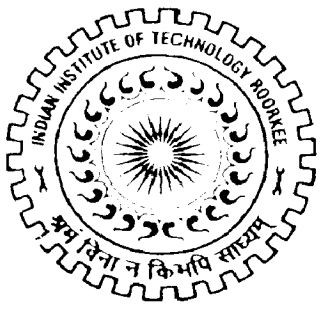
THREE DIMENSIONAL ANALYSIS OF STRESSES IN CONCRETE AROUND SPIRAL CASE USING FEM (ANSYS SOFT-WARE)

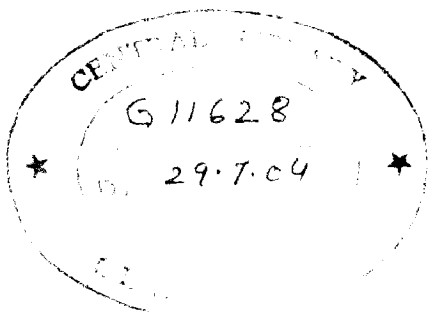
A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
of
MASTER OF TECHNOLOGY
in
WATER RESOURCES DEVELOPMENT
(CIVIL)

By

PAWAN KUMAR PRASAD





WATER RESOURCES DEVELOPMENT TRAINING CENTRE
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)
JUNE, 2004

CANDIDATE'S DECLARATION

I hereby declare that the dissertation entitled "**THREE DIMENSIONAL ANALYSIS OF STRESSES IN CONCRETE AROUND SPIRAL CASE USING FEM (ANSYS soft-ware)**" is being submitted by me in partial fulfillment of requirement for the award of degree of "**Master of Technology** in **WATER RESOURCES DEVELOPMENT (CIVIL)**" and submitted in the Water Resources Development Training Centre, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period from July, 2003 to June, 2004 under the guidance of **Dr. B.N. Asthana**, Visiting Professor, **Prof. Gopal Chauhan** and **Dr. Ram Pal Singh,** Professors, Water Resources Development Training Centre, Indian Institute of Technology, Roorkee.

The matter embodied in the dissertation has not been submitted by me for the award of any other degree.

Pawan Kumar Prasad

Dated: 27th June, 2004 (Pawan Kumar Prasad)

Place: IITR, Roorkee

This is to certify that above statement made by the candidate is correct to the best of our knowledge.

RP Singh

..... (Dr. Ram Pal Singh)
Professor, WRDTC
Indian Institute of Technology,
Roorkee, India

..... (Prof. Gopal Chauhan)
Professor, WRDTC
Indian Institute of Technology,
Roorkee, India

..... (Dr.B.N.Asthana)
Visiting Professor, WRDTC.
Indian Institute of Technology,
Roorkee, India

ACKNOWLEDGMENT

I take this as a great pleasure and proud privilege to express my deep sense of respect and gratitude to Dr. B.N. Asthana, Visiting Professor, Prof. Gopal Chauhan and Dr. Ram pal Singh, Professors, Water Resources Development Training Centre, Indian Institute of Technology Roorkee, for their valuable, inspiring and painstaking guidance, constant assistance and encouragement in bringing out this work.

I am grateful to extend my hearty thanks to Dr. U.C. Chaube, Professor and Head of Department, all the faculty members and staff of WRDTC, for their kind cooperation during the preparation of this dissertation.

I would also like to extend my thank to Mr. Kumar Venkatesh, Research Scholar, Civil Engineering Department, Mr. Ashis Bhargava, Project Associate, Earthquake Engineering Department, IITR, Roorkee for their kind cooperation.

I wish to express my thanks to Department of Irrigation, Ministry of Water Resources, His Majesty's Government of Nepal for giving me an opportunity to undergo M. Tech. Course at Indian Institute of Technology, Roorkee, India.

The author is grateful to officers and staff of Irrigation Research Institute Roorkee for providing required data for preparing the model of a unit of Chilla Power House for this dissertation.

I am also thankful to all my fellow trainee officers of Water Resources Development Training Center, for their cooperation and encouragement.

Last but not the least I would like to express my greatest appreciation to my family and almighty God for continuous inspiration and encouragement with out which it was very difficult to complete this course.

Pawan Kumar Prasad

Trainee Officer, M.Tech.(Civil)

W.R.D.T.C., I.I.T.R., Roorkee

CONTENTS

Title	Page No.
CANDIDATE'S DECLARATION	i
ACKNOWLEDGEMENT	ii
CONTENTS	iii
LIST OF TABLES	vi
LIST OF FIGURES	vii
LIST OF NOTATIONS	xii
SYNOPSIS	xiii
CHAPTERS	
1 INTRODUCTION	1
1.1 General	1-1
1.2 Type of Scroll Cases	1-1
1.3 Loads and Forces on the Intermediate Structure	1-2
1.4 Design Practices	1-4
1.5 Scope of the Study	1-11
1.6 Organisation of the Study	1-11
2 3-D ANALYSIS TECHNIQUES	2
2.1 General	2-1
2.2 Stress Analysis by Photo-elasticity Technique	2-1
2.2.1 Description of the Method	2-1
2.2.2 Basic Photo Elastic Equations	2-2
2.3 Stress Analysis by Finite Element Method	2-3
2.3.1 2-D Analysis	2-3
2.3.2 3-D Analysis	2-4
3 THE FINITE ELEMENT METHOD	3
3.1 General	3-1
3.2 Description of the Method	3-1
3.2.1 Discretisation of the Continuum	3-1
3.2.2 Selection of Proper Interpolation or Displacement Model	3-2
3.2.3 Convergence Requirements	3-2
3.2.4 Nodal Degrees of Freedom	3-3

3.2.5 Element Stiffness Matrix 3-4
3.2.6 Nodal Forces and Loads 3-4
3.2.7 Assembly of Algebraic Equations for the Overall Discretised Continuum 3-5
3.2.8 Boundary Conditions 3-5
3.2.9 Solution for the Unknown Displacements 3-6
3.3 Summary of Procedure 3-6
3.4 Mathematical Model 3-7
3.4.1 Displacement Function 3-7
3.4.2 Shape Functions 3-8
3.4.3 Strains 3-8
3.4.4 Stresses 3-11
3.4.5 Stiffness Matrix 3-12
3.5 Sign Convention 3-13
3.6 Process in ANSYS 3-14
3.7 ANSYS Inputs 3-14
4 STRUCTURAL MODELING OF SPIRAL CASE 4
4.1 General 4-1
4.2 Assumptions in the Model 4-1
4.3 Dimensions of the Model 4-2
4.4 Loads on spiral casing 4-5
4.4.1 Machine and its Support Loads 4-5
4.4.2 Generator Floor and Barrel Loads 4-5
4.4.3 Load due to Unilateral Magnetic Attraction 4-5
4.4.4 Load due to Double Short Circuit of Rotor Winding 4-6
4.4.5 Live Load on Turbine Floor 4-6
4.4.6 Self Weight of Concrete 4-6
4.4.7 Water Pressure 4-6
4.5 Modeling Steps 4-6
4.5.1 Element Type and Material Properties 4-6
4.5.2 Model of the Problem 4-7
4.6 Meshing of the Model 4-7
4.7 Solution 4-7
4.7.1 Boundary Conditions 4-7

4.7.2 Loading Conditions 4-7

5 RESULTS OF ANALYSIS 5

5.1 General 5-1

5.2 Nature of Stress Component σ_x (SX) in X-Direction

5.2.1 Load Condition 1a 5-2

5.2.2 Load Condition 1b 5-4

5.2.3 Load Condition 2a 5-7

5.2.4 Load Condition 2b 5-10

5.3 Nature of Stress Component σ_y (SY) in Y-Direction

5.3.1 Load Condition 1a 5-12

5.3.2 Load Condition 1b 5-14

5.3.3 Load Condition 2a 5-16

5.3.4 Load Condition 2b 5-18

5.4 Nature of Stress Component σ_z (SZ) in Z-Direction

5.4.1 Load Condition 1a 5-21

5.4.2 Load Condition 1b 5-23

5.4.3 Load Condition 2a 5-25

5.4.4 Load Condition 2b 5-27

5.5 Summary of Results 5-29

5.6 Comparison with 2-D Results 5-33

6 SUMMARY, CONCLUSIONS AND SUGGESTIONS 6

6.1 Summary of Results 6-1

6.2 Conclusions 6-2

6.3 Suggestions for the Further Study 6-3

REFERENCES 7

APPENDIX-A 8

APPENDIX-B 9

4.B.1 Define Element Type and Material Properties AB-1

4.B.2 Create the Model of the Problem AB-2

4.B.3 Meshing of Model AB-14

4.B.4 Solution AB-14

LIST OF TABLES

Table No.	Title	Page No.
4.1	Radial and Circular Dimensions of Spiral Case	4-4
4.2	Tangential Load at Different Nodes	4-9
5.5.1	Maximum Deflections and Stresses with Their Locations For Different Condition	5-32
5.6.1	Comparison of Results Obtained by 2-D & 3-D Analysis at Section 180^0	5-35
5.1	Displacement in X-direction	AA-1
5.2	Displacement in Y-direction	AA-5
5.3	Displacement in Z-direction,	AA-9
5.4	Normal Stress in X-direction	AA-13
5.5	Normal Stress in Y-direction	AA-17
5.6	Normal Stress in Z-direction	AA-21
5.7	Shear Stress in X-Y plane	AA-25
5.8	Shear Stress in Y-Z plane	AA-29
5.9	Shear Stress in X-Z plane	AA-33
5.10	Principal Stress, S1	AA-37
5.11	Principal Stress, S2	AA-41
5.12	Principal Stress, S3	AA-45
4.B.1	Detail of Key Points at Each Section	AB-6
4.B.2	Detail of Lines at Each Section	AB-9
4.B.3	Detail of Volumes and Areas for Each Section	AB-13

LIST OF FIGURES

Figure No.	Title	Page No.
1.1	Forces Acting on a Power House	1-2
1.2	Location of Different Loads in a Power House	
	(a) Internal Plan of Machine Halls Showing Relative Position of Loads Acting at Different Levels	1-3
	(b) Position of Loads at Various Levels and Concrete in a Power House	1-3
1.3	Arrangement of Beams in Concrete Scroll Case (a, b)	1-4
1.4	Plan of Steel Spiral Case	1-6
1.5	Beams and Column Arrangement	1-7
1.6	Arch Arrangement at Speed Ring	1-8
1.7	Ring Arrangement	1-9
2.1	Different Types of 2-D Element	2-4
2.2	Different Types of 3-D Element	2-5
3.1	A 10 Noded Isoparametric Tetrahedral Solid Element	3-7
3.1	Stress Vector Defnition	3-13
4.1	Dimensions of the Model	4-3
4.2	Section Along Center Line of Spiral Case	4-4
4.3	View of Volume at Angle 270-360^0 of Model	4-13
4.4	View of Volume at Angle 180-270^0 of Model	4-13
4.5	View of Volume at Angle 090-180^0 of Model	4-14
4.6	View of Volume at Angle 000-090^0 of Model	4-14
4.7	Isometric View of Spiral Casing	4-15
4.8	Isometric View of 3-D Model	4-15
4.9	Isometric View of 3-D Model with Meshing	4-16
4.10	Top View of 3-D Model	4-16
4.11	Typical Section Showing Different Loadings and Critical Points for study	4-17
4.12	Isometric View Showing Different Type of Loading	4-18
4.13	Back View Showing Different Type of Loading	4-18
5.5.1	Stress Contour for SX Under Load 1a(ii) at section 270^0	5-37

LIST OF FIGURES

Figure No.	Title	Page No.
5.5.2	Stress Contour for SX Under Load 1a(ii) at section 7.5^0	5-37
5.5.3	Stress Contour for SY Under Load 1a(ii) at section 7.5^0	5-38
5.5.4	Stress Contour for SY Under Load 1a(iv) at section 352.5^0	5-38
5.5.5	Stress Contour for SZ Under Load 1a(iv) at section 360^0	5-39
5.5.6	Stress Contour for SZ Under Load 1a(ii) at section 195^0	5-39
5.5.7	Stress Contour for SX Under Load 1b(iii) at section 54.418^0	5-40
5.5.8	Stress Contour for SX Under Load 1b(ii) at section 47.267^0	5-40
5.5.9	Stress Contour for SY Under Load 1b(ii) at section 51.418^0	5-41
5.5.10	Stress Contour for SY Under Load 1b(ii) at section 50.107^0	5-41
5.5.11	Stress Contour for SZ Under Load 1b(ii) at section 55.09^0	5-42
5.5.12	Stress Contour for SZ Under Load 1b(ii) at section 54.149^0	5-42
5.5.13	Stress Contour for SX Under Load 2a(iii) at section 285^0	5-43
5.5.14	Stress Contour for SX Under Load 2a(ii) at section 38.7^0	5-43
5.5.15	Stress Contour for SY Under Load 2a(ii) at section 317.02^0	5-44
5.5.16	Stress Contour for SY Under Load 2a(iii) at section 360^0	5-44
5.5.17	Stress Contour for SZ Under Load 2a(ii) at section 345^0	5-45
5.5.18	Stress Contour for SZ Under Load 2a(iii) at section 360^0	5-45
5.5.19	Stress Contour for SX Under Load 2b(iii) at section 187.5^0	5-46
5.5.20	Stress Contour for SX Under Load 2b(iii) at section 39.42^0	5-46
5.5.21	Stress Contour for SY Under Load 2b(iii) at section 97.07^0	5-47
5.5.22	Stress Contour for SY Under Load 2b(iii) at section 360^0	5-47
5.5.23	Stress Contour for SZ Under Load 2b(iii) at section 97.07^0	5-48
5.5.24	Stress Contour for SZ Under Load 2b(ii) at section 82.72^0	5-48
5.1	Displacement Contours for load 1(i) at section 060-240	AA-49
5.2	Stress Contour for load 1a(i) at section 060-240	AA-50
5.3	Displacement Contours for load 1a(ii) at section 060-240	AA-51
5.4	Stress Contours for load 1a(ii) at section 060-240	AA-52
5.5	Displacement Contours for load 1a(iii) at section 060-240	AA-53
5.6	Stress Contours for load 1a(iii) at section 060-240	AA-54
5.7	Displacement Contours for load 1a(iv) at section 060-240	AA-55

LIST OF FIGURES

Figure No.	Title	Page No.
5.8	Stress Contours for load 1a(iv) at section 060-240	AA-56
5.9	Displacement Contours for load 1a(v) at section 060-240	AA-57
5.10	Stress Contours for load 1a(v) at section 060-240	AA-58
5.11	Displacement Contours for load 1b(i) at section 060-240	AA-59
5.12	Stress Contour for load 1b(i) at section 060-240	AA-60
5.13	Displacement Contours for load 1b(ii) at section 060-240	AA-61
5.14	Stress Contours for load 1b(ii) at section 060-240	AA-62
5.15	Displacement Contours for load 1b(iii) at section 060-240	AA-63
5.16	Stress Contours for load 1b(iii) at section 060-240	AA-64
5.17	Displacement Contours for load 1b(iv) at section 060-240	AA-65
5.18	Stress Contours for load 1b(iv) at section 060-240	AA-66
5.19	Displacement Contours for load 1b(v) at section 060-240	AA-67
5.20	Stress Contours for load 1b(v) at section 060-240	AA-68
5.21	Displacement Contours for load 2a(i) at section 060-240	AA-69
5.22	Stress Contour for load 2a(i) at section 060-240	AA-70
5.23	Displacement Contours for load 2a(ii) at section 060-240	AA-71
5.24	Stress Contours for load 2a(ii) at section 060-240	AA-72
5.25	Displacement Contours for load 2a(iii) at section 060-240	AA-73
5.26	Stress Contours for load 2a(iii) at section 060-240	AA-74
5.27	Displacement Contours for load 2a(iv) at section 060-240	AA-75
5.28	Stress Contours for load 2a(iv) at section 060-240	AA-76
5.29	Displacement Contours for load 2a(v) at section 060-240	AA-77
5.30	Stress Contours for load 2a(v) at section 060-240	AA-78
5.31	Displacement Contours for load 2b(i) at section 060-240	AA-79
5.32	Stress Contour for load 2b(i) at section 060-240	AA-80
5.33	Displacement Contours for load 2b(ii) at section 060-240	AA-81
5.34	Stress Contours for load 2b(ii) at section 060-240	AA-82
5.35	Displacement Contours for load 2b(iii) at section 060-240	AA-83
5.36	Stress Contours for load 2b(iii) at section 060-240	AA-84
5.37	Displacement Contours for load 2b(iv) at section 060-240	AA-85

LIST OF FIGURES

Figure No.	Title	Page No.
5.38	Stress Contours for load 2b(iv) at section 060-240	AA-86
5.39	Displacement Contours for load 2b(v) at section 060-240	AA-87
5.40	Stress Contours for load 2b(v) at section 060-240	AA-88
5.41	Maximum Deflection and Stress for load case 1a(i)	AA-89
5.42	Maximum Deflection and Stress for load case 1a(ii)	AA-90
5.43	Maximum Deflection and Stress for load case 1a(iii)	AA-91
5.44	Maximum Deflection and Stress for load case 1a(iv)	AA-92
5.45	Maximum Deflection and Stress for load case 1a(v)	AA-93
5.46	Maximum Deflection and Stress for load case 1b(i)	AA-94
5.47	Maximum Deflection and Stress for load case 1b(ii)	AA-95
5.48	Maximum Deflection and Stress for load case 1b(iii)	AA-96
5.49	Maximum Deflection and Stress for load case 1b(iv)	AA-97
5.50	Maximum Deflection and Stress for load case 1b(v)	AA-98
5.51	Maximum Deflection and Stress for load case 2a(i)	AA-99
5.52	Maximum Deflection and Stress for load case 2a(ii)	AA-100
5.53	Maximum Deflection and Stress for load case 2a(iii)	AA-101
5.54	Maximum Deflection and Stress for load case 2a(iv)	AA-102
5.55	Maximum Deflection and Stress for load case 2a(v)	AA-103
5.56	Maximum Deflection and Stress for load case 2b(i)	AA-104
5.57	Maximum Deflection and Stress for load case 2b(ii)	AA-105
5.58	Maximum Deflection and Stress for load case 2b(iii)	AA-106
5.59	Maximum Deflection and Stress for load case 2b(iv)	AA-107
5.60	Maximum Deflection and Stress for load case 2b(v)	AA-108
5.61	Maximum Deflection and Stress for load case 1a	AA-109
5.62	Maximum Deflection and Stress for load case 1b	AA-110
5.63	Maximum Deflection and Stress for load case 2a	AA-111
5.64	Maximum Deflection and Stress for load case 2b	AA-112
5.65	Maximum Deflection and Stress for all load case	AA-113
5.66	Distribution of SX along sections in zone A	AA-114
5.67	Distribution of SX along sections in zone B	AA-114

LIST OF FIGURES

Figure No.	Title	Page No.
5.68	Distribution of SX along sections in zone C	AA-115
5.69	Distribution of SX along sections in zone D	AA-115
5.70	Distribution of SX along sections in zone E	AA-116
5.71	Distribution of SX along sections in zone F	AA-116
5.72	Distribution of SX along sections in zone G	AA-117
5.73	Distribution of SX along sections in zone H	AA-117
5.74	Distribution of SX along sections in zone I	AA-118
5.75	Distribution of SY along sections in zone A	AA-118
5.76	Distribution of SY along sections in zone B	AA-119
5.77	Distribution of SY along sections in zone C	AA-119
5.78	Distribution of SY along sections in zone D	AA-120
5.79	Distribution of SY along sections in zone E	AA-120
5.80	Distribution of SY along sections in zone F	AA-121
5.81	Distribution of SY along sections in zone G	AA-121
5.82	Distribution of SY along sections in zone H	AA-122
5.83	Distribution of SY along sections in zone I	AA-122
5.84	Distribution of SZ along sections in zone A	AA-123
5.85	Distribution of SZ along sections in zone B	AA-123
5.86	Distribution of SZ along sections in zone C	AA-124
5.87	Distribution of SZ along sections in zone D	AA-124
5.88	Distribution of SZ along sections in zone E	AA-125
5.89	Distribution of SZ along sections in zone F	AA-125
5.90	Distribution of SZ along sections in zone G	AA-126
5.91	Distribution of SZ along sections in zone H	AA-126
5.92	Distribution of SZ along sections in zone I	AA-127
4.B.1	Symbol of Key Points for Section	AB-5
4.B.2	Symbol of lines for Section	AB-7
4.B.3	Symbol of Lines for In-Between Section	AB-8
4.B.4	Symbol of Areas in-between Section	AB-11
4.B.5	Symbol of Key Point, Line & Areas for Penstock Part	AB-12

LIST OF NOTATIONS

	NOTATIONS	DETAILS
1.	ρ	Density of concrete
2.	ν	Poison's Ratio
3.	bckt.	Bracket
4.	cm.	Centimeter
5.	DOF	Degrees of freedom
6.	DSCRW	Double short circuit of rotor winding
7.	E	Young's Modulus
8.	El.	Elevation
9.	FX	Force in x-direction
10.	FY	Force in y-direction
11.	FZ	Force in z-direction
12.	kg.	Kilogram
13.	NOL	Normal operating load
14.	S1 or σ_1	First Principal stress
15.	S2 or σ_2	Second Principal stress
16.	S3 or σ_3	Third principal stress
17.	sq.	Square
18.	SX or σ_x	Normal stress in X-direction
19.	SXY or σ_{xy}	Shear stress in X-Y plane
20.	SXZ or σ_{xz}	Shear stress in X-Z plane
21.	SY or σ_y	Normal stress in Y-direction
22.	SYZ or σ_{yz}	Shear stress in Y-Z plane
23.	SZ or σ_z	Normal stress in Z-direction
24.	UX	Displacement in X-direction
25.	UY	Displacement in Y-direction
26.	UZ	Displacement in Z-direction

SYNOPSIS

Although a number of Power Houses have been constructed both in India as well as in other countries, no exact analysis or standards for the design of Power House Structure are yet available. The power engineers consider each Powerhouse as an individual problem, which should be tackled in its own way. Thus, due to its complex shape and force system acting upon it, the determination of stress distribution in the Power House structure is still an unsolved question, leaving much to the personal judgment of the design engineers.

The present dissertation is limited to the stress analysis in intermediate structure (concrete around a steel scroll case) of a Hydro Power Station with vertical axis reaction turbine. Scroll case is required to distribute the water from penstock to circumference of the turbine runner uniformly and smoothly in order to obtain the maximum efficiency. Steel scroll case is generally used for medium and high head while concrete scroll case can be used for low head.

In case of steel spiral case the forces acting on the concrete section depend upon the mode of encasing and the section of scroll case, which varies from section to section. Since the exact behavior of concrete is unpredictable, these section may be designed in one of the arrangement like Beam and column arrangement, Arch arrangement, Ring arrangement, Hollow cylinder, Mass concrete and Numerical method etc.

Finite Element Method is one of the most popular amongst all the numerical methods for 3-D analysis of intermediate structures. The results obtained by this method are more accurate than obtained by other simplified methods. The basic concept of this method is that every structure may be considered to be an assemblage of individual structuraly small and simpler components or elements. The structural idealization is obtained merely by dividing the original continuum into segments, all the material properties of the original system being retained in the individual elements.

The intermediate structure (spiral case concrete) of Chilla Power House has been idealized into a three dimensional problem in this study. Three-dimensional model is created in this dissertation as per the dimension of one unit of Chilla powerhouse. Analysis is carried out for the following loading conditions and combinations:

1. Concrete not sharing the internal water pressure. This means that spiral case liner withstands full static head plus water hammer effect.

2. Concrete takes full internal water pressure.

For these two conditions the scroll case concrete is analyzed for following two cases:

a) Free at speed ring.

b) Hinged at speed ring

For these above conditions and cases, model is analyzed for the following loading individually:

i. Dead load, floors load and machine load i.e. Normal Operating Load (NOL)

ii. NOL with Radial force due to unequal magnetic attraction toward positive x-direction.

iii. NOL with Radial force due to unequal magnetic attraction toward negative x-direction.

iv. NOL with Tangential force due to double short circuit of rotor winding in anti-clockwise direction.

v. NOL with Tangential force due to double short circuit of rotor winding in clockwise direction.

Results of the study for deflections and distribution of stresses at various sections and zones for different cases analyzed are discussed in this thesis.

The study conducted reveals that the intermediate structure (spiral case concrete) of a hydro-power station is in fact a low tensile stressed (except few zones around the opening) stable structure which needs only nominal reinforcement to prevent crack formations of the surface due to shrinkage of concrete, thus disapproving the present trend of providing a lot of reinforcement for the case when concrete around scroll case is not allowed to take internal water pressure. But for the case when concrete around the scroll case is allowed to withstand the hydrostatic pressure, more tensile stresses are developed and hence reinforcement is required to overcome the tensile stresses in some critical zones only. The results obtained by 3-D analysis are compared with the results obtained by 2-D analysis in angular section 180^0 for loading conditions 1a(i), 1b(i), 2a(i), 2b(i) and it is found that the 2-D results are much more than the 3-D results. Hence 3-D analysis gives a better insight to the behavior of concrete around scroll case resulting in an economical and safe design.

CHAPTER-1

INTRODUCTION

1.1 General
1.2 Type of Scroll Cases
1.3 Loads and Forces on the Intermediate Structure
1.4 Design Practices
1.5 Scope of the Study
1.6 Organisation of the Study

CHAPTER 1

INTRODUCTION

1.1 GENERAL

In a hydroelectric power station, two characteristics of water that is quantity and its elevation (drop) are utilized as a prime mover in rotating the water turbine, which is coupled to the generator, and hence electric power is generated.

A hydroelectric power station can be structurally divide into 3 main subdivisions as shown in figure 1.1:

- Substructure: - containing the draft tube.
- Intermediate structure: - containing the spiral case and foundation for the generator & turbine.
- Superstructure: - containing the covering roof and walls for the generating equipment with electric overhead traveling (EOT) crane's supports.

The intermediate structure of a powerhouse is a part, which extends from the top of the draft tube to the top of the generator foundation. It contains two important elements of the powerhouse. One is the generator foundation, galleries and other is the scroll case. Intermediate structure has mainly two functions, firstly it is to safely support the barrel and superstructure loads and transmits the same to the substructure and secondly to provide support and encased the spiral case to minimize the vibration and leakage of water.

The scroll or spiral case is that part of turbine which distributes water from the penstock uniformly and smoothly through the guide vanes to the runner. The spiral case is required only in case of Francis and Kaplan types of turbine. The design of the spiral case is somewhat complicated from both hydraulic and structural considerations, due its hydraulic function and irregular shape.

1.2 TYPE OF SCROLL CASES

There are two type of spiral cases. One is concrete spiral case, which is used in low head power station having a shape of rectangular or trapezoidal in section with an angle of envelopment varying from 200^0 to 250^0. Another is steel spiral case, which is

generally used in medium and high head power station having a shape circular in section with an angle of envelopment varying from 300^0 to 360^0.

1.3 LOADS AND FORCES ON THE INTERMEDIATE STRUCTURE

A section of power house and forces acting on it is shown in Fig. 1.1 and 1.2. The arrows indicate the center of gravity of the various forces and loads and may not give the exact point of application of these loads. The figure itself indicates that neither the geometry of intermediate structure nor the loads acting over it are symmetrical.

Generator support loads are the major loads. Floor load, dead load, Tangential force due to short circuit and Radial loads due to unequal magnetic attraction are others loads acting on the intermediate structure. Beside its hydrostatic force including water hammer effect is also a major part of load acting on the inner face of spiral case.

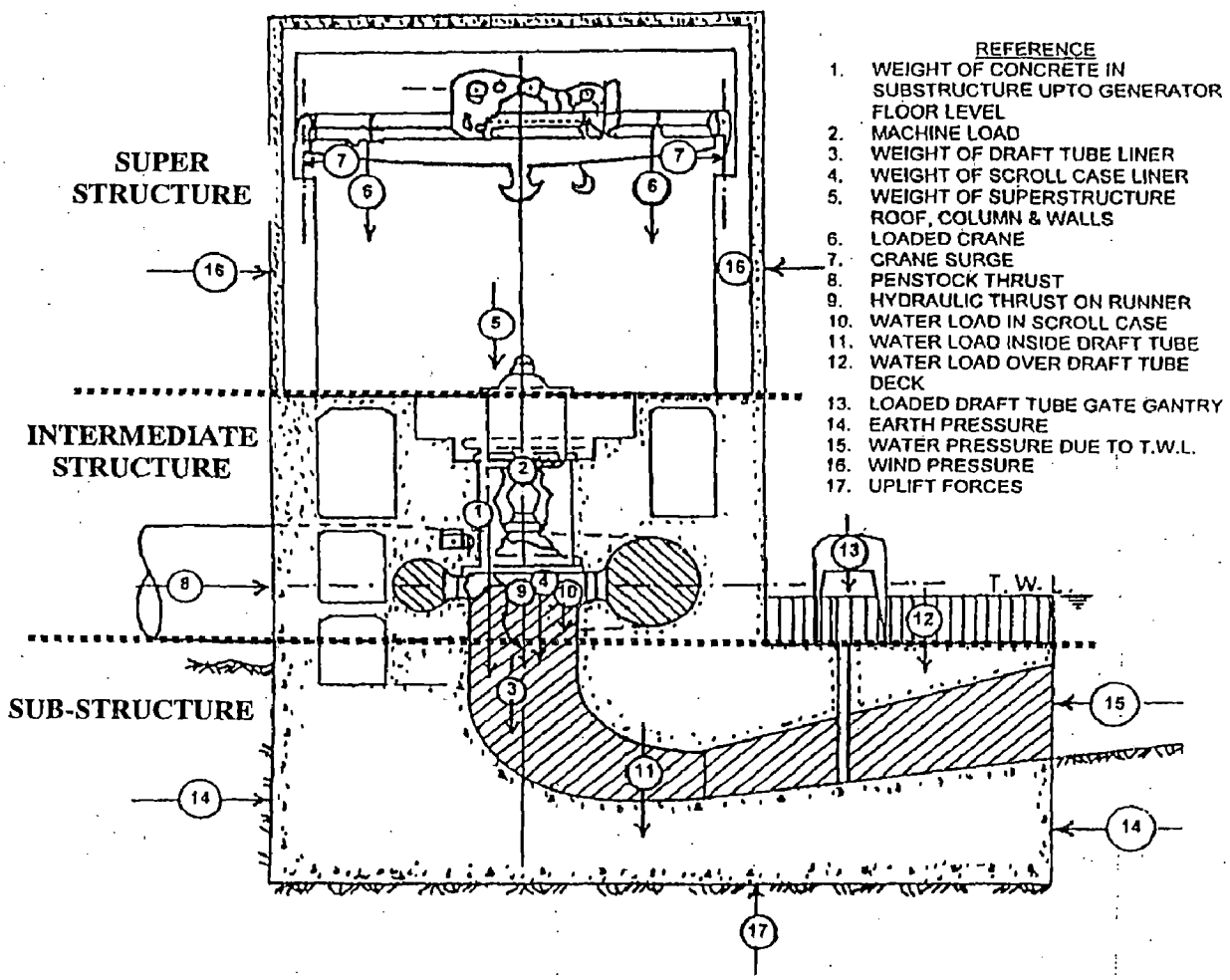
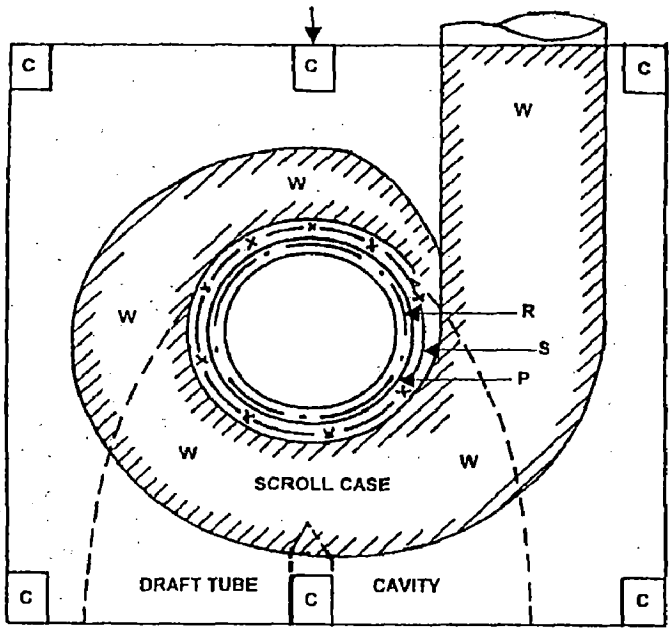
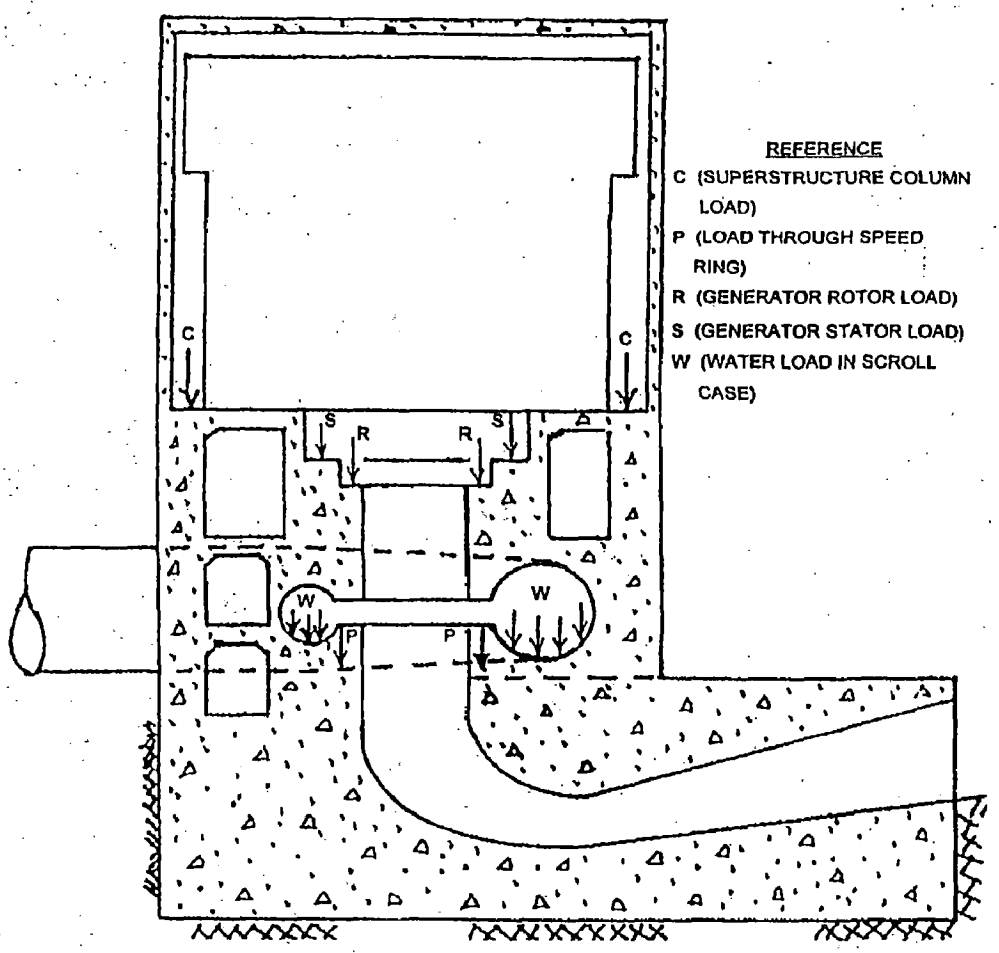


FIG. 1.1 FORCES ACTING ON A POWER HOUSE



(a) Internal plan of machine hall showing relative position of loads acting at different levels



(b) Position of Loads at various levels and concrete in a power house (Equipment and plant not shown)

FIG. 1.2 LOCATION OF DIFFERENT LOADS IN A POWER HOUSE

1.4 DESIGN PRACTICES

Different practices adopted for the design by various design organization for these two types of spiral case are as follows:

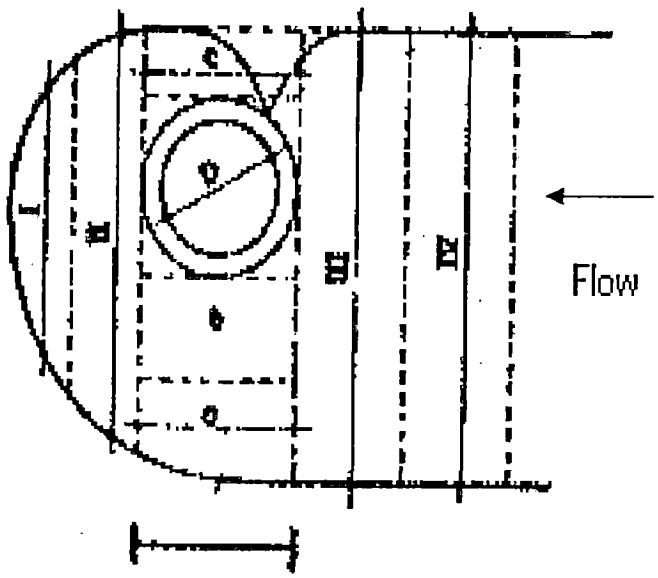
1.4.1 Concrete spiral case

The load on the spiral case roof may either be carried by the roof itself or transmitted (at least partially) to the substructure by the stay vanes.

i) Load carried by spiral roof:

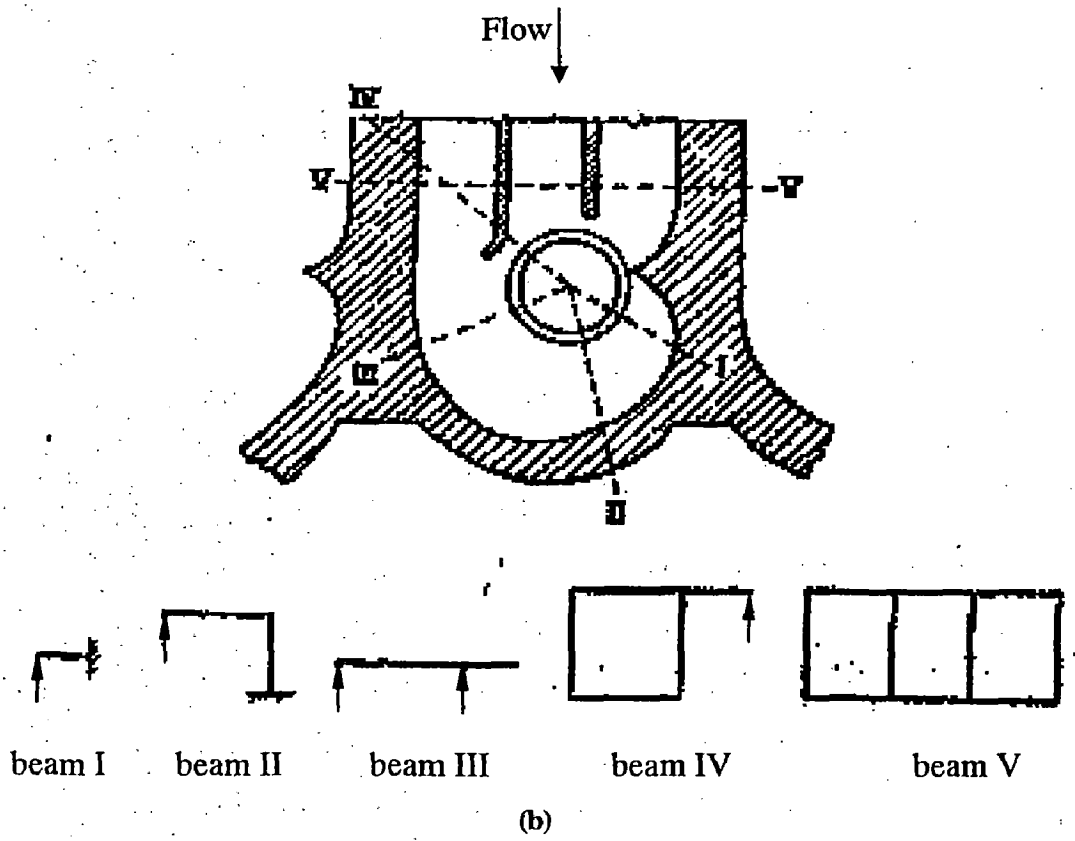
For shorter span and smaller load, the roof of the spiral case can carry the machine load and in this case, the structural design can be carried out in two ways.

a) The roof of the spiral case is considered as a reinforced concrete slab with a large opening for the turbine, which rests upon or is fixed into the side walls whose structural system is composed of a system of beams and cross beams as shown in the figure 1.3(a)



(a)

FIG. 1.3 ARRANGEMENT OF BEAMS IN CONCRETE SPIRAL CASE



(b)

FIG. 1.3 ARRANGEMENT OF BEAMS IN CONCRETE SPIRAL CASE

Beams a, b, and c are secondary beams which are partially fixed to the primary beams II and III. In the case of relatively wide spiral case walls, the primary beams I, II, III, and IV may be designed as fully fixed. Sometimes it may be advantageous to adopt a radial arrangement of beams as shown in figure 1.3(b)

b) The downstream side of the spiral case is assumed to be a cylinder and therefore, circular reinforcement fixed into the upstream section is provided. If the spiral case is not too high, the sidewalls may be designed as fully or partially fixed vertical slabs, depending upon their relative stiffness. The load may be divided into two parts, one including tensile stresses in the circular direction, i.e. in the horizontal elements, and the remaining partial load including bending moment in the vertical direction.

ii) <u>Load transmitted by stay vanes:</u>

The steel stay vanes are fixed at their lower and upper ends with the steel speed rings. This stay vanes should be well embedded into the concrete in order to ensure reliable load transmission and the structural

arrangement should be such as to prevent the crushing of the relatively thin spiral case cone by the heavy loads transmitted through the stay vanes. These elements carry not only downward loads but also the resultant of the pressure tending to lift the roof of the deeply set spiral case as anchorage also.

1.4.2 Steel scroll case

The forces acting on the concrete section depend upon the mode of placing concrete in the case of fully encased spiral casing and the section of scroll case which varies from place to place. As the boundary of concrete around the spiral case is rectangular in shape, the width of the wall surrounding the spiral case varies from one section to the next. On account of these varying factors the scroll case is divided into a number of section as shown in the figure-1.4 for purpose of design.

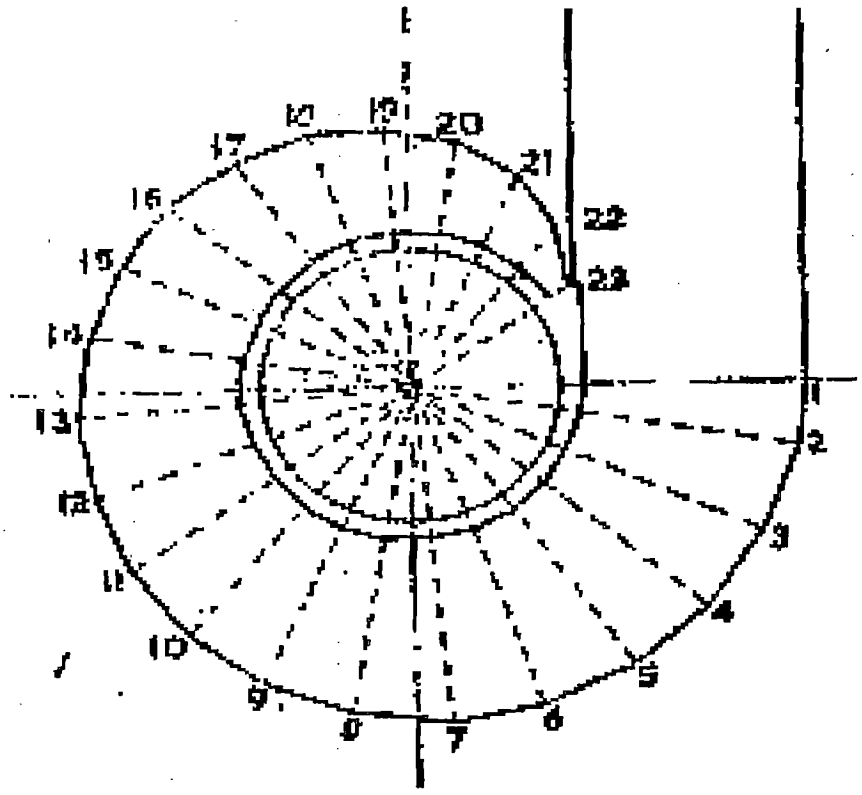
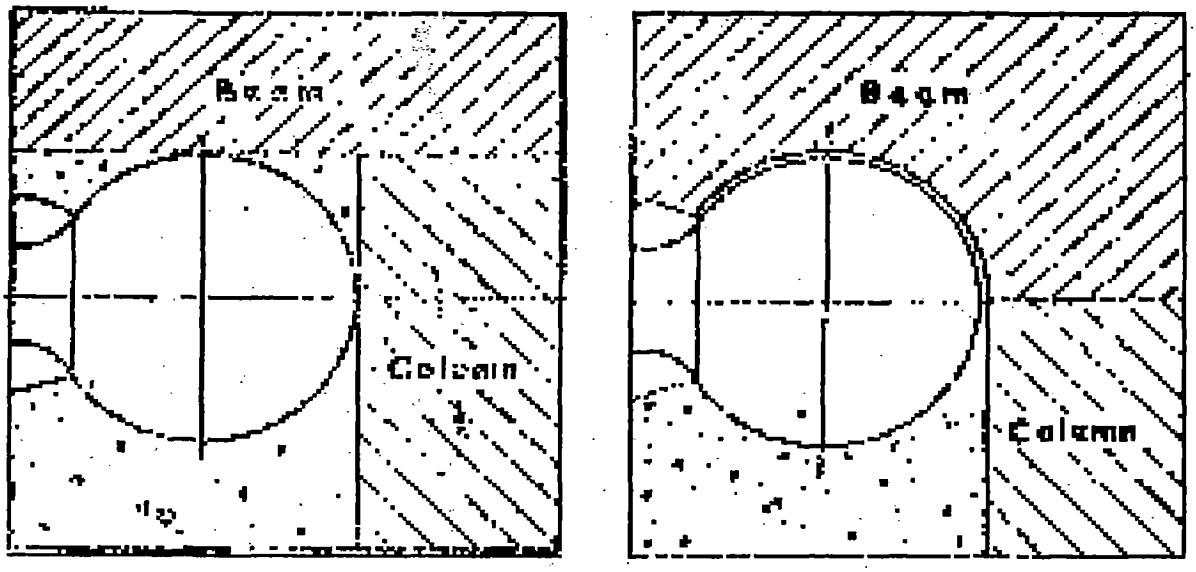


FIG. 1.4 PLAN OF STEEL SPIRAL CASE

Since the exact behavior of concrete is unpredictable these section may be designed in one of the following ways:

i) ***Beam and Column Arrangement***

In this arrangement the top of the concrete is considered as a beam. After deciding the level of generator floor and hence the level of the top of the beam, there are two alternatives for considering the depth of beam:



(a) Beam with fixed depth (b) Beam with variable depth

FIG. 1.5 BEAM AND COLUMN ARRANGEMENT

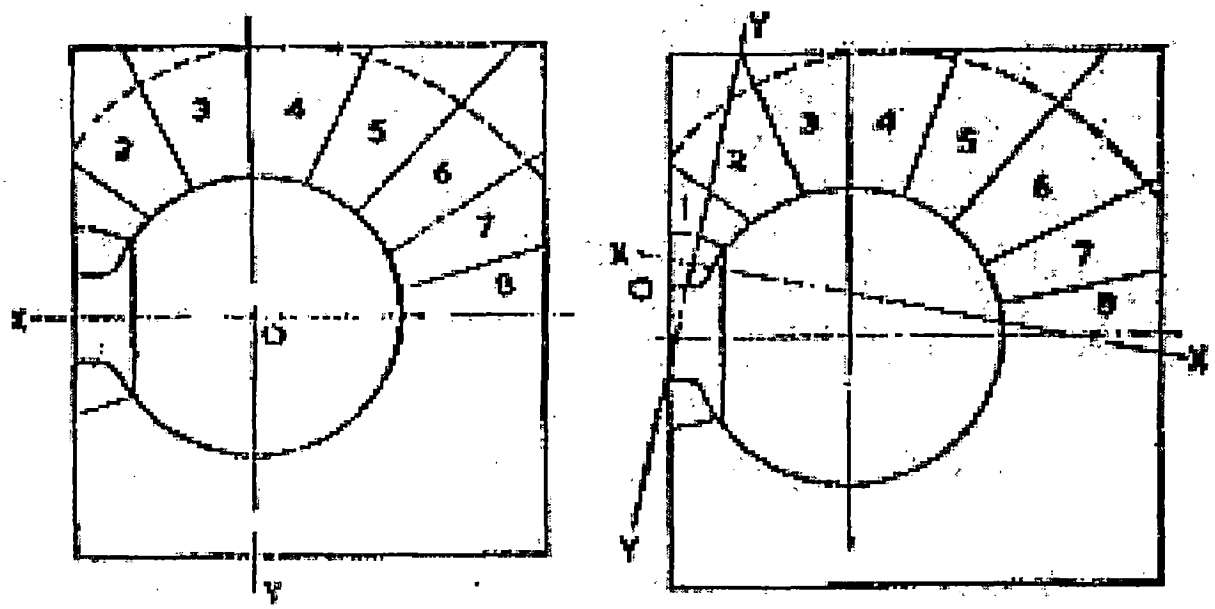
- The depth of the beam is equal to the minimum depth at the crown as shown in the figure-1.5(a). The concrete at the side is considered as a column having the width available at the centerline of the runner.
- As shown in the above figure-1.5(b) the beam is of variable depth and follows the profile of the scroll case in section. Since the concrete will be laid in such a manner as to fill the entire space above the spiral liner, it will be economical to take into account the full area of concrete as well.

The end conditions at the columns support will be altered since the depth of the beam and the width of the column is varying at every section. So if the width of the column is comparable to the depth of the beam, the end will

be considered as fixed; otherwise it is taken as hinged and the top slab may be treated as fixed at the outer end & hinged at the inner end (speed ring). Since there is an element of doubt in the support condition on the speed ring, it may be taken as hinged.

ii) ***Arch Arrangement***

In this arrangement the top concrete is treated as an arch. The inner boundary of the arch is circular while the outer boundary of the arch may also be drawn circular with a different center so as to keep the boundary within the concrete to be poured monolithically as shown in the figure-1.6.



(a) Fixed arch (b) Hinged arch

FIG. 1.6 ARCH ARRANGEMENT AT SPEED RING

The outer end of the arch is taken as fixed at the center of runner, the fixity being provided by the concrete below the scroll case. Since the degree of fixity provided at the speed ring is not very definite, this end may be treated either as fixed or hinged. The analysis is carried out with both the end conditions and to design the section the maximum moments obtained by the two methods should be taken.

iii) ***Ring Arrangement***

In this arrangement the section is considered as a ring between two hinged speed ring supports.

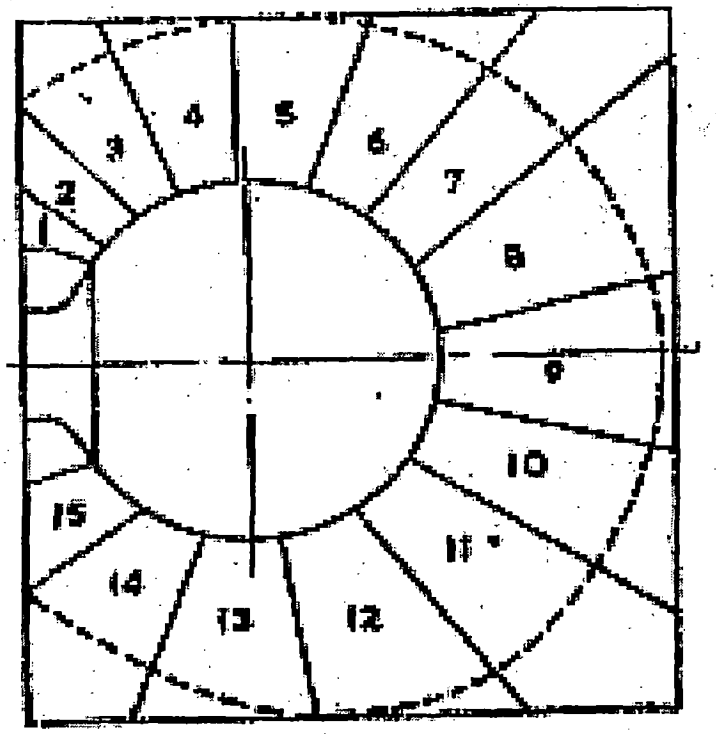


FIG. 1.7 RING ARRANGEMENT

As shown in the figure-1.7, an arch is inscribed with a different radius within the monolithically laid concrete. The ring is divided into a convenient number of sections. This method has more importance when some horizontal thrust, say, on account of high tail water is to be resisted by the encasing concrete.

iv) ***Hollow cylinder***

In this type of arrangement, each section of the encasing concrete may be treated as part of hollow cylinder which is subjected to uniform pressure on the inner (for internal hydrostatic plus water hammer forces) and outer surfaces. In this method the distribution of external forces on account of

superimposed loads of machinery will have to be converted into equivalent uniform pressure.

v) ***Mass concrete***

Many of the design organizations do not make any special analysis for this part and provide only normal reinforcement against surface cracks and openings and to distribute shrinkage strains. It is supposed that this concrete is a space filler and provides foundation for generator. It would behave like a block in which some openings have been scooped out, and the superimposed loads are transmitted to speed ring or concrete outside the scroll case.

vi) ***Model test***

Since any well defined analytical procedure for the analysis of scroll case is not available, it is advisable to support the results by experimental methods of stress analysis. The 3-dimensional stress analysis by photo-elastic method can be effectively employed to identify the areas of critical stresses.

vii) ***Numerical method***

With the availability of high speed and large memory computers, it is possible to carry out the rigorous analysis of the scroll case unit. Some of the available numerical method such as Finite Difference Method, Finite Element Method etc. render it possible for the whole unit to be considered as the 3-D structure. These can be regarded as the most accurate analysis procedure. In certain cases, reasonably accurate results may be obtained by simplication of the problem, e.g. splitting the essentially 3-D problem as a series of 2-D problems. It will be always worth which to analyze the problem by 3-D Finite Element Technique for obtaining greater degree of accuracy. Now a days many soft-wares for 3-D FEM analysis are available. ANSYS is one of them to analyze the structure as 3-D problem.

1.5 SCOPE OF THE STUDY

From the above, it is clear that the present knowledge about the actual structural behavior of the intermediate structure is inadequate and the prevalent 2-dimensional design practices are only approximate.

Therefore, an attempt has been made in this study to investigate stresses and deflections in concrete around a spiral casing on account of a various loading conditions by analyzing it as 3-dimensional structure using Finite Element Method (ANSYS soft-ware). The intermediate structure of Chillla Power House is taken as an example.

1.6 ORGANISATION OF THE STUDY

This dissertation report is presented in the six chapters as follows:

Chapter 1	Introduction to the problem and scope of the study.
Chapter 2	3-D Analysis techniques.
Chapter 3	Gives the basic concepts of the Finite Element Method (FEM) and basic equations .
Chapter 4	Details of structural model of the of scroll case concrete with assumptions, dimensions and different loading conditions.
Chapter 5	The results of analysis.
Chapter 6	Conclusions and suggestions for the further study.

CHAPTER-2

3-D ANALYSIS TECHNIQUES

2.1 General

2.2 Stress Analysis By Photo-elasticity Technique

2.3 Stress Analysis By Finite Element Method

CHAPTER 2

3-D ANLYSIS TECHNIQUES

2.1 GENERAL

Photo elasticity technique and Finite Element techniques are the two methods employed for 3-D analysis. Photo elasticity technique is an experimental method to study the three dimensional behavior of the structure and has been extensively used before the advent of Finite Element Method which is a numerical method. A brief description about the both methods is as follows.

2.2 STRESS ANALYSIS BY PHOTO ELASTICITY TECHNIQUE

2.2.1 Description Of The Method

Stress freezing method is employed in 3-D model photo elasticity technique to find out the stresses in the model. It is based on the diphase behavior of polymer materials when heated. The polymeric materials are composed of long chain hydrocarbon molecules some of which are well bonded into a 3-D network of primary bonds. However a large number of molecules are less solidly bonded together into shorter secondary chains. At room temperature both primary and secondary molecular bonds act to resist deformation due to applied load. However as the temperature of the polymer is increased the secondary bonds breakdown and the primary bonds in effect carry the entire applied load. Since the secondary bonds constitute a very large portion of the polymer, the deflections which the primary bonds undergo are quite large yet elastic in character.

If the temperature of the polymer is lowered to room temperature while the load is maintained on the model, the secondary bonds will be reformed between the highly elongated primary bonds and serve to lock them into their extended positions.

When the load is removed the primary bonds relax to a very modest degree but the main portion of their deformation is not recovered. The elastic deformation of the primary bonds is permanently locked into the model by the reformed secondary bonds.

As these deformations are locked-in on a molecular scale, the accompanying birefringence is maintained in any small section cut from the original model. The cutting or slicing process may relieve the molecular layer on each face of slice cut from a model but this relieved layer is so thin relative to the thickness of the slice that the effect is not observed.

Different steps for the stress freezing are as follows:

1. Place the model into the stress-freezing oven.
2. Heat the model relatively rapidly until the critical temperature is attained.
3. Apply the required loads.
4. Soak the model for at least two to four hours until a uniform temperature throughout the model is obtained.
5. Cool the model sufficiently slowly that temperature gradients are minimized at the rate 1^0 C per hour.
6. Remove the load and slice the model.

2.2.2 Basic Photo-elastic Equations

The basic photo elastic equation is

$$\sigma_1 - \sigma_2 = \frac{Nf_\sigma}{h}$$

where, h = thickness of the slice.

σ_1, σ_2 = principal stresses along two principal axes.

$$N = \frac{\Delta}{2\pi}$$

where, N = relative retardation in terms of complete cycle of retardation, 2π

Δ = Relative retardation,

$$f_\sigma = \frac{\lambda}{c} = \text{the material stress fringe value,}$$

where, λ = wave length,

$c = c_1 - c_2$ = Relative stress optic coefficient,

where c_1 and c_2 are stress optic coefficients along the two principal axes.

According to Maxwell:

"The changes in the indices of refraction are linearly proportional to the stresses induced in the model" i.e.

$$n_1 - n_0 = c_1 \sigma_1 + c_2 \sigma_2$$

$$n_2 - n_0 = c_1 \sigma_2 + c_2 \sigma_1$$

where, n_0 = index of refraction of the model in the unstressed state,

n_1 and n_2 are indices of refraction along the two principal axes associated with σ_1 and σ_2 respectively.

The component stresses computed from the above experimental method can be presented in the form of stress contours at different planes. Analysis of spiral casing (intermediate structure) of a powerhouse using photo-elastic technique has been carried out by Nigam[8] for machine load and stress contours are given in his book "Hand book of Hydro Electric Engineering (1985)".

2.3 STRESS ANALYSIS BY FINITE ELEMENT METHOD

2.3.1 2-D Analysis

Finite Element Method is essentially a generation of standard structural analytical procedure, which permits the calculations of stresses and deflections in two and three-dimensional structures. The basic concept of the FEM is discussed in chapter 3. This method is not the structural approximation of the continuum, but rather the use of two or three-dimensional structural elements assembled together, being interconnected at nodal points, which represent the whole structure. Some of the element for the 2-D and 3-D Finite Element Method is shown in the following figure-2.1 & 2.2. For three-dimensional discretization a large number of elements of different shapes are to be employed to achieve a reasonable physical approximation. So there was a necessity for a large capacity computer, which is available at present.

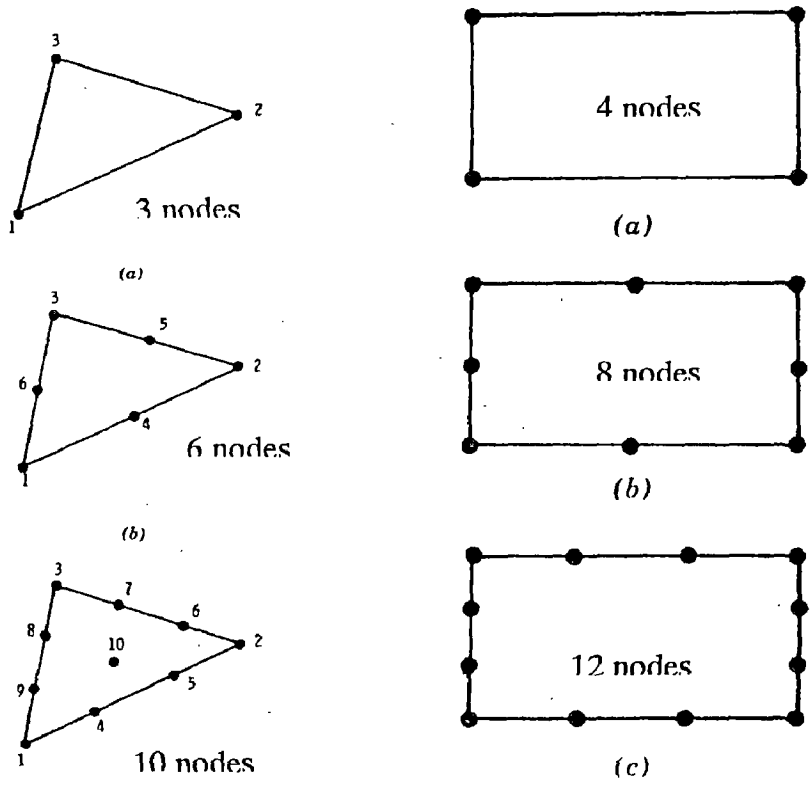
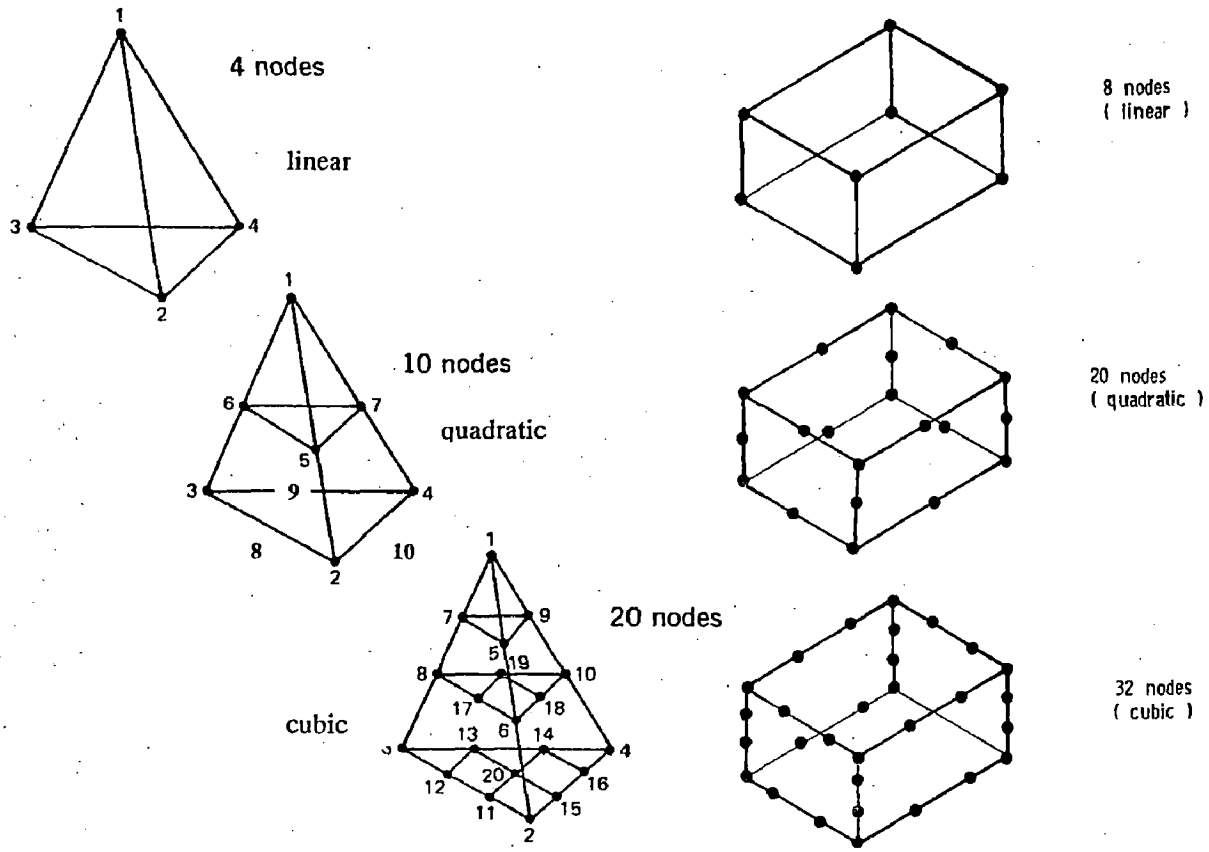


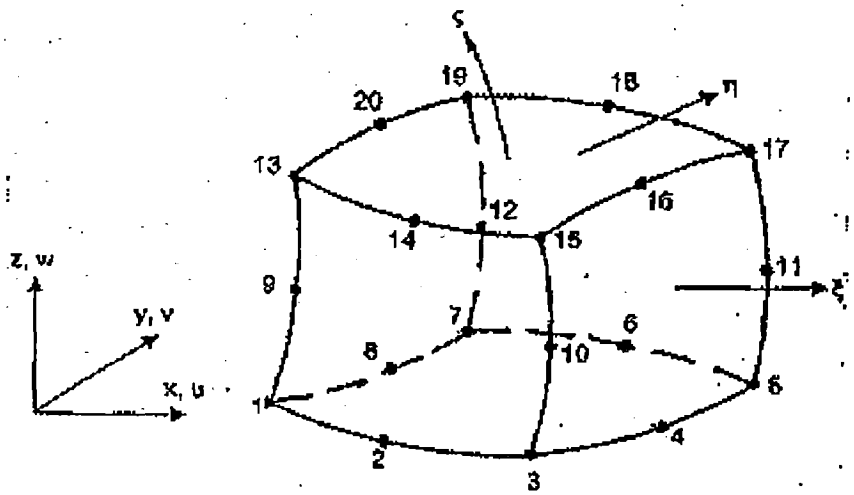
FIG. 2.1 DIFERENT TYPES OF 2-D ELEMENT

(a: linear; b: quadratic; c: cubic)

2.3.2 3-D Analysis

The intermediate structure of powerhouse is essentially a 3-dimensional structure with complex shaped cavities and loading conditions are also varying in all directions and levels. So the assumptions of two-dimensional model for the intermediate structure will not give the exact picture of nature of stresses developed at different locations. A 3-dimensional model study will give a clear picture sufficiently reliable and correct stress distribution pattern. In 3-dimensional model, number of elements can be increased to get more accurate results. But for large number of elements, more computer capacity and computation time is required so there should be a compromise between accuracy and computational time and computer capacity. In the present study in the FEM analysis, a 3-dimensional model of powerhouse intermediate has been adopted with the help of ANSYS package and results worked out are plotted and presented in the form of tables, contours and graphs.





20 noded Brick element (Quadratic)

FIG. 2.2 DIFERENT TYPES OF 3-D ELEMENT

Method and steps involved in FEM analysis are given in chapter 3.

CHAPTER-3

THE FINITE ELEMENT METHOD

3.1 General

3.2 Description of the Method

3.3 Summary of Procedure

3.4 Mathematical Model

3.5 Sign Convention

3.6 Process in Ansys

3.7 ANSYS Inputs

CHAPTER 3
THE FINITE ELEMENT METHOD

3.1 GENERAL

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems like analyzing structures, which permit the calculations of stresses and deflections. The most distinctive feature of finite element method that separates it from others is the division of a given domain into a set of sub-domains, called elements. The finite element procedure produces many simultaneous algebraic equations, which are generated and solved on a digital computer. Results are rarely exact. However, processing more equations minimizes errors, and results accurate enough for engineering purposes are obtainable at reasonable cost.

Using such elements, the structural idealization is obtained merely by dividing the original continuum into segments, all the material properties of the original system being retained in the individual elements. This is known as discretisation. Instead of solving the problem for entire body in one operation, the solutions are formulated at each constituent unit and combined to obtain the solution for the original structure.

3.2 DESCRIPTION OF THE METHOD

3.2.1 Discretization of the Continuum

Discretization is the process in which the given body is subdivided into an equivalent system of finite elements. Hence the body of the structure is essentially a piece of the whole. These elements provide natural representation of the properties of the original continuum. It may be noted that the continuum is simply zoned into small regions by imaginary planes in 3-D bodies and by imaginary lines in 2-D bodies. The first decision is to make the choice of the elements type. The boundaries of finite element may be straight or curvilinear.

The size of the element and the number in which the continuum is to be discretized depends upon the choice of the designer. As a general guideline it can be said that where the stress or strain gradients are expected to be comparatively flat i.e. variation is not rapid, the mesh can be coarse to reduce computations. Where as in the zones in which stress or strain gradients are expected to be steep i.e. pronounced variation occurs,

a finer mesh is indicated to get more accurate results. Theoretically speaking to get an exact solution the number of nodal points is infinite. So a compromised has to be made between computation effort and corresponding accuracy.

3.2.2 Selection of Proper Interpolation or Displacement Model

In finite element method we approximate a solution to a complicated problem by subdividing the region of interest into finite number of elements and representing the solution within each element by a relatively simple function of polynomials for ease of computation. The degree of the polynomial chosen depends on the number of nodes assigned to the element.

For the triangular element {fig.2.1(a)} the linear polynomial

$$\phi = \alpha_1 + \alpha_2 x + \alpha_3 y \qquad (3.1)$$

is appropriate,

where α_1 , α_2 , and α_3 are constants which can be expressed in terms of ϕ_1, ϕ_2 and ϕ_3 which are the values of ϕ at these nodes.

For 10 node tetrahedral element (fig.3.1), a quadratic variation is given by

$$\phi = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 z + \alpha_5 x^2 + \alpha_6 y^2 + \alpha_7 z^2 + \alpha_8 xy + \alpha_9 xz + \alpha_{10} yz \qquad (3.2)$$

To have a complete polynomial of n^{th} order, the tetrahedral must have $\frac{1}{6}(n+1)*(n+2)*(n+3)$ nodes when ϕ is the only nodal variable.

For the four nodded quadrilateral the bilinear function

$$\phi = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 xy \qquad (3.3)$$

is appropriate.

Eight node quadrilaterals have eight α_i in its polynomial expansion and can represent a parabolic function.

Equation (3.1), (3.2) are interpolations of function ϕ in terms of the position (x,y) within an element.

3.2.3 Convergence Requirements

In any acceptable numerical formulation the numerical solution must converge or tend to the exact solution of the problem. For this the criteria are:

a) **Displacement model must be continuous within the element and the displacements must be compatible within the adjacent elements.**

The first part is automatically satisfied if displacement functions are polynomials. The second part implies that the adjacent elements must deform without causing openings, overlaps or discontinuities between them. This can be satisfied if displacements along the side of an element depend only upon displacements of the nodes occurring on that side. Since the displacements of nodes on common boundary will be same, displacement for boundary line for both elements will be identical.

b) **The displacement model must include rigid body displacement of the element.**

Basically this condition states that there should exist such combinations of value of coefficients in displacement function that cause all points in the elements to experience the same displacement.

c) **The displacement model must include the constant strain of elements.**

This means that there should be such combinations of values of the coefficients in the displacement function that cause all points on the element to experience the same strain. The necessity of this requirement can be understood, if we imagine that the continuum is divided into infinitesimally small elements. In such a case the strains in each element approach constant values all over the element. The elements, which meet first criterion, are called compatible or conforming. The elements which meet second and third criteria are called complete. For plain strain and plain stress and 3-D elasticity problem the three conditions mentioned above are easily satisfied by linear polynomials.

3.2.4 Nodal Degree of Freedom

The nodal displacements, rotations and/or strains necessary to specify completely the deformation of finite elements or the parameter assigned to an element are called degree of freedom (DOF) of elements.

3.2.5 Element Stiffness Matrix

The equilibrium equation derived from principle of minimum potential energy between nodal loads and nodal displacements is expressed as

$$\{F\}^e = [K]^e \{\delta\}^e$$

where, $\{F\}^e$ = nodal force vector

$[K]^e$ = element stiffness matrix, and

$\{\delta\}^e$ = nodal displacement vector.

The stiffness matrix consists of the coefficients of equilibrium equations derived from material and geometric properties of the element. Stiffness of a structure is an influence coefficient that gives the force at one point on a structure associated with a unit displacement at the same or a different point.

Local material properties as stated above are one of the factors, which determine stiffness matrix. For an elastic isotropic body, Modulus of elasticity (E) and Poison's Ratio (ν) define the local material properties. The stiffness matrix is essentially a symmetric matrix, which follows from the principle of stationary potential energy, that "In an elastic structure work done by internal forces is equal in magnitude to the change in strain energy". And also from Maxwell Betti reciprocal theorem which states that: " If two sets of loads $\{F\}_1$ and $\{F\}_2$ act on a structure, work done by the first set in acting through displacements caused by the second set is equal to the work done by second set in acting through displacements caused by first set".

3.2.6 Nodal Forces and Loads

Generally when subdividing a structure we select nodal locations that coincide with the locations of the concentrated external forces. In case of distributed loading over the body such as water pressure on dam or the gravity forces the loads acting over an element are distributed to the nodes of that element by principle of minimum potential energy. If the body forces are due to gravity only then they are equally distributed among the three nodes of a triangular element.

3.2.7 Assembly of Algebraic Equations for the Overall Discretized Continuum

This procedure includes the assembly of overall or global stiffness matrix for the entire body from individual stiffness matrices of the elements and the overall or global force or load vectors. In general the basis for an assembly method is that the nodal interconnections require the displacement at a node to be the same for all elements adjacent to that node. The overall equilibrium relations between global stiffness matrix [K], the total load vector {F} and the nodal displacement vector for entire body {δ} is expressed by a set of simultaneous equations.

$$[K]\{\delta\} = \{F\}$$

The global stiffness matrix [K] will be banded and also symmetric of size of n x n where, n = total number of nodal points in the entire body. The steps involved in generation of global stiffness matrix are:

i) **All elements of global stiffness matrix [K] are assumed to be equal to zero.**

ii) **Individual element stiffness matrix [K] are determined successively.**

iii) **The element k_{ij} of element stiffness matrix are directed to the address of element K_{ij} of global stiffness matrix which means**

$$K_{ij} = \Sigma\, k_{ij}$$

Similarly nodal load $\{F_i\}^e$ at a node 'i' of an element 'e' is directed to the address of $\{F_i\}$ of total load vector i.e.

$$\{F_i\} = \Sigma\, \{F_i\}^e$$

3.2.8 Boundary Conditions

A problem in solid mechanics is not completely specified unless boundary conditions are prescribed. Boundary conditions arise from the fact that at certain points or near the edges the displacements are prescribed. The physical significance of this is that a loaded body or a structure is free to experience unlimited rigid body motion unless some supports or kinematics constraints are imposed that will ensure the equilibrium of the loads. These conditions are called the boundary conditions. There are two basic types of boundary conditions, geometric and natural. One of the principal advantages of Finite Element Method is, we need to specify only geometric boundary conditions, and the natural boundary conditions are implicitly satisfied in the solution procedure as long as

we employ a suitable valid variation principle. In other numerical methods, solutions are to be obtained by trial and error method to satisfy boundary conditions whereas in Finite Element Method boundary conditions are inserted prior to solving algebraic equations and the solution is obtained directly without requiring any trial.

3.2.9 Solution for the Unknown Displacements

The algebraic equations $[K]\{\delta\} = \{F\}$ formed are solved for unknown displacements $\{\delta\}$ wherein, $[K]$ and $\{F\}$ are already determined. The equations can be solved either by iterative or elimination procedure. Once the nodal displacements are found, then elements strains or stress can be easily found from generalized Hooke's law for a linear isotropic material.

The assumption in displacement function is that the stresses or strains are constant at all points over the element, may cause discontinuities at the boundaries of adjacent elements. To avoid this, sometimes it is assumed the values of stresses and strains obtained are for the centers of gravity of the elements and linear variation is assumed to calculate them at other points in the body.

3.3 SUMMARY OF PROCEDURE

The principal computational steps of linear static stress analysis by Finite Element Method are now listed.

i) **Input And Initialization**: Input the number of nodes and elements, nodal co-ordinates, structure node numbers of each element, material properties, temperature changes, mechanical loads and boundary conditions. Reserve storage space for structure arrays $[K]$ and $\{F\}$. Initialize $[K]$ and $\{F\}$ to null arrays. If array ID is used to manage boundary conditions, initialize ID and then convert it to a table of equation numbers.

ii) **Compute Element Properties**: For each element, compute element property matrix $[k]$ and element load vector $\{f\}$.

iii) **Assemble The Structure**: Add $[k]$ into $[K]$ and $\{f\}$ into $\{F\}$. Go back to step (ii), repeat steps (ii) and (iii) until all elements are assembled. Add external

loads {P} to {F}. Impose displacement boundary conditions (if not imposed implicitly during assembly by use of array ID).

iv) **Solve The Equations**: [K] {δ} = {F} for {δ}

v) **Stress Calculation**: For each element extract nodal D.O.F. of element $\{\delta\}^e$ from nodal D.O.F. of structure{δ}. Compute mechanical strains, if any and convert resultant strains to stresses.

3.4 MATHEMATICAL MODEL

3.4.1 Displacement Function

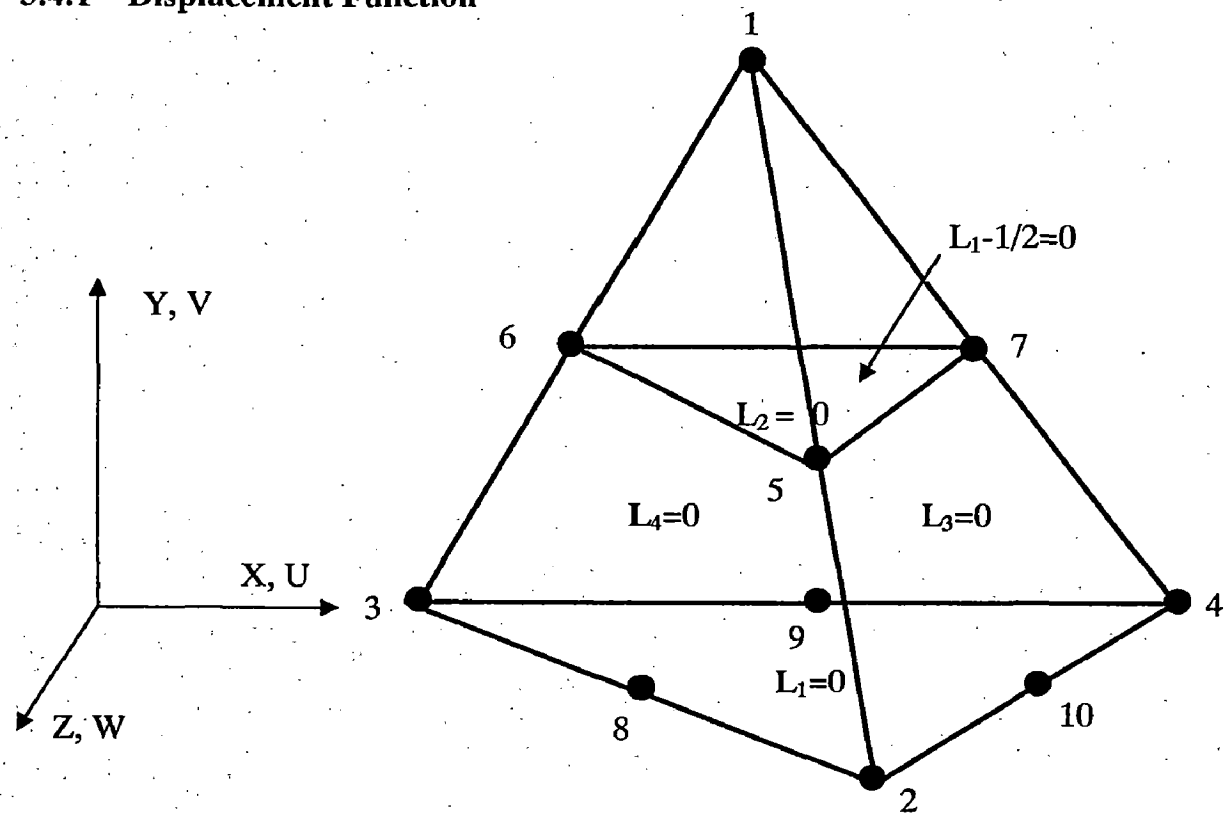


FIG. 3.1 A 10 NODED ISOPARAMETRIC TETRAHEDRAL SOLID ELEMENT

A 10 noded isoparametric finite element is shown in fig. 3.1. For a typical finite element 'e' defined by nodes i, j, k etc. the displacements {f} within the element are expressed as:

$$\{f\} = [N]\{\delta\}^e$$

where $[N] = [N_i \; N_j \; N_m \; \ldots.]$ (3.4)

and $\{\delta\}^e = \{\delta_i \; \delta_j \; \delta_m \; \ldots.\}$ (3.5)

The components of [N] are in general functions of position and $\{\delta\}^e$ represents a listing of nodal displacements for a particular element.

For the three dimensional element

$$\{f\} = \begin{Bmatrix} u \\ v \\ w \end{Bmatrix} \tag{3.6}$$

represents the displacements in x, y and z directions at a point within the element and

$$\{\delta_i\} = \begin{Bmatrix} u_i \\ v_i \\ w_i \end{Bmatrix} \tag{3.7}$$

are the corresponding displacements of node i.

[N] is equal to [IN] where N is the shape function of node and I is an identity matrix.

3.4.2 Shape Functions

The shape functions of a 10-node isoparametric tetrahedral element used in this study (shown in fig.3.1) are given by the following.

At corner nodes (node numbers 1, 2, 3, 4)

$$N_i = L_i (2L_i - 1) \tag{3.8a}$$

For mid side nodes:

i) $N_5 = 4L_1L_2$ (3.8b)

ii) $N_6 = 4L_1L_3$ (3.8c)

iii) $N_7 = 4L_1L_4$ (3.8d)

iv) $N_8 = 4L_2L_3$ (3.8e)

v) $N_9 = 4L_3L_4$ (3.8f)

vi) $N_{10} = 4L_2L_4$ (3.8g)

Where, $L_1+L_2+L_3+L_4 = 1$ (3.9)

L_1, L_2, L_3 and L_4 are the local (volume) coordinates of the point concerned.

3.4.3 Strains

With displacements known at all points within the element the strains at any point can be determined. Six strain components are relevant in three-dimensional analysis and the strain vector can be expressed as:

$$\{\in\} = \begin{Bmatrix} \in_x \\ \in_y \\ \in_z \\ \in_{xy} \\ \in_{yz} \\ \in_{zx} \end{Bmatrix} = \begin{Bmatrix} \frac{\partial u}{\partial x} \\ \frac{\partial v}{\partial y} \\ \frac{\partial w}{\partial z} \\ \frac{\partial u}{\partial y}+\frac{\partial v}{\partial x} \\ \frac{\partial v}{\partial z}+\frac{\partial w}{\partial y} \\ \frac{\partial w}{\partial x}+\frac{\partial u}{\partial z} \end{Bmatrix} \quad (3.10)$$

which can be further written as:

$$\{\in\}=[B]\{\delta\}^e=[B_i \ B_j \ B_k \ \ldots]\{\delta\}^e \quad (3.11)$$

in which $[B_i]$ is the strain displacement matrix.

$[B_i]$ is given by

$$[B_i] = \begin{bmatrix} \frac{\partial N_i}{\partial x} & 0 & 0 \\ 0 & \frac{\partial N_i}{\partial y} & 0 \\ 0 & 0 & \frac{\partial N_i}{\partial z} \\ \frac{\partial N_i}{\partial y} & \frac{\partial N_i}{\partial x} & 0 \\ 0 & \frac{\partial N_i}{\partial z} & \frac{\partial N_i}{\partial y} \\ \frac{\partial N_i}{\partial z} & 0 & \frac{\partial N_i}{\partial x} \end{bmatrix} \quad (3.12)$$

with other sub matrices obtained in a similar manner simply by interchange of subscripts.

For isoparametric elements

$$x = \sum_{i=1}^{n} N_i x_i \ ; \ y = \sum_{i=1}^{n} N_i y_i \ ; \ z = \sum_{i=1}^{n} N_i z_i \ ;$$

$$u = \sum_{i=1}^{n} N_i u_i \ ; \ v = \sum_{i=1}^{n} N_i v_i \ ; \ w = \sum_{i=1}^{n} N_i w_i \quad (3.13)$$

the summation being over total number of nodes in an element.

Because the displacement model is formulated in terms of the natural coordinates L_1, L_2 and L_3, and it is necessary to relate Eq. (3.12) to the derivatives with respect to these local coordinates.

The natural coordinatesL1, L2 and L3 are functions of global coordinates x, y, and z. Using the chain rule of partial differentiation we can write :

$$\frac{\partial N_i}{\partial L_1} = \frac{\partial N_i}{\partial x}.\frac{\partial x}{\partial L_1} + \frac{\partial N_i}{\partial y}.\frac{\partial y}{\partial L_1} + \frac{\partial N_i}{\partial z}.\frac{\partial z}{\partial L_1} \tag{3.14}$$

Performing the same differentiation with respect to the other two co-ordinates and writing in matrix form

$$\begin{Bmatrix} \frac{\partial N_i}{\partial L_1} \\ \frac{\partial N_i}{\partial L_2} \\ \frac{\partial N_i}{\partial L_3} \end{Bmatrix} = \begin{bmatrix} \frac{\partial x}{\partial L_1} & \frac{\partial y}{\partial L_1} & \frac{\partial z}{\partial L_1} \\ \frac{\partial x}{\partial L_2} & \frac{\partial y}{\partial L_2} & \frac{\partial z}{\partial L_2} \\ \frac{\partial x}{\partial L_3} & \frac{\partial y}{\partial L_3} & \frac{\partial z}{\partial L_3} \end{bmatrix} * \begin{Bmatrix} \frac{\partial N_i}{\partial x} \\ \frac{\partial N_i}{\partial y} \\ \frac{\partial N_i}{\partial z} \end{Bmatrix} = [J] \begin{Bmatrix} \frac{\partial N_i}{\partial x} \\ \frac{\partial N_i}{\partial y} \\ \frac{\partial N_i}{\partial z} \end{Bmatrix} \tag{3.15}$$

where [J] is given by:

$$[J] = \begin{bmatrix} \frac{\partial x}{\partial L_1} & \frac{\partial y}{\partial L_1} & \frac{\partial z}{\partial L_1} \\ \frac{\partial x}{\partial L_2} & \frac{\partial y}{\partial L_2} & \frac{\partial z}{\partial L_2} \\ \frac{\partial x}{\partial L_3} & \frac{\partial y}{\partial L_3} & \frac{\partial z}{\partial L_3} \end{bmatrix} \tag{3.16}$$

The matrix [J] is called the Jacobian matrix. The global derivatives can be found by inverting [J] as follows:

$$\begin{Bmatrix} \frac{\partial N_i}{\partial x} \\ \frac{\partial N_i}{\partial y} \\ \frac{\partial N_i}{\partial z} \end{Bmatrix} = [J]\text{-}1 \begin{Bmatrix} \frac{\partial N_i}{\partial L_1} \\ \frac{\partial N_i}{\partial L_2} \\ \frac{\partial N_i}{\partial L_3} \end{Bmatrix} \tag{3.17}$$

Substituting Eq. (3.13) into Eq. (3.16) the Jacobian matrix is given by

$$[J] = \begin{bmatrix} \sum \frac{\partial N_i}{\partial L_1} x_i & \sum \frac{\partial N_i}{\partial L_1} y_i & \sum \frac{\partial N_i}{\partial L_1} z_i \\ \sum \frac{\partial N_i}{\partial L_2} x_i & \sum \frac{\partial N_i}{\partial L_2} y_i & \sum \frac{\partial N_i}{\partial L_2} z_i \\ \sum \frac{\partial N_i}{\partial L_3} x_i & \sum \frac{\partial N_i}{\partial L_3} y_i & \sum \frac{\partial N_i}{\partial L_3} z_i \end{bmatrix} \tag{3.18a}$$

$$[J] = \begin{bmatrix} \frac{\partial N_1}{\partial L_1} & \frac{\partial N_2}{\partial L_1} & \cdots\cdots\cdots \\ \frac{\partial N_1}{\partial L_2} & \frac{\partial N_2}{\partial L_2} & \cdots\cdots\cdots \\ \frac{\partial N_1}{\partial L_3} & \frac{\partial N_2}{\partial L_3} & \cdots\cdots\cdots \end{bmatrix} \begin{bmatrix} x_1 & y_1 & z_1 \\ x_1 & y_1 & z_1 \\ x_1 & y_1 & z_1 \\ . & . & . \\ . & . & . \\ . & . & . \end{bmatrix} \tag{3.18b}$$

3.4.4 Stresses

The stresses are related to the strains as:

$$\{\sigma\} = [D](\{\in\} - \{\in_0\})\{\sigma_0\} \tag{3.19}$$

Where [D] is an elasticity matrix containing the appropriate material properties.

$\{\in_0\}$ is the initial strain vector.

$\{\sigma\}$ is the stress vector given by,

$\{\sigma\} = \{\sigma_x, \quad ,\sigma_y, \quad \sigma_z, \quad \sigma_{xy}, \quad \sigma_{yz}, \quad \sigma_{zx}, \}^T$ and

$\{\sigma_0\}$ is the initial stress vector.

For elastic, isotropic material the elasticity matrix is given by

$$[D] = \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} 1-\nu & \nu & \nu & 0 & 0 & 0 \\ \nu & 1-\nu & \nu & 0 & 0 & 0 \\ \nu & \nu & 1-\nu & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1-2\nu}{2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1-2\nu}{2} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix} \tag{3.20}$$

where E is the Young's modulus of elasticity and ν is the Poisson's ratio of the material of the element.

3.4.5 Stiffness Matrix

The stiffness matrix of the element is given by the following relation

$$\{F\}^e = [K]^e \{\delta\}^e \tag{3.21}$$

where $\{F\}^e$ is the element nodal load vector, $\{\delta\}^e$ is nodal displacement vector and $[K]^e$ is the element stiffness matrix given by:

$$[K]^e = \int_v [B]^T [D][B] dV = [B]^T [D][B] \int_v dV = [B]^T [D] [B] V \tag{3.22}$$

where V refers to the volume of the element.

The equivalent nodal forces are obtained as

i) Forces due to body forces $\{\Phi_x , \Phi_y , \Phi_z\}^T$ per unit volume are given by

$$\{F\}_b = \int_v [N]^T \{\Phi\} dV \tag{3.23a}$$

ii) Forces due to pressure distribution $\{p_x , p_y , p_z\}^T$ per unit area are given by:

$$\{F^e\}_p = \int [N]^T \{p\} dA \tag{3.23b}$$

For the complete structure relation of the form

$[K] \{\delta\} = \{F\}$

is obtained.

Where $\{\delta\}$ is the vector of global displacements, $\{F\}$ the nodal vector and $[K]$ the stiffness matrix.

The global stiffness matrix [K] is obtained by directly adding the individual stiffness coefficients in the global stiffness matrix. Similarly the global load vector for the system is also obtained by adding individual element loads at he appropriate locations in the global vector.

The mathematical statement of the assembly procedure is:

$$[K] = \sum_{e=1}^{E} [K]^e$$

$$\{F\} = \sum_{e=1}^{E} \{F\}^e \tag{3.25}$$

where E is the total number of elements.

To transform the variable and the region with respect to which the integration is made the relationship

$$dV = dx\,dy\,dz = \det[J]\,dL_1\,dL_2\,dL_3 \tag{3.26}$$

is used.

Writing explicitly

$$\int_v L_1^{\alpha} L_2^{\beta} L_3^{\gamma} L_4^{\delta} = \frac{\alpha!\beta!\gamma!\delta!}{(\alpha+\beta+\gamma+\delta+3)!}\,6V \tag{3.27}$$

and the characteristic element stiffness matrix can be expressed as

$$[K]^e = [B]^T [D] [B] \int_v L_1^{\alpha} L_2^{\beta} L_3^{\gamma} L_4^{\delta} \tag{3.28}$$

A 2 x 2 x 2 integration has been used for the three dimensional analysis.

3.5 SIGN CONVENTION

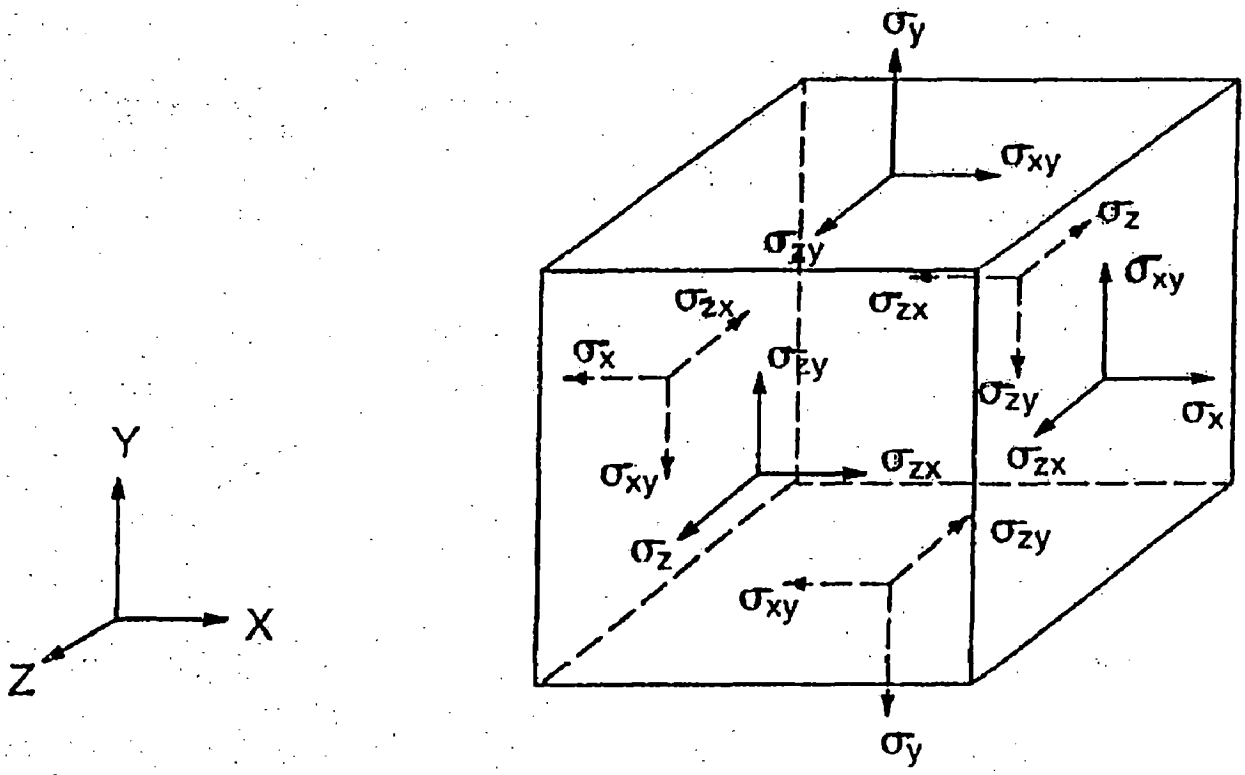


FIG.3.2 STRESS VECTOR DEFINITION

The stress vectors are shown in fig.3.2. The sign convention for ANSYS programmed is that tension is positive and compression is negative. Shear is positive when it rotates in anti-clockwise direction about positive axes.

3.6 PROCESSES IN ANSYS

ANSYS programmed has many finite element analysis capabilities, ranging from a simple linear, static analysis to a complex, non-linear, transient and dynamic analysis.

The distinct steps in ANSYS are as follows:

i) Building the model.

ii) Define an element type.

iii) Define material properties.

iv) Meshing the model into elements and nodes.

v) Apply boundary conditions and loads.

vi) Obtain the solution.

- Form element matrices.
- Prepares elements for solver.
- Solves equations.
- Calculates element results.

vii) Review of results in general post processor.

3.7 ANSYS INPUTS

E_x = Young's Modulus (input as EX)

ν_{xy} = Poisson's ratio (input as NUXY)

ρ = Density of concrete (input as DENS)

CHAPTER-4

STRUCTURAL MODELING OF SPIRAL CASE

4.1 General

4.2 Assumptions in the Model

4.3 Dimensions of the Model

4.4 Loads on Spiral Casing

4.5 Modeling Steps

4.6 Meshing of the Model

4.7 Solution

G11628

CHAPTER –4

STRUCTURAL MODELING OF SPIRAL CASE

4.1 GENERAL

The Scroll Case of Chilla Power House Garwal-Rishikesh-Chilla hydel scheme has been selected as a case study of this dissertation. This Power House utilizes the 32.0m drop in river Ganges between Rishikesh and Bhimgoda weir for the generation of hydroelectric power of 144 MW (4 units of 36MW each). The river flow has been diverted by constructing a 312m long barrage at Birbhadra across river Ganges and about 12.5km long channel on left bank of river for feeding the Power House at Chilla. The Tail Race Channel, down stream of the Power House is about 1.2km long and join river Ganges on its left bank upstream of Bhimgoda head-works.

A 3-D model of the scroll case of Chilla Power House and concrete surrounding it has been prepared to determine the deflections and stresses. Finite Element Method (FEM) using ANSYS software is used to analyze the model under different loading conditions to get an insight to the structural behavior of the spiral casing.

4.2 ASSUMPTIONS IN THE MODEL

The various simplified assumptions made in analysis are as follows:

a) The material is within its elastic limit.
b) Concrete around the spiral casing is homogeneous.
c) The material is isotropic.
d) Foundation for intermediate structure is rigid.
e) Model does not provide for any gallery or cavity in encasing concrete.
f) Loads of stator foundations and lower brackets are uniformly distributed on top surface of scroll case inside the generator barrel
g) Young's Modulus of Elasticity of concrete (M20), $E_{xx}=2.05 \times 10^5$ kg/sq.cm.
h) Poisson's Ratio of concrete, $\nu = 0.2$

4.3 DIMENSIONS OF THE MODEL

The dimensions of different parts are as below and these are shown in the fig.4.1, fig.4.2. and table 4.1.

a. The maximum diameter of scroll case is 6.00m at the inlet and contracting to zero.
b. The inner diameter of the barrel is 5.50m at turbine floor level and 9.50m at generator floor level.
c. The outer diameter of the generator barrel is 11.00m.
d. The discharge diameter of the turbine is 3.90m.
e. Length of the Penstock considered in the model is 6.351m.
f. Total length (in x-direction) of the unit considered is 19.25m.
g. Total width (in z-direction) of the unit considered is 16.601
h. Total height (y-direction) of the model is 8.70m.

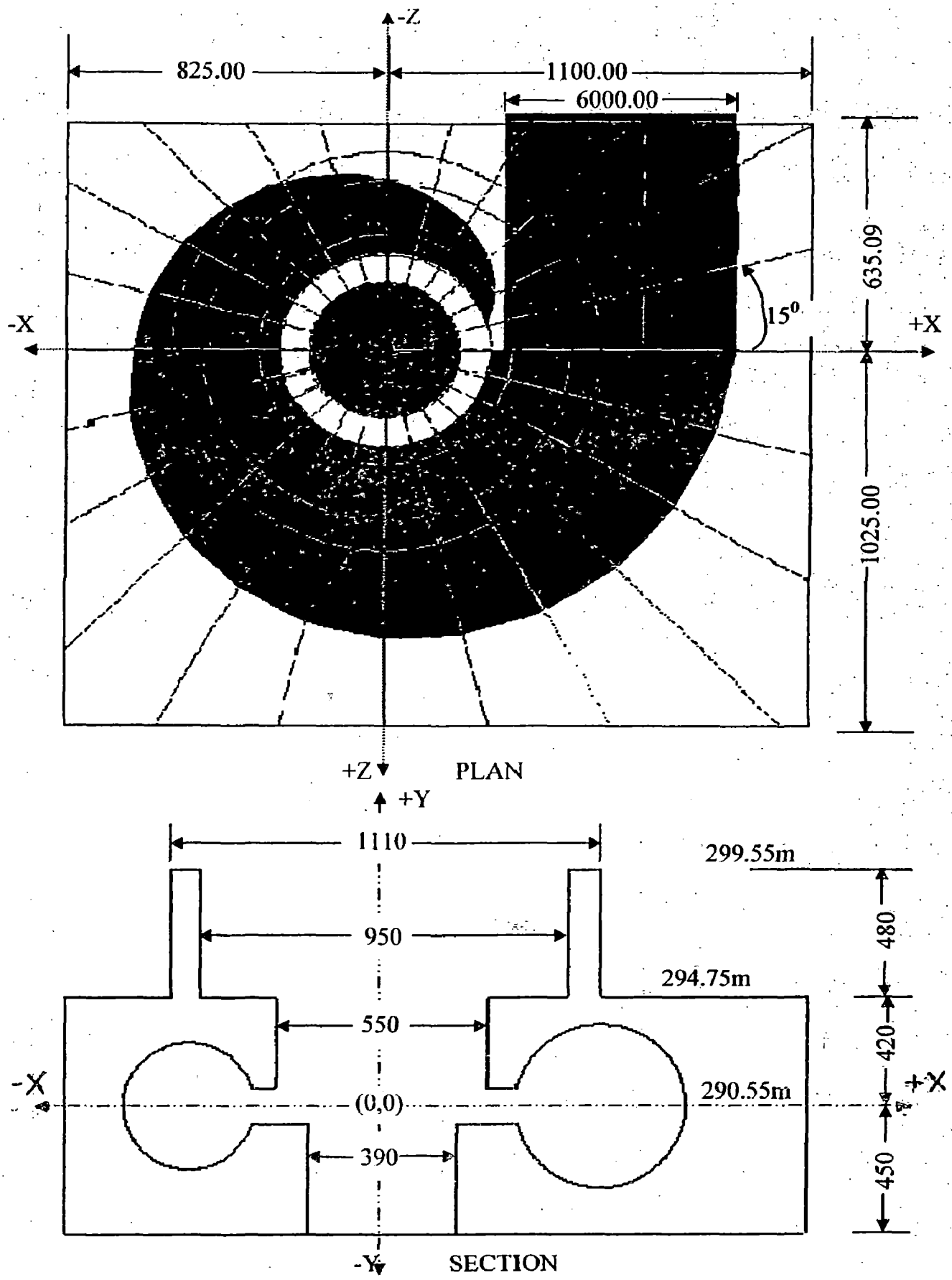


FIG. 4.1 DIMENSIONS OF THE MODEL
(All dimensions are in cm.)

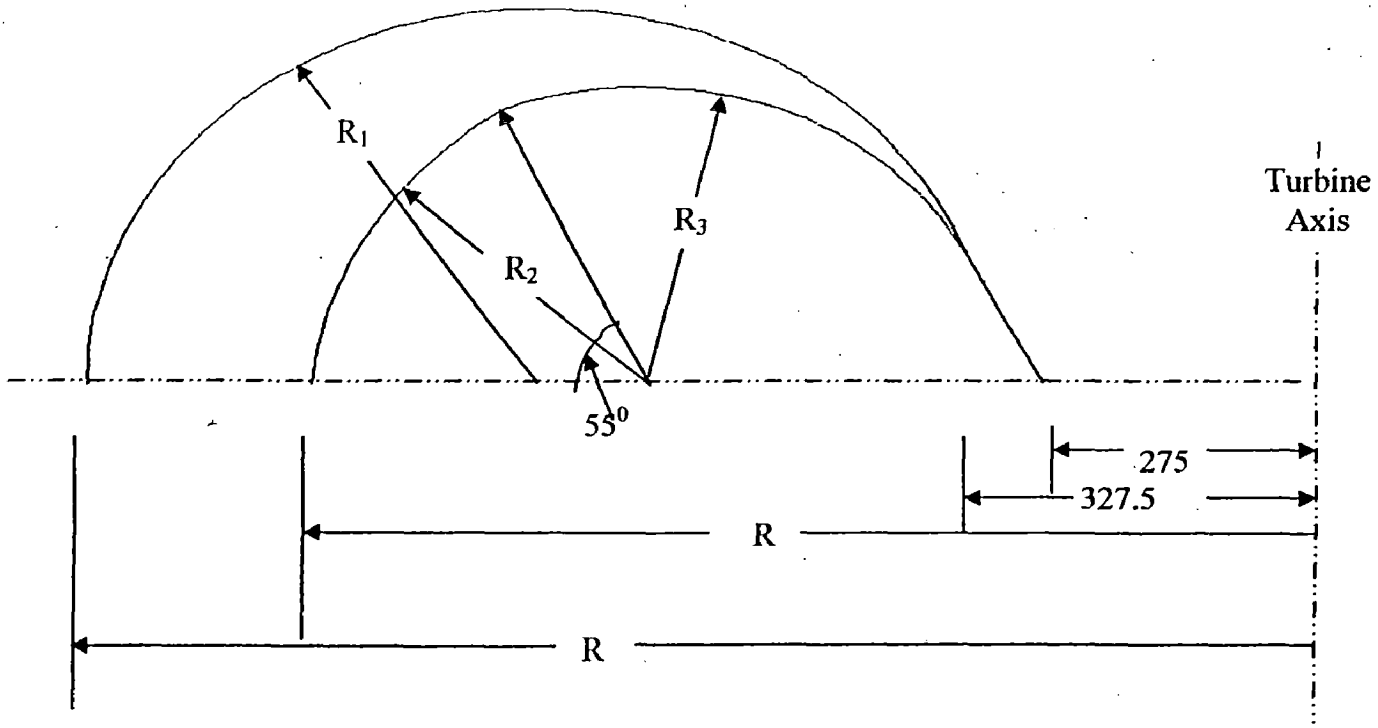


FIG. 4.2 SECTION ALONG CENTER LINE OF SPIRAL CASE

Table-4.1
RADIAL AND CIRCULAR DIMENSIONS OF SPIRAL CASE

Angle	360	345	330	315	300	285	270	255	240	225	210	195
R (cm)	906.6	887.5	868.5	849.5	830.4	811.3	792.1	772.9	753.7	733.9	711.9	688.1
R_1 (cm.)	300	290.8	281.7	272.6	263.5	254.4	245.3	236.3	227.3	218.1	207.8	197.1
R_2 (cm.)												
R_3 (cm.)												

Angle	180	165	150	135	120	105	090	075	060	045	030	015
R (cm)	662.4	635.3	606.3	574.1	541.2	508.7	477.7	446.6	415.2	366.0	327.5	275.0
R_1 (cm.)										112.0		
R_2 (cm.)	189.1	183.7	178.0	171.6	165.2	158.7	152.6	146.5	140.3			
R_3 (cm.)	182.6	164.8	145.7	124.5	102.9	81.5	61.1	40.7	20.0			

4.4 LOADS ON SPIRAL CASING

The following loads are assumed to be acting on the top of spiral casing concrete (El.294.75) and water pressure inside the spiral:

4.4.1 Machine and its Support Loads

The number of lower brackets and stator foundations are same =6
Load of Generator and Turbine rotating parts, water reaction and generator stationary parts on each stator foundation plate =135.00Tons
Load of rotating parts of Turbine and Generator on each lower brackets while lifting rotor =48.00Tons
Load of concrete pedestal for stator foundation (7*6) =42.00Tons
Load of conc. pedestal for lower bckt. foundation (2.75*6) =16.50Tons
Therefore, Total loads of machine and its foundation on spiral casing acting at level of 294.75m and in length between 2.75m to 4.75 from center line of Turbine pit in downward direction, W_1 =**1161.00**Tons

4.4.2 Generator Floor and Barrel Loads

Generator floor load (live and steel plate) inside the barrel =70.00Tons
Generator floor load (live and concrete) out side the barrel =270.00Tons
Concrete load of generator barrel =300.00Tons
Therefore, Total Load through Generator barrel on spiral casing acting at level 294.75m and in length between 4.75m to 5.55m from center line of Turbine pit in downward direction, W_2 =**640.00**Tons

4.4.3 Load due to Unilateral Magnetic Attraction

a) Radial force due to unilateral magnetic attraction on each lower bracket acting at distance 2.75m from center line of Turbine pit in both horizontally inward and outward direction, R1=±**80.00**Tons
b) Radial force due to unilateral magnetic attraction on each upper bracket acting at distance 4.75m from center line of Turbine pit in both horizontally inward and outward direction, R2=±**60.00**Tons

4.4.4 Load due to Double Short Circuit of Rotor Winding (DSCRW)

a) Circumferential (Tangential) force due to Double Short Circuit of Rotor Winding on each lower bracket acting at distance 2.75m from center line of Turbine pit, $T_1 = \pm 1.00$Tons

b) Circumferential (Tangential) force due to Double Short Circuit of Rotor Winding on each upper bracket acting at distance 4.75m from center line of Turbine pit, $T_2 = \pm 92.00$Tons

(positive and negative respectively for anticlockwise & clockwise directions when viewed from top)

4.4.5 Live Load on Turbine Floor

Turbine floor load acting at level 294.75m outside the barrel, in vertically downward direction Q =0.75Ton/sq.m.

4.4.6 Self Weight of Concrete

Specific (self) weight of scroll case concrete acting in downward direction, W=2.40Ton/cu.m.

4.4.7 Water Pressure

Total head available for hydropower is 32.0m. Assuming 10% as water hammer effect, Total internal water pressure acting at inner surface of scroll case, P=35.00Ton/sq.m.

4.5 MODELING STEPS

4.5.1 ELEMENT TYPE AND MATERIAL PROPERTIES

❖ **ELEMENT TYPE:**

A 10 noded tetrahedral element is selected for 3-d analysis i.e. PLANE2/SOLID92

❖ **MATERIAL PROPERTIES:**

M20 concrete is selected for analysis whose properties are as:

- Young' Modulus, E = 2.05 x 10^5 kg/sq.cm.
- Density of concrete, ρ = 0.0024kg/cu.m.
- Poision's Ratio, ν = 0.2

4.5.2 MODEL OF THE PROBLEM

Details of steps to create a model in ANSYS software, Key points, lines, Areas and volumes are given in Appendix-B and the isometric views of the model as developed by using ANSYS are shown in fig, 4.3 to 4.8.

4.6 MESHING OF MODEL

Model is meshed using smart size free meshing for level 5 (1 is finest and 10 is coarsest) and isometric views of meshed model are shown in fig. 4.9 and 4.10.

4.7 SOLUTION

Solution is carried out applying the boundary condition and loading condition as described below and typical views showing boundary conditions and loading conditions are shown in fig. 4.11 to 4.13.

4.7.1 BOUNDARY CONDITIONS

The Boundary condition is applied in such a way that the model is fixed with bottom i.e. sub structure. For that all nodes of lowest plane (i.e. Y= -450, X= -925.00 to 1100.00 and Z= -635.01 to 1025.00cm) are made constrained for all DOF.

4.7.2 LOADING CONDITIONS

All the loads coming through generator barrel are assumed as uniformly distributed on spiral casing in area between outer and inner

diameter of barrel. Machines and their foundation loads, Radial force due unequal magnetic attraction and Torque due to double short circuit of rotor winding are assumed to be acted as uniformly distributed on spiral casing in area between inner diameter of barrel and turbine pit diameter. Turbine floor loads are also assumed to be acted as uniformly distributed on spiral casing in outer area of the barrel diameter. All these loads are considered in analysis for following loading conditions: -

4.7.2.1 Without Internal Water Pressure Inside Scroll Casing: -

a) Free at speed ring support

i. Normal operating loads i.e. under combination of dead loads, live loads, and machine loads:

Density of concrete (for dead load, W) = .0024kg per cu.cm.

Applied gravity, FY = **1** (i.e. as density of conc.)

Machines and their foundations load, W_1 = 11610000.00kgs

Select Nodes (of the area in between inner diameter of barrel and turbine pit diameter) = 672nos. (found)

Load applied per Node, FY = -11610000/672kgs.

= **-1727.679**kgs.

Load through generator barrel, W_2 = 640000.00kgs.

Select Nodes (of the area in between outer and inner diameter of the barrel) = 480nos. (found)

Load applied per Node, FY = -640000/480 kgs.

= **-1333.333**kgs.

Load on the Turbine floor, Q = 167056.607kgs.

Select Nodes (of the area out side the barrel = 875nos. (found)

Load applied per Node, FY = -167056.607/875 kgs.

= **-190.922**kgs.

ii. Normal operating loads Radial Force due to unilateral magnetic attraction towards positive x- direction.

Radial Force due to unilateral magnetic attraction towards positive x direction (assumed), R = 840000.00kgs.

Load applied per Node, FX = 840000/672 kgs
= **1250.000**kgs.

In addition to NOL as above.

iii. Normal operating loads with Radial Force due to unilateral magnetic attraction towards negative x-direction.

Radial Force due to unilateral magnetic attraction towards negative x-direction (assumed), R = 840000.00kgs.

Load applied per Node, FX = **-1250.000**kgs.

In addition to NOL as above

iv. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in anti-clockwise direction.

Tangential Force due to DSCRW (double short circuit of rotor winding) acting in anti clockwise direction, T = 558000.000kgs

This total tangential load is equally divided through 24 areas of equal angular width of 15^0 and then these loads are resolve in x and z direction as shown in table-4.2.

In addition to NOL as above

v. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in clockwise direction.

Tangential Force due to DSCRW (double short circuit of rotor winding) acting in clockwise direction, T= 558000.000kgs

This total tangential load is equally divided through 24 areas of equal angular width of 15^0 and then these loads are resolve in x and z direction as shown in table-4.7.1. in addition to NOL as above.

Table-4.2
TANGENTIAL LOAD AT DIFFERENT NODES

Anti-clockwise				Clockwise			
Angle	No. of nodes	FX/node	FZ/node	Angle	Node	FX/node	FZ/node
0	7	0.00	-704.55	0	7	0.00	704.55
7.5	26	-91.96	-698.52	7.5	26	91.96	698.52
15	7	-240.70	-898.31	15	7	240.70	898.31
22.5	18	-355.90	-859.21	22.5	18	355.90	859.21
30	7	-465.00	-805.40	30	7	465.00	805.40
37.5	18	-566.15	-737.82	37.5	18	566.15	737.82

Table-4.2 (contd...)
TANGENTIAL LOAD AT DIFFERENT NODES

Anti-clockwise				Clockwise			
Angle	No. of nodes	Fx/node	Fz/node	Angle	Node	Fx/node	Fz/node
45	7	-657.61	-657.61	45	7	657.61	657.61
52.5	18	-737.82	-566.15	52.5	18	737.82	566.15
60	7	-805.40	-465.00	60	7	805.40	465.00
67.5	18	-859.21	-355.90	67.5	18	859.21	355.90
75	7	-680.54	-182.35	75	7	680.54	182.35
82.5	26	-698.52	-91.96	82.5	26	698.52	91.96
90	7	-801.72	0.00	90	7	801.72	0.00
97.5	22	-794.87	104.65	97.5	22	794.87	-104.65
105	7	-774.41	207.50	105	7	774.41	-207.50
112.5	22	-740.70	306.81	112.5	22	740.70	-306.81
120	7	-694.31	400.86	120	7	694.31	-400.86
127.5	22	-636.05	488.06	127.5	22	636.05	-488.06
135	7	-566.90	566.90	135	7	566.90	-566.90
142.5	22	-488.06	636.05	142.5	22	488.06	-636.05
150	7	-400.86	694.31	150	7	400.86	-694.31
157.5	22	-306.81	740.70	157.5	22	306.81	-740.70
165	7	-207.50	774.41	165	7	207.50	-774.41
172.5	22	-104.65	794.87	172.5	22	104.65	-794.87
180	7	0.00	704.55	180	7	0.00	-704.55
187.5	26	91.96	698.52	187.5	26	-91.96	-698.52
195	7	240.70	898.31	195	7	-240.70	-898.31
202.5	18	355.90	859.21	202.5	18	-355.90	-859.21
210	7	352.27	610.15	210	7	-352.27	-610.15
217.5	26	428.90	558.95	217.5	26	-428.90	-558.95
225	7	657.61	657.61	225	7	-657.61	-657.61
232.5	18	737.82	566.15	232.5	18	-737.82	-566.15
240	7	805.40	465.00	240	7	-805.40	-465.00
247.5	18	859.21	355.90	247.5	18	-859.21	-355.90
255	7	680.54	182.35	255	7	-680.54	-182.35
262.5	26	698.52	91.96	262.5	26	-698.52	-91.96
270	7	930.00	0.00	270	7	-930.00	0.00
277.5	18	922.04	-121.39	277.5	18	-922.04	121.39
285	7	898.31	-240.70	285	7	-898.31	240.70
292.5	18	859.21	-355.90	292.5	18	-859.21	355.90
300	7	610.15	-352.27	300	7	-610.15	352.27
307.5	26	558.95	-428.90	307.5	26	-558.95	428.90
315	7	657.61	-657.61	315	7	-657.61	657.61
322.5	18	566.15	-737.82	322.5	18	-566.15	737.82
330	7	465.00	-805.40	330	7	-465.00	805.40
337.5	18	355.90	-859.21	337.5	18	-355.90	859.21
345	7	240.70	-898.31	345	7	-240.70	898.31
352.5	18	121.39	-922.04	352.5	18	-121.39	922.04

b) Hinged at speed ring support

i) Normal operating loads i.e. under combination of dead loads, live loads, and machine loads.

ii) Normal operating loads with Radial Force due to unilateral magnetic attraction towards positive x-direction

ii) Normal operating loads with Radial Force due to unilateral magnetic attraction towards negative x-direction.

iv) Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in anti-clockwise direction.

v) Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in clockwise direction.

4.7.2.2 With Internal Water Pressure Inside Scroll Casing: -

a) Free at speed ring support

i. Normal operating loads i.e. under combination of dead loads, live loads, and machine loads.

ii. Normal operating loads with Radial Force due to unilateral magnetic attraction towards positive x-direction.

iii. Normal operating loads with Radial Force due to unilateral magnetic attraction towards negative x-direction.

iv. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in anti-clockwise direction.

v. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in clockwise direction.

b) Hinged at speed ring support

i. Normal operating loads i.e. under combination of dead loads, live loads, and machine loads.

ii. Normal operating loads with Radial Force due to unilateral magnetic attraction towards positive x-direction

iii. Normal operating loads with Radial Force due to unilateral magnetic attraction towards negative x-direction.

iv. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in anti-clockwise direction.

v. Normal operating loads with circumferential force due to DSCRW (for 3-D Analysis) in anti-clockwise direction.

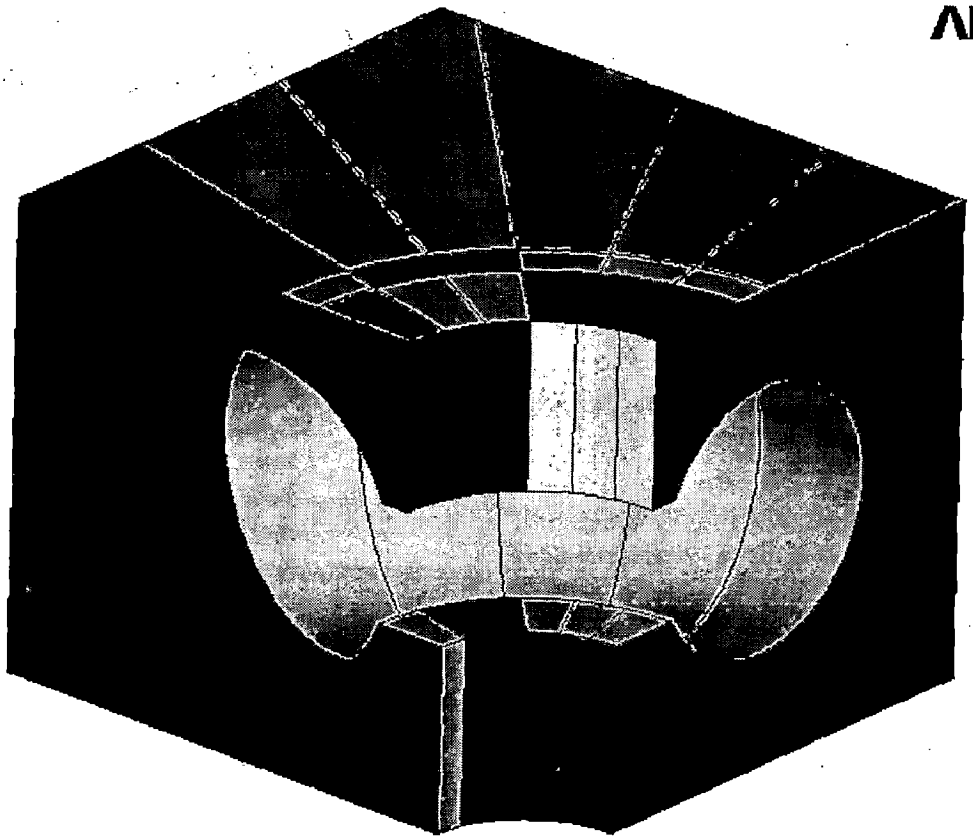


FIG. 4.3 VIEW OF VOLUME AT ANGLE 270 – 360^0 OF MODEL

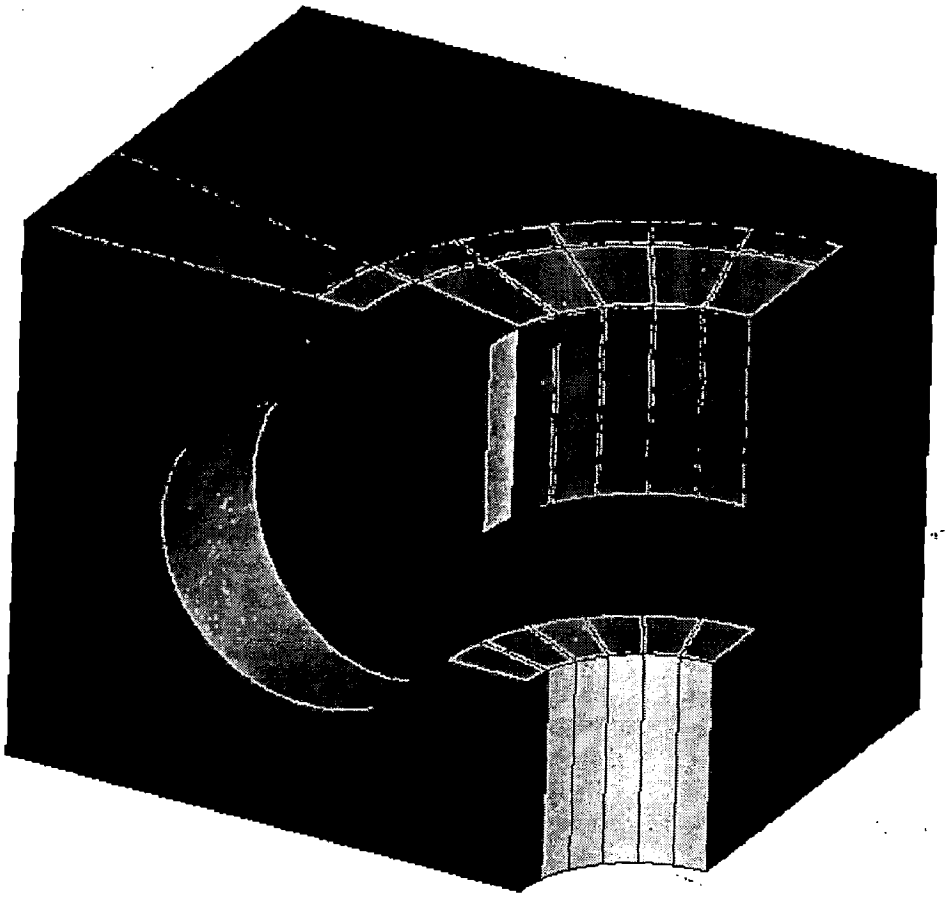


FIG. 4.4 VIEW OF VOLUME AT ANGLE 180 – 270^0 OF MODEL

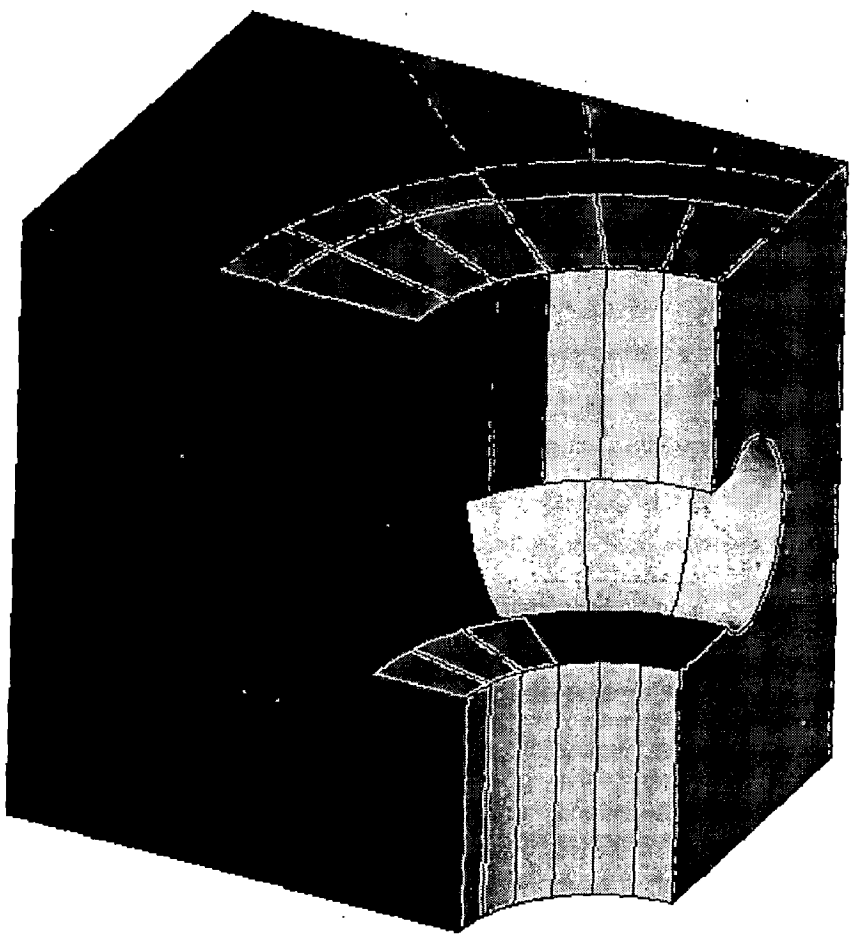


FIG. 4.5 VIEW OF VOLUME AT ANGLE 090 – 180^0 OF MODEL

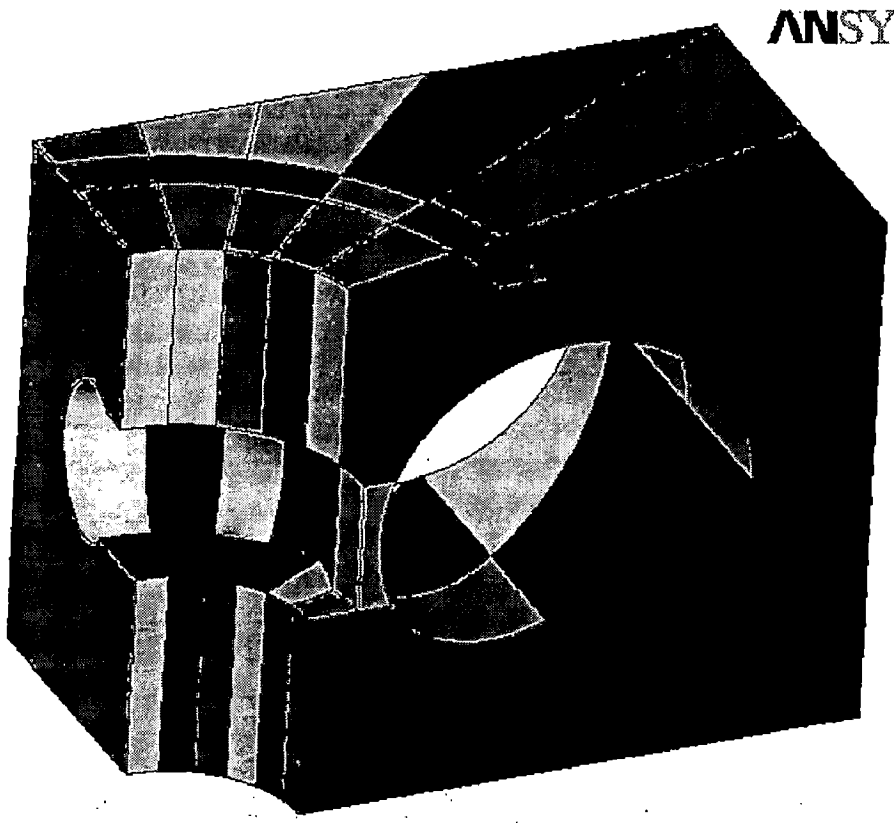


FIG. 4.6 VIEW OF VOLUME AT ANGLE 000 – 090^0 OF MODEL

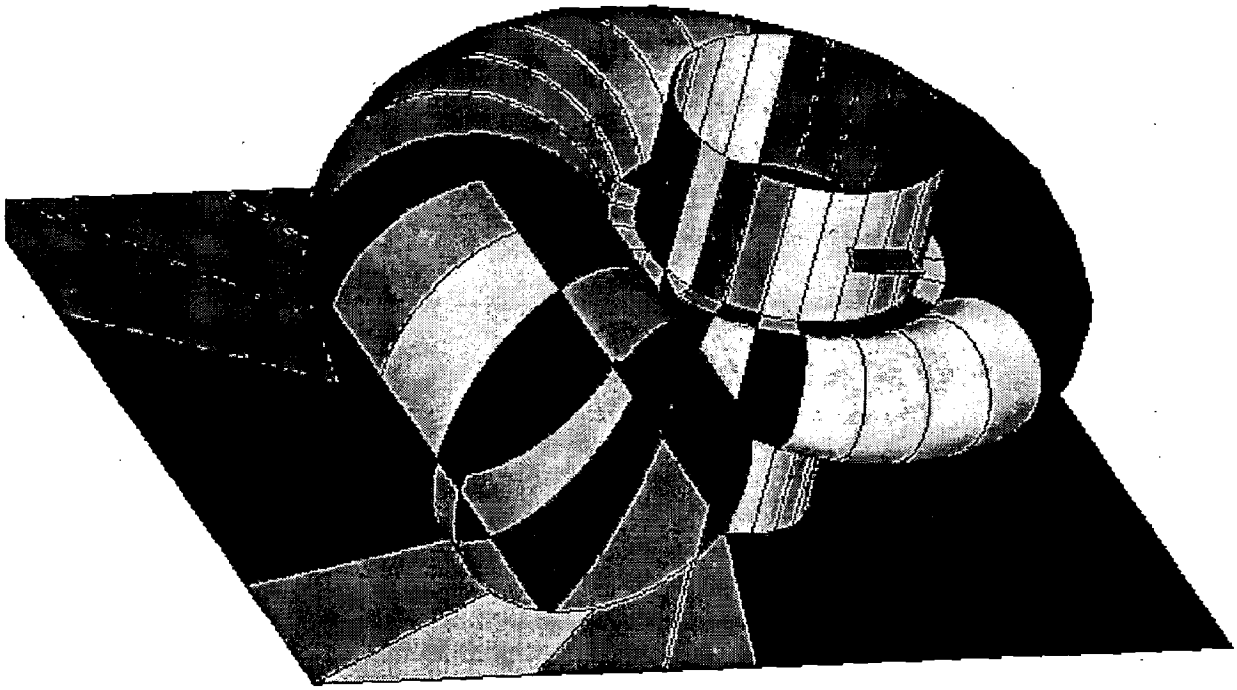


FIG. 4.7 ISOMETRIC VIEW OF SPIRAL CASING

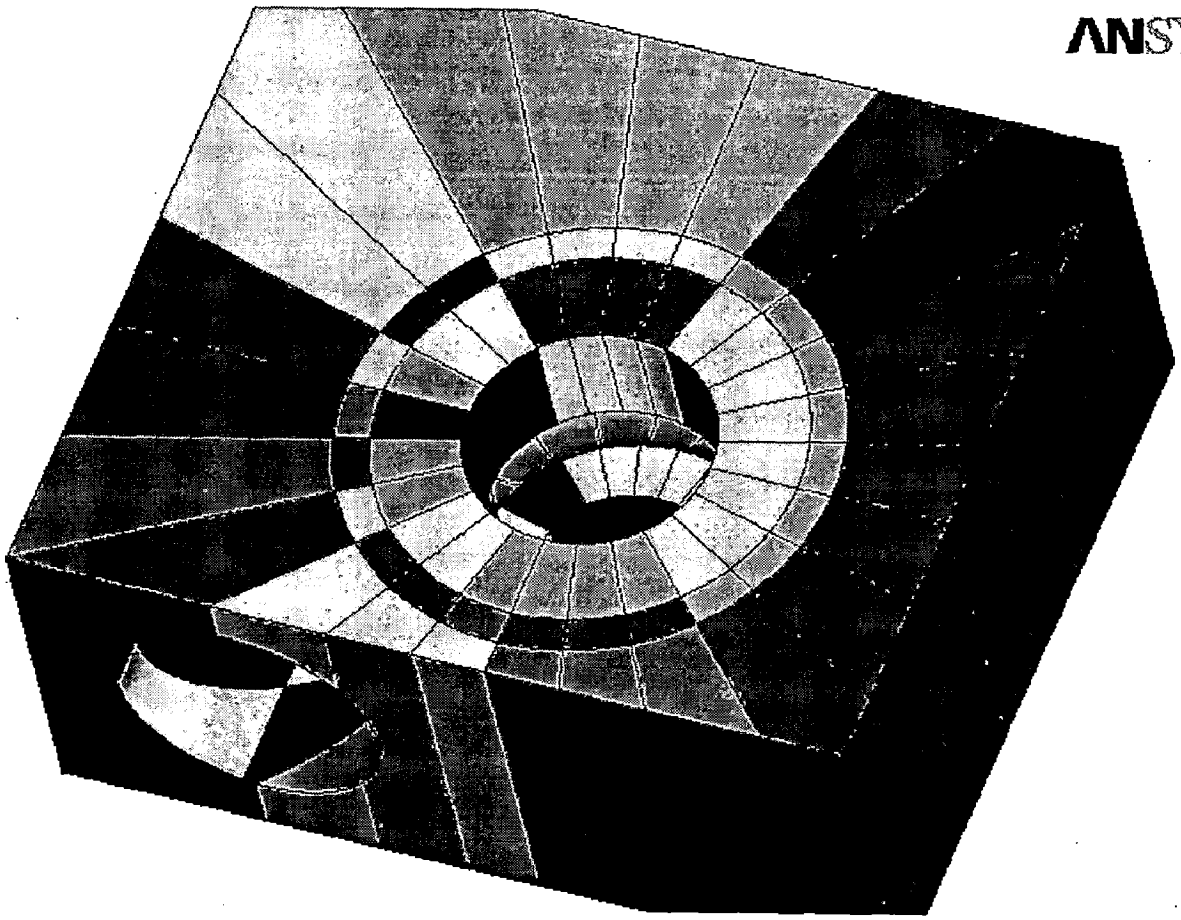


FIG. 4.8 ISOMETRIC VIEW OF 3-D MODEL

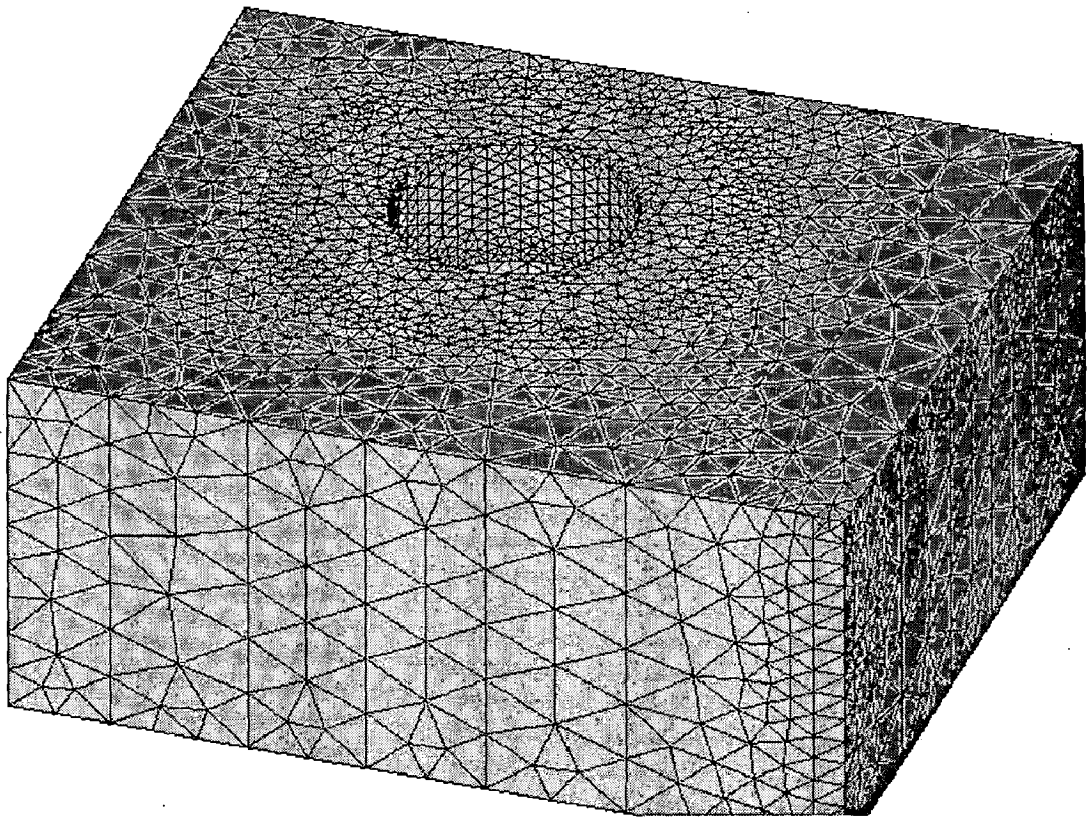


FIG. 4.9 ISOMETRIC VIEW OF 3-D MODEL WITH MESHING

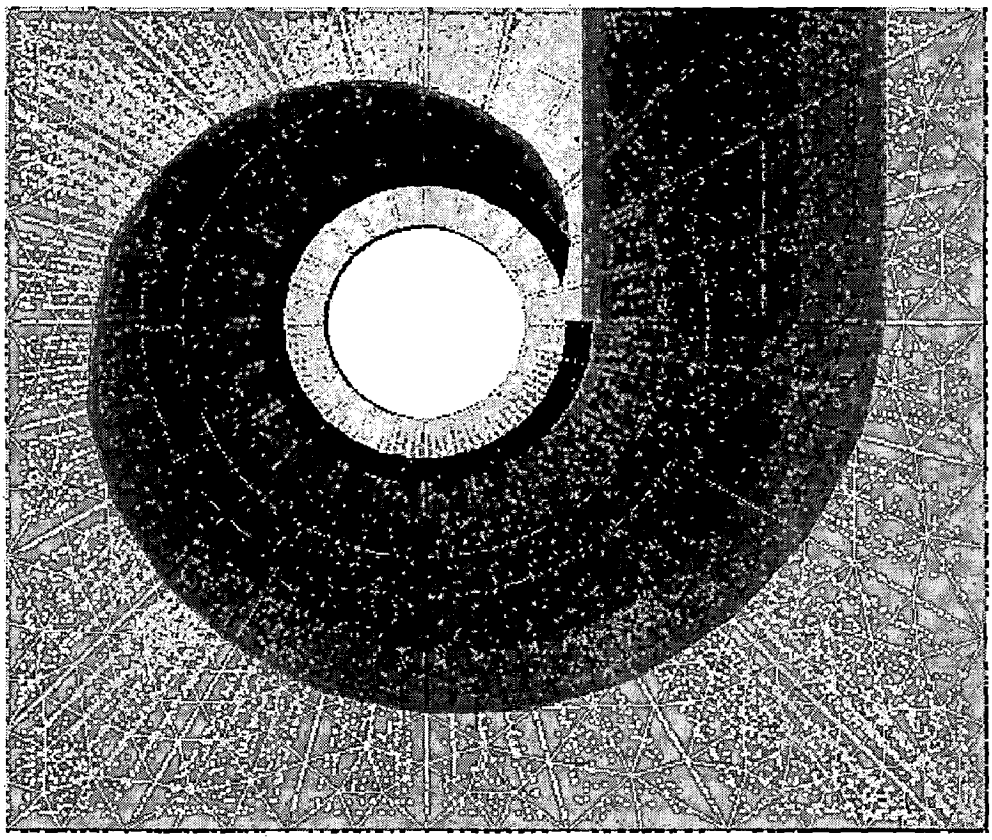


FIG. 4.10 TOP VIEW OF 3-D MODEL

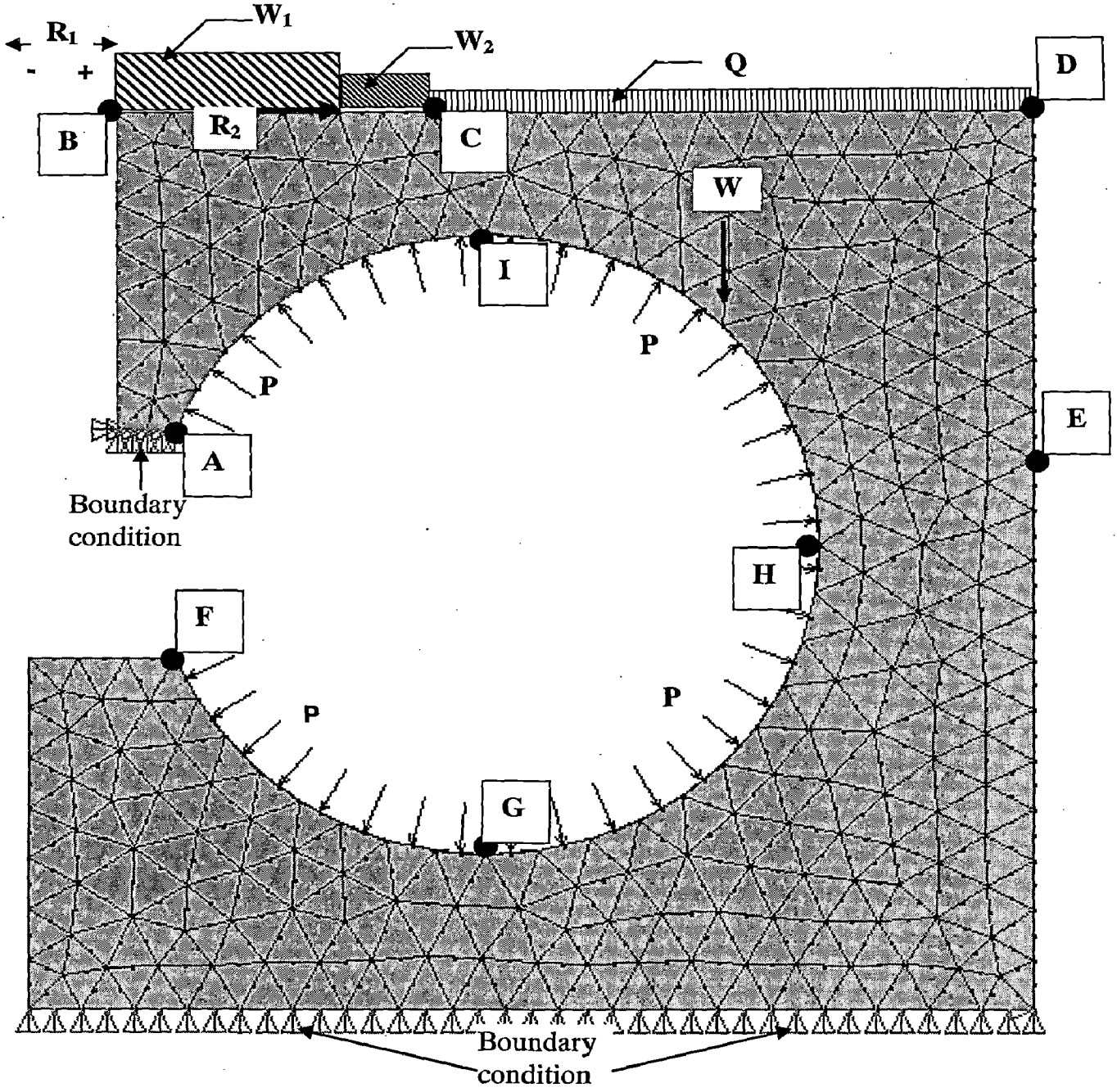


FIG. 4.11 TYPICAL SECTION SHOWING DIFFERENT LOADINGS AND CRITICAL POINTS FOR STUDY

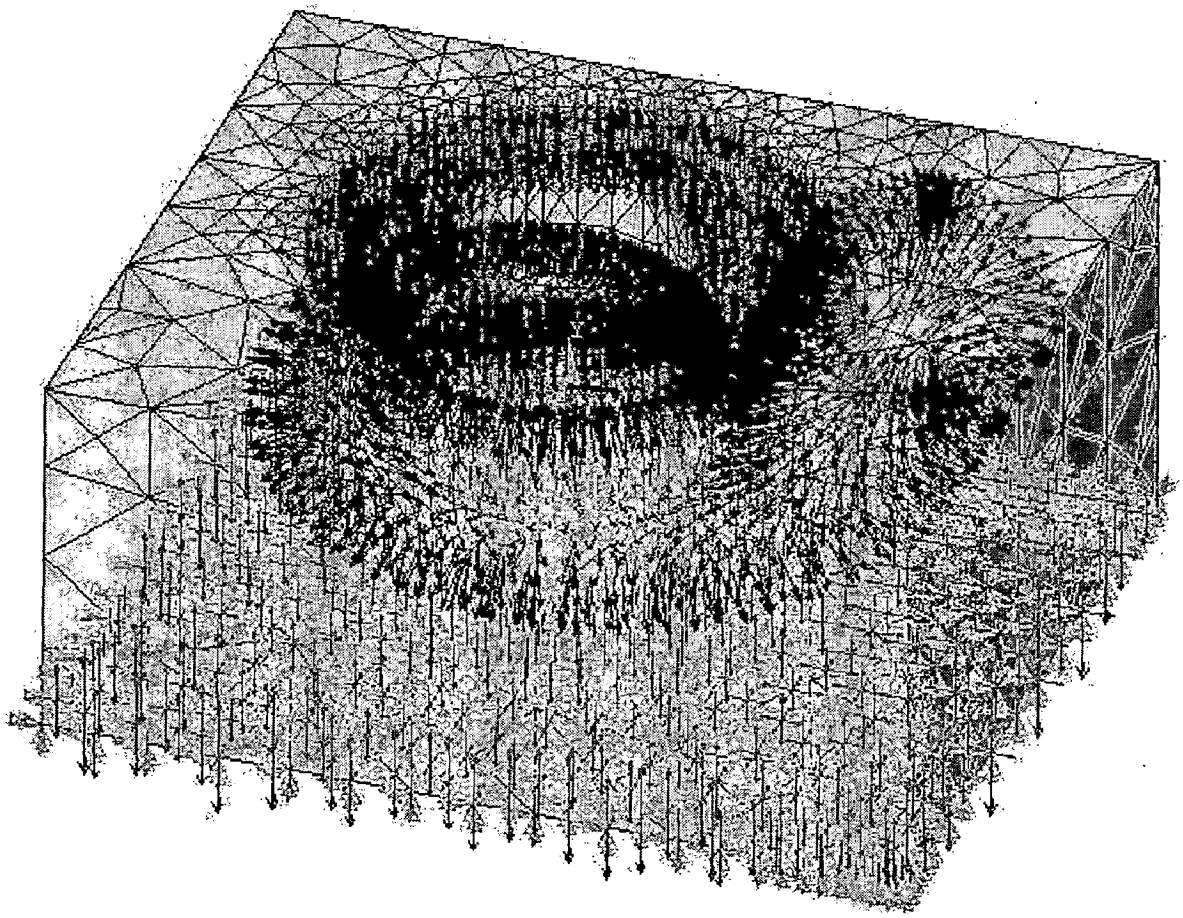


FIG. 4.12 ISOMETRIC VIEW SHOWING DIFFERENT TYPE OF LOADING

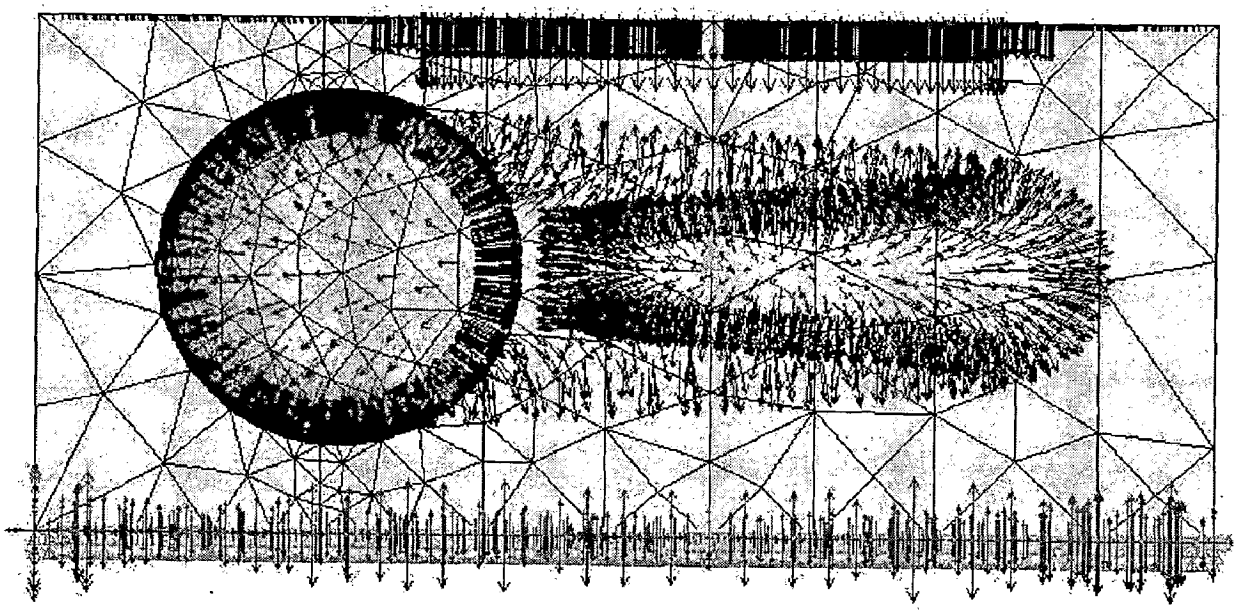


FIG. 4.13 BACK VIEW SHOWING DIFFERENT TYPE OF LOADING

CHAPTER-5

RESULTS OF ANALYSIS

5.1 General

5.2 Nature of Stress Component σ_x in X-Direction

5.3 Nature of Stress Component σ_y in Y-Direction

5.4 Nature of Stress Component σ_z in Z-Direction

5.5 Summary of Results

5.6 Comparison with 2-D Results

CHAPTER 5

RESULTS OF ANALYSIS

5.1 GENERAL

For analysis, the model is divided into 12 angular sections at interval of 30^0 and it is analyzed for the following conditions:

1. Concrete not sharing the internal water pressure. This means that spiral case liner withstands full static head plus water hammer effect.
2. Concrete take full internal water pressure.

For these two conditions the scroll case encasing concrete is analyzed for following two cases:

a) Free at speed ring. b) Hinged at speed ring

The model for these above conditions and cases is analyzed for the following loading combinations separately.

i. Dead load, floors load and machine load i.e. Normal Operating Load (NOL)
ii. NOL with Radial force due to unequal magnetic attraction toward positive x-direction.
iii. NOL with Radial force due to unequal magnetic attraction toward negative x-direction.
iv. NOL with Tangential force due to double short circuit torque of rotor winding in anti-clockwise direction.
v. NOL with Tangential force due to double short circuit torque of rotor winding in clockwise direction.

The model is analyzed for 20 loading combinations. Nine critical points are selected for study on each angular section as shown in figure-4.1 & 4.11 and results of deflections and stresses are tabulated for the same in the tables 5.1 to 5.12 (Appendix-A). The maximum and minimum values of deflections and stresses obtained globally (any point may or may not lie on defined sections) for all loading conditions are also tabulated in the said tables and plotted in figures-5.41 to 5.65 (Appendix-A). The nature of distribution of deflections and stresses are shown as contours in figures-5.1 to 5.40 (Appendix-A), for the section 060^0 and 240^0 only due to time constraint. However, contours of maximum and minimum normal stresses only are plotted in figures-5.5.1 to 5.5.24 placed at the end of this chapter. Contours for others parameters are obtained but

being similar in nature these are not included in this study. Variations of normal stresses in various zones along different sections for different conditions and cases are shown in figures-5.66 to 5.92 (Appendix-A).

