ISBN 0-7727-7025-5
Publication No. 81-08

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CIRCULAR REINFORCED CONCRETE MEMBERS SUBJECTED TO SHEAR

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December 1981

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by

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ABSTRACT

This report describes an experimental investigation of circular reinforced concrete members loaded monotonically in shear. Five full scale specimens were tested. The prime variable was the amount of transverse reinforcement, which varied from no transverse reinforcement to almost the maximum allowed by the ACI provisions.

The results indicated that the shear strengths of circular members were typically about 20% greater than the strengths predicted by the ACI code equations. The shear strengths predicted by the expressions suggested by ACI-ASCE Committee 426 and the suggested expressions for the CSA code were closer to the experimental values than the ACI predictions. The Compression Field Theory predicted the behaviour of the specimens reasonably well with both the predicted shear strengths and the predicted strains being in good agreement with the actual test results.

KEY WORDS: axial load; beams; building codes; circular members; Compression Field Theory; flexure; reinforced concrete; research; shear.

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NOTATION

A_g = gross area of concrete cross-section

A_ℓ = area of longitudinal reinforcing bars

A_s = area of tension reinforcement

A_v = cross-sectional area of shear reinforcement within distance s

b' = width of assumed strips

b_w = web width (for circular section the diameter)

d = distance from extreme compression fibre to centroid of longitudinal tension reinforcement

D = overall diameter of section

D_h = outside diameter of hoop

D_1 = tangential deviation of one end of specimen with respect to other

D_2 = total displacement in testing system

E_s = modulus of elasticity of steel

f'_c = cylinder compressive strength of concrete

f_y = specified yield strength of reinforcement

M = moment at section

N_u, P = axial load at section

s = spacing of shear reinforcement in direction parallel to longitudinal axis

v_b = basic shear stress

v_c = nominal shear stress carried by concrete

v_u = nominal total shear stress

V = shear at section

V_c = shear force carried by concrete

V_s = shear force transferred by stirrups

V_u = total applied shear force at section

α_H = angle between measured diagonal strain and longitudinal axis of member

ε_o = strain corresponding to maximum stress in a concrete cylinder

θ	= angle of inclination to longitudinal axis of member (in degrees) of diagonal compressive stresses
θ_s	= angle between hoop and vertical axis through section for the assumed concrete strips in section
ρ_t	= effective transverse reinforcement ratio in each concrete strip (= $A_v \mathrm{Cos}\theta s/b'$)
ρ_w	= $A_s/b_w d$
ϕ	= strength reduction factor defined in Section 9.3 of ACI 318-77

CHAPTER 1

INTRODUCTION

1.1 Problem Description

Many structures contain reinforced concrete members with circular cross-sections. Usually these members are columns. For example, the columns of multi-storey buildings are often circular, as are many of the piers supporting bridges. These circular members can be subjected to considerable shear forces arising from wind or earthquake activity. It is therefore desirable to be able to predict the behaviour of circular reinforced concrete members loaded in shear. This is the problem discussed in this report.

1.2 Previous Work

A study of the literature available on shear in reinforced concrete members shows that the amount of work done on members with circular cross-sections is very limited when compared to the work on members with rectangular cross-sections.

One study involving circular members was carried out at the Autonomous National University of Mexico in 1965 by Faradji and Diaz de Cassio [6]. In their program they tested twenty-one 250 mm diameter specimens. However, only four of these specimens contained web reinforcement.

Some work on circular members was conducted at the University of Toronto in 1974 by Aregawi [3]. He tested four specimens 460 mm in diameter. An attempt was made to measure hoop and longitudinal strains, but because of the difficulties he encountered measuring strains over curved surfaces, much of the strain data was unreliable.

A study involving five spirally reinforced concrete columns, octagonal in cross-section, was carried out by Priestley, Park and Pontangaroa [7]. The study was, directed towards investigating the ductility of the columns under reversed, cyclic lateral loads.

Other than the aforementioned studies, the authors were unable to find any experimental work which addresses specifically the problem of the shear strength of circular reinforced concrete members.

The current American Concrete Institute (ACI 318-71) [1] treats the design of circular members under shear, in a manner similar to the design of rectangular members, with 'b_w' taken as the overall diameter of the member and 'd' as the distance from the extreme compression fibre to the centroid of the longitudinal reinforcement in the opposite half of the member.

1.3 Objectives of Current Work

The current work represents one phase of the research being conducted at the University of Toronto, aimed at developing rational design procedures for reinforced concrete members subjected to shear and torsion. These methods are based on "The Compression Field Theory" (CFT) [4][5]. The theory assumes that a cracked reinforced concrete beam resists shear by means of compressive stresses in the concrete and tensile stresses in the reinforcement.

The main objective of this study was to obtain reliable experimental data for circular reinforced concrete members loaded monotonically in shear. Hopefully this data will enable the CFT to be extended to predict the response of such members.

A secondary objective of the investigation was to compare the predictions of the shear strength by the CFT and by the ACI expression with the experimental results.

1.4 Outline of the Report

First the experimental setup is explained. Detailed descriptions of the geometric and material properties of each specimen are then presented. Chapter 3 describes the testing of each specimen. Load-deformation curves and photographs of the crack patterns at different load stages are also presented.

The experimental results obtained are then discussed in Chapter 4. The shear strengths of the specimens are compared with the predictions of various suggested techniques. Detailed strain analysis is also presented and the actual strains are compared to the strains predicted by the CFT. Chapter 5 presents the conclusions drawn from the test results.

Appendix A contains the calculations for the predicted shear strengths for the various approaches; and the measured strains and the calculated principal strains are presented in Appendix B.

CHAPTER 2

EXPERIMENTAL PROGRAM

2.1 Objective of the Tests

To achieve the objectives outlined in Chapter 1, five specimens were tested under simulated column loads (Fig. 2.1).

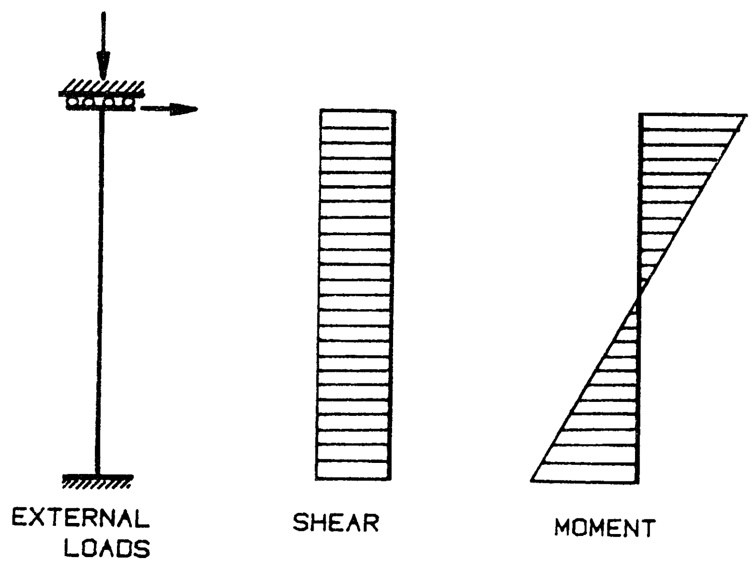

Fig. 2.1: Loading simulated during test.

Although the shear strength of reinforced concrete depends on many factors, probably one of the most critical is the amount of transverse reinforcement. Hence this was the prime variable; ranging from no transverse steel to about the maximum allowed by the ACI. As far as possible, all other variables were kept constant. All specimens were designed to fail in shear rather than flexure.

2.2 Test Apparatus

The test rig developed by Sadler [8] was used. This rig (Fig. 2.2) was designed to introduce the transverse load into the specimen in a reasonably uniform manner. The transverse load was applied to the specimen through

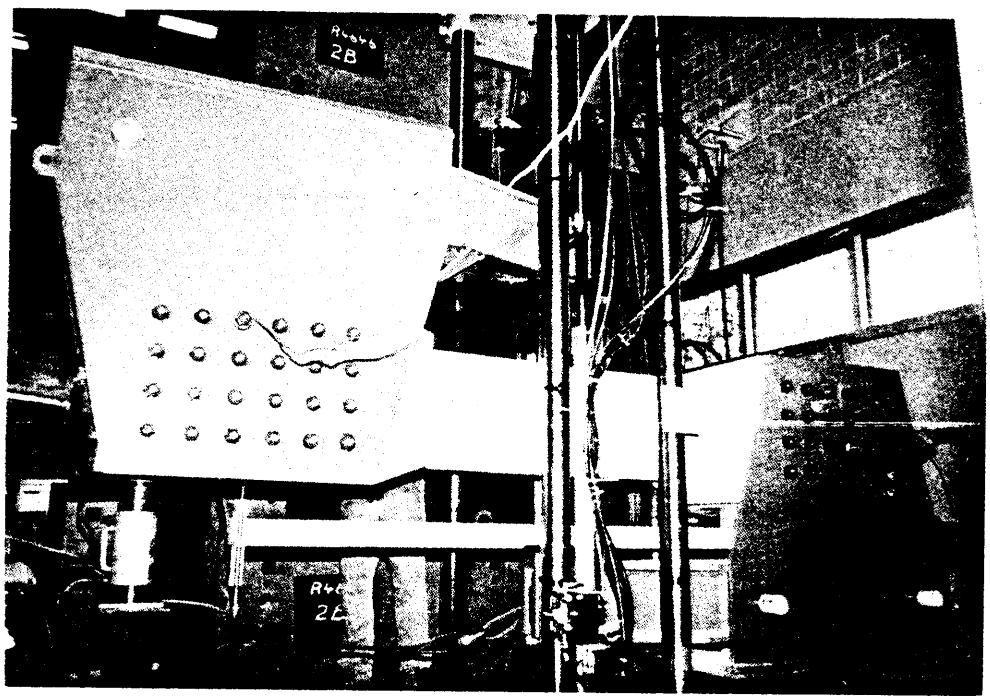

Fig. 2.2: Rig used for testing the specimen

two yokes holding the flared ends of the specimen as if they were fixed ended. The two side plates of each yoke were clamped to each end of the specimen by twenty-four high strength bolts threaded through the ends of the specimen and the plates (Fig. 2.2).

The axial load was applied to the specimen by post-tensioning a 65 mm high-strength steel rod threaded through a 76 mm diameter hole located along the longitudinal axis of the specimen. A 300 ton jack was used for applying the axial load.

The transverse load was applied by a 1000 kN MTS testing machine. This produced a constant shear over the test length of the specimen. The self weight of the specimen and the rig (56 kN), however, produced a dead load shear which varied from one end to the other. The variation of shear over the test length was only 5 kN and was small compared to the applied loads. However, the dead loads did cause a significant difference in moments at the two ends. The orientation of the specimen and the applied loads are illustrated in Fig. 2.3. The moments and shears used for analysis are shown in Fig. 2.4

2.3 Test Specimens

2.3.1 Geometric properties.

The overall dimensions of all specimens were identical and are given in Fig. 2.5. There was a hole 76 mm in diameter through the centre of all specimens running the entire length. (As mentioned before, this was used for applying the axial load). The test section was 1270 mm long and 445 mm in diameter. The longitudinal reinforcement consisted of twelve 25 M bars, each with an area of 500 mm^2, placed symmetrically around the circumference (Fig. 2.6).

The transverse reinforcement consisted of welded hoops. These hoops were fabricated from 10 M bars and for one specimen from special #2 bars imported from Sweden. The welded joint in the hoop was placed in the compression zones of the specimen whenever possible. The

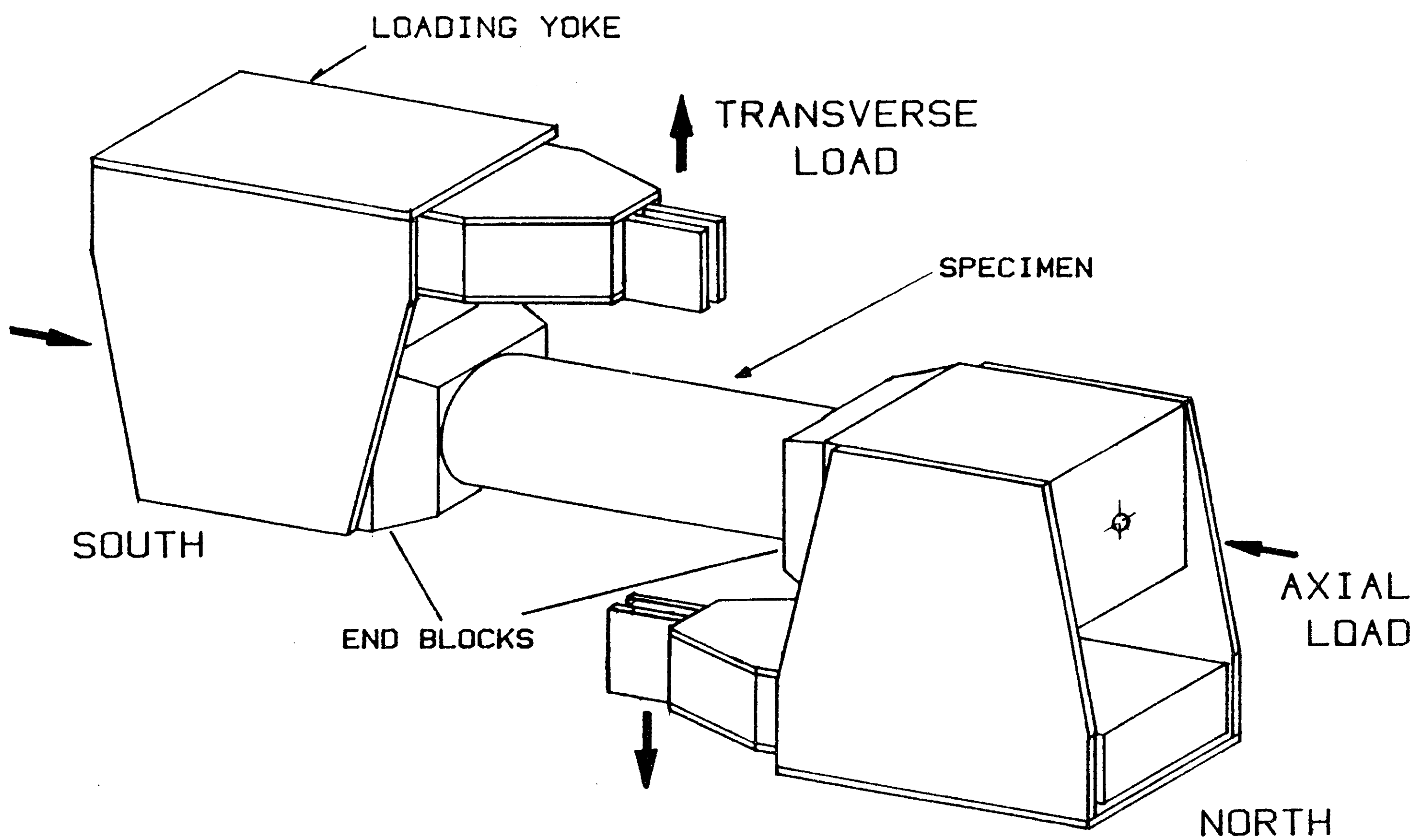

Fig. 2.3: Specimen orientation and the applied loads.

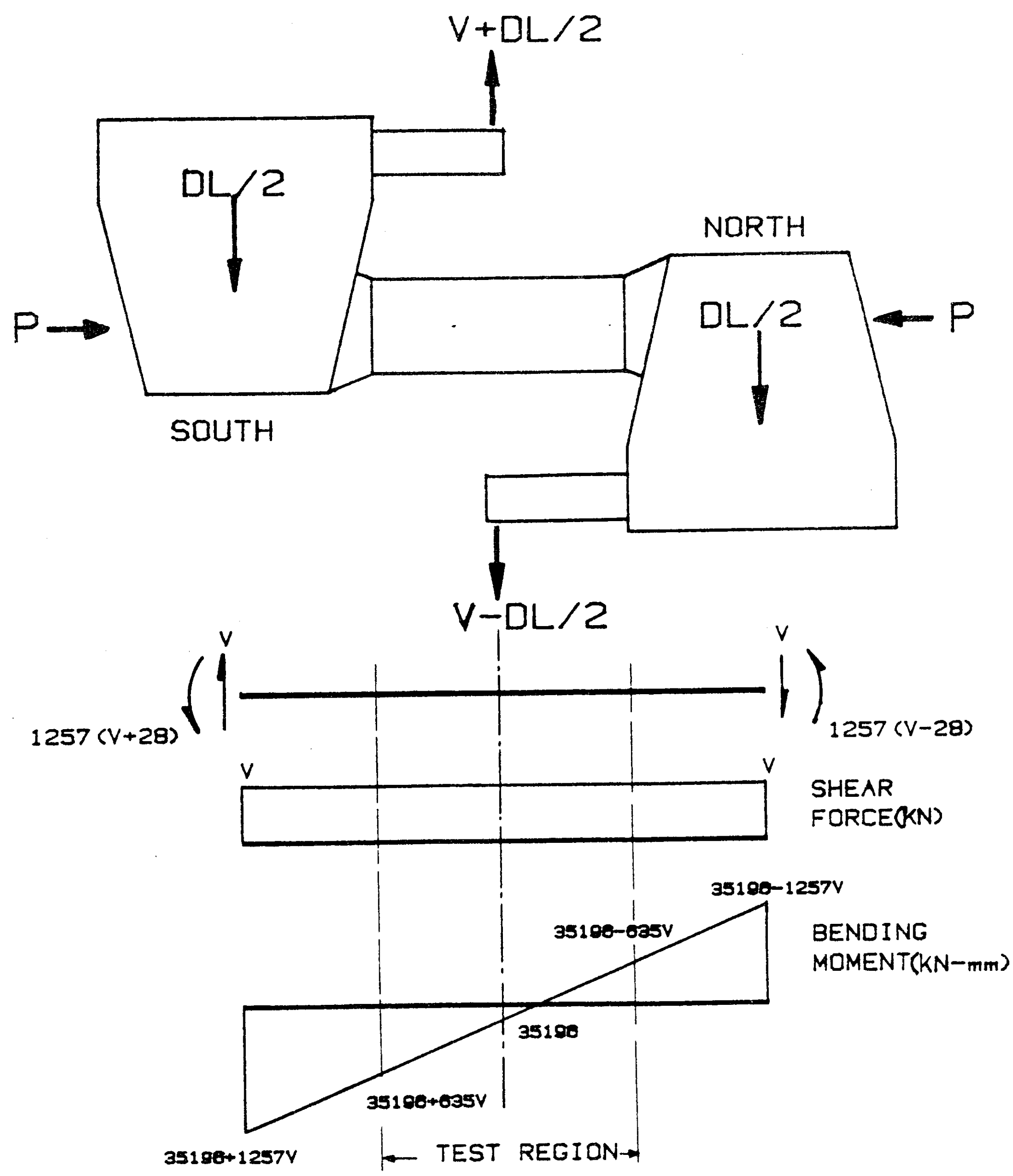

Fig. 2.4: Assumed moment and shear diagrams for test region.

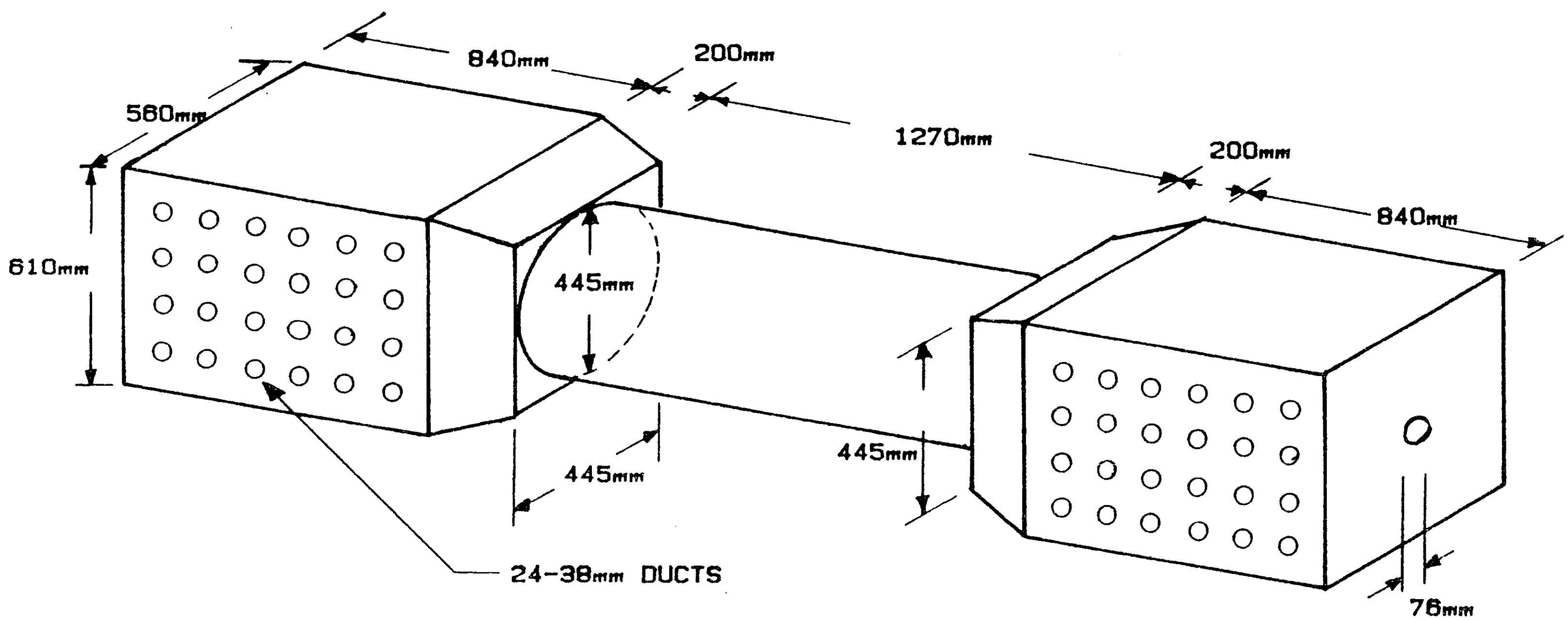

Fig. 2.5: Typical specimen dimensions.

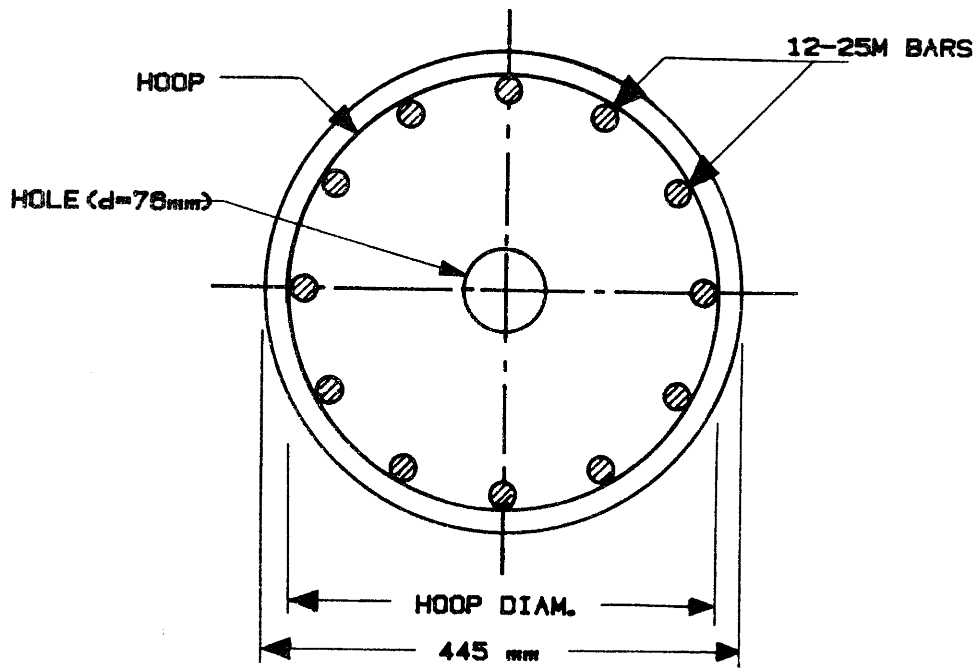

Fig. 2.6: Typical cross-section

spacing of the hoops and their diameter for each specimen are listed in Table 2.1. Specimen SC4 was constructed with effectively no cover, to investigate the effect of cover on the ultimate shear strength.

TABLE 2.1: TRANSVERSE REINFORCEMENT DETAIL

SPECIMEN	BAR SIZE	NOMINAL AREA (mm^2)	SPACING (mm)	HOOP DIAMETER[1] D_h (mm)	CLEAR COVER (mm)
SC 0		--	--	--	--
SC 1	#2	34	150	400	22.5
SC 2	10M	100	150	400	22.5
SC 3	10M	100	100	400	22.5
SC 4	10M	100	150	430	7.5

1 measured out-to-out.

The test span tapered out to two end blocks 560 mm x 610 mm in cross-section. These end blocks were heavily reinforced. It was observed that the part of the end blocks (confined by the two yokes) of the first specimen tested (SC2) were uncracked after the test. Subsequently the end block reinforcement was reduced for the other specimens. The end blocks contained twenty-four 32 mm ducts (to accommodate 25 mm high strength bolts). Figure 2.7 shows a typical reinforcing cage for the test section and the end blocks.

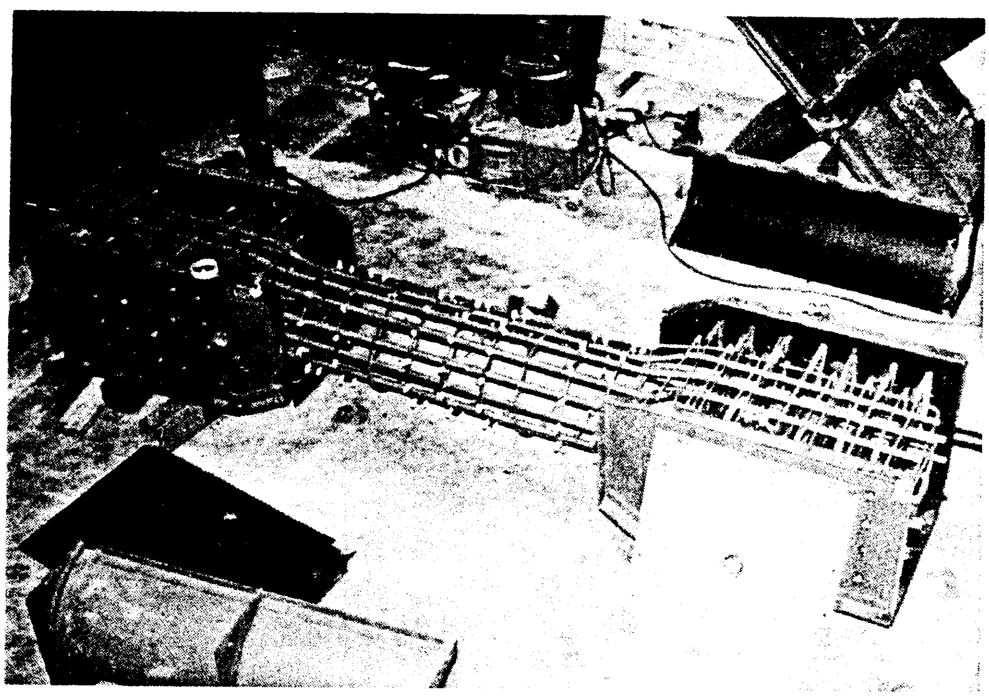

Fig. 2.7: Typical reinforcing cage for the test specimens.

2.3.2 Material Properties

2.3.2(a) Reinforcing Steel: The longitudinal reinforcement consisted of 25 M bars (area = 500 mm^2) with a yield strength of 516 MPa. The transverse reinforcement consisted of 10 M bars (area = 100 mm^2) and #2 bars (area = 34 mm^2). The hoops made from the 10 M bars were heat treated after being welded. The #2 bars exhibited a very flat yield plateau so the hoops made from this steel were not heat treated. Two sets of hoops were made from the 10 M bars and were heat treated at different times, therefore they have different characteristics. Figures 2.8 and 2.9 give the typical stress-strain curves for the reinforcing steel.

2.3.2(b) Concrete: A local ready-mix plant supplied the concrete. The strength specified for the concrete was 25 MPa at 14 days having a slump of 200 mm to facilitate the vertical casting of the specimen. Pea gravel aggregate with a maximum size of 10 mm was used. Figure 2.10 gives the stress-strain curves for the concrete used in constructing the specimens. The ultimate strength of the concrete ranged from 19.3 MPa to 26.5 MPa.

TABLE 2.2: SPECIMEN MATERIAL PROPERTIES

SPECIMEN	CONCRETE PROPERTIES		LONGITUDINAL[1] REINFORCEMENT YIELD, f_y (MPa)	HOOP REINFORCEMENT		
	f'_c (MPa)	ε_o (10^{-3})		Size	Yield, f_y MPa	$A_v f_y/s$ (N/mm)
SC0	23.4	1.75	516	-	-	-
SC1	19.3	1.65	516	#2	410	187
SC2	23.0	2.00	516	10M	510	680
SC3	24.5	1.90	516	10M	510	1020
SC4	26.5	2.15	516	10M	430	573

[1]Longitudinal steel consists of 25M bars (area = 500 mm^2)

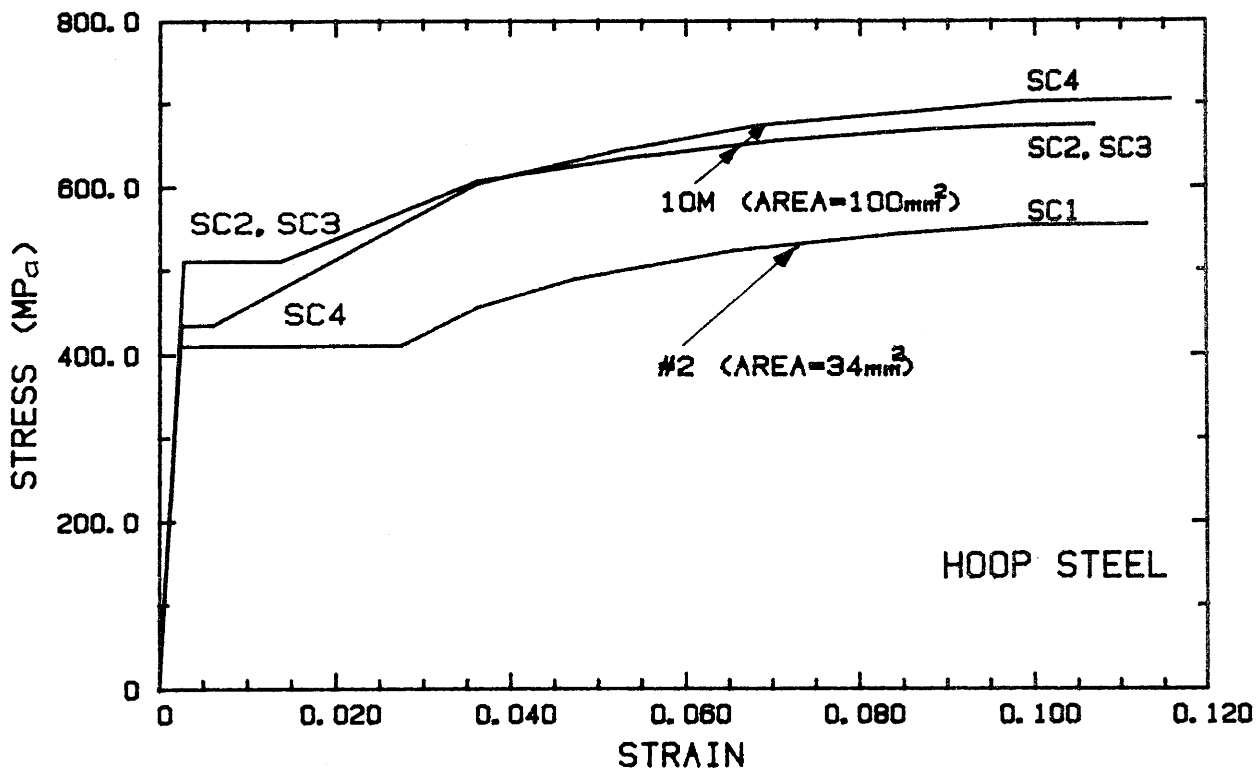

Fig.2.8: Typical stress-strain curves for hoop steel.

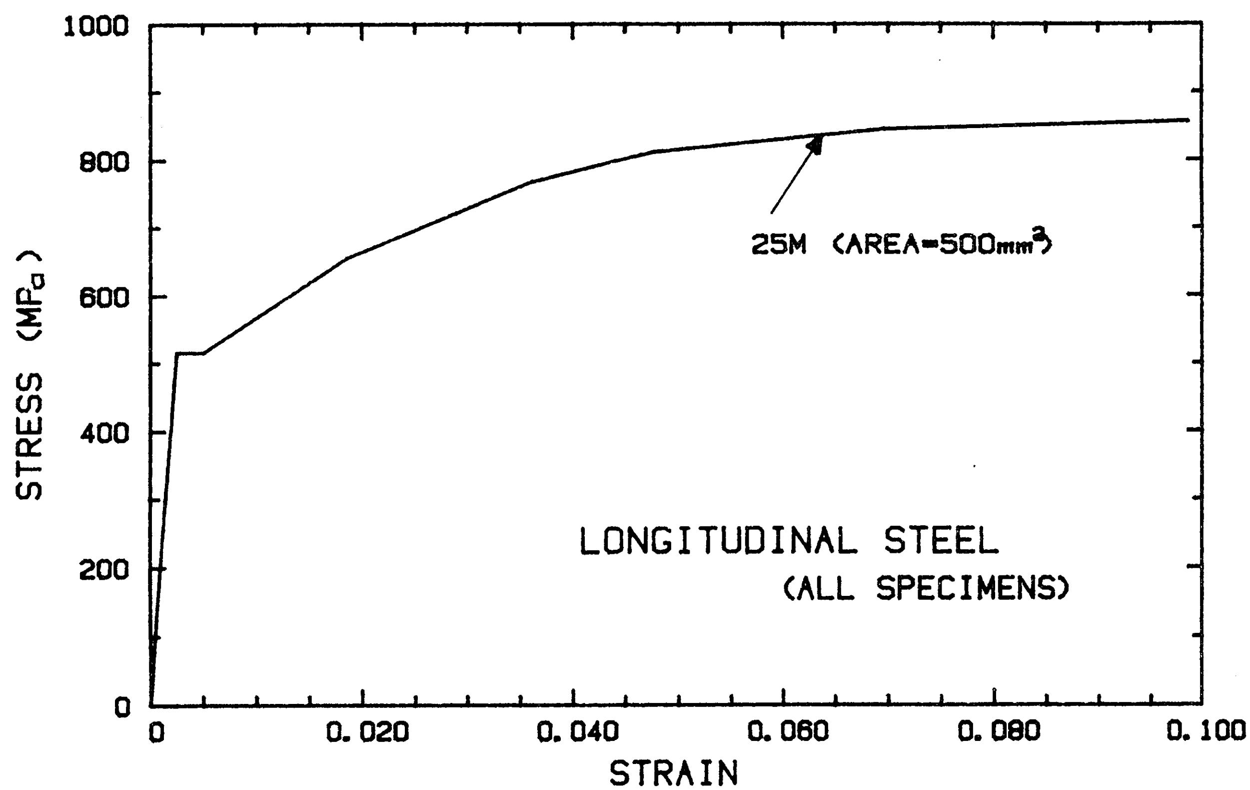

Fig. 2.9: Typical stress-strain curve for longitudinal steel.

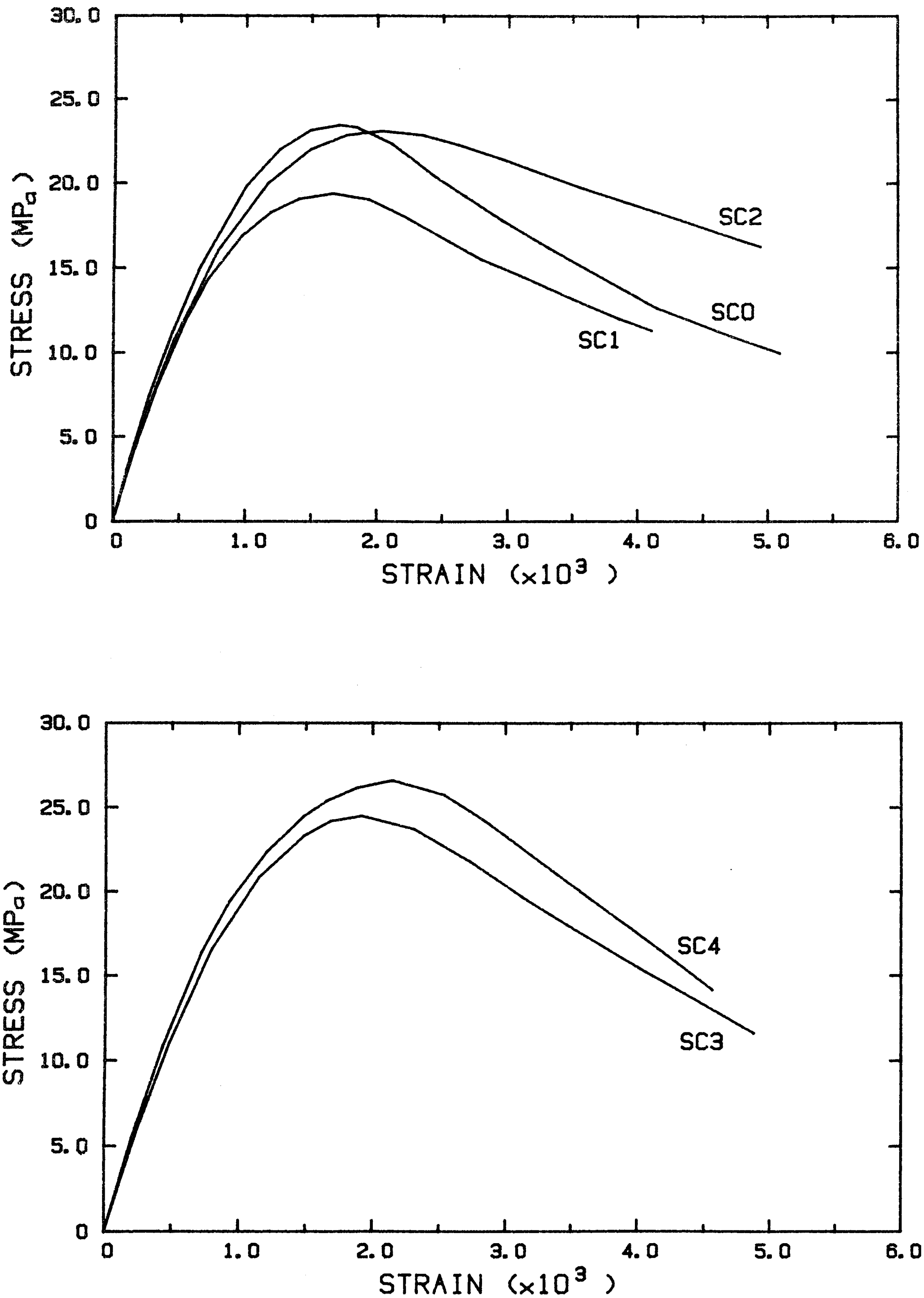

Fig. 2.10: Stress-strain characteristics of concrete.

The material information is summarized in Table 2.2.

2.3.3 Construction

The reinforcing cage was made first. This was then transferred to a prefabricated steel form (Fig. 2.11). All specimens were cast vertically as is the normal practice for columns.

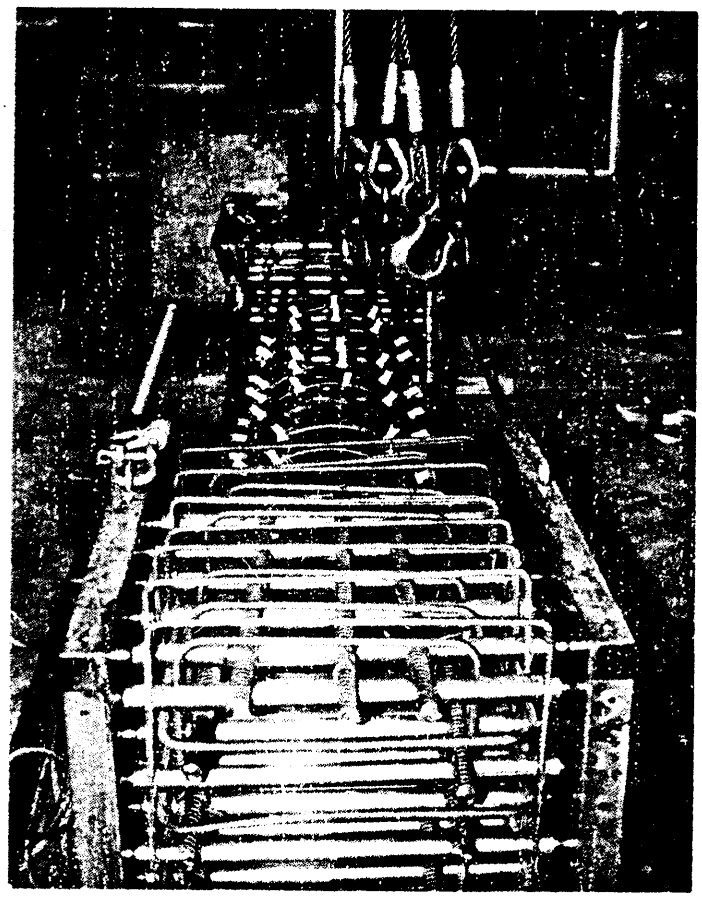

Fig. 2.11: Reinforcing cage placed in the prefabricated steel form.

