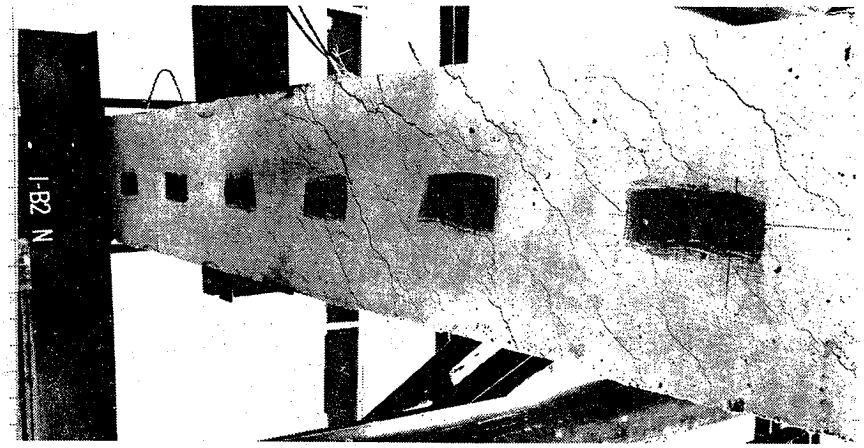
1

2



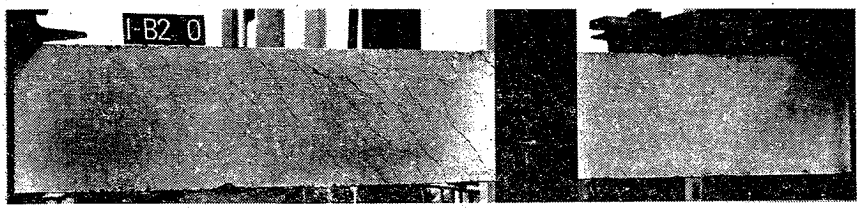
2

3



3

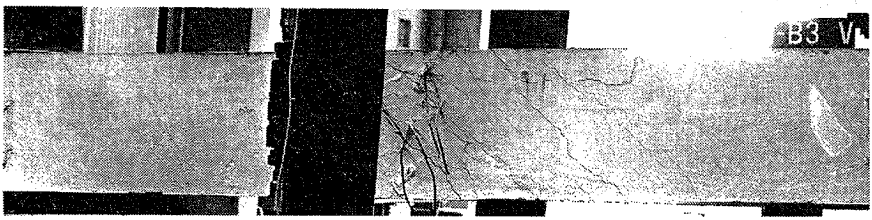
4

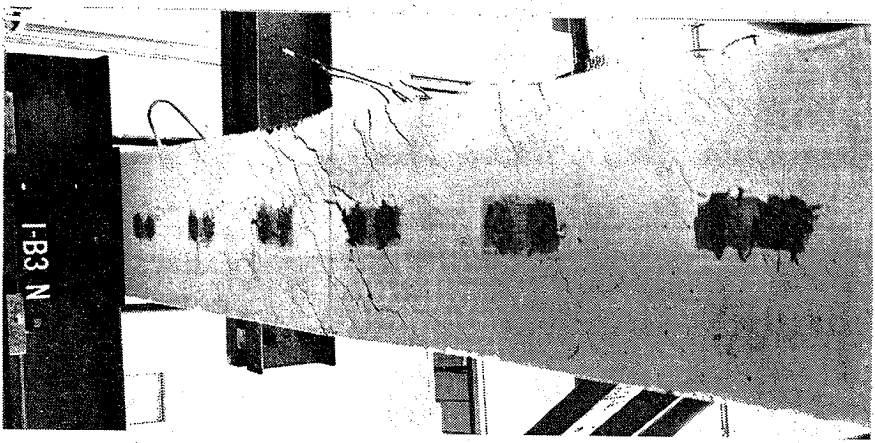


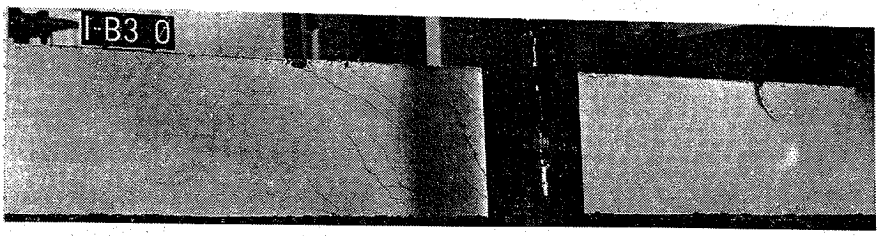
1

4

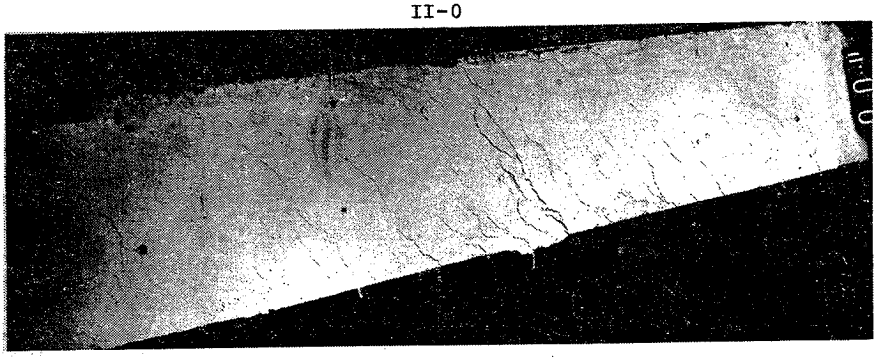
I B3







II-0

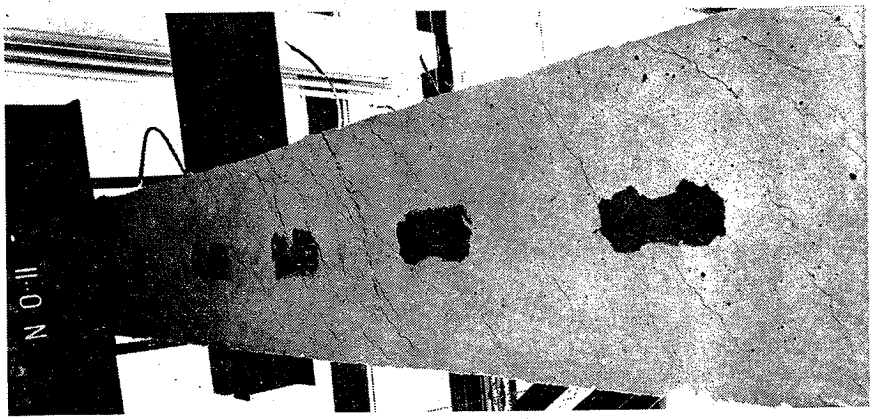


1

2

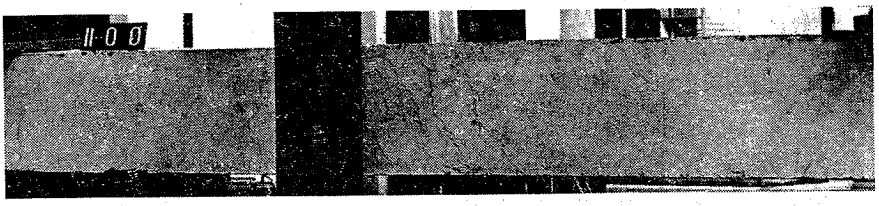
2

3



3

4



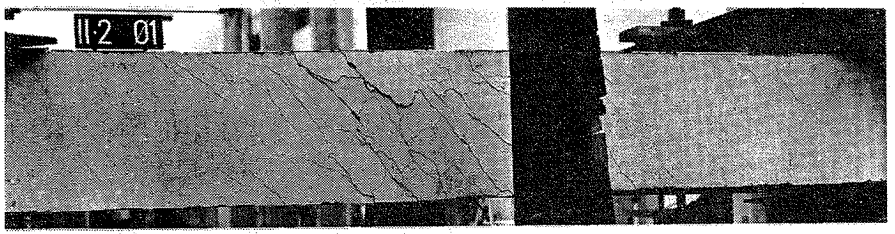
1

4

II-2

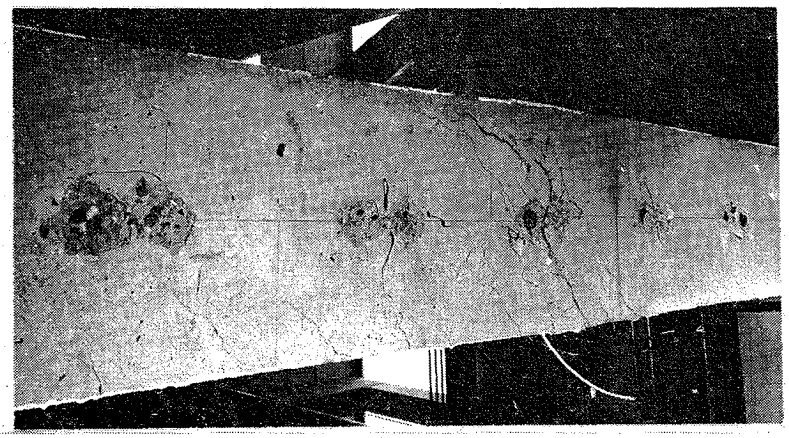
1

2



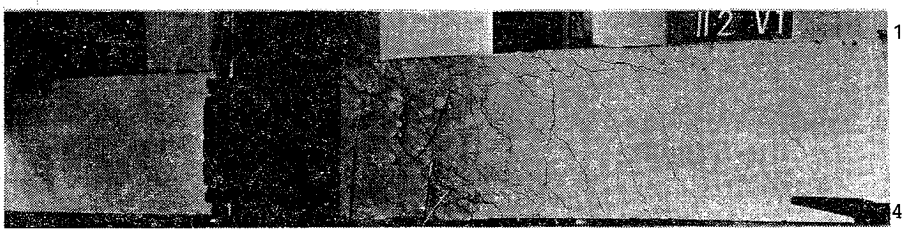
2

3



4

3



1

4

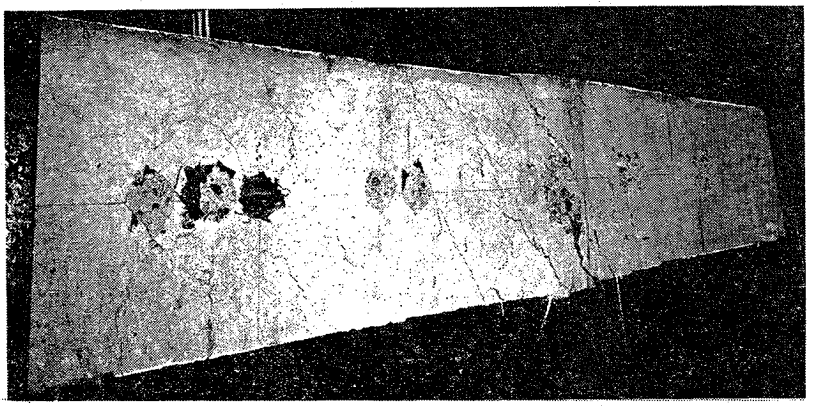
II-3

1

2

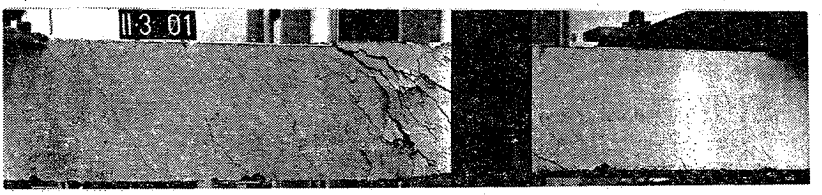
2

3



4

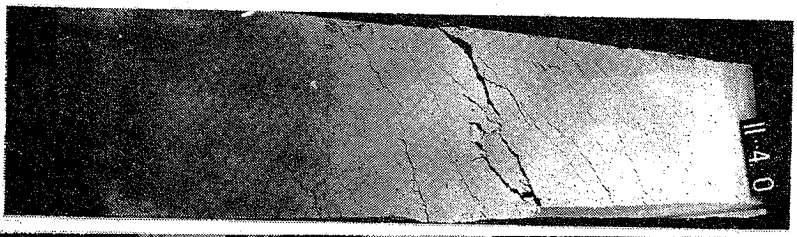
3



1

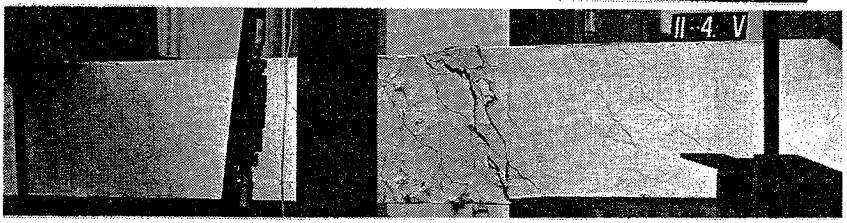
4

II-4



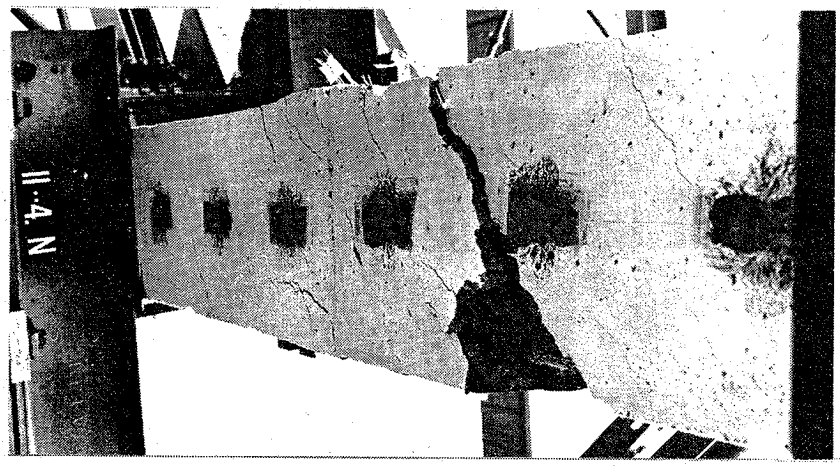
1

2



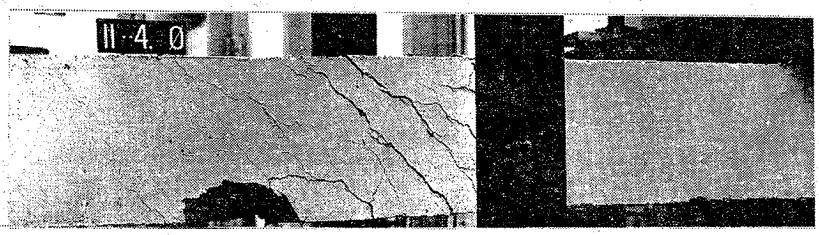
2

3



3

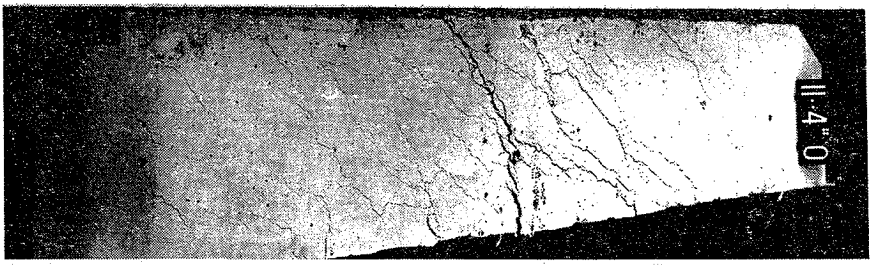
4



1

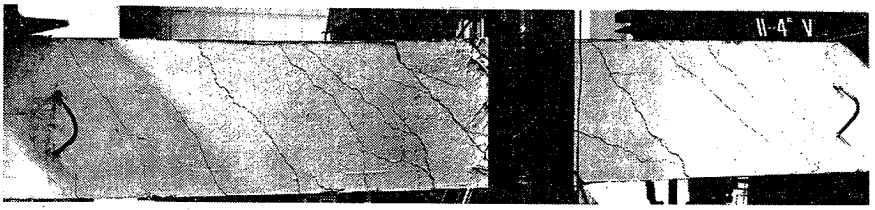
4

II-4*



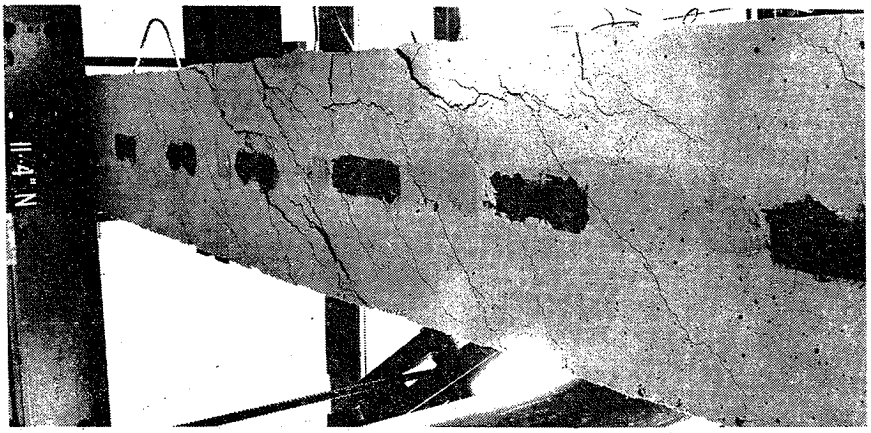
1

2



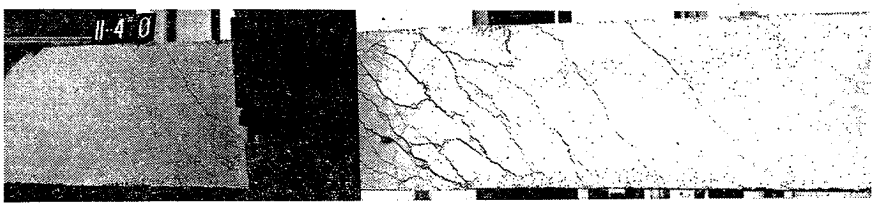
2

3



3

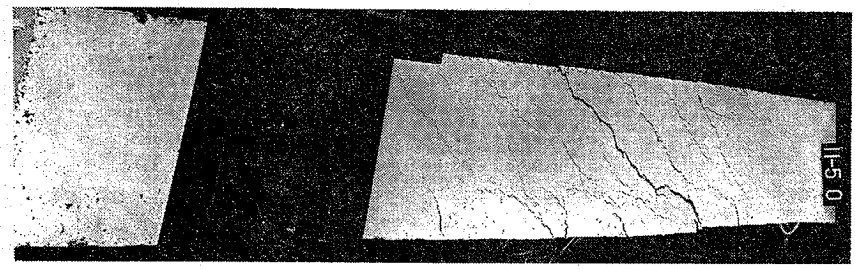
4



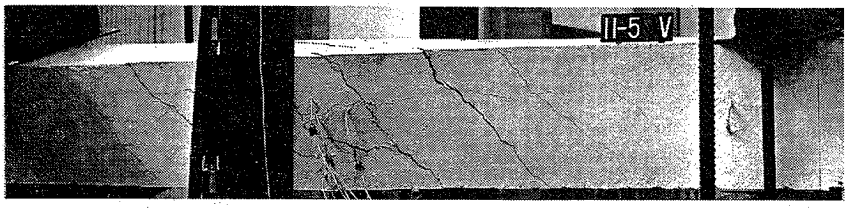
1

4

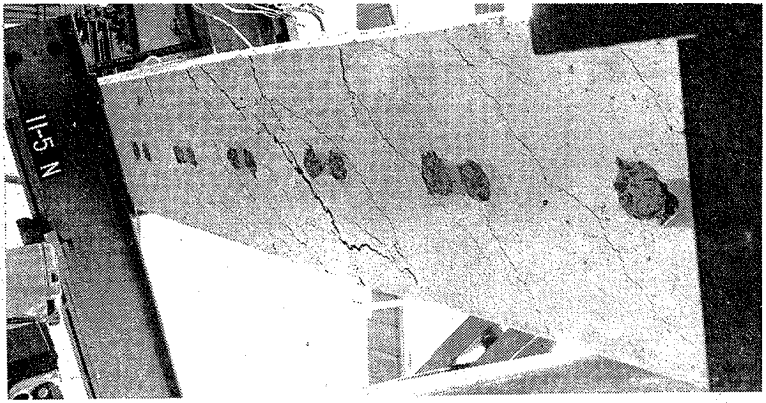
II-5



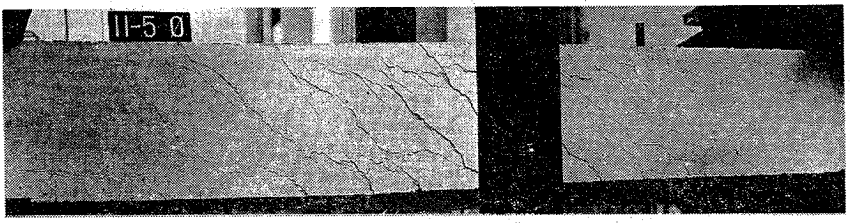
1 2



2 3

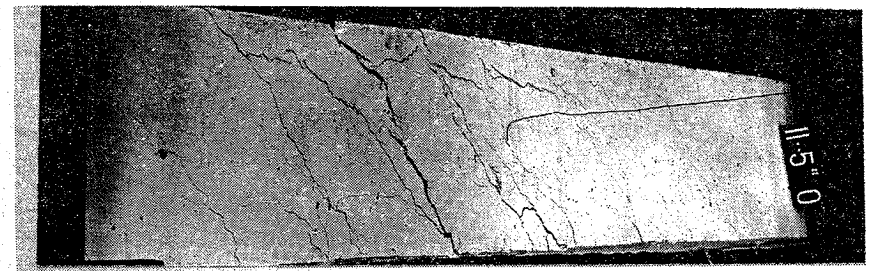


3 4



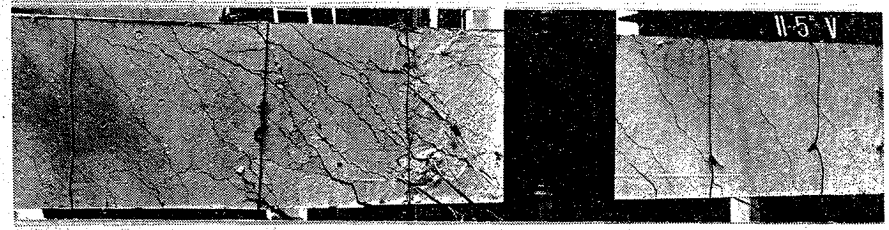