5.2 NATURE OF STRESS COMPONENT σ_X (SX) IN X-DIRECTION (As shown in table-5.4, Appendix-A)

5.2.1 LOAD CONDITION 1a

i. Normal Operating Load (NOL)

- It is observed that zone A is in tension except the section 30, 60 and 360^0 where it is in compression. The maximum tension at A is observed as 11.58kg/sq.cm. at the section 270^0. Likewise zone I is in compression except the section 270, 150 and 120^0 where it is in tension.
- Zone B, C, and D is in compression almost for all section except 180, 210^0 for C & D where these zones are little bit in tension. The maximum compression is observed as 13.82kg/sq.cm.at B of the section270^0.
- Small amount of stresses (-0.5 to 1.5kg/sq.cm.) are observed in zone E and F except section 360^0 for zone F where compressive stress (5.86kg/sq.cm.) is transferred from A to F at this section.
- For almost all sections, it is also observed that zone G is in tension and zone H is in compression with small amount of stresses.
- It is observed that considerable amount of stresses are developed in zone A, B, C, and I only.

ii. NOL with Radial force due to unequal magnetic attraction in +ve x-direction

- At A, it is observed that additional compressive stress is developed for the section 30, 60, 90, 300 and 330^0 and tensile stresses in the remaining sections. Tensile stress at A becomes 12.28kg/sq.cm at section 270^0. And also, at the point I additional compressive stress is observed for the section 30, 60, 90, 300, 330 and 360^0 and tensile stress in the remaining sections.
- At point B and C additional compressive stress is developed for the section 30, 60, 240, 270, 300, 330 and 360^0 and tensile in the remaining sections, so maximum compressive stress is observed as 14.18kg/sq.cm.at section 270^0 and at location B.
- Additional tensile is developed at point D for the section 30, 90, 300, 330 and 360^0, at G for the section 60, 90, 300, 330 and 360^0 and compressive in remaining sections.

iii. **NOL with Radial force due to unequal magnetic attraction in –ve x-direction**

- Exactly reverse action is observed compare to load case (ii) in every zone and at every sections. And in this case maximum tensile stress is observed as 10.87kg/sq.cm.and maximum compressive stress as 13.46kg/sq.cm.at the same location and section as previous loading.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- It is observed that additional compressive stress is developed at point A for the section 30, 60, 90, 330 and 360^0 and tensile at the remaining section. Since the increment in the tensile stress is less than as in load case (ii), the maximum tensile stress is obtained as 11.75kg/sq.cm.only at the same location.
- In similar way additional compressive stress is observed at point B for the section 120, 150, 180, 300, 330 and 360^0, at point C for the section 90, 120, 150, 180, 270, 300, 330 and 360^0, at point I for the section 120, 150, 180, 300 and 330^0. Since the variation in compressive stress is more than compare to load case (ii), maximum compressive stress is observed as 13.06kg/sq.cm at the same location.
- At other locations increment of stresses are small.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Additional tensile and compressive stresses are found in exactly reverse manner than it observed for load case (iv).
- Maximum tensile stress is observed as 11.40kg/sq.cm.and compressive stresses as 14.57kg/sq.cm.at the same locations.

Hence

- Maximum tensile stress (12.28kg/sq.cm) is observed at point A in the section 270^0 for load (ii) and
- Maximum compressive stress (14.57kg/sq.cm.) is observed at point B for load (v) at the same section.

Globally, it is observed that:

- Maximum compression (17.483kg/sq.cm.) is observed at (470.94, 420.00, and 62.00) the inner edge of generator barrel & the turbine floor level (zone C) of 7.5^0 angular section for load (ii).

- ❖ Maximum tension (14.212kg/sq.cm.) is observed at (0.0, 110.0, and 275.0) the outer edge of speed ring position (zone A) of 270^0 angular section for load (ii).
- ❖ Maximum deflection (0.0826cm) is observed at (x=0.0, y=420.0, z=275.0) the top of turbine pit (zone B) of 270^0 angular section for load (ii) in y-direction.
- ❖ Loading (ii) gives the maximum deflections and stresses. At most of the sections A, C, G and area around these points is under tension and rest of the area is under nominal tension or compression except area around B, which has more compression.
- ❖ Maximum and minimum values of deflections and stresses are shown in figure-5.61.

5.2.2 LOAD CONDITION 1b

i. <u>Normal Operating Load (NOL)</u>

- o It is observed that zone A, C and H is in compression except the section 60 and 90^0 where C is in tension. The maximum compression at A is observed as 11.30kg/sq.cm.at section 060^0.
- o Likewise it is observed that zone B, G and I are in tension except the section 330 and 360^0 for I and section 60^0 for G, which are in compression. The maximum tension is observed as 2.43kg/sq.cm.at point I of the section 030^0.
- o At zone D, E and F nominal tensile (1.58kg/sq.cm) and compressive (0.81kg/sq.cm.) stresses are observed.
- o It is observed that considerable amount of stresses are developed in zone A, B, C, and I only for this load case also.

ii. <u>NOL with Radial force due to unequal magnetic attraction in +ve x-direction</u>

- o It is observed that additional compressive stress is developed in all zones except D & G, for the section 300, 330 and 360^0. Beside it compressive stress is developed in zone A for the sections 120, 150, 180, 210 and 270^0, in zone C for the sections 30 & 270^0 and in zone H for the sections 060, 090, 120, 180, 240 and 270^0. For the remaining sections additional tensile stress is developed in zone A, C and H. Compressive stress at A becomes 9.19kg/sq.cm at section 060^0.

- It is also observed that additional tensile stress is developed in zone B for sections except 30, 300, 330 and 360^0, in zone G for sections 060, 090, 300, 330 and 360^0 and in zone I for sections 30, 60, 240 and 270^0. In the remaining sections additional compressive stress is observed for sections B, G and I. So maximum tensile is observed as 3.25kg/sq.cm at point I for section 30^0.
- Additional compressive stress is observed in zone D for sections 60, 150, 180 and 270^0 where as additional tensile stress is developed in zone E for section 30, 90, and210^0, and in zone F for sections 30, 60, 90, and 180^0. Additional tensile and compressive stresses respectively are developed for remaining sections in zone D, E and F.

iii. **NOL with Radial force due to unequal magnetic attraction in –ve x-direction**

- Exactly reverse action is observed compare to load case (ii) in every zone and at every sections.
- Maximum tensile stress is observed as 4.71kg/sq.cm at the point I and shifted for section 150^0 and maximum compressive stress as 13.41kg/sq.cm.at the same location and section as previous loading.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- It is observed that additional compressive stress is developed in zone A for sections 60, 90, 180, 210, 240 and 270^0, in zone C for sections 90, 120, 150, 180, 300, 330 and 360^0 and very small variations are observed in tensile and compressive stresses in zone H for almost all the sections. For remaining sections, additional tensile stress is observed in zone A and C. So maximum compressive stress becomes as 12.17kg/sq.cm at point A for section 60^0 i.e. at the same location
- In similar way additional compressive stress is observed in zone B for the section 120, 150, 180, 300, 330 and 360^0, in zone I for the section 60, 300 and 330^0 and very small variations are observed in tensile and compressive stresses in zone G for almost all the sections. For remaining sections, additional tensile stress is observed in zone B and I. So maximum tensile stress becomes as 2.91kg/sq.cm at point I for section 30^0 i.e. at the same location

- At other locations, since nominal tensile and compressive stresses are observed, increments of stresses are small.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Additional tensile and compressive stresses are found in exactly reverse manner than it observed for load case (iv).
- Maximum tensile stress is observed as 3.27kg/sq.cm shifted to the point B and shifted for section 300^0 and maximum compressive stress as 10.44kg/sq.cm.at the same location and section as previous loading (ii).

Hence

- Maximum tensile stress (4.71kg/sq.cm) is observed at point I for the section 150^0 for load (iii)
- Maximum compressive stress (13.41kg/sq.cm.) is observed at point A for load (iii) at section 60^0.

Globally, it is observed that:

- Maximum compression (25.823kg/sq.cm.) is observed at (204.24, 110.00, and 256.01) the inner edge of upper speed ring position (zone A) of 51.418^0 angular section for load (iii).
- Maximum tension (6.721kg/sq.cm.) is observed at (232.55, 99.16, -251.72) inner edge of scroll case towards upper speed ring position (zone I) of 47.267^0 angular section for load (ii)
- Maximum deflection (0.0234cm) is observed at (x=505.41, y=420.0, z=-89.70) the joining of the generator barrel and the turbine floor (zone C) of 10.064^0 angular section for load (ii) in y-direction.
- Loading (ii) gives the maximum deflections and tensile stresses where as loading (iii) gives the maximum compression. A, C, H and area around these points is under compression and Zone B, G and I is in compression except the section 60^0 for C and G, section 90^0 for C and sections 330 & 360^0 for zone I where opposite stresses are observed. And rest of the area is under nominal tension or compression.
- Maximum and minimum values of deflections and stresses are shown in figure-5.62.

5.2.3 LOAD CONDITION 2a

i. Normal Operating Load (NOL)

- It is observed that zones B, C, G and I are in tension except the sections 90 &120^0 for B, sections 180 & 210^0 for C and section 60^0 for G and I where it is observed compression. The maximum tension at I is observed as 8.24kg/sq.cm.at the section 30^0.
- Zones A, and F are in compression for all sections except 90 and 120^0 for A where this zone is tension. The maximum compression is observed as 6.96kg/sq.cm.at A of the section 300^0.
- Small amount of tensile and compressive stresses are observed in zone D and E except section 60 and 270^0 where considerable amount of stresses (-3.34 to 3.33kg/sq.cm.) are observed. And also a considerable amount (2.61kg/sq.cm) of tensile stress is observed in zone E for section 90^0.
- Zone H is in tension for the sections 90, 120, 240, 270 and 300^0 and in compression for the remaining sections.

ii. NOL with Radial force due to unequal magnetic attraction in +ve x-direction

- At A, it is observed that additional compressive stress is developed for the section 30, 60, 90, 300 and 330^0 and tensile stresses in the remaining sections. So maximum compressive stress at A becomes 7.15kg/sq.cm at same section 300^0. And also at point B and C additional compressive stress is developed for the section 30, 60, 240, 270, 300, 330 and 360^0 and tensile in the remaining sections. Zone F is still in compression for all sections.
- At the point I additional compressive stress is observed for the section 30, 60, 90, 300, 330 and 360^0 and tensile stress in the remaining sections. Maximum tensile stress is observed as 7.93kg/sq.cm at same location (point I for section 30^0).
- Additional tensile is developed at point D for the section 30, 90,300,330 and 360^0, at G for the section 60, 90, 300, 330 and 360^0 and compressive in remaining sections. Tensile stress at D becomes as 2.50kg/sq.cm for the section 60^0, 2.48kg/sq.cm for section 270^0. Since, additional tensile stress is developed at E for the section 90^0 and 270^0 its value becomes as 2.93 and 2.38kg/sq.cm respectively.

- In zone H, additional tensile stress is observed for the sections 30, 150, 210, 330 & 360^0 and additional compressive in remaining sections.
- It is observed that additional tensile and compressive stresses are developed in same manner as in load case (ii) for respective locations.

iii. **NOL with Radial force due to unequal magnetic attraction in –ve x-direction**

- Exactly reverse action is observed compare to load case (ii) in every zone and at every sections. Since additional tensile stress is developed in zone I of the section 30^0, maximum tensile stress becomes as 8.54kg/sq.cm at same location and section as previous loading.
- In zone A, since additional tensile stress is developed for section 300^0 and compressive for section 270^0, the maximum compressive stress is observe as 7.58kg/sq.cm for section 270^0 at point A.
- Since, additional compressive stress is developed at E for the section 90^0 and 270^0 its value becomes as 2.30 and 2.36kg/sq.cm respectively. Similarly tensile stress at D for sections 60^0 & 270^0 becomes as 4.17 & 3.01kg/sq.cm

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- At A, it is observed that additional compressive stress is developed for the section 360^0 only & remain same for section 180^0 and tensile stresses in the remaining sections. So maximum compressive stress at A becomes 6.74kg/sq.cm for same section 300^0. And also at point B additional compressive stress is developed for the section 120, 150, 180, 300, 330 & 360^0 and at C for the section 90, 120, 150, 180, 270, 300 and 330^0 and tensile in the remaining sections.
- At the point I additional compressive stress is observed for the section 150, 180, 300, 330 and 360^0 and tensile stress in the remaining sections. So maximum tensile stress becomes as 8.66kg/sq.cm at same location (point I for section 30^0).
- Very small amount of additional stresses are observed at point D, F, G &H for almost all section But considerable amount of tensile stress (4.65kg/sq.cm.) is observed at D for section 60^0. Since, additional compressive stress is developed at E for the section 90^0 and 270^0 its value becomes as 2.47 and 2.29kg/sq.cm respectively.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Additional tensile and compressive stresses are found in exactly reverse manner than it observed for load case (iv) in zone B, D & E for all sections, in zone A for the sections 150, 180, 210, 240 & 270^0, in zone C for sections except 360^0 and in zone I for sections except 60 & 360^0. Maximum compressive stress becomes as 6.88kg/sq.cm at point A for section 300^0.
- Maximum tensile stress is observed as 7.35kg/sq.cm at same point I for the section 30^0.
- Since additional tensile stress is developed at E for the sections 90 & 270^0 its values becomes as 2.67 and 2.40kg/sq.cm respectively.
- Very small variations are observed in zone F, G, & H for almost all sections.

Hence

- Maximum tensile stress (8.66kg/sq.cm) is observed at point I in the section 30^0 for load (iv) and
- Maximum compressive stress (7.58kg/sq.cm.) is observed at point A for load (iii) at section 270^0.
- Zone F is in compression for all sections & load case. Variations in stresses are very small in zone F, G and H due to Tangential force.

Globally, it is observed that:

- Maximum compression (8.252kg/sq.cm.) is observed at (71.18, 110.00, and 265.63) the outer edge upper speed ring position (near to zone A) of 285^0 angular section for load (iii).
- Maximum tension (13.104kg/sq.cm.) is observed at (659.28, 420.00, -528.17) c/l of the penstock at turbine floor level of 38.7^0 angular section for load (ii).
- Maximum deflection (0.0385cm) is observed at (x=307.75, y=26.12, z=0.0) in between upper and lower speed ring position (between zone A & F) of 360^0 angular section for load (iii) in x-direction.
- Loading (ii) gives the maximum tensile stress where as maximum deflection and compressive stresses are occurred for load (iii). At most of the sections B, C, G, I and area around these points is under tension and A, F and area around these points is under compression, rest of the area is under nominal tension or compression except area around D & E which has some more tension or compression for sections 60, 90 and 270^0.

- ❖ Maximum and minimum values of deflections and stresses are shown in figure-5.63.

5.2.4 LOAD CONDITION 2b

i. **Normal Operating Load (NOL)**

- o Compressive stress is observed at A for sections 120, 150, 180 and 210^0 and very small amount of tensile & compressive stresses for remaining sections except 360^0 where considerable amount of tensile stress is observed. Zone B and C are in tension for all sections except section 150 & 180^0 where very small amount of compressive stress occurred.
- o The nature and amount of stresses in zone D, E, F, G and H for all sections are observed as nearly same as in load case 2a(i). Maximum compressive stress is observed as 4.99kg/sq.cm at point F for the section 360^0.
- o Zones I is in tension except section 60^0 where small amount of compression is observed. The maximum tension is observed as 8.19kg/sq.cm.at I of the section 30^0.

ii. **NOL with Radial force due to unequal magnetic attraction in +ve x-direction**

- o It is observed that the nature of additional compressive and tensile stresses developed in all zones for all sections are same as in load case 1b (ii).
- o Since additional tensile and compressive stresses are developed in zone I and F for the section 30^0 & 360^0, maximum tensile compressive stresses observed are 9.00 and 5.26kg/sq.cm respectively.

iii. **NOL with Radial force due to unequal magnetic attraction in –ve x-direction**

- o Exactly reverse action is observed compare to load case (ii) in every zone and at every sections.
- o Since additional compressive and tensile stresses are developed in zone I and F for the section 30^0 & 360^0, maximum tensile compressive stresses observed are 7.37 and 4.72kg/sq.cm respectively.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- o It is observed that additional compressive stress is developed in zone A for sections 60, 90, 180, 210, 240 270 and 360^0, in zone B for sections 120, 150, 150, 300, 330, and 360^0, in zone C for sections 90, 150, 180, 300, and 330^0

and in zone I for sections 60, 300 and 330^0. So maximum tensile stress at point I for section 30^0 becomes as 8.66kg/sq.cm.

- Nature and amount of stresses in zone D, E, F, G and H for all sections are nearly same as in load case 2a(iv)
- Since the reduction in compressive stress at point F for section 360^0 is very large, the compressive stress 3.59kg/sq.cm of point H for section 30^0 becomes as maximum.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Additional tensile and compressive stresses are found in exactly reverse manner than it observed for load case (iv) in all zones of all sections except in zone A & F for section 30 & 360^0 where same action is occurred.
- Maximum tensile stress is observed as 7.69kg/sq.cm at point I for section 30^0.
- Nature and amount of stresses in zone D, E, F, G and H for all sections are nearly same as in load case 2a(v)
- Since the reduction in compressive stress at point F for section 360^0 is very large, the compressive stress 3.57kg/sq.cm of point H for section 30^0 becomes as maximum.

Hence

- Maximum tensile stress (9.00kg/sq.cm) is observed at point I for the section 30^0 for load (ii)
- Maximum compressive stress (5.26kg/sq.cm.) is observed at point F for load (ii) at section 360^0.

Globally, it is observed that:

- Maximum compression (8.012kg/sq.cm.) is observed at (-470.94, 420.00, 62.00) the inner edge of generator barrel at turbine floor level (near zone C) of 187.5^0 angular section for load (iii).
- Maximum tension (12.89kg/sq.cm.) is observed at (591.24, 420.00, -485.99) c/l of penstock at turbine floor level of 39.419^0 angular section for load (iii)
- Maximum deflection (0.0283cm) is observed at (x=1004.98, y=420.0, z=-635.09) outer edge of turbine floor level (point D) of 32.29^0 angular section for load (ii) in x-direction.

- ❖ Loading (ii) gives the maximum deflections and stresses for sectional analysis where as loading (iii) gives the maximum compression and tension stress.
- ❖ Nature and amount of stresses in zone D, E, F, G and H are same as in load case 2a.
- ❖ A, B, C, I and area around these points is almost under tension except zone A for sections 120, 150, 180 and 210^0 where compressive stress is observed. Zone F and H is in compression except the section 120, 240, 270 and 300^0 for H.
- ❖ Maximum and minimum values of deflections and stresses are shown in figure-5.64.

5.3 NATURE OF STRESS COMPONENT σ_y (SY) IN Y-DIRECTION

(As shown in table-5.5, Appendix-A)

5.3.1 LOAD CONDITION 1a

i. Normal Operating Load (NOL)

- o Zone B, C, H and I for almost all the sections are observed as compressive except 270, 150 and 30^0 in zone I where small amount of tensile stress is observed. Maximum compressive stress is obtained as 35.13kg/sq.cm at point F of section 360^0. Beside of this maximum compressive stress is obtained as 21.3kg/sq.cm at point H of section 60^0.
- o Zone A, E, F, and G are founded as tension for almost all sections except section 360^0 in zone A & F where compressive stress is founded which is developed due to continuity of concrete between A and F, section 60^0 in zone E where compressive stress is observed. Maximum tensile stress is observed as 3.84kg/sq.cm at point A of section 30^0.
- o Very small amount of stresses are observed in zones D, F and G for almost all sections.

ii. NOL with Radial force due to unequal magnetic attraction in +ve x-direction

- o Additional compressive stress is observed in zone B for sections 90, 120, 150 180, 210 and 240^0, in zone E for sections 30, 60, 90, 180, 210, 300 & 330^0, in zone H for sections 60, 90, 120, 180, 240, 270 and 300^0 and in zone I for sections 60, 90, 120, 150, 300, 330 and 360^0. So maximum compressive

stress (rather than section 360^0) of point H for section 60^0 becomes as 24.06kg/sq.cm.

- Very small amount of additional stresses are observed in zones A, C, D, F and G for almost all sections except zone A and F for section 360^0.
- Since additional tensile stress is developed at A for sections 30 & 360^0 and at F for section 360^0, maximum compressive stress at this location F becomes as 33.74kg/sq.cm. and maximum tensile stress of point A for the section 30^0 becomes as 4.03kg/sq.cm.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Reverse nature of additional stresses are obtained with almost same amount as in previous load case (ii).
- Maximum compressive stress of point F for section 360^0 becomes as 36.52 & of point H for section 60^0 becomes as 18.57kg/sq.cm.
- Maximum tensile stress is observed as 3.64kg/sq.cm at point A for section 30^0.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Nearly same nature and amount are observed in zones A, C, D, F and G for almost all sections except zone A and F for section 360^0.
- Additional compressive stress is observed in zone B for sections 210, 300, 330 and 360^0, in zone E for sections 30, & 60^0, in zone H for section except 60 and 90^0 and additional tensile in zone I for almost all sections. So maximum compressive stress (rather than section 360^0) of point H for section 60^0 becomes as 20.96kg/sq.cm.
- Since additional compressive stress is developed at A for sections 30 & 360^0 and tensile at F for section 360^0, maximum compressive stress at this location F becomes as 33.38kg/sq.cm and maximum tensile stress of point A for the section 30^0 becomes as 3.79kg/sq.cm.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Reverse nature of additional stresses are obtained with almost same amount as in previous load case (iv).

- Maximum compressive stress of point F for section 360^0 becomes as 36.87 & of point H for section 60^0 becomes as 21.67kg/sq.cm.
- Maximum tensile stress is observed as 3.89kg/sq.cm at point A for section 30^0.

Hence

- Maximum tensile stress (3.89kg/sq.cm) is observed at point A for the section 30^0 for load (v)
- Maximum compressive stress (36.87kg/sq.cm.) is observed at point F for load (v) at section 360^0.
- Small effects of Radial and Tangential force are observed.

Globally,

- Maximum compression (50.11kg/sq.cm.) is observed at (307.23, -19.31, and 40.44) in between upper and lower speed ring position (between zone A & F) of 7.5^0 angular section for load (ii).
- Maximum tension (7.66kg/sq.cm.) is observed at (301.83, 110.00, 39.74) upper speed ring (zone A) of 352.5^0 angular section for load (iv)
- Loading (v) gives the maximum compressive and tensile stresses for sectional analysis where as loading (ii) and (iv) gives the maximum compression and tension stress respectively.
- B, C, H, I and area around these points are almost under compression. Zone A, E, F and G is in tension except the section 360^0 for A & F.
- Maximum and minimum values of deflections and stresses are shown in figure-5.61.

5.3.2 LOAD CONDITION 1b

i. <u>Normal Operating Load (NOL)</u>

- Zone A, B, C, and H for all the sections are observed as compressive. Maximum compressive stress is obtained as 35.33kg/sq.cm at point A of section 60^0.
- Zone I is founded as tension for almost all sections except section 300, 330 and 360^0 where very small amount of compressive stress is founded. Maximum tensile stress is observed as 2.46kg/sq.cm at point I of section 60^0.
- Very small amount of stresses are observed in zones D, E, F and G for almost all sections except section 60 & 90^0 in zone E, section 360^0 in zone F where, considerable compressive stress is observed.

ii. **NOL with Radial force due to unequal magnetic attraction in +ve x-direction**

- Additional compressive stress is observed in zone A & H for sections 60, 90, 270, 300, 330, 360^0 and also 90^0 for H, in zone B for sections 120, 150, 180, 210 & 240^0, and very small variations are observed in zone C for almost all sections. So maximum compressive stress of point A for section 60^0 becomes as 41.94kg/sq.cm.
- The amount of stresses in zone D, E, F and G for almost all sections are still very less except section 60^0 for E and section 360^0 for F, where, additional compressive stress is observed.
- Since additional tensile stress is developed at I for sections 30, 60,180, 210, 240 & 270^0, maximum tensile stress at this location I becomes as 2.93kg/sq.cm for same section 60^0.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Additional stresses are observed as nearly same as in previous load (ii) but with opposite nature (sign) at respective locations.
- Hence, maximum compressive stress of point A and tensile stress of point I for section 60^0 becomes as 28.78 and 1.98kg7sq.cm respectively.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Variations in stresses observed are very small in this load case.
- Additional compressive stress is observed in zone A for sections 120, 150, 180, 210, 240 & 270^0, in zone H for section except 60 & 90^0, in zone B for sections 60, 180, 210, 330 & 360^0, and nearly same stresses are observed in zone C for almost all sections. And maximum compressive stress of point A for section 60^0 becomes as 34.58kg/sq.cm.
- The amount of stresses in zone D, E, F and G for almost all sections are still very less except section 60^0 for E where, additional compressive stress is observed and section 360^0 for F, where, additional tensile stress is observed.
- Since additional compressive stress is developed at I for sections 60^0, maximum tensile stress at this location I becomes as 2.35kg/sq.cm for it section 60^0.

v. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Variations in stresses observed are very small in this load case also.
- Additional stresses are observed as nearly same as in previous load (iv) but with opposite nature (sign) at respective locations.
- Hence, maximum compressive stress of point A and tensile stress of point I for section 60^0 becomes as 36.14 and 2.57kg7sq.cm respectively.

Hence

- Maximum tensile stress (2.93kg/sq.cm) is observed at point A for the section 60^0 for load (ii)
- Maximum compressive stress (41.94kg/sq.cm.) is observed at point I for load (ii) at section 60^0.
- It is observed that the effect of Radial force is more than Tangential force.

Globally,

- Maximum compression (46.93kg/sq.cm.) is observed at (204.24, 110.00, -256.01) inner edge of upper speed ring position (point A) of 51.418^0 angular section for load (ii).
- Maximum tension (10.49kg/sq.cm.) is observed in (221.13, 102.88, -264.54) between zone H & I of 50.107^0 angular section for load (ii)
- Loading (ii) gives the maximum compressive and tensile stresses.
- A, B, C, E, H, and area around these points are almost under compression. Zone I, F and G is in tension with very small amount except the section 60^0 I, where considerable tension is observed.
- Maximum and minimum values of deflections and stresses are shown in figure-5.62.

5.3.3 LOAD CONDITION 2a

i. **Normal Operating Load (NOL)**

- Zone A, B, C, G and I is observed as compressive for almost all sections except 360^0 for A, where maximum tensile stress is observed as 18.76kg/sq.cm.
- Small amount of compressive stress is observed in zone D and F for all sections except 360^0 for F, where maximum compressive stress is observed as 11.58 kg/sq.cm.

- Tensile zone is observed for sections except 150, 240, 300 & 330^0 at point E and for sections except 90, 120, 150, 180 & 210^0 at point H.

ii. **NOL with Radial force due to unequal magnetic attraction in +ve x-direction**

- The nature of additional stresses are observed as same as in load case 1a (ii) with nearly same amount.
- Since additional tensile stress is developed in zone A & F for section 360^0, maximum tensile at point A and maximum compressive at F is obtained as 20.74 and 10.18 kg/sq.cm respectively for section 360^0.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Maximum tensile stress at point A for section 360^0 decreased to 16.78 and maximum compressive stress at point F for same section 360^0 increased to 12.97kg/sq.cm.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Very small variations are observed in tensile and compressive stresses in almost all zones and sections except section 360^0 for zone A & F.
- Very large additional tensile stress (18.49kg/sq.cm) is observed at F and additional compressive stress (14.88kg/sq.cm) is observed at A. Tensile stress 6.91kg/sq.cm of point F for section 360^0 is observed as maximum.
- Compressive stress 5.32 kg/sq.cm of point B for section 30^0 is observed as maximum.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Very small variations are observed in tensile and compressive stresses in almost all zones and sections except section 360^0 for zone A & F.
- The additional tensile stress (15.01kg/sq.cm) observed at F and additional compressive stress (12.78kg/sq.cm) observed at A is little less than in previous load case (iv). So tensile stress 5.98kg/sq.cm of point A for section 360^0 is observed as maximum.
- Compressive stress 5.43kg/sq.cm of point B for section 30^0 is observed as maximum.

Hence

- Maximum tensile stress (20.74kg/sq.cm) is observed at point A for the section 360^0 for load (ii)
- Maximum compressive stress (12.97kg/sq.cm.) is observed at point F for load (iii) at section 360^0.
- It is observed that the effect of Tangential force is much more than Radial force at point A & F for section 360^0 and slightly more effect of Radial force than Tangential force at almost all others locations and sections.

Globally,

- Maximum compression (14.80kg/sq.cm.) is observed at (1100.00, -450.00, 1025.00) outer edge of lower support of 317.02^0 angular section for load (ii).
- Maximum tension (25.55kg/sq.cm.) is observed at (275.00, 1.70, 0.00) in between upper and lower speed ring position (between zone A & F) of 0.00^0 angular section for load (iii)
- Loading (ii) & (iii) gives the maximum tension and compression stress respectively for sectional analysis and vice versa for globally.
- A, B, C, G, I and area around these points are almost under compression except section 360^0 for point A where large amount of tensile is occurred. Zone E and H is in tension except some sections.
- Maximum and minimum values of deflections and stresses are shown in figure-5.63.

5.3.4 LOAD CONDITION 2b

i. <u>Normal Operating Load (NOL)</u>

- Zone A, B, C, G and I is observed as compressive for almost all sections except 30, 240, 270, 300, 330 and 360^0 for A. Maximum tensile stress is observed as 17.62kg/sq.cm at point A for section 360^0.
- Small amount of compressive stress is observed in zone D and F for all sections except section 360^0 for F, where maximum compressive stress is observed as 10.86kg/sq.cm, section 30^0 for D, which is in tension.
- Tensile zone is observed for sections except 150, 240, 300 & 330^0 at point E and for sections except 90, 120, 150, 180 & 210^0 at point H.

ii. **NOL with Radial force due to unequal magnetic attraction in +ve x-direction**

- The nature of additional stresses are observed as same as in load case 1b (ii) with nearly same amount.
- Since additional compressive stress is developed in zone A & F for section 360^0, maximum tensile at point A and maximum compressive at F is obtained as 14.90 and 12.26kg/sq.cm respectively for section 360^0.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Maximum tensile stress at point A for section 360^0 increased to 20.35 and compressive stress at point F for same section 360^0 decreased to 9.45kg/sq.cm. And the compressive stress 13.27kg/sq.cm of point A for section 150^0 is observed as maximum.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Very small variations are observed in tensile and compressive stresses in almost all zones and sections except section 360^0 for zone A & F.
- Very large additional tensile stress (14.81kg/sq.cm) is observed at F and additional compressive stress (15.75kg/sq.cm) is observed at A for section 360^0. Tensile stress 5.35kg/sq.cm of point E for section 30^0 is observed as maximum.
- Since additional tensile stress at point F for section 360^0 is much more, the compressive stress 10.89kg/sq.cm of point A for section 90 &120^0 is observed as maximum.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Very small variations are observed in tensile and compressive stresses in almost all zones and sections except section 360^0 for zone A & F likewise in previous load case (iv).
- The additional tensile stress (13.87kg/sq.cm) observed at F and additional compressive stress (15.76kg/sq.cm) observed at A for section 360^0. So tensile stress 5.44kg/sq.cm of point E for section 30^0 is observed as maximum.

- Since additional tensile stress at point F for section 360^0 is much more, the compressive stress 11.33kg/sq.cm of point A for section 90^0 is observed as maximum.

Hence

- Maximum tensile stress (20.35kg/sq.cm) is observed at point A for the section 360^0 for load (iii)
- Maximum compressive stress (12.26kg/sq.cm.) is observed at point F for load (ii) at section 360^0.
- It is observed that the effect of Tangential force is much more than Radial force at point A & F for section 360^0 and slightly more effect of Radial force than Tangential force for almost all others locations and sections.

Globally,

- Maximum compression (17.14kg/sq.cm.) is observed at (-40.33, 110.00, -325.01) inner edge of upper speed ring (point A) of 82.926^0 angular section for load (iii).
- Maximum tension (20.35kg/sq.cm.) is observed at (327.50, 110.00, 0.00) inner edge of upper speed ring (point A) of 0.00^0 angular section for load (iii)
- Loading (ii) gives the maximum compressive stresses for sectional analysis where as loading (iii) gives the maximum compressive for globally and tensile stress for both.
- A, B, C, G, I and area around these points are almost under compression except section30, 240, 270, 300, 330 and 360^0 for point A where large and considerable amount of tensile is occurred. Zone E and H is in tension except for sections 150, 240, 300 & 330^0 at point E and for sections except 90, 120, 150, 180 & 210^0 at point H..
- Maximum and minimum values of deflections and stresses are shown in figure-5.64.

5.4 NATURE OF STRESS COMPONENT σz (SZ) IN Z-DIRECTION

(As shown in table-5.6, Appendix-A)

5.4.1 LOAD CONDITION 1a

i. Normal Operating Load (NOL)

- Zone A and G is observed as tensile for all sections except 360^0 where, maximum compressive stress is obtained as 13.12kg/sq.cm at point A and maximum tensile stress is observed as 8.34kg/sq.cm at A for section 330^0. Zone B, C, G and H are observed as compressive for almost all sections except 360^0 for A, sections 60, 90, 270^0 for B and sections 60, 90, 120 and 270^0 for C.
- Small amount of tensile stress is observed at D for sections 60, 90, 120, at E for sections 30, 150, 180, 210, 240, 360, at F for section except 360^0 and small amount of compressive (except section 180^0 for D, 360^0 for F) for remaining sections.
- Zone I is observed as tensile for sections 180, 210, and 270^0 and compressive for remaining sections except 360^0 which is neutral.

ii. NOL with Radial force due to unequal magnetic attraction in +ve x-direction

- Additional compressive stress is developed in zone A for sections 120, 330^0, in zone F for sections 60, 330^0, in zone G for sections 150, 180, 210, 240 and in zone H for sections 150, 180, 210, 240, 270^0 and additional tensile in remaining sections. Maximum tensile stress is observed as 9.12kg/sq.cm at point A for section 180^0 and compressive stress 13.11kg/sq.cm. of point B for section 180^0 becomes as maximum.
- Additional tensile stress is observed in zone B & C for sections 90, 120, 270, 330, & 360^0 and also for section 300^0 in zone C. Likewise additional tensile stress is observed in zone E for sections 120, 210, 240, 360^0, in zone I for sections 30, 60, 180, 270 & 360^0 and additional compressive in remaining sections.
- Zone D is observed as in compression for sections 30, 150, 180, 210, 240, & 300^0 and tension in remaining sections.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Maximum compressive stress at point A for same section 360^0 increased to 13.14 and Maximum tensile stress at point A for same section 330^0 is also increased to 8.65kg/sq.cm.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Additional compressive stress is developed in zone A for sections 30, 60, 90, 360^0. Maximum tensile stress is observed as 8.27kg/sq.cm at same point A for same section 330^0 and also compressive stress 14.19kg/sq.cm of point A for section 360^0 is observed as maximum.
- Very small amount of additional compressive and tensile stresses are observed in zone D, E, F, G and H for almost all sections.
- Additional compressive stress is observed in zone B & C for sections 30, 60, 180, 210, & 240^0, also for section 360^0 in zone B and for section 270^0 in zone C. Likewise additional compressive stress is observed in zone I for sections 30, 60, 210, & 240^0 and additional tensile in remaining sections.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (iv) for all sections.
- Since additional tensile stress is developed in zone A for section 330 & 360^0, maximum compressive stress of the point A for section 360^0 decreased to 12.06kg/sq.cm and tensile stress of the point A for section 330^0 increased to 8.40kg/sq.cm.

Hence

- Maximum tensile stress (9.12kg/sq.cm) is observed at point A for the section 180^0 for load (ii)
- Maximum compressive stress (14.19kg/sq.cm.) is observed at point A for load (iv) at section 360^0.

Globally,

- Maximum compression (14.19kg/sq.cm.) is observed at (327.50, 110.00, 0.00) inner edge of upper speed ring (point A) of 360^0 angular section for load (iv).
- Maximum tension (11.65kg/sq.cm.) is observed at (-265.63, 110.00, 71.18) outer edge of upper speed ring (near point A) of 195.00^0 angular section for load (ii)
- Loading (ii) gives the maximum tensile stresses where as loading (iv) gives maximum compressive for both sectional analysis and globally.
- B, C, H and area around these points are almost under compression except section 60, 90, 120 and 270^0, and also 120^0 for point C.
- D, E, F and area around these points are under nominal compressive and tensile except section 180^0 for D and 360^0 for F, where considerable amount of tensile is occurred.
- Zone A and G is in tension except for sections 360^0 at point A.
- Zone I is observed as in tension for sections 30, 180, 210, 270 & 360^0.
- Maximum and minimum values of deflections and stresses are shown in figure-5.61.

5.4.2 LOAD CONDITION 1b

i. <u>Normal Operating Load (NOL)</u>

- Zone A, C and H are observed as compressive for all sections and maximum is obtained at point A for section 60^0 as 10.36kg/sq.cm.
- Zone B, G and I is observed as tensile for sections except section 300^0 for point I and maximum is obtained at point I for section 60^0 as 7.02kg/sq.cm.
- Small amount of tensile and compressive stresses are observed in zone D, E, and F for all sections.

ii. <u>NOL with Radial force due to unequal magnetic attraction in +ve x-direction</u>

- Additional compressive stress is observed in zone A & C for section 60, 270, 300, 330, & 360^0, in zone B for sections 60, 150, 180,210 & 300^0. And also in zone A for section 90^0, in zone C for section 30^0 additional compressive stress is obtained. And maximum compressive stress at point A of section 60^0 becomes as 13.28kg/sq.cm.

- Very small amount of additional tensile and compressive stresses are observed in zone D, E, F, G & H for almost all sections except, section 180^0 for point D (-0.55), point E (-0.69); section 360^0 for point E (-0.35), for point F (0.45) and section 60^0 for point H (-0.49).
- Additional tensile stress is observed in zone I for section 30, 60, 90, 270 and 360^0. So maximum tensile stress of point I for the section 60^0 becomes as 8.25kg/sq.cm.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Compressive stress 7.44kg/sq.cm of point A for section 90^0 becomes as maximum, and Maximum tensile stress at point I for same section 60^0 is decreased to 5.80kg/sq.cm.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Additional compressive stress is observed in zone B & C for section 30, 60, 180, 220 & 240^0, in zone A for sections 120, 150, 180, 270,300 & 360^0. And also in zone B for section 360^0, in zone C for section 270^0 additional compressive stress is obtained. And maximum compressive stress at point A of section 60^0 becomes as 9.25kg/sq.cm.
- Very small amount of additional tensile and compressive stresses are observed in zone D, E, F, G & H for almost all sections.
- Additional tensile stress is observed in zone I for section 30, 60, 180, 270 and 360^0. So maximum tensile stress of point I for the section 60^0 becomes as 7.71kg/sq.cm.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (iv) for all sections.
- So maximum compressive stress at point A for same section 60^0 increased to 11.48 and Maximum tensile stress at point I for same section 60^0 is decreased to 6.33kg/sq.cm.

Hence

- Maximum tensile stress (8.25kg/sq.cm) is observed at point I for the section 60^0 for load (ii)
- Maximum compressive stress (13.28kg/sq.cm.) is observed at point A for load (ii) at section 60^0.

Globally,

- Maximum compression (18.23kg/sq.cm.) is observed at (187.40, 110.00, -268.58) inner edge of upper speed ring (point A) of 55.09^0 angular section for load (ii).
- Maximum tension (11.41kg/sq.cm.) is observed at (201.16, 110.00, -278.40) the location of I of 54.149^0 angular section for load (ii)
- Loading (ii) gives the maximum tensile and compressive for both sectional analysis and globally.
- A, C, H and area around these points are almost under compression where as zone B, G, and I except section 300^0 for zone I are almost under tension.
- The compressive and tensile stresses observed in zone D, E, and F are nominal.
- Maximum and minimum values of deflections and stresses are shown in figure-5.62.

5.4.3 LOAD CONDITION 2a

i. Normal Operating Load (NOL)

- Zone A and F is observed as compressive for almost all sections; except 150, 180, 360^0 for A and except 30^0 for F where small amount of tensile stress is obtained. Maximum compressive stress is observed as 6.52kg/sq.cm at point A for section330^0.
- Likewise zone D for sections 30, 60, 150, 240, 270, 300 & 330^0 and zone H for sections 30, 90, 120, 150, 240, 270 and 300^0 are also in compression.
- Zone B, G and I is in tension for all sections except sections 120 & 150^0 for zone B where small amount of compression is observed. Maximum tensile stress 7.05kg/sq.cm is observed at point I for section 120^0.
- For sections 180, 210, 240, 270, 300 & 360^0 in zone C and E tensile stress is observed. And also zone C for section 330^0 and zone E for section 30^0 are in tension.

ii. **NOL with Radial force due to unequal magnetic attraction in +ve x-direction**

- The nature of additional stresses observed are as same as in load case 1a(ii) with nearly same amount.
- Since additional compressive stress is developed in zone A for section 330^0, in zone I for section120^0 & additional tensile in zone I for section 270^0, maximum compressive at point A for section 330^0 and maximum tensile at I for section 270^0 is obtained as 6.83 and 6.14kg/sq.cm respectively.

iii. **NOL with Radial force due to unequal magnetic attraction in -ve x-direction**

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Tensile stress 8.43kg/sq.cm at point I for section 120^0 is observed as maximum and maximum compressive stress of point A for section 330^0 decreased to 6.21kg/sq.cm.

iv. **NOL with Tangential force due to DSCRW in anti-clockwise direction**

- Very small amount of additional tensile stress is observed in zone A for almost all sections except section 330^0 where maximum compressive stress becomes as 6.67kg/sq.cm, but considerable amount (2.43) at section 30^0. Additional tensile is also observed in zone B for sections 90, 120, 150, 270, 300 and 330^0, in zone C for sections 90, 120, 150, 300, 330 and 360^0 and compressive in remaining sections.
- Very small amount additional tensile and compressive stress is observed in zone D, E, F, G and H for almost all sections except section 360^0 for F (2.53kg/sq.cm.).
- Zone I is observed in additional tension for sections except 30, 210 & 240^0 and maximum tensile stress of point I for section 120^0 becomes as 7.32kg/sq.cm.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Small amount of additional tensile and compressive stress is observed in zone A for almost all sections except section 30^0 (2.95) & 360^0(3.95), and maximum compressive stress of point A for section 330^0 becomes as 6.54kg/sq.cm.

- Very small amount additional tensile and compressive stress is observed in zone D, E, F, G and H for almost all sections except section 360^0 for F (1.67kg/sq.cm.).
- Nature of additional stress in Zone I is observed opposite than previous load (iv) for almost all sections except sections 60 & 90^0 which where are of same nature. And maximum tensile stress of point I for section 120^0 becomes as 6.75kg/sq.cm.

Hence

- Maximum tensile stress (8.43kg/sq.cm) is observed at point I for the section 120^0 for load (iii)
- Maximum compressive stress (6.83kg/sq.cm.) is observed at point A for load (ii) at section 330^0.

Globally,

- Maximum compression (8.09kg/sq.cm.) is observed at (265.63, 110.00, 71.16) outer edge of upper speed ring (near point A) of 345.00^0 angular section for load (ii).
- Maximum tension (10.40kg/sq.cm.) is observed at (275.00, 110.00, 0.00) the outer edge of upper speed ring (near point A) of 360^0 angular section for load (iii)
- Loading (ii) gives the maximum compressive stresses where as loading (iii) gives maximum tensile stress for both sectional analysis and globally.
- Zone A & F is in compression where as Zone B, C, E, G and I are in tension for almost all sections.

5.4.4 LOAD CONDITION 2b

i. Normal Operating Load (NOL)

- Zone A, F and H are observed as compressive for almost all the sections except; sections 30, 300, 330, 360^0 for A, section 30^0 for F and sections 180, 210, 330 & 360^0. Maximum compressive stress is observed at point A for section 120^0 as 3.82kg/sq.cm.
- Zone B, C. G and I are observed as tensile for almost all sections except sections 60, 90 and 120^0 for zone C and maximum is observed at point I for section 90^0 as 9.79kg/sq.cm.

- Very small amount of tensile and compressive stresses are observed in zone D and E except sections 180 & 210^0 where some considerable amount (0.86 to 2.14kg/sq.cm) is observed.

ii. <u>NOL with Radial force due to unequal magnetic attraction in +ve x-direction</u>

- The nature of additional stresses observed is as same as in load case 1b(ii) with nearly same amount.
- Since additional compressive stress is developed in zone A for section 90^0, and tensile for section 120^0, compressive stress 3.69kg/sq.cm of same point A but for section 90^0 becomes as maximum.
- And since additional tensile is developed in zone I for section 90^0, maximum tensile of point I for section same section 90^0 is obtained as 10.04kg/sq.cm.

iii. <u>NOL with Radial force due to unequal magnetic attraction in -ve x-direction</u>

- Nearly same amount of additional stresses are observed at respective locations but with opposite sign as it observed in previous load case (ii) for all sections.
- Maximum tensile stress of point I for section 90^0 is decreased to 9.53kg/sq.cm and maximum compressive stress of point A for section 120^0 increased to 5.33kg/sq.cm.

iv. <u>NOL with Tangential force due to DSCRW in anti-clockwise direction</u>

- Very small amount of additional compressive and tensile stress is observed in zone A for almost all sections and maximum compressive stress of point A for section 120^0 increased to 4.30kg/sq.cm. Additional tensile is observed in zone B for sections 90, 120, 150, 270, 300 and 330^0, in zone C for sections 120, 150, 300, 330 and 360^0 and compressive in remaining sections.
- Very small amount additional tensile and compressive stress is observed in zone D, E, F, G and H for almost all sections except section 360^0 for F (2.09kg/sq.cm.).
- Zone I is observed in additional tension for sections except 30, 90, 210, & 240^0 and maximum tensile stress of point I for section 90^0 decreased to 9.76kg/sq.cm.

v. **NOL with Tangential force due to DSCRW in clockwise direction**

- Small amount of additional tensile and compressive stress is observed in zone A for almost all sections except section 360^0(-3.14), and compressive stress 3.64kg/sq.cm.of point A for section 90^0 becomes as maximum.
- Very small amount additional tensile and compressive stress is observed in zone D, E, F, G and H for almost all sections except section 360^0 for F (1.87kg/sq.cm.).
- Nature of additional stress in Zone I is observed opposite than previous load (iv) of nearly same amount for almost all sections. And maximum tensile stress of point I for section 90^0 becomes as 9.81kg/sq.cm.

Hence

- Maximum tensile stress (10.04kg/sq.cm) is observed at point I for the section 90^0 for load (ii)
- Maximum compressive stress (5.33kg/sq.cm.) is observed at point A for load (iii) at section 120^0.

Globally,

- Maximum compression (6.64kg/sq.cm.) is observed at (-40.33, 110.00, -325.01) inner edge of upper speed ring (point A) of 97.07^0 angular section for load (iii).
- Maximum tension (10.86kg/sq.cm.) is observed at (47.24, 131.29, -369.71) the location of I of 82.72^0 angular section for load (ii)
- Loading (ii) gives the maximum tensile stresses where as loading (iii) gives maximum compressive for both sectional analysis and globally.
- Zones B, C, G, and I are in tension for all most all sections except 60, 90 & 120 for C which are in compression, where as zone A, F and H are in compression for almost all sections except; 30, 300, 330 & 360^0 for A, 30^0 for F, 150, 180, 330 & 360^0 for H which are in tension.

5.5 SUMMARY OF RESULTS:

Now, the above results can be summarized as follows:

- For load condition 1a:

- Zone C for section 7.5^0 and load case (ii) is critical for compressive stress σ_x (fig-5.5.2) and zone A for section 270^0 and same load case (ii) for tensile stress σ_x (fig.5.5.1).

- Maximum compressive stress σ_y is in zone between A and F for section 7.5^0 (fig-5.5.3) & load case (ii) where as maximum tensile stress is in zone A for section 352.5^0 & load case (iv) (fig-5.5.4).
- Similarly, zone A is critical for section 360^0 and load case (iv) where maximum compressive stress σ_z is occurred (fig-5.5.5) likewise zone near point A for section 195^0 & load case (ii) is critical for maximum tensile stress (fig-5.5.6).

❖ <u>For load condition 1b:</u>

- Zone A for section 51.42^0 and load case (iii) is critical for compressive stress σ_x (fig-5.5.7) where as zone I for section 47.27^0 and load case (ii) for tensile stress (fig-5.5.8.).
- Maximum compressive stress σ_y is in zone near A for section 51.42^0 & load case (ii) (fig-5.5.9) where as maximum tensile stress is in zone I for section 50.11^0 & load case (ii) (fig-5.5.10).
- Similarly, zone A is critical for section 55.09^0 and load case (ii) where maximum compressive stress σ_z is occurred (fig-5.5.11) likewise zone I for section 54.15^0 & load case (ii) is critical for maximum tensile stress (fig-5.5.12).

❖ <u>For load condition 2a:</u>

- Zone A for section 285^0 and load case (iii) is critical for compressive stress σ_x (fig-5.5.13) and zone around c/l of penstock at turbine floor level for section 38.7^0 and load case (ii) for tensile stress σ_x (fig-5.5.14).
- Maximum compressive stress σ_y is at outer edge of lower support for section 317.02^0 (fig-5.5.15) & load case (ii) where as maximum tensile stress is in zone between A and F for section 360^0 & load case (iii) (fig-5.5.16).
- Similarly, zone near A is critical for section 345^0 and load case (ii) where maximum compressive stress σ_z is occurred (fig-5.5.17) likewise same zone near A but for section 360^0 & load case (iii) is critical for maximum tensile stress (fig-5.5.18).

❖ <u>For load condition 2b:</u>

- Zone near C for section 187.5^0 and load case (iii) is critical for compressive stress σ_x (fig-5.5.19) and zone around c/l of penstock at

turbine floor level for section 39.42^0 and load case (iii) for tensile stress σ_x (fig-5.5.20).

- Maximum compressive stress σ_y is in zone A for section 97.07^0 (fig-5.5.21) & load case (iii) where as maximum tensile stress is in same zone A & load case (iii) but for section 360^0 (fig-5.5.22).
- Similarly, zone A is critical for section 97.07^0 and load case (iii) where maximum compressive stress σ_z is occurred (fig-5.5.23) likewise zone I for section 82.72^0 & load case (ii) is critical for maximum tensile stress (fig-5.5.24).

And hence,

- In X-direction, maximum tensile stress in zone A for section 270^0 is 14.212kg/sq.cm.which is for loading case 1a(ii); maximum compressive stress is 46.93kg/sq.cm.in same zone A but for section 51.42^0 and loading case 1b(iii), where as maximum deflection is 0.039cm at point B for section 195^0 and load case 1a(ii). Variations of tensile and compressive stresses in various zone for different conditions is shown in fig.5.66 to fig.5.74.
- In Y-direction, maximum compressive stress is 50.11kg/sq.cm. in zone between A and F for section 7.5^0 & load case 1a(ii); maximum tensile stress is 25.25kg/sq.cm. in zone between A and F for section 360^0 & load case 2a(iii), where as maximum deflection is -0.083cm at point B for section 270^0 and load case 1a(ii). Variations of tensile and compressive stresses in various zone for different conditions is shown in fig.5.75 to fig.5.83.
- In Z-direction, maximum compressive stress is 18.23kg/sq.cm at point A for section 55.09^0 & load case 1b(ii); maximum tensile stress is 11.65kg/sq.cm. in zone near A (outer edge of upper speed ring) for section 195^0 & load case 1a(ii) where as maximum deflection is -0.02cm at point near C for section 267.63^0 and load case 1a(ii). Variations of tensile and compressive stresses in various zone for different conditions is shown in fig.5.84 to fig.5.92.
- Maximum shear stress σ_{xy} (SXY) is –20.07kg/sq.cm in zone A for section 51.42^0 and load case 1b(iii) (Table-5.7, Appendix-A).

- Shear stress σ_{yz} (SYZ) –16.33kg/sq.cm is maximum in zone near A for section 360^0 and load case 1a(ii) (Table-5.8, Appendix-A).
- Zone A is critical for maximum shear stress σ_{xz} (SXZ) as 10.58kg/sq.cm for section 55.09^0 and load case 1b(iii) (Table-5.9, Appendix-A).
- Maximum Principal stress σ_1 (S1) 26.80 & -9.53kg/sq.cm are in zone A for section 360^0 & load case 2a(ii) and for section 97.07^0 & load case 1b(i) respectively (Table-5.10, Appendix-A).
- Principal stresses σ_2 (S2) –13.95 & 8.85kg/sq.cm in zone A for section 55.09^0 & load case 1b(ii) and in zone I for section 54.15^0 & same load case 1b(ii) respectively are maximum (Table-5.11, Appendix-A).
- Maximum principal stresses σ_3 (S3) –57.89 & 2.11kg/sq.cm are in zone near A for section 360^0 & load case 1a(ii) and for section 30^0 & load case 2b(ii) respectively (Table-5.12, Appendix-A).
- Critical deflections and stresses and their location are shown in table-5.5.1.

Table-5.5.1

MAXIMUM DEFLECTIONS AND STRESSES WITH THEIR LOCATIONS FOR DIFFERENT CONDITION

Loading conditions	Dedlection/ stresses	Maximum				Minimum			
		Value	Section	Zone	Load case	Value	Section	Zone	Load case
1a	UX	0.0388	195.00	B	ii				
	UY					0.0826	270.00	B	ii
	UZ					0.0197	267.63	C	ii
	SX	14.21	270.00	A	ii	17.48	7.50	C	ii
	SY	7.66	352.50	A	iv	50.11	7.50	A/F	ii
	SZ	11.65	195.00	A	ii	14.19	360.00	A	iv
	SXY	9.75	23.95	A	ii	9.88	15.00	G	v
	SYZ	5.95	15.00	A	ii	16.33	360.00	A	ii
	SXZ	9.24	315.00	B	iii	9.32	135.00	B	ii
	S1	14.22	270.00	A	ii	6.72	152.50	C	ii
	S2	7.56	278.51	I	iii	11.39	310.07	C	ii
	S3	1.17	308.80	I	ii	57.89	360.00	A	ii
1b	UX	0.0184	15.00	B	ii				
	UY					0.0234	10.06	C	ii
	UZ					0.0054	45.00	C	iv
	SX	6.72	47.27	I	ii	25.82	51.42	A	iii
	SY	10.49	50.11	I	ii	46.93	51.42	A	ii
	SZ	11.41	54.15	I	ii	18.23	55.09	A	ii
	SXY	12.51	97.07	A	ii	20.07	51.42	A	iii
	SYZ	9.85	61.79	I	ii	8.17	280.09	I	ii
	SXZ	10.58	55.09	A	iii	7.47	54.15	I	ii
	S1	20.63	47.27	I	ii	9.53	97.07	A	I
	S2	8.85	54.15	I	ii	13.95	55.09	A	ii
	S3	1.29	180.00	I	ii	50.35	51.42	A	ii

Table-5.5.1 (contd....)

MAXIMUM DEFLECTIONS AND STRESSES WITH THEIR LOCATIONS FOR DIFFERENT CONDITION

Loading conditions	Dedlection/ stresses	Maximum				Minimum			
		Value	Section	Zone	Load case	Value	Section	Zone	Load case
2a	UX					0.0385	360.00	A/F	iii
	UY	0.0206	47.70	I	iii				
	UZ	0.0177	330.00	D	ii				
	SX	13.10	38.70	*	ii	8.25	285.00	A	iii
	SY	25.55	360.00	A/F	iii	14.80	317.02	**	ii
	SZ	10.40	360.00	A	iii	8.09	345.00	A	ii
	SXY	10.30	360.00	A/F	ii	10.18	360.00	A/F	iii
	SYZ	9.31	7.47	A/F	ii	5.87	6.35	A/F	iii
	SXZ	5.29	315.00	A	ii	5.21	24.96	A	ii
	S1	26.80	360.00	A	ii	2.32	317.02	**	ii
	S2	7.17	23.48	A/F	ii	5.64	202.50	C	iii
	S3	0.36	334.97	C	iv	18.92	360.00	A	iii
2b	UX	0.0283	32.29	D	ii				
	UY	0.0213	46.28	I	iii				
	UZ	0.016	330.00	D	ii				
	SX	12.89	39.42	*	iii	8.01	187.50	C	iii
	SY	20.35	360.00	A	iii	17.14	97.07	A	iii
	SZ	10.86	82.72	I	ii	6.64	97.07	A	iii
	SXY	11.96	360.00	A/F	ii	13.09	97.07	A	iii
	SYZ	7.76	7.47	A/F	iii	6.43	51.42	A	iii
	SXZ	4.82	86.45	I	iii	9.11	57.39	I	ii
	S1	25.51	360.00	A	iii	4.31	97.07	A	v
	S2	6.94	23.48	A/F	iii	6.35	97.07	A	iii
	S3	2.11	330.00	A	ii	25.68	97.07	A	iii

* c/l of penstock at turbine floor level

** outer edge at lower support

5.6 COMPARISON WITH 2-D RESULTS:

A 2-D model of section 180^0 is prepared and it is analyzed for four loading condition 1a(i), 1b(i), 2a(i) and 2b(i) to compare the results obtained by both 2-D and 3-D analysis. Comparison of the results obtained by both analyses in critical zones for section 180^0 is shown in tables 5.6.1.

Maximum deflections in both x & y direction is observed as 0.471 and -0.528cm respectively which are much more than the deflections observed in 3-D analysis in same zones B and same loading condition 1a(i).

Maximum compressive stress is observed in zone I for loading 1a(i) and maximum tensile in zone C for same loading of the amount 12.324 and 10.388kg/sq.cm respectively as far as normal stresses in x-direction is considered. In y-direction,

maximum compressive stress is observed in zone H for loading 1a(i) and maximum tensile in zone E for same loading with the amount of order 72.235 and 42.572kg/sq.cm respectively which are much more than the results obtained by the 3-D analysis.

I t is observed that shear stress SXY is maximum in zone H for loading 1a(i) as 10.2kg/sq.cm for 2-D analysis where as zone I is having maximum shear stress of very less amount of order 2.7kg/sq.cm but for the same loading condition 1a(i).

First principal tensile stress S1 is maximum in zone E for loading 1a(i) as 42.65kg/sq.cm for 2-D analysis, where as zone I is observed in maximum tensile for loading 2(b) with lesser amount of order 7.35kg/sq.cm. Compressive stresses are of very less amount for both type of analysis

Nominal tensile and compressive second principal stresses S2 are observed for both type of analysis.

Third principal compressive stress S3 is maximum in zone H for loading 1a(i) as 73.72kg/sq.cm for 2-D analysis, where as zone I is observed in maximum compressive for loading 2(b) with less amount of order 24.795kg/sq.cm. Tensile stresses are of very less amount for both type of analysis.

It is observed that among four above loading, 1a(i) is critical for all deflections and stresses for 2-D analysis. Maximum deflections and stresses for all four loading condition is shown in table-5.6.1..

Table-5.6.1

COMPARISON OF RESULTS OBTINED BY 2-D AND 3-D ANALYSIS AT SECTION 180^0

1a

Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	0.1096	-0.0101	-0.4658	-0.0502	0.066	0.258	0.015	0.019	-0.022	-0.179	0.075	7.349	0.007	0.301	0.000	-0.089
B	0.4708	0.0181	-0.5284	-0.0575	-0.159	0.513	-2.656	-4.178	0.277	-0.856	0.000	0.749	-0.129	-4.326	-2.686	-11.555
C	0.4652	0.0167	-0.2014	-0.0273	10.388	2.144	-1.092	-1.551	-0.549	0.206	10.414	2.616	0.000	-1.559	-1.118	-5.135
D	0.4569	0.0135	0.0898	-0.0053	-0.722	0.146	-0.312	0.111	-0.785	0.140	0.294	0.422	0.000	-0.111	-1.328	-2.851
E	0.1103	0.0002	0.0647	-0.0059	0.426	-0.003	42.572	1.519	1.788	0.552	42.648	1.863	0.350	0.236	0.000	-0.290
F	0.0002	-0.0004	-0.0013	-0.0005	0.148	-0.031	0.010	-0.002	0.054	0.042	0.166	0.452	0.000	0.028	-0.008	-0.063
G	0.0005	-0.0013	-0.0033	-0.0004	-1.442	2.567	0.570	0.299	0.195	-0.295	0.589	2.621	0.000	1.015	-1.461	0.251
H	0.0721	-0.0064	-0.0630	-0.0067	-3.599	-0.720	-72.235	-10.025	-10.199	0.370	0.000	-0.526	-2.115	-1.044	-73.718	-10.040
I	0.1945	-0.0047	-0.2484	-0.0285	-12.324	-5.011	-0.653	-1.423	-2.889	-2.771	0.022	1.412	0.000	-0.066	-13.000	-7.498
Minimum					-12.324	-5.011	-72.235	-10.025	-10.199	-2.771	0.000	-0.526	-2.115	-4.326	-73.718	-11.555
Maximum	0.4708	0.0181	-0.5284	-0.0575	10.388	2.144	42.572	1.519	1.788	0.552	42.648	7.349	0.350	1.015	0.000	0.251

1b

Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	0.0000	0.0000	0.0000	0.0000	-4.579	-6.218	-21.417	-21.426	4.577	7.301	0.000	-2.871	-3.415	-5.560	-22.581	-24.795
B	-0.0085	-0.0015	-0.0077	-0.0097	0.103	0.797	-2.325	-3.941	-0.217	-1.098	0.123	1.108	0.000	0.654	-2.344	-4.221
C	-0.0062	-0.0001	-0.0118	-0.0101	-2.606	-1.560	-1.210	-1.544	-0.446	0.223	0.000	-0.367	-1.080	-1.334	-2.737	-1.778
D	-0.0056	0.0001	-0.0087	-0.0060	0.053	0.093	-0.035	0.026	0.052	0.101	0.077	0.211	0.000	0.055	-0.059	-0.047
E	-0.0074	-0.0019	-0.0079	-0.0057	0.024	0.028	-0.347	-0.525	0.102	0.054	0.051	0.465	0.000	0.033	-0.374	-0.543
F	-0.0007	-0.0002	-0.0005	-0.0005	-0.065	-0.033	-0.002	0.000	-0.015	0.008	0.001	0.132	0.000	0.000	-0.068	-0.036
G	-0.0010	-0.0006	-0.0005	-0.0005	1.346	1.117	0.080	0.151	-0.124	-0.133	1.358	1.141	0.069	0.402	0.000	0.129
H	-0.0069	-0.0027	-0.0067	-0.0039	-0.390	-0.364	-6.204	-4.365	-1.006	0.373	0.000	-0.256	-0.221	-0.436	-6.373	-4.403
I	-0.0058	-0.0019	-0.0111	-0.0093	3.824	2.037	0.295	0.199	0.444	-0.039	3.879	2.157	0.240	0.823	0.000	0.193
Minimum					-4.579	-6.218	-21.417	-21.426	-1.006	-1.098	0.000	-2.871	-3.415	-5.560	-22.581	-24.795
Maximum	-0.0085	-0.0027	-0.0118	-0.0101	3.824	2.037	0.295	0.199	4.577	7.301	3.879	2.157	0.240	0.823	0.000	0.193

Table-5.5.1 (contd....)

MAXIMUM DEFLECTIONS AND STRESSES WITH THEIR LOCATIONS FOR DIFFERENT CONDITION

Loading conditions	Dedlection/ stresses	Maximum				Minimum			
		Value	Section	Zone	Load case	Value	Section	Zone	Load case
2a	UX					0.0385	360.00	A/F	iii
	UY	0.0206	47.70	I	iii				
	UZ	0.0177	330.00	D	ii				
	SX	13.10	38.70	*	ii	8.25	285.00	A	iii
	SY	25.55	360.00	A/F	iii	14.80	317.02	**	ii
	SZ	10.40	360.00	A	iii	8.09	345.00	A	ii
	SXY	10.30	360.00	A/F	ii	10.18	360.00	A/F	iii
	SYZ	9.31	7.47	A/F	ii	5.87	6.35	A/F	iii
	SXZ	5.29	315.00	A	ii	5.21	24.96	A	ii
	S1	26.80	360.00	A	ii	2.32	317.02	**	ii
	S2	7.17	23.48	A/F	ii	5.64	202.50	C	iii
	S3	0.36	334.97	C	iv	18.92	360.00	A	iii
2b	UX	0.0283	32.29	D	ii				
	UY	0.0213	46.28	I	iii				
	UZ	0.016	330.00	D	ii				
	SX	12.89	39.42	*	iii	8.01	187.50	C	iii
	SY	20.35	360.00	A	iii	17.14	97.07	A	iii
	SZ	10.86	82.72	I	ii	6.64	97.07	A	iii
	SXY	11.96	360.00	A/F	ii	13.09	97.07	A	iii
	SYZ	7.76	7.47	A/F	iii	6.43	51.42	A	iii
	SXZ	4.82	86.45	I	iii	9.11	57.39	I	ii
	S1	25.51	360.00	A	iii	4.31	97.07	A	v
	S2	6.94	23.48	A/F	iii	6.35	97.07	A	iii
	S3	2.11	330.00	A	ii	25.68	97.07	A	iii

* c/l of penstock at turbine floor level

** outer edge at lower support

5.6 COMPARISON WITH 2-D RESULTS:

A 2-D model of section 180^0 is prepared and it is analyzed for four loading condition 1a(i), 1b(i), 2a(i) and 2b(i) to compare the results obtained by both 2-D and 3-D analysis. Comparison of the results obtained by both analyses in critical zones for section 180^0 is shown in tables 5.6.1.

Maximum deflections in both x & y direction is observed as 0.471 and -0.528cm respectively which are much more than the deflections observed in 3-D analysis in same zones B and same loading condition 1a(i).

Maximum compressive stress is observed in zone I for loading 1a(i) and maximum tensile in zone C for same loading of the amount 12.324 and 10.388kg/sq.cm respectively as far as normal stresses in x-direction is considered. In y-direction,

maximum compressive stress is observed in zone H for loading 1a(i) and maximum tensile in zone E for same loading with the amount of order 72.235 and 42.572kg/sq.cm respectively which are much more than the results obtained by the 3-D analysis.

I t is observed that shear stress SXY is maximum in zone H for loading 1a(i) as 10.2kg/sq.cm for 2-D analysis where as zone I is having maximum shear stress of very less amount of order 2.7kg/sq.cm but for the same loading condition 1a(i).

First principal tensile stress S1 is maximum in zone E for loading 1a(i) as 42.65kg/sq.cm for 2-D analysis, where as zone I is observed in maximum tensile for loading 2(b) with lesser amount of order 7.35kg/sq.cm. Compressive stresses are of very less amount for both type of analysis

Nominal tensile and compressive second principal stresses S2 are observed for both type of analysis.

Third principal compressive stress S3 is maximum in zone H for loading 1a(i) as 73.72kg/sq.cm for 2-D analysis, where as zone I is observed in maximum compressive for loading 2(b) with less amount of order 24.795kg/sq.cm. Tensile stresses are of very less amount for both type of analysis.

It is observed that among four above loading, 1a(i) is critical for all deflections and stresses for 2-D analysis. Maximum deflections and stresses for all four loading condition is shown in table-5.6.1..

Table-5.6.1

COMPARISON OF RESULTS OBTINED BY 2-D AND 3-D ANALYSIS AT SECTION 180^0

1a

Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	0.1096	-0.0101	-0.4658	-0.0502	0.066	0.258	0.015	0.019	-0.022	-0.179	0.075	7.349	0.007	0.301	0.000	-0.089
B	0.4708	0.0181	-0.5284	-0.0575	-0.159	0.513	-2.656	-4.178	0.277	-0.856	0.000	0.749	-0.129	-4.326	-2.686	-11.555
C	0.4652	0.0167	-0.2014	-0.0273	10.388	2.144	-1.092	-1.551	-0.549	0.206	10.414	2.616	0.000	-1.559	-1.118	-5.135
D	0.4569	0.0135	0.0898	-0.0053	-0.722	0.146	-0.312	0.111	-0.785	0.140	0.294	0.422	0.000	-0.111	-1.328	-2.851
E	0.1103	0.0002	0.0647	-0.0059	0.426	-0.003	42.572	1.519	1.788	0.552	42.648	1.863	0.350	0.236	0.000	-0.290
F	0.0002	-0.0004	-0.0013	-0.0005	0.148	-0.031	0.010	-0.002	0.054	0.042	0.166	0.452	0.000	0.028	-0.008	-0.063
G	0.0005	-0.0013	-0.0033	-0.0004	-1.442	2.567	0.570	0.299	0.195	-0.295	0.589	2.621	0.000	1.015	-1.461	0.251
H	0.0721	-0.0064	-0.0630	-0.0067	-3.599	-0.720	-72.235	-10.025	-10.199	0.370	0.000	-0.526	-2.115	-1.044	-73.718	-10.040
I	0.1945	-0.0047	-0.2484	-0.0285	-12.324	-5.011	-0.653	-1.423	-2.889	-2.771	0.022	1.412	0.000	-0.066	-13.000	-7.498
Minimum					-12.324	-5.011	-72.235	-10.025	-10.199	-2.771	0.000	-0.526	-2.115	-4.326	-73.718	-11.555
Maximum	0.4708	0.0181	-0.5284	-0.0575	10.388	2.144	42.572	1.519	1.788	0.552	42.648	7.349	0.350	1.015	0.000	0.251

1b

Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	0.0000	0.0000	0.0000	0.0000	-4.579	-6.218	-21.417	-21.426	4.577	7.301	0.000	-2.871	-3.415	-5.560	-22.581	-24.795
B	-0.0085	-0.0015	-0.0077	-0.0097	0.103	0.797	-2.325	-3.941	-0.217	-1.098	0.123	1.108	0.000	0.654	-2.344	-4.221
C	-0.0062	-0.0001	-0.0118	-0.0101	-2.606	-1.560	-1.210	-1.544	-0.446	0.223	0.000	-0.367	-1.080	-1.334	-2.737	-1.778
D	-0.0056	0.0001	-0.0087	-0.0060	0.053	0.093	-0.035	0.026	0.052	0.101	0.077	0.211	0.000	0.055	-0.059	-0.047
E	-0.0074	-0.0019	-0.0079	-0.0057	0.024	0.028	-0.347	-0.525	0.102	0.054	0.051	0.465	0.000	0.033	-0.374	-0.543
F	-0.0007	-0.0002	-0.0005	-0.0005	-0.065	-0.033	-0.002	0.000	-0.015	0.008	0.001	0.132	0.000	0.000	-0.068	-0.036
G	-0.0010	-0.0006	-0.0005	-0.0005	1.346	1.117	0.080	0.151	-0.124	-0.133	1.358	1.141	0.069	0.402	0.000	0.129
H	-0.0069	-0.0027	-0.0067	-0.0039	-0.390	-0.364	-6.204	-4.365	-1.006	0.373	0.000	-0.256	-0.221	-0.436	-6.373	-4.403
I	-0.0058	-0.0019	-0.0111	-0.0093	3.824	2.037	0.295	0.199	0.444	-0.039	3.879	2.157	0.240	0.823	0.000	0.193
Minimum					-4.579	-6.218	-21.417	-21.426	-1.006	-1.098	0.000	-2.871	-3.415	-5.560	-22.581	-24.795
Maximum	-0.0085	-0.0027	-0.0118	-0.0101	3.824	2.037	0.295	0.199	4.577	7.301	3.879	2.157	0.240	0.823	0.000	0.193

Table-5.6.1 (contd...)

COMPARISON OF RESULTS OBTINED BY 2-D AND 3-D ANALYSIS AT SECTION 180^0

2a																
Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	-0.0531	0.0004	0.0394	-0.0034	-2.122	-2.291	-0.789	-0.739	-0.964	-0.886	0.000	0.723	-0.284	-0.622	-2.627	-2.734
B	-0.0922	-0.0046	0.0421	-0.0079	-0.021	0.717	-2.473	-4.032	-0.003	-1.014	0.000	1.454	-0.021	0.381	-2.473	-4.304
C	-0.0925	-0.0042	0.0106	-0.0075	0.953	-0.044	-1.181	-1.540	-0.422	0.236	1.033	0.995	0.000	-0.326	-1.262	-1.580
D	-0.0939	-0.0043	-0.0202	-0.0035	-0.102	-0.045	-0.110	-0.087	-0.116	-0.032	0.010	1.423	0.000	-0.003	-0.223	-0.132
E	-0.0523	-0.0070	-0.0225	-0.0031	0.149	0.027	2.034	0.108	-0.008	0.222	2.034	2.203	0.149	0.225	0.000	-0.206
F	-0.0020	0.0001	-0.0026	-0.0033	-2.060	-2.544	-0.664	-0.676	0.659	1.024	0.000	-0.215	-0.402	-1.150	-2.322	-3.002
G	-0.0044	-0.0018	-0.0016	-0.0029	8.170	5.037	-3.408	-3.106	-0.390	-0.390	8.183	5.059	0.000	0.477	-3.421	-3.150
H	-0.0460	-0.0099	0.0031	-0.0029	-3.751	-3.134	-0.964	-1.328	-0.194	-1.121	0.000	1.323	-0.951	-1.306	-3.764	-3.746
I	-0.0656	-0.0070	0.0181	-0.0049	2.419	5.297	-3.338	-2.534	0.926	2.321	2.564	6.221	0.000	2.334	-3.483	-3.226
Minimum					-3.751	-3.134	-3.408	-4.032	-0.964	-1.014	0.000	-0.215	-0.951	-1.306	-3.764	-4.304
Maximum	-0.0939	-0.0099	0.0421	-0.0079	8.170	5.297	2.034	0.108	0.926	2.321	8.183	6.221	0.149	2.334	0.000	

2b																
Critical Points	UX		UY		SX		SY		SXY		S1		S2		S3	
	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D	2-D	3D
A	0.0000	0.0000	0.0000	0.0000	-1.836	-2.918	-12.154	-6.471	-3.091	1.047	0.000	-1.701	-0.981	-2.290	-13.009	-7.425
B	-0.0175	-0.0051	-0.0044	-0.0059	0.040	0.738	-2.385	-4.008	-0.163	-1.028	0.051	2.018	0.000	0.976	-2.396	-4.260
C	-0.0154	-0.0047	-0.0092	-0.0064	-1.761	-0.051	-1.198	-1.536	-0.462	0.245	0.000	1.106	-0.939	-0.017	-2.021	-1.575
D	-0.0153	-0.0047	-0.0053	-0.0033	-0.046	-0.060	-0.079	-0.100	-0.031	-0.043	0.000	1.686	-0.028	-0.014	-0.098	-0.147
E	-0.0195	-0.0070	-0.0069	-0.0028	0.149	0.025	4.089	0.108	0.303	0.210	4.112	2.271	0.126	0.206	0.000	-0.209
F	-0.0006	0.0001	-0.0030	-0.0033	-1.940	-2.543	-0.659	-0.676	0.693	1.022	0.000	-0.216	-0.356	-1.171	-2.243	-3.000
G	-0.0026	-0.0018	-0.0026	-0.0029	6.008	4.950	-3.327	-3.117	-0.154	-0.380	6.010	4.972	0.000	0.446	-3.330	-3.160
H	-0.0202	-0.0096	-0.0042	-0.0027	-3.829	-3.110	-4.709	-0.928	-0.078	-1.108	0.000	1.262	-3.823	-0.832	-4.715	-3.685
I	-0.0156	-0.0068	-0.0070	-0.0037	9.202	5.423	-3.006	-2.480	2.206	2.344	9.588	6.077	0.000	2.259	-3.392	-3.179
Minimum					-3.829	-3.110	-12.154	-6.471	-3.091	-1.108	0.000	-1.701	-3.823	-2.290	-13.009	-7.425
Maximum	-0.0202	-0.0096	-0.0092	-0.0064	9.202	5.423	4.089	0.108	2.206	2.344	9.588	6.077	0.126	2.259	0.000	

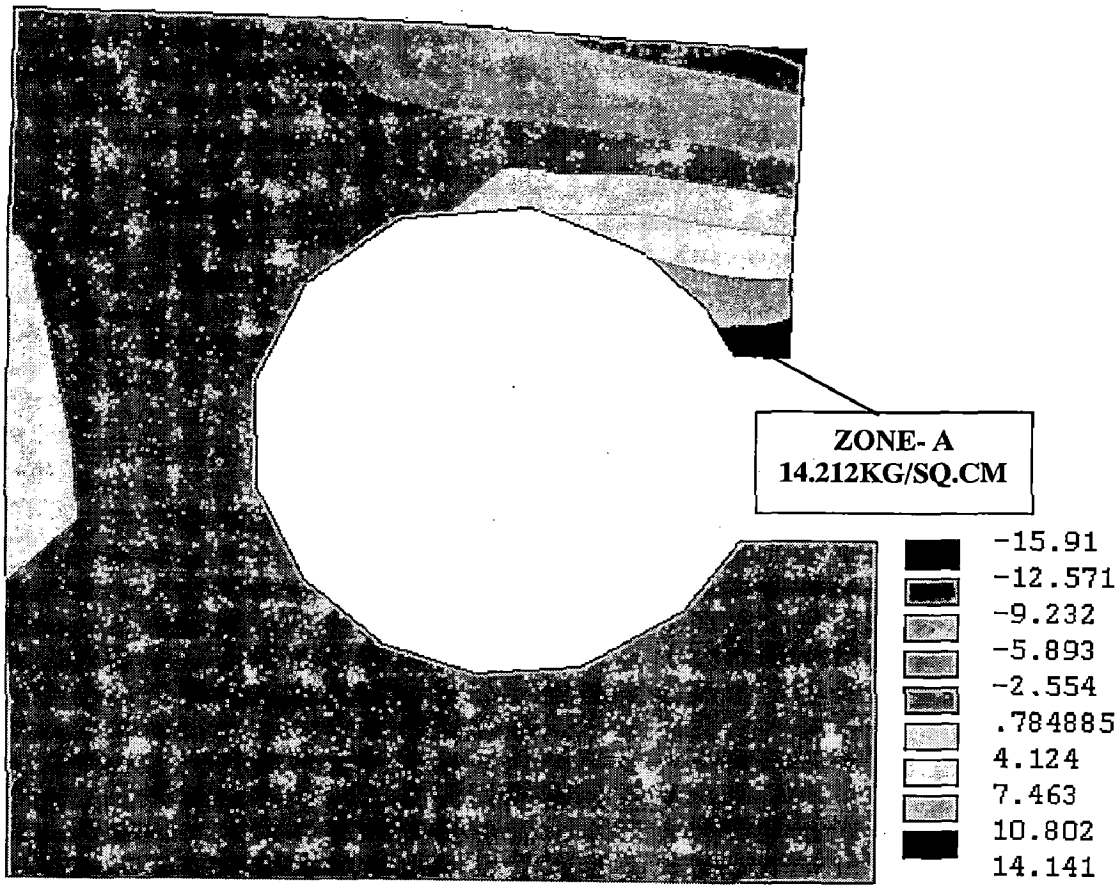


FIG. 5.5.1 STRESS CONTOUR FOR SX UNDER LOAD 1a(ii) AT SECTION 270^0

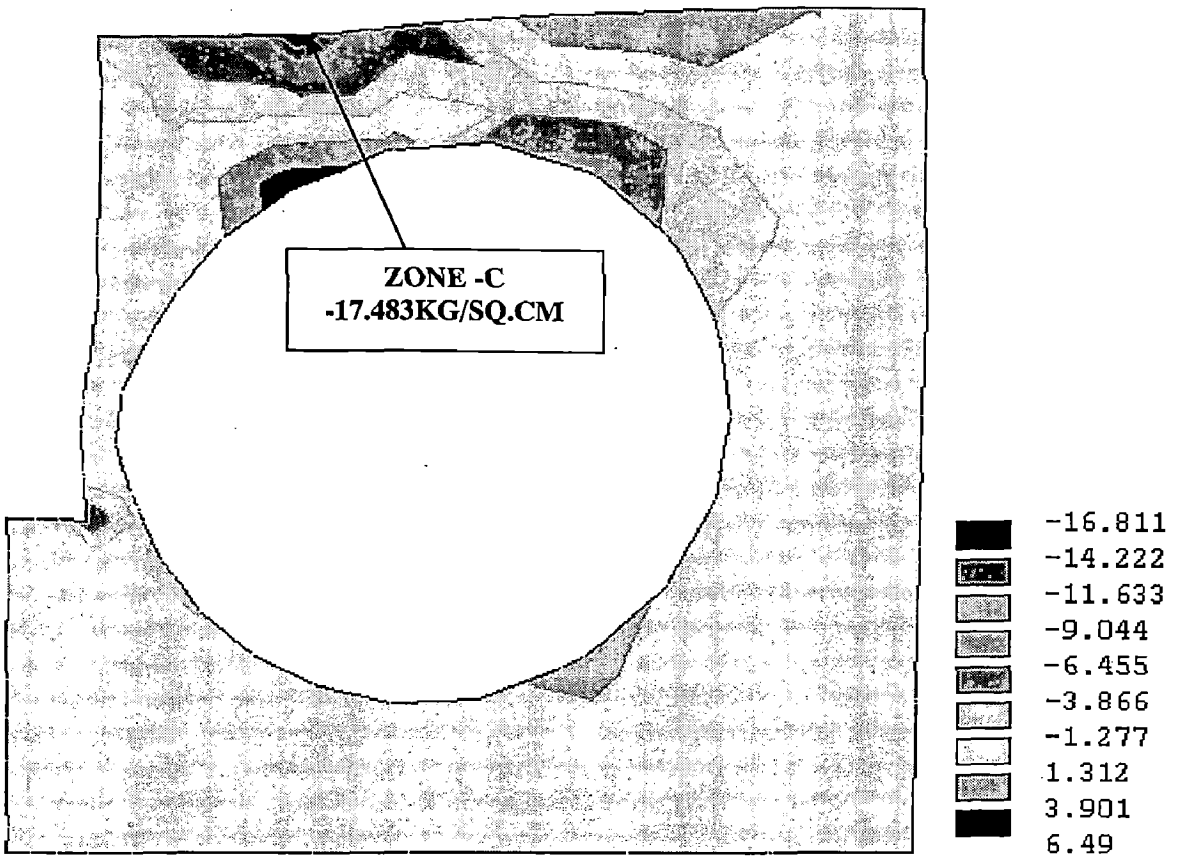


FIG. 5.5.2 STRESS CONTOUR FOR SX UNDER LOAD 1a(ii) AT SECTION 7.5^0

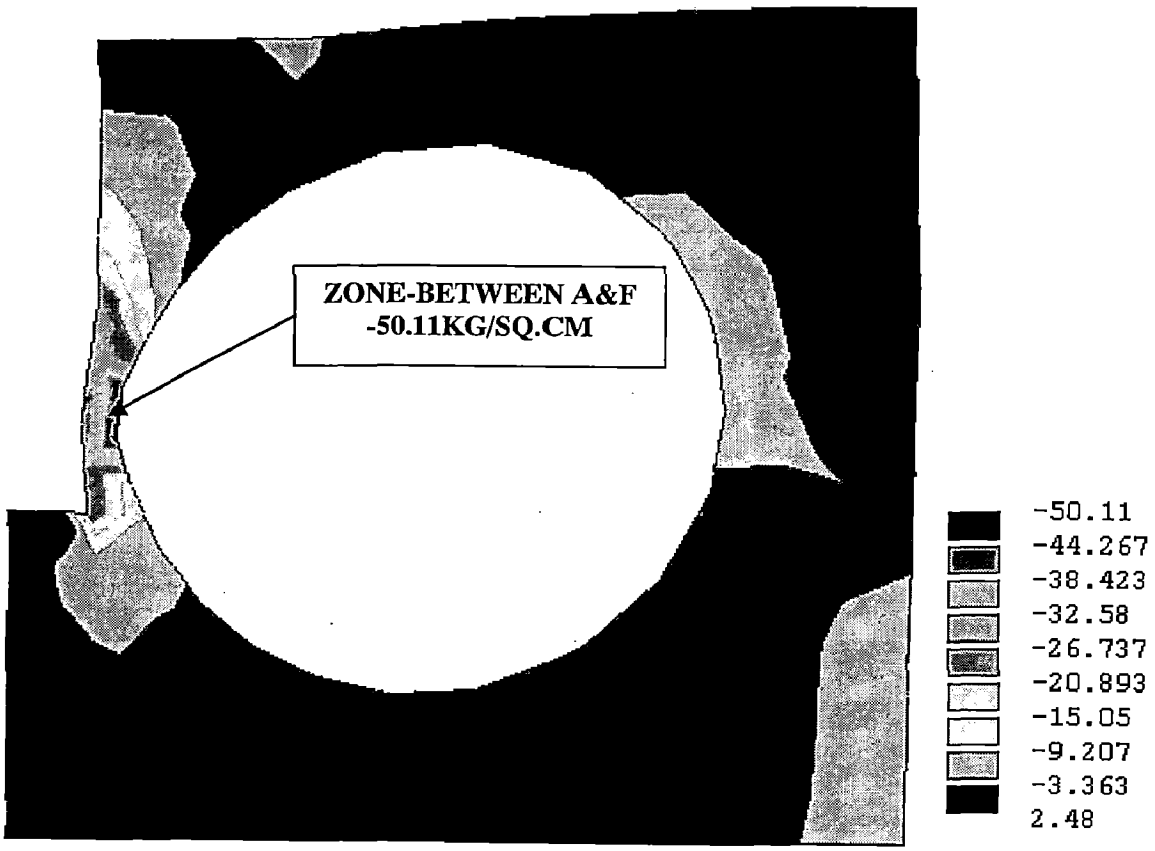


FIG. 5.5.3 STRESS CONTOUR FOR SY UNDER LOAD 1a(ii) AT SECTION 7.5^0

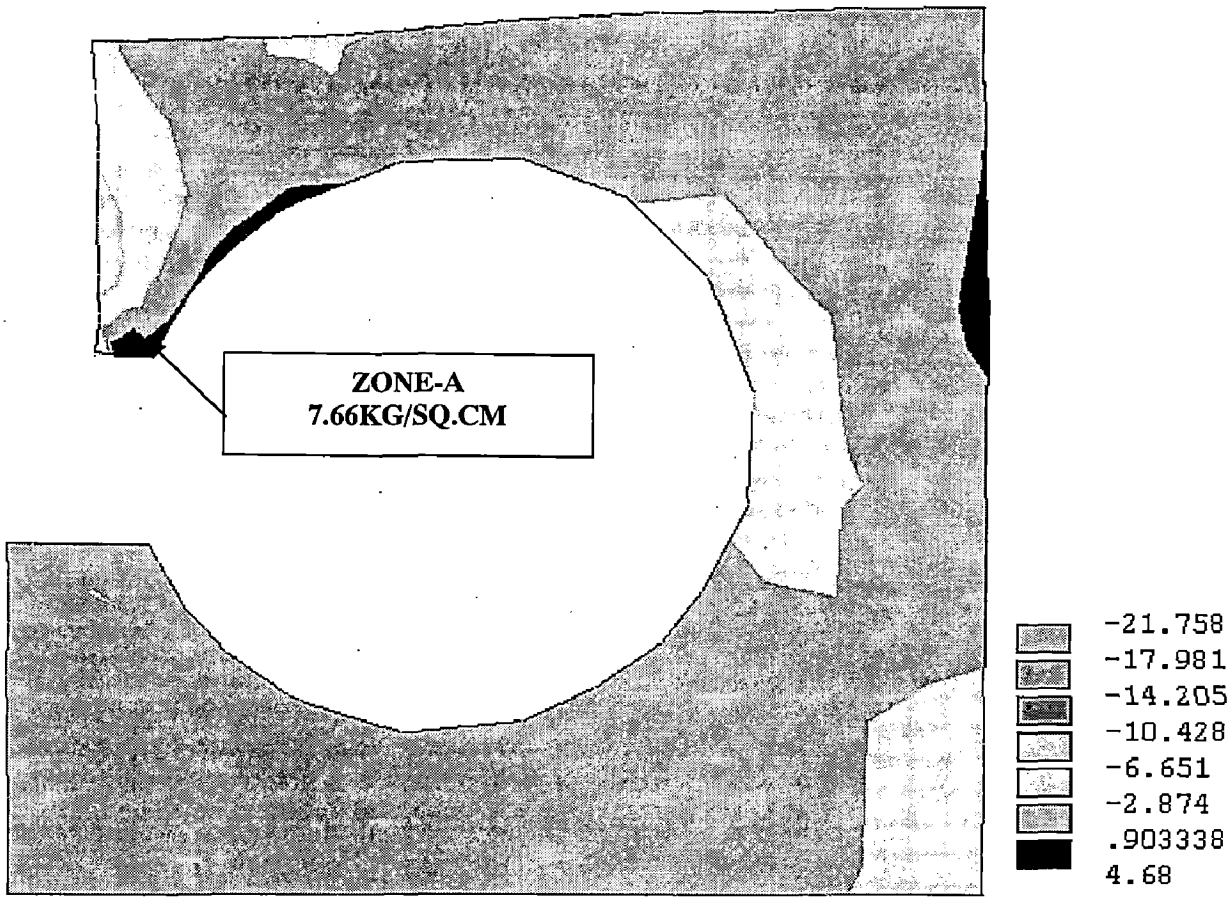


FIG. 5.5.4 STRESS CONTOUR FOR SY UNDER LOAD 1a(iv) AT SECTION 352.5^0

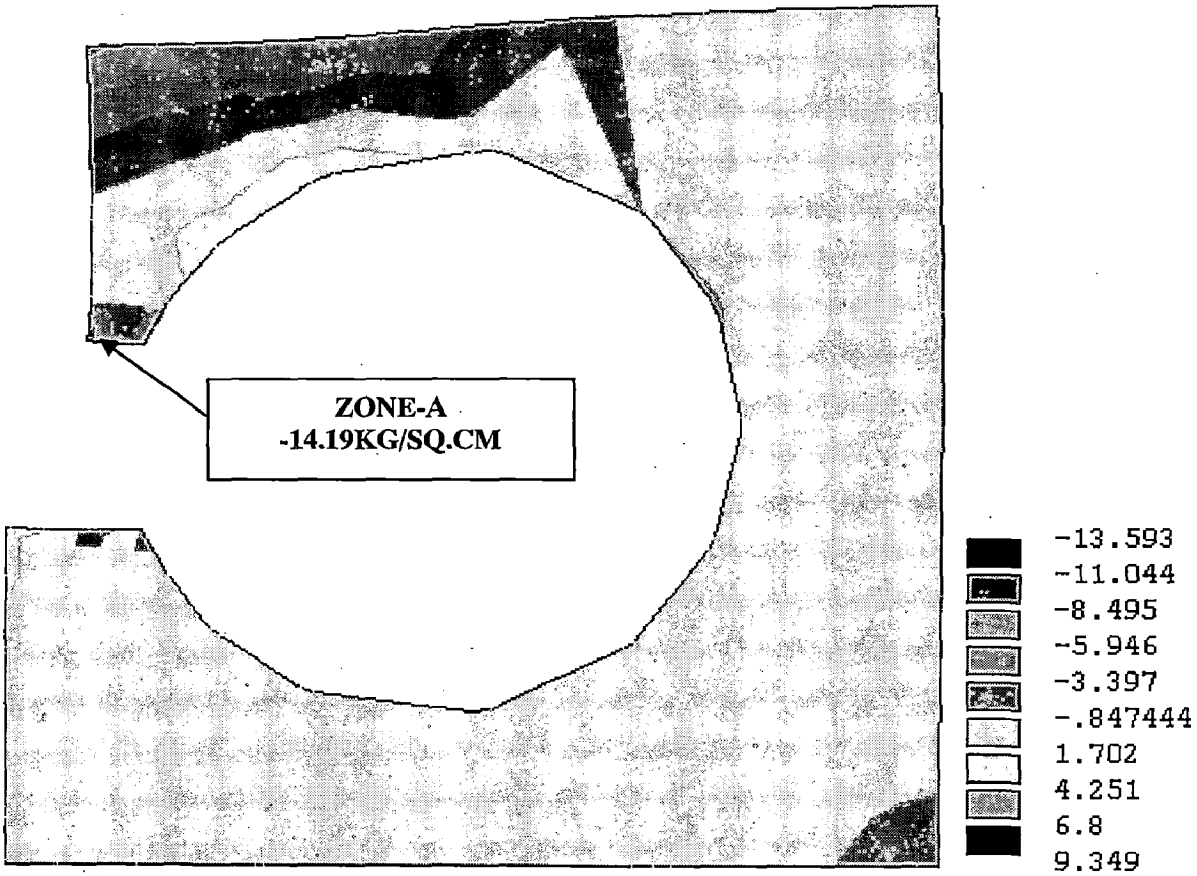


FIG. 5.5.5 STRESS CONTOUR FOR SZ UNDER LOAD 1a(iv) AT SECTION 360^0

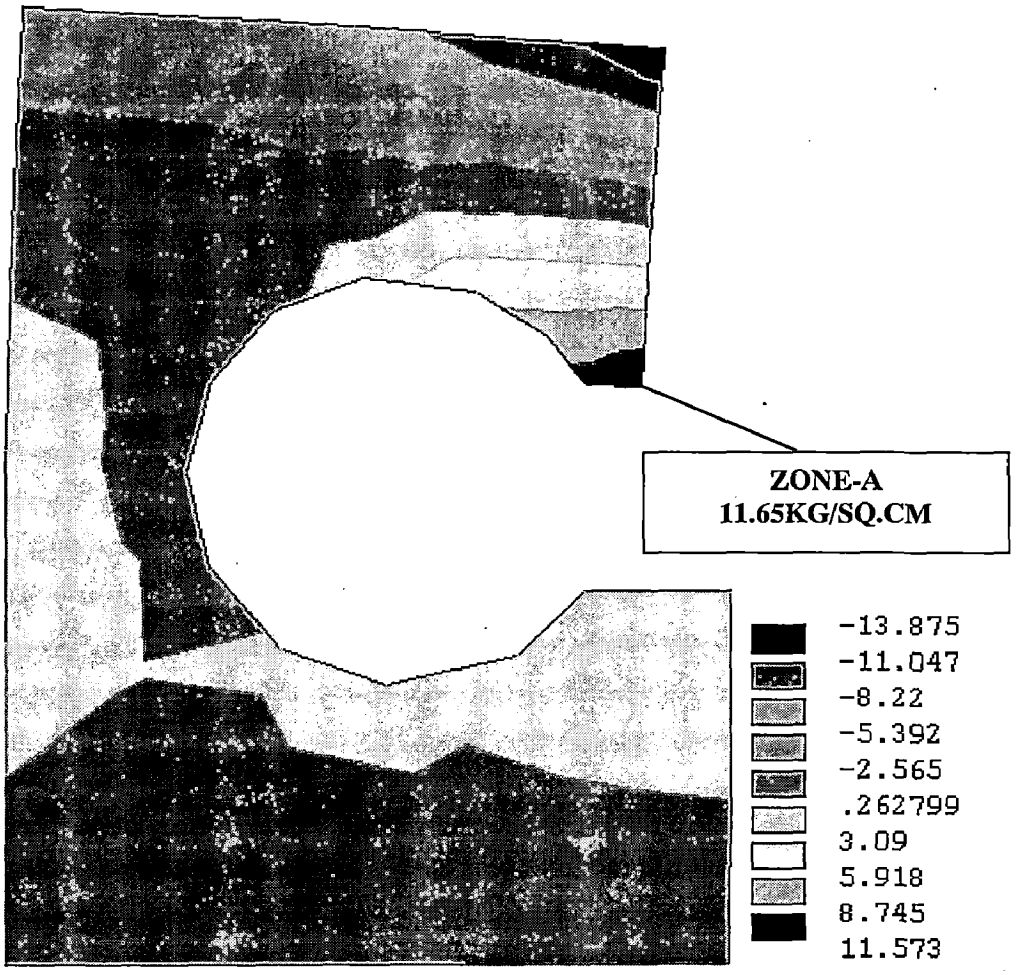


FIG. 5.5.6 STRESS CONTOUR FOR SZ UNDER LOAD 1a(ii) AT SECTION 195^0

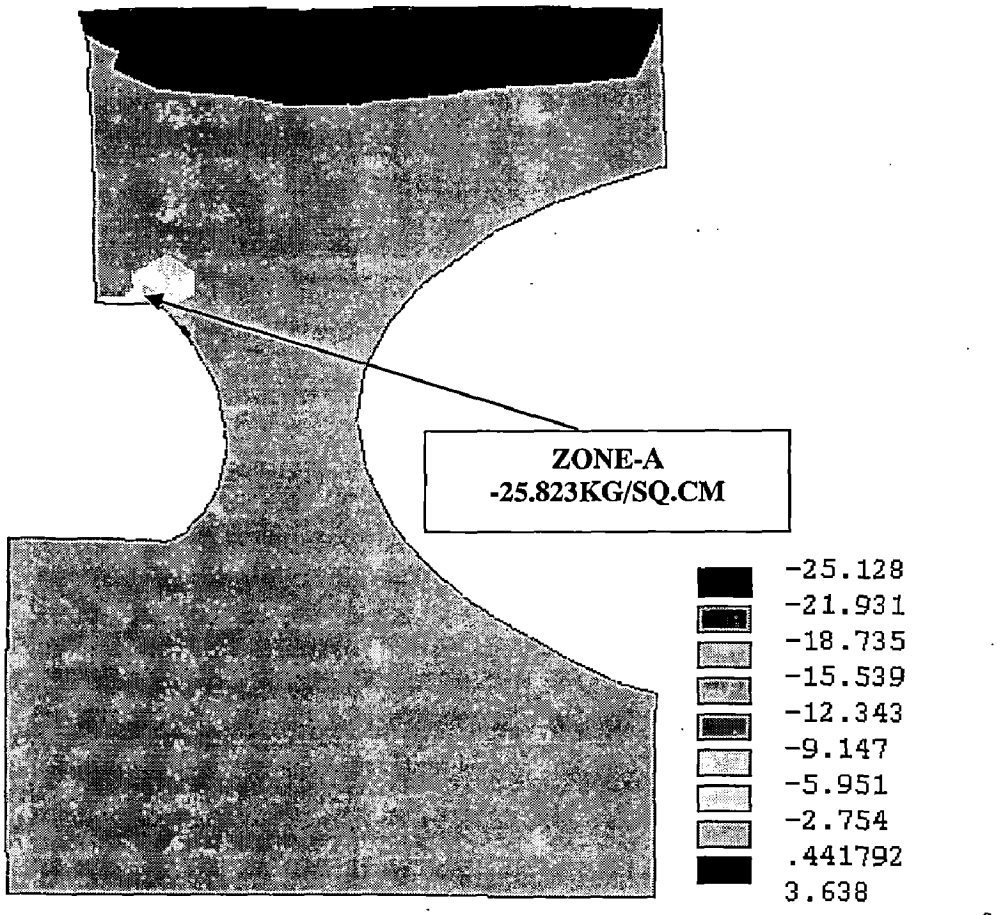


FIG. 5.5.7 STRESS CONTOUR FOR SX UNDER LOAD 1b(iii) AT SECTION 54.418^0

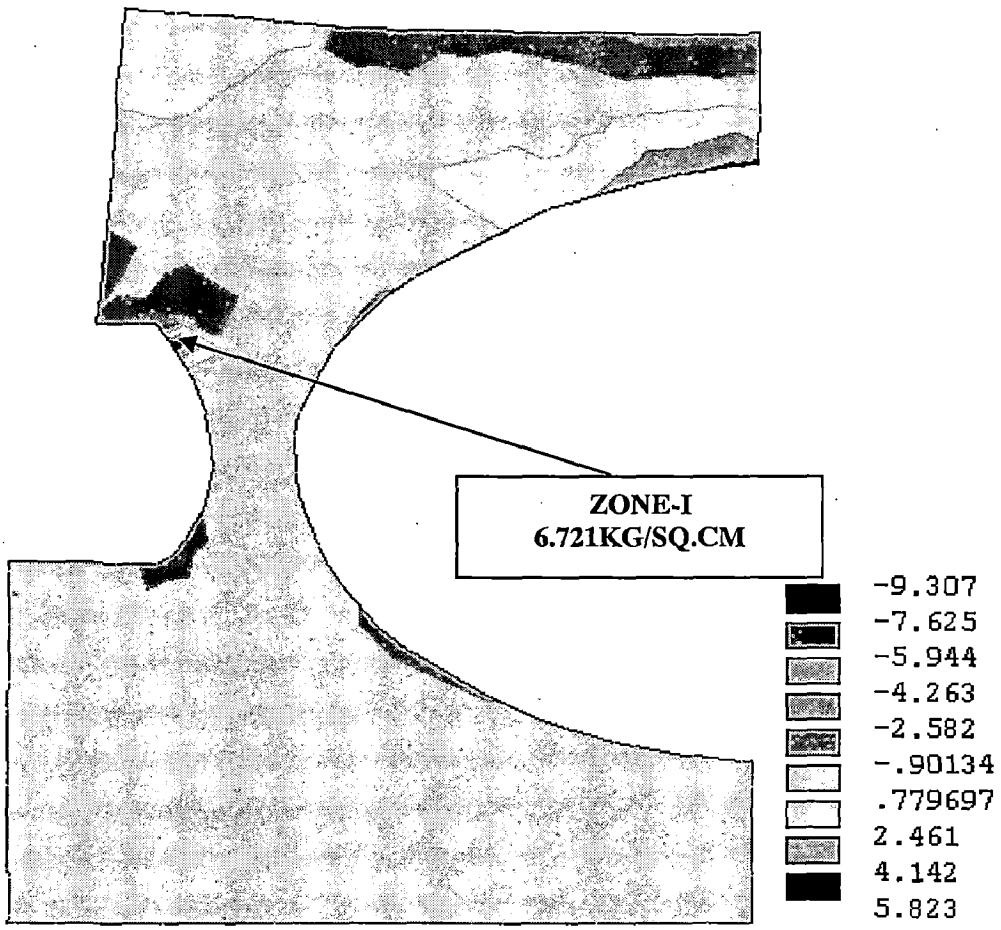


FIG. 5.5.8 STRESS CONTOUR FOR SX UNDER LOAD 1b(ii) AT SECTION 47.267^0

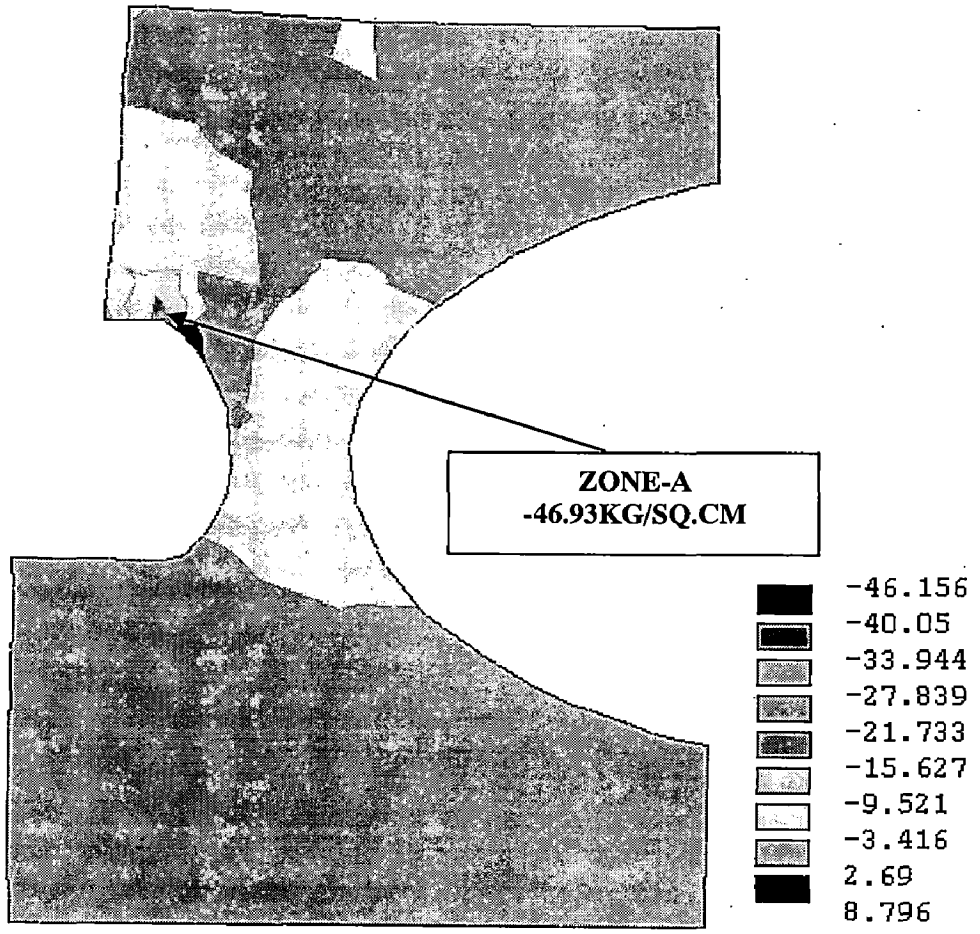


FIG. 5.5.9 STRESS CONTOUR FOR SY UNDER LOAD 1b(ii) AT SECTION 51.418^0

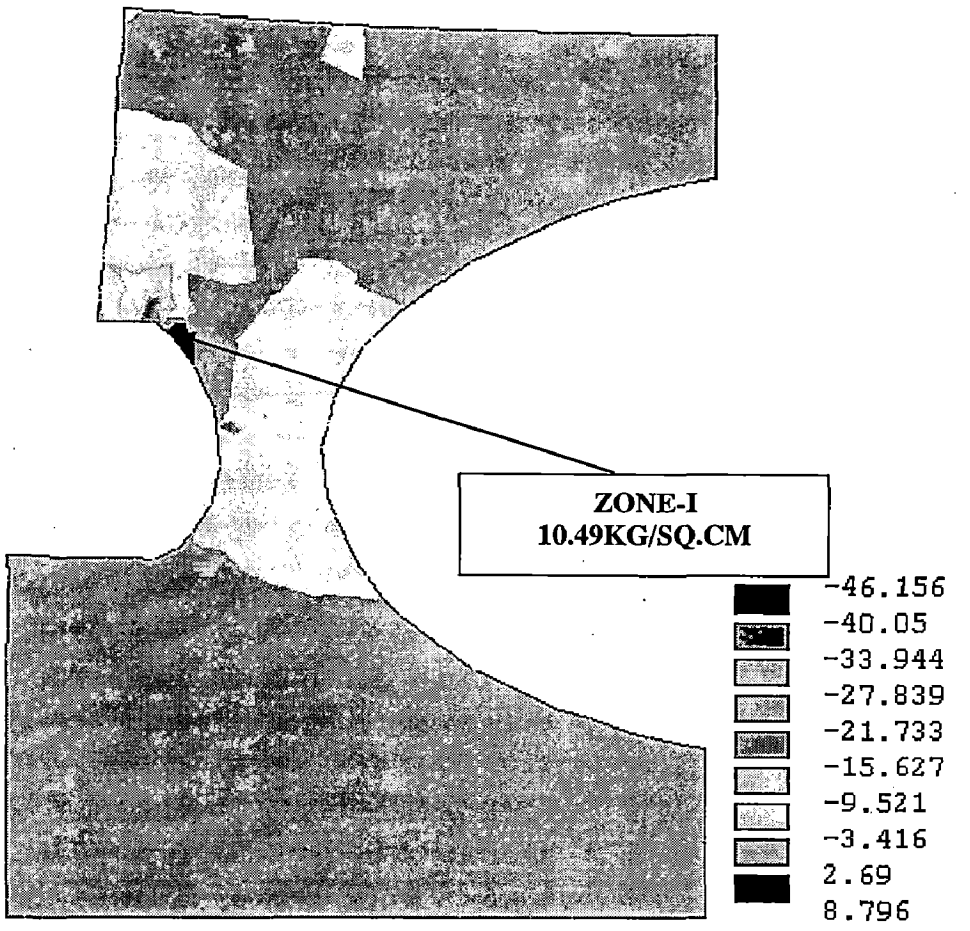


FIG. 5.5.10 STRESS CONTOUR FOR SY UNDER LOAD 1b(ii) AT SECTION 50.107^0

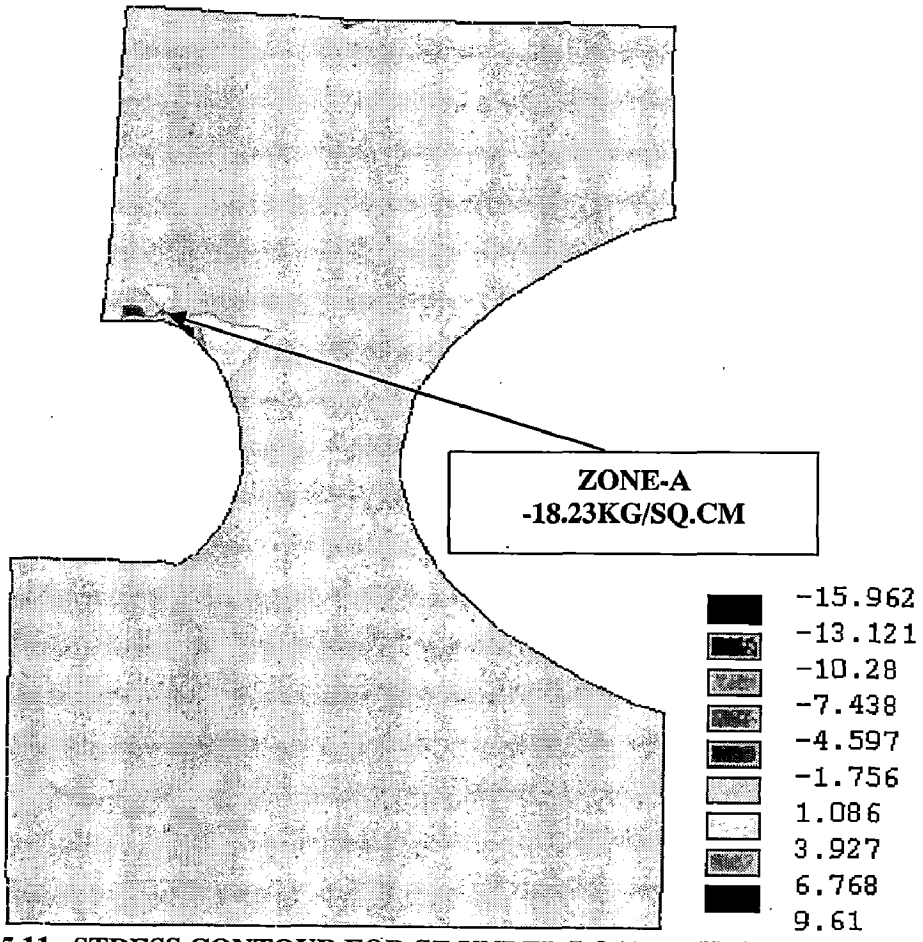


FIG. 5.5.11 STRESS CONTOUR FOR SZ UNDER LOAD 1b(ii) AT SECTION 55.09^0

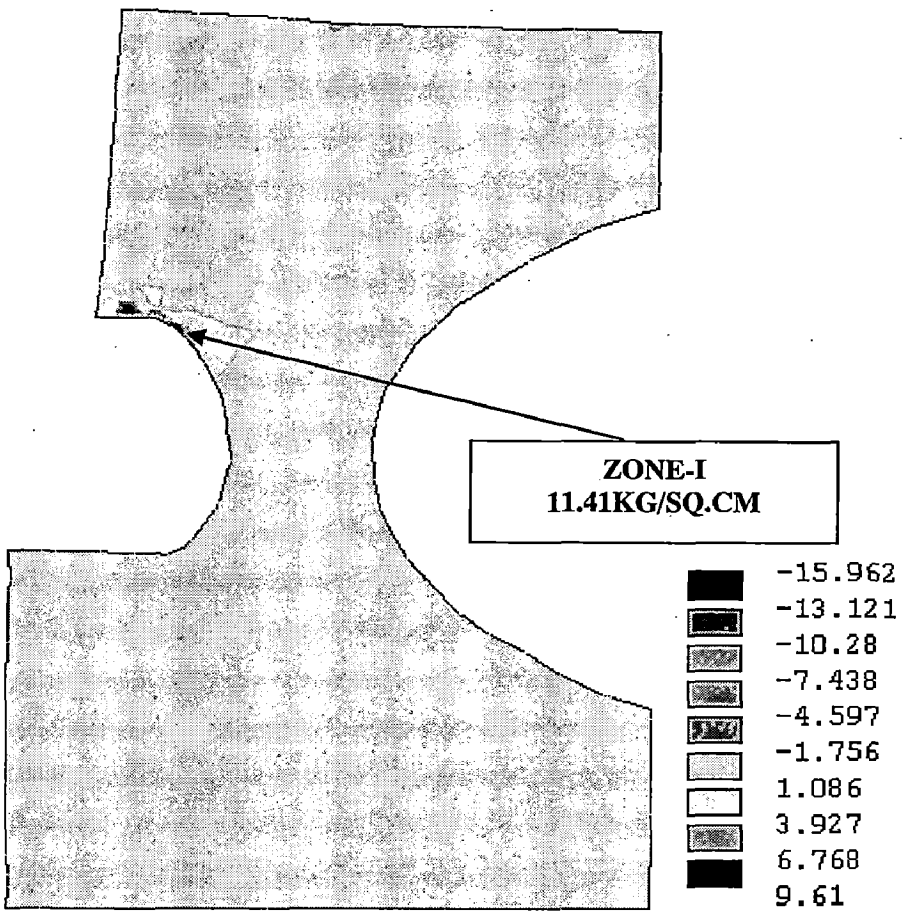


FIG. 5.5.12 STRESS CONTOUR FOR SZ UNDER LOAD 1b(ii) AT SECTION 54.149^0

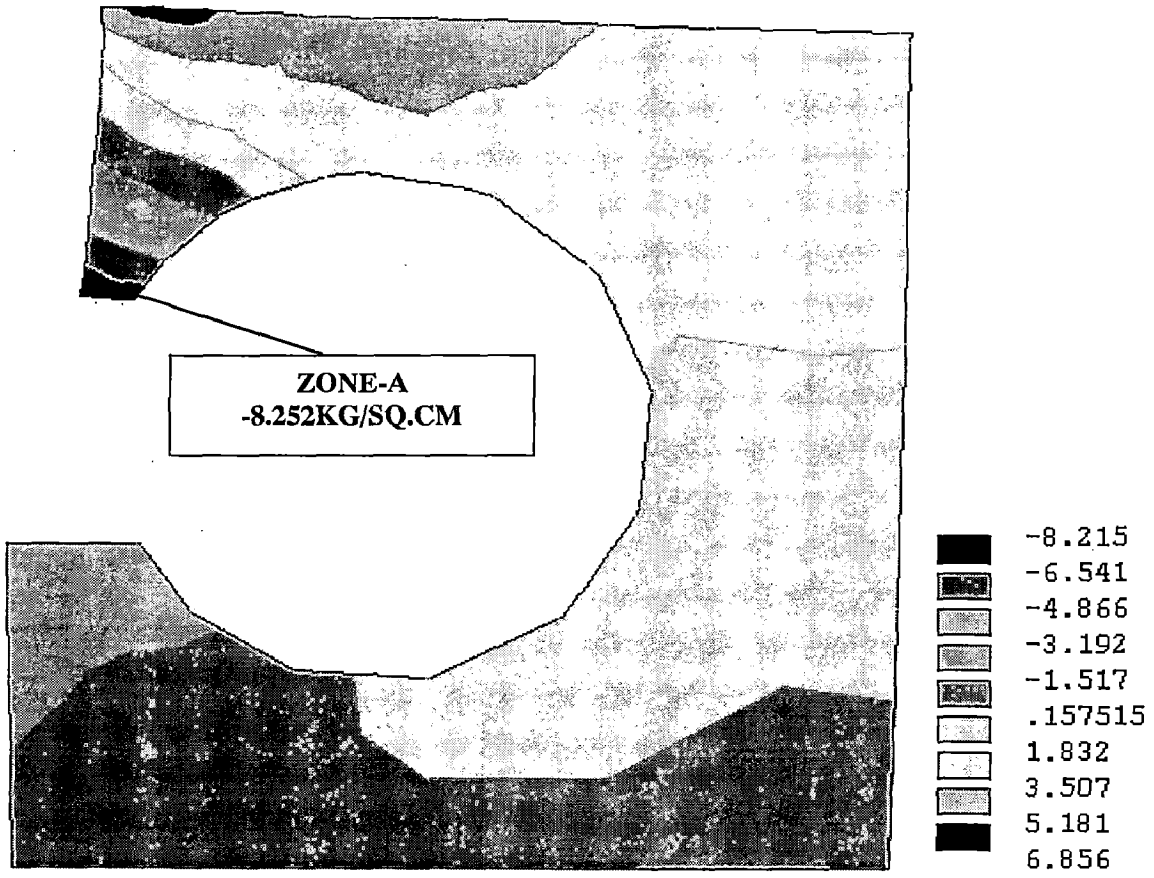


FIG. 5.5.13 STRESS CONTOUR FOR SX UNDER LOAD 2a(iii) AT SECTION 285^0

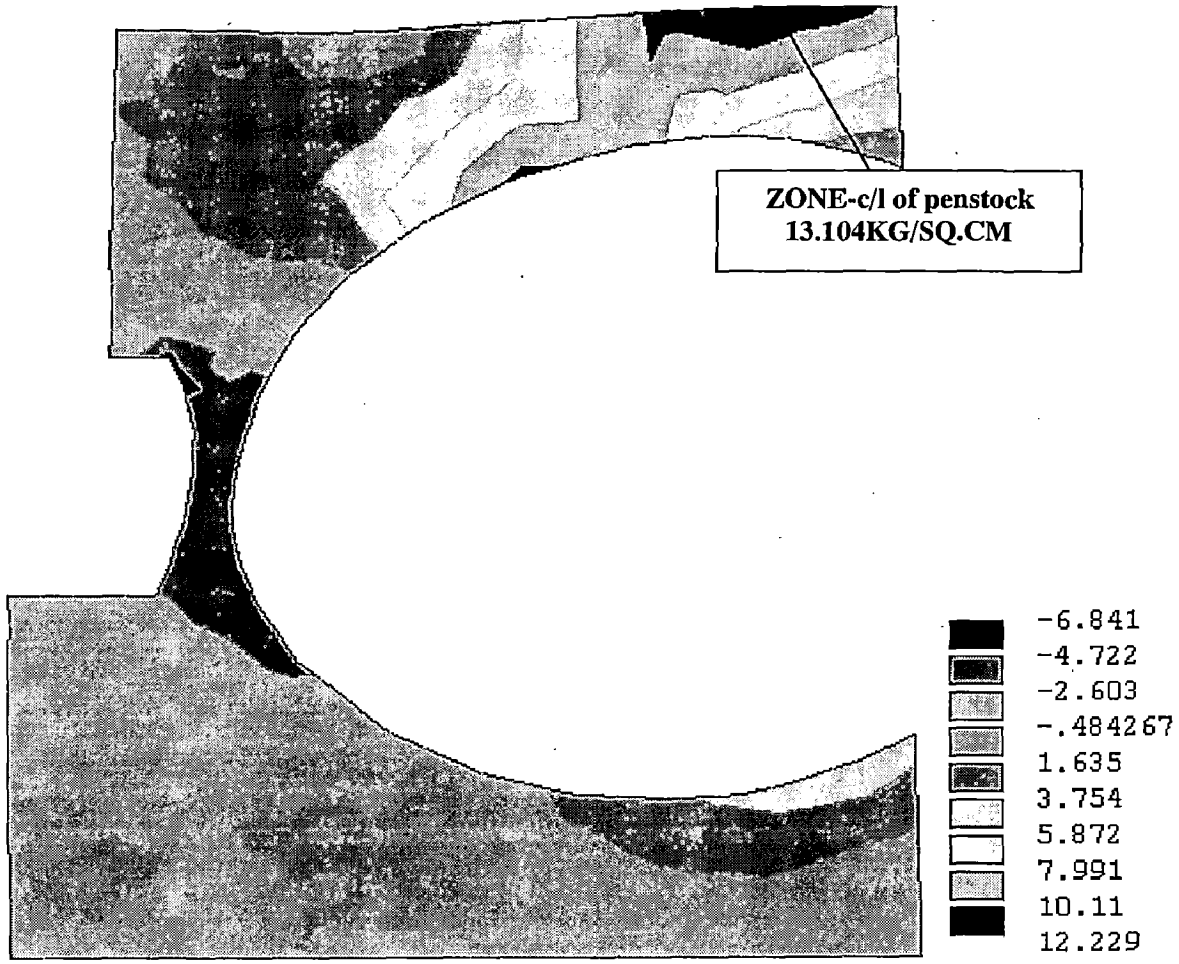


FIG. 5.5.14 STRESS CONTOUR FOR SX UNDER LOAD 2a(ii) AT SECTION 38.7^0

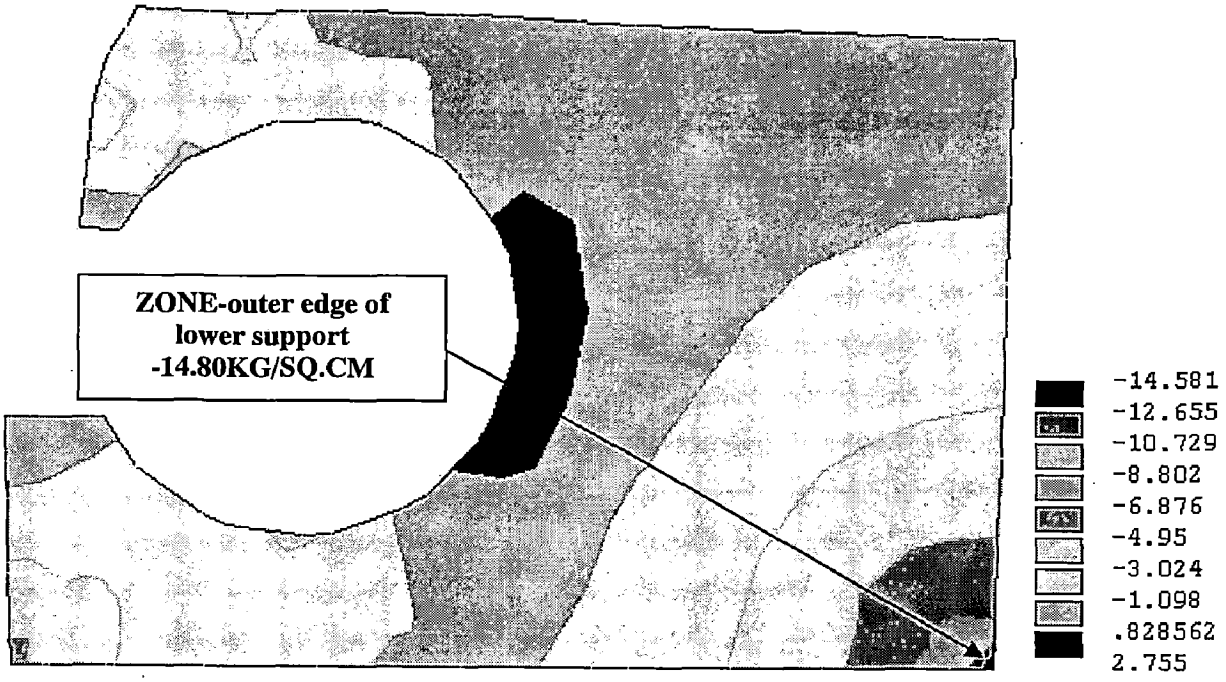


FIG. 5.5.15 STRESS CONTOUR FOR SY UNDER LOAD 2a(ii) AT SECTION 317.02^0

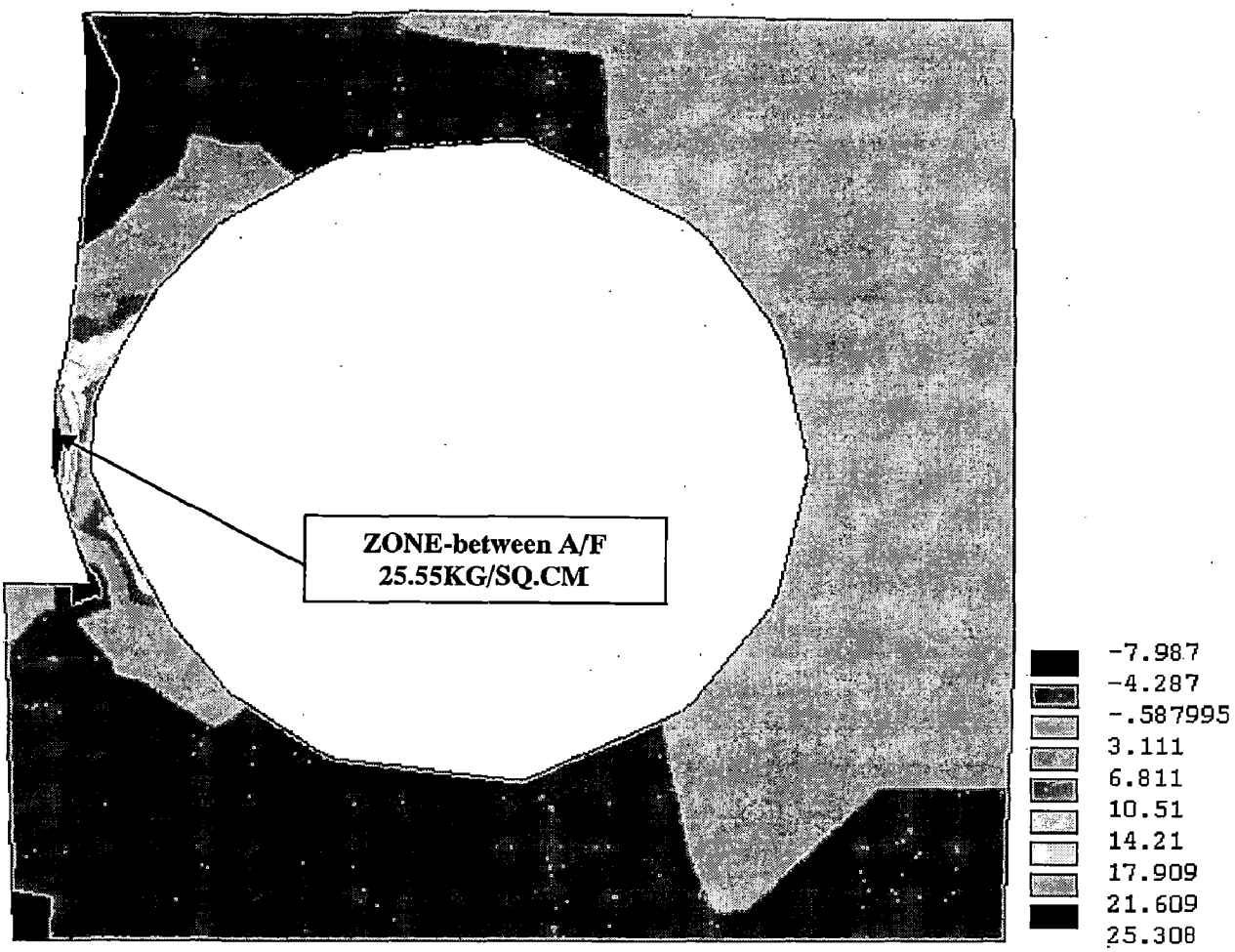


FIG. 5.5.16 STRESS CONTOUR FOR SY UNDER LOAD 2a(iii) AT SECTION 360^0

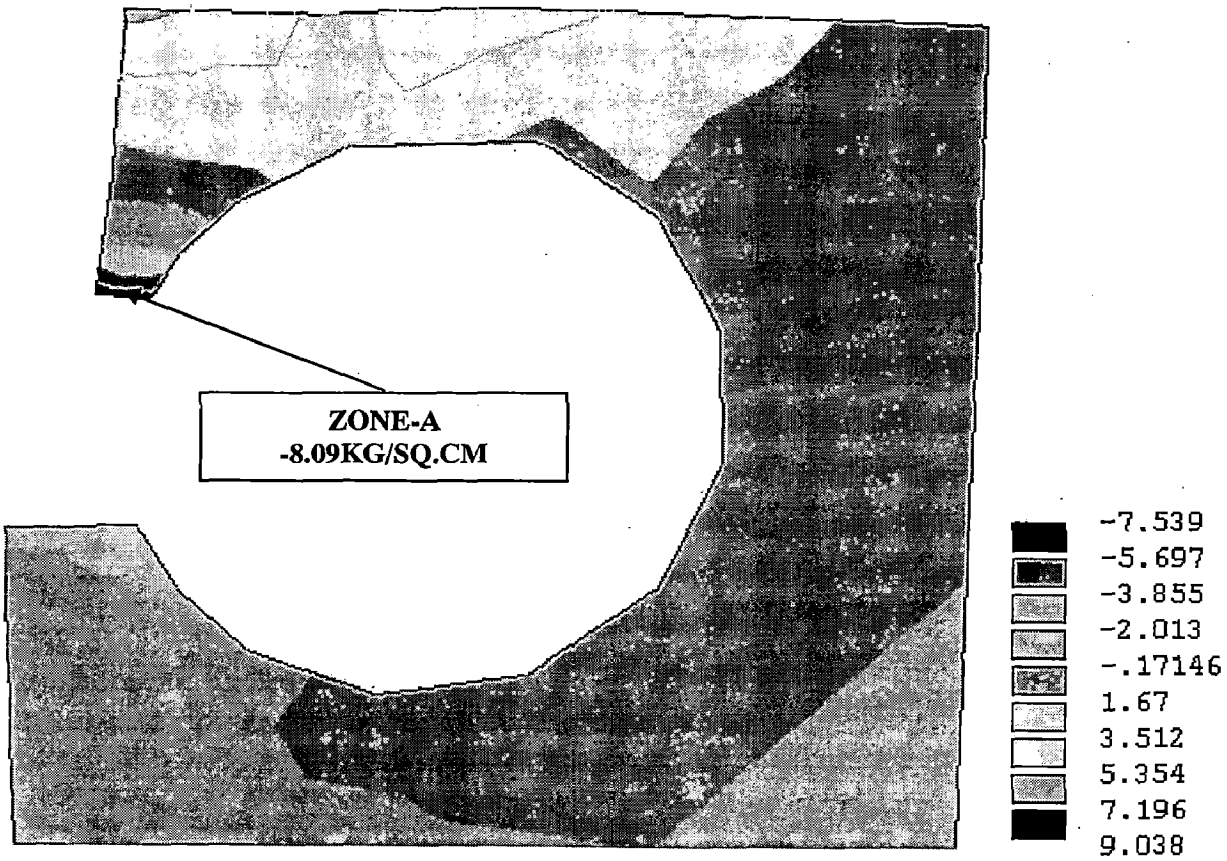


FIG. 5.5.17 STRESS CONTOUR FOR SZ UNDER LOAD 2a(ii) AT SECTION 345^0

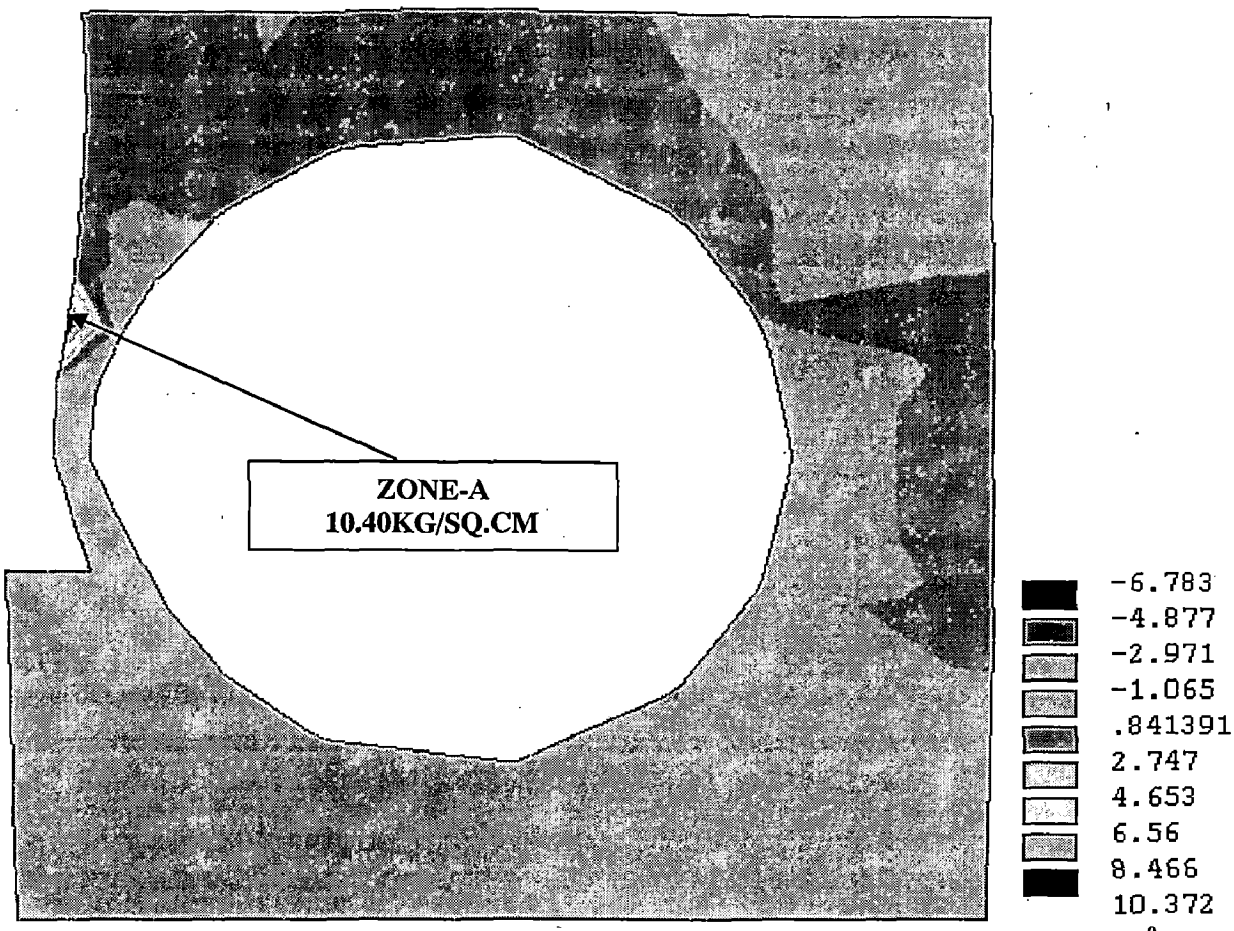


FIG. 5.5.18 STRESS CONTOUR FOR SZ UNDER LOAD 2a(iii) AT SECTION 360^0

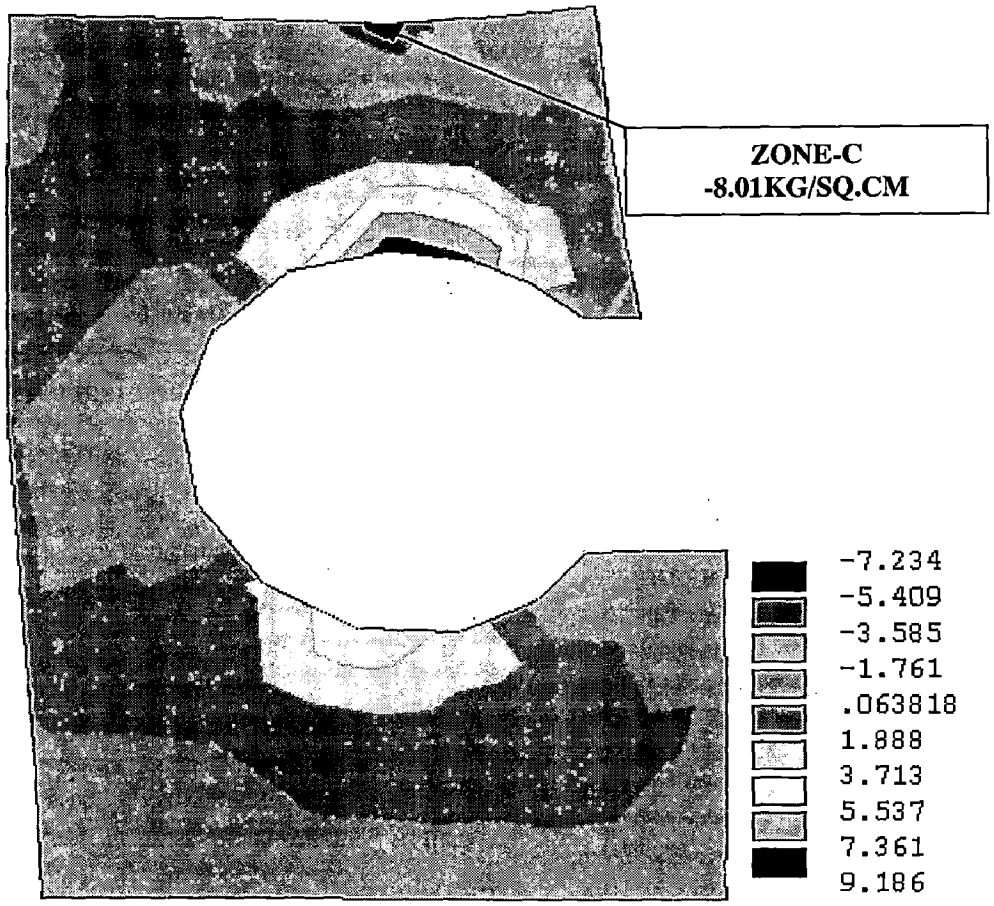


FIG. 5.5.19 STRESS CONTOUR FOR SX UNDER LOAD 2b(iii) AT SECTION 187.5^0

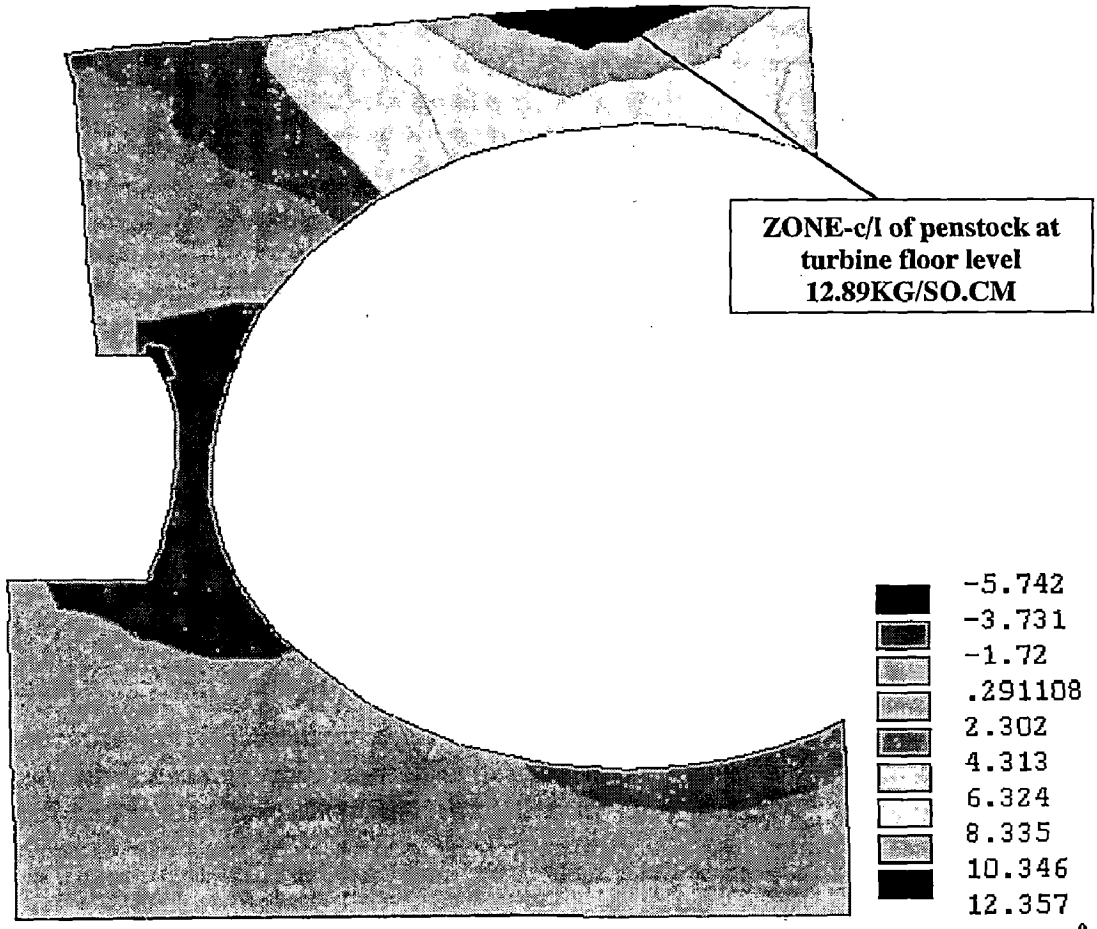


FIG. 5.5.20 STRESS CONTOUR FOR SX UNDER LOAD 2b(iii) AT SECTION 39.42^0

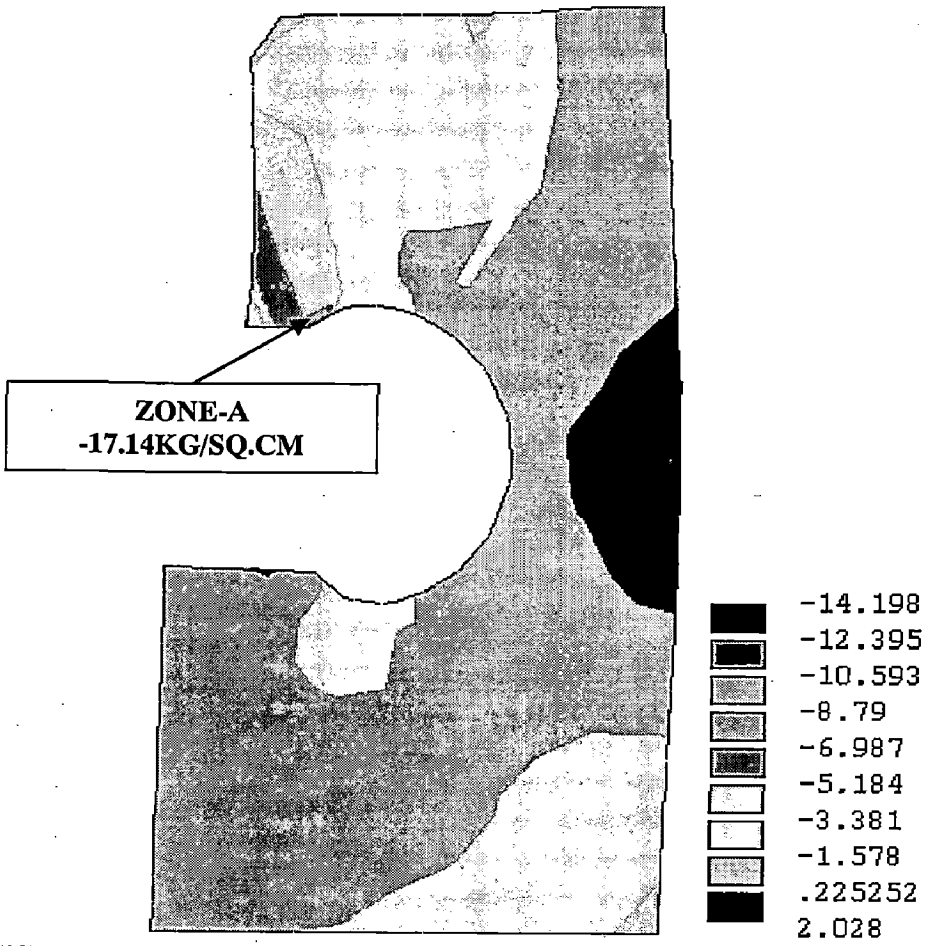


FIG. 5.5.21 STRESS CONTOUR FOR SY UNDER LOAD 2b(iii) AT SECTION 97.07^0

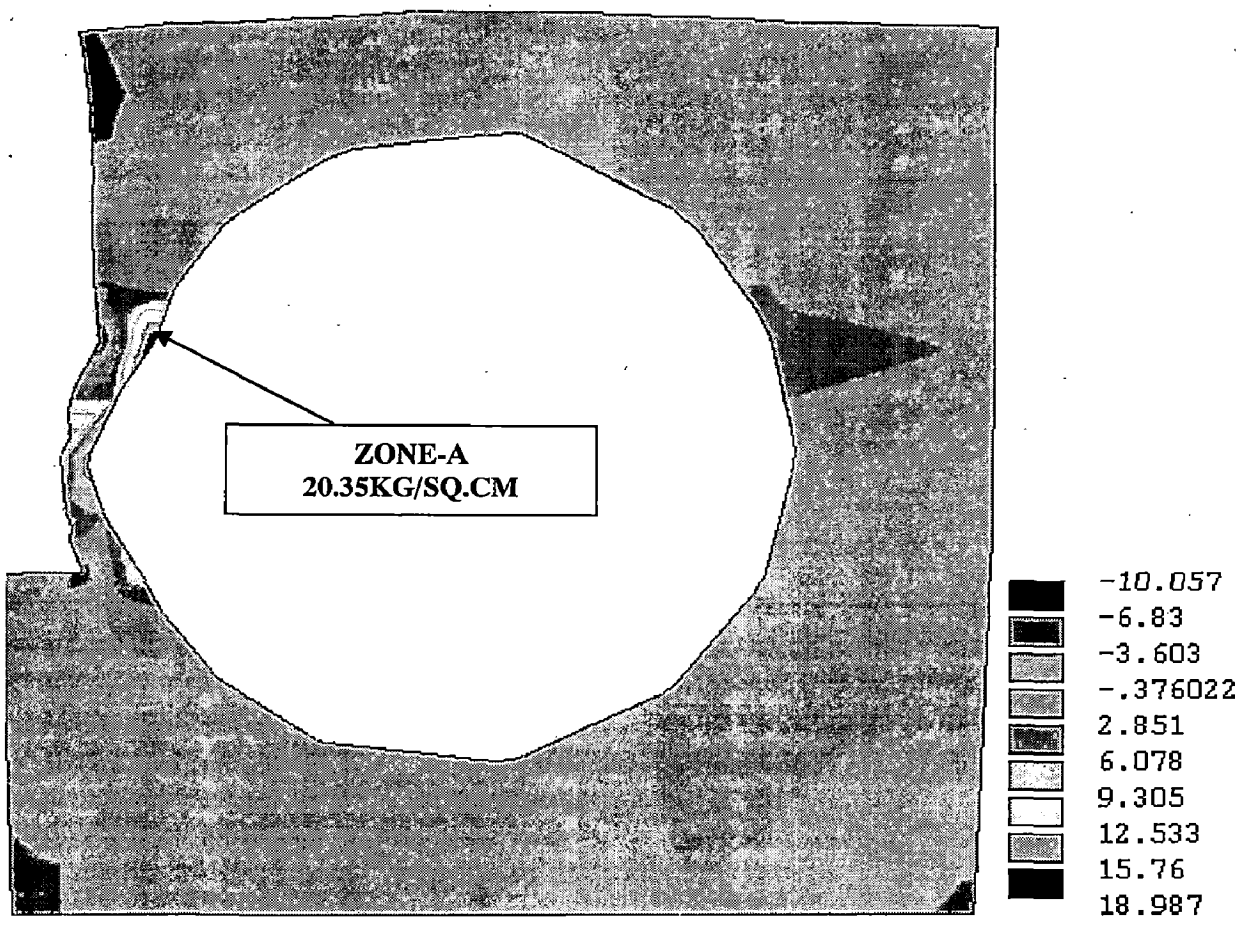


FIG. 5.5.22 STRESS CONTOUR FOR SY UNDER LOAD 2b(iii) AT SECTION 360^0

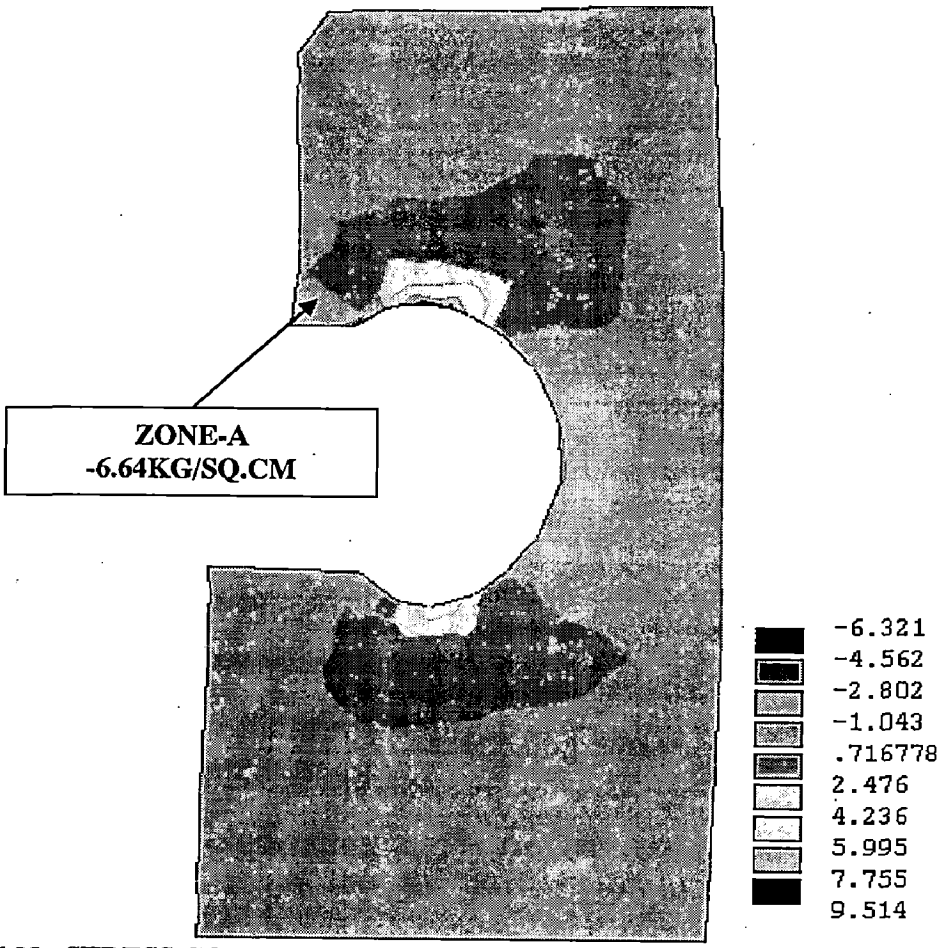


FIG. 5.5.23 STRESS CONTOUR FOR SZ UNDER LOAD 2b(iii) AT SECTION 97.07 ^{0}

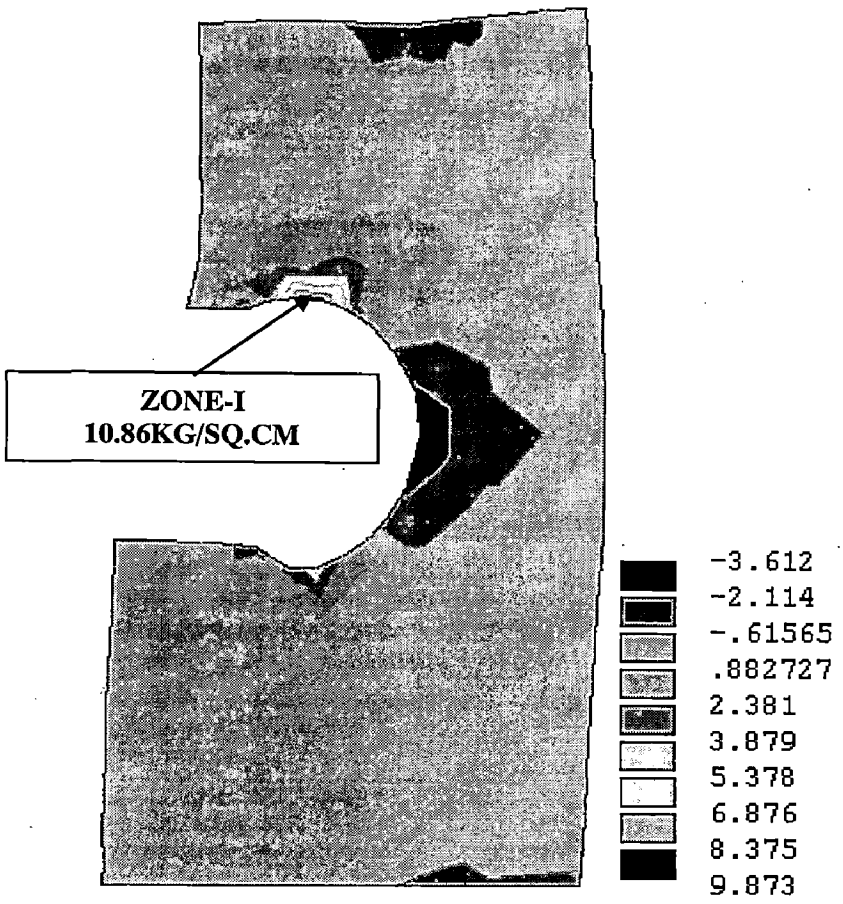


FIG. 5.5.24 STRESS CONTOUR FOR SZ UNDER LOAD 2b(ii) AT SECTION 82.72 ^{0}

CHAPTER-6

SUMMARY CONCLUSIONS AND SUGGESTIONS

6.1 Summary of Results
6.2 Conclusions
6.3 Suggestions for the Further Study

CHAPTER-6

SUMMARY, CONCLUSIONS AND SUGGESTIONS

6.1 SUMMARY OF RESULTS

FINITE ELEMENT METHOD analysis is a convenient and less time consuming tool for three-dimensional analysis of complex structure like concrete around spiral casing of a powerhouse. The deflection and stress patterns obtained by FEM analysis for different loading conditions and cases at various points and sections are described in chapter-5 with the help of tables, figures and contours which are shown in same chapter and appendix. The results of the analysis reveals the following: -

- The pattern of stresses and deflections at different sections are found largely varying.
- Shear stresses are found excessive in zone A and in-between A & F requiring designing for the excessive shear. The maximum compressive and principal stresses in all zones of all sections for all loading conditions and cases are found within the permissible limit of respective stresses (M20 concrete), the structure is found safe and stable as far as compressive and principal stress is considered. The patterns of deflections and tensile stresses are very much different for different loading condition, so some conclusions have been made for different loading conditions and are given below for zones and sections mentioned in figures-4.1 and 4.11.

(i) For load condition 1a

All zones of all the sections are stable and safe for deflections in all directions being of small magnitude (maximum -0.08cm in y-direction. Tensile reinforcement is required to withstand excessive tensile stress in zone A for sections 195 and 330^0 in z-direction (11.65kg/sq.cm.) and for section 270^0 in x-direction (14.21kg/sq.cm.).

(ii) For load condition 1b

The maximum deflection is quite small (-0.023cm in y-direction) for this loading case; whereas tensile reinforcement (for stress of 11.41kg/sq.cm.) is required in zone A & I for sections from 45^0 to 90^0.

(iii) For load condition 2a

Tensile stress (25.55kg/sq.cm.) of the zones A and in-between A & F for sections 360^0 are in excess of allowable limit. So reinforcement is essential to withstand these excessive tensile-stressed zones including the zone of center line of penstock at turbine floor level. Deflections are quite small (maximum – 0.038cm in x-direction).