Concrete was vibrated by a form vibrator and an immersion vibrator (Fig. 2.12).

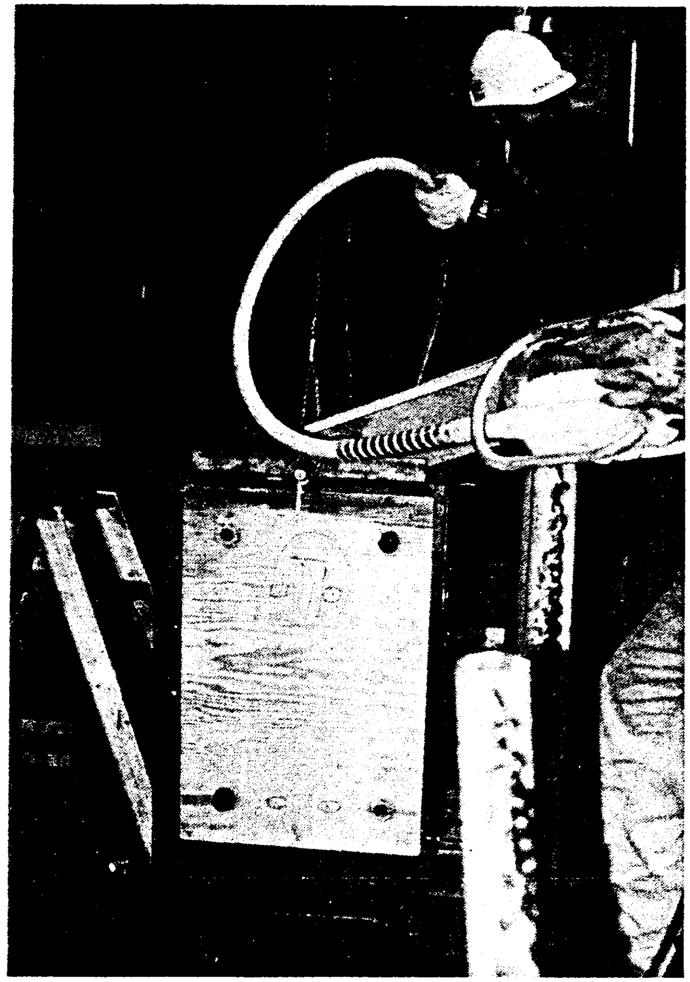

Fig. 2.12: Specimen being vibrated during casting.

A standard slump test was conducted and ten standard 12" x 6" ϕ cylinders were cast for each specimen.

2.4 Specimen Instrumentation

2.4.1 Strain Measurement

To measure strains a grid was formed using brass targets attached to the hoops. Each instrumented hoop had eleven targets placed as sho in Fig. 2.13. Each specimen had three distinct grids on both the East and the West sides (Fig. 2.14). The two grids at the ends of the test section consisted of two instrumented hoops each, and the grid in the centre of three instrumented hoops.

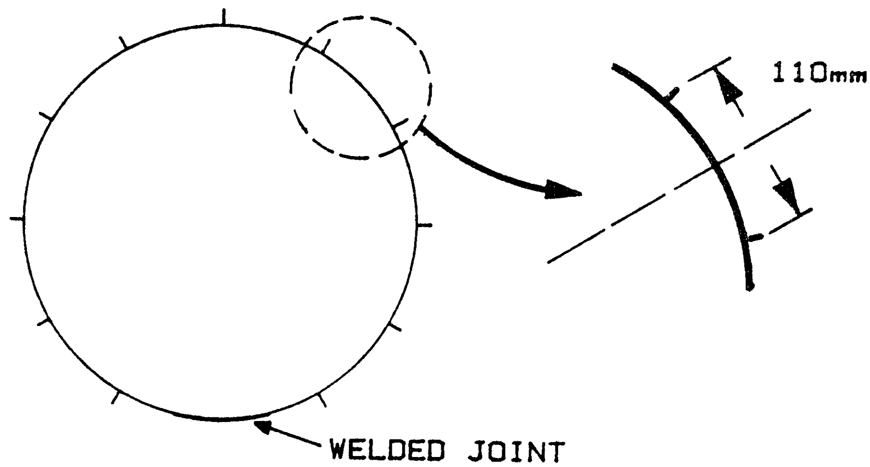

Fig. 2.13: Typical instrumented hoop.

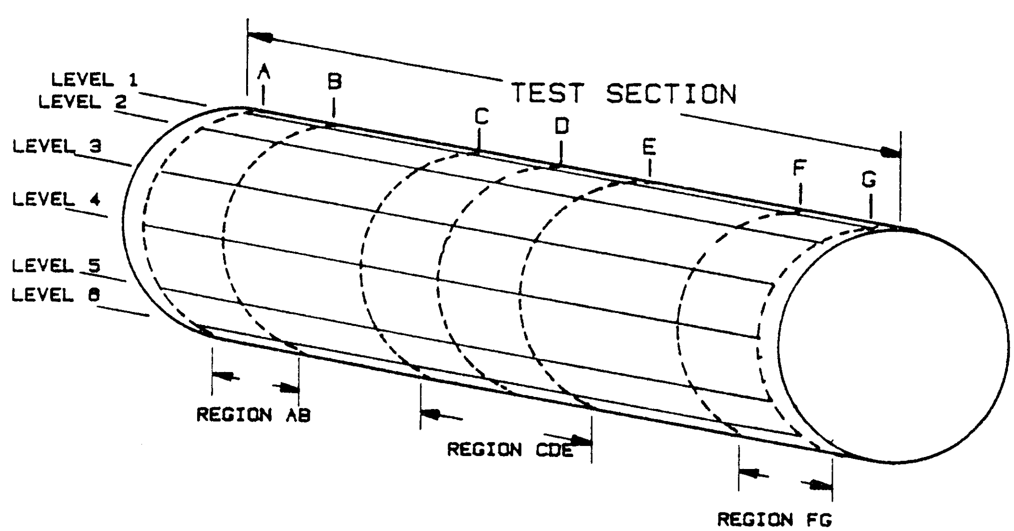

Fig. 2.14: Position of instrumented hoops in the specimen.

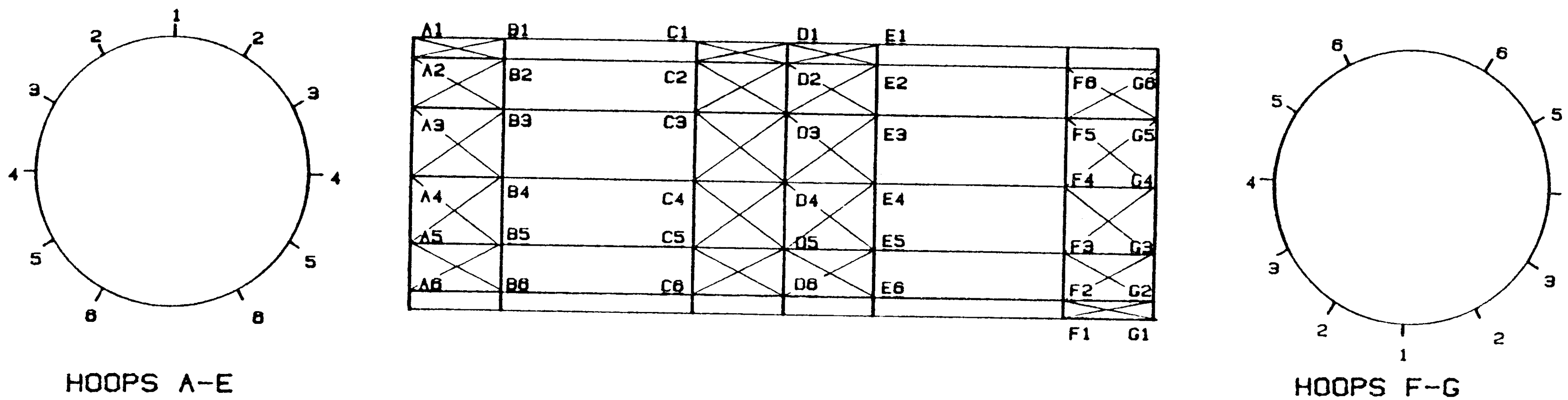

Fig. 2.15: Lines in the grid along which strains were measured.

The gauge length along the length of the specimen depended upon the spacing of the hoops. Strains were measured along the lines between the gauge points (Fig. 2.15). The targets were numbered starting from the bottom on the North side because the tension face is on the bottom on that side, and it was expected that the strain variation would be more pronounced in that region. As specimen SCO contained no hoops, strain readings were not taken.

Strains were measured along straight lines although the actual surface was curved (Fig. 2.16). It was estimated that the actual

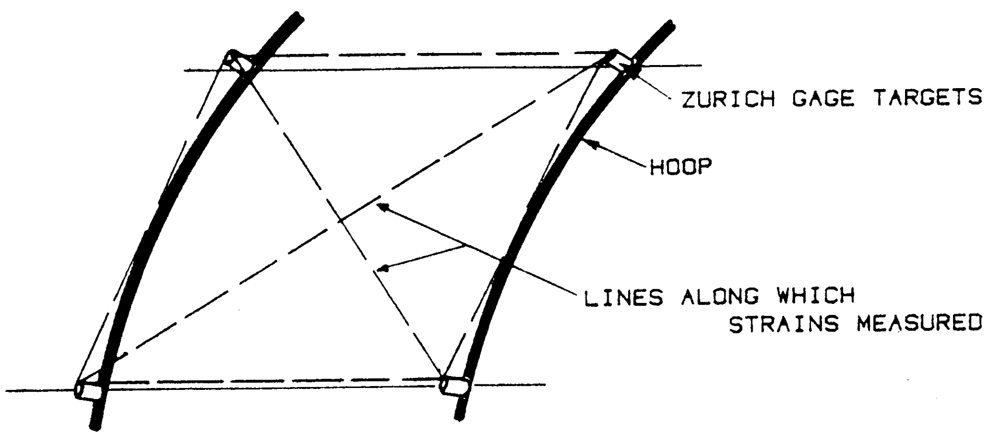

Fig. 2.16: Difference between true and measured strain.

strains on the surface would be about five per cent different from the measured strains. So for the purpose of this study, it was assumed that the measured strains were equal to the actual strains.

Zurich gauges were used for measuring strains. These gauges had a least count of 0.01 mm. The gauge length depended upon the spacing of the hoops. At every load stage 99 gauge readings were taken on each face of the specimen, making a total of 198 readings.

2.4.2 Deformation Measurements

Only the two deformation measurements shown in Fig. 2.17 were taken. One was the total deformation in the system which included

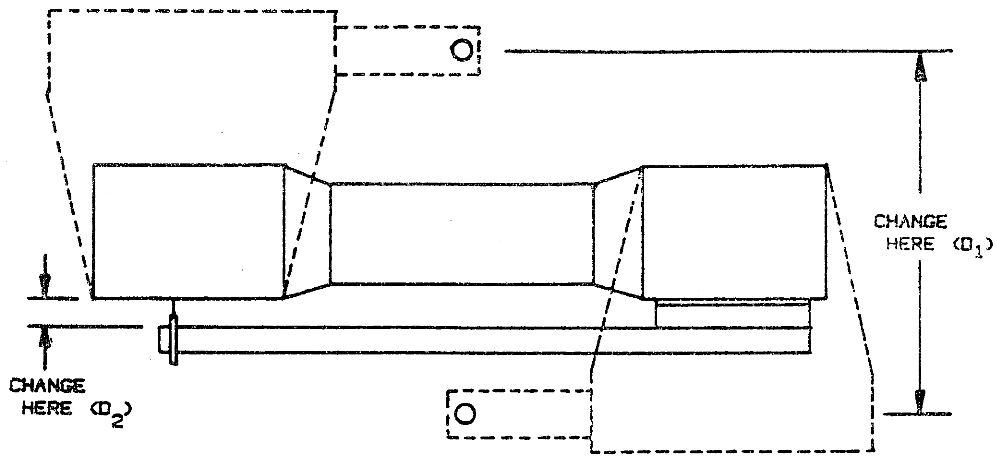

Fig. 2.17: Deformations measured during test.

the deformation of the loading rig as well as the specimen; the second was the tangential deviation of one end with respect to the other end of the specimen. Both these deflections were plotted against the transverse load on X-Y plotters.

2.4.3 Load Measurement

The transverse load was monitored by a load cell built into the MTS testing machine. The axial load was monitored during the test by a load cell mounted on the post-tensioning bar.

2.5 Test Procedure

After the test specimen was placed into the machine, initial readings were taken with both ends of the specimen temporarily supported to reduce the deal load moments. These readings were considered as the zero readings for data analysis. Axial load was then applied by tensioning the high strength steel bar to 1000 kN. The transverse load was then applied in stages, strain readings taken, and the crack patterns photographically recorded. At each load stage the machine deformation was held constant while strain readings were taken.

CHAPTER 3

EXPERIMENTAL OBSERVATIONS

3.1 Introduction

This chapter contains the description of the five tests conducted. The information is presented in tabular form. The second column of the table contains the shear force on the specimen which was assumed constant over the test region and equal to the shear at the centre of the test region. Load deflection-curves and photographs of crack patterns at selected load stages are also presented.

During the test, the machine deformation was kept constant at each load stage for about 30 minutes while strain readings were taken. Typically it took about 4-1/2 hours for each test to be completed except for SCO for which no strain readings were taken and the whole test took only about 45 minutes.

3.2 Specimen SCO

TABLE 3.1: TEST DESCRIPTION OF SPECIMEN SCO

Load Stage	Shear (kN)	Axial Load (kn)	Observations
-	0	0	No readings taken. (Specimen supported on ends).
0	0	1000	Axial load applied.
1	172	1000	No visible cracks on surface.
2	222	1000	First moment cracks appeared on South end of test section.
3	285	1009	New diagonal cracks appeared in region AB.
4	326	1022	Diagonal cracks appeared in South end block. No cracks below level 4, except for a couple of flexural cracks on bottom side of North end block.
5	292	1012	Load dropped as a large crack formed running diagonally from one end block to the other, starting from lower South side and going to the top on North end. Two or three other diagonal cracks parallel to the larger one also appeared in the central region. Cracks in region CDE at failure were inclined at 18° to the horizontal.

3.2 Specimen SCO

TABLE 3.1: TEST DESCRIPTION OF SPECIMEN SCO

Load Stage	Shear (kN)	Axial Load (kn)	Observations
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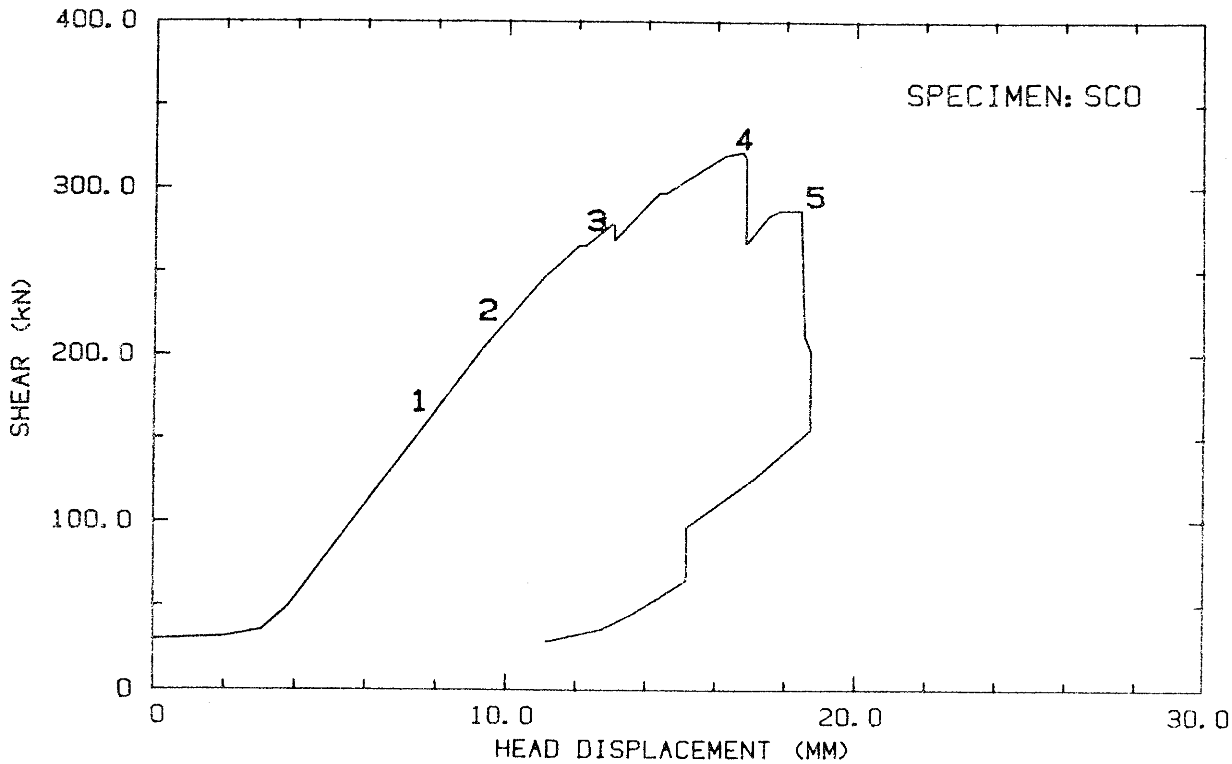


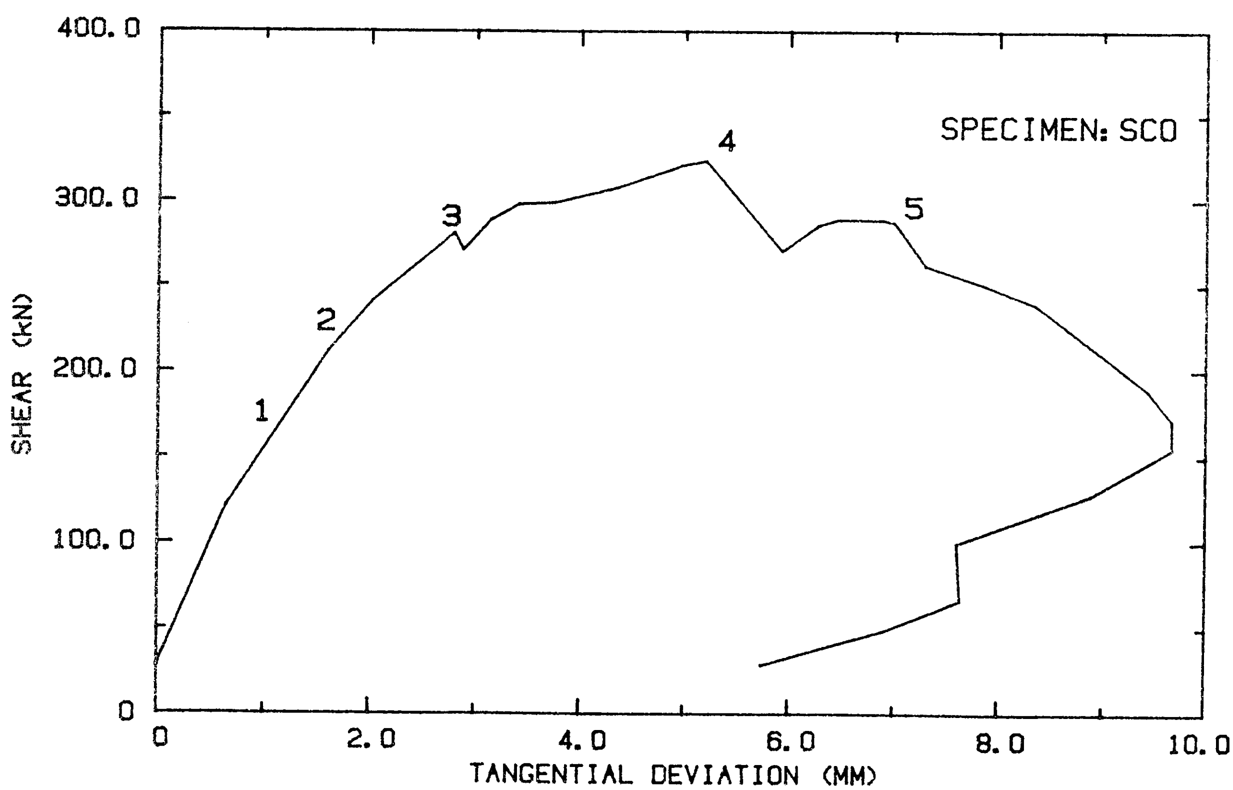


Fig. 3.1: Load-displacement curves for specimen SCO.

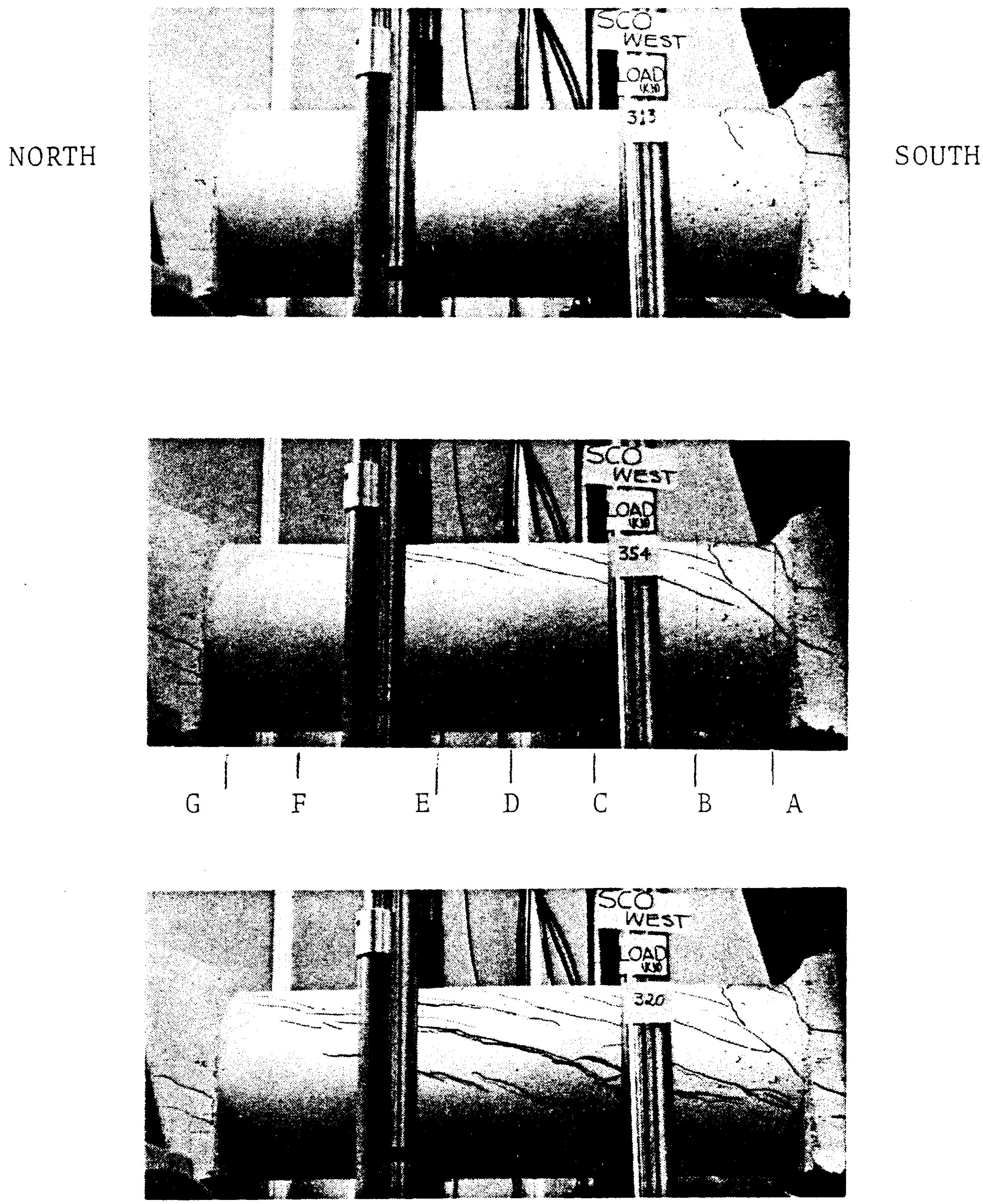
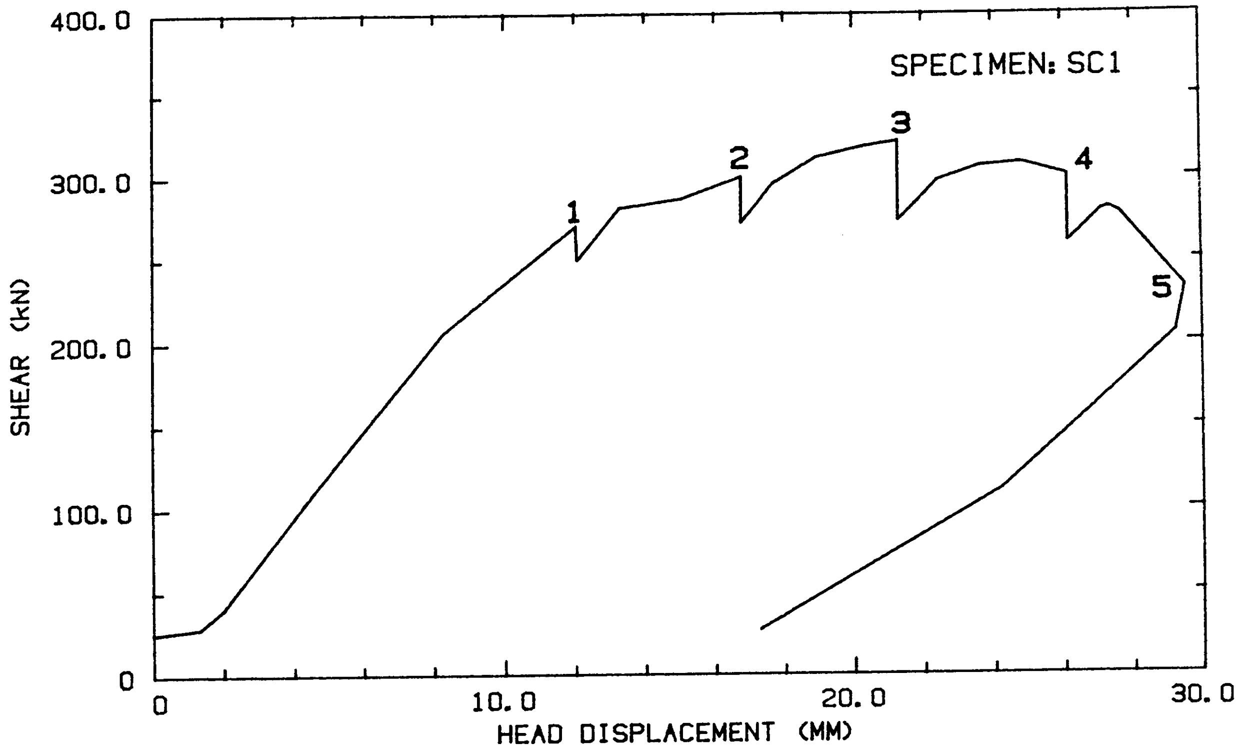


Fig. 3.2: Crack patterns at selected load stages for SC0.
(Note that load shown include dead load
i.e. Shear=Load-28 kN)

3.3 Specimen SC1

TABLE 3.2: TEST DESCRIPTION OF SPECIMEN SC1

Load Stage	Shear (kN)	Axial Load (kn)	Observations
1	0	0	Initial readings taken. (Specimen supported on ends).
0	0	1000	Axial load applied.
1	272	1009	A diagonal crack formed in South end block. Flexural cracks appeared on top of beam along hoop line A and B. No cracking on North side. Bottom face of South end block started to crack, therefore LVDT readings were distorted.
2	302	1013	Wide flexural cracks on top of South end block. Diagonal cracks formed in region AB. A couple of cracks originated at A4 propagated towards B3. Region CDE still uncracked.
3	324	1017	Load started to drop although deformation was being increased. New cracks formed in region CDE. More cracks formed in region AB. Cracks between D3-E2 and C4-D3. Still no cracks on North end.
4	303	1016	Load dropped further although deformation was being increased. More cracks formed in regions AB and CDE. Cracks propagated into region FG.
5	224	986	Concrete crushed between B4-B5 on West side. Cracks more uniformly distributed. Bottom half of specimen on North side still uncracked. Cracks in region CDE inclined at 22° to the horizontal.



TANGENTIAL DEVIATION PLOT NOT POSSIBLE FOR SC1 AS LVDT READINGS WERE DISTORTED BECAUSE OF CRACKING OF BOTTOM FACE OF SOUTH END BLOCK.

Fig. 3.3: Load-displacement curves for specimen SC1.

SOUTH

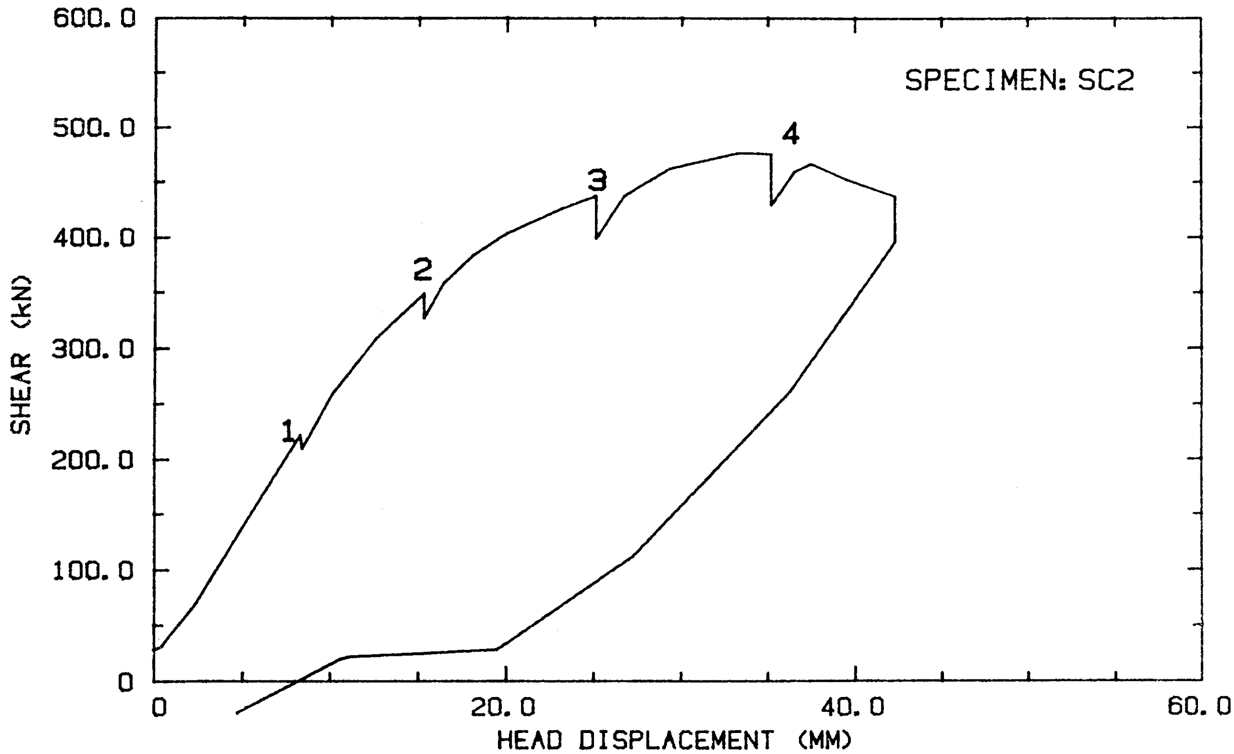
NORTH

Fig. 3.4: Crack patterns at selected load stages for SC1

3.4 Specimen SC2

TABLE 3.3: TEST DESCRIPTION OF SPECIMEN SC2

Load Stage	Shear (kN)	Axial Load (kn)	Observations
-	0	0	Initial readings taken. (Specimen supported on ends)
0	0	1000	Axial load applied.
1	222	1006	No cracks visible.
2	347	1026	Some cracks formed in region AB, between A3-B3 and along hoops A and B on top of beam on South side.
3	439	1060	New diagonal cracks formed in region CDE and in regions AB and FG. Cracks between B6-D5-F5, C4-E3 and F2-G4.
4	478	1083	Load peaked and started to drop. Crack pattern uniform in all regions. Additional cracks developed in end blocks. Specimen was assumed to have failed. Cracks in region CDE inclined at 24° to the horizontal.



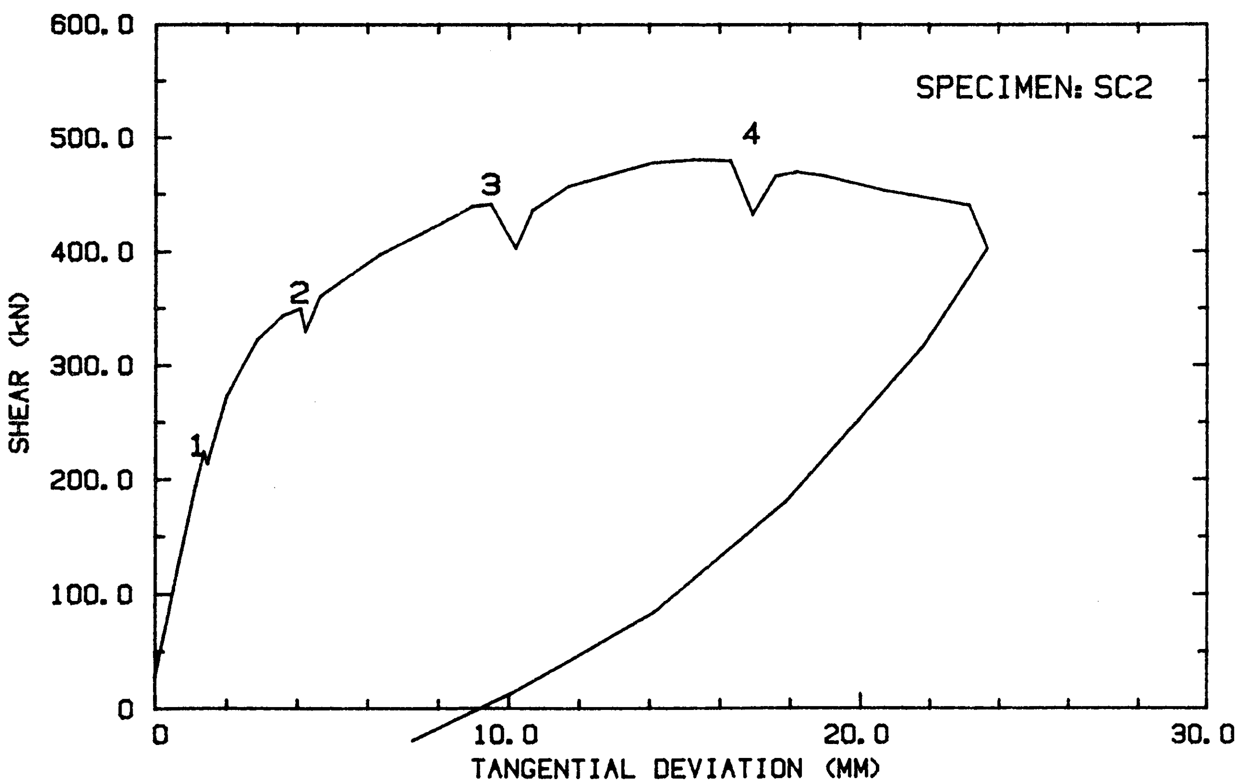


Fig. 3.5: Load-displacement curves for specimen SC2.

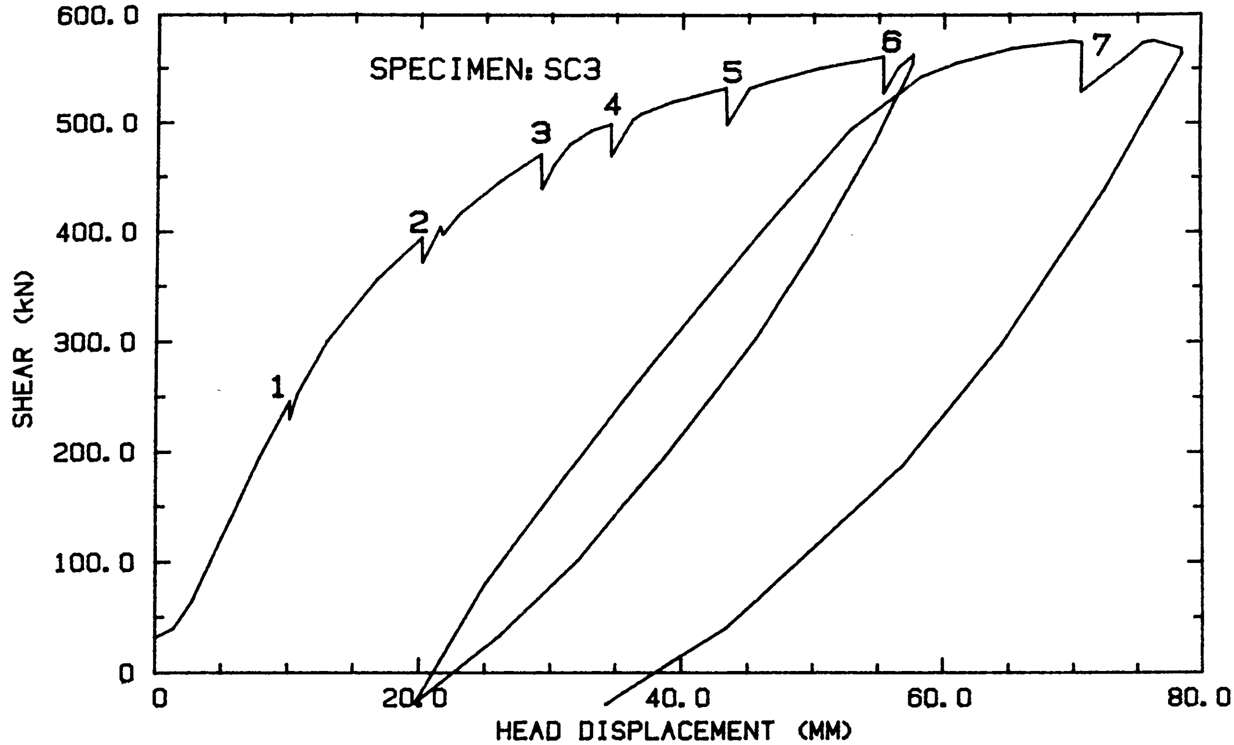
SOUTH NORTH

Fig. 3.6: Crack patterns at selected load stages for SC3.

3.5 Specimen SC3

TABLE 3.4: TEST DESCRIPTION OF SPECIMEN SC3

Load Stage	Shear (kN)	Axial Load (kn)	Observations
-	0	0	Initial readings taken. (Specimen supported on ends)
0	0	1000	Axial load applied.
1	247	1001	No cracks visible.
2	397	1034	Cracks formed in North as well as South end blocks. Flexural cracks along hoop lines A and B on top of beam. A diagonal crack between A4-B3.
3	472	1051	Cracks developed in regions CDE and FG. Specimen cracked throughout the depth in all regions. A crack along D5-E4-F5-G5. Flexural cracks on bottom North side on hoop line F.
4	502	1066	No new cracks formed. Previous cracks extended.
5	532	1076	Previous cracks widening. Concrete started to crush on bottom South side.
6	564	1089	New cracks appeared in all regions, and in end blocks. Concrete crushed on hoop line A on bottom. Specimen was unloaded and kept at zero load for 2 hours. Load then increased up to failure.
7	578	1085	Concrete crushed and spalled off on South bottom side near hoop A. Crack pattern much more uniform. Bottom face of South end block started crushing, therefore LVDT measurements were distorted. Ultimate load reached. Cracks in region CDE inclined at 27° to the horizontal.