1 4

II-5*



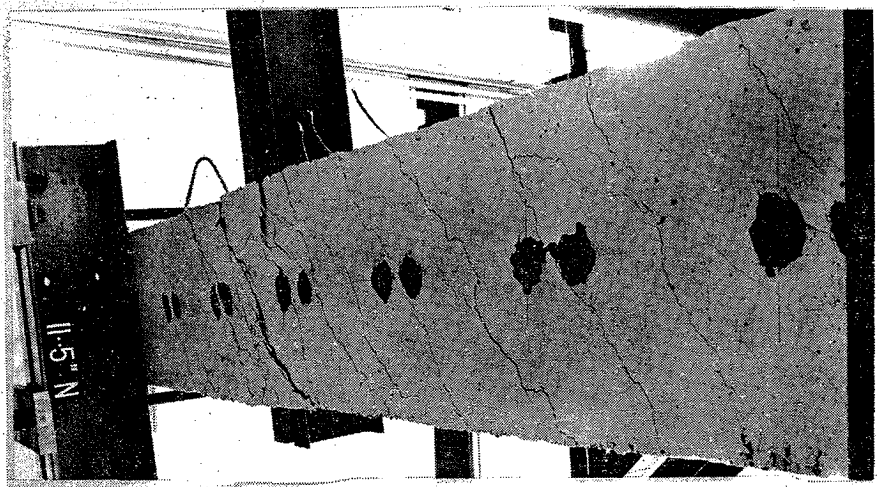
1

2



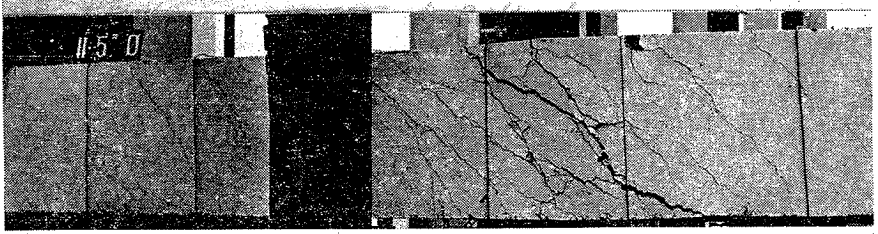
2

3



3

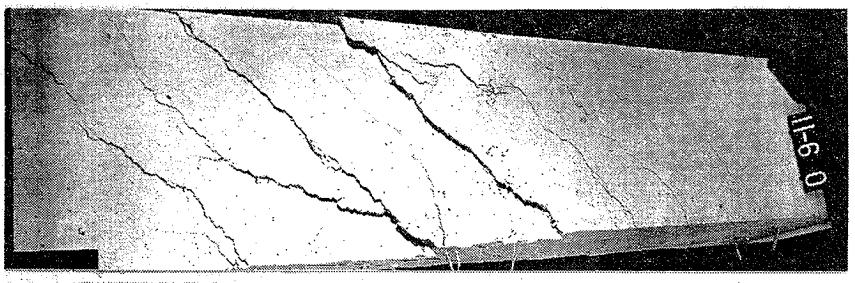
4



1

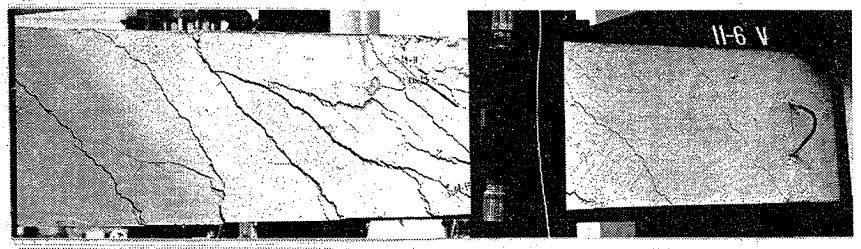
4

II-6



1

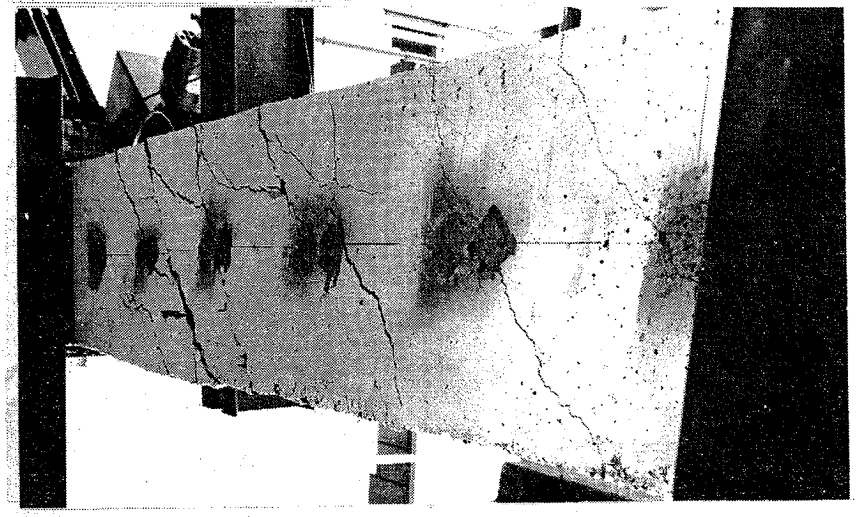
2



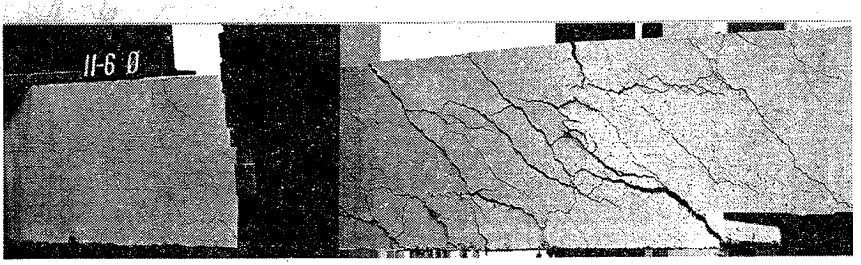
2

3

3



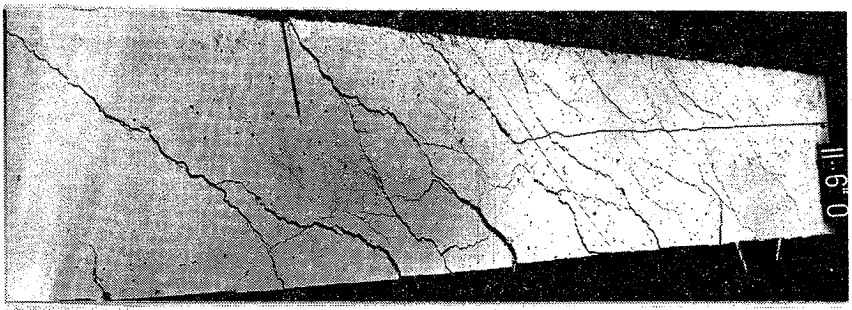
4



1

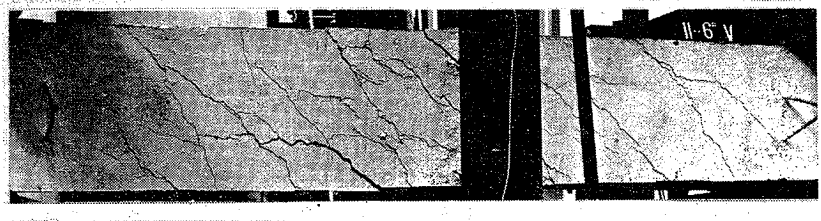
4

II-6*



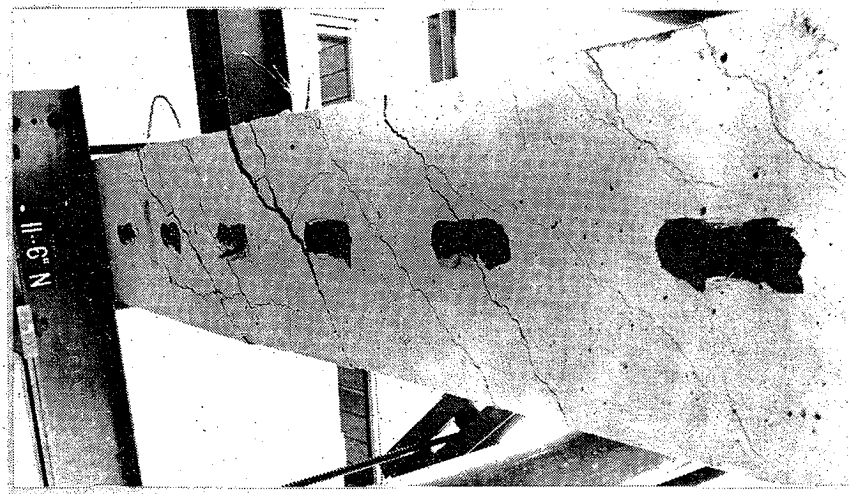
1

2



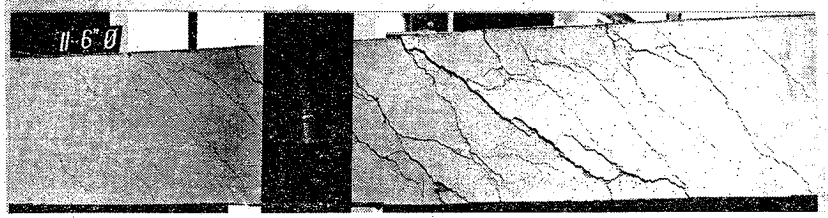
2

3



3

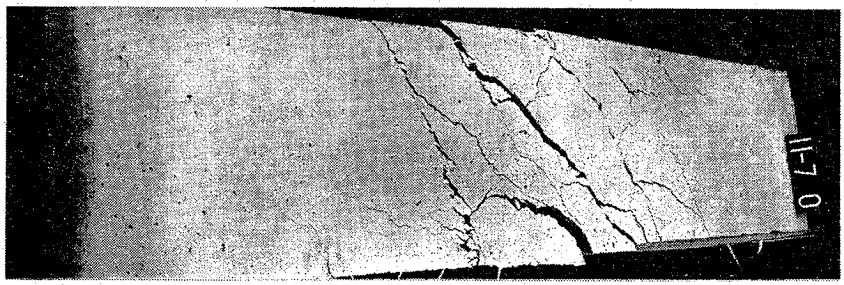
4



1

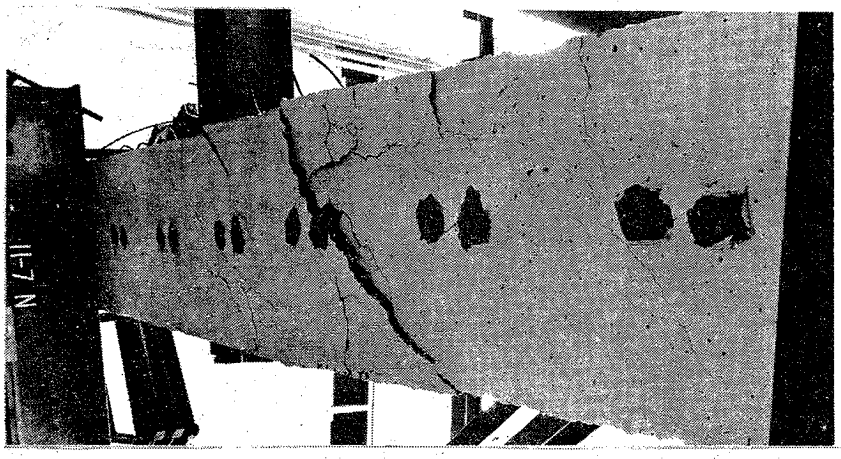
4

II-7

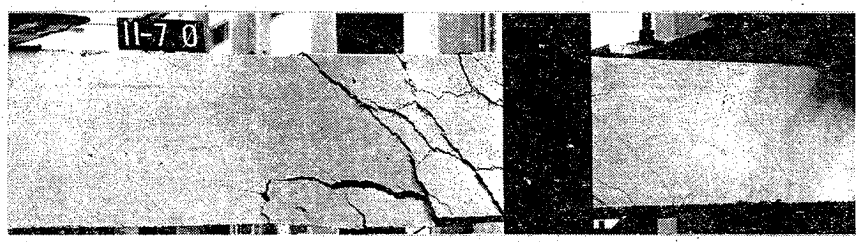


1 2

2 3

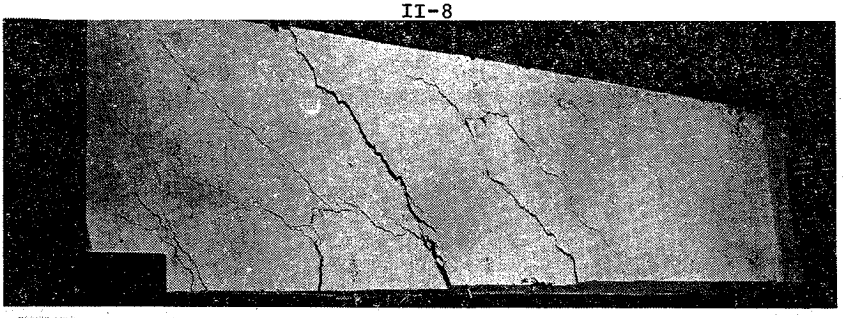


3 4



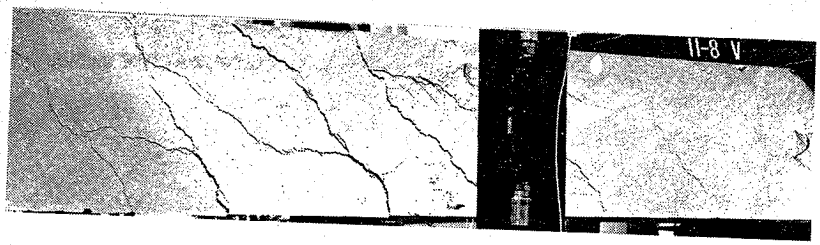
1 4

II-8



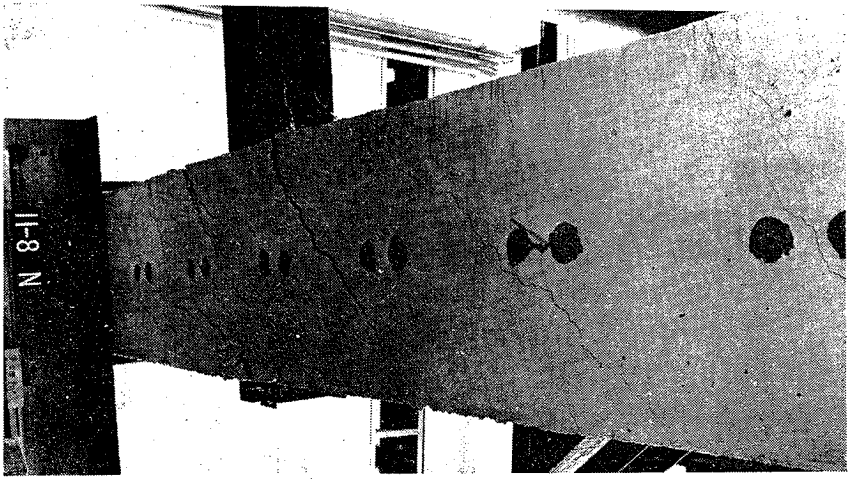
1

2



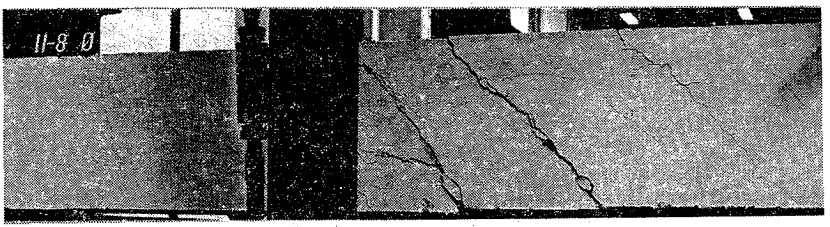
2

3



3

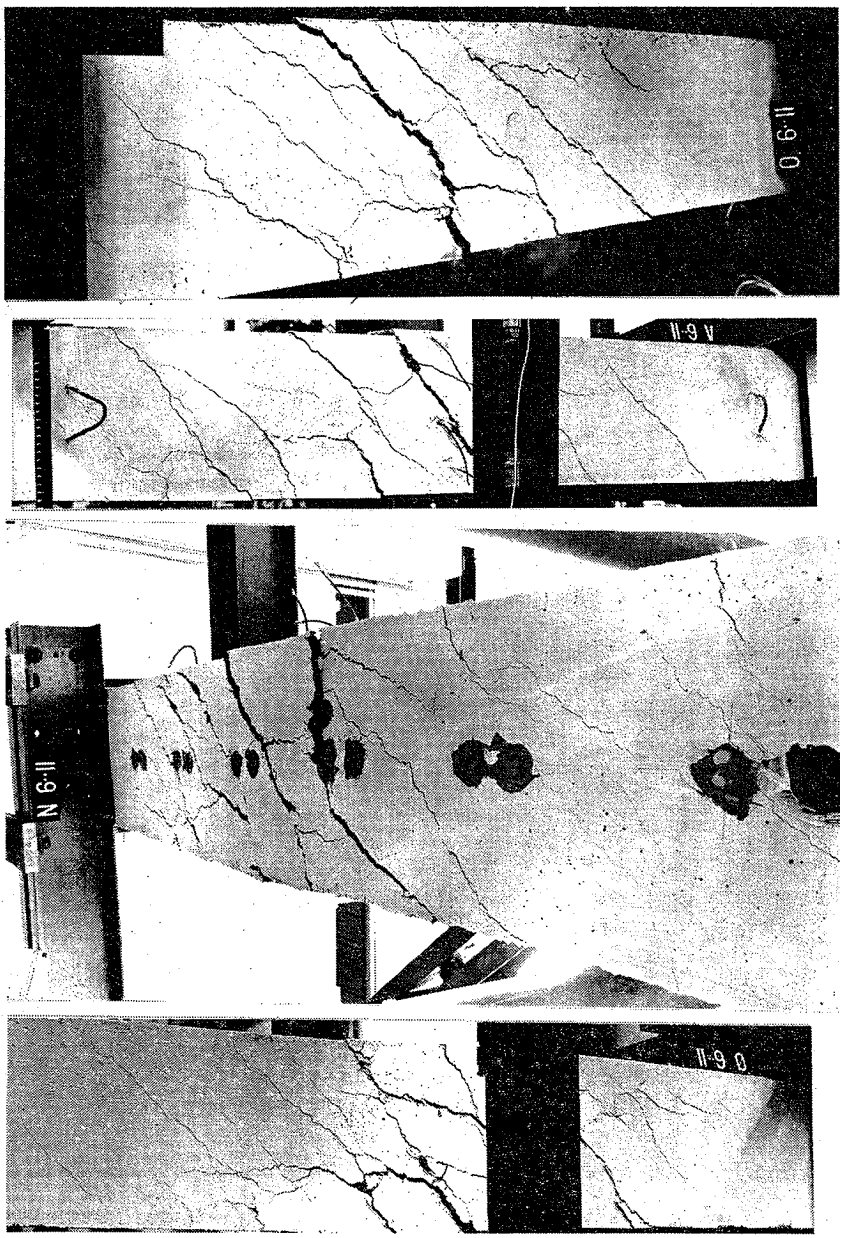
4

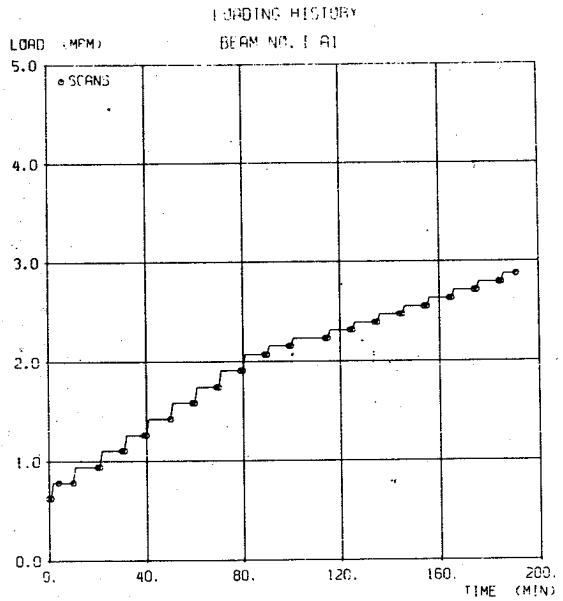


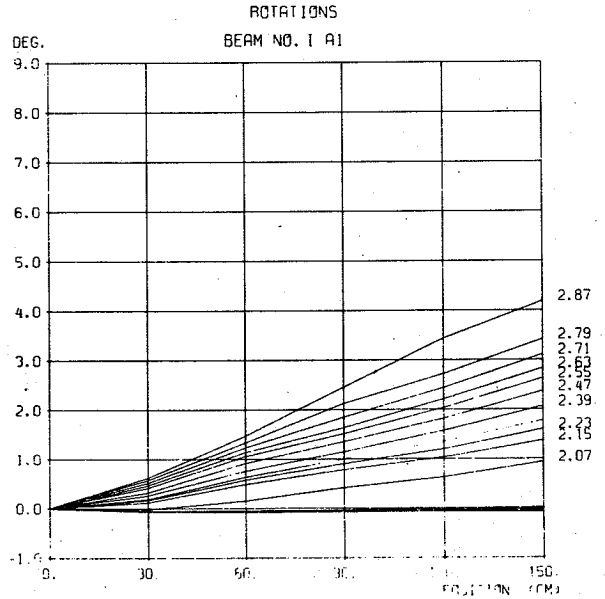
1

4

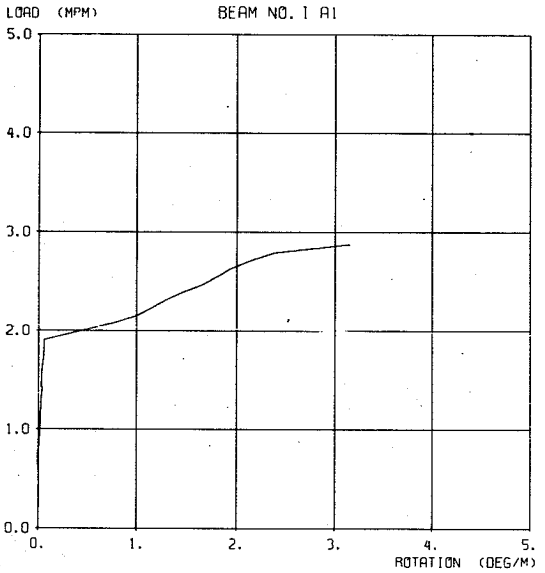
II-9



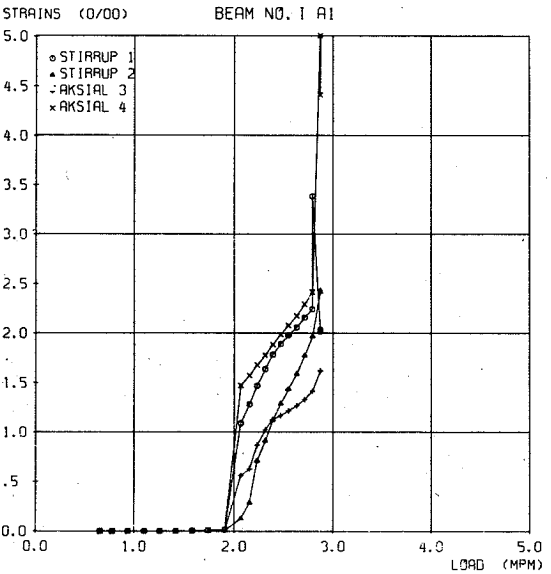

LOADING HISTORY
LOAD (MPM)
BEAM NO. I A1
5.0
4.0
3.0
2.0
1.0
0.0
SCANS
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I A1
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.
30.
60.
150.
2.87
2.79
2.71
2.63
2.55
2.47
2.39
2.23
2.15
2.07