(iv) For load condition 2b

Tensile stresses of zone A, C, I and center line of penstock at turbine level (max^m 20.35kg/sq.cm.), are more than allowable limit. Hence reinforcement is required to withstand the excessive tensile stress. Rest of the zones are within permissible limit and hence safe and stable

6.2 CONCLUSIONS

From the above, the following general conclusions are made

1. The Intermediate structure of the power house is essentially a low stressed stable structure.
2. Tensile zones are along the scroll case opening concrete on top of scroll case (i.e. zones A, I and H) and at top of free surface (i.e. zones B and C) for most of the sections under all loading conditions. It is thus inferred that designing as cantilever in 2-D approach for both internal and external loads is adequate. In rest of zones only nominal reinforcement for distribution and shrinkage is sufficient.
3. The internal hydrostatic pressure reduces tensile stresses due to external loads and causes reversal stresses at many points.

4. Because of large variation and reversal of stresses under various conditions and loading, it is advisable to analyze the structure for both internal and external loading as well as for hinged and free conditions at speed ring if these can not be precisely determined before analysis.
5. The 2-D analysis gives much more stresses and deflections than the 3-D results. Therefore 3-D analysis should be carried out as far as possible because it gives a better insight to the behavior of concrete around scroll case resulting in a safe and economical design.

6.3 SUGGESTIONS FOR FURTHER STUDY

- The intermediate structure has a number of cavities and galleries, which make the shape very complex, finer meshing should be attempted to model the actual shape for better results.
- In this study construction joints have been omitted in the model
- This intermediate structure shall also be analyzed for dynamic loading i.e. seismic forces and vibrations.

REFERENCES

REFFERENCES

1. Anonymous, IS: 4247 (Part I - III)-1978, "Code Of Practice For Structural Design Of Surface Hydel Power Stations", Bureau Of Indian Standards, New Delhi.
2. Anonymous, IS: 456-2000, "Code Of Practice For Plain And Reinforcement Concrete", Bureau Of Indian Standards, New Delhi.
3. Anonymous, IS:7207-1992, "Criteria For Design Of Generator Foundation For Hydroelectric Power Stations", Bureau Of Indian Standards, New Delhi.
4. Anonymous, IS:7418-1924, "Criteria For Design Of Scroll Casing", Bureau Of Indian Standards, New Delhi.
5. Desai C.S. & Abel J.F. (1987), "Introduction To The Finite Element Method", C.B.S., Delhi.
6. Kenneth H. Huebner (1975), "The Finite Element Method for Engineers", John Wiley & Sons, USA.
7. Mandal Gouranga (2003), "Stress Analysis In Concrete Over The Draft Tube In A Power House By Finite Element Method", M.Tech. Dissertation, W.R.D.T.C., I.I.T. Roorkee.
8. Nigam P.S. (1985), "Handbook Of Hydro Electric Engineering", Nem Chand And Brothers, Roorkee.
9. Rao S.S. (1998), "The Finite Element Method In Engineering", B.S. Publications, Hyderabad.
10. V.N, Vazirani & M.M. Rathwani (1981), "Analysis Of Structures", Khanna Publishers, Delhi

APPENDIX-A

LIST OF TABLES
LIST OF FIGURES

TABLE-5.1 DISPLACEMENT IN X-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	0.001	0.013	-0.011	0.001	0.001	0.000	0.000	0.000	0.000	0.000	-0.014	-0.003	-0.026	-0.005	-0.005	0.000	0.000	0.000	0.000	0.000
	B	6	-0.002	0.016	-0.020	-0.002	-0.002	0.006	0.018	-0.007	0.005	0.006	0.003	0.021	-0.015	0.003	0.004	0.003	0.015	-0.010	0.002	0.003
	C	8	-0.006	0.007	-0.019	-0.006	-0.006	0.003	0.010	-0.005	0.003	0.003	0.005	0.018	-0.007	0.006	0.006	0.005	0.012	-0.002	0.005	0.005
	D	9	-0.002	0.011	-0.014	-0.002	-0.001	0.001	0.008	-0.006	0.001	0.001	0.015	0.027	0.002	0.015	0.016	0.016	0.022	0.009	0.015	0.016
	E	296	0.007	0.015	0.000	0.007	0.007	0.005	0.010	0.000	0.005	0.005	0.014	0.021	0.006	0.014	0.014	0.014	0.019	0.010	0.014	0.014
	F	2	-0.001	0.000	-0.001	-0.001	-0.001	0.000	0.000	-0.001	-0.001	0.000	-0.008	-0.007	-0.009	-0.005	-0.004	-0.008	-0.008	-0.008	-0.004	-0.004
	G	24	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	H	23	0.007	0.012	0.002	0.007	0.007	0.005	0.008	0.001	0.004	0.005	0.014	0.019	0.009	0.014	0.014	0.015	0.018	0.011	0.015	0.015
	I	27	0.006	0.019	-0.007	0.006	0.006	0.004	0.012	-0.004	0.004	0.004	0.010	0.023	-0.003	0.010	0.011	0.011	0.019	0.004	0.011	0.011
330	A	260	0.011	0.024	-0.002	0.012	0.010	0.000	0.000	0.000	0.000	0.000	-0.009	0.004	-0.021	-0.006	-0.008	0.000	0.000	0.000	0.000	0.000
	B	258	-0.006	0.010	-0.021	-0.004	-0.007	0.004	0.015	-0.007	0.005	0.003	0.004	0.020	-0.011	0.006	0.003	0.003	0.014	-0.008	0.004	0.002
	C	256	-0.009	0.002	-0.020	-0.008	-0.010	0.001	0.008	-0.005	0.002	0.001	0.006	0.016	-0.005	0.007	0.005	0.004	0.010	-0.002	0.005	0.003
	D	255	-0.001	0.006	-0.008	0.000	-0.001	0.001	0.005	-0.003	0.001	0.000	0.008	0.015	0.001	0.008	0.008	0.008	0.012	0.004	0.008	0.007
	E	2413	0.002	0.007	-0.003	0.002	0.002	0.002	0.005	-0.001	0.002	0.001	0.006	0.011	0.001	0.006	0.006	0.006	0.009	0.003	0.006	0.006
	F	251	-0.001	0.000	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.005	-0.005	-0.005	-0.004	-0.004	-0.005	-0.005	-0.005	-0.004	-0.004
	G	2453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	H	2447	0.004	0.007	0.000	0.004	0.003	0.002	0.004	0.000	0.002	0.002	0.007	0.011	0.004	0.007	0.007	0.008	0.010	0.005	0.008	0.007
	I	2441	0.006	0.016	-0.004	0.007	0.006	0.003	0.009	-0.003	0.003	0.002	0.007	0.017	-0.003	0.008	0.006	0.008	0.014	0.002	0.008	0.007
300	A	240	0.009	0.022	-0.004	0.010	0.007	0.000	0.000	0.000	0.000	0.000	-0.003	0.010	-0.017	-0.001	-0.004	0.000	0.000	0.000	0.000	0.000
	B	238	-0.002	0.012	-0.017	0.000	-0.004	0.002	0.012	-0.007	0.004	0.000	0.002	0.016	-0.012	0.004	0.000	0.002	0.011	-0.008	0.004	0.000
	C	236	-0.005	0.005	-0.014	-0.003	-0.006	0.001	0.006	-0.005	0.002	0.000	0.002	0.012	-0.007	0.004	0.001	0.001	0.007	-0.004	0.003	0.000
	D	235	-0.001	0.004	-0.006	0.000	-0.002	0.000	0.003	-0.002	0.001	0.000	0.005	0.010	0.000	0.006	0.004	0.004	0.007	0.002	0.005	0.004
	E	2213	0.001	0.005	-0.003	0.002	0.000	0.001	0.003	-0.001	0.002	0.000	0.003	0.007	-0.001	0.004	0.003	0.003	0.005	0.001	0.004	0.003
	F	231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	2245	0.002	0.006	-0.002	0.003	0.002	0.001	0.003	-0.001	0.001	0.000	0.003	0.007	-0.001	0.004	0.003	0.003	0.006	0.001	0.004	0.003
	I	2241	0.004	0.012	-0.004	0.005	0.003	0.001	0.006	-0.003	0.002	0.000	0.003	0.011	-0.005	0.004	0.002	0.004	0.008	-0.001	0.005	0.003

TABLE-5.1 (contd....) DISPLACEMENT IN X-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.000	0.014	-0.013	0.002	-0.002	0.000	0.000	0.000	0.000	0.000	0.002	0.016	-0.011	0.005	0.001	0.000	0.000	0.000	0.000	0.000
	B	218	0.006	0.020	-0.008	0.009	0.003	0.001	0.009	-0.008	0.003	-0.002	-0.002	0.012	-0.016	0.001	-0.005	0.000	0.008	-0.009	0.002	-0.003
	C	216	0.004	0.013	-0.005	0.006	0.002	0.001	0.006	-0.005	0.002	-0.001	-0.002	0.007	-0.011	0.000	-0.004	-0.001	0.004	-0.006	0.000	-0.003
	D	215	0.001	0.006	-0.004	0.002	0.000	0.000	0.003	-0.002	0.001	-0.001	-0.003	0.002	-0.007	-0.001	-0.004	-0.002	0.000	-0.005	-0.001	-0.003
	E	2051	0.000	0.004	-0.004	0.001	-0.001	0.000	0.002	-0.002	0.001	-0.001	-0.002	0.002	-0.006	-0.001	-0.003	-0.002	0.000	-0.004	-0.001	-0.003
	F	199	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	G	2091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.000
	H	2083	0.001	0.004	-0.003	0.001	0.000	0.000	0.002	-0.002	0.000	-0.001	-0.001	0.003	-0.004	0.000	-0.001	-0.001	0.001	-0.003	0.000	-0.001
	I	2077	0.002	0.012	-0.008	0.004	0.000	0.000	0.005	-0.005	0.001	-0.001	0.000	0.010	-0.010	0.002	-0.002	0.000	0.005	-0.005	0.001	-0.002
240	A	198	-0.008	0.004	-0.021	-0.007	-0.010	0.000	0.000	0.000	0.000	0.000	0.006	0.018	-0.006	0.007	0.005	0.000	0.000	0.000	0.000	0.000
	B	196	0.015	0.030	-0.001	0.017	0.012	-0.001	0.009	-0.010	0.002	-0.003	-0.006	0.010	-0.021	-0.003	-0.008	-0.003	0.007	-0.012	0.000	-0.005
	C	194	0.012	0.023	0.002	0.014	0.011	0.000	0.006	-0.005	0.002	-0.001	-0.005	0.006	-0.016	-0.003	-0.007	-0.003	0.002	-0.009	-0.002	-0.005
	D	193	0.004	0.010	-0.002	0.005	0.003	0.000	0.003	-0.003	0.001	-0.001	-0.006	0.000	-0.012	-0.004	-0.007	-0.005	-0.002	-0.008	-0.004	-0.006
	E	1882	0.000	0.004	-0.004	0.002	-0.001	-0.001	0.001	-0.003	0.000	-0.002	-0.005	-0.001	-0.009	-0.004	-0.006	-0.004	-0.002	-0.006	-0.003	-0.005
	F	189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	G	1922	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.001
	H	1914	-0.001	0.002	-0.005	-0.001	-0.002	-0.001	0.001	-0.003	-0.001	-0.001	-0.004	0.000	-0.008	-0.003	-0.004	-0.004	-0.002	-0.006	-0.004	-0.004
	I	1908	-0.002	0.009	-0.012	0.000	-0.003	-0.001	0.004	-0.006	0.000	-0.002	-0.002	0.008	-0.012	-0.001	-0.003	-0.003	0.002	-0.008	-0.002	-0.004
210	A	178	-0.012	-0.001	-0.023	-0.012	-0.013	0.000	0.000	0.000	0.000	0.000	0.005	0.016	-0.006	0.005	0.004	0.000	0.000	0.000	0.000	0.000
	B	176	0.019	0.038	0.001	0.020	0.018	-0.001	0.009	-0.012	0.000	-0.003	-0.006	0.012	-0.025	-0.005	-0.007	-0.005	0.006	-0.015	-0.003	-0.006
	C	174	0.017	0.031	0.003	0.018	0.016	0.000	0.007	-0.006	0.001	-0.001	-0.006	0.009	-0.020	-0.004	-0.006	-0.005	0.002	-0.011	-0.004	-0.005
	D	173	0.009	0.021	-0.002	0.010	0.009	0.000	0.005	-0.005	0.001	0.000	-0.005	0.006	-0.017	-0.004	-0.006	-0.005	0.000	-0.010	-0.004	-0.005
	E	1712	-0.001	0.006	-0.009	-0.001	-0.002	-0.002	0.002	-0.006	-0.001	-0.002	-0.006	0.002	-0.013	-0.005	-0.006	-0.006	-0.002	-0.010	-0.005	-0.006
	F	169	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.001	0.001
	G	1759	-0.001	0.000	-0.001	-0.001	-0.001	0.000	0.000	-0.001	0.000	0.000	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001
	H	1751	-0.005	0.000	-0.011	-0.005	-0.006	-0.003	0.001	-0.006	-0.002	-0.003	-0.009	-0.003	-0.014	-0.008	-0.009	-0.009	-0.005	-0.012	-0.008	-0.009
	I	1745	-0.004	0.007	-0.015	-0.003	-0.004	-0.002	0.004	-0.007	-0.001	-0.002	-0.005	0.006	-0.016	-0.004	-0.005	-0.005	0.000	-0.011	-0.005	-0.006
180	A	158	-0.010	0.001	-0.021	-0.010	-0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.011	-0.011	0.000	0.001	0.000	0.000	0.000	0.000	0.000
	B	156	0.018	0.038	-0.002	0.018	0.018	-0.001	0.010	-0.013	-0.002	-0.001	-0.005	0.015	-0.025	-0.004	-0.004	-0.005	0.006	-0.017	-0.005	-0.005
	C	154	0.017	0.033	0.000	0.017	0.017	0.000	0.007	-0.007	0.000	0.000	-0.004	0.012	-0.021	-0.004	-0.004	-0.005	0.003	-0.012	-0.005	-0.005
	D	153	0.013	0.029	-0.002	0.013	0.014	0.000	0.007	-0.007	0.000	0.000	-0.004	0.011	-0.020	-0.004	-0.004	-0.005	0.002	-0.012	-0.005	-0.005
	E	1560	0.000	0.012	-0.012	0.000	0.001	-0.002	0.004	-0.008	-0.002	-0.002	-0.007	0.005	-0.019	-0.007	-0.007	-0.007	-0.001	-0.013	-0.007	-0.007
	F	149	0.000	0.000	-0.001	-0.001	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	G	1594	-0.001	0.000	-0.002	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.002	-0.001	-0.003	-0.002	-0.002	-0.002	-0.001	-0.002	-0.002	-0.002
	H	1588	-0.006	-0.001	-0.011	-0.007	-0.006	-0.003	0.000	-0.006	-0.003	-0.003	-0.010	-0.005	-0.015	-0.010	-0.010	-0.010	-0.007	-0.013	-0.010	-0.009
	I	1582	-0.005	0.007	-0.016	-0.005	-0.004	-0.002	0.004	-0.007	-0.002	-0.002	-0.007	0.004	-0.018	-0.007	-0.007	-0.007	-0.001	-0.012	-0.007	-0.007

TABLE-5.1 (contd....) DISPLACEMENT IN X-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-0.005	0.007	-0.016	-0.006	-0.004	0.000	0.000	0.000	0.000	0.000	-0.002	0.009	-0.014	-0.003	-0.001	0.000	0.000	0.000	0.000	0.000
	B	134	0.013	0.032	-0.006	0.012	0.015	-0.001	0.010	-0.012	-0.002	0.000	-0.003	0.016	-0.022	-0.004	-0.001	-0.004	0.007	-0.015	-0.006	-0.003
	C	132	0.012	0.027	-0.003	0.010	0.013	0.000	0.007	-0.007	-0.001	0.001	-0.003	0.012	-0.018	-0.004	-0.001	-0.004	0.003	-0.011	-0.005	-0.003
	D	131	0.007	0.021	-0.006	0.006	0.009	0.000	0.006	-0.006	-0.002	0.001	-0.004	0.010	-0.017	-0.005	-0.002	-0.004	0.002	-0.011	-0.006	-0.003
	E	1393	-0.003	0.002	-0.008	-0.004	-0.002	-0.002	0.001	-0.004	-0.002	-0.001	-0.005	0.000	-0.010	-0.005	-0.004	-0.004	-0.002	-0.007	-0.005	-0.004
	F	127	-0.001	0.000	-0.002	-0.001	0.000	0.000	0.000	-0.001	0.000	0.000	-0.001	0.000	-0.002	-0.001	0.000	-0.001	0.000	-0.001	-0.001	0.000
	G	1431	-0.001	0.000	-0.002	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	0.000	-0.002	0.000	-0.003	-0.002	-0.001	-0.002	-0.001	-0.002	-0.002	-0.001
	H	1423	-0.003	0.003	-0.010	-0.004	-0.002	-0.002	0.002	-0.005	-0.002	-0.001	-0.007	0.000	-0.013	-0.007	-0.006	-0.006	-0.003	-0.010	-0.007	-0.006
	I	1417	-0.002	0.010	-0.014	-0.003	-0.001	0.000	0.004	-0.005	-0.001	0.000	-0.004	0.007	-0.016	-0.005	-0.003	-0.004	0.001	-0.008	-0.004	-0.003
120	A	116	0.000	0.013	-0.012	-0.001	0.002	0.000	0.000	0.000	0.000	0.000	-0.002	0.010	-0.015	-0.003	-0.001	0.000	0.000	0.000	0.000	0.000
	B	114	0.007	0.024	-0.010	0.004	0.010	0.000	0.010	-0.010	-0.002	0.002	-0.003	0.014	-0.020	-0.005	0.000	-0.004	0.006	-0.014	-0.006	-0.001
	C	112	0.006	0.020	-0.007	0.004	0.009	0.000	0.007	-0.007	-0.002	0.002	-0.003	0.010	-0.016	-0.005	0.000	-0.003	0.003	-0.010	-0.005	-0.002
	D	111	0.006	0.018	-0.006	0.004	0.008	0.000	0.006	-0.006	-0.002	0.001	-0.003	0.009	-0.016	-0.005	0.000	-0.004	0.002	-0.010	-0.006	-0.002
	E	1233	-0.002	0.005	-0.010	-0.004	0.000	-0.001	0.002	-0.005	-0.003	0.000	-0.005	0.003	-0.012	-0.006	-0.003	-0.004	-0.001	-0.008	-0.005	-0.003
	F	107	-0.001	0.001	-0.002	-0.001	0.000	0.000	0.000	-0.001	0.000	0.000	-0.001	0.000	-0.003	-0.002	-0.001	-0.001	-0.001	-0.002	-0.001	-0.001
	G	1269	-0.001	0.001	-0.002	-0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.002	0.000	-0.003	-0.002	-0.001	-0.001	-0.001	-0.002	-0.002	-0.001
	H	1263	-0.001	0.005	-0.007	-0.002	0.000	-0.001	0.002	-0.004	-0.002	0.000	-0.003	0.002	-0.009	-0.004	-0.002	-0.003	0.000	-0.006	-0.004	-0.002
	I	1255	0.001	0.012	-0.011	-0.001	0.002	0.000	0.004	-0.004	-0.001	0.001	-0.003	0.008	-0.015	-0.004	-0.001	-0.002	0.002	-0.007	-0.003	-0.001
90	A	96	0.003	0.015	-0.010	0.001	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.012	-0.013	-0.001	0.002	0.000	0.000	0.000	0.000	0.000
	B	94	0.003	0.020	-0.014	0.000	0.006	0.001	0.011	-0.008	-0.001	0.004	-0.004	0.012	-0.021	-0.007	-0.001	-0.003	0.006	-0.013	-0.006	-0.001
	C	90	0.003	0.016	-0.011	0.000	0.006	0.001	0.008	-0.006	-0.001	0.003	-0.003	0.010	-0.016	-0.006	0.000	-0.002	0.005	-0.009	-0.005	0.000
	D	89	0.002	0.015	-0.010	-0.001	0.006	0.001	0.008	-0.006	-0.002	0.003	-0.003	0.010	-0.015	-0.005	0.001	-0.002	0.005	-0.009	-0.004	0.001
	E	1064	0.000	0.008	-0.007	-0.001	0.002	0.000	0.003	-0.004	-0.002	0.001	0.000	0.007	-0.008	-0.002	0.002	0.000	0.003	-0.004	-0.002	0.001
	F	85	0.000	0.001	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	-0.002	0.000	-0.003	-0.002	-0.001	-0.002	-0.001	-0.002	-0.002	-0.001
	G	1121	0.000	0.002	-0.002	-0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.002	0.000	-0.004	-0.002	-0.001	-0.002	-0.001	-0.002	-0.002	-0.001
	H	1113	0.000	0.007	-0.006	-0.001	0.002	-0.001	0.002	-0.003	-0.002	0.000	-0.001	0.005	-0.008	-0.002	0.000	-0.001	0.001	-0.004	-0.002	0.000
	I	1105	0.002	0.014	-0.009	0.000	0.004	0.000	0.004	-0.004	-0.001	0.001	-0.001	0.011	-0.012	-0.002	0.002	-0.001	0.003	-0.004	-0.002	0.000
60	A	64	0.003	0.014	-0.009	0.001	0.004	0.000	0.000	0.000	0.000	0.000	0.001	0.013	-0.011	0.001	0.004	0.000	0.000	0.000	0.000	0.000
	B	59	0.002	0.020	-0.016	-0.001	0.005	0.003	0.014	-0.007	0.001	0.006	-0.004	0.013	-0.022	-0.007	-0.001	-0.002	0.009	-0.013	-0.005	0.000
	C	61	0.002	0.017	-0.012	0.000	0.005	0.004	0.012	-0.005	0.002	0.006	-0.002	0.012	-0.017	-0.004	0.000	-0.001	0.007	-0.009	-0.003	0.001
	D	62	0.002	0.015	-0.012	-0.001	0.004	0.004	0.012	-0.003	0.002	0.006	0.000	0.014	-0.013	-0.001	0.003	0.002	0.009	-0.006	0.000	0.003
	E	978	0.001	0.009	-0.006	0.000	0.003	0.000	0.003	-0.003	-0.002	0.001	-0.002	0.006	-0.010	-0.003	0.000	-0.002	0.001	-0.005	-0.003	-0.001
	F	56	0.001	0.002	-0.001	0.000	0.001	0.000	0.000	-0.001	0.000	0.000	-0.002	-0.001	-0.004	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002
	G	727	0.000	0.002	-0.002	0.000	0.001	0.000	0.000	-0.001	-0.001	0.000	-0.002	-0.001	-0.004	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002
	H	715	0.002	0.009	-0.006	0.001	0.003	-0.001	0.001	-0.003	-0.002	-0.001	-0.001	0.006	-0.009	-0.002	0.001	-0.001	0.001	-0.003	-0.002	-0.001
	I	707	0.002	0.014	-0.009	0.001	0.004	-0.001	0.001	-0.003	-0.001	0.000	0.001	0.012	-0.011	0.000	0.003	0.000	0.002	-0.002	0.000	0.001

TABLE-5.1 (contd....) DISPLACEMENT IN X-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	0.000	0.012	-0.012	-0.001	0.001	0.000	0.000	0.000	0.000	0.000	-0.003	0.008	-0.015	-0.001	0.001	0.000	0.000	0.000	0.000	0.000
	B	34	0.002	0.020	-0.017	0.000	0.003	0.005	0.018	-0.007	0.004	0.007	-0.001	0.017	-0.020	-0.003	0.001	0.000	0.012	-0.013	-0.002	0.001
	C	38	0.000	0.014	-0.014	-0.001	0.001	0.005	0.012	-0.003	0.004	0.005	0.001	0.015	-0.013	0.001	0.003	0.002	0.010	-0.006	0.001	0.003
	D	35	0.000	0.015	-0.015	-0.001	0.001	0.003	0.011	-0.005	0.002	0.004	0.019	0.034	0.004	0.019	0.021	0.020	0.028	0.012	0.019	0.021
	E	486	0.006	0.012	0.000	0.006	0.007	0.006	0.010	0.002	0.006	0.006	0.016	0.022	0.010	0.016	0.016	0.017	0.020	0.013	0.016	0.017
	F	465	0.001	0.002	0.000	0.001	0.001	0.000	0.000	-0.001	0.000	0.000	-0.005	-0.004	-0.006	-0.004	-0.003	-0.005	-0.004	-0.005	-0.003	-0.003
	G	644	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	47	0.006	0.013	0.000	0.006	0.007	0.006	0.010	0.002	0.006	0.006	0.018	0.024	0.012	0.018	0.018	0.019	0.023	0.015	0.018	0.019
	I	637	0.004	0.018	-0.011	0.002	0.005	0.004	0.012	-0.004	0.002	0.005	0.008	0.023	-0.007	0.007	0.010	0.009	0.017	0.001	0.008	0.010
Minimum	Node	No.																				
		X																				
		Y																				
		Z																				
	Value																					
Maximum	Node	No.	15318	166	178	176	166	3797	14	156	3797	3764	337	35	329	802	545	330	545	330	802	545
		X	-254.07	-265.63	-283.62	-238.16	-265.63	928.70	265.63	-275.00	928.70	962.76	275.00	1100.00	307.75	894.63	1004.98	306.71	1004.98	306.71	894.63	1004.98
		Y	420.00	420.00	110.00	420.00	420.00	101.94	420.00	420.00	101.94	120.01	1.70	420.00	26.12	83.87	420.00	-7.81	420.00	-7.81	83.87	420.00
		Z	105.24	71.18	163.75	137.50	71.18	-635.09	-71.18	0.00	-635.09	-635.09	0.00	-635.09	0.00	-635.09	-635.09	0.00	-635.09	0.00	-635.09	-635.09
	Value		0.019	0.039	-0.023	0.020	0.019	0.007	0.018	-0.013	0.007	0.008	-0.031	0.034	-0.038	0.019	0.021	-0.024	0.028	-0.023	0.020	0.021

TABLE-5.2 DISPLACEMENT IN Y-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-0.049	-0.051	-0.047	-0.048	-0.050	0.000	0.000	0.000	0.000	0.000	0.005	0.004	0.007	0.009	0.007	0.000	0.000	0.000	0.000	0.000
	B	6	-0.060	-0.059	-0.060	-0.059	-0.060	-0.010	-0.010	-0.011	-0.010	-0.011	0.006	0.006	0.005	0.007	0.005	-0.002	-0.001	-0.003	-0.002	-0.002
	C	8	-0.044	-0.045	-0.042	-0.044	-0.044	-0.018	-0.022	-0.014	-0.018	-0.018	0.007	0.005	0.008	0.008	0.008	0.004	0.000	0.008	0.004	0.004
	D	9	-0.004	-0.007	-0.001	-0.004	-0.004	-0.005	-0.007	-0.003	-0.005	-0.005	0.001	-0.002	0.004	0.001	0.001	0.001	-0.001	0.003	0.001	0.001
	E	296	-0.006	-0.009	-0.003	-0.006	-0.006	-0.005	-0.007	-0.003	-0.005	-0.005	0.000	-0.003	0.004	0.000	0.000	0.000	-0.002	0.002	0.000	0.000
	F	2	-0.006	-0.006	-0.006	-0.005	-0.006	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.002	-0.002	-0.004	-0.004	-0.003	-0.002	-0.003
	G	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	23	-0.005	-0.005	-0.006	-0.005	-0.005	-0.004	-0.004	-0.004	-0.004	-0.004	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	I	27	-0.030	-0.030	-0.031	-0.030	-0.030	-0.015	-0.017	-0.013	-0.015	-0.015	0.011	0.011	0.010	0.012	0.012	0.009	0.007	0.012	0.009	0.010
330	A	260	-0.066	-0.067	-0.066	-0.066	-0.067	0.000	0.000	0.000	0.000	0.000	0.013	0.013	0.014	0.014	0.014	0.000	0.000	0.000	0.000	0.000
	B	258	-0.073	-0.073	-0.073	-0.073	-0.073	-0.010	-0.009	-0.011	-0.010	-0.010	0.011	0.011	0.011	0.011	0.011	-0.001	-0.001	-0.002	-0.001	-0.001
	C	256	-0.046	-0.047	-0.046	-0.047	-0.046	-0.016	-0.018	-0.013	-0.016	-0.016	0.008	0.008	0.008	0.009	0.009	0.003	0.000	0.005	0.003	0.003
	D	255	-0.004	-0.007	-0.001	-0.004	-0.004	-0.005	-0.006	-0.003	-0.005	-0.005	-0.005	-0.008	-0.002	-0.005	-0.005	-0.005	-0.007	-0.003	-0.005	-0.005
	E	2413	-0.004	-0.007	-0.001	-0.004	-0.004	-0.004	-0.006	-0.003	-0.004	-0.004	-0.005	-0.008	-0.002	-0.005	-0.005	-0.005	-0.007	-0.003	-0.005	-0.005
	F	251	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	2447	-0.005	-0.004	-0.006	-0.005	-0.005	-0.004	-0.003	-0.004	-0.004	-0.004	0.001	0.002	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.001
	I	2441	-0.031	-0.030	-0.032	-0.031	-0.031	-0.013	-0.014	-0.012	-0.013	-0.013	0.010	0.011	0.009	0.010	0.011	0.007	0.006	0.008	0.007	0.007
300	A	240	-0.071	-0.073	-0.070	-0.072	-0.071	0.000	0.000	0.000	0.000	0.000	0.015	0.013	0.016	0.015	0.015	0.000	0.000	0.000	0.000	0.000
	B	238	-0.080	-0.081	-0.078	-0.080	-0.079	-0.010	-0.009	-0.011	-0.010	-0.010	0.012	0.011	0.013	0.012	0.012	-0.002	-0.001	-0.002	-0.002	-0.002
	C	236	-0.046	-0.046	-0.046	-0.046	-0.046	-0.014	-0.015	-0.013	-0.014	-0.014	0.007	0.006	0.007	0.007	0.007	0.000	-0.001	0.001	0.000	0.000
	D	235	-0.003	-0.004	-0.002	-0.003	-0.004	-0.004	-0.005	-0.004	-0.004	-0.005	-0.006	-0.007	-0.005	-0.006	-0.007	-0.006	-0.006	-0.005	-0.006	-0.006
	E	2213	-0.003	-0.004	-0.003	-0.003	-0.004	-0.004	-0.005	-0.004	-0.004	-0.004	-0.006	-0.007	-0.005	-0.005	-0.006	-0.005	-0.006	-0.005	-0.005	-0.006
	F	231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	2245	-0.009	-0.008	-0.009	-0.009	-0.009	-0.005	-0.005	-0.005	-0.005	-0.005	0.001	0.002	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.000
	I	2241	-0.030	-0.030	-0.030	-0.030	-0.030	-0.011	-0.012	-0.011	-0.011	-0.011	0.008	0.008	0.007	0.007	0.008	0.004	0.003	0.004	0.004	0.004

TABLE-5.2 (contd....) DISPLACEMENT IN Y-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	-0.070	-0.073	-0.067	-0.071	-0.070	0.000	0.000	0.000	0.000	0.000	0.012	0.009	0.015	0.012	0.012	0.000	0.000	0.000	0.000	0.000
	B	218	-0.079	-0.083	-0.076	-0.080	-0.079	-0.010	-0.010	-0.010	-0.010	-0.010	0.009	0.006	0.013	0.009	0.010	-0.003	-0.003	-0.003	-0.003	-0.003
	C	216	-0.043	-0.044	-0.041	-0.043	-0.042	-0.013	-0.013	-0.013	-0.013	-0.013	0.003	0.002	0.005	0.003	0.004	-0.002	-0.002	-0.002	-0.002	-0.002
	D	215	-0.003	-0.003	-0.003	-0.003	-0.003	-0.005	-0.005	-0.005	-0.005	-0.005	-0.004	-0.004	-0.004	-0.004	-0.004	-0.003	-0.003	-0.003	-0.003	-0.003
	E	2051	-0.004	-0.004	-0.004	-0.004	-0.004	-0.005	-0.004	-0.005	-0.005	-0.005	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	F	199	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	2083	-0.009	-0.010	-0.009	-0.010	-0.009	-0.005	-0.005	-0.005	-0.005	-0.005	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001
	I	2077	-0.048	-0.049	-0.046	-0.048	-0.047	-0.013	-0.013	-0.012	-0.013	-0.012	0.006	0.005	0.008	0.006	0.007	0.000	0.000	0.001	0.000	0.000
240	A	198	-0.065	-0.070	-0.061	-0.066	-0.065	0.000	0.000	0.000	0.000	0.000	0.007	0.003	0.012	0.007	0.008	0.000	0.000	0.000	0.000	0.000
	B	196	-0.074	-0.080	-0.068	-0.075	-0.074	-0.010	-0.011	-0.009	-0.010	-0.010	0.004	-0.002	0.009	0.003	0.004	-0.004	-0.005	-0.003	-0.004	-0.004
	C	194	-0.038	-0.040	-0.036	-0.038	-0.037	-0.012	-0.011	-0.013	-0.012	-0.012	-0.001	-0.003	0.001	-0.001	0.000	-0.004	-0.003	-0.004	-0.004	-0.003
	D	193	-0.002	0.001	-0.004	-0.002	-0.001	-0.004	-0.003	-0.006	-0.005	-0.004	-0.006	-0.004	-0.008	-0.006	-0.006	-0.005	-0.004	-0.006	-0.005	-0.005
	E	1882	-0.002	0.000	-0.004	-0.002	-0.002	-0.004	-0.003	-0.005	-0.004	-0.004	-0.005	-0.003	-0.008	-0.005	-0.005	-0.005	-0.004	-0.006	-0.005	-0.005
	F	189	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1914	-0.008	-0.008	-0.007	-0.008	-0.008	-0.004	-0.004	-0.004	-0.004	-0.004	-0.001	-0.002	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002
	I	1908	-0.040	-0.043	-0.038	-0.041	-0.040	-0.011	-0.010	-0.012	-0.011	-0.011	0.002	0.000	0.005	0.002	0.003	-0.001	0.000	-0.002	-0.001	-0.001
210	A	178	-0.058	-0.063	-0.053	-0.059	-0.058	0.000	0.000	0.000	0.000	0.000	0.002	-0.003	0.007	0.001	0.002	0.000	0.000	0.000	0.000	0.000
	B	176	-0.066	-0.074	-0.059	-0.067	-0.066	-0.010	-0.012	-0.008	-0.010	-0.010	-0.003	-0.010	0.005	-0.003	-0.002	-0.005	-0.007	-0.003	-0.005	-0.005
	C	174	-0.033	-0.034	-0.031	-0.033	-0.032	-0.011	-0.009	-0.013	-0.011	-0.011	-0.005	-0.006	-0.003	-0.005	-0.004	-0.005	-0.003	-0.007	-0.005	-0.005
	D	173	-0.004	0.000	-0.007	-0.003	-0.004	-0.005	-0.003	-0.007	-0.005	-0.005	-0.004	0.000	-0.007	-0.003	-0.004	-0.003	-0.001	-0.005	-0.003	-0.004
	E	1712	-0.004	-0.001	-0.008	-0.004	-0.005	-0.005	-0.003	-0.007	-0.005	-0.005	-0.003	0.000	-0.007	-0.003	-0.003	-0.003	-0.001	-0.005	-0.003	-0.003
	F	169	0.000	-0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1759	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1751	-0.010	-0.010	-0.009	-0.010	-0.010	-0.005	-0.004	-0.006	-0.005	-0.005	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002
	I	1745	-0.035	-0.037	-0.033	-0.035	-0.034	-0.010	-0.009	-0.012	-0.010	-0.010	-0.002	-0.004	0.000	-0.002	-0.002	-0.003	-0.001	-0.004	-0.003	-0.002
180	A	158	-0.050	-0.055	-0.046	-0.051	-0.050	0.000	0.000	0.000	0.000	0.000	-0.003	-0.008	0.001	-0.004	-0.003	0.000	0.000	0.000	0.000	0.000
	B	156	-0.057	-0.065	-0.050	-0.058	-0.057	-0.010	-0.012	-0.008	-0.010	-0.010	-0.008	-0.015	0.000	-0.009	-0.008	-0.006	-0.008	-0.004	-0.006	-0.006
	C	154	-0.027	-0.028	-0.027	-0.028	-0.027	-0.010	-0.008	-0.012	-0.010	-0.010	-0.007	-0.008	-0.007	-0.008	-0.007	-0.006	-0.004	-0.009	-0.007	-0.006
	D	153	-0.005	-0.001	-0.010	-0.005	-0.005	-0.006	-0.003	-0.009	-0.006	-0.006	-0.004	0.001	-0.008	-0.004	-0.003	-0.003	0.000	-0.006	-0.003	-0.003
	E	1560	-0.006	-0.002	-0.010	-0.006	-0.006	-0.006	-0.003	-0.009	-0.006	-0.006	-0.003	0.001	-0.007	-0.003	-0.003	-0.003	0.000	-0.006	-0.003	-0.003
	F	149	0.000	-0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1594	0.000	-0.001	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1588	-0.007	-0.007	-0.007	-0.007	-0.007	-0.004	-0.003	-0.005	-0.004	-0.004	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	I	1582	-0.028	-0.030	-0.027	-0.029	-0.028	-0.009	-0.007	-0.011	-0.009	-0.009	-0.005	-0.006	-0.004	-0.005	-0.005	-0.004	-0.002	-0.006	-0.004	-0.004

TABLE-5.2 (contd....) DISPLACEMENT IN Y-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-0.042	-0.046	-0.038	-0.042	-0.042	0.000	0.000	0.000	0.000	0.000	-0.007	-0.010	-0.003	-0.007	-0.007	0.000	0.000	0.000	0.000	0.000
	B	134	-0.049	-0.055	-0.043	-0.049	-0.049	-0.009	-0.011	-0.008	-0.009	-0.009	-0.012	-0.018	-0.005	-0.012	-0.011	-0.007	-0.009	-0.005	-0.007	-0.007
	C	132	-0.023	-0.023	-0.023	-0.023	-0.022	-0.009	-0.007	-0.011	-0.009	-0.009	-0.009	-0.009	-0.009	-0.009	-0.009	-0.007	-0.005	-0.009	-0.007	-0.007
	D	131	-0.003	0.003	-0.008	-0.003	-0.003	-0.005	-0.002	-0.008	-0.005	-0.005	-0.005	0.001	-0.010	-0.005	-0.004	-0.005	-0.002	-0.008	-0.005	-0.005
	E	1393	-0.005	0.000	-0.009	-0.005	-0.005	-0.004	-0.002	-0.007	-0.004	-0.004	-0.005	0.000	-0.009	-0.005	-0.004	-0.005	-0.002	-0.007	-0.005	-0.004
	F	127	-0.001	-0.001	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1431	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1423	-0.010	-0.010	-0.010	-0.010	-0.009	-0.005	-0.004	-0.006	-0.005	-0.005	-0.004	-0.004	-0.004	-0.004	-0.004	-0.003	-0.003	-0.004	-0.003	-0.003
	I	1417	-0.032	-0.034	-0.030	-0.033	-0.032	-0.008	-0.007	-0.010	-0.008	-0.008	-0.007	-0.009	-0.005	-0.008	-0.007	-0.004	-0.002	-0.006	-0.004	-0.004
120	A	116	-0.036	-0.038	-0.033	-0.036	-0.035	0.000	0.000	0.000	0.000	0.000	-0.008	-0.010	-0.005	-0.008	-0.008	0.000	0.000	0.000	0.000	0.000
	B	114	-0.042	-0.046	-0.038	-0.042	-0.042	-0.009	-0.010	-0.008	-0.009	-0.009	-0.013	-0.017	-0.009	-0.013	-0.013	-0.007	-0.008	-0.006	-0.007	-0.007
	C	112	-0.019	-0.020	-0.019	-0.019	-0.019	-0.009	-0.008	-0.010	-0.009	-0.009	-0.008	-0.009	-0.008	-0.008	-0.008	-0.006	-0.006	-0.007	-0.006	-0.007
	D	111	-0.008	-0.007	-0.009	-0.008	-0.009	-0.007	-0.006	-0.008	-0.006	-0.007	-0.004	-0.003	-0.005	-0.004	-0.005	-0.004	-0.003	-0.005	-0.004	-0.005
	E	1233	-0.009	-0.008	-0.010	-0.009	-0.009	-0.006	-0.005	-0.006	-0.005	-0.006	-0.004	-0.003	-0.004	-0.003	-0.004	-0.003	-0.003	-0.004	-0.003	-0.004
	F	107	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1269	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1263	-0.009	-0.009	-0.008	-0.009	-0.009	-0.005	-0.004	-0.005	-0.005	-0.005	-0.004	-0.004	-0.003	-0.004	-0.004	-0.003	-0.003	-0.003	-0.003	-0.003
	I	1255	-0.027	-0.029	-0.026	-0.028	-0.027	-0.007	-0.006	-0.008	-0.007	-0.007	-0.007	-0.009	-0.006	-0.008	-0.007	-0.004	-0.003	-0.005	-0.004	-0.004
90	A	96	-0.031	-0.033	-0.030	-0.031	-0.031	0.000	0.000	0.000	0.000	0.000	-0.006	-0.008	-0.004	-0.006	-0.006	0.000	0.000	0.000	0.000	0.000
	B	94	-0.037	-0.039	-0.035	-0.037	-0.038	-0.009	-0.009	-0.009	-0.009	-0.009	-0.011	-0.013	-0.009	-0.011	-0.011	-0.007	-0.007	-0.007	-0.007	-0.007
	C	90	-0.017	-0.019	-0.016	-0.017	-0.018	-0.009	-0.010	-0.009	-0.009	-0.010	-0.005	-0.007	-0.004	-0.005	-0.006	-0.004	-0.005	-0.004	-0.004	-0.004
	D	89	-0.012	-0.013	-0.010	-0.011	-0.012	-0.009	-0.009	-0.008	-0.009	-0.009	-0.003	-0.004	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.003
	E	1064	-0.012	-0.013	-0.011	-0.012	-0.012	-0.006	-0.007	-0.006	-0.006	-0.006	-0.002	-0.003	-0.001	-0.002	-0.002	-0.001	-0.002	-0.001	-0.001	-0.001
	F	85	-0.002	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	G	1121	-0.003	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	1113	-0.012	-0.013	-0.012	-0.012	-0.012	-0.005	-0.006	-0.005	-0.005	-0.005	-0.003	-0.003	-0.002	-0.003	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002
	I	1105	-0.026	-0.027	-0.025	-0.026	-0.026	-0.006	-0.006	-0.006	-0.006	-0.006	-0.005	-0.007	-0.004	-0.005	-0.005	-0.002	-0.003	-0.002	-0.002	-0.002
60	A	64	-0.031	-0.032	-0.029	-0.030	-0.031	0.000	0.000	0.000	0.000	0.000	-0.002	-0.003	0.000	-0.001	-0.002	0.000	0.000	0.000	0.000	0.000
	B	59	-0.038	-0.039	-0.037	-0.037	-0.038	-0.009	-0.008	-0.010	-0.009	-0.009	-0.007	-0.008	-0.006	-0.007	-0.008	-0.006	-0.005	-0.007	-0.006	-0.006
	C	61	-0.022	-0.026	-0.018	-0.022	-0.023	-0.012	-0.015	-0.008	-0.011	-0.012	-0.001	-0.005	0.004	0.000	-0.001	0.000	-0.003	0.003	0.000	0.000
	D	62	-0.013	-0.019	-0.008	-0.013	-0.014	-0.012	-0.017	-0.008	-0.012	-0.012	0.006	0.001	0.012	0.006	0.006	0.006	0.002	0.010	0.006	0.006
	E	978	-0.015	-0.020	-0.010	-0.014	-0.015	-0.008	-0.010	-0.005	-0.007	-0.008	0.000	-0.005	0.004	0.000	-0.001	0.000	-0.003	0.003	0.000	0.000
	F	56	-0.004	-0.004	-0.003	-0.003	-0.004	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	G	727	-0.005	-0.005	-0.004	-0.004	-0.005	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002
	H	715	-0.017	-0.019	-0.016	-0.017	-0.018	-0.006	-0.007	-0.005	-0.006	-0.006	-0.001	-0.002	0.000	0.000	-0.001	0.000	-0.001	0.001	0.000	0.000
	I	707	-0.028	-0.030	-0.027	-0.028	-0.029	-0.005	-0.006	-0.004	-0.005	-0.005	-0.001	-0.003	0.000	-0.001	-0.002	0.000	-0.001	0.001	0.000	0.000

TABLE-5.2 (contd....) DISPLACEMENT IN Y-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-0.038	-0.039	-0.037	-0.037	-0.039	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.004	0.003	0.002	0.000	0.000	0.000	0.000	0.000
	B	34	-0.046	-0.046	-0.046	-0.045	-0.046	-0.010	-0.009	-0.011	-0.010	-0.010	-0.001	-0.001	-0.001	-0.001	-0.002	-0.004	-0.003	-0.005	-0.004	-0.004
	C	38	-0.035	-0.039	-0.031	-0.035	-0.035	-0.017	-0.022	-0.012	-0.017	-0.017	0.004	0.001	0.008	0.006	0.005	0.004	-0.001	0.009	0.004	0.004
	D	35	-0.004	-0.007	-0.001	-0.005	-0.003	-0.005	-0.007	-0.004	-0.006	-0.005	0.007	0.004	0.009	0.006	0.007	0.006	0.005	0.008	0.006	0.007
	E	486	-0.006	-0.009	-0.003	-0.007	-0.006	-0.006	-0.008	-0.004	-0.006	-0.006	0.002	-0.001	0.005	0.001	0.002	0.002	-0.001	0.004	0.001	0.002
	F	465	-0.003	-0.003	-0.003	-0.003	-0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002
	G	644	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	H	47	-0.005	-0.004	-0.006	-0.005	-0.004	-0.004	-0.004	-0.005	-0.005	-0.004	0.005	0.006	0.004	0.005	0.006	0.005	0.006	0.005	0.005	0.006
	I	637	-0.028	-0.031	-0.026	-0.028	-0.028	-0.017	-0.021	-0.012	-0.017	-0.016	0.012	0.009	0.014	0.013	0.013	0.012	0.007	0.016	0.012	0.012
Minimum	Node	No.																				
		X																				
		Y																				
		Z																				
	Value																					
Maximum	Node	No.	228	218	238	228	228	22748	22749	1735	22748	22748	55	810	902	55	3760	3760	811	900	55	3760
		X	71.18	0.00	137.50	71.18	71.18	510.94	505.41	-438.8	510.94	510.94	635.09	689.60	577.95	635.09	648.88	648.88	676.17	607.34	635.09	648.88
		Y	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	298.63	288.27	298.61	298.63	296.99	296.99	291.81	299.98	298.63	296.99
		Z	265.63	275.00	238.16	265.63	265.63	-47.45	-89.70	181.77	-47.45	-47.45	-635.09	-635.09	-635.09	-635.09	-635.09	-635.09	-635.09	-635.09	-635.09	-635.09
	Value		-0.080	-0.083	-0.078	-0.081	-0.080	-0.019	-0.023	-0.014	-0.018	-0.019	0.019	0.018	0.021	0.018	0.020	0.019	0.017	0.021	0.018	0.019

TABLE-5.3 DISPLACEMENT IN Z-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-0.012	-0.012	-0.011	-0.014	-0.010	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.007	0.004	0.009	0.000	0.000	0.000	0.000	0.000
	B	6	0.005	0.003	0.007	0.002	0.008	-0.002	-0.002	-0.001	-0.004	0.001	0.003	0.001	0.005	0.000	0.006	0.004	0.004	0.005	0.002	0.007
	C	8	0.000	0.000	0.001	-0.002	0.003	-0.001	-0.002	-0.001	-0.003	0.001	0.006	0.006	0.007	0.004	0.009	0.007	0.006	0.007	0.005	0.009
	D	9	0.000	0.002	-0.002	-0.002	0.002	0.000	0.001	-0.001	-0.001	0.001	0.013	0.015	0.010	0.011	0.014	0.013	0.014	0.011	0.011	0.014
	E	296	0.001	0.002	-0.001	0.000	0.002	0.001	0.002	0.000	0.000	0.002	0.009	0.011	0.008	0.008	0.010	0.009	0.010	0.008	0.008	0.010
	F	2	-0.003	-0.003	-0.003	-0.003	-0.002	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	G	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	23	0.000	0.001	-0.001	-0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.005	0.006	0.005	0.005	0.006	0.005	0.006	0.005	0.005	0.006
	I	27	-0.001	-0.001	-0.001	-0.003	0.001	-0.001	0.000	-0.001	-0.002	0.001	0.008	0.008	0.008	0.006	0.010	0.007	0.008	0.007	0.006	0.009
330	A	260	-0.005	-0.006	-0.004	-0.007	-0.003	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.003	0.000	0.005	0.000	0.000	0.000	0.000	0.000
	B	258	-0.004	-0.005	-0.003	-0.007	-0.001	0.000	0.000	0.000	-0.002	0.003	0.007	0.006	0.008	0.004	0.010	0.005	0.006	0.005	0.003	0.008
	C	256	-0.008	-0.008	-0.008	-0.010	-0.006	-0.001	-0.001	-0.001	-0.003	0.000	0.009	0.009	0.009	0.007	0.011	0.008	0.007	0.008	0.006	0.009
	D	255	-0.001	0.003	-0.004	-0.002	0.001	0.001	0.003	-0.001	0.000	0.002	0.014	0.018	0.011	0.013	0.016	0.014	0.016	0.012	0.013	0.015
	E	2413	0.001	0.004	-0.002	0.000	0.002	0.001	0.003	0.000	0.000	0.002	0.011	0.014	0.008	0.010	0.012	0.011	0.013	0.009	0.010	0.012
	F	251	-0.002	-0.002	-0.002	-0.002	-0.002	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	H	2447	0.001	0.002	0.000	0.001	0.002	0.001	0.001	0.000	0.000	0.001	0.007	0.008	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0.007
	I	2441	0.001	0.002	0.000	-0.001	0.003	0.001	0.002	0.000	0.000	0.002	0.010	0.011	0.009	0.008	0.011	0.009	0.010	0.008	0.008	0.010
300	A	240	0.005	0.005	0.006	0.004	0.007	0.000	0.000	0.000	0.000	0.000	-0.001	-0.002	-0.001	-0.004	0.000	0.000	0.000	0.000	0.000	0.000
	B	238	-0.013	-0.014	-0.013	-0.015	-0.012	0.001	0.002	0.001	0.000	0.003	0.010	0.010	0.011	0.008	0.012	0.006	0.007	0.006	0.005	0.007
	C	236	-0.016	-0.016	-0.016	-0.017	-0.015	-0.001	-0.001	-0.001	-0.002	0.000	0.012	0.012	0.012	0.010	0.013	0.008	0.008	0.008	0.007	0.009
	D	235	-0.004	-0.002	-0.006	-0.005	-0.003	0.000	0.001	-0.001	-0.001	0.000	0.014	0.015	0.012	0.013	0.015	0.012	0.013	0.011	0.012	0.013
	E	2213	0.001	0.002	0.000	0.000	0.002	0.001	0.002	0.000	0.001	0.002	0.010	0.011	0.009	0.009	0.011	0.010	0.011	0.009	0.009	0.010
	F	231	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	H	2245	0.004	0.004	0.003	0.003	0.004	0.002	0.002	0.001	0.002	0.002	0.011	0.011	0.010	0.010	0.011	0.010	0.011	0.010	0.010	0.011
	I	2241	0.003	0.004	0.002	0.002	0.004	0.001	0.002	0.001	0.001	0.002	0.011	0.012	0.010	0.010	0.012	0.010	0.011	0.010	0.010	0.011

TABLE-5.3 (contd...) DISPLACEMENT IN Z-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.010	0.011	0.009	0.010	0.011	0.000	0.000	0.000	0.000	0.000	-0.003	-0.002	-0.004	-0.004	-0.003	0.000	0.000	0.000	0.000	0.000
	B	218	-0.017	-0.018	-0.016	-0.017	-0.017	0.002	0.002	0.002	0.002	0.002	0.010	0.009	0.011	0.009	0.010	0.006	0.006	0.006	0.006	0.006
	C	216	-0.019	-0.020	-0.018	-0.019	-0.018	0.000	0.000	0.000	0.000	0.000	0.011	0.010	0.012	0.010	0.011	0.007	0.007	0.007	0.007	0.007
	D	215	-0.010	-0.010	-0.009	-0.010	-0.010	-0.001	-0.001	-0.001	-0.001	-0.001	0.012	0.012	0.013	0.012	0.012	0.010	0.010	0.010	0.010	0.010
	E	2051	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
	F	199	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	G	2091	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.001	0.002	0.001
	H	2083	0.005	0.005	0.005	0.005	0.005	0.003	0.003	0.003	0.003	0.003	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
	I	2077	0.004	0.005	0.004	0.004	0.004	0.001	0.001	0.001	0.001	0.001	0.008	0.008	0.007	0.007	0.008	0.007	0.007	0.007	0.007	0.007
240	A	198	0.008	0.009	0.006	0.008	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.001	-0.002	0.000	-0.001	0.000	0.000	0.000	0.000	0.000
	B	196	-0.014	-0.015	-0.012	-0.013	-0.015	0.001	0.001	0.002	0.003	0.000	0.006	0.005	0.008	0.007	0.005	0.004	0.003	0.005	0.005	0.003
	C	194	-0.015	-0.017	-0.013	-0.014	-0.016	0.000	0.000	0.000	0.001	-0.001	0.007	0.005	0.008	0.007	0.006	0.005	0.004	0.005	0.005	0.004
	D	193	-0.006	-0.009	-0.003	-0.005	-0.007	0.000	-0.001	0.001	0.001	-0.001	0.007	0.004	0.010	0.008	0.006	0.006	0.005	0.007	0.007	0.005
	E	1882	-0.001	-0.003	0.001	0.000	-0.002	0.001	0.000	0.002	0.002	0.000	0.006	0.004	0.008	0.007	0.005	0.005	0.004	0.006	0.006	0.005
	F	189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	G	1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	1914	0.002	0.002	0.003	0.003	0.002	0.001	0.001	0.002	0.002	0.001	0.007	0.007	0.007	0.007	0.006	0.007	0.006	0.007	0.007	0.006
	I	1908	0.003	0.003	0.003	0.004	0.002	0.001	0.001	0.001	0.002	0.000	0.006	0.006	0.006	0.007	0.005	0.005	0.005	0.006	0.006	0.005
210	A	178	0.000	0.001	-0.001	0.001	-0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.004	0.003	0.005	0.002	0.000	0.000	0.000	0.000	0.000
	B	176	-0.006	-0.007	-0.005	-0.004	-0.008	0.001	0.000	0.002	0.003	-0.001	0.002	0.001	0.003	0.004	0.000	0.002	0.001	0.003	0.004	0.000
	C	174	-0.007	-0.009	-0.006	-0.006	-0.009	0.000	0.000	0.000	0.001	-0.001	0.003	0.001	0.004	0.004	0.001	0.002	0.002	0.002	0.004	0.001
	D	173	-0.005	-0.009	-0.002	-0.004	-0.007	0.000	-0.001	0.001	0.001	-0.001	0.005	0.001	0.009	0.006	0.004	0.004	0.003	0.006	0.005	0.003
	E	1712	-0.001	-0.003	0.002	0.001	-0.002	0.001	0.000	0.002	0.002	0.000	0.005	0.002	0.008	0.006	0.004	0.004	0.003	0.006	0.005	0.003
	F	169	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.002	-0.002	-0.001	-0.001	-0.002	-0.002	-0.002	-0.001	-0.001	-0.002
	G	1759	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	1751	0.000	-0.001	0.001	0.001	-0.001	0.001	0.000	0.001	0.001	0.000	0.004	0.003	0.005	0.005	0.003	0.003	0.003	0.004	0.004	0.003
	I	1745	0.000	0.000	0.001	0.002	-0.001	0.000	0.000	0.001	0.002	-0.001	0.004	0.004	0.005	0.006	0.003	0.003	0.003	0.003	0.004	0.002
180	A	158	-0.008	-0.008	-0.007	-0.006	-0.009	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.005	0.006	0.003	0.000	0.000	0.000	0.000	0.000
	B	156	0.003	0.003	0.003	0.006	0.000	0.000	0.000	0.000	0.002	-0.002	0.000	0.000	0.000	0.003	-0.003	0.000	0.000	0.000	0.002	-0.002
	C	154	0.001	0.001	0.001	0.003	-0.001	0.000	0.000	0.000	0.002	-0.002	0.001	0.001	0.001	0.003	-0.001	0.000	0.000	0.000	0.002	-0.002
	D	153	0.000	-0.001	0.000	0.002	-0.002	0.000	0.000	0.000	0.001	-0.002	0.000	0.000	0.001	0.002	-0.002	0.000	0.000	0.000	0.002	-0.002
	E	1560	-0.002	-0.002	-0.001	0.000	-0.003	0.000	-0.001	0.000	0.001	-0.002	0.001	0.000	0.001	0.002	-0.001	0.000	0.000	0.000	0.002	-0.001
	F	149	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	G	1594	-0.001	-0.001	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	0.000	-0.001	-0.001	-0.001	-0.001	0.000	-0.001
	H	1588	-0.001	-0.002	-0.001	-0.001	-0.002	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.001	0.001	-0.001	0.000	0.000	0.000	0.001	-0.001
	I	1582	-0.003	-0.003	-0.002	-0.001	-0.004	-0.001	-0.001	0.000	0.001	-0.002	0.002	0.001	0.002	0.003	0.000	0.000	0.000	0.001	0.002	-0.001

TABLE-5.3 (contd...) DISPLACEMENT IN Z-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-0.012	-0.014	-0.010	-0.011	-0.013	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.004	0.003	0.001	0.000	0.000	0.000	0.000	0.000
	B	134	0.009	0.010	0.007	0.011	0.006	-0.001	0.000	-0.001	0.001	-0.003	0.000	0.002	-0.001	0.003	-0.002	-0.001	-0.001	-0.002	0.001	-0.004
	C	132	0.006	0.007	0.005	0.008	0.004	0.000	0.000	0.000	0.001	-0.002	0.000	0.002	-0.001	0.002	-0.002	-0.001	-0.001	-0.001	0.001	-0.003
	D	131	0.003	0.004	0.001	0.005	0.001	0.000	0.000	-0.001	0.001	-0.002	-0.001	0.001	-0.002	0.001	-0.003	-0.002	-0.001	-0.002	0.000	-0.004
	E	1393	-0.004	-0.004	-0.004	-0.003	-0.005	-0.001	-0.001	-0.002	0.000	-0.002	-0.002	-0.002	-0.002	-0.001	-0.003	-0.002	-0.002	-0.003	-0.002	-0.003
	F	127	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	G	1431	-0.001	-0.002	-0.001	-0.001	-0.002	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.002	-0.001	-0.001	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
	H	1423	-0.004	-0.005	-0.004	-0.003	-0.005	-0.001	-0.001	-0.001	-0.001	-0.002	-0.003	-0.004	-0.003	-0.002	-0.004	-0.003	-0.003	-0.004	-0.003	-0.004
	I	1417	-0.007	-0.008	-0.006	-0.005	-0.008	-0.001	-0.001	-0.001	0.000	-0.002	0.000	-0.001	0.001	0.001	-0.001	-0.001	-0.001	-0.001	0.000	-0.002
120	A	116	-0.012	-0.014	-0.010	-0.012	-0.013	0.000	0.000	0.000	0.000	0.000	-0.001	-0.003	0.001	0.000	-0.002	0.000	0.000	0.000	0.000	0.000
	B	114	0.011	0.012	0.010	0.012	0.009	-0.002	-0.001	-0.002	0.000	-0.003	0.001	0.002	0.000	0.003	0.000	-0.002	-0.001	-0.002	0.000	-0.003
	C	112	0.008	0.009	0.007	0.010	0.007	-0.001	-0.001	-0.001	0.000	-0.002	0.001	0.002	0.000	0.003	0.000	-0.001	-0.001	-0.001	0.000	-0.003
	D	111	0.007	0.008	0.005	0.008	0.005	-0.001	-0.001	-0.001	0.000	-0.002	0.001	0.002	-0.001	0.002	-0.001	-0.001	-0.001	-0.001	0.000	-0.003
	E	1233	-0.007	-0.007	-0.007	-0.006	-0.008	-0.002	-0.002	-0.002	-0.001	-0.003	-0.005	-0.005	-0.005	-0.004	-0.005	-0.005	-0.005	-0.005	-0.004	-0.005
	F	107	-0.003	-0.003	-0.002	-0.002	-0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	G	1269	-0.003	-0.003	-0.003	-0.003	-0.003	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1263	-0.008	-0.009	-0.008	-0.008	-0.009	-0.002	-0.002	-0.002	-0.002	-0.003	-0.007	-0.008	-0.007	-0.007	-0.008	-0.007	-0.007	-0.007	-0.007	-0.007
	I	1255	-0.008	-0.010	-0.007	-0.008	-0.009	-0.001	-0.002	-0.001	-0.001	-0.002	-0.003	-0.004	-0.002	-0.002	-0.004	-0.003	-0.003	-0.002	-0.002	-0.004
90	A	96	-0.011	-0.013	-0.010	-0.011	-0.011	0.000	0.000	0.000	0.000	0.000	-0.003	-0.004	-0.001	-0.003	-0.002	0.000	0.000	0.000	0.000	0.000
	B	94	0.010	0.009	0.010	0.009	0.010	-0.003	-0.004	-0.002	-0.003	-0.003	0.002	0.001	0.003	0.002	0.003	0.000	-0.001	0.000	0.000	0.000
	C	90	0.008	0.008	0.009	0.008	0.009	-0.003	-0.003	-0.002	-0.002	-0.003	0.002	0.001	0.002	0.002	0.002	0.000	-0.001	0.000	0.000	0.000
	D	89	0.008	0.007	0.009	0.008	0.008	-0.002	-0.003	-0.002	-0.002	-0.002	0.002	0.001	0.002	0.002	0.002	0.000	-0.001	0.000	0.000	0.000
	E	1064	-0.011	-0.012	-0.010	-0.011	-0.011	-0.003	-0.003	-0.002	-0.003	-0.003	-0.006	-0.007	-0.005	-0.006	-0.005	-0.005	-0.006	-0.005	-0.005	-0.005
	F	85	-0.004	-0.004	-0.004	-0.004	-0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.002	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003
	G	1121	-0.005	-0.005	-0.004	-0.005	-0.005	-0.001	-0.001	-0.001	-0.001	-0.001	-0.004	-0.004	-0.003	-0.004	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	H	1113	-0.011	-0.012	-0.010	-0.011	-0.010	-0.002	-0.002	-0.002	-0.002	-0.002	-0.007	-0.008	-0.006	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007	-0.007
	I	1105	-0.009	-0.010	-0.008	-0.009	-0.009	-0.001	-0.001	-0.001	-0.001	-0.001	-0.004	-0.005	-0.002	-0.003	-0.003	-0.003	-0.003	-0.002	-0.003	-0.003
60	A	64	-0.010	-0.011	-0.009	-0.011	-0.009	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	0.000	-0.001	0.001	0.000	0.000	0.000	0.000	0.000
	B	59	0.008	0.006	0.011	0.006	0.011	-0.003	-0.005	-0.001	-0.005	-0.002	0.002	0.000	0.005	0.000	0.005	0.002	0.000	0.003	0.000	0.003
	C	61	0.006	0.004	0.009	0.004	0.009	-0.003	-0.004	-0.002	-0.004	-0.001	0.004	0.002	0.006	0.002	0.006	0.003	0.002	0.004	0.002	0.005
	D	62	0.005	0.003	0.008	0.003	0.007	-0.003	-0.003	-0.002	-0.004	-0.001	0.006	0.004	0.008	0.004	0.008	0.005	0.004	0.006	0.004	0.006
	E	978	-0.011	-0.012	-0.010	-0.012	-0.010	-0.002	-0.002	-0.002	-0.003	-0.001	-0.002	-0.003	0.000	-0.003	-0.001	-0.002	-0.002	-0.002	-0.003	-0.002
	F	56	-0.004	-0.005	-0.004	-0.005	-0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	G	727	-0.005	-0.005	-0.005	-0.005	-0.005	-0.001	-0.001	-0.001	-0.001	-0.001	-0.003	-0.003	-0.002	-0.003	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003
	H	715	-0.010	-0.011	-0.009	-0.011	-0.009	-0.001	-0.001	-0.001	-0.002	-0.001	-0.003	-0.004	-0.002	-0.004	-0.002	-0.003	-0.004	-0.003	-0.004	-0.003
	I	707	-0.009	-0.010	-0.009	-0.010	-0.008	-0.001	0.000	-0.001	-0.001	0.000	-0.001	-0.002	0.000	-0.002	0.000	-0.001	-0.001	-0.001	-0.002	-0.001

TABLE-5.3 (contd....) DISPLACEMENT IN Z-DIRECTION

(CENTIMETER)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-0.010	-0.010	-0.009	-0.011	-0.008	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.003	0.001	0.004	0.000	0.000	0.000	0.000	0.000
	B	34	0.008	0.005	0.010	0.004	0.011	-0.002	-0.004	-0.001	-0.005	0.000	0.002	-0.001	0.005	-0.001	0.005	0.003	0.002	0.005	0.001	0.006
	C	38	0.005	0.003	0.007	0.002	0.008	-0.002	-0.002	-0.001	-0.004	0.000	0.006	0.004	0.008	0.003	0.008	0.006	0.005	0.006	0.004	0.008
	D	35	0.000	0.002	-0.001	-0.001	0.002	0.000	0.001	-0.001	-0.001	0.001	0.012	0.013	0.010	0.010	0.013	0.012	0.012	0.011	0.010	0.013
	E	486	-0.001	0.000	-0.002	-0.002	0.000	0.000	0.000	-0.001	-0.001	0.000	0.007	0.007	0.006	0.006	0.008	0.007	0.007	0.006	0.006	0.007
	F	465	-0.003	-0.003	-0.003	-0.003	-0.003	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	G	644	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	H	47	-0.001	0.000	-0.001	-0.002	0.000	-0.001	-0.001	-0.001	-0.001	0.000	0.006	0.006	0.005	0.005	0.006	0.005	0.006	0.005	0.005	0.006
	I	637	-0.002	-0.003	-0.001	-0.005	0.000	-0.002	-0.003	-0.002	-0.004	-0.001	0.006	0.005	0.007	0.003	0.008	0.005	0.005	0.006	0.003	0.007
Minimum	Node	No.																				
		X																				
		Y																				
		Z																				
	Value																					
Maximum	Node	No.	18741	18051	2183	18739	18051	7552	686	70	555	1243	19342	255	18713	19342	261	255	255	261	261	20808
		X	22.19	-22.08	72.44	58.41	-22.08	159.50	191.78	366.67	297.23	-173.50	-317.13	1100.00	149.85	317.13	1100.00	1100.00	1100.00	1100.00	1100.00	1100.00
		Y	420.00	420.00	420.00	420.00	420.00	420.00	420.00	180.07	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00
		Z	533.19	533.20	550.25	530.82	533.20	-385.10	-332.18	-635.09	-297.23	-300.51	759.94	635.09	764.34	759.94	1025.00	635.09	635.09	1025.00	1025.00	464.91
	Value		-0.019	-0.020	-0.018	-0.019	-0.018	-0.004	-0.005	-0.003	-0.005	-0.004	0.014	0.018	0.014	0.014	0.016	0.014	0.016	0.012	0.013	0.015

TABLE-5.4 STRESSES IN X-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-3.56	-3.29	-3.83	-3.72	-3.40	-0.60	-1.34	0.15	-0.37	-0.83	0.07	0.34	-0.19	-2.25	-1.94	3.30	2.56	4.05	-0.09	-0.56
	B	6	0.24	-1.94	2.43	0.17	0.32	0.42	-1.76	2.60	0.33	0.51	0.21	-1.97	2.40	0.12	0.28	0.14	-2.04	2.32	0.06	0.24
	C	8	-5.77	-8.63	-2.91	-5.81	-5.73	-5.37	-8.99	-1.75	-5.39	-5.34	6.32	3.46	9.18	6.62	6.71	6.71	3.09	10.33	6.72	6.77
	D	9	0.14	0.19	0.09	0.14	0.14	0.08	0.12	0.03	0.08	0.08	-0.26	-0.21	-0.31	-0.26	-0.26	-0.25	-0.21	-0.29	-0.25	-0.25
	E	296	-0.45	-0.56	-0.34	-0.45	-0.45	-0.22	-0.33	-0.12	-0.22	-0.22	-0.19	-0.30	-0.08	-0.18	-0.18	-0.22	-0.32	-0.11	-0.21	-0.21
	F	2	-5.86	-5.42	-6.30	-5.60	-6.12	-0.81	-1.08	-0.54	-0.72	-0.90	-5.51	-5.07	-5.95	-0.90	-1.42	-4.99	-5.26	-4.72	-1.32	-1.49
	G	24	0.80	1.14	0.45	0.80	0.79	0.48	0.73	0.22	0.48	0.47	3.70	4.05	3.36	3.68	3.67	3.76	4.01	3.50	3.73	3.72
	H	23	-0.42	-0.38	-0.46	-0.42	-0.41	-0.30	-0.30	-0.30	-0.30	-0.30	-3.07	-3.03	-3.10	-3.06	-3.05	-3.07	-3.07	-3.07	-3.07	-3.07
	I	27	-4.96	-8.34	-1.57	-4.82	-5.10	-0.19	-2.24	1.85	-0.14	-0.25	5.10	1.71	8.48	5.07	4.80	4.09	2.05	6.13	4.20	4.09
330	A	260	1.69	1.47	1.91	1.69	1.70	-4.90	-5.53	-4.26	-4.71	-5.09	-4.49	-4.71	-4.27	-4.23	-4.22	-0.11	-0.75	0.52	0.15	-0.24
	B	258	-2.29	-3.45	-1.13	-2.88	-1.71	1.08	-0.16	2.32	0.45	1.72	1.21	0.05	2.37	0.59	1.76	0.28	-0.95	1.52	-0.36	0.91
	C	256	-4.07	-5.90	-2.23	-4.75	-3.39	-3.80	-6.25	-1.35	-4.40	-3.20	4.22	2.39	6.05	3.82	5.18	4.61	2.16	7.06	4.02	5.23
	D	255	-0.05	0.00	-0.10	-0.03	-0.06	0.00	0.02	-0.03	0.01	-0.01	-0.10	-0.05	-0.15	-0.09	-0.11	-0.11	-0.08	-0.13	-0.10	-0.12
	E	2413	-0.01	-0.02	0.01	0.00	-0.01	0.01	0.01	0.02	0.01	0.01	0.05	0.04	0.06	0.05	0.05	0.05	0.04	0.05	0.05	0.05
	F	251	-0.11	-0.11	-0.12	-0.11	-0.11	-0.06	-0.07	-0.05	-0.06	-0.06	-3.16	-3.16	-3.17	-3.00	-3.00	-3.14	-3.15	-3.14	-3.00	-3.00
	G	2453	0.61	0.90	0.32	0.62	0.60	0.32	0.51	0.12	0.33	0.31	2.66	2.94	2.37	2.65	2.62	2.70	2.90	2.51	2.69	2.67
	H	2447	-0.12	0.03	-0.26	-0.11	-0.12	-0.10	-0.01	-0.19	-0.09	-0.10	-1.44	-1.30	-1.59	-1.43	-1.44	-1.45	-1.36	-1.54	-1.44	-1.45
	I	2441	-6.77	-9.51	-4.02	-7.22	-6.31	-0.04	-1.46	1.38	-0.43	0.35	3.88	1.13	6.62	3.31	4.22	2.37	0.95	3.79	1.99	2.76
300	A	240	8.35	8.17	8.53	8.42	8.28	-5.85	-6.35	-5.35	-5.73	-5.98	-6.96	-7.15	-6.78	-6.74	-6.88	0.58	0.08	1.08	0.73	0.48
	B	238	-9.73	-10.20	-9.26	-10.85	-8.61	2.16	1.86	2.46	1.05	3.27	4.44	3.97	4.91	3.40	5.64	1.62	1.32	1.91	0.47	2.69
	C	236	-6.22	-7.37	-5.07	-6.90	-5.55	-1.61	-2.79	-0.42	-2.18	-1.03	3.98	2.83	5.13	3.32	4.68	2.77	1.58	3.95	2.19	3.33
	D	235	0.20	0.45	-0.05	0.10	0.30	0.13	0.24	0.02	0.05	0.21	1.18	1.44	0.93	1.10	1.30	1.19	1.30	1.08	1.11	1.27
	E	2213	0.01	-0.09	0.10	-0.10	0.12	0.02	-0.02	0.05	-0.07	0.10	0.67	0.57	0.77	0.55	0.77	0.66	0.62	0.69	0.57	0.74
	F	231	0.00	-0.02	0.02	0.00	0.00	-0.06	-0.07	-0.05	-0.06	-0.05	-2.79	-2.81	-2.78	-2.77	-2.76	-2.79	-2.80	-2.78	-2.76	-2.76
	G	2251	0.42	0.60	0.23	0.42	0.41	0.20	0.31	0.09	0.21	0.19	1.17	1.35	0.99	1.19	1.17	1.21	1.32	1.10	1.22	1.20
	H	2245	-0.97	-1.17	-0.77	-1.03	-0.90	-0.23	-0.32	-0.14	-0.28	-0.18	1.30	1.10	1.50	1.23	1.36	1.16	1.07	1.25	1.11	1.20
	I	2241	-2.64	-4.10	-1.17	-3.07	-2.21	0.45	-0.01	0.90	0.10	0.79	2.71	1.25	4.18	2.26	3.13	2.35	1.89	2.81	2.00	2.69

TABLE-5.4 (contd...) STRESSES IN X-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	11.58	12.28	10.87	11.75	11.40	-5.67	-5.71	-5.63	-5.69	-5.65	-6.87	-6.17	-7.58	-6.54	-6.88	0.30	0.26	0.35	0.29	0.32
	B	218	-13.82	-14.18	-13.46	-13.06	-14.57	1.57	2.43	0.70	2.43	0.70	5.29	4.93	5.65	6.12	4.62	2.67	3.54	1.80	3.52	1.78
	C	216	-6.88	-7.43	-6.33	-6.94	-6.82	-0.66	-0.70	-0.63	-0.65	-0.67	3.22	2.67	3.77	3.12	3.24	2.06	2.03	2.10	2.07	2.05
	D	215	-1.65	-1.91	-1.38	-1.76	-1.54	0.06	-0.05	0.17	-0.01	0.12	2.75	2.48	3.01	2.60	2.81	2.30	2.19	2.42	2.24	2.37
	E	2051	0.98	0.99	0.97	0.92	1.03	0.55	0.53	0.57	0.51	0.58	2.37	2.38	2.36	2.29	2.40	2.33	2.31	2.35	2.30	2.37
	F	199	0.07	0.06	0.09	0.07	0.08	-0.05	-0.07	-0.04	-0.05	-0.05	-2.36	-2.38	-2.34	-2.35	-2.34	-2.35	-2.36	-2.33	-2.34	-2.33
	G	2091	0.43	0.33	0.54	0.42	0.45	0.20	0.14	0.27	0.19	0.22	0.62	0.52	0.72	0.61	0.63	0.64	0.58	0.70	0.63	0.65
	H	2083	-1.49	-1.64	-1.34	-1.55	-1.42	-0.43	-0.45	-0.40	-0.47	-0.38	1.73	1.58	1.89	1.67	1.80	1.58	1.56	1.61	1.54	1.63
	I	2077	3.15	3.43	2.88	3.31	3.00	1.35	1.46	1.25	1.45	1.25	2.13	2.40	1.85	2.36	2.05	2.78	2.89	2.68	2.88	2.68
240	A	198	7.83	9.07	6.59	7.98	7.68	-6.20	-6.14	-6.25	-6.43	-5.97	-3.70	-2.46	-4.93	-3.46	-3.75	-0.10	-0.04	-0.15	-0.32	0.13
	B	196	-9.85	-11.05	-8.65	-9.17	-10.52	0.87	1.17	0.57	1.66	0.08	3.46	2.26	4.66	4.09	2.75	2.67	2.97	2.38	3.46	1.88
	C	194	-2.46	-2.46	-2.46	-1.98	-2.94	-0.87	-0.09	-1.65	-0.42	-1.32	1.23	1.24	1.23	1.71	0.76	1.78	2.56	1.00	2.23	1.33
	D	193	-0.25	-0.46	-0.05	-0.26	-0.25	0.03	-0.04	0.10	0.02	0.03	-0.10	-0.31	0.10	-0.12	-0.10	-0.10	-0.17	-0.03	-0.10	-0.09
	E	1882	0.01	0.07	-0.06	0.05	-0.04	0.01	0.04	-0.01	0.05	-0.02	-0.07	-0.01	-0.14	-0.03	-0.11	-0.08	-0.06	-0.11	-0.05	-0.12
	F	189	0.06	0.04	0.09	0.06	0.06	-0.02	-0.05	0.00	-0.03	-0.02	-2.15	-2.18	-2.13	-2.14	-2.13	-2.15	-2.17	-2.12	-2.13	-2.12
	G	1922	0.52	0.29	0.75	0.51	0.54	0.24	0.09	0.40	0.23	0.26	0.79	0.56	1.02	0.80	0.83	0.81	0.66	0.96	0.82	0.85
	H	1914	0.06	-0.11	0.24	0.02	0.11	-0.01	-0.09	0.08	-0.04	0.03	0.25	0.08	0.42	0.20	0.29	0.25	0.16	0.33	0.21	0.28
	I	1908	-0.68	0.75	-2.11	-0.04	-1.32	1.46	1.62	1.31	1.95	0.98	4.00	5.43	2.57	4.75	3.47	3.25	3.40	3.09	3.73	2.76
210	A	178	2.05	2.62	1.48	2.10	2.01	-5.73	-6.03	-5.44	-6.13	-5.34	-1.83	-1.26	-2.39	-1.76	-1.85	-2.03	-2.33	-1.74	-2.43	-1.64
	B	176	-2.54	-1.39	-3.68	-2.18	-2.89	0.58	2.18	-1.03	0.97	0.19	0.77	1.91	-0.37	1.09	0.38	1.09	2.69	-0.52	1.48	0.70
	C	174	1.58	2.31	0.85	2.03	1.13	-1.69	-0.34	-3.05	-1.32	-2.07	-0.26	0.47	-0.99	0.19	-0.72	0.66	2.02	-0.69	1.04	0.29
	D	173	0.18	0.13	0.23	0.16	0.20	0.06	0.01	0.10	0.04	0.07	-0.09	-0.14	-0.04	-0.11	-0.08	-0.08	-0.12	-0.04	-0.10	-0.07
	E	1712	-0.18	-0.16	-0.19	-0.19	-0.16	-0.03	-0.02	-0.05	-0.04	-0.02	-0.03	-0.02	-0.04	-0.04	-0.02	-0.04	-0.02	-0.06	-0.05	-0.03
	F	169	-0.01	-0.02	0.01	-0.01	0.00	-0.02	-0.03	0.00	-0.02	-0.01	-2.42	-2.44	-2.40	-2.42	-2.41	-2.42	-2.43	-2.41	-2.41	-2.41
	G	1759	1.66	0.96	2.35	1.65	1.67	0.76	0.28	1.24	0.74	0.78	3.57	2.87	4.26	3.56	3.58	3.56	3.09	4.04	3.56	3.60
	H	1751	-0.63	-0.57	-0.70	-0.63	-0.63	-0.24	-0.15	-0.32	-0.23	-0.24	-2.47	-2.41	-2.53	-2.47	-2.47	-2.51	-2.43	-2.60	-2.51	-2.52
	I	1745	-3.87	-2.60	-5.13	-3.39	-4.34	2.10	1.72	2.48	2.50	1.69	6.65	7.91	5.38	7.17	6.22	5.43	5.05	5.81	5.84	5.03
180	A	158	0.26	0.34	0.18	0.26	0.25	-6.22	-6.40	-6.04	-6.31	-6.13	-2.29	-2.21	-2.37	-2.29	-2.29	-2.92	-3.10	-2.74	-3.01	-2.82
	B	156	0.51	3.05	-2.03	0.47	0.55	0.80	3.32	-1.73	0.76	0.83	0.72	3.26	-1.82	0.67	0.76	0.74	3.26	-1.79	0.70	0.78
	C	154	2.14	3.30	0.99	2.14	2.15	-1.56	0.02	-3.14	-1.60	-1.52	-0.04	1.11	-1.20	-0.06	-0.05	-0.05	1.53	-1.63	-0.09	-0.01
	D	153	0.15	0.08	0.21	0.15	0.15	0.09	0.02	0.17	0.09	0.09	-0.05	-0.11	0.02	-0.05	-0.04	-0.06	-0.14	0.02	-0.06	-0.06
	E	1560	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.01	0.04	0.03	0.02
	F	149	-0.03	0.02	-0.08	-0.03	-0.03	-0.03	-0.01	-0.06	-0.03	-0.03	-2.54	-2.49	-2.60	-2.55	-2.54	-2.54	-2.52	-2.57	-2.55	-2.54
	G	1594	2.57	1.48	3.66	2.63	2.51	1.12	0.37	1.86	1.15	1.09	5.04	3.95	6.13	5.09	4.97	4.95	4.20	5.70	4.99	4.92
	H	1588	-0.72	-0.89	-0.55	-0.72	-0.72	-0.36	-0.37	-0.36	-0.36	-0.36	-3.13	-3.30	-2.97	-3.14	-3.14	-3.11	-3.12	-3.10	-3.11	-3.11
	I	1582	-5.01	-3.79	-6.24	-5.02	-5.00	2.04	1.56	2.51	2.10	1.98	5.30	6.52	4.07	5.29	5.31	5.42	4.95	5.90	5.49	5.36

TABLE-5.4 (contd...) STRESSES IN X-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	2.03	2.48	1.58	2.07	1.98	-5.57	-6.06	-5.08	-5.33	-5.80	-1.74	-1.29	-2.19	-1.68	-1.77	-2.62	-3.11	-2.13	-2.38	-2.85
	B	134	-2.53	-0.99	-4.07	-3.18	-1.88	0.94	2.71	-0.83	0.31	1.57	0.56	2.10	-0.97	-0.12	1.19	0.96	2.74	-0.81	0.34	1.59
	C	132	-0.05	0.74	-0.83	-0.50	0.41	-1.00	0.32	-2.31	-1.41	-0.59	0.12	0.91	-0.66	-0.32	0.59	-0.12	1.20	-1.44	-0.53	0.29
	D	131	-0.04	-0.07	0.00	-0.02	-0.05	0.03	0.00	0.06	0.04	0.02	-0.02	-0.06	0.02	-0.01	-0.04	-0.01	-0.04	0.02	0.00	-0.03
	E	1393	0.04	-0.01	0.09	0.05	0.04	0.01	-0.01	0.03	0.01	0.00	0.04	-0.01	0.09	0.04	0.03	0.03	0.01	0.05	0.04	0.02
	F	127	0.11	0.19	0.03	0.11	0.12	0.00	0.03	-0.02	0.00	0.01	-2.20	-2.12	-2.28	-2.19	-2.18	-2.20	-2.17	-2.22	-2.19	-2.19
	G	1431	1.80	0.75	2.86	1.90	1.70	0.79	0.12	1.45	0.85	0.72	3.15	2.09	4.20	3.26	3.06	3.04	2.37	3.71	3.13	3.00
	H	1423	-0.26	-0.02	-0.49	-0.34	-0.17	-0.19	-0.03	-0.34	-0.25	-0.12	-0.87	-0.64	-1.11	-0.95	-0.79	-0.79	-0.64	-0.95	-0.86	-0.73
	I	1417	2.25	3.37	1.13	2.11	2.39	2.22	-0.28	4.71	2.30	2.13	4.65	5.77	3.53	4.58	4.85	5.23	2.74	7.73	5.33	5.15
120	A	116	3.05	3.51	2.59	3.12	2.97	-5.76	-7.05	-4.48	-5.33	-6.19	1.08	1.54	0.62	1.27	1.12	-2.74	-4.03	-1.46	-2.31	-3.17
	B	114	-5.75	-5.40	-6.09	-6.30	-5.19	1.48	2.10	0.87	0.92	2.05	-1.56	-1.22	-1.91	-2.08	-0.97	0.21	0.83	-0.40	-0.36	0.77
	C	112	-2.31	-1.96	-2.66	-2.90	-1.72	-0.10	0.71	-0.90	-0.58	0.38	-0.34	0.01	-0.69	-0.92	0.26	0.26	1.07	-0.54	-0.23	0.73
	D	111	-1.27	-1.65	-0.89	-1.79	-0.75	0.16	0.40	-0.09	-0.23	0.55	0.44	0.05	0.82	-0.08	0.96	0.84	1.09	0.60	0.44	1.22
	E	1233	1.00	1.18	0.82	0.76	1.24	0.26	0.17	0.34	0.08	0.44	1.49	1.68	1.31	1.28	1.76	1.44	1.36	1.53	1.26	1.62
	F	107	0.64	0.73	0.55	0.62	0.66	0.17	0.17	0.17	0.15	0.18	-1.23	-1.14	-1.32	-1.22	-1.17	-1.26	-1.26	-1.26	-1.25	-1.22
	G	1269	1.49	0.86	2.12	1.55	1.42	0.54	0.12	0.95	0.58	0.49	1.37	0.74	1.99	1.46	1.34	1.24	0.82	1.66	1.33	1.24
	H	1263	-0.78	-0.95	-0.61	-0.81	-0.75	-0.46	-0.60	-0.32	-0.49	-0.44	0.93	0.76	1.09	0.90	0.97	0.98	0.84	1.11	0.95	1.00
	I	1255	1.62	2.68	0.57	1.48	1.77	1.50	0.38	2.62	1.60	1.40	3.36	4.41	2.31	3.38	3.67	3.61	2.49	4.73	3.71	3.52
90	A	96	1.30	0.78	1.83	1.28	1.33	-7.13	-6.97	-7.30	-7.17	-7.10	2.54	2.02	3.07	2.82	2.88	-2.97	-2.81	-3.13	-2.99	-2.92
	B	94	-3.99	-3.47	-4.50	-3.82	-4.16	2.17	2.72	1.61	2.35	1.98	-1.97	-1.46	-2.49	-1.66	-2.00	0.08	0.64	-0.47	0.21	-0.16
	C	90	-1.63	-0.76	-2.51	-1.77	-1.49	1.27	2.04	0.50	1.12	1.43	0.09	0.97	-0.79	-0.11	0.17	0.74	1.52	-0.03	0.57	0.88
	D	89	-1.70	-0.79	-2.61	-1.84	-1.56	1.58	2.39	0.78	1.41	1.76	0.74	1.65	-0.18	0.46	0.74	1.39	2.20	0.59	1.20	1.55
	E	1064	1.52	1.84	1.21	1.43	1.62	-0.19	-0.19	-0.20	-0.28	-0.10	2.61	2.93	2.30	2.47	2.67	2.14	2.14	2.13	2.04	2.22
	F	85	1.11	1.42	0.80	1.06	1.16	0.20	0.25	0.14	0.17	0.23	-0.84	-0.53	-1.15	-0.82	-0.71	-0.88	-0.82	-0.93	-0.86	-0.80
	G	1121	1.38	2.02	0.73	1.29	1.46	0.07	0.16	-0.02	0.01	0.14	0.34	0.99	-0.31	0.34	0.50	0.23	0.33	0.14	0.21	0.34
	H	1113	-2.31	-2.51	-2.11	-2.35	-2.27	-0.87	-1.29	-0.45	-0.86	-0.87	0.37	0.17	0.58	0.44	0.52	0.37	-0.06	0.79	0.39	0.38
	I	1105	-0.75	-1.82	0.32	-0.69	-0.81	0.69	0.35	1.04	0.73	0.66	2.44	1.37	3.51	2.71	2.59	2.57	2.23	2.92	2.62	2.54
60	A	64	-0.51	-1.42	0.41	-0.68	-0.34	-11.30	-9.19	-13.41	-12.17	-10.44	-0.79	-1.70	0.12	-0.40	-0.06	-0.94	1.17	-3.05	-1.71	0.02
	B	59	-0.63	-1.35	0.09	0.12	-1.37	2.05	2.11	1.99	2.74	1.36	1.24	0.52	1.96	1.85	0.36	2.03	2.09	1.97	2.66	1.28
	C	61	0.25	-0.51	1.01	1.08	-0.58	1.66	1.31	2.02	2.29	1.04	1.59	0.82	2.35	2.40	0.74	1.38	1.02	1.74	2.01	0.77
	D	62	-0.17	-1.00	0.67	1.03	-1.36	1.10	0.34	1.86	1.99	0.22	3.33	2.50	4.17	4.65	2.26	3.19	2.43	3.95	4.11	2.34
	E	978	-0.17	-0.23	-0.11	-0.18	-0.16	-0.14	-0.18	-0.10	-0.15	-0.13	-3.34	-3.40	-3.29	-3.35	-3.34	-3.34	-3.38	-3.31	-3.35	-3.33
	F	56	0.32	0.82	-0.17	0.22	0.43	-0.13	-0.08	-0.18	-0.18	-0.09	-1.94	-1.45	-2.44	-1.78	-1.57	-1.95	-1.91	-2.00	-1.83	-1.73
	G	727	-2.16	-0.37	-3.94	-2.31	-2.01	-1.59	-1.56	-1.63	-1.67	-1.51	-1.69	0.09	-3.48	-1.47	-1.17	-1.75	-1.72	-1.79	-1.70	-1.54
	H	715	-1.54	-2.01	-1.07	-1.48	-1.59	-0.54	-1.08	0.01	-0.42	-0.65	-1.79	-2.26	-1.31	-1.64	-1.75	-1.94	-2.48	-1.40	-1.78	-2.01
	I	707	-4.82	-7.53	-2.11	-4.75	-4.88	1.28	3.08	-0.51	0.73	1.83	-3.09	-5.80	-0.38	-2.67	-2.80	-0.13	1.66	-1.93	-0.64	0.46

TABLE-5.4 (contd....) STRESSES IN X-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-0.73	-0.92	-0.54	-0.79	-0.67	-2.71	-1.64	-3.78	-2.62	-2.80	-1.99	-2.19	-1.80	-0.25	-0.14	0.07	1.14	-1.00	0.32	0.14
	B	34	-0.58	-3.11	1.96	0.35	-1.49	0.88	-1.27	3.03	1.74	0.04	1.64	-0.89	4.17	2.42	0.58	1.38	-0.77	3.53	2.26	0.57
	C	38	-5.61	-9.08	-2.15	-4.78	-6.45	-3.46	-6.81	-0.10	-2.75	-4.16	5.52	2.06	8.98	6.67	5.00	5.36	2.01	8.71	6.14	4.72
	D	35	0.13	0.27	-0.01	0.10	0.16	0.13	0.22	0.04	0.11	0.15	-0.45	-0.31	-0.59	-0.47	-0.42	-0.44	-0.35	-0.53	-0.46	-0.42
	E	486	-0.21	-0.17	-0.26	-0.23	-0.20	-0.17	-0.16	-0.18	-0.18	-0.16	-0.29	-0.25	-0.34	-0.30	-0.27	-0.29	-0.28	-0.30	-0.30	-0.28
	F	465	1.18	1.22	1.15	1.14	1.23	-0.03	-0.08	0.02	-0.03	-0.03	-2.48	-2.45	-2.51	-1.27	-1.19	-2.17	-2.22	-2.11	-1.08	-1.08
	G	644	0.31	0.12	0.50	0.38	0.24	0.24	0.22	0.25	0.28	0.19	3.12	2.93	3.31	3.12	2.99	3.14	3.12	3.16	3.15	3.06
	H	47	-0.14	-0.08	-0.19	-0.16	-0.12	-0.12	-0.09	-0.14	-0.13	-0.10	-3.58	-3.53	-3.64	-3.59	-3.56	-3.58	-3.56	-3.60	-3.59	-3.57
	I	637	2.14	1.83	2.44	2.79	1.49	2.43	3.25	1.61	2.91	1.95	8.24	7.93	8.54	8.66	7.35	8.19	9.00	7.37	8.66	7.69
Minimum		**No.**	**218**	**393**	**218**	**228**	**218**	**845**	**2578**	**845**	**845**	**845**	**229**	**4929**	**229**	**229**	**229**	**20**	**2578**	**1679**	**1199**	**1199**
	Node	**X**	0.00	470.94	0.00	71.18	0.00	204.24	470.94	204.24	204.24	204.24	71.18	210.34	71.18	71.18	71.18	265.63	470.94	-470.94	-40.33	-40.33
		Y	420.00	420.00	420.00	420.00	420.00	110.00	420.00	110.00	110.00	110.00	110.00	107.64	110.00	110.00	110.00	-110.00	420.00	420.00	110.00	110.00
		Z	275.00	-62.00	275.00	265.63	275.00	-256.01	62.00	-256.01	-256.01	-256.01	265.63	-271.33	265.63	265.63	265.63	-71.18	62.00	62.00	-325.01	-325.01
	Value		**-13.82**	**-17.48**	**-13.46**	**-13.36**	**-14.57**	**-17.39**	**-14.51**	**-25.82**	**-19.90**	**-14.88**	**-7.84**	**-7.72**	**-8.25**	**-7.28**	**-7.60**	**-5.70**	**-7.78**	**-8.01**	**-4.31**	**-4.59**
Maximum		**No.**	**219**	**219**	**219**	**219**	**219**	**3579**	**4930**	**1580**	**3579**	**4930**	**3694**	**3693**	**3694**	**3694**	**498**	**3694**	**3693**	**3694**	**3694**	**498**
	Node	**X**	0.00	0.00	0.00	0.00	0.00	257.78	232.55	-435.30	257.78	232.55	591.24	659.28	591.24	591.24	653.85	591.24	659.28	591.24	591.24	653.85
		Y	110.00	110.00	110.00	110.00	110.00	85.67	99.16	179.37	85.67	99.16	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00	420.00
		Z	275.00	275.00	275.00	275.00	275.00	-226.34	-251.72	0.00	-226.34	-251.72	-485.99	-528.17	-485.99	-485.99	-377.50	-485.99	-528.17	-485.99	-485.99	-377.50
	Value		**13.40**	**14.21**	**12.59**	**13.57**	**13.23**	**4.24**	**6.72**	**5.72**	**4.25**	**4.51**	**12.05**	**13.10**	**12.44**	**12.53**	**12.05**	**12.05**	**12.36**	**12.89**	**12.31**	**11.98**

TABLE-5.5 STRESSES IN Y-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-22.51	-20.53	-24.49	-23.57	-21.46	-5.78	-8.50	-3.05	-5.77	-5.79	18.76	20.74	16.78	3.88	5.98	17.62	14.90	20.35	1.87	1.86
	B	6	-3.67	-3.03	-4.32	-3.76	-3.59	-3.62	-2.97	-4.26	-3.70	-3.53	-3.87	-3.22	-4.51	-3.95	-3.78	-3.88	-3.23	-4.53	-3.96	-3.79
	C	8	-0.28	-0.25	-0.32	-0.28	-0.29	-0.23	-0.20	-0.26	-0.23	-0.23	-0.17	-0.14	-0.20	-0.16	-0.17	-0.17	-0.14	-0.20	-0.17	-0.17
	D	9	0.21	0.32	0.11	0.21	0.22	0.09	0.18	0.00	0.09	0.09	-0.55	-0.45	-0.65	-0.56	-0.55	-0.53	-0.45	-0.62	-0.54	-0.54
	E	296	1.95	2.19	1.71	1.95	1.95	0.54	0.93	0.16	0.55	0.54	3.46	3.70	3.21	3.39	3.38	3.60	3.98	3.22	3.60	3.58
	F	2	-35.13	-33.74	-36.52	-33.38	-36.87	-4.32	-5.73	-2.92	-3.86	-4.79	-11.58	-10.18	-12.97	6.91	3.43	-10.86	-12.26	-9.45	3.95	3.01
	G	24	0.32	0.45	0.20	0.32	0.33	0.22	0.30	0.13	0.22	0.22	-2.78	-2.65	-2.90	-2.76	-2.76	-2.75	-2.67	-2.84	-2.74	-2.74
	H	23	-6.16	-6.05	-6.28	-6.24	-6.09	-4.18	-4.50	-3.85	-4.24	-4.11	2.45	2.56	2.33	2.51	2.66	2.29	1.96	2.61	2.23	2.36
	I	27	-0.47	-0.69	-0.25	-0.45	-0.50	-0.03	-0.24	0.18	-0.01	-0.05	-2.81	-3.03	-2.59	-2.75	-2.81	-2.84	-3.05	-2.63	-2.82	-2.85
330	A	260	0.29	0.28	0.30	0.29	0.29	-23.22	-29.39	-17.05	-23.01	-23.43	-0.66	-0.67	-0.65	-0.70	-0.70	4.69	-1.48	10.86	5.20	4.79
	B	258	-4.15	-3.33	-4.98	-4.17	-4.14	-4.07	-3.23	-4.92	-4.09	-4.06	-4.41	-3.59	-5.24	-4.44	-4.41	-4.47	-3.63	-5.31	-4.49	-4.45
	C	256	-1.89	-1.89	-1.88	-1.89	-1.88	-1.83	-1.83	-1.82	-1.83	-1.82	-1.86	-1.86	-1.86	-1.86	-1.86	-1.87	-1.87	-1.86	-1.87	-1.87
	D	255	0.01	0.02	-0.01	0.01	0.00	0.00	0.02	-0.01	0.01	0.00	-0.12	-0.10	-0.13	-0.11	-0.12	-0.12	-0.11	-0.13	-0.11	-0.12
	E	2413	0.63	0.57	0.70	0.67	0.60	-0.13	-0.09	-0.16	-0.10	-0.15	-0.44	-0.50	-0.37	-0.43	-0.50	-0.32	-0.28	-0.35	-0.29	-0.34
	F	251	0.03	0.03	0.03	0.03	0.03	0.00	0.00	-0.01	0.00	0.00	-0.58	-0.58	-0.58	-0.59	-0.59	-0.58	-0.58	-0.58	-0.59	-0.59
	G	2453	0.30	0.36	0.24	0.30	0.31	0.20	0.24	0.16	0.20	0.20	-3.10	-3.04	-3.16	-3.10	-3.09	-3.09	-3.04	-3.13	-3.08	-3.08
	H	2447	-5.90	-5.55	-6.26	-5.97	-5.84	-3.56	-3.61	-3.50	-3.60	-3.51	2.45	2.80	2.09	2.46	2.59	2.06	2.01	2.12	2.02	2.11
	I	2441	-0.79	-0.99	-0.59	-0.76	-0.82	-0.05	-0.25	0.14	-0.03	-0.07	-2.74	-2.94	-2.54	-2.69	-2.76	-2.86	-3.05	-2.66	-2.83	-2.87
300	A	240	0.15	0.15	0.16	0.15	0.15	-24.82	-28.49	-21.15	-24.70	-24.94	-0.75	-0.75	-0.74	-0.75	-0.75	4.32	0.65	7.99	4.52	4.28
	B	238	-4.20	-3.71	-4.68	-4.28	-4.12	-4.11	-3.61	-4.62	-4.20	-4.03	-4.27	-3.79	-4.76	-4.36	-4.20	-4.33	-3.83	-4.84	-4.42	-4.25
	C	236	-0.65	-0.65	-0.65	-0.65	-0.65	-0.71	-0.71	-0.71	-0.71	-0.71	-0.64	-0.64	-0.64	-0.64	-0.64	-0.62	-0.62	-0.62	-0.62	-0.62
	D	235	-0.03	-0.03	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.13	-0.13	-0.12
	E	2213	1.00	0.98	1.01	1.00	1.00	-0.13	-0.10	-0.16	-0.14	-0.13	-0.22	-0.23	-0.20	-0.23	-0.23	-0.01	0.02	-0.04	-0.01	0.00
	F	231	0.01	0.01	0.01	0.01	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62
	G	2251	0.31	0.32	0.29	0.30	0.31	0.19	0.20	0.18	0.19	0.19	-3.21	-3.20	-3.23	-3.22	-3.21	-3.20	-3.18	-3.21	-3.20	-3.19
	H	2245	-8.38	-8.60	-8.15	-8.42	-8.34	-3.70	-4.02	-3.37	-3.71	-3.69	2.21	1.98	2.43	2.20	2.27	1.31	0.99	1.64	1.30	1.32
	I	2241	-2.15	-2.40	-1.90	-2.13	-2.17	-0.29	-0.51	-0.08	-0.28	-0.31	-2.31	-2.57	-2.06	-2.29	-2.32	-2.67	-2.89	-2.46	-2.66	-2.69

TABLE-5.5 (contd...) STRESSES IN Y-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.22	0.22	0.21	0.22	0.21	-23.00	-23.31	-22.70	-23.11	-22.90	-0.81	-0.80	-0.81	-0.80	-0.81	2.62	2.31	2.92	2.51	2.73
	B	218	-4.55	-4.48	-4.62	-4.47	-4.62	-4.43	-4.35	-4.51	-4.36	-4.50	-4.55	-4.48	-4.62	-4.48	-4.62	-4.60	-4.52	-4.68	-4.53	-4.68
	C	216	-1.09	-1.06	-1.11	-1.07	-1.10	-1.13	-1.11	-1.16	-1.12	-1.15	-1.05	-1.02	-1.08	-1.03	-1.06	-1.04	-1.01	-1.06	-1.02	-1.05
	D	215	-0.09	-0.09	-0.08	-0.09	-0.09	-0.04	-0.04	-0.04	-0.04	-0.04	-0.23	-0.23	-0.22	-0.23	-0.23	-0.24	-0.24	-0.23	-0.24	-0.24
	E	2051	2.39	2.51	2.26	2.41	2.36	0.05	0.06	0.03	0.06	0.03	0.60	0.73	0.47	0.62	0.57	0.95	0.97	0.94	0.96	0.94
	F	199	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67
	G	2091	0.18	0.17	0.19	0.18	0.18	0.10	0.10	0.11	0.10	0.10	-3.11	-3.12	-3.10	-3.11	-3.11	-3.10	-3.11	-3.09	-3.10	-3.10
	H	2083	-9.80	-10.07	-9.52	-9.89	-9.71	-4.00	-4.01	-4.00	-4.04	-3.96	1.45	1.18	1.73	1.35	1.54	0.51	0.51	0.52	0.47	0.55
	I	2077	0.40	0.41	0.39	0.41	0.39	0.42	0.43	0.40	0.43	0.40	-3.31	-3.30	-3.32	-3.29	-3.31	-3.24	-3.23	-3.26	-3.23	-3.25
240	A	198	0.12	0.13	0.10	0.12	0.12	-25.97	-23.26	-28.69	-26.29	-25.66	-0.81	-0.79	-0.83	-0.81	-0.81	1.56	4.27	-1.16	1.24	1.86
	B	196	-5.32	-6.00	-4.64	-5.31	-5.33	-5.14	-5.83	-4.45	-5.13	-5.14	-5.24	-5.92	-4.57	-5.23	-5.25	-5.28	-5.97	-4.60	-5.28	-5.29
	C	194	-0.92	-0.93	-0.90	-0.92	-0.92	-0.93	-0.94	-0.92	-0.93	-0.93	-0.86	-0.88	-0.85	-0.87	-0.86	-0.87	-0.88	-0.86	-0.87	-0.87
	D	193	-0.08	-0.09	-0.07	-0.08	-0.09	-0.04	-0.04	-0.03	-0.03	-0.04	-0.07	-0.08	-0.07	-0.07	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08
	E	1882	1.06	1.26	0.86	1.13	0.99	-0.19	-0.17	-0.20	-0.14	-0.23	-0.33	-0.13	-0.53	-0.25	-0.39	-0.19	-0.17	-0.20	-0.14	-0.24
	F	189	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72	-0.72
	G	1922	0.07	0.09	0.05	0.07	0.07	0.04	0.05	0.03	0.04	0.04	-3.17	-3.15	-3.19	-3.17	-3.17	-3.17	-3.16	-3.18	-3.16	-3.16
	H	1914	-9.32	-9.70	-8.94	-9.44	-9.20	-4.06	-3.79	-4.33	-4.12	-4.01	0.97	0.59	1.35	0.82	1.06	0.41	0.68	0.14	0.35	0.47
	I	1908	-0.04	-0.01	-0.07	-0.03	-0.05	0.30	0.34	0.26	0.31	0.29	-3.41	-3.38	-3.44	-3.40	-3.41	-3.40	-3.36	-3.44	-3.39	-3.41
210	A	178	0.20	0.25	0.16	0.20	0.20	-23.09	-19.24	-26.94	-23.42	-22.77	-0.80	-0.76	-0.85	-0.80	-0.80	-2.61	1.24	-6.46	-2.94	-2.29
	B	176	-4.70	-5.68	-3.72	-4.79	-4.61	-4.48	-5.48	-3.47	-4.56	-4.39	-4.57	-5.55	-3.58	-4.66	-4.48	-4.58	-5.59	-3.57	-4.67	-4.49
	C	174	-1.19	-1.22	-1.16	-1.19	-1.19	-1.22	-1.25	-1.20	-1.22	-1.23	-1.20	-1.23	-1.18	-1.20	-1.21	-1.20	-1.22	-1.18	-1.20	-1.20
	D	173	0.21	0.16	0.25	0.20	0.21	0.04	-0.01	0.10	0.04	0.05	-0.08	-0.13	-0.04	-0.09	-0.08	-0.07	-0.13	-0.02	-0.08	-0.07
	E	1712	1.83	1.77	1.88	1.84	1.82	-0.31	-0.44	-0.18	-0.32	-0.30	0.38	0.32	0.44	0.39	0.38	0.49	0.36	0.62	0.48	0.50
	F	169	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79	-0.79
	G	1759	0.18	0.17	0.19	0.18	0.18	0.10	0.08	0.12	0.10	0.10	-3.27	-3.28	-3.26	-3.27	-3.27	-3.27	-3.28	-3.25	-3.27	-3.26
	H	1751	-11.32	-10.87	-11.76	-11.44	-11.19	-4.40	-3.19	-5.60	-4.45	-4.34	-0.35	0.09	-0.80	-0.49	-0.24	-0.50	0.70	-1.70	-0.55	-0.45
	I	1745	-0.28	-0.21	-0.36	-0.27	-0.29	0.27	0.31	0.23	0.29	0.26	-3.04	-2.96	-3.11	-3.02	-3.05	-3.08	-3.04	-3.12	-3.06	-3.09
180	A	158	0.02	0.04	0.00	0.02	0.02	-21.43	-17.15	-25.71	-21.83	-21.02	-0.74	-0.72	-0.76	-0.74	-0.74	-6.47	-2.19	-10.75	-6.88	-6.07
	B	156	-4.18	-5.13	-3.22	-4.20	-4.15	-3.94	-4.92	-2.96	-3.96	-3.92	-4.03	-4.99	-3.08	-4.06	-4.01	-4.01	-4.99	-3.03	-4.03	-3.98
	C	154	-1.55	-1.55	-1.55	-1.55	-1.55	-1.54	-1.53	-1.55	-1.55	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.54	-1.53	-1.55	-1.54	-1.53
	D	153	0.11	0.06	0.16	0.11	0.11	0.03	-0.05	0.10	0.03	0.02	-0.09	-0.14	-0.04	-0.09	-0.09	-0.10	-0.17	-0.03	-0.10	-0.10
	E	1560	1.52	1.16	1.88	1.53	1.51	-0.52	-0.61	-0.44	-0.53	-0.52	0.11	-0.25	0.47	0.12	0.10	0.11	0.03	0.19	0.10	0.12
	F	149	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.68	-0.67	-0.68	-0.68	-0.68	-0.68	-0.68	-0.68	-0.68	-0.68
	G	1594	0.30	0.21	0.38	0.30	0.29	0.15	0.08	0.22	0.15	0.15	-3.11	-3.19	-3.02	-3.10	-3.11	-3.12	-3.18	-3.05	-3.11	-3.12
	H	1588	-10.03	-10.37	-9.68	-10.19	-9.86	-4.36	-3.50	-5.23	-4.47	-4.26	-1.33	-1.67	-0.99	-1.51	-1.18	-0.93	-0.06	-1.79	-1.03	-0.83
	I	1582	-1.42	-1.17	-1.67	-1.40	-1.44	0.20	0.40	0.00	0.23	0.17	-2.53	-2.28	-2.78	-2.51	-2.56	-2.48	-2.28	-2.68	-2.45	-2.51

TABLE-5.5 (contd...) STRESSES IN Y-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	0.13	0.17	0.10	0.14	0.13	-22.11	-18.41	-25.80	-22.42	-21.80	-0.80	-0.77	-0.84	-0.80	-0.80	-9.58	-5.88	-13.27	-9.89	-9.27
	B	134	-4.30	-5.17	-3.44	-4.30	-4.30	-4.04	-4.92	-3.17	-4.04	-4.05	-4.14	-5.00	-3.27	-4.14	-4.14	-4.08	-4.96	-3.20	-4.08	-4.08
	C	132	-1.38	-1.40	-1.35	-1.37	-1.38	-1.40	-1.43	-1.38	-1.40	-1.41	-1.39	-1.42	-1.36	-1.39	-1.40	-1.40	-1.42	-1.37	-1.39	-1.40
	D	131	-0.10	-0.12	-0.07	-0.09	-0.10	-0.07	-0.09	-0.04	-0.06	-0.07	-0.09	-0.11	-0.07	-0.08	-0.10	-0.09	-0.12	-0.07	-0.09	-0.10
	E	1393	0.37	1.84	-1.11	0.40	0.34	-1.09	-0.30	-1.88	-1.06	-1.12	-0.24	1.24	-1.71	-0.18	-0.23	-0.40	0.39	-1.19	-0.38	-0.43
	F	127	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.81	-0.81	-0.81	-0.81	-0.81	-0.81	-0.81	-0.81	-0.81	-0.81
	G	1431	0.16	0.14	0.18	0.16	0.16	0.07	0.05	0.10	0.07	0.08	-3.31	-3.33	-3.29	-3.31	-3.31	-3.32	-3.34	-3.30	-3.32	-3.32
	H	1423	-12.15	-11.70	-12.61	-12.29	-12.02	-4.44	-3.13	-5.75	-4.50	-4.38	-2.34	-1.88	-2.79	-2.48	-2.21	-1.34	-0.03	-2.66	-1.41	-1.29
	I	1417	0.56	0.54	0.58	0.57	0.55	0.92	0.71	1.13	0.94	0.90	-3.15	-3.17	-3.13	-3.14	-3.16	-2.96	-3.17	-2.74	-2.94	-2.98
120	A	116	0.10	0.12	0.09	0.11	0.10	-21.15	-19.37	-22.93	-21.16	-21.14	-0.74	-0.72	-0.75	-0.73	-0.74	-10.88	-9.10	-12.67	-10.89	-10.87
	B	112	-4.13	-4.64	-3.62	-4.13	-4.12	-3.90	-4.41	-3.39	-3.90	-3.90	-4.00	-4.51	-3.49	-4.00	-3.99	-3.92	-4.44	-3.41	-3.93	-3.92
	C	113	-1.14	-1.17	-1.11	-1.14	-1.15	-1.21	-1.24	-1.17	-1.20	-1.21	-1.18	-1.22	-1.15	-1.18	-1.19	-1.20	-1.23	-1.16	-1.19	-1.20
	D	111	-0.09	-0.11	-0.07	-0.09	-0.08	-0.03	-0.06	0.00	-0.03	-0.03	-0.07	-0.09	-0.05	-0.07	-0.06	-0.07	-0.11	-0.04	-0.08	-0.07
	E	1233	1.24	1.61	0.86	1.23	1.24	-1.18	-0.89	-1.48	-1.20	-1.17	0.85	1.22	0.48	0.84	0.84	0.65	0.94	0.36	0.63	0.66
	F	107	0.05	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02	0.02	-0.69	-0.69	-0.69	-0.69	-0.69	-0.69	-0.70	-0.69	-0.69	-0.69
	G	1269	0.42	0.41	0.43	0.41	0.43	0.13	0.11	0.15	0.12	0.14	-2.88	-2.89	-2.86	-2.89	-2.87	-2.90	-2.92	-2.88	-2.91	-2.89
	H	1263	-12.09	-12.54	-11.63	-12.11	-12.06	-4.60	-4.07	-5.14	-4.62	-4.59	-2.79	-3.24	-2.34	-2.85	-2.81	-1.54	-1.01	-2.08	-1.56	-1.54
	I	1255	-0.04	-0.13	0.04	-0.03	-0.06	0.52	0.41	0.62	0.52	0.51	-2.80	-2.89	-2.72	-2.78	-2.82	-2.67	-2.77	-2.57	-2.66	-2.68
90	A	96	0.06	0.06	0.06	0.06	0.06	-27.65	-28.45	-26.84	-27.43	-27.87	-0.64	-0.64	-0.64	-0.63	-0.63	-11.16	-11.97	-10.36	-10.89	-11.33
	B	94	-4.35	-4.36	-4.34	-4.34	-4.37	-4.23	-4.24	-4.22	-4.21	-4.25	-4.30	-4.31	-4.29	-4.28	-4.32	-4.25	-4.26	-4.24	-4.23	-4.27
	C	90	-1.47	-1.48	-1.46	-1.47	-1.47	-1.47	-1.48	-1.47	-1.47	-1.47	-1.47	-1.47	-1.46	-1.47	-1.47	-1.47	-1.47	-1.46	-1.47	-1.47
	D	89	0.06	0.05	0.07	0.06	0.06	0.07	0.06	0.08	0.07	0.06	0.06	0.05	0.07	0.06	0.06	0.05	0.04	0.06	0.05	0.05
	E	1064	1.56	1.55	1.57	1.64	1.49	-1.87	-1.87	-1.87	-1.86	-1.88	1.92	1.91	1.93	1.92	1.77	1.71	1.70	1.71	1.71	1.69
	F	85	0.12	0.13	0.11	0.12	0.12	0.04	0.04	0.03	0.04	0.04	-0.79	-0.78	-0.80	-0.79	-0.79	-0.80	-0.79	-0.80	-0.79	-0.79
	G	1121	0.56	0.74	0.39	0.55	0.58	0.04	0.10	-0.01	0.03	0.06	-2.56	-2.38	-2.74	-2.57	-2.54	-2.58	-2.53	-2.64	-2.60	-2.56
	H	1113	-15.51	-16.57	-14.45	-15.37	-15.64	-4.39	-4.58	-4.21	-4.32	-4.46	-1.97	-3.02	-0.91	-1.87	-2.14	-0.51	-0.69	-0.32	-0.44	-0.58
	I	1105	-0.65	-0.90	-0.40	-0.62	-0.67	0.89	0.87	0.91	0.89	0.88	-2.82	-3.07	-2.57	-2.78	-2.84	-2.36	-2.38	-2.34	-2.36	-2.38
60	A	64	0.06	0.08	0.04	0.06	0.06	-35.36	-41.94	-28.78	-34.58	-36.14	-0.64	-0.62	-0.65	-0.64	-0.63	-3.21	-9.79	3.37	-2.14	-3.70
	B	59	-4.79	-4.20	-5.38	-4.80	-4.78	-4.69	-4.09	-5.28	-4.70	-4.67	-4.75	-4.16	-5.34	-4.77	-4.75	-4.72	-4.12	-5.32	-4.73	-4.71
	C	61	-1.16	-1.13	-1.18	-1.16	-1.16	-1.17	-1.15	-1.20	-1.17	-1.18	-1.19	-1.16	-1.21	-1.18	-1.19	-1.19	-1.16	-1.21	-1.19	-1.19
	D	62	-0.11	-0.13	-0.10	-0.11	-0.12	-0.10	-0.09	-0.11	-0.10	-0.10	-0.10	-0.12	-0.09	-0.10	-0.11	-0.11	-0.11	-0.12	-0.11	-0.11
	E	978	-5.46	-5.74	-5.18	-5.58	-5.34	-5.39	-6.82	-3.97	-5.50	-5.29	4.37	4.09	4.65	4.43	4.68	4.19	2.77	5.61	4.12	4.33
	F	56	0.11	0.14	0.08	0.11	0.11	0.03	0.04	0.01	0.02	0.03	-0.66	-0.64	-0.69	-0.67	-0.66	-0.66	-0.65	-0.67	-0.67	-0.66
	G	727	-0.62	0.12	-1.37	-0.62	-0.62	-0.74	-0.72	-0.75	-0.74	-0.73	-2.50	-1.75	-3.24	-2.42	-2.42	-2.47	-2.45	-2.49	-2.47	-2.46
	H	715	-21.31	-24.06	-18.57	-20.96	-21.67	-3.31	-4.30	-2.32	-3.20	-3.42	1.35	-1.40	4.10	1.67	0.95	2.08	1.10	3.07	2.26	2.04
	I	707	-2.64	-3.45	-1.84	-2.61	-2.68	2.46	2.93	1.98	2.35	2.57	-3.30	-4.10	-2.49	-3.26	-3.33	-2.43	-1.95	-2.90	-2.54	-2.33

TABLE-5.5 (contd....) STRESSES IN Y-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	3.84	4.03	3.64	3.79	3.89	-11.68	-6.24	-17.12	-11.27	-12.09	-0.12	0.08	-0.31	-0.38	-0.29	0.30	5.74	-5.14	1.29	0.47
	B	34	-5.30	-4.27	-6.34	-5.30	-5.30	-5.26	-4.20	-6.31	-5.26	-5.25	-5.30	-4.26	-6.33	-5.32	-5.32	-5.34	-4.29	-6.40	-5.35	-5.34
	C	38	-0.96	-0.95	-0.97	-0.96	-0.96	-0.96	-0.94	-0.97	-0.95	-0.96	-0.91	-0.90	-0.92	-0.91	-0.91	-0.91	-0.90	-0.92	-0.91	-0.91
	D	35	0.08	0.19	-0.04	0.09	0.07	0.08	0.17	-0.01	0.09	0.07	-0.54	-0.42	-0.66	-0.53	-0.55	-0.53	-0.44	-0.62	-0.53	-0.54
	E	486	0.38	-0.52	1.27	0.32	0.43	-0.35	-0.73	0.04	-0.39	-0.31	5.45	4.56	6.35	5.31	5.43	5.40	5.01	5.78	5.35	5.44
	F	465	1.17	1.18	1.16	1.15	1.19	0.12	0.16	0.08	0.11	0.13	0.07	0.08	0.06	-0.18	-0.13	0.15	0.19	0.12	-0.05	-0.03
	G	644	0.35	0.39	0.30	0.33	0.36	0.09	0.10	0.07	0.08	0.09	-3.44	-3.40	-3.48	-3.43	-3.40	-3.42	-3.40	-3.44	-3.41	-3.40
	H	47	-5.35	-5.22	-5.49	-5.73	-4.98	-4.58	-4.88	-4.29	-4.87	-4.29	3.55	3.69	3.42	3.26	4.01	3.51	3.21	3.80	3.23	3.80
	I	637	0.29	0.35	0.22	0.31	0.27	0.24	0.34	0.15	0.26	0.23	-2.93	-2.87	-3.00	-2.92	-2.96	-2.94	-2.84	-3.03	-2.92	-2.95
Minimum	**Node**	**No.**	**22605**	**22606**	**22605**	**22605**	**330**	**845**	**845**	**1199**	**845**	**845**	**2**	**262**	**2**	**262**	**262**	**1199**	**1199**	**1199**	**1199**	**1199**
		X	309.3	307.2	309.3	309.3	306.7	204.2	204.2	-40.3	204.2	204.2	275.0	1100.0	275.0	1100.0	1100.0	-40.3	-40.3	-40.3	-40.3	-40.3
		Y	40.2	-19.3	40.2	40.2	-7.8	110.0	110.0	110.0	110.0	110.0	-110.0	-450.0	-110.0	-450.0	-450.0	110.0	110.0	110.0	110.0	110.0
		Z	-34.1	-40.4	-34.1	-34.1	0.0	-256.0	-256.0	-325.0	-256.0	-256.0	0.0	1025.0	0.0	1025.0	1025.0	-325.0	-325.0	-325.0	-325.0	-325.0
	Value		**-48.36**	**-50.11**	**-49.08**	**-48.24**	**-49.03**	**-39.21**	**-46.93**	**-37.18**	**-38.31**	**-40.11**	**-11.58**	**-14.80**	**-12.97**	**-11.05**	**-11.43**	**-16.80**	**-16.45**	**-17.14**	**-16.52**	**-17.00**
Maximum	**Node**	**No.**	**22118**	**22118**	**22118**	**22118**	**22118**	**2736**	**4921**	**22797**	**2736**	**4921**	**337**	**337**	**337**	**4**	**4**	**337**	**337**	**5**	**2575**	**249**
		X	301.83	301.83	301.83	301.83	301.83	281.16	221.13	297.53	281.16	221.13	275.00	275.00	275.00	275.00	275.00	275.00	275.00	327.50	324.70	194.45
		Y	110.00	110.00	110.00	110.00	110.00	77.43	102.88	84.31	77.43	102.88	1.70	1.70	1.70	110.00	110.00	1.70	1.70	110.00	110.00	110.00
		Z	39.74	39.74	39.74	39.74	39.74	-136.35	-264.54	0.00	-136.35	-264.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.75	194.45
	Value		**7.45**	**7.42**	**7.48**	**7.66**	**7.24**	**8.37**	**10.49**	**6.74**	**8.16**	**8.59**	**25.36**	**25.17**	**25.55**	**17.74**	**19.43**	**18.99**	**20.05**	**20.35**	**7.91**	**8.14**

TABLE-5.6 STRESSES IN Z-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-13.12	-13.11	-13.14	-14.19	-12.06	-2.24	-4.03	-0.45	-0.79	-3.69	0.02	0.03	0.00	1.85	3.97	0.63	-1.16	2.43	0.38	-2.51
	B	6	-9.04	-7.90	-10.18	-9.32	-8.75	1.23	2.27	0.19	0.63	1.84	3.09	4.23	1.94	2.67	3.24	1.00	2.04	-0.04	0.56	1.77
	C	8	-5.89	-5.68	-6.11	-5.61	-6.18	-1.12	-1.67	-0.57	-0.97	-1.26	2.04	2.26	1.83	2.72	2.15	1.87	1.32	2.42	2.06	1.77
	D	9	-0.14	0.58	-0.86	0.00	-0.28	0.23	0.66	-0.20	0.34	0.11	0.73	1.45	0.01	0.95	0.67	0.77	1.20	0.34	0.89	0.65
	E	296	1.27	1.64	0.91	1.30	1.25	0.62	0.98	0.27	0.65	0.59	1.68	2.05	1.31	1.70	1.64	1.76	2.12	1.40	1.78	1.72
	F	2	-3.97	-3.82	-4.12	-3.49	-4.45	-0.78	-1.13	-0.43	-0.62	-0.94	-2.46	-2.31	-2.61	0.17	-0.79	-2.15	-2.50	-1.80	-0.06	-0.38
	G	24	0.26	0.37	0.15	0.25	0.27	0.15	0.23	0.07	0.15	0.16	0.68	0.79	0.57	0.67	0.69	0.70	0.78	0.62	0.69	0.70
	H	23	-0.91	-0.72	-1.10	-0.90	-0.92	-0.55	-0.50	-0.60	-0.54	-0.55	0.68	0.87	0.50	0.72	0.70	0.66	0.71	0.61	0.67	0.65
	I	27	0.00	0.02	-0.01	0.24	-0.23	0.98	1.08	0.87	1.15	0.80	1.97	1.98	1.95	2.14	1.67	1.78	1.88	1.67	1.96	1.61
330	A	260	8.34	8.02	8.65	8.27	8.40	-5.58	-7.16	-3.99	-5.71	-5.44	-6.52	-6.83	-6.21	-6.67	-6.54	0.79	-0.80	2.37	0.71	0.98
	B	258	-10.63	-9.11	-12.15	-9.84	-11.42	2.10	3.33	0.86	2.82	1.38	4.09	5.61	2.56	4.92	3.34	0.87	2.10	-0.36	1.55	0.11
	C	256	-7.49	-6.94	-8.05	-6.83	-8.16	-1.63	-2.00	-1.26	-1.05	-2.21	4.53	5.08	3.97	5.21	3.89	3.10	2.73	3.47	3.67	2.50
	D	255	-0.03	-0.10	0.04	0.01	-0.08	0.11	0.08	0.13	0.15	0.07	-0.06	-0.13	0.01	-0.03	-0.13	-0.14	-0.17	-0.12	-0.10	-0.18
	E	2413	-0.10	-0.17	-0.03	-0.02	-0.18	-0.10	-0.16	-0.05	-0.04	-0.17	-0.40	-0.47	-0.32	-0.32	-0.47	-0.40	-0.45	-0.34	-0.33	-0.46
	F	251	0.74	0.73	0.76	0.76	0.73	0.02	0.00	0.03	0.03	0.00	-2.81	-2.82	-2.79	-2.75	-2.79	-2.71	-2.72	-2.70	-2.67	-2.69
	G	2453	0.39	0.47	0.32	0.38	0.41	0.17	0.23	0.11	0.16	0.18	1.41	1.49	1.33	1.37	1.40	1.43	1.49	1.37	1.40	1.42
	H	2447	-0.14	0.00	-0.28	-0.16	-0.12	-0.08	0.01	-0.17	-0.10	-0.07	0.47	0.61	0.32	0.45	0.49	0.45	0.54	0.36	0.44	0.46
	I	2441	-2.69	-3.13	-2.26	-1.99	-3.40	0.02	-0.48	0.51	0.54	-0.51	1.73	1.30	2.17	2.52	1.11	1.50	1.01	2.00	2.06	1.00
300	A	240	3.44	3.49	3.38	3.48	3.39	-5.81	-6.87	-4.75	-5.91	-5.70	-4.17	-4.12	-4.22	-4.06	-4.15	0.51	-0.55	1.57	0.42	0.63
	B	238	-3.57	-3.74	-3.41	-3.20	-3.94	1.00	0.88	1.11	1.40	0.59	1.70	1.54	1.87	2.12	1.37	0.74	0.62	0.85	1.12	0.31
	C	236	-3.51	-3.10	-3.92	-3.00	-4.02	-3.07	-3.31	-2.83	-2.57	-3.57	3.40	3.81	3.00	3.90	2.88	3.29	3.05	3.53	3.77	2.77
	D	235	-0.07	-0.08	-0.07	-0.08	-0.06	0.00	-0.01	0.00	-0.01	0.00	-0.04	-0.05	-0.04	-0.06	-0.03	-0.06	-0.07	-0.06	-0.07	-0.05
	E	2213	-0.04	-0.05	-0.03	-0.04	-0.04	-0.01	-0.02	0.00	-0.01	-0.01	0.06	0.05	0.06	0.06	0.06	0.05	0.04	0.06	0.05	0.05
	F	231	0.18	0.18	0.17	0.18	0.17	-0.02	-0.02	-0.02	-0.02	-0.03	-2.73	-2.72	-2.73	-2.72	-2.72	-2.70	-2.70	-2.70	-2.69	-2.70
	G	2251	0.90	0.96	0.85	0.88	0.93	0.40	0.44	0.37	0.38	0.42	3.14	3.19	3.08	3.11	3.16	3.18	3.22	3.15	3.17	3.21
	H	2245	-0.97	-0.81	-1.12	-0.94	-0.99	-0.37	-0.34	-0.40	-0.35	-0.39	-1.77	-1.62	-1.93	-1.73	-1.78	-1.87	-1.84	-1.91	-1.85	-1.89
	I	2241	-7.66	-8.06	-7.26	-7.13	-8.19	-0.62	-1.16	-0.09	-0.23	-1.02	2.85	2.45	3.24	3.48	2.43	1.68	1.14	2.21	2.08	1.29

TABLE-5.6 (contd....) STRESSES IN Z-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.02	0.02	0.02	0.02	0.02	-4.87	-4.93	-4.81	-4.90	-4.85	-2.78	-2.78	-2.78	-2.78	-2.78	-0.59	-0.65	-0.52	-0.61	-0.56
	B	218	0.57	0.62	0.53	0.69	0.46	0.81	0.87	0.74	0.92	0.70	0.72	0.77	0.67	0.83	0.60	0.65	0.71	0.58	0.76	0.54
	C	216	0.01	0.09	-0.07	-0.04	0.05	-3.32	-3.37	-3.27	-3.34	-3.30	2.25	2.33	2.17	2.19	2.28	2.79	2.74	2.84	2.77	2.81
	D	215	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
	E	2051	-0.22	-0.24	-0.21	-0.22	-0.22	-0.03	-0.02	-0.03	-0.03	-0.03	0.02	0.00	0.03	0.02	0.02	0.00	0.00	-0.01	0.00	0.00
	F	199	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78	-2.78
	G	2091	1.31	1.34	1.28	1.32	1.30	0.60	0.59	0.61	0.61	0.59	4.10	4.13	4.07	4.13	4.10	4.15	4.14	4.17	4.19	4.16
	H	2083	-0.94	-1.02	-0.87	-0.96	-0.92	-0.36	-0.38	-0.34	-0.37	-0.35	-3.16	-3.24	-3.09	-3.18	-3.15	-3.25	-3.27	-3.23	-3.26	-3.24
	I	2077	2.27	2.35	2.19	2.48	2.06	3.19	3.34	3.05	3.28	3.10	6.06	6.14	5.98	6.42	6.01	6.46	6.60	6.31	6.55	6.37
240	A	198	2.77	3.04	2.51	2.80	2.74	-6.12	-5.28	-6.95	-6.07	-6.17	-3.36	-3.10	-3.62	-3.34	-3.40	-0.19	0.65	-1.02	-0.14	-0.24
	B	196	-3.35	-3.59	-3.12	-4.20	-2.50	0.80	1.03	0.57	-0.02	1.62	2.01	1.78	2.25	1.16	2.86	1.34	1.57	1.11	0.52	2.16
	C	194	-1.49	-1.72	-1.27	-2.10	-0.89	-2.24	-2.06	-2.42	-2.76	-1.71	2.61	2.39	2.83	1.94	3.16	2.18	2.36	2.01	1.66	2.71
	D	193	-0.11	-0.13	-0.09	-0.11	-0.12	-0.01	-0.01	0.00	0.00	-0.01	-0.04	-0.06	-0.02	-0.03	-0.05	-0.05	-0.06	-0.05	-0.05	-0.06
	E	1882	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	F	189	0.02	0.03	0.02	0.02	0.02	-0.02	-0.02	-0.03	-0.03	-0.02	-2.48	-2.47	-2.48	-2.49	-2.48	-2.48	-2.48	-2.48	-2.49	-2.49
	G	1922	0.70	0.69	0.70	0.71	0.68	0.32	0.28	0.35	0.33	0.31	2.25	2.24	2.26	2.27	2.24	2.25	2.22	2.29	2.27	2.25
	H	1914	0.00	-0.06	0.06	-0.02	0.02	-0.03	-0.04	-0.01	-0.04	-0.01	-1.45	-1.51	-1.39	-1.47	-1.43	-1.44	-1.46	-1.43	-1.46	-1.43
	I	1908	-0.22	-0.70	0.26	-0.64	0.20	2.17	1.66	2.68	1.86	2.49	4.41	3.93	4.89	4.00	4.84	4.74	4.24	5.25	4.43	5.06
210	A	178	7.11	8.48	5.75	7.22	7.01	-6.01	-4.60	-7.42	-5.72	-6.29	-2.45	-1.08	-3.81	-2.34	-2.55	-1.10	0.31	-2.50	-0.81	-1.38
	B	176	-10.06	-11.95	-8.16	-11.30	-8.81	0.81	0.14	1.48	-0.33	1.95	2.90	1.00	4.79	1.55	4.04	2.51	1.84	3.17	1.37	3.65
	C	174	-5.13	-5.82	-4.45	-5.78	-4.49	-1.04	-0.69	-1.40	-1.58	-0.51	2.14	1.46	2.83	1.44	2.73	1.59	1.94	1.24	1.05	2.13
	D	173	-0.51	-1.06	0.04	-0.76	-0.26	0.17	-0.16	0.50	-0.02	0.37	1.72	1.17	2.27	1.45	1.95	1.45	1.12	1.78	1.25	1.64
	E	1712	0.16	-0.12	0.44	-0.08	0.40	0.20	0.04	0.36	0.01	0.39	0.82	0.54	1.09	0.57	1.05	0.86	0.70	1.02	0.67	1.05
	F	169	0.19	0.21	0.17	0.18	0.20	0.02	0.01	0.03	0.01	0.03	-1.87	-1.86	-1.89	-1.88	-1.87	-1.88	-1.89	-1.87	-1.89	-1.87
	G	1759	0.80	0.68	0.91	0.81	0.78	0.35	0.23	0.46	0.36	0.34	1.33	1.22	1.45	1.34	1.32	1.31	1.20	1.43	1.32	1.31
	H	1751	-0.67	-0.87	-0.47	-0.80	-0.54	-0.22	-0.21	-0.23	-0.32	-0.12	1.22	1.02	1.42	1.08	1.34	1.23	1.24	1.23	1.13	1.34
	I	1745	1.50	1.47	1.52	1.07	1.92	1.48	0.99	1.97	1.17	1.79	2.64	2.62	2.66	2.18	3.03	3.11	2.62	3.61	2.80	3.43
180	A	158	7.28	9.12	5.44	7.42	7.15	-5.58	-4.61	-6.55	-5.71	-5.45	0.40	2.24	-1.44	0.52	0.25	-2.03	-1.06	-3.00	-2.16	-1.90
	B	156	-11.47	-13.33	-9.60	-11.90	-11.04	0.68	-0.22	1.59	0.37	1.00	0.85	-1.02	2.71	0.26	1.12	2.00	1.10	2.91	1.70	2.32
	C	154	-4.67	-5.66	-3.68	-4.85	-4.50	-0.37	-0.18	-0.57	-0.49	-0.25	0.67	-0.32	1.66	0.46	0.81	1.10	1.30	0.90	0.98	1.22
	D	153	-2.80	-4.65	-0.94	-3.02	-2.57	0.10	-0.45	0.65	-0.07	0.27	1.42	-0.44	3.28	1.18	1.64	1.68	1.13	2.24	1.52	1.85
	E	1560	0.29	-1.23	1.81	0.15	0.44	0.45	-0.24	1.14	0.34	0.57	2.09	0.56	3.61	1.94	2.23	2.14	1.45	2.82	2.02	2.25
	F	149	0.45	0.46	0.44	0.44	0.47	0.13	0.10	0.16	0.11	0.14	-1.15	-1.14	-1.15	-1.16	-1.13	-1.17	-1.20	-1.14	-1.18	-1.15
	G	1594	1.02	0.81	1.23	0.99	1.05	0.40	0.22	0.58	0.38	0.43	0.46	0.25	0.66	0.42	0.48	0.42	0.25	0.61	0.40	0.46
	H	1588	-0.86	-1.09	-0.64	-0.97	-0.76	-0.37	-0.38	-0.35	-0.45	-0.29	0.73	0.51	0.96	0.62	0.83	0.78	0.77	0.80	0.70	0.86
	I	1582	0.28	0.40	0.17	0.32	0.25	0.94	0.69	1.18	0.97	0.90	2.57	2.68	2.45	2.58	2.51	2.21	1.97	2.46	2.25	2.18

TABLE-5.6 (contd....) STRESSES IN Z-DIRECTION

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	3.72	4.68	2.76	3.79	3.65	-5.34	-4.07	-6.61	-5.75	-4.93	1.11	2.07	0.15	1.17	1.04	-3.01	-1.74	-4.28	-3.42	-2.61
	B	134	-6.48	-7.37	-5.59	-6.03	-6.93	1.11	0.65	1.57	1.58	0.64	-0.60	-1.49	0.29	-0.23	-1.13	1.07	0.61	1.53	1.55	0.61
	C	132	-0.39	-0.57	-0.21	-0.10	-0.68	-0.21	-0.01	-0.42	0.04	-0.46	-0.21	-0.39	-0.03	0.04	-0.54	0.32	0.53	0.12	0.58	0.08
	D	131	-0.18	-0.25	-0.10	-0.20	-0.15	0.03	-0.01	0.06	0.01	0.04	-0.19	-0.26	-0.11	-0.21	-0.17	-0.09	-0.13	-0.06	-0.11	-0.08
	E	1393	0.00	-0.07	0.07	0.02	-0.01	-0.01	-0.03	0.01	0.00	-0.02	-0.04	-0.11	0.02	-0.03	-0.06	-0.08	-0.11	-0.06	-0.07	-0.10
	F	127	0.67	0.75	0.59	0.65	0.69	0.21	0.22	0.21	0.19	0.23	-1.03	-0.95	-1.11	-1.06	-1.02	-1.08	-1.07	-1.08	-1.10	-1.06
	G	1431	2.00	1.87	2.13	1.90	2.10	0.70	0.54	0.87	0.61	0.80	2.29	2.16	2.42	2.17	2.37	2.21	2.04	2.37	2.10	2.30
	H	1423	-0.23	-0.30	-0.16	-0.27	-0.19	-0.18	-0.15	-0.22	-0.21	-0.15	-0.11	-0.17	-0.04	-0.15	-0.07	-0.10	-0.06	-0.13	-0.13	-0.07
	I	1417	-0.96	-1.33	-0.58	-0.62	-1.29	1.44	0.58	2.30	1.54	1.34	5.39	5.02	5.76	5.68	5.00	3.92	3.06	4.78	4.02	3.82
120	A	116	0.77	0.69	0.86	0.78	0.77	-5.34	-3.82	-6.85	-5.82	-4.85	-0.69	-0.78	-0.60	-0.69	-0.69	-3.82	-2.31	-5.33	-4.30	-3.33
	B	114	-1.02	-0.62	-1.42	-0.34	-1.69	1.09	1.48	0.70	1.74	0.45	-0.11	0.29	-0.51	0.57	-0.78	0.50	0.89	0.11	1.14	-0.15
	C	112	1.05	1.37	0.73	1.30	0.80	-0.48	-0.24	-0.71	-0.28	-0.67	-0.40	-0.08	-0.72	-0.18	-0.67	-0.58	-0.34	-0.81	-0.38	-0.77
	D	111	0.04	0.03	0.05	0.03	0.06	0.08	0.06	0.10	0.07	0.09	0.06	0.05	0.07	0.05	0.07	0.06	0.04	0.07	0.05	0.07
	E	1233	-0.15	-0.12	-0.17	-0.15	-0.15	-0.03	0.00	-0.05	-0.03	-0.03	-0.07	-0.04	-0.10	-0.07	-0.07	-0.05	-0.03	-0.08	-0.05	-0.05
	F	107	0.56	0.73	0.39	0.54	0.58	0.16	0.22	0.10	0.14	0.18	-1.65	-1.48	-1.82	-1.68	-1.64	-1.68	-1.62	-1.74	-1.71	-1.67
	G	1269	3.93	4.14	3.72	3.81	4.04	1.03	1.01	1.05	0.90	1.16	5.50	5.71	5.29	5.36	5.58	5.26	5.23	5.28	5.14	5.39
	H	1263	-0.59	-0.51	-0.66	-0.61	-0.56	-0.32	-0.26	-0.39	-0.35	-0.30	-3.11	-3.04	-3.19	-3.14	-3.08	-3.06	-2.99	-3.13	-3.08	-3.04
	I	1255	-3.25	-4.63	-1.86	-2.97	-3.53	3.10	2.09	4.10	3.09	3.10	7.05	5.66	8.43	7.32	6.75	7.68	6.67	8.68	7.68	7.69
90	A	96	0.38	0.40	0.35	0.37	0.38	-8.02	-8.09	-7.95	-7.97	-8.07	-1.94	-1.92	-1.97	-1.94	-1.93	-3.62	-3.69	-3.55	-3.54	-3.64
	B	94	0.71	0.71	0.71	0.75	0.67	0.92	0.92	0.92	0.96	0.88	0.79	0.79	0.79	0.83	0.75	0.86	0.86	0.86	0.90	0.82
	C	90	0.26	0.31	0.20	0.25	0.26	-0.29	-0.27	-0.30	-0.29	-0.29	-0.20	-0.14	-0.26	-0.19	-0.19	-0.31	-0.29	-0.32	-0.31	-0.31
	D	89	0.14	0.13	0.15	0.14	0.14	0.18	0.18	0.19	0.18	0.18	0.17	0.16	0.18	0.17	0.17	0.17	0.17	0.18	0.17	0.17
	E	1064	-0.18	-0.21	-0.16	-0.19	-0.18	0.00	-0.01	0.01	0.00	0.00	-0.06	-0.09	-0.04	-0.06	-0.06	-0.03	-0.04	-0.02	-0.03	-0.03
	F	85	0.18	0.19	0.17	0.18	0.19	0.09	0.10	0.09	0.09	0.09	-2.28	-2.27	-2.29	-2.28	-2.27	-2.29	-2.28	-2.30	-2.28	-2.28
	G	1121	4.73	5.21	4.25	4.76	4.70	0.82	0.94	0.69	0.78	0.86	5.70	6.17	5.22	5.76	5.69	5.48	5.60	5.35	5.53	5.60
	H	1113	-0.66	-0.61	-0.71	-0.68	-0.65	-0.21	-0.22	-0.20	-0.22	-0.20	-3.21	-3.16	-3.26	-3.21	-3.19	-3.19	-3.20	-3.18	-3.20	-3.18
	I	1105	-3.26	-3.87	-2.64	-3.26	-3.25	5.36	5.62	5.11	5.33	5.39	6.26	5.65	6.88	6.44	6.44	9.79	10.04	9.53	9.76	9.81
60	A	64	0.49	0.87	0.12	0.40	0.59	-10.36	-13.28	-7.44	-9.25	-11.48	-0.35	0.02	-0.73	-0.22	-0.04	-0.45	-3.37	2.46	0.79	-1.44
	B	59	0.03	-0.37	0.42	-0.85	0.90	0.94	0.79	1.09	0.06	1.82	0.49	0.09	0.88	-0.42	1.32	1.13	0.98	1.28	0.22	1.98
	C	61	0.58	0.28	0.87	0.36	0.79	-0.31	-0.60	-0.02	-0.50	-0.11	-0.86	-1.15	-0.57	-1.10	-0.67	-0.45	-0.74	-0.16	-0.66	-0.27
	D	62	0.04	0.04	0.04	0.06	0.02	0.06	0.08	0.05	0.08	0.05	-0.02	-0.01	-0.02	0.00	-0.03	-0.03	-0.01	-0.05	-0.01	-0.05
	E	978	-0.79	-0.84	-0.75	-0.82	-0.77	0.07	0.18	-0.05	0.05	0.08	-0.06	-0.11	-0.02	-0.12	-0.07	-0.19	-0.07	-0.31	-0.21	-0.18
	F	56	0.84	0.71	0.97	0.86	0.82	0.32	0.30	0.33	0.34	0.30	-1.35	-1.48	-1.22	-1.30	-1.35	-1.39	-1.41	-1.37	-1.33	-1.37
	G	727	3.34	3.89	2.79	3.61	3.07	-0.04	-0.09	0.00	0.09	-0.18	2.51	3.06	1.96	2.79	2.25	2.55	2.51	2.59	2.73	2.45
	H	715	-3.01	-2.60	-3.42	-3.16	-2.86	-0.40	-0.89	0.08	-0.37	-0.44	0.20	0.61	-0.21	0.28	0.58	-0.29	-0.78	0.19	-0.22	-0.29
	I	707	-4.62	-4.25	-4.99	-4.94	-4.30	7.02	8.25	5.80	7.71	6.33	4.28	4.65	3.91	4.34	4.99	6.26	7.48	5.04	6.96	5.58

TABLE-5.6 (contd....) STRESSES IN Z-DIRECTION

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	0.91	0.94	0.88	0.65	1.17	-2.88	-1.68	-4.07	-2.80	-2.95	-1.10	-1.08	-1.13	1.33	1.85	0.01	1.21	-1.19	0.25	0.10
	B	34	-1.84	-1.92	-1.75	-2.41	-1.24	0.82	1.46	0.18	0.04	1.62	1.40	1.31	1.49	0.54	1.71	1.92	2.56	1.29	1.23	2.81
	C	38	-1.22	-1.67	-0.76	-1.39	-1.04	-0.49	-1.30	0.32	-0.70	-0.28	-0.39	-0.84	0.07	-0.51	-0.16	0.23	-0.58	1.04	0.05	0.47
	D	35	-0.01	-0.06	0.04	-0.01	-0.01	-0.03	-0.06	0.01	-0.03	-0.02	-0.01	-0.06	0.04	-0.01	-0.01	-0.01	-0.04	0.02	-0.01	-0.01
	E	486	0.08	0.04	0.13	0.09	0.08	0.07	0.05	0.09	0.08	0.07	0.15	0.11	0.20	0.16	0.14	0.15	0.13	0.17	0.15	0.14
	F	465	2.18	2.30	2.05	2.24	2.12	0.44	0.49	0.39	0.48	0.40	0.64	0.76	0.52	0.56	0.44	0.59	0.64	0.54	0.52	0.44
	G	644	0.21	0.21	0.20	0.21	0.20	0.09	0.10	0.07	0.09	0.08	0.00	0.00	-0.01	-0.01	-0.02	0.01	0.02	0.00	0.00	-0.01
	H	47	-0.40	-0.36	-0.44	-0.42	-0.37	-0.34	-0.35	-0.34	-0.36	-0.33	-0.36	-0.32	-0.40	-0.37	-0.33	-0.36	-0.36	-0.35	-0.37	-0.34
	I	637	0.03	0.41	-0.34	-0.08	0.15	0.80	1.13	0.48	0.67	0.94	0.67	1.05	0.30	0.53	0.77	0.44	0.77	0.12	0.31	0.58
Minimum	Node	**No.**	**5**	**166**	**5**	**5**	**2478**	**841**	**841**	**1199**	**841**	**841**	**270**	**270**	**270**	**2566**	**2566**	**1199**	**1199**	**1199**	**1199**	**1199**
		X	327.5	-265.6	327.5	327.5	376.8	187.4	187.4	-40.3	187.4	187.4	265.6	265.6	265.6	302.6	302.6	-40.3	-40.3	-40.3	-40.3	-40.3
		Y	110.0	420.0	110.0	110.0	420.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0
		Z	0.0	71.2	0.0	0.0	289.2	-268.6	-268.6	-325.0	-268.6	-268.6	71.2	71.2	71.2	125.3	125.3	-325.0	-325.0	-325.0	-325.0	-325.0
	Value		**-13.12**	**-14.03**	**-13.14**	**-14.19**	**-14.17**	**-14.53**	**-18.23**	**-12.32**	**-12.19**	**-16.87**	**-7.49**	**-8.09**	**-6.88**	**-6.87**	**-6.59**	**-6.18**	**-5.73**	**-6.64**	**-6.19**	**-6.15**
Maximum	Node	**No.**	**22118**	**167**	**22118**	**167**	**22118**	**4930**	**4920**	**4930**	**4920**	**4930**	**4**	**579**	**4**	**474**	**4**	**8976**	**8976**	**10046**	**8976**	**8976**
		X	301.83	-265.63	301.83	-265.63	301.83	232.55	201.16	232.55	201.16	232.55	275.00	313.13	275.00	283.62	275.00	47.24	47.24	-49.35	47.24	47.24
		Y	110.00	110.00	110.00	110.00	110.00	99.16	110.60	99.16	110.60	99.16	110.00	62.21	110.00	57.50	110.00	131.29	131.29	139.82	131.29	131.29
		Z	39.74	71.18	39.74	71.18	39.74	-251.72	-278.40	-251.72	-278.40	-251.72	0.00	-180.78	0.00	-163.75	0.00	-369.71	-369.71	-389.81	-369.71	-369.71
	Value		**9.64**	**11.65**	**10.01**	**9.57**	**10.11**	**8.95**	**11.41**	**7.50**	**10.02**	**8.11**	**9.74**	**10.12**	**10.40**	**7.60**	**9.15**	**9.96**	**10.86**	**9.96**	**10.03**	**9.91**

TABLE-5.7 SHEAR STRESSES IN XY PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-3.51	-2.88	-4.13	-3.70	-3.31	0.76	2.07	-0.55	0.62	0.90	9.24	9.86	8.62	1.43	1.81	6.38	7.70	5.07	-0.36	-0.08
	B	6	1.14	2.20	0.08	1.14	1.13	1.08	2.16	-0.01	1.08	1.07	0.75	1.82	-0.31	0.74	0.72	0.74	1.83	-0.34	0.74	0.73
	C	8	0.58	0.81	0.35	0.56	0.60	0.13	0.38	-0.12	0.12	0.14	0.50	0.74	0.27	0.45	0.48	0.52	0.77	0.27	0.50	0.52
	D	9	-0.21	-0.29	-0.13	-0.21	-0.21	-0.11	-0.18	-0.04	-0.11	-0.11	0.33	0.25	0.41	0.33	0.33	0.31	0.25	0.38	0.32	0.31
	E	296	-0.02	0.12	-0.15	-0.03	0.00	-0.05	0.04	-0.13	-0.05	-0.04	-0.65	-0.52	-0.79	-0.66	-0.64	-0.64	-0.56	-0.73	-0.65	-0.64
	F	2	-4.83	-4.83	-4.83	-4.62	-5.04	-0.45	-0.58	-0.31	-0.40	-0.50	-6.38	-6.37	-6.38	1.21	0.79	-6.34	-6.48	-6.21	0.74	0.64
	G	24	0.30	0.47	0.14	0.31	0.30	0.21	0.33	0.09	0.21	0.21	1.67	1.84	1.51	1.66	1.66	1.69	1.81	1.58	1.68	1.68
	H	23	0.62	0.98	0.25	0.62	0.62	0.29	0.56	0.02	0.29	0.29	0.15	0.51	-0.22	0.14	0.14	0.20	0.48	-0.07	0.20	0.19
	I	27	2.00	2.81	1.20	1.94	2.07	0.73	1.41	0.06	0.70	0.77	-1.51	-0.71	-2.32	-1.60	-1.48	-1.35	-0.68	-2.03	-1.40	-1.33
330	A	260	-0.21	-0.26	-0.16	-0.21	-0.22	-4.93	-3.12	-6.74	-4.12	-5.74	0.37	0.32	0.42	0.46	0.45	-1.38	0.43	-3.19	-0.51	-2.13
	B	258	1.61	3.22	0.00	2.51	0.71	1.04	2.69	-0.61	1.92	0.16	0.53	2.14	-1.08	1.39	-0.41	0.61	2.25	-1.04	1.49	-0.27
	C	256	0.17	0.23	0.12	0.16	0.18	-0.09	-0.03	-0.15	-0.10	-0.08	-0.07	-0.02	-0.12	-0.08	-0.06	-0.02	0.04	-0.08	-0.03	-0.01
	D	255	0.01	-0.02	0.05	0.01	0.02	-0.01	-0.03	0.00	-0.02	-0.01	0.13	0.10	0.17	0.13	0.14	0.14	0.12	0.15	0.13	0.14
	E	2413	-0.25	-0.27	-0.23	-0.25	-0.25	-0.11	-0.13	-0.08	-0.11	-0.11	-0.08	-0.10	-0.06	-0.08	-0.07	-0.10	-0.13	-0.08	-0.10	-0.10
	F	251	0.10	0.10	0.10	0.10	0.10	0.02	0.03	0.02	0.03	0.02	-0.37	-0.37	-0.37	-0.39	-0.40	-0.37	-0.36	-0.37	-0.39	-0.39
	G	2453	0.15	0.25	0.04	0.14	0.15	0.10	0.16	0.03	0.09	0.10	0.49	0.59	0.38	0.49	0.50	0.50	0.57	0.43	0.50	0.50
	H	2447	0.15	0.64	-0.33	0.24	0.06	-0.04	0.24	-0.31	0.03	-0.11	0.16	0.64	-0.33	0.27	0.10	0.26	0.53	-0.02	0.33	0.19
	I	2441	2.52	3.15	1.89	2.53	2.51	0.72	1.23	0.22	0.73	0.71	-1.42	-0.79	-2.05	-1.42	-1.44	-1.06	-0.55	-1.56	-1.05	-1.07
300	A	240	-0.27	-0.33	-0.21	-0.28	-0.26	-2.70	2.09	-7.50	-1.25	-4.16	0.27	0.21	0.33	0.26	0.27	-1.06	3.73	-5.86	0.41	-2.50
	B	238	1.19	3.44	-1.06	2.45	-0.07	0.86	3.13	-1.41	2.10	-0.38	0.74	2.99	-1.52	1.99	-0.54	0.67	2.94	-1.59	1.91	-0.56
	C	236	0.18	0.06	0.31	0.10	0.27	0.05	-0.09	0.19	-0.04	0.14	0.08	-0.05	0.20	-0.01	0.17	0.11	-0.03	0.25	0.02	0.20
	D	235	-0.42	-0.44	-0.40	-0.42	-0.41	-0.11	-0.12	-0.10	-0.11	-0.11	0.02	0.00	0.03	0.01	0.02	-0.06	-0.07	-0.04	-0.06	-0.06
	E	2213	-0.87	-0.58	-1.16	-0.80	-0.94	-0.18	-0.03	-0.34	-0.12	-0.25	-0.26	0.03	-0.55	-0.19	-0.33	-0.43	-0.27	-0.59	-0.36	-0.49
	F	231	0.08	0.08	0.08	0.08	0.08	0.01	0.01	0.01	0.01	0.01	-0.21	-0.21	-0.22	-0.21	-0.22	-0.21	-0.21	-0.21	-0.21	-0.21
	G	2251	0.07	0.11	0.02	0.07	0.06	0.03	0.06	0.01	0.03	0.03	0.28	0.32	0.23	0.28	0.28	0.28	0.31	0.25	0.28	0.28
	H	2245	1.75	2.79	0.72	1.92	1.58	0.55	1.09	0.01	0.68	0.43	-0.57	0.47	-1.60	-0.35	-0.69	-0.28	0.26	-0.82	-0.15	-0.41
	I	2241	2.18	2.87	1.50	2.31	2.06	0.46	0.80	0.12	0.56	0.36	-0.74	-0.05	-1.43	-0.59	-0.85	-0.40	-0.07	-0.74	-0.30	-0.50