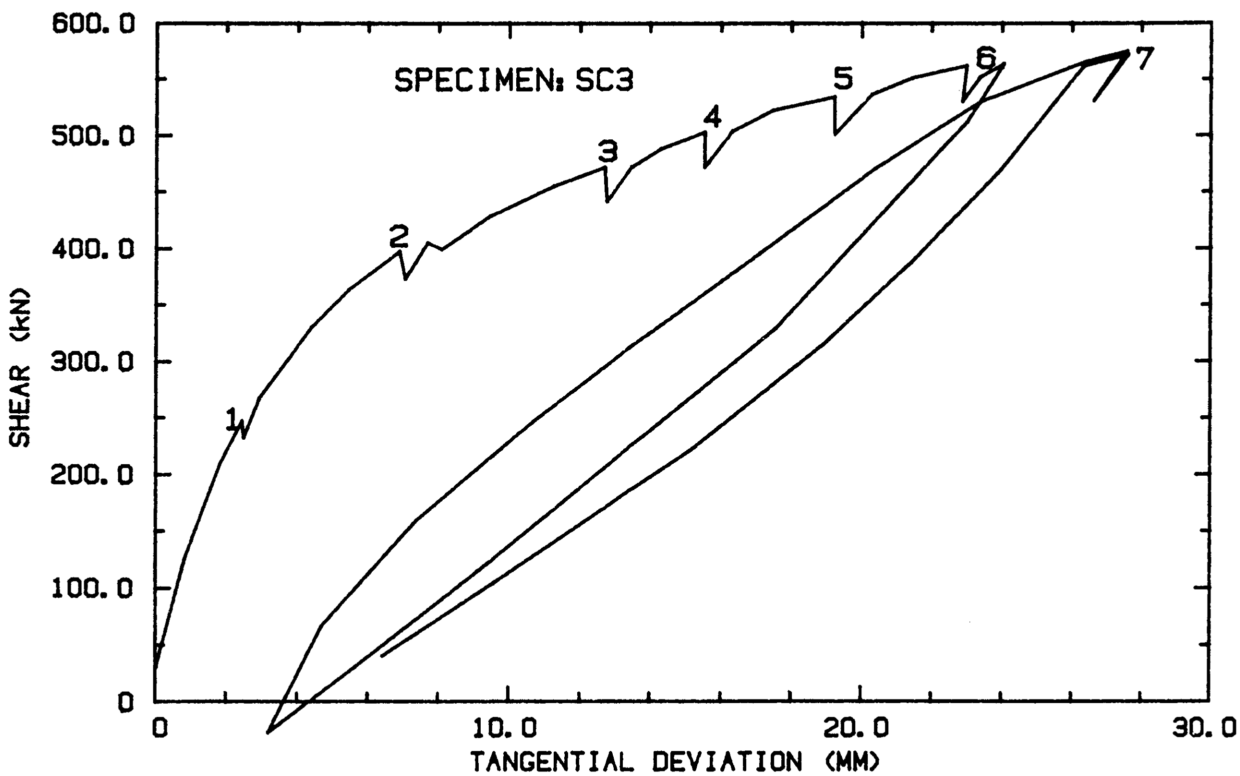


Fig. 3.7: Load-displacement curves for specimen SC3.

SOUTH NORTH

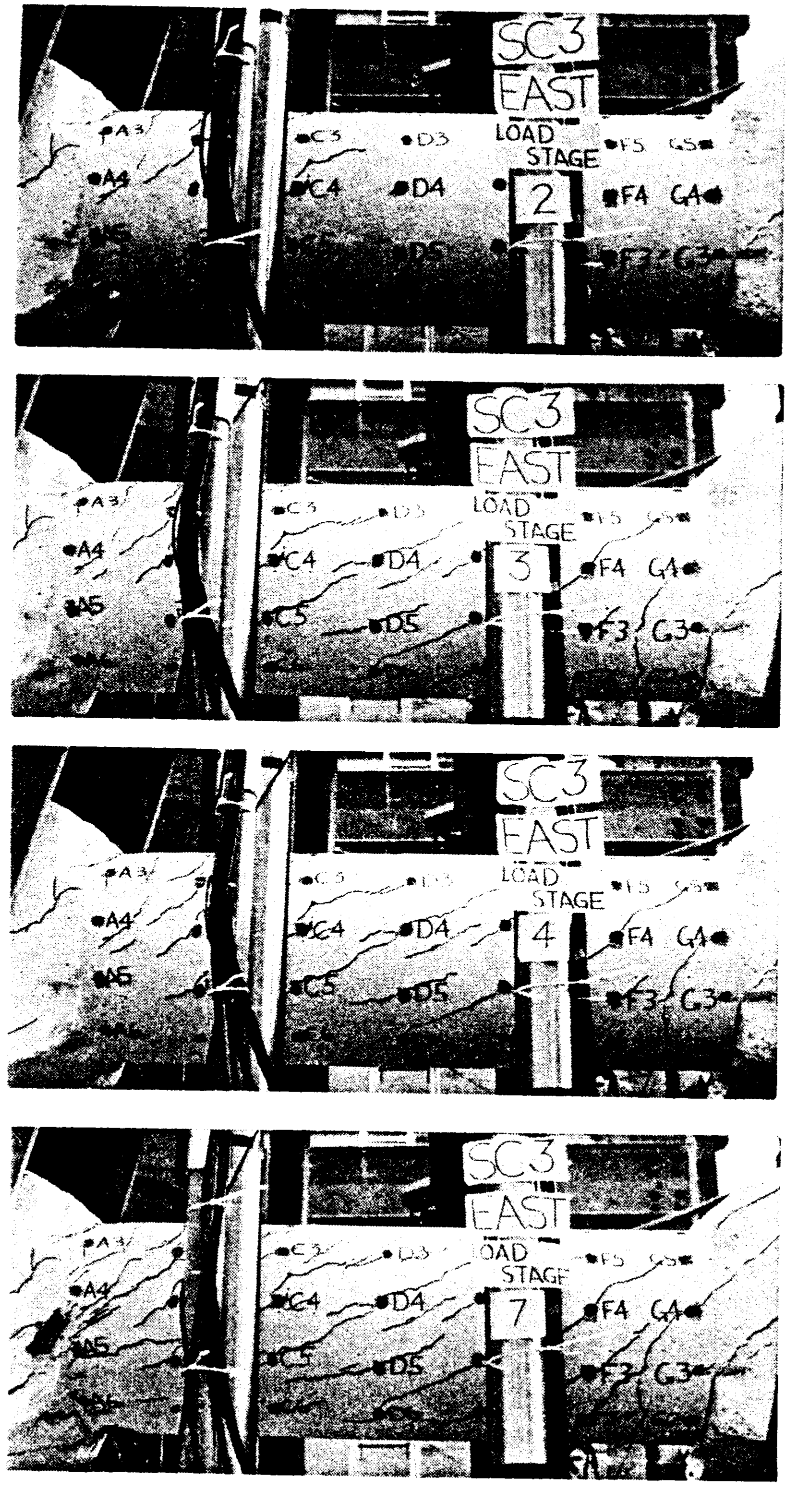


Fig. 3.8: Crack patterns at selected load stages for SC

3.6 Specimen SC4

TABLE 3.5: TEST DESCRIPTION OF SPECIMEN SC4

Load Stage	Shear (kN)	Axial Load (kn)	Observations
-	0	0	Initial readings taken. (Specimen resting on ends).
0	0	1000	Axial load applied.
1	298	1005	Cracks formed in each of the two end blocks. First flexural crack formed on hoop line A on top at a shear of 212 kN. Cracks also appeared in region AB. A crack on hoop line G on bottom.
2	360	1015	More diagonal cracks formed in region AB and extended to hoop C.
3	391	1025	Cracks formed in regions CDE and FG, and new cracks appeared in region AB. New cracks develop in end blocks too. A couple of cracks extend from region AB to region FG. Concrete started to crack on bottom face of South end.
4	422	1039	More cracks formed in end block and regions AB and CDE. Cracks in regions AB and FG widening.
5	447	1046	Cracks more uniformly distributed. New cracks appeared in regions AB and CDE. Cracks in South end block widen further.
6	456	1050	Concrete started to crush on South bottom side of test region. Crushing extended into the end block, thus LVDT readings were distorted. Transverse load started to drop.
7	434	1026	Load dropped although deformation was increased. Bottom face of South end block further cracked and crushed. Large diagonal crack on B4 on West side. Targets F2 on East side and B5 on West side dropped off. Cracks very closely spaced in region AB. Concrete crushed near A4 on West side. Cracks in region CDE inclined at 25° to the horizontal.

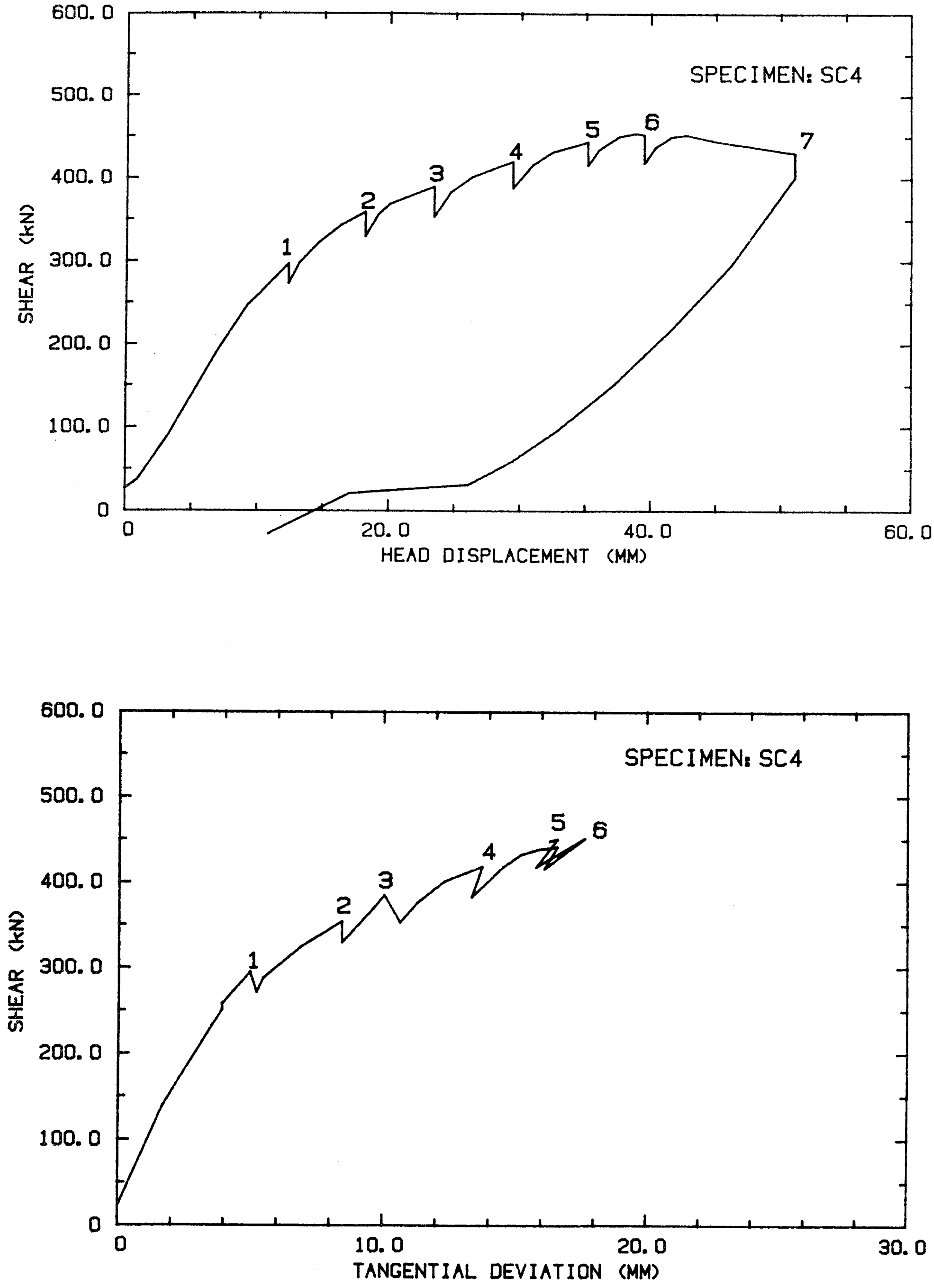


Fig. 3.9: Load-displacement curves for specimen SC4.

SOUTH

NORTH

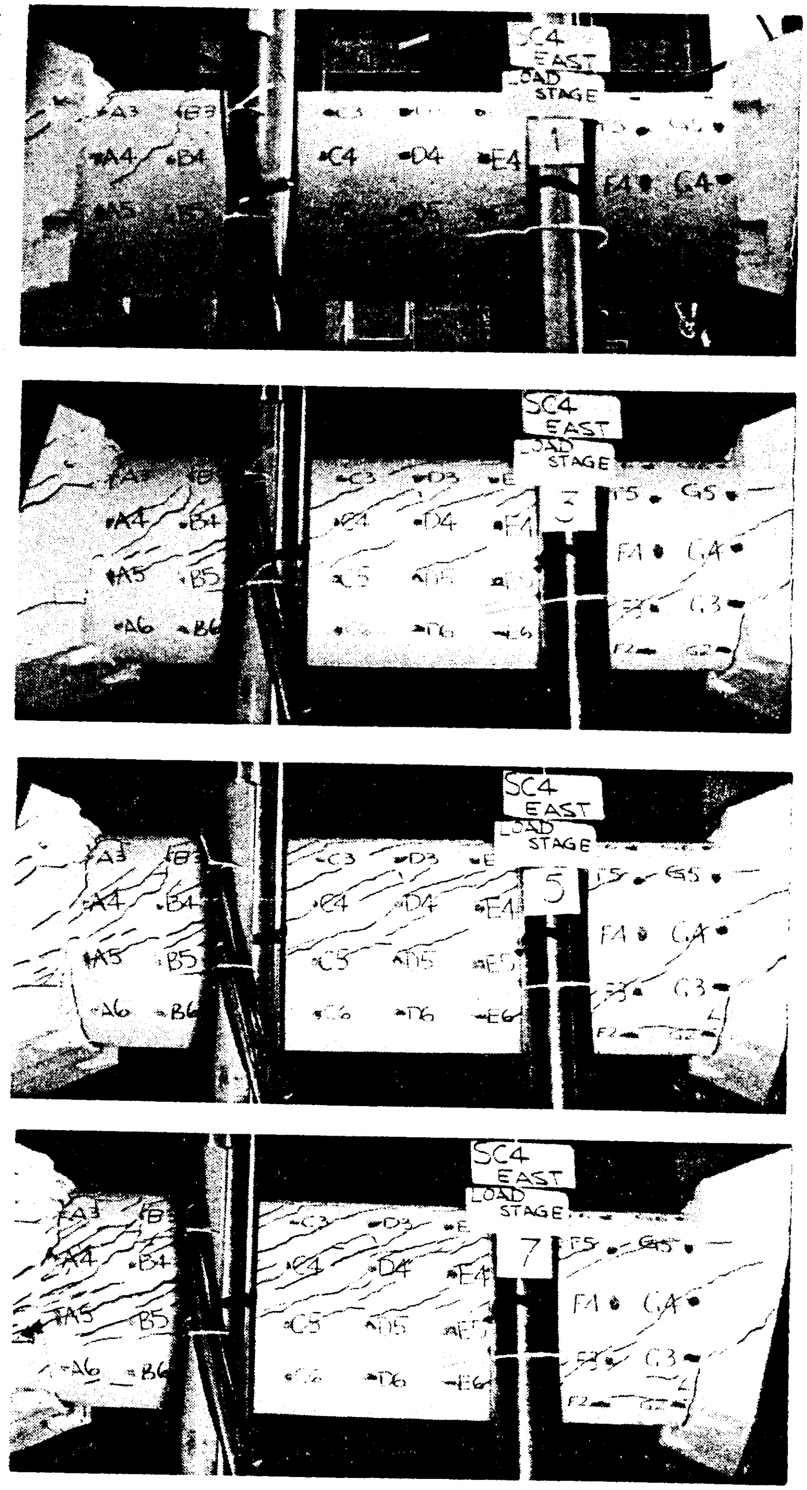
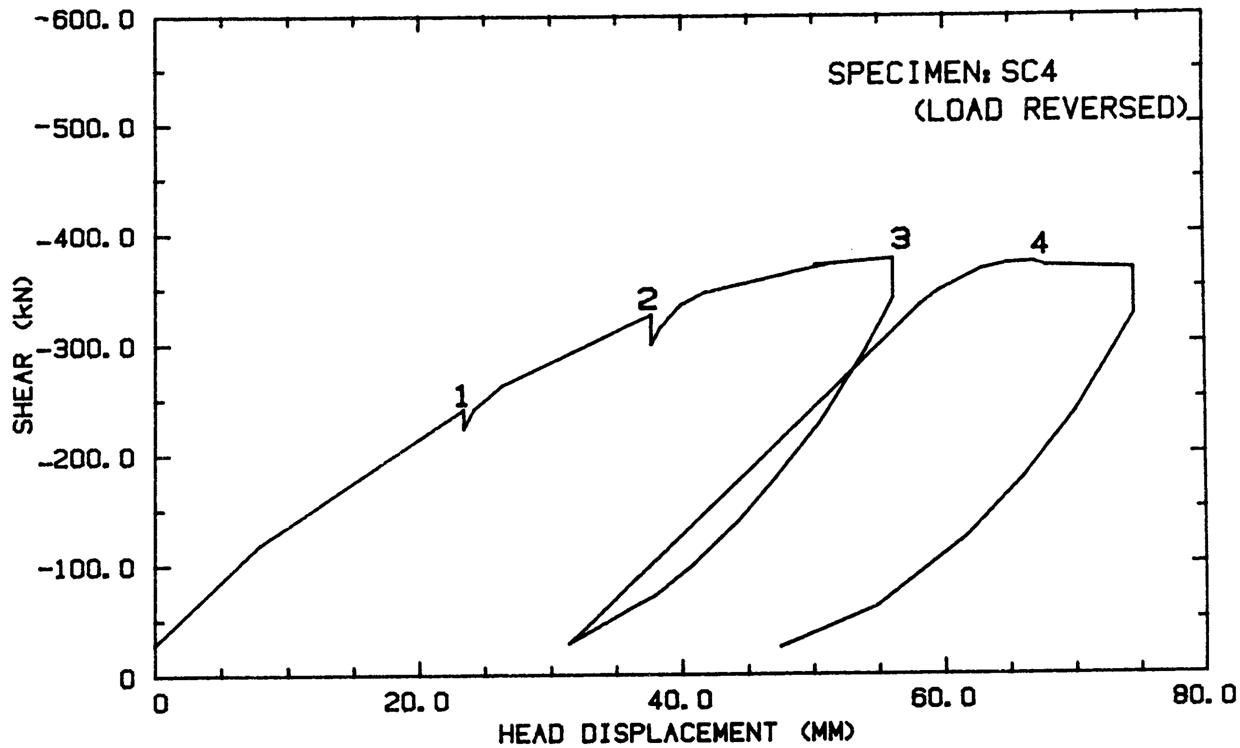


Fig. 3.10: Crack patterns at selected load stages for SC4.

3.7 Specimen SC4 - Load Reversed

TABLE 3.6: TEST DESCRIPTION FOR SPECIMEN SC4 - LOAD REVERSED

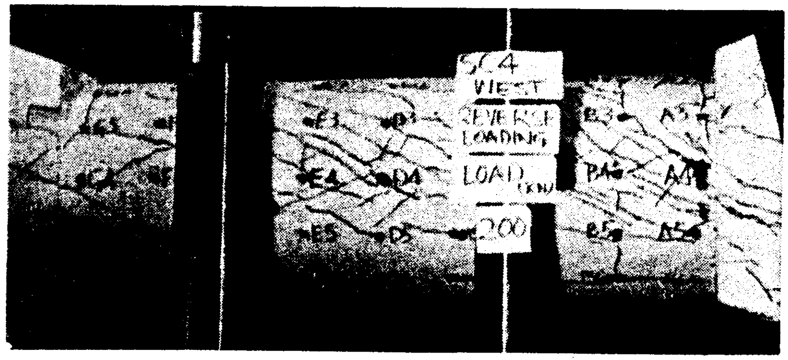
Load Stage	Shear (kN)	Axial Load (kn)	Observations
			No strain readings taken, crack patterns were photographically recorded.
0	0	1015	Most of the previous cracks closed.
1	-228	1026	New cracks appeared in all regions. North end block cracked. Cracks along G4-F5-F6, G5-G6, B6-A6-A5-A4, B4-A3, C3-D4-D5.
2	-328	1058	New cracks formed in all regions. Crack patterns more uniform. Previous cracks extended in both directions.
3	-378	1075	Concrete crushed on bottom side of North of test regions. Concrete also crushed on hoop line A on both East and West side.
			Specimen taken through one cycle of unloading.
4	-378	1108	Specimen failed to take more load. Extensive spalling off of cover at levels 4-5 along hoops A, C and D. Cracks in region CDE inclined at 25° to the horizontal.



TANGENTIAL DEVIATION PLOT NOT POSSIBLE FOR SC4 (LOAD REVERSED) AS LVDT READINGS WERE DISTORTED DUE TO CRACKING OF BOTTOM OF SOUTH END BLOCK.

Fig. 3.11: Load-displacement curve for specimen SC4 (load reversed).

NORTH



SOUTH

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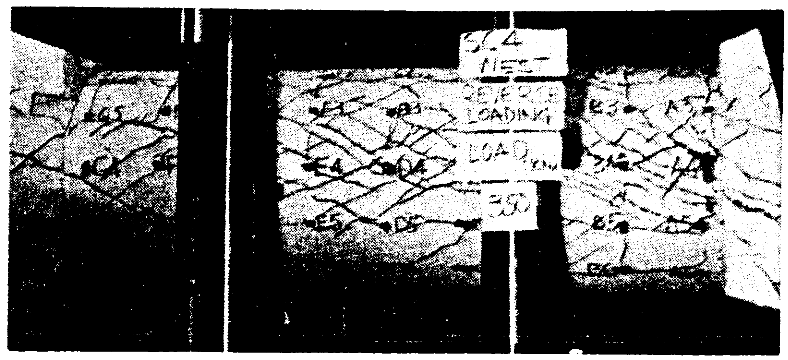

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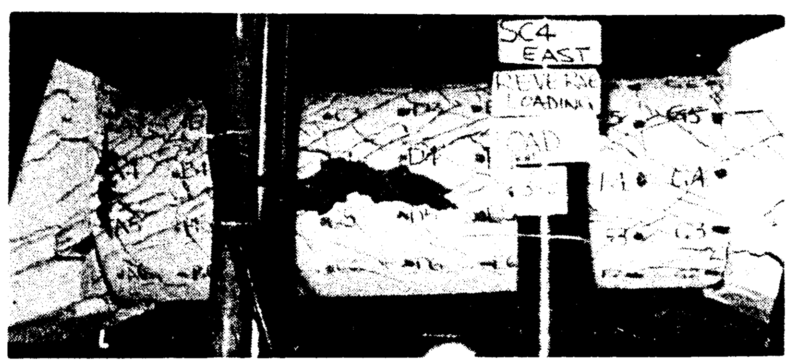


NORTH

Fig. 3.12: Crack patterns at selected load stages for SC4 load reversed.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Ultimate Strength

The most important results of the investigation were probably the observed shear strengths of the test specimens. The shear strengths of the specimens have been plotted against the amount of transverse reinforcement in Fig. 4.1. Both parameters have been non-dimensionalized. The same figure also contains the ACI prediction and the CFT prediction of the shear strengths. There are two plots for the CFT; one for no moment on the section simulating the centre of the test region, and the second for moment equal to 635V (N-mm) which simulates the end of the test region. The CFT calculations were based on a procedure developed by Vecchio [9]. The procedure, based on a modified version of the CFT, also accounts for the tensile stresses in the concrete between cracks, in a cracked reinforced concrete beam. During the tests, it was observed that at failure the average axial load on the different specimens was about 1050 kN. Hence the predictions were based on an axial load of 1050 kN. An average concrete cylinder strength of 23.3 MPa was used. Details of the prediction for the CFT and the ACI are given in Appendix A. The shear strength predicted using the actual concrete cylinder strength for each specimen is given in Table 4.1.

A study of Fig. 4.1 indicates that the experimental values are about 20% higher than the ACI prediction. It is to be noted that the ACI prediction was based on the formulae as given in the code, with 'b_w'

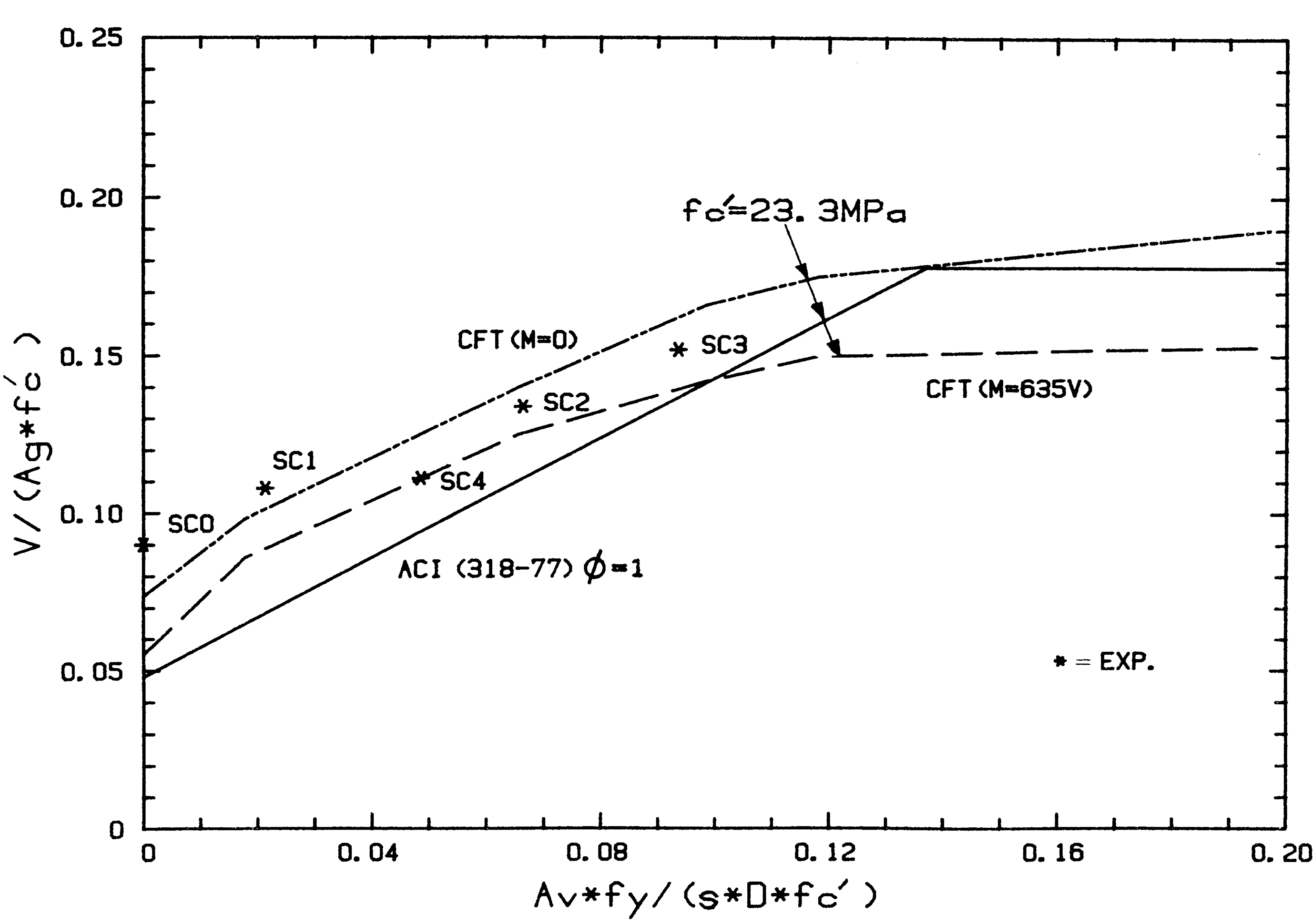


Fig. 4.1: Relationship between shear strength and amount of transverse reinforcement predicted by ACI, CFT and experiments.

TABLE 4.1: SHEAR STRENGTH PREDICTED USING ACTUAL MATERIAL PROPERTIES

SPECIMEN	SHEAR STRENGTH (kN)			
	EXPERIMENTAL	ACI	CFT (M = 0)	CFT (M = 635V)
SC0	326	174	267	200
SC1	324	215	356	311
SC2	478	399	507	454
SC3	578	524	601	489
SC4	456	356	498	445
SC4 (Reversed Loading)	378	-	-	-

and 'd' as previously defined. If, however, the rationale behind the ACI formulation (assuming a 45° failure crack crossing the stirrups) is used, the contribution of circular hoops would be less than that of stirrups with their legs parallel to the shear force. Considering only the appropriate component of the force in the circular hoops leads to the following expression for the steel contribution

$$V_s = \frac{2}{\pi} \frac{A_v f_y d}{s}$$

The above expression is used by a number of engineers (e.g. Priestley [7]) in calculating the ACI shear capacity of circular members. Using this interpretation of the code would lower the values of V_s by about 36%. This would make the ACI predictions even more conservative. It was expected that the experimental values would be bound by the two CFT predictions, as the actual specimens were subjected to a moment, varying over the test region from 0 to 635V, in addition to the shear. It can be seen (Fig. 4.1 and Table 4.1) that all specimens except SC0 did lie within the two bounds. Specimen SC4 was observed to have failed near the end of the test region with extensive concrete crushing. Thus the fact that its failure strength was closer to the M=635V prediction, is explainable. However, as SC4 had larger hoops (meaning a larger spalled section area), it was expected that it would have taken more load than it actually did. The end block on the South side was significantly cracked at failure. This could be a reason for the premature failure of SC4. Specimens with low transverse reinforcement ratio (especially SC0) exhibited a higher failure shear compared to the CFT prediction. The possible reason could be the strengthening effect of the end blocks, which would be more pronounced for low transverse reinforcement ratios.

It was also observed that the CFT prediction for shear plus flexure was below the ACI prediction for high transverse reinforcement ratios. In actual structures high flexure could be present in addition to high shear, and the ACI predictions might be unconservative.

Fig. 4.2 contains plots of predicted shear force versus amount of transverse reinforcement (both non-dimensionalized) for the ACI equation, the suggestions of the ACI-ASCE Committee 426 [2], and the proposed recommendations for the Canadian Code [4] in addition to the observed failure loads. The suggestions of Reference 2 and 4 are much closer to the actual points than the ACI prediction. They are, however, still conservative for low transverse reinforcement ratios.

After failure, the transverse loading on specimen SC4 was reversed. It was observed that the specimen took about 83% of the monotonic failure load under the reversed loading. The specimen was also much more flexible.

4.2 Strain Analyses

The strain measured on the East and West sides were averaged and these average strains were used in all strain calculations. Six strain readings were taken on each of the rectangles shown in Fig. 4.3(a). These

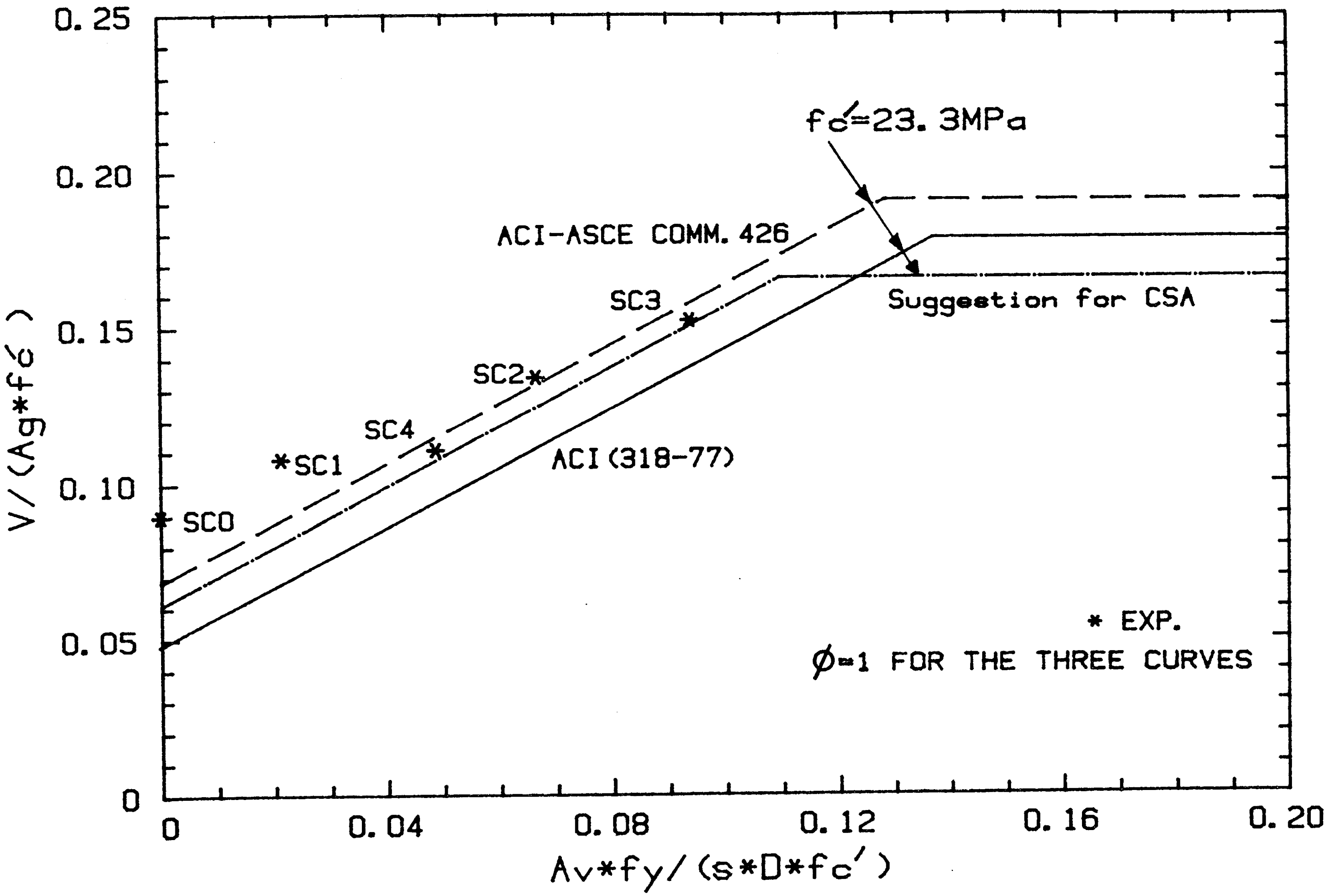


Fig. 4.2: Shear strengths versus amount of transverse reinforcement curves predicted by the ACI, References 2 and 4, and the experimental points.

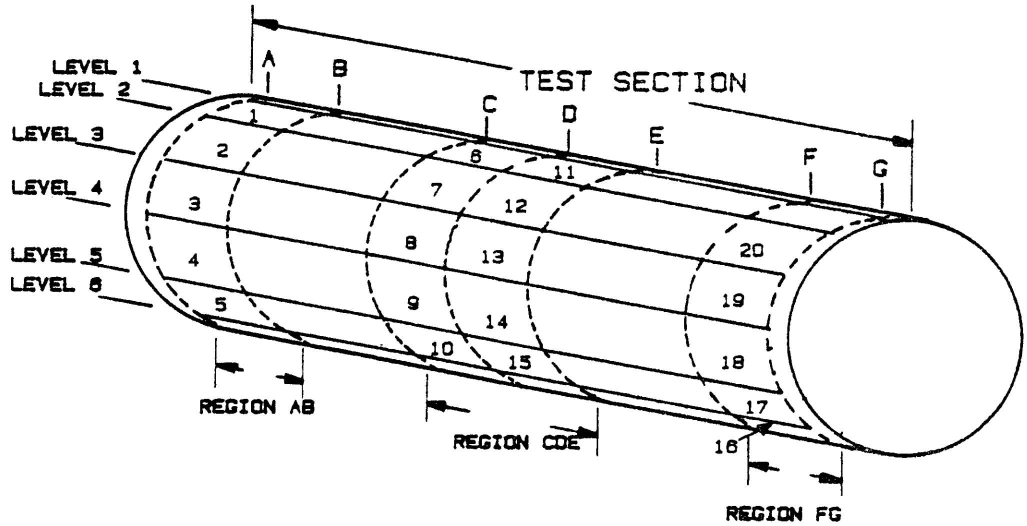


Fig. 4.3(a): Grid elements on which readings were taken.

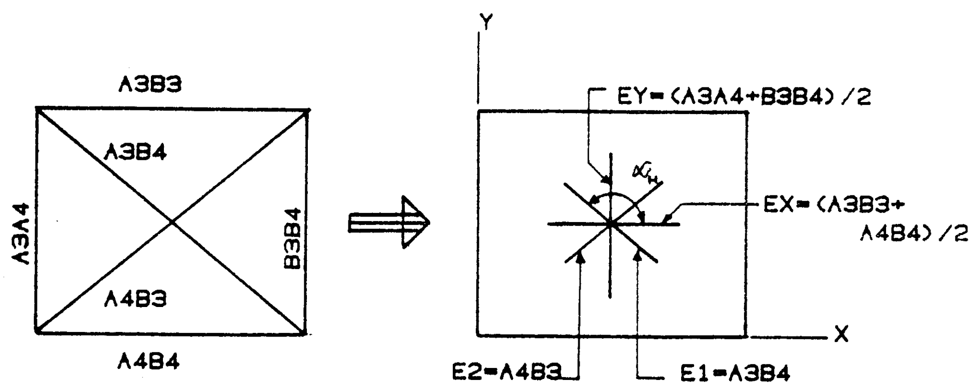


Fig. 4.3(b): Strains measured in a typical grid element.

strains were assumed to act at the centre of each rectangle (Fig. 4.3(b)) and were used to calculate the shear strains and the principal strains. These strains are listed in Appendix B.

As specimen SC2 was the first specimen tested, some difficulties were encountered taking readings on curved surfaces and as a consequence not all the mentioned readings were taken. The problem was, however, resolved and most strains were measured for the remaining specimens.

4.3 Hoop Strains

Three sets of hoop strains were plotted. The first was the strain distribution around the hoops. Typical strain distributions for regions AB and FG (subjected to high shear and moment) and region CDE (low moment region) are shown in Figures 4.4 through 4.7. The plotted strain distributions were the average of the hoops in that region. It is observed that for region AB the strains are more or less uniform around the hoop until hoop yield. After hoop yield, however, strains are higher at mid-depth of the beam. In the central (CDE) region the strains are observed to be generally higher at mid-depth as compared to the top and bottom of the specimen. Hoops in regions G were lightly strained as the dead load moment and shear was lower in this region.

The second set plotted (Figures 4.8 through 4.11), shows the variation of hoop strain (at mid-depth of the beam) along the test length. It is observed that the strains were usually higher in region AB. This is is because during the test, the dead load moment and shear was higher in this region. In specimen SC2, at failure almost all hoops had yielded at mid-depth and the strains were quite uniform over the test length. In specimen SC3, however, only hoops A and B had yielded at failure. A possible reason could be the fact that for heavily reinforced concrete, failure would occur by the crushing of concrete, rather than steel yield. Only hoops A, B and C had yielded (at mid-depth) at failure in specimen SC1 and for specimen SC4 only hoops F and G had not yielded.

The third set (Fig. 4.12) shows the variation of hoop strain (again at the mid-depth of the beam) with increase in the shear on the specimen. The strains have been plotted for the centre of the

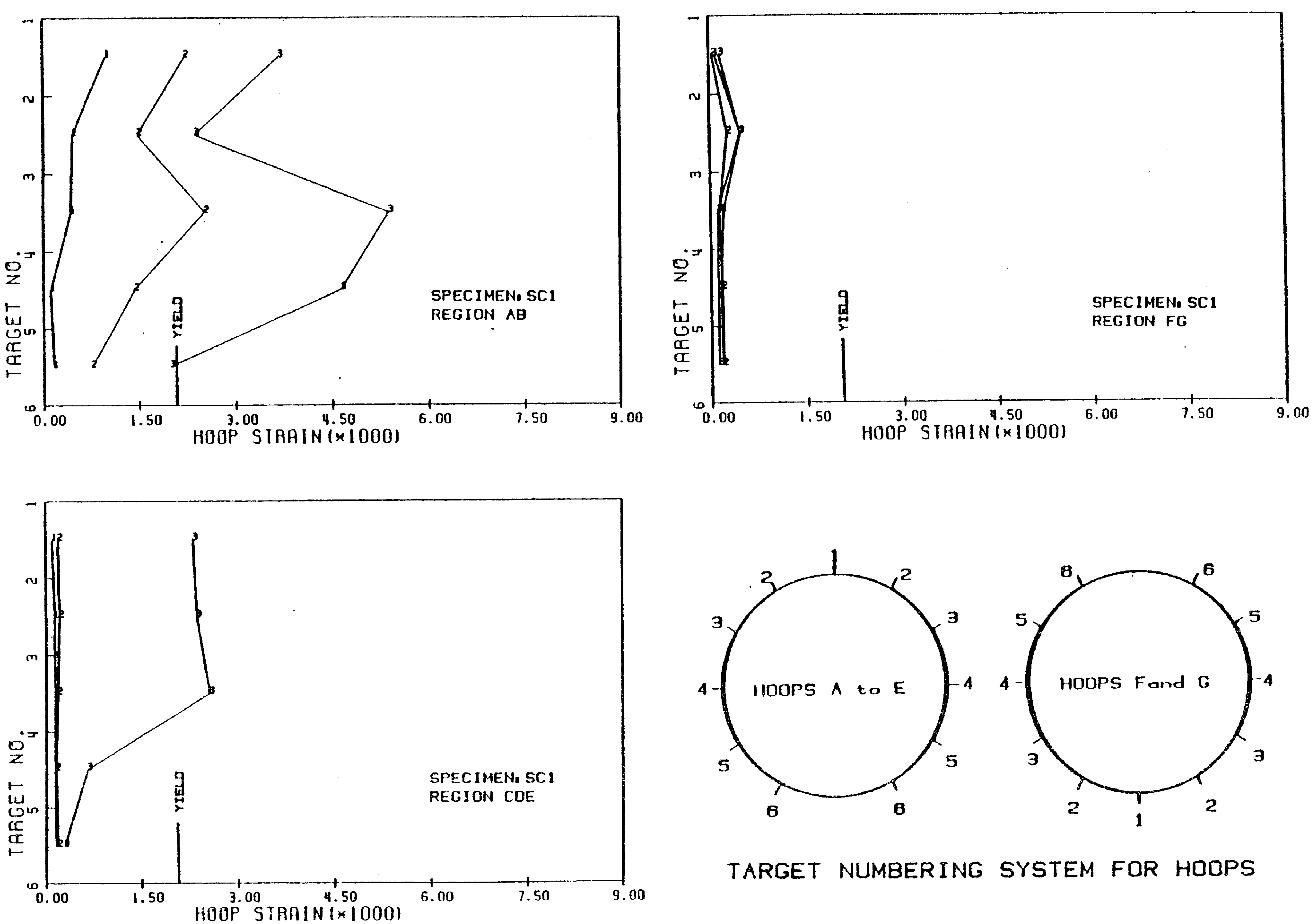


Fig. 4.4: Strain distribution along hoops at different load stages for SC1.