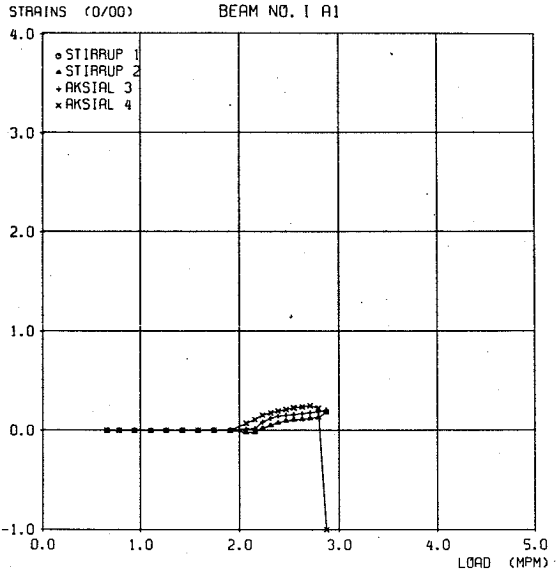
ROTATIONS



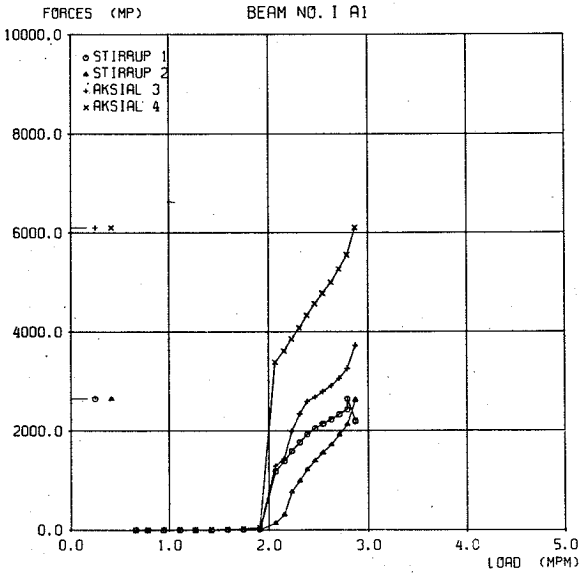
AVERAGE GAUGE STRAINS

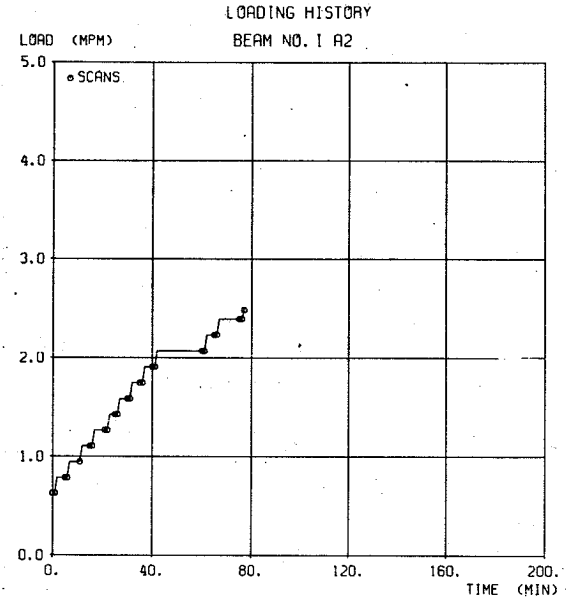


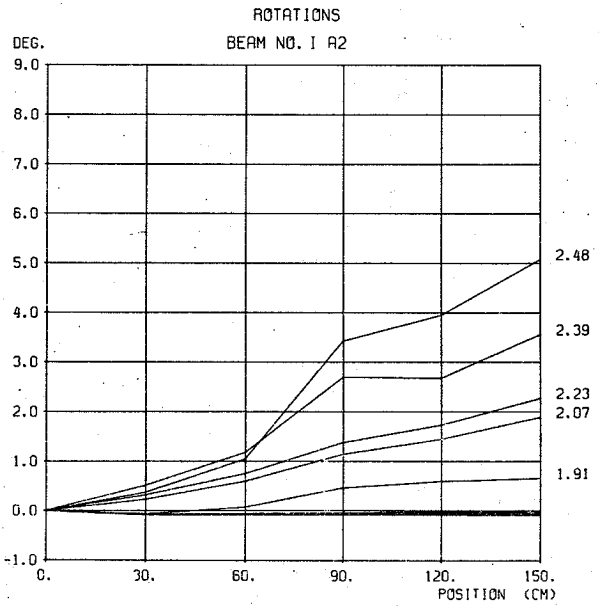
DIFFERENCE BETWEEN GAUGE STRAINS

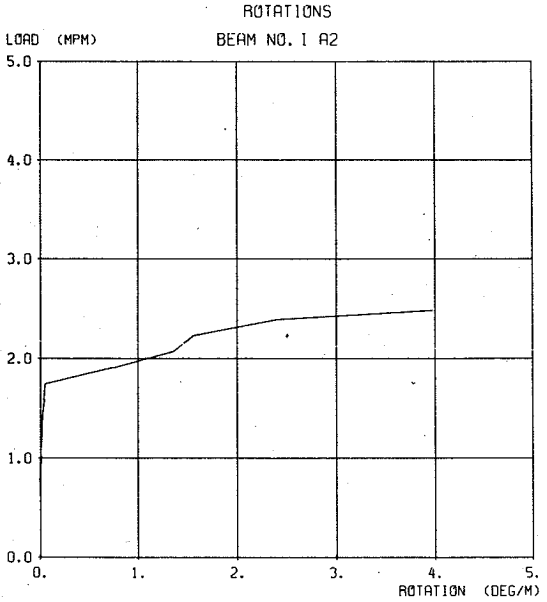


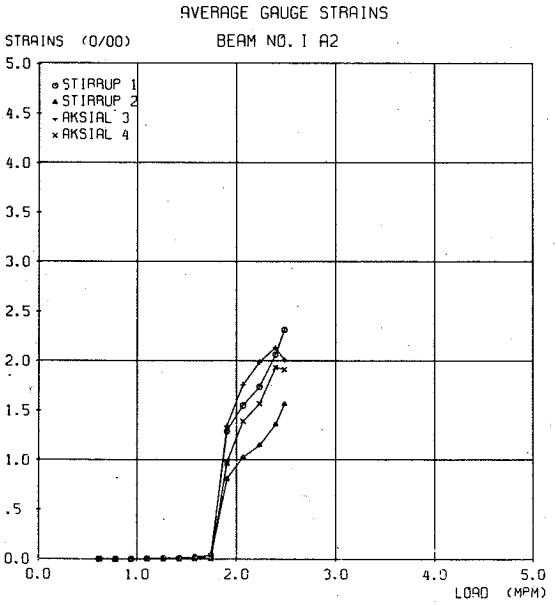
REINFORCEMENT FORCES



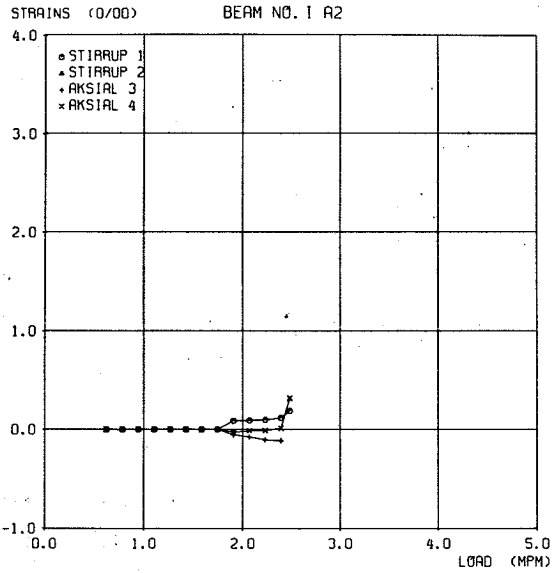

LOADING HISTORY
LOAD (MPM)
BEAM NO. I A2
o SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I A2
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
2.48
2.39
2.23
2.07
1.91

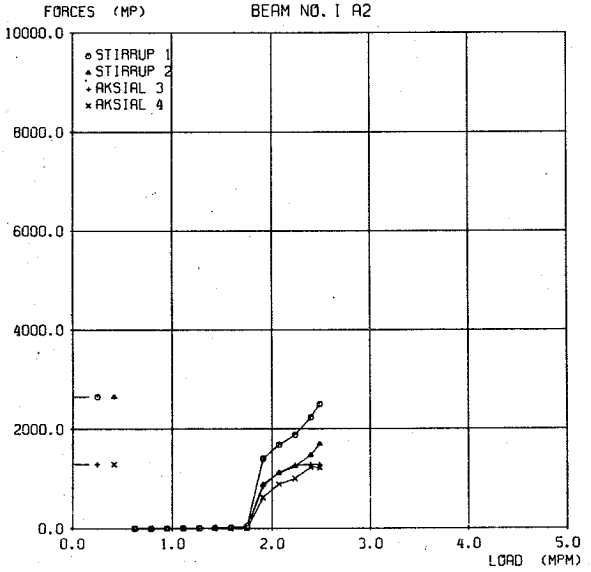

ROTATIONS
LOAD (MPM)
BEAM NO. I A2
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

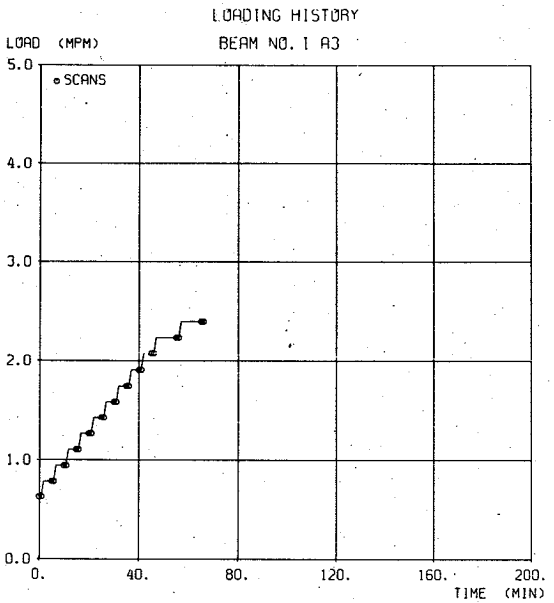

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. I A2
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

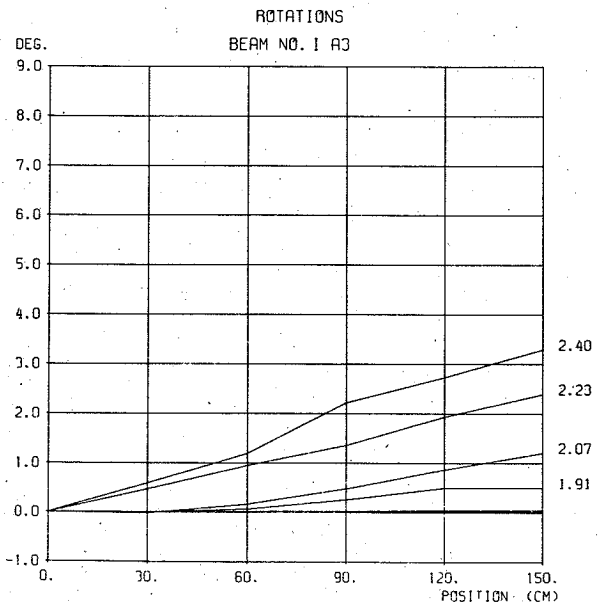
DIFFERENCE BETWEEN GAUGE STRAINS

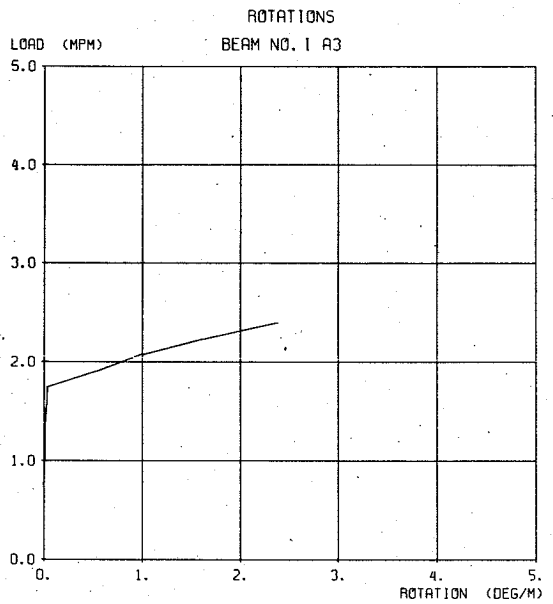


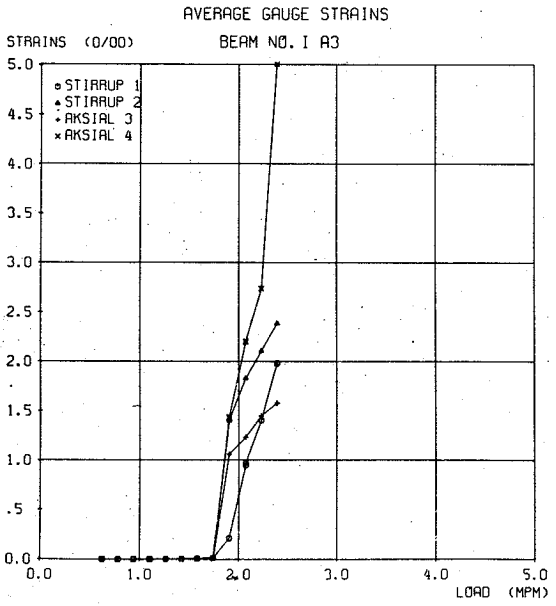
REINFØRCEMENT FØRCES



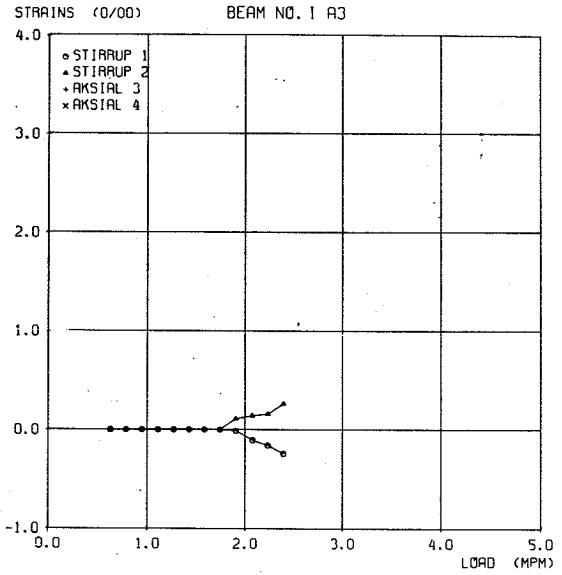

LOADING HISTORY
LOAD (MPM)
BEAM NO. I A3
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I A3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
2.40
2.23
2.07
1.91

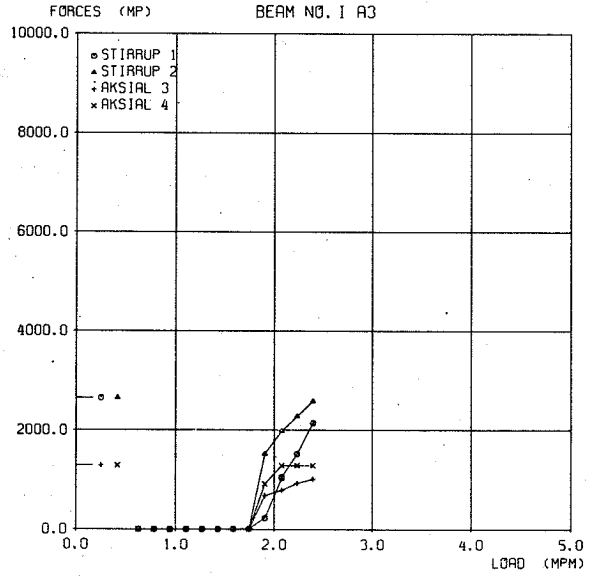

ROTATIONS
LOAD (MPM)
BEAM NO. I A3
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

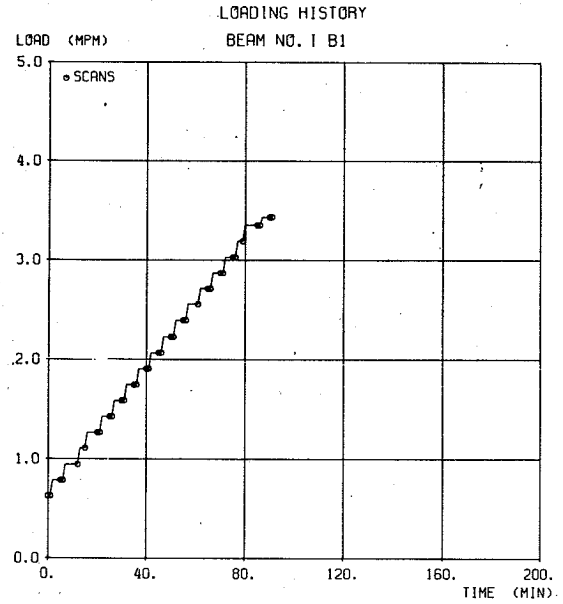

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. I A3
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

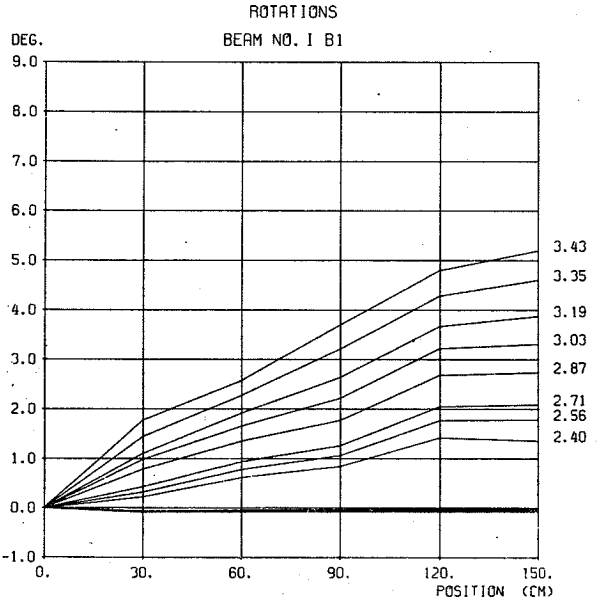
DIFFERENCE BETWEEN GAUGE STRAINS

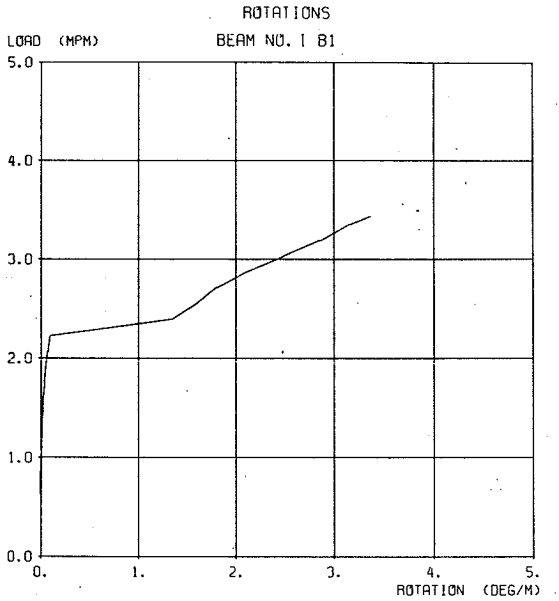


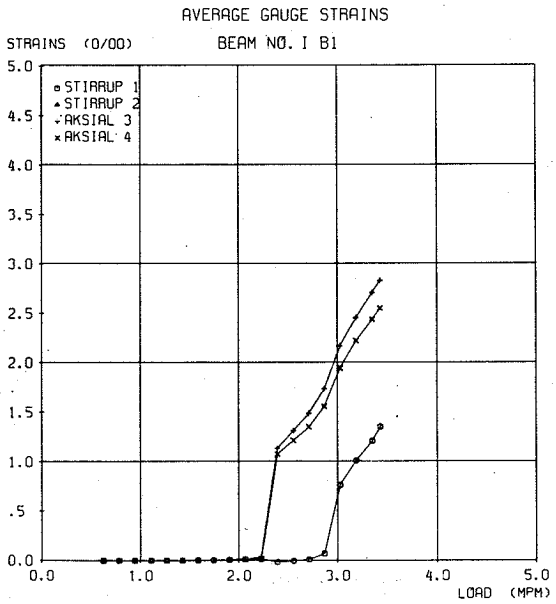
REINFØRCEMENT FØRCES



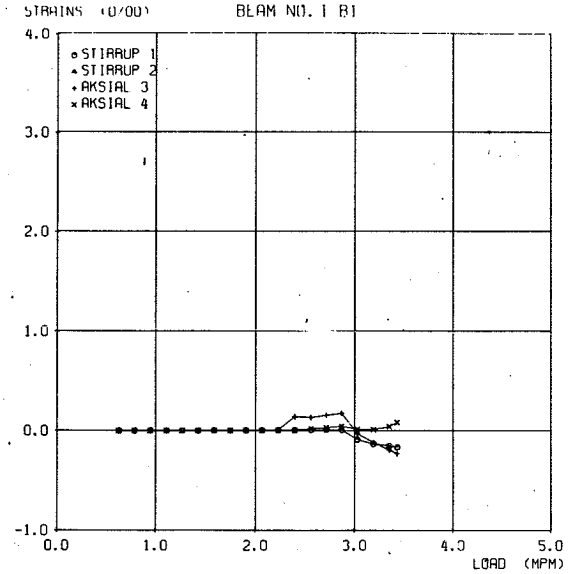

LOADING HISTORY
LOAD (MPM)
BEAM NO. I B1
o SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I B1
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.43
3.35
3.19
3.03
2.87
2.71
2.56
2.40