TABLE-5.7 (contd....) SHEAR STRESSES IN XY PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	-0.17	-0.27	-0.07	-0.19	-0.15	-0.11	5.97	-6.20	1.48	-1.71	-0.03	-0.13	0.07	-0.08	-0.03	0.40	6.48	-5.69	1.99	-1.20
	B	218	-0.27	2.53	-3.07	1.37	-1.91	-0.16	2.60	-2.92	1.46	-1.78	0.07	2.86	-2.73	1.71	-1.57	-0.20	2.56	-2.96	1.42	-1.81
	C	216	-0.08	-0.11	-0.05	-0.10	-0.05	-0.04	-0.08	0.01	-0.06	-0.02	0.02	-0.01	0.05	0.00	0.04	0.00	-0.04	0.05	-0.02	0.03
	D	215	0.05	0.01	0.09	0.07	0.04	0.03	0.04	0.03	0.05	0.02	-0.09	-0.13	-0.05	-0.07	-0.11	-0.06	-0.06	-0.07	-0.05	-0.07
	E	2051	0.23	0.60	-0.13	0.41	0.06	0.11	0.33	-0.12	0.25	-0.04	-0.16	0.20	-0.52	0.02	-0.32	-0.09	0.13	-0.32	0.05	-0.24
	F	199	0.02	0.02	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.02	0.02
	G	2091	-0.02	0.03	-0.06	-0.01	-0.02	-0.01	0.02	-0.03	0.00	-0.01	-0.26	-0.21	-0.31	-0.25	-0.27	-0.26	-0.23	-0.29	-0.26	-0.27
	H	2083	0.24	1.52	-1.04	0.43	0.05	-0.04	0.55	-0.62	0.12	-0.19	0.32	1.60	-0.96	0.55	0.17	0.30	0.88	-0.29	0.45	0.14
	I	2077	0.05	-0.12	0.22	-0.01	0.11	0.00	-0.11	0.12	-0.05	0.05	0.34	0.17	0.51	0.27	0.39	0.38	0.26	0.50	0.33	0.43
240	A	198	-0.05	-0.13	0.03	-0.06	-0.04	2.69	8.35	-2.97	4.20	1.18	-0.46	-0.54	-0.38	-0.49	-0.47	1.47	7.13	-4.19	2.97	-0.05
	B	196	-0.92	1.81	-3.64	0.81	-2.64	-0.59	2.09	-3.27	1.13	-2.30	-0.17	2.55	-2.90	1.56	-1.89	-0.52	2.16	-3.21	1.19	-2.24
	C	194	-0.25	-0.25	-0.25	-0.26	-0.24	0.00	0.02	-0.02	-0.01	0.01	0.02	0.03	0.02	0.01	0.03	-0.01	0.01	-0.03	-0.02	0.00
	D	193	0.29	0.28	0.31	0.29	0.29	0.08	0.07	0.09	0.08	0.08	-0.02	-0.03	0.00	-0.01	-0.02	0.02	0.01	0.04	0.03	0.02
	E	1882	0.72	0.85	0.59	0.81	0.63	0.18	0.26	0.10	0.25	0.11	-0.06	0.07	-0.19	0.05	-0.14	0.09	0.17	0.01	0.16	0.02
	F	189	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.30	0.30	0.31	0.31	0.31	0.31	0.30	0.31	0.31	0.31
	G	1922	-0.03	-0.05	-0.02	-0.03	-0.03	-0.02	-0.03	-0.02	-0.02	-0.02	0.29	0.28	0.30	0.30	0.30	0.29	0.28	0.29	0.30	0.30
	H	1914	-0.01	0.89	-0.91	0.13	-0.15	0.00	0.42	-0.41	0.13	-0.12	0.30	1.20	-0.60	0.46	0.18	0.19	0.61	-0.23	0.31	0.06
	I	1908	-0.86	-0.78	-0.93	-0.85	-0.87	-0.19	-0.17	-0.22	-0.19	-0.20	0.36	0.43	0.29	0.38	0.35	0.26	0.29	0.24	0.27	0.26
210	A	178	-0.04	-0.11	0.02	-0.05	-0.04	5.88	8.93	2.82	6.75	5.01	-0.88	-0.94	-0.81	-0.89	-0.88	1.46	4.51	-1.60	2.32	0.58
	B	176	-1.05	0.63	-2.72	-0.29	-1.80	-0.89	0.78	-2.57	-0.14	-1.65	-0.58	1.09	-2.26	0.17	-1.34	-0.80	0.88	-2.47	-0.04	-1.55
	C	174	-0.04	-0.04	-0.04	-0.05	-0.02	0.14	0.16	0.11	0.12	0.15	0.14	0.14	0.14	0.12	0.16	0.14	0.16	0.11	0.12	0.15
	D	173	0.17	0.13	0.22	0.17	0.18	0.07	0.02	0.13	0.07	0.08	-0.09	-0.13	-0.04	-0.09	-0.08	-0.09	-0.14	-0.04	-0.09	-0.08
	E	1712	0.39	0.40	0.37	0.40	0.38	0.11	0.09	0.13	0.12	0.10	0.22	0.23	0.20	0.23	0.21	0.24	0.23	0.26	0.25	0.24
	F	169	-0.01	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.70	0.69	0.70	0.70	0.70	0.70	0.69	0.70	0.70	0.70
	G	1759	-0.23	-0.12	-0.34	-0.23	-0.23	-0.11	-0.03	-0.18	-0.11	-0.11	-0.39	-0.28	-0.50	-0.39	-0.39	-0.39	-0.31	-0.46	-0.39	-0.39
	H	1751	-1.59	-1.24	-1.94	-1.51	-1.67	-0.50	-0.22	-0.78	-0.42	-0.58	0.80	1.15	0.44	0.88	0.72	0.67	0.95	0.39	0.75	0.59
	I	1745	-1.29	-1.05	-1.54	-1.24	-1.35	-0.09	0.01	-0.19	-0.05	-0.14	1.25	1.49	1.00	1.31	1.20	1.08	1.18	0.98	1.13	1.03
180	A	158	-0.18	-0.23	-0.12	-0.18	-0.18	7.30	9.49	5.11	7.33	7.27	-0.89	-0.94	-0.83	-0.89	-0.88	1.05	3.24	-1.15	1.07	1.01
	B	156	-0.86	0.26	-1.97	-0.86	-0.86	-1.10	0.04	-2.24	-1.10	-1.10	-1.01	0.10	-2.13	-1.01	-1.01	-1.03	0.11	-2.17	-1.03	-1.03
	C	154	0.21	0.18	0.23	0.20	0.21	0.22	0.22	0.23	0.22	0.22	0.24	0.21	0.26	0.23	0.24	0.24	0.24	0.25	0.24	0.25
	D	153	0.14	0.08	0.20	0.14	0.14	0.10	0.03	0.17	0.10	0.10	-0.03	-0.09	0.03	-0.03	-0.03	-0.04	-0.11	0.03	-0.04	-0.04
	E	1560	0.55	0.48	0.62	0.56	0.55	0.05	0.01	0.10	0.05	0.05	0.22	0.15	0.29	0.23	0.22	0.21	0.16	0.26	0.21	0.21
	F	149	0.04	0.04	0.05	0.04	0.04	0.01	0.00	0.01	0.01	0.01	1.02	1.02	1.03	1.02	1.02	1.02	1.02	1.03	1.02	1.02
	G	1594	-0.30	-0.11	-0.48	-0.30	-0.29	-0.13	-0.02	-0.25	-0.13	-0.13	-0.39	-0.21	-0.57	-0.39	-0.38	-0.38	-0.27	-0.49	-0.38	-0.38
	H	1588	0.37	0.91	-0.17	0.34	0.40	0.37	0.59	0.16	0.35	0.39	-1.12	-0.58	-1.66	-1.14	-1.08	-1.11	-0.89	-1.32	-1.13	-1.09
	I	1582	-2.77	-2.28	-3.26	-2.75	-2.79	-0.04	0.16	-0.24	0.00	-0.08	2.32	2.81	1.83	2.34	2.30	2.34	2.55	2.14	2.39	2.30

TABLE-5.7 (contd....) SHEAR STRESSES IN XY PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-0.32	-0.38	-0.25	-0.32	-0.31	5.81	10.11	1.51	4.89	6.73	-0.65	-0.72	-0.59	-0.67	-0.65	0.39	4.69	-3.91	-0.53	1.31
	B	134	-0.43	1.13	-1.98	-1.12	0.27	-0.99	0.53	-2.51	-1.69	-0.29	-1.05	0.51	-2.60	-1.74	-0.35	-0.99	0.53	-2.52	-1.70	-0.29
	C	132	0.11	0.12	0.09	0.12	0.09	0.12	0.14	0.09	0.13	0.10	0.12	0.13	0.11	0.13	0.10	0.12	0.15	0.10	0.14	0.11
	D	131	-0.04	-0.08	-0.01	-0.03	-0.05	0.03	0.00	0.06	0.04	0.02	-0.01	-0.05	0.03	0.00	-0.02	0.00	-0.04	0.03	0.00	-0.01
	E	1393	-0.10	-0.02	-0.17	-0.11	-0.08	-0.01	0.03	-0.05	-0.02	0.00	-0.02	0.05	-0.09	-0.03	0.00	0.00	0.04	-0.04	-0.01	0.01
	F	127	0.01	0.01	0.02	0.01	0.01	0.00	-0.01	0.01	0.00	0.00	0.79	0.78	0.79	0.79	0.79	0.79	0.78	0.80	0.79	0.79
	G	1431	-0.06	0.01	-0.13	-0.06	-0.06	-0.03	0.01	-0.06	-0.03	-0.03	-0.04	0.03	-0.11	-0.03	-0.03	-0.03	0.00	-0.07	-0.03	-0.03
	H	1423	-0.90	0.20	-2.00	-1.12	-0.68	-0.27	0.31	-0.84	-0.44	-0.09	-0.42	0.68	-1.51	-0.62	-0.18	-0.15	0.43	-0.73	-0.33	0.02
	I	1417	-0.48	-0.63	-0.34	-0.46	-0.50	-0.14	0.10	-0.38	-0.13	-0.15	-0.69	-0.84	-0.55	-0.68	-0.72	-0.73	-0.49	-0.97	-0.72	-0.74
120	A	116	-0.26	-0.40	-0.13	-0.27	-0.26	4.03	10.79	-2.73	2.37	5.68	-0.32	-0.46	-0.18	-0.34	-0.33	-0.84	5.93	-7.60	-2.50	0.81
	B	114	-0.03	2.25	-2.32	-1.19	1.12	-0.55	1.65	-2.75	-1.73	0.62	-0.62	1.67	-2.90	-1.78	0.54	-0.67	1.52	-2.87	-1.85	0.50
	C	112	0.03	-0.02	0.09	0.07	-0.01	0.03	-0.03	0.09	0.07	-0.01	0.02	-0.03	0.08	0.06	-0.02	0.02	-0.04	0.08	0.07	-0.02
	D	111	0.48	0.51	0.44	0.47	0.48	0.02	0.05	-0.01	0.02	0.02	0.19	0.22	0.15	0.19	0.19	0.11	0.14	0.08	0.11	0.11
	E	1233	0.29	1.47	-0.89	-0.04	0.63	-0.11	0.45	-0.67	-0.36	0.14	0.28	1.46	-0.90	0.00	0.67	0.34	0.90	-0.22	0.08	0.58
	F	107	-0.09	-0.15	-0.03	-0.09	-0.10	-0.02	-0.05	0.01	-0.01	-0.02	0.28	0.23	0.34	0.30	0.29	0.29	0.26	0.32	0.30	0.29
	G	1269	0.08	0.27	-0.10	0.06	0.11	0.02	0.10	-0.06	0.00	0.03	-0.04	0.15	-0.22	-0.05	-0.01	-0.04	0.04	-0.12	-0.06	-0.02
	H	1263	0.64	2.95	-1.68	0.24	1.03	0.04	0.98	-0.89	-0.27	0.35	-0.25	2.06	-2.56	-0.58	0.20	-0.19	0.75	-1.13	-0.51	0.12
	I	1255	-0.27	-0.12	-0.42	-0.30	-0.24	0.14	0.16	0.12	0.12	0.16	-0.12	0.03	-0.26	-0.14	-0.08	0.00	0.02	-0.01	-0.02	0.02
90	A	96	-0.15	-0.41	0.11	-0.13	-0.16	-0.09	9.23	-9.40	-2.42	2.26	0.02	-0.24	0.28	0.02	-0.02	-1.49	7.82	-10.81	-3.84	0.84
	B	94	0.34	3.00	-2.33	-0.98	1.65	0.10	2.71	-2.51	-1.23	1.44	0.11	2.78	-2.56	-1.21	1.41	-0.09	2.52	-2.70	-1.43	1.24
	C	90	0.07	-0.04	0.18	0.14	0.00	0.05	-0.06	0.17	0.13	-0.02	0.04	-0.07	0.15	0.11	-0.03	0.04	-0.08	0.15	0.11	-0.03
	D	89	-0.03	-0.10	0.04	-0.05	-0.01	0.00	-0.03	0.04	-0.01	0.02	-0.04	-0.11	0.03	-0.06	-0.02	0.02	-0.01	0.06	0.01	0.04
	E	1064	0.17	1.54	-1.20	-0.36	0.70	-0.18	0.38	-0.74	-0.59	0.23	0.73	2.10	-0.64	0.26	1.32	0.78	1.34	0.21	0.36	1.18
	F	85	-0.14	-0.28	-0.01	-0.13	-0.16	-0.01	-0.06	0.04	0.00	-0.02	-0.07	-0.21	0.06	-0.05	-0.08	-0.08	-0.13	-0.03	-0.06	-0.08
	G	1121	0.12	0.52	-0.27	0.07	0.17	-0.11	0.01	-0.23	-0.15	-0.07	0.42	0.81	0.03	0.39	0.49	0.43	0.55	0.31	0.38	0.47
	H	1113	-0.22	2.34	-2.78	-0.64	0.20	0.02	0.82	-0.78	-0.29	0.33	1.22	3.78	-1.34	0.94	1.78	1.11	1.91	0.31	0.79	1.41
	I	1105	0.62	1.20	0.04	0.54	0.69	0.01	-0.06	0.08	0.02	0.01	-0.36	0.22	-0.94	-0.43	-0.28	-0.50	-0.57	-0.43	-0.49	-0.51
60	A	64	-0.09	-0.31	0.12	-0.09	-0.10	-8.83	0.00	-17.66	-11.44	-6.21	0.25	0.04	0.46	0.26	0.24	0.39	9.22	-8.44	-2.16	3.07
	B	59	0.64	3.17	-1.89	-0.94	2.23	0.72	3.31	-1.87	-0.88	2.32	0.86	3.39	-1.66	-0.75	2.42	0.57	3.16	-2.02	-1.02	2.18
	C	61	-0.04	-0.15	0.06	0.02	-0.11	-0.03	-0.13	0.06	0.03	-0.10	-0.05	-0.16	0.06	0.01	-0.11	-0.05	-0.14	0.04	0.01	-0.11
	D	62	-0.26	-0.42	-0.10	-0.23	-0.29	-0.15	-0.26	-0.04	-0.13	-0.17	0.04	-0.13	0.20	0.05	0.00	0.04	-0.07	0.16	0.07	0.02
	E	978	-0.90	-0.94	-0.86	-0.93	-0.87	-0.91	-1.15	-0.67	-0.93	-0.88	1.37	1.33	1.41	1.37	1.43	1.34	1.10	1.57	1.32	1.37
	F	56	0.00	-0.19	0.19	0.02	-0.02	0.08	0.04	0.12	0.10	0.07	-0.36	-0.55	-0.17	-0.36	-0.40	-0.37	-0.40	-0.33	-0.36	-0.39
	G	727	-1.42	-0.37	-2.47	-1.49	-1.35	-1.02	-0.98	-1.05	-1.06	-0.97	0.75	1.80	-0.30	0.83	0.97	0.75	0.79	0.72	0.74	0.82
	H	715	1.27	3.20	-0.66	0.89	1.65	0.57	1.00	0.14	0.39	0.75	1.44	3.37	-0.49	1.24	1.99	0.91	1.33	0.48	0.69	1.04
	I	707	2.73	4.10	1.36	2.65	2.82	-0.14	-1.04	0.77	0.14	-0.41	0.48	1.85	-0.89	0.36	0.53	-0.83	-1.74	0.07	-0.58	-1.13

TABLE-5.7 (contd....) SHEAR STRESSES IN XY PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-0.79	-0.75	-0.83	-0.78	-0.80	-2.36	0.49	-5.21	-2.84	-1.88	0.88	0.92	0.84	0.32	0.30	-0.02	2.83	-2.88	-0.43	0.54
	B	34	0.76	2.47	-0.94	-0.23	1.76	1.10	2.86	-0.66	0.10	2.10	1.35	3.05	-0.36	0.32	2.31	1.11	2.87	-0.66	0.11	2.11
	C	38	-0.28	-0.31	-0.25	-0.26	-0.30	-0.25	-0.30	-0.19	-0.23	-0.27	0.02	-0.02	0.05	0.04	0.00	0.01	-0.04	0.06	0.03	-0.01
	D	35	-0.12	-0.22	-0.03	-0.12	-0.13	-0.13	-0.19	-0.06	-0.12	-0.13	0.54	0.45	0.64	0.55	0.54	0.54	0.47	0.60	0.54	0.53
	E	486	0.59	1.02	0.17	0.59	0.60	0.53	0.82	0.24	0.52	0.53	0.21	0.64	-0.22	0.21	0.21	0.25	0.54	-0.04	0.24	0.25
	F	465	0.97	1.02	0.93	0.95	0.99	0.10	0.13	0.07	0.09	0.10	-0.05	0.00	-0.10	-0.08	-0.04	0.04	0.07	0.01	0.02	0.03
	G	644	-0.14	-0.11	-0.17	-0.15	-0.13	-0.03	-0.02	-0.04	-0.04	-0.02	-0.80	-0.77	-0.83	-0.82	-0.80	-0.81	-0.81	-0.82	-0.82	-0.81
	H	47	0.31	0.61	0.01	0.29	0.33	0.25	0.45	0.05	0.24	0.27	0.25	0.55	-0.04	0.24	0.28	0.28	0.48	0.08	0.26	0.29
	I	637	0.65	1.15	0.15	0.63	0.67	0.42	0.91	-0.08	0.40	0.43	1.65	2.15	1.15	1.60	1.64	1.65	2.14	1.15	1.62	1.65
Minimum		**No.**	**20**	**20**	**20**	**20**	**20**	**845**	**22140**	**845**	**845**	**845**	**22798**	**22798**	**22798**	**4149**	**4149**	**22798**	**22798**	**1199**	**4149**	**4149**
	Node	**X**	265.6	265.6	265.6	265.6	265.6	204.2	337.1	204.2	204.2	204.2	297.7	297.7	297.7	804.3	804.3	297.7	297.7	-40.3	804.3	804.3
		Y	-110.0	-110.0	-110.0	-110.0	-110.0	110.0	142.8	110.0	110.0	110.0	-85.2	-85.2	-85.2	225.6	225.6	-85.2	-85.2	110.0	225.6	225.6
		Z	-71.2	-71.2	-71.2	-71.2	-71.2	-256.0	64.1	-256.0	-256.0	-256.0	0.0	0.0	0.0	-583.5	-583.5	0.0	0.0	-325.0	-583.5	-583.5
	Value		**-9.74**	**-9.37**	**-10.10**	**-9.59**	**-9.88**	**-12.79**	**-8.95**	**-20.07**	**-15.08**	**-10.50**	**-10.03**	**-9.88**	**-10.18**	**-5.68**	**-5.44**	**-9.20**	**-9.25**	**-13.09**	**-5.62**	**-5.42**
Maximum		**No.**	**523**	**523**	**523**	**523**	**523**	**158**	**1199**	**158**	**158**	**148**	**22797**	**22797**	**22797**	**908**	**908**	**22797**	**22797**	**22797**	**908**	**908**
	Node	**X**	279.30	279.30	279.30	279.30	279.30	-327.50	-40.3	-327.50	-327.50	-316.34	297.53	297.53	297.53	411.78	411.78	297.53	297.53	297.53	411.78	411.78
		Y	110.00	110.00	110.00	110.00	110.00	110.00	110.0	110.00	110.00	110.00	84.31	84.31	84.31	228.12	228.12	84.31	84.31	84.31	228.12	228.12
		Z	-124.04	-124.04	-124.04	-124.04	-124.04	0.00	-325.0	0.00	0.00	-84.76	0.00	0.00	0.00	-635.09	-635.09	0.00	0.00	0.00	-635.09	-635.09
	Value		**8.94**	**9.75**	**8.14**	**8.74**	**9.14**	**7.30**	**12.51**	**5.11**	**7.33**	**7.64**	**9.96**	**10.30**	**9.63**	**7.17**	**7.29**	**11.56**	**11.96**	**11.17**	**7.38**	**7.52**

TABLE-5.8 SHEAR STRESSES IN YZ PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-10.39	-9.86	-10.92	-10.99	-9.79	4.68	5.80	3.56	3.79	5.57	3.90	4.43	3.37	2.16	3.37	3.80	4.92	2.67	-0.65	1.13
	B	6	-1.78	-1.72	-1.85	-3.19	-0.39	-0.22	-0.13	-0.32	-1.61	1.15	0.49	0.56	0.42	-0.88	1.92	-0.05	0.04	-0.15	-1.45	1.31
	C	8	0.02	0.07	-0.02	0.04	0.01	0.00	0.03	-0.04	0.01	-0.02	0.01	0.05	-0.03	0.02	-0.01	0.01	0.04	-0.03	0.02	-0.01
	D	9	-0.10	-0.07	-0.13	-0.14	-0.07	-0.12	-0.13	-0.11	-0.15	-0.09	-0.04	-0.01	-0.07	-0.06	0.01	-0.01	-0.02	0.01	-0.03	0.02
	E	296	-0.06	0.32	-0.45	-0.31	0.18	0.03	0.23	-0.17	-0.16	0.22	0.70	1.09	0.32	0.47	0.96	0.70	0.90	0.50	0.51	0.89
	F	2	4.29	4.10	4.48	3.85	4.73	0.87	1.23	0.51	0.72	1.02	-1.02	-1.21	-0.83	-0.70	0.17	-1.08	-0.73	-1.44	-0.40	-0.10
	G	24	0.03	0.06	0.01	0.02	0.04	0.01	0.03	0.00	0.01	0.02	0.31	0.34	0.29	0.30	0.32	0.31	0.33	0.30	0.30	0.32
	H	23	-0.08	-0.04	-0.12	-0.29	0.12	-0.01	0.03	-0.05	-0.16	0.15	1.07	1.11	1.03	0.85	1.26	0.98	1.02	0.94	0.82	1.13
	I	27	0.05	0.15	-0.05	-0.08	0.18	0.06	0.15	-0.02	-0.03	0.16	-0.25	-0.15	-0.35	-0.38	-0.13	-0.30	-0.21	-0.38	-0.40	-0.21
330	A	260	0.78	0.85	0.71	0.77	0.79	-3.85	-5.95	-1.75	-5.43	-2.27	0.51	0.58	0.45	0.30	0.32	2.48	0.38	4.58	0.83	3.99
	B	258	-0.62	-1.36	0.11	-2.18	0.94	0.49	-0.25	1.23	-1.03	2.02	0.72	-0.01	1.46	-0.79	2.32	0.46	-0.28	1.20	-1.07	1.98
	C	256	0.15	0.20	0.11	0.17	0.14	-0.02	0.04	-0.08	0.00	-0.04	0.00	0.05	-0.04	0.01	-0.02	0.03	0.08	-0.03	0.04	0.01
	D	255	-0.22	-0.10	-0.33	-0.22	-0.21	-0.09	-0.04	-0.14	-0.10	-0.09	0.12	0.23	0.00	0.12	0.13	0.11	0.16	0.06	0.10	0.11
	E	2413	-0.43	0.05	-0.91	-0.54	-0.32	-0.16	0.09	-0.40	-0.24	-0.07	0.49	0.97	0.01	0.42	0.64	0.49	0.73	0.24	0.40	0.57
	F	251	-0.20	-0.19	-0.20	-0.20	-0.20	-0.02	-0.03	-0.02	-0.02	-0.02	-0.39	-0.38	-0.39	-0.30	-0.30	-0.39	-0.40	-0.39	-0.32	-0.31
	G	2453	0.10	0.15	0.04	0.09	0.10	0.06	0.09	0.02	0.05	0.06	0.58	0.64	0.52	0.58	0.59	0.59	0.63	0.55	0.59	0.59
	H	2447	-0.45	-0.83	-0.07	-0.59	-0.30	-0.21	-0.42	0.00	-0.32	-0.10	0.75	0.37	1.13	0.58	0.87	0.62	0.41	0.83	0.51	0.73
	I	2441	1.44	1.66	1.22	1.31	1.57	0.49	0.78	0.21	0.40	0.58	-1.03	-0.80	-1.25	-1.19	-0.93	-0.92	-0.63	-1.21	-1.01	-0.84
300	A	240	0.36	0.39	0.33	0.37	0.36	-5.04	-7.20	-2.87	-6.01	-4.07	0.50	0.53	0.47	0.50	0.49	0.16	-2.01	2.32	-0.82	1.12
	B	238	0.65	0.00	1.30	-0.09	1.39	0.91	0.28	1.54	0.19	1.63	0.77	0.12	1.42	0.04	1.51	0.76	0.13	1.39	0.03	1.48
	C	236	0.35	0.43	0.27	0.40	0.30	0.05	0.15	-0.05	0.10	0.00	-0.04	0.04	-0.12	0.01	-0.09	0.03	0.13	-0.07	0.08	-0.02
	D	235	0.03	0.04	0.03	0.04	0.03	-0.01	-0.01	-0.01	-0.01	-0.02	0.12	0.12	0.11	0.13	0.11	0.13	0.13	0.13	0.13	0.12
	E	2213	-0.24	-0.23	-0.25	-0.25	-0.24	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.08	-0.10	-0.09	-0.08	-0.12	-0.12	-0.11	-0.12	-0.12
	F	231	-0.05	-0.05	-0.05	-0.05	-0.05	0.01	0.01	0.01	0.01	0.01	-0.48	-0.49	-0.48	-0.48	-0.48	-0.49	-0.49	-0.49	-0.49	-0.49
	G	2251	0.24	0.28	0.20	0.24	0.25	0.10	0.13	0.08	0.10	0.11	1.20	1.24	1.16	1.19	1.20	1.21	1.24	1.19	1.21	1.22
	H	2245	1.63	1.31	1.95	1.56	1.70	0.65	0.56	0.75	0.59	0.71	-1.38	-1.70	-1.06	-1.48	-1.34	-1.23	-1.32	-1.13	-1.29	-1.17
	I	2241	3.83	4.09	3.56	3.72	3.93	0.84	1.16	0.52	0.76	0.92	-2.31	-2.04	-2.58	-2.44	-2.23	-1.75	-1.43	-2.07	-1.84	-1.67

TABLE-5.8 (contd....) SHEAR STRESSES IN YZ PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.17	0.18	0.16	0.17	0.17	-6.66	-6.81	-6.51	-6.75	-6.57	0.63	0.64	0.63	0.64	0.63	-0.38	-0.53	-0.23	-0.47	-0.29
	B	218	1.04	1.06	1.01	1.05	1.02	1.15	1.18	1.11	1.16	1.13	1.01	1.03	0.98	1.02	0.99	0.97	1.00	0.94	0.99	0.95
	C	216	0.41	0.42	0.39	0.41	0.41	0.00	-0.01	0.01	-0.01	0.01	-0.02	-0.01	-0.03	-0.02	-0.02	0.04	0.03	0.06	0.04	0.05
	D	215	0.04	0.04	0.04	0.04	0.04	-0.02	-0.02	-0.03	-0.02	-0.02	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
	E	2051	-0.39	-0.40	-0.37	-0.39	-0.38	-0.12	-0.12	-0.11	-0.12	-0.11	-0.28	-0.30	-0.27	-0.29	-0.28	-0.33	-0.33	-0.32	-0.33	-0.32
	F	199	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60	-0.60
	G	2091	0.28	0.27	0.29	0.28	0.28	0.13	0.12	0.14	0.13	0.13	1.09	1.08	1.10	1.09	1.09	1.10	1.09	1.11	1.10	1.10
	H	2083	2.04	2.23	1.85	2.07	2.01	0.73	0.79	0.67	0.75	0.71	-1.12	-0.93	-1.31	-1.08	-1.15	-0.93	-0.87	-0.98	-0.91	-0.95
	I	2077	1.58	1.54	1.61	1.57	1.59	0.55	0.55	0.56	0.54	0.57	1.08	1.04	1.12	1.08	1.10	1.35	1.34	1.36	1.33	1.37
240	A	198	0.16	0.13	0.18	0.15	0.16	-5.13	-3.19	-7.06	-4.34	-5.92	0.45	0.42	0.47	0.43	0.44	-0.76	1.17	-2.70	0.02	-1.56
	B	196	0.78	1.64	-0.08	1.79	-0.22	1.17	1.99	0.34	2.17	0.17	1.30	2.16	0.43	2.30	0.30	1.05	1.88	0.22	2.05	0.05
	C	194	0.29	0.25	0.32	0.28	0.29	-0.07	-0.15	0.01	-0.08	-0.06	-0.02	-0.05	0.01	-0.03	-0.02	0.00	-0.07	0.08	0.00	0.01
	D	193	0.08	0.09	0.07	0.08	0.08	0.00	0.00	0.00	0.00	0.01	0.06	0.07	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.07
	E	1882	-0.27	-0.27	-0.28	-0.28	-0.27	-0.08	-0.06	-0.10	-0.09	-0.08	-0.09	-0.09	-0.09	-0.09	-0.08	-0.10	-0.08	-0.12	-0.11	-0.10
	F	189	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	-0.53	-0.53	-0.52	-0.53	-0.53	-0.53	-0.53	-0.53	-0.52	-0.53
	G	1922	-0.04	-0.05	-0.03	-0.04	-0.04	0.00	-0.01	0.00	0.00	0.00	-0.94	-0.95	-0.92	-0.94	-0.94	-0.93	-0.94	-0.93	-0.94	-0.94
	H	1914	0.29	0.84	-0.25	0.40	0.18	0.00	0.22	-0.22	0.10	-0.09	0.32	0.87	-0.22	0.44	0.22	0.25	0.47	0.03	0.35	0.16
	I	1908	1.35	1.25	1.46	1.33	1.37	0.40	0.22	0.57	0.37	0.42	0.25	0.14	0.36	0.23	0.27	0.37	0.19	0.54	0.34	0.39
210	A	176	0.32	0.30	0.35	0.31	0.33	-4.32	-2.22	-6.41	-2.96	-5.68	0.10	0.07	0.12	0.08	0.09	0.38	2.47	-1.72	1.74	-0.99
	B	176	0.13	1.01	-0.76	1.42	-1.17	0.80	1.64	-0.05	2.09	-0.50	1.16	2.04	0.27	2.46	-0.13	0.76	1.60	-0.08	2.06	-0.54
	C	174	0.01	-0.02	0.03	-0.01	0.03	-0.05	-0.09	-0.01	-0.07	-0.03	-0.02	-0.05	0.01	-0.04	0.00	-0.03	-0.07	0.01	-0.05	-0.01
	D	173	-0.69	-0.83	-0.54	-0.69	-0.69	-0.11	-0.12	-0.10	-0.11	-0.11	-0.21	-0.35	-0.06	-0.21	-0.21	-0.18	-0.19	-0.17	-0.18	-0.19
	E	1712	-1.24	-1.86	-0.62	-1.11	-1.38	-0.11	-0.34	0.13	0.02	-0.23	-0.52	-1.14	0.10	-0.39	-0.66	-0.54	-0.78	-0.30	-0.42	-0.66
	F	169	0.00	-0.02	0.02	0.00	0.00	0.01	0.00	0.02	0.01	0.01	-0.34	-0.37	-0.32	-0.34	-0.34	-0.34	-0.35	-0.33	-0.34	-0.34
	G	1759	-0.01	-0.02	0.01	0.00	-0.01	0.01	0.00	0.02	0.01	0.01	-0.22	-0.24	-0.20	-0.22	-0.22	-0.22	-0.23	-0.21	-0.22	-0.22
	H	1751	0.79	1.11	0.46	1.04	0.53	0.33	0.32	0.34	0.55	0.11	0.67	1.00	0.35	0.93	0.42	0.41	0.40	0.42	0.63	0.19
	I	1745	0.64	0.54	0.73	0.68	0.59	0.06	-0.03	0.15	0.09	0.03	0.11	0.02	0.21	0.16	0.07	0.06	-0.03	0.15	0.09	0.03
180	A	158	0.35	0.35	0.35	0.35	0.35	-0.87	-1.12	-0.61	0.77	-2.50	-0.36	-0.36	-0.36	-0.36	-0.36	1.21	0.95	1.46	2.84	-0.44
	B	156	-0.67	-0.64	-0.70	0.57	-1.91	0.06	0.12	0.01	1.32	-1.19	0.46	0.49	0.43	1.71	-0.78	0.11	0.16	0.05	1.36	-1.15
	C	154	-0.01	-0.01	0.00	-0.04	0.03	0.00	0.00	0.01	-0.03	0.04	0.00	-0.01	0.00	-0.04	0.03	0.00	0.00	0.01	-0.03	0.04
	D	153	0.22	0.22	0.23	0.25	0.20	0.04	0.02	0.06	0.06	0.02	0.00	-0.01	0.01	0.03	-0.03	0.05	0.04	0.07	0.07	0.04
	E	1560	0.55	0.38	0.72	0.81	0.28	0.11	-0.01	0.23	0.33	-0.10	0.49	0.32	0.66	0.75	0.22	0.54	0.42	0.66	0.76	0.33
	F	149	0.01	-0.02	0.04	0.01	0.01	0.01	0.00	0.02	0.01	0.01	0.05	0.02	0.07	0.04	0.05	0.05	0.03	0.06	0.04	0.05
	G	1594	-0.11	-0.07	-0.15	-0.11	-0.11	-0.04	-0.01	-0.07	-0.04	-0.04	-0.31	-0.27	-0.35	-0.30	-0.31	-0.30	-0.27	-0.33	-0.30	-0.31
	H	1588	0.06	-0.34	0.46	0.35	-0.23	0.11	-0.13	0.35	0.36	-0.14	0.71	0.31	1.11	1.00	0.42	0.48	0.24	0.72	0.73	0.24
	I	1582	-0.90	-0.91	-0.89	-0.77	-1.03	-0.05	-0.01	-0.09	0.05	-0.15	0.82	0.81	0.83	0.94	0.68	0.58	0.63	0.54	0.68	0.48

TABLE-5.8 (contd....) SHEAR STRESSES IN YZ PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	0.22	0.24	0.19	0.22	0.21	2.00	-0.27	4.28	3.65	0.36	-0.72	-0.69	-0.74	-0.70	-0.72	2.02	-0.25	4.29	3.66	0.37
	B	134	-1.01	-1.73	-0.28	0.20	-2.21	-0.56	-1.20	0.08	0.66	-1.77	-0.29	-1.01	0.44	0.92	-1.49	-0.46	-1.11	0.18	0.75	-1.68
	C	132	0.01	0.04	-0.01	-0.01	0.04	0.02	0.05	-0.02	-0.01	0.04	0.01	0.04	-0.01	-0.01	0.04	0.02	0.05	-0.01	0.00	0.05
	D	131	0.27	0.31	0.22	0.27	0.27	0.04	0.04	0.05	0.04	0.05	0.06	0.10	0.01	0.06	0.06	0.04	0.04	0.05	0.04	0.05
	E	1393	-0.94	-0.85	-1.03	-0.75	-1.13	-0.21	-0.08	-0.33	-0.05	-0.36	-0.27	-0.18	-0.36	-0.10	-0.48	-0.26	-0.13	-0.38	-0.10	-0.41
	F	127	0.08	0.08	0.08	0.07	0.08	0.03	0.03	0.03	0.02	0.03	0.59	0.59	0.59	0.58	0.59	0.58	0.58	0.58	0.58	0.58
	G	1431	-0.21	-0.18	-0.23	-0.20	-0.21	-0.07	-0.05	-0.09	-0.06	-0.08	-0.45	-0.42	-0.47	-0.43	-0.45	-0.44	-0.41	-0.46	-0.43	-0.44
	H	1423	-1.22	-2.13	-0.30	-0.99	-1.44	-0.27	-0.58	0.04	-0.08	-0.46	0.52	-0.39	1.44	0.74	0.29	0.42	0.11	0.73	0.62	0.23
	I	1417	0.02	0.02	0.02	0.02	0.03	0.00	0.19	-0.19	-0.02	0.01	-0.01	-0.01	-0.01	-0.02	0.00	-0.01	0.18	-0.20	-0.03	0.01
120	A	116	-0.02	0.04	-0.08	-0.02	-0.02	4.36	2.13	6.59	5.40	3.32	-1.06	-1.00	-1.12	-1.05	-1.05	1.38	-0.85	3.62	2.41	0.33
	B	114	-1.06	-1.77	-0.36	-0.40	-1.73	-1.04	-1.69	-0.39	-0.36	-1.72	-0.90	-1.61	-0.20	-0.23	-1.57	-0.94	-1.59	-0.28	-0.26	-1.62
	C	112	0.09	0.12	0.06	0.07	0.12	0.02	0.05	-0.02	-0.01	0.04	0.03	0.06	-0.01	0.00	0.05	0.02	0.05	-0.01	-0.01	0.04
	D	111	0.10	0.08	0.11	0.09	0.10	0.11	0.09	0.14	0.11	0.12	0.09	0.07	0.10	0.08	0.10	0.08	0.06	0.10	0.07	0.09
	E	1233	-0.02	-0.01	-0.02	0.00	-0.03	0.10	0.08	0.12	0.12	0.09	0.19	0.20	0.19	0.21	0.18	0.19	0.17	0.21	0.20	0.17
	F	107	0.18	0.21	0.14	0.17	0.18	0.05	0.06	0.04	0.05	0.06	0.90	0.93	0.87	0.89	0.90	0.89	0.90	0.88	0.88	0.89
	G	1269	-0.59	-0.62	-0.56	-0.56	-0.61	-0.09	-0.09	-0.09	-0.06	-0.12	-1.37	-1.40	-1.34	-1.34	-1.39	-1.34	-1.34	-1.34	-1.31	-1.36
	H	1263	0.57	0.01	1.12	0.68	0.45	0.46	0.18	0.73	0.56	0.36	-0.13	-0.68	0.42	-0.02	-0.26	-0.22	-0.49	0.06	-0.12	-0.32
	I	1255	-0.91	-1.14	-0.68	-0.87	-0.96	0.26	0.26	0.25	0.28	0.23	1.14	0.92	1.37	1.19	1.09	1.23	1.24	1.23	1.25	1.21
90	A	96	-0.08	-0.06	-0.09	-0.08	-0.08	5.47	5.00	5.93	5.51	5.42	-1.14	-1.12	-1.15	-1.15	-1.15	-0.58	-1.05	-0.11	-0.58	-0.67
	B	94	-0.88	-0.88	-0.89	-0.88	-0.89	-1.05	-1.06	-1.05	-1.05	-1.06	-0.98	-0.98	-0.98	-0.97	-0.98	-1.03	-1.03	-1.03	-1.03	-1.04
	C	90	0.15	0.16	0.15	0.16	0.15	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.09
	D	89	0.30	0.29	0.31	0.30	0.30	0.33	0.32	0.33	0.33	0.32	0.32	0.31	0.33	0.32	0.32	0.31	0.31	0.32	0.31	0.31
	E	1064	0.15	0.14	0.16	0.15	0.15	0.15	0.15	0.14	0.15	0.14	0.27	0.26	0.28	0.27	0.27	0.28	0.28	0.28	0.28	0.28
	F	85	0.19	0.21	0.18	0.19	0.19	0.07	0.07	0.06	0.07	0.07	0.90	0.92	0.89	0.91	0.91	0.89	0.90	0.89	0.90	0.90
	G	1121	-0.71	-0.98	-0.44	-0.70	-0.72	0.06	-0.02	0.13	0.08	0.03	-1.83	-2.10	-1.56	-1.82	-1.84	-1.81	-1.88	-1.73	-1.78	-1.84
	H	1113	-1.14	-0.65	-1.64	-1.23	-1.05	-0.17	-0.01	-0.34	-0.23	-0.11	0.37	0.86	-0.12	0.32	0.49	0.46	0.63	0.30	0.40	0.52
	I	1105	-1.41	-1.84	-0.99	-1.37	-1.46	0.60	0.71	0.50	0.59	0.62	1.37	0.94	1.80	1.42	1.32	1.93	2.03	1.83	1.91	1.94
60	A	64	-0.06	-0.15	0.02	-0.05	-0.08	6.95	9.57	4.32	5.21	8.69	-1.15	-1.24	-1.07	-1.16	-1.19	-2.95	-0.33	-5.58	-4.85	-1.37
	B	59	-0.83	-0.06	-1.60	-1.74	0.08	-0.96	-0.16	-1.75	-1.87	-0.04	-0.82	-0.05	-1.59	-1.73	0.09	-1.01	-0.21	-1.80	-1.92	-0.08
	C	61	0.15	0.12	0.19	0.17	0.13	0.11	0.07	0.14	0.13	0.08	0.11	0.07	0.14	0.13	0.08	0.11	0.08	0.15	0.14	0.09
	D	62	0.05	0.05	0.05	0.06	0.04	0.08	0.11	0.06	0.09	0.07	0.04	0.04	0.04	0.04	0.03	0.02	0.05	0.00	0.03	0.01
	E	978	-1.32	-1.52	-1.13	-1.60	-1.05	-0.13	-0.05	-0.20	-0.34	0.08	0.58	0.38	0.77	0.31	0.86	0.51	0.59	0.44	0.33	0.75
	F	56	0.34	0.37	0.32	0.36	0.33	0.08	0.09	0.06	0.08	0.07	0.96	0.99	0.93	0.96	0.94	0.96	0.97	0.94	0.96	0.95
	G	727	-0.59	-1.13	-0.05	-0.68	-0.50	0.42	0.39	0.45	0.39	0.45	-1.89	-2.43	-1.35	-1.96	-1.78	-1.96	-1.99	-1.93	-1.96	-1.89
	H	715	-5.00	-3.81	-6.19	-5.32	-4.68	-0.17	-0.02	-0.33	-0.33	-0.01	2.78	3.97	1.59	2.63	3.27	2.41	2.56	2.26	2.22	2.54
	I	707	-2.57	-2.94	-2.20	-2.59	-2.55	1.96	2.86	1.06	1.94	1.99	1.47	1.10	1.84	1.41	1.45	2.37	3.27	1.47	2.35	2.40

TABLE-5.8 (contd....) SHEAR STRESSES IN YZ PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	0.97	1.06	0.87	0.97	0.96	-1.20	-0.51	-1.90	-2.30	-0.10	1.37	1.46	1.27	0.59	0.59	1.04	1.73	0.34	-0.08	2.12
	B	34	-1.04	-0.38	-1.70	-2.76	0.67	-0.56	0.18	-1.30	-2.28	1.16	0.01	0.67	-0.65	-1.73	1.71	-0.37	0.37	-1.11	-2.07	1.36
	C	38	0.02	-0.03	0.06	0.06	-0.03	0.08	0.02	0.14	0.13	0.03	0.04	0.00	0.08	0.10	0.00	0.05	-0.01	0.11	0.10	0.01
	D	35	-0.01	-0.04	0.01	0.00	-0.02	-0.01	-0.03	0.01	0.00	-0.02	-0.04	-0.07	-0.02	-0.03	-0.05	-0.04	-0.06	-0.03	-0.03	-0.05
	E	486	-0.02	0.11	-0.14	-0.03	0.00	0.07	0.13	0.01	0.06	0.09	0.14	0.26	0.01	0.13	0.15	0.15	0.21	0.09	0.13	0.16
	F	465	-0.17	-0.19	-0.15	-0.16	-0.17	-0.04	-0.06	-0.03	-0.04	-0.05	-0.02	-0.04	0.00	-0.01	-0.02	-0.02	-0.04	0.00	-0.02	-0.03
	G	644	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.02	0.01	0.01	0.01	0.02	0.02
	H	47	-0.33	-0.50	-0.17	-0.42	-0.24	-0.25	-0.36	-0.14	-0.31	-0.19	0.49	0.33	0.66	0.41	0.59	0.45	0.34	0.56	0.39	0.51
	I	637	0.00	0.06	-0.06	0.06	-0.06	-0.01	-0.01	0.00	0.04	-0.06	0.02	0.08	-0.04	0.10	-0.02	0.06	0.06	0.07	0.11	0.01
Minimum	Node	No.	4	4	4	4	4	18803	18803	17491	18803	17491	22564	22564	22564	10028	10028	22564	22564	845	845	10028
		X	275.0	275.0	275.0	275.0	275.0	61.0	61.0	-150.8	61.0	-150.8	273.3	273.3	273.3	-55.3	-55.3	273.3	273.3	204.2	204.2	-55.3
		Y	110.0	110.0	110.0	110.0	110.0	144.9	144.9	143.0	144.9	143.0	-54.3	-54.3	-54.3	-127.7	-127.7	-54.3	-54.3	110.0	110.0	-127.7
		Z	0.0	0.0	0.0	0.0	0.0	342.7	342.7	315.1	342.7	315.1	-30.4	-30.4	-30.4	-422.0	-422.0	-30.4	-30.4	-256.0	-256.0	-422.0
	Value		-15.60	-16.33	-14.87	-16.16	-15.05	-7.66	-8.17	-7.89	-7.89	-7.50	-5.68	-5.50	-5.87	-4.13	-4.17	-5.20	-4.94	-6.43	-6.22	-4.18
Maximum	Node	No.	18106	13	18106	18106	18106	6965	6965	6965	6965	6965	22561	22561	22561	4	4	22561	22561	22561	10037	2575
		X	-89.96	265.63	-89.96	-89.96	-89.96	158.38	158.38	158.38	158.38	158.38	272.67	272.67	272.67	275.0	275.0	272.67	272.67	272.67	-54.92	324.70
		Y	193.09	110.00	193.09	193.09	193.09	116.73	116.73	116.73	116.73	116.73	66.51	66.51	66.51	110.0	110.0	66.51	66.51	66.51	126.85	110.00
		Z	676.61	-71.18	676.61	676.61	676.61	-295.26	-295.26	-295.26	-295.26	-295.26	-35.73	-35.73	-35.73	0.0	0.0	-35.73	-35.73	-35.73	-423.17	42.75
	Value		5.70	5.95	5.52	5.74	5.65	8.64	9.85	7.42	7.74	9.53	9.08	9.31	8.86	7.03	8.14	7.73	7.71	7.76	4.35	5.65

TABLE-5.9 SHEAR STRESSES IN XZ PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	0.62	1.07	0.17	0.52	0.73	1.69	1.25	2.13	1.72	1.66	3.04	3.49	2.59	-0.49	-0.28	4.02	3.58	4.46	1.06	1.00
	B	6	-1.26	-1.30	-1.22	-0.65	-1.86	-0.14	-0.13	-0.15	0.47	-0.76	0.53	0.49	0.56	1.15	-0.06	0.14	0.14	0.13	0.75	-0.48
	C	8	-2.77	-2.67	-2.86	-1.99	-3.54	-0.50	-0.58	-0.42	0.16	-1.16	2.28	2.38	2.19	3.07	1.51	1.58	1.50	1.67	2.24	0.91
	D	9	0.06	0.04	0.08	0.08	0.03	0.08	0.09	0.07	0.10	0.06	0.04	0.02	0.07	0.06	0.01	0.01	0.02	0.01	0.04	-0.01
	E	296	-0.05	-0.08	-0.01	-0.05	-0.05	-0.08	-0.11	-0.04	-0.07	-0.08	-0.15	-0.18	-0.12	-0.14	-0.15	-0.13	-0.16	-0.10	-0.13	-0.13
	F	2	-0.05	-0.22	0.13	-0.16	0.06	0.21	0.32	0.10	0.16	0.26	2.69	2.51	2.86	-0.03	0.19	2.17	2.28	2.06	-0.20	-0.10
	G	24	0.03	0.05	0.01	0.00	0.05	-0.01	0.00	-0.03	-0.03	0.00	0.38	0.39	0.36	0.35	0.40	0.38	0.40	0.36	0.36	0.40
	H	23	-0.02	-0.04	-0.01	-0.02	-0.02	-0.05	-0.07	-0.04	-0.06	-0.05	-0.51	-0.52	-0.49	-0.51	-0.50	-0.49	-0.51	-0.48	-0.50	-0.49
	I	27	0.42	-0.08	0.92	1.18	-0.34	-0.23	-0.58	0.13	0.37	-0.82	0.12	-0.38	0.62	0.89	-0.63	0.45	0.10	0.81	1.07	-0.12
330	A	260	-3.89	-3.61	-4.16	-3.86	-3.91	0.37	0.59	0.15	0.26	0.49	2.36	2.64	2.08	2.18	2.13	-0.19	0.03	-0.41	-0.32	-0.09
	B	258	5.13	3.44	6.81	5.40	4.85	-1.03	-2.58	0.51	-0.69	-1.37	-1.95	-3.64	-0.26	-1.66	-2.22	-0.37	-1.92	1.17	-0.02	-0.69
	C	256	0.13	-0.56	0.82	0.43	-0.18	-1.91	-2.73	-1.09	-1.63	-2.20	0.89	0.20	1.59	1.18	0.57	1.21	0.39	2.03	1.49	0.92
	D	255	0.31	0.20	0.42	0.31	0.31	0.13	0.09	0.17	0.13	0.13	-0.10	-0.22	0.01	-0.11	-0.12	-0.08	-0.12	-0.04	-0.08	-0.08
	E	2413	-0.15	-0.18	-0.11	-0.15	-0.15	-0.06	-0.08	-0.03	-0.06	-0.05	0.01	-0.02	0.04	0.01	0.01	-0.01	-0.03	0.02	-0.01	-0.01
	F	251	-0.12	-0.12	-0.12	-0.13	-0.12	0.02	0.04	0.01	0.02	0.03	0.22	0.22	0.22	0.03	0.04	0.17	0.19	0.16	0.00	0.01
	G	2453	0.16	0.26	0.06	0.16	0.16	0.05	0.11	-0.01	0.05	0.05	1.41	1.51	1.31	1.39	1.39	1.42	1.48	1.36	1.40	1.40
	H	2447	-0.21	-0.31	-0.12	-0.22	-0.21	-0.13	-0.21	-0.06	-0.14	-0.13	-2.57	-2.66	-2.48	-2.57	-2.56	-2.58	-2.65	-2.51	-2.58	-2.57
	I	2441	-3.64	-5.03	-2.26	-3.29	-4.00	-0.81	-1.85	0.24	-0.56	-1.05	0.17	-1.22	1.55	0.53	-0.18	-0.35	-1.39	0.70	-0.08	-0.57
300	A	240	-5.32	-5.31	-5.32	-5.37	-5.26	0.31	0.67	-0.05	0.37	0.24	2.42	2.42	2.42	2.27	2.38	-0.25	0.11	-0.61	-0.19	-0.31
	B	238	6.57	5.24	7.91	6.47	6.68	-0.58	-1.99	0.82	-0.72	-0.45	-2.02	-3.36	-0.69	-2.19	-1.98	-0.46	-1.87	0.95	-0.57	-0.30
	C	236	1.88	0.76	3.00	1.49	2.27	-1.70	-2.78	-0.62	-2.06	-1.34	-0.11	-1.23	1.01	-0.45	0.33	0.66	-0.41	1.75	0.31	1.03
	D	235	0.48	0.48	0.49	0.50	0.47	0.13	0.14	0.13	0.14	0.13	-0.08	-0.08	-0.07	-0.06	-0.09	0.01	0.01	0.00	0.01	0.00
	E	2213	-0.22	-0.25	-0.20	-0.22	-0.22	-0.07	-0.09	-0.05	-0.07	-0.07	-0.03	-0.06	-0.01	-0.03	-0.03	-0.06	-0.08	-0.04	-0.06	-0.06
	F	231	-0.16	-0.16	-0.16	-0.17	-0.16	0.01	0.01	0.00	0.01	0.01	-0.12	-0.12	-0.12	-0.14	-0.13	-0.14	-0.14	-0.15	-0.16	-0.15
	G	2251	0.15	0.34	-0.05	0.17	0.13	0.06	0.17	-0.05	0.08	0.05	1.16	1.36	0.97	1.19	1.15	1.18	1.29	1.06	1.20	1.16
	H	2245	-0.49	-0.69	-0.28	-0.51	-0.47	-0.19	-0.31	-0.08	-0.21	-0.18	-2.05	-2.25	-1.84	-2.08	-2.04	-2.11	-2.23	-2.00	-2.13	-2.10
	I	2241	-3.79	-5.31	-2.27	-4.08	-3.50	-0.53	-1.23	0.17	-0.77	-0.29	0.28	-1.24	1.80	-0.06	0.52	-0.35	-1.05	0.35	-0.59	-0.11

TABLE-5.9 (contd....) SHEAR STRESSES IN XZ PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	-0.23	-0.36	-0.09	-0.25	-0.20	0.04	0.91	-0.83	0.28	-0.20	-0.05	-0.19	0.08	-0.12	-0.07	-0.02	0.84	-0.89	0.21	-0.26
	B	218	-0.20	-1.00	0.60	-0.99	0.59	-0.11	-0.93	0.71	-0.91	0.69	0.12	-0.68	0.92	-0.66	0.91	-0.11	-0.93	0.71	-0.91	0.69
	C	216	-1.10	-2.38	0.17	-1.83	-0.38	-0.13	-1.15	0.89	-0.77	0.51	1.22	-0.05	2.50	0.47	1.92	0.53	-0.48	1.55	-0.10	1.17
	D	215	-0.05	0.01	-0.10	-0.06	-0.03	-0.03	-0.03	-0.03	-0.04	-0.02	0.12	0.17	0.07	0.10	0.14	0.09	0.09	0.09	0.08	0.10
	E	2051	0.04	0.02	0.06	0.03	0.05	0.01	0.02	0.01	0.01	0.02	-0.01	-0.03	0.01	-0.02	0.00	0.01	0.01	0.00	0.00	0.01
	F	199	-0.03	-0.04	-0.03	-0.04	-0.03	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.01	-0.02	-0.02	-0.01	-0.01	-0.01	-0.03	-0.03
	G	2091	0.01	0.22	-0.21	0.04	-0.02	0.00	0.12	-0.13	0.02	-0.02	0.00	0.21	-0.22	0.02	-0.03	0.01	0.13	-0.12	0.02	-0.02
	H	2083	-0.09	-0.38	0.19	-0.14	-0.05	0.00	-0.11	0.12	-0.03	0.04	0.48	0.19	0.76	0.42	0.51	0.49	0.37	0.60	0.45	0.52
	I	2077	0.47	-1.35	2.29	-0.30	1.24	-0.10	-0.63	0.42	-0.66	0.45	0.04	-1.78	1.86	-0.84	0.70	0.43	-0.09	0.95	-0.13	0.98
240	A	198	4.53	5.11	3.96	4.60	4.46	-0.23	0.14	-0.60	-0.16	-0.30	-0.96	-0.39	-1.54	-0.88	-1.01	0.29	0.67	-0.08	0.36	0.23
	B	196	-6.29	-8.62	-3.96	-6.85	-5.73	0.16	-1.36	1.67	-0.34	0.66	2.02	-0.31	4.35	1.45	2.56	1.26	-0.26	2.77	0.76	1.75
	C	194	-4.15	-5.55	-2.74	-4.54	-3.76	0.99	0.12	1.85	0.68	1.29	1.51	0.10	2.91	1.09	1.87	0.55	-0.32	1.41	0.24	0.86
	D	193	-0.35	-0.37	-0.33	-0.35	-0.34	-0.08	-0.08	-0.09	-0.08	-0.08	-0.03	-0.05	-0.01	-0.04	-0.03	-0.07	-0.07	-0.07	-0.07	-0.07
	E	1882	0.16	0.14	0.17	0.16	0.16	0.05	0.03	0.07	0.05	0.05	0.01	-0.01	0.02	0.01	0.01	0.01	-0.01	0.03	0.01	0.01
	F	189	0.07	0.06	0.07	0.07	0.07	0.01	0.00	0.02	0.01	0.01	0.31	0.30	0.31	0.30	0.31	0.31	0.30	0.31	0.30	0.31
	G	1922	-0.12	-0.01	-0.23	-0.12	-0.11	-0.08	-0.02	-0.15	-0.09	-0.08	-1.22	-1.11	-1.33	-1.24	-1.23	-1.22	-1.15	-1.28	-1.24	-1.23
	H	1914	0.19	0.09	0.29	0.17	0.22	0.06	0.01	0.11	0.04	0.08	2.80	2.69	2.90	2.77	2.82	2.81	2.76	2.86	2.79	2.83
	I	1908	2.36	1.28	3.45	2.02	2.71	-0.56	-0.81	-0.32	-0.82	-0.30	-1.58	-2.67	-0.49	-1.99	-1.31	-1.00	-1.25	-0.75	-1.26	-0.74
210	A	178	3.72	4.58	2.87	3.79	3.66	0.04	0.04	0.04	-0.14	0.23	0.65	1.51	-0.20	0.74	0.60	0.34	0.35	0.34	0.16	0.53
	B	176	-5.69	-7.98	-3.40	-5.64	-5.74	-0.14	-1.69	1.40	-0.03	-0.25	0.71	-1.59	3.00	0.70	0.60	0.88	-0.67	2.42	0.99	0.77
	C	174	-2.59	-3.88	-1.31	-2.29	-2.90	0.87	0.18	1.56	1.17	0.58	0.15	-1.13	1.43	0.45	-0.16	0.38	-0.31	1.07	0.68	0.09
	D	173	-0.88	-1.08	-0.68	-0.89	-0.87	-0.13	-0.15	-0.10	-0.13	-0.12	-0.16	-0.36	0.04	-0.18	-0.15	-0.15	-0.18	-0.13	-0.16	-0.15
	E	1712	0.48	0.41	0.54	0.47	0.48	0.09	0.02	0.16	0.08	0.09	0.17	0.10	0.23	0.17	0.17	0.17	0.10	0.24	0.17	0.18
	F	169	0.11	0.08	0.14	0.11	0.12	0.04	0.01	0.07	0.04	0.04	0.51	0.48	0.54	0.52	0.52	0.51	0.49	0.54	0.51	0.52
	G	1759	-0.17	-0.09	-0.26	-0.21	-0.13	-0.12	-0.06	-0.18	-0.15	-0.08	-1.30	-1.22	-1.39	-1.34	-1.26	-1.29	-1.23	-1.35	-1.32	-1.25
	H	1751	0.25	0.17	0.33	0.25	0.26	0.09	0.03	0.15	0.08	0.09	2.20	2.12	2.28	2.19	2.21	2.16	2.10	2.23	2.16	2.17
	I	1745	1.49	1.11	1.88	1.79	1.19	-0.51	-0.44	-0.58	-0.29	-0.73	-0.42	-0.81	-0.03	-0.11	-0.72	-0.79	-0.72	-0.86	-0.57	-1.01
180	A	158	-0.55	-0.55	-0.56	-0.56	-0.55	0.27	0.29	0.26	-0.21	0.76	0.51	0.51	0.50	0.50	0.51	-0.40	-0.38	-0.41	-0.88	0.09
	B	156	0.63	0.57	0.69	1.25	0.02	-0.05	-0.13	0.02	0.55	-0.66	-0.41	-0.47	-0.36	0.20	-1.03	-0.09	-0.16	-0.01	0.52	-0.69
	C	154	1.83	1.84	1.82	2.49	1.18	0.09	0.01	0.18	0.64	-0.46	-0.57	-0.56	-0.58	0.08	-1.23	-0.08	-0.16	0.01	0.48	-0.63
	D	153	0.34	0.36	0.32	0.38	0.30	0.05	0.04	0.07	0.08	0.03	-0.06	-0.04	-0.08	-0.02	-0.10	0.03	0.01	0.04	0.05	0.00
	E	1560	-0.06	-0.05	-0.07	-0.04	-0.07	-0.01	0.00	-0.02	0.00	-0.02	0.00	0.01	-0.01	0.02	-0.01	-0.01	0.00	-0.02	0.00	-0.02
	F	149	-0.01	-0.06	0.04	-0.01	-0.02	0.02	0.00	0.04	0.02	0.02	0.04	-0.01	0.09	0.04	0.04	0.04	0.02	0.06	0.04	0.04
	G	1594	0.15	-0.03	0.32	0.10	0.19	0.06	-0.02	0.15	0.02	0.10	0.11	-0.07	0.28	0.05	0.14	0.11	0.03	0.20	0.07	0.15
	H	1588	-0.25	-0.17	-0.33	-0.28	-0.22	-0.10	-0.03	-0.17	-0.12	-0.07	-0.96	-0.88	-1.04	-0.99	-0.93	-0.95	-0.88	-1.02	-0.97	-0.92
	I	1582	-2.65	-2.78	-2.51	-2.19	-3.11	-0.38	-0.25	-0.51	-0.01	-0.75	0.84	0.70	0.97	1.29	0.37	0.05	0.18	-0.08	0.42	-0.32

TABLE-5.9 (contd....) SHEAR STRESSES IN XZ PLANE

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-2.64	-3.27	-2.02	-2.70	-2.58	0.27	0.20	0.34	0.10	0.44	-1.56	-2.18	-0.94	-1.63	-1.51	-0.30	-0.37	-0.23	-0.47	-0.13
	B	134	4.65	6.26	3.05	5.09	4.22	-0.19	1.08	-1.46	0.22	-0.60	0.52	2.13	-1.09	1.00	0.13	-0.25	1.02	-1.52	0.15	-0.66
	C	132	3.70	4.77	2.63	4.06	3.34	-0.52	0.02	-1.06	-0.24	-0.80	-0.07	1.00	-1.14	0.30	-0.43	-0.46	0.08	-1.01	-0.18	-0.75
	D	131	0.37	0.41	0.33	0.37	0.37	0.06	0.05	0.07	0.06	0.07	0.14	0.18	0.09	0.14	0.14	0.11	0.10	0.11	0.10	0.11
	E	1393	-0.10	-0.13	-0.06	-0.10	-0.09	-0.03	-0.04	-0.03	-0.04	-0.03	-0.08	-0.11	-0.05	-0.09	-0.07	-0.06	-0.07	-0.06	-0.07	-0.06
	F	127	-0.34	-0.36	-0.32	-0.33	-0.35	-0.10	-0.09	-0.11	-0.09	-0.11	-0.74	-0.76	-0.72	-0.74	-0.75	-0.72	-0.71	-0.74	-0.72	-0.73
	G	1431	0.46	-0.03	0.95	0.48	0.45	0.23	-0.02	0.48	0.23	0.23	1.47	0.98	1.96	1.46	1.44	1.46	1.21	1.71	1.46	1.46
	H	1423	-0.88	-0.90	-0.86	-0.84	-0.92	-0.21	-0.15	-0.26	-0.17	-0.24	-3.05	-3.07	-3.03	-3.01	-3.09	-2.99	-2.93	-3.04	-2.95	-3.02
	I	1417	-2.62	-2.72	-2.53	-2.46	-2.78	0.70	-0.18	1.59	0.76	0.65	2.03	1.93	2.12	2.17	1.85	1.99	1.11	2.88	2.05	1.93
120	A	116	-1.30	-1.33	-1.27	-1.33	-1.28	-0.29	-1.44	0.85	-0.04	-0.55	-2.31	-2.34	-2.28	-2.36	-2.32	-0.07	-1.22	1.07	0.19	-0.33
	B	114	3.20	4.35	2.05	2.78	3.62	-0.41	0.67	-1.49	-0.79	-0.02	1.37	2.53	0.22	0.94	1.78	0.41	1.49	-0.67	0.03	0.80
	C	112	1.84	2.42	1.27	1.61	2.08	-0.68	-0.18	-1.17	-0.87	-0.49	0.21	0.78	-0.37	0.02	0.48	-0.23	0.26	-0.72	-0.43	-0.04
	D	111	0.45	0.48	0.43	0.46	0.45	0.02	0.03	0.00	0.02	0.01	0.16	0.19	0.14	0.17	0.16	0.09	0.10	0.07	0.09	0.08
	E	1233	-0.38	-0.40	-0.37	-0.37	-0.39	-0.03	-0.03	-0.02	-0.02	-0.03	-0.28	-0.30	-0.26	-0.27	-0.29	-0.22	-0.22	-0.22	-0.21	-0.23
	F	107	-0.67	-0.80	-0.54	-0.65	-0.69	-0.18	-0.22	-0.14	-0.16	-0.19	-0.99	-1.12	-0.86	-0.97	-1.00	-0.96	-1.00	-0.92	-0.94	-0.97
	G	1269	0.11	-0.80	1.03	0.23	0.00	0.20	-0.23	0.62	0.28	0.11	1.11	0.19	2.02	1.23	0.99	1.08	0.65	1.50	1.20	1.03
	H	1263	-0.25	-0.48	-0.02	-0.19	-0.30	0.02	-0.05	0.09	0.06	-0.03	-1.52	-1.75	-1.29	-1.48	-1.58	-1.49	-1.56	-1.42	-1.45	-1.53
	I	1255	-0.71	0.37	-1.78	-0.88	-0.53	1.04	0.32	1.75	1.03	1.04	0.72	1.79	-0.36	0.63	0.98	1.84	1.12	2.56	1.84	1.85
90	A	96	0.19	0.63	-0.26	0.16	0.21	-0.07	-2.17	2.04	0.49	-0.62	-0.04	0.40	-0.49	-0.02	0.03	0.25	-1.86	2.36	0.80	-0.30
	B	94	-0.29	0.32	-0.90	-1.04	0.46	-0.08	0.61	-0.77	-0.80	0.64	-0.06	0.55	-0.67	-0.81	0.69	0.16	0.85	-0.52	-0.56	0.88
	C	90	-0.31	-0.26	-0.36	-0.85	0.24	-0.19	0.02	-0.41	-0.63	0.24	-0.11	-0.06	-0.16	-0.65	0.44	0.33	0.55	0.12	-0.11	0.76
	D	89	-0.06	-0.13	0.01	-0.10	-0.02	-0.04	-0.06	-0.01	-0.06	-0.01	-0.06	-0.13	0.01	-0.10	-0.02	0.01	-0.01	0.04	-0.02	0.04
	E	1064	0.17	0.20	0.15	0.17	0.18	0.03	0.03	0.03	0.03	0.03	0.21	0.24	0.18	0.21	0.22	0.16	0.16	0.16	0.16	0.16
	F	85	-0.28	-0.50	-0.06	-0.26	-0.30	-0.03	-0.12	0.05	-0.01	-0.05	-0.09	-0.31	0.13	-0.05	-0.10	-0.10	-0.19	-0.01	-0.06	-0.10
	G	1121	-0.24	-1.54	1.06	-0.07	-0.41	0.35	-0.11	0.82	0.49	0.22	-0.22	-1.52	1.08	-0.06	-0.40	-0.29	-0.76	0.17	-0.11	-0.38
	H	1113	-0.33	-0.21	-0.44	-0.37	-0.29	-0.12	-0.18	-0.06	-0.14	-0.10	1.21	1.32	1.09	1.20	1.28	1.16	1.10	1.22	1.15	1.18
	I	1105	1.99	4.28	-0.30	1.63	2.35	-0.06	-1.07	0.96	0.16	-0.27	0.97	3.27	-1.32	0.77	1.49	0.29	-0.72	1.31	0.50	0.08
60	A	64	-0.45	-0.41	-0.50	-0.56	-0.34	1.69	-0.43	3.81	2.21	1.16	1.33	1.37	1.28	1.52	1.74	0.11	-2.01	2.23	0.62	-0.43
	B	59	-0.69	0.52	-1.91	-1.23	-0.15	0.74	2.37	-0.89	0.18	1.30	0.18	1.39	-1.04	-0.42	0.66	0.92	2.56	-0.71	0.32	1.44
	C	61	-0.58	-0.10	-1.07	-0.84	-0.33	0.63	1.24	0.03	0.38	0.89	0.75	1.24	0.26	0.36	0.86	1.06	1.66	0.45	0.79	1.30
	D	62	-0.23	-0.26	-0.20	-0.23	-0.24	-0.04	-0.03	-0.05	-0.04	-0.04	0.08	0.05	0.11	0.07	0.06	0.09	0.09	0.08	0.09	0.09
	E	978	-0.19	-0.20	-0.19	-0.23	-0.15	-0.06	-0.05	-0.07	-0.09	-0.02	0.11	0.10	0.11	0.07	0.15	0.08	0.09	0.08	0.05	0.13
	F	56	0.04	-0.07	0.16	0.06	0.03	0.00	-0.08	0.08	0.02	-0.02	0.41	0.30	0.53	0.52	0.50	0.39	0.31	0.47	0.49	0.45
	G	727	0.53	-0.45	1.51	0.54	0.51	0.79	0.64	0.94	0.83	0.76	-0.23	-1.21	0.75	-0.17	-0.20	-0.34	-0.49	-0.19	-0.21	-0.27
	H	715	-1.12	-1.03	-1.21	-1.17	-1.07	-0.28	-0.69	0.13	-0.21	-0.35	2.45	2.54	2.36	2.55	2.65	2.12	1.72	2.53	2.24	2.09
	I	707	2.54	3.79	1.28	2.37	2.70	-2.22	-4.92	0.49	-1.69	-2.74	1.33	2.58	0.08	1.47	1.80	-0.76	-3.46	1.94	-0.24	-1.29

TABLE-5.9 (contd....) SHEAR STRESSES IN XZ PLANE

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-1.25	-1.41	-1.09	-1.38	-1.12	-0.25	-0.17	-0.32	-0.25	-0.25	-2.07	-2.23	-1.90	0.13	0.40	0.02	0.09	-0.06	0.05	0.04
	B	34	-1.80	-0.72	-2.87	-1.15	-2.45	0.19	1.78	-1.41	0.72	-0.35	1.08	2.16	0.01	1.54	0.24	1.02	2.61	-0.58	1.60	0.54
	C	38	-2.02	-1.16	-2.88	-1.66	-2.37	0.72	1.43	0.01	0.97	0.47	1.93	2.79	1.07	2.35	1.63	1.62	2.33	0.91	1.89	1.39
	D	35	-0.06	-0.12	-0.01	-0.08	-0.05	-0.05	-0.09	-0.01	-0.06	-0.04	0.04	-0.02	0.10	0.02	0.05	0.03	-0.01	0.07	0.02	0.04
	E	486	0.04	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
	F	465	-0.28	-0.38	-0.18	-0.29	-0.27	-0.05	-0.12	0.02	-0.04	-0.06	-1.70	-1.80	-1.59	-0.64	-0.62	-1.65	-1.72	-1.58	-0.67	-0.69
	G	644	0.19	0.12	0.25	0.21	0.16	0.00	-0.03	0.03	0.02	-0.02	0.14	0.07	0.20	0.19	0.14	0.17	0.14	0.20	0.22	0.18
	H	47	0.05	0.03	0.06	0.04	0.05	0.03	0.02	0.03	0.03	0.03	0.00	-0.01	0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00
	I	637	1.29	1.88	0.70	1.77	0.82	0.63	0.96	0.29	0.99	0.26	1.26	1.85	0.67	1.82	0.86	1.50	1.83	1.17	1.86	1.12
Minimum		**No.**	**186**	**186**	**249**	**196**	**186**	**4930**	**4920**	**113**	**4930**	**4930**	**2769**	**2769**	**2769**	**1423**	**1423**	**4927**	**4927**	**1423**	**1423**	**4927**
	Node	**X**	-194.5	-194.5	194.5	-137.5	-194.5	232.5	201.2	-237.5	232.5	232.5	266.7	266.7	266.7	-524.5	-524.5	181.8	181.8	-524.5	-524.5	181.8
		Y	420.0	420.0	110.0	420.0	420.0	99.2	110.6	420.0	99.2	99.2	110.0	110.0	110.0	15.2	15.2	115.1	115.1	15.2	15.2	115.1
		Z	194.5	194.5	194.5	238.2	194.5	-251.7	-278.4	-411.4	-251.7	-251.7	-124.1	-124.1	-124.1	-302.8	-302.8	-284.2	-284.2	-302.8	-302.8	-284.2
	Value		**-6.96**	**-9.32**	**-6.15**	**-6.85**	**-7.22**	**-4.34**	**-7.47**	**-2.90**	**-4.16**	**-4.52**	**-4.71**	**-5.21**	**-4.22**	**-3.01**	**-3.09**	**-3.23**	**-9.11**	**-3.04**	**-2.95**	**-4.22**
Maximum		**No.**	**248**	**187**	**248**	**248**	**248**	**841**	**43**	**841**	**841**	**841**	**249**	**249**	**249**	**249**	**249**	**5**	**43**	**10041**	**526**	**1827**
	Node	**X**	194.45	-194.45	194.45	194.45	194.45	187.40	335.88	187.40	187.40	187.40	194.45	194.45	194.45	194.45	194.45	327.50	335.88	-21.38	438.84	-517.31
		Y	420.00	110.00	420.00	420.00	420.00	110.00	420.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	420.00	127.64	420.00	-31.65
		Z	194.45	194.45	194.45	194.45	194.45	-268.58	-335.88	-268.58	-268.58	-268.58	194.45	194.45	194.45	194.45	194.45	0.00	-335.88	-344.85	-181.77	517.31
	Value		**7.14**	**6.55**	**9.24**	**6.76**	**7.52**	**6.88**	**3.31**	**10.58**	**7.63**	**6.13**	**5.19**	**5.29**	**5.09**	**4.59**	**4.69**	**4.02**	**3.79**	**4.82**	**3.49**	**2.93**

TABLE-5.10 PRINCIPAL STRESSES S1

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-1.74	-1.54	-1.94	-1.91	-1.56	11.00	11.54	10.78	11.73	10.49	24.38	26.80	21.97	5.51	8.99	23.40	22.00	25.51	5.25	5.59
	B	6	0.86	0.34	2.57	0.75	1.02	1.32	2.29	2.62	1.19	2.27	3.24	4.34	2.83	3.17	3.74	1.02	2.05	2.36	1.25	2.12
	C	8	-0.21	-0.17	-0.22	-0.22	-0.19	-0.23	-0.18	-0.25	-0.22	-0.22	7.34	5.38	9.79	8.33	7.19	7.21	4.06	10.67	7.65	6.97
	D	9	0.55	0.74	0.38	0.56	0.54	0.37	0.73	0.14	0.47	0.30	0.74	1.45	0.06	0.96	0.67	0.77	1.20	0.35	0.89	0.65
	E	296	1.95	2.34	1.91	2.08	1.99	0.64	1.19	0.40	0.78	0.79	3.81	4.31	3.44	3.63	3.91	3.94	4.42	3.50	3.84	4.04
	F	2	-1.72	-1.47	-1.96	-1.49	-1.94	-0.38	-0.52	-0.22	-0.31	-0.43	1.14	1.56	0.78	7.29	3.59	1.26	0.81	1.76	4.17	3.14
	G	24	0.95	1.38	0.51	0.95	0.95	0.59	0.91	0.28	0.60	0.59	4.17	4.58	3.76	4.13	4.13	4.23	4.53	3.92	4.19	4.19
	H	23	-0.35	-0.21	-0.44	-0.35	-0.35	-0.27	-0.21	-0.29	-0.26	-0.27	2.95	3.12	2.82	2.85	3.28	2.75	2.54	2.99	2.59	2.92
	I	27	0.40	0.28	0.77	0.72	0.30	1.03	1.19	1.87	1.27	1.31	5.38	2.27	9.01	5.65	5.17	4.44	2.19	6.73	4.91	4.34
330	A	260	10.19	9.70	10.68	10.12	10.26	-2.84	-3.86	-1.11	-2.62	-2.92	-0.51	-0.52	-0.50	-0.57	-0.57	6.20	-0.22	13.75	5.43	7.76
	B	258	0.49	0.15	2.16	0.45	0.56	2.74	4.99	2.54	3.35	3.17	5.09	7.49	3.14	5.63	5.38	1.06	3.27	2.15	1.78	1.63
	C	256	-1.87	-1.87	-1.82	-1.87	-1.86	-0.52	-0.66	-0.21	-0.39	-0.45	5.28	5.09	6.91	5.88	5.40	5.28	2.93	7.98	5.35	5.51
	D	255	0.36	0.23	0.51	0.39	0.32	0.23	0.17	0.29	0.26	0.19	0.03	0.17	0.03	0.06	0.02	0.03	0.04	0.03	0.03	0.03
	E	2413	0.87	0.69	1.32	0.99	0.76	0.08	0.15	0.30	0.18	0.06	0.11	0.50	0.07	0.09	0.17	0.18	0.41	0.07	0.15	0.21
	F	251	0.82	0.80	0.83	0.84	0.80	0.03	0.03	0.04	0.04	0.02	-0.45	-0.46	-0.45	-0.49	-0.49	-0.45	-0.45	-0.45	-0.49	-0.48
	G	2453	0.76	1.13	0.40	0.76	0.76	0.39	0.64	0.17	0.39	0.39	3.65	3.99	3.32	3.61	3.61	3.71	3.93	3.48	3.67	3.67
	H	2447	0.12	0.50	-0.14	0.14	0.10	0.05	0.26	-0.10	0.06	0.04	2.92	2.90	3.18	2.72	3.14	2.55	2.41	2.81	2.41	2.70
	I	2441	0.14	0.05	0.28	0.16	0.15	0.84	0.97	1.50	0.81	1.14	4.23	2.44	7.64	4.06	4.50	2.61	2.37	4.53	2.36	3.05
300	A	240	11.77	11.66	11.88	11.88	11.66	-3.97	-4.36	-1.92	-3.82	-3.96	-0.60	-0.61	-0.59	-0.60	-0.61	4.63	4.51	11.92	4.74	5.78
	B	238	0.92	0.13	2.17	0.80	1.06	2.44	4.19	2.97	2.25	3.41	5.52	6.88	5.39	5.31	6.53	1.84	3.60	2.60	1.67	2.82
	C	236	-0.57	-0.57	-0.48	-0.57	-0.56	-0.49	-0.21	-0.20	-0.28	-0.41	4.00	4.65	5.54	4.15	4.74	3.74	3.16	5.50	3.83	4.12
	D	235	0.71	0.89	0.57	0.66	0.77	0.25	0.35	0.18	0.21	0.31	1.19	1.44	0.94	1.11	1.31	1.20	1.31	1.09	1.12	1.27
	E	2213	1.51	1.25	1.81	1.43	1.60	0.14	0.09	0.30	0.04	0.26	0.74	0.58	1.02	0.60	0.87	0.87	0.73	1.01	0.74	0.99
	F	231	0.30	0.30	0.30	0.30	0.29	0.00	0.00	0.00	0.00	0.00	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
	G	2251	1.03	1.26	0.92	1.02	1.05	0.46	0.61	0.40	0.46	0.47	3.88	4.12	3.66	3.88	3.89	3.94	4.08	3.80	3.94	3.95
	H	2245	-0.48	-0.12	-0.56	-0.47	-0.48	-0.09	0.05	-0.10	-0.09	-0.08	2.65	3.54	3.65	2.84	2.69	2.37	2.74	2.37	2.46	2.30
	I	2241	-0.10	-0.23	0.10	-0.12	-0.06	0.69	0.77	0.98	0.72	0.90	3.96	3.72	6.46	4.39	4.05	2.54	2.75	3.52	2.94	2.74

TABLE-5.10 (contd....) PRINCIPAL STRESSES S1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	11.58	12.30	10.87	11.76	11.41	-2.65	-1.82	-1.69	-2.58	-2.58	-0.62	-0.60	-0.63	-0.61	-0.62	2.82	7.93	7.57	3.77	3.32
	B	218	0.81	0.88	0.75	0.96	0.70	1.62	3.43	2.04	2.99	1.52	5.29	5.76	6.41	6.44	5.01	2.68	4.39	2.99	3.94	2.38
	C	216	0.30	0.87	0.06	0.53	0.20	-0.65	-0.26	-0.36	-0.44	-0.58	4.05	2.68	5.59	3.31	4.74	3.07	2.99	4.07	2.78	3.66
	D	215	0.25	0.26	0.24	0.25	0.24	0.10	0.07	0.18	0.09	0.13	2.75	2.50	3.01	2.60	2.82	2.31	2.20	2.42	2.24	2.37
	E	2051	2.48	2.76	2.32	2.57	2.41	0.57	0.70	0.59	0.62	0.59	2.38	2.40	2.49	2.29	2.45	2.34	2.32	2.42	2.30	2.41
	F	199	0.09	0.08	0.10	0.09	0.09	0.00	0.00	0.00	0.00	0.00	-0.51	-0.52	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51
	G	2091	1.37	1.44	1.41	1.39	1.36	0.63	0.64	0.69	0.64	0.62	4.26	4.29	4.25	4.29	4.26	4.32	4.30	4.34	4.35	4.33
	H	2083	-0.49	-0.50	-0.49	-0.50	-0.48	-0.22	-0.22	-0.22	-0.22	-0.21	1.96	3.03	3.11	2.11	1.89	1.68	2.06	1.83	1.71	1.69
	I	2077	3.60	4.59	5.18	3.58	4.16	3.31	3.63	3.26	3.58	3.32	6.18	6.93	6.84	6.69	6.26	6.70	6.78	6.75	6.73	6.82
240	A	198	10.49	11.99	9.01	10.67	10.32	-4.36	-2.27	-4.42	-4.37	-4.21	-0.60	-0.53	-0.64	-0.59	-0.60	2.58	9.87	4.20	3.59	2.76
	B	196	0.73	2.12	-0.22	0.80	0.70	1.14	2.51	2.98	1.87	1.97	4.92	3.10	8.31	5.23	5.50	3.43	3.51	5.21	3.97	4.04
	C	194	2.24	3.50	1.02	2.54	2.03	-0.35	-0.08	-0.15	-0.24	-0.21	3.58	2.40	5.06	2.92	4.17	2.57	2.80	3.00	2.32	3.12
	D	193	0.27	0.22	0.37	0.28	0.27	0.13	0.08	0.18	0.13	0.12	0.02	0.02	0.10	0.02	0.02	0.03	0.02	0.04	0.03	0.02
	E	1882	1.45	1.72	1.18	1.59	1.32	0.12	0.22	0.07	0.22	0.04	0.07	0.10	0.07	0.07	0.07	0.09	0.12	0.10	0.12	0.08
	F	189	0.11	0.10	0.13	0.11	0.12	0.00	0.00	0.01	0.00	0.00	-0.54	-0.54	-0.54	-0.54	-0.54	-0.54	-0.54	-0.54	-0.54	-0.54
	G	1922	0.76	0.70	0.95	0.77	0.75	0.37	0.28	0.53	0.38	0.37	3.09	2.95	3.24	3.13	3.10	3.09	2.98	3.21	3.13	3.12
	H	1914	0.23	0.16	0.54	0.18	0.29	0.04	0.00	0.20	0.00	0.10	2.45	3.00	2.81	2.49	2.43	2.38	2.54	2.45	2.39	2.39
	I	1908	2.04	1.49	2.89	1.75	2.41	2.57	2.49	2.89	2.79	2.63	5.80	7.45	5.00	6.40	5.63	5.25	5.14	5.51	5.39	5.29
210	A	178	9.09	10.99	7.21	9.25	8.95	-2.90	-1.10	-3.35	-2.93	-2.72	-0.26	0.65	-0.47	-0.21	-0.27	-0.33	5.95	-0.54	0.90	-0.59
	B	176	0.74	2.94	-0.35	0.69	0.81	1.15	3.18	2.37	1.08	2.02	3.24	3.16	6.22	2.73	4.16	2.94	3.13	4.56	2.72	3.95
	C	174	2.47	3.86	1.16	2.65	2.35	-0.44	-0.25	-0.45	-0.27	-0.32	2.15	2.20	3.30	1.59	2.74	1.72	2.30	1.71	1.72	2.13
	D	173	1.12	1.12	1.14	1.05	1.21	0.32	0.15	0.56	0.22	0.45	1.76	1.33	2.28	1.50	1.98	1.48	1.17	1.80	1.29	1.67
	E	1712	2.50	2.92	2.13	2.35	2.66	0.24	0.22	0.45	0.09	0.47	1.16	1.58	1.17	0.88	1.45	1.25	1.33	1.19	1.00	1.50
	F	169	0.24	0.24	0.26	0.23	0.25	0.05	0.02	0.08	0.04	0.06	-0.51	-0.51	-0.52	-0.51	-0.51	-0.52	-0.51	-0.52	-0.51	-0.51
	G	1759	1.72	1.00	2.45	1.73	1.72	0.81	0.32	1.30	0.81	0.81	4.17	3.52	4.85	4.20	4.15	4.16	3.70	4.63	4.18	4.16
	H	1751	-0.33	-0.42	-0.15	-0.39	-0.25	-0.13	-0.13	-0.10	-0.18	-0.06	2.56	2.78	2.53	2.61	2.52	2.37	2.53	2.32	2.40	2.37
	I	1745	1.93	1.80	2.06	1.74	2.19	2.39	1.92	2.88	2.57	2.48	6.84	8.23	5.50	7.33	6.51	5.79	5.40	6.19	6.07	5.61
180	A	158	7.35	9.18	5.53	7.48	7.22	-2.87	-0.74	-3.55	-2.98	-2.61	0.72	2.38	-0.17	0.82	0.61	-1.70	1.11	-1.28	-0.76	-1.85
	B	156	0.75	3.12	-0.37	0.77	0.75	1.11	3.37	1.59	1.25	1.64	1.45	3.35	2.81	1.15	2.02	2.02	3.32	2.91	2.08	2.68
	C	154	2.62	3.67	1.64	2.94	2.36	-0.37	0.05	-0.56	-0.19	-0.10	0.99	1.32	1.78	0.47	1.68	1.11	1.63	0.90	1.16	1.49
	D	153	0.42	0.31	0.58	0.43	0.41	0.21	0.03	0.67	0.20	0.28	1.42	-0.02	3.28	1.18	1.64	1.69	1.13	2.24	1.52	1.85
	E	1560	1.86	1.38	2.63	2.03	1.73	0.46	0.02	1.17	0.45	0.58	2.20	0.68	3.74	2.21	2.26	2.27	1.56	2.98	2.28	2.30
	F	149	0.45	0.47	0.45	0.44	0.47	0.13	0.10	0.17	0.12	0.15	-0.22	-0.21	-0.21	-0.22	-0.21	-0.22	-0.22	-0.21	-0.22	-0.22
	G	1594	2.62	1.49	3.77	2.67	2.57	1.14	0.37	1.92	1.17	1.12	5.06	3.95	6.18	5.11	4.99	4.97	4.21	5.73	5.01	4.95
	H	1588	-0.53	-0.70	-0.24	-0.54	-0.50	-0.26	-0.24	-0.18	-0.27	-0.21	1.32	0.78	2.03	1.42	1.22	1.26	1.13	1.40	1.37	1.19
	I	1582	1.41	1.81	1.08	1.13	1.72	2.16	1.65	2.70	2.10	2.36	6.22	7.51	5.04	6.51	6.01	6.08	5.79	6.40	6.23	6.00

TABLE-5.10 (contd....) PRINCIPAL STRESSES S1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	5.67	7.05	4.30	5.79	5.55	-3.23	-0.33	-3.99	-3.34	-2.93	1.86	3.17	0.69	1.97	1.77	-2.31	0.59	0.18	-1.34	-2.44
	B	134	0.76	2.89	-0.50	0.83	0.72	1.37	3.23	2.56	1.71	1.97	1.03	3.13	1.68	0.98	1.28	1.37	3.20	2.62	1.69	2.01
	C	132	3.48	4.90	2.13	3.77	3.24	0.04	0.33	0.06	0.07	0.28	0.14	1.46	0.84	0.21	0.73	0.62	1.22	0.62	0.61	0.94
	D	131	0.33	0.32	0.34	0.33	0.33	0.11	0.05	0.17	0.11	0.11	0.06	0.05	0.07	0.07	0.05	0.06	0.02	0.12	0.07	0.06
	E	1393	1.14	2.17	0.67	0.98	1.31	0.05	0.03	0.08	0.05	0.09	0.17	1.27	0.12	0.10	0.35	0.10	0.43	0.10	0.07	0.19
	F	127	0.83	0.93	0.74	0.81	0.86	0.26	0.26	0.26	0.23	0.28	-0.30	-0.28	-0.32	-0.31	-0.30	-0.31	-0.31	-0.32	-0.32	-0.31
	G	1431	2.39	1.88	3.53	2.39	2.41	0.98	0.54	1.73	0.99	1.00	4.26	3.12	5.48	4.28	4.21	4.15	3.44	4.89	4.18	4.16
	H	1423	0.64	0.95	0.64	0.54	0.76	0.02	0.19	0.05	-0.04	0.12	2.67	2.79	3.22	2.67	2.70	2.61	2.61	2.73	2.59	2.64
	I	1417	3.78	4.69	2.98	3.62	3.94	2.64	0.84	5.55	2.78	2.51	7.10	7.40	7.05	7.39	6.81	6.71	4.02	9.56	6.86	6.57
120	A	116	3.66	4.09	3.27	3.74	3.58	-3.25	-0.70	-2.72	-3.30	-2.97	2.71	3.00	2.48	2.88	2.73	-2.45	0.68	2.63	-1.45	-2.69
	B	114	0.82	2.02	-0.12	0.92	0.78	1.74	2.76	2.88	2.32	2.17	1.00	2.23	0.45	1.05	1.07	1.09	2.40	1.48	1.22	1.31
	C	112	1.87	2.64	1.16	1.85	1.97	0.41	0.74	0.37	0.45	0.57	-0.16	0.75	-0.34	-0.18	0.47	0.32	1.12	0.06	0.13	0.74
	D	111	0.38	0.34	0.43	0.32	0.48	0.19	0.41	0.20	0.14	0.55	0.56	0.35	0.88	0.27	1.03	0.87	1.11	0.62	0.49	1.24
	E	1233	1.47	2.91	1.76	1.24	1.91	0.27	0.34	0.57	0.18	0.45	1.62	2.93	1.94	1.34	2.13	1.58	2.08	1.61	1.30	1.90
	F	107	1.30	1.58	1.03	1.26	1.34	0.35	0.43	0.28	0.32	0.38	-0.03	0.18	-0.19	-0.06	-0.01	-0.07	-0.01	-0.12	-0.10	-0.05
	G	1269	4.03	4.43	4.30	3.93	4.14	1.11	1.07	1.63	1.07	1.19	5.98	5.94	6.43	5.90	6.01	5.73	5.53	6.01	5.68	5.84
	H	1263	-0.42	0.10	-0.26	-0.48	-0.34	-0.27	-0.25	-0.15	-0.27	-0.27	1.45	2.30	2.77	1.46	1.53	1.47	1.68	1.85	1.49	1.53
	I	1255	1.73	2.71	1.51	1.66	1.83	3.63	2.19	5.28	3.65	3.62	7.30	7.00	8.62	7.54	7.14	8.51	7.10	10.04	8.52	8.50
90	A	96	1.37	1.36	1.88	1.33	1.42	-5.66	-3.32	-3.44	-5.54	-5.55	2.54	2.12	3.16	2.82	2.88	-2.34	2.51	5.20	-0.99	-2.36
	B	94	0.93	0.91	0.96	1.10	0.87	2.18	3.67	2.64	2.82	2.43	1.02	1.02	1.04	1.18	1.05	1.13	1.93	1.22	1.28	1.39
	C	90	0.32	0.39	0.25	0.57	0.30	1.30	2.04	0.68	1.36	1.46	0.13	0.98	-0.21	0.50	0.47	0.84	1.67	0.04	0.59	1.25
	D	89	0.43	0.43	0.44	0.43	0.43	1.58	2.39	0.78	1.41	1.76	0.76	1.67	0.48	0.60	0.74	1.39	2.20	0.64	1.20	1.55
	E	1064	1.74	3.26	2.60	1.90	2.28	0.01	0.03	0.09	0.01	0.03	3.11	4.60	2.78	2.61	3.65	2.76	3.31	2.25	2.31	3.20
	F	85	1.22	1.67	0.80	1.16	1.28	0.21	0.34	0.21	0.17	0.25	-0.34	-0.09	-0.37	-0.35	-0.32	-0.35	-0.29	-0.39	-0.36	-0.34
	G	1121	4.87	6.06	4.61	4.88	4.88	0.96	0.96	1.23	1.02	0.92	6.10	7.11	5.70	6.14	6.13	5.89	6.14	5.71	5.91	6.04
	H	1113	-0.52	-0.53	-0.51	-0.52	-0.52	-0.18	-0.18	-0.17	-0.18	-0.18	1.25	3.08	1.58	1.13	1.78	1.45	1.88	1.23	1.19	1.72
	I	1105	0.39	1.58	0.39	0.15	0.66	5.44	5.92	5.38	5.41	5.49	6.66	7.50	7.72	6.77	7.09	10.09	10.45	10.02	10.08	10.12
60	A	64	0.68	0.97	0.79	0.65	0.71	-6.40	-6.28	-1.58	-5.79	-6.65	1.14	1.41	1.10	1.48	1.90	1.49	7.22	13.24	4.92	2.18
	B	59	0.69	0.85	2.20	0.99	0.93	2.43	4.72	2.70	2.92	3.23	1.40	2.84	2.72	1.98	1.98	2.61	4.82	2.67	2.95	3.36
	C	61	1.03	0.31	2.01	1.63	0.88	1.85	1.92	2.02	2.34	1.53	1.80	1.42	2.37	2.44	1.15	1.87	2.03	1.84	2.23	1.65
	D	62	0.29	0.21	0.75	1.13	0.11	1.13	0.48	1.87	1.99	0.32	3.34	2.50	4.19	4.65	2.26	3.20	2.44	3.96	4.11	2.34
	E	978	-0.02	-0.07	0.03	-0.02	-0.02	0.09	0.19	0.03	0.09	0.10	4.68	4.35	5.02	4.69	5.07	4.48	3.07	5.91	4.37	4.69
	F	56	0.98	1.04	1.10	1.01	0.95	0.34	0.34	0.37	0.36	0.32	0.03	0.09	0.04	0.04	0.01	0.01	0.03	-0.01	0.03	0.01
	G	727	3.53	4.23	3.19	3.82	3.23	0.29	0.16	0.43	0.42	0.16	3.19	4.80	2.40	3.48	2.92	3.29	3.31	3.28	3.42	3.15
	H	715	-0.21	-0.23	-0.19	-0.21	-0.21	-0.10	-0.17	0.19	-0.10	-0.11	4.73	5.79	4.63	4.75	5.52	4.20	3.60	4.80	4.11	4.33
	I	707	-0.55	-0.69	-0.38	-0.55	-0.54	8.39	12.19	6.14	8.65	8.31	4.80	5.49	4.40	4.90	5.64	6.99	10.22	5.78	7.53	6.64

TABLE-5.10 (contd....) PRINCIPAL STRESSES S1

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	4.39	4.61	4.17	4.33	4.45	-2.04	-1.38	-1.88	-1.50	-2.32	1.01	1.22	0.80	1.55	2.11	1.20	7.51	0.53	1.47	2.49
	B	34	0.96	-0.59	3.54	0.91	1.19	1.15	2.70	3.64	2.11	1.83	2.76	3.33	4.24	3.35	2.52	2.73	4.36	3.73	3.61	3.36
	C	38	-0.41	-0.94	1.52	-0.64	-0.14	-0.32	-0.89	0.34	-0.31	-0.22	6.10	3.76	9.11	7.37	5.47	5.83	3.38	8.82	6.67	5.14
	D	35	0.29	0.54	0.08	0.28	0.30	0.26	0.44	0.09	0.25	0.27	0.11	0.18	0.12	0.11	0.12	0.12	0.17	0.11	0.11	0.12
	E	486	0.75	0.72	1.32	0.71	0.80	0.32	0.47	0.21	0.30	0.35	5.47	4.67	6.36	5.33	5.45	5.41	5.09	5.78	5.37	5.45
	F	465	2.48	2.67	2.30	2.50	2.48	0.45	0.53	0.39	0.48	0.42	1.38	1.57	1.20	0.76	0.65	1.36	1.44	1.28	0.76	0.71
	G	644	0.52	0.43	0.70	0.58	0.47	0.24	0.23	0.27	0.29	0.20	3.22	3.02	3.43	3.24	3.10	3.25	3.23	3.27	3.26	3.17
	H	47	-0.12	-0.01	-0.18	-0.14	-0.10	-0.10	-0.05	-0.14	-0.12	-0.08	3.62	3.76	3.53	3.32	4.10	3.57	3.28	3.88	3.28	3.88
	I	637	2.89	3.45	2.62	3.74	2.06	2.70	3.82	1.68	3.33	2.10	8.67	8.78	8.71	9.25	7.71	8.69	9.75	7.67	9.26	8.11
Minimum	Node	No.	2578	2578	1930	2578	2101	1199	841	1199	1199	843	1202	262	1539	262	2358	1199	262	1539	1199	1199
		X	470.9	470.9	-289.2	470.9	-62.0	-40.3	187.4	-40.3	-40.3	196.5	-62.0	1100.0	-825.0	1100.0	950.0	-40.3	1100.0	-825.0	-40.3	-40.3
		Y	420.0	420.0	420.0	420.0	420.0	110.0	110.0	110.0	110.0	110.0	420.0	-450.0	-450.0	-450.0	-450.0	110.0	-450.0	-450.0	110.0	110.0
		Z	62.0	62.0	376.8	62.0	470.9	-325.0	-268.6	-325.0	-325.0	-262.0	-470.9	1025.0	-369.6	1025.0	1025.0	-325.0	1025.0	-369.6	-325.0	-325.0
	Value		-6.36	-6.72	-5.37	-6.06	-5.94	-9.53	-7.59	-6.13	-9.34	-9.32	-2.21	-2.32	-2.18	-1.73	-1.80	-4.11	-2.10	-1.72	-2.66	-4.31
Maximum	Node	No.	22118	219	22118	229	22118	4930	4930	5	4930	4930	337	5	337	4	4	5	5	5	3694	498
		X	301.83	0.00	301.83	71.18	301.83	232.55	232.55	327.50	232.55	232.55	275.00	327.50	275.00	275.00	275.00	327.50	327.50	327.50	591.24	653.85
		Y	110.00	110.00	110.00	110.00	110.00	99.16	99.16	110.00	99.16	99.16	1.70	110.00	1.70	110.00	110.00	110.00	110.00	110.00	420.00	420.00
		Z	39.74	275.00	39.74	265.63	39.74	-251.72	-251.72	0.00	-251.72	-251.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-485.99	-377.50
	Value		13.87	14.22	13.76	13.76	14.01	14.86	20.63	10.78	14.99	14.87	25.44	26.80	25.67	22.17	25.08	23.40	22.00	25.51	12.35	11.99

TABLE-5.11 PRINCIPAL STRESSES S2

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-6.76	-6.69	-6.75	-7.14	-6.39	-2.00	-2.83	-1.05	-1.65	-2.31	-0.65	-0.59	-0.69	0.78	1.59	2.62	0.23	5.12	0.38	-0.16
	B	6	-3.67	-4.70	-3.81	-2.88	-3.90	0.63	-0.10	0.20	0.62	0.66	0.23	-0.72	1.57	-0.05	0.40	0.27	-0.66	-0.04	0.01	0.35
	C	8	-3.12	-4.13	-1.32	-3.76	-2.48	-1.06	-1.63	-0.43	-0.97	-0.96	1.08	0.61	1.23	1.07	1.71	1.41	0.60	2.09	1.18	1.61
	D	9	-0.08	0.54	-0.16	0.01	-0.16	0.12	0.34	-0.04	0.14	0.08	0.00	0.04	-0.05	-0.01	0.00	0.01	0.06	-0.02	0.01	0.01
	E	296	1.27	1.50	0.71	1.18	1.20	0.54	0.73	0.11	0.44	0.34	1.44	1.51	1.26	1.58	1.22	1.52	1.75	1.28	1.65	1.37
	F	2	-5.78	-5.52	-6.05	-5.48	-6.08	-0.75	-1.02	-0.49	-0.66	-0.84	-3.05	-2.74	-3.39	0.36	-0.19	-2.61	-2.89	-2.33	0.09	-0.09
	G	24	0.26	0.37	0.15	0.26	0.27	0.16	0.24	0.08	0.15	0.16	0.64	0.74	0.53	0.63	0.64	0.65	0.73	0.57	0.65	0.66
	H	23	-0.91	-0.73	-1.09	-0.89	-0.92	-0.56	-0.51	-0.60	-0.55	-0.55	0.26	0.46	0.08	0.46	0.16	0.28	0.27	0.29	0.40	0.17
	I	27	-0.08	-0.04	-0.06	0.02	-0.21	0.60	0.46	0.85	0.55	0.40	1.97	1.54	1.90	1.89	1.58	1.69	1.84	1.53	1.53	1.62
330	A	260	0.31	0.26	0.36	0.32	0.31	-5.71	-6.99	-4.10	-5.50	-5.75	-3.08	-3.07	-3.09	-3.08	-3.08	0.18	-0.81	1.25	0.76	0.08
	B	258	-4.32	-4.41	-5.02	-3.52	-4.35	0.74	-0.06	0.99	0.72	0.69	0.39	-0.51	2.22	0.28	0.40	0.25	-0.70	-0.45	0.08	0.17
	C	256	-4.08	-5.66	-2.18	-4.67	-3.40	-1.82	-1.83	-1.78	-1.83	-1.82	3.47	2.37	3.12	3.15	3.67	2.43	1.96	2.55	2.35	2.22
	D	255	0.01	-0.02	0.01	0.01	0.00	0.00	0.01	-0.01	0.00	-0.01	0.02	0.03	0.01	0.03	0.00	-0.05	0.00	-0.09	-0.02	-0.07
	E	2413	0.10	0.00	0.06	0.11	0.07	0.01	-0.17	0.02	0.04	-0.10	0.02	0.03	-0.32	0.01	0.04	0.00	0.00	-0.11	-0.01	0.01
	F	251	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-2.81	-2.82	-2.80	-2.78	-2.82	-2.75	-2.75	-2.74	-2.70	-2.73
	G	2453	0.31	0.36	0.26	0.31	0.32	0.17	0.21	0.13	0.17	0.17	0.50	0.56	0.45	0.49	0.51	0.52	0.57	0.48	0.52	0.52
	H	2447	-0.33	-0.29	-0.38	-0.34	-0.33	-0.21	-0.20	-0.23	-0.22	-0.21	1.84	2.47	0.95	2.04	1.77	1.82	2.09	1.43	1.92	1.72
	I	2441	-0.56	-0.37	-0.72	-0.41	-0.63	0.46	0.37	0.50	0.53	0.33	1.87	0.37	1.74	2.28	1.31	1.67	-0.17	1.83	2.10	1.12
300	A	240	0.32	0.29	0.34	0.32	0.32	-6.11	-6.46	-4.82	-6.00	-6.10	-2.92	-2.92	-2.91	-2.92	-2.92	0.69	-0.26	1.16	0.76	0.46
	B	238	-4.46	-3.74	-4.48	-4.13	-4.30	1.04	0.22	1.34	1.00	1.01	0.87	-0.05	1.89	0.77	0.90	0.75	-0.14	0.95	0.63	0.68
	C	236	-2.63	-3.05	-1.61	-2.58	-2.48	-0.71	-0.77	-0.78	-0.73	-0.76	3.39	2.00	2.60	3.08	2.82	2.31	1.47	2.00	2.13	1.99
	D	235	-0.01	0.00	-0.01	-0.01	0.00	-0.02	-0.01	-0.02	-0.02	-0.01	0.05	0.05	0.04	0.04	0.05	0.04	0.05	0.04	0.04	0.05
	E	2213	0.11	0.15	0.08	0.10	0.12	0.03	-0.03	0.02	0.02	0.03	0.08	0.06	0.08	0.08	0.07	0.11	0.14	0.09	0.11	0.10
	F	231	0.00	0.00	0.00	0.00	0.00	-0.03	-0.03	-0.03	-0.03	-0.03	-2.66	-2.67	-2.65	-2.62	-2.62	-2.62	-2.63	-2.61	-2.59	-2.59
	G	2251	0.37	0.40	0.27	0.37	0.38	0.19	0.20	0.16	0.18	0.19	0.65	0.66	0.62	0.63	0.65	0.67	0.68	0.66	0.66	0.68
	H	2245	-0.71	-0.70	-0.75	-0.71	-0.71	-0.30	-0.32	-0.27	-0.30	-0.29	2.29	1.13	1.56	2.07	2.36	1.51	0.78	1.87	1.38	1.61
	I	2241	-0.62	-0.42	-0.56	-0.54	-0.67	0.40	0.35	0.36	0.42	0.30	2.54	0.75	2.07	2.32	2.45	2.15	0.77	2.34	1.81	1.89

TABLE-5.11 (contd....) PRINCIPAL STRESSES S2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	0.33	0.34	0.32	0.34	0.33	-5.67	-4.86	-4.76	-5.62	-5.59	-2.97	-2.97	-2.96	-2.97	-2.97	0.27	-0.46	-0.34	-0.19	0.17
	B	218	-4.77	-4.01	-3.81	-4.43	-4.45	1.03	1.11	0.99	1.00	0.73	0.93	0.98	0.84	1.03	0.73	0.84	0.88	0.76	0.83	0.65
	C	216	-1.21	-1.15	-1.25	-1.18	-1.23	-1.14	-1.11	-1.16	-1.12	-1.15	1.42	2.32	0.35	2.00	0.78	1.78	1.79	0.88	2.05	1.19
	D	215	-0.33	-0.35	-0.31	-0.34	-0.33	0.02	-0.04	0.05	-0.02	0.05	-0.02	-0.02	-0.03	-0.02	-0.02	0.00	0.00	0.00	0.00	0.00
	E	2051	0.95	0.80	0.95	0.83	1.03	0.12	0.05	0.10	0.07	0.12	0.70	0.81	0.48	0.74	0.63	1.05	1.05	0.97	1.06	1.00
	F	199	0.00	0.00	0.00	0.00	0.00	-0.04	-0.04	-0.03	-0.04	-0.04	-2.36	-2.38	-2.34	-2.35	-2.34	-2.35	-2.36	-2.33	-2.34	-2.33
	G	2091	0.43	0.29	0.48	0.42	0.45	0.20	0.11	0.23	0.19	0.21	0.64	0.53	0.72	0.62	0.65	0.66	0.59	0.71	0.65	0.67
	H	2083	-1.48	-1.38	-1.21	-1.53	-1.42	-0.43	-0.37	-0.30	-0.47	-0.37	1.54	-0.03	0.89	1.22	1.77	0.70	0.26	0.59	0.57	0.78
	I	2077	2.73	2.12	1.18	3.05	1.95	1.35	1.27	1.16	1.25	1.16	2.14	1.74	1.14	2.23	1.94	2.74	2.90	2.45	2.90	2.44
240	A	198	0.31	0.35	0.26	0.31	0.31	-6.38	-5.34	-6.25	-6.44	-6.20	-2.76	-2.52	-2.79	-2.74	-2.76	0.10	0.42	-0.65	-0.12	0.16
	B	196	-5.55	-5.51	-3.98	-5.18	-4.85	0.84	0.94	-0.02	0.78	0.65	0.84	2.22	-0.12	0.91	0.66	0.84	1.98	-0.20	0.79	0.71
	C	194	-0.96	-0.96	-0.99	-0.96	-0.96	-0.93	-0.92	-0.92	-0.93	-0.93	0.26	1.23	-0.85	0.74	-0.26	1.40	2.13	0.01	1.57	0.92
	D	193	-0.04	-0.07	-0.01	-0.03	-0.04	-0.01	-0.02	-0.01	-0.01	-0.02	-0.11	-0.15	0.01	-0.11	-0.10	-0.07	-0.11	-0.02	-0.07	-0.07
	E	1882	0.13	0.12	0.13	0.13	0.13	0.04	0.03	0.02	0.04	0.02	-0.07	0.00	-0.09	-0.02	-0.07	-0.04	0.01	-0.11	0.02	-0.12
	F	189	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	0.00	-0.02	-0.01	-1.97	-1.99	-1.95	-1.96	-1.95	-1.96	-1.99	-1.94	-1.96	-1.95
	G	1922	0.47	0.30	0.50	0.45	0.48	0.19	0.11	0.22	0.18	0.20	0.11	0.02	0.19	0.10	0.13	0.13	0.06	0.19	0.12	0.15
	H	1914	-0.16	-0.18	-0.15	-0.17	-0.15	-0.08	-0.07	-0.08	-0.08	-0.07	0.84	-0.32	1.10	0.58	1.01	0.37	0.36	0.14	0.25	0.46
	I	1908	0.54	0.91	0.29	0.70	0.40	1.15	0.83	1.24	1.10	0.93	2.64	1.93	2.49	2.37	2.71	2.77	2.52	2.88	2.80	2.56
210	A	178	0.33	0.42	0.23	0.34	0.32	-5.88	-4.74	-6.47	-5.93	-5.70	-1.79	-0.79	-2.74	-1.68	-1.89	-1.48	-0.86	-2.13	-1.61	-1.26
	B	176	-4.89	-5.58	-4.61	-4.82	-4.34	0.52	-0.20	-0.16	0.45	0.73	0.72	0.64	-0.27	0.80	0.63	0.90	1.88	-0.30	0.82	0.87
	C	174	-1.19	-1.22	-1.16	-1.19	-1.19	-1.21	-0.73	-1.20	-1.21	-1.20	-0.25	-0.26	-1.13	0.06	-0.68	0.54	1.67	-1.08	0.38	0.30
	D	173	0.05	0.04	0.07	0.05	0.05	0.00	-0.02	0.16	-0.02	0.06	0.01	0.00	0.02	0.01	0.01	0.03	0.03	0.04	0.03	0.03
	E	1712	0.28	0.07	0.67	0.24	0.31	0.00	-0.01	-0.07	-0.08	0.01	0.28	0.05	0.47	0.31	0.24	0.34	0.12	0.63	0.37	0.31
	F	169	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-1.57	-1.58	-1.55	-1.57	-1.55	-1.57	-1.60	-1.54	-1.58	-1.56
	G	1759	0.77	0.66	0.87	0.76	0.77	0.32	0.20	0.43	0.31	0.33	0.76	0.60	0.91	0.74	0.79	0.76	0.63	0.89	0.74	0.79
	H	1751	-0.68	-0.75	-0.66	-0.73	-0.63	-0.24	-0.18	-0.31	-0.26	-0.22	-0.60	-0.54	-0.85	-0.92	-0.34	-0.59	0.49	-1.76	-0.76	-0.44
	I	1745	0.12	0.18	0.08	0.16	0.09	1.19	0.78	1.59	1.11	1.02	2.60	2.51	2.67	2.18	2.89	2.89	2.44	3.34	2.71	2.98
180	A	158	0.30	0.43	0.17	0.31	0.30	-5.56	-4.58	-6.55	-5.69	-5.26	-0.62	-0.38	-1.58	-0.60	-0.66	-2.29	-1.10	-2.96	-2.37	-2.21
	B	156	-4.33	-5.13	-4.77	-4.31	-3.84	0.65	-0.22	0.04	0.57	0.79	0.38	-1.01	-0.25	0.61	0.28	0.98	1.09	-0.08	0.90	0.90
	C	154	-1.56	-1.56	-1.56	-1.56	-1.56	-1.33	-0.18	-1.52	-1.45	-1.37	-0.33	-0.51	-1.14	-0.04	-0.86	-0.02	1.22	-1.34	-0.23	-0.23
	D	153	-0.11	-0.14	-0.08	-0.11	-0.11	0.06	-0.06	0.29	-0.05	0.15	0.00	-0.22	0.08	0.00	-0.01	-0.01	-0.02	0.07	-0.01	-0.01
	E	1560	0.24	-0.15	1.29	0.10	0.43	0.03	-0.24	0.06	0.03	0.03	0.22	0.07	0.50	0.16	0.27	0.21	0.13	0.29	0.15	0.26
	F	149	0.03	0.04	0.01	0.03	0.03	0.00	0.00	0.00	0.00	0.00	-1.15	-1.14	-1.16	-1.16	-1.13	-1.17	-1.20	-1.14	-1.18	-1.16
	G	1594	1.01	0.82	1.19	1.00	1.03	0.40	0.22	0.57	0.38	0.42	0.48	0.27	0.68	0.45	0.50	0.45	0.27	0.62	0.42	0.47
	H	1588	-1.04	-1.18	-0.93	-1.12	-0.96	-0.44	-0.40	-0.49	-0.47	-0.39	-1.31	-1.61	-1.10	-1.68	-0.99	-0.83	-0.04	-1.52	-1.11	-0.59
	I	1582	-0.07	-0.04	-0.09	-0.04	-0.09	0.82	0.63	1.03	0.98	0.59	2.33	2.57	2.00	2.06	2.48	2.26	1.99	2.51	2.22	2.22

TABLE-5.11 (contd....) PRINCIPAL STRESSES S2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	0.24	0.31	0.16	0.24	0.23	-5.60	-4.10	-6.29	-5.72	-5.27	-0.47	-0.34	-0.72	-0.45	-0.48	-2.52	-1.86	-3.25	-2.59	-2.55
	B	134	-4.43	-4.54	-4.38	-4.33	-3.74	0.97	0.50	-0.07	0.88	0.92	-0.80	-2.03	-0.59	-0.33	-0.54	0.94	0.47	-0.18	0.90	0.81
	C	132	-1.38	-1.41	-1.34	-1.37	-1.38	-1.20	-0.01	-1.37	-1.30	-1.26	-0.22	-0.93	-1.33	-0.48	-0.68	-0.40	0.52	-1.36	-0.54	-0.56
	D	131	-0.03	-0.02	-0.04	-0.03	-0.03	-0.03	-0.04	-0.01	-0.03	-0.03	-0.07	-0.07	-0.07	-0.07	-0.08	-0.08	-0.09	-0.07	-0.07	-0.07
	E	1393	0.07	0.03	0.11	0.08	0.05	-0.02	-0.06	0.02	-0.03	-0.01	0.02	0.04	0.07	-0.03	0.02	-0.01	0.02	0.01	-0.08	0.01
	F	127	0.02	0.05	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	-0.75	-0.67	-0.84	-0.76	-0.72	-0.78	-0.79	-0.78	-0.79	-0.76
	G	1431	1.43	0.75	1.48	1.43	1.41	0.51	0.12	0.61	0.47	0.53	1.22	1.17	1.19	1.18	1.26	1.13	1.01	1.23	1.09	1.17
	H	1423	-0.93	-0.88	-0.96	-0.95	-0.90	-0.36	-0.23	-0.48	-0.37	-0.34	-2.42	-1.97	-3.35	-2.66	-2.23	-1.37	0.00	-2.85	-1.51	-1.28
	I	1417	0.52	0.48	0.56	0.54	0.50	1.06	0.50	1.51	1.09	1.03	3.01	3.47	2.29	2.93	3.12	2.51	1.83	3.04	2.55	2.47
120	A	116	0.27	0.24	0.27	0.27	0.27	-5.35	-3.27	-4.96	-5.41	-5.07	-0.23	-0.15	-0.36	-0.21	-0.23	-3.14	-2.80	-3.51	-3.17	-3.07
	B	114	-4.27	-3.01	-3.07	-4.00	-3.43	1.15	1.74	0.27	0.99	1.01	-2.39	-1.39	-0.60	-1.42	-1.75	-0.08	0.36	0.07	0.40	0.06
	C	112	-1.14	-1.17	-1.11	-1.14	-1.15	-0.98	-0.27	-1.17	-1.18	-0.86	-0.58	-0.81	-1.05	-0.91	-0.87	-0.64	-0.39	-1.16	-0.73	-0.77
	D	111	-0.15	-0.17	-0.14	-0.17	-0.13	0.13	0.11	-0.07	-0.11	0.17	0.00	-0.07	0.08	-0.09	0.07	0.08	0.05	0.12	0.04	0.10
	E	1233	0.89	0.17	0.16	0.89	0.68	-0.02	0.00	-0.05	-0.03	-0.02	0.83	0.31	-0.09	0.88	0.62	0.61	0.39	0.37	0.69	0.50
	F	107	0.06	0.02	0.09	0.06	0.06	0.03	0.01	0.06	0.03	0.03	-0.70	-0.67	-0.79	-0.69	-0.66	-0.73	-0.74	-0.73	-0.72	-0.70
	G	1269	1.49	0.71	1.63	1.54	1.43	0.47	0.15	0.38	0.42	0.48	1.11	0.74	1.07	1.13	1.13	0.99	0.74	1.14	1.00	1.02
	H	1263	-0.88	-0.85	-0.66	-0.90	-0.86	-0.46	-0.34	-0.30	-0.47	-0.41	-2.75	-3.69	-3.34	-2.87	-2.79	-1.51	-1.27	-2.33	-1.59	-1.52
	I	1255	0.19	0.13	0.25	0.21	0.18	0.99	0.45	1.46	1.07	0.92	3.24	3.18	2.29	3.29	3.40	2.93	2.22	3.52	3.02	2.84
90	A	96	0.34	0.19	0.33	0.35	0.33	-7.15	-6.00	-5.59	-6.98	-7.02	0.03	-0.06	-0.04	0.04	0.05	-3.53	-3.91	-3.51	-3.55	-3.62
	B	94	-3.82	-0.94	-2.07	-3.04	-2.61	1.16	1.17	1.12	1.01	1.03	-1.97	0.23	-0.67	-1.23	-1.33	0.05	0.93	0.82	0.52	-0.07
	C	90	-1.45	-0.81	-1.44	-1.42	-1.47	-0.30	-0.27	-0.45	-0.51	-0.32	-0.22	-0.14	-0.78	-0.77	-0.48	-0.40	-0.44	-0.36	-0.31	-0.67
	D	89	-0.23	-0.22	-0.23	-0.22	-0.23	0.47	0.46	0.48	0.47	0.47	0.44	0.42	-0.17	0.33	0.46	0.45	0.44	0.40	0.45	0.44
	E	1064	1.37	0.15	0.29	1.20	0.85	-0.18	-0.13	0.01	-0.09	-0.10	1.46	0.26	1.52	1.83	0.83	1.13	0.59	1.64	1.49	0.76
	F	85	0.24	0.15	0.32	0.25	0.24	0.13	0.06	0.06	0.13	0.12	-0.86	-0.76	-1.17	-0.83	-0.75	-0.90	-0.89	-0.93	-0.87	-0.83
	G	1121	1.36	1.41	0.53	1.30	1.41	0.13	0.15	0.10	0.12	0.15	0.36	0.59	-0.48	0.38	0.51	0.25	0.24	0.18	0.25	0.34
	H	1113	-2.36	-2.19	-1.52	-2.37	-2.32	-0.89	-1.13	-0.29	-0.86	-0.86	-2.47	-3.56	-1.60	-2.20	-3.00	-1.24	-2.27	-0.40	-0.90	-1.56
	I	1105	-0.13	-0.24	-0.07	-0.13	-0.14	0.81	0.78	0.87	0.82	0.80	2.29	-0.37	3.07	2.64	2.17	2.62	2.19	2.77	2.66	2.59
60	A	64	0.07	0.13	0.06	0.06	0.08	-9.20	-10.53	-5.86	-8.33	-9.69	-0.46	-0.97	0.05	-0.30	-0.22	-0.94	-3.06	-0.97	-1.65	-1.55
	B	59	-1.07	-0.45	-0.41	-0.71	-0.26	0.85	-0.14	1.37	0.64	0.80	0.61	-0.33	0.97	0.19	0.70	0.83	-0.14	1.62	0.72	0.68
	C	61	-0.19	-0.50	-0.10	-0.17	-0.64	-0.48	-1.06	0.00	-0.53	-0.57	-1.00	-1.13	-0.56	-1.03	-1.00	-0.88	-1.13	-0.25	-0.83	-1.03
	D	62	-0.08	-0.08	-0.01	0.02	-0.11	0.09	0.09	0.07	0.12	0.04	0.02	0.02	0.01	0.04	0.00	0.00	0.03	-0.02	0.02	-0.01
	E	978	-0.45	-0.42	-0.48	-0.34	-0.54	0.00	0.01	-0.05	-0.01	0.00	-0.13	-0.14	-0.14	-0.14	-0.22	-0.25	-0.19	-0.34	-0.24	-0.30
	F	56	0.32	0.70	0.07	0.21	0.43	0.05	0.04	0.05	0.04	0.05	-1.42	-1.20	-1.55	-1.24	-1.12	-1.45	-1.49	-1.42	-1.30	-1.27
	G	727	0.04	0.20	-0.09	0.04	0.04	-0.08	-0.08	-0.09	-0.08	-0.08	-1.49	-0.14	-3.47	-1.22	-0.90	-1.59	-1.60	-1.58	-1.49	-1.33
	H	715	-3.02	-3.34	-2.04	-2.95	-3.06	-0.72	-1.50	-0.05	-0.60	-0.79	-1.49	-3.44	1.38	-0.97	-2.25	-0.86	-2.20	0.49	-0.37	-1.10
	I	707	-2.18	-1.79	-1.77	-2.48	-1.88	2.00	2.13	1.86	1.99	2.03	-3.20	-3.52	-0.11	-2.96	-3.11	-0.13	0.06	-2.33	-0.56	0.23

TABLE-5.11 (contd....) PRINCIPAL STRESSES S2

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	1.10	1.18	1.03	1.00	1.22	-2.80	-1.83	-3.92	-2.53	-3.06	0.03	0.11	-0.06	-0.12	-0.12	0.07	1.11	-1.20	0.25	0.11
	B	34	-3.05	-2.43	-2.36	-1.19	-2.70	0.83	-0.62	-0.05	0.56	0.78	0.57	-1.01	1.52	0.18	0.88	0.81	-0.79	1.33	0.56	0.87
	C	38	-0.97	-1.50	-0.98	-1.03	-0.96	-0.93	-0.99	-0.06	-0.93	-0.94	-0.89	-0.90	-0.05	-0.89	-0.63	-0.23	-0.90	0.94	-0.47	0.06
	D	35	0.01	0.03	0.01	0.00	0.01	0.00	0.02	0.01	0.00	0.00	-0.04	-0.10	-0.04	-0.05	-0.04	-0.04	-0.08	-0.04	-0.04	-0.04
	E	486	0.09	0.03	0.12	0.10	0.09	0.03	0.02	0.07	0.03	0.03	0.16	0.10	0.21	0.16	0.15	0.15	0.13	0.17	0.16	0.15
	F	465	1.85	1.86	1.84	1.84	1.84	0.16	0.18	0.12	0.15	0.16	0.07	0.08	0.06	-0.17	-0.13	0.15	0.19	0.12	-0.05	-0.04
	G	644	0.31	0.28	0.29	0.31	0.30	0.09	0.10	0.08	0.09	0.09	-0.01	0.00	-0.02	-0.02	-0.02	0.00	0.01	-0.02	-0.01	-0.02
	H	47	-0.38	-0.31	-0.44	-0.39	-0.36	-0.33	-0.32	-0.34	-0.34	-0.32	-0.42	-0.35	-0.51	-0.42	-0.41	-0.41	-0.40	-0.43	-0.42	-0.40
	I	637	0.24	0.31	0.23	0.24	0.28	0.63	0.90	0.41	0.36	0.90	0.48	0.63	0.25	0.16	0.67	0.18	0.42	-0.06	-0.06	0.42
Minimum	Node	**No.**	**2341**	**21403**	**1735**	**2478**	**2817**	**841**	**841**	**1199**	**845**	**841**	**3579**	**2578**	**1735**	**4921**	**1735**	**1199**	**1199**	**1199**	**1199**	**1199**
		X	289.2	284.0	-438.8	376.8	306.7	187.4	187.4	-40.3	204.2	204.2	257.8	470.9	-438.8	221.1	-438.8	-40.3	-40.3	-40.3	-40.3	-40.3
		Y	420.0	420.0	420.0	420.0	-5.9	110.0	110.0	110.0	110.0	110.0	85.7	420.0	420.0	102.9	420.0	110.0	110.0	110.0	110.0	110.0
		Z	376.8	337.6	181.8	289.2	-134.2	-268.6	-268.6	-325.0	-256.0	-256.0	-226.3	62.0	181.8	-264.5	181.8	-325.0	-325.0	-325.0	-325.0	-325.0
			-9.16	**-11.39**	**-9.16**	**-10.10**	**-9.08**	**-11.58**	**-13.95**	**-10.54**	**-11.51**	**-11.78**	**-4.49**	**-5.20**	**-5.64**	**-4.36**	**-4.62**	**-6.14**	**-6.02**	**-6.35**	**-6.08**	**-6.21**
Maximum	Node	**No.**	**18802**	**16779**	**18802**	**18802**	**18802**	**4920**	**4920**	**4920**	**4920**	**4920**	**2819**	**2819**	**20181**	**2323**	**2420**	**2819**	**432**	**2819**	**2420**	**432**
		X	57.2	-245.1	57.2	57.2	57.2	201.2	201.2	201.2	201.2	201.2	317.6	317.6	244.6	449.0	549.9	317.6	499.1	317.6	549.9	499.1
		Y	187.9	181.8	187.9	187.9	187.9	110.6	110.6	110.6	110.6	110.6	80.5	80.5	420.0	420.0	420.0	80.5	280.1	80.5	420.0	280.1
		Z	382.4	306.8	382.4	382.4	382.4	-278.4	-278.4	-278.4	-278.4	-278.4	-138.0	-138.0	187.7	449.0	317.5	-138.0	0.0	-138.0	317.5	0.0
	Value		**7.23**	**7.32**	**7.56**	**7.13**	**7.32**	**7.16**	**8.85**	**6.12**	**7.39**	**7.06**	**5.41**	**7.17**	**4.33**	**4.21**	**4.06**	**4.74**	**4.41**	**6.94**	**3.46**	**3.24**

TABLE-5.12 PRINCIPAL STRESSES S3

(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
360	A	5	-30.69	-28.70	-32.77	-32.43	-28.97	-17.62	-22.58	-13.08	-17.00	-18.50	-4.88	-5.09	-4.70	-2.81	-2.55	-4.46	-5.92	-3.82	-3.48	-6.64
	B	6	-9.67	-8.52	-10.83	-10.78	-9.13	-3.91	-4.65	-4.30	-4.54	-4.10	-4.04	-4.59	-4.56	-4.27	-4.39	-4.03	-4.61	-4.56	-4.60	-4.25
	C	8	-8.62	-10.26	-7.79	-7.72	-9.52	-5.43	-9.05	-1.89	-5.40	-5.66	-0.23	-0.41	-0.22	-0.21	-0.21	-0.22	-0.39	-0.21	-0.22	-0.22
	D	9	-0.25	-0.19	-0.88	-0.22	-0.30	-0.10	-0.11	-0.26	-0.10	-0.10	-0.81	-0.69	-0.95	-0.82	-0.81	-0.80	-0.71	-0.90	-0.80	-0.80
	E	296	-0.45	-0.57	-0.35	-0.45	-0.45	-0.23	-0.34	-0.20	-0.24	-0.23	-0.30	-0.37	-0.26	-0.30	-0.29	-0.32	-0.39	-0.26	-0.32	-0.32
	F	2	-37.46	-36.00	-38.93	-35.50	-39.42	-4.78	-6.41	-3.18	-4.22	-5.35	-17.64	-16.39	-18.92	-1.47	-2.17	-16.65	-17.94	-15.40	-1.69	-1.91
	G	24	0.17	0.21	0.13	0.17	0.17	0.09	0.12	0.06	0.09	0.10	-3.19	-3.13	-3.26	-3.18	-3.17	-3.18	-3.14	-3.22	-3.16	-3.16
	H	23	-6.23	-6.22	-6.29	-6.32	-6.16	-4.20	-4.58	-3.85	-4.27	-4.14	-3.15	-3.17	-3.17	-3.14	-3.13	-3.16	-3.22	-3.13	-3.16	-3.15
	I	27	-5.75	-9.27	-2.55	-5.77	-5.92	-0.88	-3.05	0.18	-0.82	-1.20	-3.10	-3.14	-3.06	-3.08	-3.10	-3.10	-3.14	-3.08	-3.09	-3.11
330	A	260	-0.19	-0.19	-0.19	-0.18	-0.19	-25.14	-31.23	-20.09	-25.32	-25.28	-8.08	-8.63	-7.54	-7.95	-7.81	-1.02	-2.00	-1.25	-0.14	-2.31
	B	258	-13.25	-11.62	-15.41	-13.82	-13.47	-4.38	-4.99	-5.27	-4.90	-4.81	-4.59	-4.91	-5.66	-4.85	-5.09	-4.62	-5.05	-5.86	-5.16	-5.23
	C	256	-7.50	-7.20	-8.16	-6.92	-8.17	-4.92	-7.59	-2.44	-5.07	-4.96	-1.86	-1.86	-1.86	-1.86	-1.86	-1.87	-1.88	-1.87	-1.87	-1.87
	D	255	-0.43	-0.29	-0.60	-0.41	-0.46	-0.11	-0.06	-0.18	-0.10	-0.13	-0.34	-0.48	-0.31	-0.33	-0.39	-0.35	-0.40	-0.31	-0.32	-0.38
	E	2413	-0.44	-0.31	-0.72	-0.46	-0.43	-0.31	-0.22	-0.52	-0.35	-0.28	-0.91	-1.46	-0.39	-0.80	-1.13	-0.85	-1.11	-0.60	-0.72	-0.97
	F	251	-0.16	-0.16	-0.17	-0.17	-0.16	-0.08	-0.10	-0.07	-0.08	-0.08	-3.29	-3.29	-3.29	-3.07	-3.07	-3.23	-3.25	-3.22	-3.07	-3.07
	G	2453	0.23	0.24	0.22	0.23	0.23	0.12	0.14	0.09	0.12	0.13	-3.19	-3.16	-3.23	-3.19	-3.19	-3.18	-3.15	-3.21	-3.18	-3.18
	H	2447	-5.94	-5.73	-6.28	-6.04	-5.86	-3.57	-3.67	-3.53	-3.63	-3.52	-3.28	-3.26	-3.31	-3.28	-3.27	-3.30	-3.31	-3.31	-3.31	-3.30
	I	2441	-9.84	-13.31	-6.43	-9.71	-10.06	-1.38	-3.52	0.04	-1.25	-1.70	-3.22	-3.32	-3.14	-3.20	-3.24	-3.26	-3.29	-3.22	-3.24	-3.27
300	A	240	-0.14	-0.14	-0.14	-0.14	-0.14	-26.40	-30.89	-24.51	-26.52	-26.56	-8.36	-8.49	-8.24	-8.04	-8.26	0.09	-4.07	-2.44	0.15	-0.86
	B	238	-13.96	-14.04	-15.03	-15.00	-13.44	-4.44	-5.28	-5.36	-5.00	-4.59	-4.52	-5.11	-5.27	-4.92	-4.61	-4.56	-5.35	-5.62	-5.12	-4.75
	C	236	-7.18	-7.50	-7.55	-7.40	-7.18	-4.19	-5.84	-2.98	-4.44	-4.15	-0.64	-0.64	-0.65	-0.64	-0.65	-0.62	-0.63	-0.64	-0.62	-0.63
	D	235	-0.61	-0.54	-0.70	-0.67	-0.55	-0.12	-0.11	-0.15	-0.16	-0.09	-0.21	-0.22	-0.21	-0.23	-0.20	-0.23	-0.24	-0.23	-0.25	-0.22
	E	2213	-0.66	-0.56	-0.81	-0.68	-0.65	-0.30	-0.19	-0.44	-0.28	-0.32	-0.31	-0.25	-0.47	-0.30	-0.35	-0.27	-0.17	-0.40	-0.25	-0.30
	F	231	-0.11	-0.13	-0.10	-0.12	-0.11	-0.06	-0.07	-0.05	-0.06	-0.06	-2.99	-2.99	-2.98	-2.99	-2.98	-2.99	-2.99	-2.99	-2.99	-2.99
	G	2251	0.22	0.21	0.20	0.22	0.22	0.15	0.14	0.08	0.15	0.15	-3.43	-3.43	-3.43	-3.43	-3.43	-3.42	-3.42	-3.42	-3.42	-3.42
	H	2245	-9.13	-9.77	-8.73	-9.21	-9.05	-3.91	-4.42	-3.55	-3.95	-3.89	-3.20	-3.21	-3.20	-3.21	-3.19	-3.28	-3.31	-3.26	-3.29	-3.28
	I	2241	-11.72	-13.92	-9.87	-11.67	-11.83	-1.56	-2.81	-0.61	-1.55	-1.73	-3.26	-3.34	-3.17	-3.24	-3.26	-3.34	-3.37	-3.30	-3.33	-3.34

TABLE-5.12 (contd....) PRINCIPAL STRESSES S3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
270	A	220	-0.11	-0.12	-0.10	-0.11	-0.10	-25.23	-27.27	-26.69	-25.50	-25.22	-6.87	-6.18	-7.58	-6.54	-6.88	-0.76	-5.54	-4.48	-1.39	-1.00
	B	218	-13.83	-14.91	-14.50	-13.37	-14.98	-4.70	-5.58	-6.10	-4.99	-5.36	-4.77	-5.53	-5.56	-4.99	-5.14	-4.81	-5.54	-6.05	-5.03	-5.39
	C	216	-7.05	-8.12	-6.34	-7.40	-6.84	-3.33	-3.80	-3.54	-3.55	-3.39	-1.05	-1.02	-1.08	-1.03	-1.06	-1.04	-1.01	-1.06	-1.02	-1.05
	D	215	-1.65	-1.91	-1.40	-1.76	-1.54	-0.08	-0.10	-0.08	-0.09	-0.07	-0.30	-0.32	-0.29	-0.30	-0.30	-0.33	-0.33	-0.33	-0.33	-0.33
	E	2051	-0.28	-0.30	-0.26	-0.29	-0.28	-0.12	-0.19	-0.12	-0.15	-0.11	-0.10	-0.10	-0.11	-0.10	-0.10	-0.11	-0.10	-0.11	-0.11	-0.11
	F	199	-0.05	-0.05	-0.04	-0.05	-0.05	-0.05	-0.07	-0.05	-0.05	-0.06	-2.94	-2.94	-2.94	-2.94	-2.94	-2.94	-2.94	-2.94	-2.94	-2.94
	G	2091	0.11	0.11	0.12	0.12	0.11	0.07	0.07	0.07	0.07	0.07	-3.29	-3.29	-3.29	-3.29	-3.29	-3.28	-3.28	-3.28	-3.28	-3.28
	H	2083	-10.25	-10.86	-10.03	-10.37	-10.14	-4.14	-4.25	-4.22	-4.19	-4.11	-3.48	-3.48	-3.47	-3.48	-3.47	-3.52	-3.52	-3.52	-3.53	-3.52
	I	2077	-0.51	-0.53	-0.91	-0.44	-0.66	0.31	0.33	0.28	0.32	0.29	-3.45	-3.44	-3.47	-3.43	-3.46	-3.44	-3.42	-3.47	-3.43	-3.46
240	A	198	-0.08	-0.09	-0.07	-0.08	-0.08	-27.55	-27.08	-31.22	-27.97	-27.39	-4.51	-3.30	-5.95	-4.28	-4.61	-1.41	-5.41	-5.88	-2.70	-1.17
	B	196	-13.70	-17.24	-12.20	-14.30	-14.20	-5.45	-7.09	-6.27	-6.14	-6.07	-5.53	-7.20	-5.85	-6.12	-5.80	-5.54	-6.92	-6.12	-6.05	-6.01
	C	194	-6.15	-7.65	-4.67	-6.58	-5.81	-2.76	-2.09	-3.92	-2.95	-2.82	-0.86	-0.88	-0.99	-0.87	-0.87	-0.87	-0.88	-0.86	-0.87	-0.87
	D	193	-0.69	-0.82	-0.57	-0.69	-0.68	-0.12	-0.15	-0.11	-0.12	-0.13	-0.13	-0.32	-0.10	-0.13	-0.14	-0.19	-0.21	-0.17	-0.18	-0.19
	E	1882	-0.50	-0.50	-0.50	-0.53	-0.48	-0.32	-0.36	-0.29	-0.34	-0.31	-0.36	-0.19	-0.61	-0.29	-0.46	-0.27	-0.31	-0.26	-0.29	-0.27
	F	189	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.05	-0.04	-0.04	-0.04	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84	-2.84
	G	1922	0.07	0.08	0.05	0.07	0.07	0.04	0.04	0.03	0.04	0.04	-3.33	-3.31	-3.34	-3.33	-3.33	-3.33	-3.32	-3.33	-3.32	-3.32
	H	1914	-9.33	-9.85	-9.04	-9.46	-9.21	-4.06	-3.85	-4.38	-4.13	-4.01	-3.52	-3.52	-3.53	-3.53	-3.52	-3.53	-3.52	-3.54	-3.54	-3.53
	I	1908	-3.52	-2.37	-5.09	-3.17	-3.97	0.21	0.30	0.11	0.22	0.18	-3.44	-3.41	-3.47	-3.43	-3.44	-3.43	-3.38	-3.48	-3.42	-3.44
210	A	178	-0.06	-0.07	-0.06	-0.06	-0.06	-26.05	-24.03	-29.97	-26.41	-25.98	-3.03	-2.95	-3.84	-3.02	-3.05	-3.94	-5.87	-8.03	-5.48	-3.46
	B	176	-13.13	-16.38	-10.60	-14.14	-12.78	-4.77	-6.14	-5.23	-5.46	-5.00	-4.86	-6.44	-5.12	-5.55	-4.86	-4.83	-6.07	-5.18	-5.36	-4.97
	C	174	-6.02	-7.37	-4.76	-6.40	-5.72	-2.32	-1.30	-3.99	-2.64	-2.28	-1.22	-1.24	-1.51	-1.22	-1.25	-1.21	-1.23	-1.27	-1.21	-1.22
	D	173	-1.30	-1.93	-0.69	-1.49	-1.12	-0.04	-0.28	-0.03	-0.14	-0.03	-0.22	-0.43	-0.11	-0.25	-0.20	-0.22	-0.33	-0.13	-0.25	-0.20
	E	1712	-0.96	-1.50	-0.66	-1.02	-0.92	-0.38	-0.63	-0.26	-0.36	-0.41	-0.27	-0.79	-0.14	-0.27	-0.29	-0.28	-0.41	-0.24	-0.27	-0.28
	F	169	-0.06	-0.06	-0.08	-0.06	-0.06	-0.05	-0.04	-0.06	-0.05	-0.05	-3.00	-2.99	-3.01	-3.00	-3.00	-3.00	-2.99	-3.01	-3.00	-3.00
	G	1759	0.14	0.15	0.14	0.14	0.14	0.08	0.07	0.09	0.08	0.08	-3.31	-3.31	-3.31	-3.31	-3.31	-3.31	-3.32	-3.30	-3.31	-3.31
	H	1751	-11.61	-11.14	-12.12	-11.75	-11.48	-4.48	-3.24	-5.73	-4.56	-4.43	-3.56	-3.53	-3.60	-3.57	-3.55	-3.56	-3.50	-3.64	-3.57	-3.56
	I	1745	-4.71	-3.31	-6.11	-4.49	-5.00	0.27	0.31	0.21	0.28	0.25	-3.20	-3.17	-3.24	-3.20	-3.20	-3.22	-3.21	-3.23	-3.21	-3.22
180	A	158	-0.09	-0.10	-0.08	-0.09	-0.09	-24.80	-22.84	-28.20	-25.19	-24.73	-2.73	-2.69	-2.82	-2.73	-2.74	-7.43	-6.35	-12.25	-8.92	-6.73
	B	156	-11.56	-13.40	-9.71	-12.08	-11.55	-4.22	-4.97	-4.73	-4.65	-4.51	-4.30	-5.09	-4.75	-4.88	-4.43	-4.26	-5.04	-4.73	-4.62	-4.47
	C	154	-5.14	-6.03	-4.31	-5.65	-4.70	-1.78	-1.56	-3.18	-2.00	-1.84	-1.58	-1.56	-1.71	-1.58	-1.61	-1.58	-1.54	-1.84	-1.58	-1.58
	D	153	-2.85	-4.69	-1.06	-3.09	-2.61	-0.05	-0.46	-0.04	-0.11	-0.05	-0.13	-0.44	-0.10	-0.13	-0.13	-0.15	-0.28	-0.08	-0.15	-0.15
	E	1560	-0.29	-1.30	-0.23	-0.45	-0.22	-0.54	-0.61	-0.50	-0.64	-0.53	-0.21	-0.41	-0.15	-0.29	-0.17	-0.21	-0.20	-0.22	-0.29	-0.17
	F	149	-0.06	-0.03	-0.11	-0.06	-0.06	-0.04	-0.01	-0.07	-0.04	-0.03	-3.00	-2.95	-3.05	-3.00	-3.00	-3.00	-2.97	-3.03	-3.00	-3.00
	G	1594	0.25	0.20	0.30	0.26	0.25	0.13	0.08	0.18	0.13	0.13	-3.15	-3.22	-3.09	-3.14	-3.16	-3.16	-3.22	-3.10	-3.16	-3.16
	H	1588	-10.04	-10.46	-9.71	-10.22	-9.88	-4.40	-3.61	-5.26	-4.53	-4.31	-3.75	-3.63	-3.94	-3.77	-3.72	-3.68	-3.51	-3.98	-3.69	-3.68
	I	1582	-7.50	-6.33	-8.72	-7.20	-7.83	0.19	0.38	-0.04	0.23	0.10	-3.23	-3.16	-3.30	-3.22	-3.23	-3.18	-3.14	-3.24	-3.17	-3.19

TABLE-5.12 (contd....) PRINCIPAL STRESSES S3

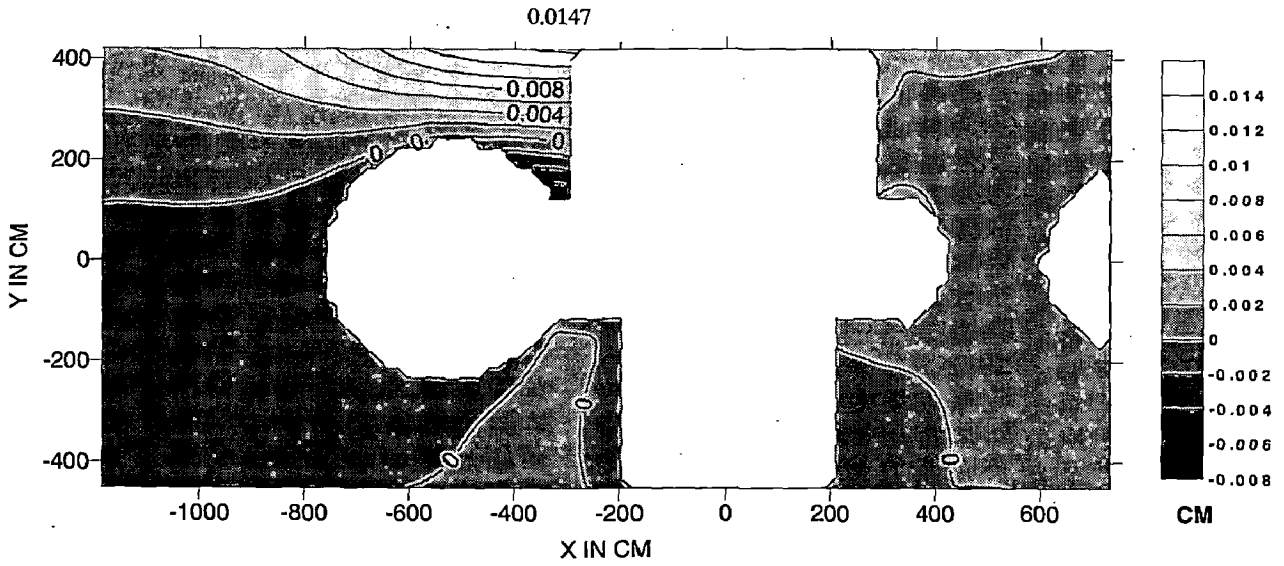
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
150	A	136	-0.03	-0.04	-0.02	-0.03	-0.03	-24.19	-24.11	-27.21	-24.44	-24.33	-2.83	-2.81	-2.85	-2.82	-2.83	-10.37	-9.46	-16.61	-11.76	-9.74
	B	134	-9.63	-11.88	-8.21	-10.02	-10.09	-4.33	-5.28	-4.91	-4.74	-4.72	-4.41	-5.50	-5.05	-5.13	-4.81	-4.35	-5.28	-4.93	-4.79	-4.70
	C	132	-3.93	-4.73	-3.17	-4.37	-3.52	-1.46	-1.44	-2.79	-1.55	-1.48	-1.40	-1.43	-1.56	-1.41	-1.41	-1.41	-1.43	-1.94	-1.41	-1.41
	D	131	-0.61	-0.74	-0.48	-0.61	-0.61	-0.09	-0.12	-0.07	-0.08	-0.09	-0.28	-0.41	-0.16	-0.29	-0.27	-0.19	-0.23	-0.15	-0.19	-0.19
	E	1393	-0.80	-0.43	-1.73	-0.60	-1.00	-1.13	-0.33	-1.94	-1.07	-1.23	-0.43	-0.19	-1.79	-0.24	-0.63	-0.54	-0.16	-1.31	-0.41	-0.71
	F	127	-0.08	-0.04	-0.13	-0.08	-0.07	-0.04	-0.01	-0.07	-0.04	-0.04	-2.99	-2.93	-3.05	-2.99	-2.98	-2.99	-2.96	-3.02	-2.99	-2.98
	G	1431	0.13	0.12	0.15	0.13	0.13	0.07	0.05	0.08	0.07	0.07	-3.35	-3.37	-3.33	-3.35	-3.35	-3.35	-3.37	-3.34	-3.35	-3.35
	H	1423	-12.35	-12.08	-12.94	-12.48	-12.24	-4.48	-3.26	-5.88	-4.55	-4.43	-3.56	-3.51	-3.81	-3.58	-3.54	-3.47	-3.35	-3.61	-3.48	-3.46
	I	1417	-2.44	-2.59	-2.40	-2.09	-2.80	0.88	-0.33	1.09	0.91	0.84	-3.21	-3.25	-3.18	-3.20	-3.22	-3.03	-3.23	-2.83	-3.01	-3.05
120	A	116	-0.01	-0.02	0.00	-0.01	-0.01	-23.64	-26.26	-26.59	-23.61	-24.14	-2.83	-2.81	-2.85	-2.82	-2.83	-11.85	-13.32	-18.58	-12.89	-11.62
	B	114	-7.44	-9.67	-7.93	-7.70	-8.36	-4.21	-5.32	-4.97	-4.55	-4.58	-4.27	-6.27	-5.75	-5.13	-5.07	-4.23	-5.48	-5.26	-4.76	-4.67
	C	112	-3.13	-3.23	-3.09	-3.45	-2.89	-1.21	-1.24	-1.98	-1.33	-1.21	-1.18	-1.23	-1.18	-1.19	-1.20	-1.20	-1.24	-1.42	-1.20	-1.21
	D	111	-1.54	-1.91	-1.19	-2.01	-1.12	-0.11	-0.12	-0.11	-0.23	-0.11	-0.14	-0.26	-0.11	-0.28	-0.13	-0.12	-0.14	-0.10	-0.12	-0.12
	E	1233	-0.27	-0.41	-0.41	-0.28	-0.26	-1.20	-1.07	-1.71	-1.30	-1.19	-0.18	-0.38	-0.15	-0.17	-0.21	-0.16	-0.20	-0.17	-0.14	-0.18
	F	107	-0.11	-0.09	-0.14	-0.12	-0.11	-0.03	-0.03	-0.04	-0.03	-0.03	-2.84	-2.81	-2.86	-2.83	-2.83	-2.83	-2.82	-2.84	-2.83	-2.83
	G	1269	0.32	0.26	0.34	0.32	0.32	0.12	0.01	0.14	0.11	0.12	-3.10	-3.12	-3.08	-3.10	-3.10	-3.12	-3.14	-3.10	-3.12	-3.12
	H	1263	-12.15	-13.24	-11.99	-12.15	-12.17	-4.65	-4.34	-5.40	-4.70	-4.65	-3.67	-4.12	-3.86	-3.68	-3.67	-3.59	-3.57	-3.62	-3.59	-3.59
	I	1255	-3.60	-4.92	-3.01	-3.38	-3.84	0.49	0.23	0.60	0.50	0.48	-2.94	-2.99	-2.89	-2.93	-2.95	-2.82	-2.93	-2.71	-2.82	-2.82
90	A	96	0.03	-0.31	0.03	0.03	0.03	-29.99	-34.19	-33.06	-30.05	-30.46	-2.61	-2.59	-2.66	-2.61	-2.61	-11.88	-17.06	-18.73	-12.87	-11.90
	B	94	-4.73	-7.10	-7.02	-5.46	-6.12	-4.48	-5.44	-5.44	-4.73	-4.85	-4.53	-6.23	-6.35	-5.06	-5.28	-4.49	-5.62	-5.89	-4.92	-4.93
	C	90	-1.72	-1.49	-2.59	-2.14	-1.54	-1.48	-1.49	-1.50	-1.49	-1.48	-1.48	-1.48	-1.51	-1.50	-1.48	-1.48	-1.49	-1.49	-1.48	-1.48
	D	89	-1.70	-0.81	-2.61	-1.85	-1.56	-0.22	-0.23	-0.22	-0.22	-0.23	-0.23	-0.23	-0.24	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23
	E	1064	-0.21	-0.23	-0.27	-0.22	-0.20	-1.90	-1.96	-2.16	-2.07	-1.91	-0.10	-0.12	-0.11	-0.11	-0.10	-0.08	-0.09	-0.07	-0.08	-0.08
	F	85	-0.05	-0.07	-0.04	-0.05	-0.05	-0.01	-0.01	-0.01	-0.01	-0.01	-2.71	-2.73	-2.71	-2.71	-2.70	-2.71	-2.71	-2.71	-2.71	-2.71
	G	1121	0.44	0.50	0.23	0.44	0.44	-0.15	0.10	-0.66	-0.32	-0.01	-2.99	-2.93	-3.05	-2.99	-2.98	-3.01	-2.99	-3.03	-3.01	-3.00
	H	1113	-15.60	-16.97	-15.25	-15.51	-15.72	-4.40	-4.77	-4.39	-4.36	-4.49	-3.58	-5.53	-3.57	-3.57	-3.59	-3.54	-3.55	-3.54	-3.54	-3.54
	I	1105	-4.91	-7.93	-3.04	-4.59	-5.25	0.69	0.13	0.81	0.73	0.63	-3.06	-3.17	-2.97	-3.05	-3.06	-2.72	-2.75	-2.69	-2.71	-2.73
60	A	64	-0.70	-1.57	-0.29	-0.93	-0.48	-41.42	-47.59	-42.19	-41.88	-41.70	-2.47	-2.73	-2.41	-2.43	-2.41	-5.15	-16.15	-9.49	-6.34	-5.74
	B	59	-5.02	-6.31	-6.66	-5.80	-5.92	-4.97	-5.76	-6.27	-5.46	-5.53	-5.04	-6.07	-6.20	-5.52	-5.76	-4.99	-5.72	-6.36	-5.52	-5.50
	C	61	-1.17	-1.18	-1.22	-1.19	-1.18	-1.19	-1.30	-1.22	-1.20	-1.20	-1.26	-1.78	-1.24	-1.29	-1.27	-1.24	-1.77	-1.23	-1.23	-1.31
	D	62	-0.45	-1.22	-0.13	-0.17	-1.46	-0.15	-0.24	-0.13	-0.15	-0.19	-0.14	-0.16	-0.13	-0.14	-0.14	-0.15	-0.15	-0.16	-0.15	-0.15
	E	978	-5.95	-6.33	-5.59	-6.22	-5.71	-5.55	-7.01	-4.09	-5.68	-5.43	-3.58	-3.63	-3.53	-3.59	-3.58	-3.57	-3.57	-3.58	-3.58	-3.57
	F	56	-0.03	-0.07	-0.30	-0.03	-0.02	-0.18	-0.13	-0.25	-0.22	-0.13	-2.57	-2.46	-2.84	-2.56	-2.47	-2.57	-2.51	-2.63	-2.56	-2.51
	G	727	-3.01	-0.78	-5.63	-3.18	-2.84	-2.58	-2.44	-2.72	-2.66	-2.51	-3.38	-3.25	-3.69	-3.36	-3.36	-3.37	-3.37	-3.38	-3.37	-3.37
	H	715	-22.63	-25.10	-20.83	-22.44	-22.86	-3.43	-4.59	-2.37	-3.28	-3.61	-3.48	-5.40	-3.44	-3.47	-3.49	-3.48	-3.56	-3.42	-3.48	-3.49
	I	707	-9.35	-12.75	-6.79	-9.28	-9.44	0.36	-0.05	-0.74	0.16	0.39	-3.71	-7.22	-3.25	-3.53	-3.67	-3.16	-3.09	-3.25	-3.19	-3.16

TABLE-5.12 (contd....) PRINCIPAL STRESSES S3

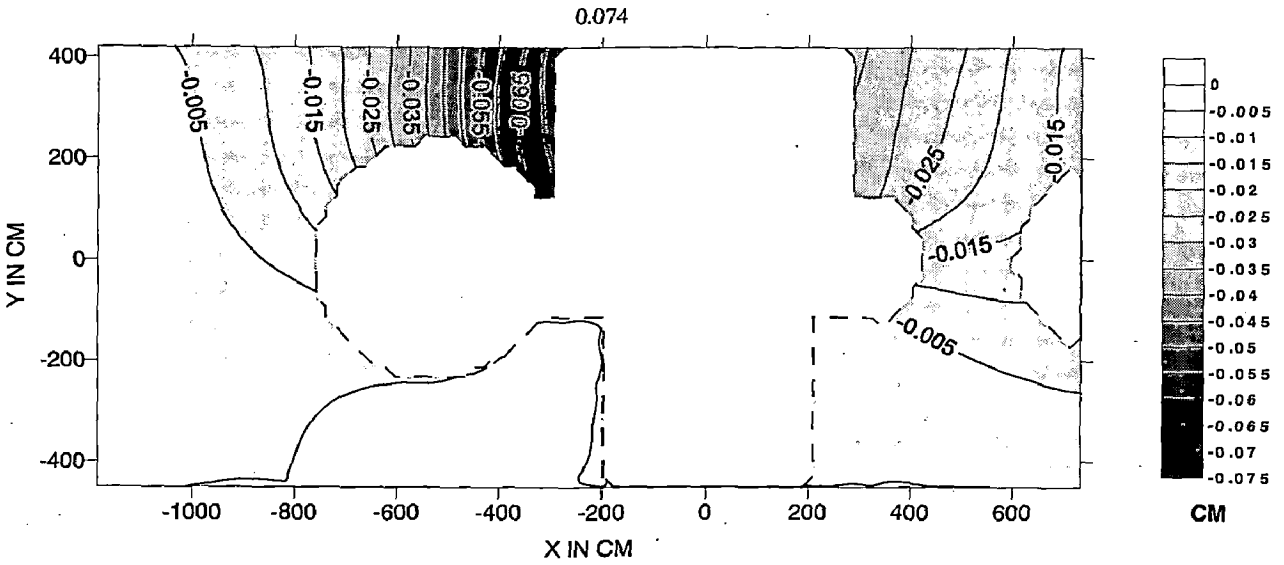
(KG/SQ.CM.)