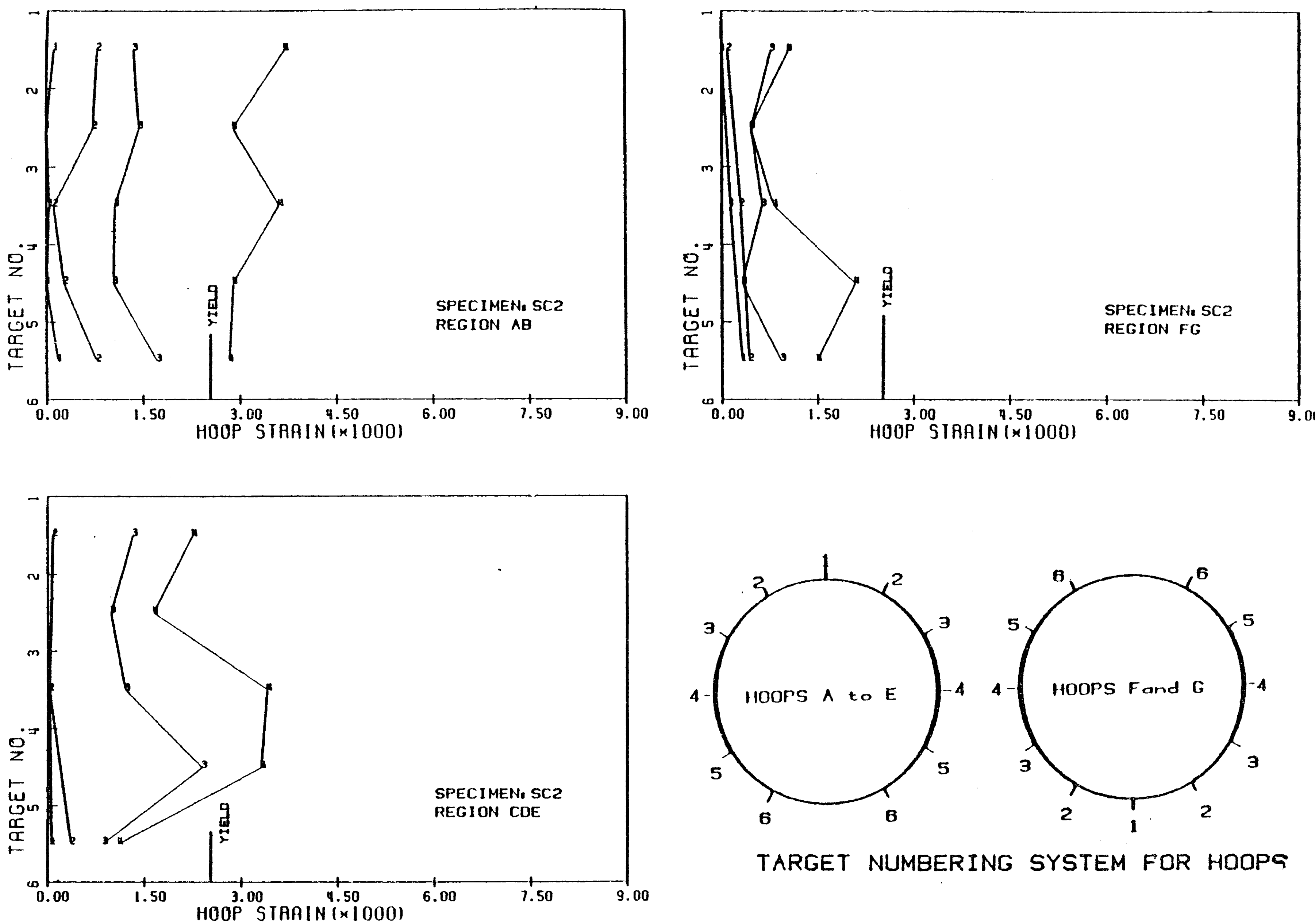
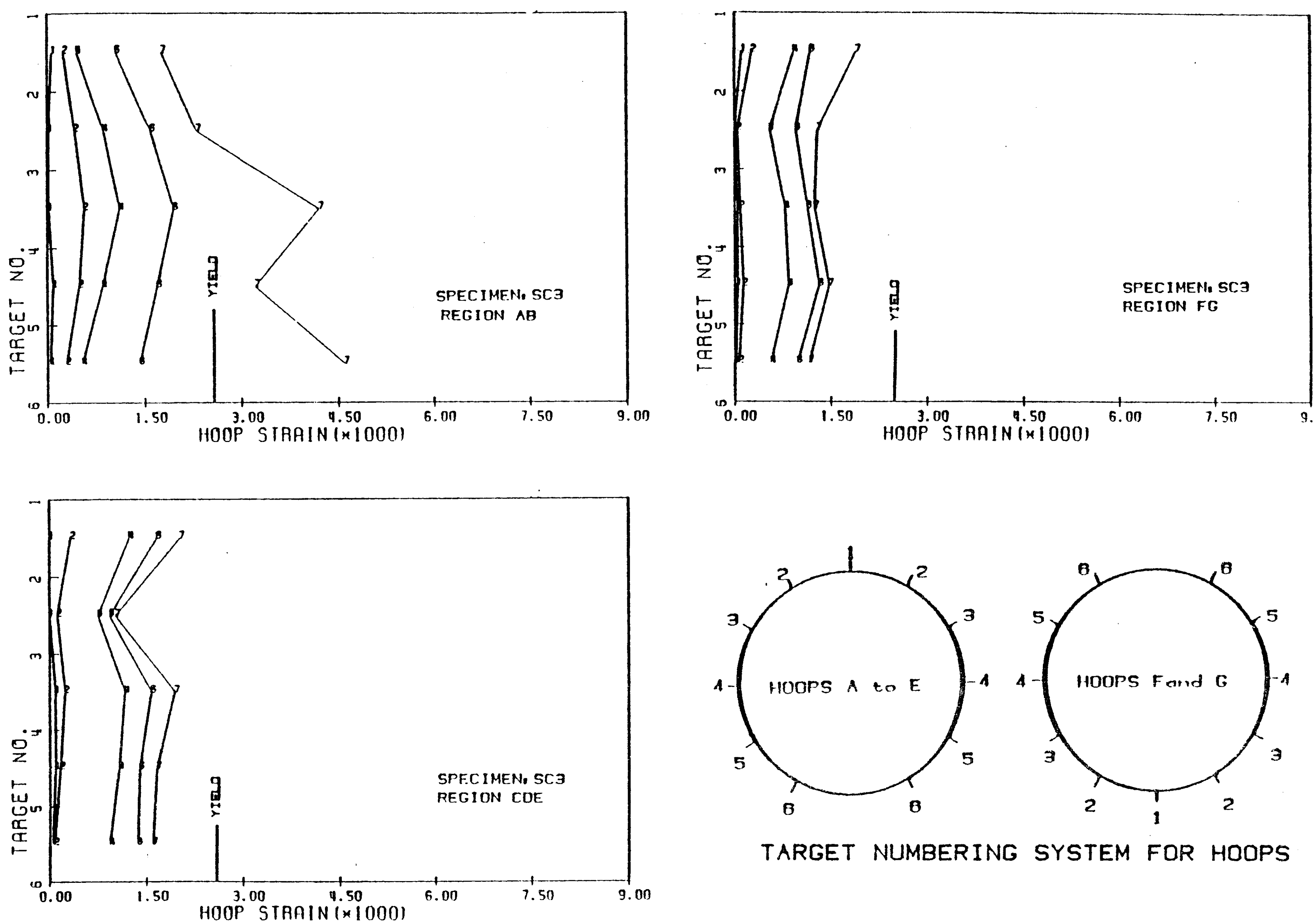


Fig. 4.5: Strain distribution along hoops at different load stages for SC2.



... along hoops at different load stages for SC3

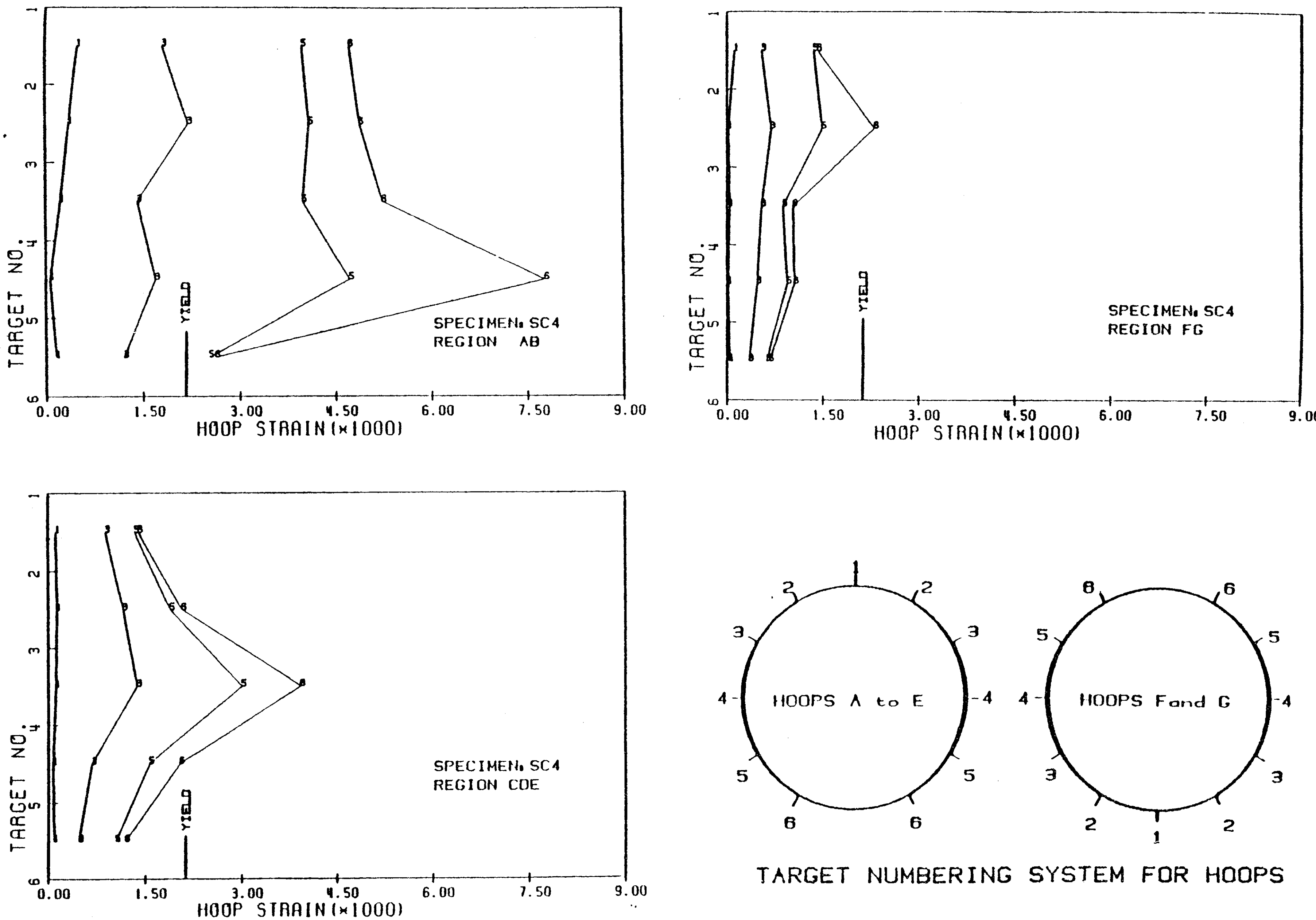


Fig. 4.7: Strain distribution along hoops at different load stages for SC4.

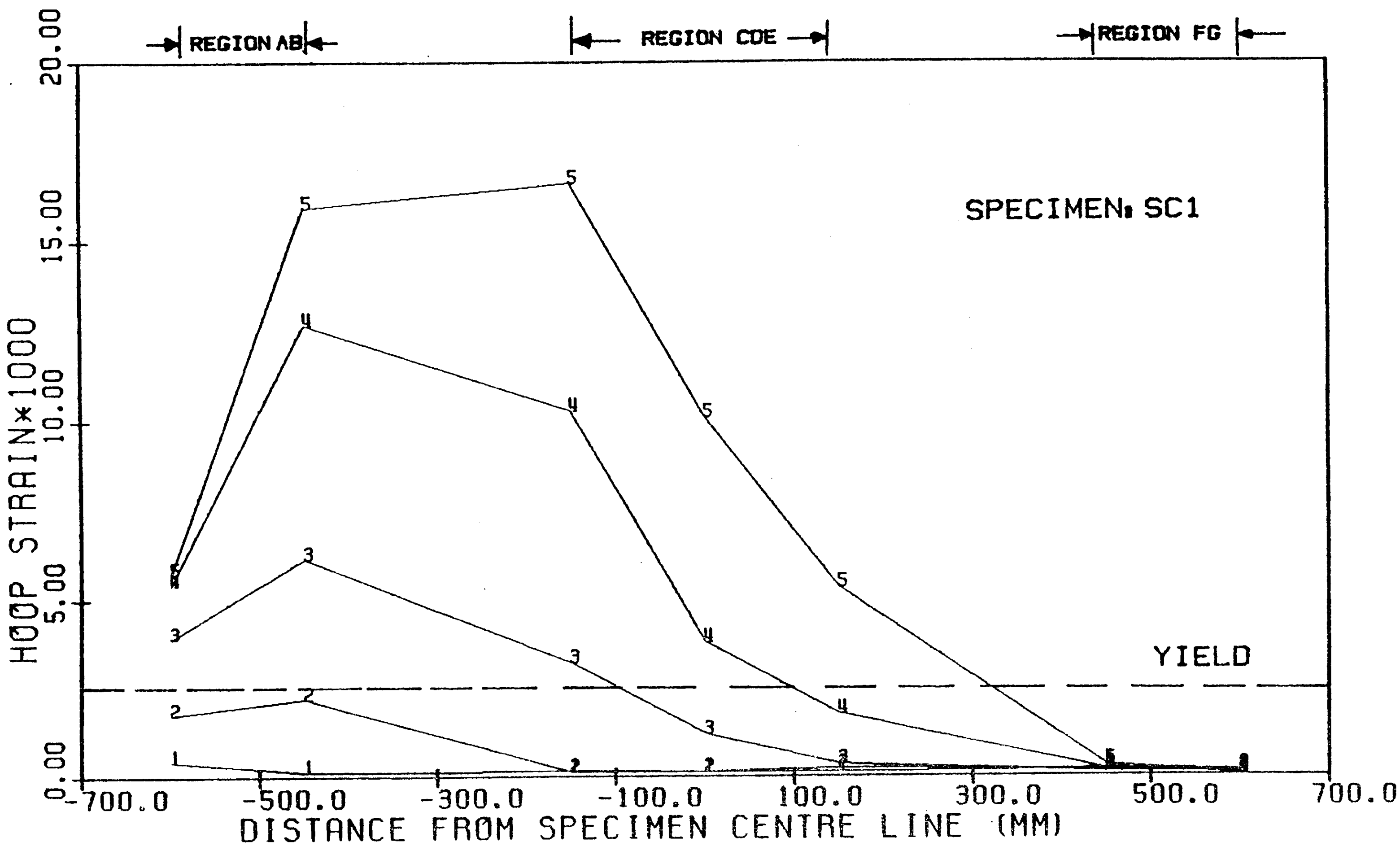


Fig. 4.8: Hoop strain variation along the length of test region for SC1.

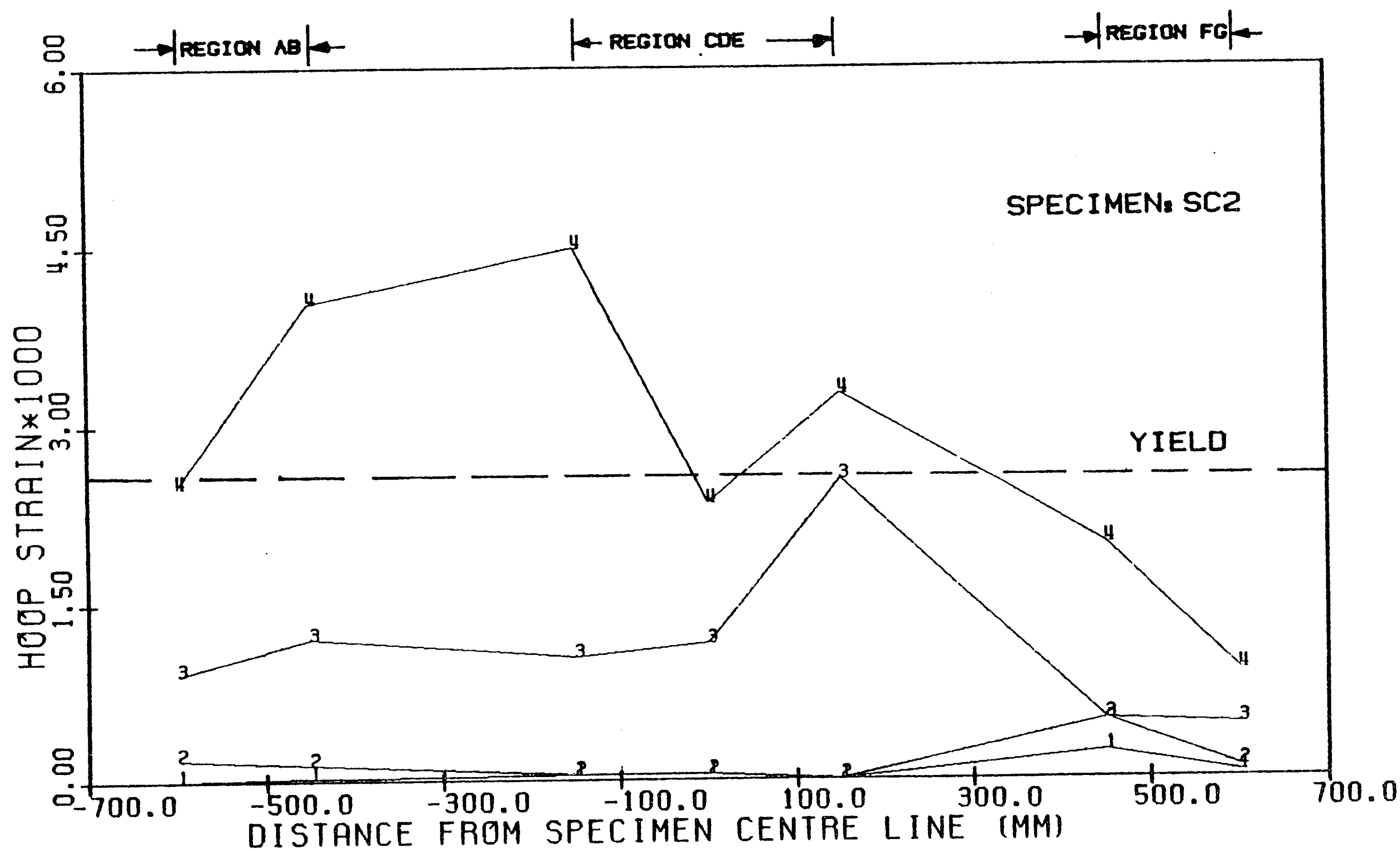


Fig. 4.9: Hoop strain variation along the length of test region for SC2.

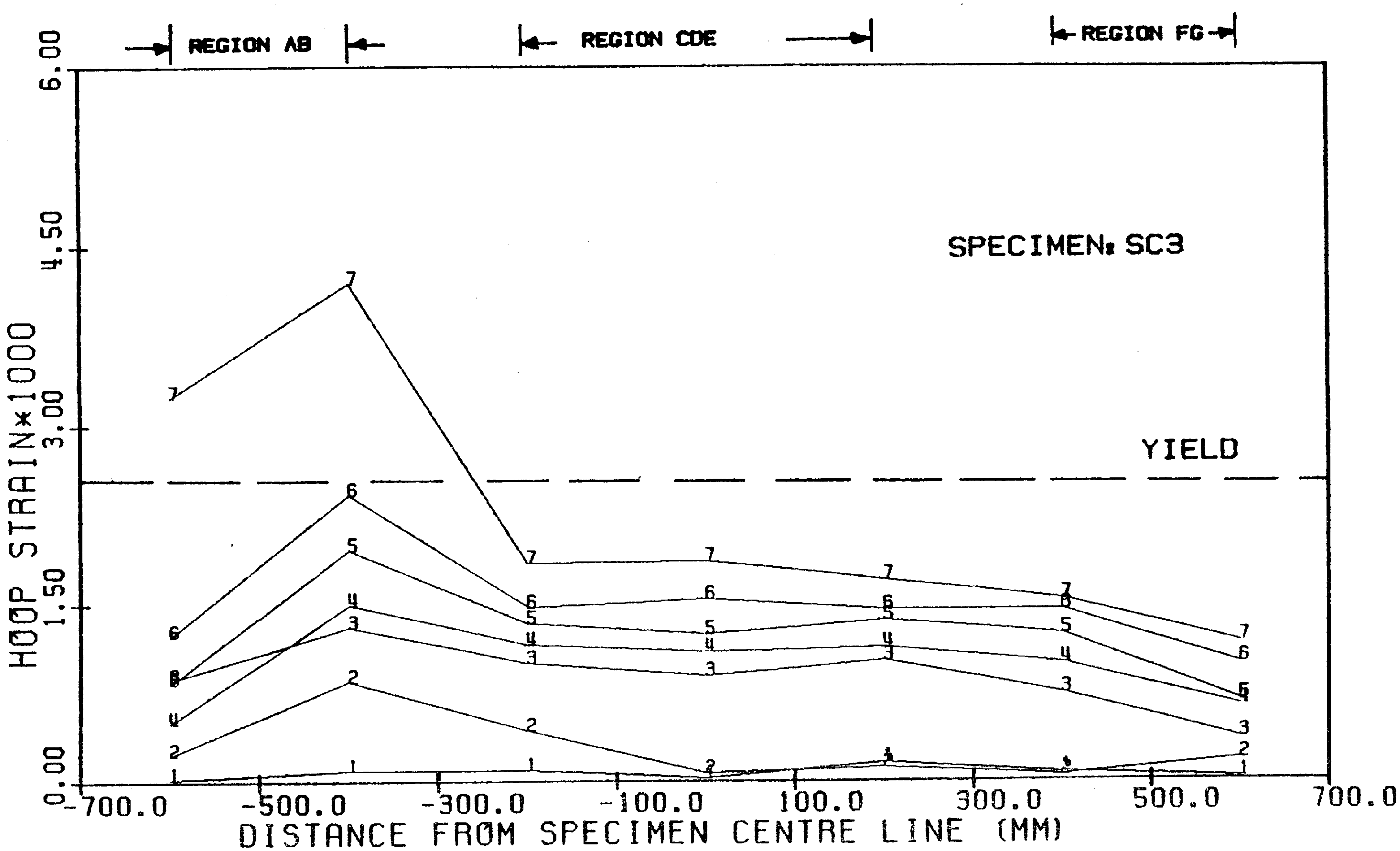


Fig. 4.10: Hoop strain variation along the length of test region for SC3.

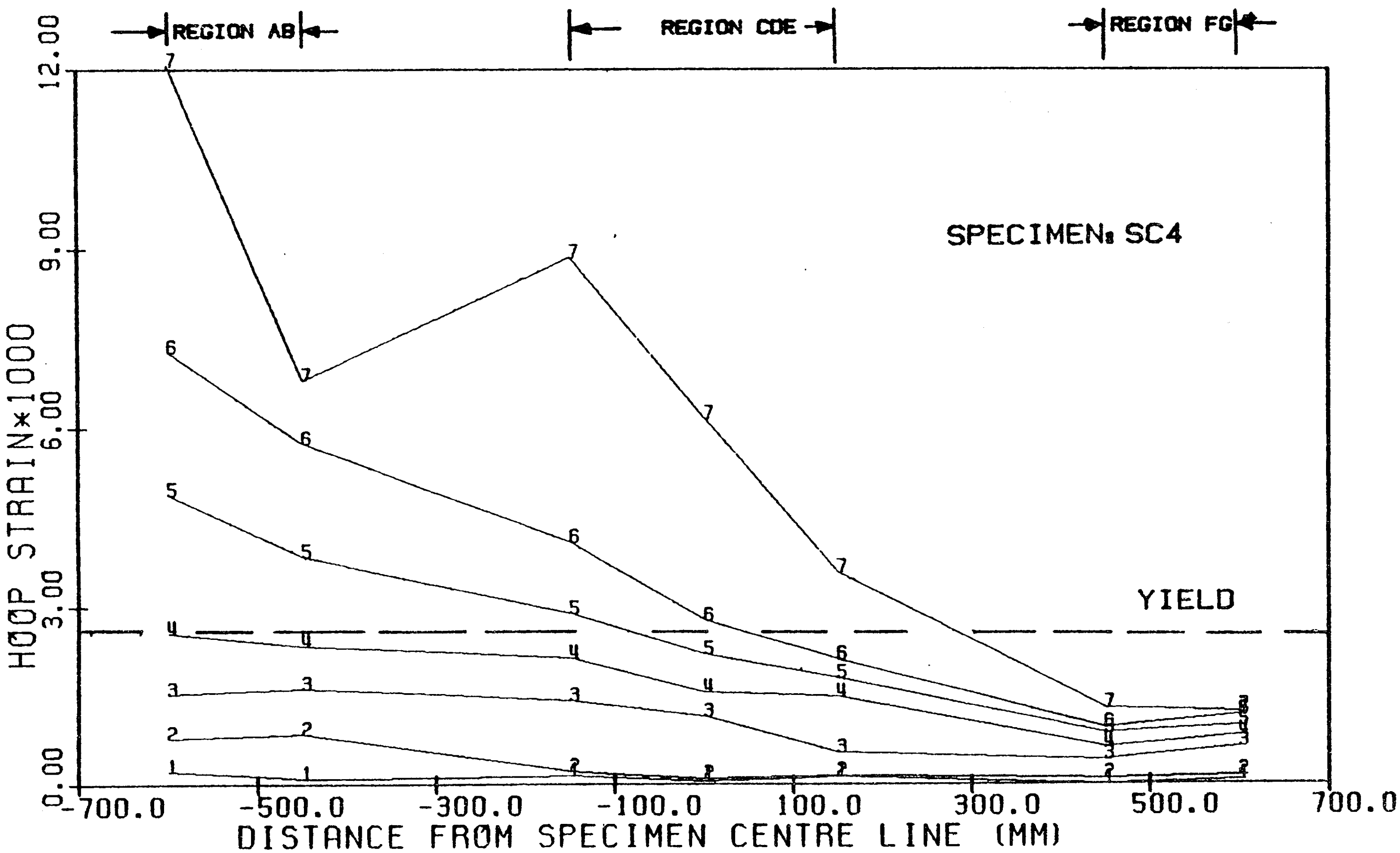


Fig. 4.11: Hoop strain variation along the length of test region for SC4.

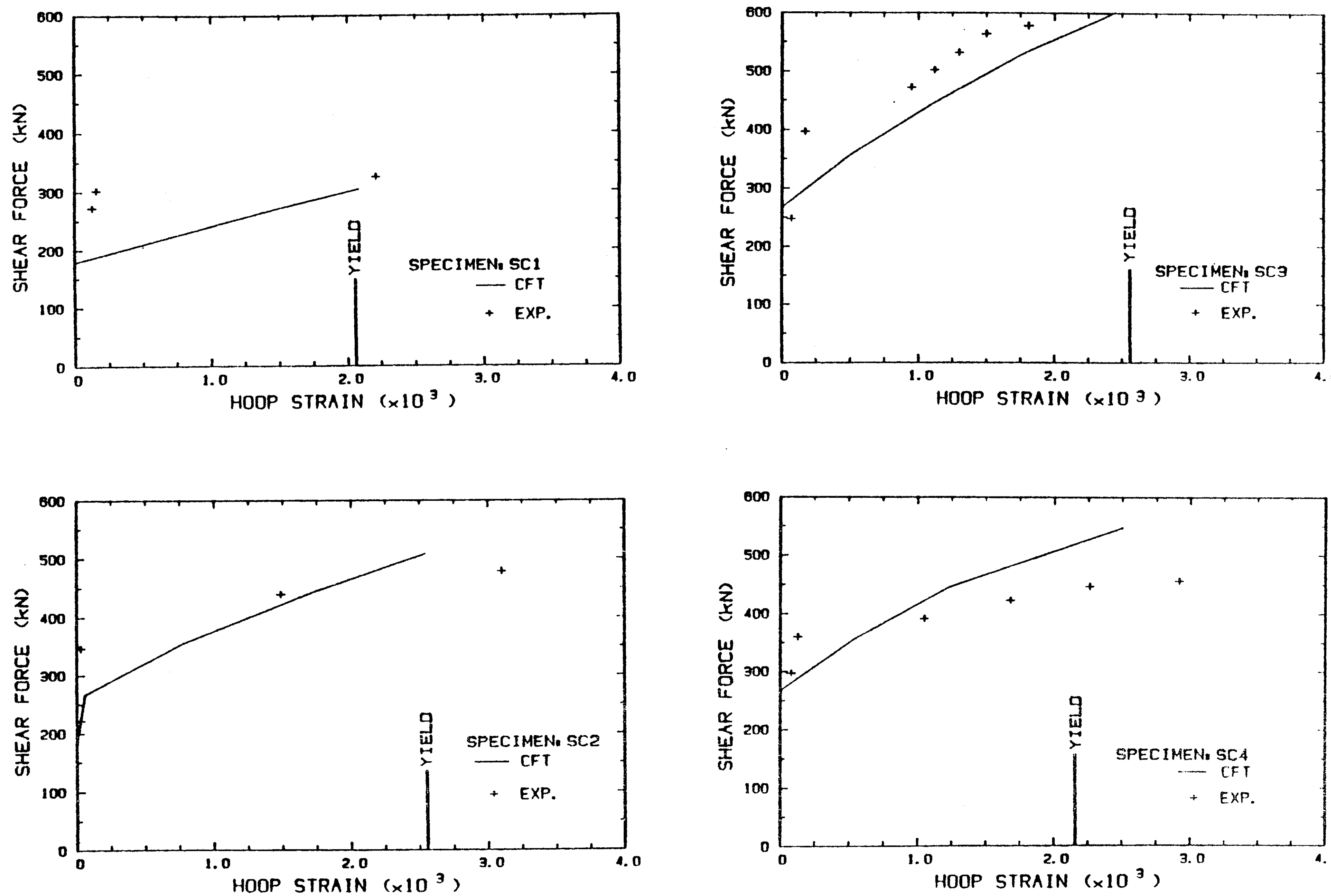


Fig. 4.12: Hoop strain -shear force curves for the specimens.

test section (i.e. hoop D). On the same plot hoop strains predicted by the CFT (Using Vecchio's model) are also given. It is observed that the CFT predicts the strains reasonably well, except for specimen SC4.

4.4 Shear Strains

The variation of shear strain with applied shear is shown in Fig. 4.13. The shear strains at mid-depth at the centre of the test section were plotted. Again it is observed that the CFT predicts the strains with reasonably accuracy.

4.5 Longitudinal Strains

Figures 4.14 through 4.17 show the longitudinal strain variation across the depth of the specimen for the different regions. The strain distribution was not linear near the end of the test section (subjected to high moment) but the strains reduced near the top and the bottom. As the strains were not measured directly on the longitudinal steel but across the hoops, this peculiar strain distribution could have been caused by relative slip between the hoops and the longitudinal steel. Figures 4.18 and 4.19 show the predicted (by CFT) and the actual measured longitudinal strains at failure. Strains in regions AB and FG were averaged for the plot showing the strain variation for regions subjected to high shear and moment. The correlation is not very good. However, as the longitudinal strains were generally quite low, there was a greater possibility of an error in the measurement. This could partly account for the discrepancy in the measured and predicted values.

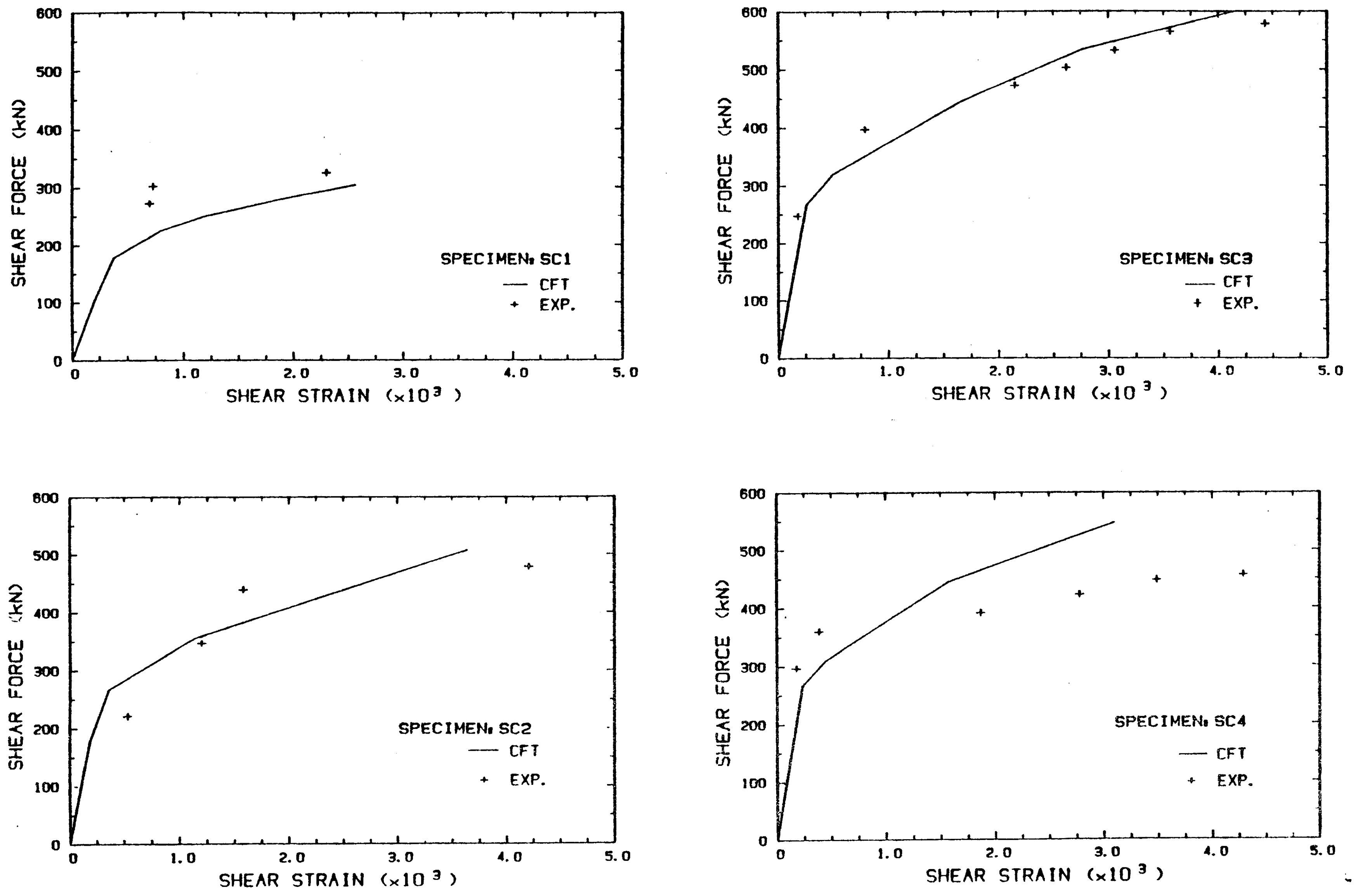


Fig. 4.13: Shear strain-shear stress curves for the specimens.

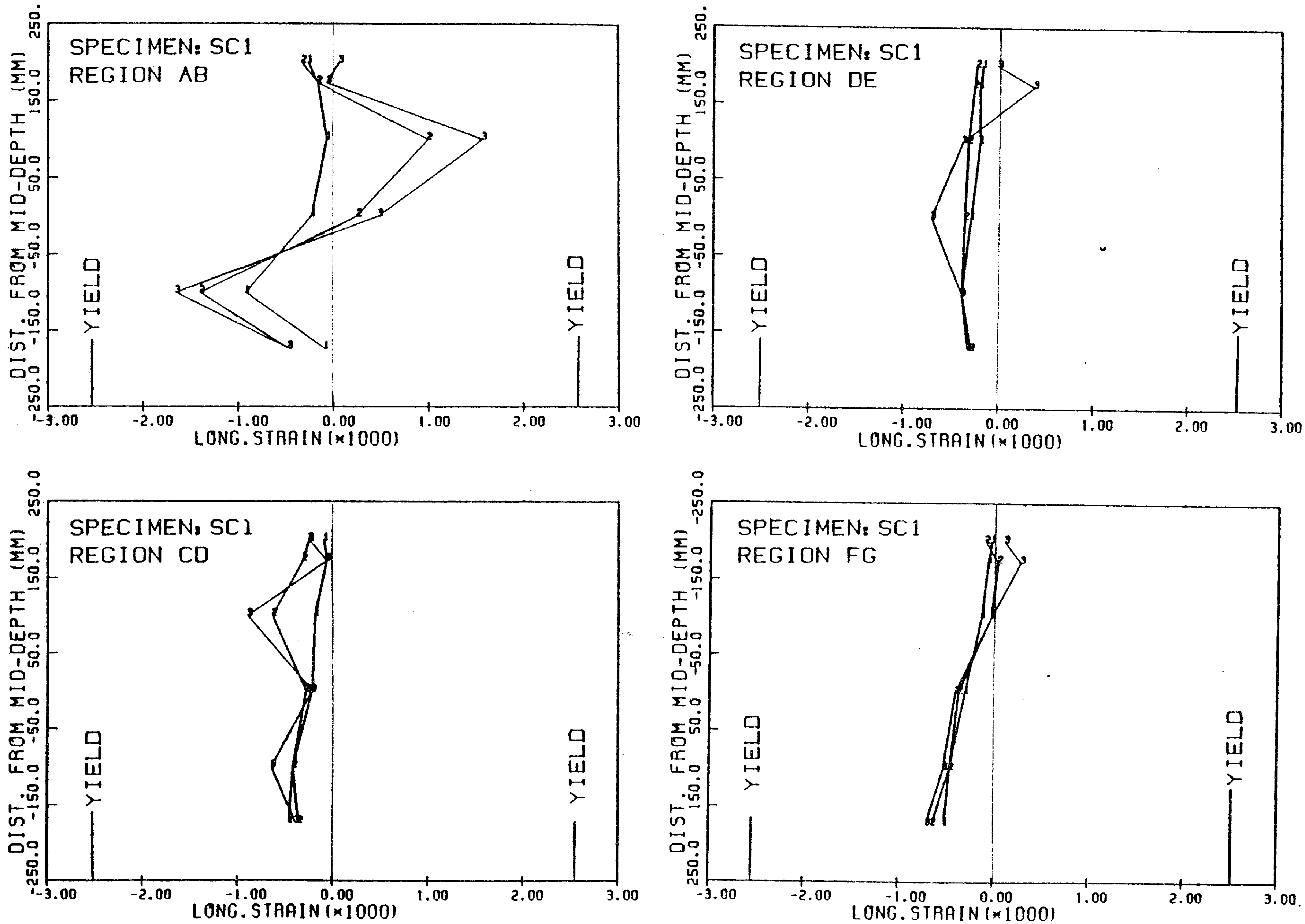


Fig. 4.14: Longitudinal strain distribution for SC1 at different load stages.