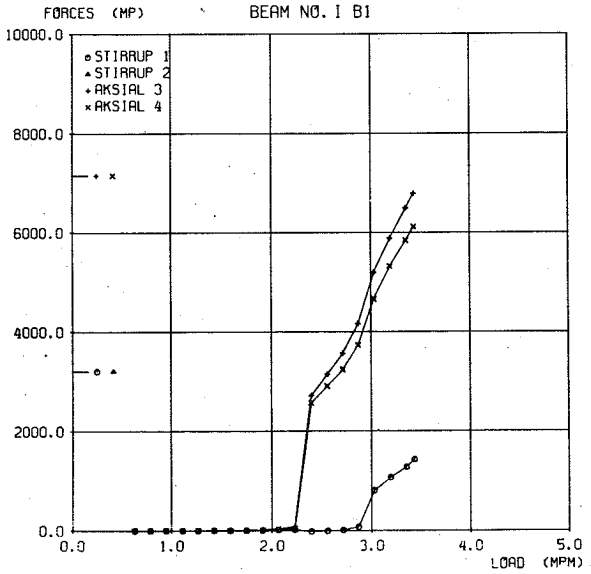

ROTATIONS
LOAD (MPM)
BEAM NO. I B1
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

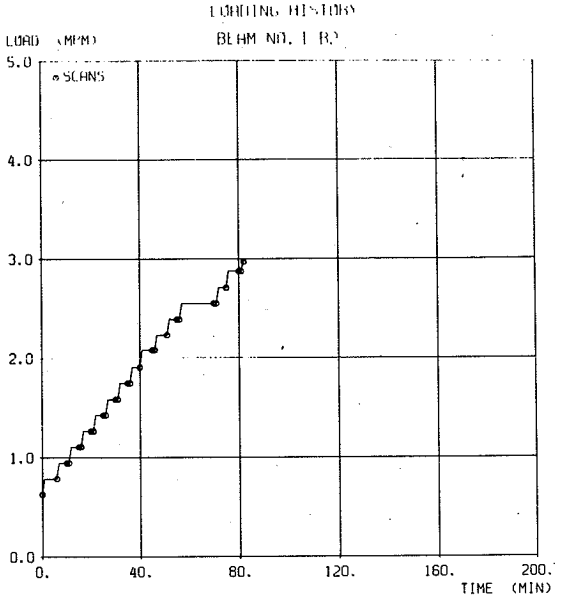

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. I B1
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

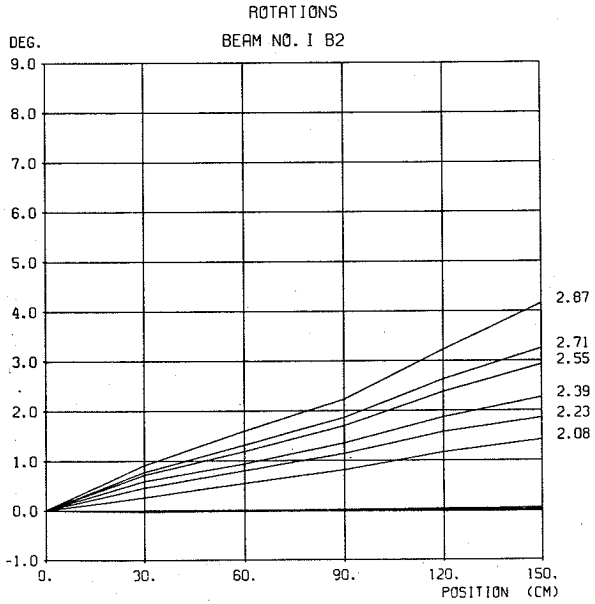
DIFFERENCE BETWEEN GAUGE STRAINS



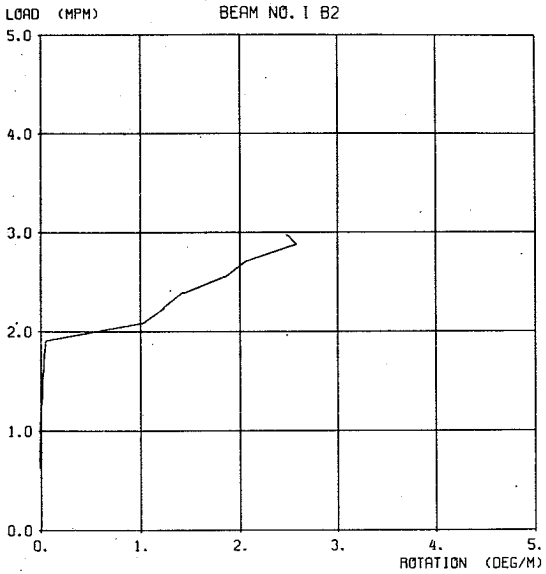
REINFØRCEMENT FØRCES



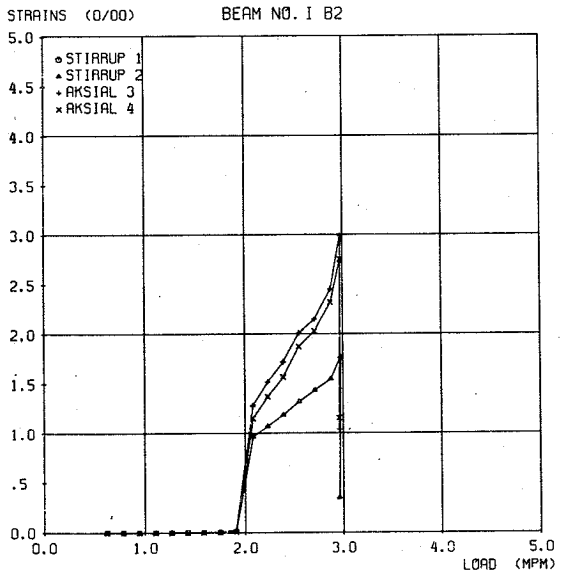

LOADING HISTORY
LOAD (MPM)
BEAM NO. I B2
5.0
4.0
3.0
2.0
1.0
0.0
* SCANS
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I B2
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
2.87
2.71
2.55
2.39
2.23
2.08

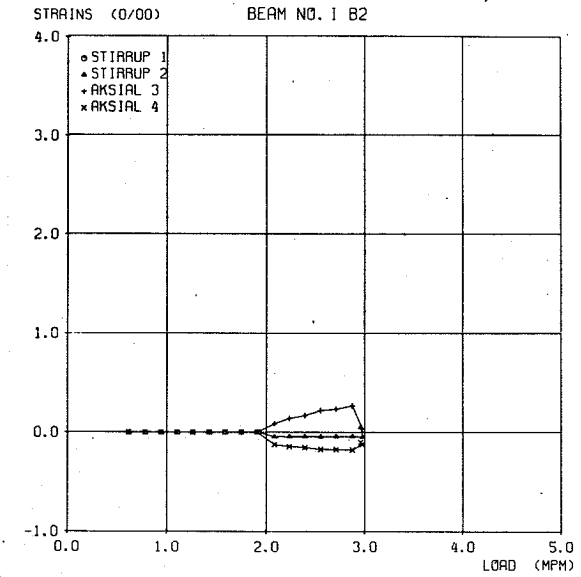
ROTATIONS



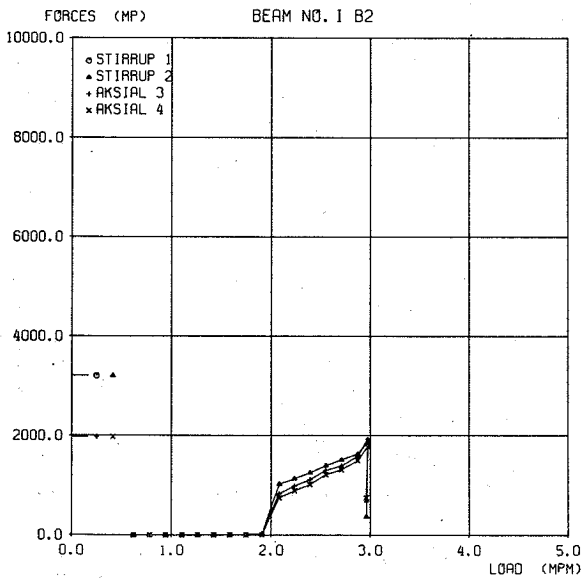
AVERAGE GAUGE STRAINS

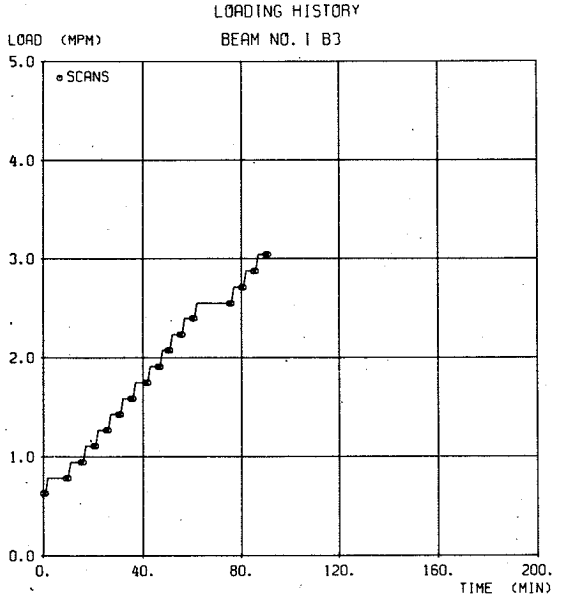


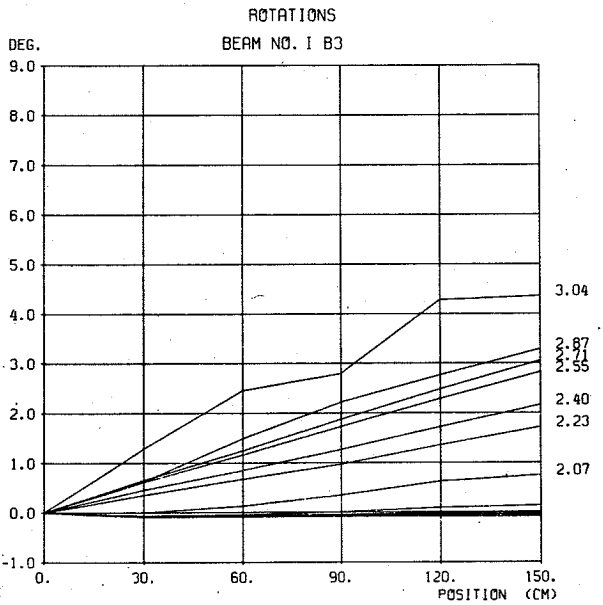
DIFFERENCE BETWEEN GAUGE STRAINS



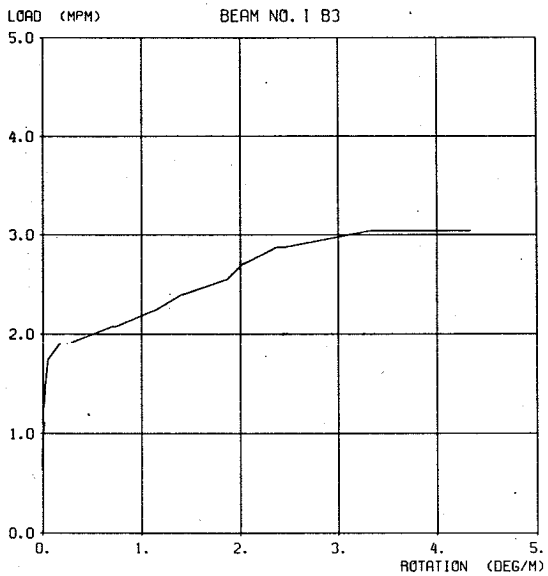
REINFØRCEMENT FØRCES



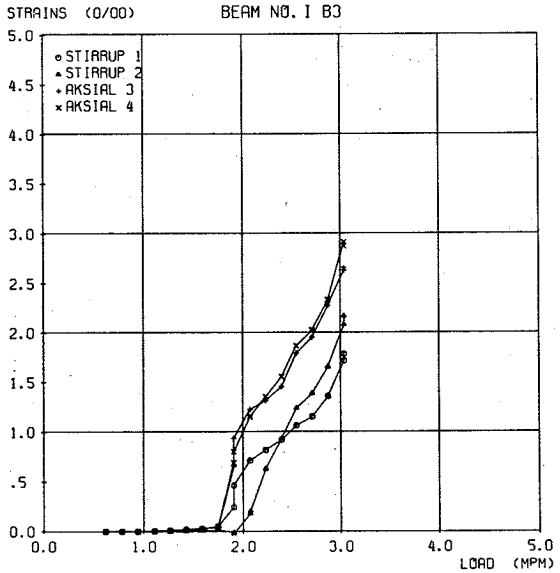

LOADING HISTORY
LOAD (MPM)
BEAM NO. I B3
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. I B3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.04
2.87
2.71
2.55
2.40
2.23
2.07

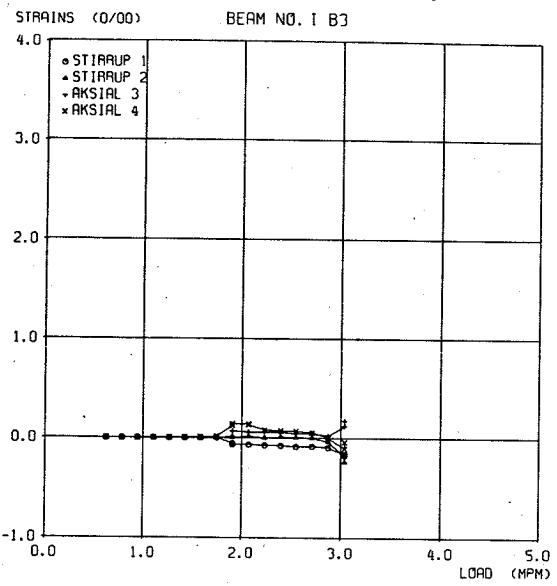
ROTATIONS



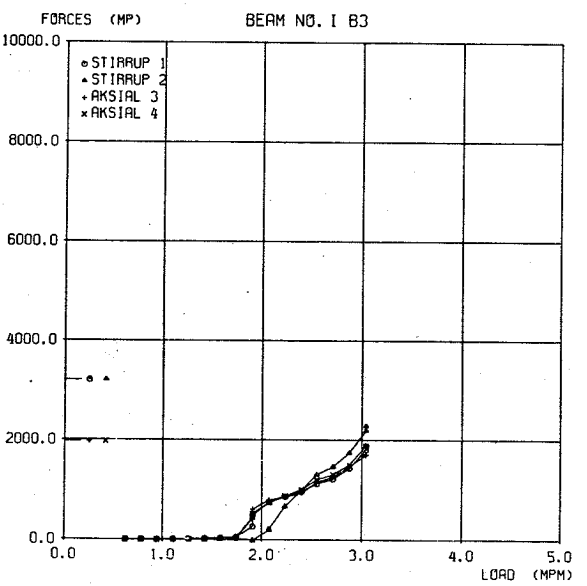
AVERAGE GAUGE STRAINS

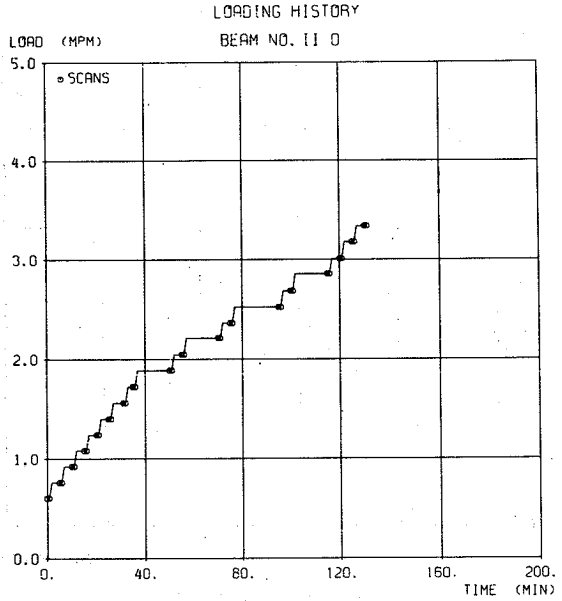


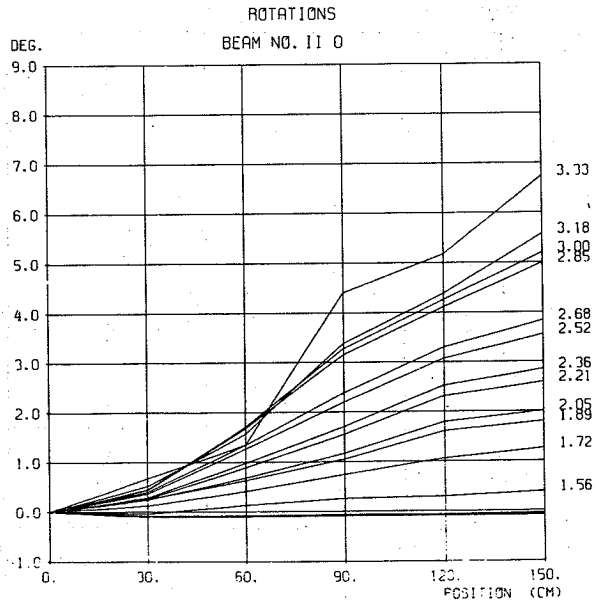
DIFFERENCE BETWEEN GAUGE STRAINS



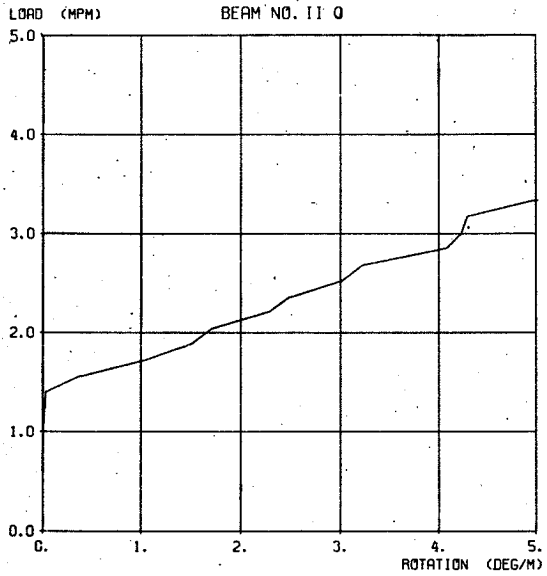
REINFØRCEMENT FØRCES



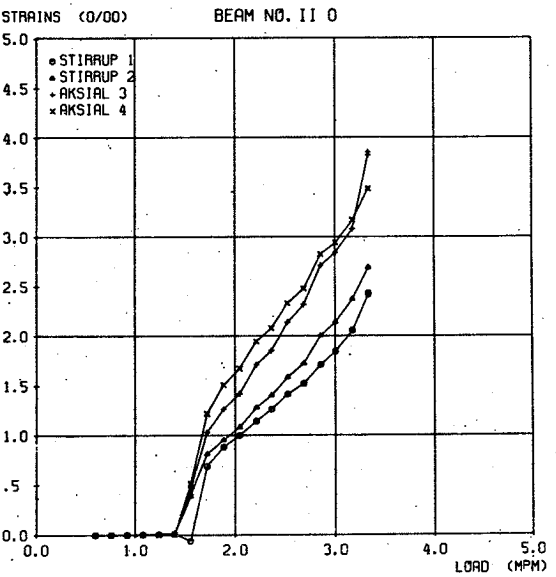

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 0
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.33
3.18
3.00
2.85
2.68
2.52
2.36
2.21
2.05
1.89
1.72
1.56