i Floors load, Machine load and Dead load (I.e. Normal Operating Load)
ii Normal Operating Load with Radial force due to one sided magnetic attraction (positive x-direction)
iii Normal Operating Load with Radial force due to one sided magnetic attraction (negative x-direction)
iv Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Anticlockwise direction)
V Normal operating load with Tangential force due to Double Short Circuit of Rotor Winding (Clockwise direction)

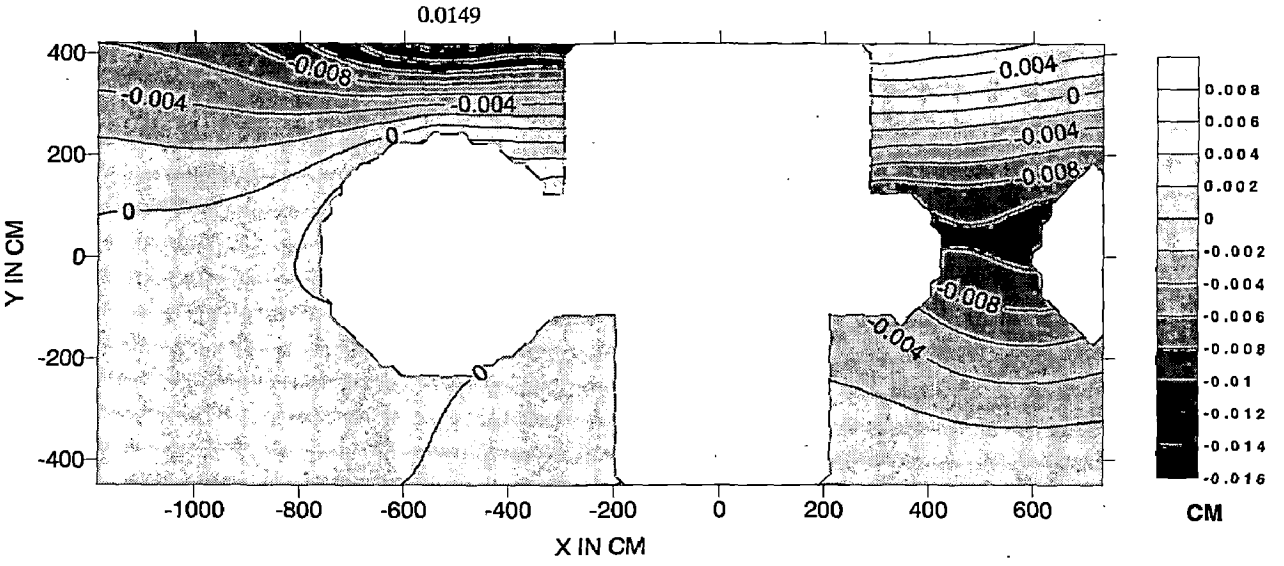
Section	Location		1. Without Internal Water Pressure										2. With Internal Water Pressure									
	Symbol	Node No.	a) Free at Speed Ring					b) Hinged at Speed Ring					a) Free at Speed Ring					b) Hinged at Speed Ring				
			i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v	i	ii	iii	iv	v
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
30	A	33	-1.47	-1.75	-1.20	-1.68	-1.29	-12.42	-6.34	-19.17	-12.65	-12.46	-4.25	-4.52	-3.99	-0.74	-0.56	-0.90	-0.54	-6.66	0.15	-1.89
	B	34	-5.63	-6.29	-7.32	-7.08	-6.54	-5.53	-6.10	-6.68	-6.15	-6.20	-5.58	-6.16	-6.43	-5.90	-6.44	-5.59	-6.07	-6.64	-6.02	-6.19
	C	38	-6.41	-9.26	-4.42	-5.47	-7.36	-3.65	-7.17	-1.02	-3.17	-4.24	-0.98	-2.54	-0.92	-1.23	-0.91	-0.91	-1.95	-0.93	-0.92	-0.91
	D	35	-0.10	-0.16	-0.10	-0.10	-0.10	-0.08	-0.13	-0.06	-0.08	-0.08	-1.07	-0.87	-1.28	-1.08	-1.06	-1.06	-0.92	-1.20	-1.07	-1.05
	E	486	-0.60	-1.39	-0.30	-0.63	-0.57	-0.80	-1.32	-0.34	-0.82	-0.78	-0.31	-0.35	-0.36	-0.32	-0.29	-0.31	-0.35	-0.31	-0.32	-0.30
	F	465	0.20	0.17	0.23	0.19	0.21	-0.08	-0.15	-0.02	-0.08	-0.08	-3.23	-3.25	-3.20	-1.48	-1.40	-2.94	-3.02	-2.85	-1.32	-1.34
	G	644	0.03	0.01	0.02	0.03	0.03	0.08	0.09	0.05	0.07	0.08	-3.54	-3.49	-3.58	-3.53	-3.50	-3.52	-3.50	-3.54	-3.51	-3.50
	H	47	-5.39	-5.34	-5.49	-5.78	-5.01	-4.61	-4.95	-4.29	-4.90	-4.32	-3.59	-3.57	-3.64	-3.60	-3.57	-3.59	-3.59	-3.61	-3.60	-3.58
	I	637	-0.67	-1.17	-0.52	-0.97	-0.44	0.14	-0.01	0.14	0.14	0.11	-3.18	-3.30	-3.12	-3.15	-3.22	-3.18	-3.23	-3.16	-3.15	-3.21
Minimum	Node	No.	4	4	4	4	4	845	845	845	845	845	2	2	2	262	262	1199	1199	1199	1199	1199
		X	275.0	275.0	275.0	275.0	275.0	204.2	204.2	204.2	204.2	204.2	275.0	275.0	275.0	1100.0	1100.0	-40.3	-40.3	-40.3	-40.3	-40.3
		Y	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	-450.0	-450.0	110.0	110.0	110.0	110.0	110.0
		Z	0.0	0.0	0.0	0.0	0.0	-256.0	-256.0	-256.0	-256.0	-256.0	0.0	0.0	0.0	1025.0	1025.0	-325.0	-325.0	-325.0	-325.0	-325.0
	Value		-55.07	-57.89	-52.24	-56.42	-53.71	-46.50	-49.75	-50.35	-47.52	-46.27	-17.64	-16.39	-18.92	-11.63	-12.03	-17.19	-21.86	-25.68	-18.29	-17.21
Maximum	Node	No.	21465	21465	21465	21465	21465	1499	4926	1580	1499	4926	17391	17391	22760	20824	17391	239	259	167	249	229
		X	259.98	259.98	259.98	259.98	259.98	-420.51	192.91	-435.30	-420.51	192.91	-209.35	-209.35	589.78	543.25	-209.35	137.50	238.16	-265.63	194.45	71.18
		Y	217.82	217.82	217.82	217.82	217.82	178.02	112.44	179.37	178.02	112.44	420.00	420.00	420.00	420.00	420.00	110.00	110.00	110.00	110.00	110.00
		Z	323.34	323.34	323.34	323.34	323.34	-112.68	-288.63	0.00	-112.68	-288.63	566.79	566.79	-100.62	253.71	566.79	238.16	137.50	71.18	194.45	265.63
	Value		1.10	1.16	1.02	1.11	1.09	1.04	1.03	1.29	1.06	1.07	0.35	0.34	0.32	0.36	0.34	1.38	2.11	0.77	1.44	1.22



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1a(i) AT SECTION 060-240

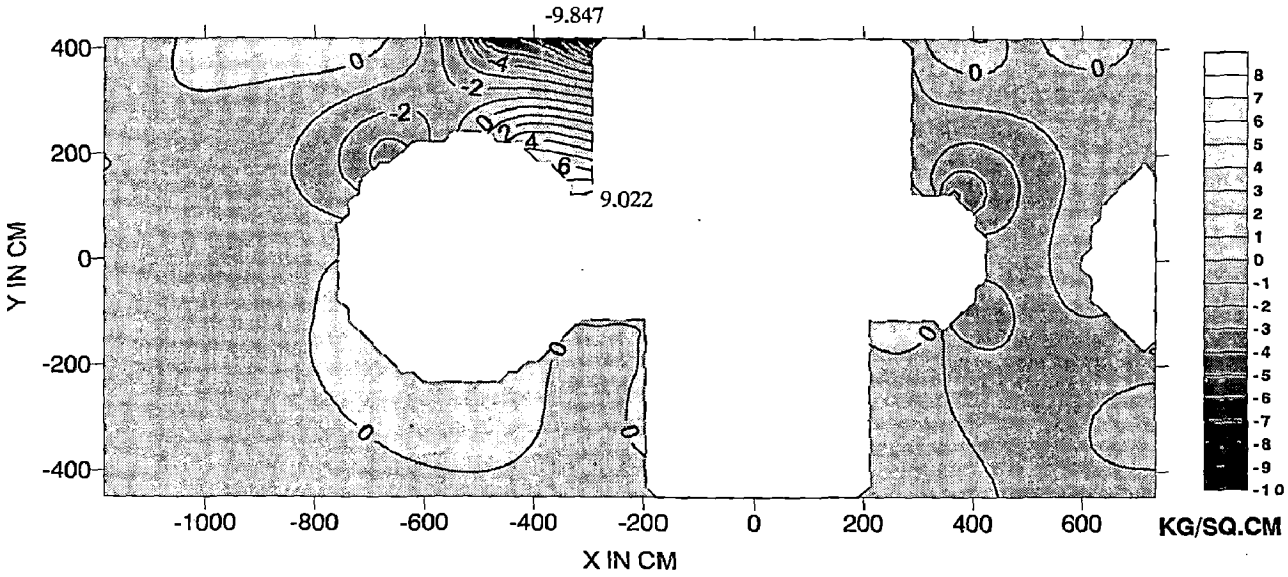


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1a(i) AT SECTION 060-240

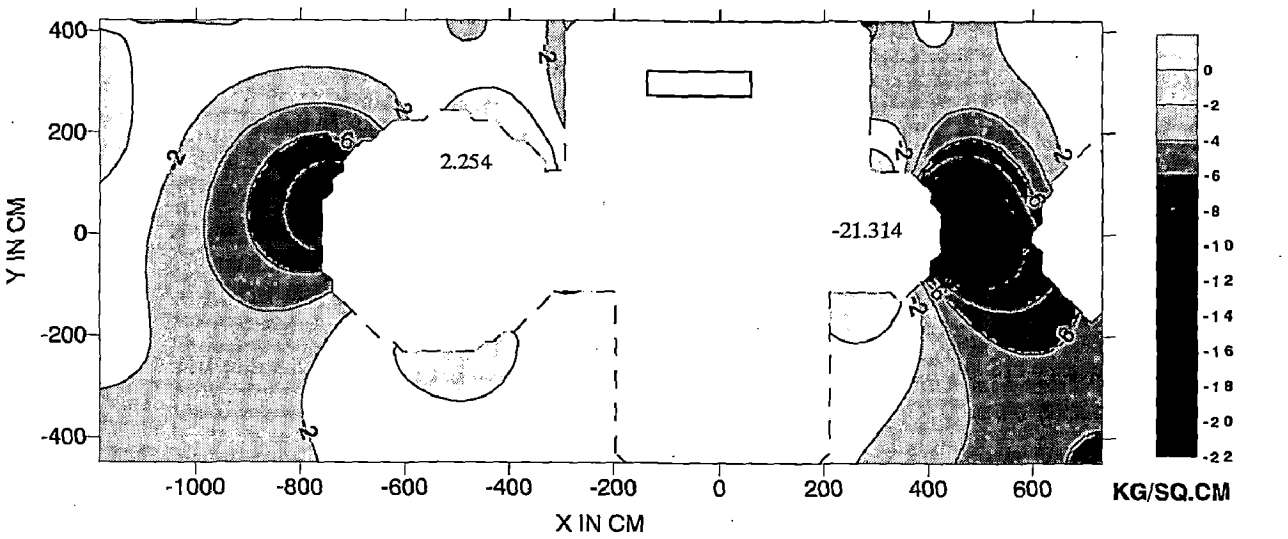


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1a(i) AT SECTION 060-240

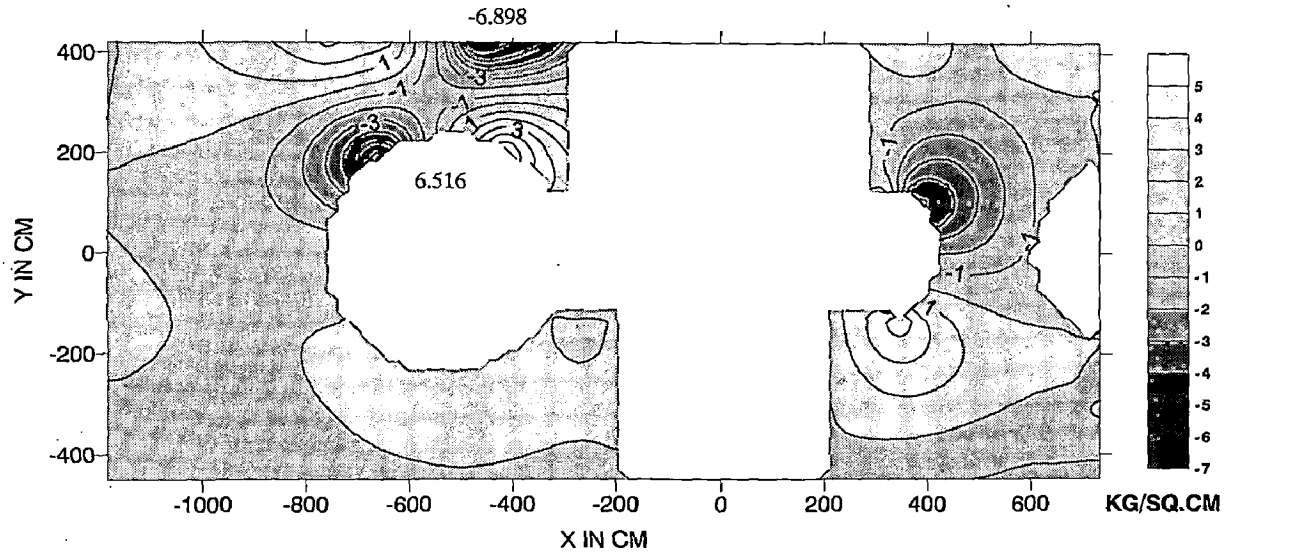
FIG. 5.1 DISPLACEMENT CONTOURS FOR LOAD 1a(i) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1a(i) AT SECTION 060-240

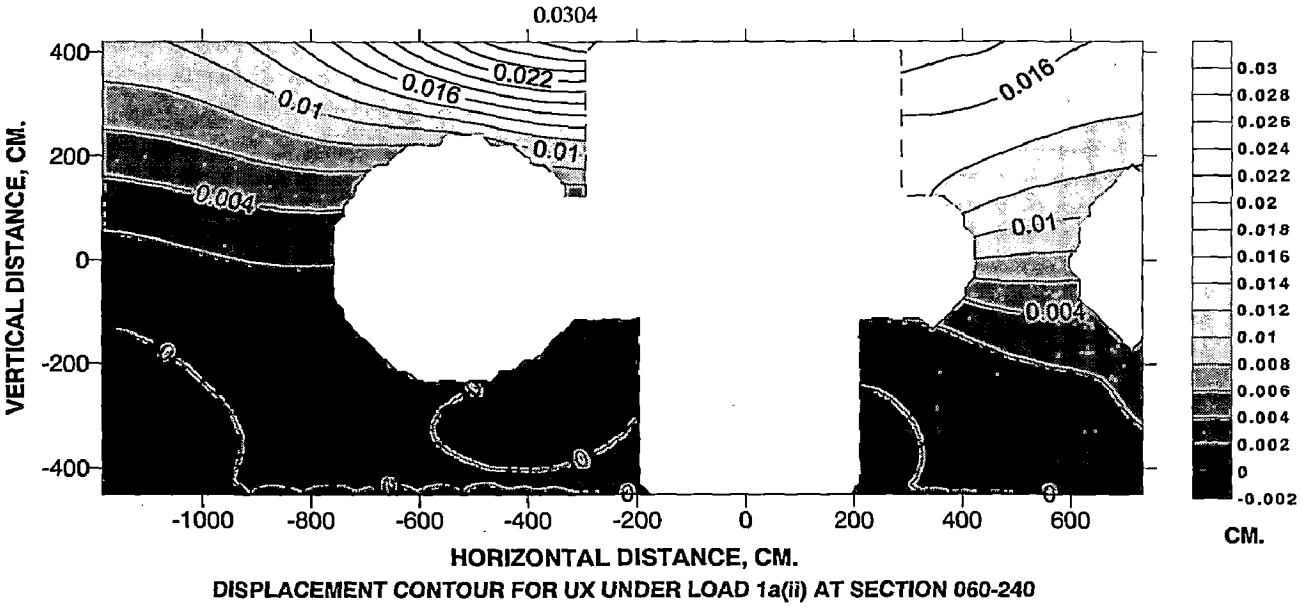


STRESS CONTOUR FOR SY UNDER LOAD 1a(i) AT SECTION 060-240

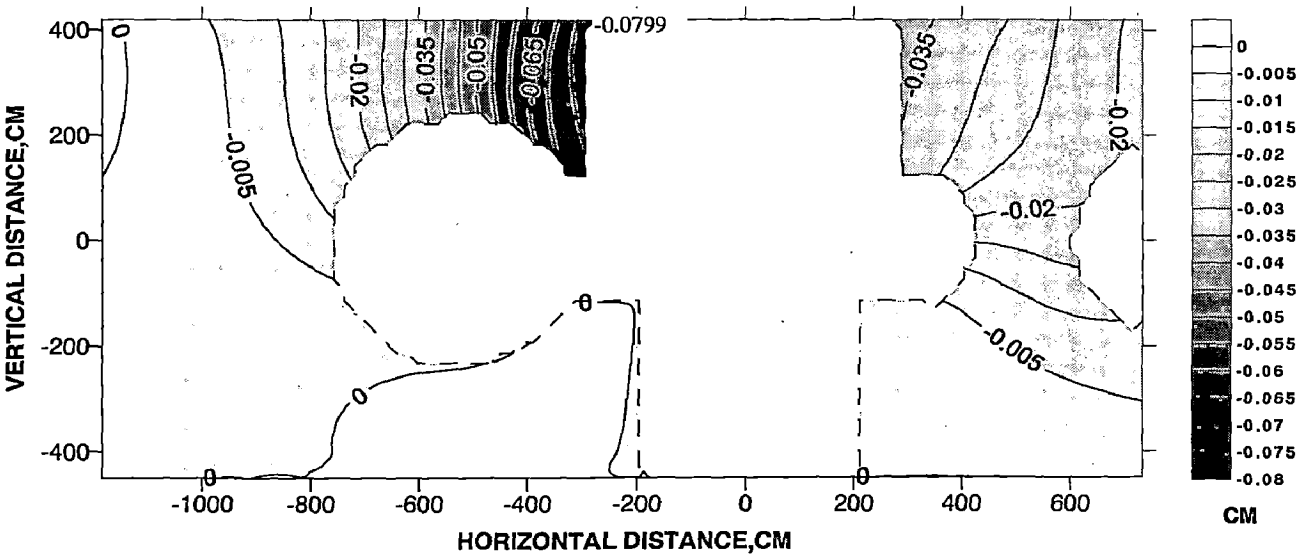


STRESS CONTOUR FOR SZ UNDER LOAD 1a(i) AT SECTION 060-240

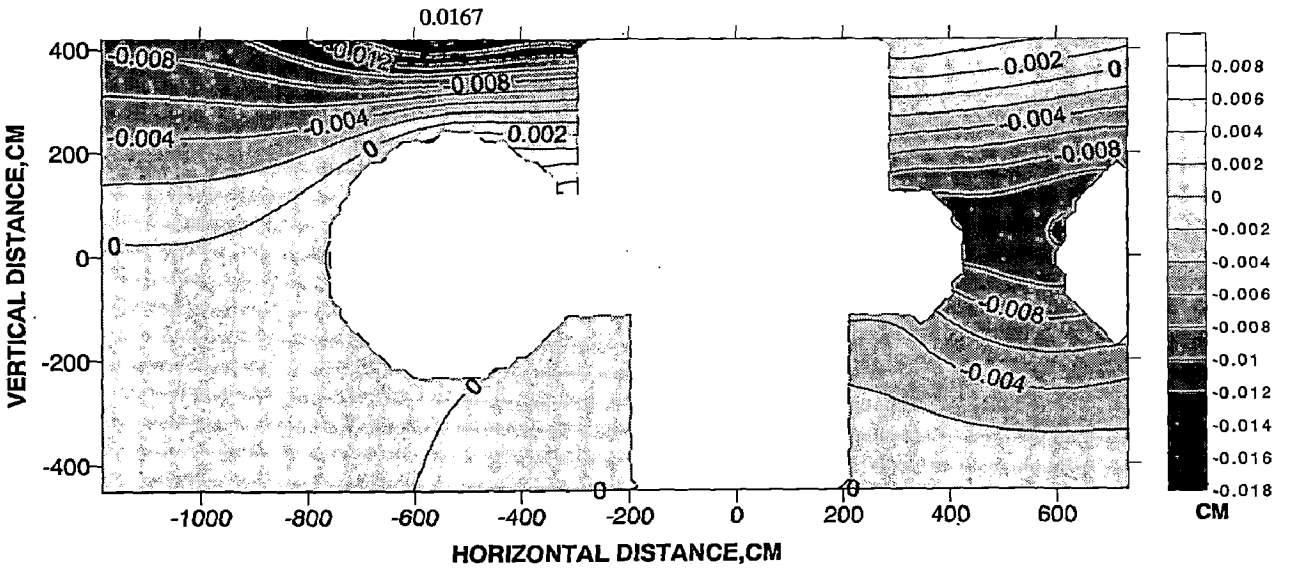
FIG. 5.2 STRESS CONTOURS FOR LOAD 1a(i) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1a(ii) AT SECTION 060-240

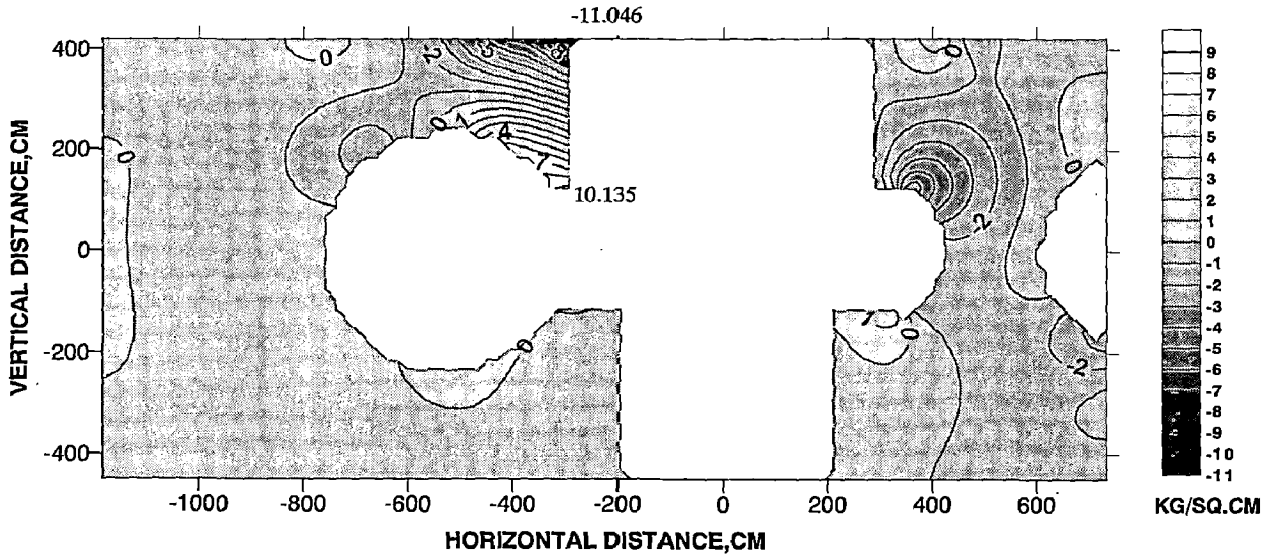


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1a(ii) AT SECTION 060-240

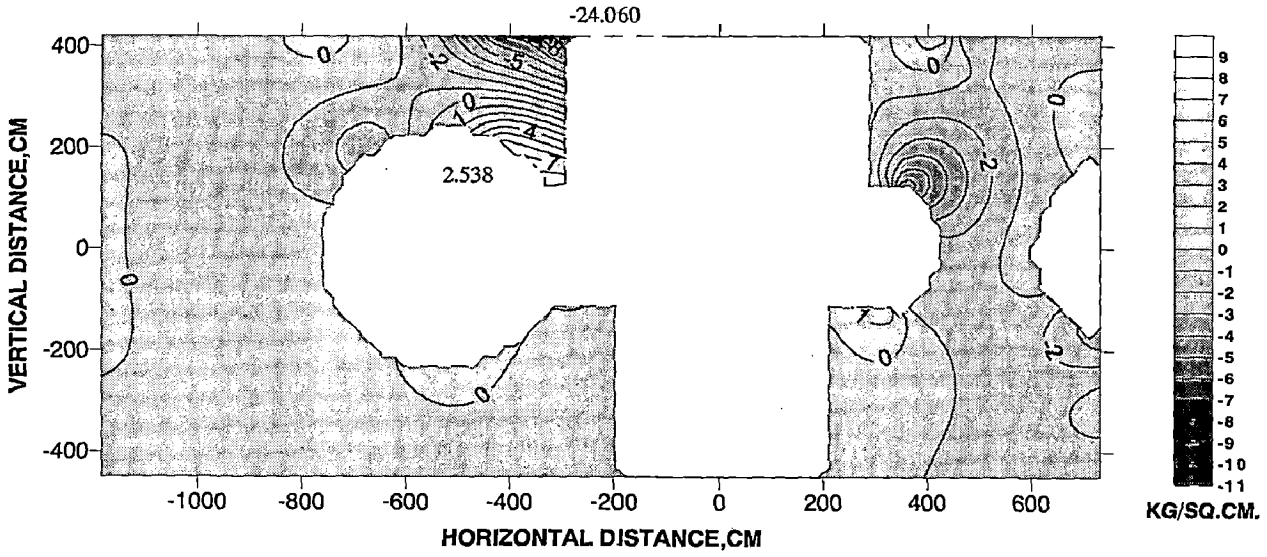


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1a(ii) AT SECTION 060-240

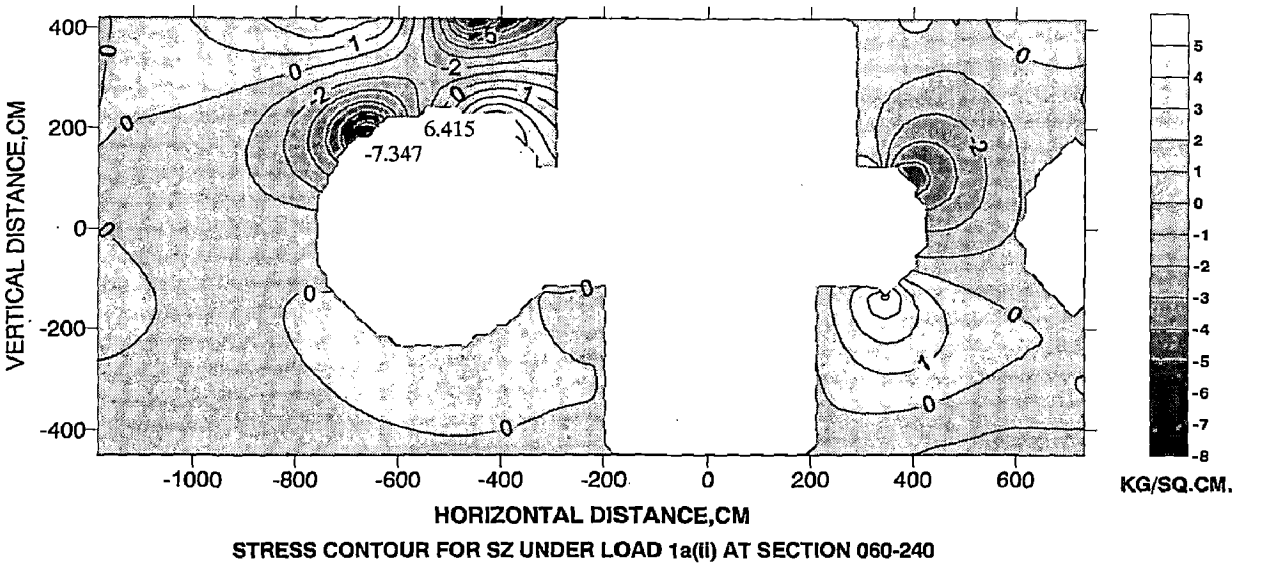
FIG. 5.3 DISPLACEMENT CONTOURS FOR LOAD 1a(ii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1a(ii) AT SECTION 060-240

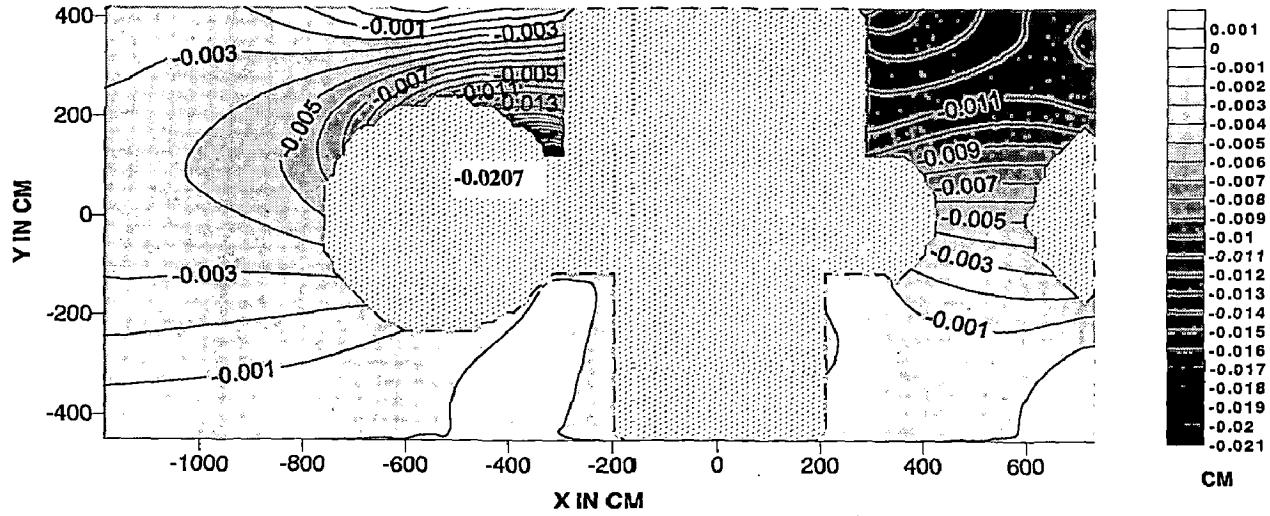


STRESS CONTOUR FOR SY UNDER LOAD 1a(ii) AT SECTION 060-240

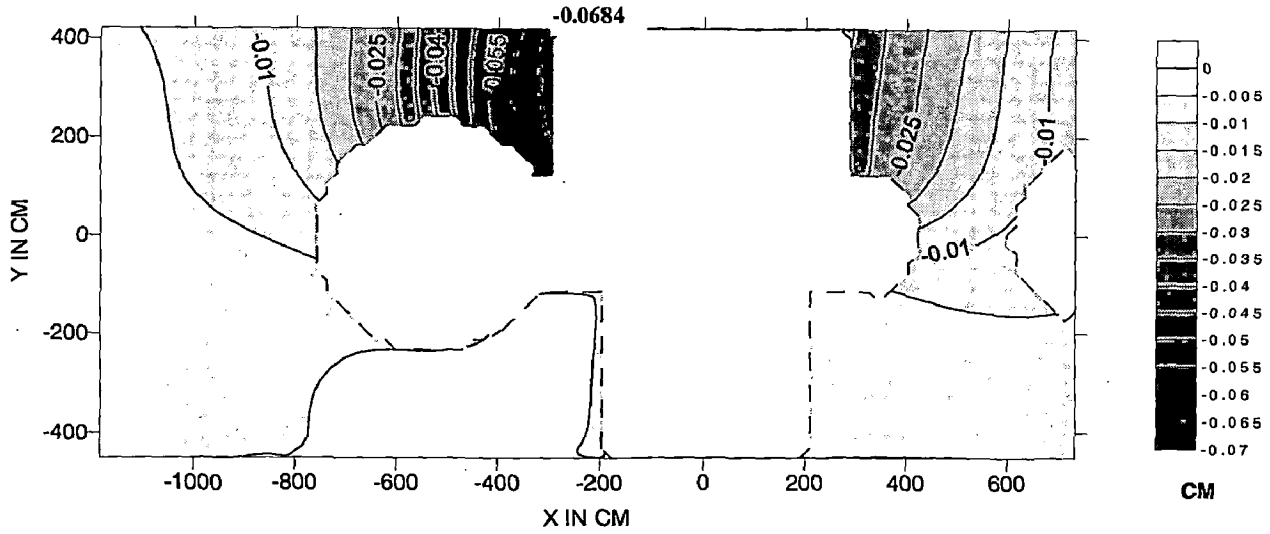


STRESS CONTOUR FOR SZ UNDER LOAD 1a(ii) AT SECTION 060-240

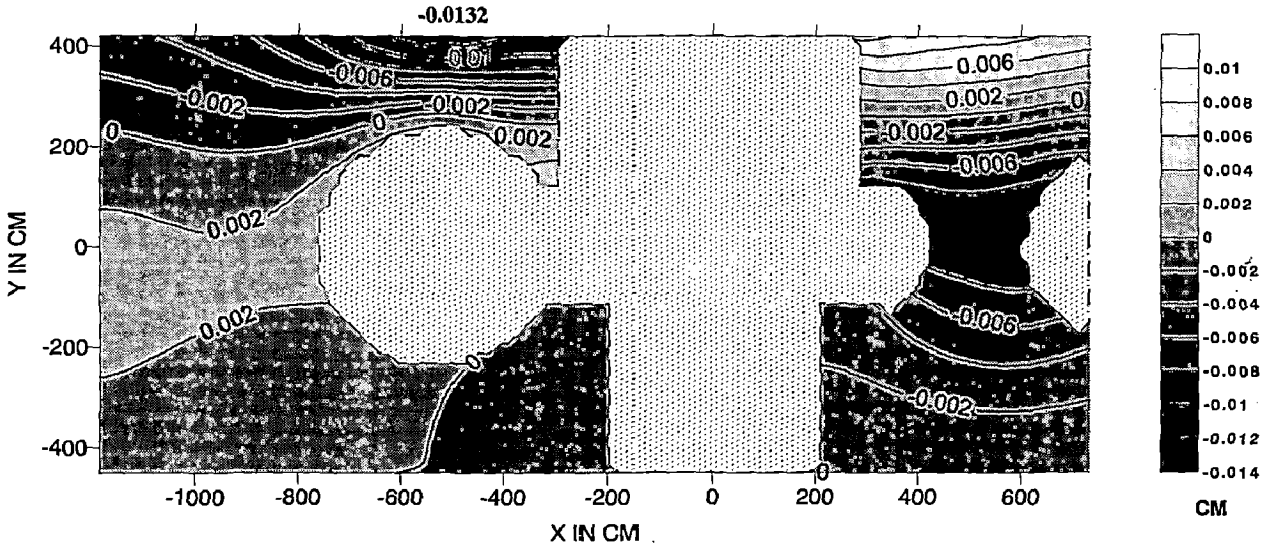
FIG. 5.4 STRESS CONTOURS FOR LOAD 1a(ii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1a(iii) AT SECTION 060-240

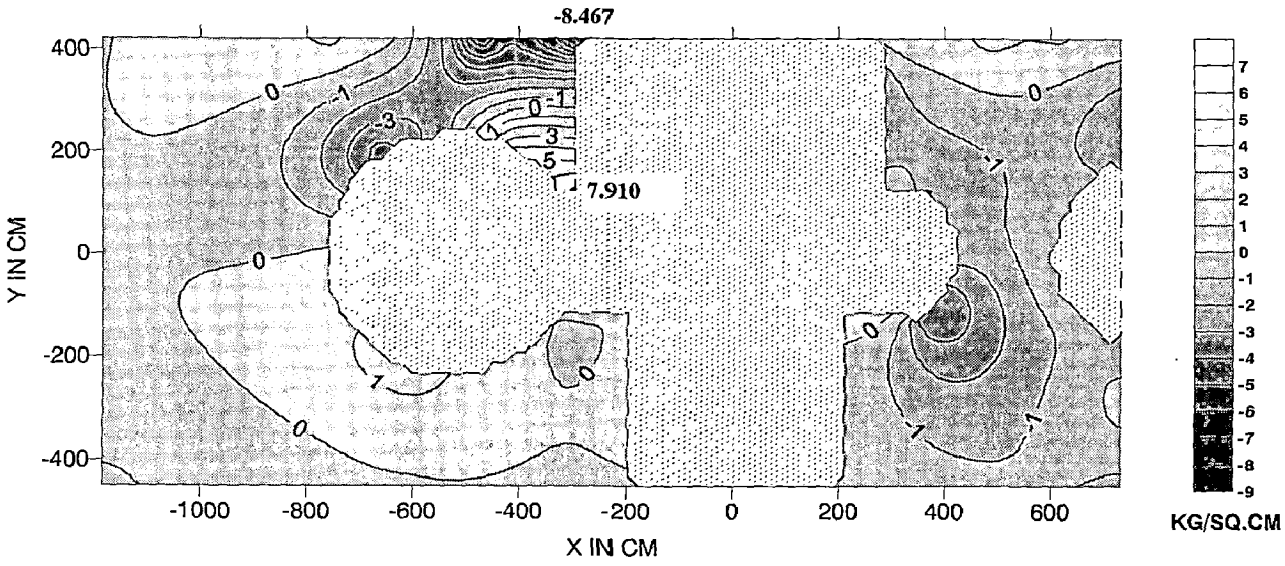


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1a(iii) AT SECTION 060-240

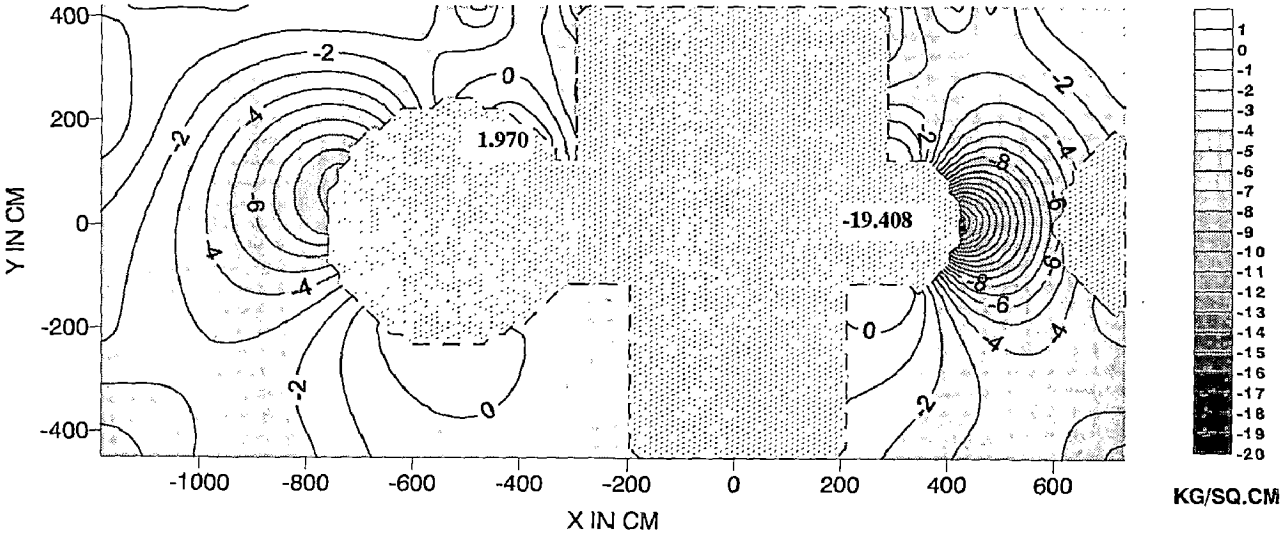


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1a(iii) AT SECTION 060-240

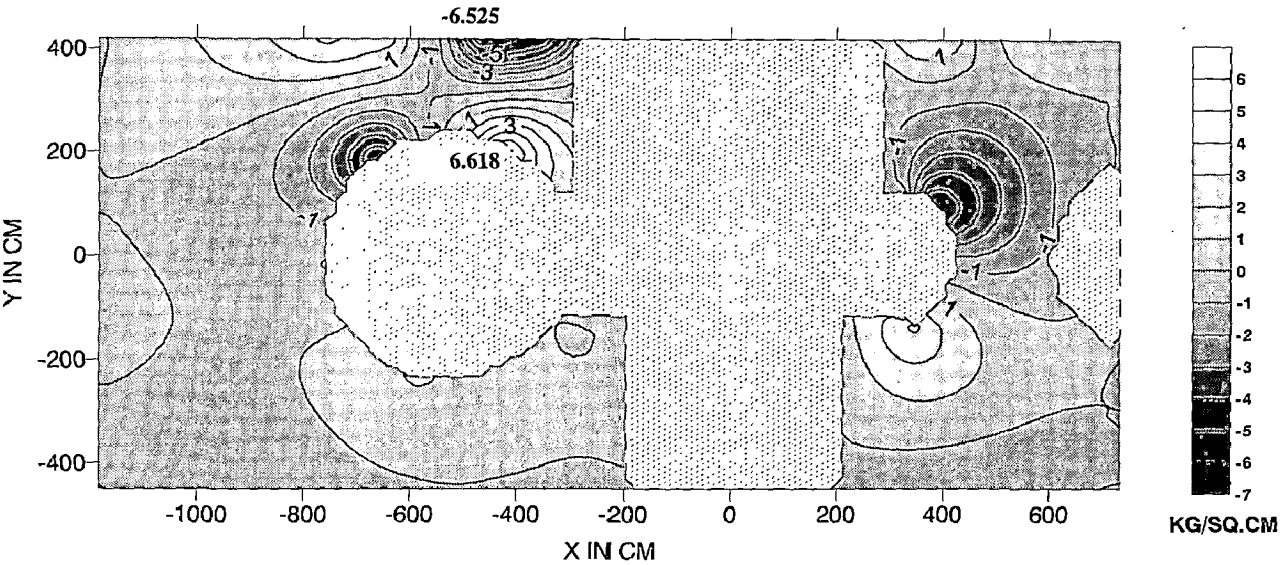
FIG. 5.5 DISPLACEMENT CONTOURS FOR LOAD 1a(iii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1a(iii) AT SECTION 060-240

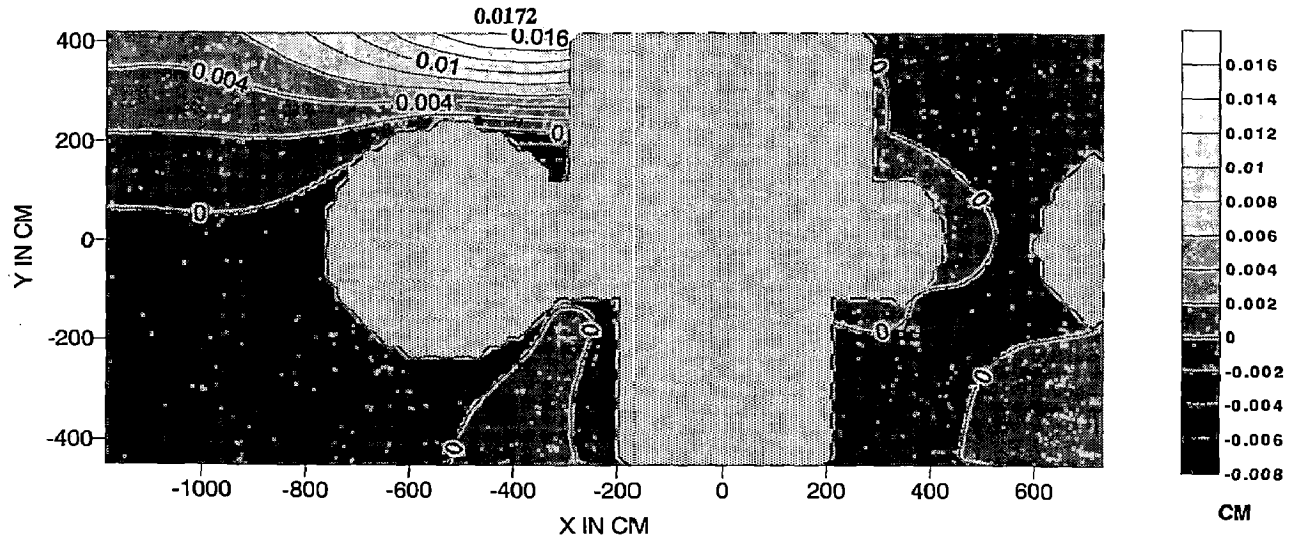


STRESS CONTOUR FOR SY UNDER LOAD 1a(iii) AT SECTION 060-240

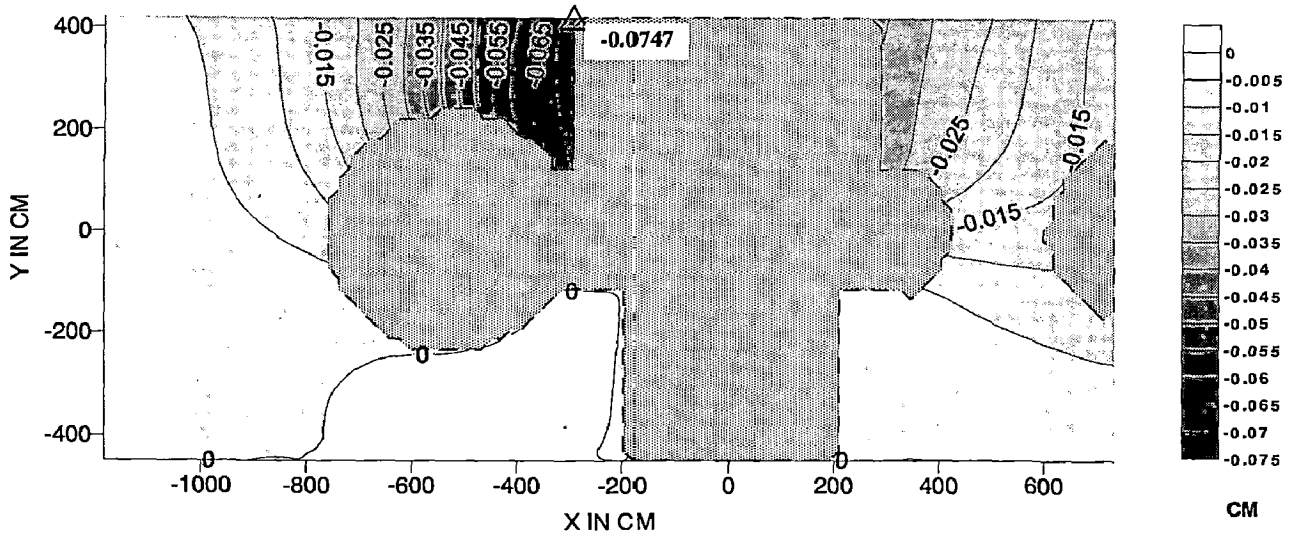


STRESS CONTOUR FOR SZ UNDER LOAD 1a(iii) AT SECTION 060-240

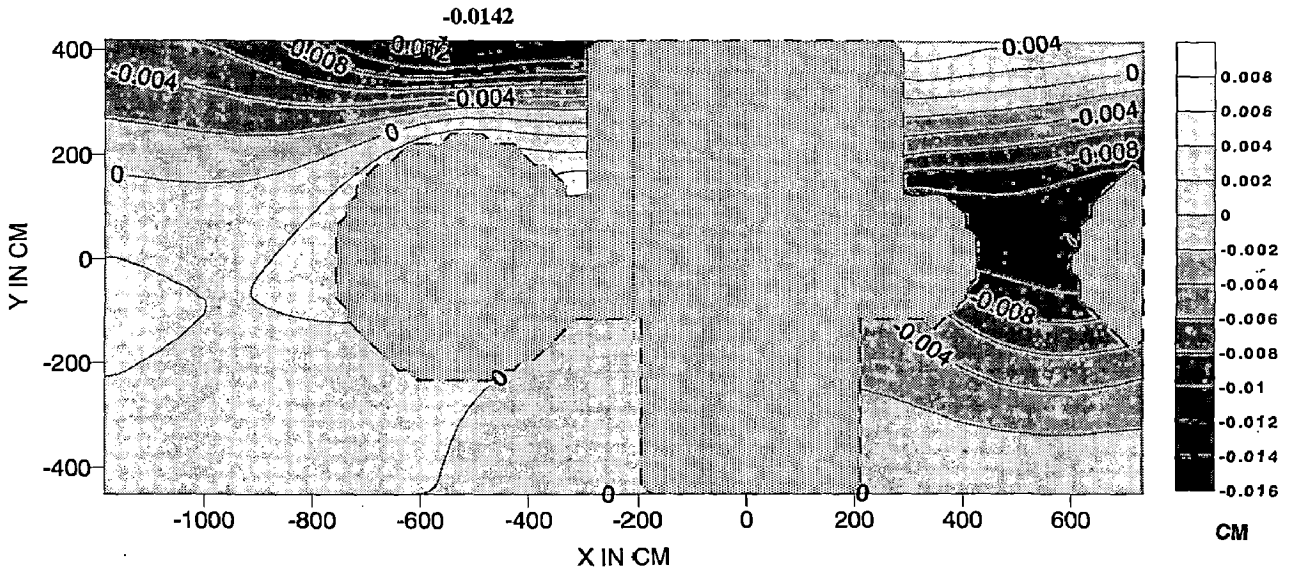
FIG. 5.6 STRESS CONTOURS FOR LOAD 1a(iii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1a(iv) AT SECTION 060-240

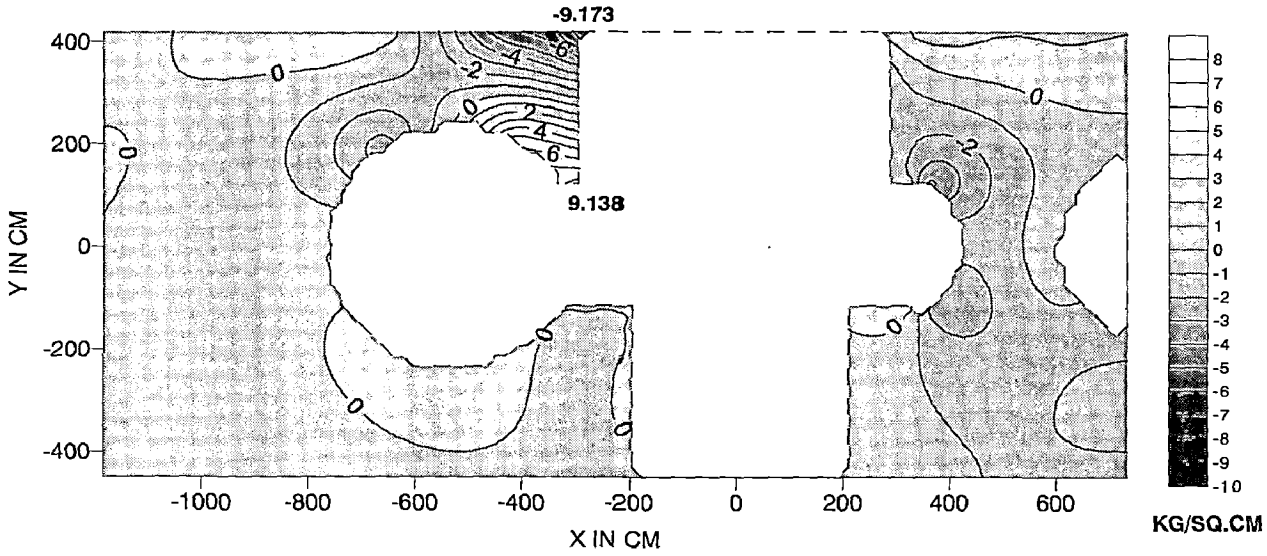


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1a(iv) AT SECTION 060-240

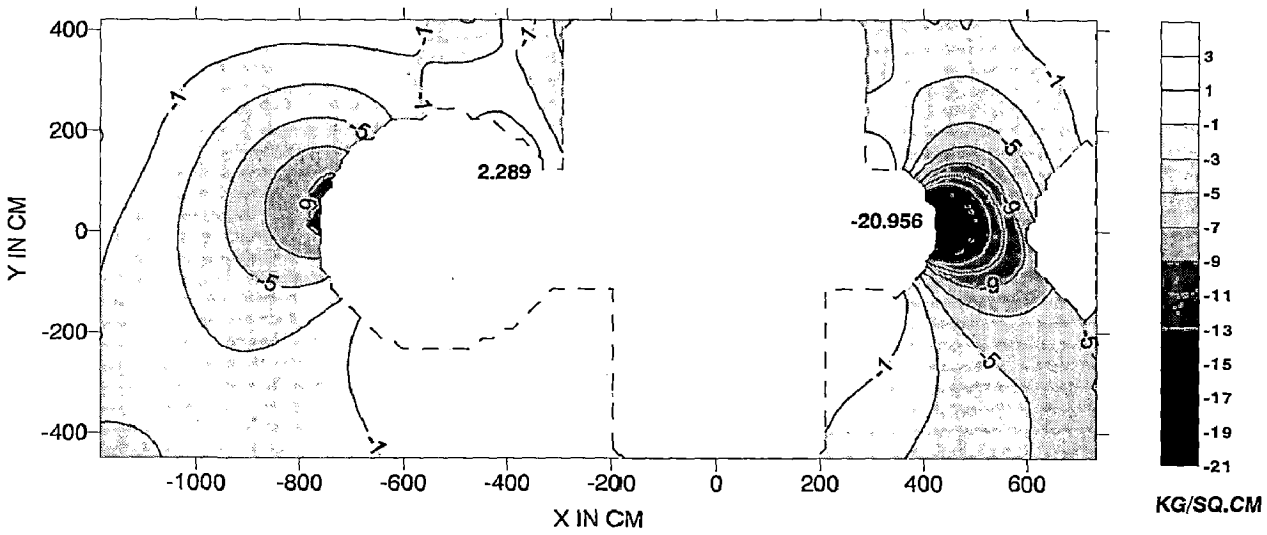


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1a(iv) AT SECTION 060-240

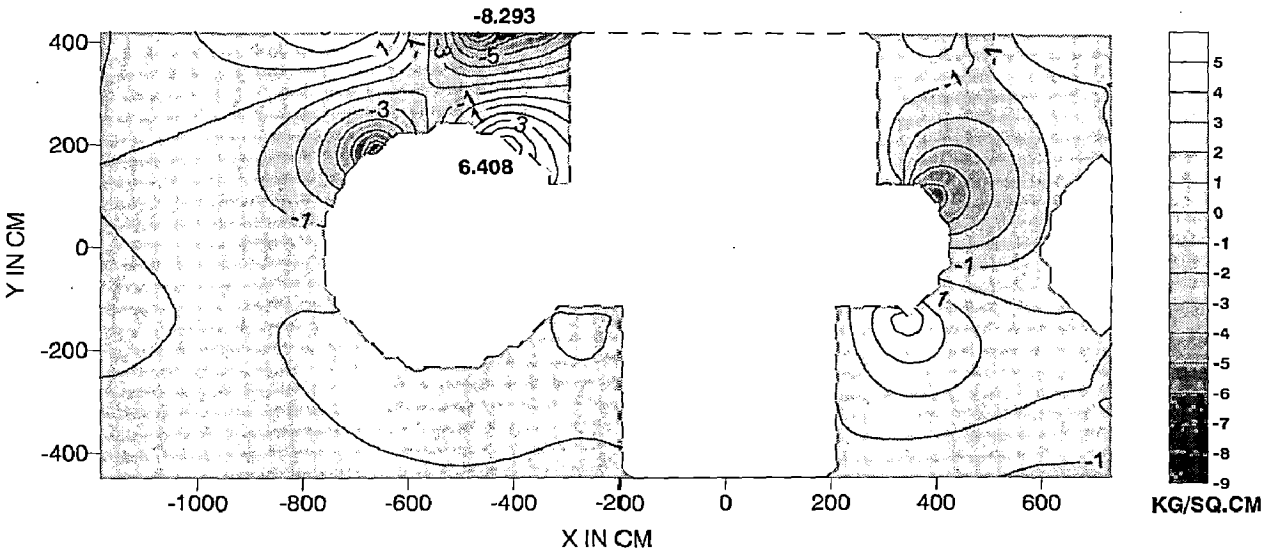
FIG. 5.7 DISPLACEMENT CONTOURS FOR LOAD 1a(iv) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1a(iv) AT SECTION 060-240

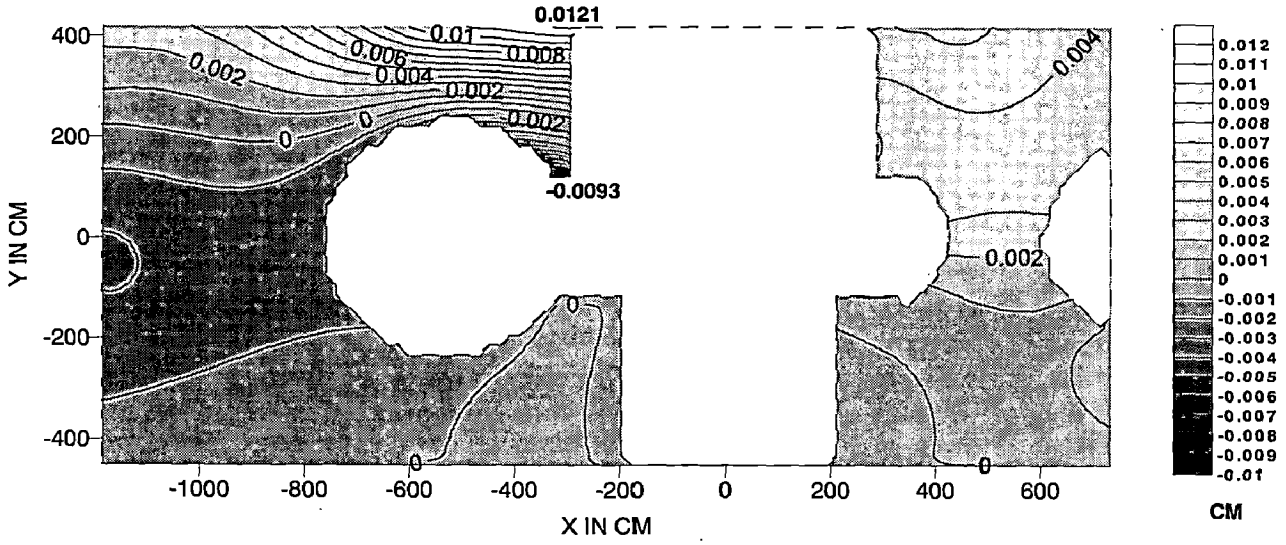


STRESS CONTOUR FOR SY UNDER LOAD 1a(iv) AT SECTION 060-240

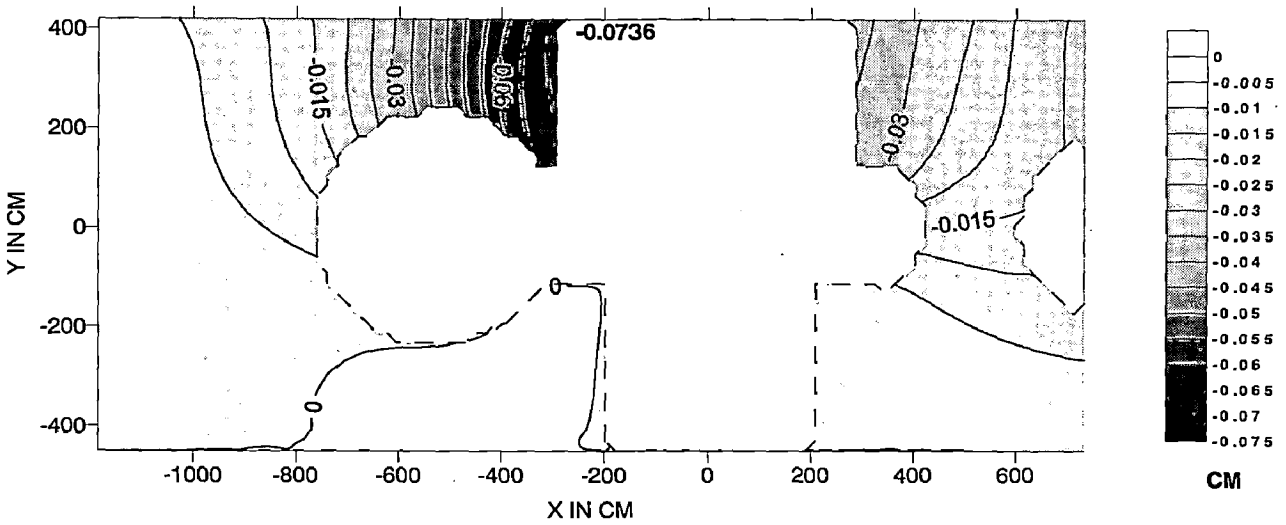


STRESS CONTOUR FOR SZ UNDER LOAD 1a(iv) AT SECTION 060-240

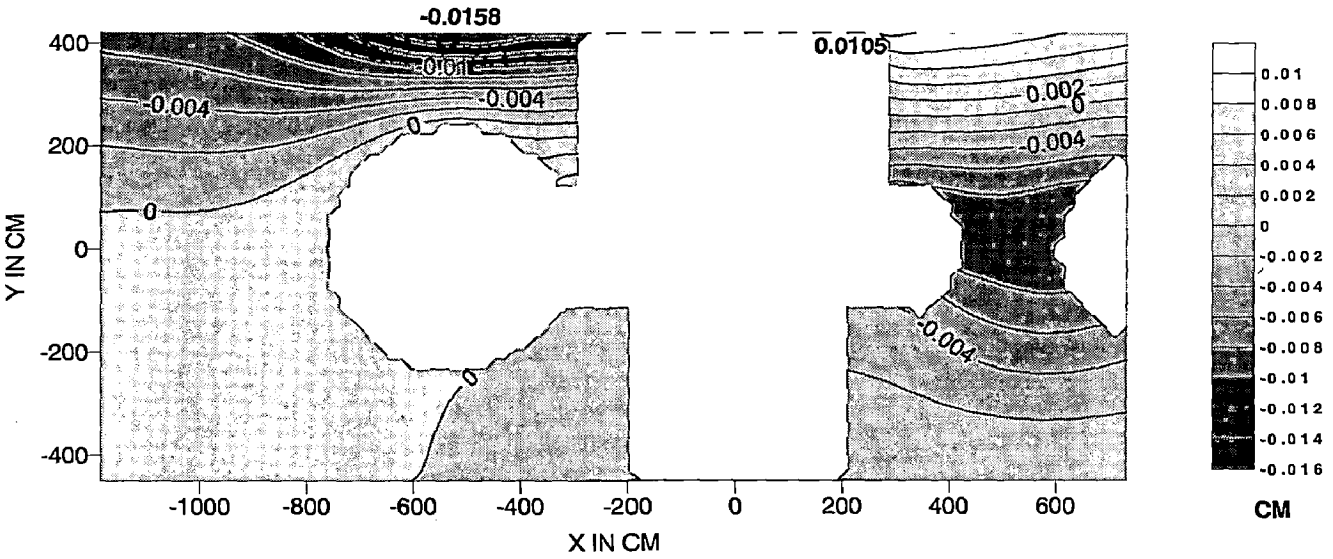
FIG. 5.8 STRESS CONTOURS FOR LOAD 1a(iv) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1a(v) AT SECTION 060-240

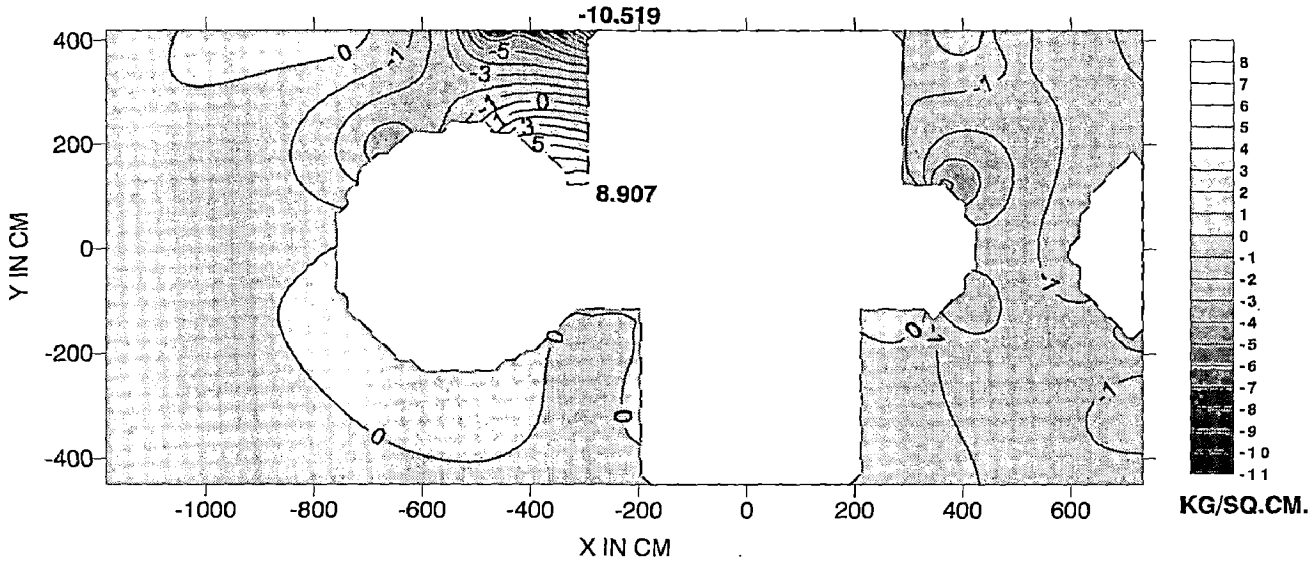


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1a(v) AT SECTION 040-260

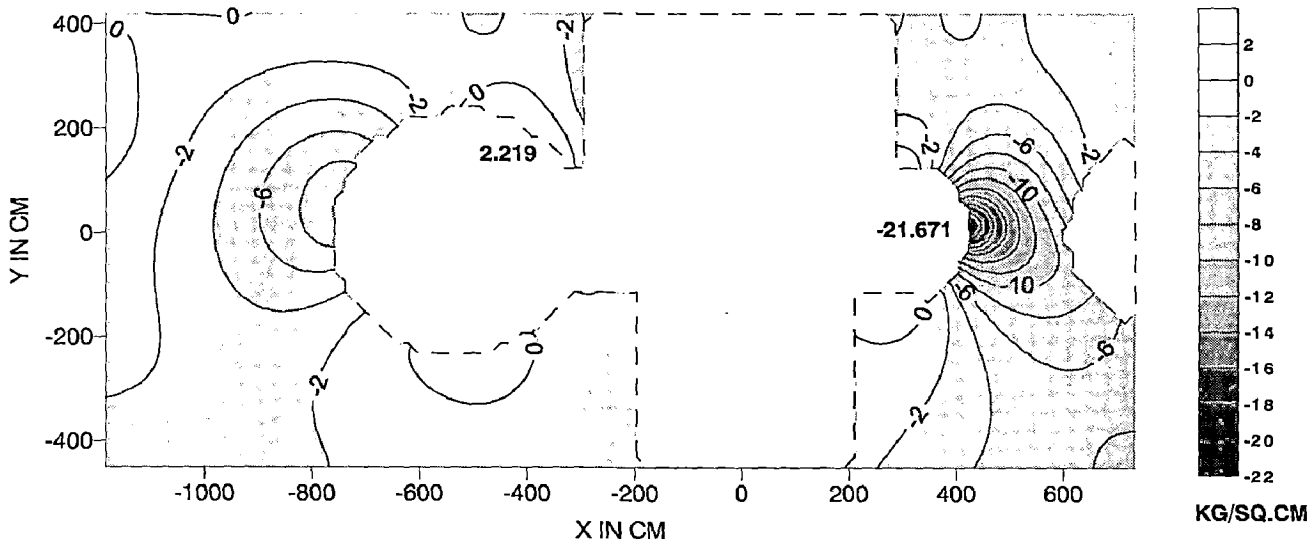


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1a(v) AT SECTION 040-260

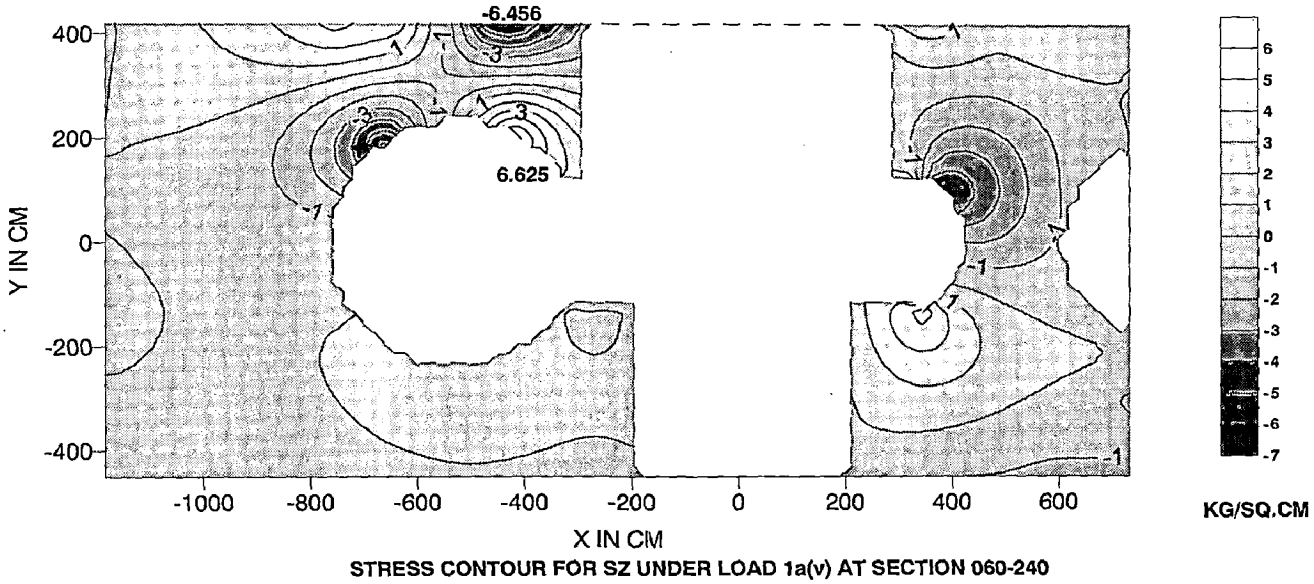
FIG. 5.9 DISPLACEMENT CONTOURS FOR LOAD 1a(v) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1a(v) AT SECTION 060-240

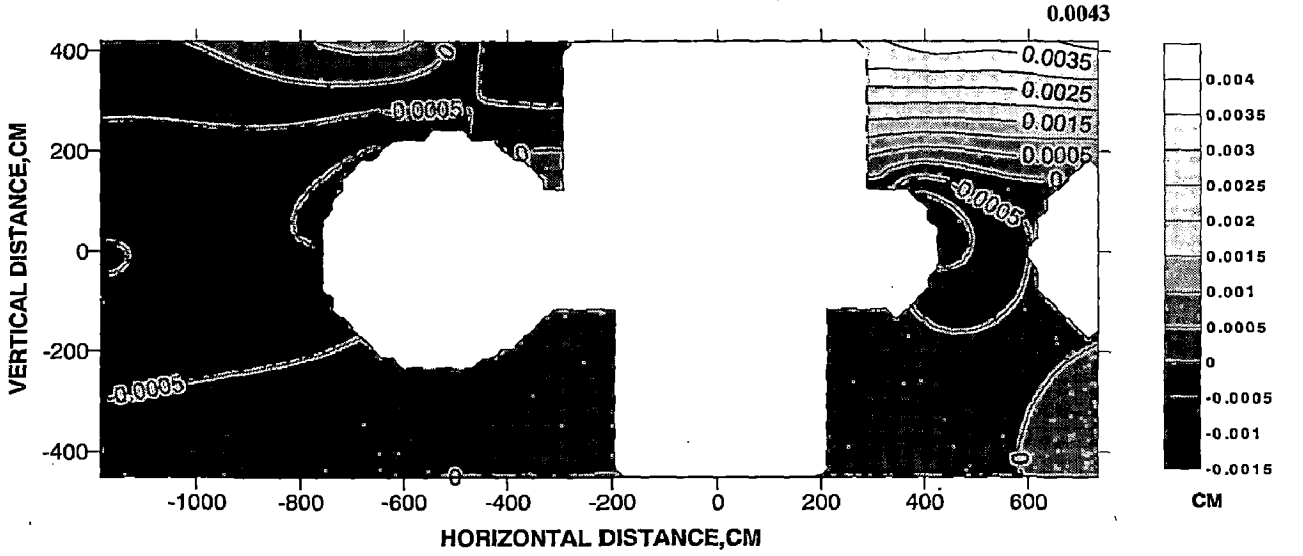


STRESS CONTOUR FOR SX UNDER LOAD 1a(v) AT SECTION 060-240

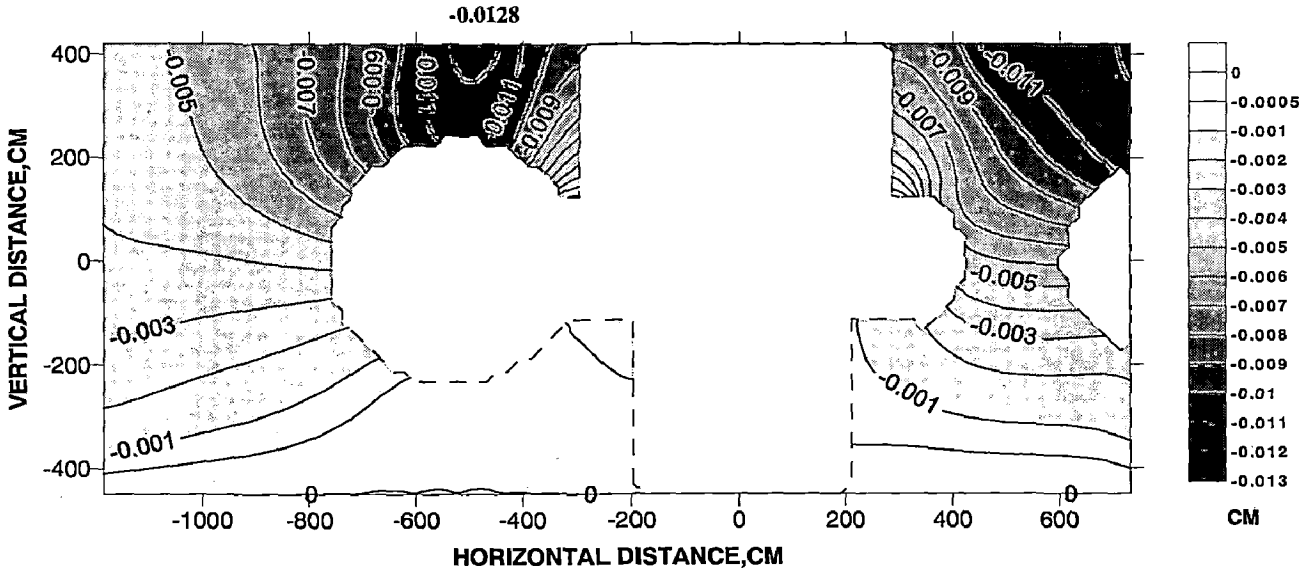


STRESS CONTOUR FOR SZ UNDER LOAD 1a(v) AT SECTION 060-240

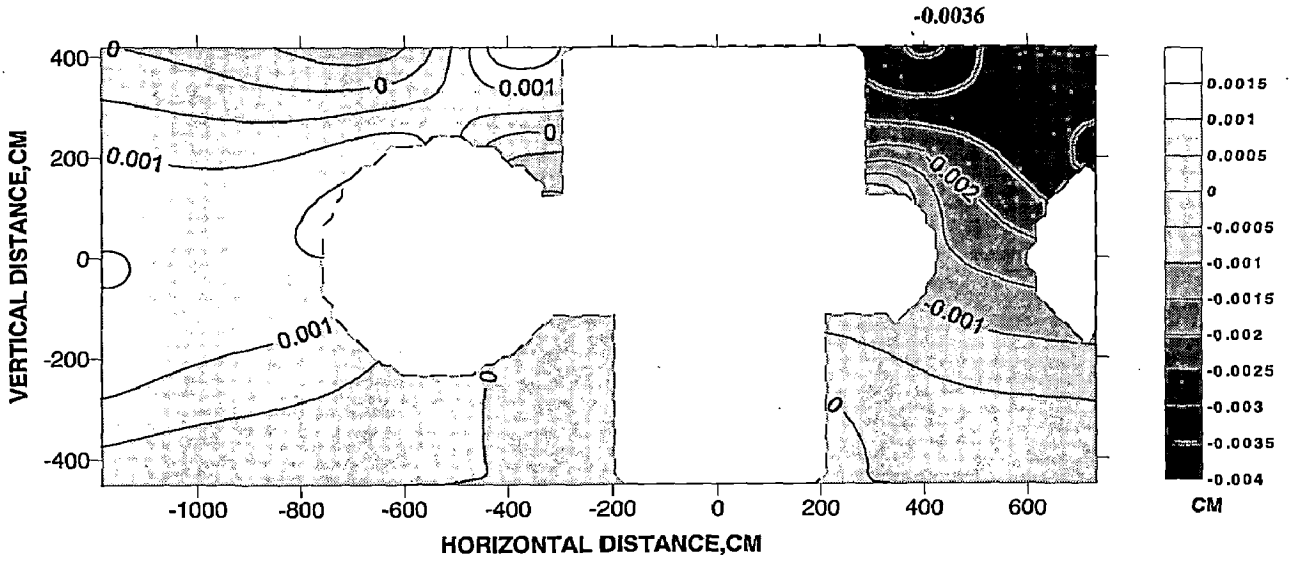
FIG. 5.10 STRESS CONTOURS FOR LOAD 1a(v) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(i) AT SECTION 060-240

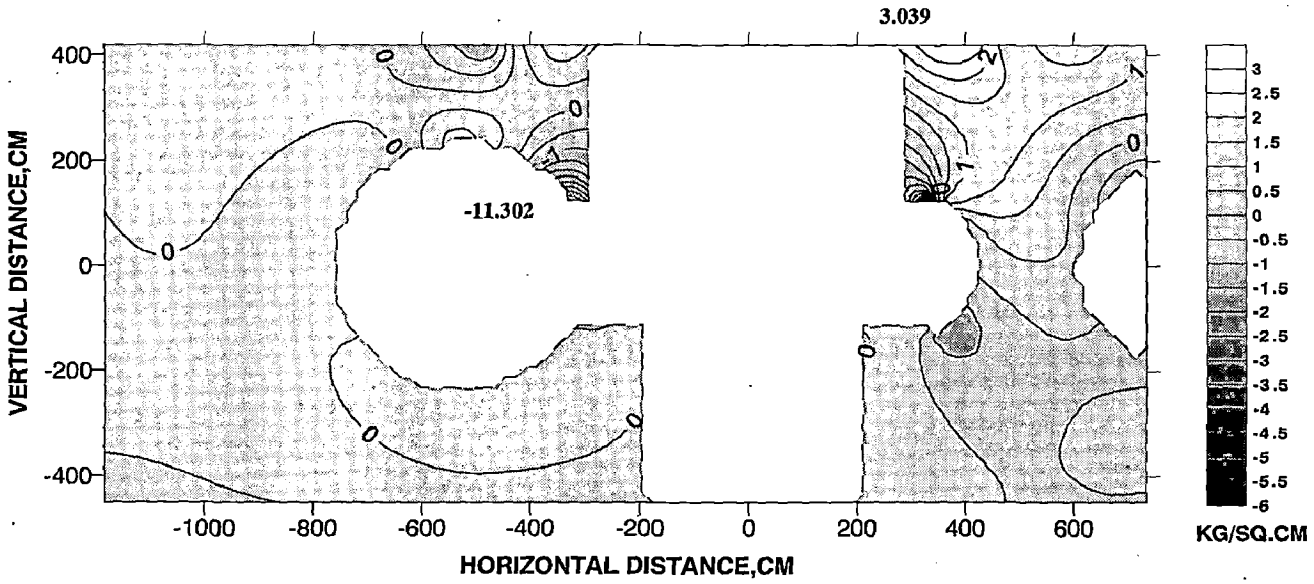


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1b(i) AT SECTION 060-240

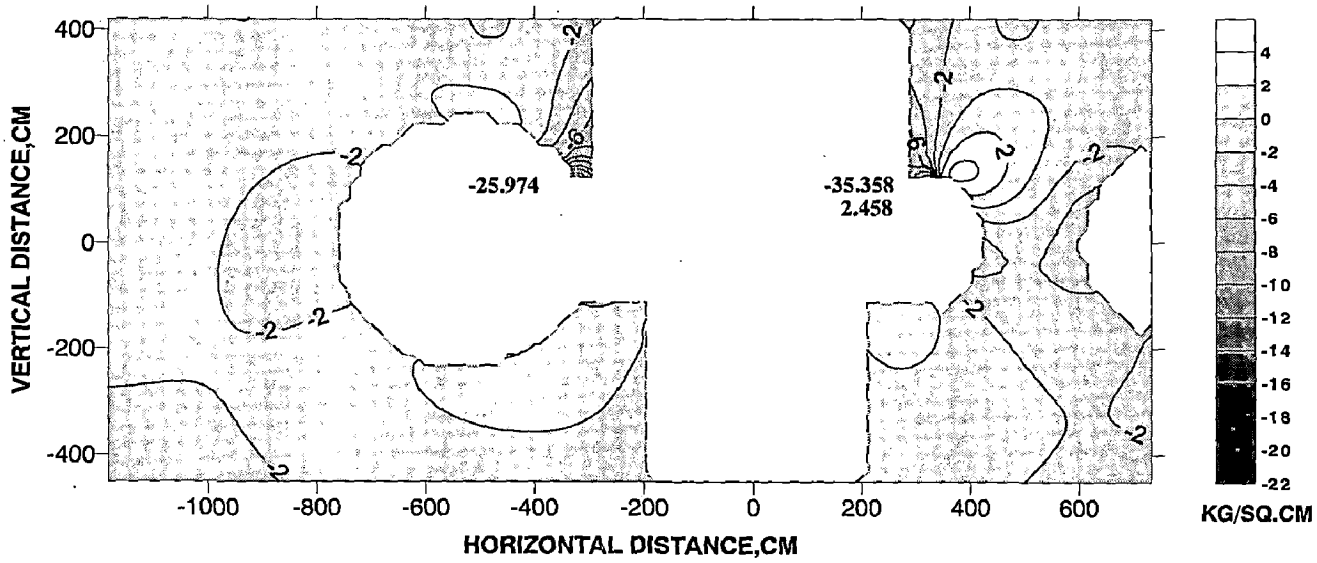


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1b(i) AT SECTION 060-240

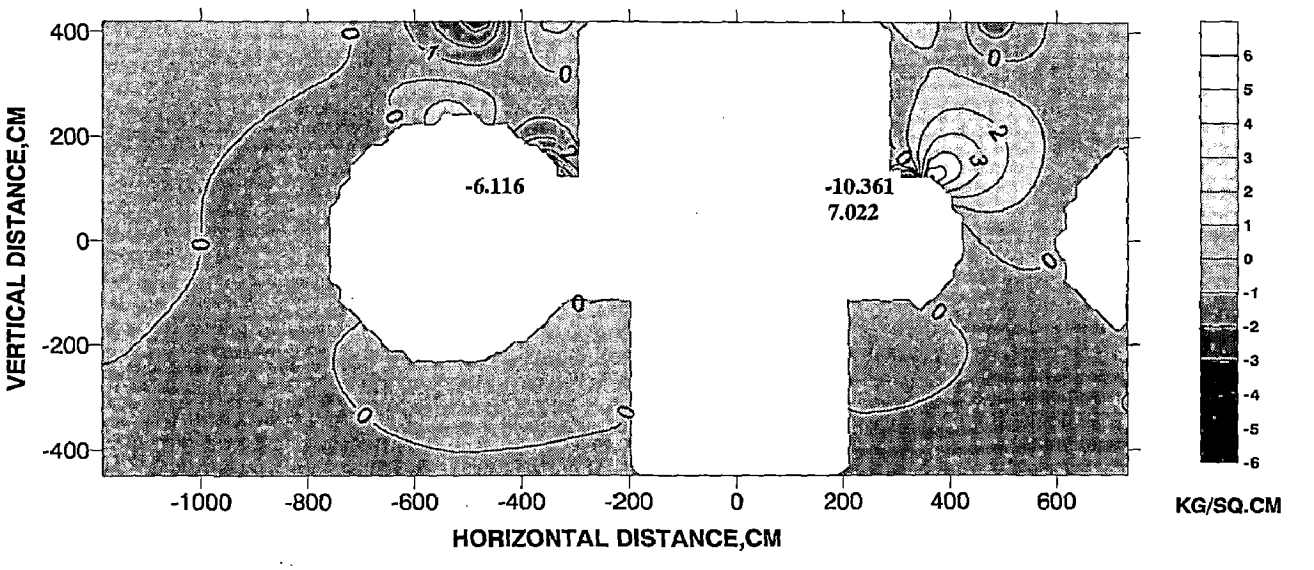
FIG. 5.11 DISPLACEMENT CONTOURS FOR LOAD 1b(i) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1b(i) AT SECTION 060-240

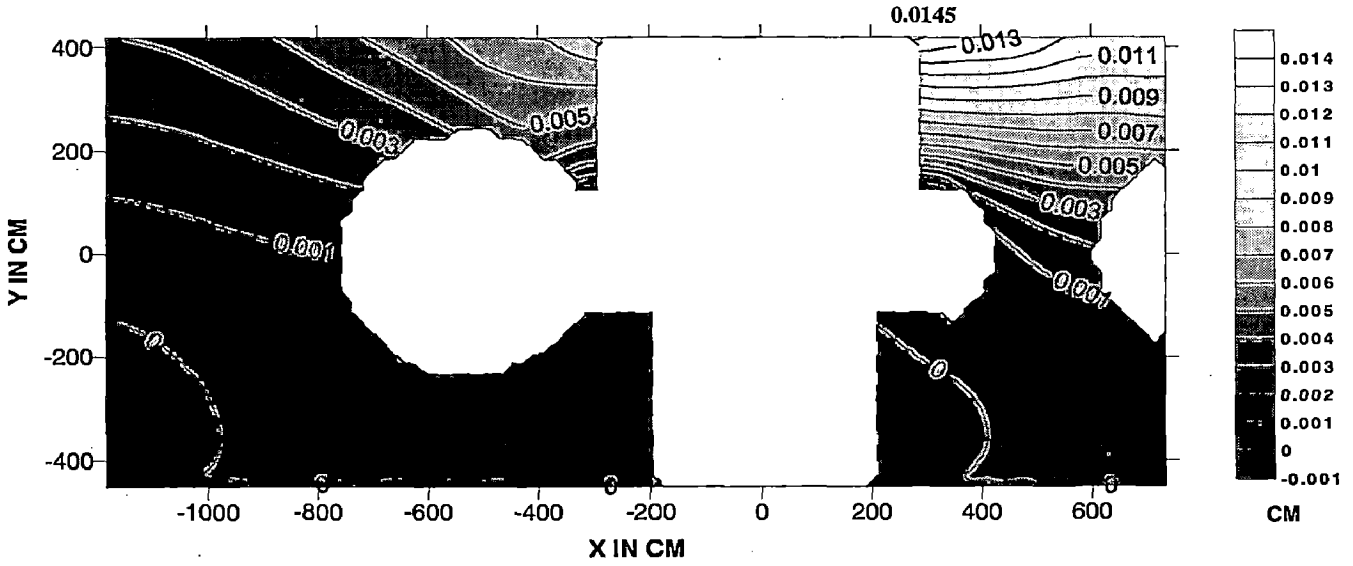


STRESS CONTOUR FOR SY UNDER LOAD 1b(i) AT SECTION 060-240

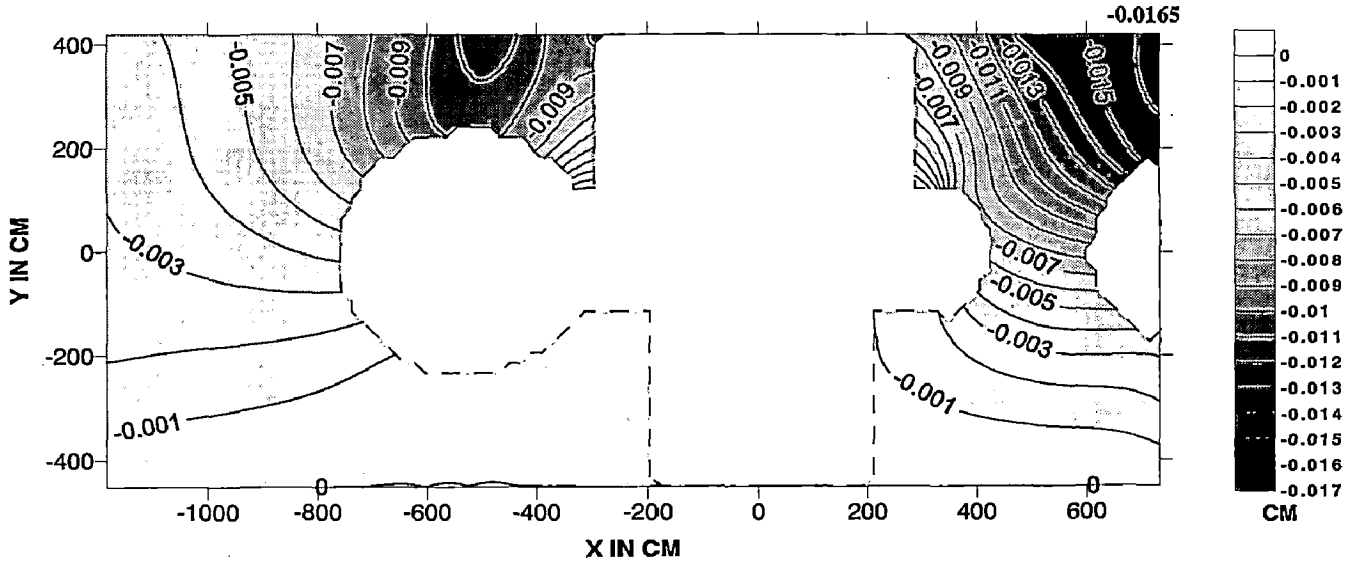


STRESS CONTOUR FOR SZ UNDER LOAD 1b(i) AT SECTION 060-240

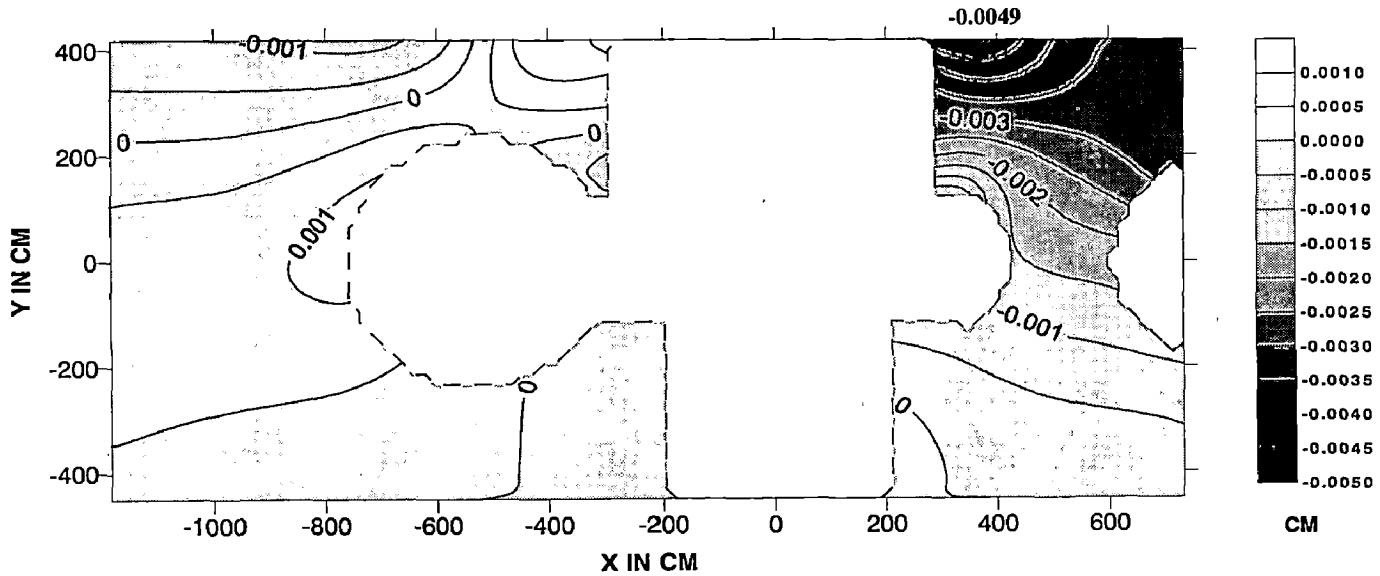
FIG. 5.12 STRESS CONTOURS FOR LOAD 1b(i) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(ii) AT SECTION 060-240

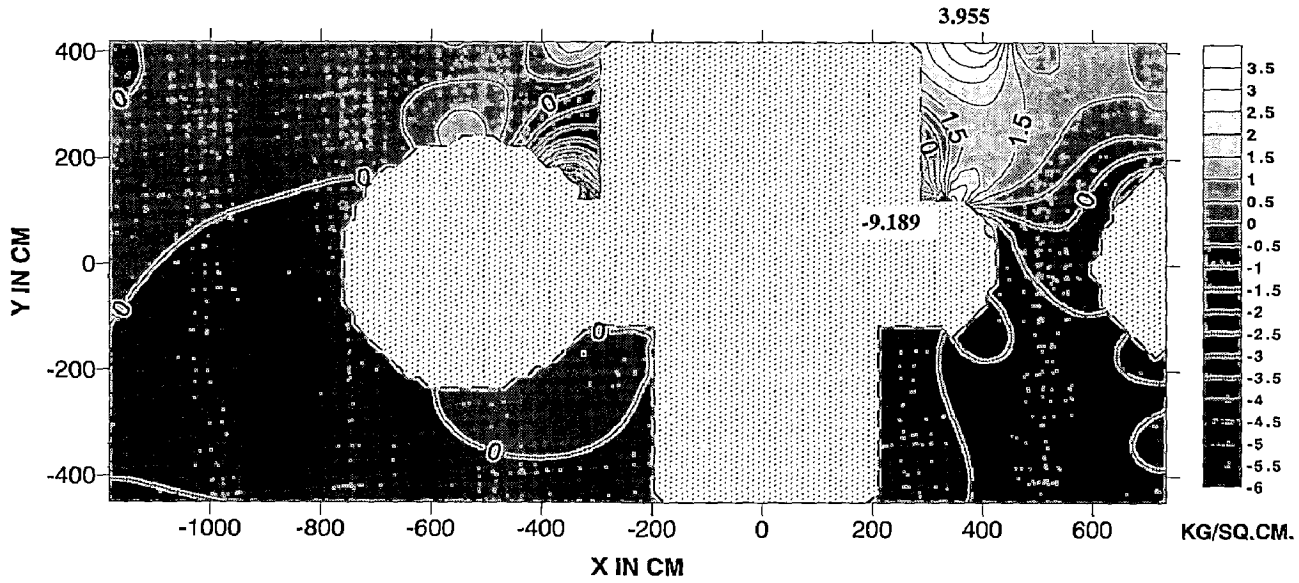


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1b(ii) AT SECTION 060-240

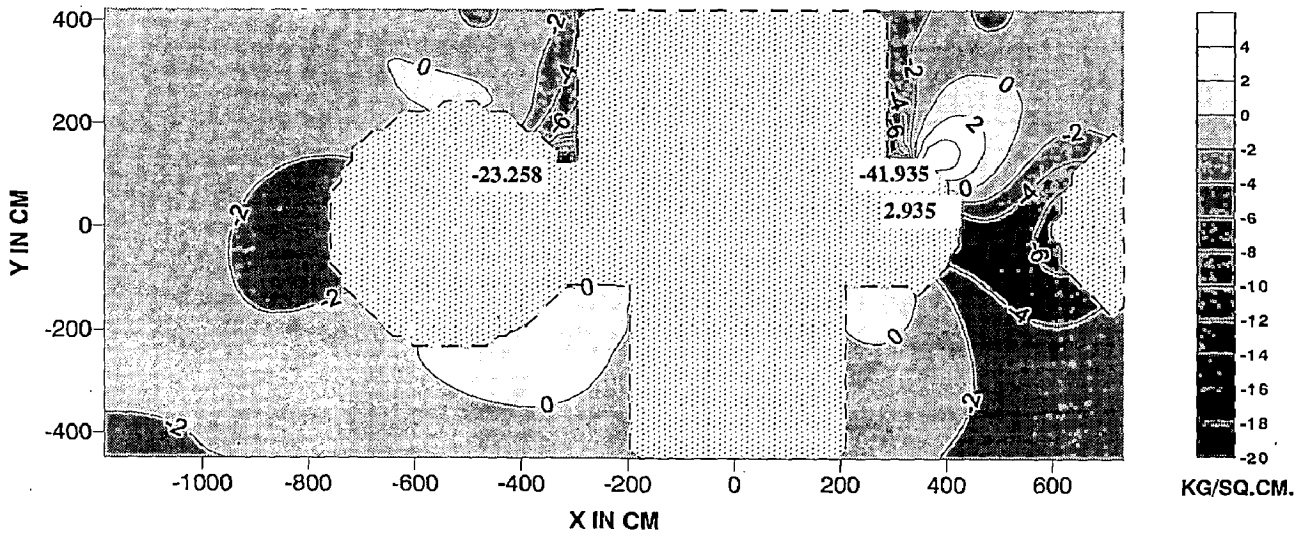


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1b(ii) AT SECTION 060-240

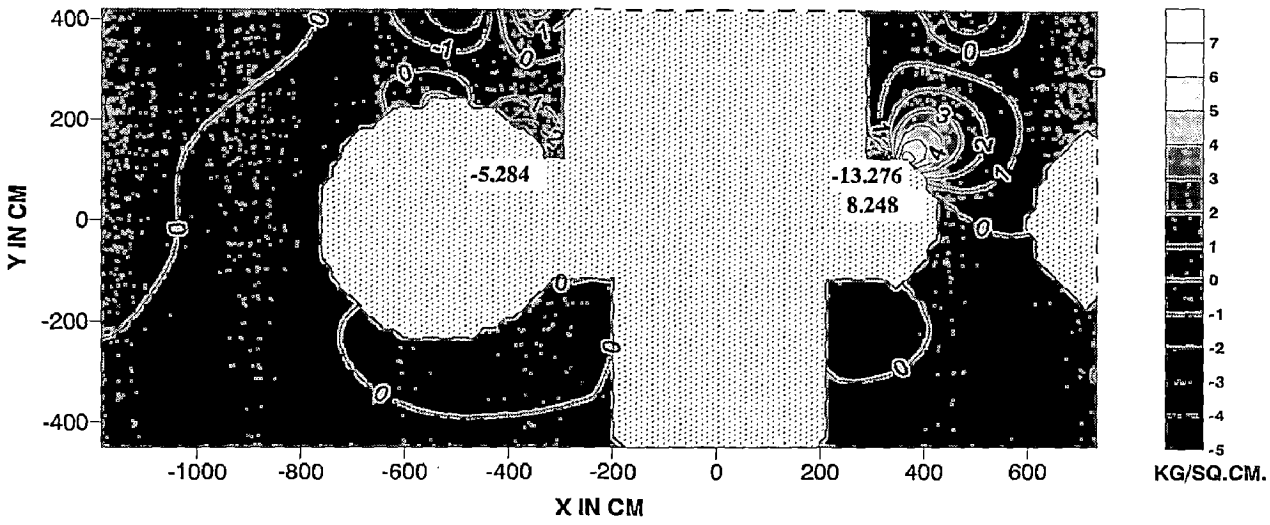
FIG. 5.13 DISPLACEMENT CONTOURS FOR LOAD 1b(ii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1b(ii) AT SECTION 060-240

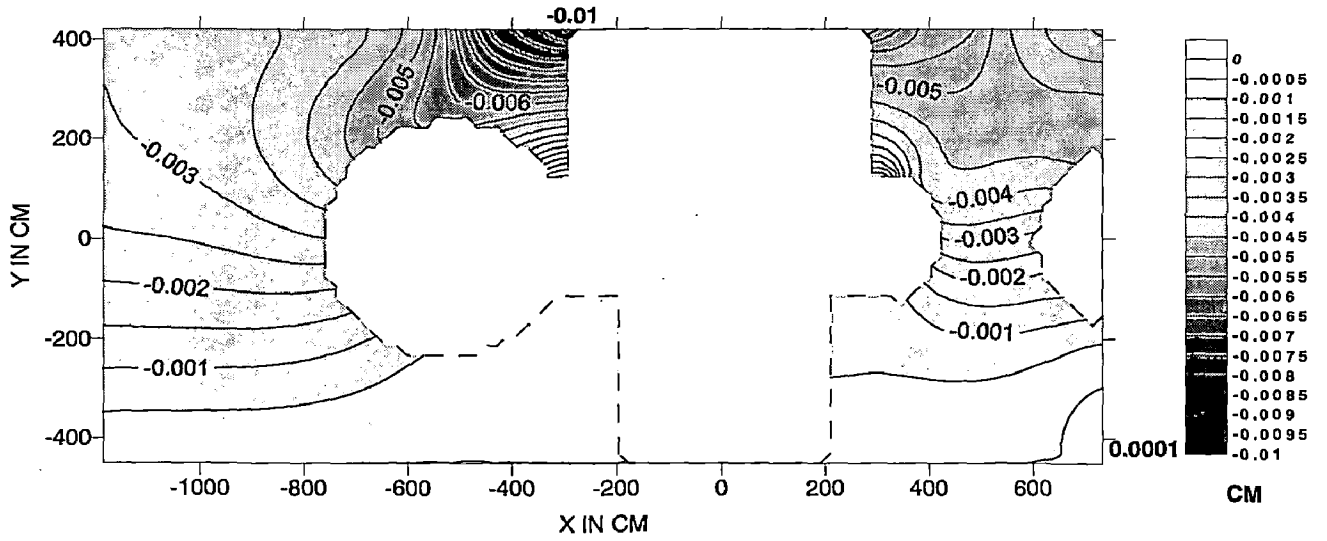


STRESS CONTOUR FOR SY UNDER LOAD 1b(ii) AT SECTION 060-240

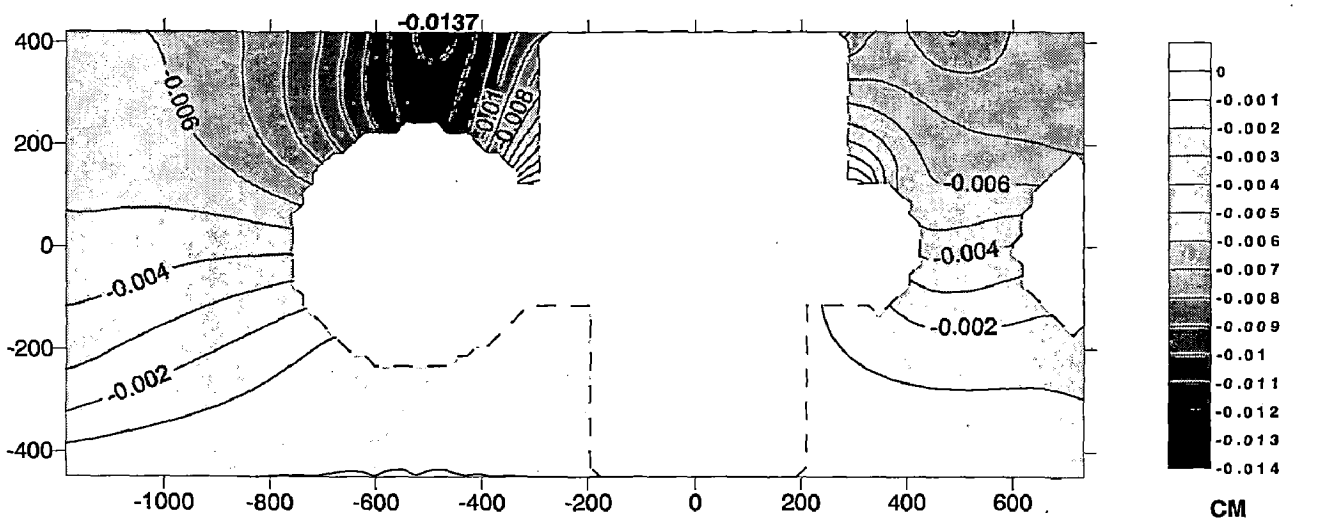


STRESS CONTOUR FOR SZ UNDER LOAD 1b(ii) AT SECTION 060-240

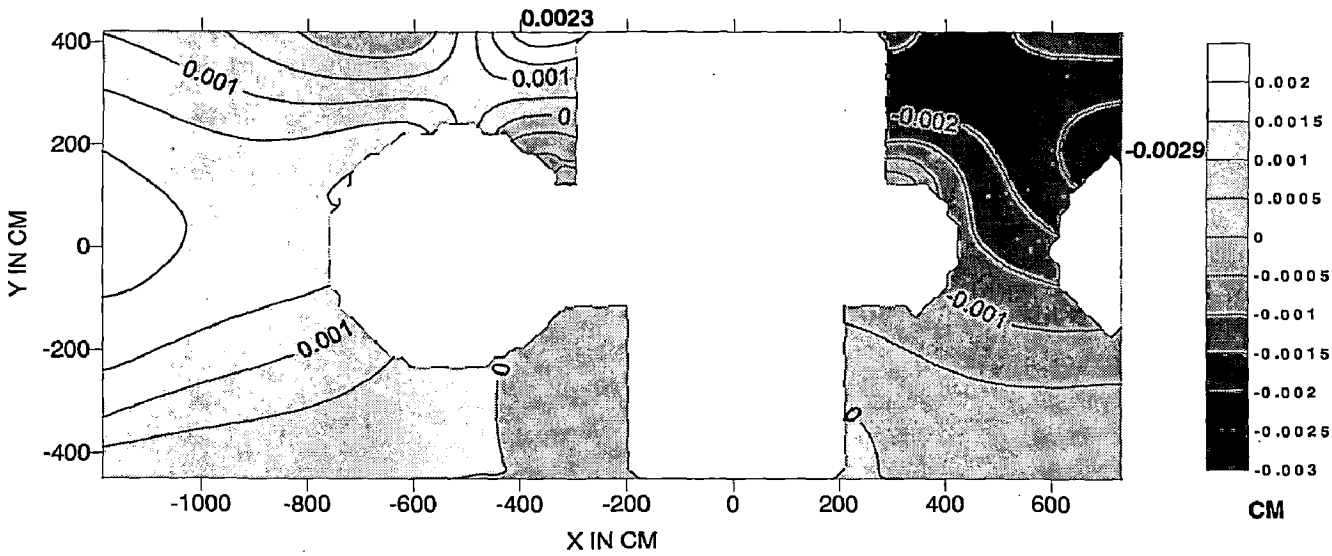
FIG. 5.14 STRESS CONTOURS FOR LOAD 1b(ii) AT SECTION 060 -240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(ii) AT SECTION 040-260

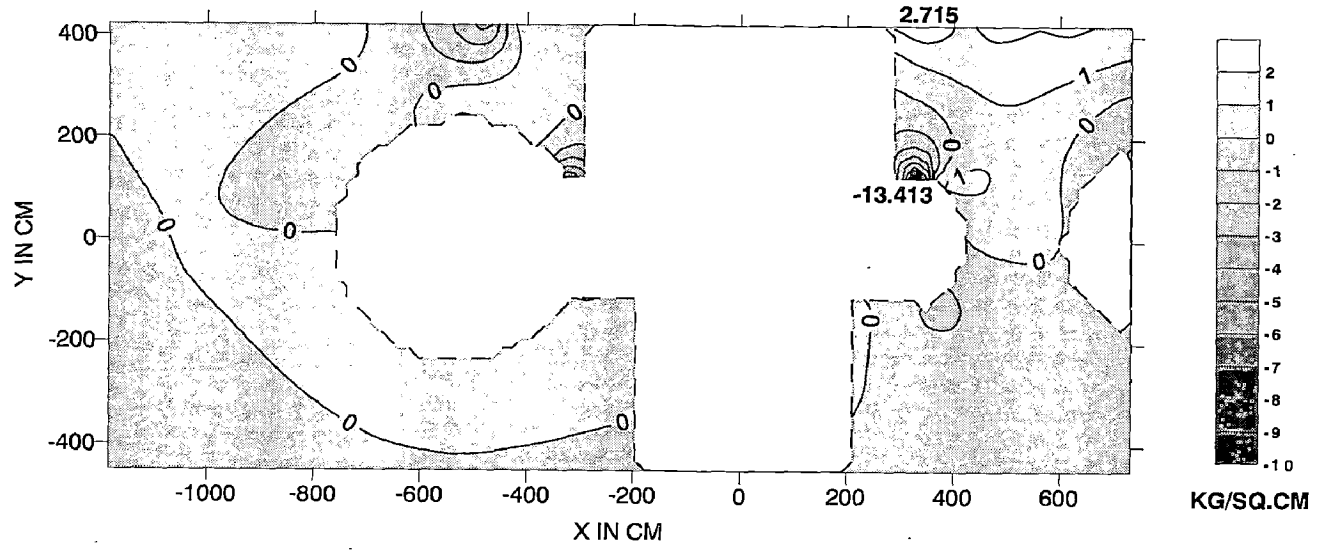


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1b(iii) AT SECTION 040-260

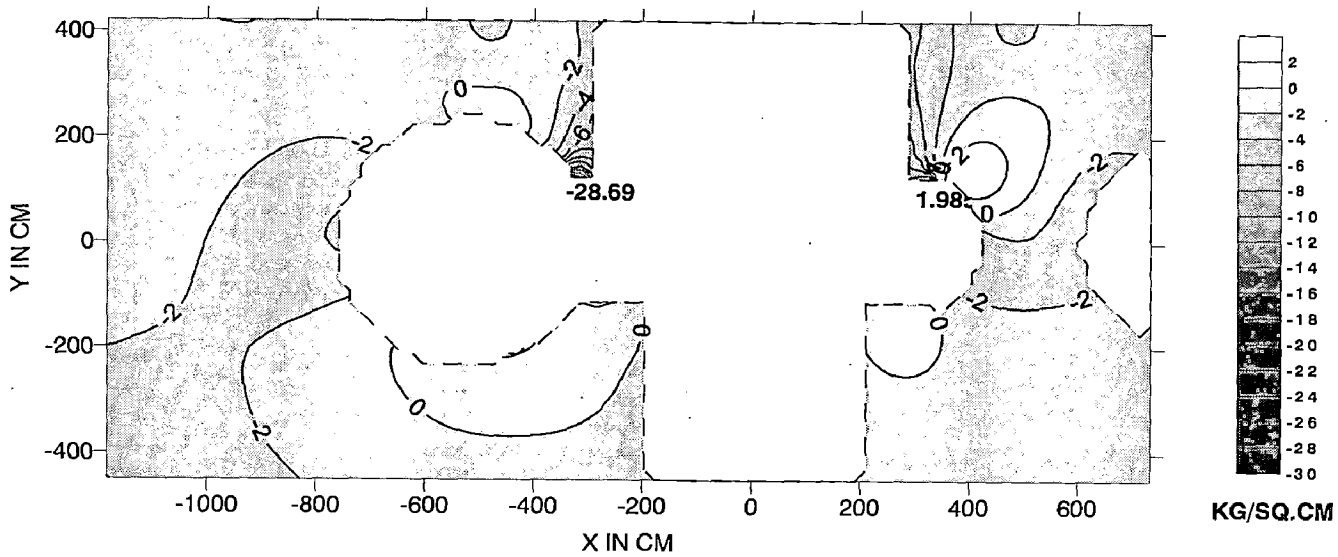


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1b(iii) AT SECTION 040-260

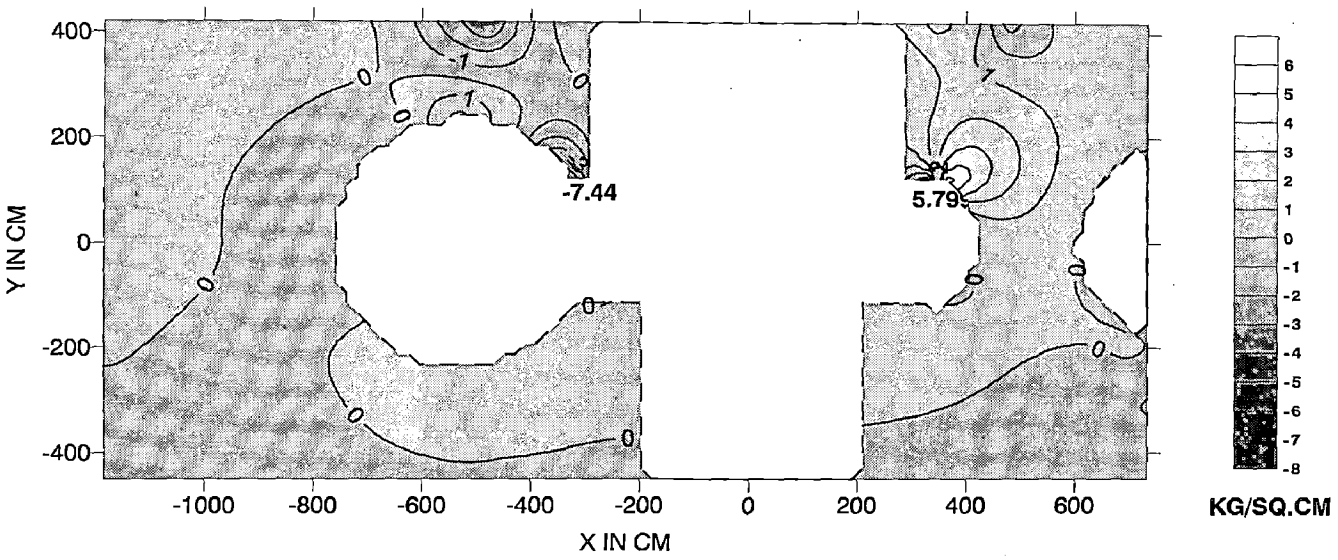
FIG. 5.15 DISPLACEMENT CONTOURS FOR LOAD 1b(iii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1b(ii) AT SECTION 040-260

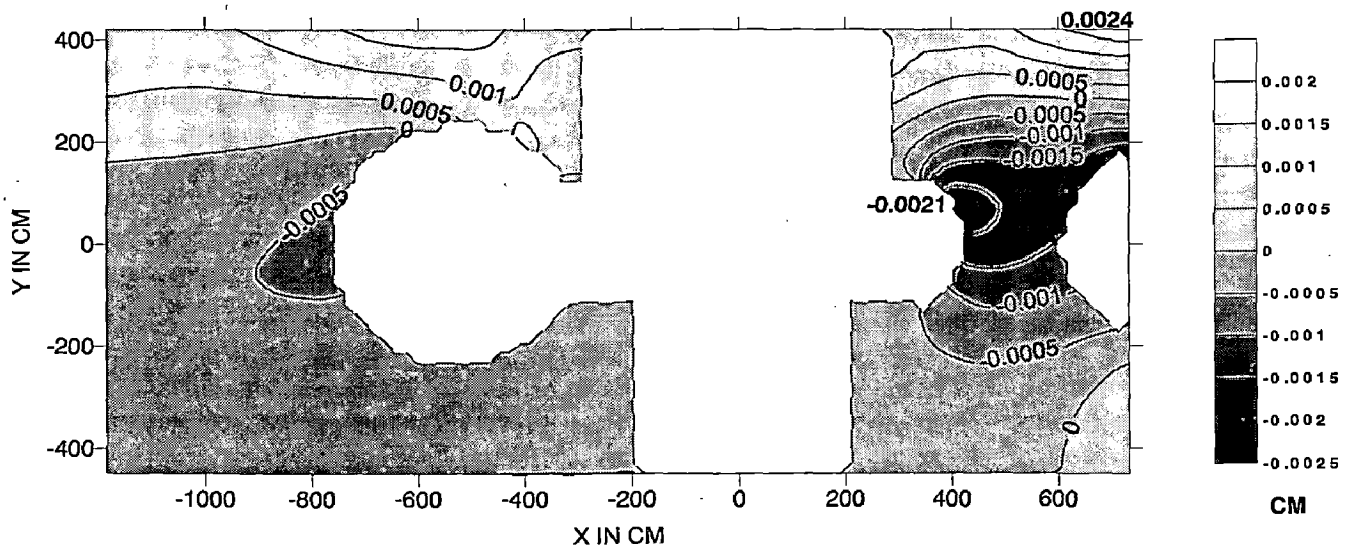


STRESST CONTOUR FOR SY UNDER LOAD 1b(iii) AT SECTION 040-260

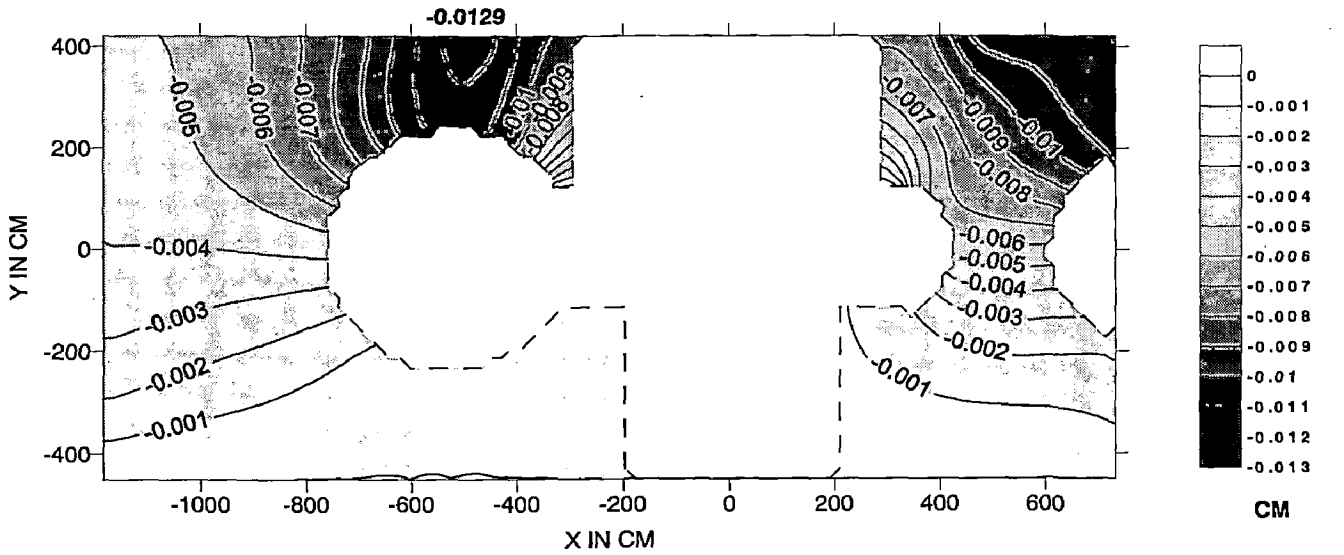


STRESS CONTOUR FOR SZ UNDER LOAD 1b(ii) AT SECTION 040-260

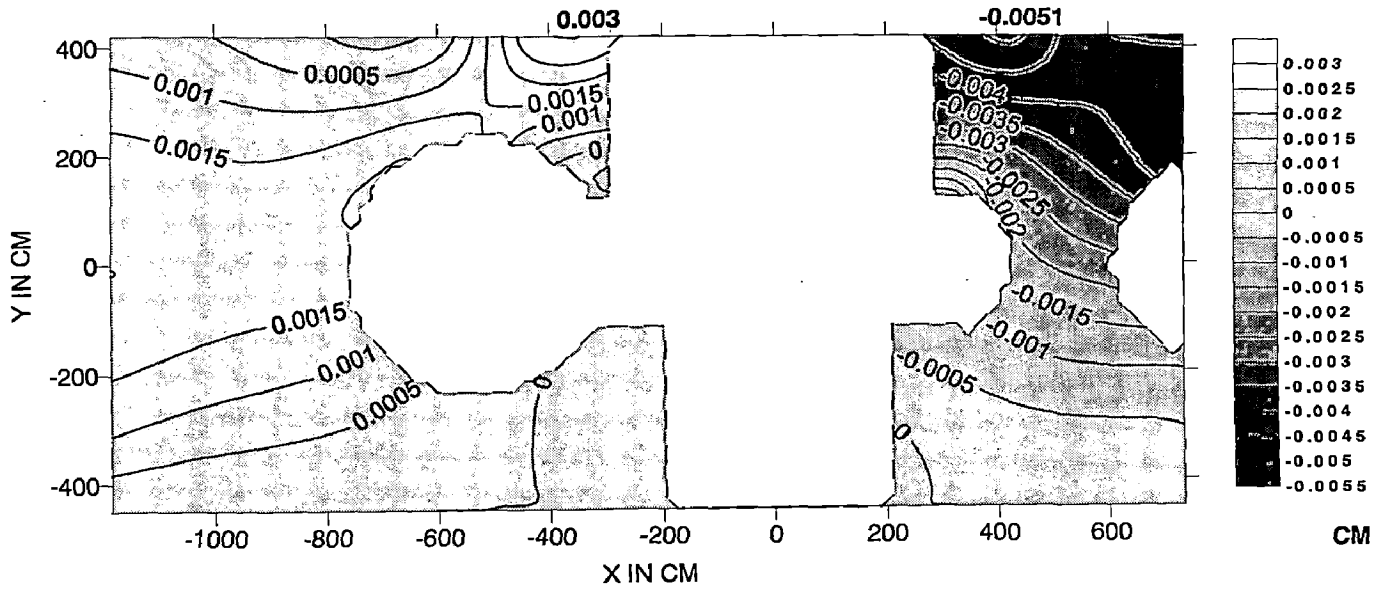
FIG. 5.16 STRESS CONTOURS FOR LOAD 1b(iii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(iv) AT SECTION 060-240

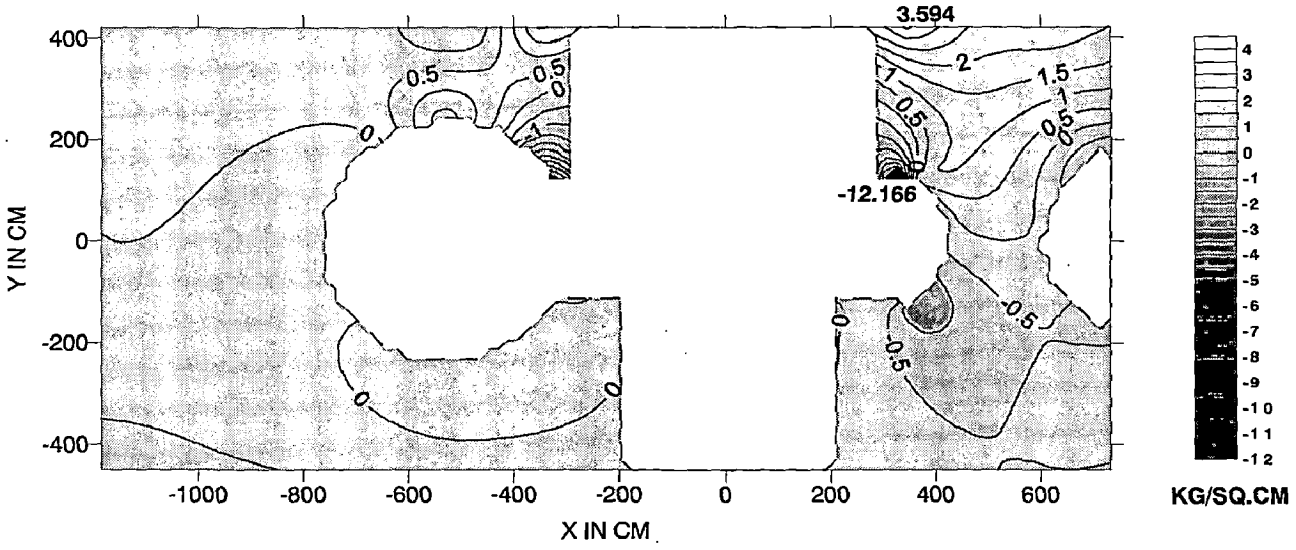


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 1b(iv) AT SECTION 060-240

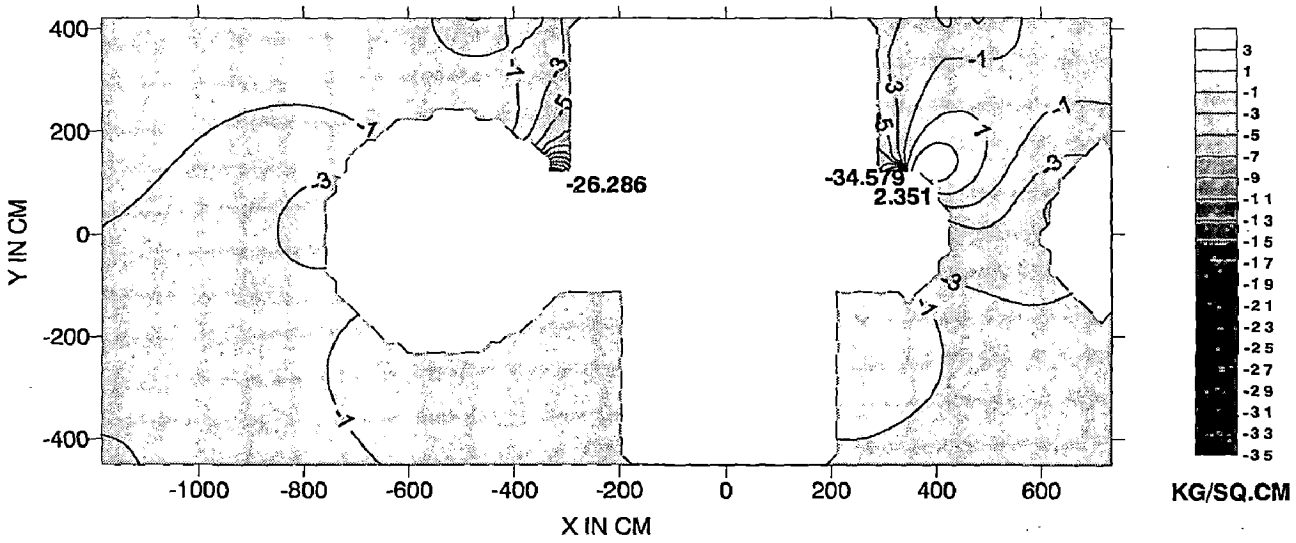


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1b(iv) AT SECTION 060-240

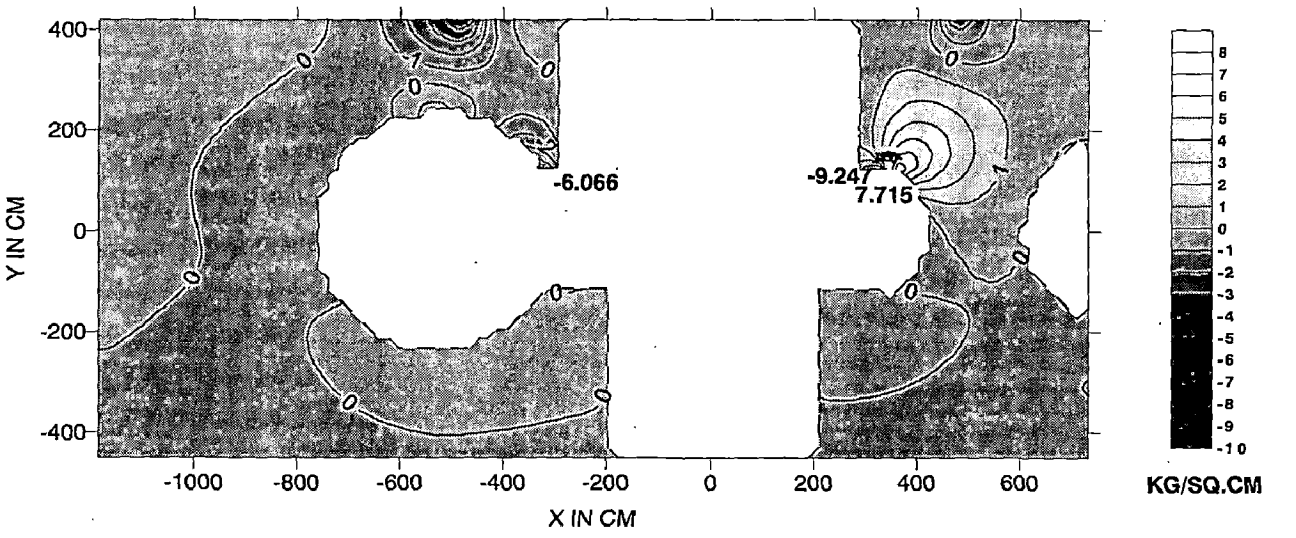
FIG. 5.17 DISPLACEMENT CONTOURS FOR LOAD 1b(iv) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1b(iv) AT SECTION 040-260

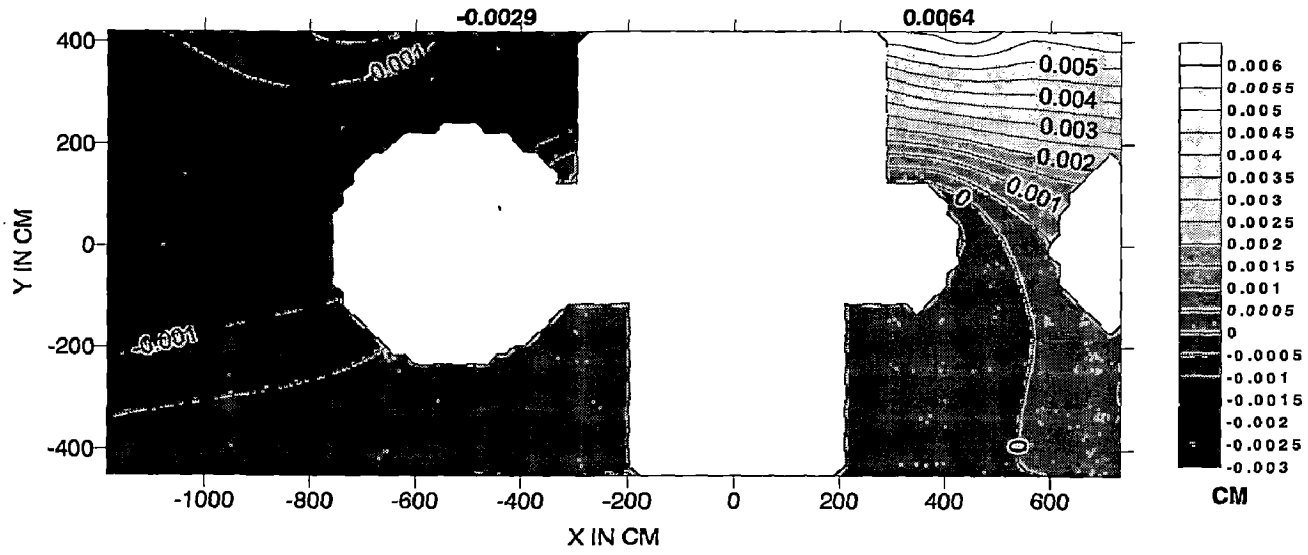


STRESS CONTOUR FOR SY UNDER LOAD 1b(iv) AT SECTION 040-260

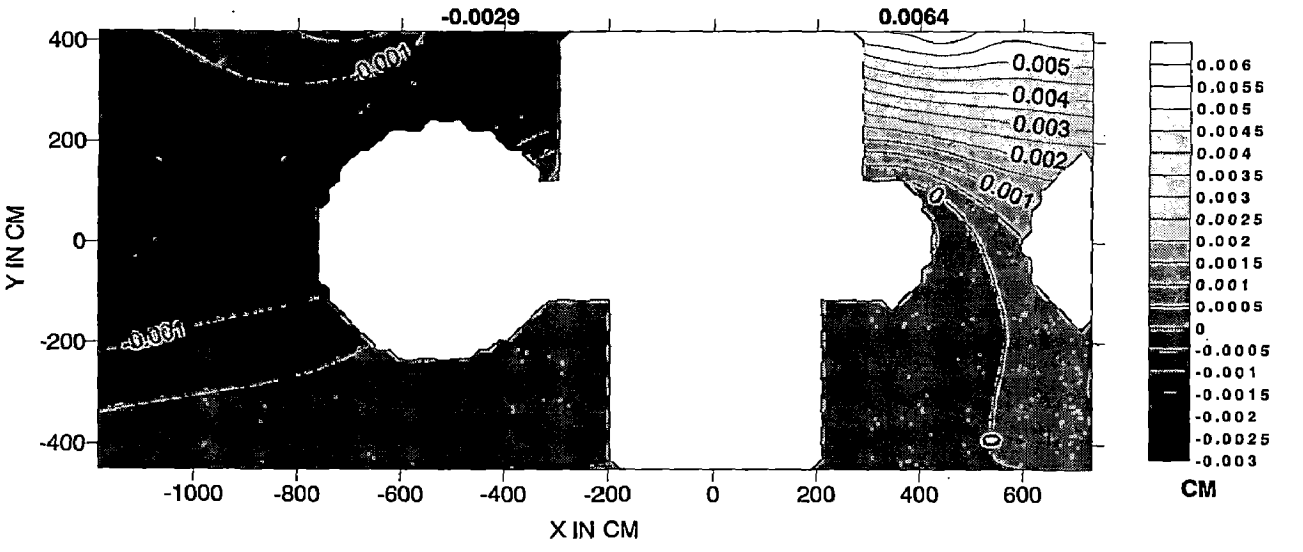


STRESS CONTOUR FOR SZ UNDER LOAD 1b(iv) AT SECTION 040-260

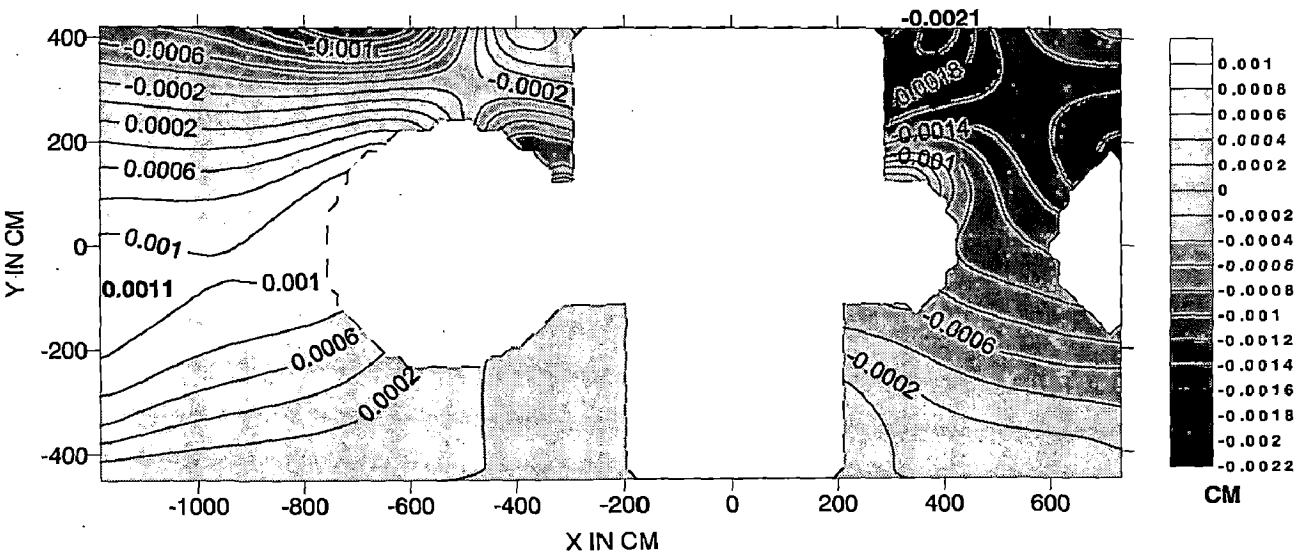
FIG. 5.18 STRESS CONTOURS FOR LOAD 1b(iv) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(v) AT SECTION 060-240

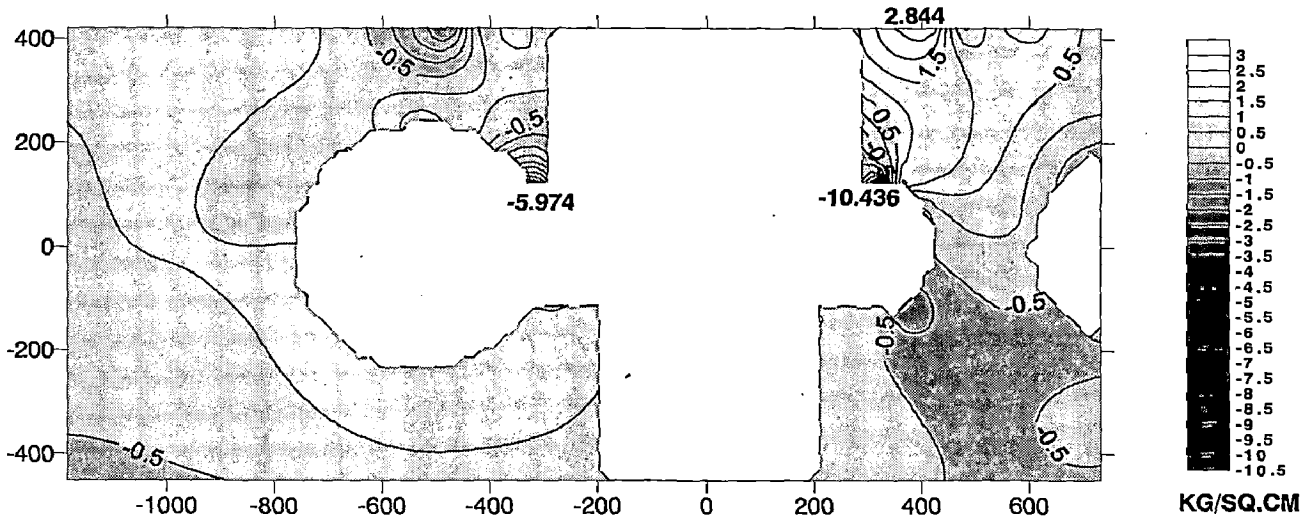


DISPLACEMENT CONTOUR FOR UX UNDER LOAD 1b(v) AT SECTION 060-240

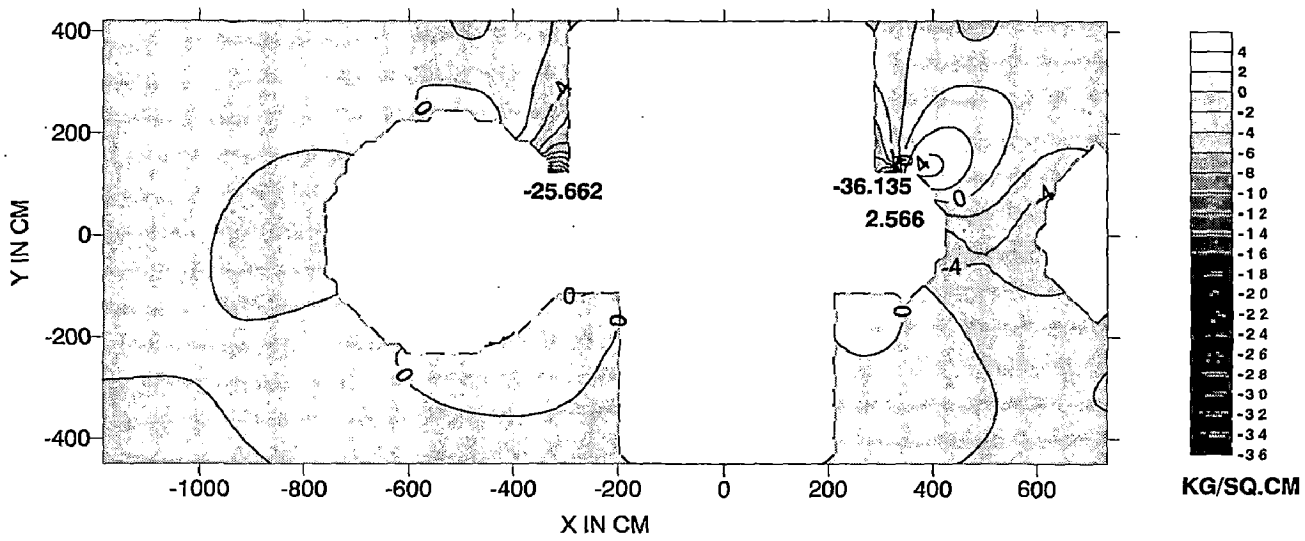


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 1b(v) AT SECTION 060-240

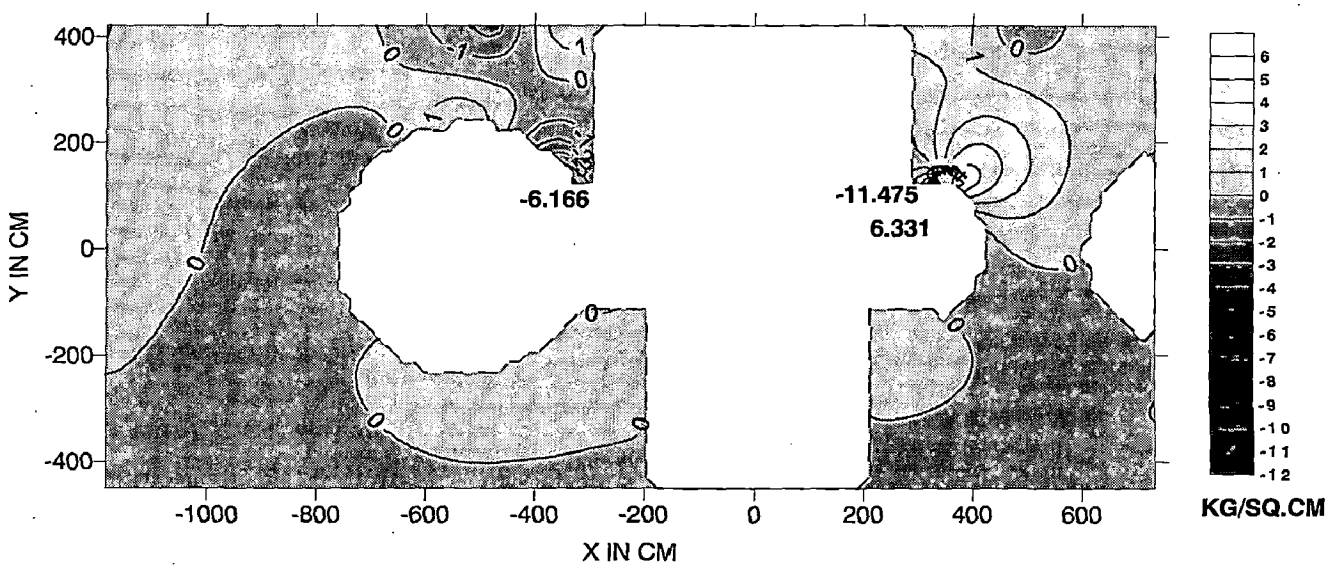
FIG. 5.19 DISPLACEMENT CONTOURS FOR LOAD 1b(v) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 1b(v) AT SECTION 060-240

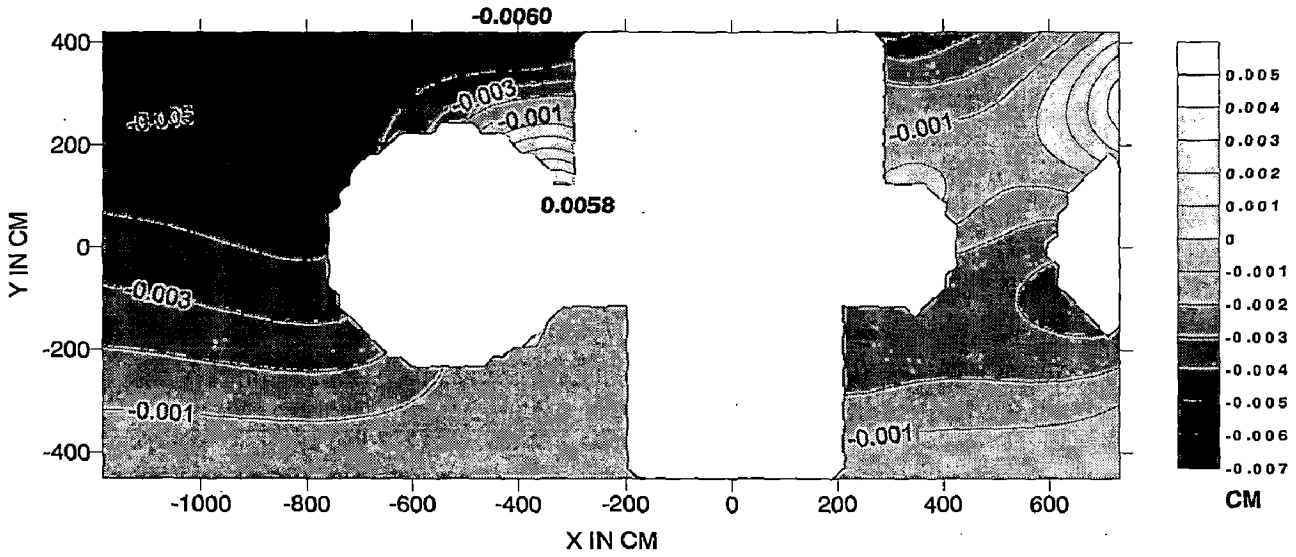


STRESS CONTOUR FOR SY UNDER LOAD 1b(v) AT SECTION 060-240

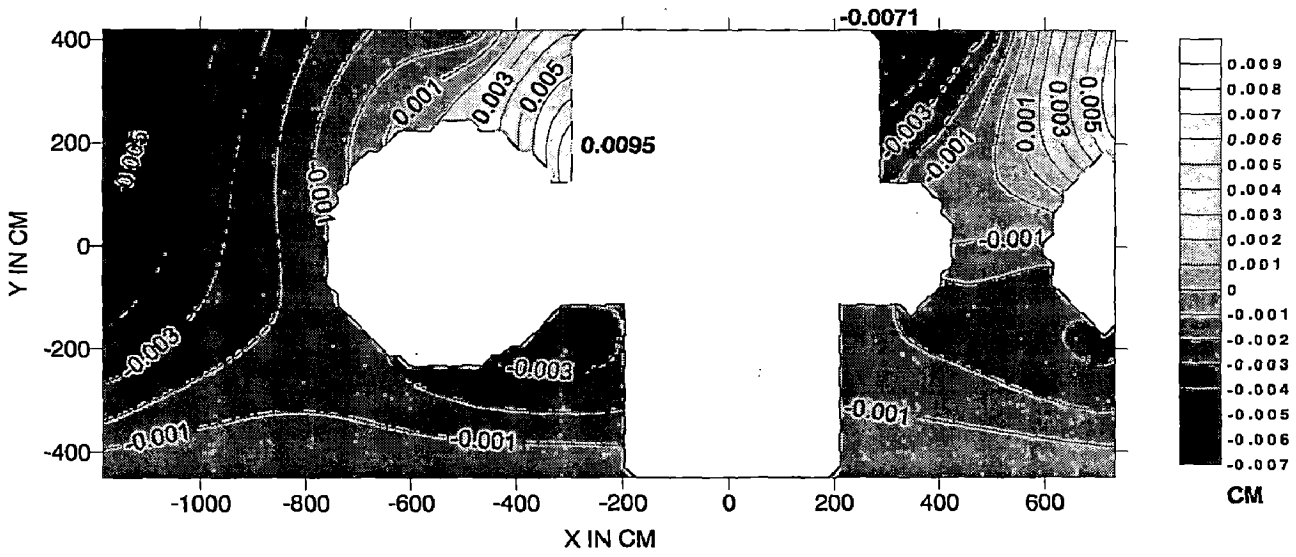


STRESS CONTOUR FOR SZ UNDER LOAD 1b(v) AT SECTION 060-240

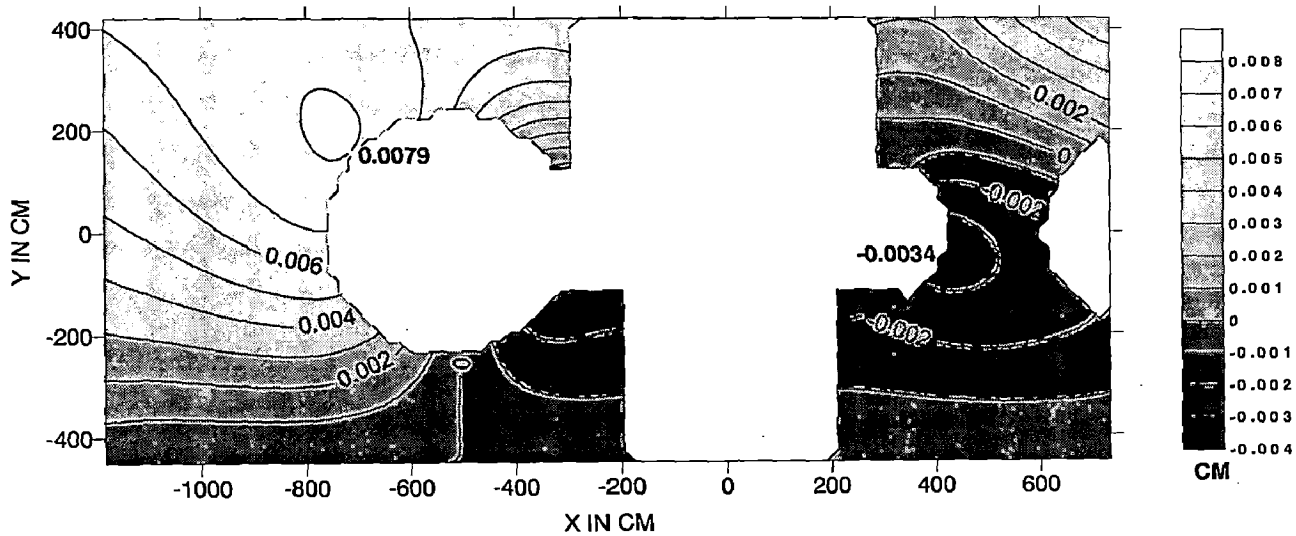
FIG. 5.20 STRESS CONTOURS FOR LOAD 1b(v) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2a(i) AT SECTION 060-240