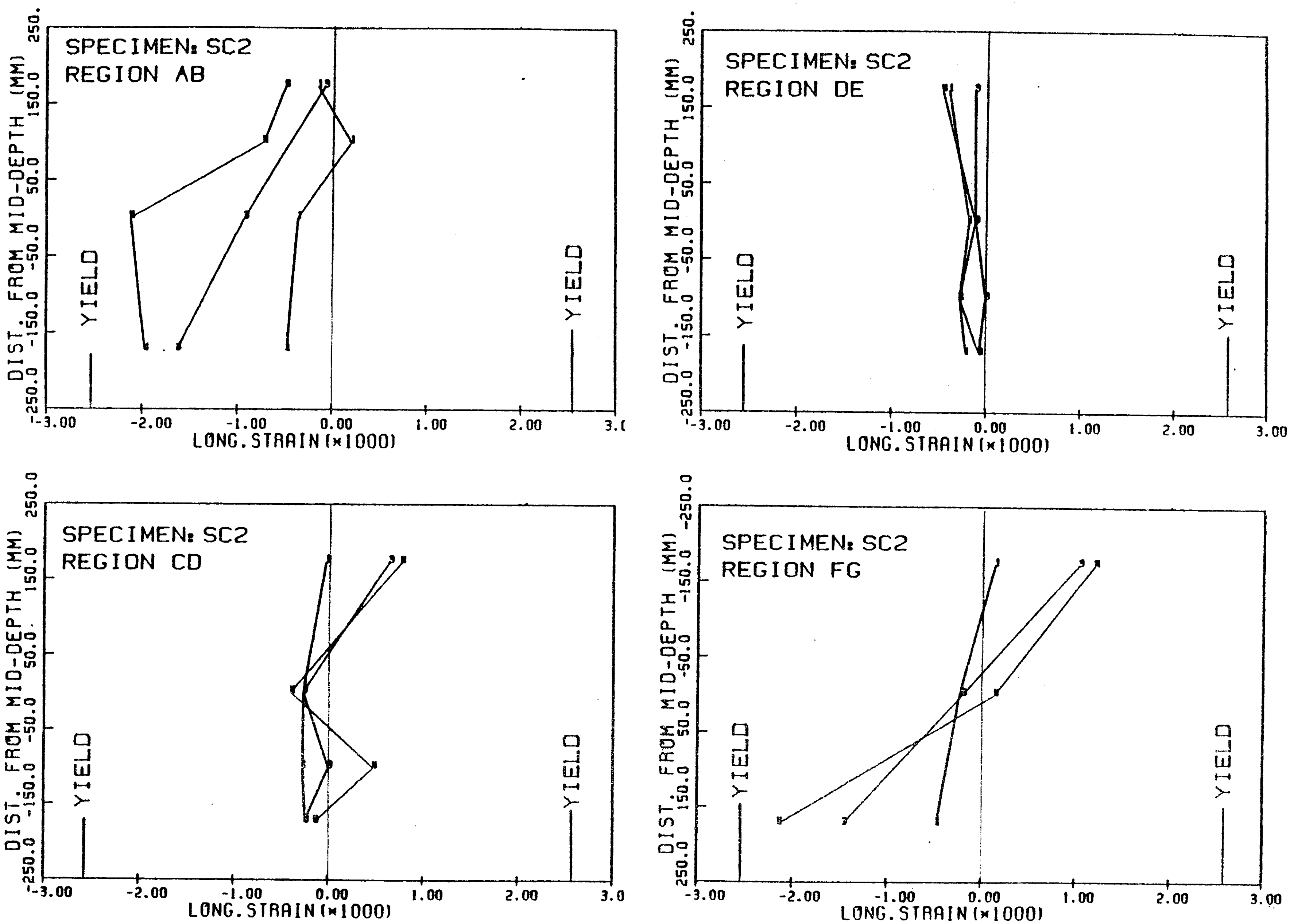


Fig. 4.15: Longitudinal strain distribution for SC2 at different load stages.

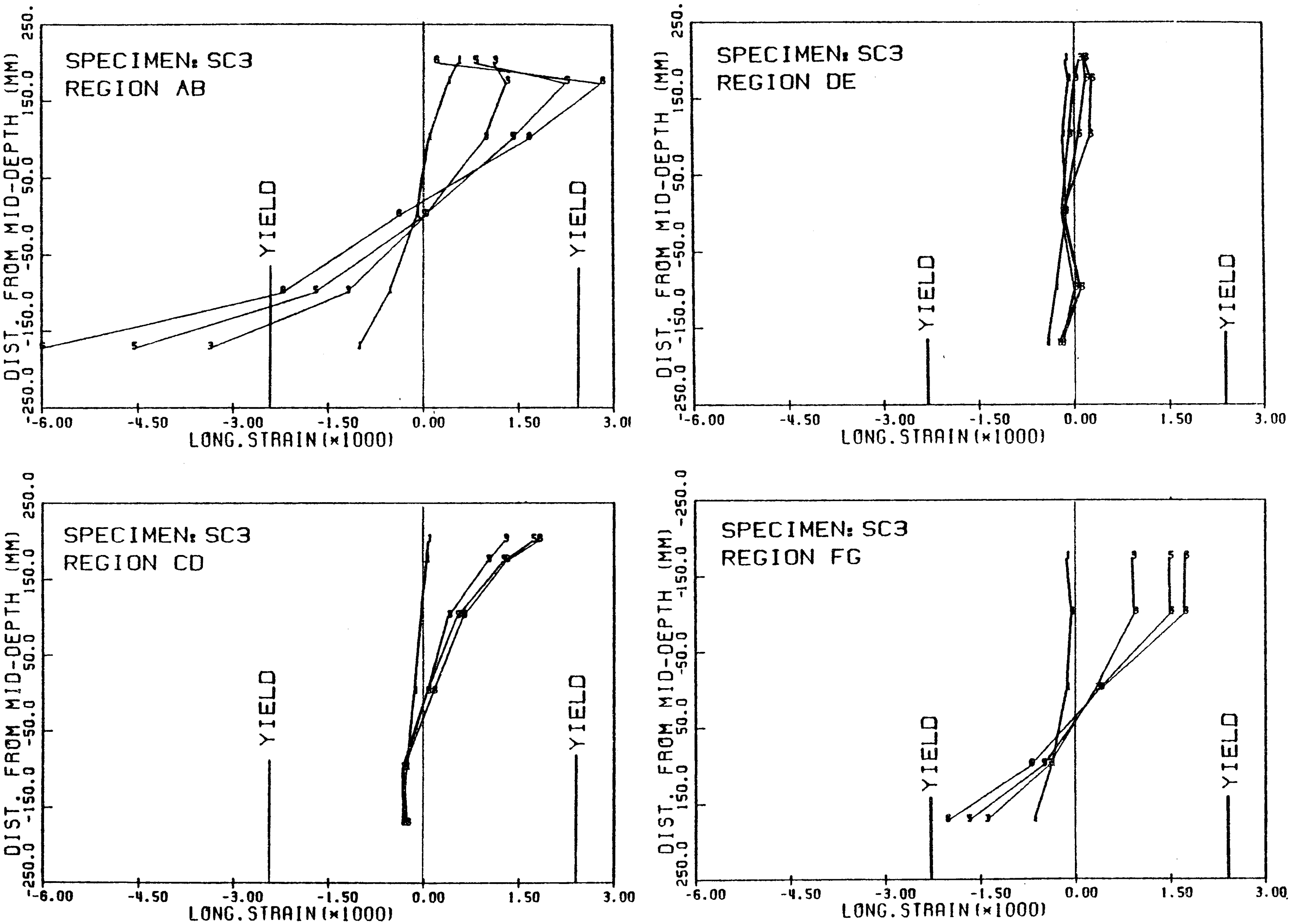


Fig. 4.16: Longitudinal strain distribution for SC3 at different load stages.

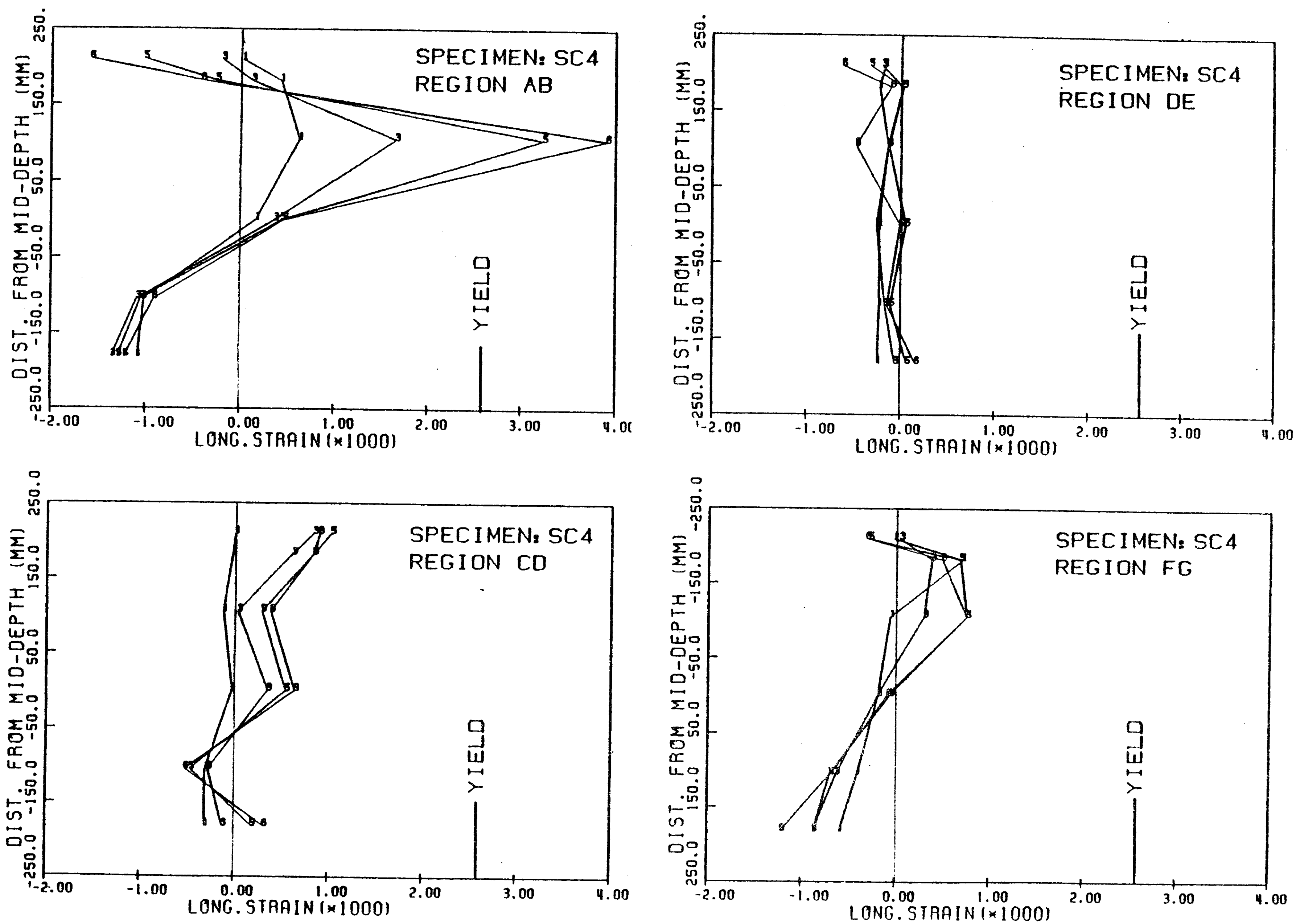


Fig. 4.17: Longitudinal strain distribution for SC4 at different load stages.

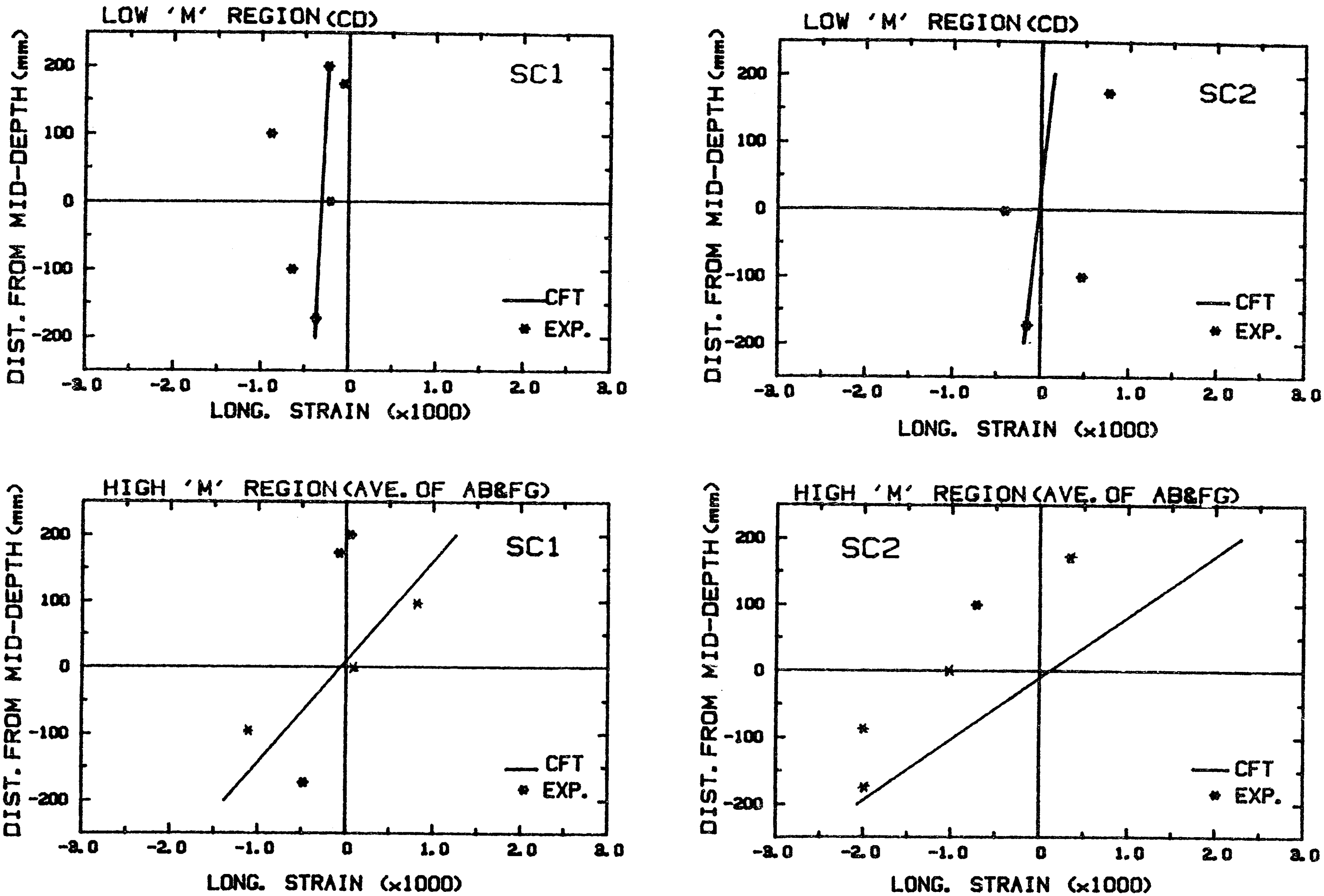


Fig. 4.18: Predicted and measured longitudinal strains (at failure) for SC1 and SC2.

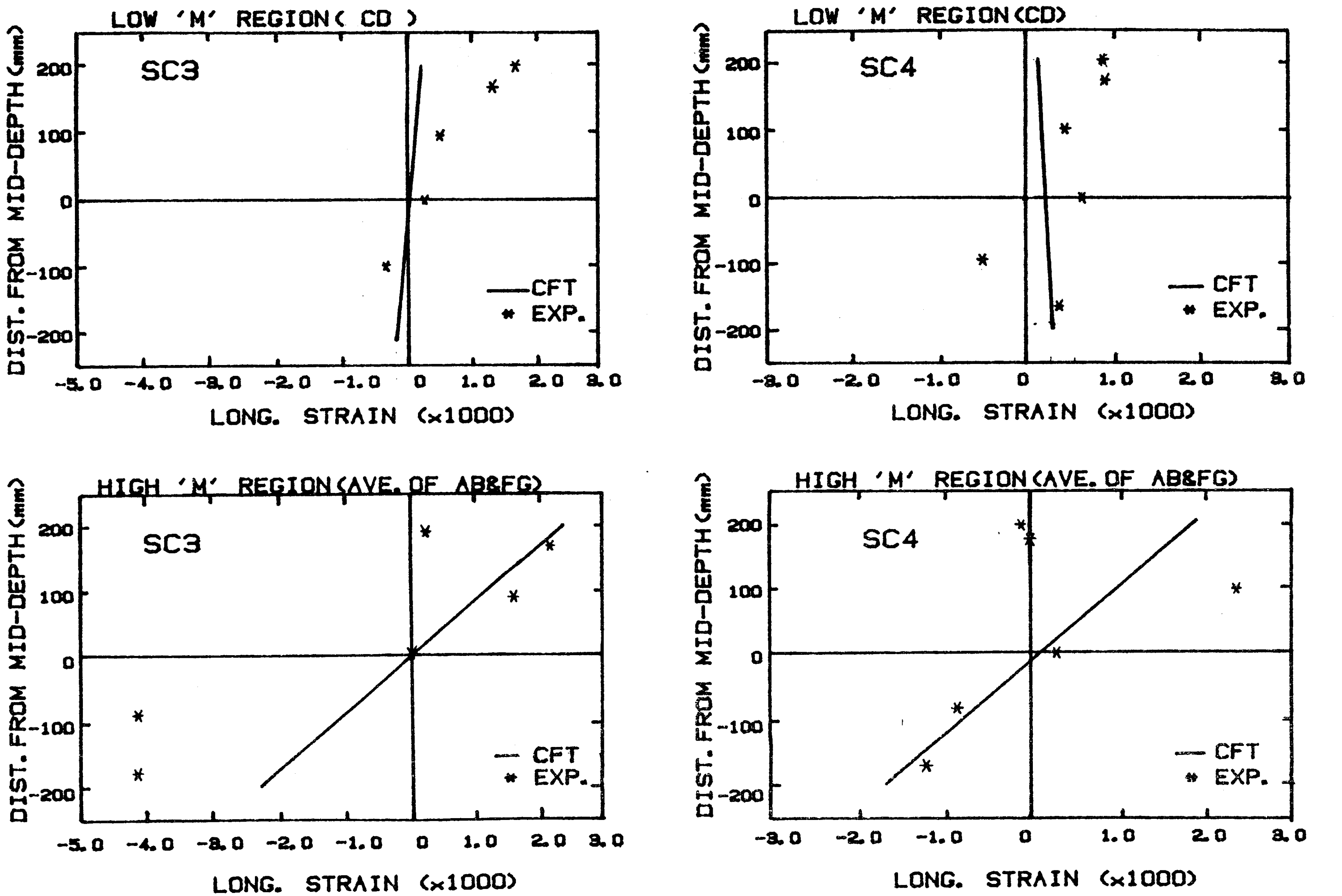


Fig. 4.19: Predicted and measured longitudinal strains at failure for SC3 and SC4.

4.6 Angle of Principal Strains

The variation of the angle of principal strains with applied shear is shown in Fig. 4.20. The angles have been plotted for the centre of the section (M=0) at mid-depth of the section. The CFT prediction for these angles is also plotted. Figure 4.21 shows the change in the angle of principal strains at failure with the change in the amount of transverse reinforcement. These angles have again been calculated at the centre of the specimen at mid-depth, at failure. The CFT prediction follows the observed trend.

4.7 Shear Stress Distribution

The shear stresses predicted by the CFT are presented in Figures 4.22 through 4.24. Plots for only SC3 are given as these were typical of the other specimens. Figure 4.22 shows the predicted shear stress distribution on the cross-section at different load stages. The high peak stress at mid-depth is partly due to the presence of the 76 mm ϕ central hole. Figure 4.23 gives the predicted shear stress distribution on the cross-section at failure under shear as well as moment (M=635V). The distribution for the section subjected to shear only is similar to the one subjected to shear and moment. Figure 4.24 shows the predicted shear stress distribution on a section subjected to shear only, at failure. This figure also gives the nominal shear stress predicted by the ACI for the same shear force. The ACI nominal shear stress is about 60% of the maximum shear stress predicted by the CFT.

4.8 Effect of Cover

Specimen SC4 was constructed with a minimal cover of about 8 mm. It was therefore expected that SC4 would take a higher load than

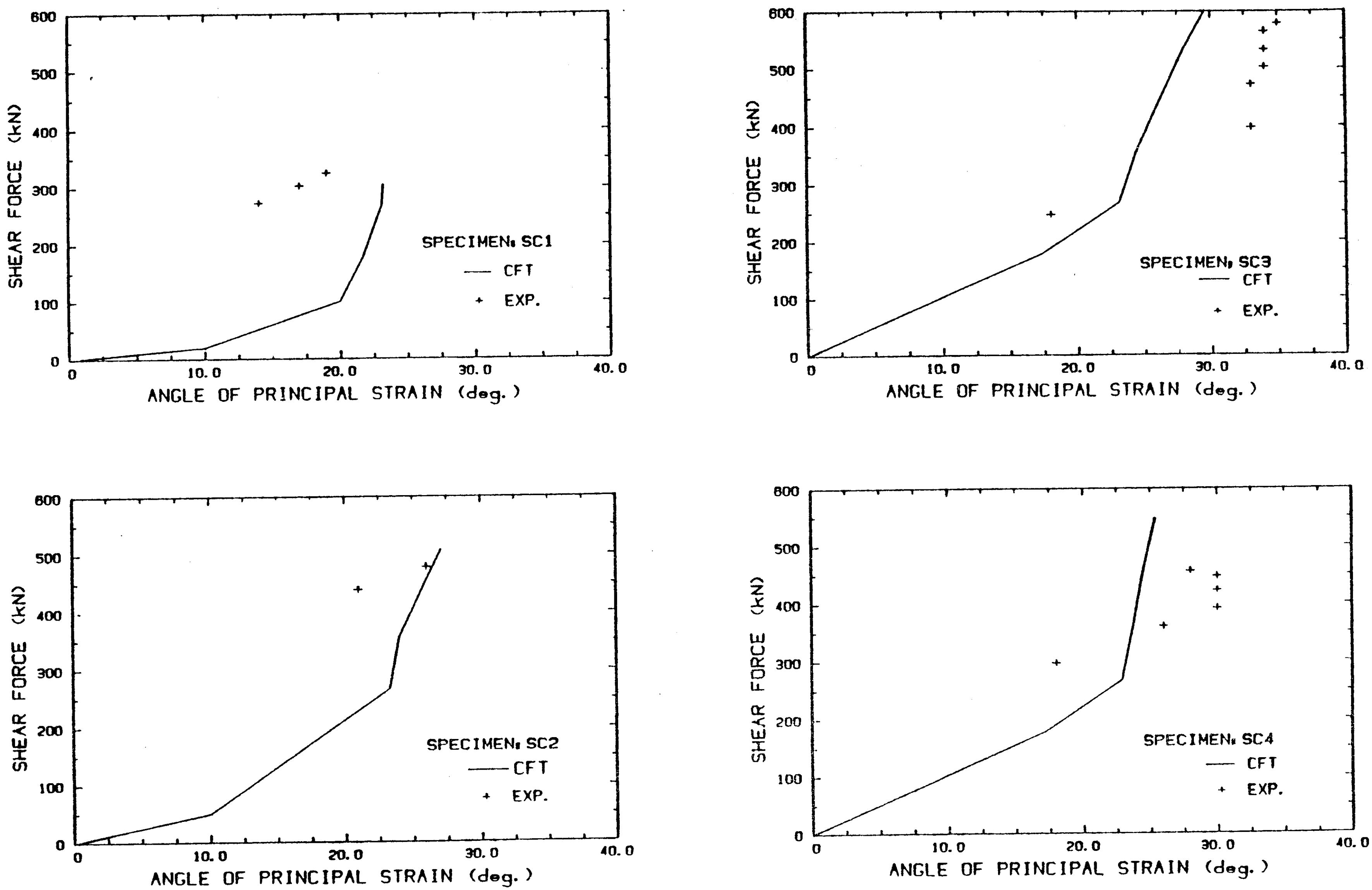


Fig. 4.20: Variation of angle of principal strains with applied shear.

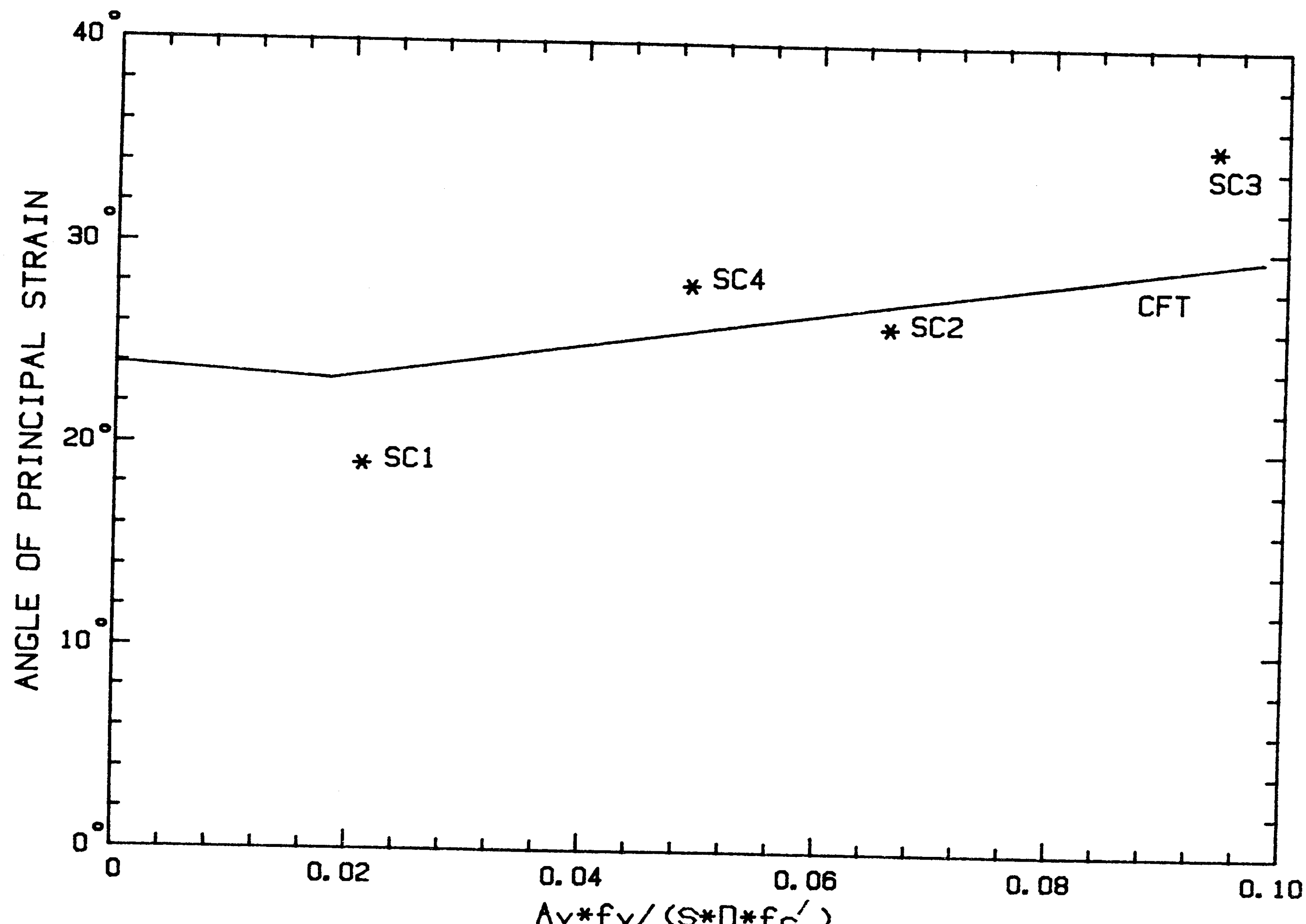


Fig. 4.21: Variation of angle of principal strains (at failure) with amount of transverse reinforcement.

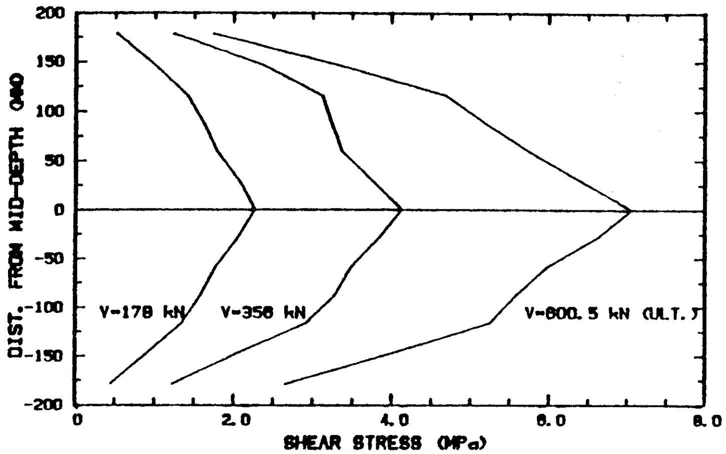


Fig. 4.22: Shear stress dist. for SC3 predicted by CFT at diff. loads.

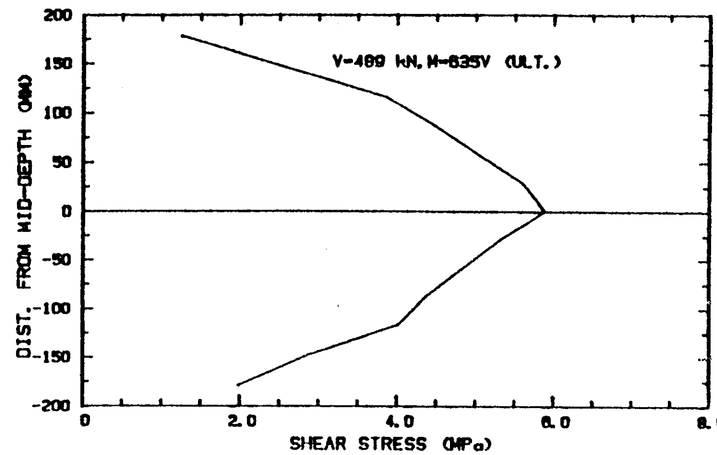


Fig. 4.23: Shear stress dist. for SC3 predicted by the CFT for the section under shear and moment at failure.

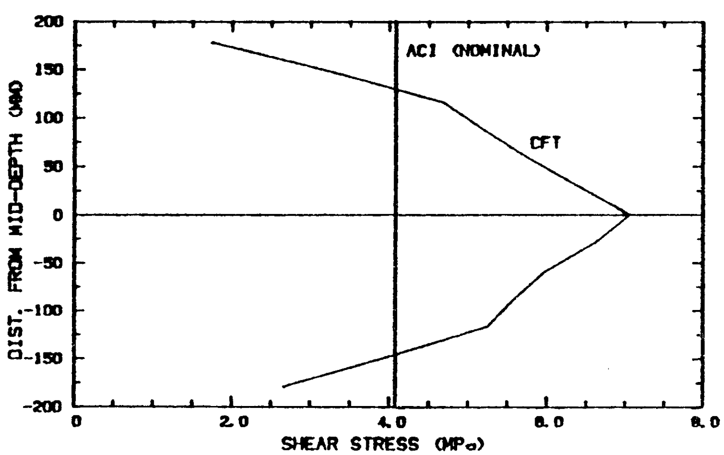


Fig. 4.24: ACI nominal shear stress and the shear stress variation predicted by CFT at failure (M=0).

its companian specimen SC2 which had a normal cover. The specimen, however, failed at a lower load. This was partly due to the lower yield strength of the hoops used in SC4 and in addition may have been due to the weaker end block reinforcement used in this specimen.

It was observed that at failure the cover for almost all specimens had separated from the core at the mid-depth of the specimen. Near the top and the bottom of the specimen the cover was, however, still intact. This would tend to indicate that for predicting the shear strength, spalled section properties should be used.

CHAPTER 5

CONCLUSIONS

The results obtained in this investigation indicated that the shear strength of circular reinforced concrete members was generally about 20% higher than predicted by the ACI code. The predictions based on the suggestions of the ACI-ASCE Committee 426 [2], and the recommendations for the Canadian Code [4], were better than the ACI. However, in low transverse reinforcement regions, these were again quite conservative. When load was reversed on a specimen after it has failed, it showed a very ductile behaviour and took about 83% of the original failure load.

The Compression Field Theory predicted the shear strength of the specimens fairly accurately, except for specimen SC4, for which it somewhat overestimated the strength in the M=635V region. It was observed that for high transverse reinforcement ratios the CFT prediction was quite close to the ACI prediction.

Detailed strain analyses showed that the strain variation around hoops was non-uniform. In regions subjected to shear only, the strains at the mid-depth of the specimen were quite high as compared to the top and bottom. At failure most of the hoops in the specimen had yielded at mid-depth whereas near the top and the bottom strains were below yield. In regions of high moment and shear the strains were more or less uniform around the hoops and at failure, in most cases, the hoops had yielded all around the circumference.

Longitudinal strain distribution across the depth of the section in high moment regions appeared to be non-linear. The observed strains at the top and the bottom were lower than the strains near the centre.

The Compression Field Theory predicted the hoop and shear strains reasonably well right up to failure. The angles of principal strains predicted by the CFT followed the general trend of the angles calculated from the measured strains. For a given shear load the ACI nominal shear stress was found to be about 60% of the maximum shear stress predi predicted by the CFT.

At failure the cover in all cases, had separated from the core of the section at mid-depth, so the spalled section properties should be used for strength predictions.

Summarizing, it could be concluded that the Compression Field Theory predicted the shear strengths as well as the local strains with reasonable accuracy for the five circular reinforced concrete members tested in this investigation.

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1. ACI Committee 318, "Building Code Requirements for Reinforced Concrete (ACI 318-77)," American Concrete Institute, Detroit, 1977.

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APPENDIX A

STRENGTH PREDICTION DETAILS

A.1 Average Material Properties Assumed in Calculation

CONCRETE: f'_c = 23.3 MPa

ε_o = 2.34 x 10^{-3}

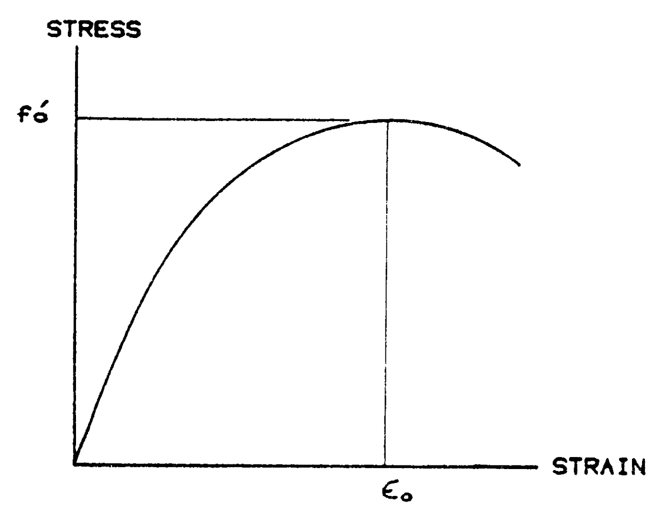

Fig. A.1:

Typical Stress Strain Curve for concrete

Longitudinal Steel: f_y = 516 MPa, E = 200,000 MPa

Hoop Steel:	SC1	f_y = 410 MPa, E = 200,000 MPa
	SC2, SC3	f_y = 510 MPa, E = 200,000 MPa
	SC4	f_y = 430 MPa, E = 200,000 MPa

A.2 ACI Prediction

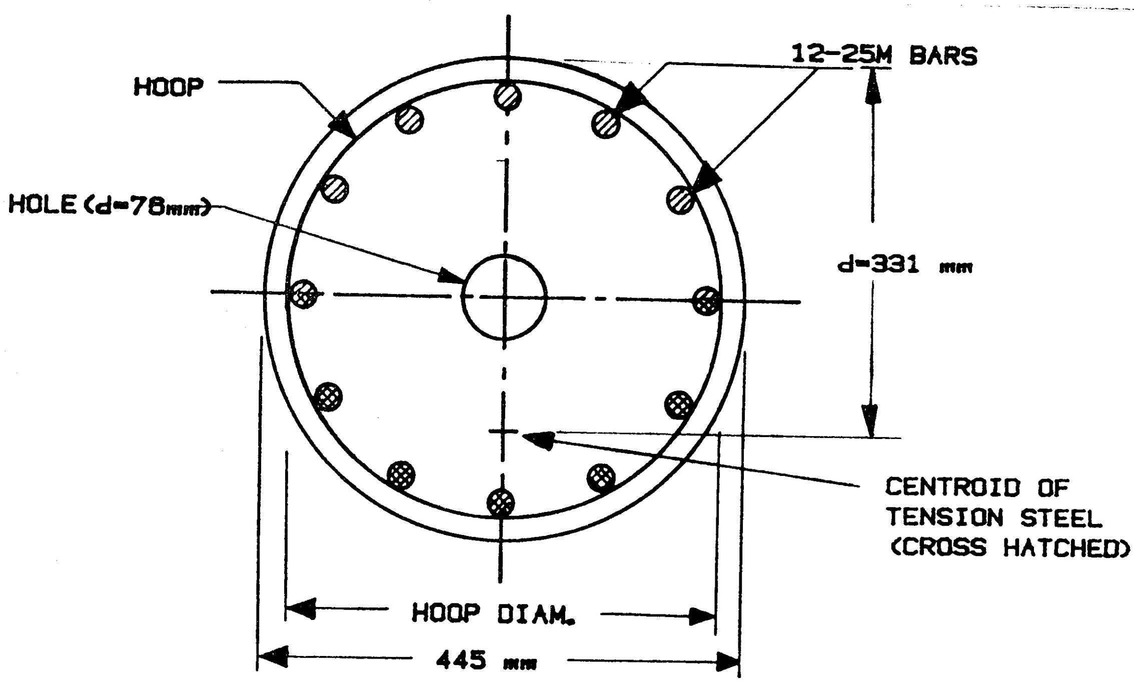

Fig. A.2: Section Properties

$$V_u = \phi \quad b_w d v_u$$

Take $\phi = 1$

$b_w = D = 445\text{mm}$

$d = 331\text{mm}$ (Fig. A.1)

$$v_u = \frac{A_v f_y}{b_w s} + v_c$$

For members under axial load,

$$v_c = 2(1 + 0.0005 \frac{N_u}{Ag}) \sqrt{f'_c} \quad \text{(psi units)}$$

$$N_u = 1050 \text{ kN} = 236 \text{ kips}$$

$$Ag = 155528 \text{ mm}^2 = 241.0 \text{ in}^2$$

$$f'_c = 23.3 \text{ MPa} = 3385 \text{ psi}$$

$$\therefore v_c = 2(1 + 0.0005 \frac{236 \times 10^3}{241}) \sqrt{3385}$$

$$= 173 \text{ psi} = 1.20 \text{ MPa}$$

$$\therefore V_u = b_w d (\frac{A_v f_y}{b_w s} + 1.20)$$

The plots are between $\frac{V_u}{A_g f'_c}$ and $\frac{A_v f_y}{sDf'_c}$, therefore equation (1) may be written as:

$$\frac{V_u}{A_g f'_c} = \frac{Dd}{Ag} (\frac{A_v f_y}{sDf'_c} + \frac{1.2 \text{ bw}}{f'_c D})$$

or

$$\frac{V}{A_g f'_c} = 0.947 (\frac{A_v f_y}{sDf'_c} + 0.0514)$$

The upper limit on (2) is found as follows:

$$v_u - v_c \leq 8 \sqrt{f'_c} \quad \text{(psi units)}$$

or

$$v_u - v_c \leq 8 \sqrt{3385} = 465 \text{ psi} = 3.2 \text{ MPa}$$

$\therefore \quad Vu_{max} = 445 \times 331\ (3.2 + 1.2) = 648100$ kN (from Eq. (1))

So the upper limit on $\frac{Vu}{A_g f'_c}$ in Eq. (2) is

$$\frac{648100}{155528 \times 23.3} = 0.179$$

A.3 Recommendation for the Canadian Code [4]

For members under axial load

$$V_c = 0.17 \sqrt{f'_c}\ (1 + \frac{3Nu}{A_g f'_c})\ b_w d \qquad \text{(MPa units)}$$

$$= 0.17 \sqrt{23.3}\ (1 + 3 \times \frac{1050000}{155328 \times 23.3})\ b_w d$$

$$= 1.53\ b_w d$$

$$V_u = \phi\ (V_s + V_c)\ ; \quad \text{take } \phi = 1$$

Thus $V_u = \frac{A_v f_y d}{s} + 1.53\ b_w d$

and $\frac{V_u}{A_g f'_c} = \frac{Dd}{Ag}\ (\frac{A_v f_y}{sDf'_c} + \frac{1.53\ bw}{f'_c D})$

or $\frac{V_u}{A_g f'_c} = 0.947\ (\frac{A_v f_y}{sDf'_c} + 0.0658)$

Now $V_{u_{max}} = \phi\ (0.84\ b_w d\ \sqrt{f'_c})$

$$= 0.84 \times 445 \times 331\ \sqrt{23.3} = 597600 \text{ N}$$

The upper limit on $\frac{V_u}{A_g f'_c}$ in Eq. (3) is

$$\frac{597600}{155528 \times 23.3} = 0.165$$

A.4 ACI - ASCE Suggestion [2]

For members under axial load,

$$v_b = (0.8 + 120\rho_w)\sqrt{f'_c} \leq 2.3\sqrt{f'_c} \quad \text{(psi units)}$$

$$\rho_w = \frac{A_s}{b_w d} = \frac{3000}{331 \times 445} = 0.00204$$

$$\therefore \quad v_b = (0.8 + 120 \times 0.00204)\sqrt{3385} = 189 \text{ psi}$$

but $$v_{bmax} = 2.3\sqrt{3385} = 134 \text{ psi}$$

$$\therefore \quad v_c = v_b \left(1 + \frac{3N_u}{A_g f'_c}\right)$$

$$= 134 \left(1 + \frac{3 \times 236000}{241 \times 3385}\right)$$

$$= 250 \text{ psi} = 1.72 \text{ MPa}$$

$$V_u = \phi\, b_w d\, v_u, \quad \text{take } \phi = 1$$

$$\therefore \quad V_u = b_w d \left(\frac{A_v f_y}{b_w s} + v_c\right)$$

or $$\frac{V_u}{A_g f'_c} = \frac{Dd}{Ag}\left(\frac{A_v f_y}{sDf'_c} + \frac{v_c bw}{f'_c D}\right)$$

or $$\frac{V_u}{A_g f'_c} = 0.947\left(\frac{A_v f_y}{sDf'_c} + 0.074\right)$$

$$V_{smax} = 8\ b_w d \sqrt{f'_c} = 8 \times 228 \sqrt{3385} = 106 \text{ kips} = 473 \text{ kN}$$

$$V_{umax} = 473000 + 1.72 \times 331 \times 445 = 727000 \text{ kN}$$

also $$V_{umax} = 0.2\ b_w d\ f'_c = 0.2 \times 331 \times 445 \times 23.3 = 686000 \text{ kN}$$

$\therefore$ Upper limit on $\frac{V_u}{A_g f'_c}$ in Eq. (4) is

$$\frac{686000}{155528 \times 23.3} = 0.189$$

A.5 Compression Field Theory Prediction

A computer program called SMAL, developed by Vecchio [9], was used for the CFT predictions. The procedure assumed that the beam section was made up of a number of strips and the equations of equilibrium, compatability and the stress strain characteristics were satisfied for each strip. The program gave local strains and stresses for each strip for a given loading (a combination of axial load, shear and moment). The axial load was assumed to be equal to 1050 kN for all calculations.