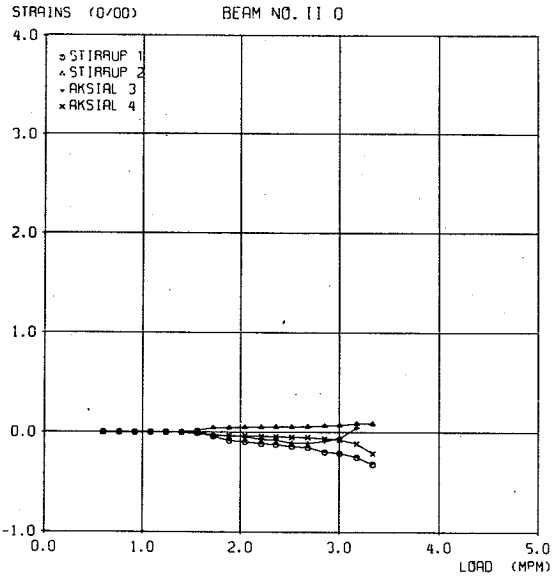
ROTATIONS



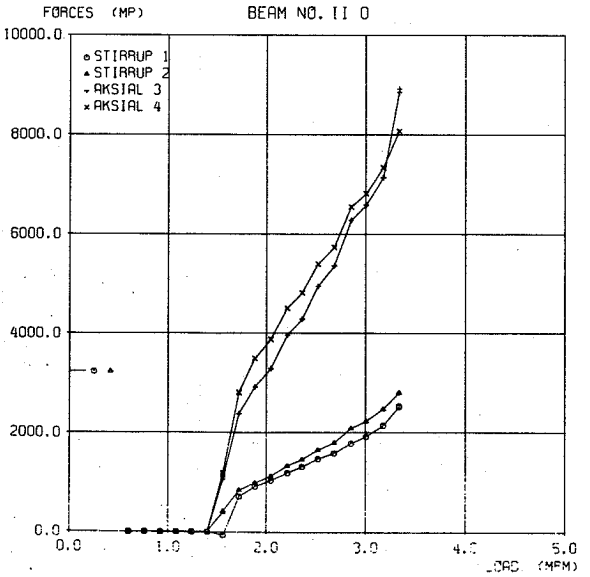
AVERAGE GAUGE STRAINS

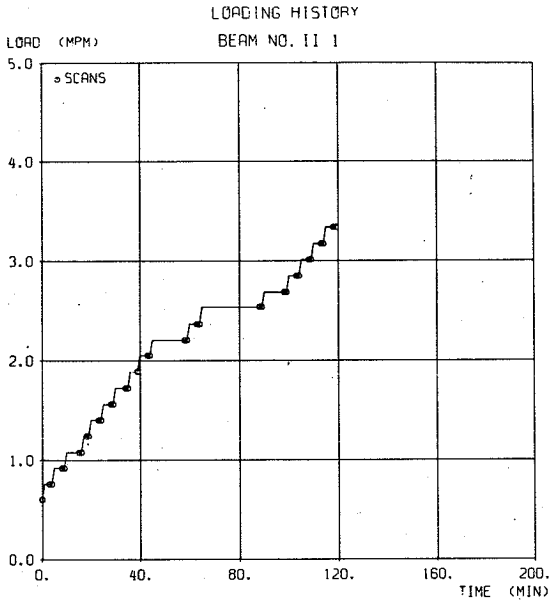


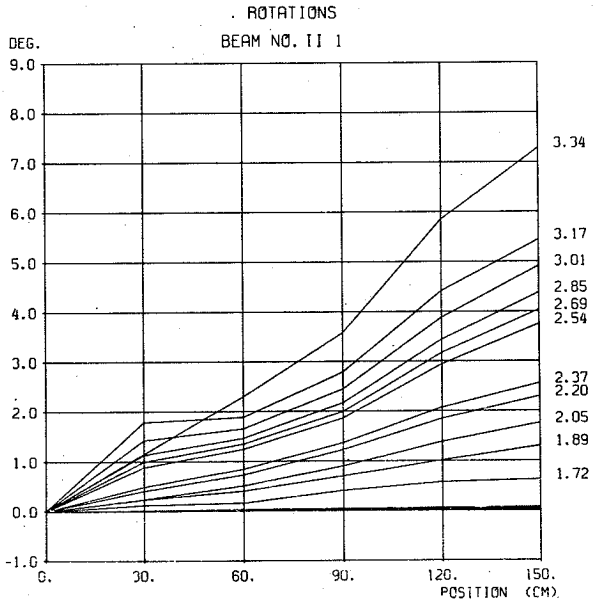
DIFFERENCE BETWEEN GAUGE STRAINS

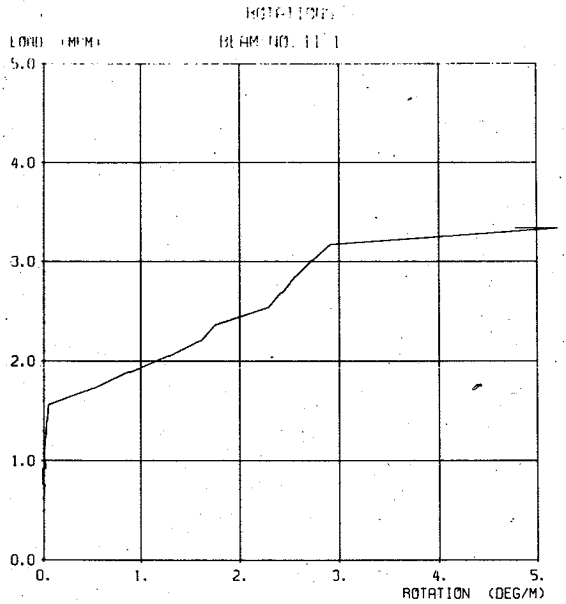


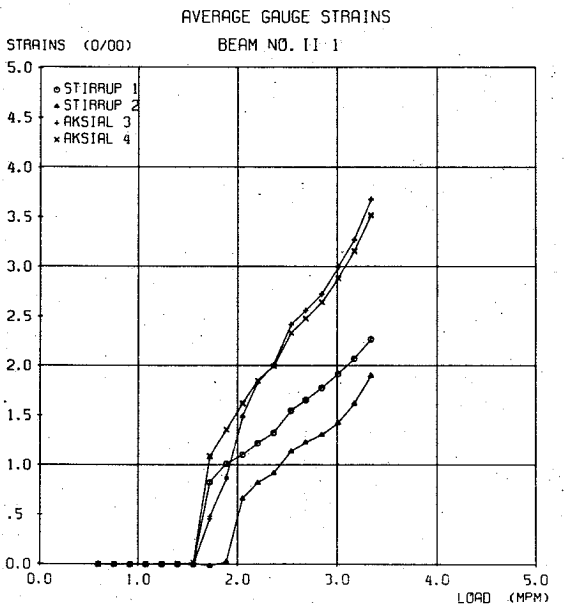
REINFØRCEMENT FØRCES



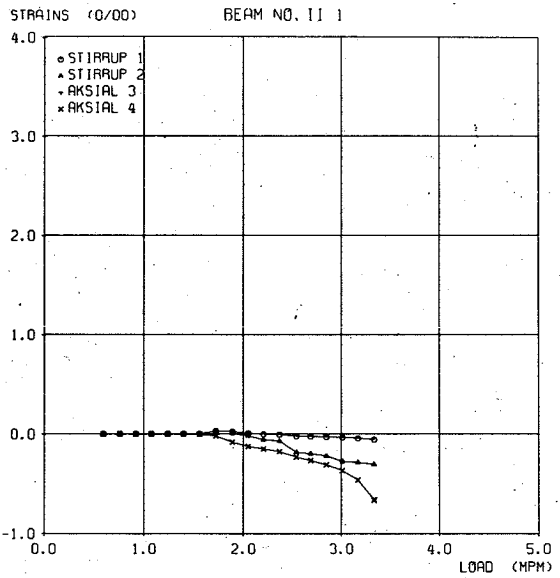

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 1
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 1
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.34
3.17
3.01
2.85
2.69
2.54
2.37
2.20
2.05
1.89
1.72

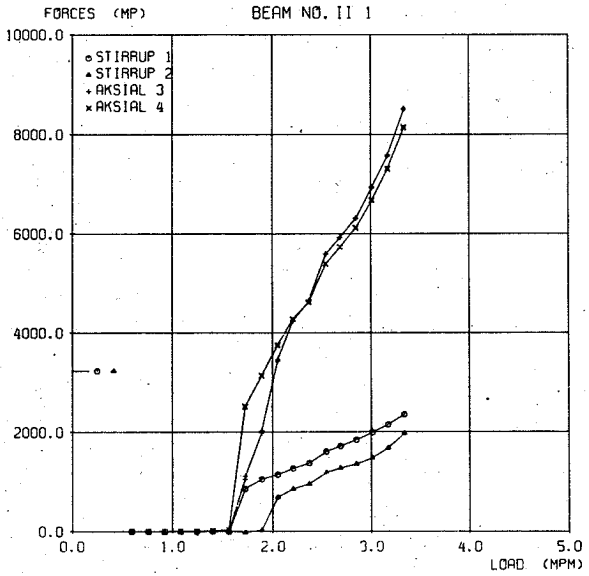

LOAD (MPM)
BEAM NO. II 1
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

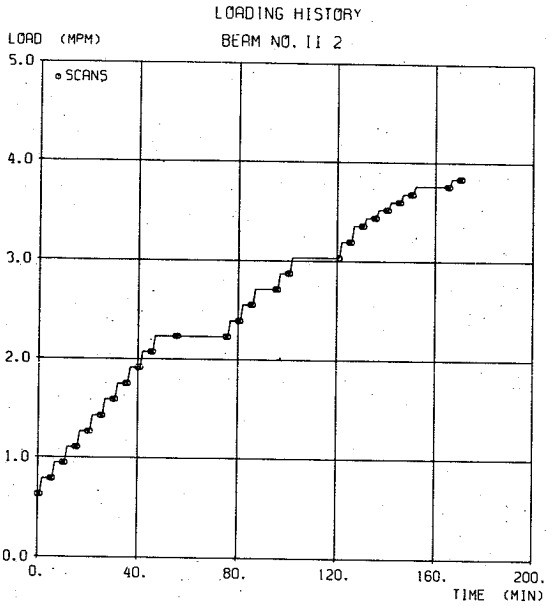

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 1
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

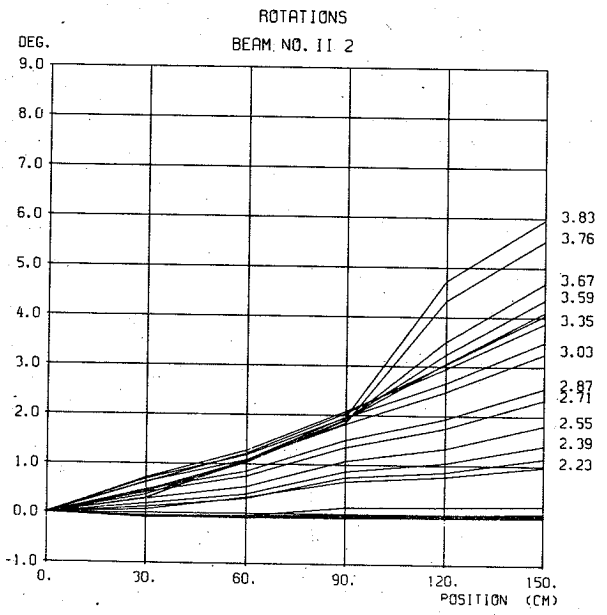
DIFFERENCE BETWEEN GAUGE STRAINS

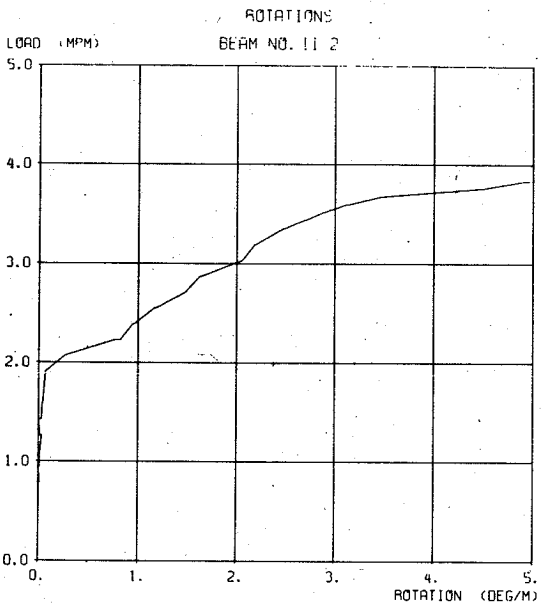


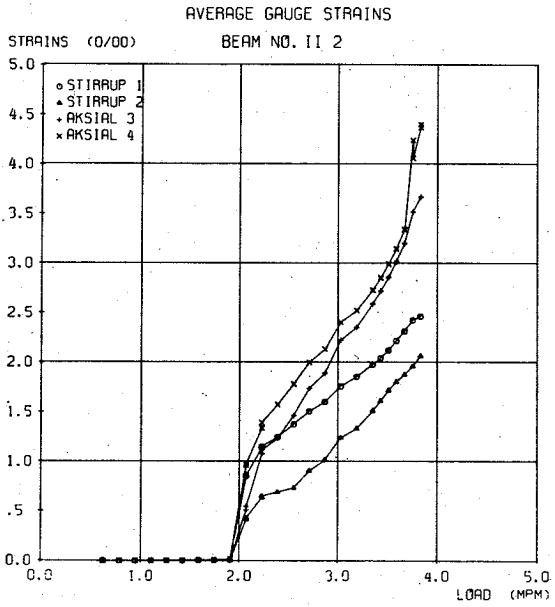
REINFORCEMENT FORCES

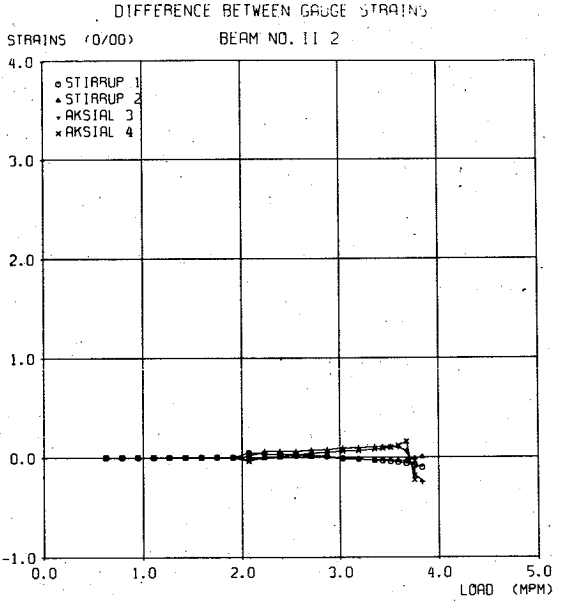


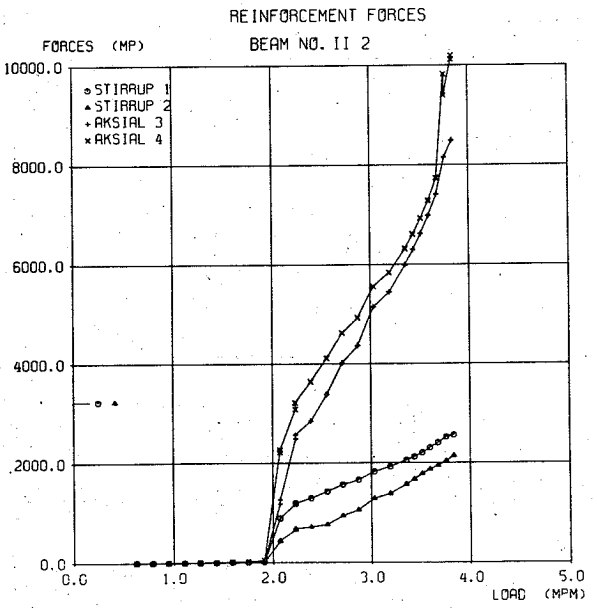

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 2
o SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)

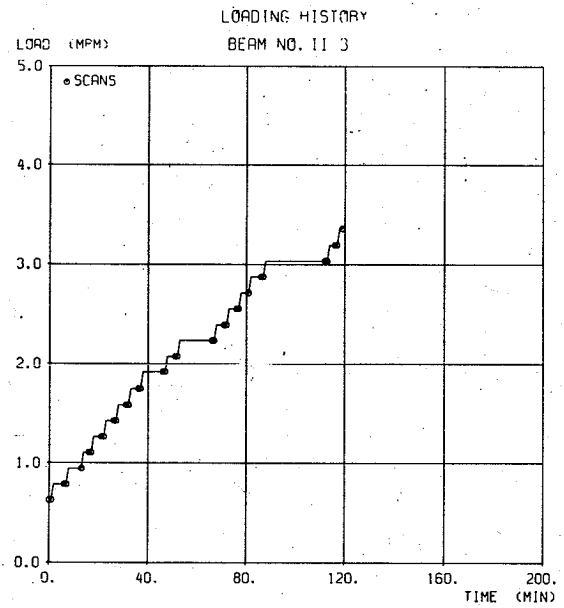

ROTATIONS
DEG.
BEAM NO. II 2
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.83
3.76
3.67
3.59
3.35
3.03
2.87
2.71
2.55
2.39
2.23

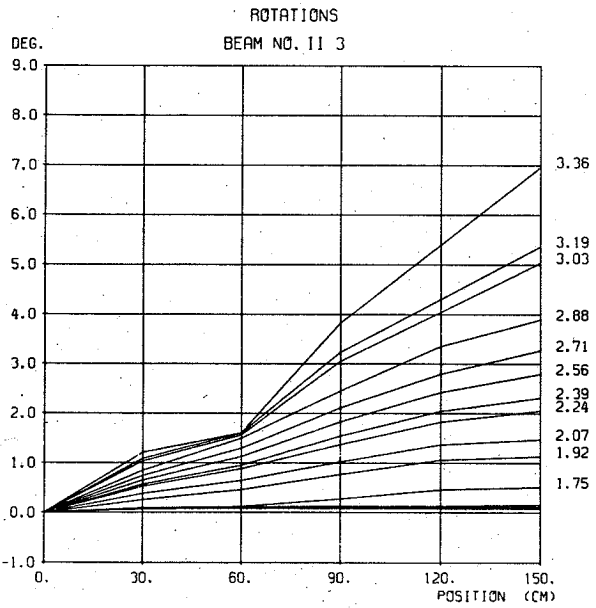

ROTATIONS
LOAD (MPM)
BEAM NO. II 2
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)


AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 2
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

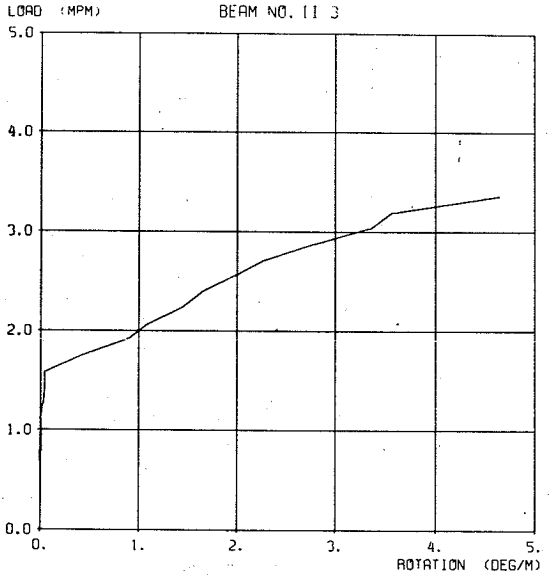

DIFFERENCE BETWEEN GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 2
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
4.0
3.0
2.0
1.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)


REINFORCEMENT FORCES
FORCES (MP)
BEAM NO. II 2
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

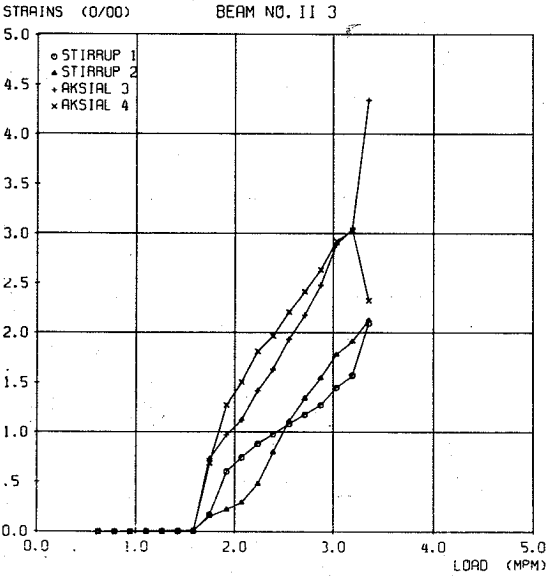

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 3
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)

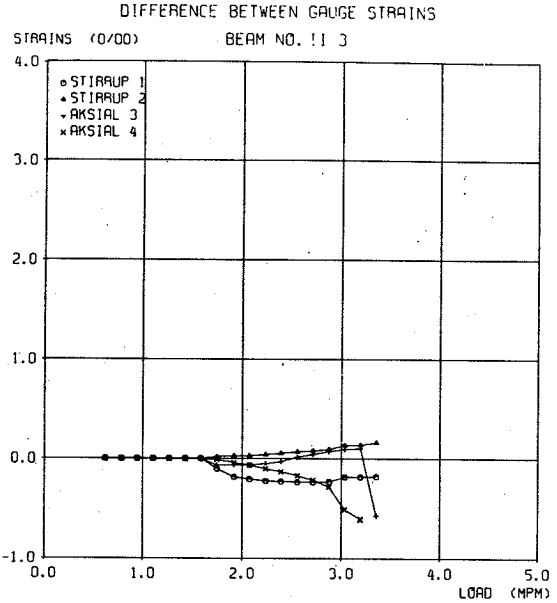

ROTATIONS
DEG.
BEAM NO. II 3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.36
3.19
3.03
2.88
2.71
2.56
2.39
2.24
2.07
1.92
1.75

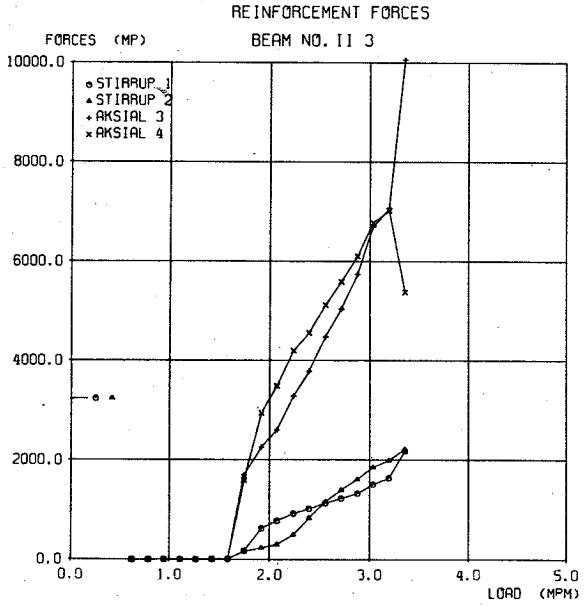
ROTATIONS

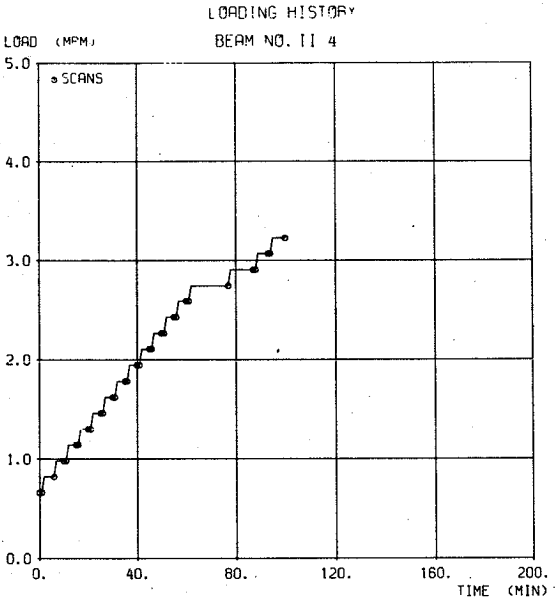


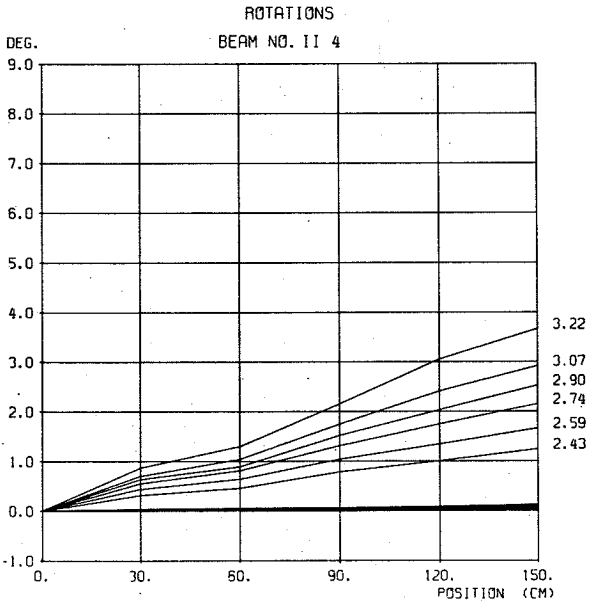
AVERAGE GAUGE STRAINS

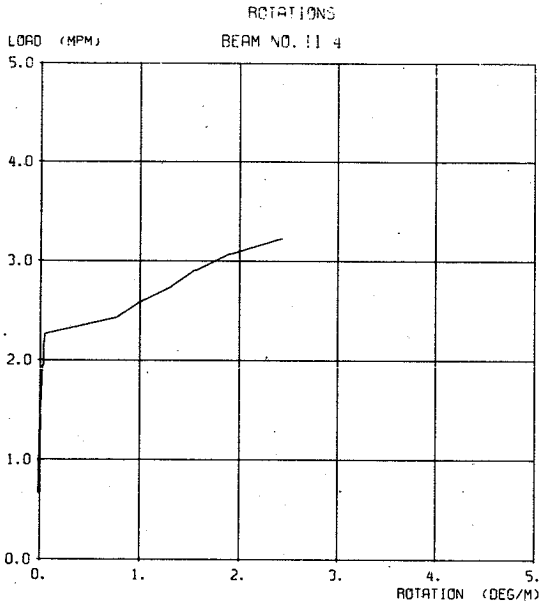


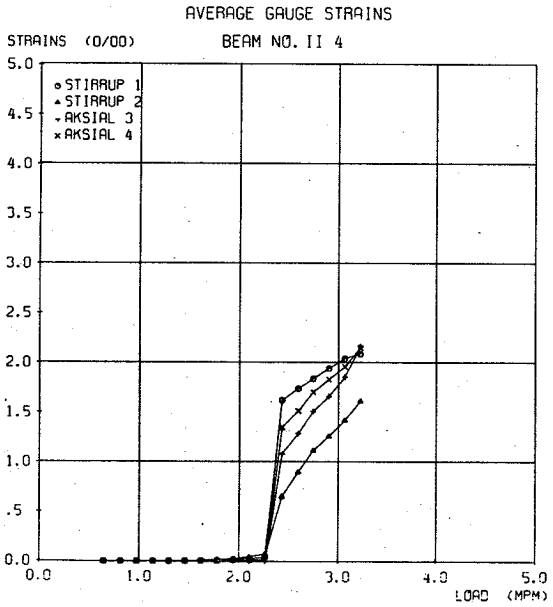

DIFFERENCE BETWEEN GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 3
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
4.0
3.0
2.0
1.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)