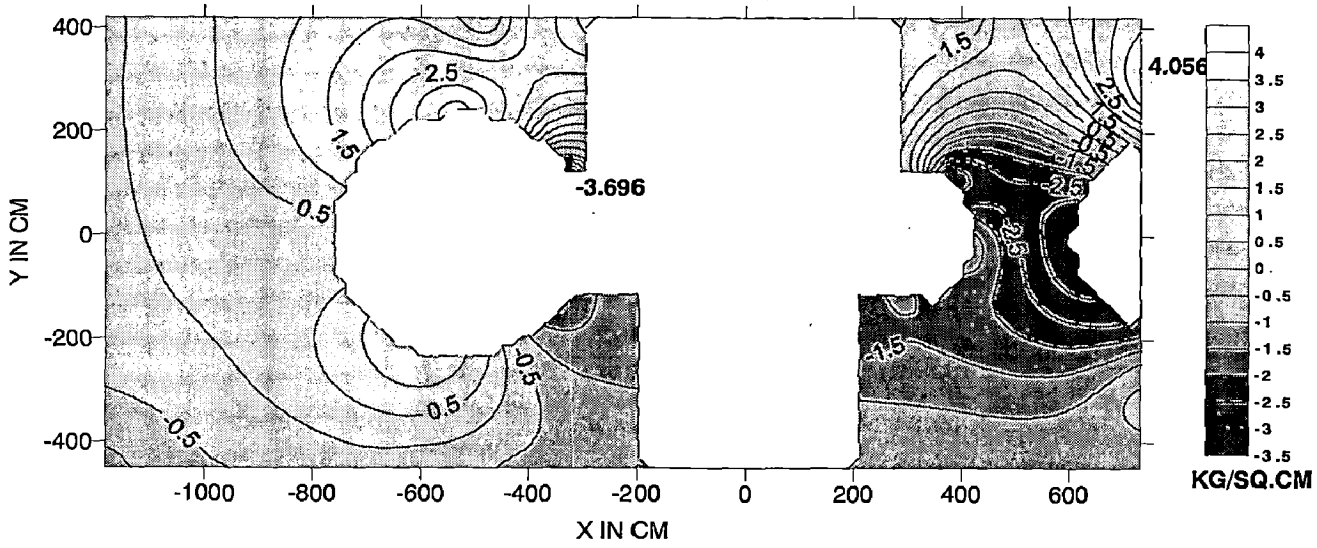


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2a(i) AT SECTION 060-240

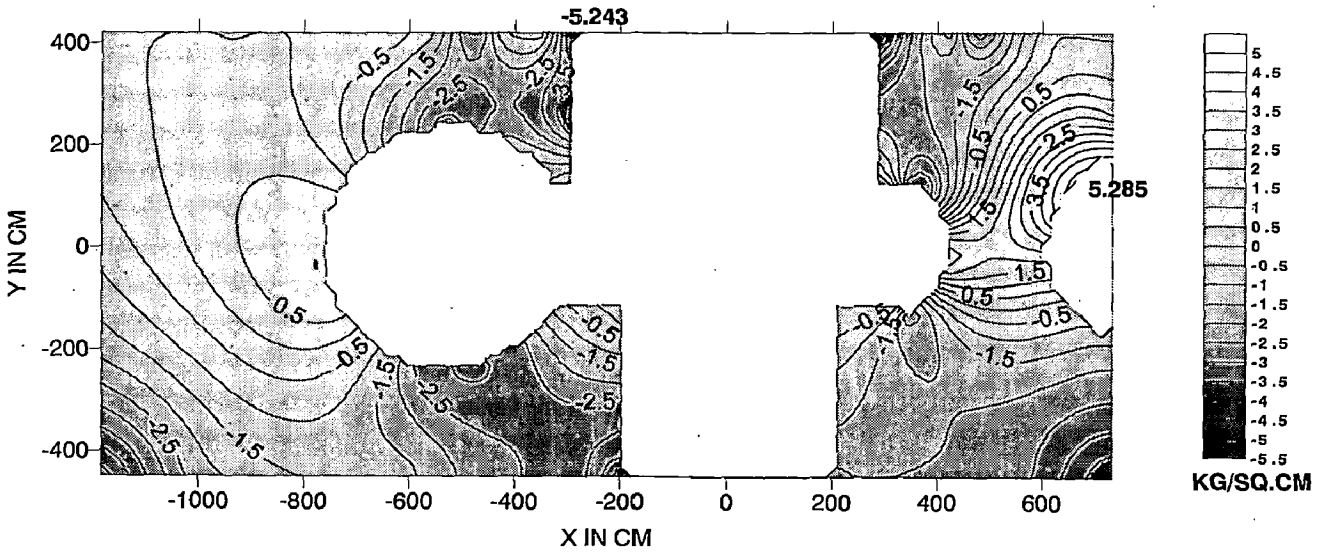


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2a(i) AT SECTION 060-240

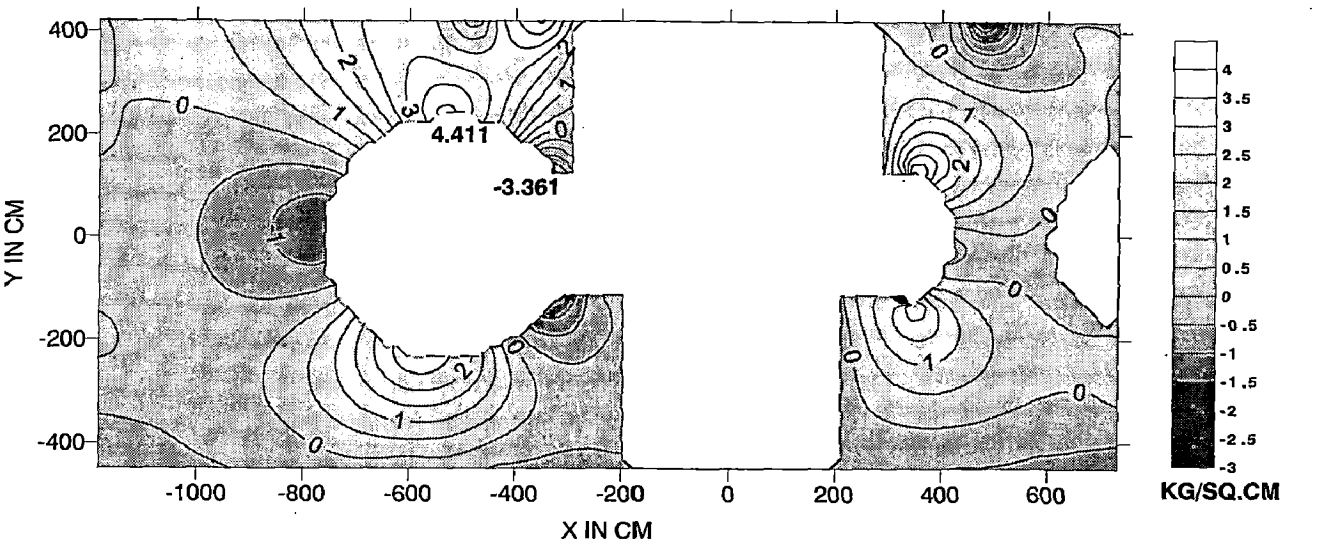
FIG. 5.21 DISPLACEMENT CONTOURS FOR LOAD 2a(i) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2a(i) AT SECTION 060-240

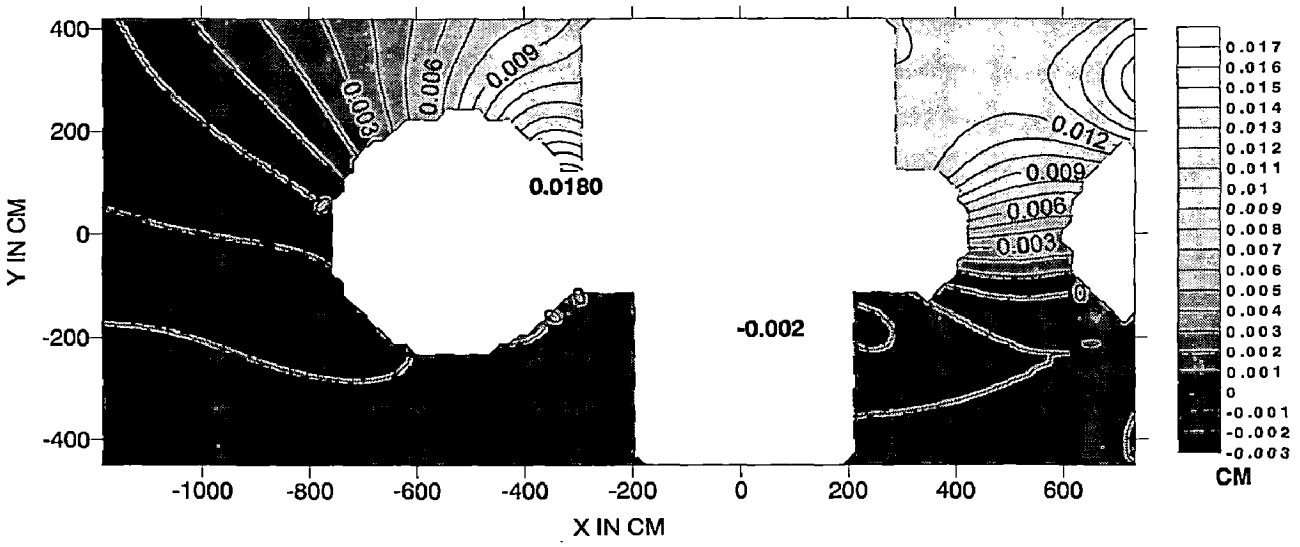


STRESS CONTOUR FOR SY UNDER LOAD 2a(i) AT SECTION 060-240

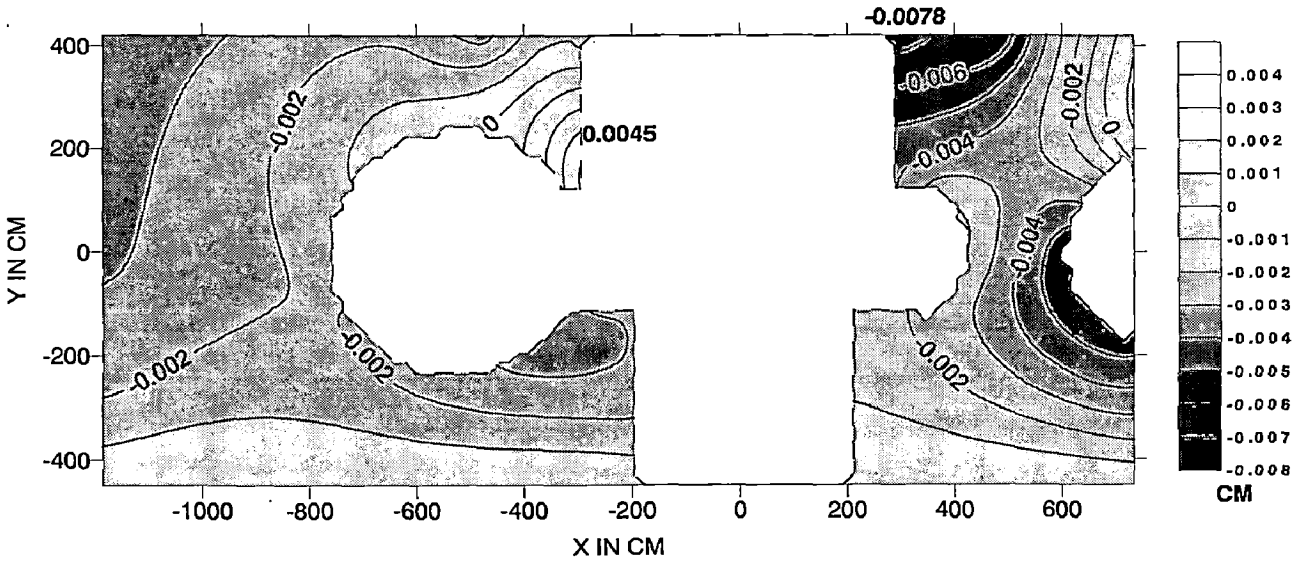


STRESS CONTOUR FOR SZ UNDER LOAD 2a(i) AT SECTION 060-240

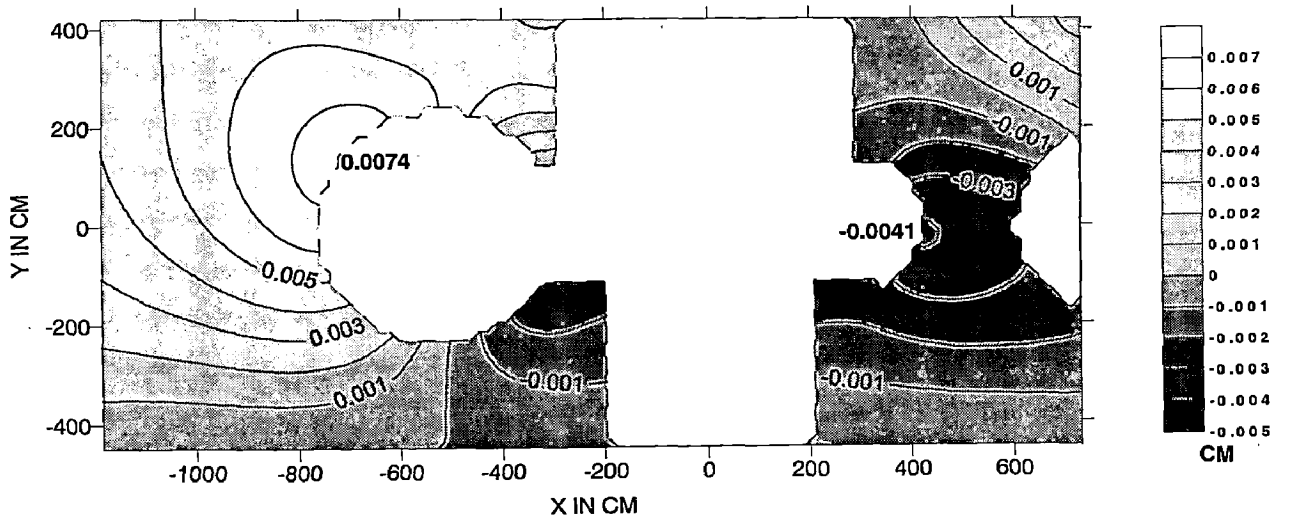
FIG. 5.22 STRESS CONTOURS FOR LOAD 2a(i) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2a(ii) AT SECTION 060-240

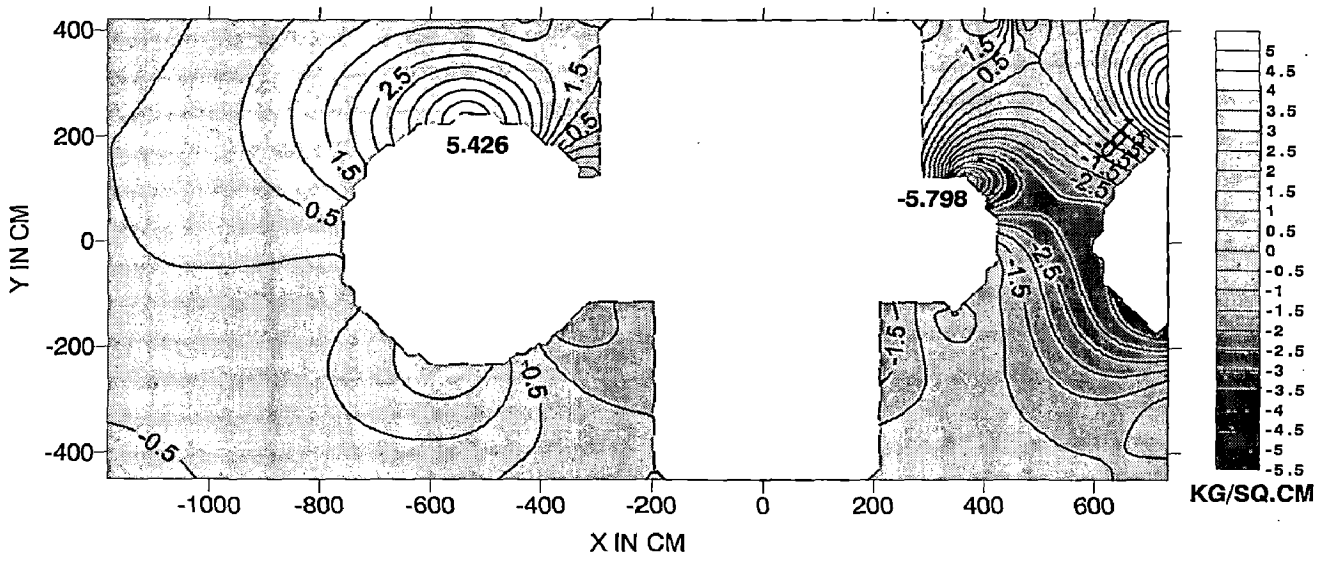


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2a(ii) AT SECTION 060-240

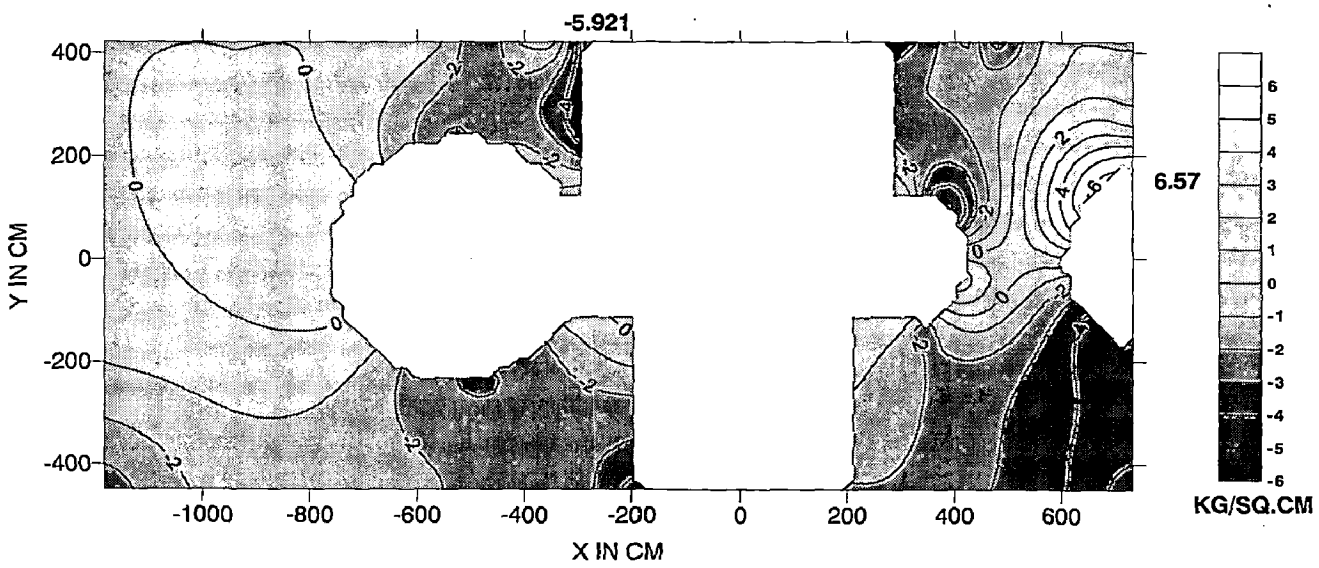


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2a(ii) AT SECTION 060-240

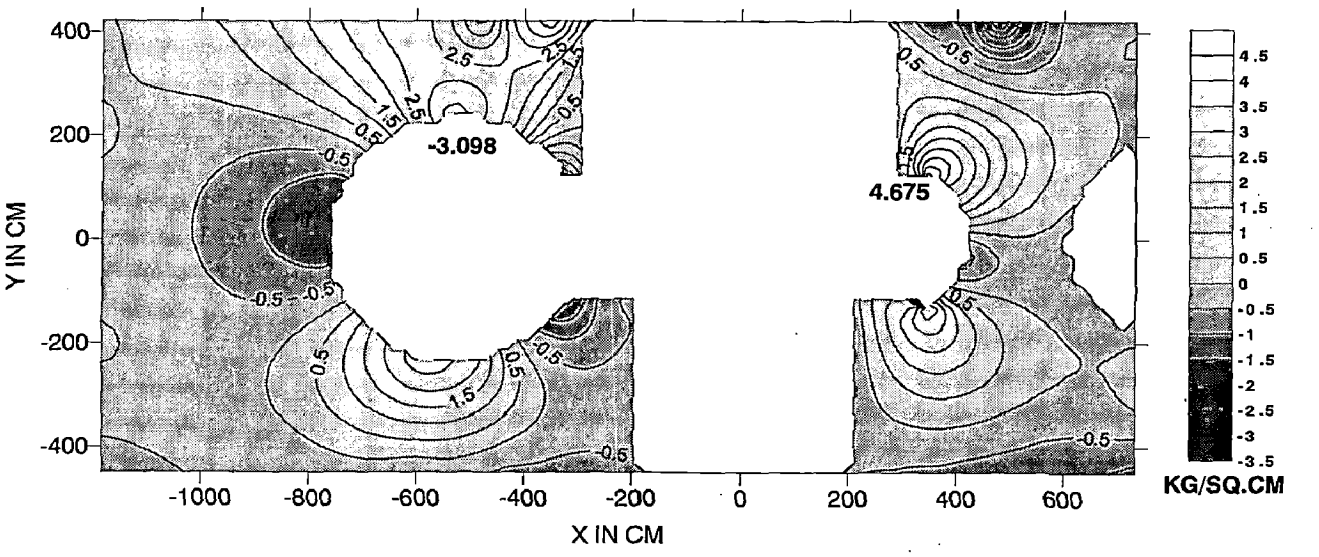
FIG. 5.23 DISPLACEMENT CONTOURS FOR LOAD 2a(ii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2a(ii) AT SECTION 060-240

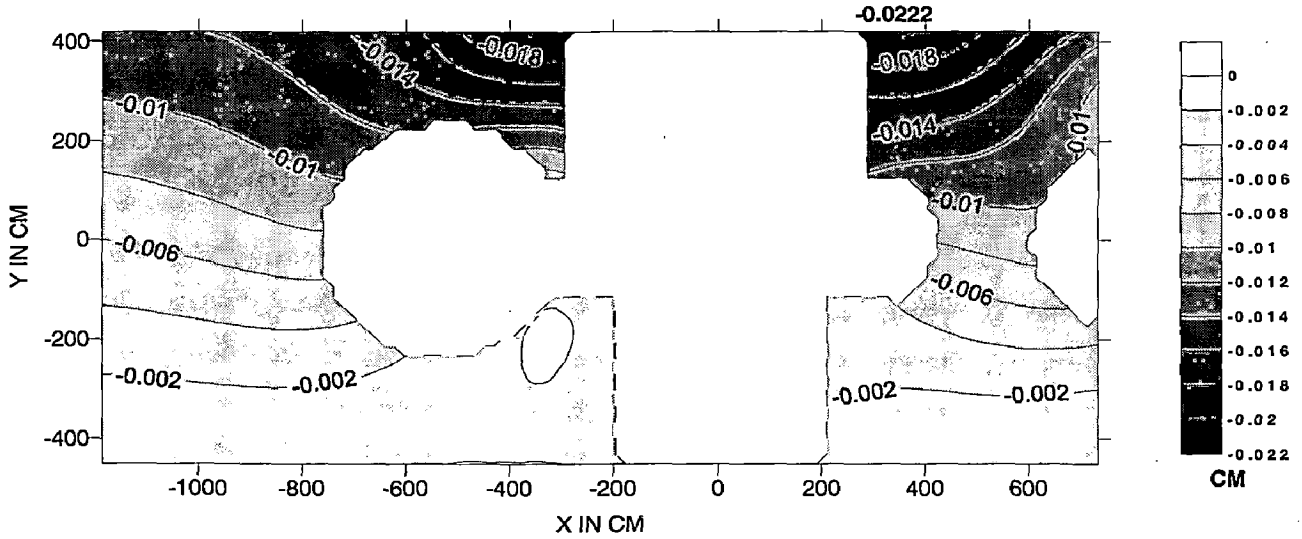


STRESS CONTOUR FOR SY UNDER LOAD 2a(ii) AT SECTION 060-240

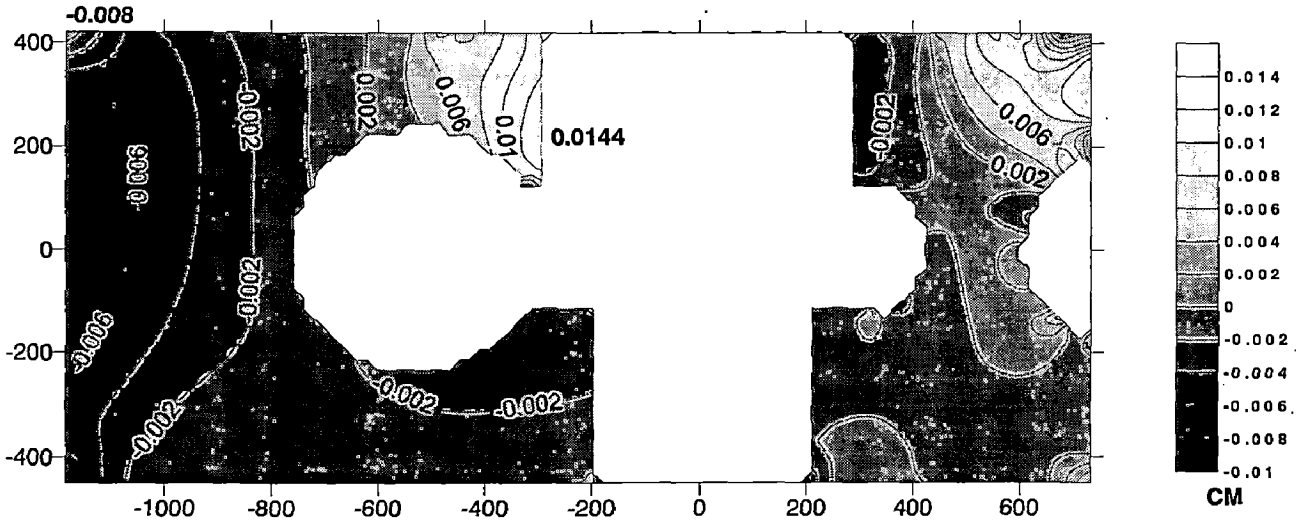


STRESS CONTOUR FOR SZ UNDER LOAD 2a(ii) AT SECTION 060-240

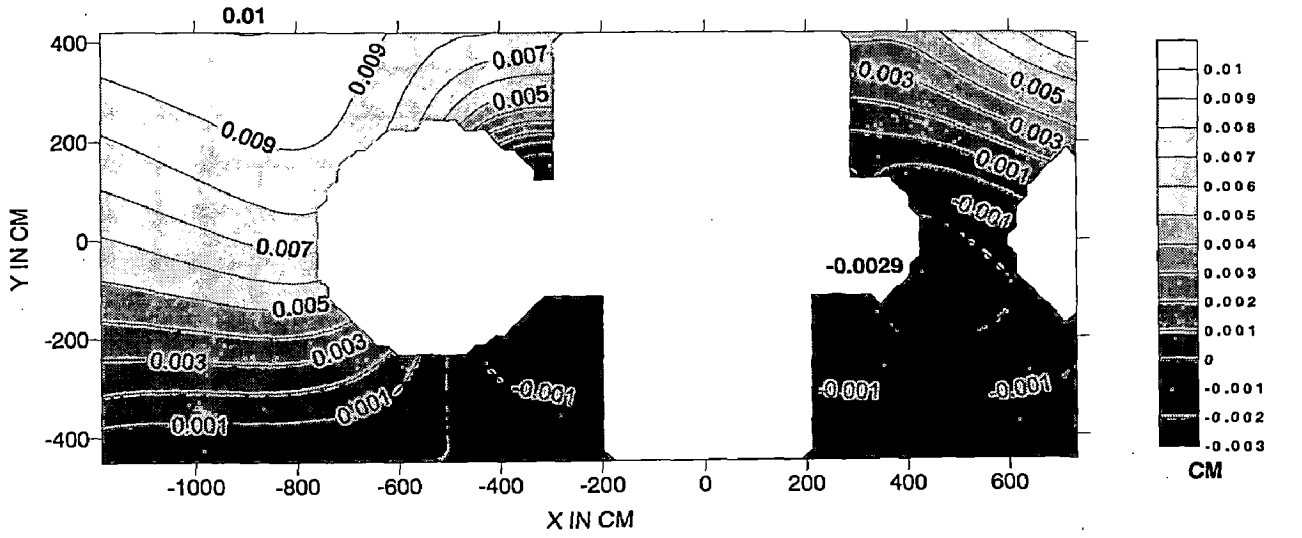
FIG. 5.24 STRESS CONTOURS FOR LOAD 2a(ii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2a(iii) AT SECTION 060-240

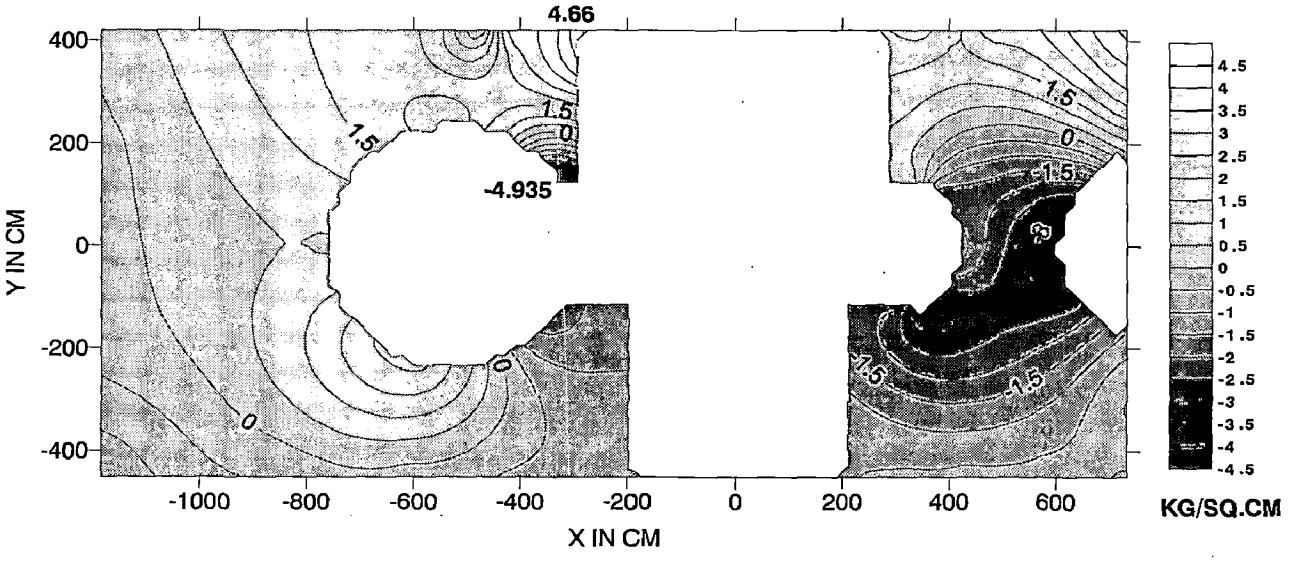


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2a(iii) AT SECTION 060-240

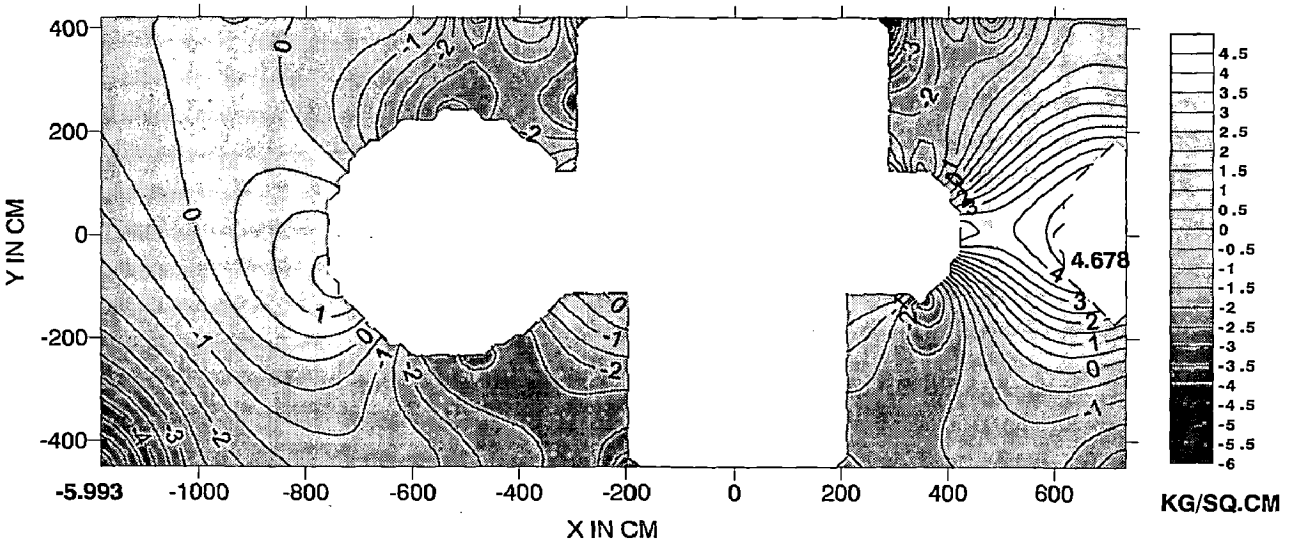


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2a(iii) AT SECTION 060-240

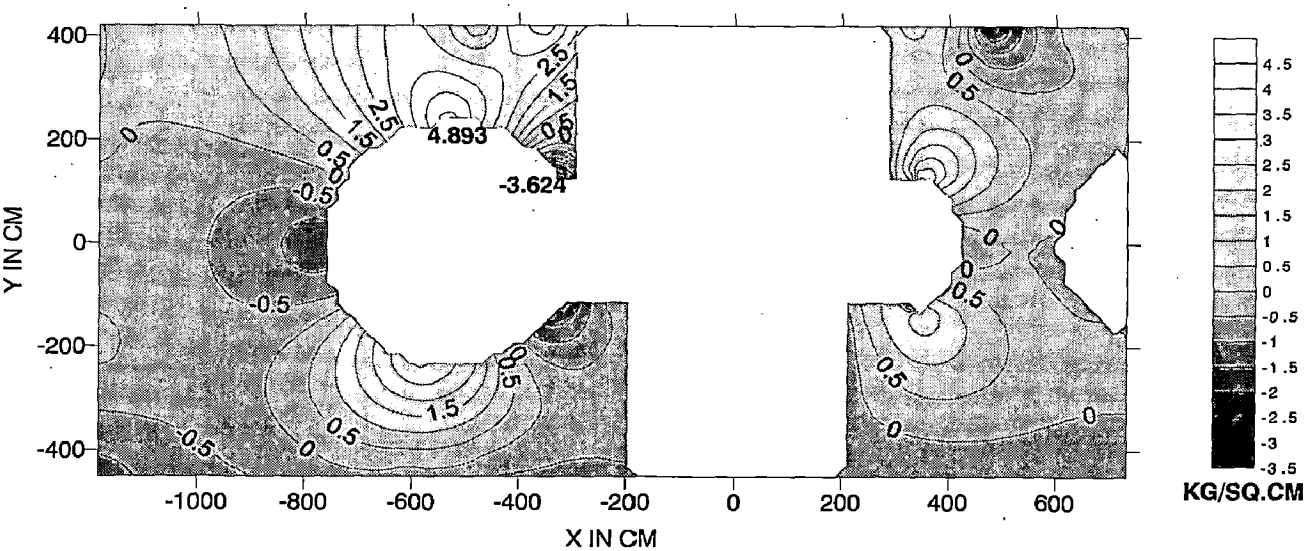
FIG. 5.25 DISPLACEMENT CONTOURS FOR LOAD 2a(iii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2a(iii) AT SECTION 060-240

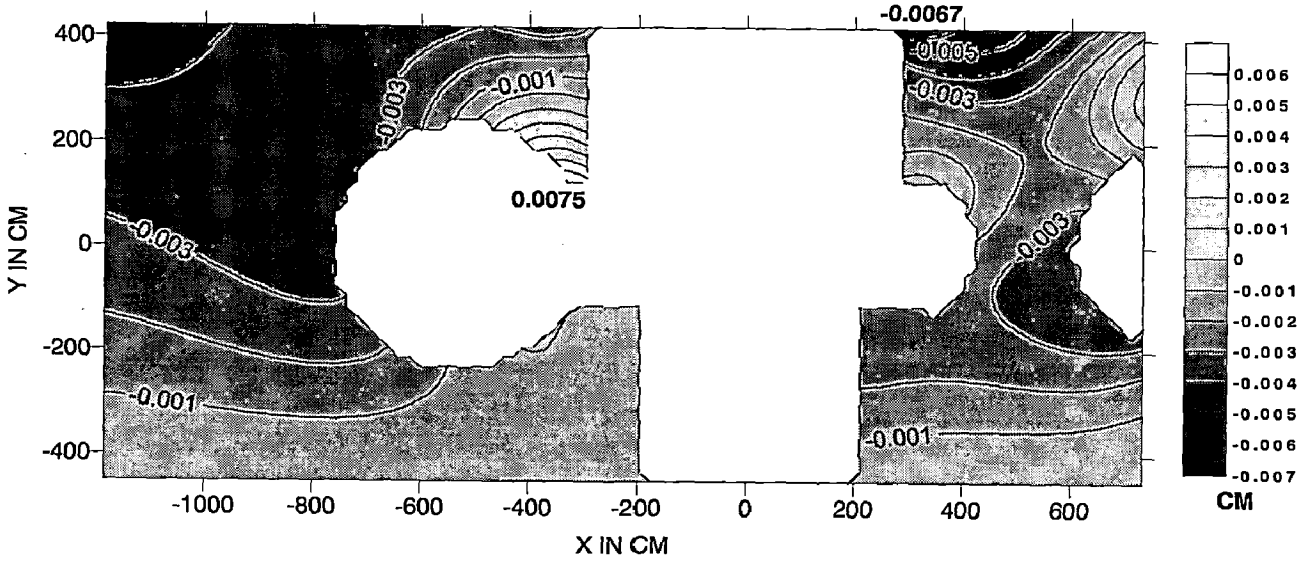


STRESS CONTOUR FOR SY UNDER LOAD 2a(iii) AT SECTION 060-240

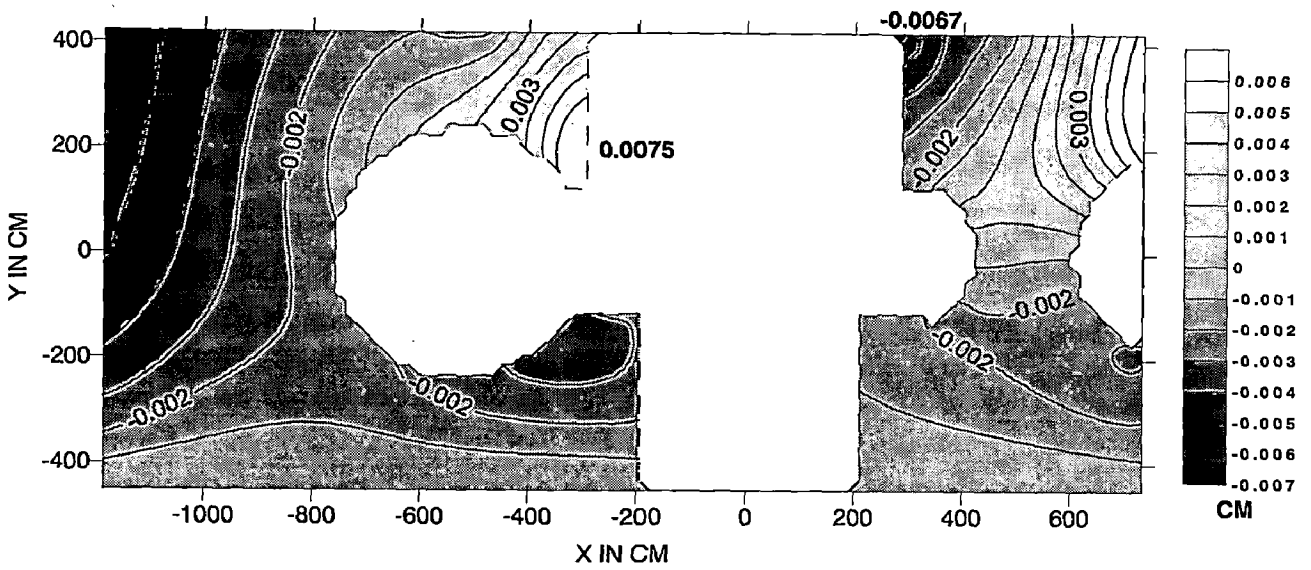


STRESS CONTOUR FOR SZ UNDER LOAD 2a(iii) AT SECTION 060-240

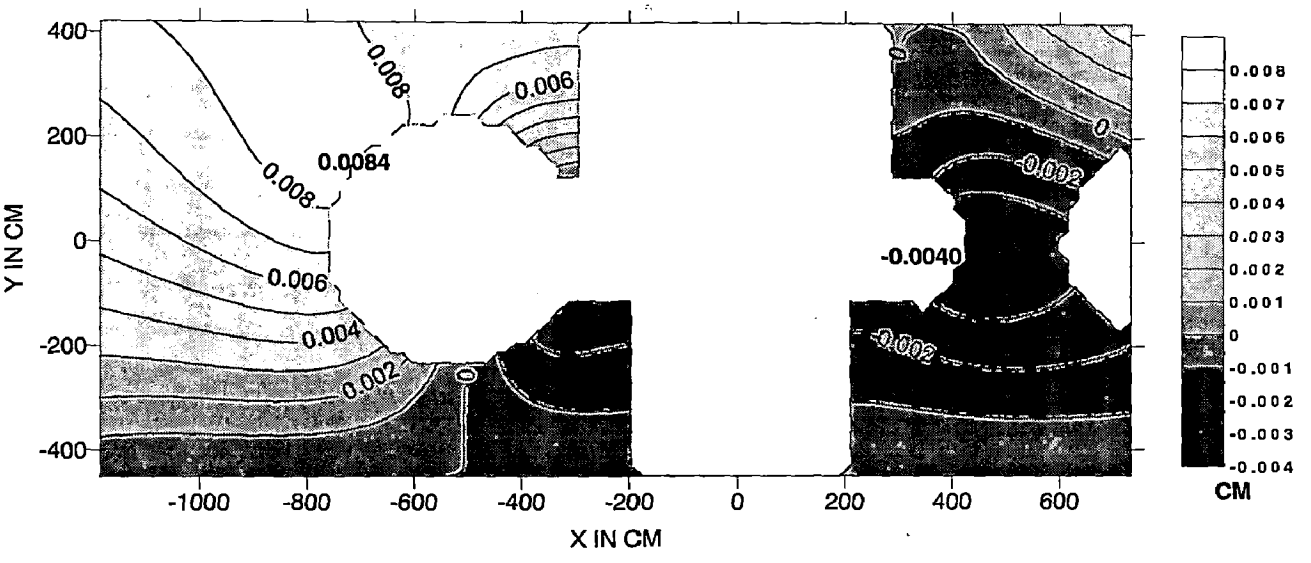
FIG. 5.26 STRESS CONTOURS FOR LOAD 2a(iii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOADING 2a(iv) AT SECTION 060-240

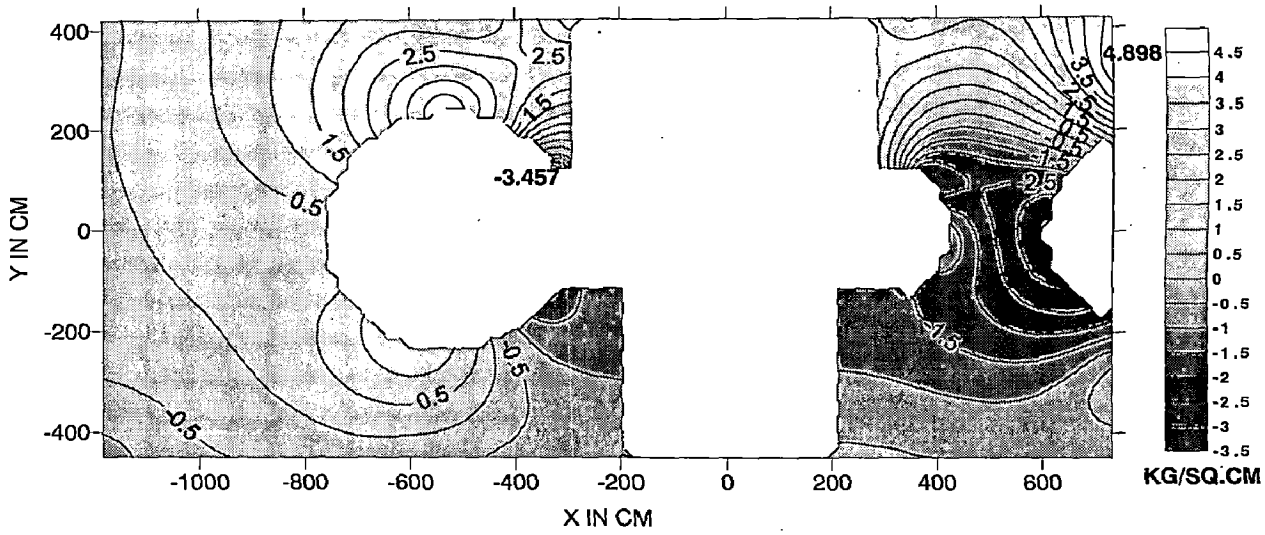


DISPLACEMENT CONTOUR FOR UY UNDER LOADING 2a(iv) AT SECTION 060-240

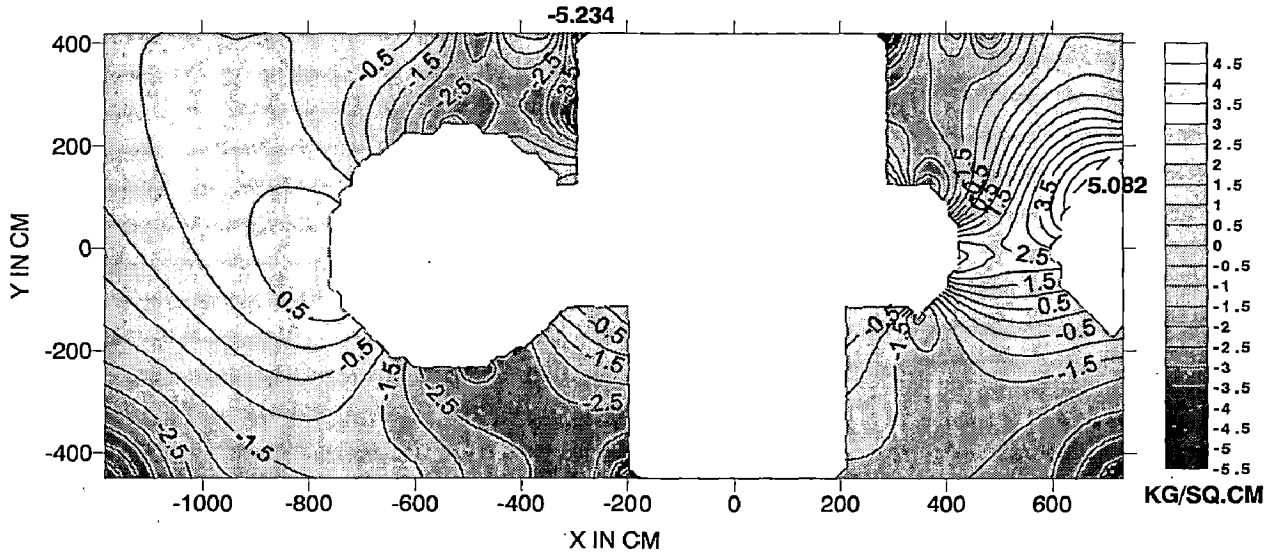


DISPLACEMENT CONTOUR FOR UZ UNDER LOADING 2a(iv) AT SECTION 060-240

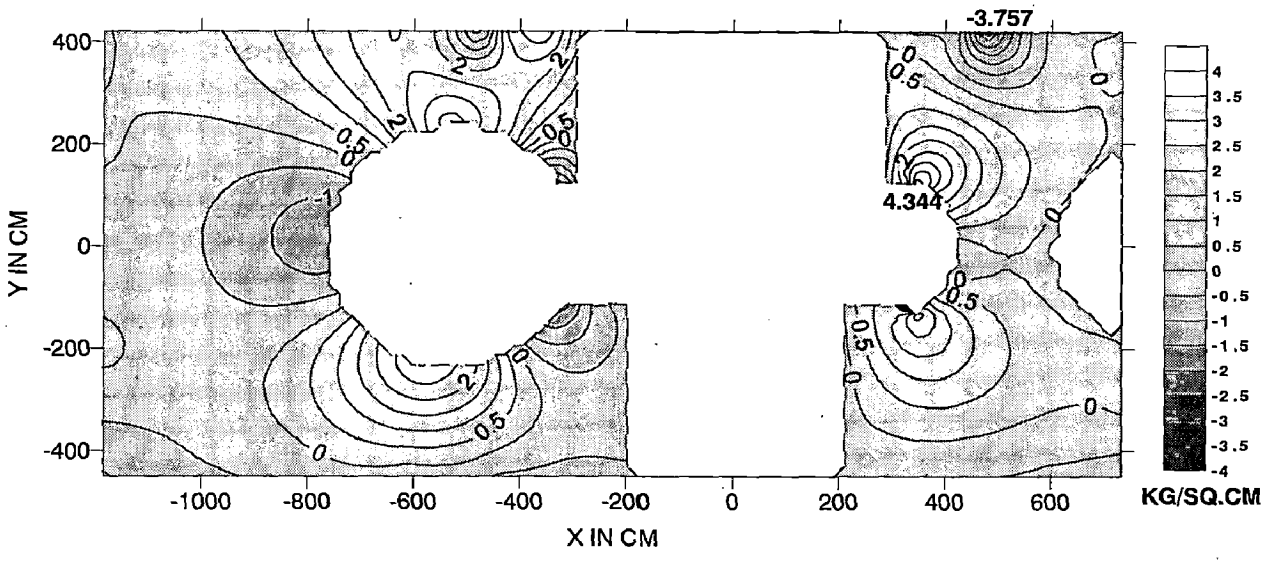
FIG. 5.27 DISPLACEMENT CONTOURS FOR LOAD 2a(iv) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOADING 2a(iv) AT SECTION 060-240

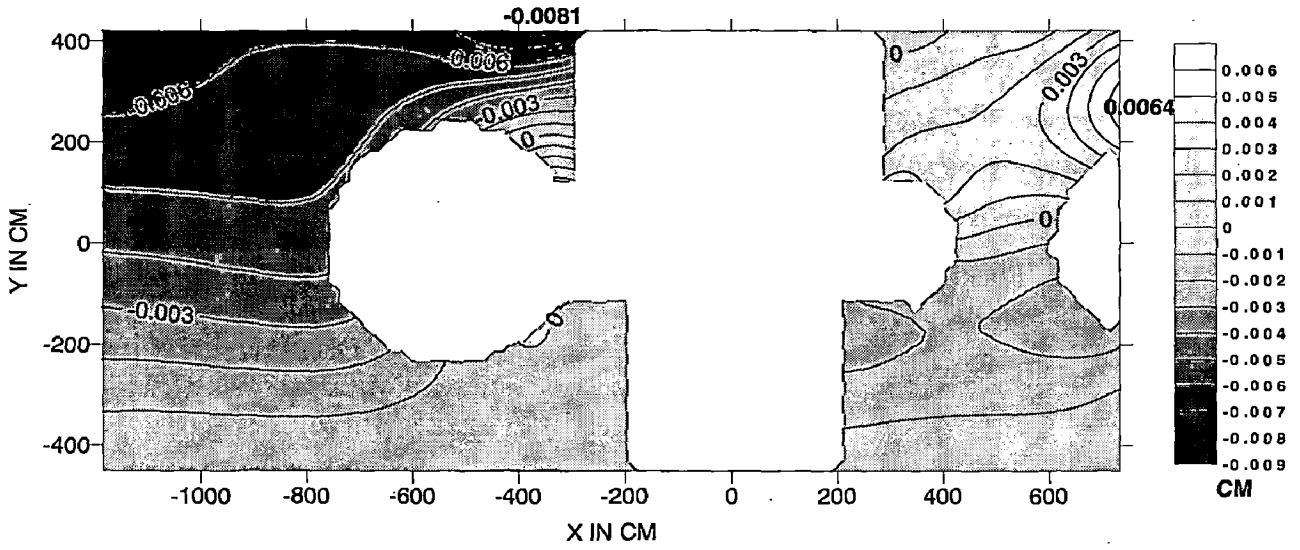


STRESS CONTOUR FOR SY UNDER LOADING 2a(iv) AT SECTION 060-240

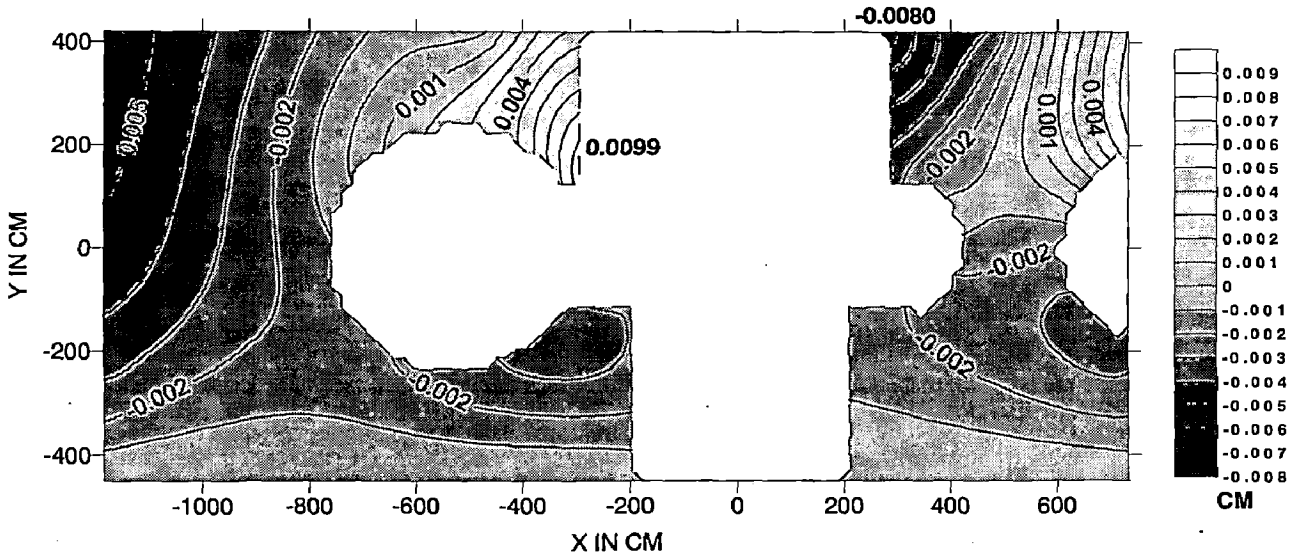


STRESS CONTOUR FOR SZ UNDER LOADING 2a(iv) AT SECTION 060-240

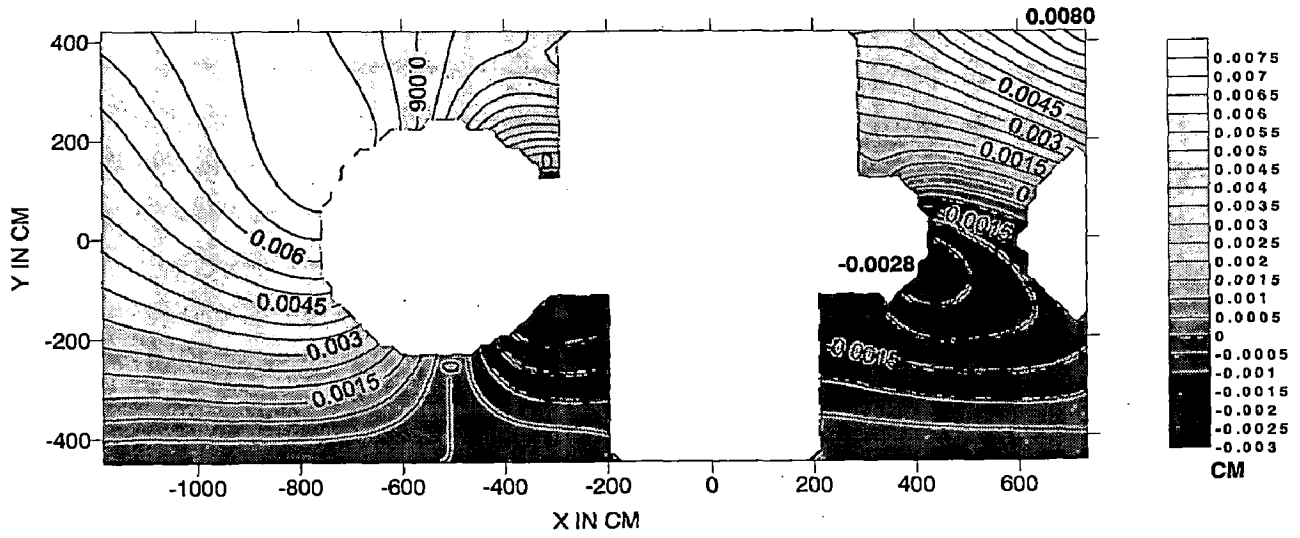
FIG. 5.28 STRESS CONTOURS FOR LOAD 2a(iv) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOADING 2a(v) AT SECTION 060-240

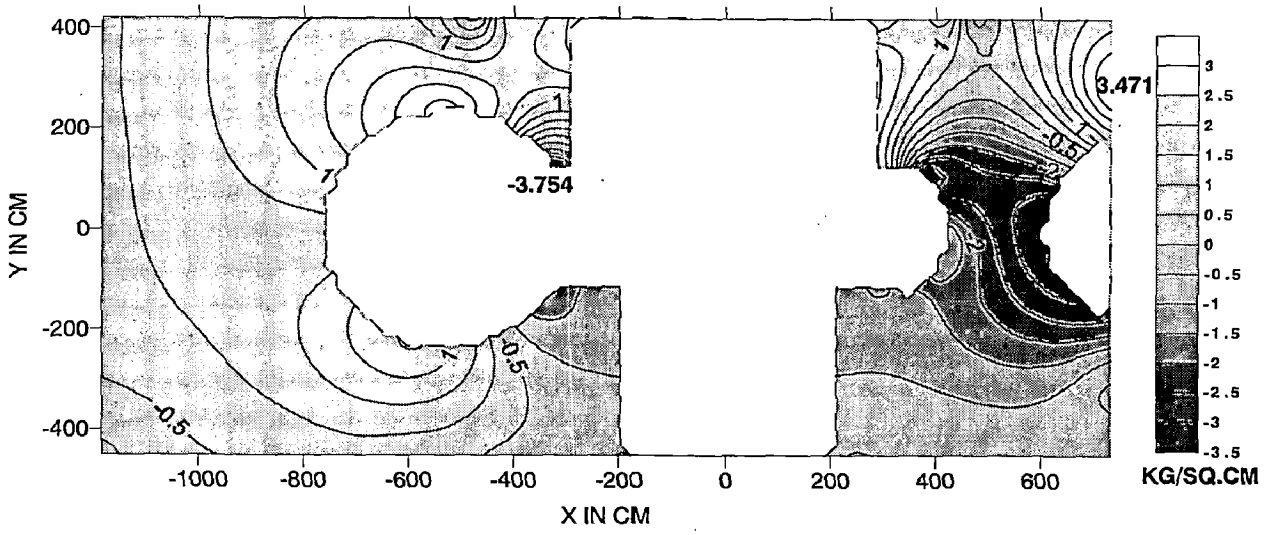


DISPLACEMENT CONTOUR FOR UY UNDER LOADING 2a(v) AT SECTION 060-240

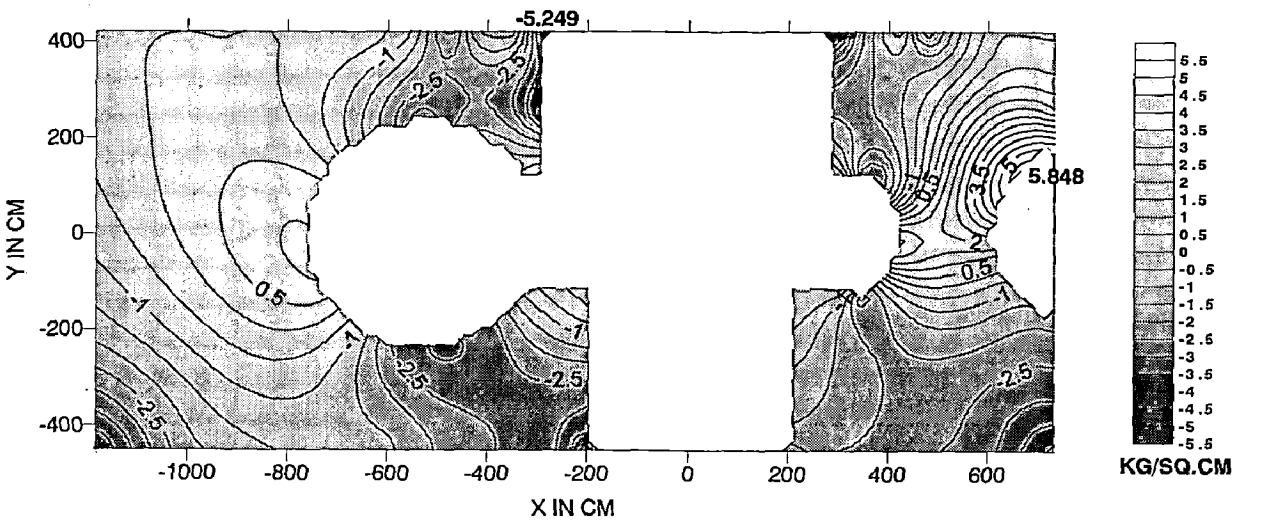


DISPLACEMENT CONTOUR FOR UZ UNDER LOADING 2a(v) AT SECTION 060-240

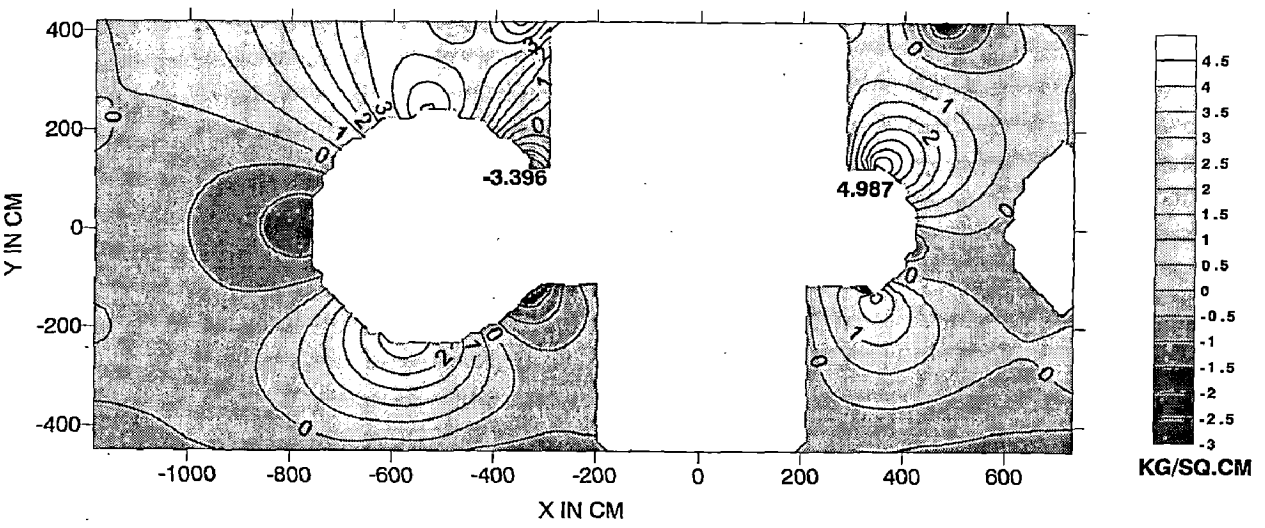
FIG. 5.29 DISPLACEMENT CONTOURS FOR LOAD 2a(v) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOADING 2a(v) AT SECTION 060-240

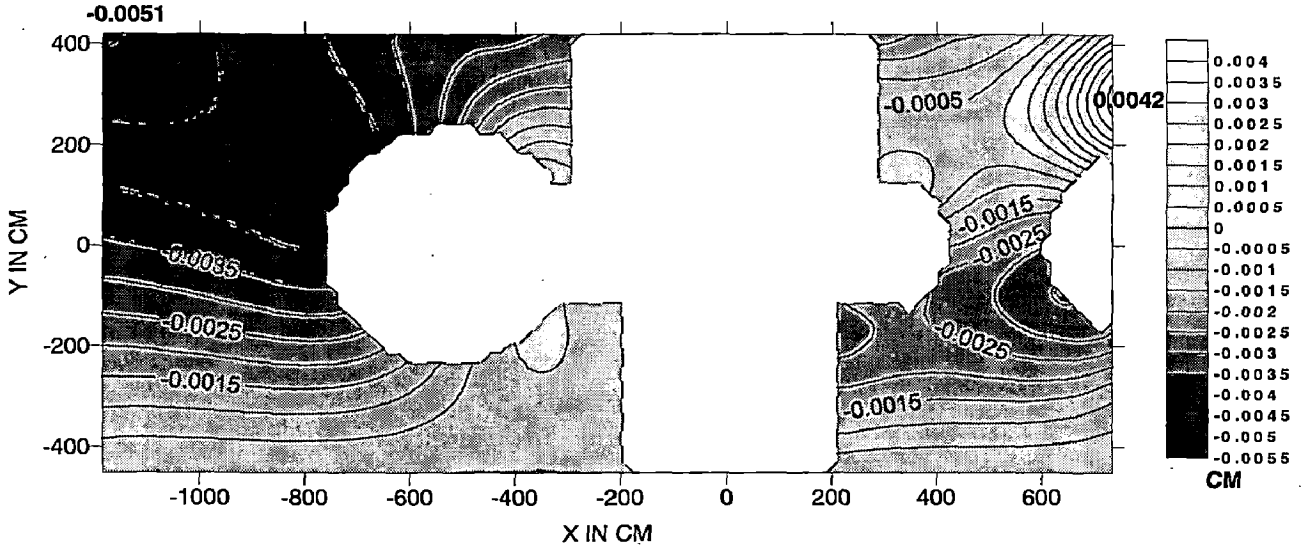


STRESS CONTOUR FOR SY UNDER LOADING 2a(v) AT SECTION 060-240

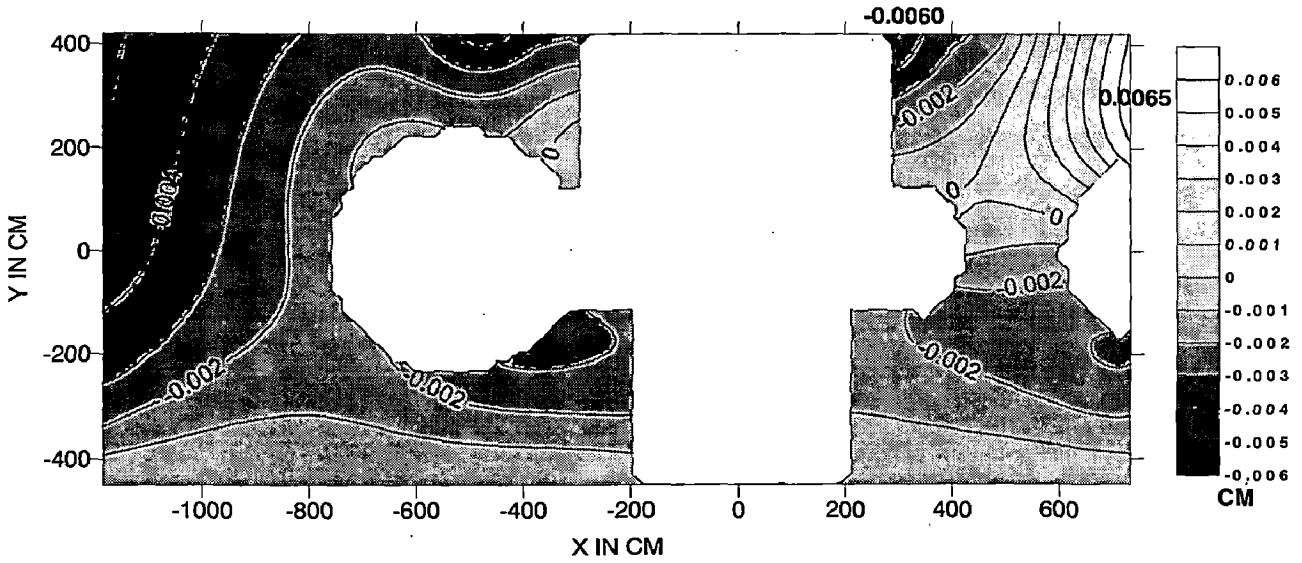


STRESS CONTOUR FOR SZ UNDER LOADING 2a(v) AT SECTION 060-240

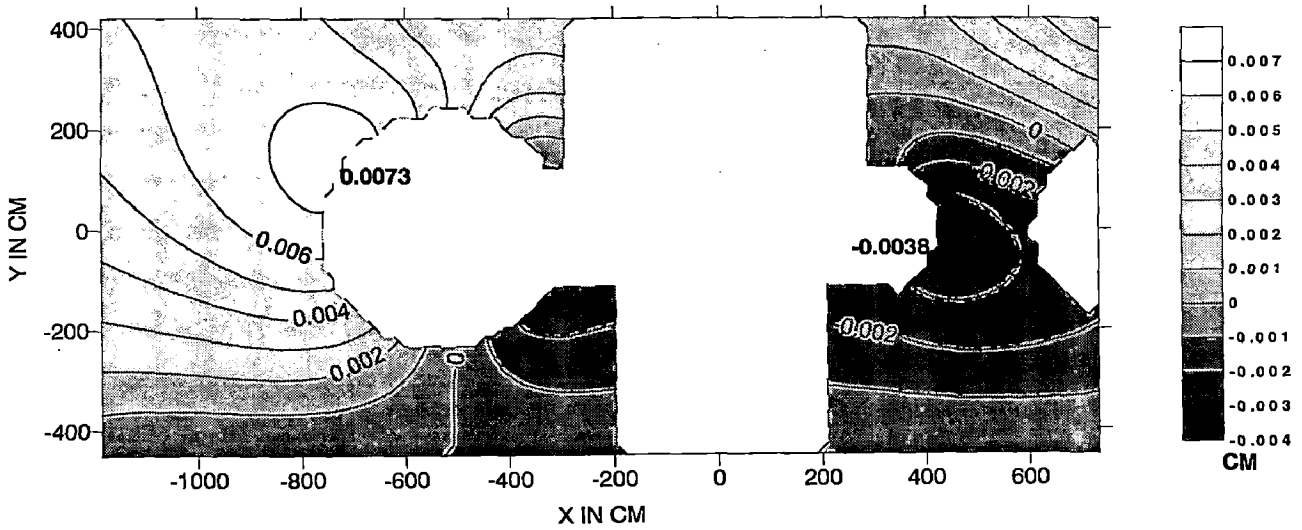
FIG. 5.30 STRESS CONTOURS FOR LOAD 2a(v) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOADING 2b(i) AT SECTION 060-240

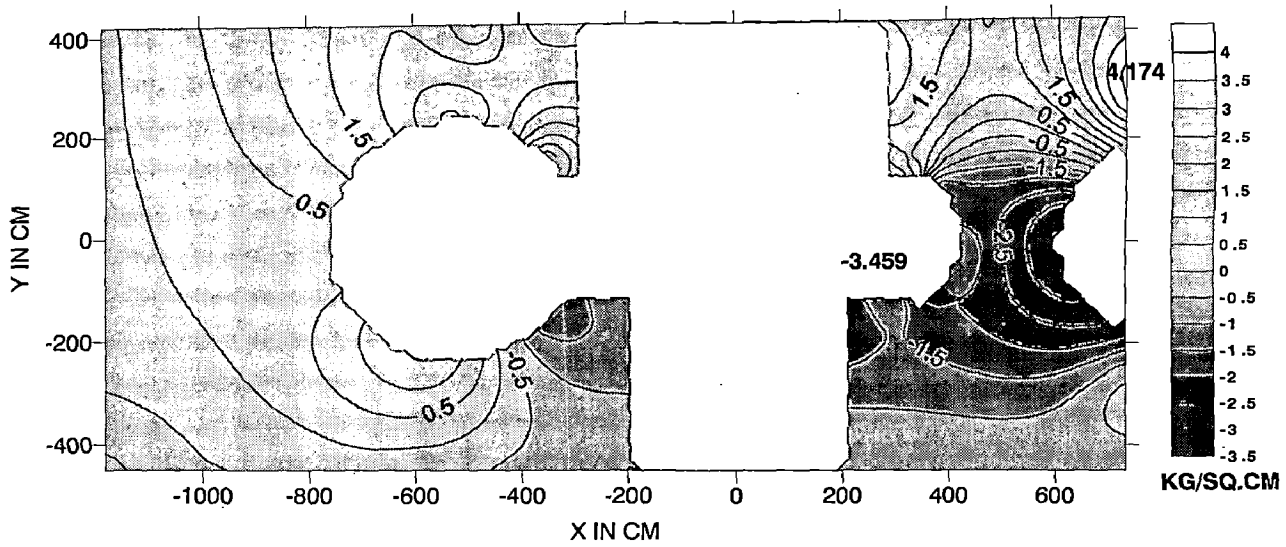


DISPLACEMENT CONTOUR FOR UY UNDER LOADING 2b(i) AT SECTION 060-240

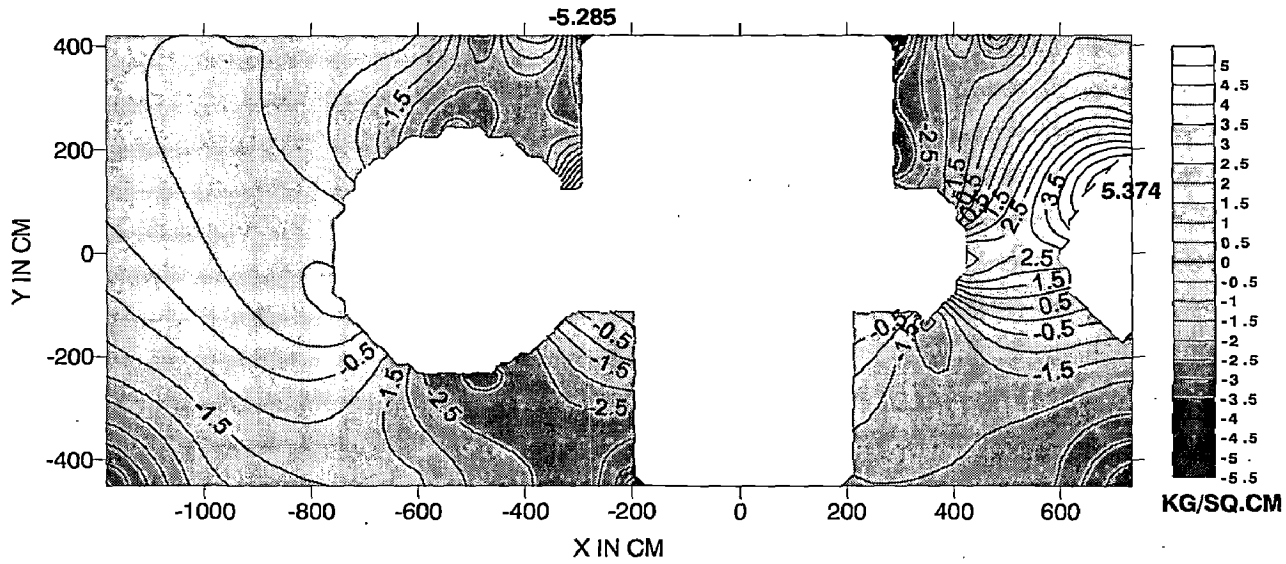


DISPLACEMENT CONTOUR FOR UZ UNDER LOADING 2b(i) AT SECTION 060-240

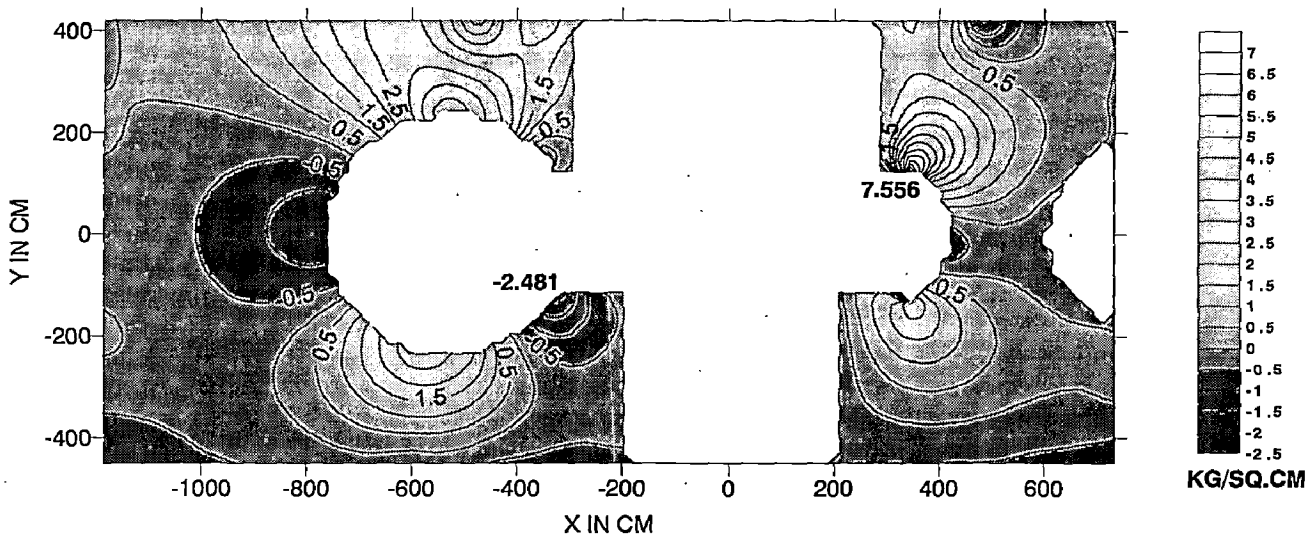
FIG. 5.31 DISPLACEMENT CONTOURS FOR LOAD 2b(i) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOADING 2b(i) AT SECTION 060-240

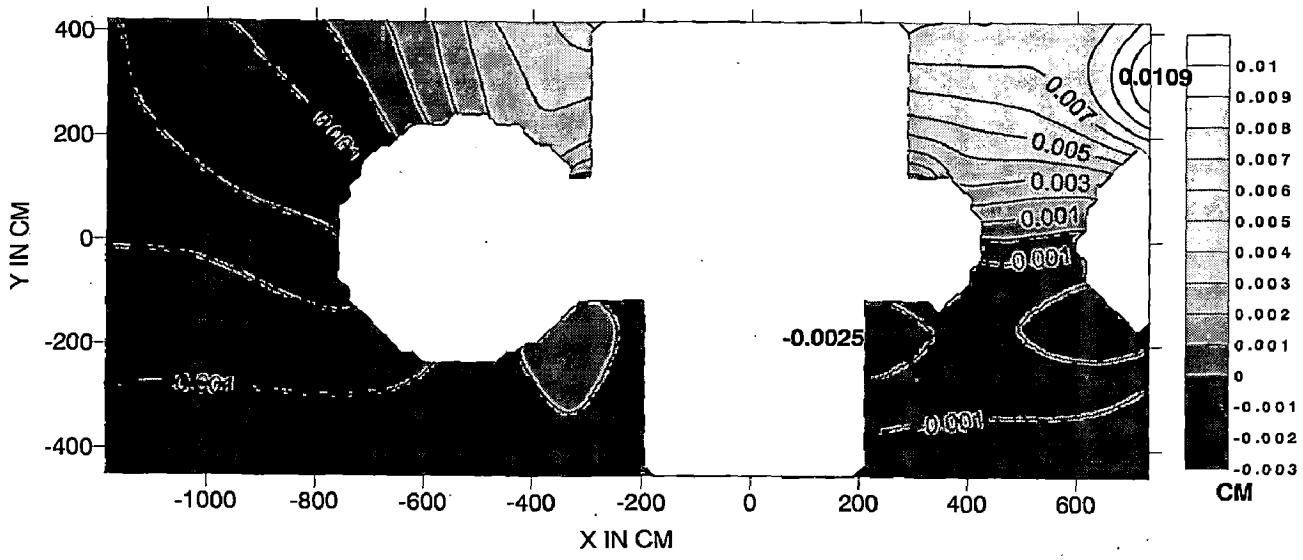


STRESS CONTOUR FOR SY UNDER LOADING 2b(i) AT SECTION 060-240

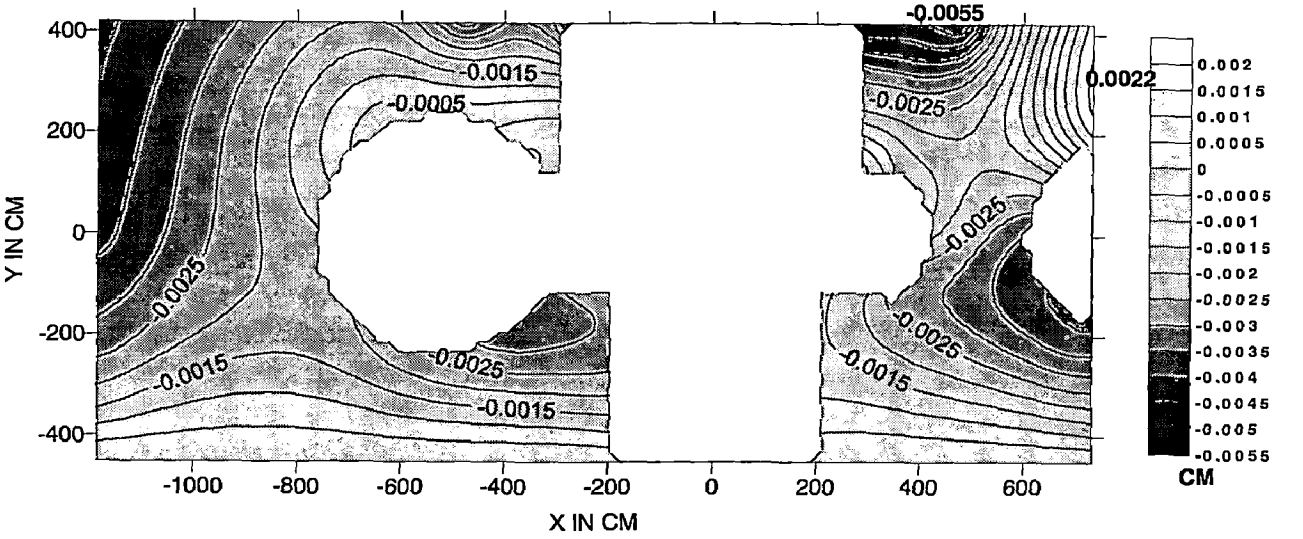


STRESS CONTOUR FOR SZ UNDER LOADING 2b(i) AT SECTION 060-240

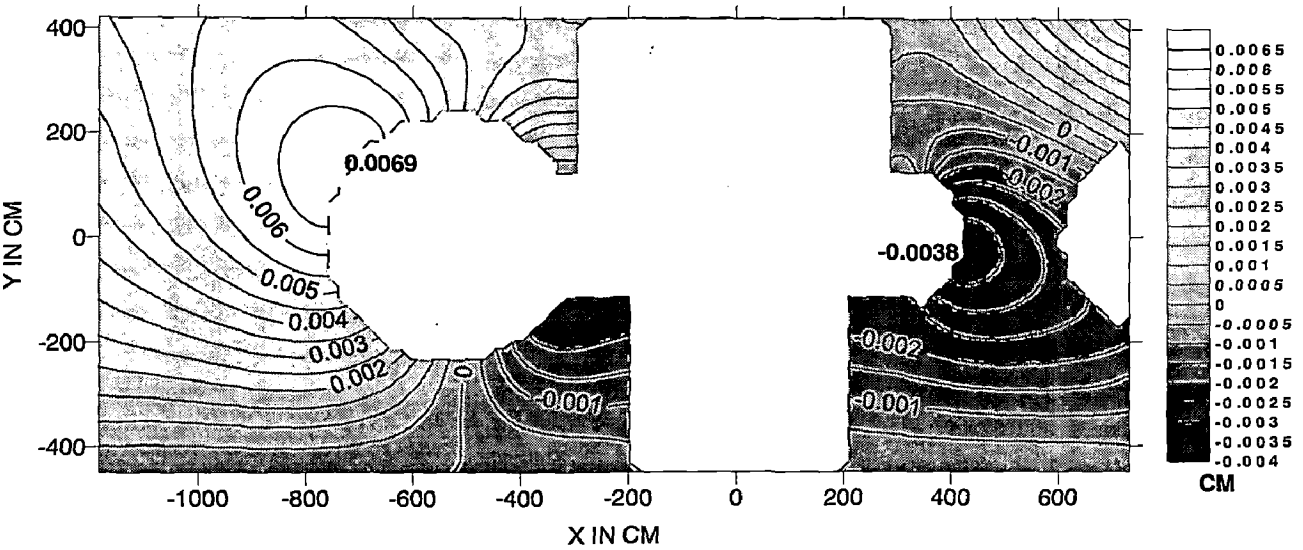
FIG. 5.32 STRESS CONTOURS FOR LOAD 2b(i) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOADING 2b(ii) AT SECTION 060-240

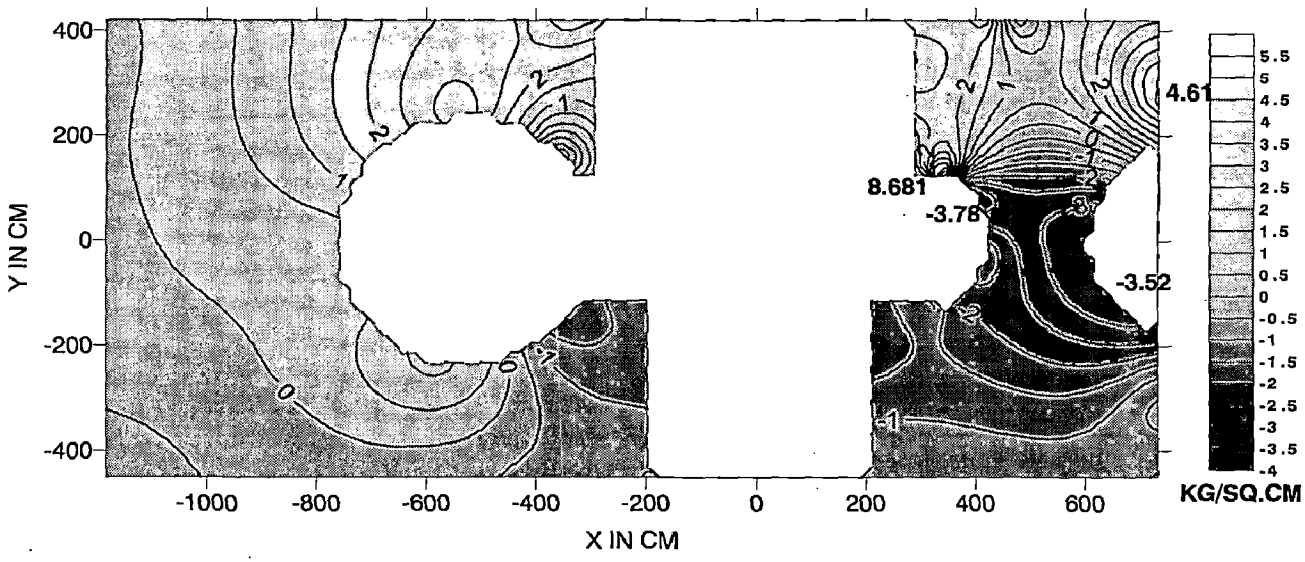


DISPLACEMENT CONTOUR FOR UY UNDER LOADING 2b(ii) AT SECTION 060-240

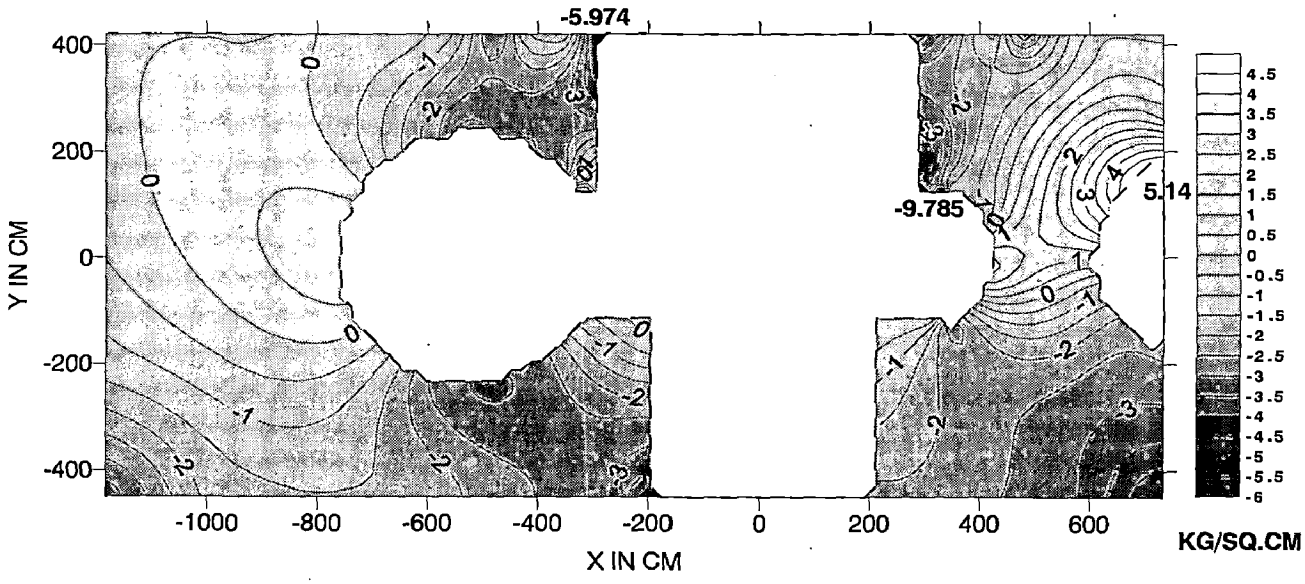


DISPLACEMENT CONTOUR FOR UZ UNDER LOADING 2b(ii) AT SECTION 060-240

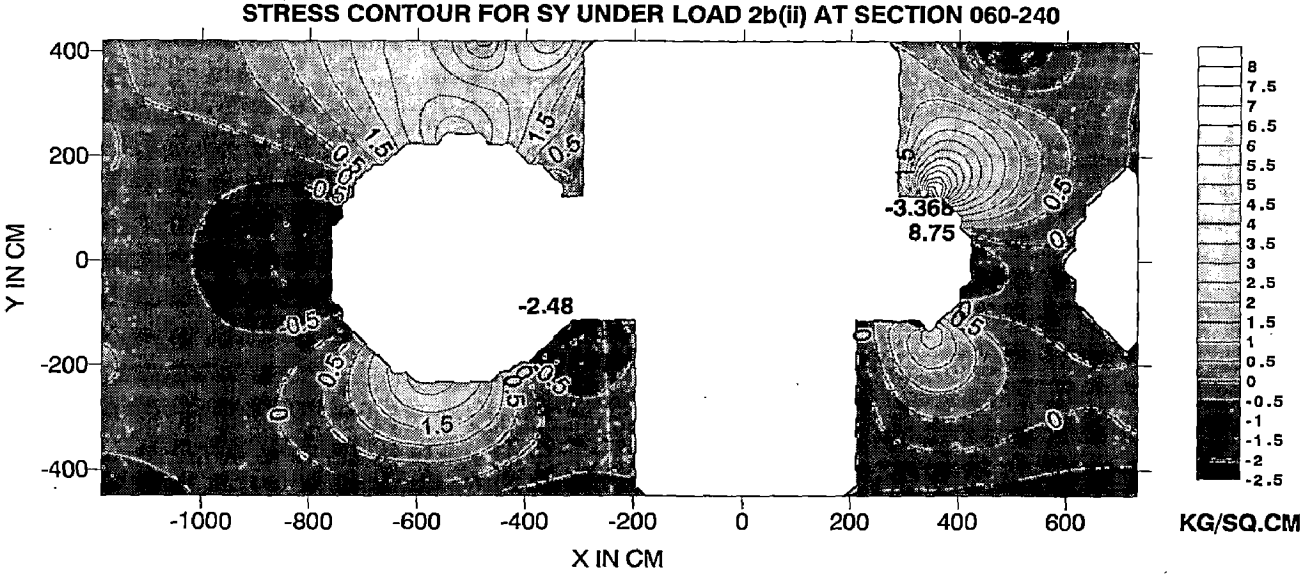
FIG. 5.33 DISPLACEMENT CONTOURS FOR LOAD 2b(ii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOADING 2b(ii) AT SECTION 060-240

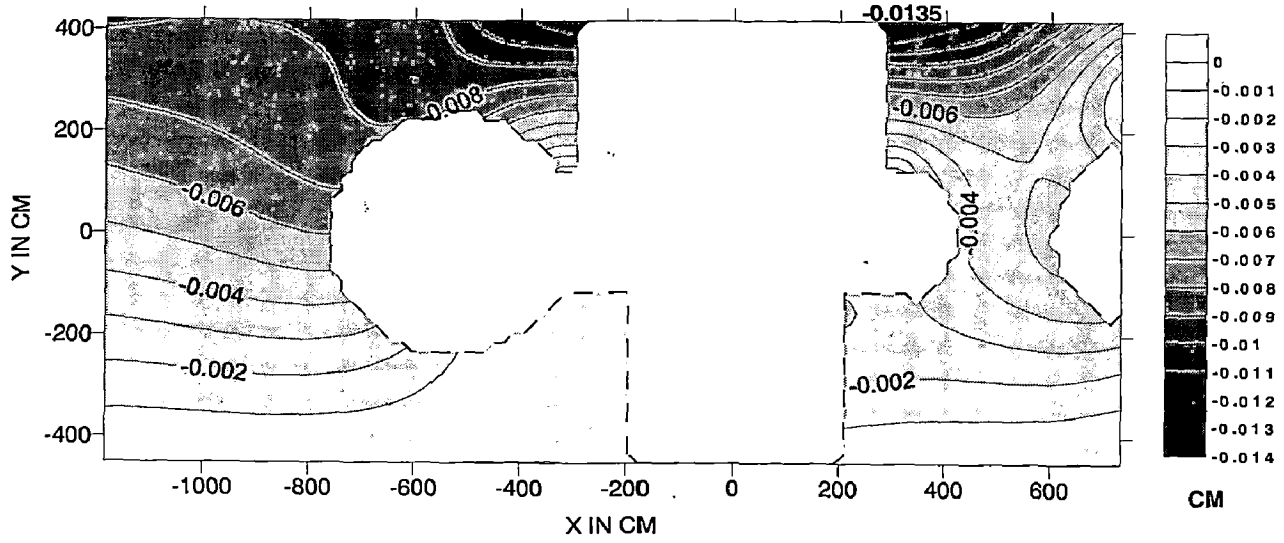


STRESS CONTOUR FOR SY UNDER LOAD 2b(ii) AT SECTION 060-240

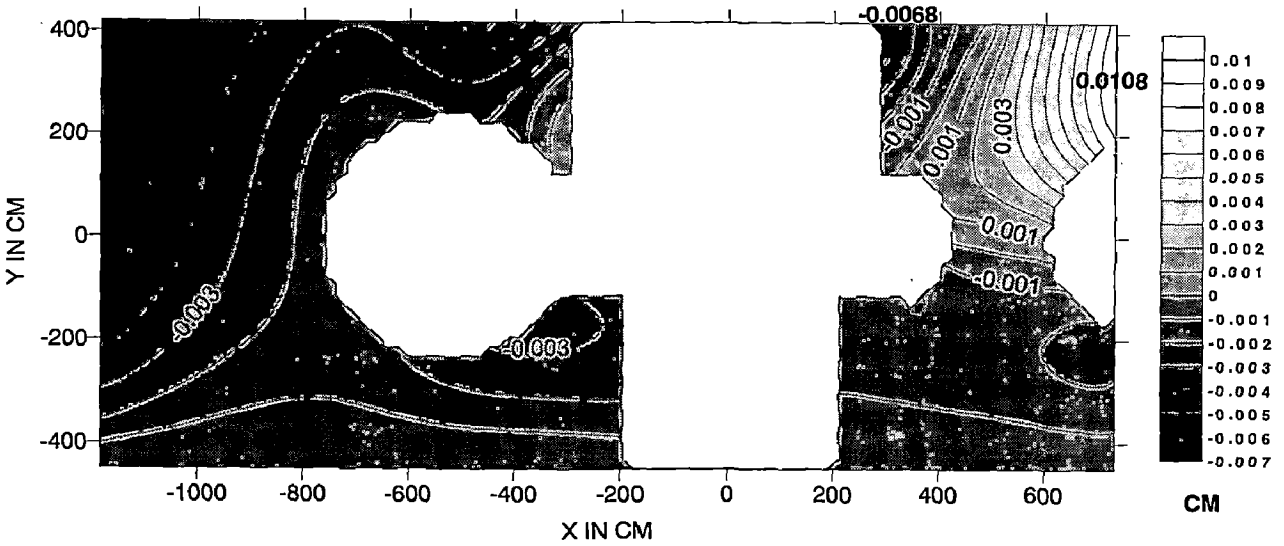


STRESS CONTOUR FOR SZ UNDER LOAD 2b(ii) AT SECTION 060-240

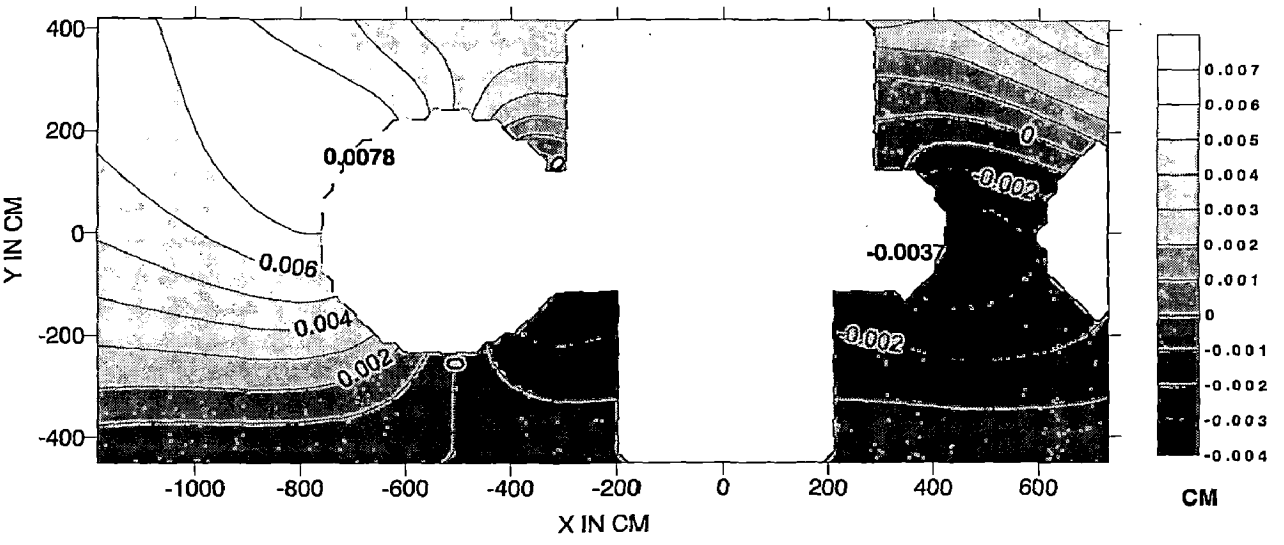
FIG. 5.34 STRESS CONTOURS FOR LOAD 2b(ii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2b(iii) AT SECTION 060-240

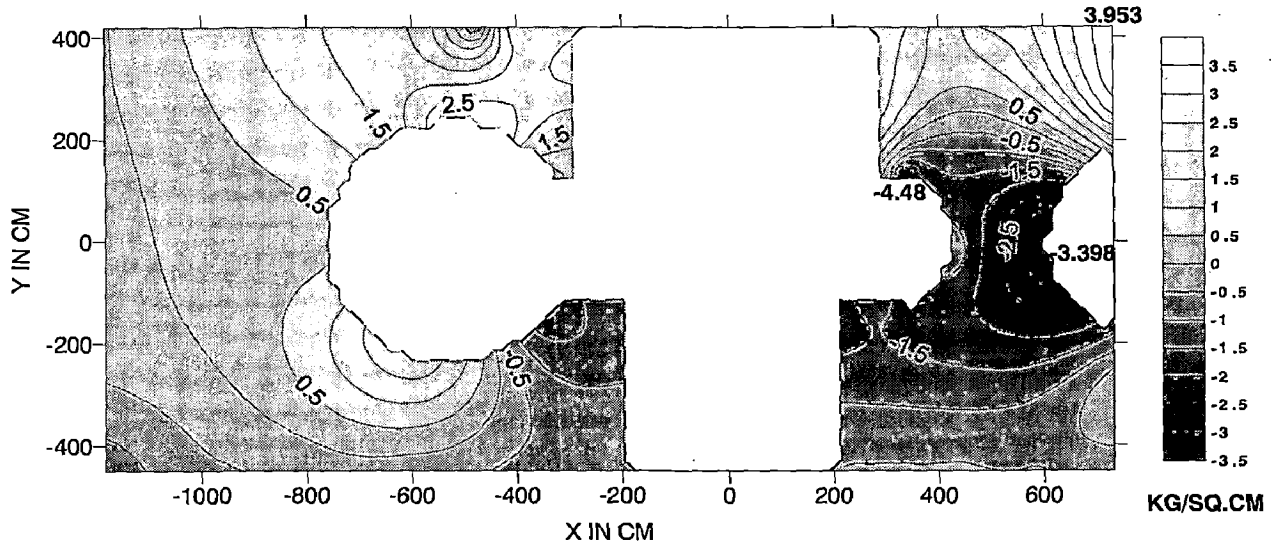


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2b(iii) AT SECTION 060-240

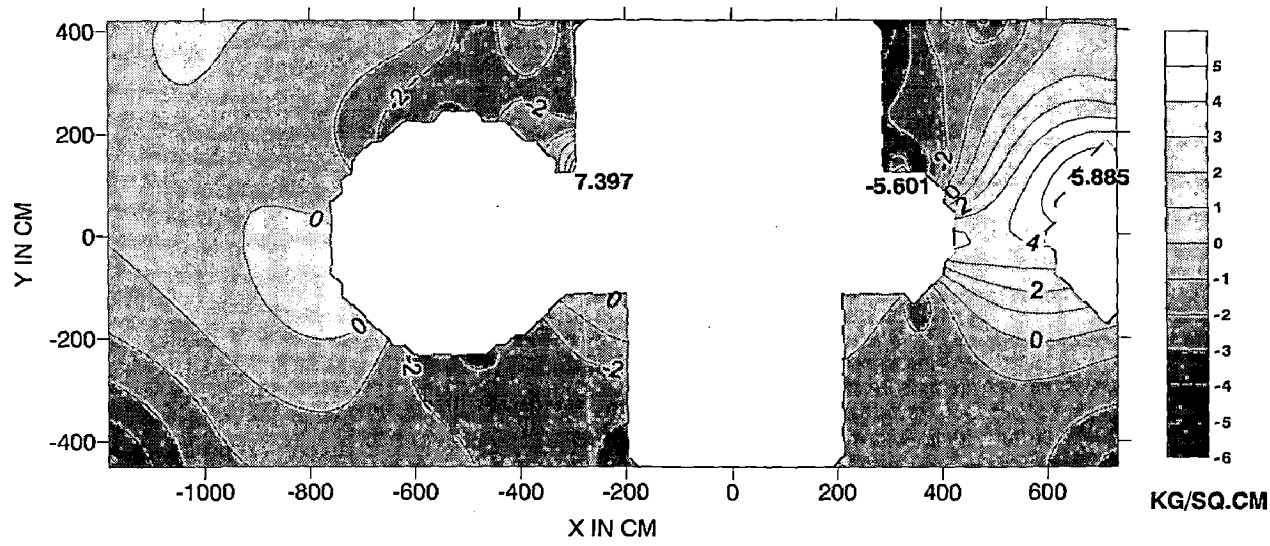


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2b(iii) AT SECTION 060-240

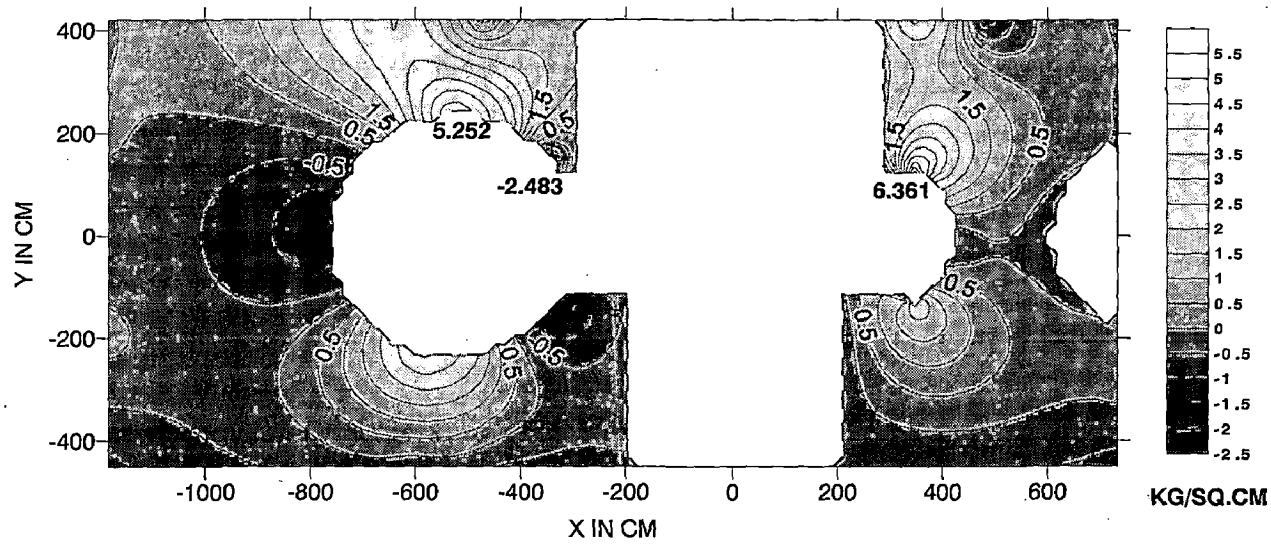
FIG. 5.35 DISPLACEMENT CONTOURS FOR LOAD 2b(iii) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2b(iii) AT SECTION 060-240

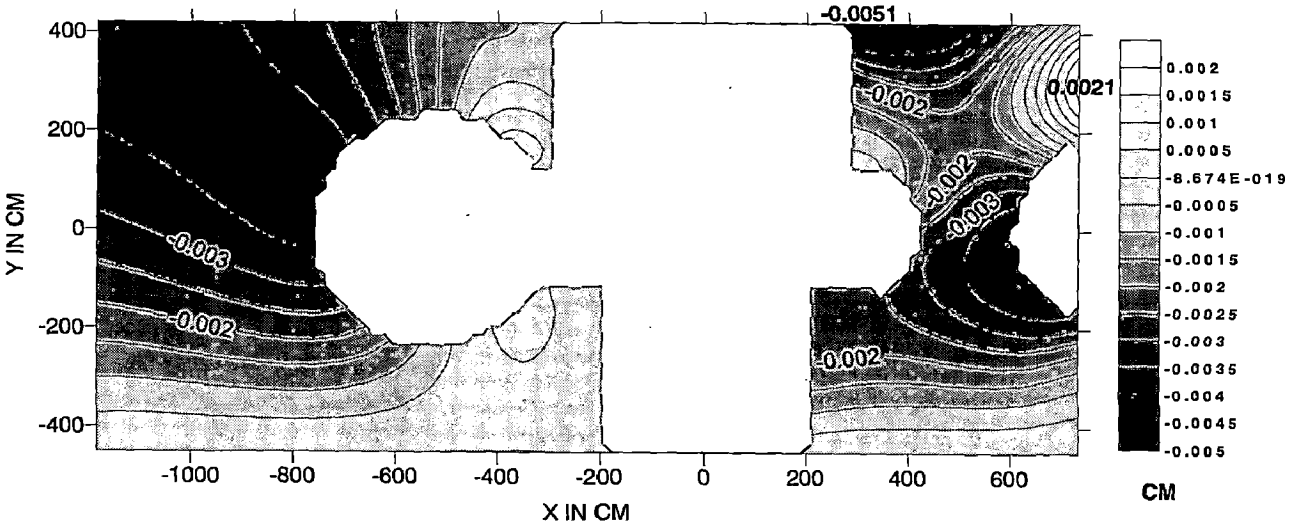


STRESS CONTOUR FOR SY UNDER LOAD 2b(iii) AT SECTION 060-240

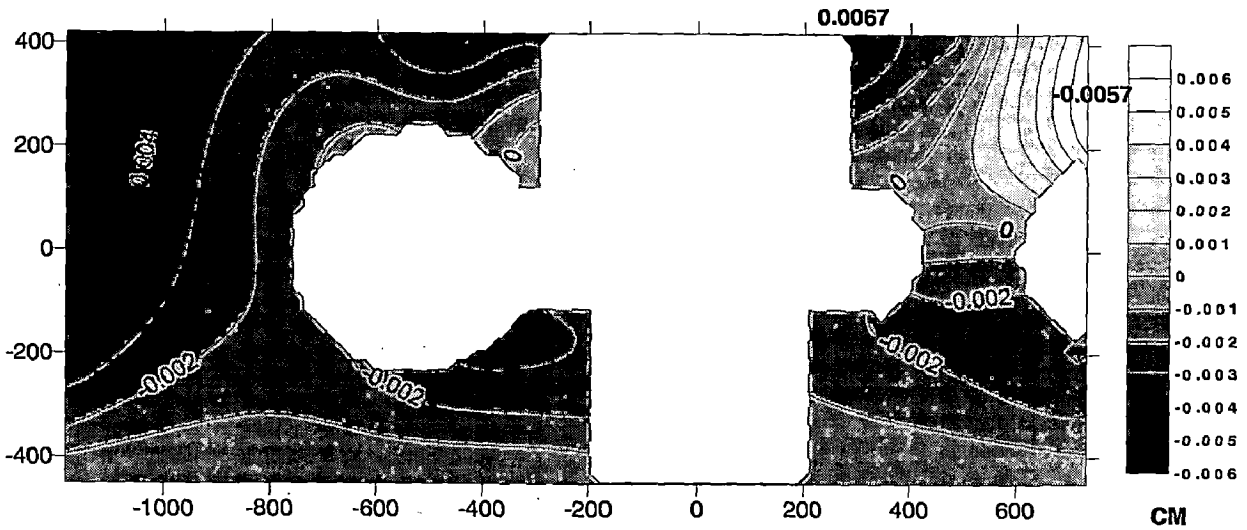


STRESS CONTOUR FOR SZ UNDER LOAD 2b(iii) AT SECTION 060-240

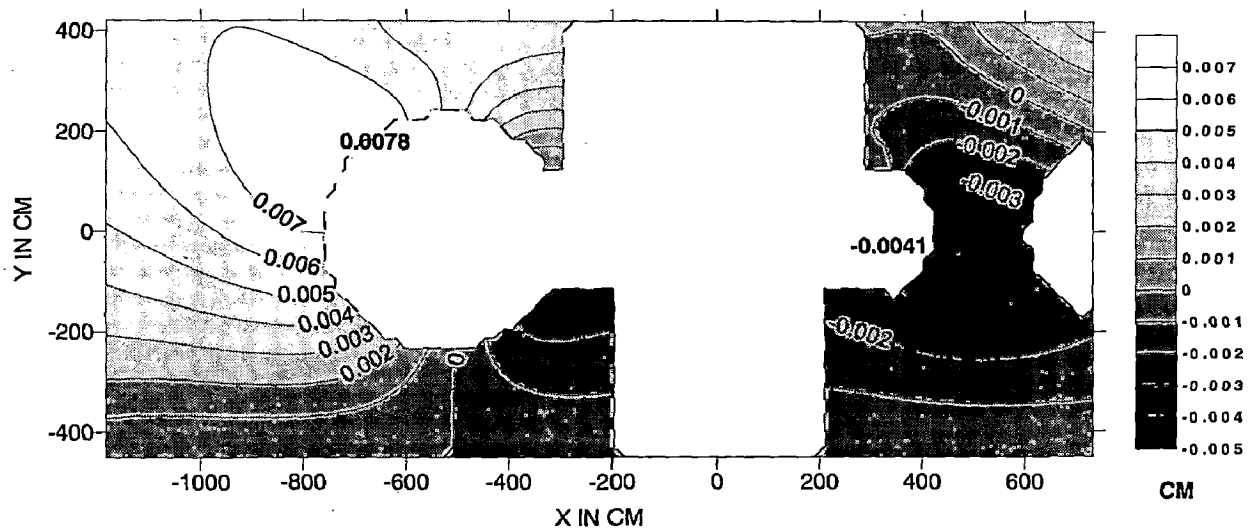
FIG. 5.36 STRESS CONTOURS FOR LOAD 2b(iii) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2b(iv) AT SECTION 060-240

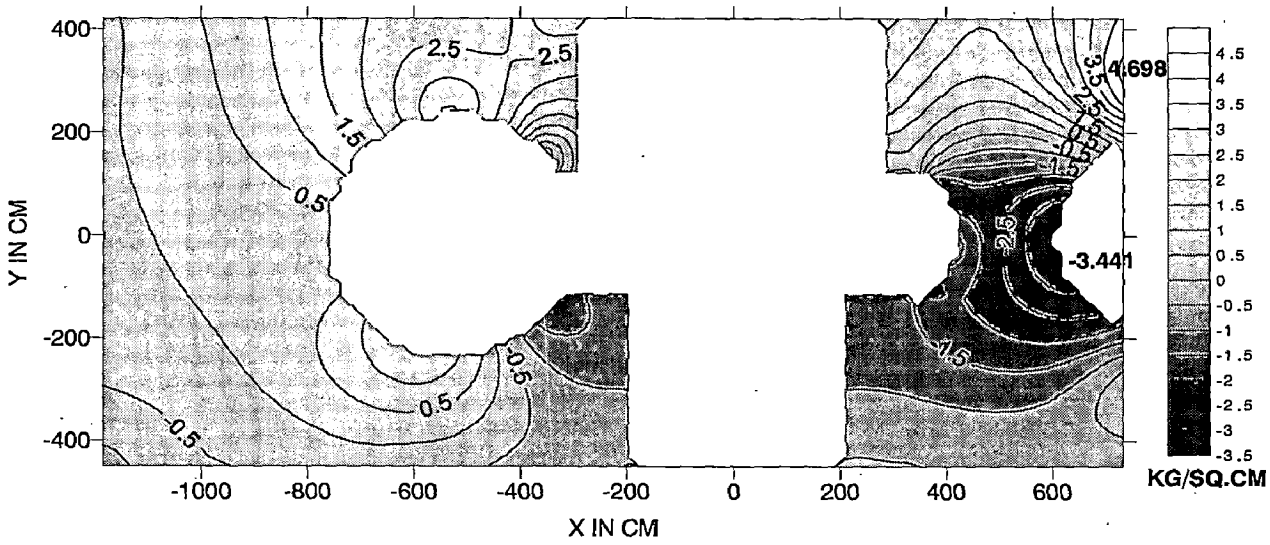


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2b(iv) AT SECTION 060-240

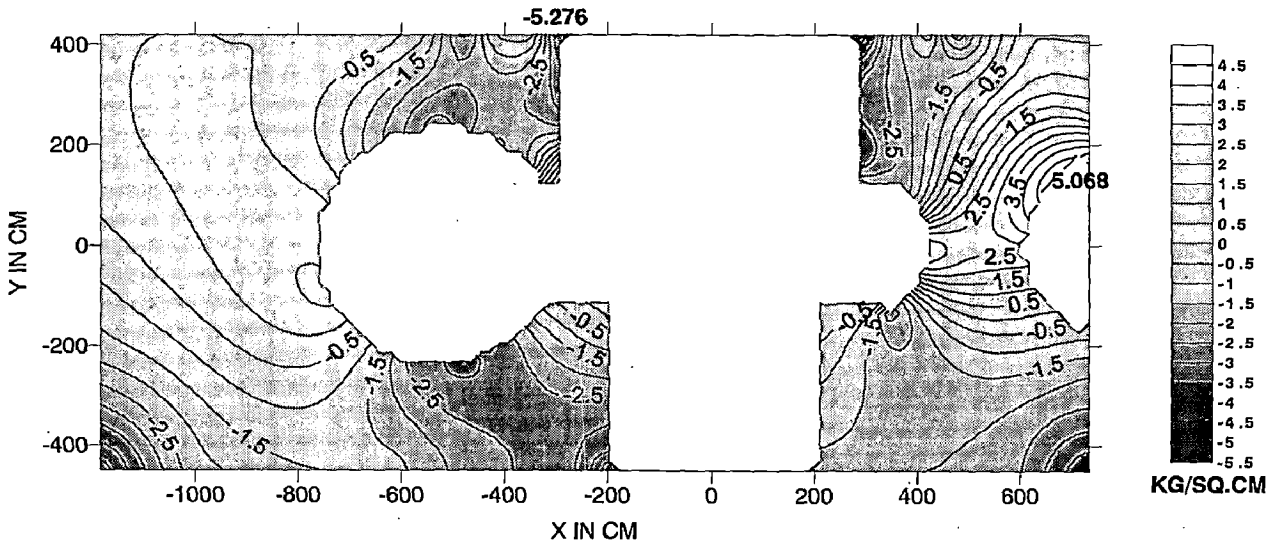


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2b(iv) AT SECTION 060-240

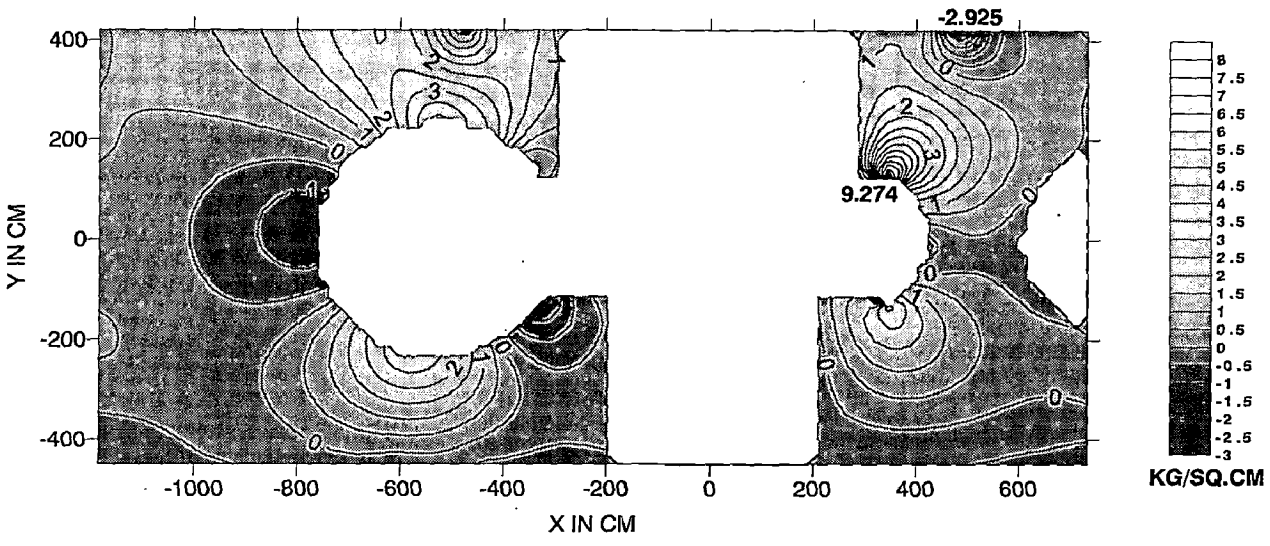
FIG. 5.37 DISPLACEMENT CONTOURS FOR LOAD 2b(iv) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2b(iv) AT SECTION 060-240

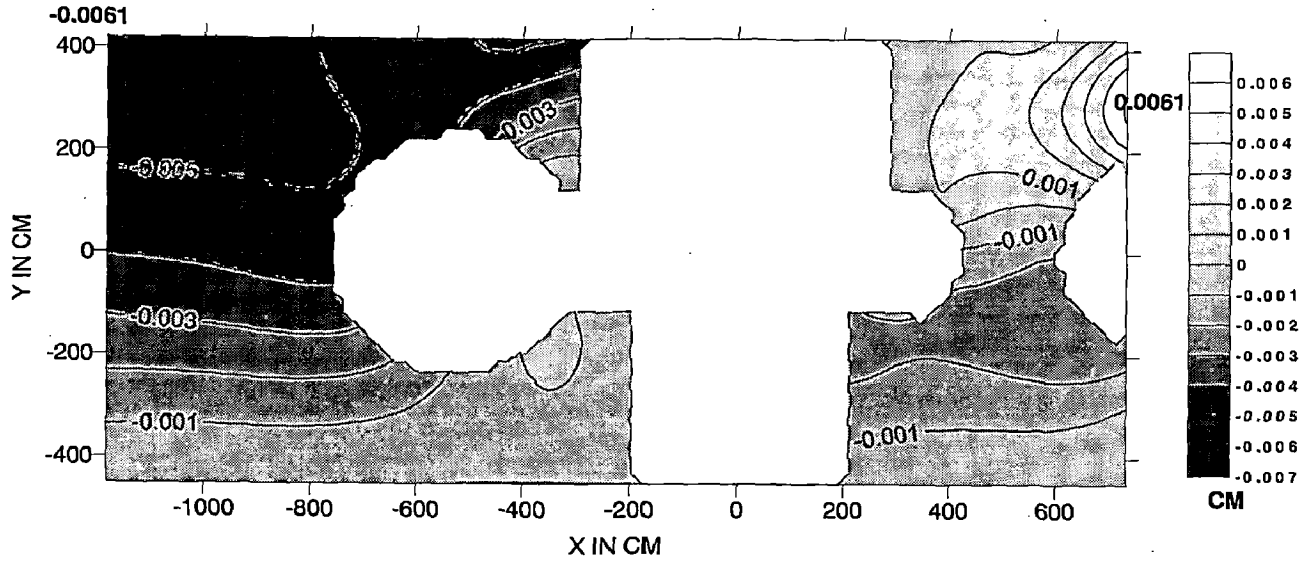


STRESS CONTOUR FOR SY UNDER LOAD 2b(iv) AT SECTION 060-240

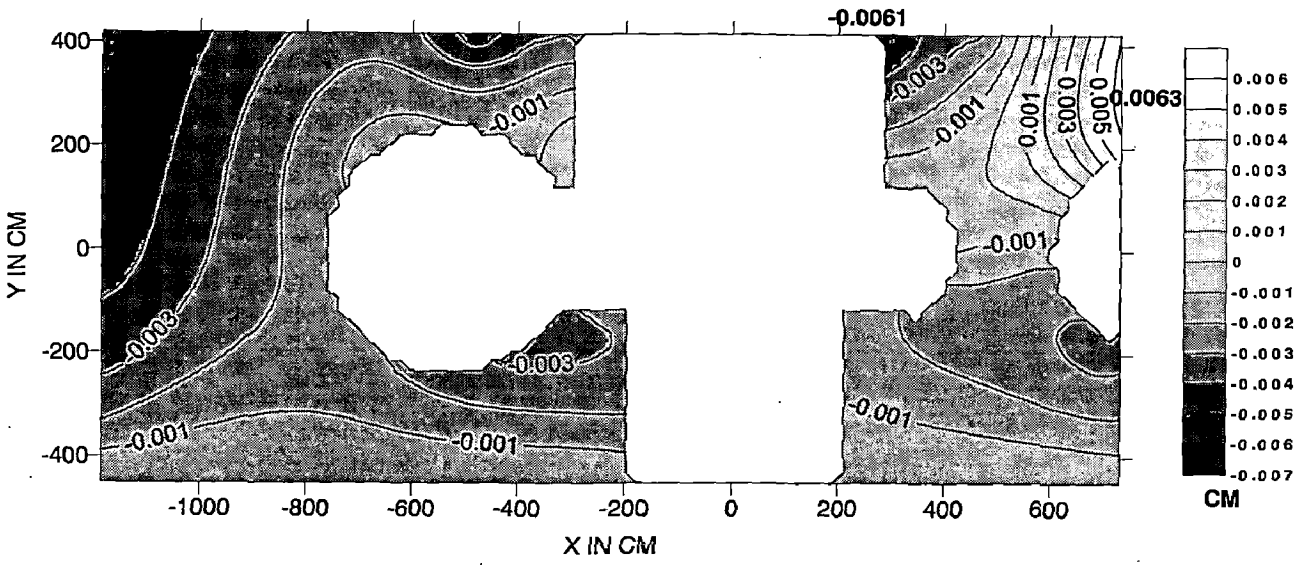


STRESS CONTOUR FOR SZ UNDER LOAD 2b(iv) AT SECTION 060-240

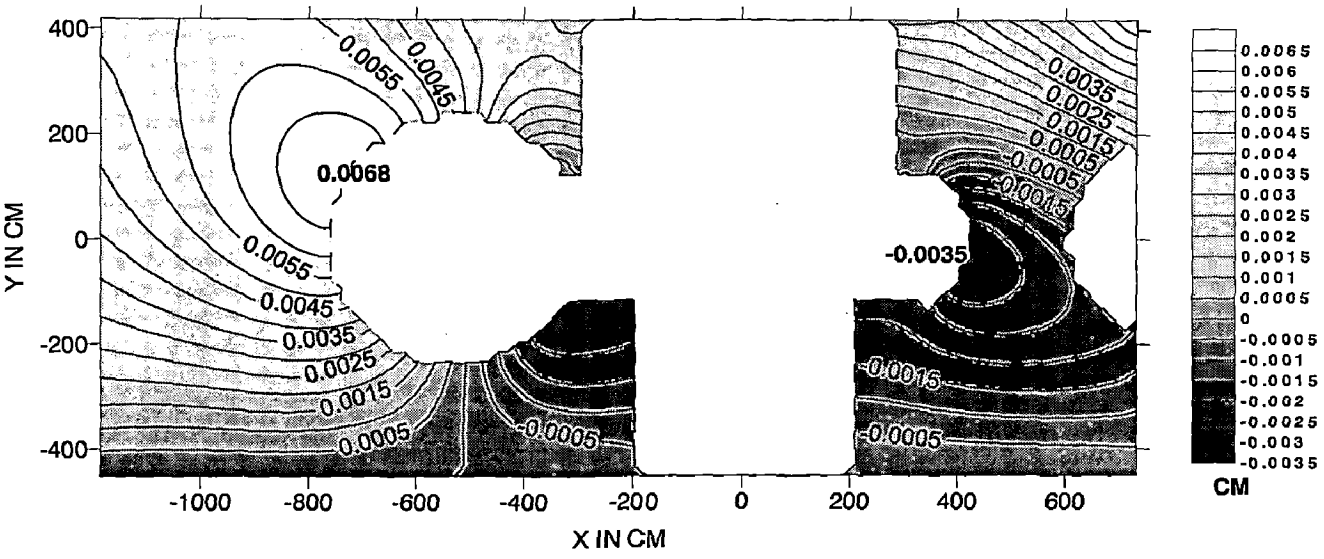
FIG. 5.38 STRESS CONTOURS FOR LOAD 2b(iv) AT SECTION 060-240



DISPLACEMENT CONTOUR FOR UX UNDER LOAD 2b(v) AT SECTION 060-240

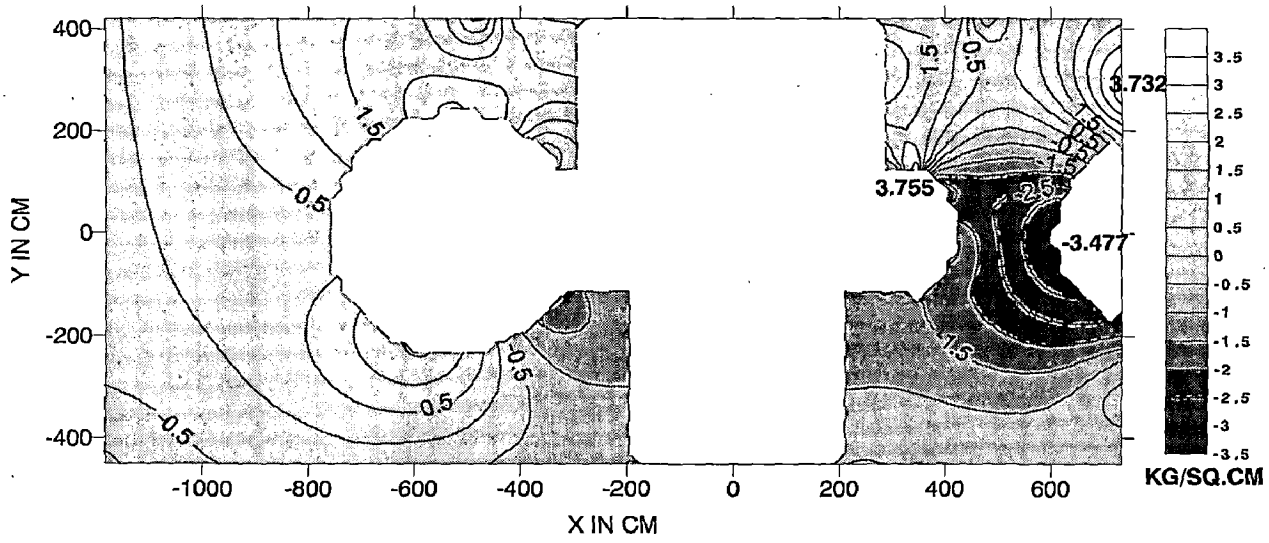


DISPLACEMENT CONTOUR FOR UY UNDER LOAD 2b(v) AT SECTION 060-240

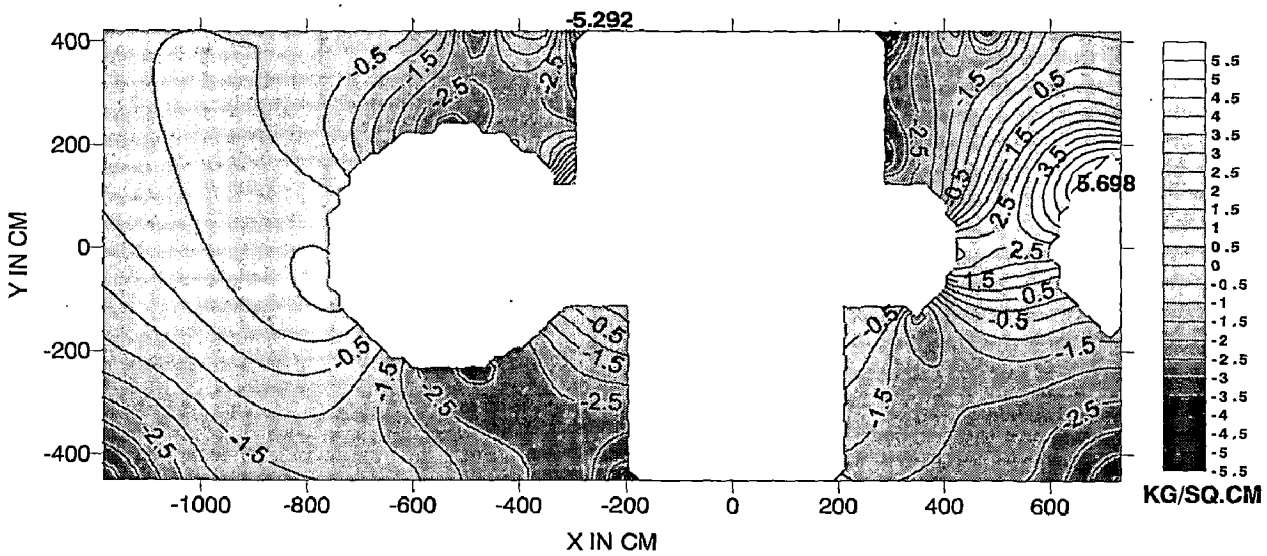


DISPLACEMENT CONTOUR FOR UZ UNDER LOAD 2b(v) AT SECTION 060-240

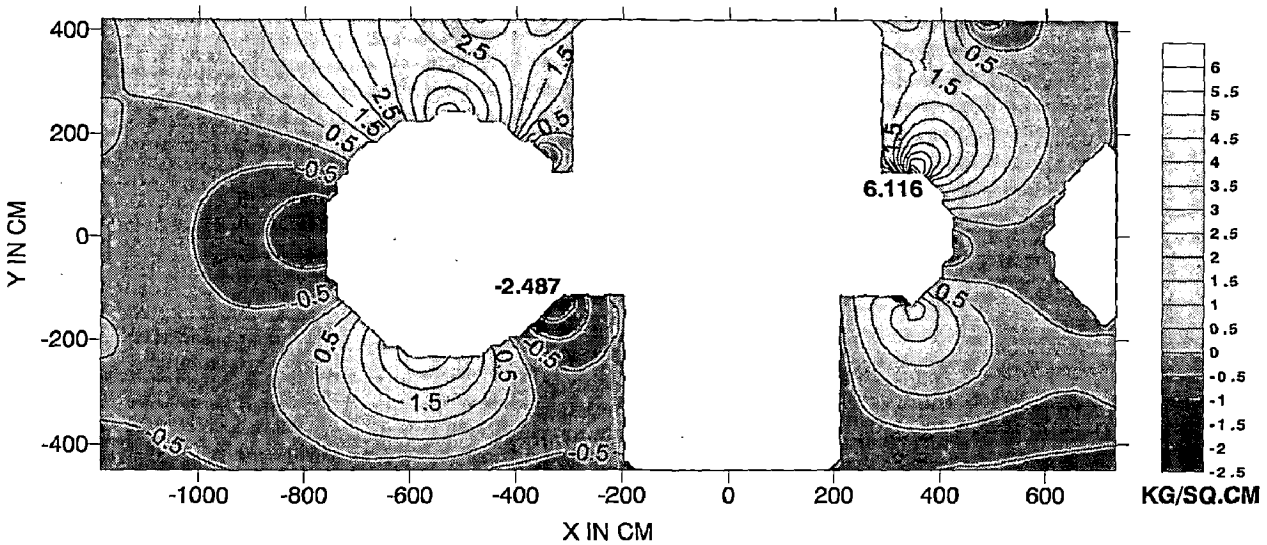
FIG. 5.39 DISPLACEMENT CONTOURS FOR LOAD 2b(v) AT SECTION 060-240



STRESS CONTOUR FOR SX UNDER LOAD 2b(v) AT SECTION 060-240

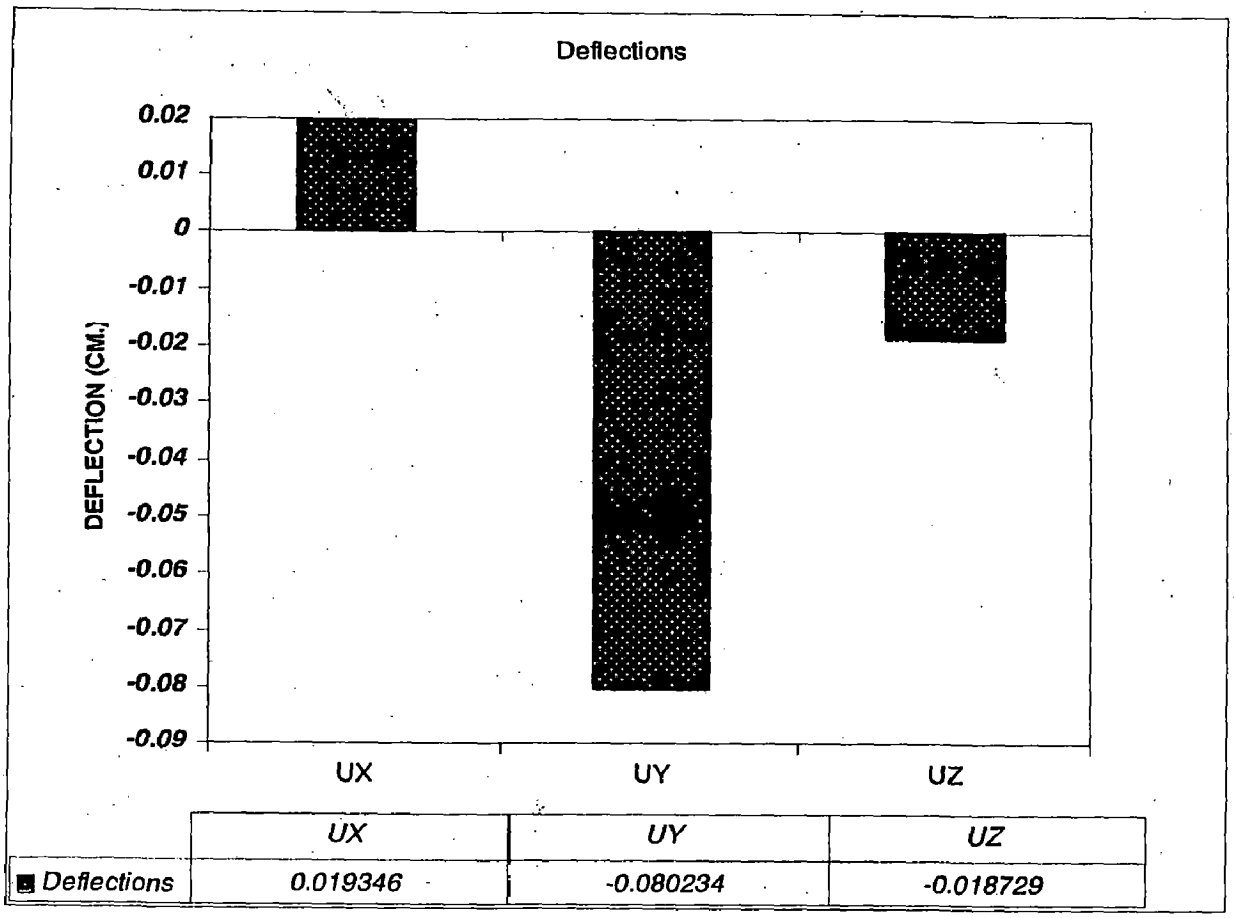


STRESS CONTOUR FOR SY UNDER LOAD 2b(v) AT SECTION 060-240

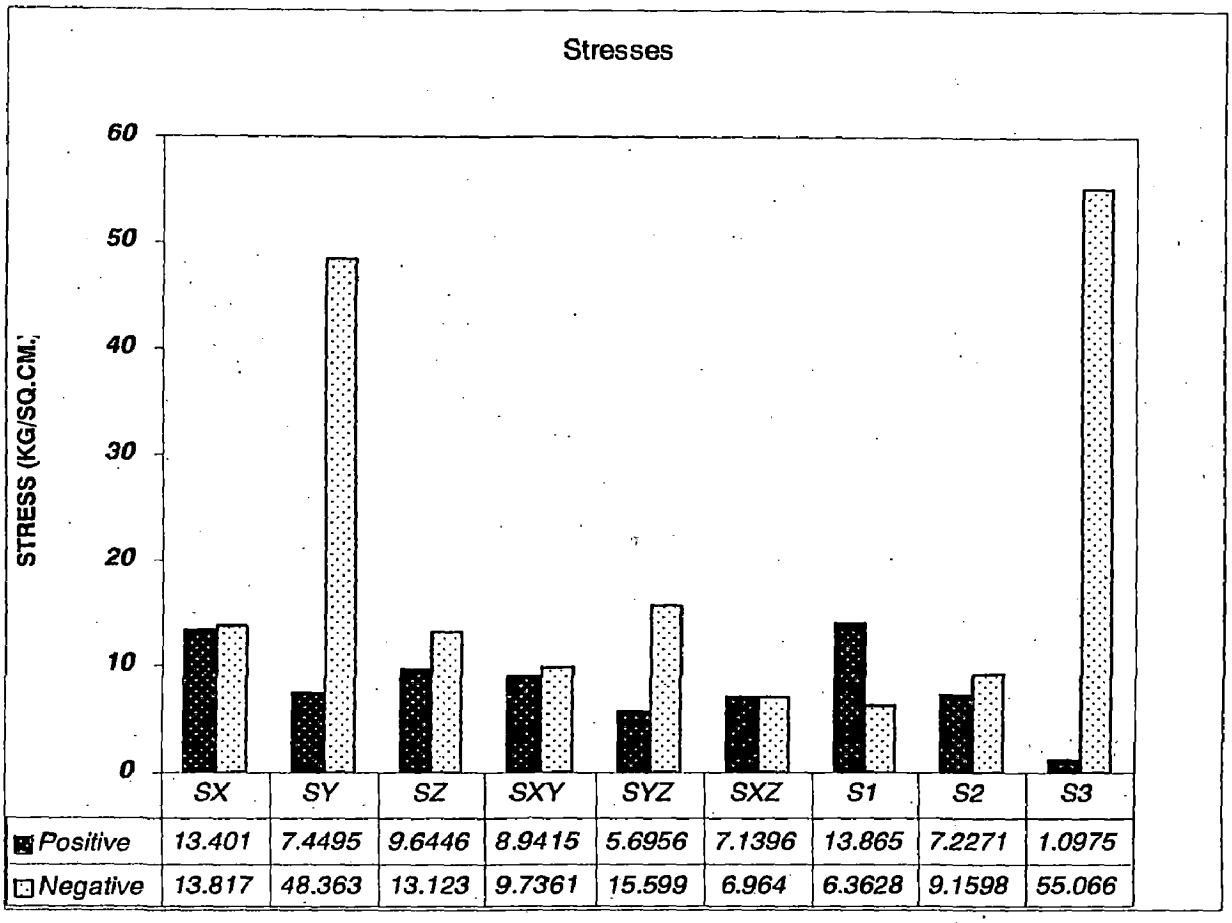


STRESS CONTOUR FOR SZ UNDER LOAD 2b(v) AT SECTION 060-240

FIG. 5.40 STRESS CONTOURS FOR LOAD 2b(v) AT SECTION 060-240

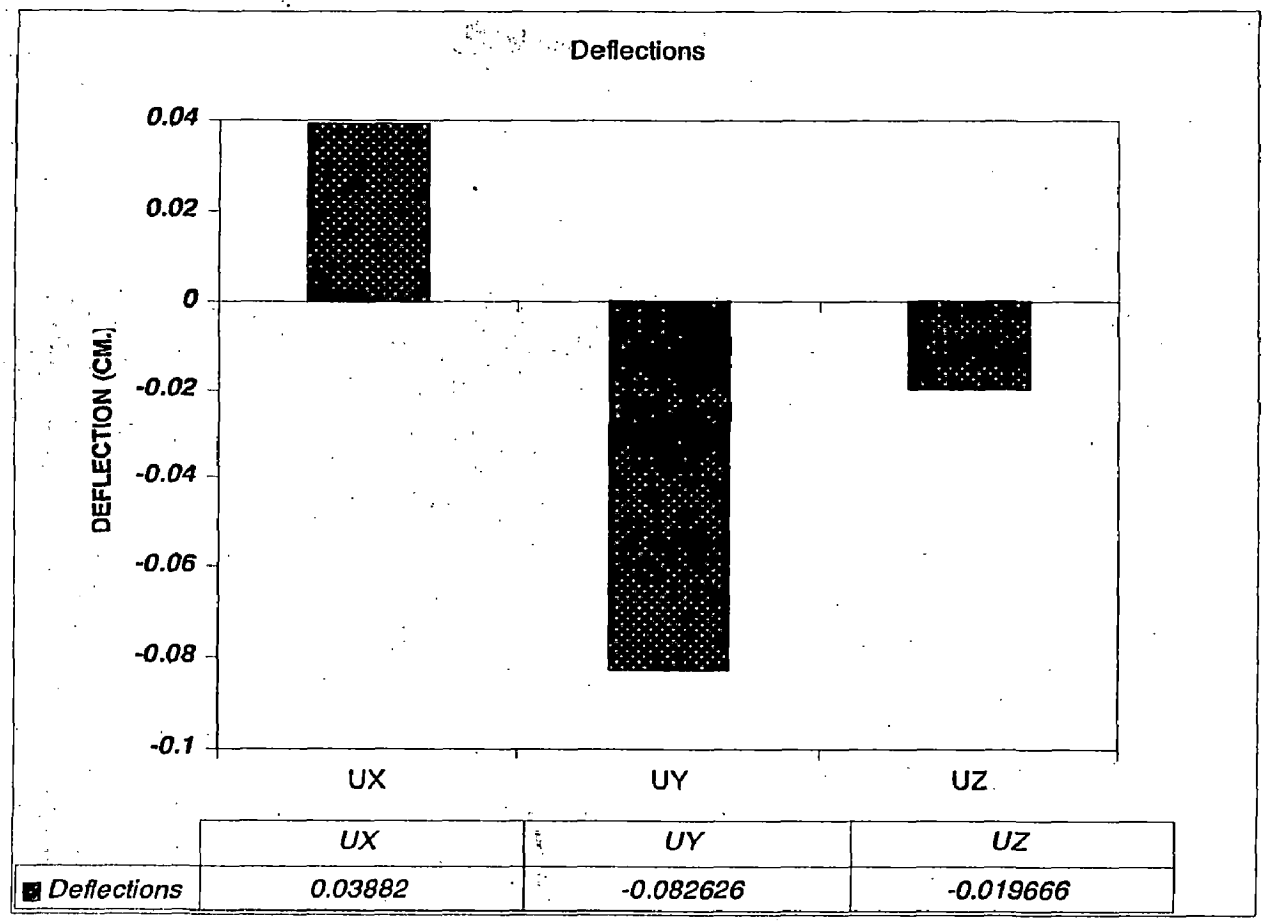


	UX	UY	UZ
Deflections	0.019346	-0.080234	-0.018729

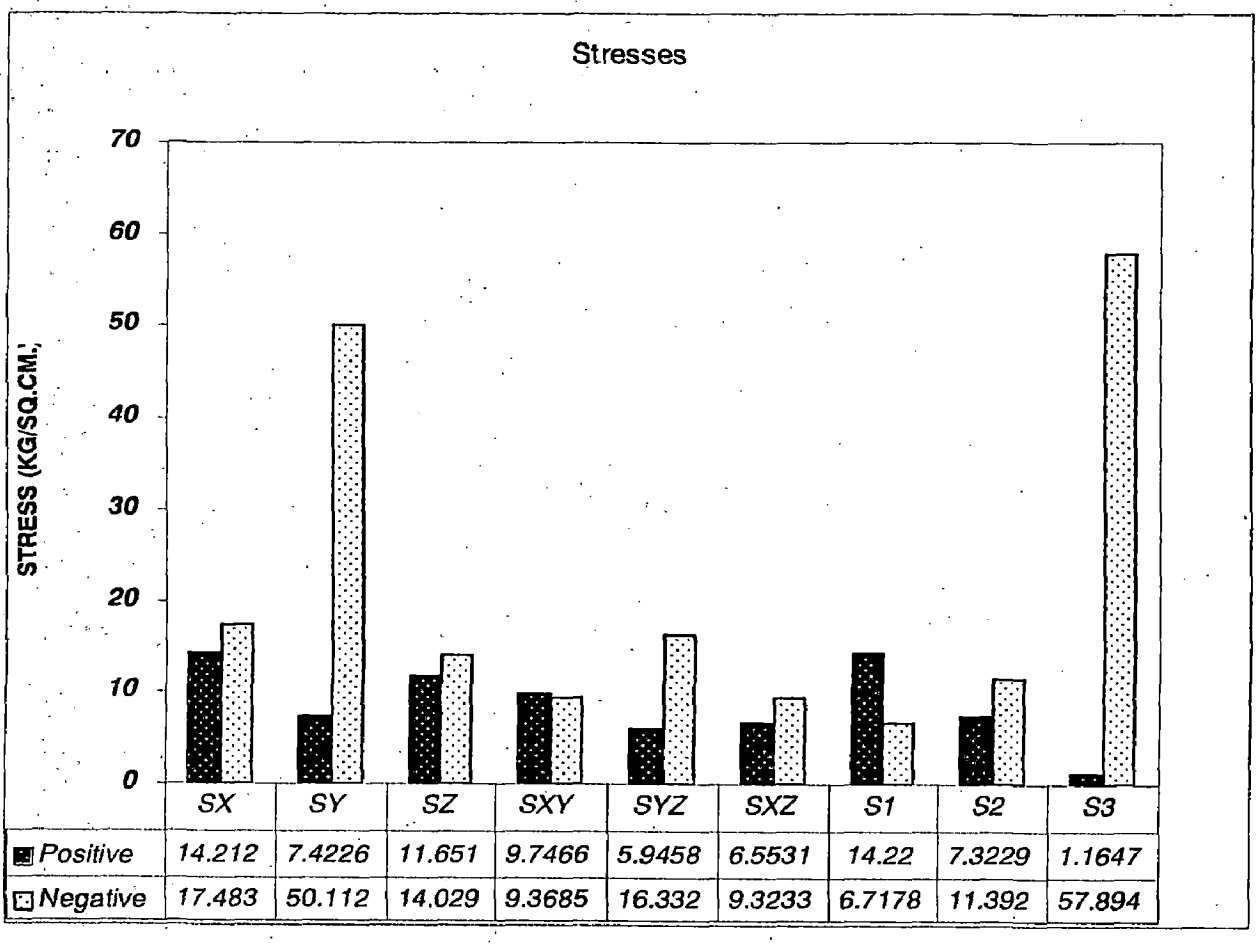


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	13.401	7.4495	9.6446	8.9415	5.6956	7.1396	13.865	7.2271	1.0975
Negative	13.817	48.363	13.123	9.7361	15.599	6.964	6.3628	9.1598	55.066

FIG. 5.41 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1a(i)

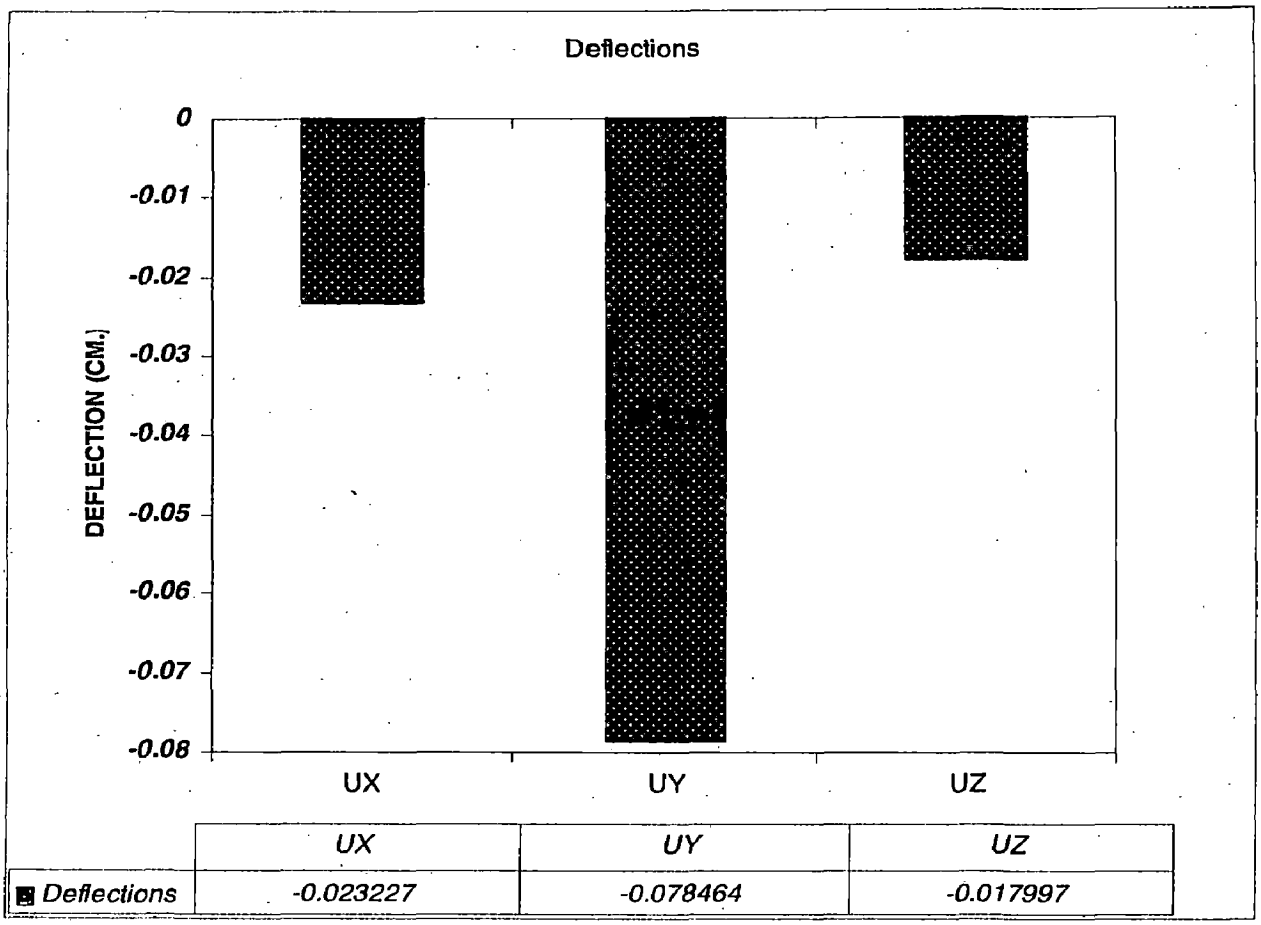


	UX	UY	UZ
Deflections	0.03882	-0.082626	-0.019666

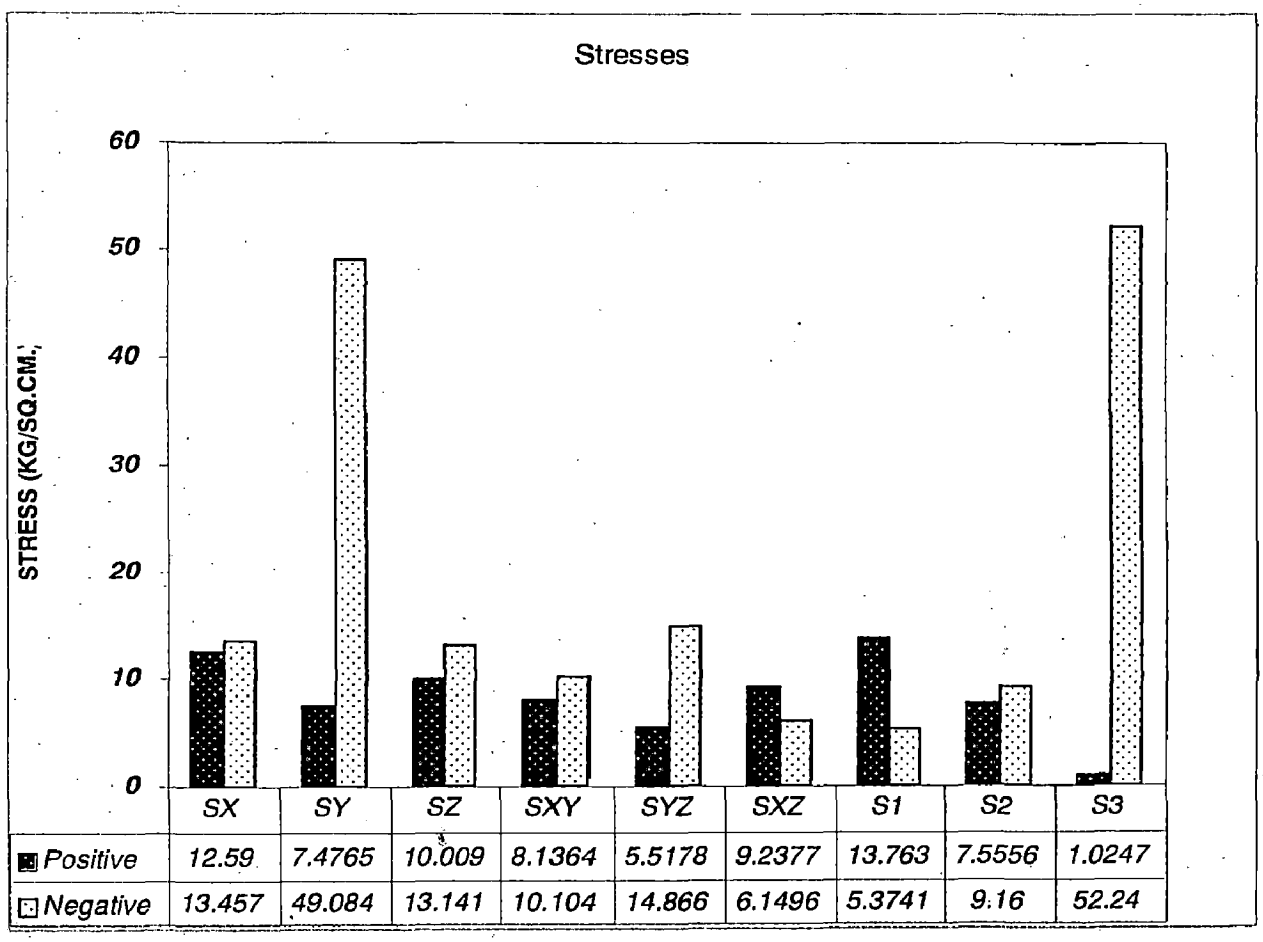


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	14.212	7.4226	11.651	9.7466	5.9458	6.5531	14.22	7.3229	1.1647
Negative	17.483	50.112	14.029	9.3685	16.332	9.3233	6.7178	11.392	57.894