As the program was developed for rectangular members, the following provisions were made for using this program for circular sections.

1) The section was divided into strips and each strip was assumed to be rectangular (Fig. A.3(a)).

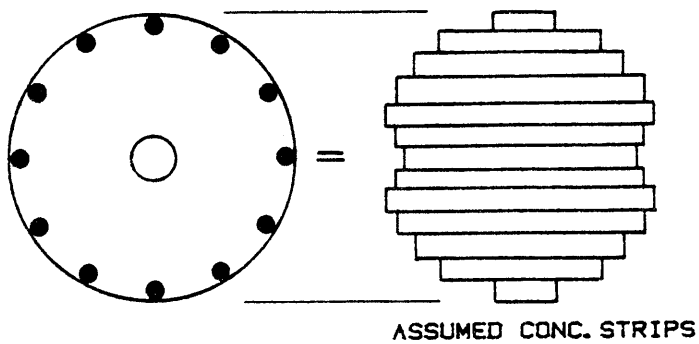

Fig. A.3(a): Section Divided into Strips

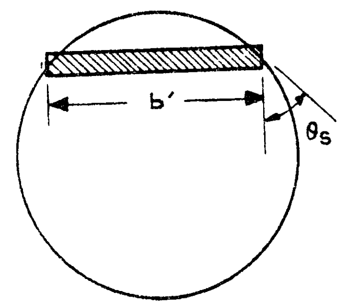

Fig. A.3(b): Angle of Transverse Reinforcement in a Typical Strip

2) Only the vertical component of the transverse steel in each strip was considered effective (Fig. A.3(b)). Thus the effective

$$\rho_t = \frac{Av\ Cos\theta s}{b'}$$

Spalled section properties were used for the calculations.

APPENDIX B

STRAIN DATA

B.1 Measured Strains

The following pages contain the measured strains on both East and West sides for the four specimens. All reported strains have been multiplied by 10^3. Tensile strains are positive.

Strains are identified by giving the names of the two targets between which the strain was measured. See Figs. 2.14 and 2.15 for location of targets. Note that the three types of strains are:

Longitudinal	Transverse	Diagonal
A1B1,A2B2,A3B3,A4B4, A5B5,A6B6,C1D1,C2D2, C3D3,C4D4,C5D5,C6D6, D1E1,D2E2,D3E3,D4E4, D5E5,D6E6,F1G1,F2G2, F3G3,F4G4,F5G5,F6G6.	A1A2,A2A3,A3A4,A4A5, A5A6,B1B2,B2B3,B3B4, B4B5,B5B6,C1C2,C2C3, C3C4,C4C5,C5C6,D1D2, D2D3,D3D4,D4D5,D5D6, E1E2,E2E3,E3E4,E4E5, E5E6,F1F2,F2F3,F3F4, F4F5,F5F6,G1G2,G2G3, G3G4,G4G5,G5G6.	A1B2,A2B1,A2B3,A3B2, A3B4,A4B3,A4B5,A5B4, A5B6,A6B5,C1D2,C3D1, C2D3,C3D2,C3D4,C4D3, C4D5,C5D4,C5D6,C6D5, D1E2,D2E1,D2E3,D3E2, D3E4,D4E3,D4E5,D5E4, D5E6,D6E5,F1G2,F2G1, F2G3,F3G2,F3G4,F4G3, F4G5,F5G4,F5G6,F6G5.

B.2 Principal Strains

The following pages contain the calculated principal strains. The strains are indicated in Figure B.1. Strains on the East and West sides were averaged for calculating the principal strains. The strains have been multiplied by 10^3. The grids identifying the strains are shown in Fig.4.3(a).

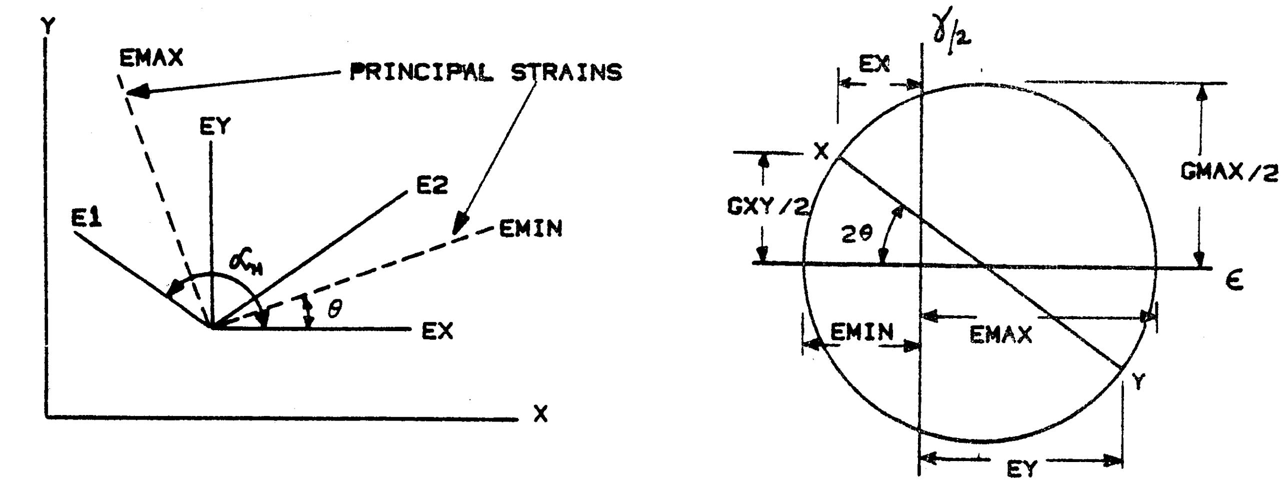

Fig. B.1: Strains in a typical grid and the Mohr's circle of strain

Shear strains (GXY) were calculated from E1 and E2 as follows:

$$GXY = (E2 - E1) / \sin 2\alpha_H$$

Principal strains were then calculated using standard Mohr's circle analysis.

TABLE B.1: STRAIN READINGS FOR SC1-EAST SIDE.

SPECIMEN:SC1 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4	5
A1B1	0.393	-0.262	-0.393	0.0	0.459	0.328
A2B2	-0.325	-0.130	-0.195	-0.065	0.195	0.195
A3B3	-0.258	-0.194	0.904	1.421	2.067	1.309
A4B4	-0.194	-0.323	0.323	0.323	0.129	0.194
A5B5	-0.256	-1.022	-1.469	-1.660	-1.788	-2.810
A6B6	-0.192	-0.256	-0.384	-0.192	-0.384	-0.331
C1D1	-0.252	0.0	-0.252	-0.252	-0.504	-0.504
C2D2	-0.254	-0.064	-0.254	0.127	0.064	-0.318
C3D3	-0.256	-0.192	-0.641	-0.898	-1.026	-1.346
C4D4	-0.189	-0.252	-0.378	-0.252	-0.126	-1.197
C5D5	-0.252	-0.440	-0.440	-0.566	-0.755	-0.692
C6D6	-0.252	-0.440	-0.314	-0.440	-0.063	0.566
D1E1	-0.256	-0.192	-0.192	0.064	0.0	-0.256
D2E2	-0.251	-0.188	-0.251	0.376	0.439	1.443
D3E3	******	******	******	******	******	******
D4E4	-0.321	-0.385	-0.385	-0.769	-0.833	0.513
D5E5	-0.257	-0.385	-0.385	-0.385	-0.257	-0.064
D6E6	-0.258	-0.387	-0.387	-0.451	0.129	0.193
F1G1	-0.273	-0.136	-0.205	0.205	0.068	0.136
F2G2	-0.271	-0.068	0.135	0.203	0.406	0.271
F3G3	-0.270	-0.135	0.0	-0.067	0.0	-0.067
F4G4	-0.337	-0.270	-0.337	-0.337	-0.472	-0.539
F5G5	-0.197	-0.527	-0.592	-0.658	-0.856	-0.987
F6G6	-0.321	-0.513	-0.642	-0.642	-0.642	-0.962
A1A2	0.0	2.359	5.262	8.528	12.067	11.250
A2A3	0.0	0.363	0.725	1.269	1.178	0.816
A3A4	0.0	0.634	1.358	1.539	1.539	1.358
A4A5	0.0	0.181	1.995	5.804	8.887	9.976
A5A6	0.0	0.0	0.999	2.453	6.541	7.267
B1B2	0.0	0.455	1.547	3.003	3.731	4.004
B2B3	0.0	0.0	0.544	0.544	0.816	1.179
B3B4	0.0	0.181	3.981	9.049	13.212	17.555
B4B5	0.0	0.0	0.723	2.893	13.743	17.631
B5B6	0.0	0.0	0.091	2.629	4.442	4.623
C1C2	0.0	0.181	0.181	5.056	3.972	11.826
C2C3	0.0	0.181	0.0	1.632	1.269	8.521
C3C4	0.0	0.090	0.0	6.064	17.560	19.913
C4C5	0.0	0.090	0.0	1.086	3.349	9.957
C5C6	0.0	0.0	0.0	0.090	0.815	4.435
D1D2	0.0	0.0	0.182	1.996	3.176	7.078
D2D3	0.0	0.0	0.091	3.449	10.982	13.069
D3D4	0.0	0.091	0.181	1.268	3.985	8.242
D4D5	0.0	0.0	0.090	0.633	1.357	7.692
D5D6	0.0	0.090	0.090	0.090	0.271	1.900
E1E2	0.0	0.182	0.091	2.452	3.360	5.902
E2E3	0.0	0.091	0.181	1.270	8.525	9.251
E3E4	0.0	0.181	0.181	0.181	0.995	7.238
E4E5	0.0	0.181	0.131	0.181	0.543	1.720
E5E6	0.0	0.181	0.453	0.363	0.363	0.634
F1F2	0.0	0.091	0.0	0.091	0.091	0.364

SPECIMEN:SC1 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4	5
F2F3	0.0	0.272	0.091	0.091	0.091	0.091
F3F4	0.0	0.452	0.362	0.181	0.271	0.271
F4F5	0.0	0.271	0.180	0.090	0.361	0.312
F5F6	0.0	0.181	0.090	0.090	0.724	1.177
G1G2	0.0	0.272	0.091	0.182	0.272	0.182
G2G3	0.0	1.451	0.635	1.542	1.451	0.907
G3G4	0.0	0.181	0.090	0.090	0.0	0.0
G4G5	0.0	0.181	0.362	0.181	0.090	0.0
G5G6	0.0	0.271	0.090	0.090	0.271	0.090
A1B2	-0.157	0.157	0.944	2.464	3.041	3.041
A2B1	-0.105	0.263	1.000	1.947	2.579	2.737
A2B3	-0.155	0.310	0.722	0.722	0.774	1.032
A3B2	-0.159	-0.053	0.106	0.846	1.375	1.058
A3B4	-0.205	0.103	3.129	5.335	7.080	8.259
A4B3	-0.212	-0.370	-0.741	-0.952	-1.164	-1.323
A4B5	-0.151	-0.202	1.464	3.836	8.630	9.842
A5B4	-0.214	-0.641	-1.443	-2.459	-3.474	-3.581
A5B6	-0.151	-0.201	-0.050	0.302	1.913	2.618
A6B5	-0.160	-0.533	-0.533	-0.800	-1.226	-1.346
C1D2	0.052	-0.104	0.418	1.829	2.613	3.240
C2D1	-0.152	-0.101	-0.051	0.304	0.811	2.586
C2D3	-0.157	-0.052	-0.105	2.829	5.815	6.338
C3D2	-0.153	-0.256	-0.409	-0.613	1.022	2.299
C3D4	-0.259	-0.207	-0.207	2.900	8.855	10.408
C4D3	-0.205	-0.256	-0.410	-0.256	-1.077	-2.718
C4D5	-0.154	-0.154	0.206	0.412	1.647	1.441
C5D4	-0.204	-0.357	-0.407	-0.407	-0.713	-1.732
C5D6	-0.155	0.0	-0.052	0.0	0.052	2.898
C6D5	-0.152	-0.354	-0.360	-0.304	-1.012	-0.253
D1E2	-0.203	-0.102	-0.102	1.676	2.336	2.438
D2E1	-0.313	-0.209	-0.156	-0.209	-0.156	1.252
D2E3	-0.152	-0.101	-0.202	1.668	5.509	6.975
D3E2	-0.155	-0.309	-0.412	-0.257	1.081	-1.905
D3E4	-0.355	-0.152	-0.203	0.355	1.418	1.773
D4E3	-0.156	-0.156	-0.208	-0.469	-0.989	-1.561
D4E5	-0.152	-0.203	0.051	0.051	0.610	4.422
D5E4	-0.159	-0.053	-0.423	-0.370	-0.529	-1.270
D5E6	-0.153	-0.153	-0.051	0.051	0.358	0.614
D6E5	-0.158	-0.158	-0.158	-0.158	0.0	0.106
F1G2	-0.164	0.0	0.273	0.164	0.273	0.655
F2G1	-0.160	-0.160	0.0	0.0	-0.160	-0.053
F2G3	-0.162	0.162	-0.162	0.215	0.108	0.108
F3G2	-0.160	0.0	-0.053	0.0	0.0	******
F3G4	-0.159	-0.159	-0.264	-0.159	0.317	0.053
F4G3	-0.434	-0.379	-0.379	-0.434	-0.542	-0.542
F4G5	-0.157	-0.314	-0.524	-0.472	-0.576	-0.524
F5G4	-0.161	-0.161	-0.161	-0.269	-0.161	-0.108
F5G6	-0.103	-0.414	-0.517	-0.517	-0.828	-0.983
F6G5	-0.106	-0.211	-0.264	-0.211	0.159	0.159

TABLE B.2: STRAIN READINGS FOR SC1-WEST SIDE.

SPECIMEN:SC1 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5
A1B1	-0.262	-0.262	-0.262	0.131	0.459	0.394
A2B2	-0.259	-0.194	-0.129	-0.065	0.129	0.065
A3B3	-0.064	0.064	1.091	1.733	2.183	2.054
A4B4	-0.255	-0.127	0.191	0.637	0.956	0.956
A5B5	-0.191	-0.828	-1.337	-1.656	-2.356	-2.993
A6B6	-0.254	0.064	-0.572	-0.763	-0.890	-0.954
C1D1	-0.126	-0.189	-0.252	-0.252	-0.378	-0.441
C2D2	-0.253	-0.063	-0.379	-0.253	-0.379	-0.253
C3D3	******	******	******	******	******	******
C4D4	-0.255	-0.191	-0.191	-0.191	-0.064	0.638
C5D5	-0.330	-0.396	-0.396	-0.727	-0.859	-2.378
C6D6	-0.271	-0.475	-0.407	-0.339	-0.203	0.407
D1E1	-0.256	-0.128	-0.256	-0.064	0.0	-0.256
D2E2	******	******	******	******	******	******
D3E3	-0.189	-0.189	-0.314	-0.377	-0.440	-1.697
D4E4	-0.253	-0.190	-0.316	-0.632	-0.569	-0.316
D5E5	******	******	******	******	******	******
D6E6	-0.251	-0.251	-0.188	-0.125	0.125	0.439
F1G1	-0.273	0.068	0.0	0.0	0.205	0.341
F2G2	-0.204	-0.068	-0.068	0.339	0.271	0.204
F3G3	-0.205	-0.136	-0.068	0.0	0.136	-0.068
F4G4	-0.272	-0.340	-0.408	-0.476	-0.544	******
F5G5	-0.325	-0.390	-0.325	-0.390	-0.520	-0.715
F6G6	-0.128	-0.512	-0.640	-0.768	-0.896	-1.152
A1A2	0.0	0.909	1.272	1.726	1.635	1.181
A2A3	0.0	1.271	3.087	5.034	5.810	5.266
A3A4	0.0	0.726	1.633	2.631	2.994	2.994
A4A5	0.0	0.181	1.992	5.614	8.150	8.512
A5A6	0.0	0.272	1.269	1.722	5.346	6.342
B1B2	0.0	0.182	0.728	1.457	1.730	1.730
B2B3	0.0	0.181	1.541	2.538	3.354	4.170
B3B4	0.0	0.181	3.070	8.308	13.635	17.428
B4B5	0.0	0.090	0.993	4.243	10.110	11.103
B5B6	0.0	0.361	0.632	1.083	4.785	6.681
C1C2	0.0	0.0	0.545	1.634	2.632	4.448
C2C3	0.0	0.363	0.727	2.816	6.269	10.448
C3C4	0.0	0.181	0.272	4.530	13.681	24.916
C4C5	0.0	0.271	0.271	1.264	6.499	11.735
C5C6	0.0	0.271	0.271	0.723	1.085	6.690
D1D2	0.0	0.091	0.091	1.270	1.724	4.355
D2D3	0.0	0.091	0.181	2.990	8.064	11.417
D3D4	0.0	0.181	0.090	2.354	7.334	18.200
D4D5	0.0	0.181	0.181	0.543	2.534	6.244
D5D6	0.0	0.181	0.181	0.362	0.634	2.718
E1E2	0.0	0.182	0.091	1.361	2.087	6.171
E2E3	0.0	0.091	0.091	1.910	5.095	6.550
E3E4	0.0	0.090	0.362	0.904	4.702	8.409
E4E5	0.0	0.090	0.181	0.181	0.905	3.392
E5E6	0.0	0.181	0.091	0.091	0.363	0.272
F1F2	0.0	0.0	0.0	0.182	0.0	0.0

SPECIMEN:SC1 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5
F2F3	0.0	0.0	0.181	0.090	0.0	0.0
F3F4	0.0	0.090	0.0	0.0	0.0	0.0
F4F5	0.0	0.0	0.090	0.090	0.090	0.090
F5F6	0.0	0.181	0.272	0.272	0.907	1.361
G1G2	0.0	0.0	0.091	0.182	0.0	0.0
G2G3	0.0	0.181	0.181	0.131	0.181	0.181
G3G4	0.0	0.090	0.090	0.181	0.090	0.0
G4G5	0.0	0.181	0.090	0.090	0.090	0.090
G5G6	0.0	0.090	0.271	0.0	0.0	0.090
A1B2	-0.155	0.052	0.569	0.827	0.879	0.931
A2B1	0.0	-0.160	-0.106	0.213	0.479	0.373
A2B3	-0.153	0.102	0.256	0.664	0.971	1.380
A3B2	-0.158	-0.687	-0.687	-0.739	-0.739	-1.056
A3B4	0.0	0.356	3.106	5.906	8.706	10.131
A4B3	-0.158	-0.526	-0.737	-1.105	-1.421	-1.737
A4B5	-0.154	-0.154	1.394	3.946	7.584	8.455
A5B4	-0.156	-0.675	-0.987	-1.351	-2.442	-3.533
A5B6	-0.156	-0.313	0.0	0.104	1.823	2.448
A6B5	-0.153	-0.153	-0.102	-0.051	0.307	0.255
C1D2	-0.154	0.102	0.051	0.767	1.432	4.349
C2D1	-0.206	0.0	-0.103	-0.309	-0.721	-2.009
C2D3	-0.153	-0.255	0.357	1.630	4.736	8.149
C3D2	-0.156	0.313	0.521	0.625	1.042	1.407
C3D4	-0.154	0.205	0.821	0.821	7.034	13.862
C4D3	-0.156	-0.208	-0.364	-0.468	-0.988	-2.547
C4D5	-0.156	1.824	-2.866	2.866	3.336	9.955
C5D4	-0.157	-0.523	-0.523	-0.733	-1.361	-5.391
C5D6	-0.211	-0.317	-0.317	-0.264	-0.106	2.270
C6D5	-0.161	-0.484	-0.430	-0.215	-0.161	-0.592
D1E2	-0.156	-0.104	0.311	1.099	1.038	9.130
D2E1	-0.254	-0.203	-0.152	-0.051	-0.102	-0.813
D2E3	-0.156	-0.104	-0.052	1.400	3.579	4.512
D3E2	-0.151	-0.251	-0.251	0.201	0.452	0.452
D3E4	-0.157	-0.105	0.0	1.203	4.288	8.262
D4E3	-0.151	-0.251	-0.302	-0.553	-0.855	-1.056
D4E5	-0.157	-0.052	-0.052	0.052	1.206	1.626
D5E4	-0.150	-0.050	-0.249	-0.349	-0.897	-1.445
D5E6	20.793	-0.157	-0.210	-0.157	0.890	0.995
D6E5	******	******	******	******	******	******
F1G2	-0.156	0.0	-0.052	-0.052	-0.052	0.0
F2G1	******	******	******	******	******	******
F2G3	-0.204	-0.051	0.0	-0.051	0.153	0.102
F3G2	******	******	******	******	******	******
F3G4	-0.103	-0.256	-0.154	-0.051	-0.103	-0.103
F4G3	******	******	******	******	******	******
F4G5	-0.154	-0.308	-0.308	-0.360	-0.463	-0.617
F5G4	-0.219	-0.164	-0.164	-0.164	-0.110	-0.274
F5G6	-0.208	-0.417	-0.417	-0.521	-0.625	-0.677
F6G5	-0.156	-0.156	-0.260	-0.260	-0.208	-0.156

TABLE B.3 : STRAIN READINGS FOR SC2-EAST SIDE.

SPECIMEN:SC2 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4
A1B1	-0.261	******	******	******	******
A2B2	-0.408	-0.340	-0.476	-0.544	-1.359
A3B3	-0.211	******	******	******	******
A4B4	-0.282	-0.352	-0.211	-0.916	-2.114
A5B5	-0.275	******	******	******	******
A6B6	-0.263	-0.394	-1.248	-2.036	-2.299
C1D1	-0.274	******	******	******	******
C2D2	-0.136	0.0	-0.068	0.610	0.407
C3D3	-0.066	******	******	******	******
C4D4	-0.268	-0.268	-0.335	-0.268	-0.402
C5D5	******	******	******	******	******
C6D6	-0.348	-0.348	-0.417	-0.278	-0.139
D1E1	-0.138	******	******	******	******
D2E2	-0.351	-0.351	-0.211	-0.491	-0.702
D3E3	-0.138	******	******	******	******
D4E4	-0.200	-0.200	-0.200	-0.133	-0.666
D5E5	-0.399	******	******	******	******
D6E6	-0.277	-0.208	-0.208	-0.069	-0.069
F1G1	-0.271	******	******	******	******
F2G2	-0.205	0.137	0.205	0.957	1.300
F3G3	-0.140	******	******	******	******
F4G4	-0.270	-0.270	-0.203	-0.067	0.473
F5G5	-0.274	******	******	******	******
F6G6	-0.072	-0.507	-1.015	-1.377	-2.029
A1A2	0.0	0.362	1.356	3.165	6.330
A2A3	******	******	******	******	******
A3A4	0.0	******	0.090	0.903	3.251
A4A5	0.0	0.0	0.271	0.904	1.717
A5A6	0.089	0.266	1.327	2.389	4.070
B1B2	0.0	0.090	0.633	0.995	1.448
B2B3	0.0	0.0	0.724	1.448	2.172
B3B4	0.0	0.090	0.271	1.629	4.976
B4B5	0.0	0.0	******	******	4.795
B5B6	0.090	0.090	0.271	0.904	1.446
C1C2	0.0	0.0	0.0	1.759	2.870
C2C3	0.0	******	******	0.271	0.632
C3C4	0.0	0.090	0.090	1.266	2.351
C4C5	-0.373	******	******	******	7.097
C5C6	0.0	0.0	0.0	0.0	0.347
D1D2	0.0	0.090	0.181	1.538	2.623
D2D3	0.0	******	******	1.085	1.628
D3D4	0.0	0.090	0.090	1.443	2.352
D4D5	******	******	******	******	******
D5D6	0.0	0.0	0.998	1.633	******
E1E2	0.090	0.090	0.090	1.267	2.352
E2E3	0.0	******	******	0.995	1.809
E3E4	0.090	0.0	0.0	1.447	4.341
E4E5	-0.090	******	******	******	1.448
E5E6	0.0	-0.090	0.090	0.452	1.266
F1F2	0.0	0.0	0.0	1.085	0.904

SPECIMEN:SC2 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4
F2F3	0.0	******	******	0.732	******
F3F4	0.090	0.269	0.627	0.985	1.074
F4F5	0.0	******	******	******	5.253
F5F6	0.452	1.086	1.447	1.900	2.081
G1G2	0.0	0.0	0.090	0.724	1.358
G2G3	0.0	******	******	0.453	******
G3G4	0.0	0.090	0.181	0.633	0.905
G4G5	0.090	******	******	******	0.995
G5G6	0.090	0.090	0.090	0.542	0.904
A1B2	-0.164	******	******	0.655	0.982
A2B1	-0.211	******	******	1.636	2.586
A2B3	-0.169	******	******	******	******
A3B2	-0.160	******	******	-1.818	-2.727
A3B4	0.225	******	******	******	******
A4B3	-0.164	******	******	-3.125	-4.551
A4B5	-0.164	******	******	******	******
A5B4	-0.279	******	******	-2.339	-1.671
A5B6	-0.598	******	******	******	******
A6B5	-0.478	******	******	-1.276	-1.860
C1D2	-0.164	-0.164	-0.219	0.820	1.421
C2D1	-0.273	-0.273	-0.273	0.819	1.092
C2D3	-0.162	******	******	******	******
C3D2	-0.322	-0.322	-0.375	-0.107	-0.429
C3D4	-0.331	-0.276	-0.221	1.545	3.201
C4D3	0.0	******	******	******	******
C4D5	******	-0.845	2.197	0.958	******
C5D4	0.0	******	******	******	******
C5D6	-0.111	-0.222	1.608	0.721	0.333
C6D5	-1.811	1.811	******	******	******
D1E2	-0.337	******	-0.337	0.056	0.056
D2E1	-0.326	-0.326	-0.326	0.217	0.651
D2E3	-0.384	******	******	******	******
D3E2	0.277	0.111	0.222	-0.222	-0.499
D3E4	-0.332	******	******	******	******
D4E3	-0.320	-0.426	-0.480	-1.119	-2.558
D4E5	-0.279	-0.335	-0.279	1.283	4.573
D5E4	******	******	******	******	******
D5E6	-0.797	-0.627	-1.367	0.235	******
D6E5	******	******	******	******	******
F1G2	-0.442	-0.331	-0.221	0.166	0.497
F2G1	-0.429	******	0.054	0.858	1.072
F2G3	-0.167	0.056	0.0	0.223	-1.729
F3G2	-0.217	******	******	******	******
F3G4	-0.170	-0.284	-0.397	-0.624	-1.361
F4G3	-0.158	******	******	******	******
F4G5	-0.176	-0.411	-0.587	-1.174	-2.290
F5G4	******	******	******	******	******
F5G6	0.404	-0.462	-0.462	-1.386	-3.754
F6G5	-0.482	******	-0.643	0.590	0.268

TABLE B.4: STRAIN READINGS FOR SC2-WEST SIDE.

SPECIMEN:SC2 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4
A1B1	-0.261	******	******	******	******
A2B2	-0.205	0.068	0.614	0.409	0.409
A3B3	-0.284	0.213	-0.569	******	-0.711
A4B4	******	******	******	******	******
A5B5	-0.359	******	******	******	******
A6B6	-0.272	-0.545	-0.886	-1.226	-1.635
C1D1	-0.137	******	******	******	******
C2D2	-0.066	-0.066	-0.066	0.660	1.121
C3D3	******	******	******	******	******
C4D4	******	******	******	******	******
C5D5	-0.270	-0.270	-0.270	0.0	0.473
C6D6	-0.294	-0.147	-0.294	-0.221	-0.147
D1E1	-0.276	******	******	******	******
D2E2	-0.277	-0.415	-0.553	0.277	-0.207
D3E3	-0.289	******	******	******	******
D4E4	-0.295	-0.148	-0.074	-0.074	0.443
D5E5	-0.275	-0.275	-0.275	0.0	-0.275
D6E6	******	******	******	******	******
F1G1	-0.271	******	******	******	******
F2G2	-0.342	0.137	0.616	1.094	1.094
F3G3	-0.349	******	******	******	******
F4G4	-0.275	-0.207	-0.275	-0.344	-0.207
F5G5	-0.606	******	******	******	******
F6G6	-0.258	-0.452	-0.840	-1.551	-2.261
A1A2	0.0	0.0	1.172	1.262	******
A2A3	******	******	******	******	******
A3A4	******	******	******	******	******
A4A5	******	******	******	******	******
A5A6	******	******	******	******	******
B1B2	0.0	0.0	0.0	0.0	0.719
B2B3	-0.091	******	******	******	3.628
B3B4	0.0	0.0	0.0	0.814	2.986
B4B5	0.090	******	******	1.176	3.347
B5B6	0.090	0.090	0.181	1.176	1.719
C1C2	0.0	0.0	0.0	0.884	1.503
C2C3	0.0	******	******	1.448	2.624
C3C4	-0.090	0.0	0.0	0.814	4.252
C4C5	0.0	******	******	******	4.243
C5C6	0.0	0.0	******	0.723	1.355
D1D2	0.090	0.181	0.181	1.267	2.262
D2D3	-0.090	******	******	******	1.357
D3D4	-0.090	0.0	0.0	0.814	1.357
D4D5	-0.090	******	******	1.176	2.805
D5D6	0.0	0.090	******	0.814	1.176
E1E2	0.453	******	******	******	1.902
E2E3	0.271	******	******	******	1.805
E3E4	0.0	0.0	0.0	******	5.790
E4E5	0.0	******	******	3.608	******
E5E6	0.272	0.363	******	1.541	******
F1F2	0.0	0.0	0.181	0.543	0.904

SPECIMEN:SC2 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4
F2F3	0.543	******	******	0.181	0.452
F3F4	0.0	0.181	0.362	0.452	0.542
F4F5	0.0	******	******	0.271	1.086
F5F6	0.0	0.090	0.090	0.905	2.171
G1G2	0.0	0.0	******	0.724	0.995
G2G3	0.0	******	******	******	0.452
G3G4	0.0	0.0	0.0	0.452	0.723
G4G5	-0.090	******	******	0.362	0.996
G5G6	0.0	0.0	******	0.362	0.815
A1B2	-0.161	******	******	0.807	1.237
A2B1	-0.160	******	******	0.267	0.214
A2B3	-0.107	******	******	******	******
A3B2	-0.171	******	******	******	******
A3B4	-0.161	******	******	******	******
A4B3	******	******	******	******	******
A4B5	-0.268	******	******	7.088	9.290
A5B4	******	******	******	******	******
A5B6	-0.158	******	******	******	******
A6B5	-0.231	******	******	0.058	-1.442
C1D2	******	******	******	******	******
C2D1	-0.279	-0.335	-0.335	0.335	0.558
C2D3	******	******	******	******	******
C3D2	0.0	-0.160	-0.267	-0.053	-0.214
C3D4	******	******	******	******	******
C4D3	0.0	0.0	0.0	0.0	0.0
C4D5	-0.162	-0.162	******	1.029	2.867
C5D4	0.0	0.0	0.0	0.0	0.0
C5D6	-0.167	-0.167	******	0.778	1.334
C6D5	-0.168	-0.335	-0.335	-0.168	5.309
D1E2	******	******	******	******	******
D2E1	-0.266	-0.479	-0.160	-0.425	0.0
D2E3	0.0	0.0	******	******	******
D3E2	1.014	0.800	1.920	1.280	-0.107
D3E4	-0.055	0.0	******	******	******
D4E3	-0.371	-0.584	-0.584	-1.061	-3.395
D4E5	-0.107	-0.215	******	******	******
D5E4	-0.176	-0.293	-0.293	-0.702	-1.405
D5E6	******	******	******	******	******
D6E5	-0.168	-0.224	-0.168	-0.224	-0.280
F1G2	-0.369	-0.053	******	0.105	0.527
F2G1	-0.225	0.0	0.281	1.011	1.405
F2G3	-0.436	-0.054	******	******	******
F3G2	-0.331	-0.166	0.221	1.160	1.602
F3G4	-0.219	-0.109	******	******	******
F4G3	-0.166	-0.111	0.277	1.439	2.767
F4G5	-0.053	-0.266	******	******	******
F5G4	-0.167	-0.167	-0.111	0.334	-2.669
F5G6	******	******	******	******	******
F6G5	-0.110	-0.165	-0.384	-0.165	0.165

TABLE B.5: STRAIN READINGS FOR SC3-EAST SIDE.

SPECIMEN:SC3 ,SIDE:EAST

STRAIN	LOAD STAGE							
	0	1	2	3	4	5	5	7
A1B1	-0.256	0.563	1.076	1.127	1.076	0.820	0.205	-0.103
A2B2	-0.199	0.349	0.697	0.797	0.996	1.444	1.842	2.739
A3B3	-0.152	0.051	0.457	0.762	0.914	1.269	1.675	2.234
A4B4	-0.253	0.0	0.253	0.303	0.303	0.404	0.455	-0.152
A5B5	-0.151	-0.454	-0.706	-0.858	-0.959	-1.059	-1.514	-4.944
A6B6	-0.397	-0.993	-2.334	-3.277	-3.675	-4.271	******	******
C1D1	-0.146	0.098	0.585	1.268	1.463	1.707	1.707	1.305
C2D2	0.0	0.048	0.432	0.673	0.769	0.865	0.913	0.913
C3D3	-0.095	-0.047	0.095	0.379	0.426	0.321	0.516	0.568
C4D4	-0.247	-0.148	0.0	0.049	0.099	0.049	0.148	0.296
C5D5	-0.195	-0.195	-0.195	-0.195	-0.195	-0.195	-0.146	-0.146
C6D6	-0.287	-0.383	-0.479	-0.526	-0.574	-0.374	-0.479	-0.383
D1E1	-0.048	-0.145	-0.193	0.048	0.097	0.145	0.145	0.048
D2E2	-0.192	0.0	-0.048	0.240	0.288	0.336	0.385	0.385
D3E3	0.0	-0.051	-0.204	-0.051	0.0	0.0	0.204	0.663
D4E4	-0.103	0.0	-0.206	-0.052	0.0	0.0	-0.052	-0.052
D5E5	******	******	******	******	******	******	******	******
D6E6	-0.206	-0.257	-0.051	-0.051	0.0	-0.154	-0.103	-0.154
F1G1	******	******	******	******	******	******	******	******
F2G2	******	******	******	******	******	******	******	******
F3G3	-0.243	-0.049	0.341	1.022	1.217	1.509	1.752	1.899
F4G4	-0.203	-0.102	-0.152	0.356	0.406	0.356	0.457	0.406
F5G5	******	******	******	******	******	******	******	******
F6G6	******	******	******	******	******	******	******	******
A1A2	0.0	0.0	0.186	0.743	1.021	1.578	3.343	6.500
A2A3	0.0	0.0	0.184	0.276	0.276	0.328	1.012	******
A3A4	0.0	0.037	0.087	2.087	0.435	0.696	1.217	0.522
A4A5	0.0	0.0	0.271	0.543	0.633	0.996	1.448	4.434
A5A6	0.0	0.091	0.634	0.906	1.087	1.540	2.355	10.958
B1B2	0.0	0.0	0.362	0.272	0.181	0.0	-0.272	-0.997
B2B3	0.0	0.0	0.264	0.264	0.351	0.615	0.878	2.196
B3B4	0.0	0.0	1.215	2.150	2.524	3.459	4.581	3.975
B4B5	0.0	0.091	0.724	0.996	1.177	1.449	1.720	2.354
B5B6	0.0	0.0	0.359	0.807	0.448	0.538	1.344	1.972
C1C2	0.0	0.0	0.725	1.178	1.449	1.721	1.902	2.174
C2C3	0.0	0.0	0.272	0.544	0.725	0.725	0.906	1.630
C3C4	0.0	0.0	0.527	0.967	1.142	1.318	1.406	1.582
C4C5	0.0	0.094	0.561	1.029	1.122	1.309	1.309	1.964
C5C6	0.0	0.091	0.181	1.087	1.268	1.359	1.359	1.449
D1D2	0.0	0.0	0.0	1.449	1.630	1.392	2.083	2.445
D2D3	0.0	0.0	0.0	0.542	0.723	0.723	0.904	0.904
D3D4	0.0	0.0	0.091	0.637	0.727	0.909	0.909	1.091
D4D5	0.0	0.0	0.086	1.211	1.298	1.471	1.730	1.990
D5D6	0.0	0.0	0.0	0.570	0.760	1.140	1.330	1.995
E1E2	0.0	0.0	0.0	0.905	1.086	1.358	1.358	1.810
E2E3	0.0	0.0	0.0	0.543	0.724	0.724	0.815	0.724
E3E4	0.0	0.272	0.272	1.268	1.268	1.630	1.630	2.173
E4E5	0.0	0.0	0.0	0.815	0.905	1.177	1.177	1.358
E5E6	0.0	0.0	0.0	0.815	0.996	1.087	1.358	1.449
F1F2	0.0	0.444	0.533	1.066	1.510	1.599	0.388	2.754

SPECIMEN:SC3 ,SIDE:EAST

STRAIN	LOAD STAGE							
	0	1	2	3	4	5	6	7
F2F3	0.0	0.0	0.0	0.453	0.543	0.815	1.087	1.539
F3F4	0.0	0.091	0.0	0.815	1.087	1.268	1.539	1.811
F4F5	0.0	0.0	0.0	0.634	0.724	1.087	1.177	1.358
F5F6	0.0	0.0	0.090	0.724	0.905	0.996	1.267	1.358
G1G2	0.0	0.0	0.091	0.131	0.181	0.181	0.272	0.091
G2G3	0.0	0.0	0.181	0.271	0.543	0.543	0.996	1.177
G3G4	0.0	0.0	0.091	0.181	0.362	0.634	0.815	0.906
G4G5	0.0	0.091	0.272	0.724	0.724	0.996	1.358	1.630
G5G6	0.0	0.0	0.090	0.181	0.362	0.815	0.996	1.539
A1B2	-0.170	0.340	0.723	0.892	0.935	0.978	1.020	1.955
A2B1	******	******	******	******	******	******	******	******
A2B3	******	******	******	******	******	******	******	******
A3B2	******	******	******	******	******	******	******	******
A3B4	-0.084	0.0	-0.042	1.505	1.840	2.383	3.052	******
A4B3	******	******	******	******	******	******	******	******
A4B5	-0.171	-0.043	0.512	0.897	1.025	1.409	1.379	3.502
A5B4	-0.251	-0.210	-0.545	-0.754	-0.964	-1.048	-1.718	******
A5B6	-0.170	-0.255	-0.383	-0.425	-0.468	-0.510	-0.595	-2.297
A6B5	-0.226	-0.362	-1.311	-2.034	-2.576	-3.074	-3.481	******
C1D2	-0.125	-0.125	0.669	1.254	1.421	1.713	1.713	1.922
C2D1	-0.131	-0.044	0.350	0.831	1.005	1.093	1.137	1.137
C2D3	******	******	******	******	******	******	******	******
C3D2	-0.173	-0.216	-0.345	-0.561	-0.733	-0.733	-0.819	-0.948
C3D4	-0.258	-0.043	0.500	1.377	1.679	1.980	2.281	2.884
C4D3	-0.126	-0.168	-0.421	-0.589	-0.758	-0.926	-1.052	-1.515
C4D5	-0.303	-0.043	0.476	1.341	1.644	1.773	2.076	2.639
C5D4	-0.043	-0.129	-0.430	-0.774	-0.903	-1.075	-1.161	-1.462
C5D6	-0.172	-0.172	-0.172	0.387	0.473	0.731	1.117	1.332
C6D5	-0.171	-0.385	-0.514	-0.771	-0.985	-1.070	-1.113	-1.241
D1E2	-0.169	-0.169	-0.042	0.421	0.421	0.548	0.632	0.632
D2E1	******	******	******	******	******	******	******	******
D2E3	-0.089	0.044	0.221	1.063	1.151	1.816	1.360	2.214
D3E2	-0.043	-0.128	-0.299	-0.385	-0.684	-0.684	-0.812	-0.812
D3E4	******	******	******	******	******	******	******	******
D4E3	-0.169	-0.212	-0.381	-0.720	-0.975	-0.975	-1.059	-1.271
D4E5	******	******	******	******	******	******	******	******
D5E4	-0.301	-0.172	-0.473	-0.688	-0.990	-0.990	-1.162	-1.549
D5E6	******	******	******	******	******	******	******	******
D6E5	-0.354	-0.177	-0.354	-0.398	-0.664	-0.752	-0.752	-0.973
F1G2	******	******	******	******	******	******	******	******
F2G1	-0.127	0.0	0.507	1.184	1.396	1.480	1.691	1.522
F2G3	******	******	******	******	******	******	******	******
F3G2	-0.170	0.128	0.554	1.278	1.618	2.002	2.385	2.598
F3G4	-0.131	-0.174	-0.348	-0.348	-0.348	-0.566	-0.596	-1.045
F4G3	-0.175	-0.044	0.350	1.443	1.836	2.317	2.754	3.191
F4G5	-0.136	-0.182	******	-0.953	-1.044	-1.498	-1.498	-1.770
F5G4	-0.223	-0.089	0.0	0.392	1.160	1.516	1.828	2.051
F5G6	-0.181	-0.363	-0.725	******	-0.906	-0.952	-0.952	-0.952
F6G5	******	******	******	******	******	******	******	******

TABLE B.6: STRAIN READINGS FOR SC3-WEST SIDE.