REINFORCEMENT FORCES
FORCES (MP)
BEAM NO. II 3
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

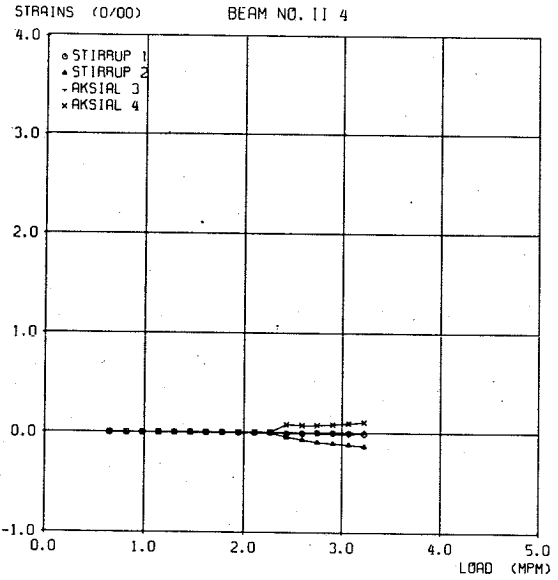

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 4
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 4
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.22
3.07
2.90
2.74
2.59
2.43

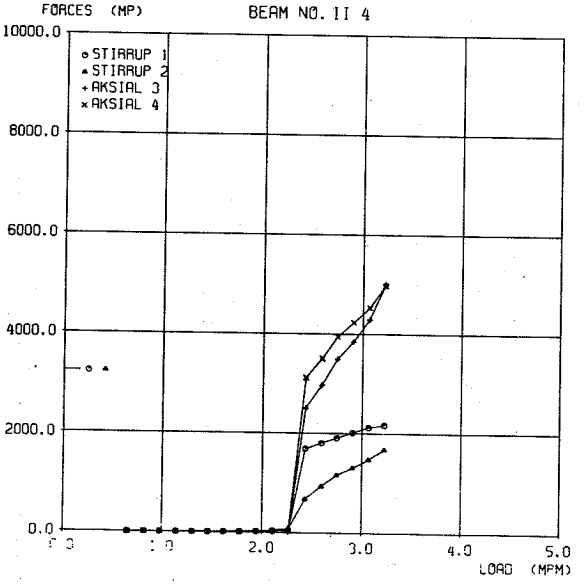

ROTATIONS
LOAD (MPM)
BEAM NO. II 4
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

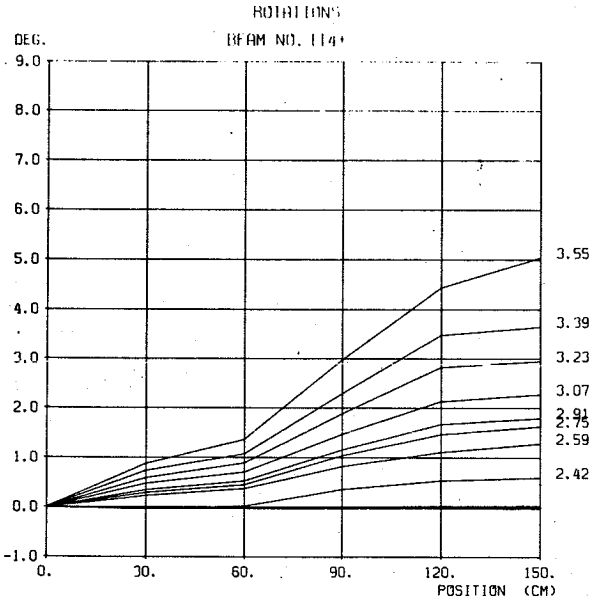

AVERAGE GAUGE STRAINS
STRAINS (O/OO)
BEAM NO. II 4
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

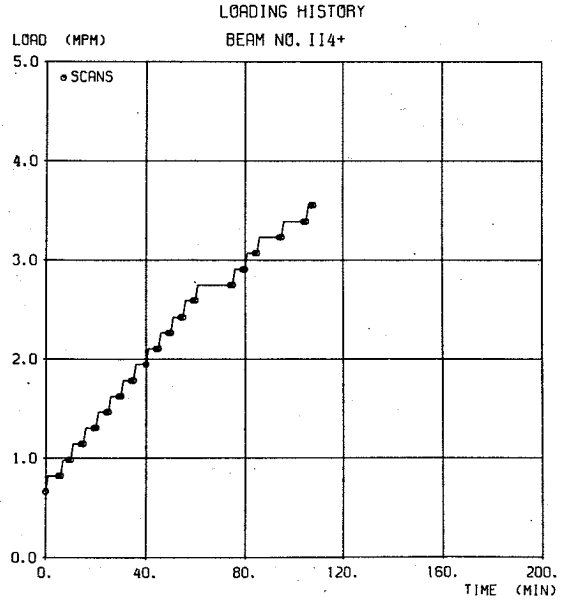
DIFFERENCE BETWEEN GAUGE STRAINS



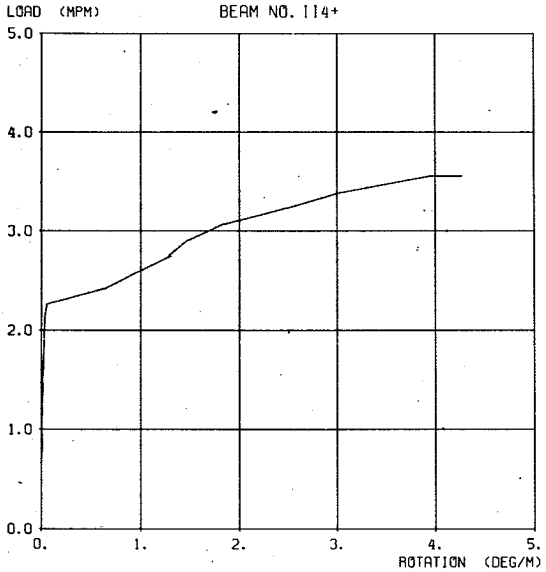
REINFORCEMENT FORCES



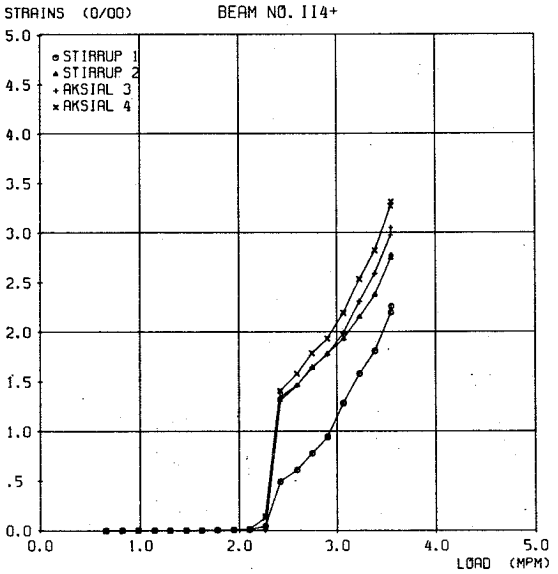

ROTATIONS
DEG.
BEAM NO. II4+
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.55
3.39
3.23
3.07
2.91
2.75
2.59
2.42


LOADING HISTORY
LOAD (MPM)
BEAM NO. II4+
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)

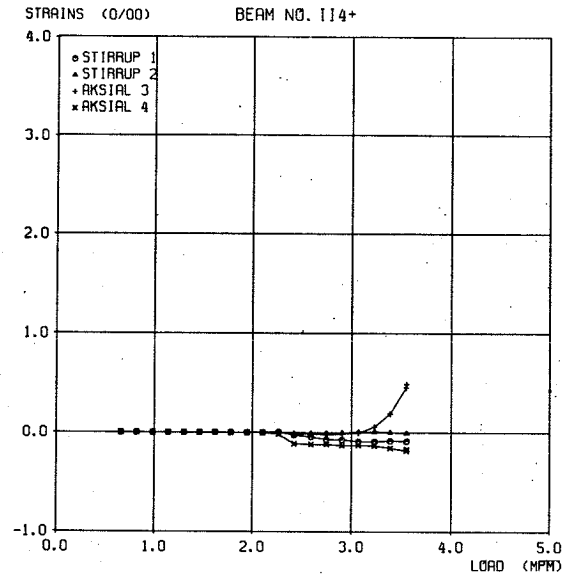
ROTATIONS



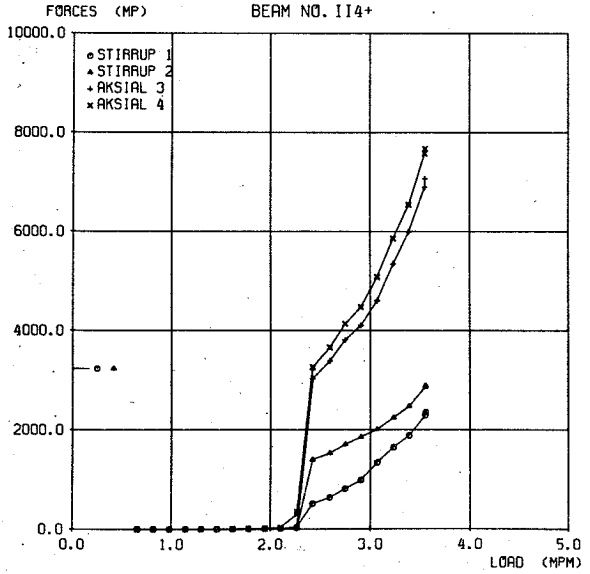
AVERAGE GAUGE STRAINS

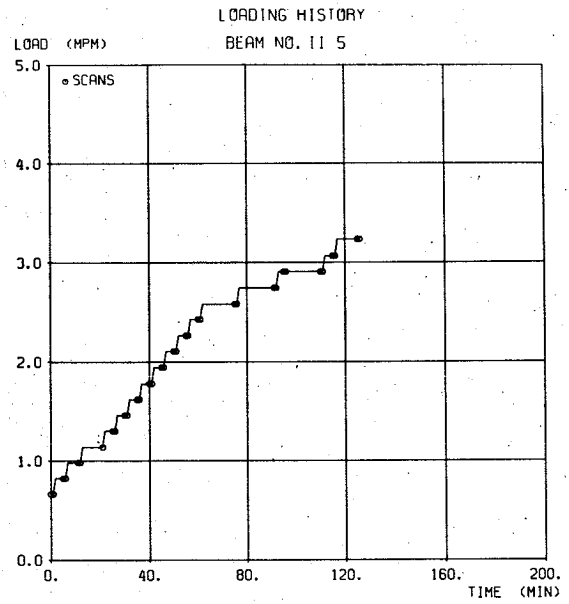


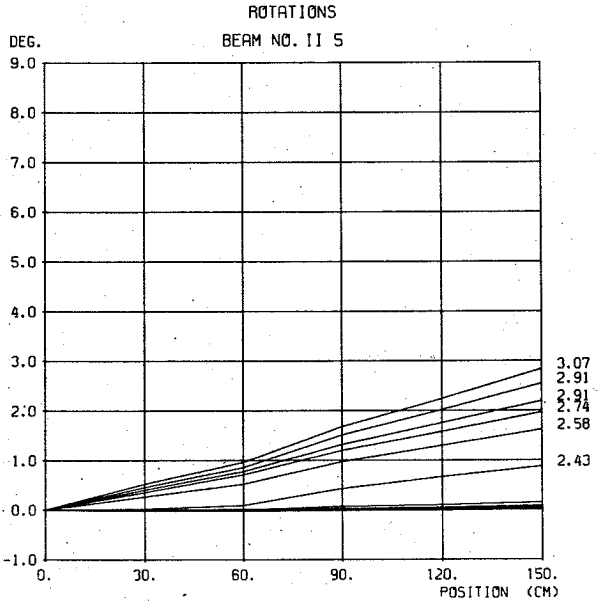
DIFFERENCE BETWEEN GAUGE STRAINS

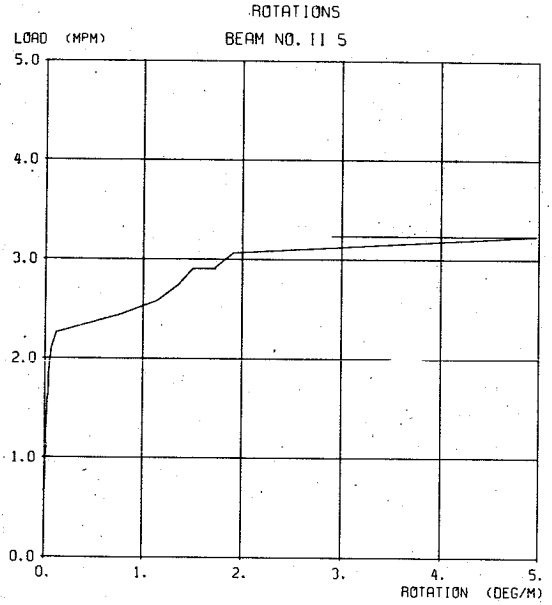


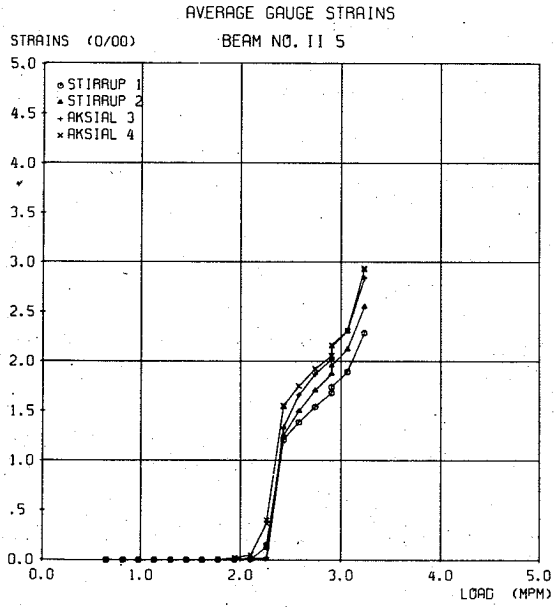
REINFØRCEMENT FØRCES



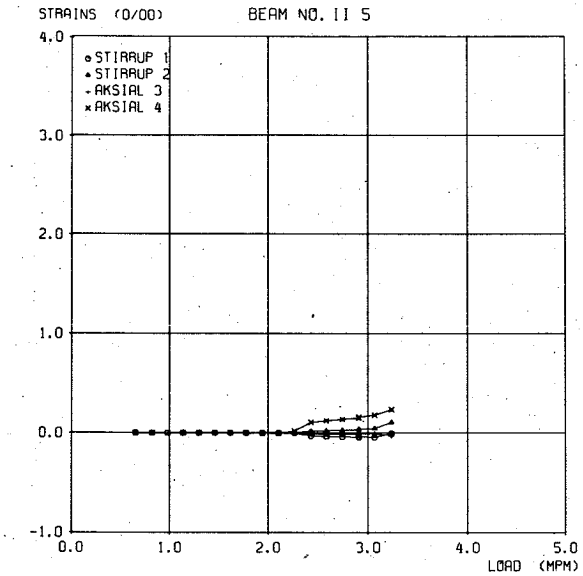

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 5
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 5
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.07
2.91
2.91
2.74
2.58
2.43

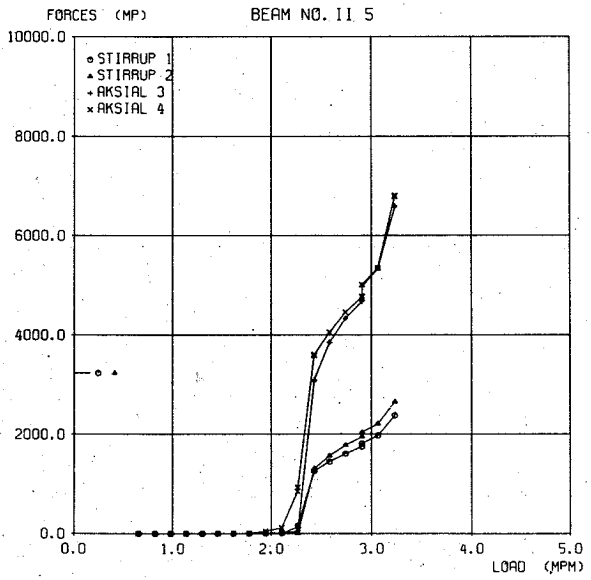

ROTATIONS
LOAD (MPM)
BEAM NO. II 5
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

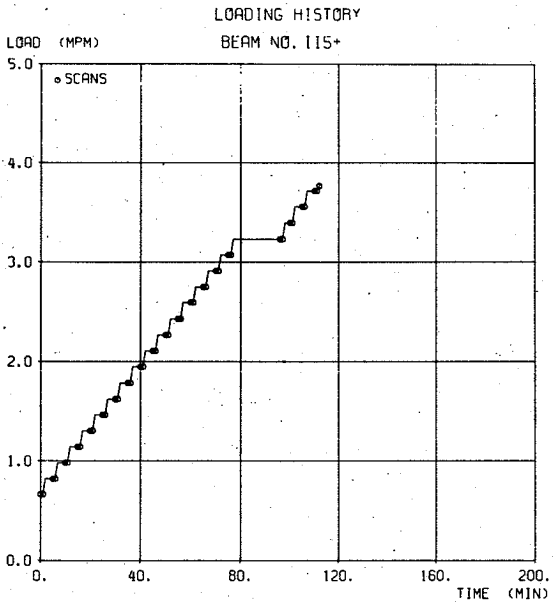

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 5
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

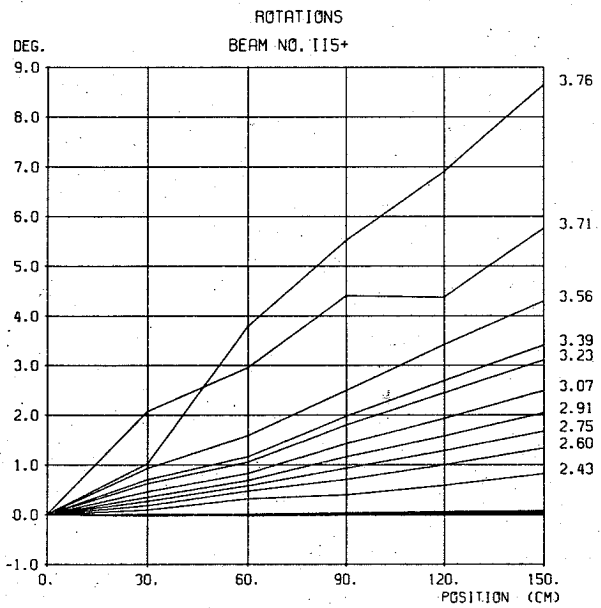
DIFFERENCE BETWEEN GAUGE STRAINS



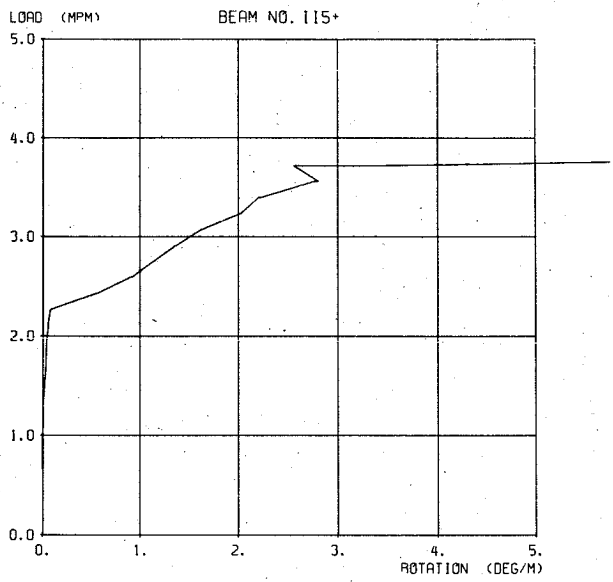
REINFORCEMENT FORCES



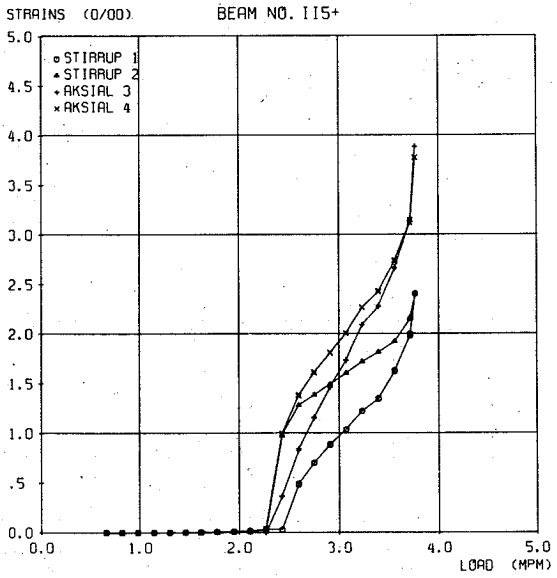

LOADING HISTORY
LOAD (MPM)
BEAM NO. II5+
o SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II5+
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.76
3.71
3.56
3.39
3.23
3.07
2.91
2.75
2.60
2.43