FIG. 5.42 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1a(ii)

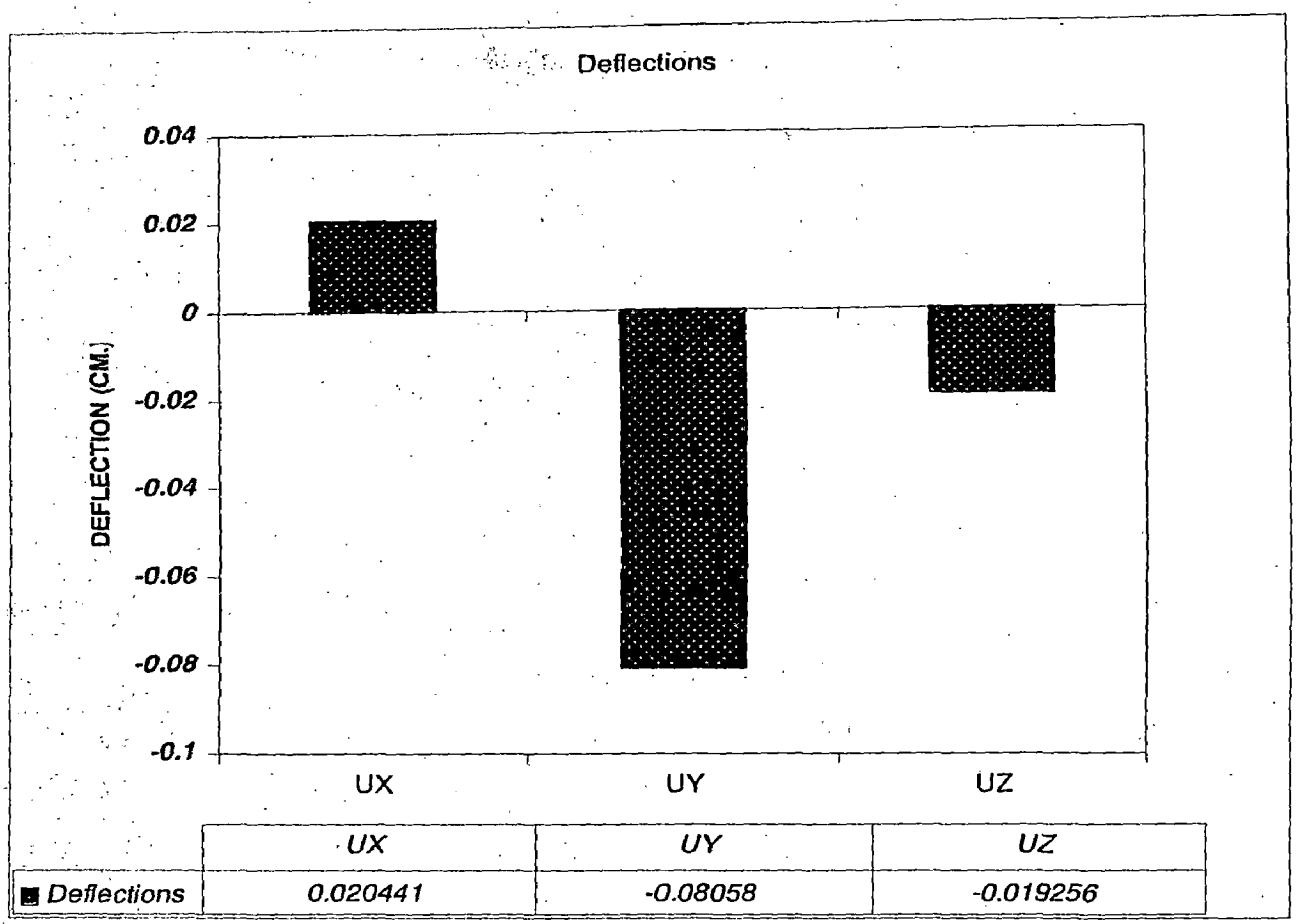


	UX	UY	UZ
Deflections	-0.023227	-0.078464	-0.017997

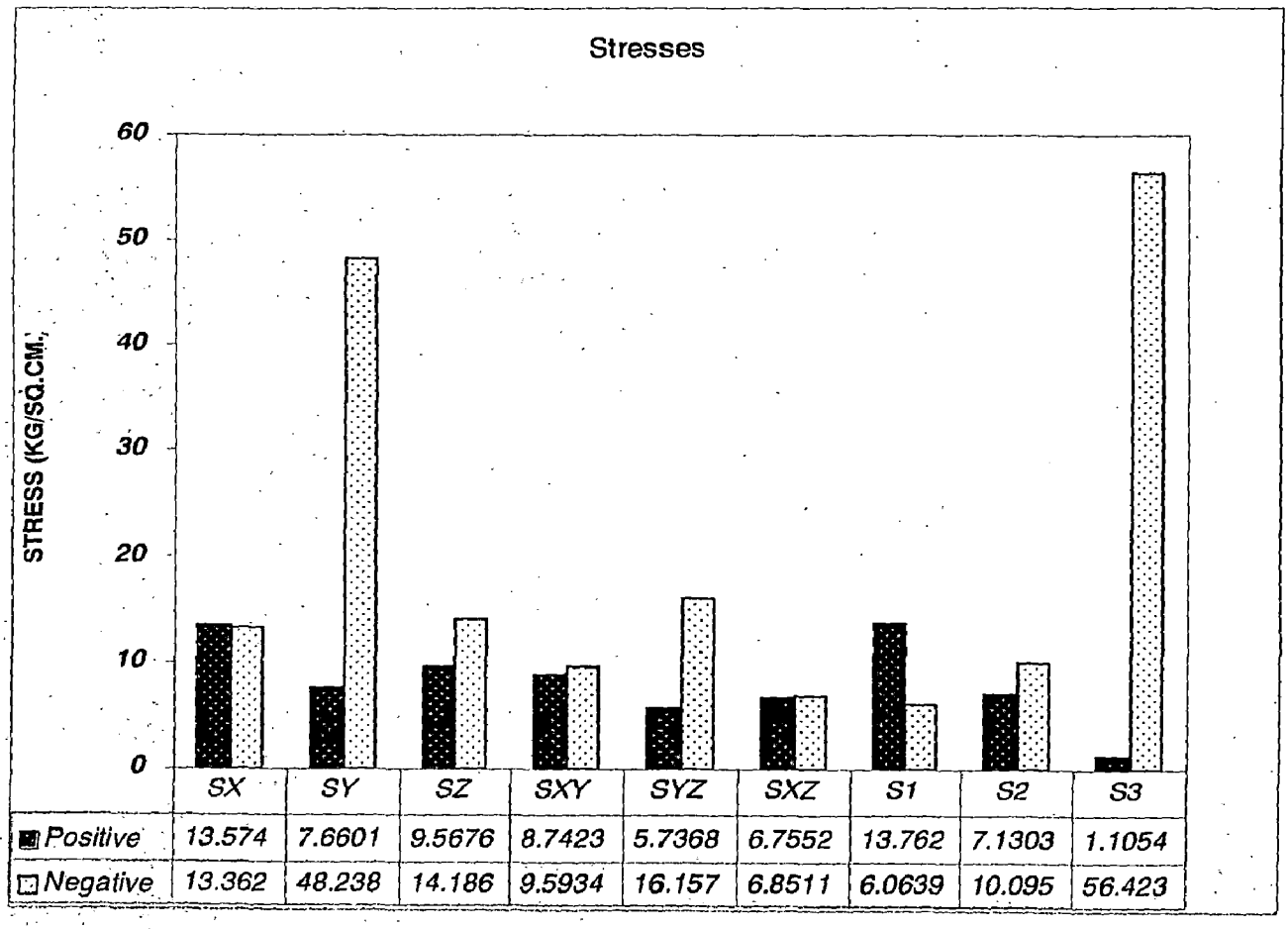


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.59	7.4765	10.009	8.1364	5.5178	9.2377	13.763	7.5556	1.0247
Negative	13.457	49.084	13.141	10.104	14.866	6.1496	5.3741	9.16	52.24

FIG. 5.43 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1a(iii)

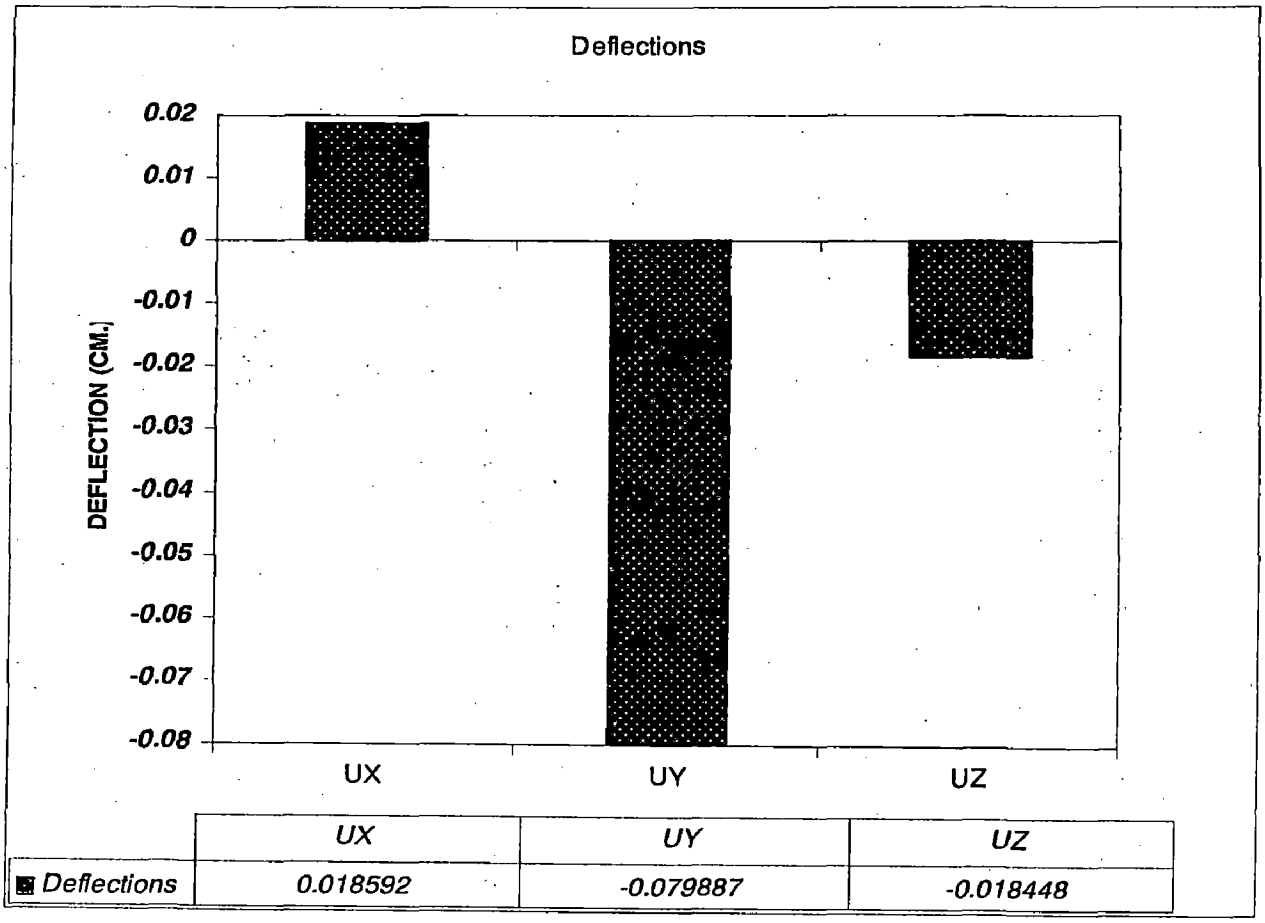


	UX	UY	UZ
Deflections	0.020441	-0.08058	-0.019256

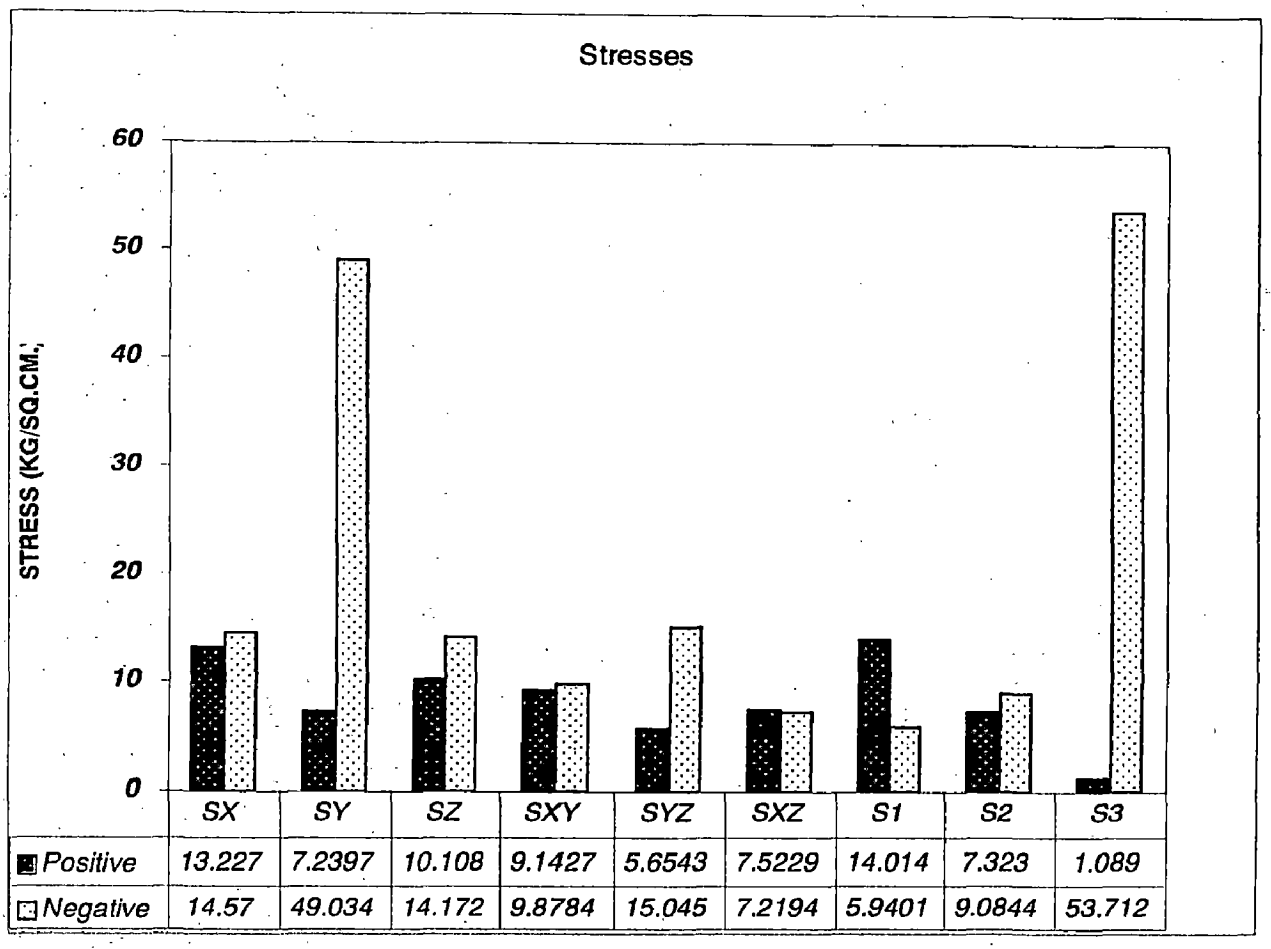


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	13.574	7.6601	9.5676	8.7423	5.7368	6.7552	13.762	7.1303	1.1054
Negative	13.362	48.238	14.186	9.5934	16.157	6.8511	6.0639	10.095	56.423

FIG. 5.44 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1a(iv)

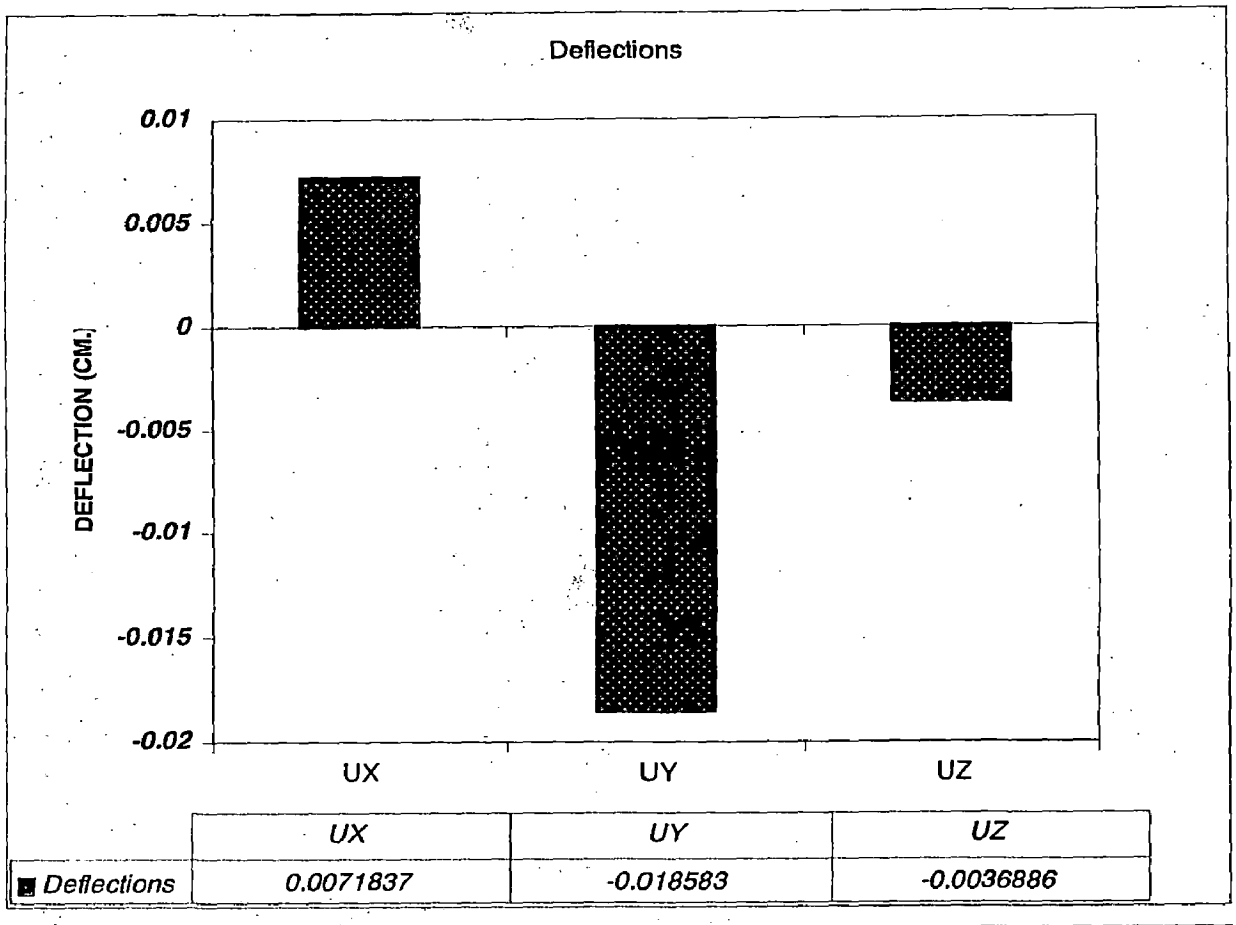


	UX	UY	UZ
Deflections	0.018592	-0.079887	-0.018448

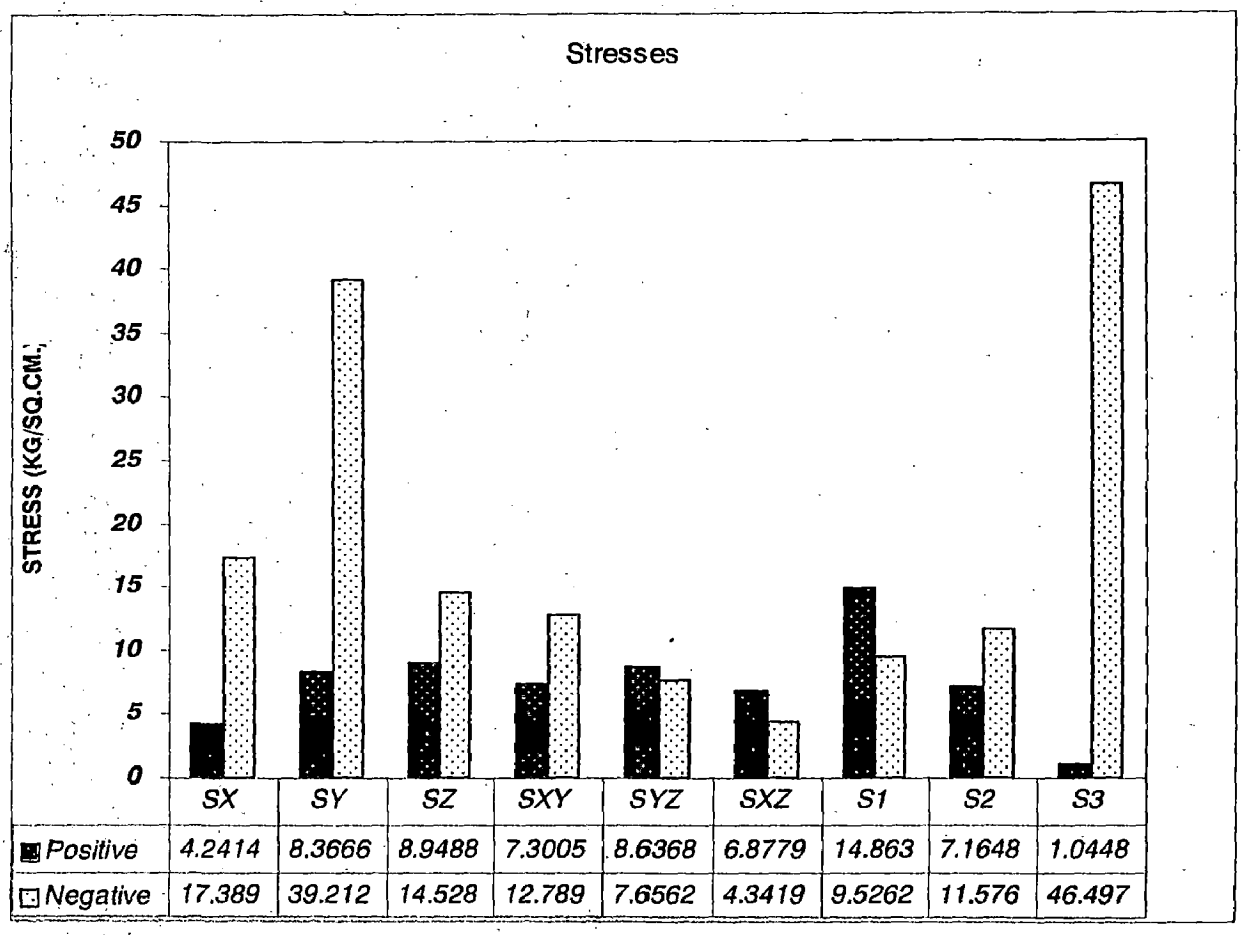


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	13.227	7.2397	10.108	9.1427	5.6543	7.5229	14.014	7.323	1.089
Negative	14.57	49.034	14.172	9.8784	15.045	7.2194	5.9401	9.0844	53.712

FIG. 5.45 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1a(v)

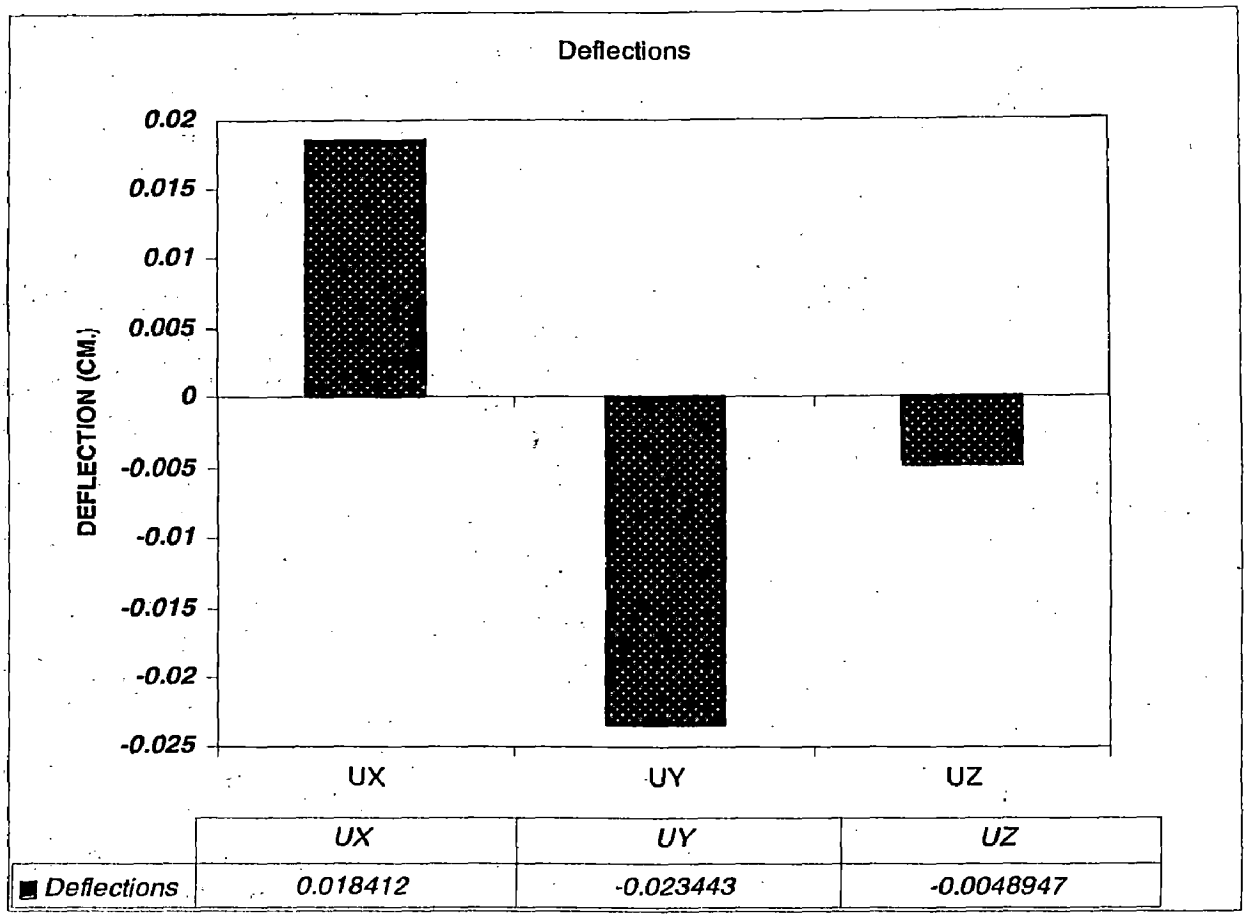


	UX	UY	UZ
Deflections	0.0071837	-0.018583	-0.0036886

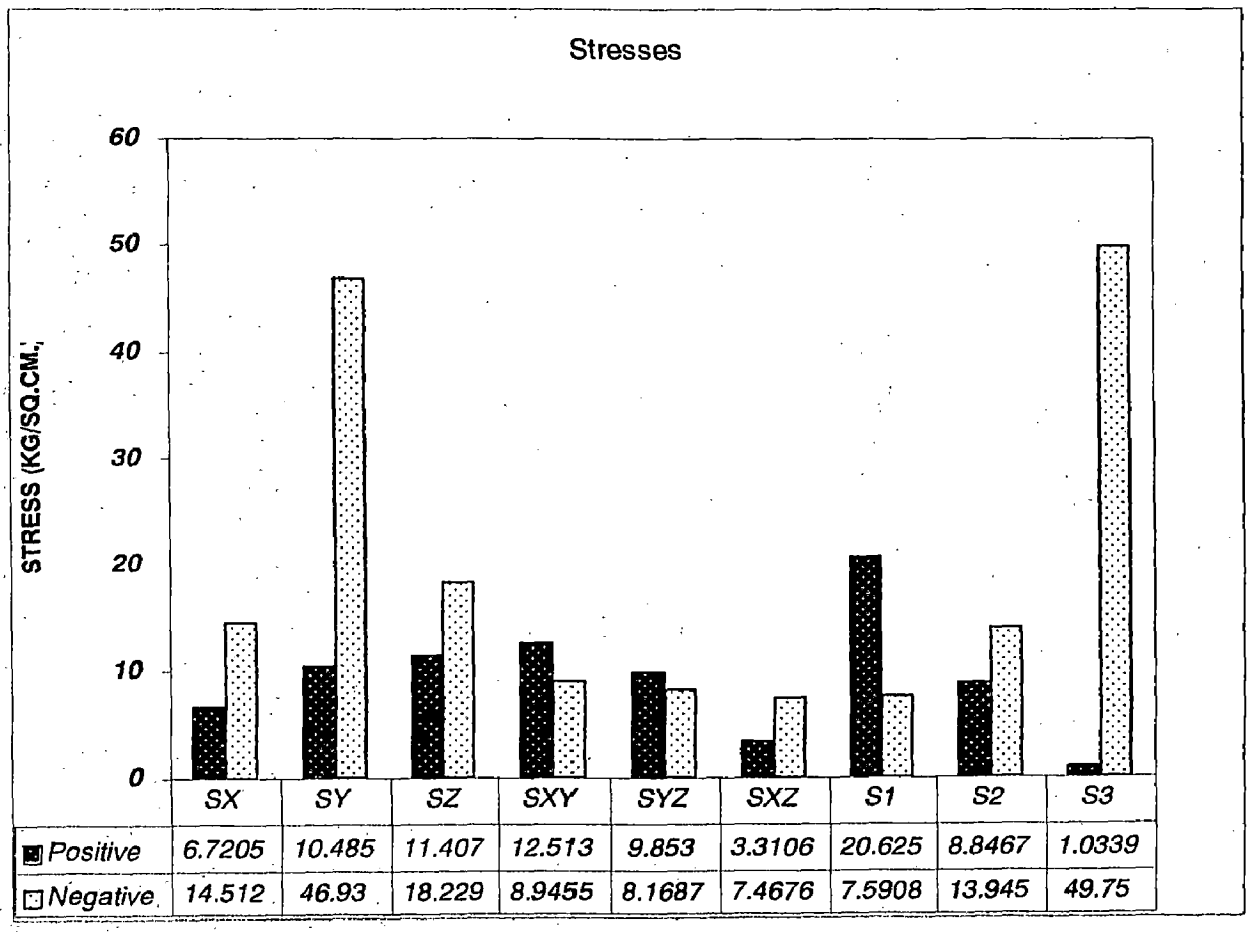


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	4.2414	8.3666	8.9488	7.3005	8.6368	6.8779	14.863	7.1648	1.0448
Negative	17.389	39.212	14.528	12.789	7.6562	4.3419	9.5262	11.576	46.497

FIG. 5.46 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1b(i)

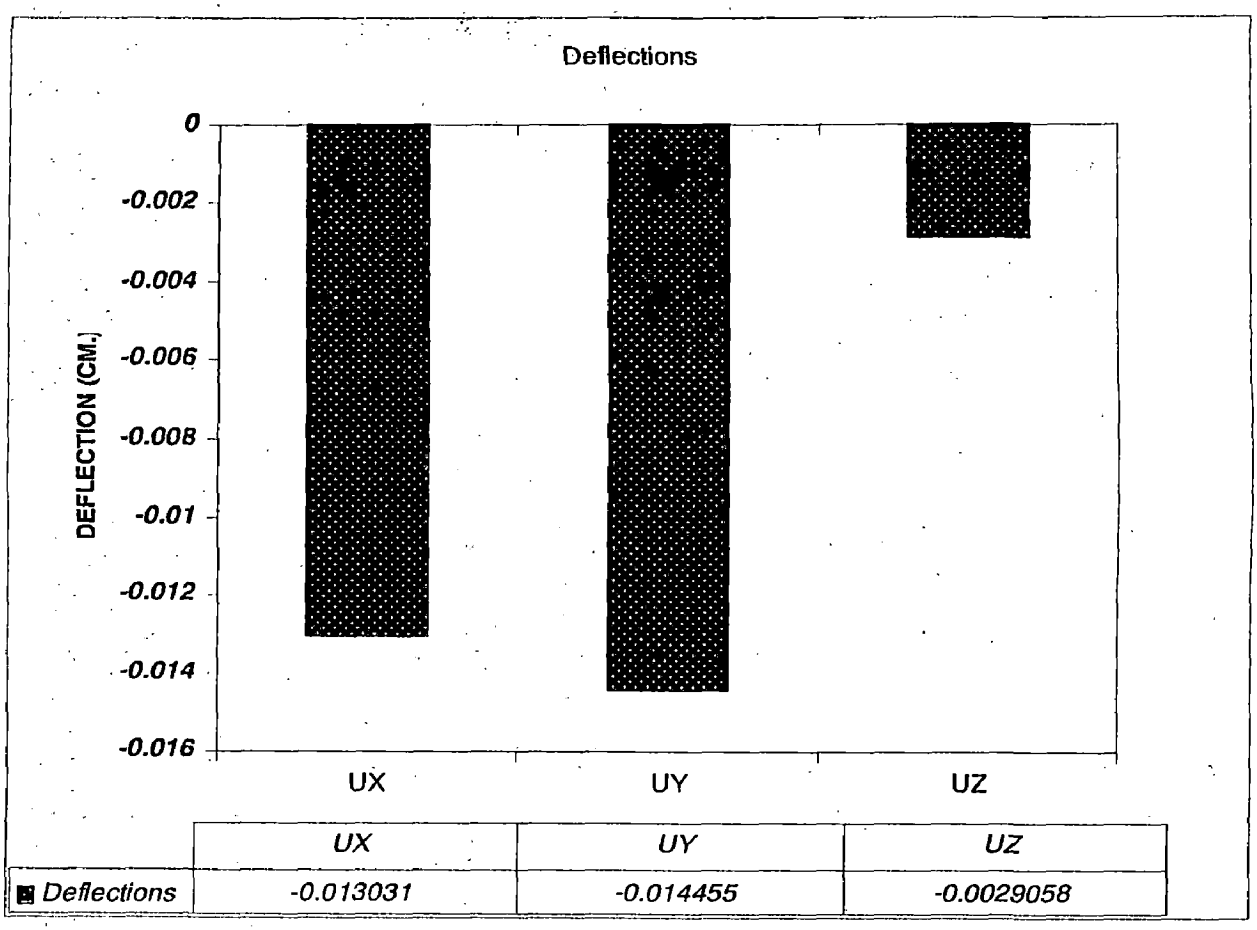


	UX	UY	UZ
Deflections	0.018412	-0.023443	-0.0048947

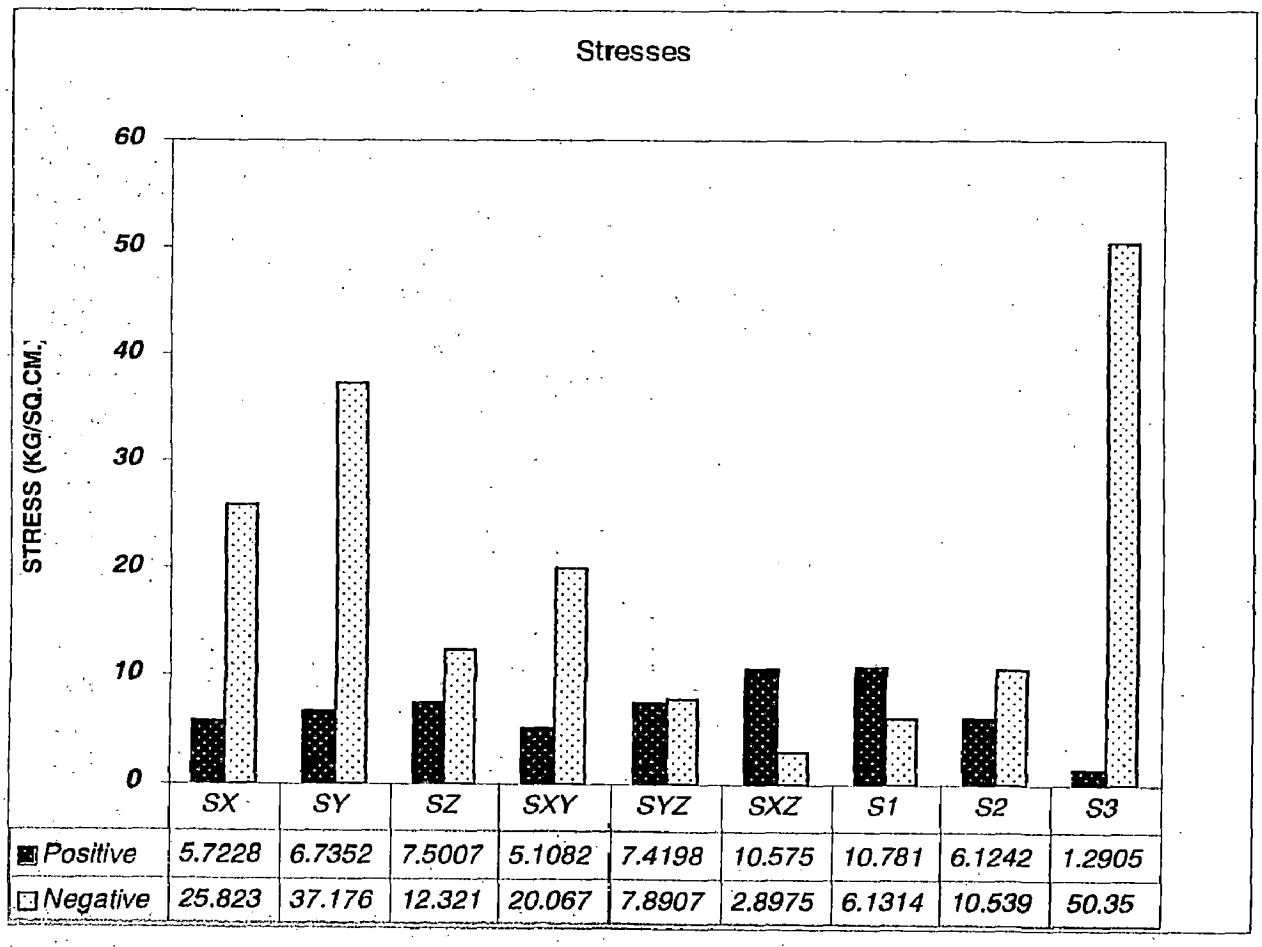


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	6.7205	10.485	11.407	12.513	9.853	3.3106	20.625	8.8467	1.0339
Negative	14.512	46.93	18.229	8.9455	8.1687	7.4676	7.5908	13.945	49.75

FIG. 5.47 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1b(ii)

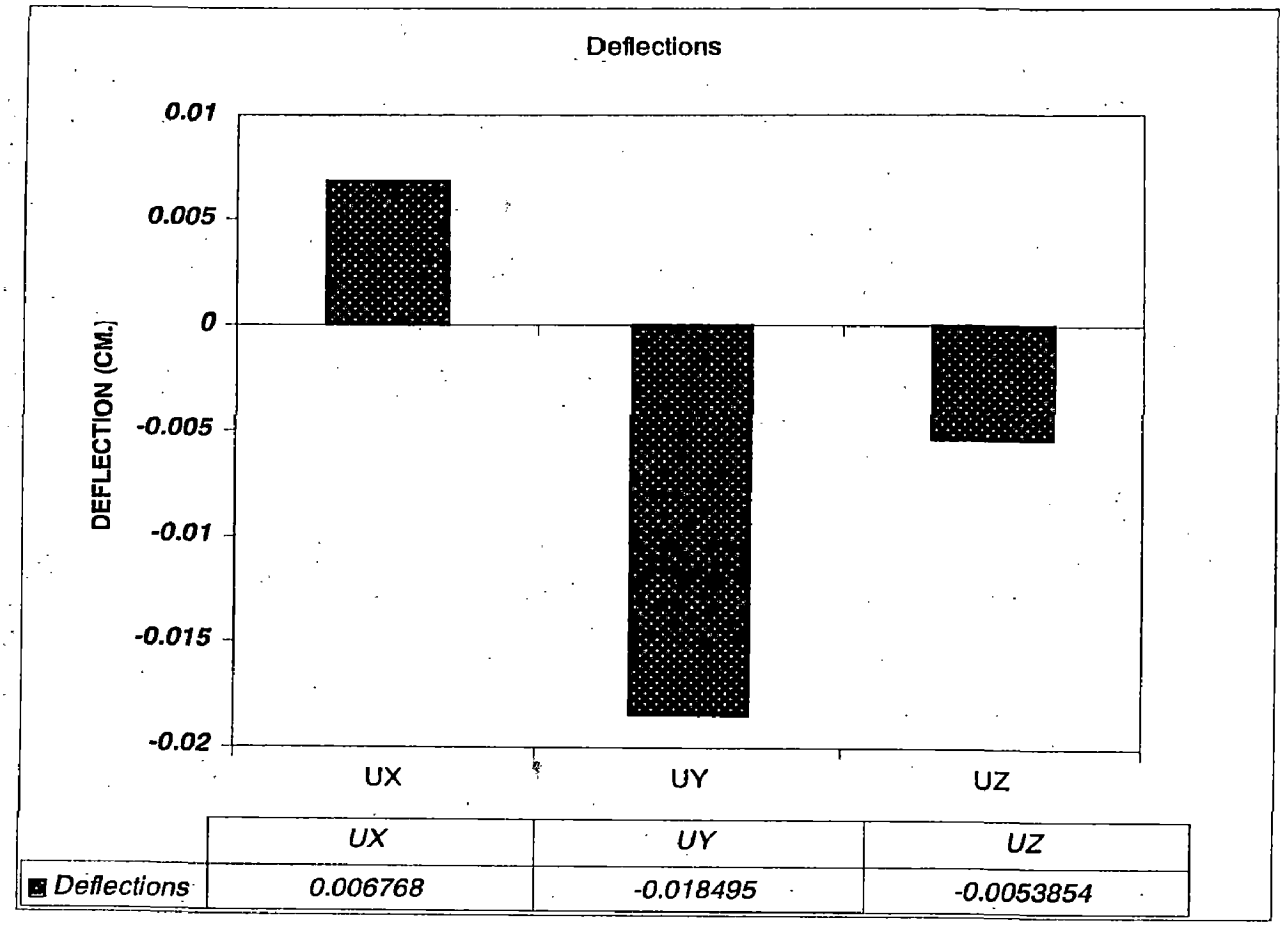


	UX	UY	UZ
Deflections	-0.013031	-0.014455	-0.0029058

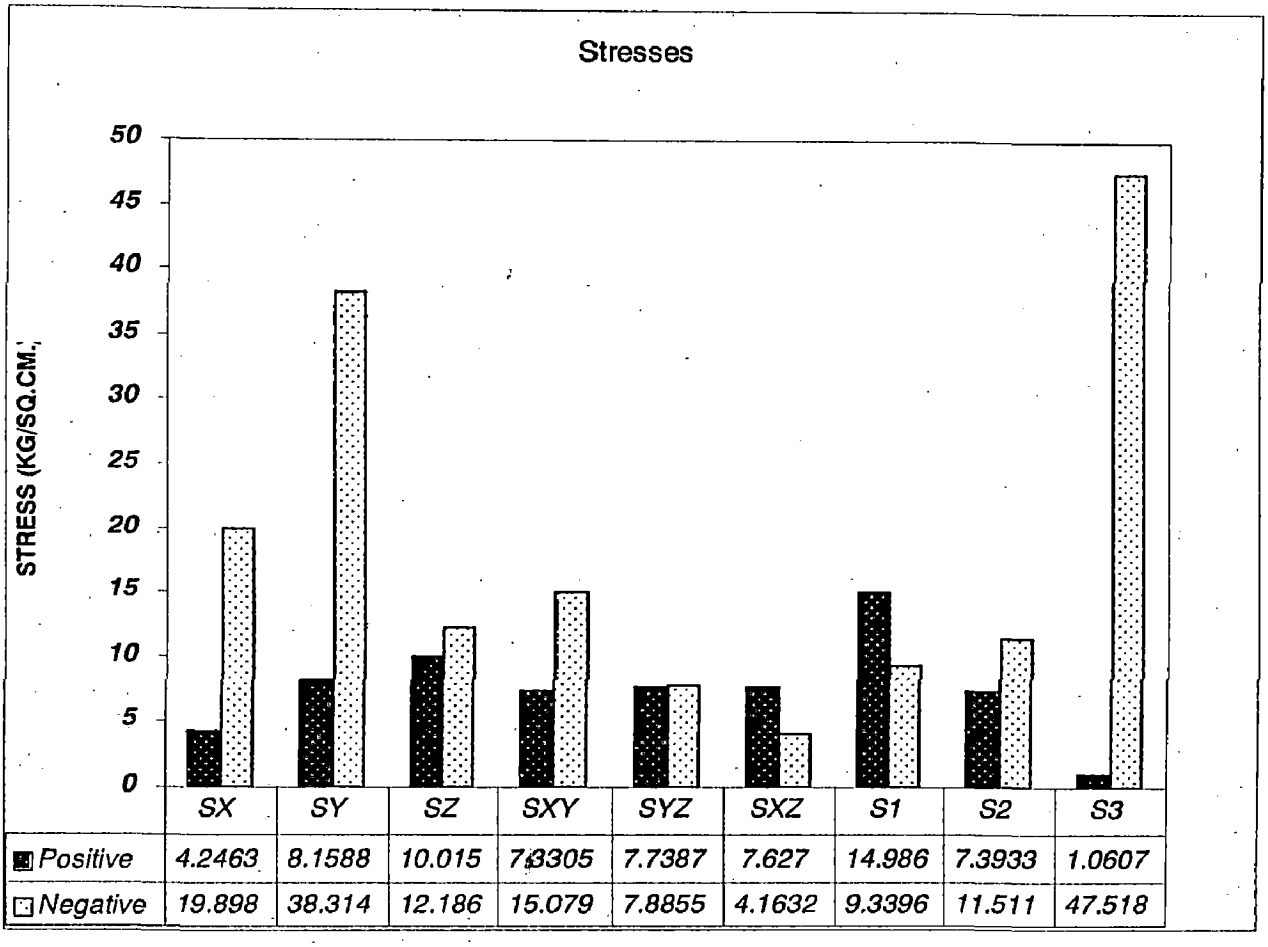


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	5.7228	6.7352	7.5007	5.1082	7.4198	10.575	10.781	6.1242	1.2905
Negative	25.823	37.176	12.321	20.067	7.8907	2.8975	6.1314	10.539	50.35

FIG. 5.48 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1b(ii)

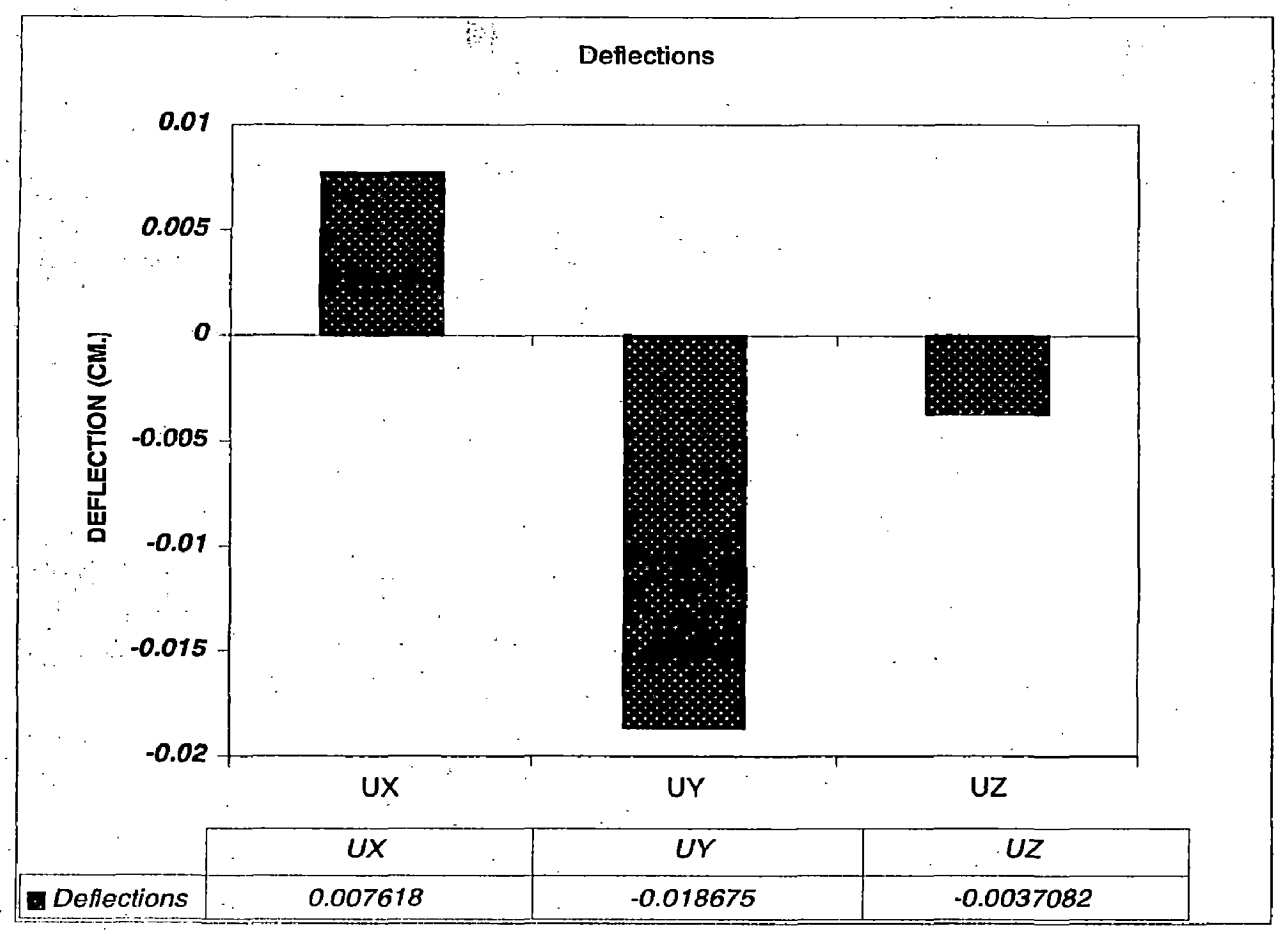


	UX	UY	UZ
Deflections	0.006768	-0.018495	-0.0053854

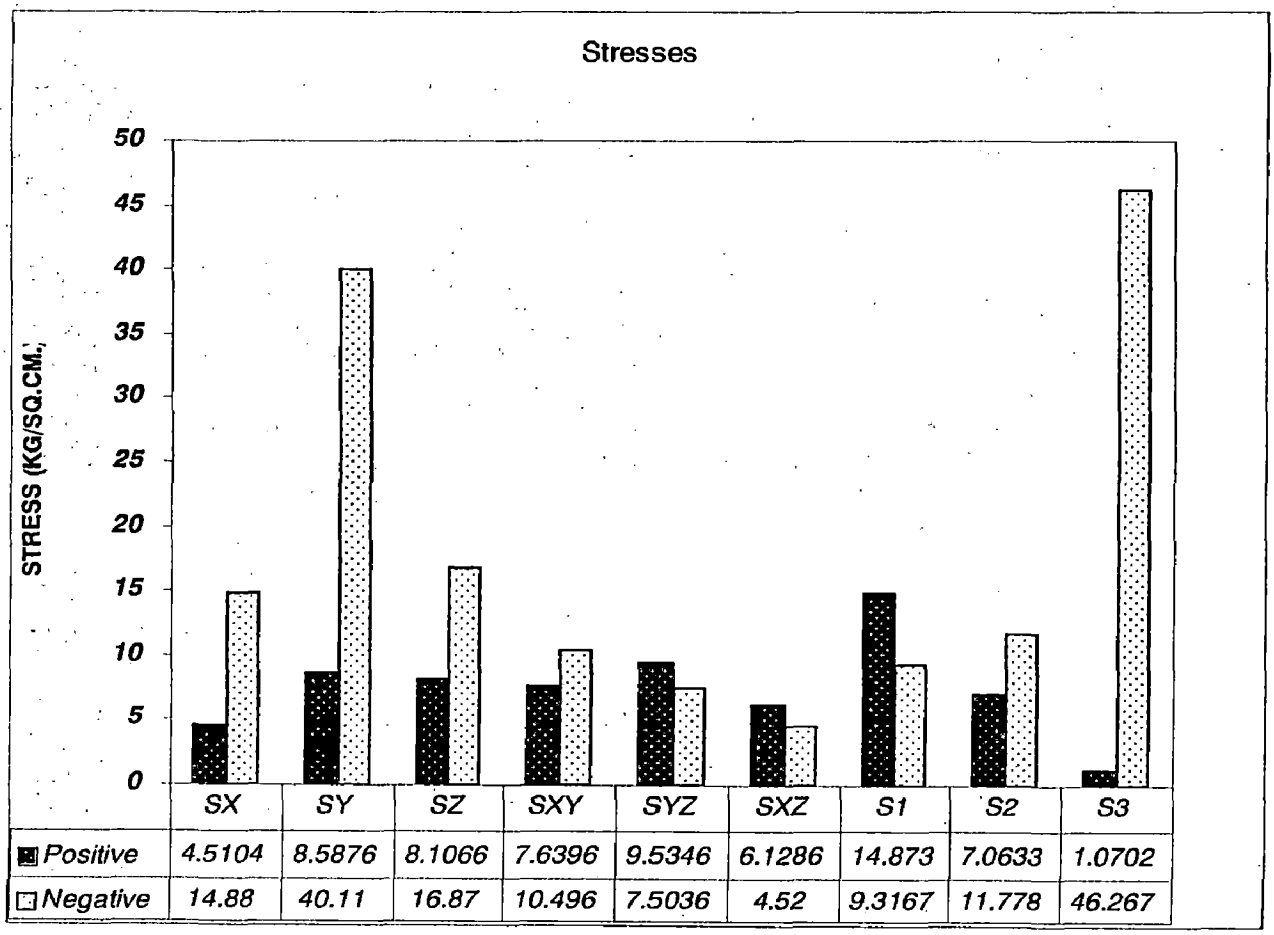


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	4.2463	8.1588	10.015	7.3305	7.7387	7.627	14.986	7.3933	1.0607
Negative	19.898	38.314	12.186	15.079	7.8855	4.1632	9.3396	11.511	47.518

FIG. 5.49 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1b(iv)

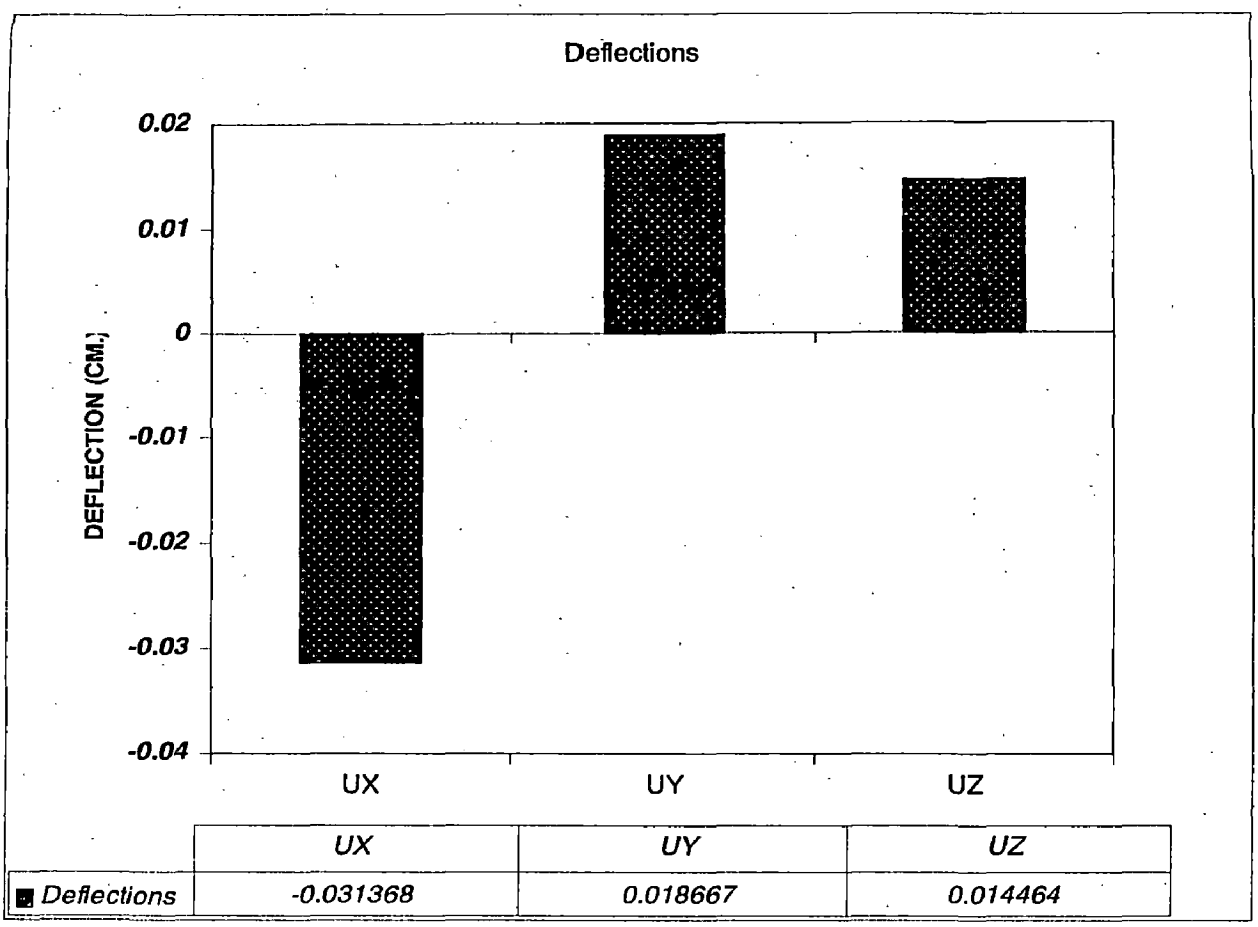


	UX	UY	UZ
Deflections	0.007618	-0.018675	-0.0037082

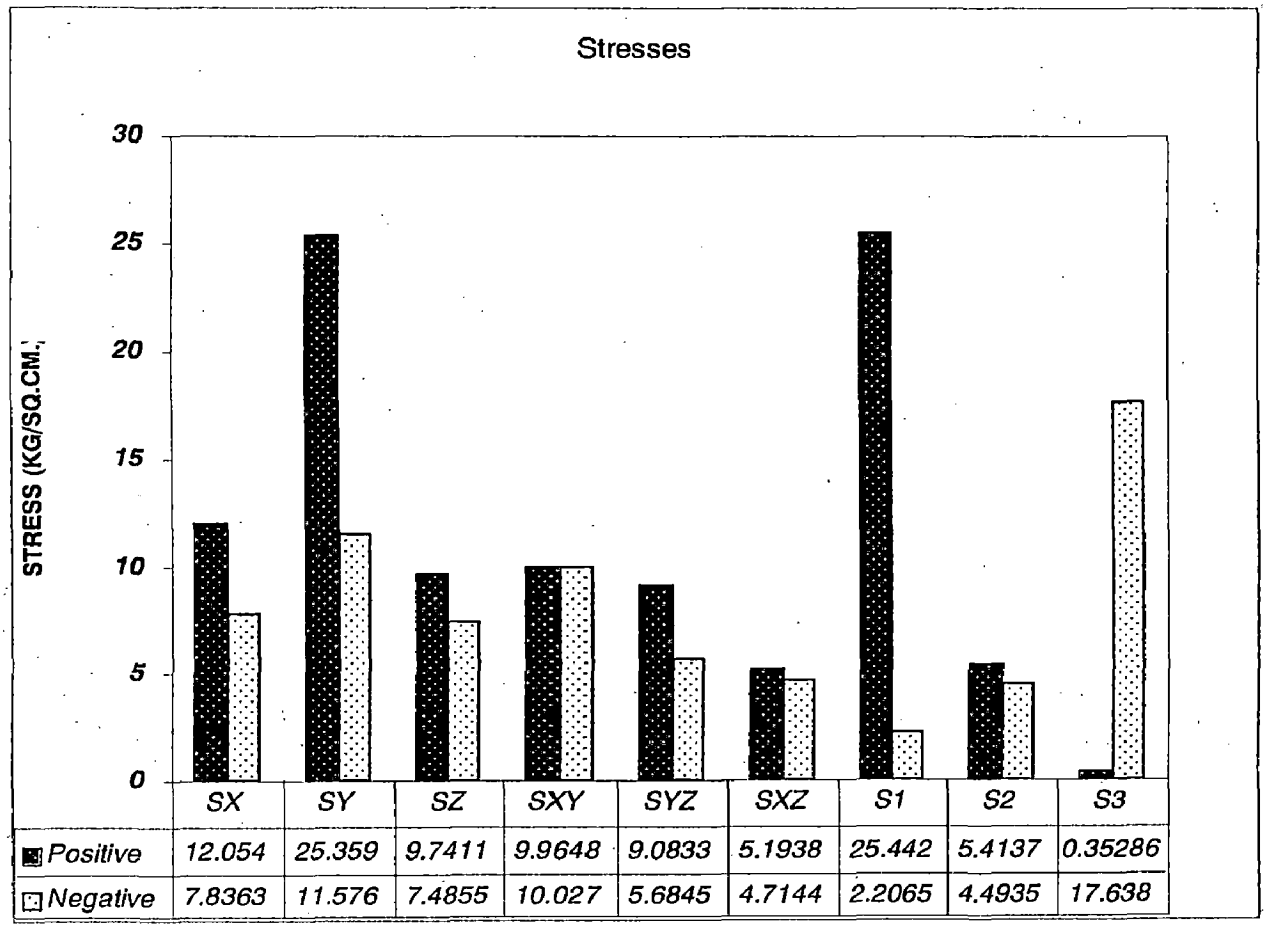


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	4.5104	8.5876	8.1066	7.6396	9.5346	6.1286	14.873	7.0633	1.0702
Negative	14.88	40.11	16.87	10.496	7.5036	4.52	9.3167	11.778	46.267

FIG. 5.50 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 1b(v)

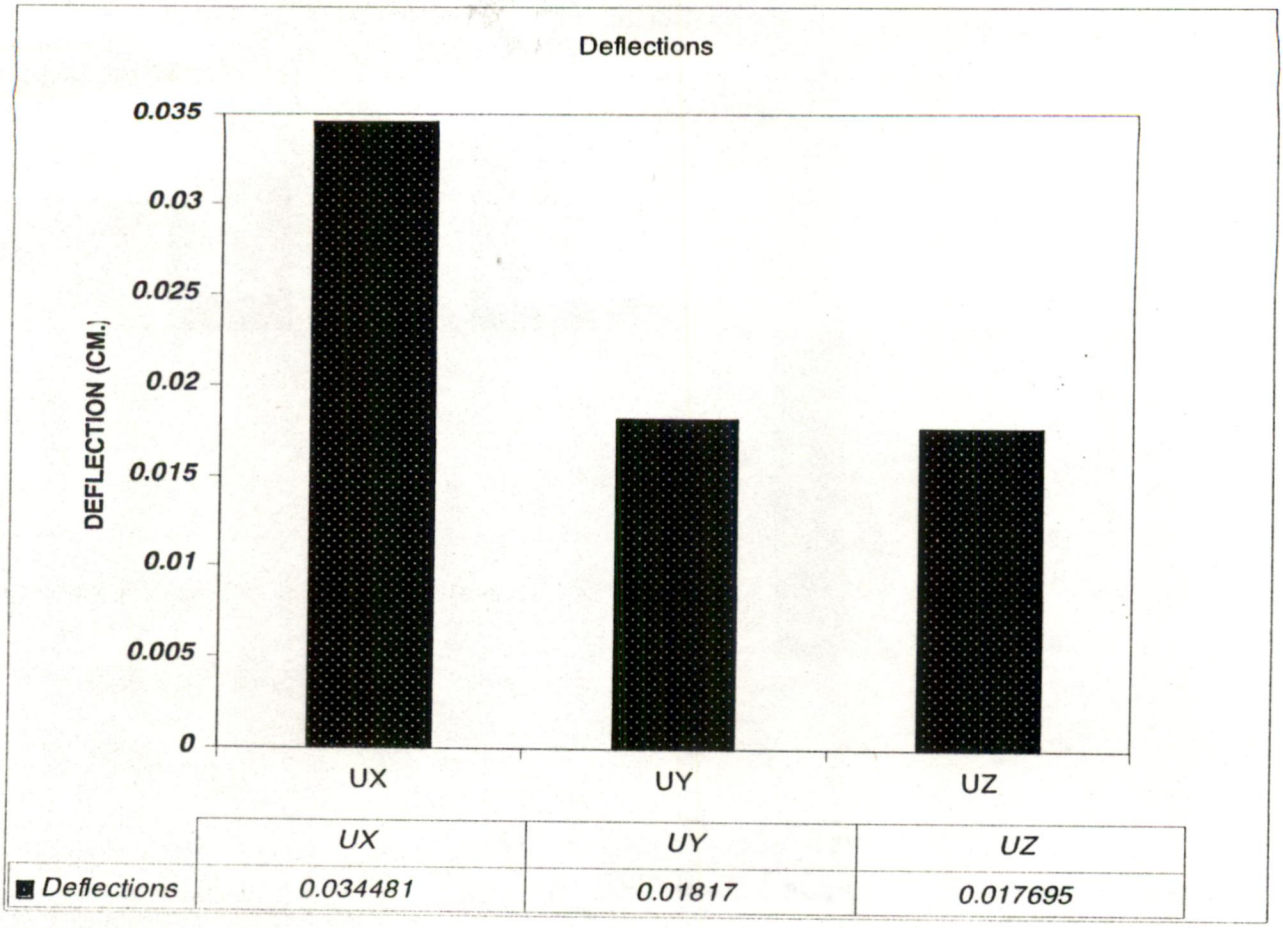


	UX	UY	UZ
Deflections	-0.031368	0.018667	0.014464

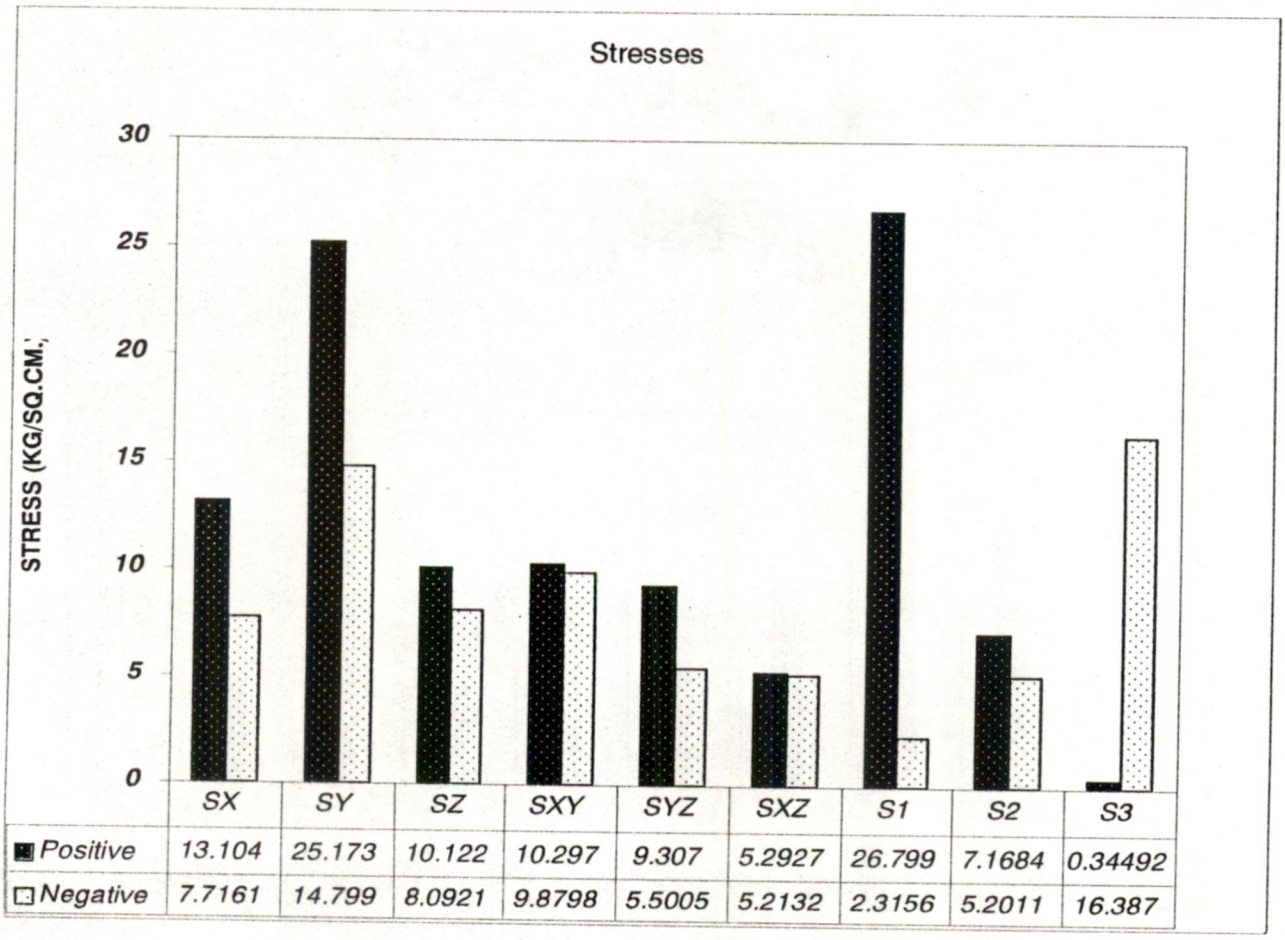


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.054	25.359	9.7411	9.9648	9.0833	5.1938	25.442	5.4137	0.35286
Negative	7.8363	11.576	7.4855	10.027	5.6845	4.7144	2.2065	4.4935	17.638

FIG. 5.51 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2a(i)

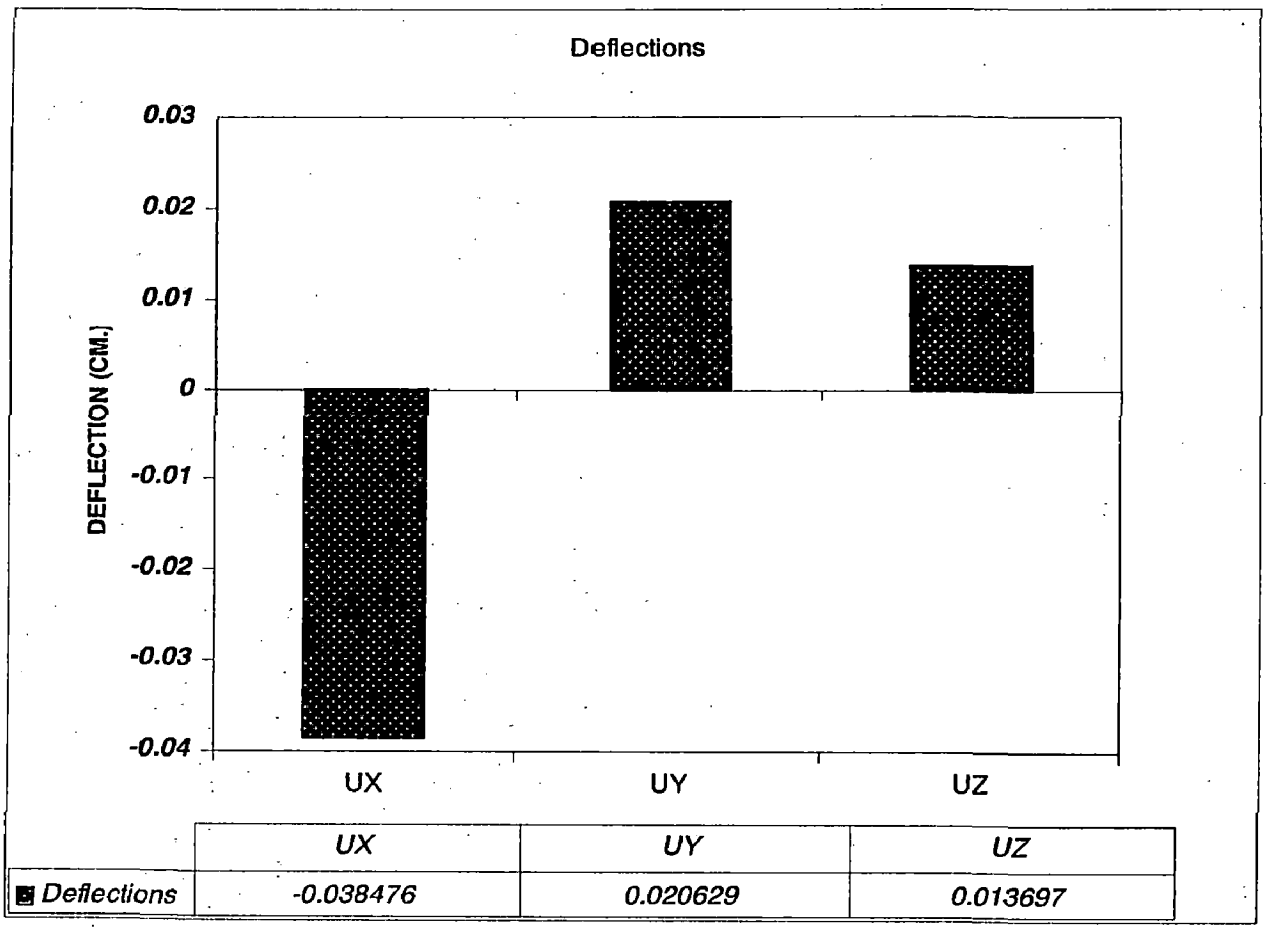


	UX	UY	UZ
Deflections	0.034481	0.01817	0.017695

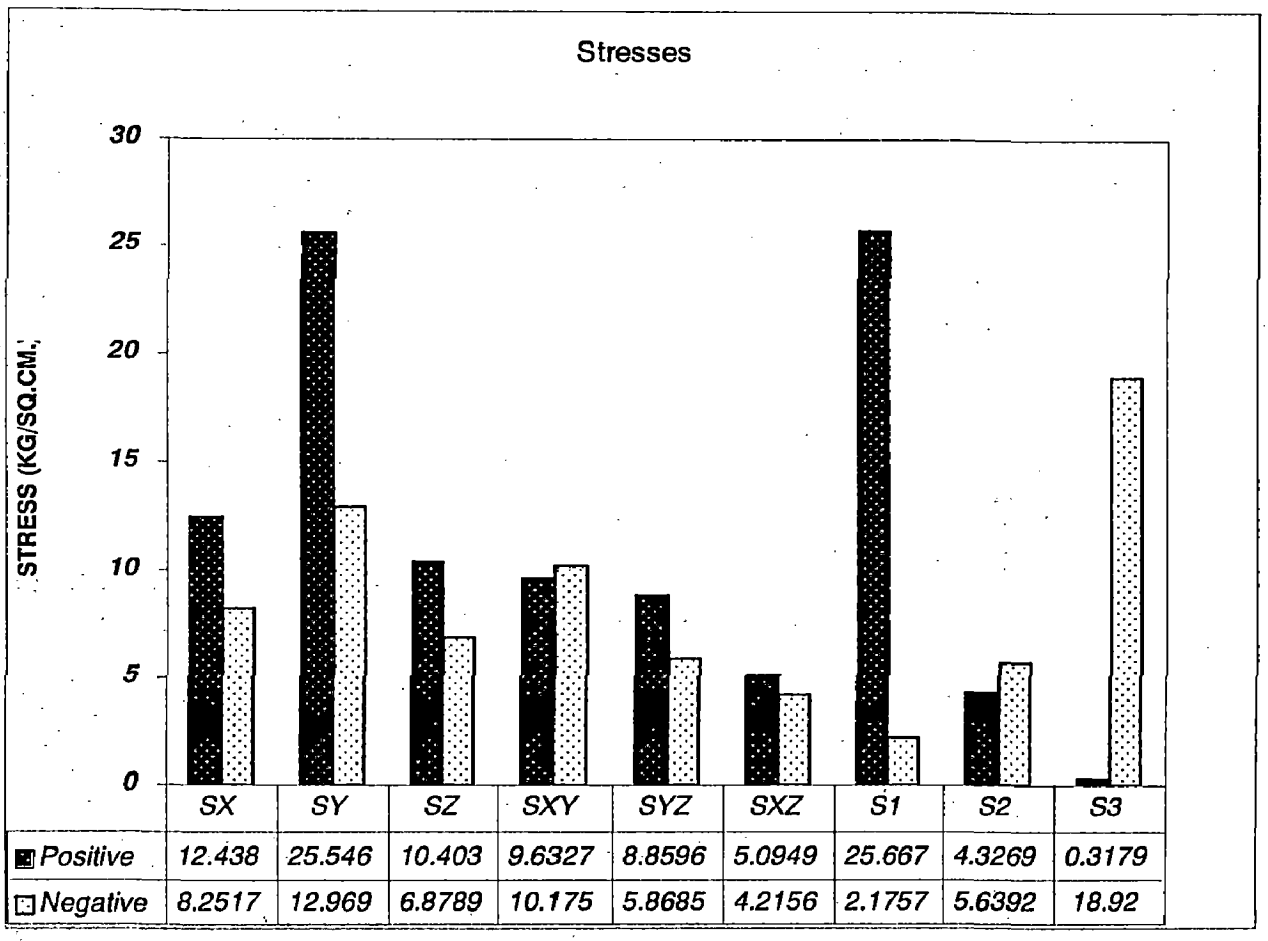


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	13.104	25.173	10.122	10.297	9.307	5.2927	26.799	7.1684	0.34492
Negative	7.7161	14.799	8.0921	9.8798	5.5005	5.2132	2.3156	5.2011	16.387

FIG. 5.52 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2a(ii)

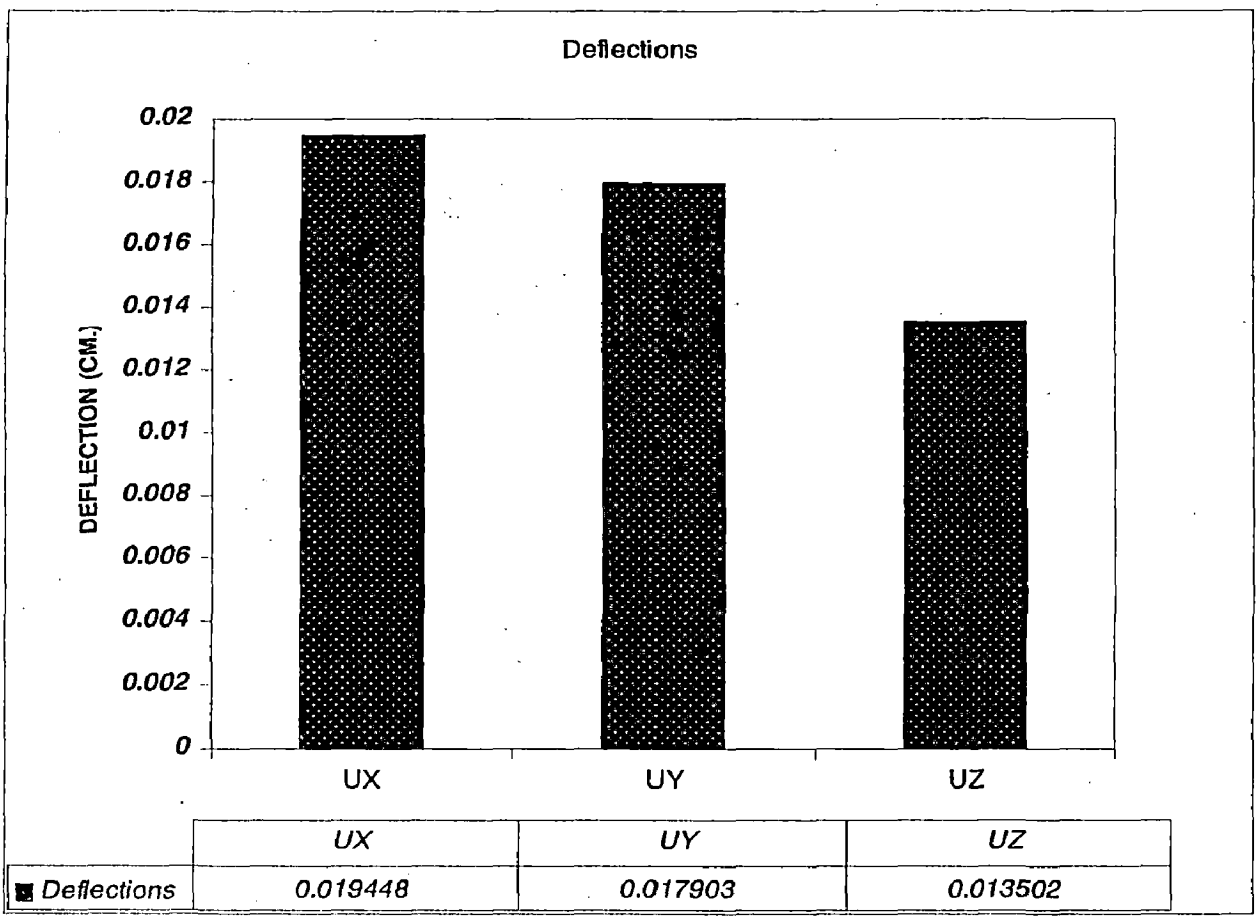


	UX	UY	UZ
Deflections	-0.038476	0.020629	0.013697

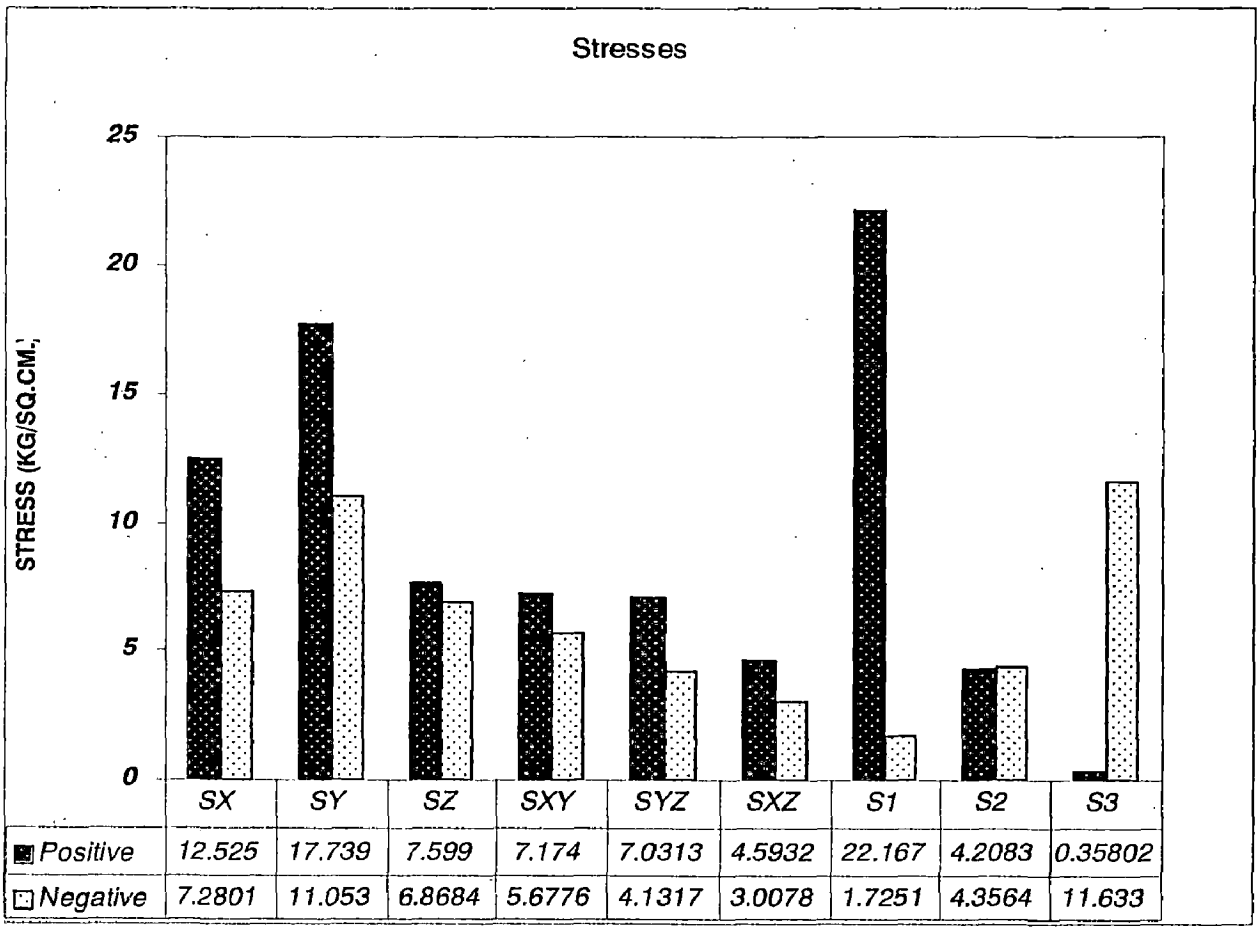


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.438	25.546	10.403	9.6327	8.8596	5.0949	25.667	4.3269	0.3179
Negative	8.2517	12.969	6.8789	10.175	5.8685	4.2156	2.1757	5.6392	18.92

FIG. 5.53 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2a(iii)

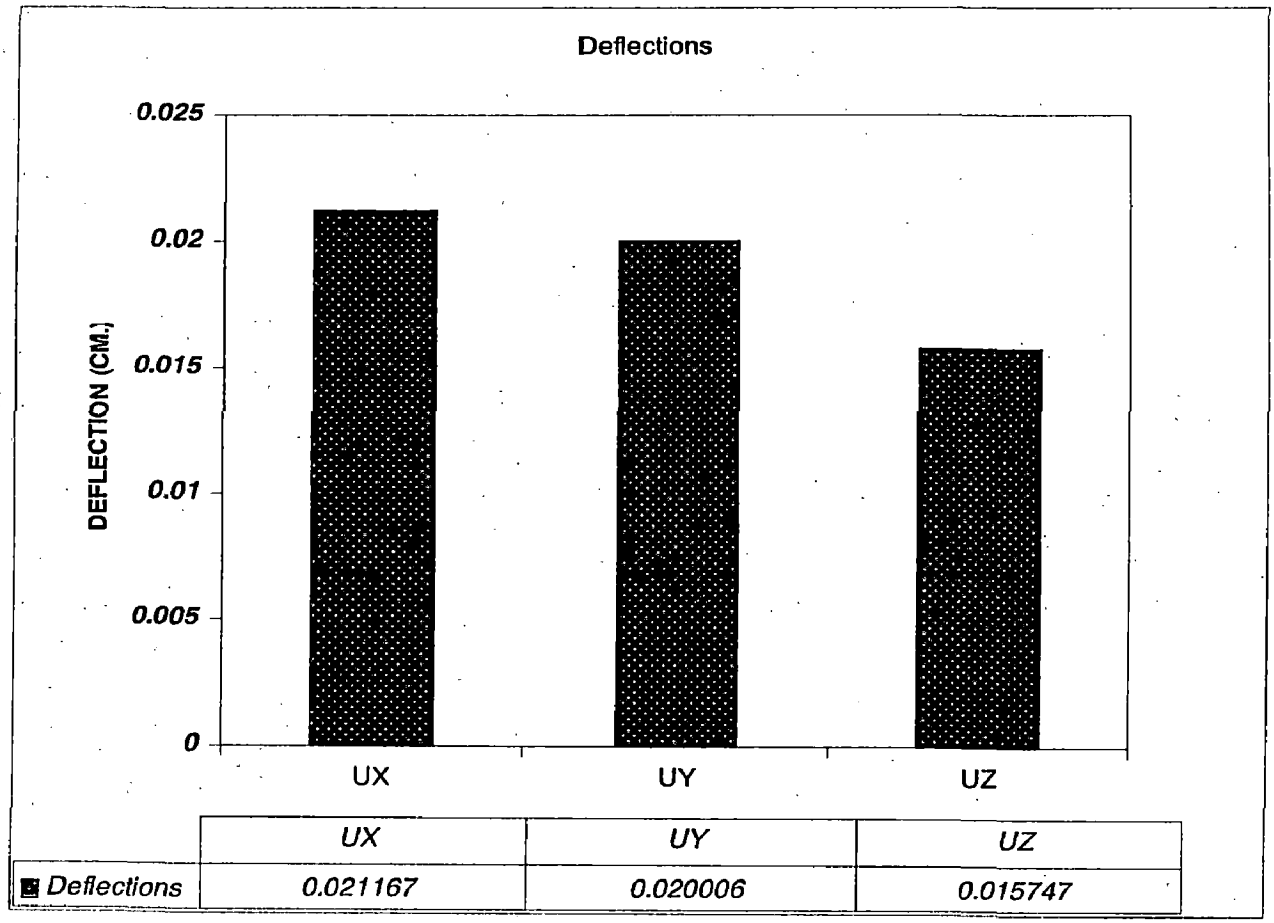


	UX	UY	UZ
Deflections	0.019448	0.017903	0.013502

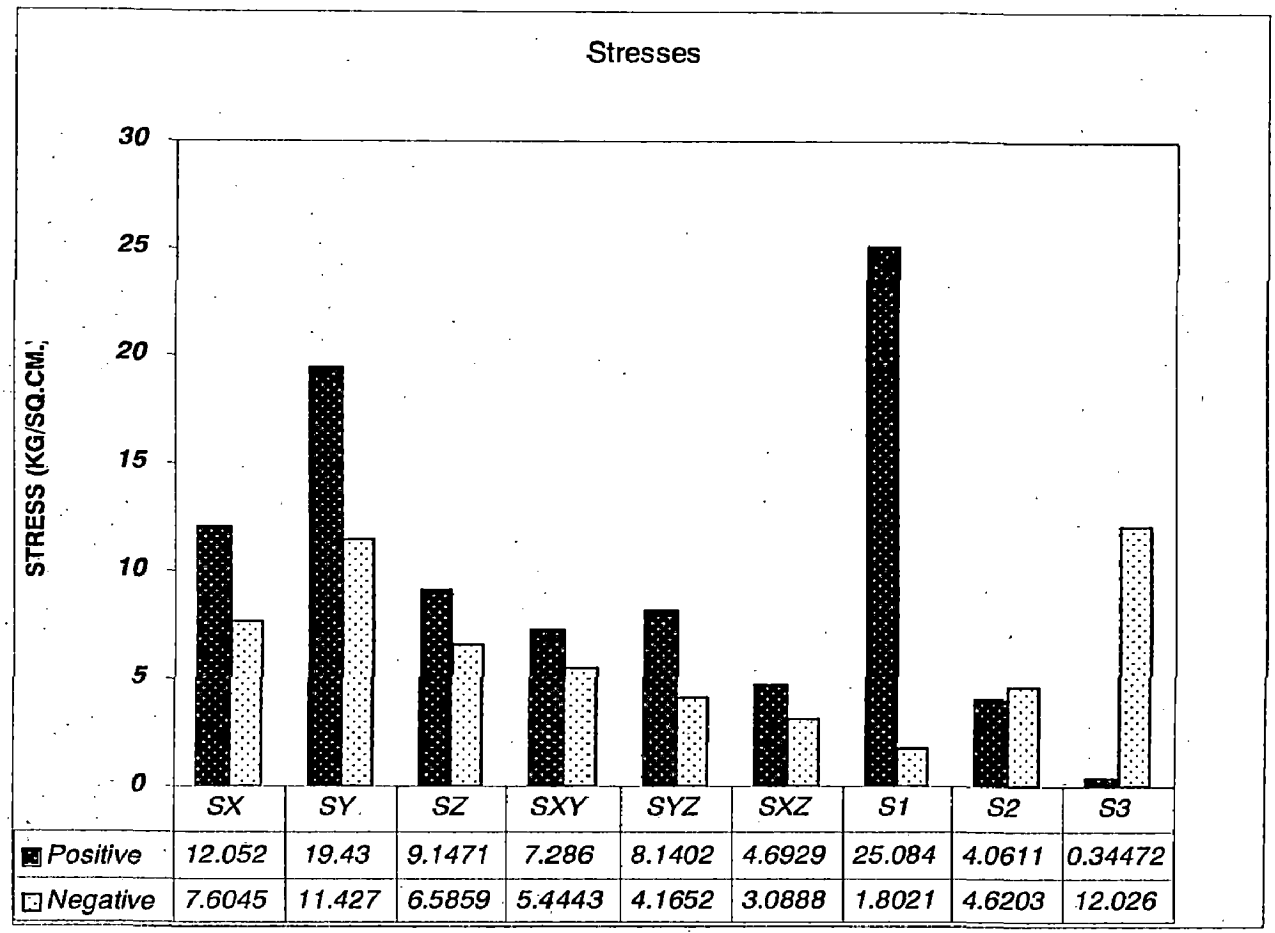


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.525	17.739	7.599	7.174	7.0313	4.5932	22.167	4.2083	0.35802
Negative	7.2801	11.053	6.8684	5.6776	4.1317	3.0078	1.7251	4.3564	11.633

FIG. 5.54 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2a(iv)

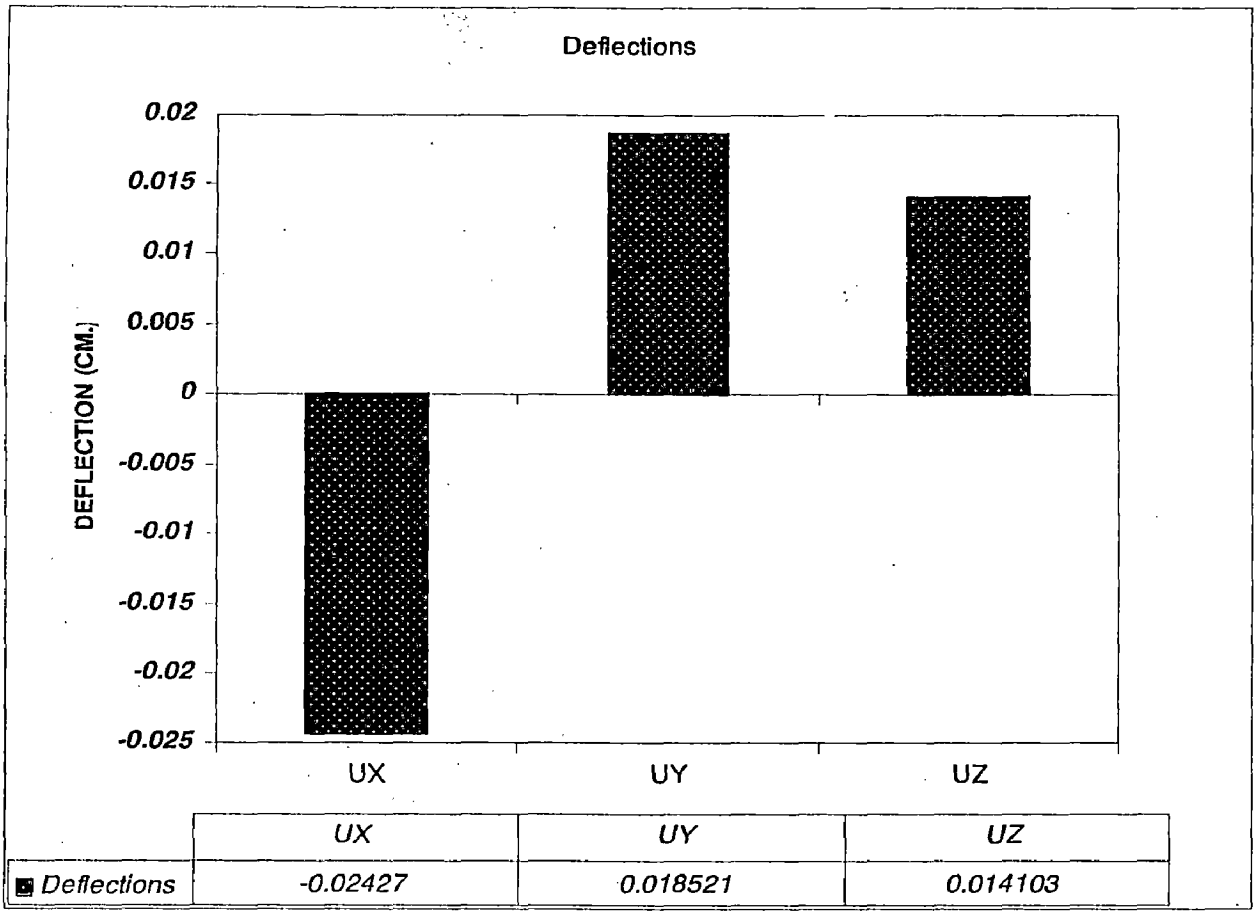


	UX	UY	UZ
Deflections	0.021167	0.020006	0.015747

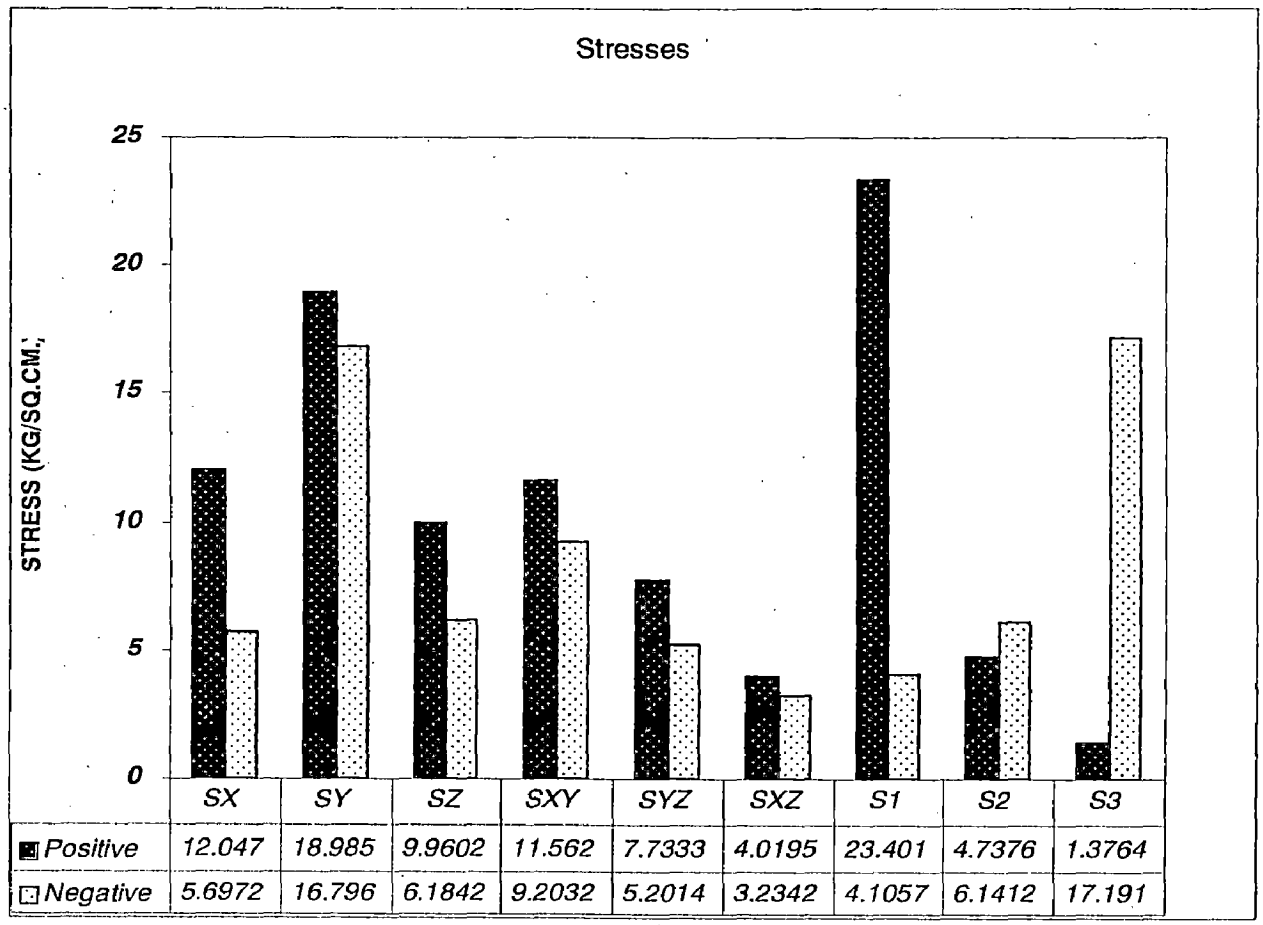


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.052	19.43	9.1471	7.286	8.1402	4.6929	25.084	4.0611	0.34472
Negative	7.6045	11.427	6.5859	5.4443	4.1652	3.0888	1.8021	4.6203	12.026

FIG. 5.55 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2a(v)

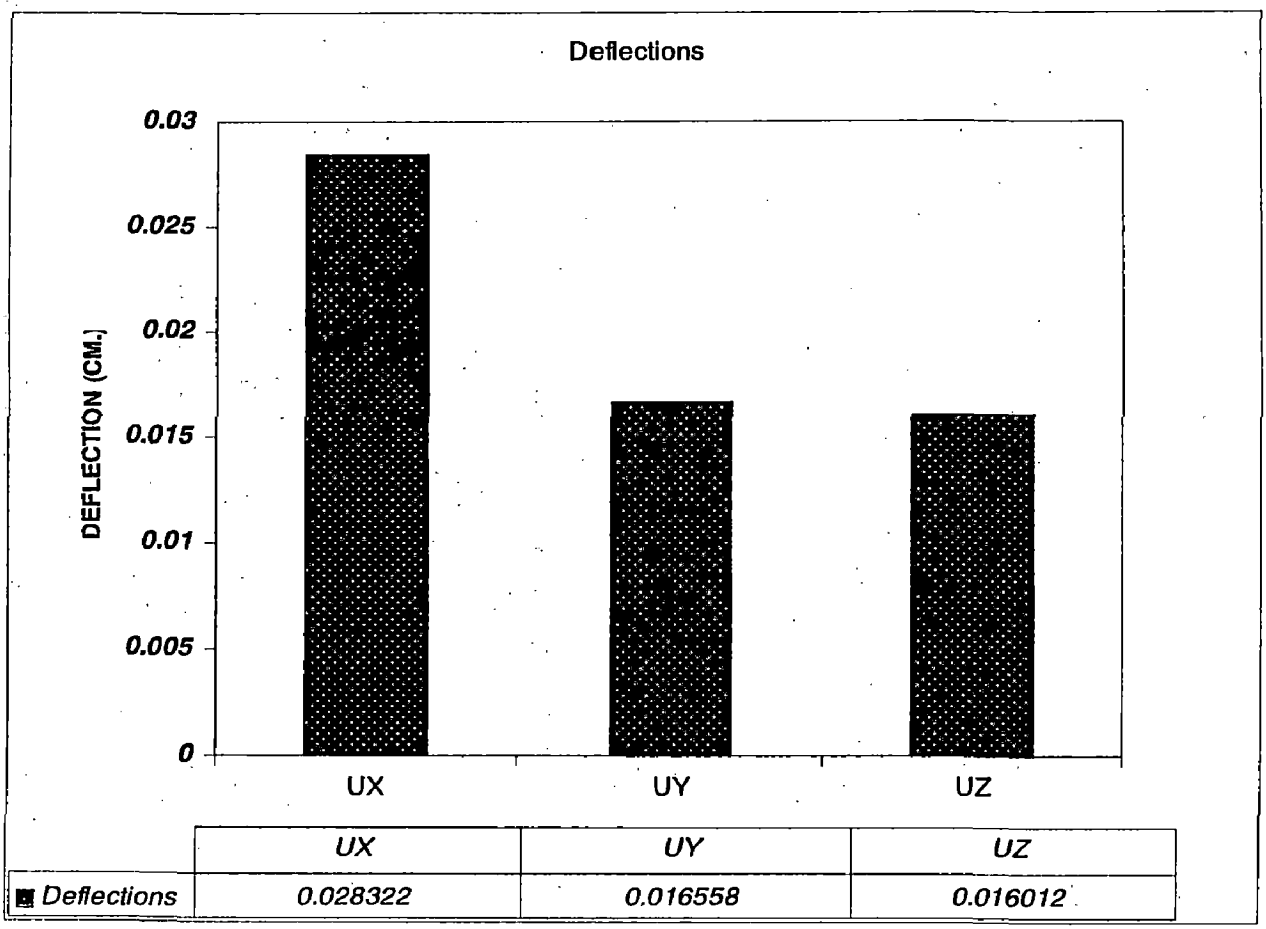


	UX	UY	UZ
Deflections	-0.02427	0.018521	0.014103

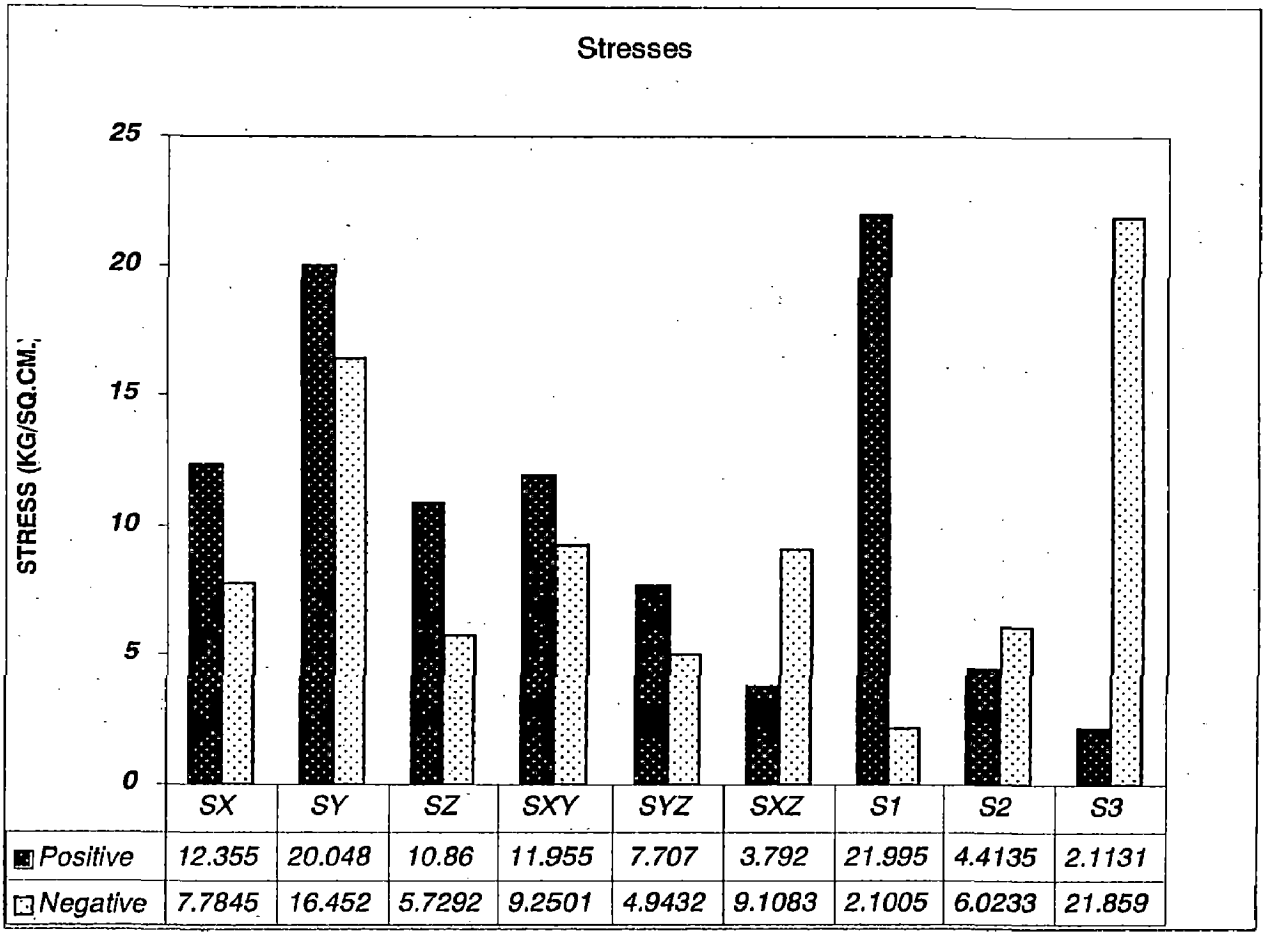


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.047	18.985	9.9602	11.562	7.7333	4.0195	23.401	4.7376	1.3764
Negative	5.6972	16.796	6.1842	9.2032	5.2014	3.2342	4.1057	6.1412	17.191

FIG. 5.56 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2b(i)

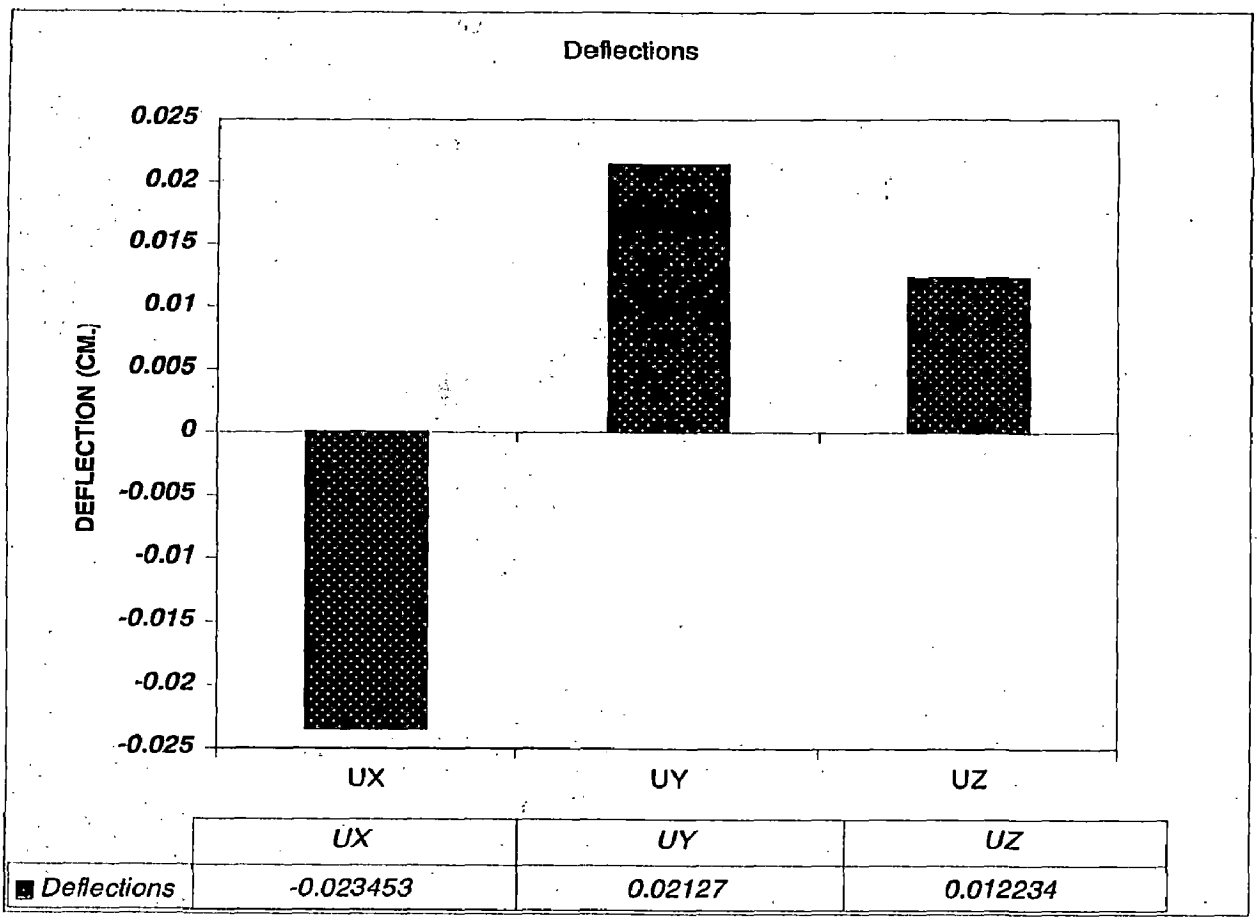


	UX	UY	UZ
Deflections	0.028322	0.016558	0.016012

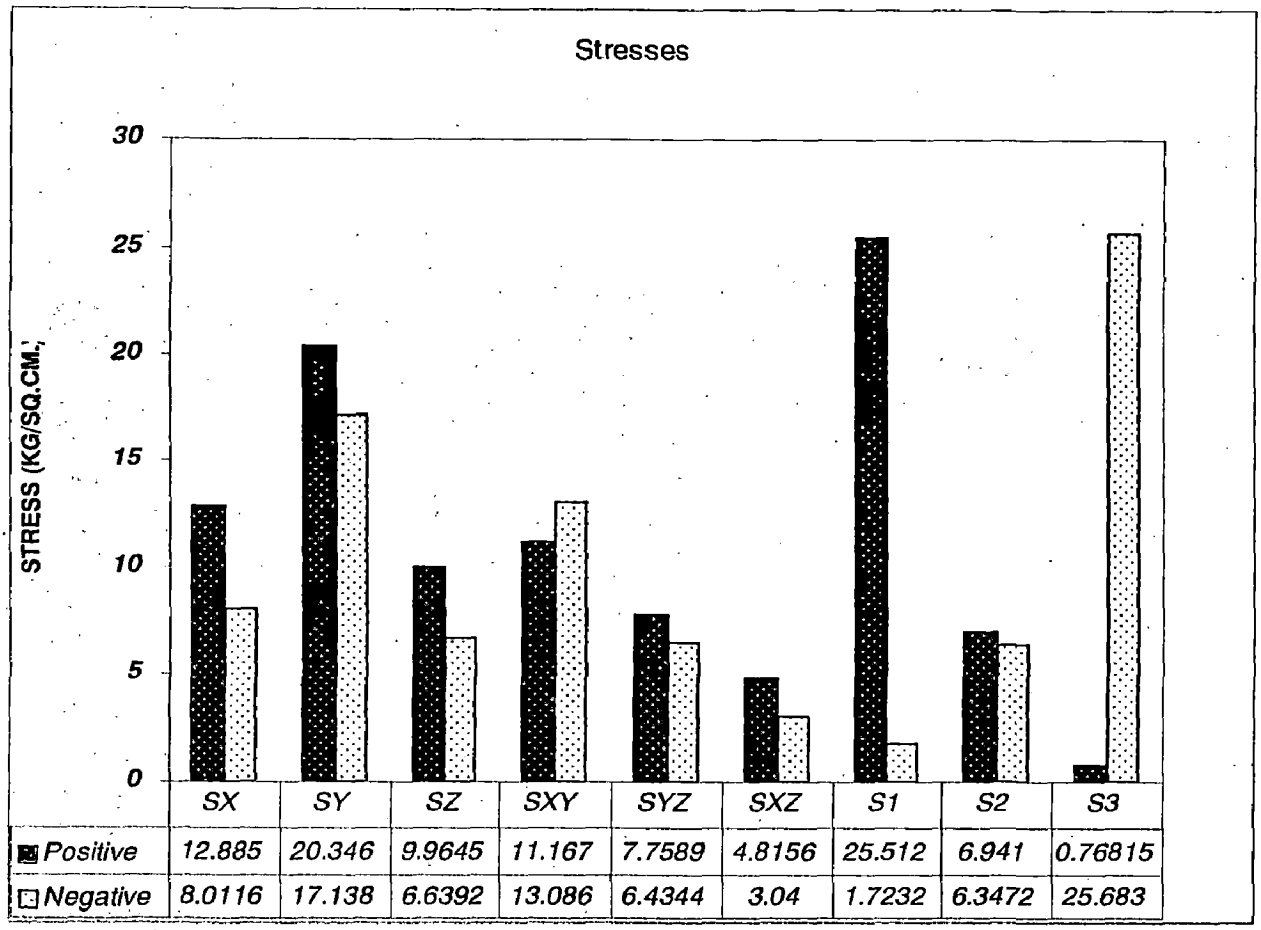


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.355	20.048	10.86	11.955	7.707	3.792	21.995	4.4135	2.1131
Negative	7.7845	16.452	5.7292	9.2501	4.9432	9.1083	2.1005	6.0233	21.859

FIG. 5.57 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2b(ii)

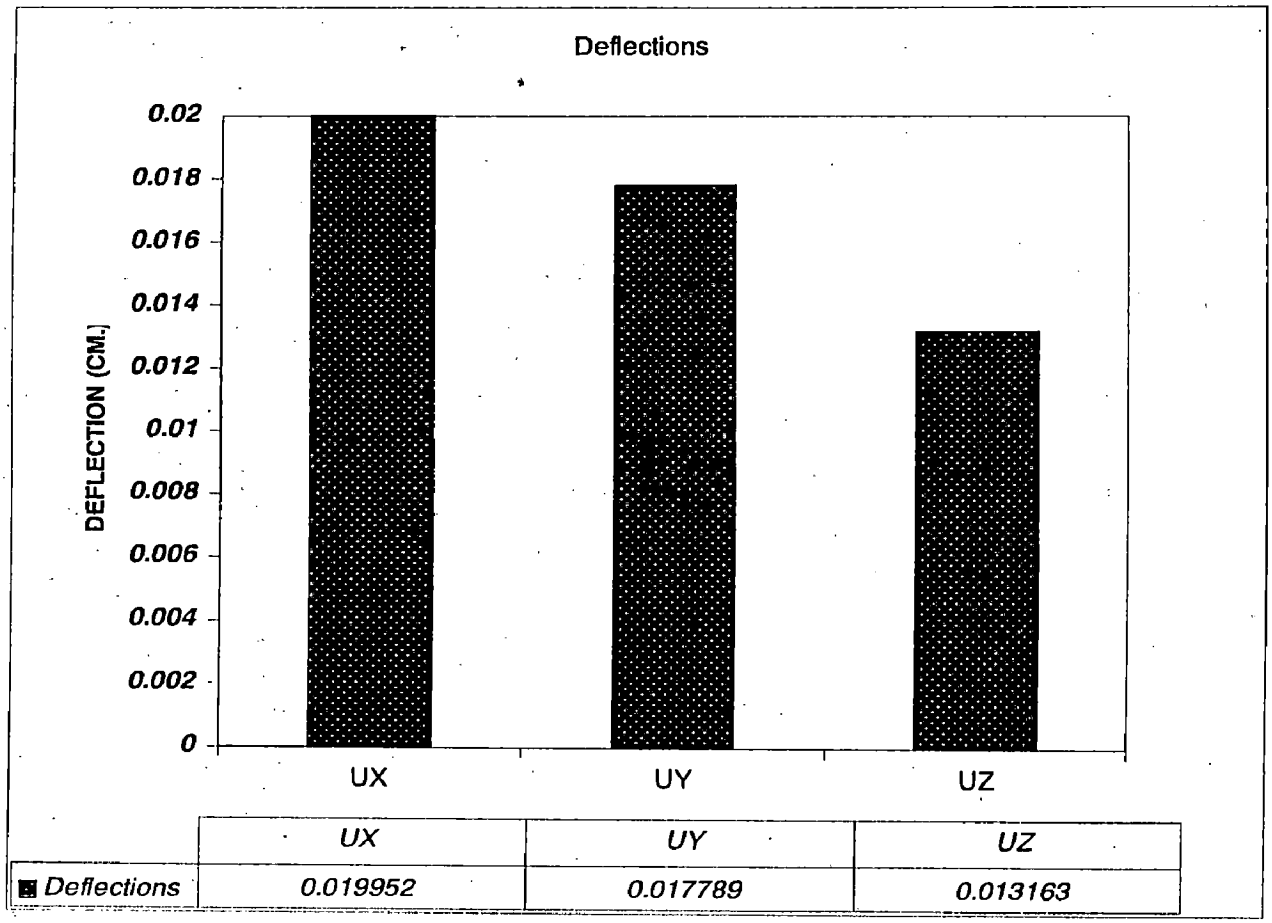


	UX	UY	UZ
Deflections	-0.023453	0.02127	0.012234

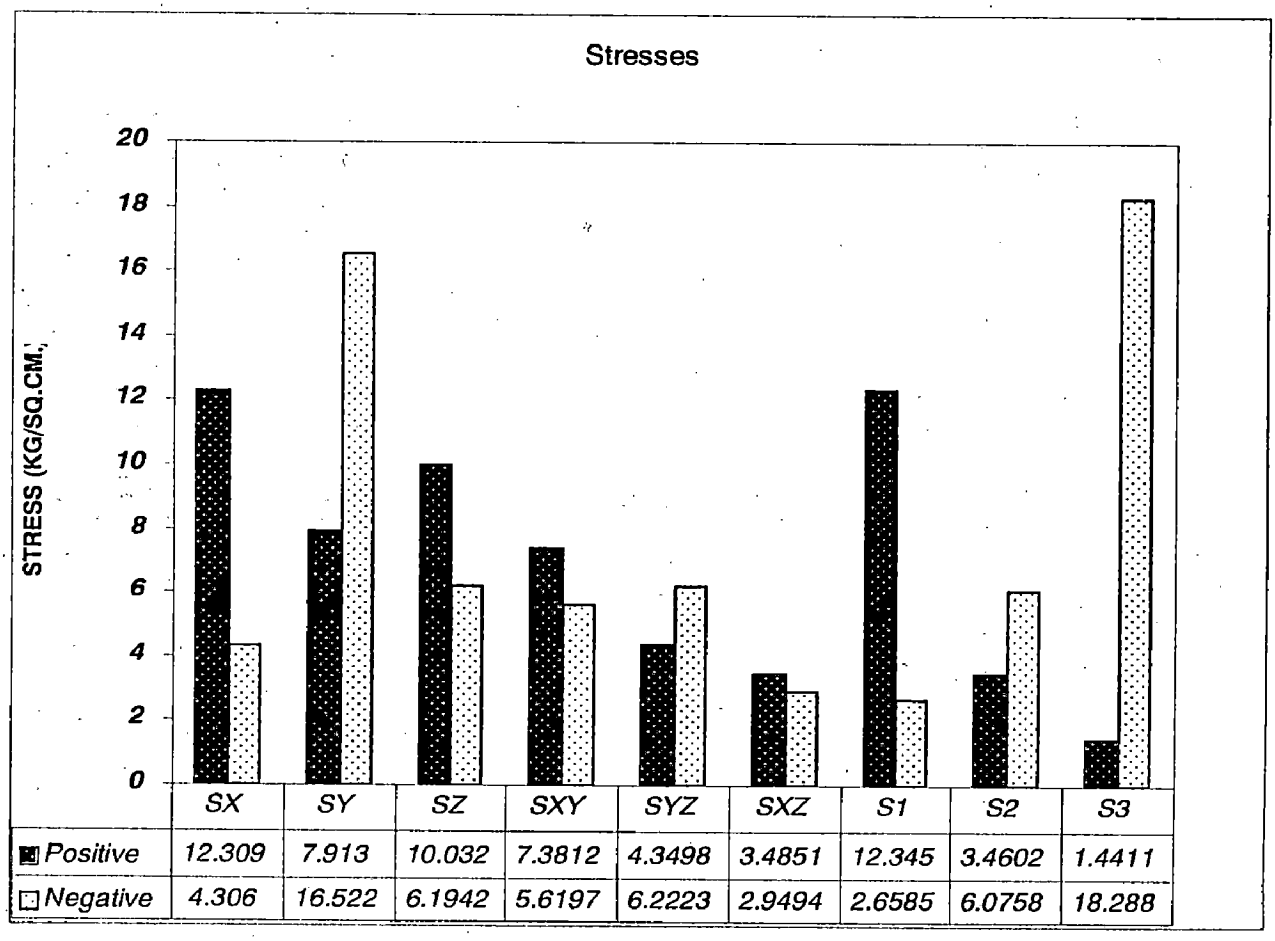


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.885	20.346	9.9645	11.167	7.7589	4.8156	25.512	6.941	0.76815
Negative	8.0116	17.138	6.6392	13.086	6.4344	3.04	1.7232	6.3472	25.683

FIG. 5.58 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2b(iii)

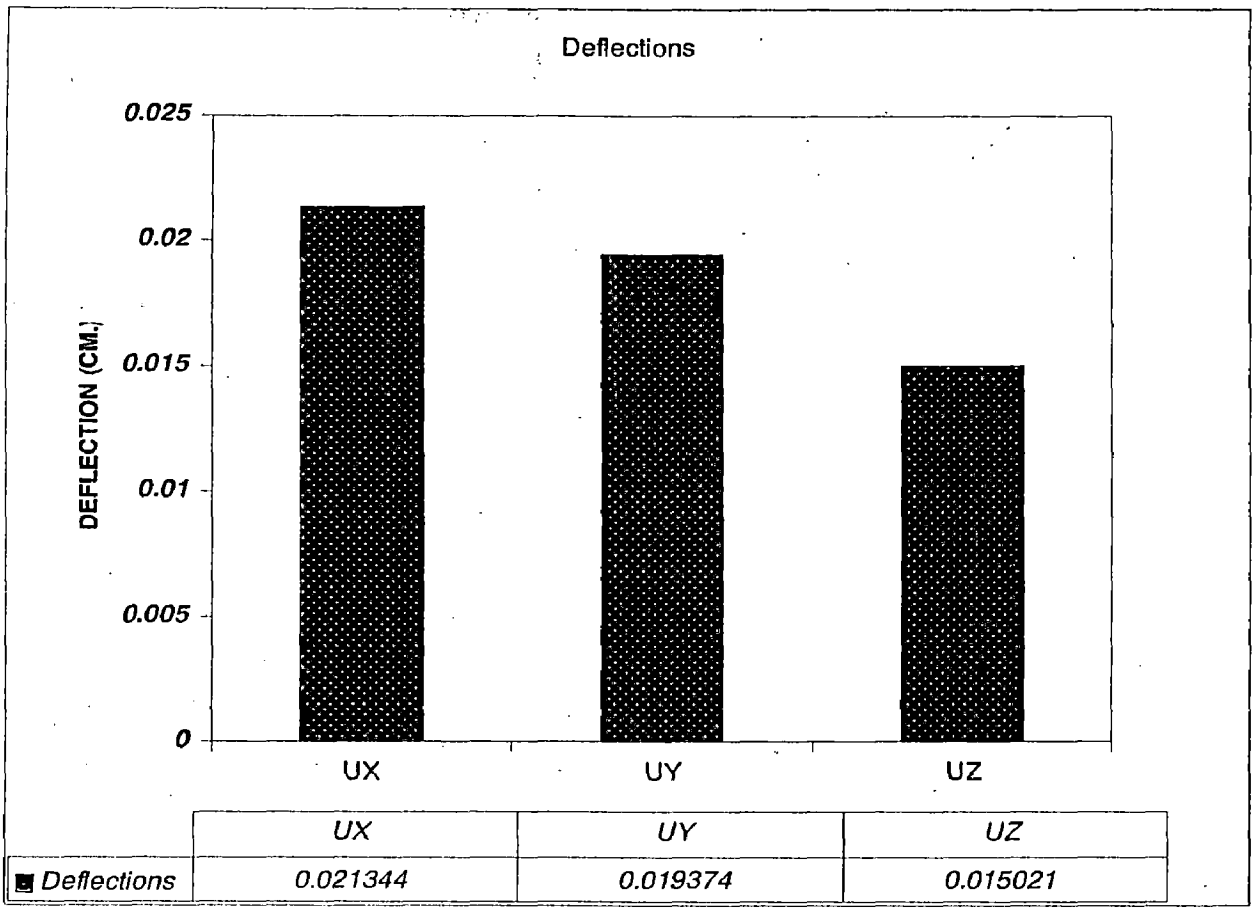


	UX	UY	UZ
Deflections	0.019952	0.017789	0.013163

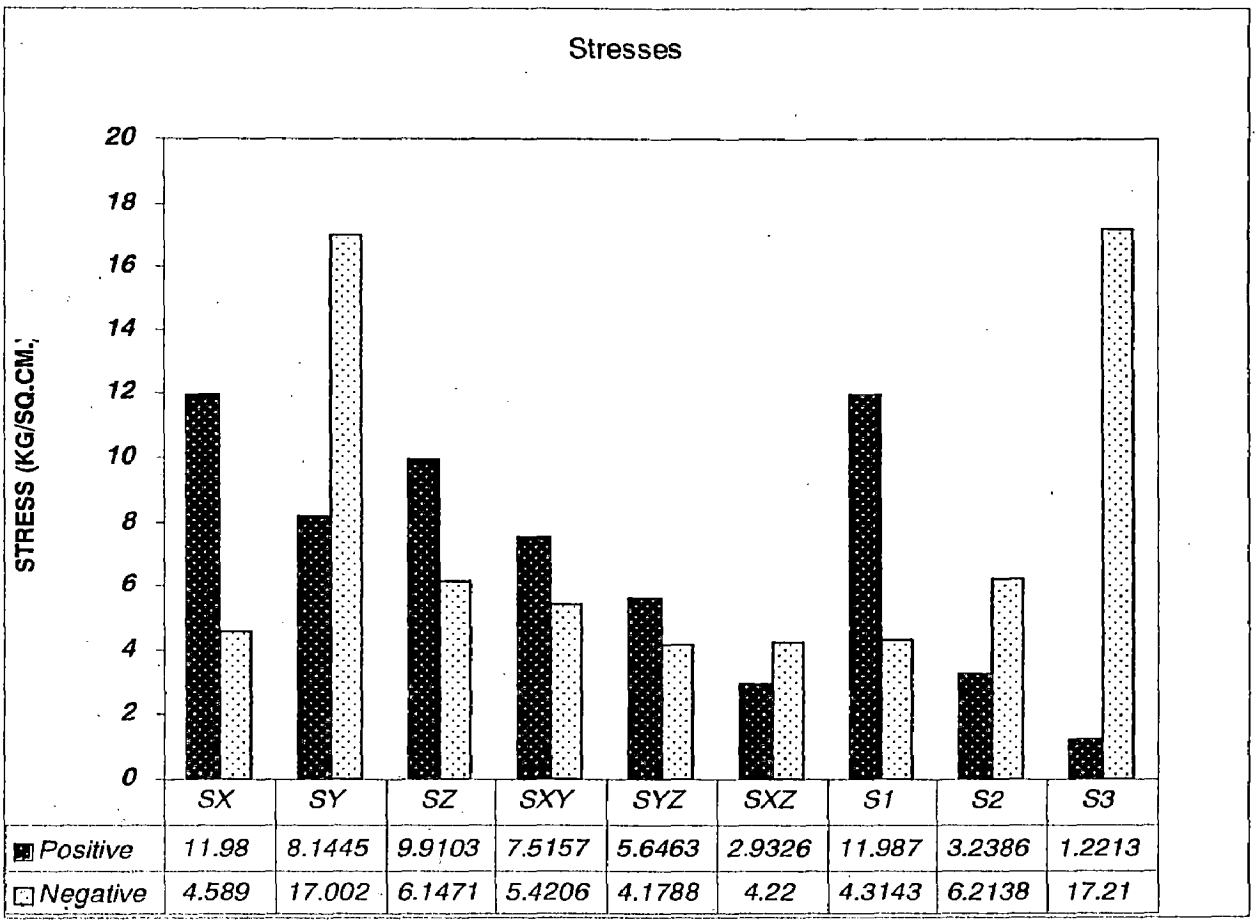


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.309	7.913	10.032	7.3812	4.3498	3.4851	12.345	3.4602	1.4411
Negative	4.306	16.522	6.1942	5.6197	6.2223	2.9494	2.6585	6.0758	18.288

FIG. 5.59 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2b(iv)

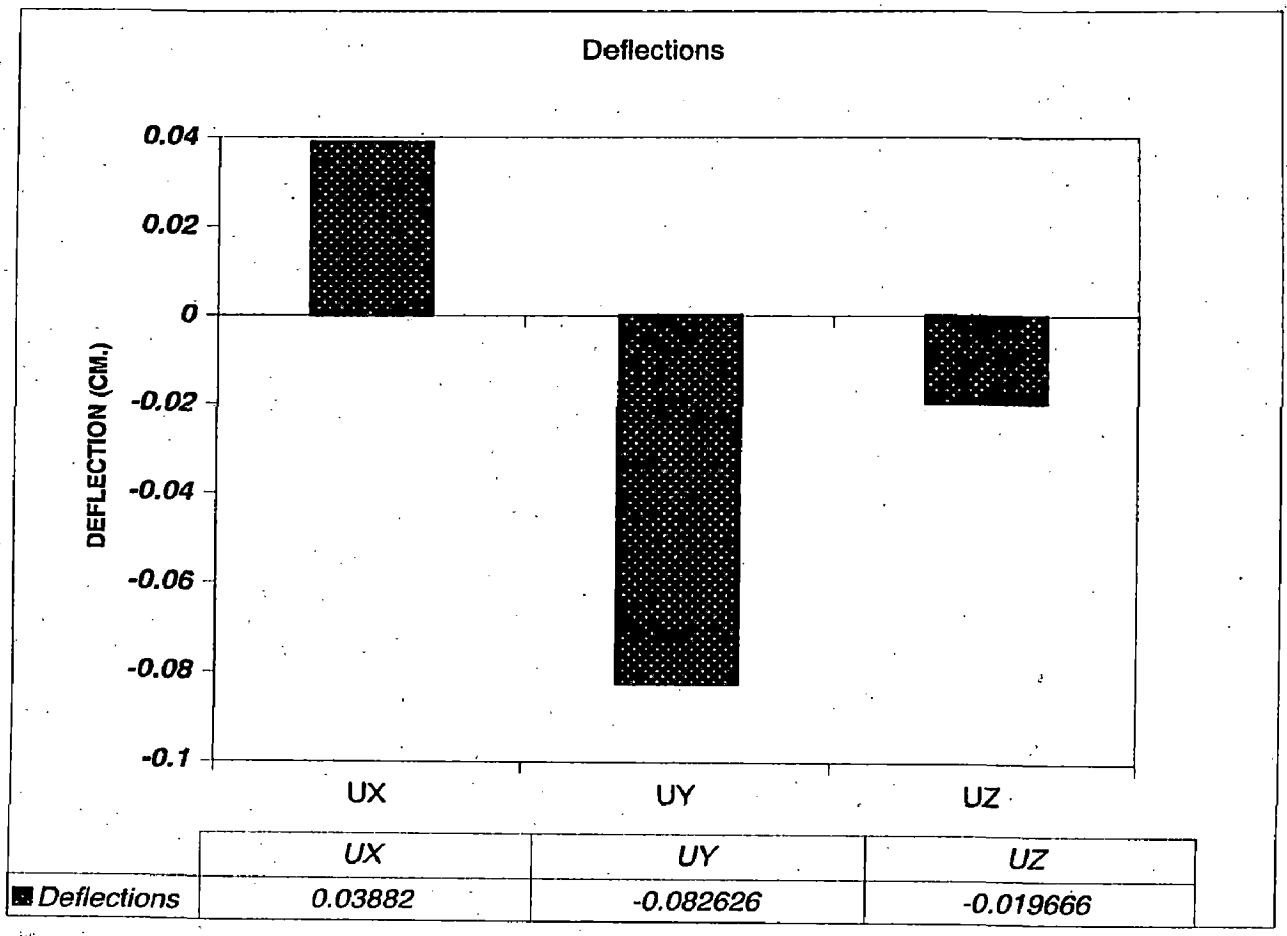


	UX	UY	UZ
Deflections	0.021344	0.019374	0.015021

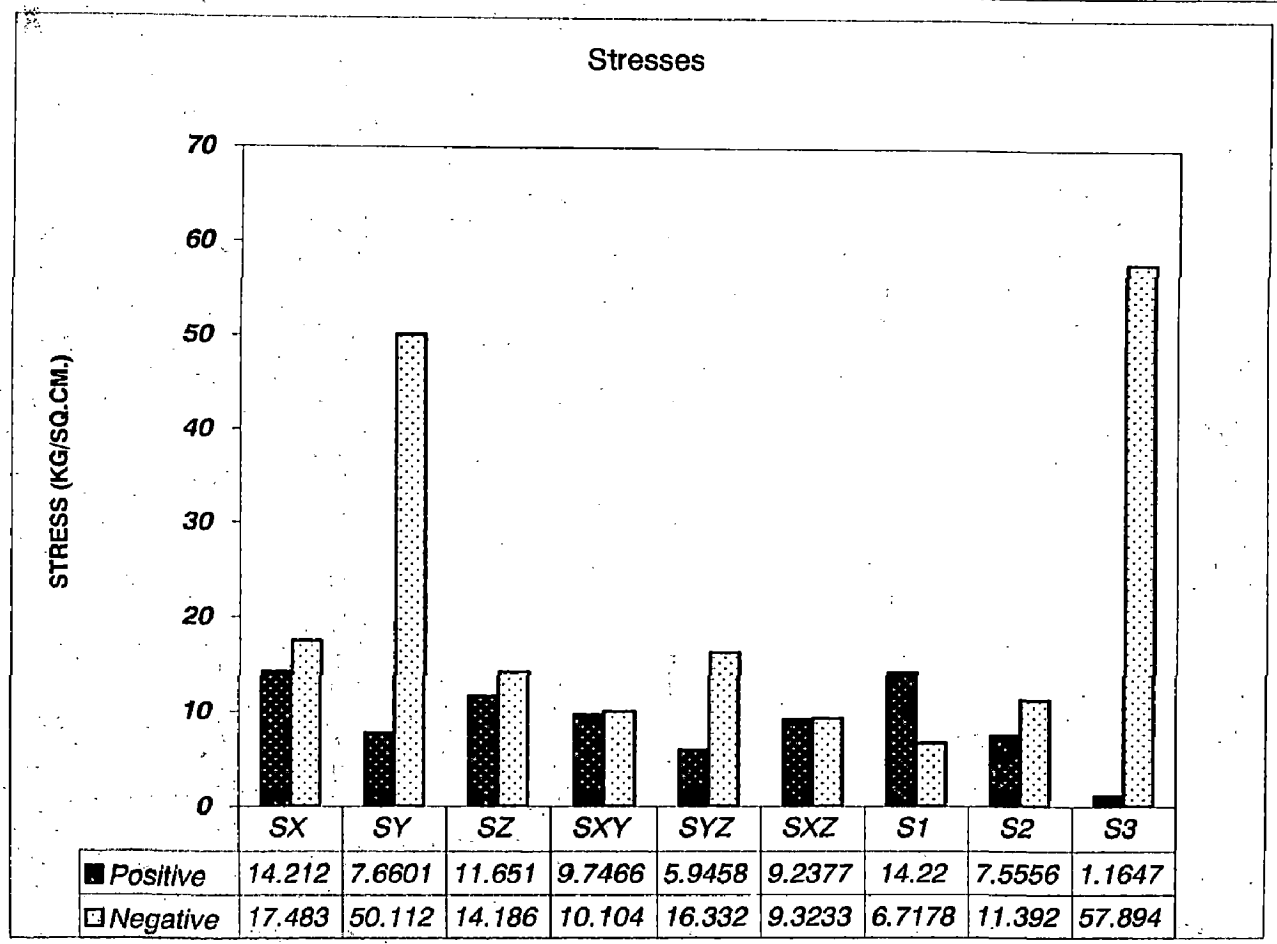


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	11.98	8.1445	9.9103	7.5157	5.6463	2.9326	11.987	3.2386	1.2213
Negative	4.589	17.002	6.1471	5.4206	4.1788	4.22	4.3143	6.2138	17.21

FIG. 5.60 MAXIMUM DEFLECTION AND STRESS FOR LOAD CASE 2b(v)

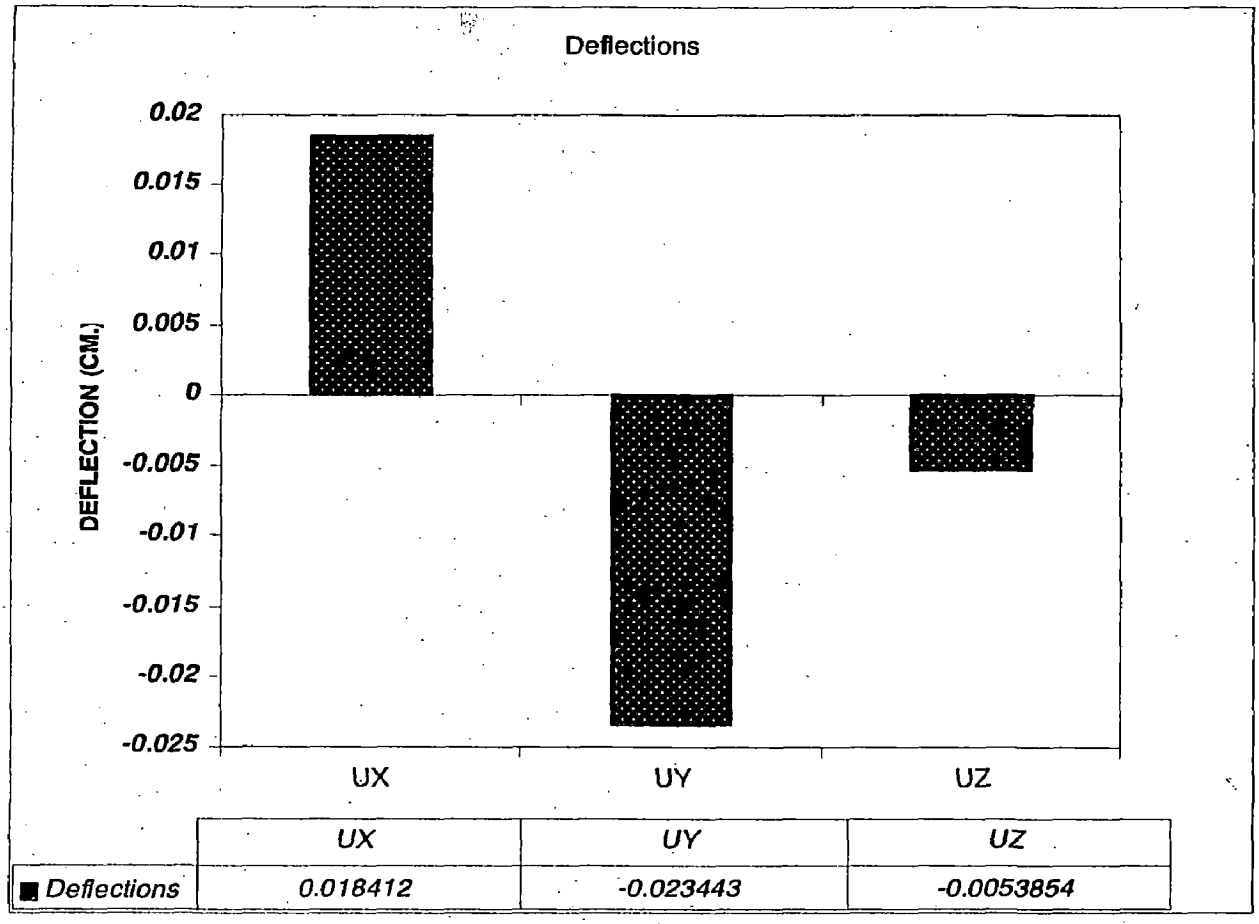


	UX	UY	UZ
Deflections	0.03882	-0.082626	-0.019666

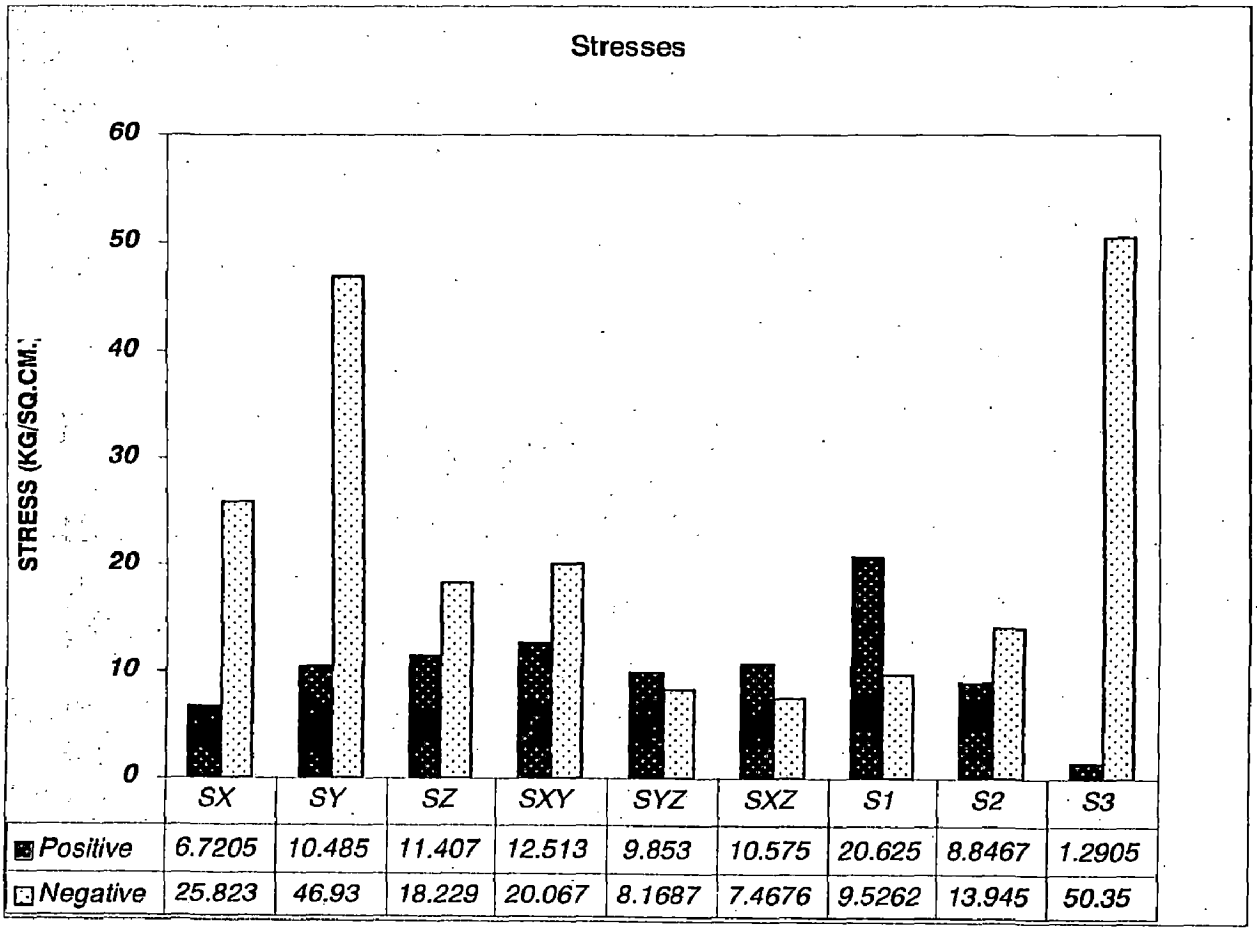


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	14.212	7.6601	11.651	9.7466	5.9458	9.2377	14.22	7.5556	1.1647
Negative	17.483	50.112	14.186	10.104	16.332	9.3233	6.7178	11.392	57.894

FIG. 5.61 MAXIMUM DEFLECTION AND STRESS FOR LOADS CASE 1a

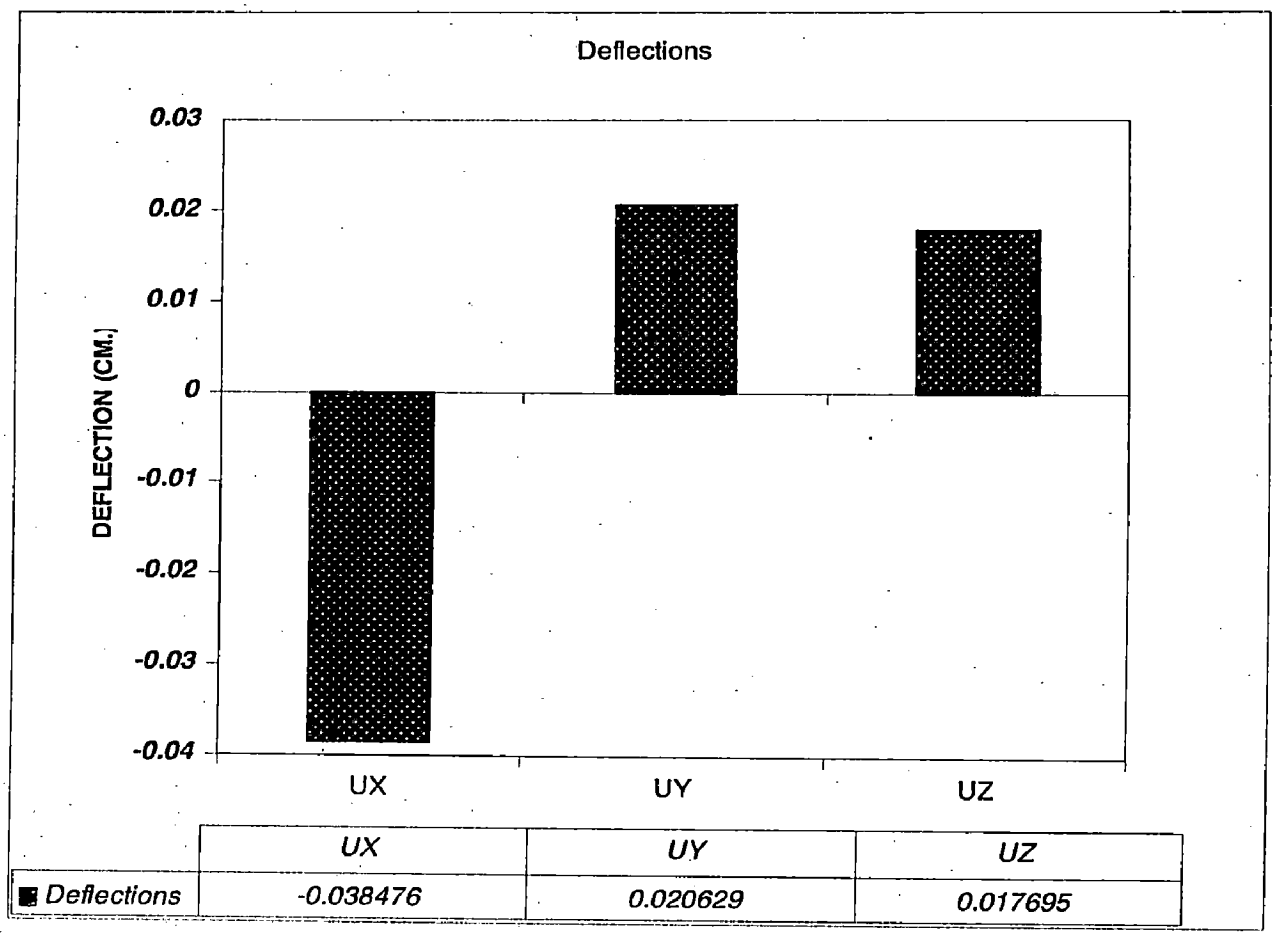


	UX	UY	UZ
Deflections	0.018412	-0.023443	-0.0053854

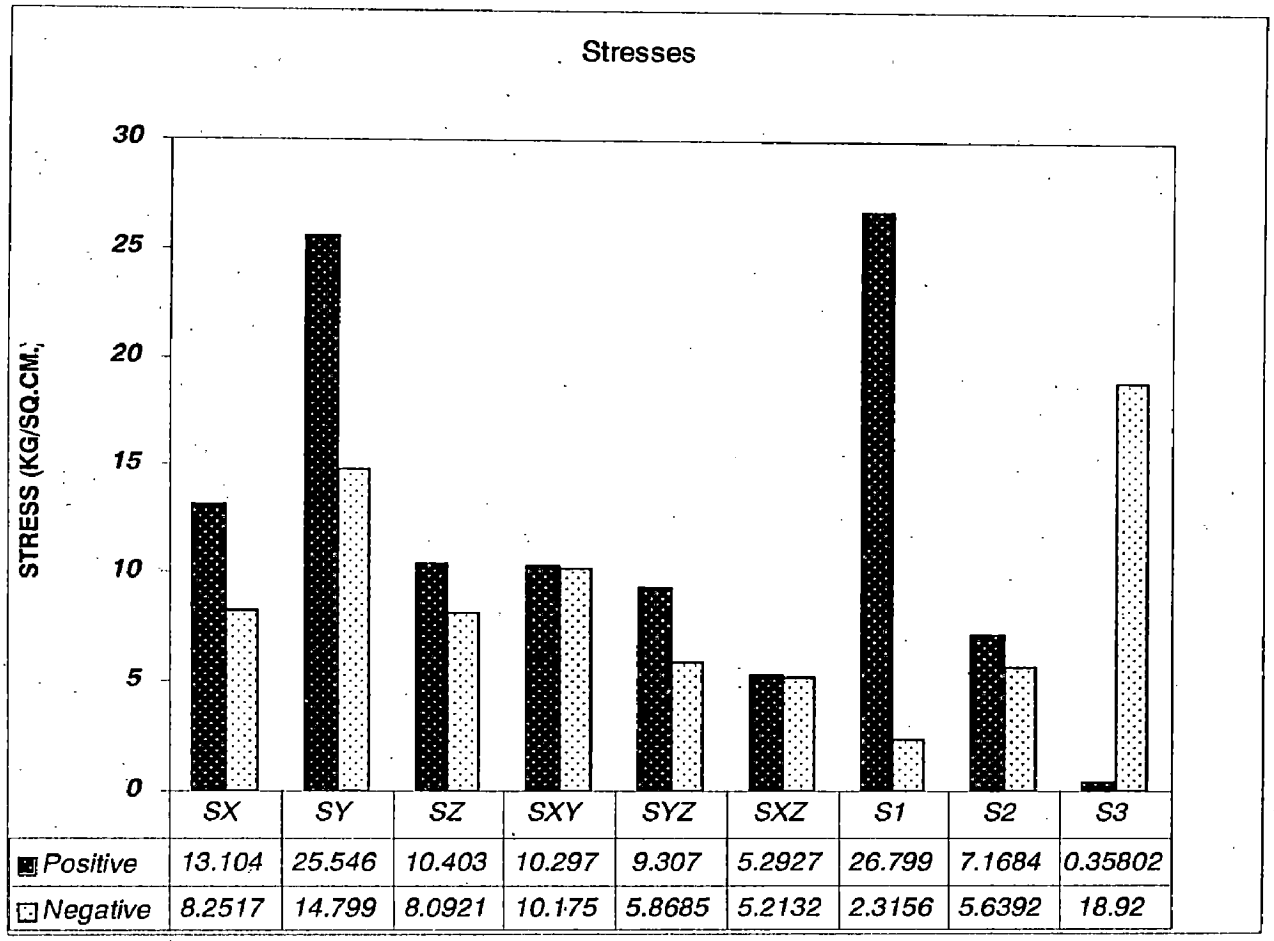


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	6.7205	10.485	11.407	12.513	9.853	10.575	20.625	8.8467	1.2905
Negative	25.823	46.93	18.229	20.067	8.1687	7.4676	9.5262	13.945	50.35