SPECIMEN:SC3 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
A1B1	-0.256	0.563	1.076	1.127	1.076	0.820	0.205	-0.103
A2B2	-0.051	0.462	1.180	1.846	2.308	3.077	3.795	5.078
A3B3	-0.198	0.149	0.942	1.190	1.389	1.538	1.637	0.992
A4B4	-0.144	-0.192	-0.192	-0.240	-0.335	-0.383	-1.246	-2.683
A5B5	-0.238	-0.619	-1.095	-1.571	-1.905	-2.381	-2.952	-4.429
A6B6	-0.388	-1.367	-2.231	-3.493	-4.123	-4.900	-6.015	******
C1D1	0.0	0.049	0.634	1.268	1.463	1.707	1.902	1.756
C2D2	-0.049	0.049	0.732	1.318	1.465	1.611	1.660	1.318
C3D3	******	******	******	******	******	******	******	******
C4D4	******	******	******	******	******	******	******	******
C5D5	-0.340	-0.340	-0.389	-0.486	-0.438	-0.438	-0.486	-0.535
C6D6	-0.244	-0.293	-0.293	-0.098	-0.244	-0.049	-0.049	0.049
D1E1	-0.048	-0.097	-0.145	0.145	0.193	0.193	0.242	0.097
D2E2	-0.096	-0.145	-0.241	-0.193	-0.048	0.048	0.193	0.338
D3E3	-0.250	-0.300	-0.450	-0.100	0.050	0.150	0.300	0.400
D4E4	-0.245	-0.245	-0.294	-0.342	-0.342	-0.294	-0.294	-0.294
D5E5	-0.294	-0.294	-0.294	0.0	0.098	0.098	0.398	0.196
D6E6	-0.599	-0.599	-0.449	-0.349	-0.249	-0.349	-0.299	-0.349
F1G1	******	******	******	******	******	******	******	******
F2G2	-0.245	-0.147	0.196	0.883	1.177	1.472	1.717	1.717
F3G3	-0.250	-0.100	0.200	0.801	1.101	1.451	1.651	1.751
F4G4	-0.198	-0.198	-0.248	0.248	0.297	0.347	0.297	0.198
F5G5	-0.242	-0.387	-0.581	-0.436	-0.484	-0.533	-0.726	-0.968
F6G6	-0.191	-0.667	-1.096	-1.430	-1.573	-1.716	-2.049	-2.478
A1A2	0.0	0.181	0.272	0.453	0.543	0.815	0.815	0.996
A2A3	0.0	0.090	0.181	0.634	0.815	1.087	1.539	1.358
A3A4	0.0	0.0	0.362	0.453	0.453	0.815	0.543	4.437
A4A5	0.0	0.0	0.181	0.362	0.452	0.814	1.719	3.529
A5A6	0.0	0.0	0.0	0.0	0.0	0.362	0.905	3.892
B1B2	0.0	0.090	0.181	0.090	0.090	0.181	0.361	0.542
B2B3	0.0	0.0	1.080	1.800	2.070	2.610	2.970	4.320
B3B4	0.0	0.0	0.634	0.815	1.087	1.358	1.449	2.898
B4B5	0.0	0.272	0.816	1.269	1.178	1.541	1.903	2.538
B5B6	0.0	0.090	0.181	0.633	0.633	0.996	1.086	1.539
C1C2	0.0	0.0	0.996	1.358	1.539	2.082	2.263	2.988
C2C3	0.0	0.0	0.453	0.634	0.724	0.815	1.086	1.267
C3C4	0.0	0.090	0.453	1.087	1.358	1.539	1.811	2.173
C4C5	0.0	0.181	0.181	0.906	0.996	1.177	1.358	1.630
C5C6	0.0	0.180	0.180	0.540	0.901	1.171	1.171	1.531
D1D2	0.0	0.0	0.272	0.815	0.815	0.996	0.996	1.177
D2D3	0.0	0.0	0.0	0.0	1.187	1.096	1.461	1.005
D3D4	0.0	0.090	0.090	1.075	1.434	1.792	2.151	2.778
D4D5	0.0	0.0	0.0	0.635	0.907	0.816	1.360	1.542
D5D6	0.0	0.0	0.090	0.718	0.808	1.615	1.705	1.436
E1E2	0.0	0.0	0.0	0.724	0.905	1.086	1.358	1.448
E2E3	0.0	0.0	0.0	0.362	0.452	0.633	0.452	0.633
E3E4	0.0	0.090	0.0	0.905	1.086	1.267	1.539	1.810
E4E5	0.0	0.272	0.181	1.087	1.267	1.358	1.449	1.449
E5E6	0.0	0.0	0.0	0.543	0.905	0.996	1.267	1.720
F1F2	0.0	0.0	0.092	0.646	0.830	0.646	1.753	1.845

SPECIMEN:SC3 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
F2F3	0.0	0.0	0.0	0.455	0.819	1.001	1.274	1.729
F3F4	0.0	0.090	0.090	0.811	1.262	1.352	1.532	1.712
F4F5	0.0	0.091	0.091	0.725	0.906	1.268	1.540	1.268
F5F6	0.0	0.091	0.091	0.634	0.815	0.815	0.997	0.997
G1G2	0.0	0.0	0.362	0.815	1.177	1.630	1.811	2.897
G2G3	0.0	0.0	0.0	0.543	0.272	0.272	0.453	0.725
G3G4	0.0	0.0	0.181	0.091	0.453	0.181	0.634	0.543
G4G5	0.0	0.0	0.181	0.453	0.996	0.906	1.177	1.630
G5G6	0.0	0.0	0.0	0.181	0.181	0.544	0.635	0.725
A1B2	-0.168	0.420	1.050	1.302	1.470	1.428	1.512	1.596
A2B1	-0.174	0.043	0.391	0.783	1.087	1.174	1.653	1.696
A2B3	-0.177	0.221	1.370	2.033	2.563	3.226	3.977	5.038
A3B2	-0.132	0.220	0.615	0.791	1.055	1.187	1.231	1.275
A3B4	-0.130	0.0	1.083	1.429	1.689	2.122	2.598	3.984
A4B3	-0.171	-0.171	-0.256	-0.512	-0.597	-0.895	-1.833	-3.497
A4B5	-0.300	-0.300	-0.043	0.043	0.171	0.214	0.257	0.300
A5B4	-0.209	-0.418	-0.710	-1.337	-1.462	-2.173	-2.800	-4.722
A5B6	-0.218	-0.742	-0.961	-1.310	-1.441	-1.703	-1.921	-2.620
A6B5	******	******	******	******	******	******	******	******
C1D2	-0.173	0.043	0.864	1.599	1.901	2.117	2.290	2.377
C2D1	0.0	0.086	0.556	0.898	1.069	1.069	1.112	1.112
C2D3	-0.170	0.0	0.937	1.448	1.789	1.959	2.258	2.471
C3D2	-0.167	-0.167	-0.292	-0.292	-0.292	-0.292	-0.292	-0.376
C3D4	-0.209	-0.125	0.418	1.002	1.002	1.545	1.379	2.464
C4D3	******	******	******	******	******	******	******	******
C4D5	-0.167	-0.167	-0.084	0.669	0.919	1.086	1.337	1.713
C5D4	-0.342	-0.342	-0.513	-0.941	-0.983	-1.069	-1.197	-1.710
C6D5	-0.263	-0.438	-0.482	-0.701	-0.789	-0.789	-0.921	-1.052
C5D6	-0.210	-0.168	-0.042	0.377	0.712	0.796	1.390	1.090
D1E2	-0.126	0.0	0.294	0.673	0.757	0.883	1.052	1.178
D2E1	-0.086	-0.173	-0.173	-0.216	-0.303	-0.303	-0.389	-0.605
D2E3	-0.128	-0.128	-0.043	0.682	0.980	1.150	1.491	1.917
D3E2	-0.220	-0.220	-0.440	-0.484	-0.484	-0.659	-0.747	-1.055
D3E4	-0.214	0.043	0.086	1.113	1.370	1.626	1.926	2.258
D4E3	-0.044	-0.220	-0.352	-0.748	-0.748	-0.881	-0.924	-1.145
D4E5	-0.298	-0.085	0.0	0.979	1.234	1.490	1.787	2.000
D5E4	-0.262	-0.262	-0.787	-0.918	-1.137	-1.224	-1.442	******
D5E6	-0.421	-0.210	-0.168	0.505	0.757	0.926	1.136	1.304
D6E5	-0.179	-0.269	-0.269	-0.359	-0.403	-0.538	-0.538	-0.672
F1G2	-0.085	0.551	0.508	0.551	0.508	0.593	0.847	0.932
F2G1	-0.172	0.129	0.729	1.415	1.715	1.929	2.101	2.144
F2G3	-0.172	-0.043	0.215	0.387	0.560	0.560	0.517	0.560
F3G2	-0.176	0.088	0.484	1.276	1.672	2.200	2.684	3.080
F3G4	-0.128	0.043	-0.171	-0.342	-0.385	-0.427	-0.769	-1.410
F4G3	-0.134	0.089	0.580	1.651	2.097	2.676	3.212	3.747
F4G5	-0.172	-0.215	-0.430	-0.689	-0.818	-1.076	-1.248	-1.679
F5G4	-0.129	-0.086	-0.043	0.907	1.166	1.511	1.770	1.770
F5G6	-0.211	-0.306	-0.886	-1.265	-1.434	-1.687	-2.108	-2.741
F6G5	-0.171	-0.214	-0.171	0.086	0.171	0.385	0.428	0.428

TABLE B .7: STRAIN READINGS FOR SC4-EAST SIDE.

SPECIMEN:SC4 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
A1B1	-0.253	-0.190	-0.127	-0.127	-0.570	-0.350	-1.583	-1.709
A2B2	-0.249	0.685	0.249	-0.124	-0.560	-0.560	-0.685	0.0
A3B3	-0.248	0.681	0.390	1.424	2.043	3.033	3.714	4.085
A4B4	-0.264	0.660	0.859	0.991	1.321	1.519	1.453	0.132
A5B5	-0.347	-1.042	-0.347	-0.278	-0.278	0.0	0.278	3.265
A6B6	******	******	******	******	******	******	******	******
C1D1	-0.318	0.0	0.572	0.826	0.890	1.017	0.953	-0.318
C2D2	-0.259	0.0	0.388	0.711	0.841	0.905	0.841	0.341
C3D3	-0.259	-0.065	0.0	-0.130	0.065	0.130	0.195	-0.908
C4D4	-0.251	-0.251	-0.126	0.188	0.251	0.314	0.314	2.073
C5D5	-0.186	-0.310	-0.186	-0.310	-0.372	-0.681	-0.743	-0.805
C6D6	-0.248	-0.310	-0.124	-0.124	0.0	0.186	0.310	0.683
D1E1	-0.260	-0.130	-0.195	-0.130	-0.260	-0.260	-0.390	-0.909
D2E2	-0.262	-0.131	-0.131	0.131	0.131	0.131	0.0	-0.459
D3E3	-0.194	-0.129	-0.194	0.258	0.452	0.516	0.516	0.968
D4E4	-0.255	-0.191	-0.255	-0.127	0.191	0.382	0.255	0.510
D5E5	-0.126	-0.189	-0.126	0.063	0.126	0.126	0.189	0.0
D6E6	-0.248	-0.357	-0.186	-0.124	0.062	0.0	0.124	0.372
F1G1	-0.263	-0.066	-0.197	-0.065	-0.395	-0.526	-0.395	-0.526
F2G2	1.472	1.472	-0.064	0.064	0.192	0.192	-0.192	******
F3G3	-0.186	-0.362	0.186	0.248	0.373	0.621	0.683	0.969
F4G4	-0.256	-0.128	-0.192	-0.128	0.064	0.192	0.128	0.192
F5G5	-0.257	-0.386	-0.514	-0.771	-0.900	-0.835	-0.835	-0.642
F6G6	-0.252	-0.504	-0.631	-0.757	-0.757	-0.567	-0.946	-0.693
A1A2	0.0	0.639	1.369	1.734	2.646	3.193	3.832	6.296
A2A3	0.0	0.728	2.356	4.095	6.278	8.169	9.827	15.287
A3A4	0.0	0.271	0.723	1.356	3.073	5.243	7.593	10.214
A4A5	0.0	0.090	0.904	1.626	2.439	4.427	7.589	13.914
A5A6	0.0	0.0	0.735	1.836	1.836	2.755	3.948	7.162
B1B2	0.0	0.362	0.634	0.996	1.540	1.721	1.721	2.626
B2B3	0.0	0.271	1.174	1.174	1.174	1.264	1.354	5.146
B3B4	0.0	0.178	0.799	1.421	2.131	3.374	5.949	6.127
B4B5	0.0	0.091	1.180	2.451	2.996	5.084	7.808	7.989
B5B6	0.0	0.180	0.180	0.540	1.171	1.261	1.441	2.162
C1C2	0.0	0.181	0.542	1.175	1.175	1.627	1.717	1.807
C2C3	0.0	0.093	0.651	1.116	1.302	1.394	1.394	2.138
C3C4	0.0	0.0	0.092	1.288	2.023	2.943	4.231	7.473
C4C5	0.0	0.270	0.090	1.351	1.802	2.613	3.243	6.757
C5C6	0.0	0.270	0.0	0.719	1.079	1.349	1.439	1.619
D1D2	0.0	0.092	0.460	0.736	1.196	1.472	1.472	1.746
D2D3	0.0	0.0	0.184	1.101	1.560	1.327	2.754	3.121
D3D4	0.0	0.091	0.273	1.820	1.320	2.547	3.366	6.551
D4D5	0.0	0.0	0.091	0.274	1.004	1.369	1.552	3.925
D5D6	0.0	0.0	0.092	0.460	0.645	0.829	0.921	1.197
E1E2	0.0	0.271	0.181	0.905	1.176	1.357	1.538	1.719
E2E3	0.0	0.181	0.181	0.544	0.906	1.178	1.178	1.341
E3E4	0.0	0.181	0.271	0.362	2.712	3.344	3.977	6.779
E4E5	0.0	0.0	0.0	0.0	0.366	0.732	0.732	1.190
E5E6	0.0	0.090	0.179	0.179	0.895	0.895	1.342	1.759
F1F2	0.0	0.0	0.090	0.090	0.180	0.542	0.542	******

SPECIMEN:SC4 ,SIDE:EAST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
F2F3	0.0	0.091	0.091	0.274	0.365	0.348	2.100	******
F3F4	0.0	0.0	0.273	0.636	0.909	1.091	1.182	1.272
F4F5	0.0	0.0	0.092	0.276	0.461	0.645	0.645	0.737
F5F6	0.0	0.0	0.0	0.456	0.639	0.913	0.913	1.369
G1G2	0.0	0.361	0.813	1.265	1.987	3.433	3.704	3.975
G2G3	0.0	0.0	0.737	1.013	1.750	3.315	4.697	5.341
G3G4	0.0	0.0	0.180	0.451	0.722	0.812	1.173	1.173
G4G5	0.0	0.0	0.0	0.543	0.725	0.906	0.996	0.996
G5G6	0.0	0.0	0.093	0.556	0.556	0.356	0.741	1.019
A1B2	-0.153	0.561	0.510	0.255	0.357	1.529	1.682	1.886
A2B1	-0.154	-0.154	-0.154	-0.411	-0.514	-0.720	-0.374	-0.374
A2B3	-0.151	0.706	1.462	1.512	2.369	2.923	3.276	3.427
A3B2	0.051	0.256	0.358	0.614	1.278	1.892	2.352	3.119
A3B4	-0.150	0.652	1.906	2.909	4.614	6.470	7.624	******
A4B3	-0.159	-0.106	-0.531	-1.009	-1.168	-1.009	-1.168	0.478
A4B5	-0.157	0.314	1.569	2.824	3.870	5.595	7.948	11.765
A5B4	-0.165	-0.496	-0.716	-1.377	-1.487	-1.707	-1.983	-4.901
A5B6	-0.217	-0.217	0.163	0.543	0.760	1.140	1.346	2.339
A6B5	******	******	******	******	******	******	******	******
C1D2	-0.156	-0.052	0.415	0.779	1.143	1.247	1.351	0.727
C2D1	-0.156	-0.104	0.052	0.488	0.676	0.728	0.728	0.156
C2D3	-0.158	0.0	0.526	1.209	1.630	1.735	1.945	2.051
C3D2	-0.052	-0.262	-0.262	-0.420	-0.315	-0.315	-0.315	-0.734
C3D4	-0.157	-0.052	0.261	2.036	2.663	3.237	4.229	2.663
C4D3	-0.155	-0.257	-0.309	-1.082	-1.545	-1.803	-1.700	-1.751
C4D5	-0.153	-0.153	0.0	0.868	1.430	1.991	2.604	1.072
C5D4	-0.152	-0.356	-0.406	-0.813	-0.965	-1.219	-1.270	-2.032
C5D6	-0.152	0.0	0.0	0.405	0.557	0.659	0.659	0.659
C6D5	-0.152	-0.406	-0.457	-0.558	-0.203	-0.203	-0.102	0.051
D1E2	-0.053	-0.053	0.0	0.474	0.737	0.895	0.947	0.842
D2E1	-0.158	-0.052	-0.210	-0.052	-0.105	-0.156	-0.262	-0.525
D2E3	-0.206	-0.052	0.052	0.619	1.084	1.291	1.446	1.652
D3E2	-0.213	-0.053	-0.107	-0.107	0.107	0.0	0.0	0.053
D3E4	-0.152	-0.102	0.0	1.525	2.847	3.254	3.965	4.677
D4E3	-0.159	-0.477	-0.530	-0.953	-1.112	-1.324	-1.483	-2.595
D4E5	-0.152	-0.355	-0.203	0.304	0.963	1.572	1.825	3.448
D5E4	-0.157	-0.367	-0.472	-0.630	-0.630	-0.392	-0.997	-1.627
D5E6	******	******	******	******	******	******	******	******
D6E5	-0.157	-0.418	-0.314	-0.523	-0.314	-0.418	-0.418	-0.209
F1G2	******	******	******	******	******	******	******	******
F2G1	-0.165	-0.055	0.110	0.275	0.275	0.771	0.661	******
F2G3	******	******	******	******	******	******	******	******
F3G2	-0.161	0.107	0.429	0.697	0.697	1.019	2.039	1.288
F3G4	******	******	******	******	******	******	******	******
F4G3	-0.161	-0.161	0.0	0.645	1.291	1.828	1.382	1.936
F4G5	-0.152	-0.303	-0.354	-0.606	-0.707	-0.859	-1.061	-1.162
F5G4	-0.161	0.107	0.054	0.268	0.805	1.127	1.342	1.718
F5G6	-0.151	-0.453	-0.402	-0.503	-0.453	-0.453	-0.303	-0.402
F6G5	-0.214	-0.214	-0.214	-0.214	0.107	0.054	0.107	0.161

TABLE B .8: STRAIN READINGS FOR SC4-WEST SIDE.

SPECIMEN:SC4 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
A1B1	-0.253	0.253	0.0	-0.253	-0.570	-1.076	-1.583	-1.773
A2B2	-0.259	0.194	0.0	0.388	0.388	0.065	-0.129	0.388
A3B3	-0.260	0.586	1.301	1.337	2.603	3.448	4.099	5.075
A4B4	-0.498	-0.311	-0.249	-0.249	-0.373	-0.623	-0.498	******
A5B5	-0.262	-0.983	-1.507	-1.900	-2.097	-2.097	-2.097	******
A6B6	-0.203	-1.081	-1.149	-1.351	-1.331	-1.284	-1.216	-0.811
C1D1	-0.254	0.0	0.445	0.826	0.953	1.017	0.826	******
C2D2	-0.138	-0.063	0.188	0.501	0.627	0.752	0.815	0.376
C3D3	-0.253	-0.190	-0.127	0.190	0.317	0.443	0.570	0.824
C4D4	-0.256	0.192	0.192	0.511	0.639	0.767	0.959	0.395
C5D5	-0.187	-0.312	-0.312	-0.250	-0.312	-0.250	-0.312	-0.062
C6D6	******	******	******	******	******	******	******	******
D1E1	-0.260	-0.195	-0.325	-0.260	-0.325	-0.390	-0.844	******
D2E2	-0.256	-0.320	-0.256	-0.064	-0.064	-0.064	-0.192	-0.704
D3E3	-0.253	-0.127	-0.317	-0.507	-0.697	-0.760	-1.457	-1.837
D4E4	-0.258	-0.258	-0.387	-0.387	-0.194	-0.258	-0.258	-0.387
D5E5	-0.060	-0.265	-0.331	-0.398	-0.331	-0.331	-0.464	-0.729
D6E6	-0.267	0.067	-0.134	0.0	0.067	0.134	0.201	0.468
F1G1	-0.263	0.0	-0.132	0.132	0.066	-0.066	-0.263	0.066
F2G2	-0.136	-0.068	0.136	0.681	0.818	1.158	1.158	1.090
F3G3	-0.269	-0.067	-0.202	0.337	0.606	0.875	0.808	0.808
F4G4	-0.258	-0.258	-0.258	-0.258	-0.322	-0.322	-0.322	-0.387
F5G5	-0.251	-0.439	-0.502	-0.502	-0.564	-0.564	-0.564	-0.439
F6G6	-0.250	-0.686	-0.811	-0.998	-1.123	-1.186	-1.498	-1.310
A1A2	0.0	0.626	1.610	3.399	6.172	8.766	10.544	16.100
A2A3	0.0	0.265	1.150	2.211	3.715	5.307	6.369	12.738
A3A4	0.0	0.452	0.904	1.446	2.260	3.344	2.983	******
A4A5	0.0	0.0	0.539	1.615	2.423	6.462	10.949	******
A5A6	0.0	0.359	0.629	1.347	1.976	3.362	2.784	5.928
B1B2	0.0	0.352	0.792	1.144	1.848	2.288	2.728	4.399
B2B3	0.0	0.182	0.635	1.361	1.361	1.633	1.996	7.259
B3B4	0.0	0.0	0.908	1.453	2.270	3.995	4.448	5.084
B4B5	0.0	0.091	0.456	1.093	1.913	2.915	4.737	******
B5B6	0.0	0.089	0.266	1.064	1.951	2.217	2.305	******
C1C2	0.0	0.089	0.621	1.065	1.331	1.508	1.597	1.597
C2C3	0.0	0.0	0.454	0.726	0.908	0.998	0.998	2.269
C3C4	0.0	0.266	0.444	1.866	3.110	3.998	5.686	12.883
C4C5	0.0	0.0	0.186	1.114	1.579	1.950	3.158	6.315
C5C6	0.0	0.090	0.090	0.990	1.349	1.530	1.709	1.709
D1D2	0.0	0.0	0.090	0.716	0.805	0.305	0.984	0.984
D2D3	0.0	0.358	0.627	1.702	2.329	3.045	3.493	4.479
D3D4	0.0	0.0	0.0	1.474	1.934	2.763	3.777	10.501
D4D5	0.0	0.090	0.0	0.992	1.443	2.075	2.345	3.608
D5D6	0.0	0.091	0.091	0.453	0.453	1.087	1.087	1.450
E1E2	0.0	0.091	0.273	0.729	0.911	1.275	1.093	1.458
E2E3	0.0	0.181	0.362	1.719	2.081	2.805	2.524	3.348
E3E4	0.0	0.179	0.179	1.433	2.419	2.419	2.509	4.838
E4E5	0.0	0.092	0.092	0.278	0.370	0.648	1.203	1.481
E5E6	0.0	0.0	0.0	0.0	0.178	0.535	0.624	0.802
F1F2	0.0	0.0	0.180	0.180	0.541	0.541	0.541	0.812

SPECIMEN:SC4 ,SIDE:WEST

STRAIN	LOAD STAGE 0	1	2	3	4	5	6	7
F2F3	0.0	0.0	0.0	0.181	0.542	0.723	0.813	0.813
F3F4	0.0	0.0	0.0	0.271	0.452	0.543	0.633	0.633
F4F5	0.0	0.0	0.0	0.442	0.618	1.148	1.325	2.474
F5F6	0.0	0.091	0.091	0.274	0.548	0.731	0.731	0.731
G1G2	0.0	0.090	0.452	0.633	0.633	0.904	0.904	0.994
G2G3	0.0	0.0	1.097	1.280	1.371	1.371	1.645	1.645
G3G4	0.0	0.179	0.269	0.806	0.396	1.075	1.164	1.164
G4G5	0.0	0.090	0.090	0.631	0.902	1.082	1.262	1.533
G5G6	0.0	0.091	0.091	0.091	0.274	0.274	0.274	0.274
A1B2	-0.155	0.361	0.465	0.723	1.446	1.962	2.427	4.595
A2B1	-0.154	0.205	0.615	0.666	1.024	1.075	0.371	1.485
A2B3	-0.104	0.939	2.034	2.608	2.973	3.286	3.912	1.878
A3B2	-0.156	-0.208	0.0	0.208	0.831	1.351	1.870	3.273
A3B4	-0.153	0.562	2.399	3.522	5.053	7.299	******	******
A4B3	-0.209	-0.157	-0.522	-1.096	-1.566	-2.036	-3.602	******
A4B5	-0.153	-0.102	0.664	1.378	2.195	3.471	******	******
A5B4	-0.157	-0.681	-1.204	-1.832	-2.251	-2.722	******	******
A5B6	-0.370	-0.370	-0.317	-0.317	-0.317	-0.159	-0.053	1.323
A6B5	-0.158	-0.686	-0.792	-0.739	-0.581	-0.317	-0.158	-0.033
C1D2	-0.157	-0.052	0.366	0.836	1.044	1.201	1.097	0.679
C2D1	-0.150	-0.100	0.050	0.449	0.499	0.599	0.649	0.050
C2D3	-0.153	0.051	0.460	1.175	1.533	1.942	2.504	4.395
C3D2	-0.154	-0.103	0.0	-0.103	-0.103	0.205	0.0	0.0
C3D4	-0.151	-0.050	0.100	1.407	2.060	2.814	3.768	3.567
C4D3	-0.106	-0.159	-0.212	-0.318	-0.265	-0.159	-0.371	-0.424
C4D5	******	******	******	******	******	******	******	******
C5D4	-0.161	-0.268	-0.432	-0.535	-0.749	-0.589	-0.303	-0.856
C5D6	******	******	******	******	******	******	******	******
C6D5	-0.158	-0.264	-0.422	-0.422	-0.369	-0.264	-0.211	0.317
D1E2	-0.159	-0.159	-0.212	0.053	0.370	0.423	0.370	-0.053
D2E1	-0.153	-0.153	-0.256	-0.153	-0.153	0.0	-0.153	-0.511
D2E3	-0.208	0.0	0.104	0.676	1.092	1.352	1.352	1.664
D3E2	-0.153	-0.102	-0.408	-0.408	-0.561	-0.459	-0.306	-1.173
D3E4	-0.205	-0.103	-0.154	1.180	1.744	2.001	2.976	3.489
D4E3	-0.157	-0.157	-0.471	-0.889	-1.360	-1.883	-1.883	-2.931
D4E5	******	0.0	-0.256	0.308	0.615	1.025	1.230	2.204
D5E4	-0.217	-0.271	-0.325	-0.542	-0.813	-0.868	-1.030	-1.410
D5E6	-0.154	-0.154	-0.256	0.051	0.205	0.461	0.566	0.620
D6E5	-0.165	-0.165	-0.165	-0.220	-0.494	-0.549	-0.549	-0.275
F1G2	0.0	-0.100	0.0	-0.199	0.399	0.698	0.848	0.897
F2G1	0.154	0.154	0.051	0.462	0.411	0.514	0.616	0.205
F2G3	******	******	******	******	******	******	******	******
F3G2	0.103	0.0	0.517	1.137	1.498	2.015	2.315	1.363
F3G4	-0.215	-0.377	-0.431	-0.646	-0.808	-0.862	-0.970	-0.970
F4G3	-0.154	-0.257	-0.052	0.257	0.721	1.081	1.287	1.236
F4G5	-0.211	-0.370	-0.476	-0.793	-0.899	-0.952	-1.005	-1.216
F5G4	-0.100	-0.050	0.0	0.150	0.548	1.047	1.246	******
F5G6	-0.105	-0.419	-0.785	-0.994	-1.308	-1.465	-1.522	-1.779
F6G5	-0.150	-0.150	-0.300	-0.050	0.300	0.351	0.351	0.601

TABLE B.9 : PRINCIPAL STRAINS FOR SC1.

LOAD STAGE: 1

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.212	0.976	0.104	0.052	0.055	0.977	-0.213	1.190	91.33	1.33
2	-0.113	0.454	0.206	-0.370	0.603	0.584	-0.244	0.828	113.39	23.39
3	-0.145	0.430	0.229	-0.448	0.710	0.600	-0.314	0.914	115.50	25.50
4	-0.575	0.113	-0.178	-0.658	0.504	0.196	-0.657	0.853	108.10	18.10
5	-0.510	0.158	-0.257	-0.343	0.090	0.161	-0.513	0.675	93.85	3.85
6	-0.079	0.068	-0.001	-0.051	0.052	0.072	-0.083	0.156	99.75	9.75
7	-0.128	0.159	-0.153	0.029	-0.191	0.188	-0.157	0.344	73.17	-16.83
8	-0.207	0.136	-0.001	-0.232	0.242	0.174	-0.246	0.420	107.63	17.63
9	-0.320	0.136	0.835	-0.440	1.336	0.614	-0.798	1.412	125.59	35.59
10	-0.438	0.136	-0.158	-0.419	0.273	0.167	-0.469	0.635	102.74	12.74
11	-0.174	0.113	-0.103	-0.206	0.108	0.123	-0.184	0.307	100.31	10.31
12	-0.188	0.068	-0.102	-0.280	0.186	0.098	-0.219	0.317	108.00	18.00
13	-0.238	0.136	-0.128	-0.204	0.079	0.140	-0.242	0.382	95.98	5.98
14	-0.336	0.113	-0.128	-0.051	-0.080	0.117	-0.340	0.456	84.94	-5.06
15	-0.352	0.159	-0.155	-0.158	0.003	0.159	-0.352	0.511	90.18	0.18
16	-0.051	0.091	0.0	-0.160	0.167	0.130	-0.090	0.219	114.86	24.86
17	-0.102	0.476	0.055	0.0	0.058	0.478	-0.103	0.581	92.86	2.86
18	-0.220	0.203	-0.207	-0.379	0.180	0.222	-0.239	0.460	101.53	11.53
19	-0.382	0.158	-0.311	-0.163	-0.156	0.169	-0.393	0.562	81.95	-8.05
20	-0.485	0.181	-0.415	-0.184	-0.243	0.202	-0.507	0.709	79.99	-10.01

LOAD STAGE: 2

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.245	2.202	0.756	0.447	0.324	2.213	-0.256	2.469	93.78	3.78
2	0.418	1.474	0.489	-0.290	0.817	1.614	0.278	1.335	108.85	18.85
3	0.627	2.511	3.117	-0.739	4.042	3.799	-0.661	4.459	122.51	32.51
4	-0.573	1.426	1.424	-1.215	2.766	2.133	-1.280	3.413	117.07	27.07
5	-0.941	0.748	-0.025	-0.318	0.307	0.761	-0.954	1.716	95.15	5.15
6	-0.284	0.249	0.235	-0.077	0.327	0.295	-0.330	0.626	105.73	15.73
7	-0.479	0.250	0.126	0.056	0.073	0.252	-0.481	0.732	92.86	2.86
8	-0.463	0.136	0.307	-0.387	0.728	0.308	-0.635	0.942	115.28	25.28
9	-0.351	0.136	-1.330	-0.465	-0.907	0.407	-0.623	1.029	59.12	-30.88
10	-0.389	0.136	-0.184	-0.645	0.483	0.230	-0.484	0.714	111.31	21.31
11	-0.237	0.113	0.105	-0.154	0.272	0.160	-0.284	0.444	108.88	18.88
12	-0.283	0.136	-0.127	-0.332	0.214	0.162	-0.308	0.470	103.56	13.56
13	-0.332	0.204	-0.101	-0.255	0.161	0.215	-0.344	0.560	98.36	8.36
14	-0.368	0.158	-0.001	-0.336	0.352	0.212	-0.421	0.633	106.88	16.88
15	-0.336	0.204	-0.130	-0.158	0.029	0.204	-0.337	0.541	91.56	1.56
16	-0.034	0.045	0.110	0.0	0.116	0.076	-0.065	0.140	117.72	27.72
17	-0.000	0.272	-0.081	-0.053	-0.029	0.273	-0.001	0.274	86.99	-3.01
18	-0.203	0.136	-0.209	-0.379	0.179	0.158	-0.225	0.383	103.90	13.90
19	-0.416	0.181	-0.416	-0.163	-0.266	0.209	-0.444	0.653	77.99	-12.01
20	-0.550	0.181	-0.467	-0.262	-0.215	0.197	-0.565	0.762	81.81	-8.19

TABLE B.9 :(Cont'd) PRINCIPAL STRAINS FOR SC1.

LOAD STAGE: 3

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.000	3.678	1.646	1.080	0.593	3.702	-0.023	3.726	94.58	4.58
2	0.756	2.359	0.693	0.054	0.671	2.426	0.689	1.737	101.35	11.35
3	1.029	5.382	5.620	-1.029	6.970	7.314	-0.904	8.217	119.01	29.01
4	-0.589	4.639	3.891	-1.905	6.075	6.032	-1.982	8.014	114.64	24.64
5	-1.068	1.972	0.203	-0.425	0.659	2.007	-1.103	3.110	96.12	6.12
6	-0.157	2.489	1.298	-0.002	1.363	2.654	-0.323	2.977	103.63	13.63
7	-0.480	2.722	2.229	0.006	2.330	3.101	-0.859	3.960	108.02	18.02
8	-0.560	3.554	1.861	-0.362	2.330	3.861	-0.867	4.728	104.76	14.76
9	-0.434	0.882	1.639	-0.570	2.316	1.555	-1.108	2.663	120.20	30.20
10	-0.518	0.317	-0.132	-0.259	0.134	0.322	-0.523	0.845	94.55	4.55
11	0.188	1.770	1.383	-0.130	1.585	2.099	-0.141	2.239	112.53	22.53
12	-0.000	2.405	1.534	-0.028	1.638	2.657	-0.253	2.910	107.13	17.13
13	-0.539	1.177	0.779	-0.511	1.352	1.411	-0.773	2.184	109.11	19.11
14	-0.543	0.385	0.052	-0.360	0.431	0.432	-0.591	1.023	102.46	12.46
15	-0.337	0.227	-0.053	-0.158	0.110	0.232	-0.342	0.574	95.54	5.54
16	0.187	0.159	0.056	0.0	0.058	0.205	0.141	0.065	147.61	57.61
17	0.119	0.476	0.082	0.0	0.086	0.481	0.114	0.368	96.78	6.78
18	-0.220	0.113	-0.105	-0.434	0.345	0.186	-0.293	0.479	112.99	22.99
19	-0.465	0.113	-0.416	-0.217	-0.209	0.131	-0.484	0.615	80.08	-9.92
20	-0.614	0.113	-0.519	-0.236	-0.297	0.142	-0.644	0.786	78.90	-11.10

LOAD STAGE: 4

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.311	4.791	1.960	1.529	0.452	4.802	0.299	4.503	92.88	2.88
2	1.144	2.790	0.872	0.318	0.581	2.840	1.094	1.746	99.72	9.72
3	1.334	7.845	7.893	-1.292	9.628	10.401	-1.222	11.623	117.97	27.97
4	-0.765	10.223	8.107	-2.958	11.599	12.717	-3.259	15.977	113.28	23.28
5	-1.354	5.278	1.868	-0.460	2.440	5.496	-1.572	7.067	100.10	10.10
6	-0.300	2.876	2.023	0.045	2.073	3.184	-0.608	3.792	106.57	16.57
7	-0.592	6.646	5.275	1.032	4.448	7.275	-1.221	8.495	105.79	15.79
8	-0.560	10.640	7.944	-1.032	9.409	12.354	-2.274	14.628	110.02	20.02
9	-0.451	3.435	2.491	-1.037	3.698	4.174	-1.190	5.364	111.79	21.79
10	-0.470	0.701	-0.027	-0.587	0.587	0.771	-0.539	1.310	103.31	13.31
11	0.220	2.587	1.687	-0.129	1.903	2.922	-0.115	3.037	109.40	19.40
12	-0.000	8.167	4.544	0.767	3.959	8.621	-0.455	9.076	102.93	12.93
13	-0.571	4.254	2.853	-0.922	3.957	4.962	-1.278	6.240	109.68	19.68
14	-0.479	1.335	0.908	-0.713	1.699	1.671	-0.815	2.486	111.57	21.57
15	-0.065	0.408	0.624	0.0	0.654	0.575	-0.232	0.807	117.08	27.08
16	0.238	0.091	0.110	-0.160	0.283	0.324	0.005	0.319	148.70	58.70
17	0.203	0.431	0.131	0.0	0.137	0.450	0.184	0.265	105.52	15.52
18	-0.220	0.090	0.107	-0.542	0.681	0.309	-0.439	0.748	122.75	32.75
19	-0.598	0.158	-0.520	-0.136	-0.403	0.208	-0.648	0.856	75.98	-14.02
20	-0.728	0.476	-0.726	-0.025	-0.735	0.579	-0.832	1.411	74.29	-15.71

TABLE B.9 :(Cont'd) PRINCIPAL STRAINS FOR SC1.

LOAD STAGE: 5

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.245	4.541	1.986	1.555	0.452	4.553	0.233	4.320	93.00	3.00
2	1.031	2.858	1.206	0.001	1.263	3.055	0.834	2.221	107.33	17.33
3	1.253	9.834	9.195	-1.530	11.242	12.615	-1.528	14.142	116.32	26.32
4	-1.163	11.805	9.148	-3.557	13.318	14.616	-3.974	18.589	112.88	22.88
5	-1.897	6.228	2.533	-0.645	3.332	6.557	-2.225	8.782	101.15	11.15
6	-0.379	6.927	3.794	0.288	3.675	7.363	-0.815	8.178	103.35	13.35
7	-0.816	10.864	7.244	1.853	5.650	11.511	-1.463	12.975	102.91	12.91
8	-0.813	17.818	12.135	-2.633	15.480	20.614	-3.609	24.222	109.86	19.86
9	-0.907	8.907	5.698	-3.561	9.706	10.901	-2.902	13.803	112.34	22.34
10	-0.524	3.935	2.584	-0.422	3.151	4.436	-1.025	5.461	107.62	17.62
11	0.594	5.876	5.784	0.219	5.832	7.170	-0.700	7.869	113.92	23.92
12	-0.127	10.072	5.744	-0.726	6.782	11.096	-1.152	12.248	106.81	16.81
13	-0.799	10.522	5.017	-1.309	6.631	11.422	-1.699	13.120	105.18	15.18
14	0.017	4.887	3.024	-1.358	4.593	5.799	-0.895	6.694	111.66	21.66
15	0.126	1.381	0.804	0.106	0.732	1.480	0.027	1.453	105.13	15.13
16	0.238	0.136	0.327	-0.053	0.399	0.393	-0.019	0.412	142.13	52.13
17	0.085	0.295	0.105	******	******	******	******	******	******	******
18	-0.303	0.068	-0.025	-0.542	0.542	0.211	-0.446	0.657	117.80	27.80
19	-0.695	0.248	-0.571	-0.191	-0.398	0.288	-0.736	1.024	78.56	-11.44
20	-0.954	0.680	-0.830	0.001	-0.871	0.788	-1.063	1.852	75.97	-14.03

TABLE B.10: PRINCIPAL STRAINS FOR SC2.