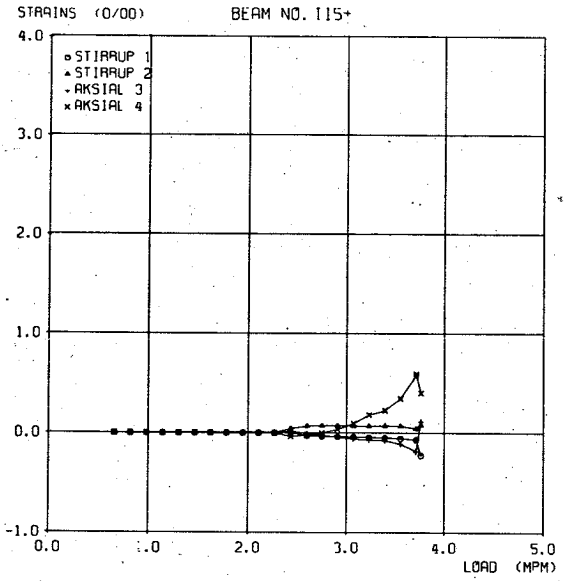
ROTATIONS



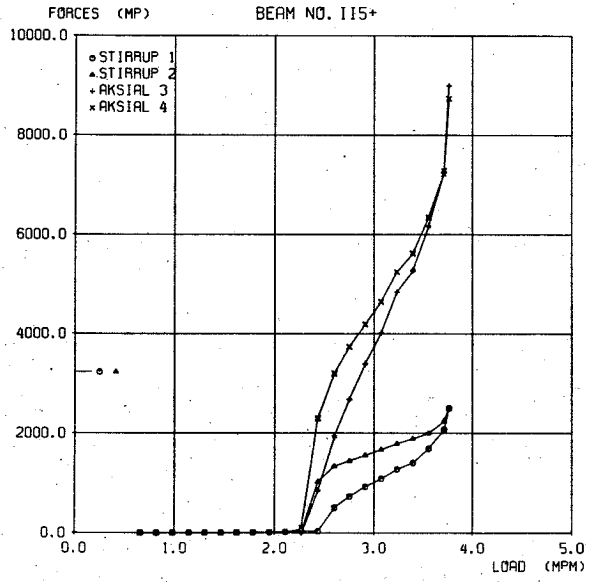
AVERAGE GAUGE STRAINS

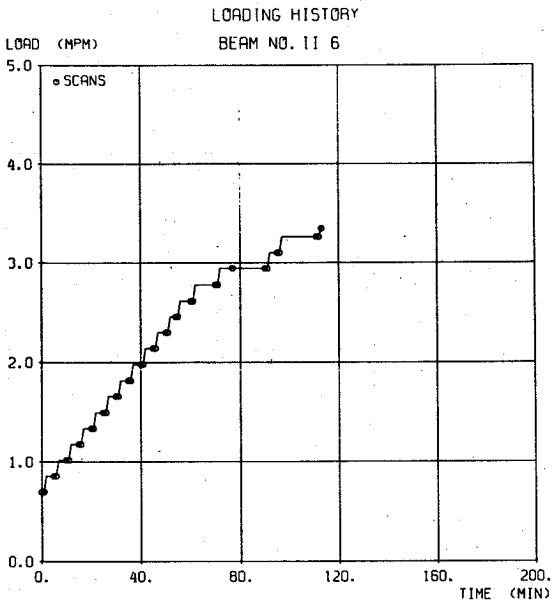


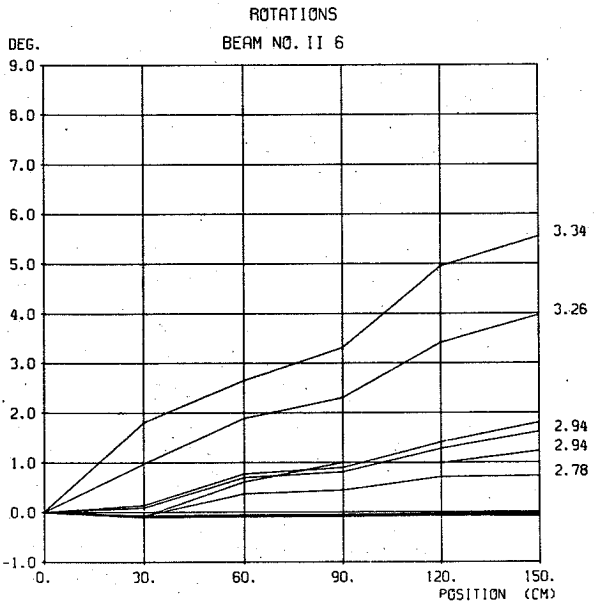
DIFFERENCE BETWEEN GAUGE STRAINS

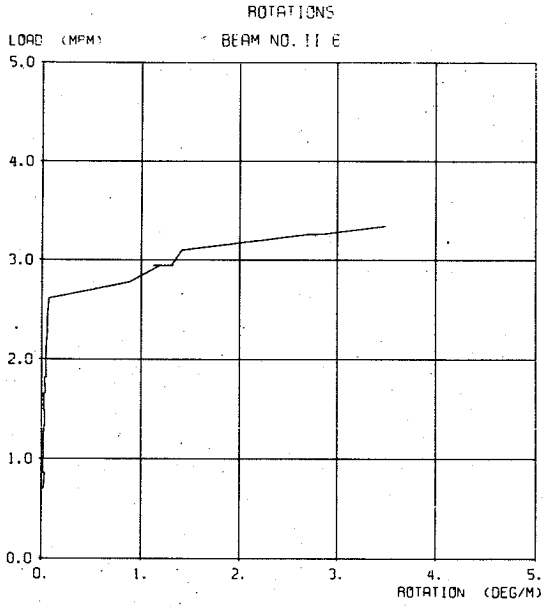


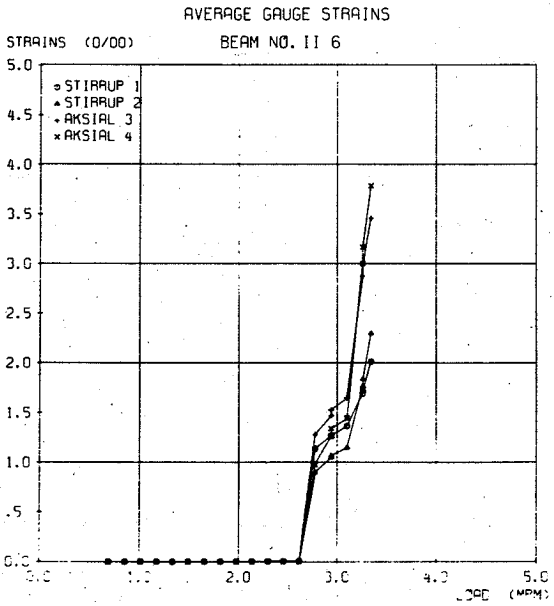
REINFORCEMENT FORCES



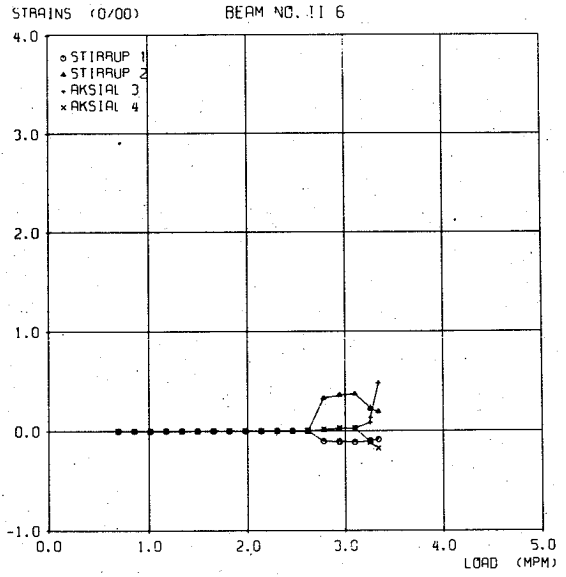

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 6
o SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 6
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.34
3.26
2.94
2.94
2.78

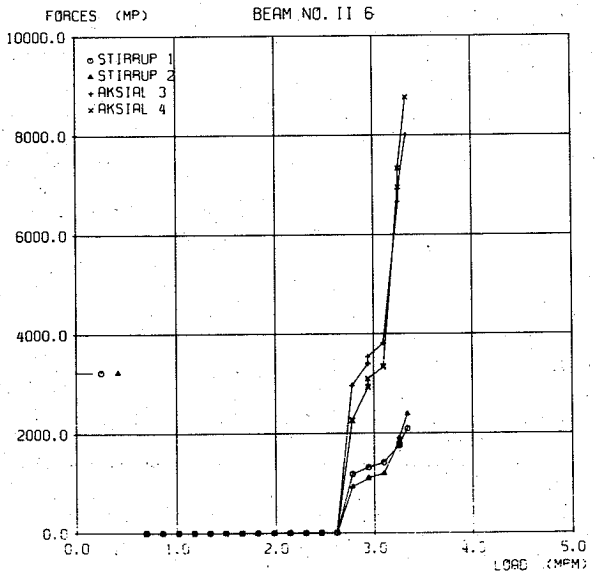

ROTATIONS
LOAD (MPM)
BEAM NO. II E
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

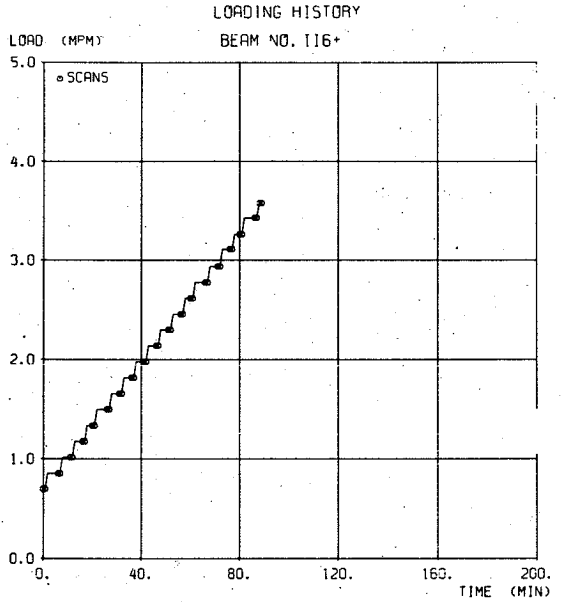

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. II 6
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

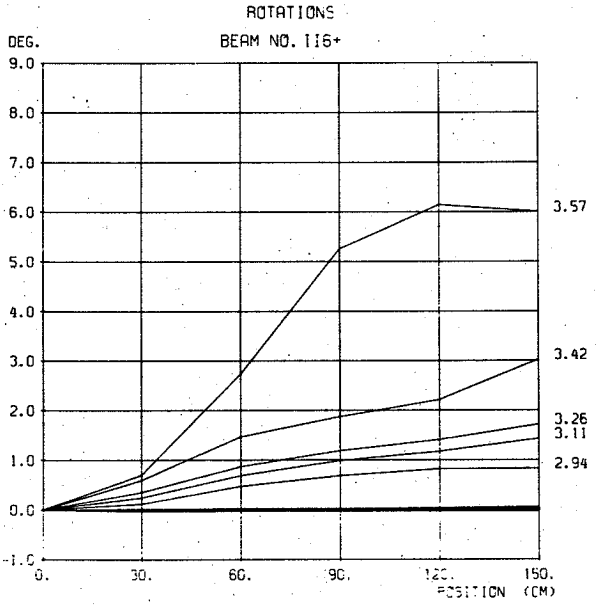
DIFFERENCE BETWEEN GAUGE STRAINS

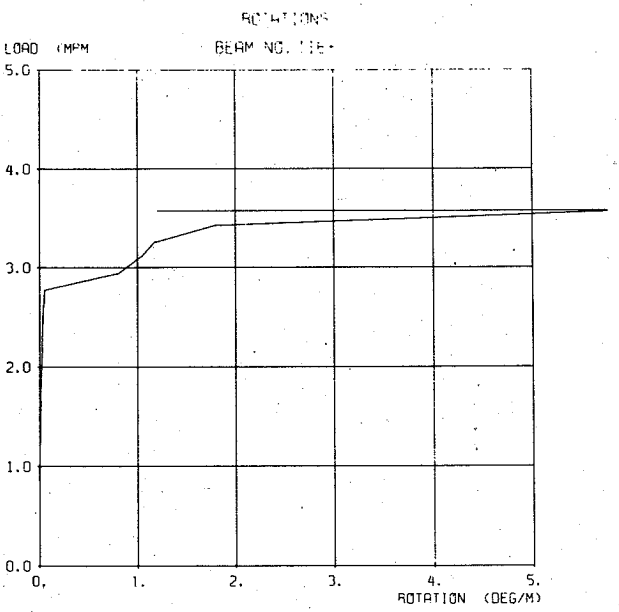


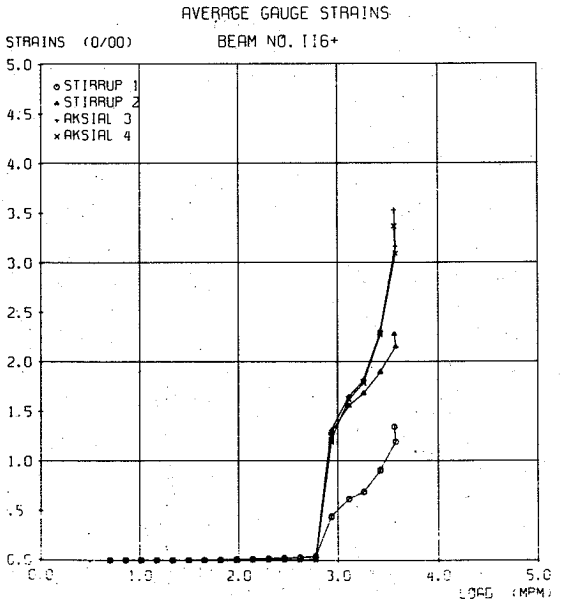
REINFORCEMENT FORCES



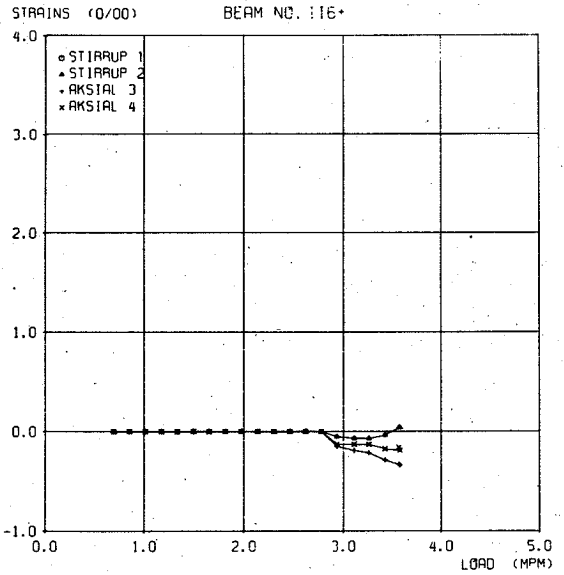

LOADING HISTORY
LOAD (MPM)
BEAM NO. II6+
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II6+
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.57
3.42
3.26
3.11
2.94

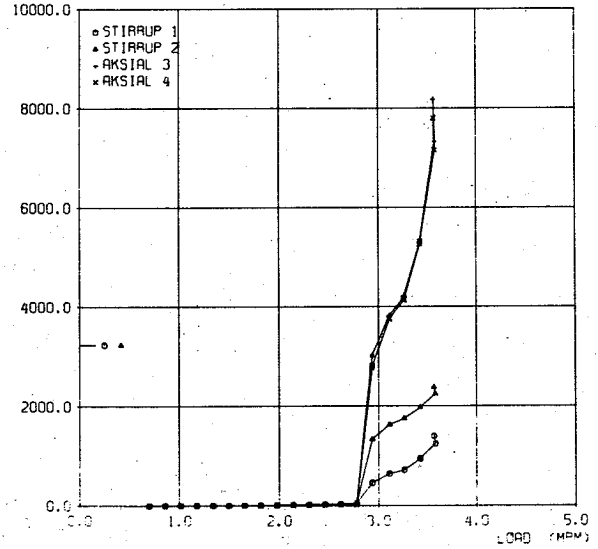

ROTATIONS
LOAD (MPM
BEAM NO. I16+
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)

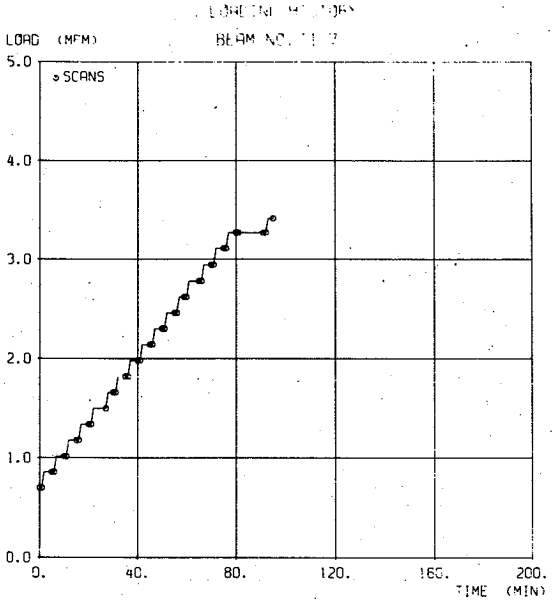

AVERAGE GAUGE STRAINS
STRAINS (0/00)
BEAM NO. I16+
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

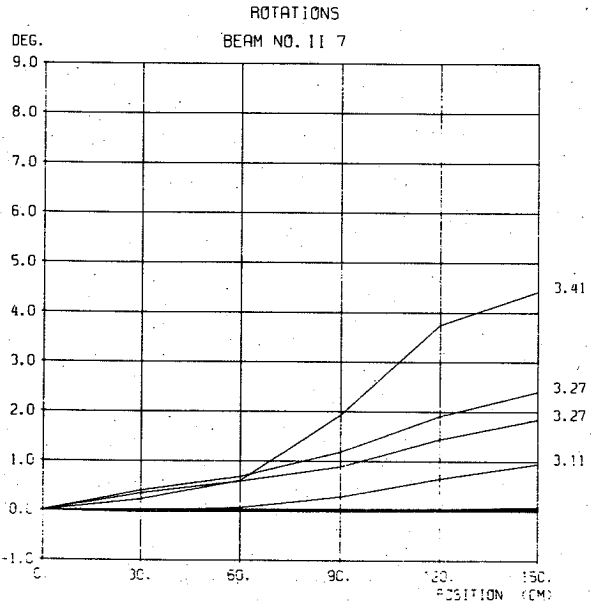
DIFFERENCE BETWEEN GAUGE STRAINS

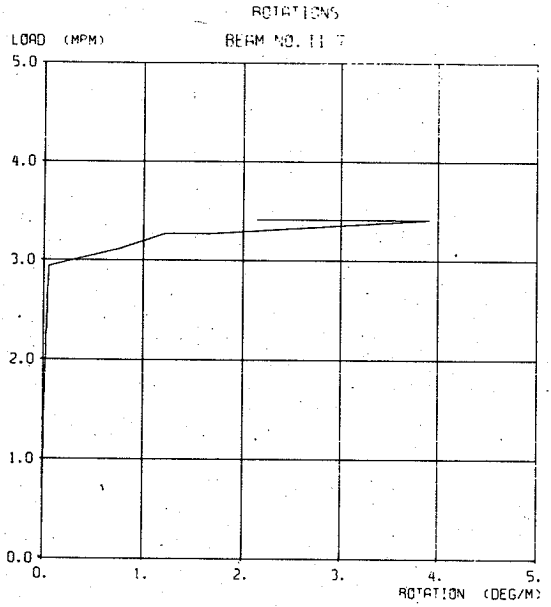


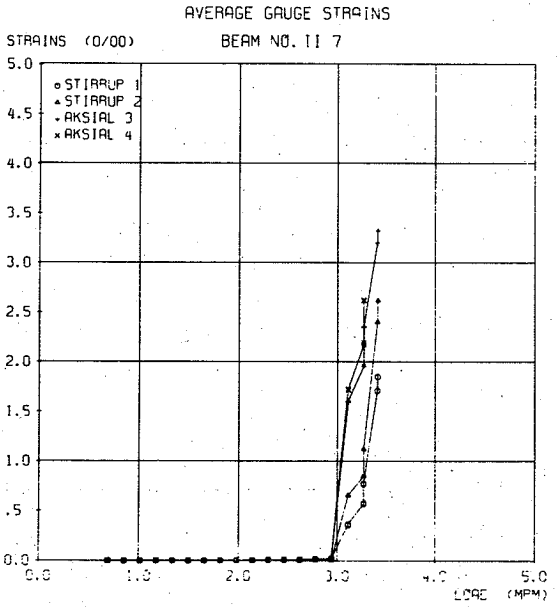
REINFORCEMENT FORCES

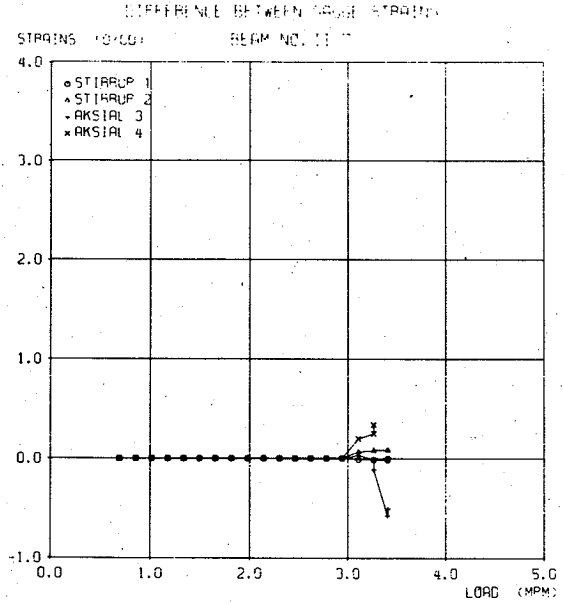


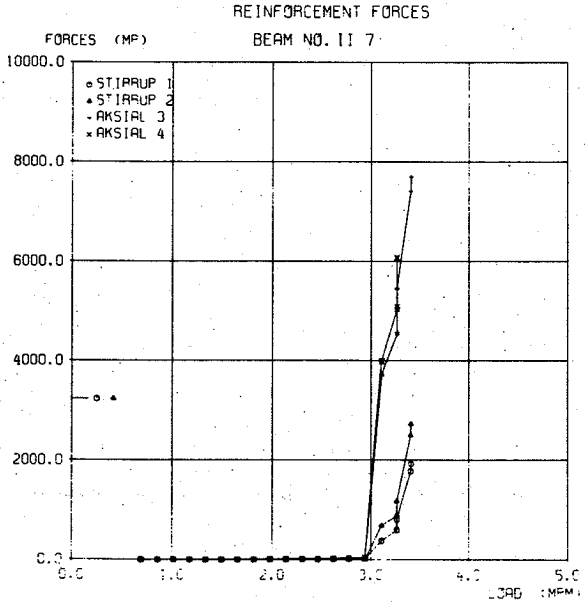

LOAD (MFM)
BEAM NO. II 7
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)