FIG. 5.62 MAXIMUM DEFLECTION AND STRESS FOR LOADS CASE 1b

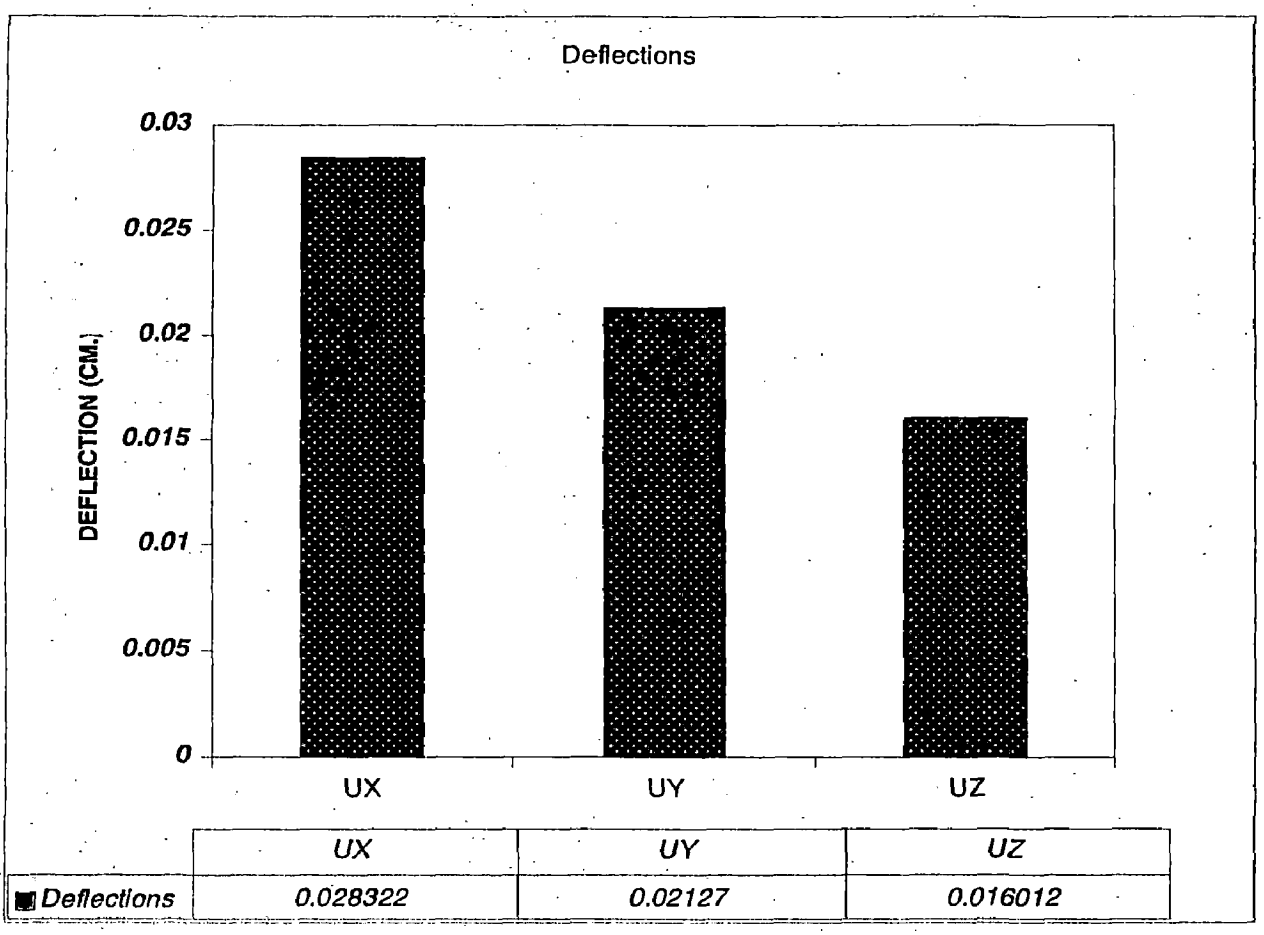


	UX	UY	UZ
Deflections	-0.038476	0.020629	0.017695

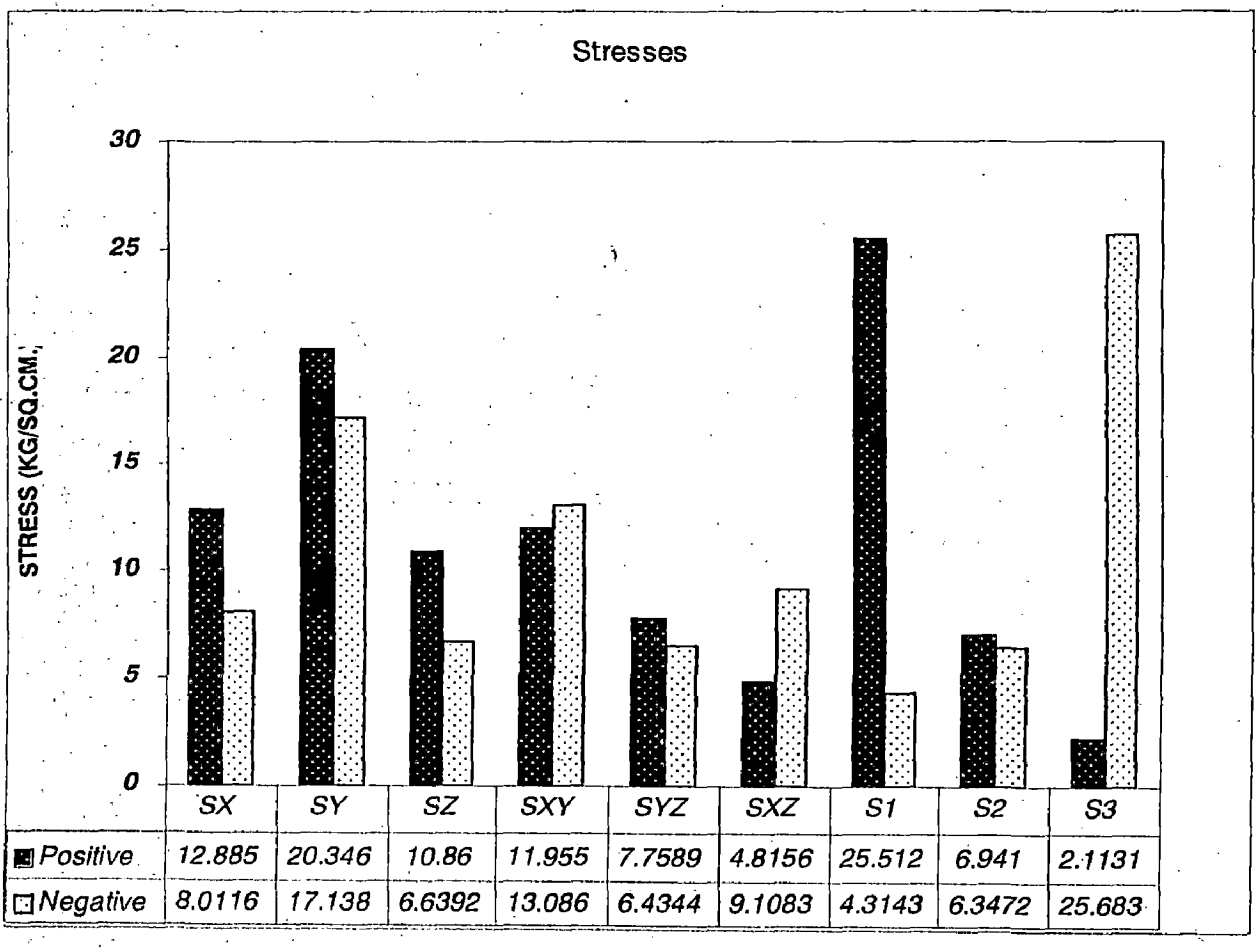


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	13.104	25.546	10.403	10.297	9.307	5.2927	26.799	7.1684	0.35802
Negative	8.2517	14.799	8.0921	10.175	5.8685	5.2132	2.3156	5.6392	18.92

FIG. 5.63 MAXIMUM DEFLECTION AND STRESS FOR LOADS CASE 2a

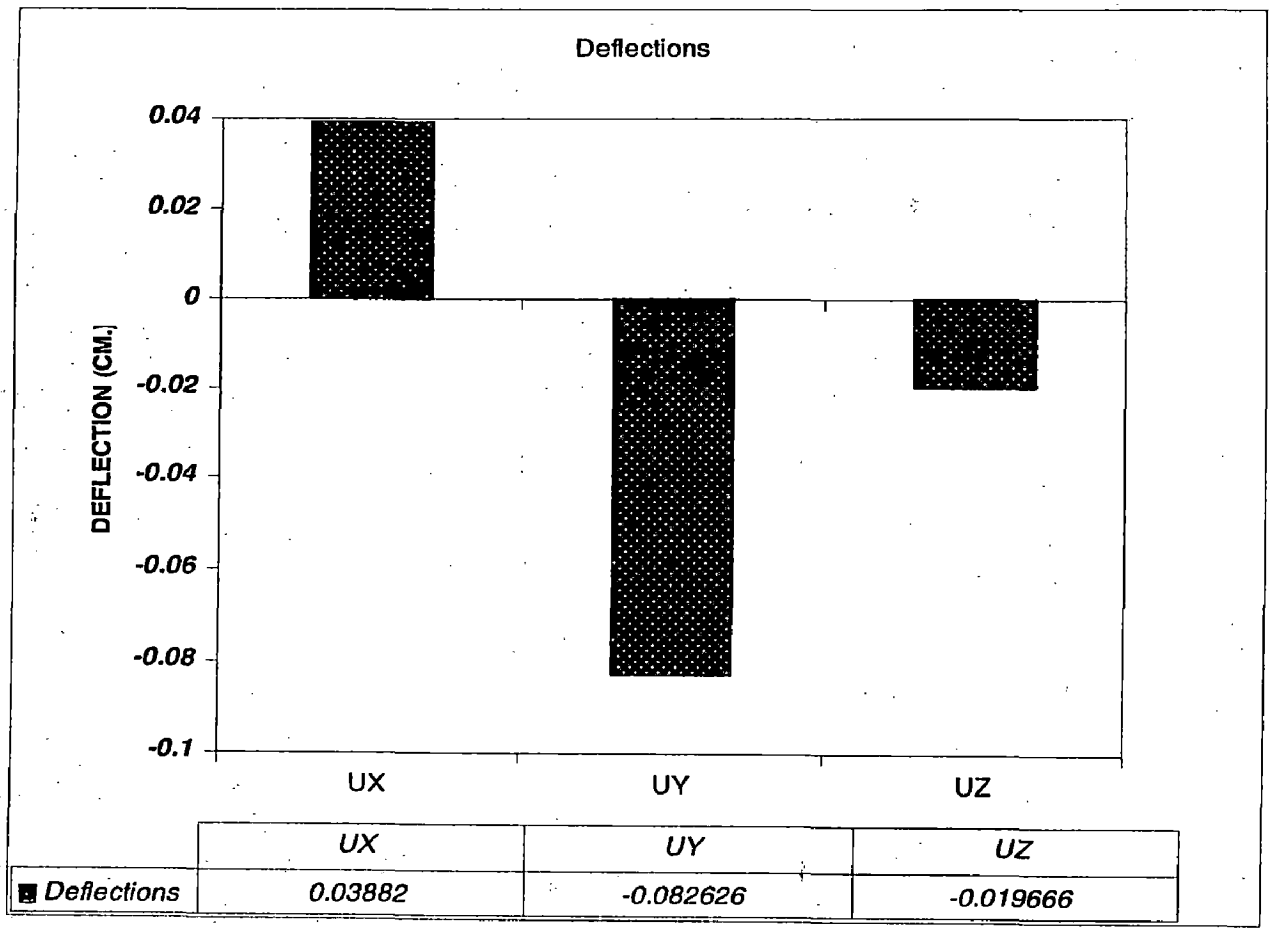


	UX	UY	UZ
Deflections	0.028322	0.02127	0.016012

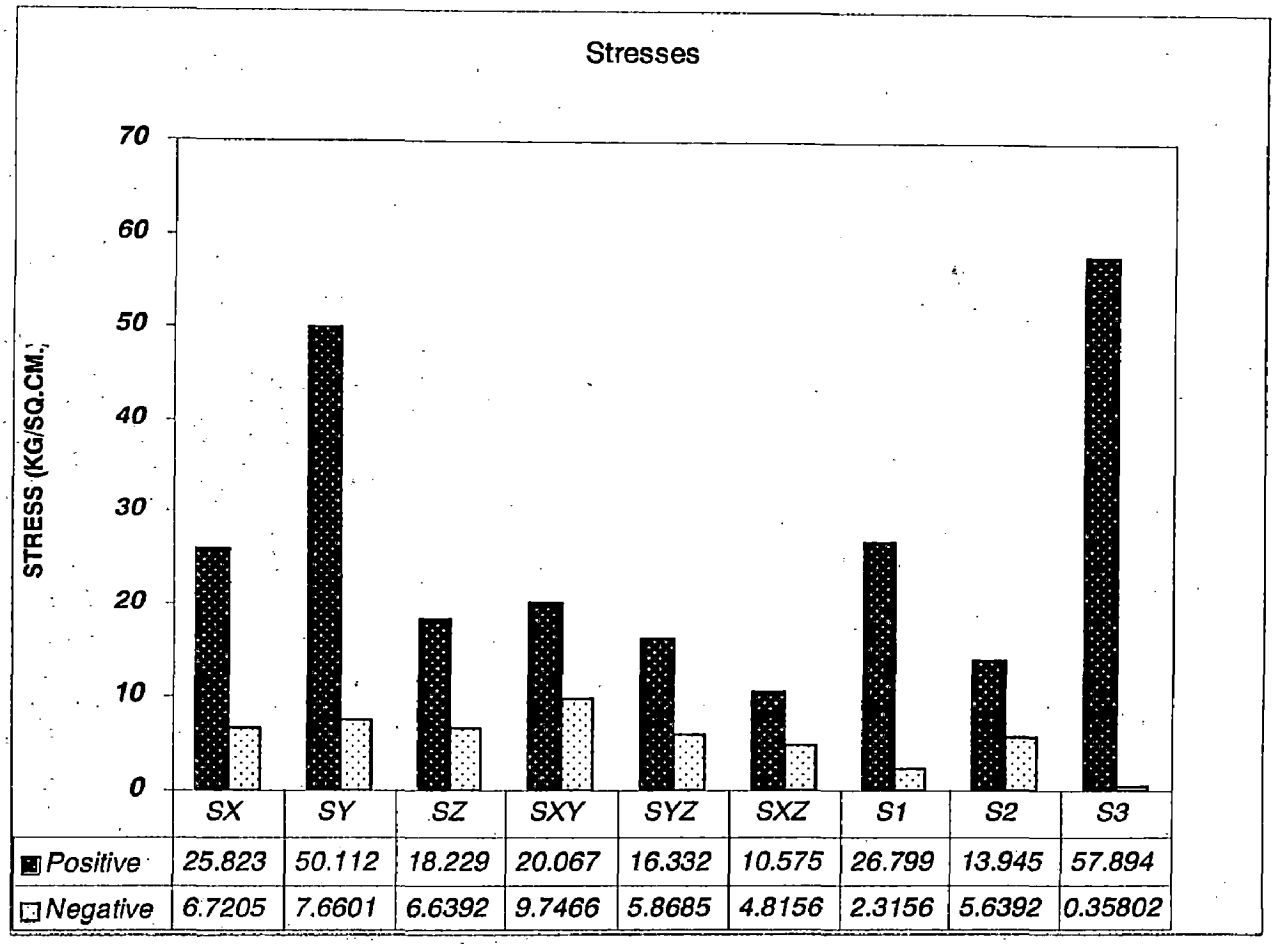


	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	12.885	20.346	10.86	11.955	7.7589	4.8156	25.512	6.941	2.1131
Negative	8.0116	17.138	6.6392	13.086	6.4344	9.1083	4.3143	6.3472	25.683

FIG. 5.64 MAXIMUM DEFLECTION AND STRESS FOR LOADS CASE 2b



	UX	UY	UZ
Deflections	0.03882	-0.082626	-0.019666



	SX	SY	SZ	SXY	SYZ	SXZ	S1	S2	S3
Positive	25.823	50.112	18.229	20.067	16.332	10.575	26.799	13.945	57.894
Negative	6.7205	7.6601	6.6392	9.7466	5.8685	4.8156	2.3156	5.6392	0.35802

FIG. 5.65 MAXIMUM DEFLECTION AND STRESS FOR ALL LOAD CASE

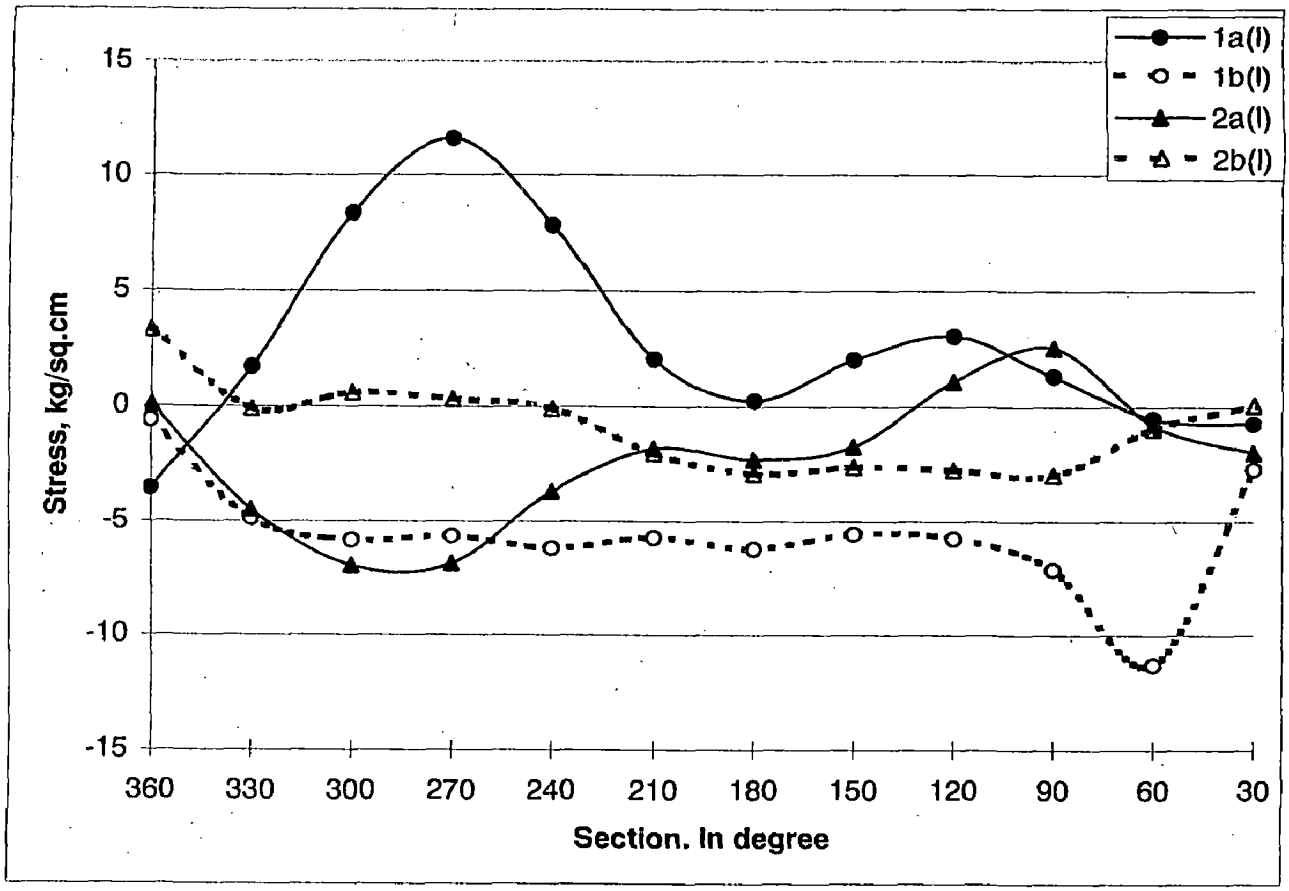


FIG. 5.66 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE A

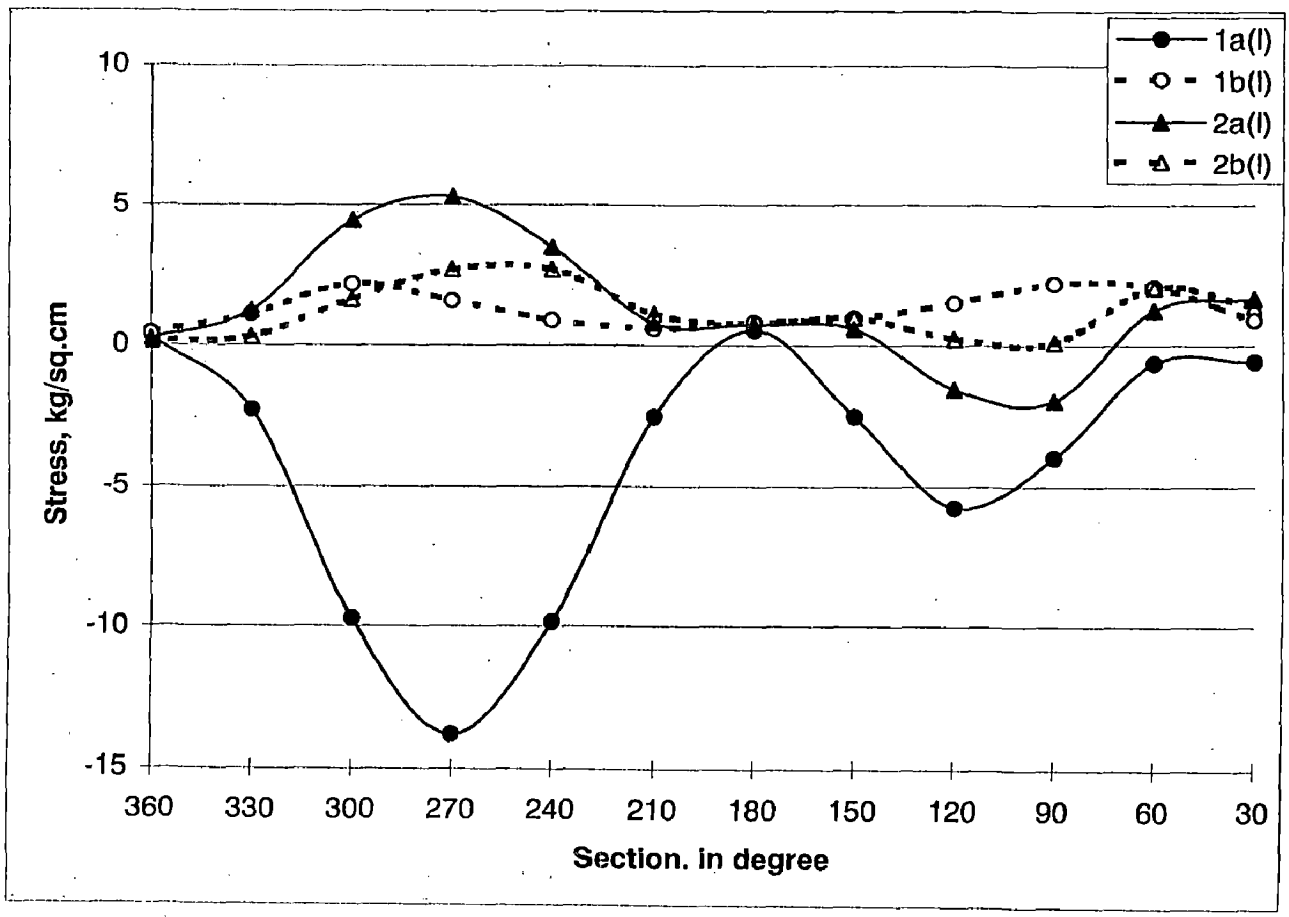


FIG. 5.67 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE B

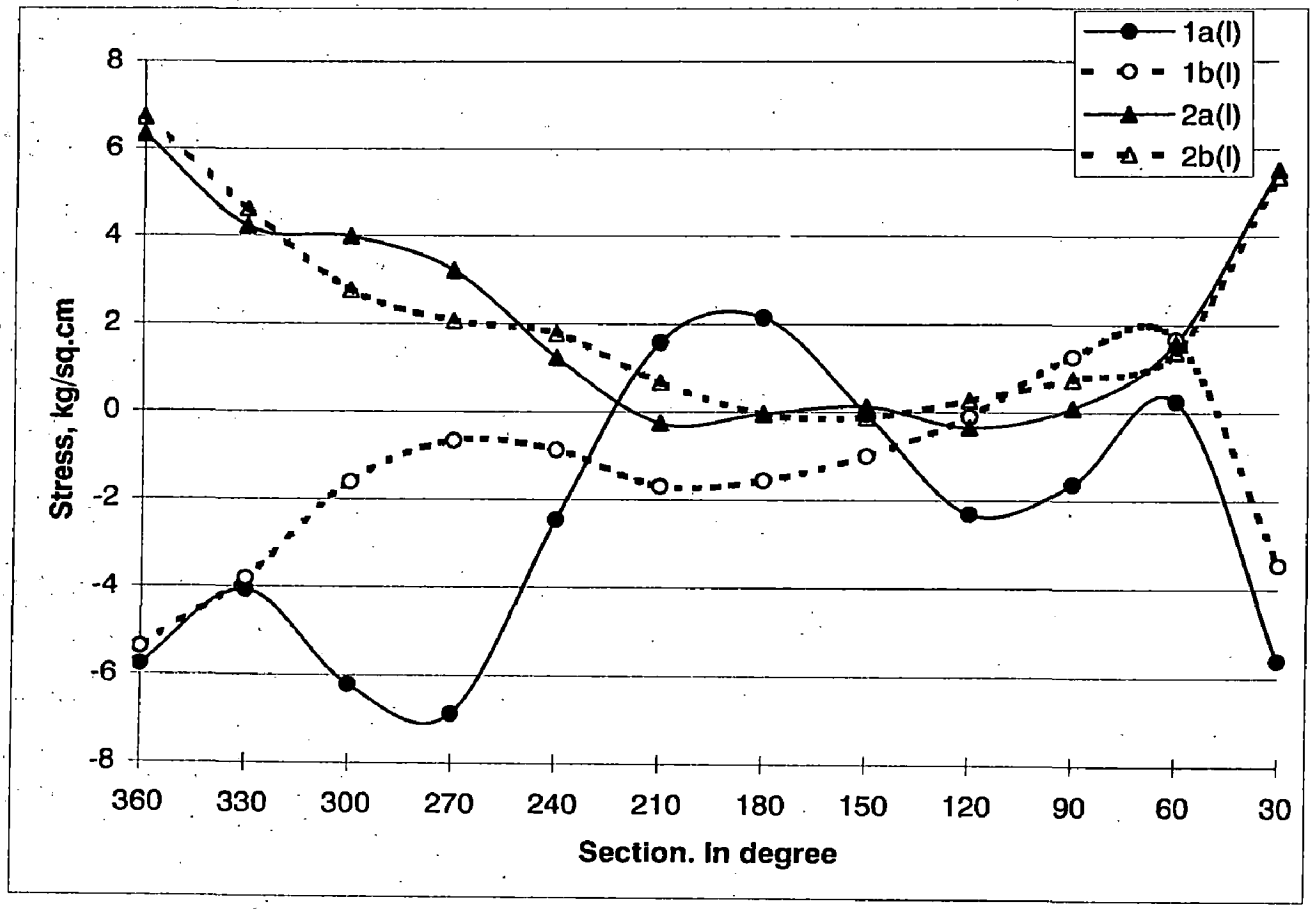


FIG. 5.68 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE C

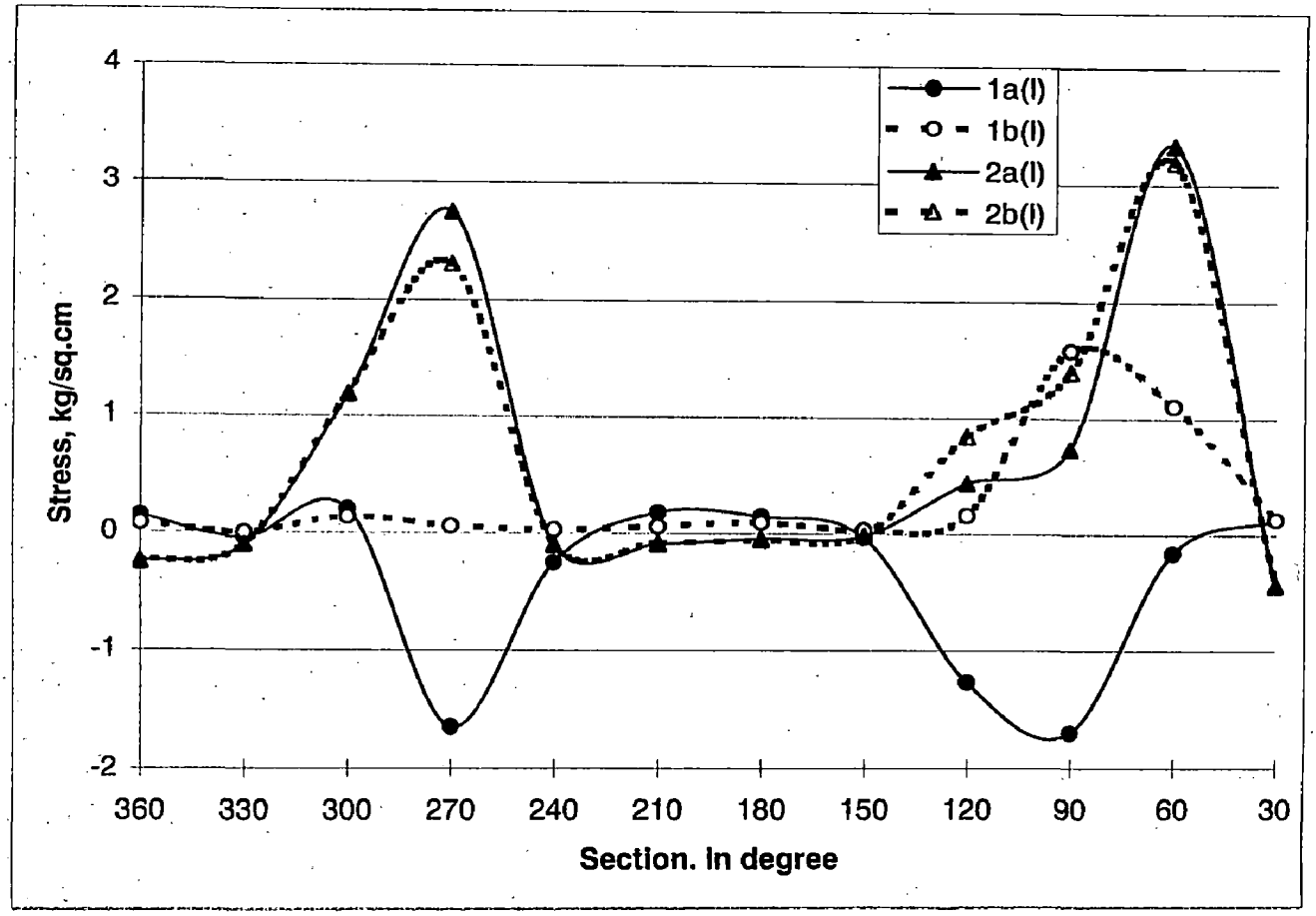


FIG. 5.69 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE D

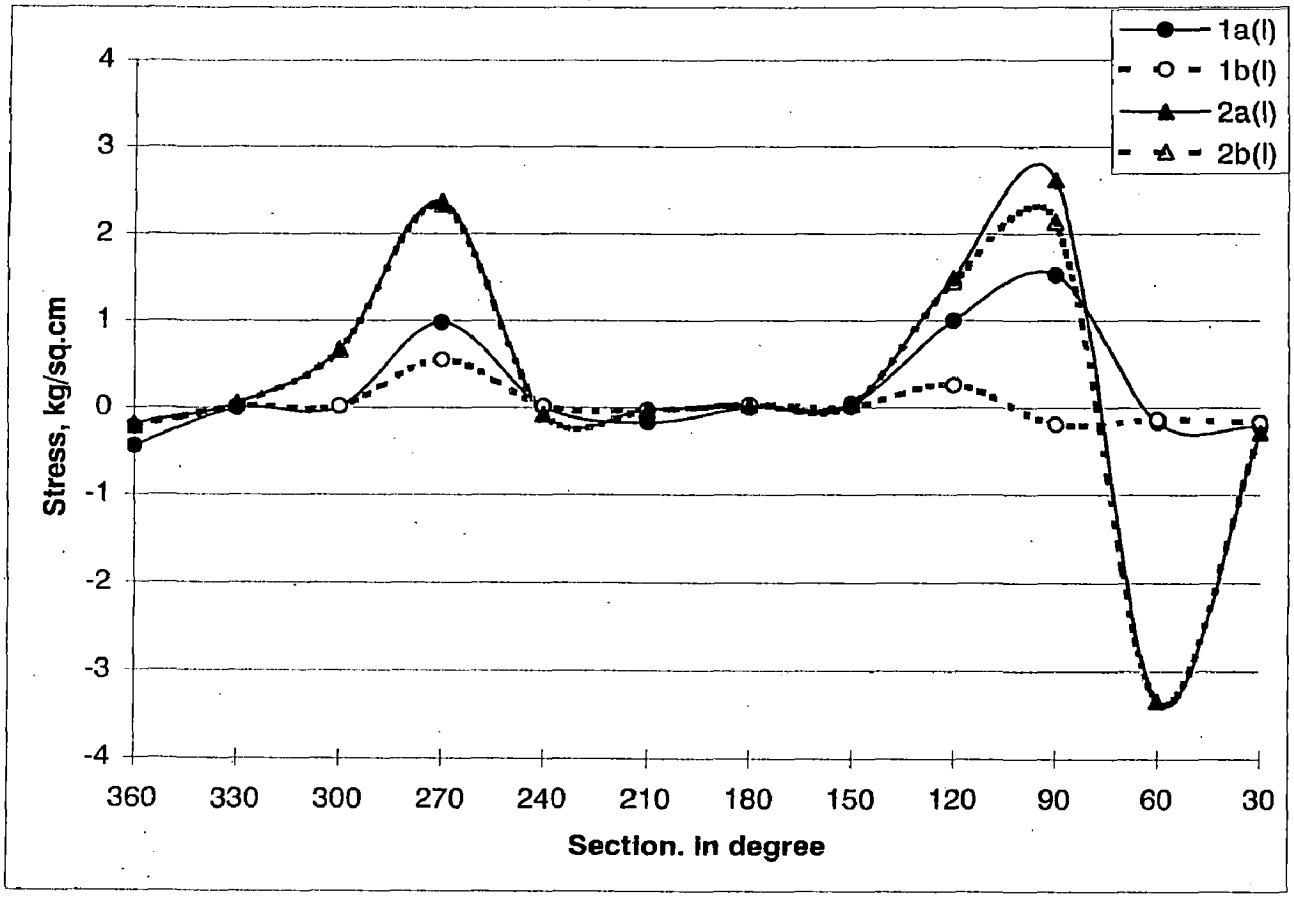


FIG. 5.70 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE E

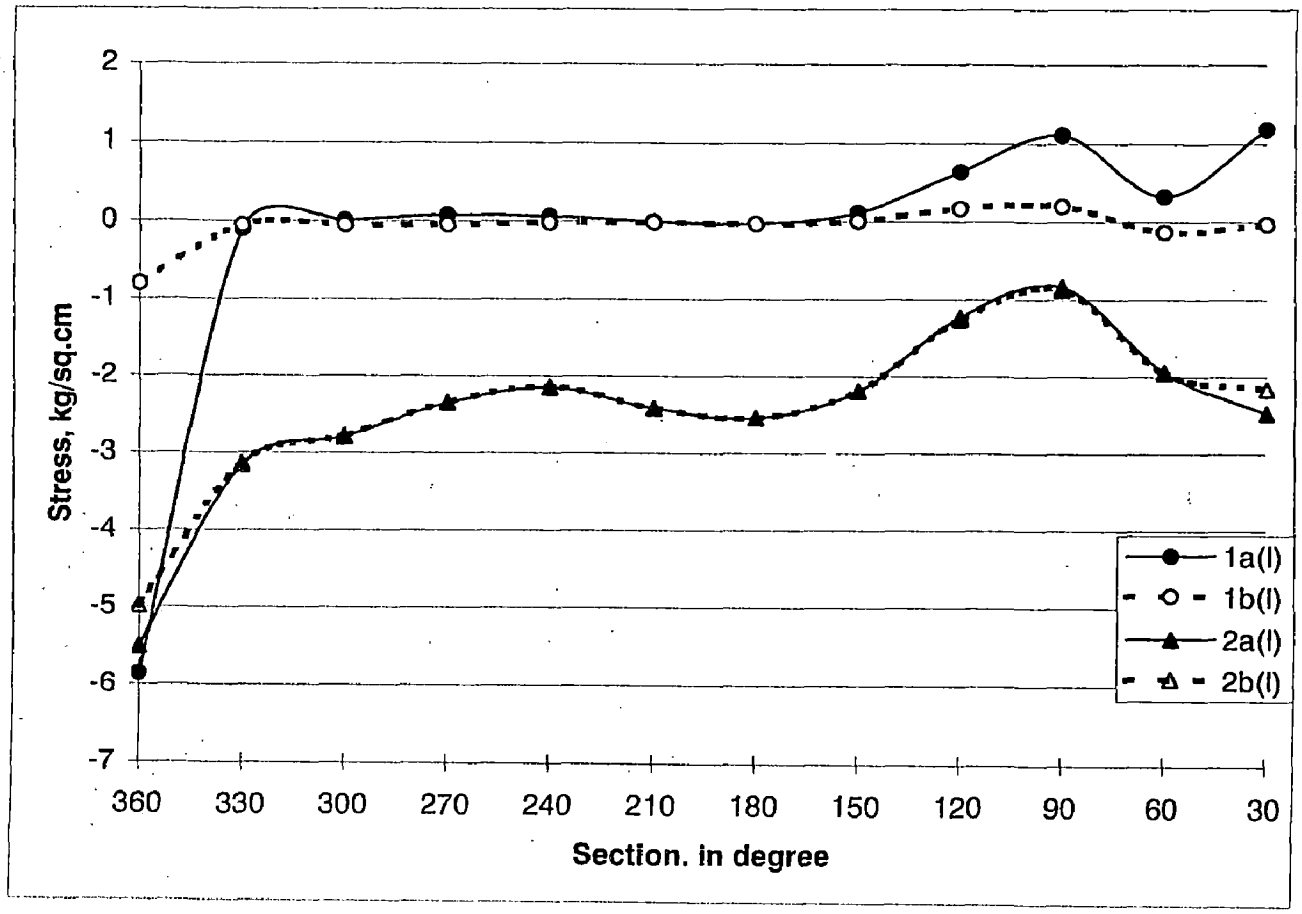


FIG. 5.71 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE F

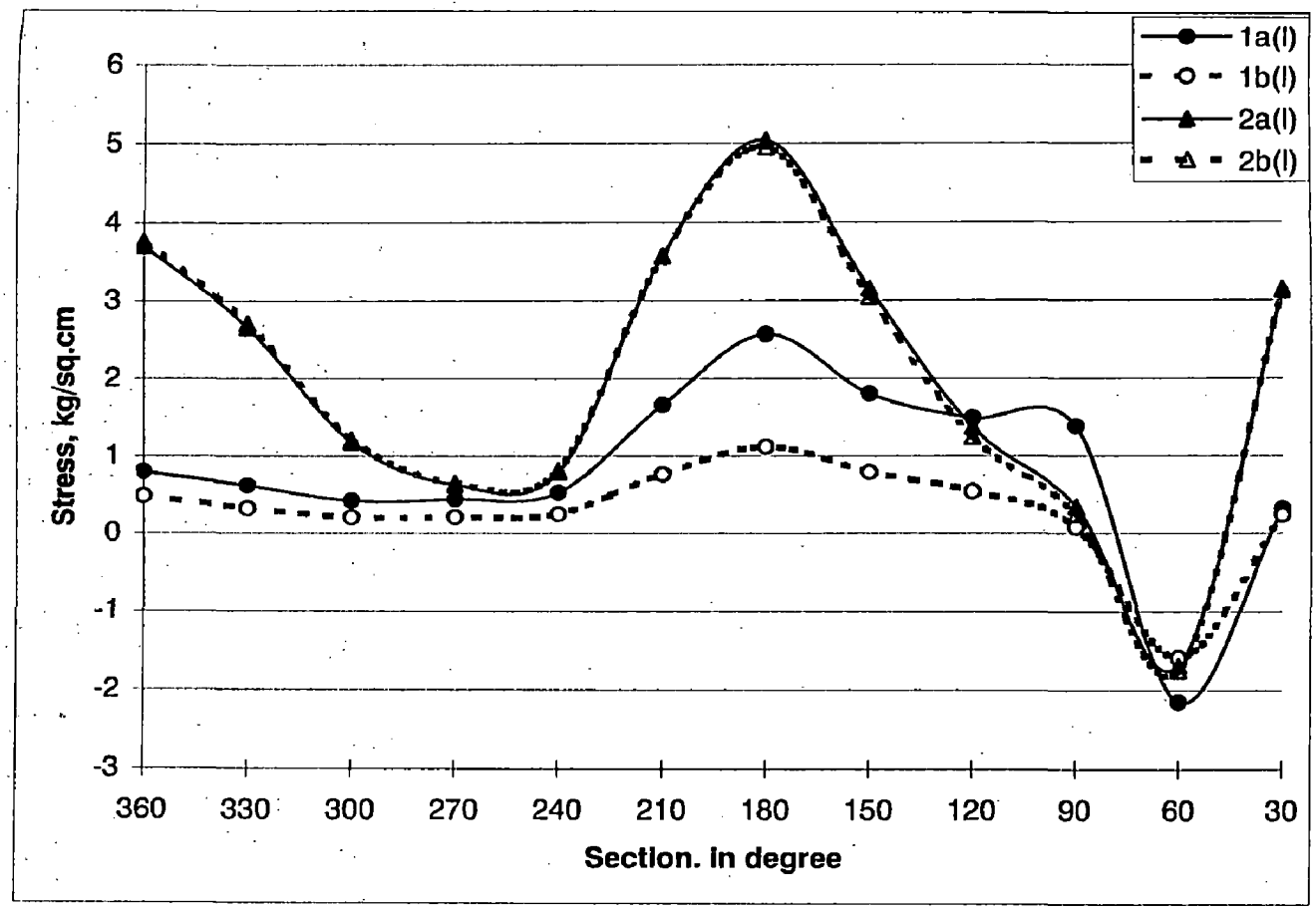


FIG. 5.72 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE G

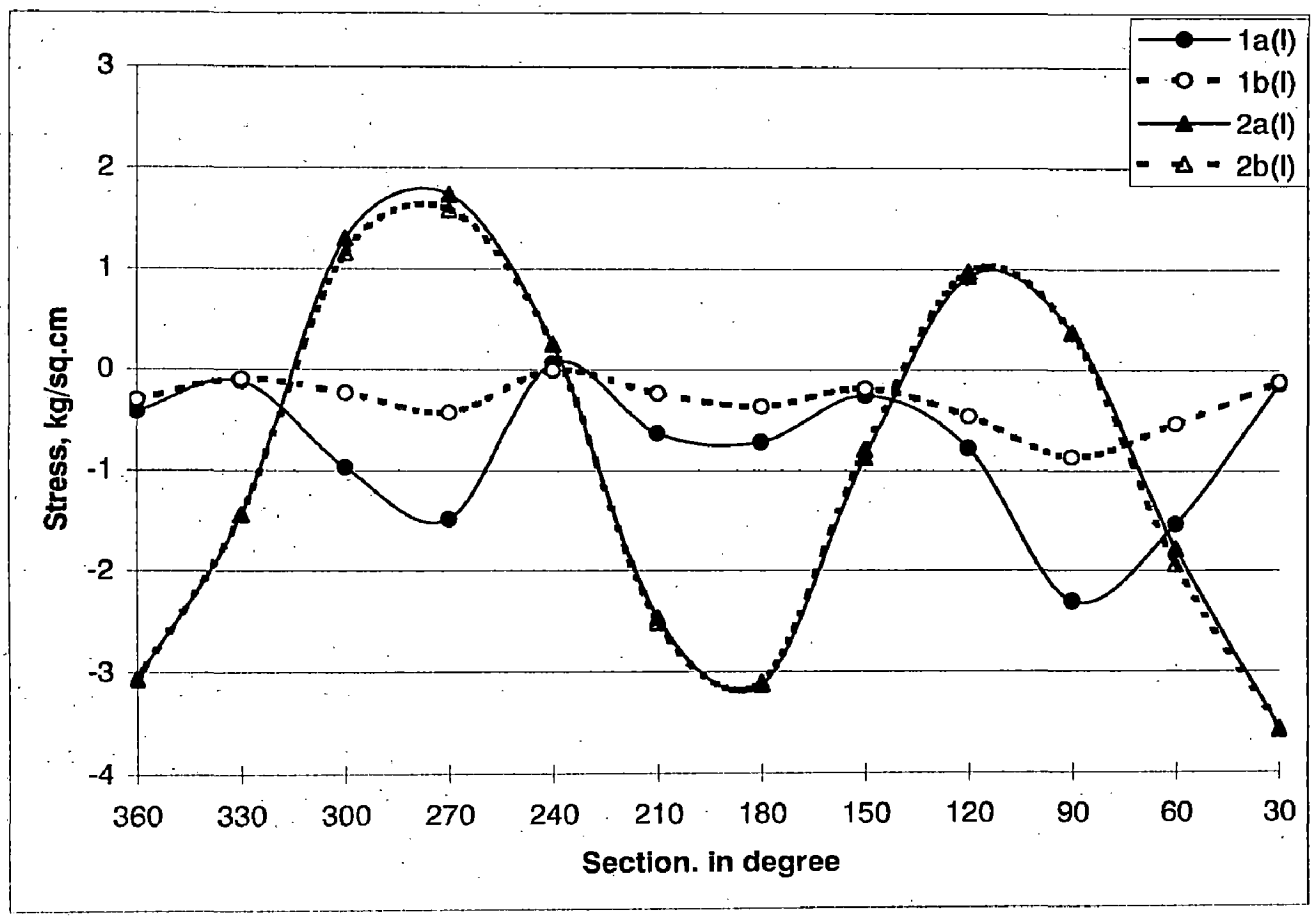


FIG. 5.73 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE H

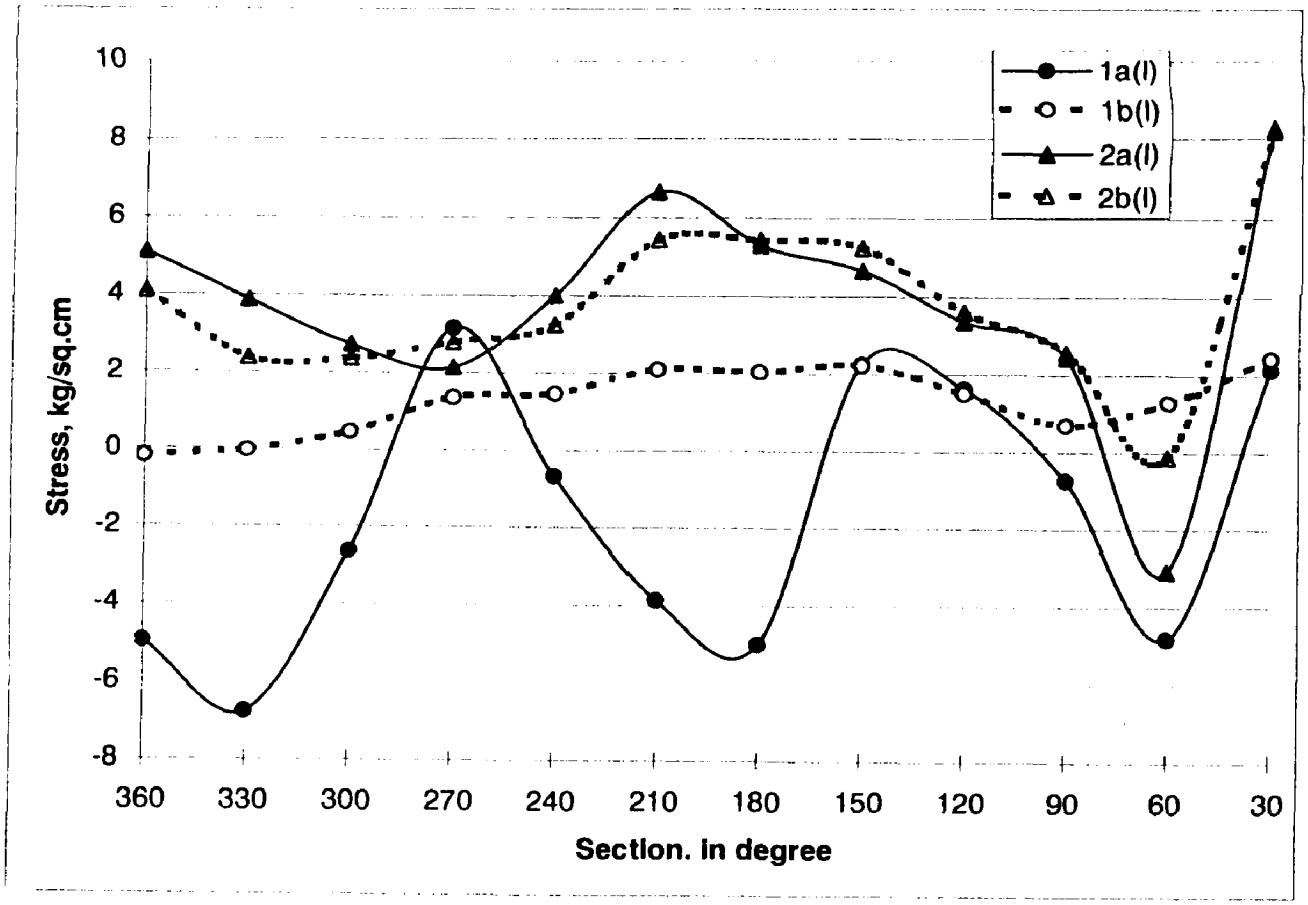


FIG. 5.74 DISTRIBUTION OF SX ALONG SECTIONS IN ZONE I

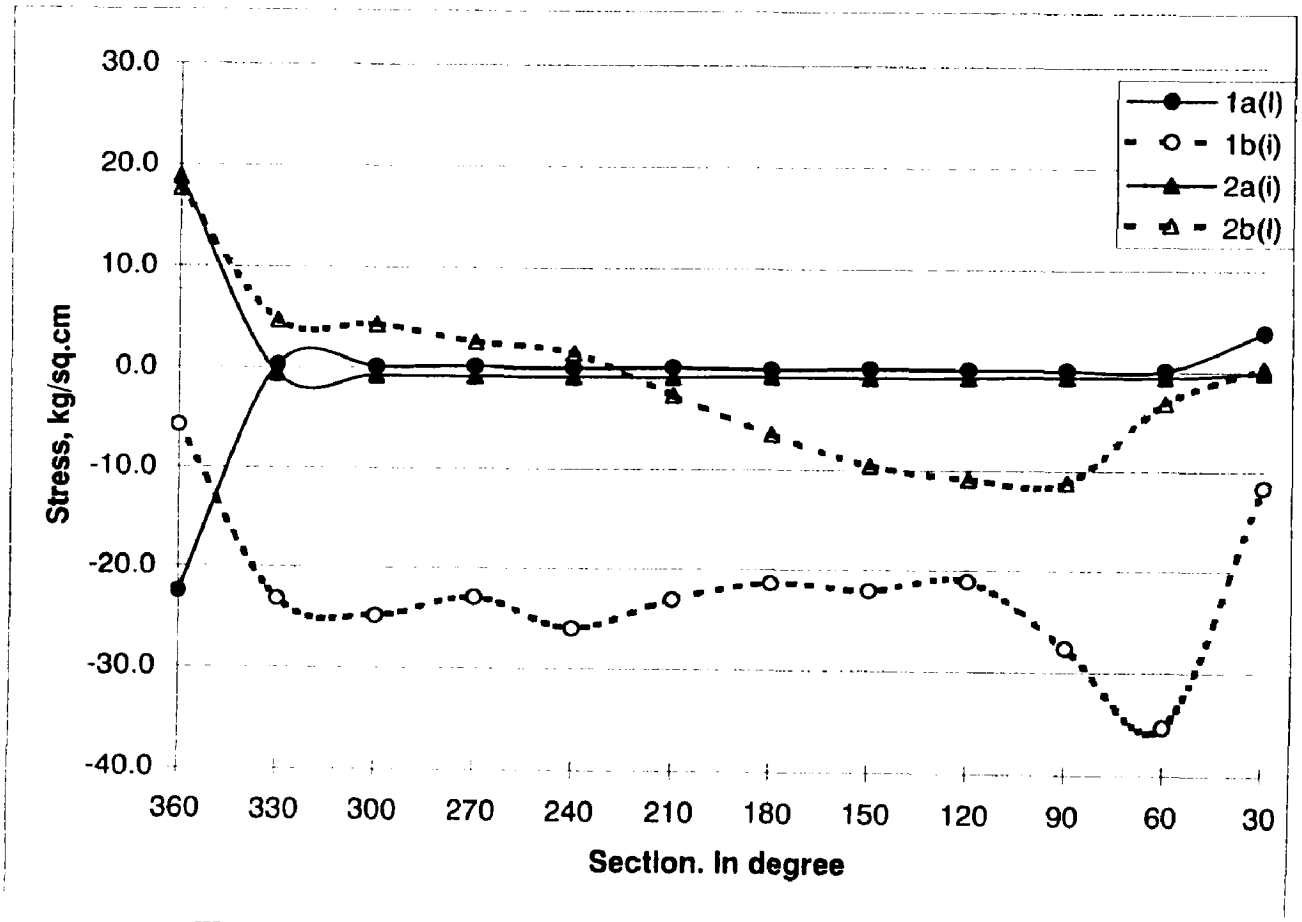


FIG. 5.75 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE A

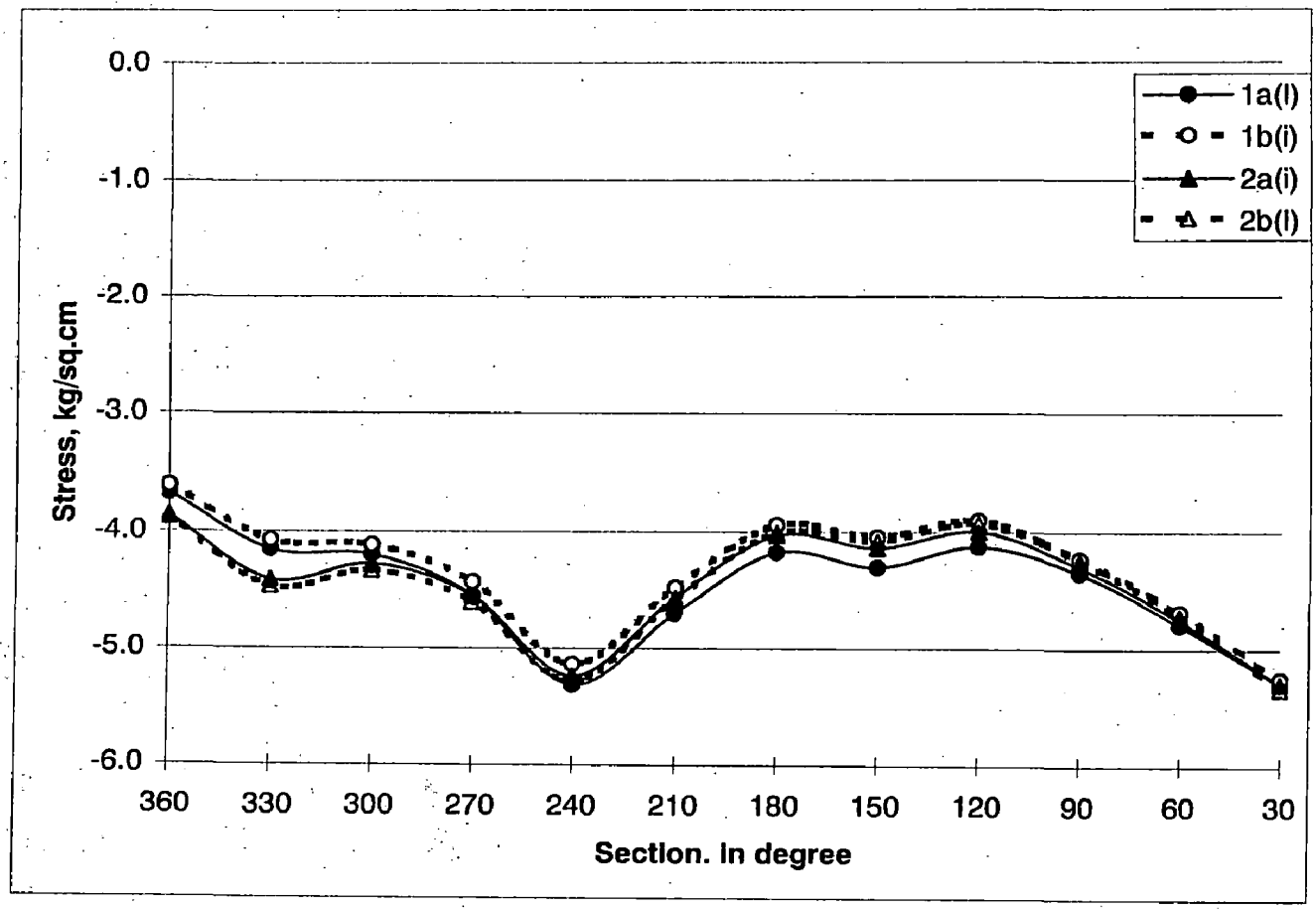


FIG. 5.76 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE B

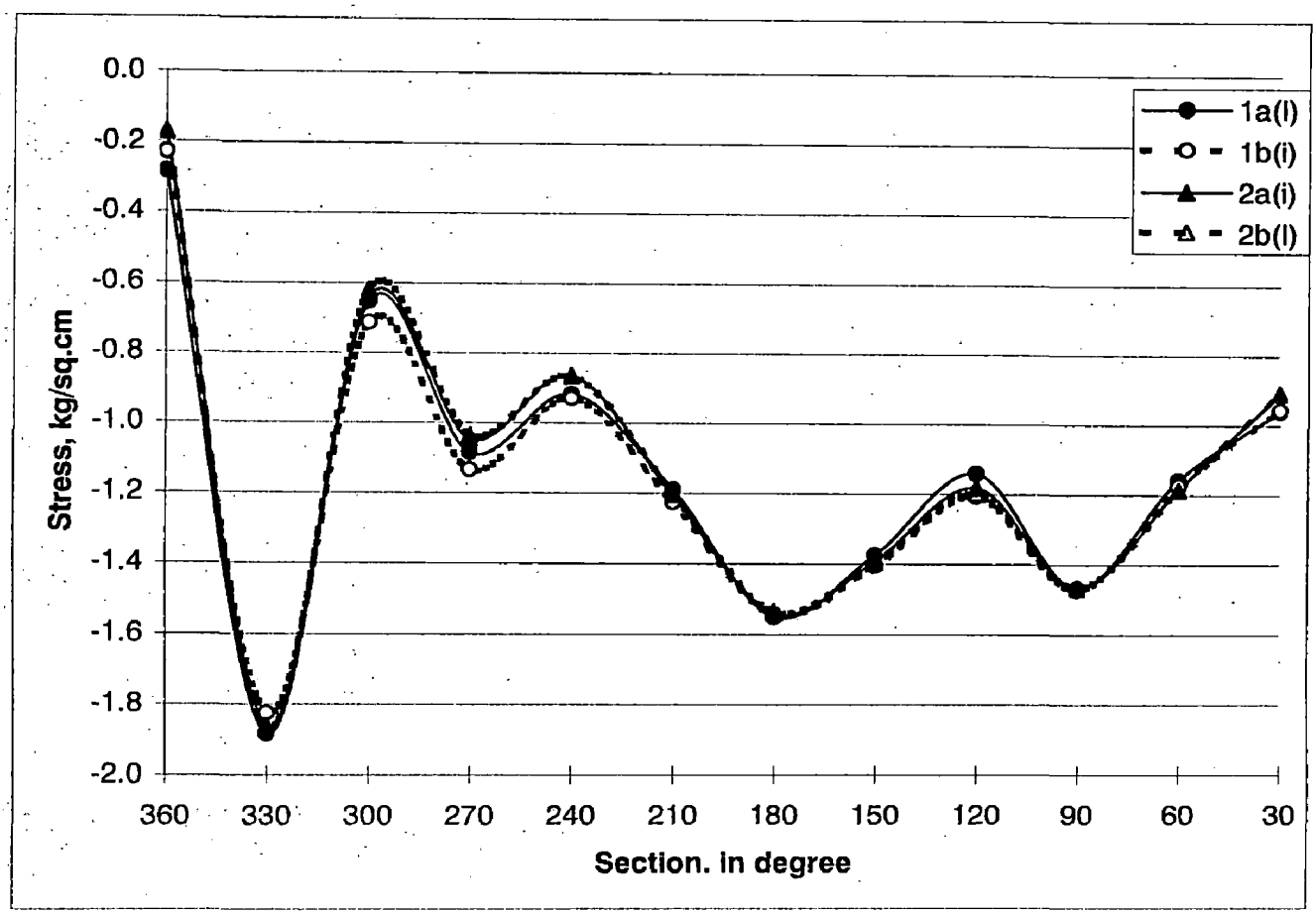


FIG. 5.77 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE C

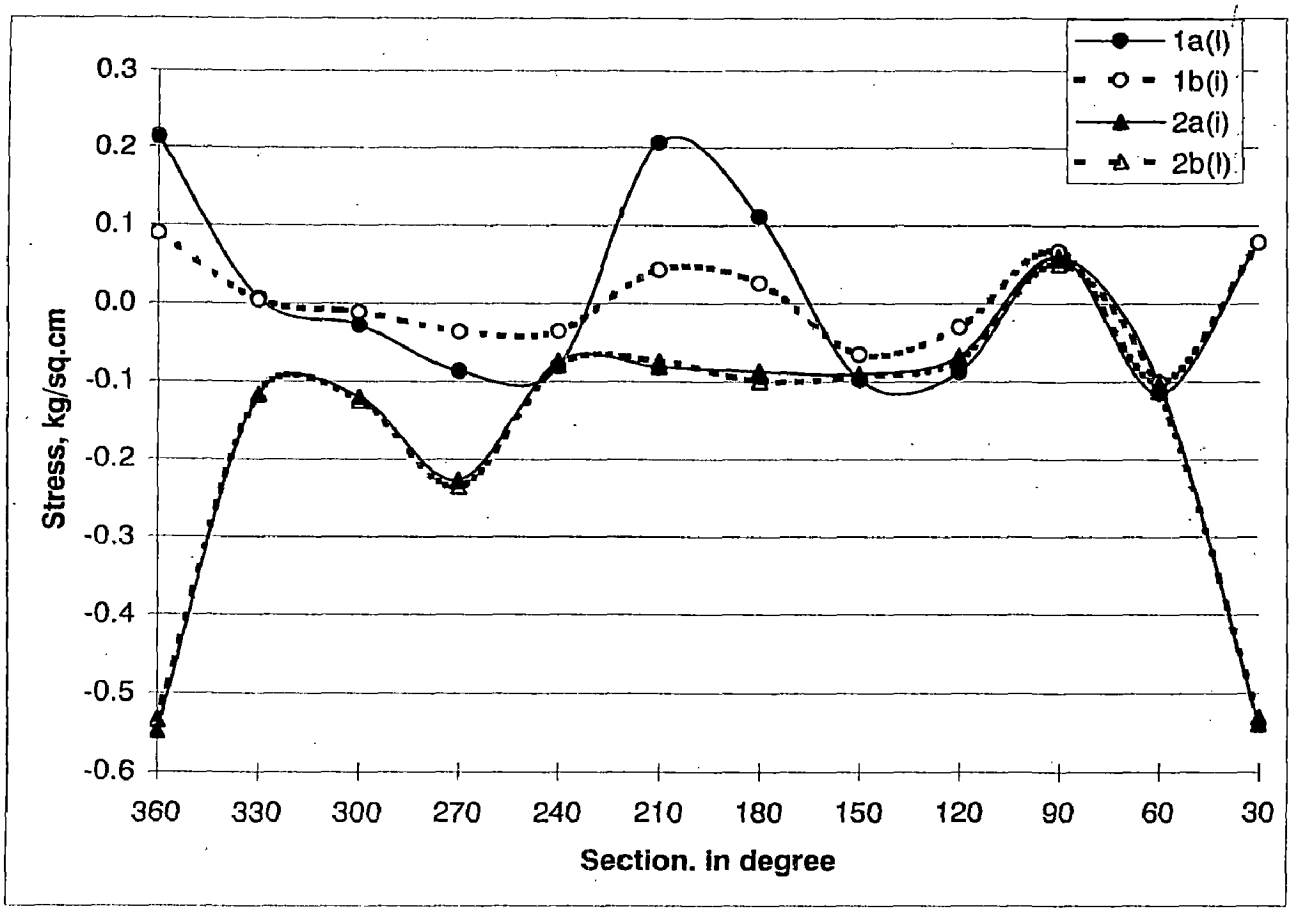


FIG. 5.78 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE D

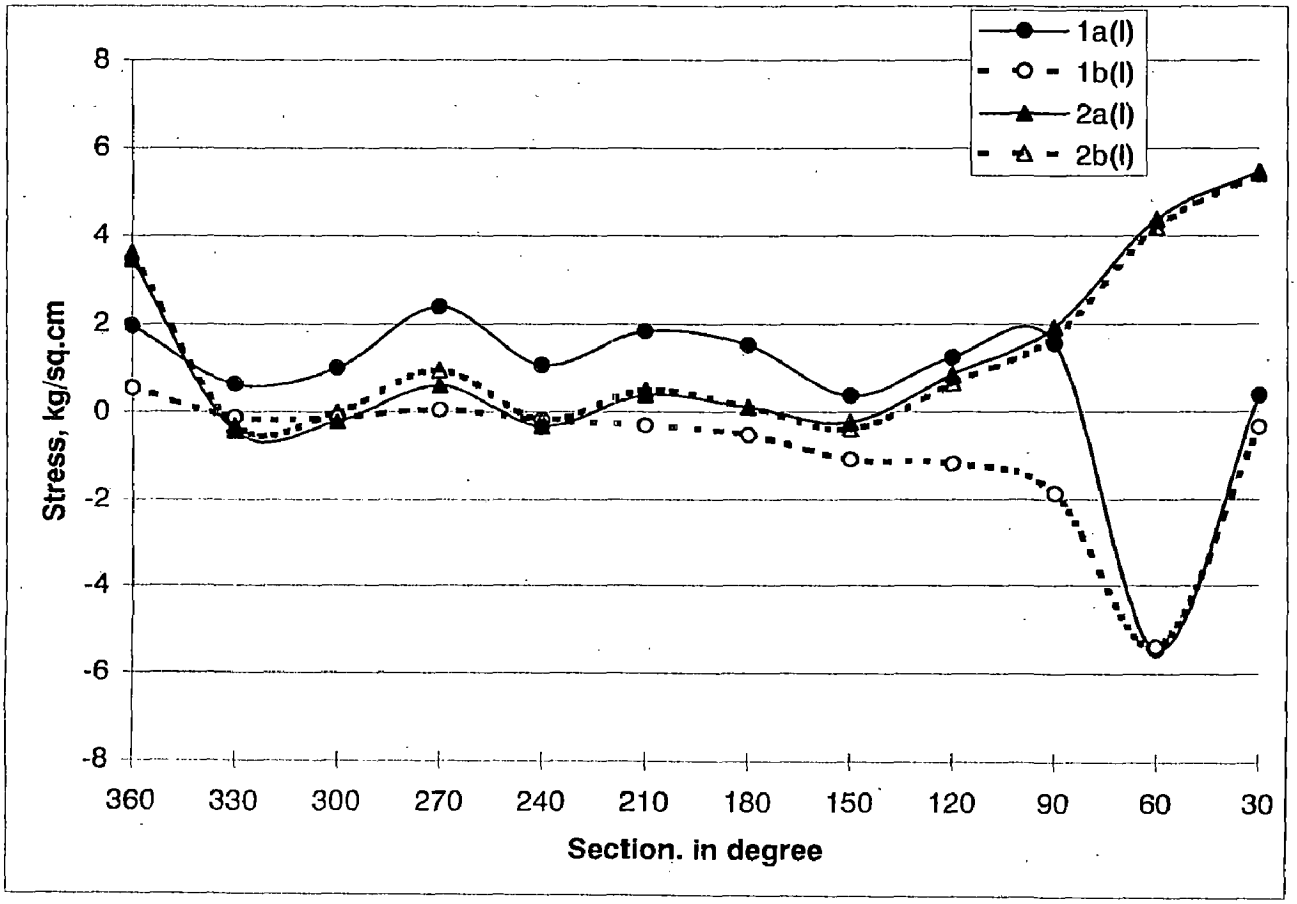


FIG. 5.79 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE E

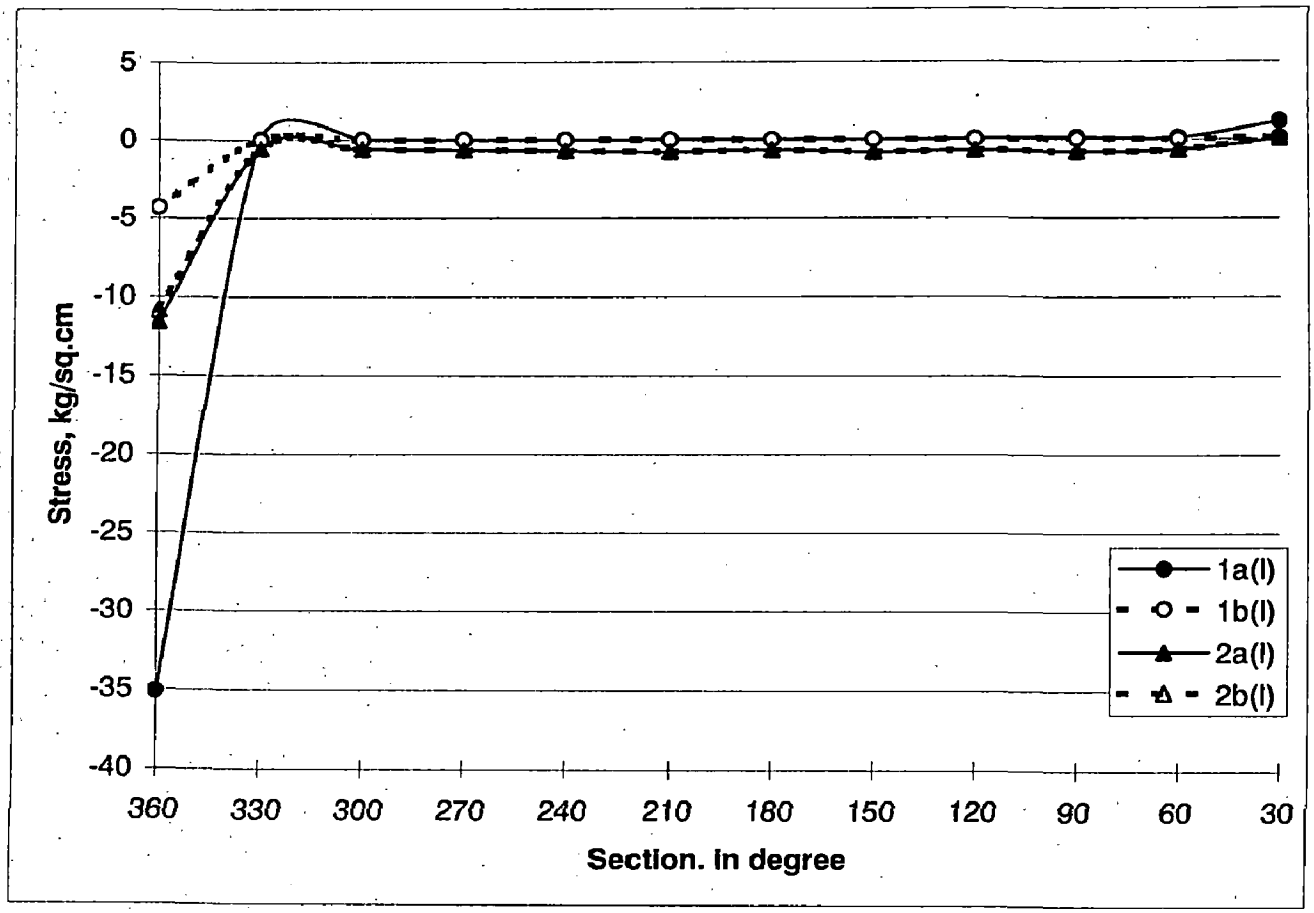


FIG. 5.80 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE F

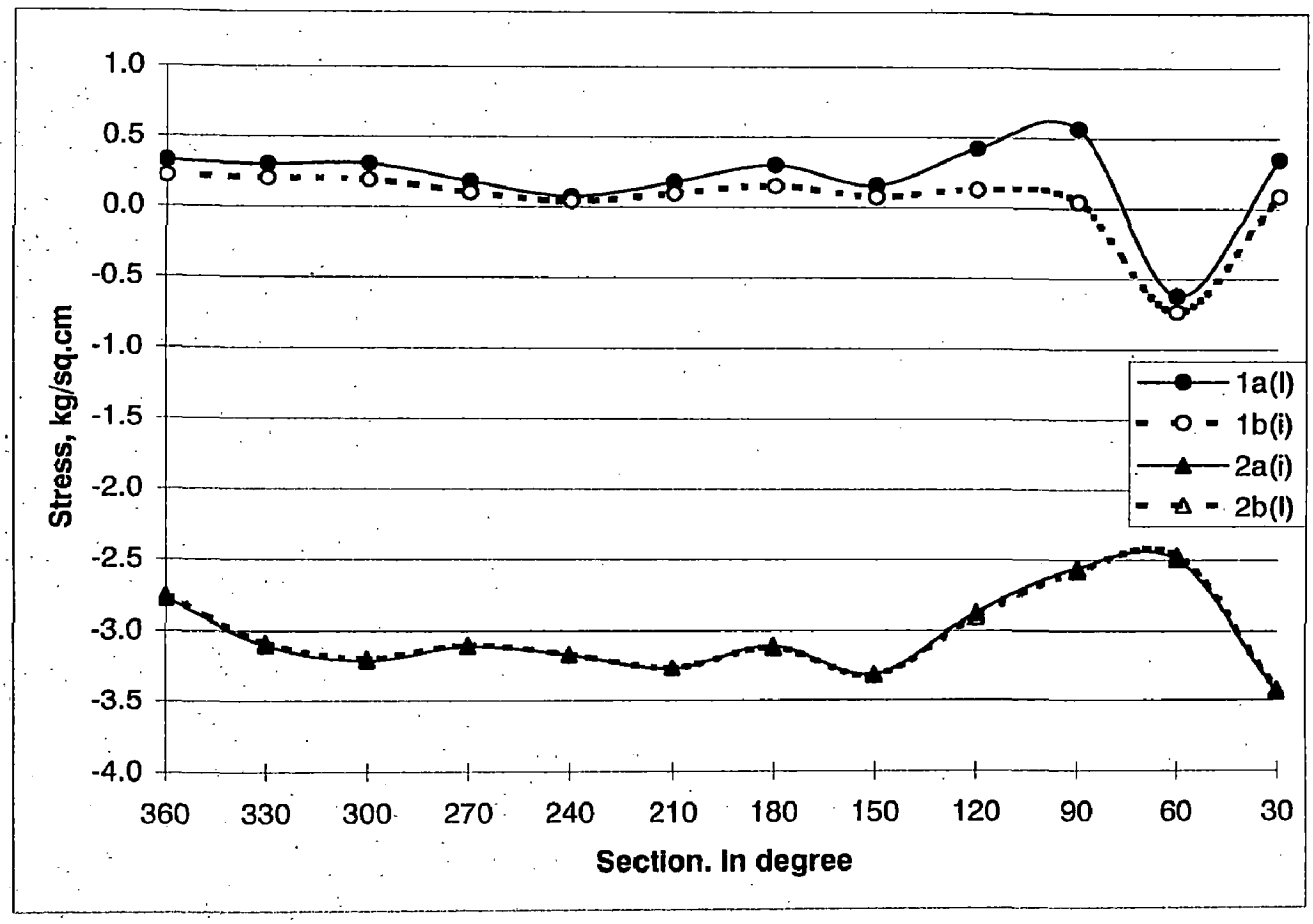


FIG. 5.81 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE G

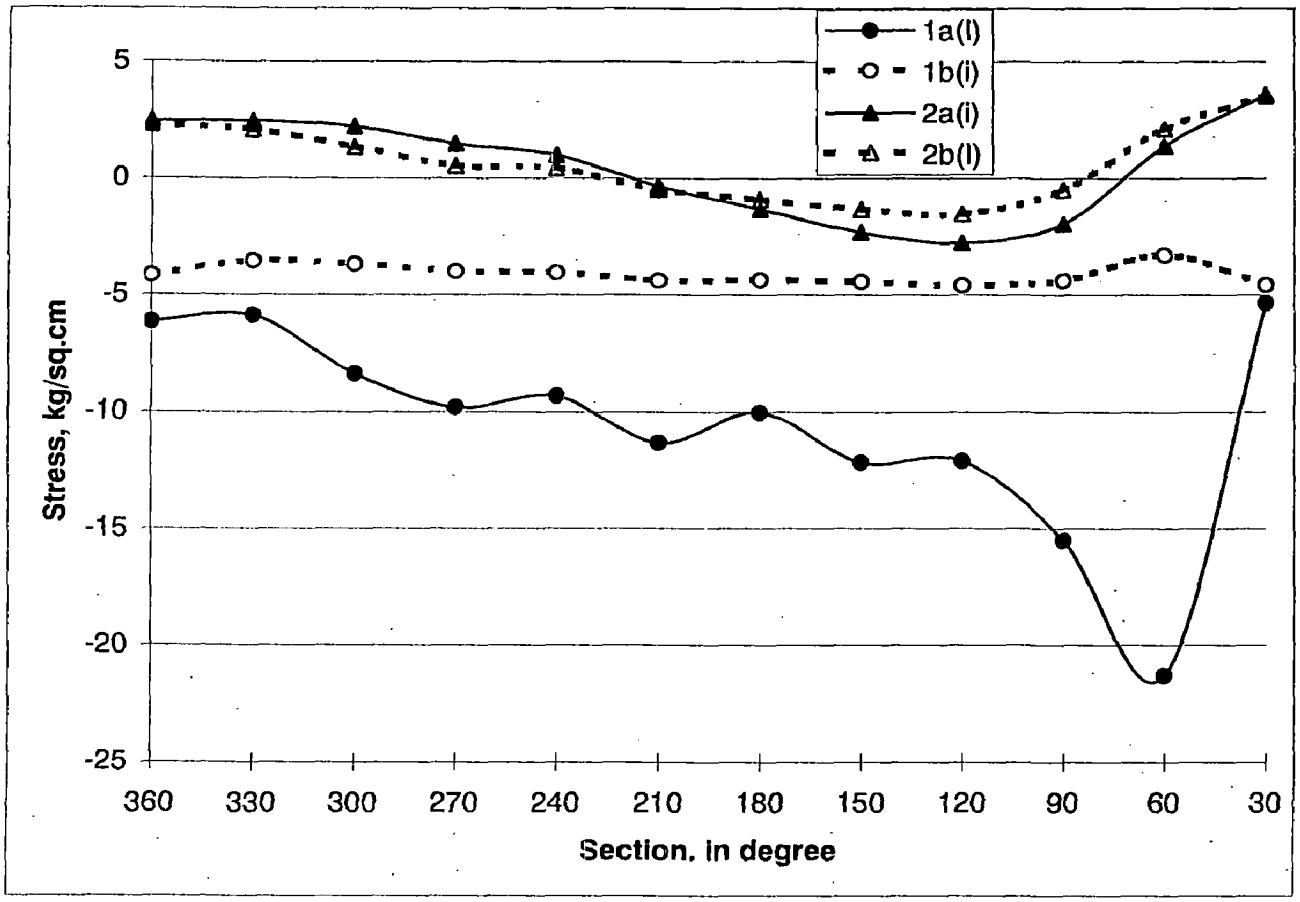


FIG. 5.82 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE H

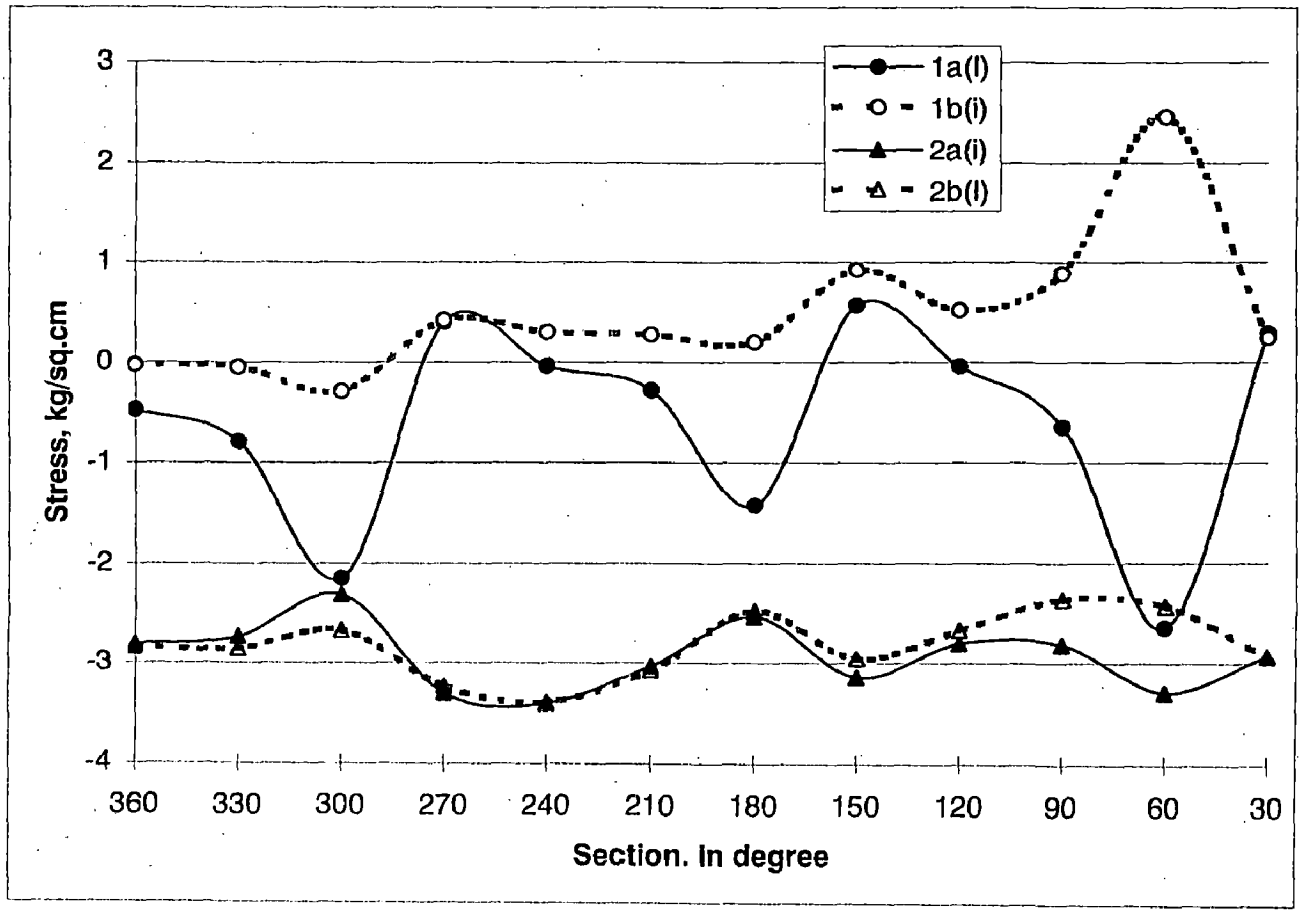


FIG. 5.83 DISTRIBUTION OF SY ALONG SECTIONS IN ZONE I

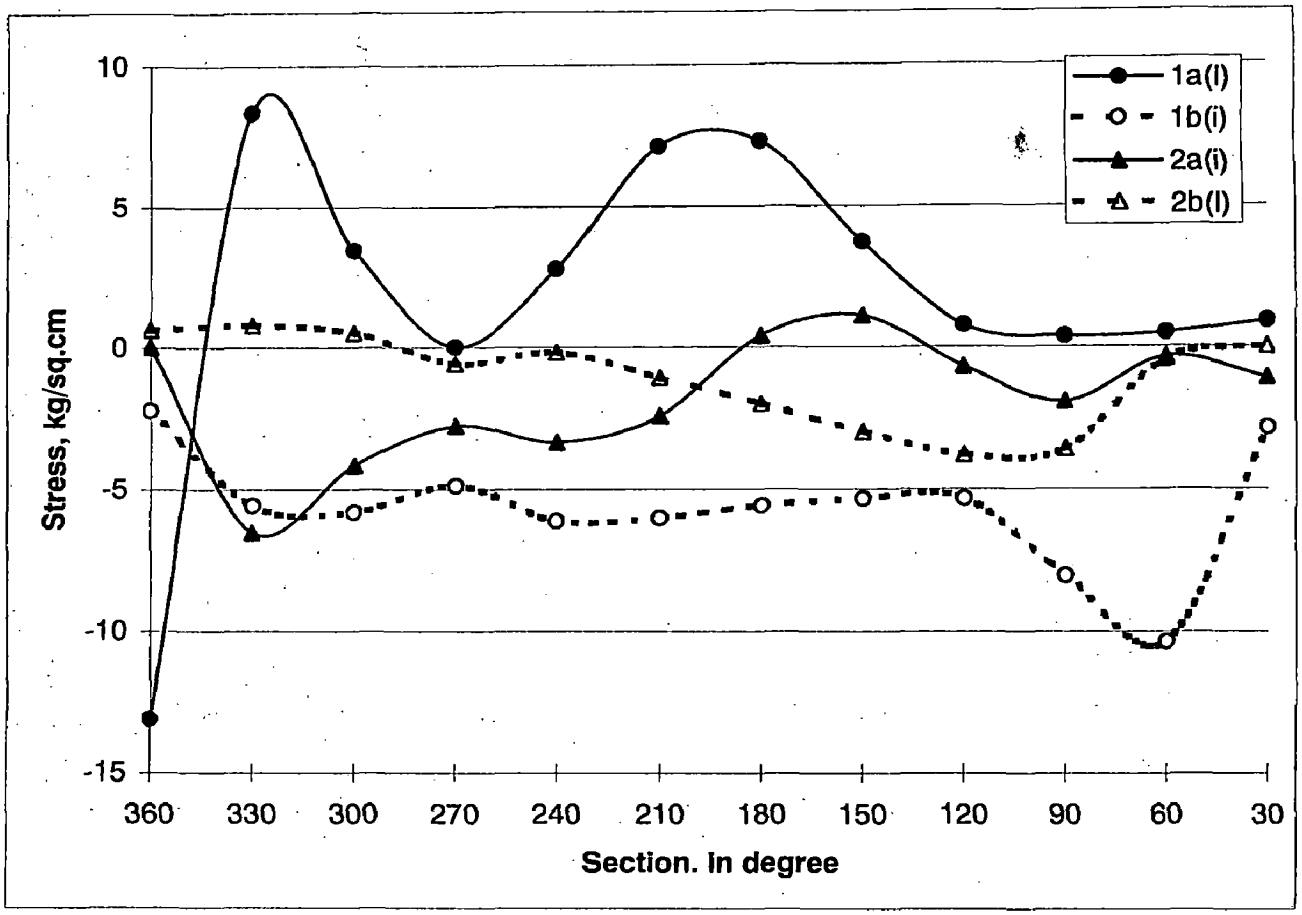


FIG. 5.84 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE A

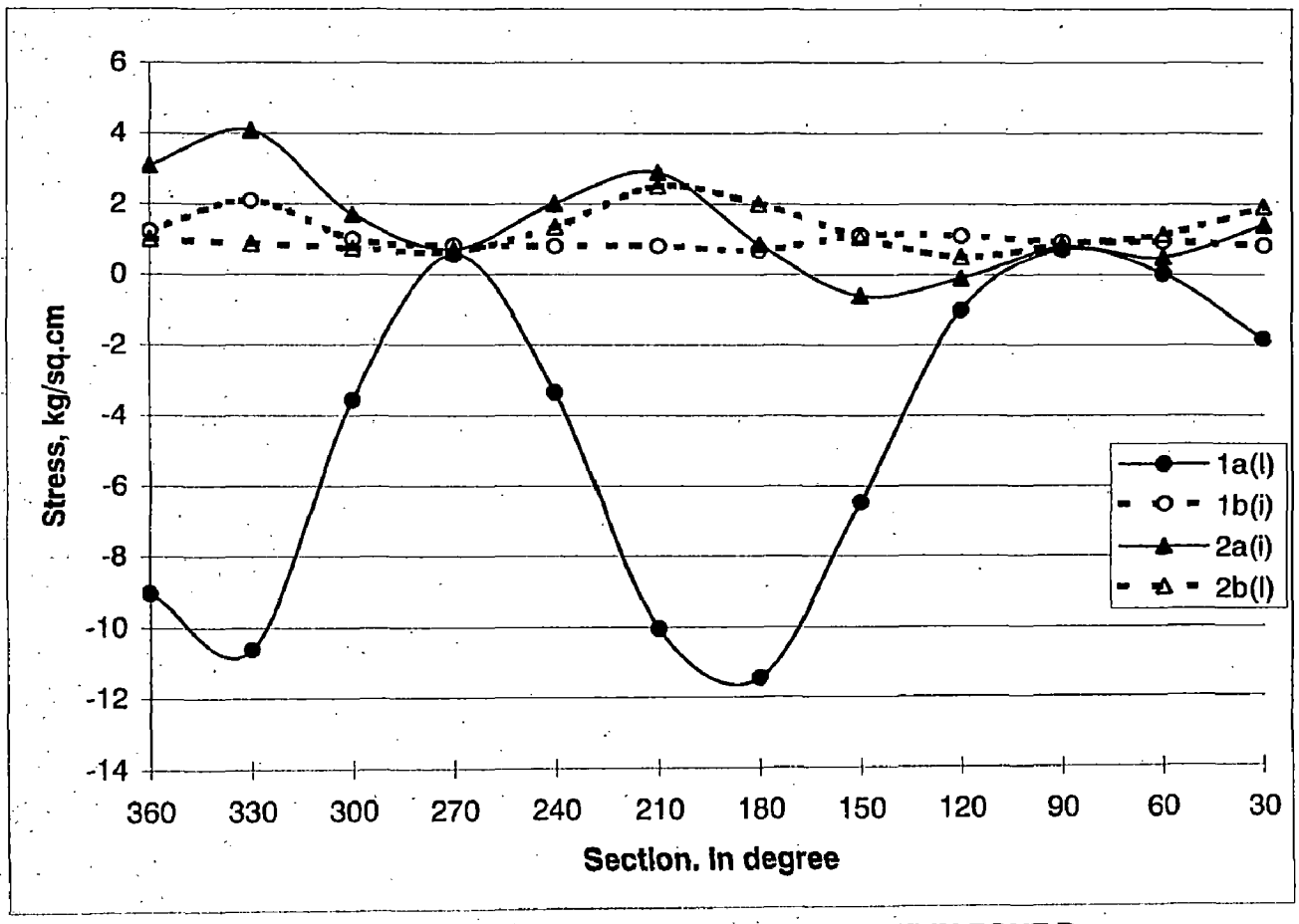


FIG. 5.85 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE B

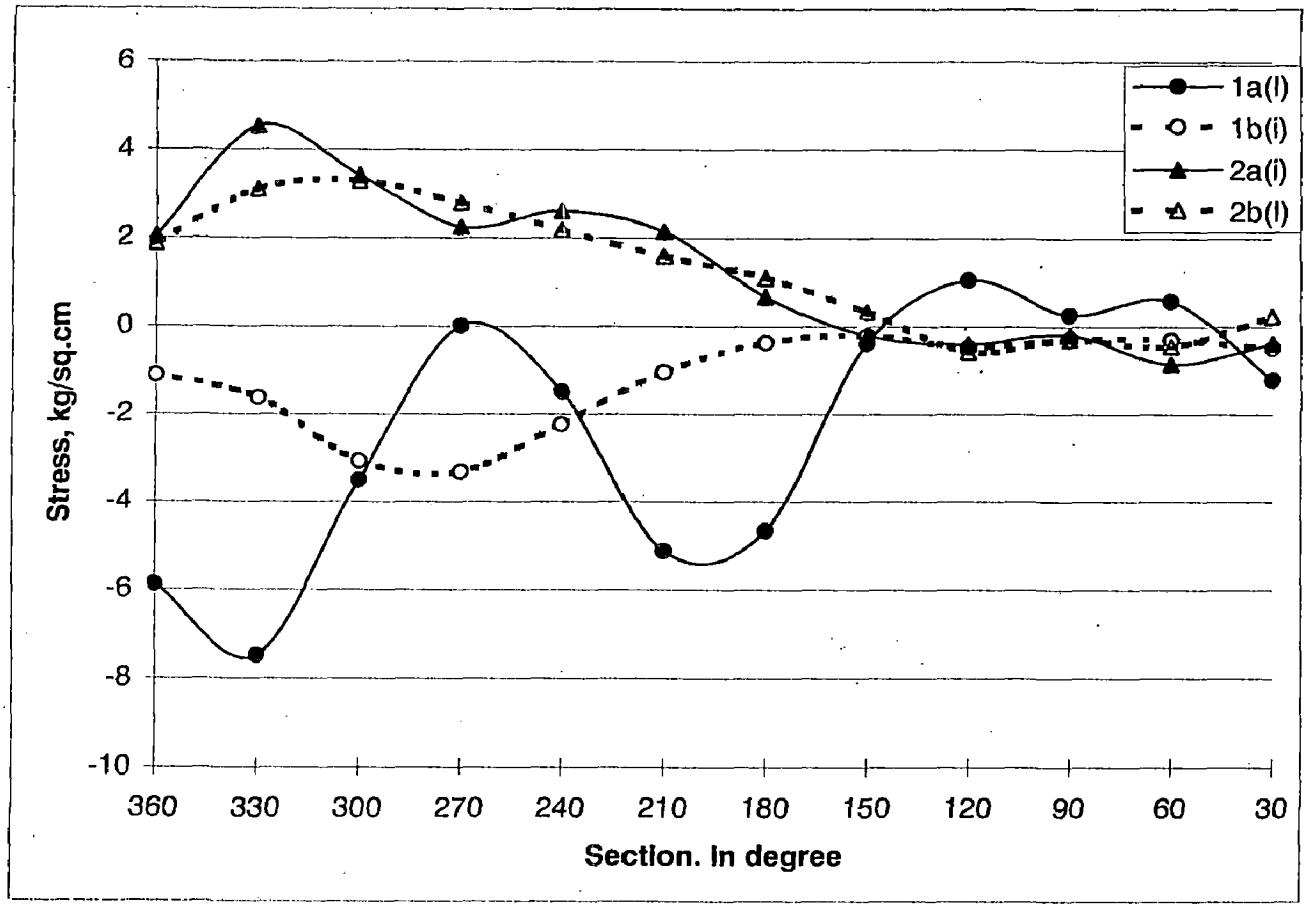


FIG. 5.86 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE C

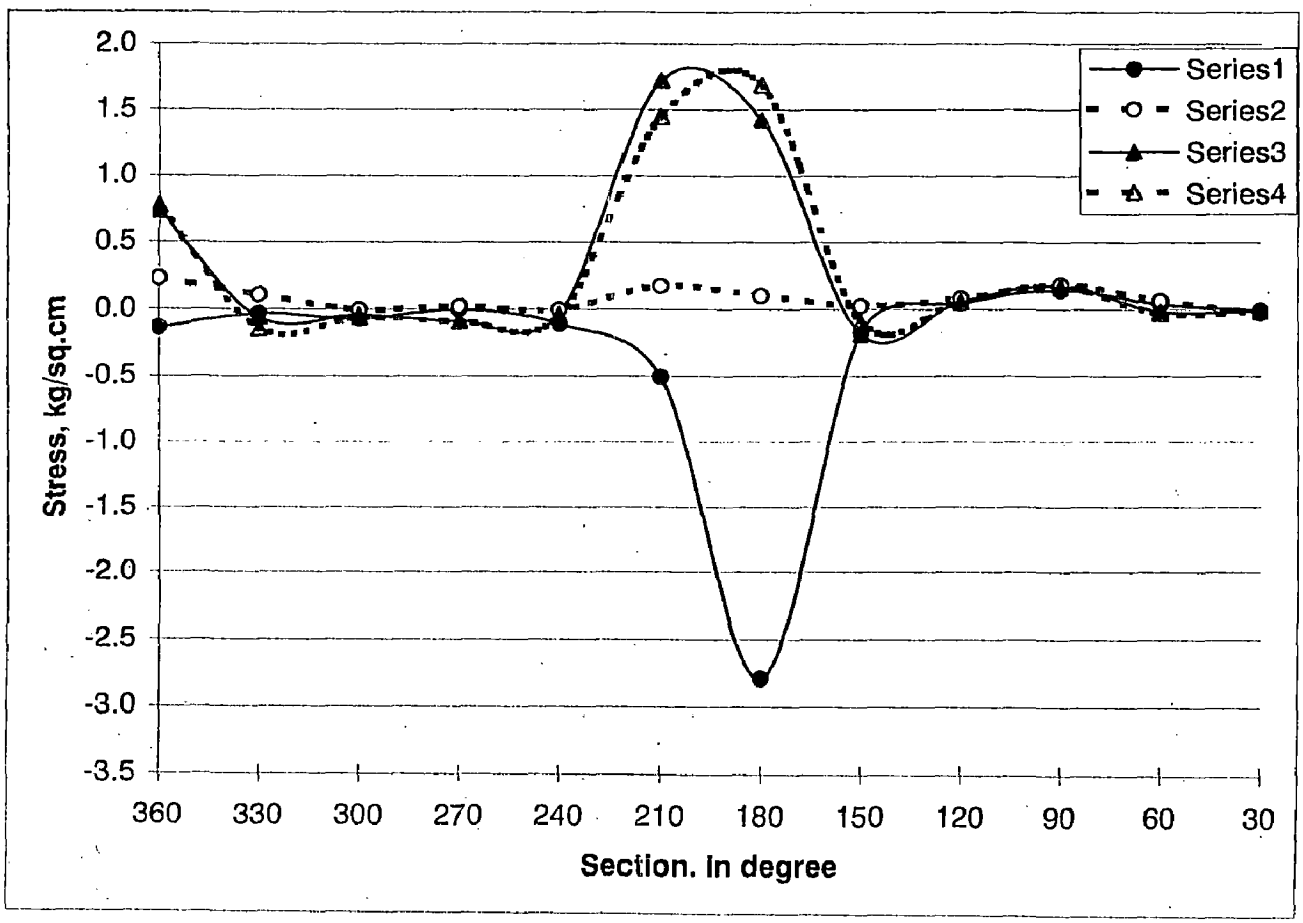


FIG. 5.87 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE D

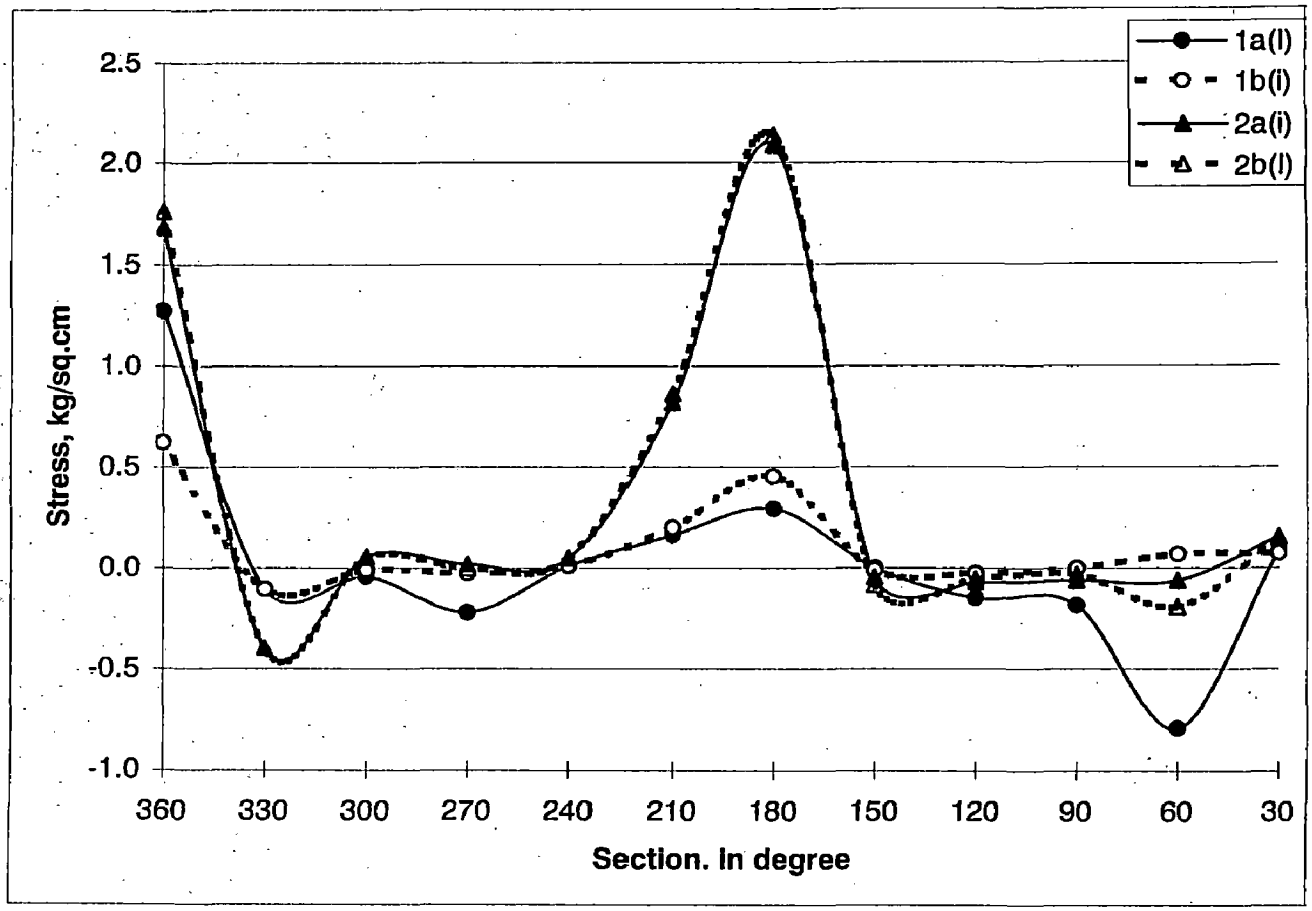


FIG. 5.88 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE E

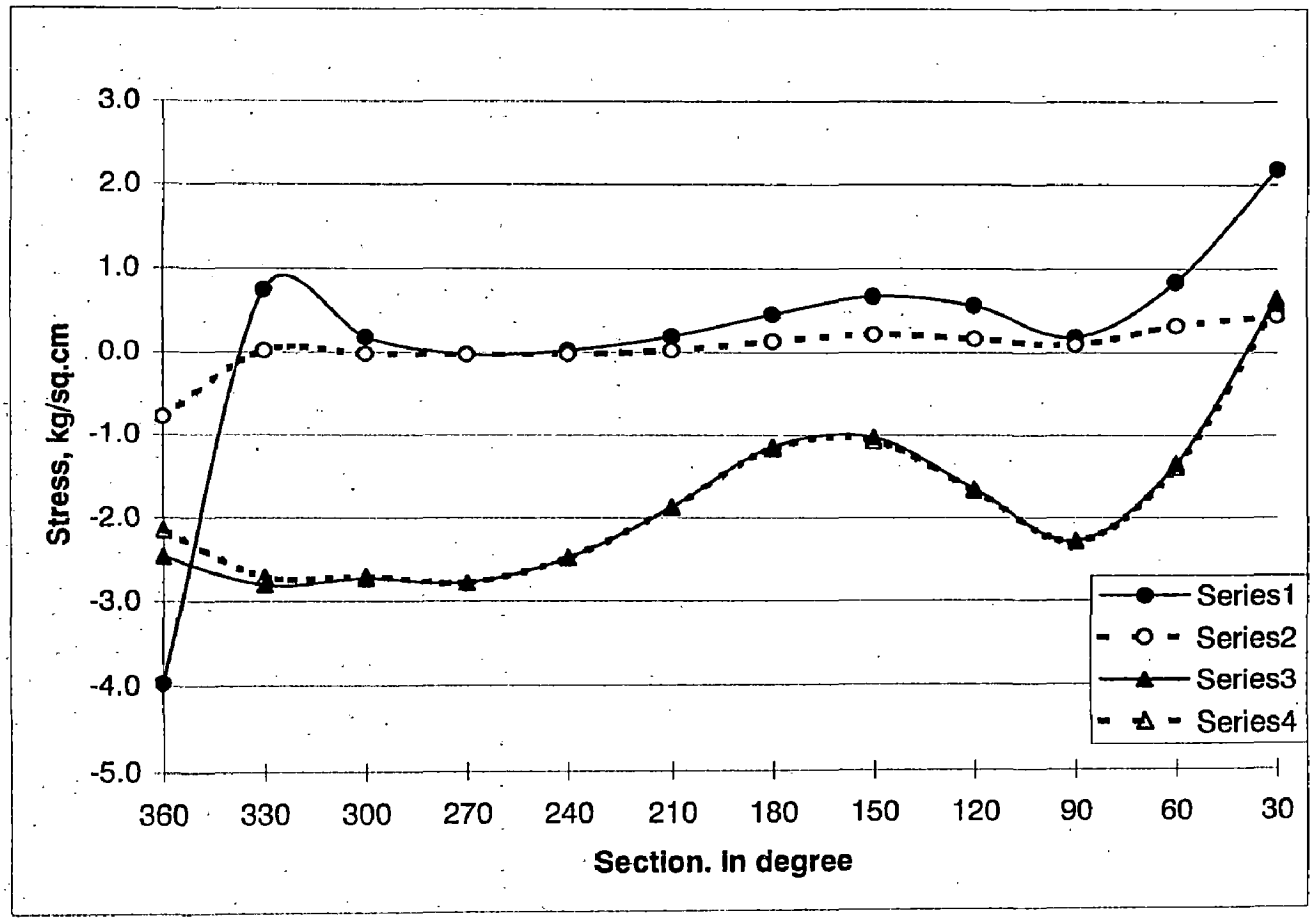


FIG. 5.89 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE F

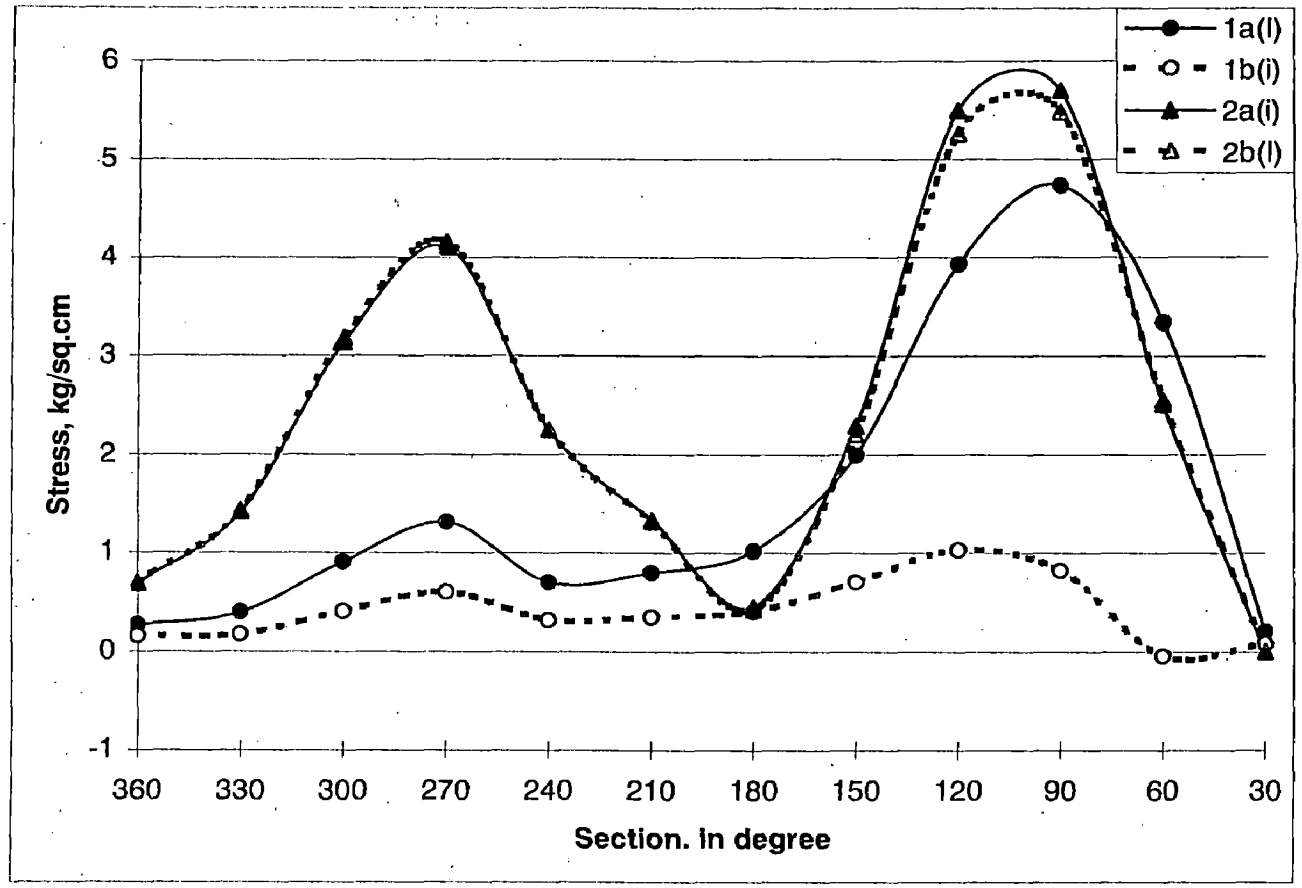


FIG. 5.90 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE G

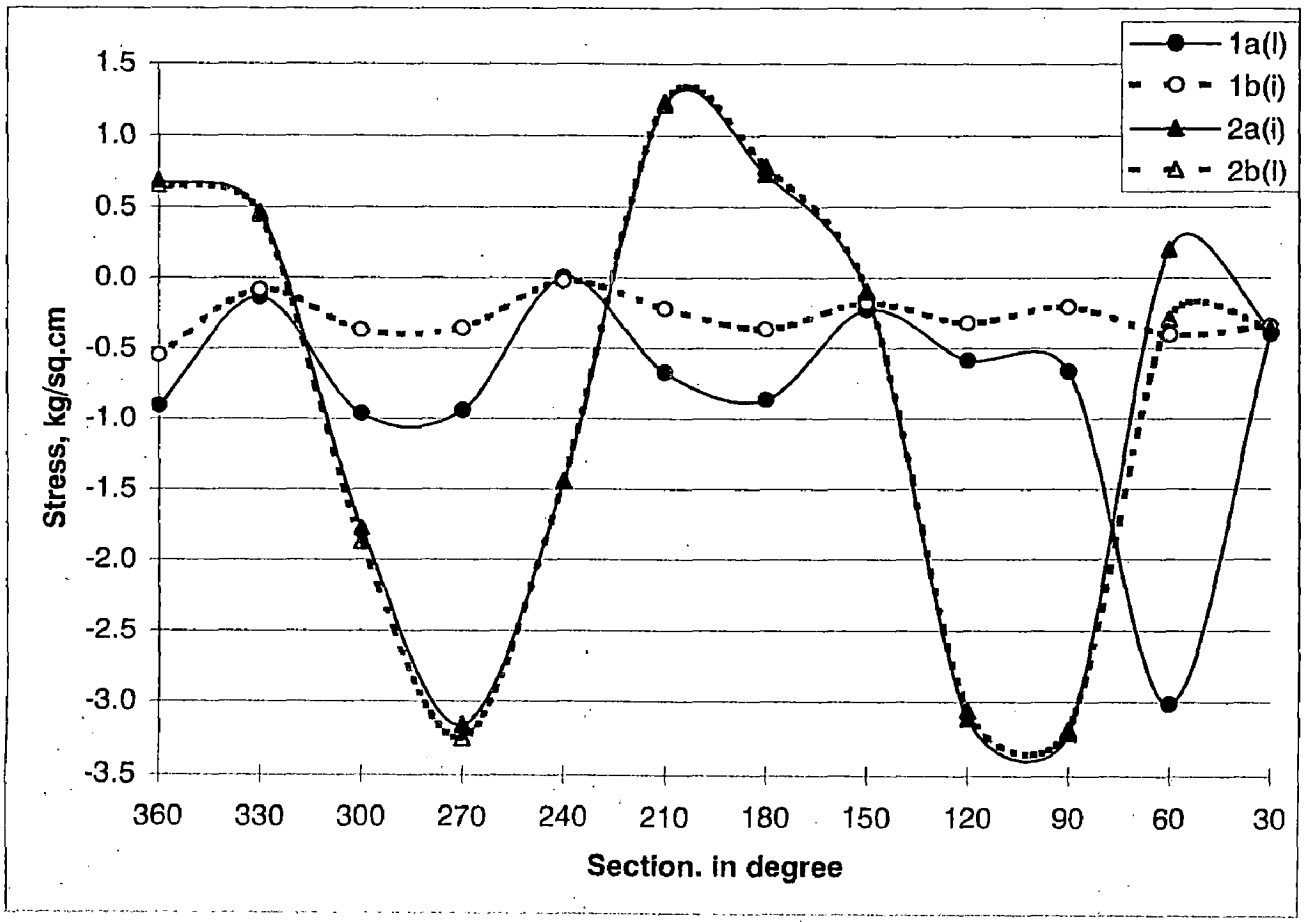


FIG. 5.91 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE H

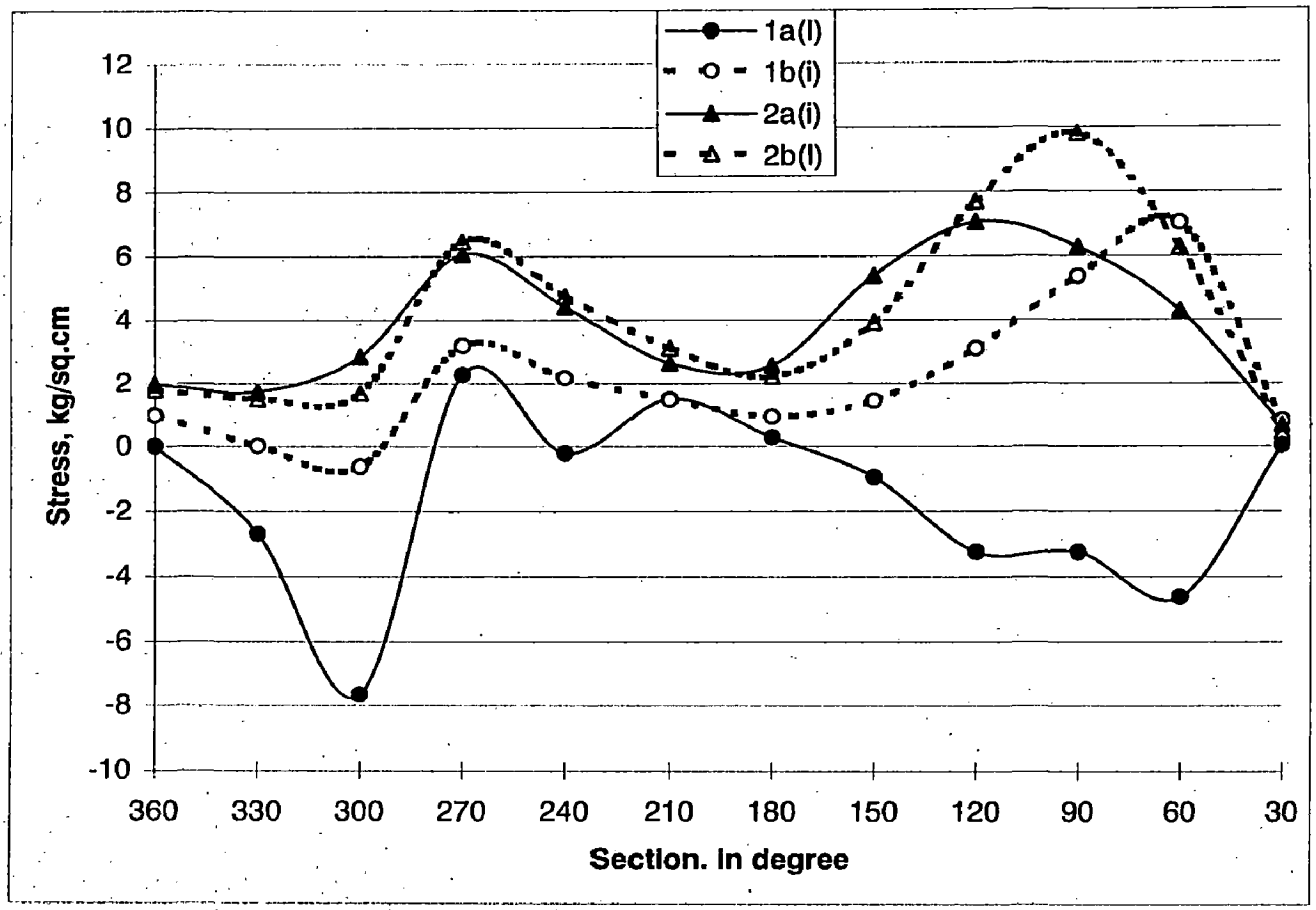


FIG. 5.92 DISTRIBUTION OF SZ ALONG SECTIONS IN ZONE I

APPENDIX-B

4.B Modeling Steps

4.B MODELING STEPS:

4.B.1 DEFINE ELEMENT TYPE AND MATERIAL PROPERTIES

❖ TO OPEN THE GUI WINDOW:

➢ ANSYS 5.4 > INTERACTIVE

- Select ANSYS/Multiphysics (unlimited) in Product selection
- Write your Initial Jobname
- Set 256 for Total Work Space (as required)
- Set 64 for Database (as required)
- Click on **Run**

ANSYS 5.4 Notice window will appear

Click on **OK**

GUI window will appear.

❖ TO SELECT THE DISCIPLINE OF THE PROBLEM:

➢ Main Menu > Preferences

Preferences for GUI Filtering Dialog box will appear

- Mark in Structural [·] for individual discipline
- Mark in h-method (•) for structural discipline options
- Click on **OK**

❖ TO SELECT THE ELEMENT TYPE:

➢ Main Menu > Preprocessor > Element Type > Add/Edit/Delete ....

Element type Dialog box will appear

- Click on **Add...**

Library of Element Types Dialog box will appear

- Select Structural Solid and Traingle 6node 2 for 2-D analysis
  Tet 10node 92 for 3-D analysis

There will be 1 in Element type reference number **1** for one element

- Click on **OK**

Type 1 PLANE2/SOLID92 will appear in Defined Element Types Dialog box

- Click on **OK**
- Close Element Type Menu (click ay X of menu at right corner)

❖ TO DEFINE MATERIAL PROPERTIES:

➢ Main Menu > Preprocessor > Material Props > Constant / Isotropic

Isotropic Material Properties Dialog box will appear

- Specify material number as 1 **1**
- Click on **OK**

Another Isotropic Material Properties Dialog box will appear

- Write 2.05e^5 for EX **2.05*10^5**
- Write 0.0024 for DENS
- Write 0.2 for NUXY **0.2**
- Click on **OK**

- Close Material Props Menu.

4.B.2 CREATE THE MODEL OF THE PROBLEM

❖ TO CREATE A KEY POINT: -

GUI: **Main Menu>Preprocessor>Modeling-Create>Key Points>In Active CS...**
Create Key-points in Active Coordinate System Dialog box will appear.

Write the Key Point number and corresponding coordinates in the dialog box clicking on apply for another key point and finally on OK as follows (e.g. for section at 360^0):

K-Point No.	Symbl on sketch	Coordinates (x, y, z)			
13		906.6	000.0	000.0	Click on **Apply**
14		606.6	000.0	000.0	Click on **Apply**
12	**a**	327.5	-110.0	000.0	Click on **Apply**
10	**b**	195.0	-110.0	000.0	Click on **Apply**
9	**c**	195.0	-450.0	000.0	Click on **Apply**
8	**d**	1100.0	-450.0	000.0	Click on **Apply**
7	**e**	1100.0	420.0	000.0	Click on **Apply**
6	**f**	555.0	420.0	000.0	Click on **Apply**
5	**g**	475.0	420.0	000.0	Click on **Apply**
4	**h**	275.0	420.0	000.0	Click on **Apply**
3	**i**	275.0	110.0	000.0	Click on **Apply**
2	**j**	327.5	110.0	000.0	Click on **OK**

Close Key Points Menu.

❖ TO CREATE A ARC: -

GUI: **Main Menu>Preprocessor>Modeling-Create>Lines-Arcs>By End KPs & Rad +**
"**Pick or enter key point at start and end of arc**" in ANSYS Input window and "**Arc by End KPs & Rad**" picker Dialog box will appear.
Either pick the key points by picker or enter the key point numbers of start and end of arc in the Input window separated by comma and press enter of Keyboard to select the Key points
Click on OK
Either pick or enter the key point number of center.
Click on OK
Write the Radius of Arc and check the key points number in the Dialog box.
Click on **Apply** for another arc and **OK** for last arc.

				Line no.
e.g.	Pick the Key Points	**13**	and **12**	
	Click on	**OK**		
	Pick the Key Point	14		
	Click on	**OK**		
	Enter the value of Radius of Arc in the Dialog box	300		
	Click on	**Apply**		**1**

Pick the Key Points **13** and **2**
Click on **OK**
Pick the Key Point **14**
Click on **OK**
Enter the value of Radius of Arc in the Dialog box 300
Click on **OK** **2**

❖ **TO CREATE A LINE: -**

GUI: **Main Menu>Preprocessor>Modeling-Create>Lines-Lines>Straight Line**
"Pick or enter end key points" in ANSYS Input window and "**Create straight Line"** picker Dialog box will appear.
Either pick the end key points by picker or enter the end key points of start and end of line in the Input window separated by comma.
Press Enter of Keyboard if u have enter the end key point numbers in the input window for next line and double press for last line.

					Line no.	**Symbol on Sketch**
e.g.	Pick the Key Points	**12**	and	**10**	**1**	**a**
	Pick the Key Points	**10**	and	**9**	**10**	**b**
	Pick the Key Points	**9**	and	**8**	**9**	**c**
	Pick the Key Points	**8**	and	**7**	**8**	**d**
	Pick the Key Points	**7**	and	**6**	**7**	**e**
	Pick the Key Points	**6**	and	**5**	**6**	**f**
	Pick the Key Points	**5**	and	**4**	**5**	**g**
	Pick the Key Points	**4**	and	**3**	**4**	**h**
	Pick the Key Points	**3**	and	**2**	**3**	**i**

Clock **OK** to finish the job.

❖ **TO ADD THE LINES: -**

GUI: **Main Menu>Preprocessor>Modeling-Operate>Add>Lines +**
"Pick or enter the lines to be added" in ANSYS Input window and "**Add Lines"** picker Dialog box will appear.
Either pick the lines by picker or enter the lines number in the Input window separated by comma & press enter of Keyboard to select the lines
Click on **OK** of Add lines Picker Menu or Press Enter for entering the line numbers in Input window.
Click on **OK** of picker box
An Add Lines Dialog box will appear. Select to "**Deleted"**
Click on **Apply** for next lines or **OK** to finish the job.

		Line no.			**Symbol on Sketch**
e.g.	Pick the lines	**1**	and	**2**	**40**	**j**

Click on OK of picker box
Click on OK of Add Lines Dialog box for Deleted option

❖ **TO CREATE AREA: -**

GUI: **Main Menu>Preprocessor>Modeling-Create>Areas-Arbitrary>By Lines**

"Pick or enter lines defining the area" in ANSYS Input window and **"Create Area by Lines"** picker Dialog box will appear.
Either pick the lines by picker or enter the lines number in the Input window separated by comma & press enter of Keyboard to select the lines.
Click on **Apply** for another area and **OK** for last area of picker box.

e.g. Pick Lines 1 10 9 8 7 6 5 4 3 and 40 with picker
Click on **OK** of picker box.

- ***In this way a solid plane area is created at section 360^0 and in similar way all the solid plane areas are created at 15^0 angular distances each.***

❖ **TO CREATE VOLUME: -**

Joined the corresponding Key points of two adjacent solid planes with arc and straight line as geometry. Form the different areas in between two planes with help of four lines.

GUI: **Main Menu>Preprocessor>Modeling-Create>Volumes-Arbitrary>By Areas**
"Pick or enter areas defining the volumes" in ANSYS Input window and **"Create Volume by Areas"** picker Dialog box will appear.
Either picks the areas by picker or enters the areas number in the Input window separated by comma & press enter of Keyboard to select the areas.
Click on **Apply** for another volume and **OK** for last volume of picker box.

Details of Key points, lines, Areas and different Volumes are shown in the following figures and Tables.

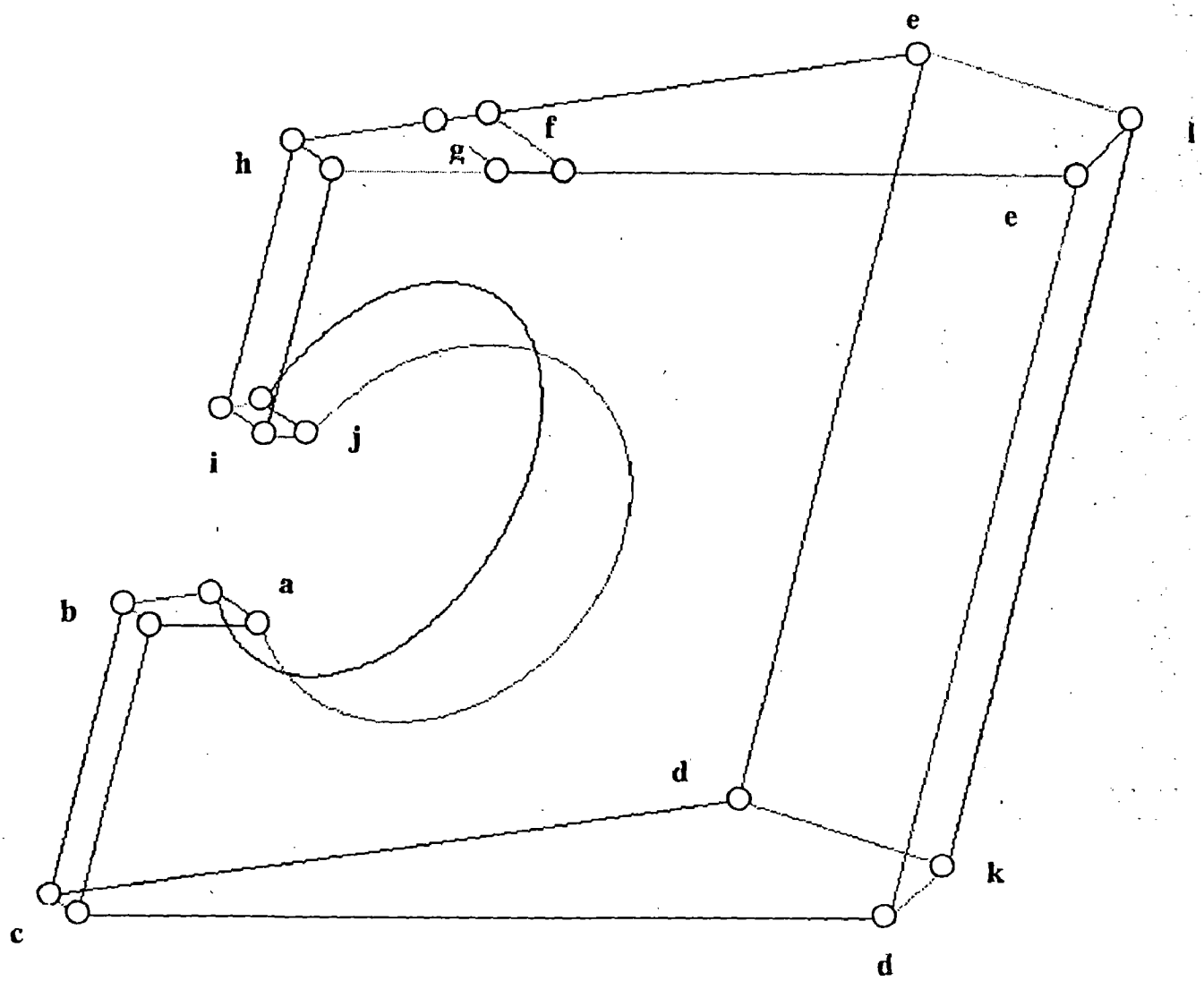


FIG. 4.B.1 SYMBOL OF KEY POINTS FOR SECTION

TABLE-4.B.1: DETAIL OF KEY POINTS AT EACH SECTION

Section	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p	q	r	s	t
0	11	10	9	8	7	6	5	4	3					2	30	1	27	12		
15	21	20	19	18	17	16	15	14	13					25	31	28	29	26		
30	39	38	37	36	35	34	33	32	24	23				42	46	44	45	43		
45	56	55	57	54	53	52	51	50	49	58				47	61	59	60	48	63	62
60	64	65	66	67	68	40	22	69	70	71				75	74		72	73	41	86
75	76	77	78	79	80	81	82	83	84	85										
90	87	88	89	90	91	92	93	94	95	96										
105	97	98	99	100	101	102	103	104	105	106										
120	107	108	109	110	111	112	113	114	115	116										
135	117	118	119	120	121	122	123	124	125	126	128	127								
150	129	130	131	132	133	134	135	136	137	138										
165	139	140	141	142	143	144	145	146	147	148										
180	149	150	151	152	153	154	155	156	157	158										
195	159	160	161	162	163	164	165	166	167	168										
210	169	170	171	172	173	174	175	176	177	178										
225	179	180	181	182	183	184	185	186	187	188	190	189								
240	191	192	193	194	195	196	197	198	199	200										
255	201	202	203	204	205	206	207	208	209	210										
270	211	212	213	214	215	216	217	218	219	220										
285	221	222	223	224	225	226	227	228	229	230										
300	231	232	233	234	235	236	237	238	239	240										
315	241	242	243	244	245	246	247	248	249	250	252	251								
330	253	254	255	256	257	258	259	260	261	262										
345	263	264	265	266	267	268	269	270	271	272										
360	12/11	10	9	8	7	6	5		3	2										

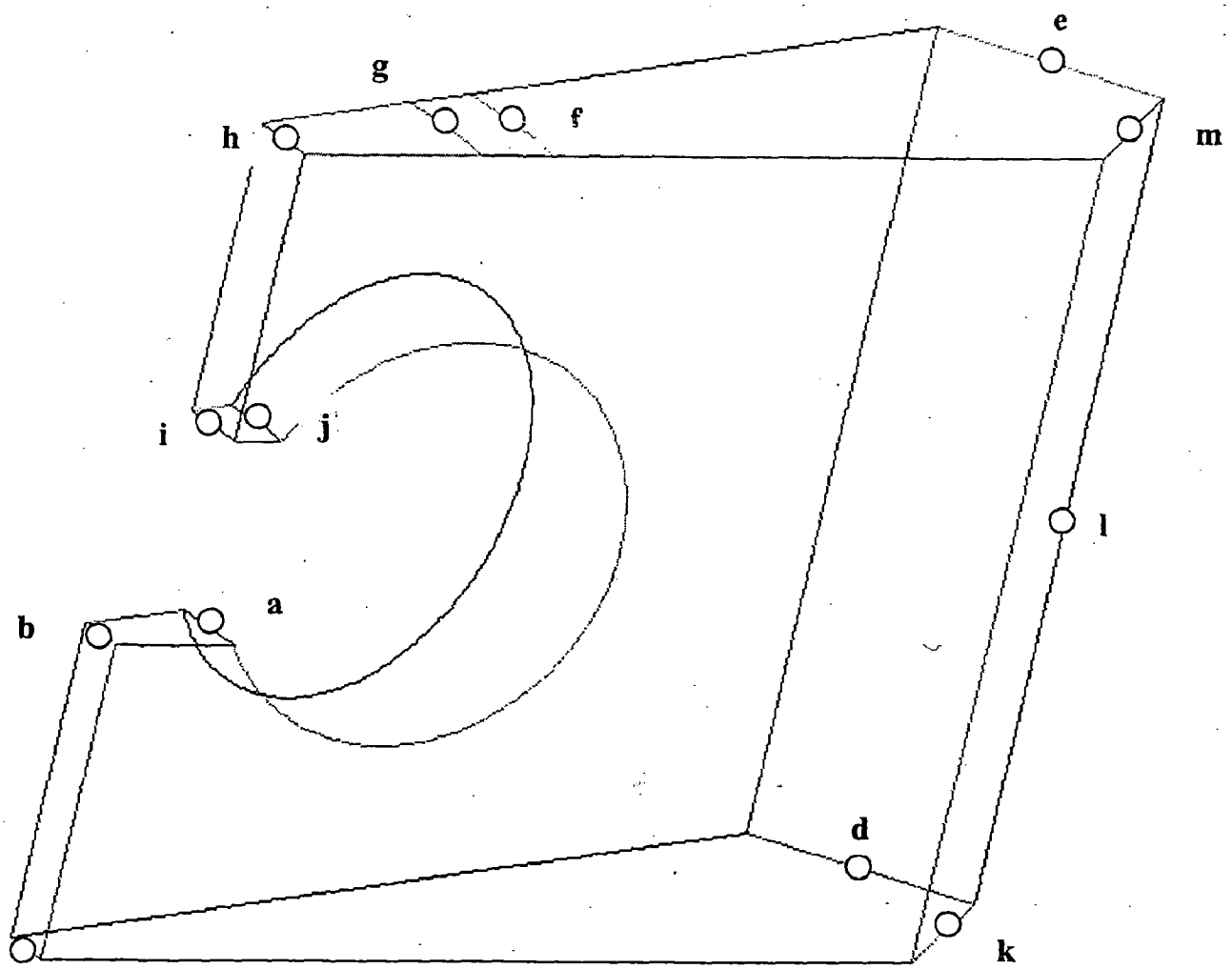


FIG. 4.B.3 SYMBOL OF LINES FOR INBETWEEN SECTION

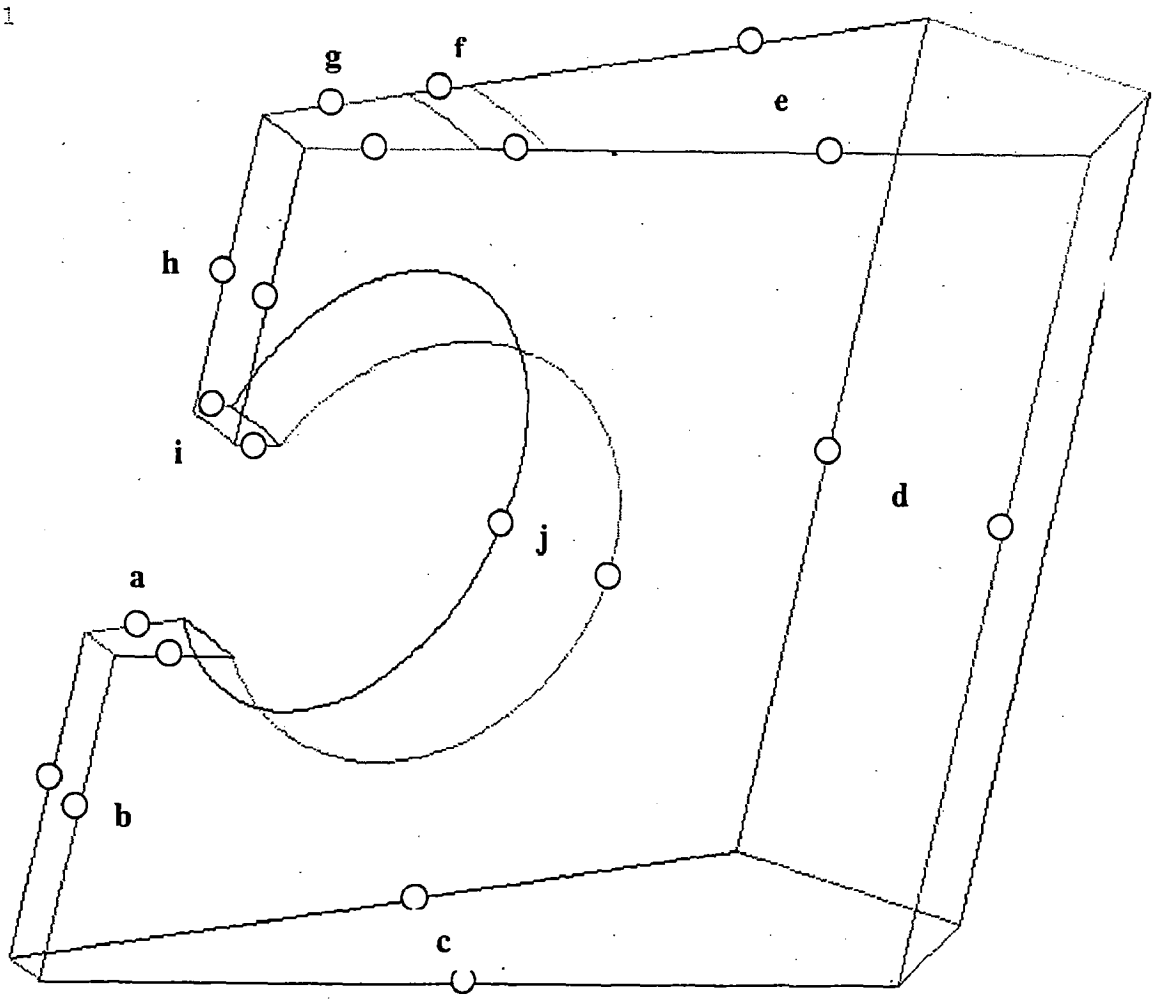


FIG. 4.B.2 SYMBOL OF LINES FOR SECTION

TABLE-4.B.2: DETAIL OF LINES AT EACH SECTION

Section	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p	q	r	s	t
0	1	10	9	8	7	6	5	4		14				40	37	33	42	13		
in between	26	23	11	44	31	30	29	28	27					24	39	34	36	25		
15	21	20	19	18	17	16	15	12		22				41	38	35	43	32		
in between	57	56	55	68	69	62	61	60	59	58				74	70	72	71	73		
30	46	45	54	50	53	52	51	49	48	47				81	80	78	82	75		
in between	98	97	88	64	65	103	102	101	99	100	**117**	**110**		105	111	108	109	106	112	116
45	84	83	79	63/86	76	67	66	77	85	104				113			114	107		
in between	119	120	121	124	125	130	129	96	118	115				126				127	132	128
60	87	89	123	131/122	92	91	90	93	94	95	**137**	**142**	**140**							
in between	150	151	152	154	153	147	146	145	149	148	**167**			170				168	161	169
75	133	134	135	136	138	139	141	143	144	155										
in between	174	173	172	171	166	179	178	177	176	175										
90	156	157	158	159	160	162	163	164	165	180										
in between	195	194	193	191	190	200	199	198	197	196										
105	181	182	183	184	185	186	187	188	189	192										
in between	215	214	213	222	221	220	219	218	217	216										
120	201	202	203	204	205	206	207	208	209	210										
in between	235	234	233	230	231	240	239	238	237	236										
135	211	212	223	224	225	226	227	228	229	232										
in between	253	252	251	262	260	258	257	256	255	254	263	259	261							
150	241	242	243	244	245	246	247	248	249	250										
in between	278	277	276	284	285	283	282	281	280	279										
165	264	265	266	267	268	269	270	271	272	273										
in between	296	295	294	303	302	301	300	299	298	297										
180	274	275	286	287	288	289	290	291	292	293										

TABLE-4.B.2 (contd.): DETAIL OF LINES AT EACH SECTION

Section	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p	q	r	s	t
in between	316	315	314	323	322	321	320	319	318	317										
195	304	305	306	307	308	309	310	311	312	313										
in between	324	325	326	327	328	329	33	331	332	343										
210	335	334	333	342	341	340	339	338	337	336										
in between	356	355	354	363	362	361	360	359	358	357										
225	344	345	346	347	348	349	350	351	352	353										
in between	376	375	374	408	405	381	380	379	378	377	407	406	404							
240	364	365	366	367	368	369	370	371	372	373										
in between	398	397	396	394	393	403	402	401	400	399										
255	384	385	386	387	388	389	390	391	392	395										
in between	419	418	417	426	425	424	423	422	421	420										
270	382	383	409	410	411	412	413	414	415	416										
in between	441	440	439	436	435	446	445	444	443	442										
285	427	428	429	430	431	432	437	433	434	438										
in between	461	460	459	457	456	466	465	464	463	462										
300	447	448	449	450	451	452	453	454	455	458										
in between	478	477	476	485	484	483	482	481	480	479										
315	467	468	469	470	471	472	473	474	475	486										
in between	500	499	498	508	509	505	504	503	502	501	507	497	506							
330	487	488	489	490	491	492	493	494	495	496										
in between	524	523	522	520	519	529	528	527	526	525										
345	518	510	511	512	513	514	515	516	517	521										
in between	560	559	558	557	556	555	554	553	552	551										
360	2/1	10	9	8	7	6	5	4	3		40	37	33	42						

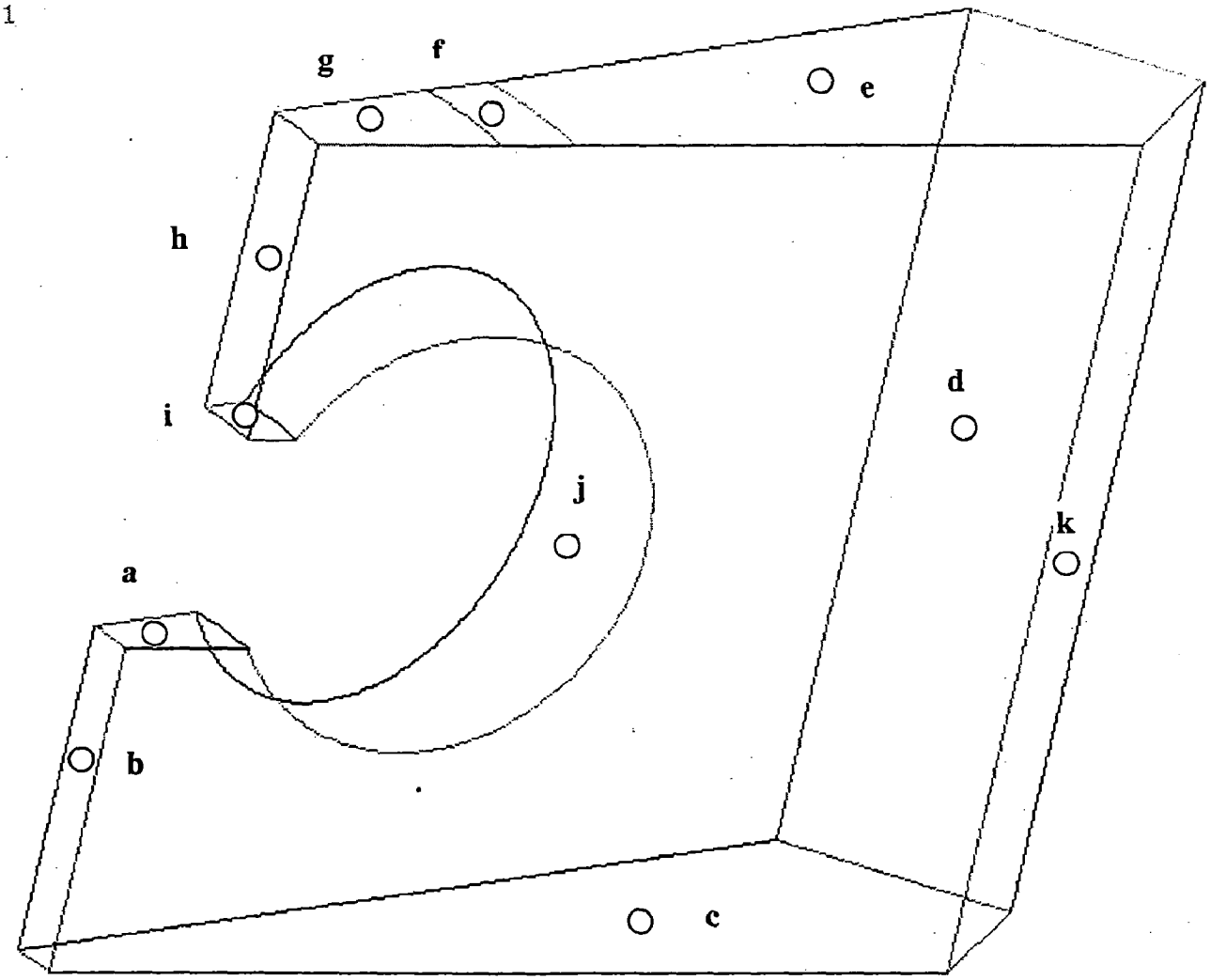


FIG. 4.B.4 SYMBOL OF AREAS FOR INBETWEEN SECTION

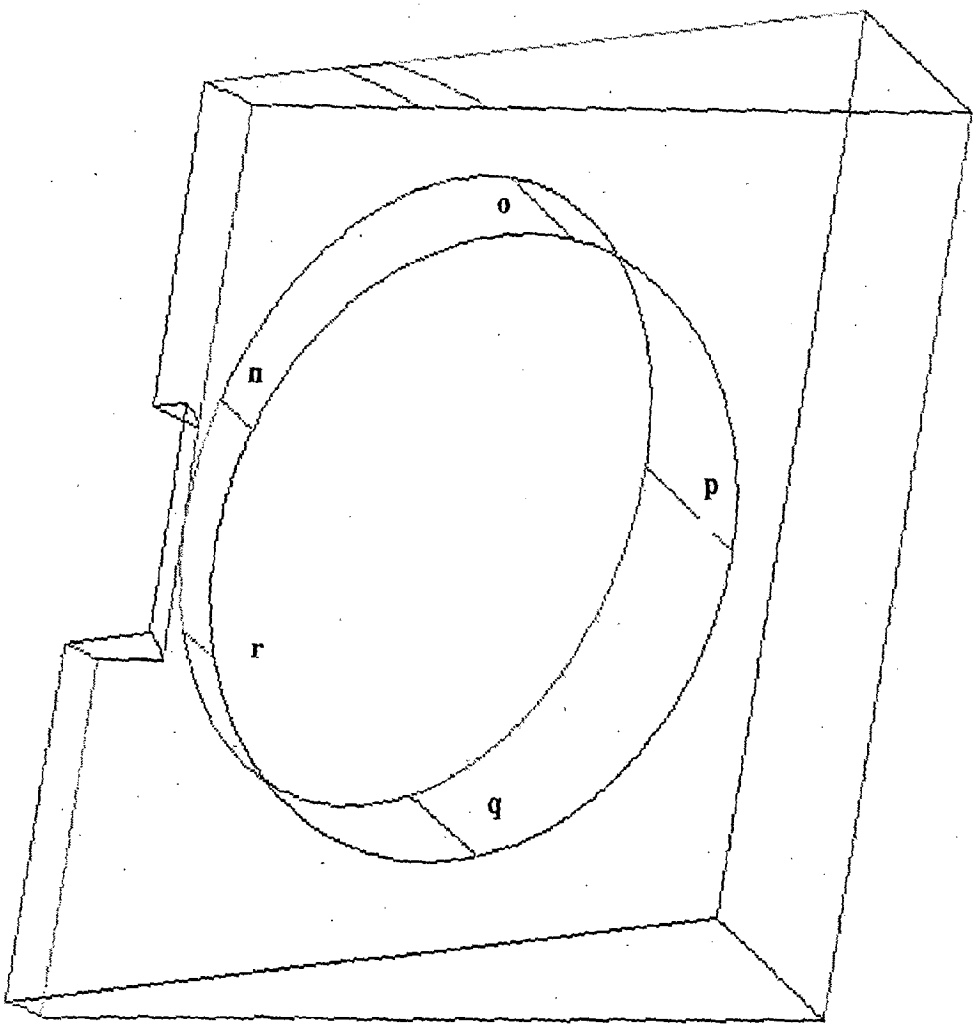


FIG. 4.B.5 SYMBOL OF KEY POINT, LINE & AREAS FOR PENSTOCK PART

TABLE-4.B.3: DETAILS OF VOLUMES AND AREAS FOR EACH SECTION

Volume	Section	Left	a	b	c	d	e	f	g	h	I	j	Right	k	n	o	p	q	r
1	000 - 015	291	6	4	3	17	16	15	14	8		7	5		12	11	10	13	9
2	015 - 030	5	20	19	18	24	26	27	28	23	22	21	34		30	31	32	29	25
3	030 - 045	34	35	33	42	43	41	40	39	38	37	36	44		56	54	53	57	52
4	045 - 060	44	47	49	50	55	64	63	62	48	46	45	59		60			61	58
5	060 - 075	59	68	69	72	70	75	74	73	67	66	65	71		80			79	82
6	075 - 090	71	87	88	76	77	78	81	83	84	85	86	89						
7	090 - 105	89	98	99	90	91	92	93	94	95	96	97	100						
8	105 - 120	100	109	110	101	102	103	104	105	106	107	108	111						
9	120 - 135	111	120	121	112	113	114	115	116	117	118	119	122						
10	135 - 150	122	132	133	123	125	126	127	128	129	130	131	134	124					
11	150 - 165	134	143	144	135	136	137	138	139	140	141	142	145						
12	165 - 180	145	154	155	146	147	148	149	150	151	152	153	156						
13	180 - 195	156	165	166	157	158	159	160	161	162	163	164	167						
14	195 - 210	167	176	177	168	169	170	171	172	173	174	175	178						
15	210 - 225	178	187	188	179	180	181	182	183	184	185	186	189						
16	225 - 240	189	198	199	190	191	212	193	194	195	196	197	200	192					
17	240 - 255	200	209	210	201	202	203	204	205	206	207	208	211						
18	255 - 270	211	221	222	213	214	215	216	217	218	219	220	223						
19	270 - 285	223	232	233	224	225	226	227	228	229	230	231	234						
20	285 - 300	234	243	244	235	236	237	238	239	240	241	242	245						
24	300 - 315	245	254	255	246	247	248	249	250	251	252	253	256						
21	315 - 330	256	266	267	257	259	260	261	262	263	264	265	268	258					
22	330 - 345	268	277	278	269	270	271	272	273	274	275	276	279						
25	345 - 360	279	298	297	296	295	294	293	292	2	1	299	300						

4.B.3 MESHING OF MODEL

GUI: **Main Menu>Preprocessor>Modeling-Size Contrls>Smart Size – Basic**

"Basic SmartSize Setting " Dialog box will appear

- Select 5 in the scroll box
- Click on OK
- Cut "Size contrls" Menu
- Click on Mesh of the Main Menu
- Click on Volume-Free

"Pick or enter volumes to be meshed" in ANSYS Input window and "**Mesh Volumes"** picker Dialog box will appear.

- Either enter all volume number in Input window or click on "Pick All" in Mesh Volumes picker

4.B.4 SOLUTION

GUI: **Main Menu>Solution>Loads-Apply**

Apply Menu will Appear

Select displacement for applying boundary condition, gravity for dead load, Force/Moment for different directions of Force and Moments.