LOAD STAGE: 1

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.136	0.113	******	******	******	******	******	******	******	******
2	0.039	0.0	******	******	******	******	******	******	******	******
3	-0.069	0.045	******	******	******	******	******	******	******	******
4	-0.352	0.0	******	******	******	******	******	******	******	******
5	-0.470	0.178	******	******	******	******	******	******	******	******
6	-0.033	0.068	-0.164	-0.304	0.147	0.106	-0.072	0.178	117.76	27.76
7	-0.033	******	******	-0.241	******	******	******	******	******	******
8	-0.268	0.045	-0.276	0.0	-0.289	0.102	-0.325	0.426	68.64	-21.36
9	-0.269	******	-0.504	0.0	******	******	******	******	******	******
10	-0.259	0.023	-0.194	0.738	-0.977	0.390	-0.626	1.017	53.04	-36.96
11	-0.383	0.113	******	-0.402	******	******	******	******	******	******
12	-0.383	******	0.0	0.456	******	******	******	******	******	******
13	-0.174	0.023	0.0	-0.505	0.529	0.207	-0.358	0.565	124.82	34.82
14	-0.224	******	-0.275	-0.293	******	******	******	******	******	******
15	-0.241	0.091	-0.627	-0.224	-0.422	0.193	-0.344	0.537	64.10	-25.90
16	0.137	0.0	-0.192	0.0	-0.201	0.190	-0.053	0.243	207.90	117.90
17	0.137	******	0.001	-0.166	******	******	******	******	******	******
18	-0.238	0.135	-0.196	-0.111	-0.090	0.140	-0.244	0.384	83.23	-6.77
19	-0.238	******	-0.339	-0.167	******	******	******	******	******	******
20	-0.480	0.317	-0.462	-0.165	-0.312	0.346	-0.509	0.855	79.31	-10.69

LOAD STAGE: 2

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.069	0.790	******	******	******	******	******	******	******	******
2	-0.250	0.724	******	******	******	******	******	******	******	******
3	-0.390	0.113	******	******	******	******	******	******	******	******
4	-0.211	0.271	******	******	******	******	******	******	******	******
5	-1.067	0.777	******	******	******	******	******	******	******	******
6	-0.067	0.090	-0.219	-0.304	0.089	0.102	-0.079	0.181	104.81	14.81
7	-0.067	******	******	-0.321	******	******	******	******	******	******
8	-0.335	0.045	-0.221	0.0	-0.231	0.078	-0.367	0.445	74.34	-15.66
9	-0.303	******	2.197	0.0	******	******	******	******	******	******
10	-0.313	0.499	1.608	-0.335	2.036	1.189	-1.003	2.192	124.13	34.13
11	-0.382	0.136	-0.337	-0.243	-0.099	0.140	-0.387	0.527	84.59	-5.41
12	-0.382	******	******	1.071	******	******	******	******	******	******
13	-0.137	0.023	******	-0.532	******	******	******	******	******	******
14	-0.206	******	-0.279	-0.293	******	******	******	******	******	******
15	-0.241	0.544	-1.367	-0.168	-1.257	0.892	-0.589	1.482	61.00	-29.00
16	0.410	0.090	-0.221	0.167	-0.407	0.509	-0.008	0.518	205.91	115.91
17	0.410	******	0.0	0.221	******	******	******	******	******	******
18	-0.239	0.292	-0.397	0.277	-0.706	0.469	-0.415	0.884	63.48	-26.52
19	-0.239	******	-0.587	-0.111	******	******	******	******	******	******
20	-0.927	0.430	-0.462	-0.514	0.054	0.430	-0.928	1.358	91.14	1.14

TABLE B.10(Cont'd) PRINCIPAL STRAINS FOR SC2.

LOAD STAGE: 3

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.067	1.355	0.731	0.952	-0.232	1.365	-0.077	1.442	85.38	-4.62
2	-0.067	1.448	******	-1.818	******	******	******	******	******	******
3	-0.916	1.062	******	-3.125	******	******	******	******	******	******
4	-0.916	1.040	7.088	-2.339	9.882	5.099	-4.975	10.073	129.40	39.40
5	-1.631	1.715	******	-0.609	******	******	******	******	******	******
6	0.635	1.362	0.820	0.577	0.255	1.383	0.613	0.770	99.65	9.65
7	0.635	0.972	******	-0.080	******	******	******	******	******	******
8	-0.268	1.085	1.545	0.0	1.620	1.464	-0.647	2.111	115.06	25.06
9	-0.134	1.176	0.993	0.0	1.041	1.358	-0.316	1.673	109.23	19.23
10	-0.125	0.793	0.749	-0.168	0.961	0.998	-0.330	1.329	113.17	23.17
11	-0.107	1.334	0.056	-0.104	0.168	1.339	-0.112	1.451	93.32	3.32
12	-0.107	1.040	******	0.529	******	******	******	******	******	******
13	-0.104	1.289	******	-1.090	******	******	******	******	******	******
14	-0.052	2.392	1.283	-0.702	2.081	2.775	-0.435	3.210	110.20	20.20
15	-0.035	1.110	0.285	-0.224	0.534	1.169	-0.094	1.263	102.49	12.49
16	1.026	0.769	0.136	0.934	-0.837	1.335	0.459	0.876	216.47	126.47
17	1.026	0.454	0.223	1.160	-0.982	1.308	0.172	1.136	209.90	119.90
18	-0.206	0.631	-0.624	1.439	-2.162	1.371	-0.947	2.318	55.57	-34.43
19	-0.206	0.317	-1.174	0.334	-1.581	0.888	-0.777	1.665	54.15	-35.85
20	-1.464	0.927	-1.386	0.212	-1.676	1.192	-1.728	2.920	72.49	-17.51

LOAD STAGE: 4

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.475	3.707	1.109	1.400	-0.305	3.712	-0.481	4.193	87.92	-2.08
2	-0.593	2.900	******	-2.727	******	******	******	******	******	******
3	-1.412	3.616	******	-4.551	******	******	******	******	******	******
4	-2.114	2.894	9.290	-1.671	11.489	6.656	-5.876	12.533	123.22	33.22
5	-1.967	2.827	******	-1.651	******	******	******	******	******	******
6	0.764	2.314	1.421	0.825	0.625	2.375	0.703	1.672	100.97	10.97
7	0.764	1.560	******	-0.321	******	******	******	******	******	******
8	-0.402	2.578	3.201	0.0	3.355	3.332	-1.156	4.488	114.19	24.19
9	0.036	4.237	2.867	0.0	3.005	4.720	-0.447	5.166	107.79	17.79
10	0.165	1.014	0.833	5.309	-4.691	2.973	-1.794	4.767	50.13	-39.87
11	-0.455	2.285	0.056	0.326	-0.282	2.292	-0.462	2.754	87.06	-2.94
12	-0.455	1.650	******	-0.303	******	******	******	******	******	******
13	-0.111	3.460	******	-2.977	******	******	******	******	******	******
14	-0.193	2.126	4.573	-1.405	6.266	4.307	-2.374	6.682	124.84	34.84
15	-0.172	1.221	******	-0.280	******	******	******	******	******	******
16	1.197	1.040	0.512	1.238	-0.761	1.507	0.730	0.777	219.19	129.19
17	1.197	0.452	-1.729	1.602	-3.491	2.609	-0.960	3.569	218.98	128.98
18	0.133	0.811	-1.361	2.767	-4.327	2.662	-1.718	4.380	49.45	-40.55
19	0.133	2.082	-2.290	-2.669	0.398	2.102	0.113	1.989	95.77	5.77
20	-2.145	1.493	-3.754	0.216	-4.161	2.437	-3.090	5.527	65.58	-24.42

TABLE B.11:PRINCIPAL STRAINS FOR SC3.

LOAD STAGE: 1

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.484	0.068	0.380	0.043	0.398	0.564	-0.012	0.576	158.14	68.14
2	0.252	0.023	0.221	0.220	0.001	0.252	-0.023	0.230	179.82	89.82
3	0.002	0.022	0.0	-0.171	0.202	0.113	-0.090	0.203	132.20	42.20
4	-0.316	0.091	-0.171	-0.314	0.169	0.107	-0.333	0.440	101.26	11.26
5	-0.783	0.045	-0.499	-0.362	-0.162	0.053	-0.791	0.844	84.46	-5.54
6	0.061	0.0	-0.041	0.021	-0.073	0.078	-0.017	0.095	205.18	115.18
7	0.000	0.0	0.0	-0.191	0.226	0.113	-0.113	0.226	135.06	45.06
8	-0.098	0.045	-0.084	-0.168	0.100	0.061	-0.113	0.174	107.47	17.47
9	-0.208	0.069	-0.105	-0.235	0.154	0.089	-0.228	0.317	104.57	14.57
10	-0.303	0.068	-0.305	-0.276	-0.034	0.068	-0.304	0.372	87.38	-2.62
11	-0.097	0.0	-0.084	-0.173	0.105	0.023	-0.120	0.143	113.68	23.68
12	-0.124	0.0	-0.042	-0.174	0.157	0.038	-0.162	0.200	115.81	25.81
13	-0.149	0.113	0.043	-0.216	0.306	0.184	-0.219	0.403	114.74	24.74
14	-0.208	0.068	-0.085	-0.217	0.156	0.088	-0.229	0.317	104.76	14.76
15	-0.361	0.0	-0.210	-0.223	0.015	0.000	-0.361	0.361	91.18	1.18
16	-0.147	0.111	0.551	0.064	0.576	0.297	-0.334	0.631	122.92	32.92
17	-0.111	0.0	-0.043	0.108	-0.179	0.050	-0.161	0.210	60.90	-29.10
18	-0.112	0.045	-0.066	0.023	-0.105	0.061	-0.128	0.189	73.18	-16.82
19	-0.269	0.045	-0.198	-0.088	-0.131	0.058	-0.282	0.340	78.69	-11.31
20	-0.527	0.023	-0.434	-0.214	-0.261	0.052	-0.557	0.609	77.31	-12.69

LOAD STAGE: 2

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.007	0.250	0.886	0.391	0.586	1.107	0.150	0.957	161.13	71.13
2	0.819	0.427	1.370	0.615	0.893	1.111	0.136	0.975	146.85	56.85
3	0.365	0.575	0.520	-0.256	0.919	0.941	-0.001	0.942	128.58	38.58
4	-0.435	0.498	0.235	-0.628	1.021	0.723	-0.660	1.383	113.78	23.78
5	-1.592	0.293	-0.672	-1.311	0.757	0.366	-1.665	2.031	100.93	10.93
6	0.596	0.498	0.766	0.453	0.371	0.739	0.355	0.384	142.40	52.40
7	0.339	0.181	0.937	-0.319	1.486	1.007	-0.487	1.495	138.02	48.02
8	0.047	0.290	0.489	-0.421	1.077	0.721	-0.383	1.104	128.65	38.65
9	-0.146	0.207	0.196	-0.472	0.790	0.463	-0.402	0.866	122.96	32.96
10	-0.339	0.113	-0.327	-0.278	-0.058	0.115	-0.341	0.455	86.32	-3.68
11	-0.157	0.068	0.126	-0.173	0.354	0.165	-0.254	0.419	118.79	28.79
12	-0.236	0.0	0.089	-0.369	0.543	0.178	-0.414	0.592	123.26	33.26
13	-0.288	0.113	0.086	-0.367	0.535	0.247	-0.422	0.669	116.57	26.57
14	-0.272	0.067	0.0	-0.630	0.746	0.307	-0.512	0.819	122.78	32.78
15	-0.272	0.022	-0.168	-0.311	0.169	0.045	-0.295	0.340	104.95	14.95
16	0.196	0.269	0.508	0.618	-0.130	0.308	0.158	0.149	59.69	-30.31
17	0.233	0.045	0.215	0.519	-0.359	0.342	-0.063	0.405	211.18	121.18
18	0.035	0.090	-0.260	0.465	-0.857	0.492	-0.367	0.859	46.84	-43.16
19	-0.391	0.136	-0.430	-0.022	-0.484	0.230	-0.485	0.715	68.70	-21.30
20	-0.839	0.068	-0.805	-0.171	-0.751	0.203	-0.974	1.177	70.18	-19.82

TABLE B.11 (Cont'd) PRINCIPAL STRAINS FOR SC3.

LOAD STAGE: 3

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.224	0.389	1.097	0.783	0.372	1.264	0.350	0.914	167.98	77.98
2	1.149	0.743	2.033	0.791	1.469	1.708	0.184	1.524	142.71	52.71
3	0.504	1.376	1.467	-0.512	2.342	2.190	-0.310	2.499	124.79	34.79
4	-0.591	0.792	0.470	-1.046	1.794	1.233	-1.032	2.266	116.18	26.18
5	-2.300	0.586	-0.868	-2.034	1.381	0.743	-2.455	3.200	102.78	12.78
6	1.132	1.200	1.426	0.864	0.665	1.500	0.832	0.669	132.08	42.08
7	0.687	0.430	1.448	-0.426	2.219	1.675	-0.558	2.234	138.31	48.31
8	0.214	0.941	1.190	-0.589	2.106	1.692	-0.536	2.228	125.47	35.47
9	-0.146	0.945	1.005	-0.857	2.204	1.629	-0.830	2.459	121.83	31.83
10	-0.326	0.729	-0.157	-0.197	0.047	0.729	-0.327	1.056	91.26	1.26
11	0.060	0.973	0.547	-0.216	0.903	1.159	-0.126	1.285	112.35	22.35
12	-0.026	0.362	0.872	-0.434	1.546	0.965	-0.629	1.594	127.96	37.96
13	-0.136	0.971	1.113	-0.734	2.186	1.643	-0.808	2.451	121.57	31.57
14	-0.098	0.937	0.979	-0.803	2.109	1.594	-0.756	2.350	121.93	31.93
15	-0.100	0.661	0.505	-0.378	1.046	0.927	-0.365	1.294	116.97	26.97
16	0.883	0.677	0.551	1.299	-0.886	1.235	0.325	0.910	218.46	128.46
17	0.897	0.431	0.387	1.277	-1.053	1.240	0.083	1.151	213.05	123.05
18	0.607	0.474	-0.345	1.547	-2.239	1.662	-0.581	2.243	223.31	133.31
19	-0.067	0.634	-0.821	0.899	-2.036	1.360	-0.793	2.153	54.50	-35.50
20	-0.933	0.430	-1.265	0.086	-1.599	0.799	-1.302	2.101	65.22	-24.78

LOAD STAGE: 4

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.364	0.459	1.203	1.087	0.137	1.369	0.454	0.915	175.70	85.70
2	1.402	0.878	2.563	1.055	1.785	2.070	0.210	1.860	143.17	53.17
3	0.568	1.125	1.764	-0.597	2.795	2.271	-0.579	2.850	129.36	39.36
4	-0.724	0.860	0.598	-1.213	2.144	1.401	-1.265	2.666	116.77	26.77
5	-2.665	0.542	-0.954	-2.576	1.920	0.807	-2.931	3.738	105.45	15.45
6	1.290	1.358	1.661	1.037	0.738	1.695	0.953	0.742	132.36	42.36
7	0.771	0.840	1.789	-0.513	2.724	2.168	-0.557	2.725	134.28	44.28
8	0.262	1.165	1.340	-0.758	2.483	2.035	-0.607	2.642	125.01	35.01
9	-0.109	1.081	1.281	-0.943	2.633	1.931	-0.959	2.889	122.84	32.84
10	-0.363	0.934	-0.158	-0.136	-0.026	0.934	-0.363	1.297	89.42	-0.58
11	0.132	1.109	0.589	-0.303	1.056	1.340	-0.098	1.438	113.61	23.61
12	0.073	0.772	1.065	-0.584	1.952	1.459	-0.615	2.073	125.15	35.15
13	-0.073	1.129	1.370	-0.862	2.641	1.979	-0.923	2.901	122.76	32.76
14	-0.037	1.094	1.234	-1.063	2.719	2.001	-0.943	2.945	123.71	33.71
15	-0.013	0.867	0.757	-0.533	1.528	1.309	-0.455	1.764	120.03	30.03
16	1.177	0.925	0.508	1.555	-1.239	1.683	0.419	1.265	219.24	129.24
17	1.168	0.544	0.560	1.645	-1.285	1.570	0.142	1.428	212.05	122.05
18	0.755	0.791	-0.366	1.966	-2.761	2.154	-0.607	2.761	45.37	-44.63
19	-0.066	0.838	-0.931	1.163	-2.478	1.705	-0.933	2.638	55.02	-34.98
20	-1.028	0.566	-1.170	0.171	-1.587	0.894	-1.356	2.250	67.56	-22.44

TABLE B.11 (Cont'd) PRINCIPAL STRAINS FOR SC3.

LOAD STAGE: 5

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.540	0.644	1.203	1.174	0.034	1.541	0.643	0.897	178.91	88.91
2	1.832	1.285	3.226	1.187	2.413	2.796	0.321	2.475	141.39	51.39
3	0.707	1.582	2.253	-0.895	3.726	3.058	-0.769	3.827	128.39	38.39
4	-0.855	1.200	0.812	-1.610	2.867	1.936	-1.591	3.527	117.18	27.18
5	-3.153	0.859	-1.107	-3.074	2.328	1.172	-3.466	4.638	105.07	15.07
6	1.473	1.698	1.915	1.081	0.988	2.092	1.079	1.013	128.57	38.57
7	0.879	0.840	1.959	-0.513	2.926	2.323	-0.604	2.926	135.39	45.39
8	0.285	1.390	1.763	-0.926	3.182	2.522	-0.847	3.368	125.43	35.43
9	-0.134	1.193	1.430	-1.072	2.961	2.152	-1.093	3.245	122.93	32.93
10	-0.314	1.321	-0.029	-0.137	0.127	1.324	-0.317	1.640	92.23	2.23
11	0.181	1.358	0.716	-0.303	1.205	1.612	-0.073	1.685	112.84	22.84
12	0.134	0.794	1.483	-0.671	2.550	1.781	-0.853	2.634	127.74	37.74
13	-0.036	1.400	1.626	-0.928	3.023	2.355	-0.991	3.346	122.30	32.30
14	-0.024	1.205	1.490	-1.107	3.073	2.246	-1.064	3.310	124.09	34.09
15	-0.077	1.209	0.926	-0.645	1.859	1.697	-0.564	2.261	117.66	27.66
16	1.472	1.014	0.593	1.705	-1.316	1.939	0.546	1.393	215.41	125.41
17	1.476	0.658	0.560	2.101	-1.824	2.066	0.067	1.999	212.92	122.92
18	0.916	0.859	-0.497	2.497	-3.543	2.659	-0.884	3.543	224.54	134.54
19	-0.091	1.064	-1.287	1.514	-3.315	2.242	-1.268	3.510	54.60	-35.40
20	-1.124	0.792	-1.319	0.385	-2.017	1.225	-1.557	2.783	66.77	-23.23

LOAD STAGE: 6

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.512	1.062	1.266	1.653	-0.457	1.608	0.965	0.642	202.72	112.72
2	2.238	1.600	3.977	1.231	3.250	3.575	0.263	3.312	140.55	50.55
3	0.630	1.948	2.825	-1.833	5.514	4.124	-1.546	5.670	128.28	38.28
4	-1.314	1.698	1.068	-2.259	3.938	2.671	-2.287	4.958	116.29	26.29
5	-4.124	1.423	-1.258	-3.481	2.630	1.719	-4.420	6.139	102.69	12.69
6	1.546	1.811	2.002	1.124	1.039	2.214	1.142	1.072	127.83	37.83
7	0.951	1.089	2.258	-0.556	3.330	2.686	-0.646	3.333	133.81	43.81
8	0.382	1.569	2.080	-1.052	3.708	2.922	-0.971	3.893	126.12	36.12
9	-0.084	1.439	1.707	-1.179	3.416	2.548	-1.192	3.740	122.98	32.98
10	-0.290	1.391	0.098	-0.012	0.130	1.394	-0.293	1.686	92.22	2.22
11	0.241	1.448	0.842	-0.389	1.457	1.791	-0.101	1.892	115.17	25.17
12	0.270	0.908	1.675	-0.780	2.906	2.077	-0.898	2.975	128.81	38.81
13	0.040	1.557	1.926	-0.992	3.454	2.685	-1.088	3.772	123.14	33.14
14	-0.037	1.429	1.787	-1.302	3.657	2.666	-1.274	3.940	124.08	34.08
15	-0.051	1.415	1.136	-0.645	2.108	1.966	-0.602	2.568	117.59	27.59
16	1.717	1.181	0.847	1.896	-1.242	2.125	0.773	1.352	213.33	123.33
17	1.709	0.952	0.517	2.534	-2.388	2.583	0.078	2.505	216.20	126.20
18	1.040	1.130	-0.733	2.983	-4.398	3.284	-1.115	4.399	45.59	-44.41
19	-0.174	1.313	-1.373	1.799	-3.755	2.589	-1.453	4.039	55.81	-34.19
20	-1.388	0.974	-1.530	0.428	-2.317	1.447	-1.861	3.309	67.77	-22.23

TABLE B.11(Cont'd) PRINCIPAL STRAINS FOR SC3.

LOAD STAGE: 7

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	1.903	1.760	1.776	1.696	0.094	1.917	1.746	0.171	163.26	73.26
2	2.761	2.308	5.038	1.275	4.454	4.773	0.296	4.477	137.90	47.90
3	0.098	4.208	3.984	-3.497	8.854	7.034	-2.728	9.762	122.55	32.55
4	-3.052	3.214	1.901	-4.722	7.839	5.099	-4.937	10.035	115.68	25.68
5	-8.480	4.590	-2.458	******	******	******	******	******	******	******
6	1.448	2.196	2.149	1.124	1.213	2.535	1.109	1.425	119.18	29.18
7	0.842	1.201	2.471	-0.662	3.708	2.884	-0.841	3.725	132.23	42.23
8	0.432	1.906	2.674	-1.515	4.958	3.755	-1.417	5.173	126.72	36.72
9	-0.022	1.781	2.176	-1.586	4.453	3.282	-1.522	4.804	123.97	33.97
10	-0.254	1.603	0.140	-0.076	0.256	1.611	-0.263	1.874	93.92	3.92
11	0.217	1.720	0.905	-0.605	1.787	2.136	-0.199	2.335	114.97	24.97
12	0.446	0.817	2.065	-0.933	3.549	2.416	-1.153	3.569	132.02	42.02
13	0.180	1.963	2.268	-1.208	4.115	3.314	-1.171	4.485	123.28	33.28
14	0.012	1.585	2.000	-1.549	4.201	3.041	-1.445	4.486	124.74	34.74
15	-0.028	1.650	1.304	-0.823	2.518	2.324	-0.702	3.025	118.16	28.16
16	1.717	1.897	0.932	1.833	-1.067	2.348	1.266	1.082	49.78	-40.22
17	1.771	1.292	0.560	2.839	-2.697	2.901	0.162	2.740	219.97	129.97
18	1.064	1.243	-1.227	3.469	-5.559	3.934	-1.627	5.562	45.92	-44.08
19	-0.333	1.472	-1.724	1.911	-4.303	2.902	-1.764	4.666	56.38	-33.62
20	-1.723	1.155	-1.846	0.428	-2.692	1.686	-2.255	3.941	68.46	-21.54

TABLE B.12: PRINCIPAL STRAINS FOR SC4.

LOAD STAGE: 1

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.236	0.495	0.461	0.025	0.457	0.628	0.103	0.525	120.21	30.21
2	0.536	0.361	0.822	0.024	0.837	0.876	0.021	0.855	140.90	50.90
3	0.404	0.225	0.607	-0.131	0.774	0.712	-0.082	0.794	141.50	51.50
4	-0.419	0.068	0.106	-0.588	0.727	0.262	-0.613	0.875	118.10	28.10
5	-1.047	0.157	-0.294	-0.686	0.411	0.191	-1.081	1.272	99.43	9.43
6	-0.016	0.090	-0.052	-0.102	0.052	0.096	-0.022	0.118	103.11	13.11
7	-0.079	0.113	0.026	-0.182	0.218	0.162	-0.129	0.291	114.30	24.30
8	-0.079	0.089	-0.051	-0.208	0.165	0.123	-0.112	0.235	112.20	22.20
9	-0.170	0.090	-0.153	-0.312	0.166	0.114	-0.195	0.309	106.26	16.26
10	-0.311	0.113	0.0	-0.335	0.351	0.176	-0.374	0.550	109.84	19.84
11	-0.194	0.114	-0.106	-0.103	-0.003	0.114	-0.194	0.308	89.73	-0.27
12	-0.177	0.180	-0.026	-0.078	0.054	0.182	-0.179	0.361	94.33	4.33
13	-0.176	0.113	-0.102	-0.317	0.225	0.151	-0.215	0.366	108.95	18.95
14	-0.226	0.046	-0.177	-0.319	0.149	0.065	-0.245	0.309	104.35	14.35
15	-0.236	0.045	-0.154	-0.292	0.144	0.063	-0.254	0.316	103.60	13.60
16	0.334	0.113	-0.100	0.049	-0.156	0.359	0.088	0.271	197.61	107.61
17	0.319	0.023	******	0.054	******	******	******	******	******	******
18	-0.129	0.045	-0.377	-0.209	-0.176	0.082	-0.166	0.247	67.32	-22.68
19	-0.303	0.023	-0.337	0.029	-0.383	0.111	-0.391	0.502	65.16	-24.84
20	-0.504	0.046	-0.436	-0.182	-0.266	0.076	-0.534	0.610	77.10	-12.90

LOAD STAGE: 2

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.031	1.101	0.487	0.230	0.269	1.118	0.014	1.104	97.06	7.06
2	0.635	1.331	1.748	0.179	1.645	1.876	0.090	1.786	123.53	33.53
3	0.725	0.833	2.153	-0.527	2.808	2.185	-0.625	2.810	133.90	43.90
4	-0.311	0.769	1.116	-0.960	2.176	1.444	-0.986	2.430	121.80	31.80
5	-1.038	0.452	-0.077	-0.792	0.749	0.541	-1.127	1.668	103.34	13.34
6	0.398	0.428	0.391	0.051	0.356	0.592	0.235	0.357	132.59	42.59
7	0.112	0.479	0.493	-0.131	0.654	0.670	-0.079	0.750	120.37	30.37
8	-0.015	0.202	0.181	-0.260	0.462	0.349	-0.162	0.511	122.41	32.41
9	-0.108	0.092	0.0	-0.444	0.465	0.245	-0.261	0.507	123.39	33.39
10	-0.187	0.068	0.0	-0.439	0.461	0.204	-0.322	0.526	120.53	30.53
11	-0.227	0.251	-0.106	-0.233	0.133	0.260	-0.235	0.496	97.79	7.79
12	-0.224	0.338	0.078	-0.257	0.351	0.389	-0.275	0.663	105.99	15.99
13	-0.288	0.181	-0.077	-0.500	0.444	0.269	-0.375	0.646	111.71	21.71
14	-0.275	0.046	-0.230	-0.399	0.177	0.069	-0.298	0.366	104.47	14.47
15	-0.194	0.090	-0.256	-0.239	-0.018	0.091	-0.194	0.285	88.22	-1.78
16	-0.064	0.384	0.0	0.081	-0.085	0.388	-0.068	0.456	84.65	-5.35
17	0.014	0.481	******	0.473	******	******	******	******	******	******
18	-0.116	0.180	-0.431	-0.026	-0.425	0.291	-0.227	0.518	62.48	-27.52
19	-0.366	0.046	-0.415	0.027	-0.463	0.149	-0.470	0.620	65.83	-24.17
20	-0.614	0.069	-0.594	-0.257	-0.352	0.112	-0.657	0.769	76.36	-13.64

TABLE B.12:PRINCIPAL STRAINS FOR SC4.

LOAD STAGE: 1

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.236	0.495	0.461	0.025	0.457	0.628	0.103	0.525	120.21	30.21
2	0.536	0.361	0.822	0.024	0.837	0.876	0.021	0.855	140.90	50.90
3	0.404	0.225	0.607	-0.131	0.774	0.712	-0.082	0.794	141.50	51.50
4	-0.419	0.068	0.106	-0.588	0.727	0.262	-0.613	0.875	118.10	28.10
5	-1.047	0.157	-0.294	-0.686	0.411	0.191	-1.081	1.272	99.43	9.43
6	-0.016	0.090	-0.052	-0.102	0.052	0.096	-0.022	0.118	103.11	13.11
7	-0.079	0.113	0.026	-0.182	0.218	0.162	-0.129	0.291	114.30	24.30
8	-0.079	0.089	-0.051	-0.208	0.165	0.123	-0.112	0.235	112.20	22.20
9	-0.170	0.090	-0.153	-0.312	0.166	0.114	-0.195	0.309	106.26	16.26
10	-0.311	0.113	0.0	-0.335	0.351	0.176	-0.374	0.550	109.84	19.84
11	-0.194	0.114	-0.106	-0.103	-0.003	0.114	-0.194	0.308	89.73	-0.27
12	-0.177	0.180	-0.026	-0.078	0.054	0.182	-0.179	0.361	94.33	4.33
13	-0.176	0.113	-0.102	-0.317	0.225	0.151	-0.215	0.366	108.95	18.95
14	-0.226	0.046	-0.177	-0.319	0.149	0.065	-0.245	0.309	104.35	14.35
15	-0.236	0.045	-0.154	-0.292	0.144	0.063	-0.254	0.316	103.60	13.60
16	0.334	0.113	-0.100	0.049	-0.156	0.359	0.088	0.271	197.61	107.61
17	0.319	0.023	******	0.054	******	******	******	******	******	******
18	-0.129	0.045	-0.377	-0.209	-0.176	0.082	-0.166	0.247	67.32	-22.68
19	-0.303	0.023	-0.337	0.029	-0.383	0.111	-0.391	0.502	65.16	-24.84
20	-0.504	0.046	-0.436	-0.182	-0.266	0.076	-0.534	0.610	77.10	-12.90

LOAD STAGE: 2

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	0.031	1.101	0.487	0.230	0.269	1.118	0.014	1.104	97.06	7.06
2	0.635	1.331	1.748	0.179	1.645	1.876	0.090	1.786	123.53	33.53
3	0.725	0.833	2.153	-0.527	2.808	2.185	-0.625	2.810	133.90	43.90
4	-0.311	0.769	1.116	-0.960	2.176	1.444	-0.986	2.430	121.80	31.80
5	-1.038	0.452	-0.077	-0.792	0.749	0.541	-1.127	1.668	103.34	13.34
6	0.398	0.428	0.391	0.051	0.356	0.592	0.235	0.357	132.59	42.59
7	0.112	0.479	0.493	-0.131	0.654	0.670	-0.079	0.750	120.37	30.37
8	-0.015	0.202	0.181	-0.260	0.462	0.349	-0.162	0.511	122.41	32.41
9	-0.108	0.092	0.0	-0.444	0.465	0.245	-0.261	0.507	123.39	33.39
10	-0.187	0.068	0.0	-0.439	0.461	0.204	-0.322	0.526	120.53	30.53
11	-0.227	0.251	-0.106	-0.233	0.133	0.260	-0.235	0.496	97.79	7.79
12	-0.224	0.338	0.078	-0.257	0.351	0.389	-0.275	0.663	105.99	15.99
13	-0.288	0.181	-0.077	-0.500	0.444	0.269	-0.375	0.646	111.71	21.71
14	-0.275	0.046	-0.230	-0.399	0.177	0.069	-0.298	0.366	104.47	14.47
15	-0.194	0.090	-0.256	-0.239	-0.018	0.091	-0.194	0.285	88.22	-1.78
16	-0.064	0.384	0.0	0.081	-0.085	0.388	-0.068	0.456	84.65	-5.35
17	0.014	0.481	******	0.473	******	******	******	******	******	******
18	-0.116	0.180	-0.431	-0.026	-0.425	0.291	-0.227	0.518	62.48	-27.52
19	-0.366	0.046	-0.415	0.027	-0.463	0.149	-0.470	0.620	65.83	-24.17
20	-0.614	0.069	-0.594	-0.257	-0.352	0.112	-0.657	0.769	76.36	-13.64

TABLE B.12 (Cont'd) PRINCIPAL STRAINS FOR SC4.

LOAD STAGE: 3

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.029	1.818	0.489	0.127	0.379	1.837	-0.048	1.886	95.80	5.80
2	0.894	2.210	2.060	0.411	1.729	2.638	0.465	2.173	116.35	26.35
3	1.013	1.419	3.215	-1.053	4.474	3.462	-1.030	4.492	132.41	42.41
4	-0.359	1.696	2.101	-1.604	3.884	2.866	-1.529	4.395	121.06	31.06
5	-1.220	1.197	0.113	-0.739	0.893	1.277	-1.300	2.577	100.14	10.14
6	0.716	0.923	0.807	0.458	0.366	1.030	0.610	0.420	120.26	30.26
7	0.318	1.161	1.192	-0.261	1.523	1.610	-0.131	1.741	120.52	30.52
8	0.190	1.612	1.721	-0.700	2.538	2.355	-0.554	2.909	120.37	30.37
9	0.035	0.933	0.868	-0.674	1.616	1.409	-0.441	1.849	120.47	30.47
10	-0.202	0.656	0.405	-0.490	0.939	0.862	-0.409	1.271	113.79	23.79
11	-0.081	0.771	0.263	-0.103	0.384	0.813	-0.122	0.934	102.13	12.13
12	-0.045	1.267	0.648	-0.257	0.949	1.420	-0.199	1.619	107.94	17.94
13	-0.191	1.272	1.353	-0.921	2.383	1.939	-0.858	2.797	119.23	29.23
14	-0.212	0.386	0.306	-0.586	0.935	0.642	-0.468	1.110	118.69	28.69
15	-0.115	0.273	0.051	-0.371	0.443	0.374	-0.215	0.589	114.40	24.40
16	0.203	0.542	-0.199	0.369	-0.596	0.715	0.030	0.685	59.83	-30.17
17	0.333	0.687	******	0.917	******	******	******	******	******	******
18	0.050	0.541	-0.646	0.451	-1.151	0.921	-0.330	1.251	56.56	-33.44
19	-0.415	0.473	-0.700	0.209	-0.953	0.680	-0.622	1.302	66.49	-23.51
20	-0.757	0.344	-0.749	-0.132	-0.646	0.432	-0.845	1.277	74.80	-15.20

LOAD STAGE: 4

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.328	3.051	0.901	0.255	0.677	3.085	-0.362	3.446	95.67	5.67
2	1.118	3.132	2.671	1.055	1.694	3.441	0.809	2.632	110.04	20.04
3	1.398	2.433	4.834	-1.367	6.500	5.207	-1.375	6.582	130.48	40.48
4	-0.357	2.443	3.032	-1.869	5.138	3.968	-1.882	5.851	120.71	30.71
5	-1.269	1.733	0.221	-0.581	0.841	1.791	-1.327	3.118	97.82	7.82
6	0.828	1.127	1.094	0.587	0.531	1.282	0.673	0.609	120.29	30.29
7	0.462	1.525	1.581	-0.209	1.876	2.072	-0.085	2.156	120.24	30.24
8	0.318	2.222	2.361	-0.905	3.424	3.229	-0.689	3.918	120.46	30.46
9	0.052	1.457	1.430	-0.857	2.397	2.144	-0.635	2.779	119.81	29.81
10	-0.171	0.882	0.557	-0.286	0.884	1.043	-0.332	1.375	110.01	20.01
11	-0.129	1.022	0.553	-0.129	0.716	1.124	-0.231	1.356	105.93	15.93
12	-0.044	1.719	1.088	-0.227	1.379	1.957	-0.282	2.239	109.01	19.01
13	-0.062	2.221	2.296	-1.236	3.702	3.254	-1.095	4.349	119.17	29.17
14	-0.052	0.796	0.789	-0.721	1.583	1.270	-0.526	1.796	120.92	30.92
15	-0.019	0.543	0.205	-0.404	0.638	0.687	-0.163	0.850	114.32	24.32
16	0.170	0.835	0.399	0.343	0.058	0.837	0.169	0.668	92.51	2.51
17	0.497	1.007	******	1.098	******	******	******	******	******	******
18	0.180	0.745	-0.808	1.006	-1.901	1.454	-0.529	1.983	53.27	-36.73
19	-0.430	0.676	-0.803	0.677	-1.551	1.076	-0.830	1.906	62.75	-27.25
20	-0.836	0.504	-0.880	0.204	-1.137	0.713	-1.044	1.757	69.85	-20.15

TABLE B.12(Cont'd) PRINCIPAL STRAINS FOR SC4.

LOAD STAGE: 5

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.630	3.992	1.746	0.178	1.643	4.134	-0.772	4.906	99.79	9.79
2	1.496	4.099	3.105	1.621	1.555	4.313	1.282	3.031	105.43	15.43
3	1.845	3.989	6.885	-1.522	8.812	7.452	-1.618	9.070	128.16	38.16
4	-0.300	4.722	4.533	-2.215	7.073	6.548	-2.126	8.675	117.31	27.31
5	-1.166	2.524	0.491	-0.317	0.846	2.572	-1.214	3.786	96.46	6.46
6	0.923	1.353	1.224	0.663	0.588	1.502	0.774	0.728	116.89	26.89
7	0.558	1.841	1.838	-0.055	1.985	2.381	0.018	2.364	118.55	28.55
8	0.414	3.063	3.025	-0.981	4.199	4.221	-0.744	4.965	118.87	28.87
9	0.037	2.002	1.991	-0.904	3.035	2.827	-0.788	3.615	118.54	28.54
10	-0.140	1.199	0.659	-0.233	0.935	1.346	-0.287	1.633	107.47	17.47
11	-0.146	1.227	0.659	-0.079	0.773	1.329	-0.247	1.576	104.69	14.69
12	-0.044	2.239	1.321	-0.229	1.626	2.499	-0.304	2.803	107.72	17.72
13	-0.030	2.769	2.627	-1.603	4.435	3.991	-1.253	5.244	118.87	28.87
14	-0.020	1.206	1.298	-0.880	2.283	1.889	-0.703	2.592	120.88	30.88
15	-0.018	0.836	0.461	-0.484	0.990	1.063	-0.245	1.308	114.61	24.61
16	0.190	1.355	0.698	0.642	0.058	1.356	0.189	1.167	91.43	1.43
17	0.712	1.489	******	1.517	******	******	******	******	******	******
18	0.342	0.880	-0.862	1.455	-2.428	1.855	-0.633	2.487	51.25	-38.75
19	-0.382	0.945	-0.905	1.007	-2.089	1.519	-0.956	2.475	61.22	-28.78
20	-0.788	0.619	-0.959	0.302	-1.322	0.880	-1.050	1.930	68.39	-21.61

LOAD STAGE: 6

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.995	4.731	2.054	-0.002	2.155	4.927	-1.191	6.118	100.31	10.31
2	1.750	4.887	3.594	2.111	1.554	5.069	1.568	3.501	103.18	13.18
3	2.192	5.243	7.624	-2.385	10.491	9.181	-1.745	10.926	126.89	36.89
4	-0.216	7.771	7.948	-1.983	10.409	10.338	-2.783	13.120	116.25	26.25
5	-1.063	2.620	0.897	-0.158	1.106	2.701	-1.144	3.845	98.36	8.36
6	0.859	1.443	1.224	0.688	0.561	1.556	0.746	0.810	111.93	21.93
7	0.605	2.160	2.225	-0.157	2.497	2.853	-0.088	2.942	119.04	29.04
8	0.509	4.265	3.999	-1.035	5.277	5.626	-0.851	6.477	117.28	27.28
9	0.054	2.575	2.604	-1.036	3.816	3.601	-0.972	4.573	118.28	28.28
10	-0.109	1.289	0.659	-0.156	0.854	1.409	-0.229	1.638	105.71	15.71
11	-0.356	1.272	0.659	-0.208	0.908	1.390	-0.475	1.865	104.58	14.58
12	-0.283	2.512	1.399	-0.153	1.627	2.732	-0.502	3.234	105.10	15.10
13	-0.236	3.407	3.470	-1.683	5.402	4.843	-1.672	6.516	118.00	28.00
14	-0.070	1.458	1.528	-1.014	2.664	2.230	-0.841	3.071	120.08	30.08
15	0.012	0.994	0.666	-0.484	1.205	1.280	-0.274	1.554	115.42	25.42
16	0.077	1.423	0.848	0.639	0.219	1.431	0.068	1.363	94.62	4.62
17	0.614	2.314	******	2.027	******	******	******	******	******	******
18	0.324	1.038	-0.970	1.585	-2.677	2.067	-0.704	2.771	52.46	-37.54
19	-0.398	1.057	-1.033	1.294	-2.439	1.750	-1.091	2.841	60.41	-29.59
20	-0.961	0.665	-1.062	0.329	-1.459	0.944	-1.240	2.184	69.05	-20.95

TABLE B.12(Cont'd) PRINCIPAL STRAINS FOR SC4.

LOAD STAGE: 7

GRID	EX	EY	E1	E2	GXY	EMAX	EMIN	GMAX	THETA-1	THETA-2
1	-0.773	7.355	3.241	0.306	3.076	7.637	-1.055	8.692	100.36	10.36
2	2.387	10.108	2.653	3.196	-0.570	10.118	2.377	7.741	87.89	-2.11
3	2.356	7.910	******	0.478	******	******	******	******	******	******
4	1.698	10.951	11.765	-4.901	17.470	16.210	-3.560	19.769	121.05	31.05
5	1.227	4.353	1.856	-0.053	2.001	4.646	0.934	3.712	106.31	16.31
6	0.145	1.534	0.703	0.103	0.629	1.602	0.077	1.525	102.18	12.18
7	0.283	3.002	3.223	-0.367	3.763	3.963	-0.679	4.642	117.08	27.08
8	0.721	9.852	3.115	-1.088	4.405	10.356	0.217	10.138	102.88	12.88
9	0.525	5.151	1.072	-1.444	2.638	5.501	0.175	5.326	104.84	14.84
10	0.124	1.494	0.659	0.184	0.498	1.538	0.081	1.457	99.99	9.99
11	-0.745	1.477	0.395	-0.518	0.956	1.576	-0.844	2.419	101.64	11.64
12	-0.508	3.122	1.658	-0.560	2.325	3.463	-0.848	4.311	106.32	16.32
13	-0.187	7.167	4.083	-2.788	7.202	8.637	-1.656	10.293	112.20	22.20
14	-0.152	2.551	2.826	-1.518	4.553	3.847	-1.449	5.295	119.65	29.65
15	0.028	1.310	0.820	-0.242	1.113	1.517	-0.180	1.698	110.48	20.48
16	0.430	1.648	0.897	0.205	0.725	1.748	0.330	1.418	105.39	15.39
17	0.964	2.153	******	1.625	******	******	******	******	******	******
18	0.371	1.061	-0.970	1.586	-2.679	2.099	-0.667	2.766	52.22	-37.78
19	-0.319	1.435	-1.189	1.718	-3.047	2.316	-1.200	3.516	59.96	-30.04
20	-0.771	0.848	-1.091	0.381	-1.543	1.157	-1.080	2.237	68.20	-21.80