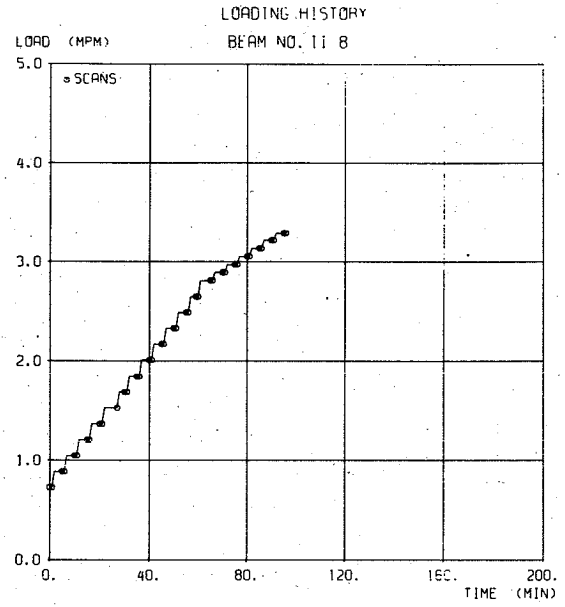

ROTATIONS
DEG.
BEAM NO. II 7
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-1.0
0
30.
60.
90.
120.
150.
POSITION (CM)
3.41
3.27
3.27
3.11

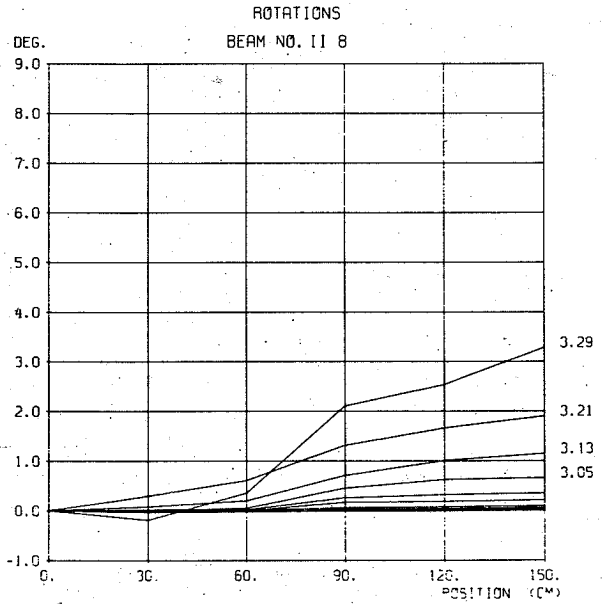

ROTATIONS
LOAD (MPM)
BEAM NO. II 7
5.0
4.0
3.0
2.0
1.0
0.0
0.
1.
2.
3.
4.
5.
ROTATION (DEG/M)


AVERAGE GAUGE STRAINS
STRAINS (O/OO)
BEAM NO. II 7
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

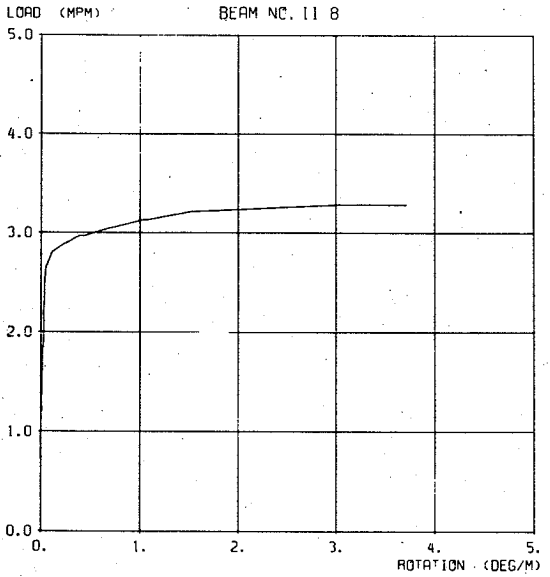

STRAINS (0/00)
BEAM NO. II 7
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
4.0
3.0
2.0
1.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)


REINFORCEMENT FORCES
FORCES (MP)
BEAM NO. II 7
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

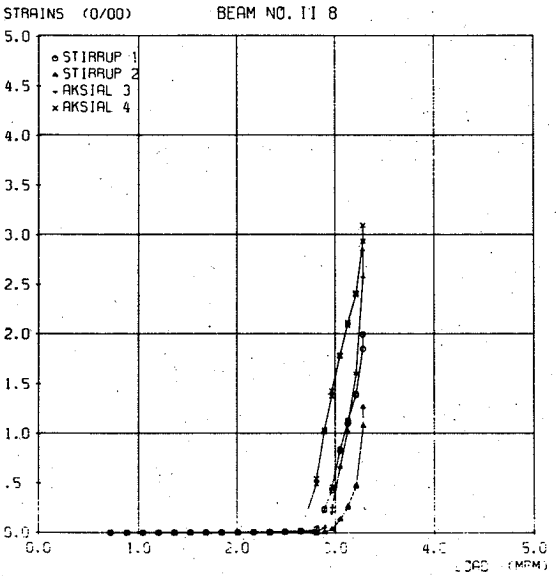

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 8
5.0
4.0
3.0
2.0
1.0
0.0
SCANS
0.
40.
80.
120.
160.
200.
TIME (MIN)

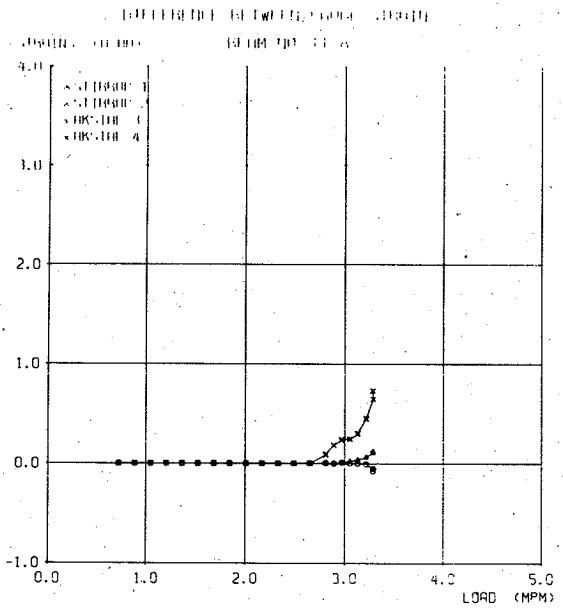

ROTATIONS
DEG.
BEAM NO. II 8
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
120.
150.
POSITION (CM)
3.29
3.21
3.13
3.05

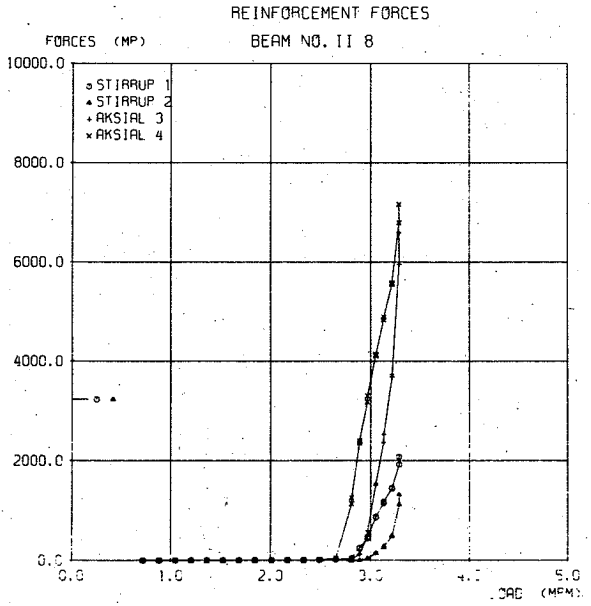
ROTATIONS

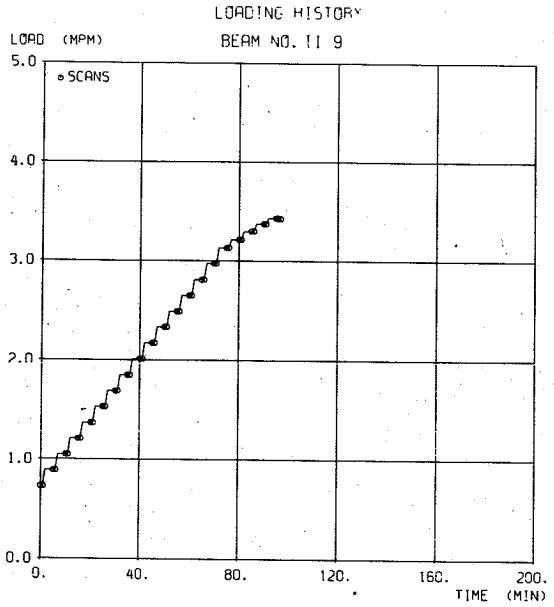


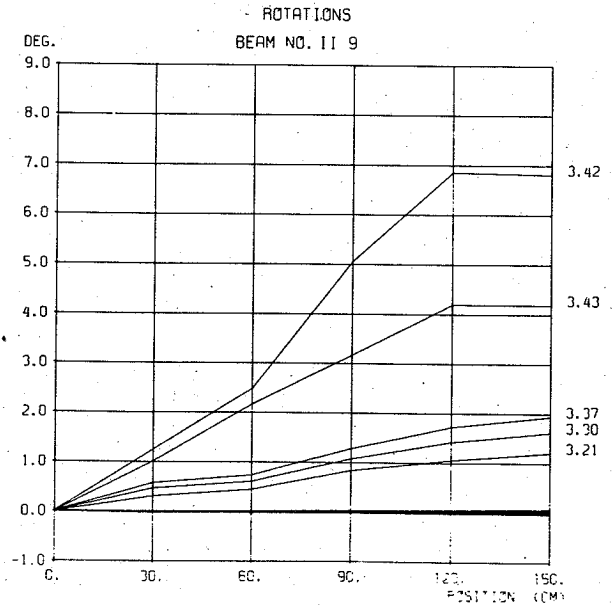
AVERAGE GAUGE STRAINS



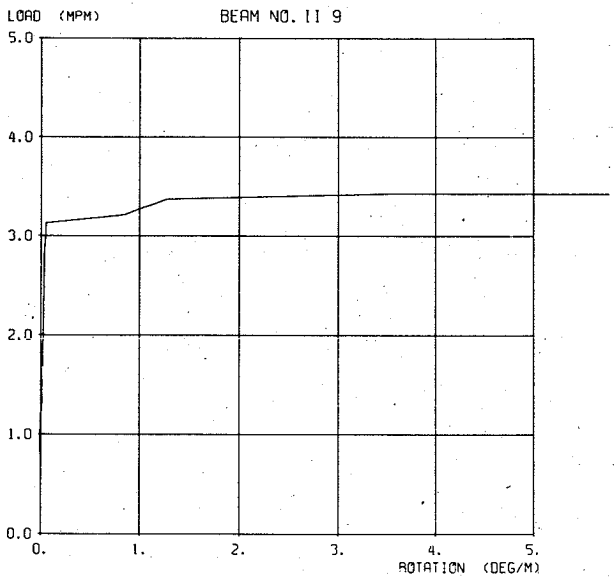

4.0
1.0
2.0
1.0
0.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)


REINFORCEMENT FORCES
FORCES (MP)
BEAM NO. II 8
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
STIRRUP 1
STIRRUP 2
AKSIAL 3
AKSIAL 4
0.0
1.0
2.0
3.0
4.0
5.0
LOAD (MPM)

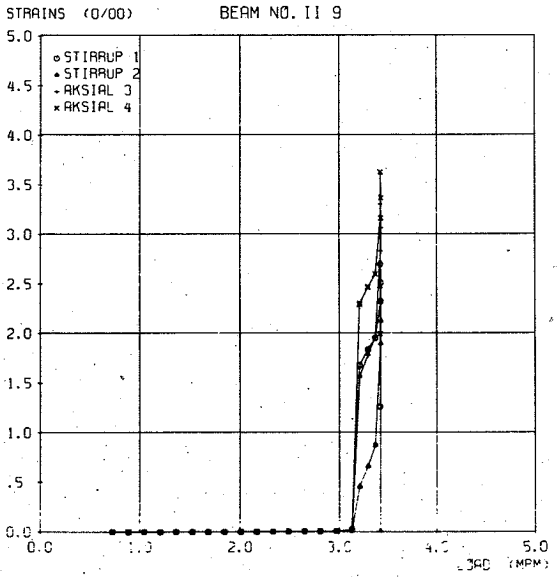

LOADING HISTORY
LOAD (MPM)
BEAM NO. II 9
SCANS
5.0
4.0
3.0
2.0
1.0
0.0
0.
40.
80.
120.
160.
200.
TIME (MIN)


ROTATIONS
DEG.
BEAM NO. II 9
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
0.
30.
60.
90.
150.
POSITION (CM)
3.42
3.43
3.37
3.30
3.21

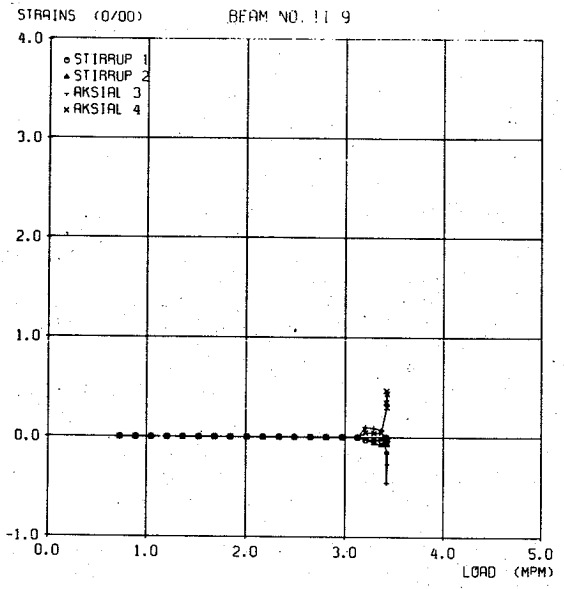
ROTATIONS



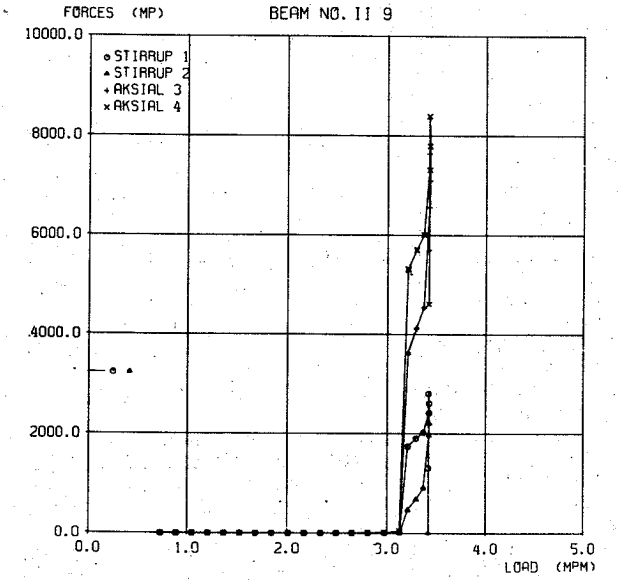
AVERAGE GAUGE STRAINS



DIFFERENCE BETWEEN GAUGE STRAINS



REINFORCEMENT FORCES



AFDELINGEN FOR BÆRENDE KONSTRUKTIONER
DANMARKS TEKNISKE HØJSKOLE

Department of Structural Engineering
Technical University of Denmark, DK-2800 Lyngby

SERIE R

(Tidligere: Rapporter)

R 126. GIMSING, NIELS J.: Four Papers on Cable Supported Bridges. 1980.
R 127. SVENSSON, SVEN EILIF og JAN KRAGERUP: Interaktiv bæreevne af sammensatte søjler. 1980.
R 128. GIMSING, NIELS J. og JØRGEN GIMSING: Analysis of Erection Procedure for Bridges with Combined Cable Systems. Cable Net Bridge Concept. 1980.
R 129. ROSTAM, STEEN og EIGIL STEEN PEDERSEN: Partially Prestressed Concrete Bridges. Danish Experience. 1980.
R 130. BRØNDUM-NIELSEN, TROELS: Stress Analysis of Cracked Arbitrary Concrete Section under Service Load. 1981.
R 131. BRINCKER, RUNE: Plane revneudvidelsesproblemer i lineært viscoelastiske materialer. Løsning af plane lineært viscoelastiske randværdiproblemer med kendt revneudbredelsesforløb. 1982.
R 132. BRINCKER, RUNE: Plane revneudbredelsesproblemer i lineært viscoelastiske materialer. Revnemodeller og udbredelseskriterier. 1983.
R 133. Reserveret.
R 134. ABK's informationsdag 1981. 1981.
R 135. Resumeoversigt 1980. Summaries of Papers 1980. 1981.
R 136. BACH, FINN og M.P. NIELSEN: Nedreværdiløsninger for jernbetonplader. 1981.
R 137. Publication pending.
R 138. NIELSEN, LEIF OTTO og PETER NITTEGAARD-NIELSEN: Elementmetodeberegninger på mikrodatamat. 1981.
R 139. MONDORF, P.E.: Concrete Bridges. Literature Index. 1981.
R 140. NIELSEN, METTE THIEL: Lamb's Problem. Internal Harmonic Point Load in a Half-Space. 1981.
R 141. JENSEN, JESPER FRØBERT: Plasticitetsteoretiske løsninger for skiver og bjælker af jernbeton. 1982.
R 142. MØLLLMANN, H.: Thin-Walled Elastic Beams with Finite Displacements. 1981.
R 143. KRAGERUP, JAN: Five Notes on Plate Buckling. 1982.
R 144. NIELSEN, LEIF OTTO: Konstitutiv modellering af friktionsdæmpning. 1982.
R 145. NIELSEN, LEIF OTTO: Materiale med friktion til numeriske beregninger. 1982.
R 146. Resumeoversigt 1981. Summary of Papers 1981. 1982.
R 147. AGERSKOV, H. and J. BJØRNBAK-HANSEN: Bolted End Plate Connections in Round Bar Steel Structures. 1982.
R 148. NIELSEN, LEIF OTTO: Svingninger med friktionsdæmpning. 1982.
R 149. PEDERSEN, CARL: Stability Properties and Non-Linear Behaviour of Thin-Walled Elastic Beams of Open Cross-Section. Part 1: Basic Analysis. 1982.
R 150. PEDERSEN, CARL: Stability Properties and Non-Linear Behaviour of Thin-Walled Elastic Beams of Open Cross-Section. Part 2: Numerical Examples. 1982.

R 151. KRENCHEL,HERBERT and HANS WINDBERG JENSEN: Organic Reinforcing Fibres for Cement and Concrete. 1982.
R 152. THIEL, METTE: Dynamic Interaction between Soil and Foundation. 1982.
R 153. THIEL, METTE: Soil-Pile Interaction in Horizontal Vibration. 1982.
R 154. RIBERHOLT, H. og PER GOLTERMANN: Sømmede træbjælker. 1982.
R 155. JENSEN, JENS HENNING: Forkammede armeringsstængers forankring, specielt ved vederlag. 1. del. 1982.
R 156. JENSEN, JENS HENNING: Forkammede armeringsstængers forankring, specielt ved vederlag. 2. del. Appendix A til F. 1982.
R 157. ARPE, ROBERT and CLAES DYRBYE: Elasto-Plastic Response to Stochastic Earthquakes. 1983.
R 158. WALD, FRANTISEK: Non-Linear Analysis of Steel Frames (with Special Consideration of Deflection). 1983.
R 159. BRÆSTRUP, MIKAEL W.: Ten Lectures on Concrete Plasticity. Course given in Nanjing, China, October 1982. 1983.
R 160. FEDDERSEN, BENT og M.P. NIELSEN: Opbøjet spændarmering som forskydningsarmering. 1983.
R 161. KRAGERUP, JAN: Buckling of Rectangular Unstiffened Steel Plates in Compression. 1983.
R 162. FEDDERSEN, BENT og M.P. NIELSEN: Revneteorier for enaksede spændingstilstande. 1983.
R 163. Reserveret.
R 164. GIMSING, NIELS J.: Preliminary Design and Optimization of Cable Systems for Bridges. 1983.
R 165 Resuméoversigt 1982. Summaries of Papers 1982. 1983.
R 166. NITTEGAARD-NIELSEN, PETER, JOHN FORBES OLESEN og HILMER RIBERHOLT: Elementmetodeberegning af skiveafstivede lamelkonstruktioner. 1983.
R 167. RIBERHOLT, HILMER og PETER SPØER: Indlimede bolte til indfæstning af vingerne på Nibemølle-B. 1983.
R 168. GIMSING, NIELS J. and ANDERS BORREGAARD SØRENSEN: Investigations into the Possibilities of Constructing Bridges with a Free Span of 3000 m. 1983.

Abonnement 1.7.1983 - 30.6.1984 Kr. 110.-.
Subscription rate 1.7.1983 - 30.6.1984 D.kr. 110.-.

Hvis De ikke allerede modtager Afdelingens resumeoversigt ved udgivelsen, kan Afdelingen tilbyde at tilsende næste års resumeoversigt, når den udgives, dersom De udfylder og returnerer nedenstående kupon.

Returneres til
Afdelingen for Bærende Konstruktioner
Danmarks tekniske Højskole
Bygning 118
2800 Lyngby

Fremtidig tilsendelse af resumeoversigter udbedes af
(bedes udfyldt med blokbogstaver):

Stilling og navn: .....

Adresse: .....

Postnr. og -distrikt: .....

The Department has pleasure in offering to send you a next year's list of summaries, free of charge. If you do not already receive it upon publication, kindly complete and return the coupon below.

To be returned to:
Department of Structural Engineering
Technical University of Denmark
Building 118
DK-2800 Lyngby, Denmark.

The undersigned wishes to receive the Department's
List of Summaries:
(Please complete in block letters)

Title and name .....

Address.....

Postal No. and district.....

Country.....