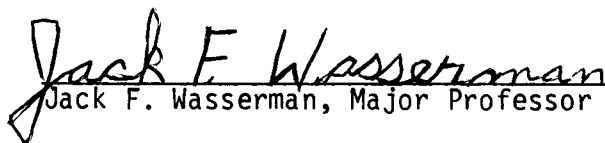
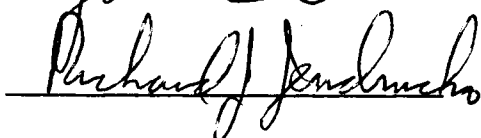


To the Graduate Council:

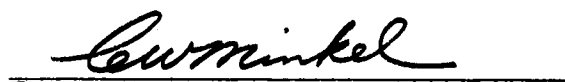
I am submitting herewith a thesis written by Martin J. McNamee entitled "Analytical and Experimental Evaluation of TLSO Plastic Jackets in Torsion." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Engineering Science and Mechanics.


Jack F. Wasserman, Major Professor

We have read this thesis and
recommend its acceptance:

Accepted for the Council:


The Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master's degree at The University of Tennessee, Knoxville, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of the source is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature Martin J. McRae

Date April 27 1985

ANALYTICAL AND EXPERIMENTAL EVALUATION OF
TLSO PLASTIC JACKETS IN TORSION

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Martin J. McNamee

June 1985

ACKNOWLEDGMENT

The author is grateful for the patience, assistance and guidance of Dr. J. F. Wasserman because this thesis would not have been possible without him. The author is also indebted to Dr. J. E. Akin and Dr. R. J. Jendruko for their constructive comments and assistance.

ABSTRACT

This study was initiated to find a replacement for the plaster Risser jacket used in postoperative scoliosis treatment. Experimental results strongly support the use of thermal plastic materials used in the construction of TLSO jackets. The thermal plastic TLSO jackets are capable of superior vertebra rotational restraint when compared to the plaster Risser jacket. Analytical results show that the thermal plastic material is not overstressed and is capable of handling the loading induced by the human body.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. LITERATURE SURVEY	4
A. Fusion	4
B. Harrington Instrumentation	6
C. Plaster of Paris Cast	9
D. Nonoperative Scoliosis	12
E. Summary	13
III. ANALYTICAL ANALYSIS	14
A. Introduction	14
B. Theory	14
C. Input Data Preparation	17
D. Element Types	18
E. 43210 Semi-Loof Element	18
F. 41320 Triangle Element	20
G. 44100 Triangular Element	24
H. Mesh Generation	25
I. Coordinate System	26
J. Boundary Condition Determination	30
K. Loads	34
IV. EXPERIMENTAL ANALYSIS	36
A. Kinematic and Geometric Considerations	36
B. Optical Considerations	37
C. Source of Error	41
D. Application to the Finite Element Model	42
E. In Vivo Application	43
F. Jacket Construction and Preparation	43
G. In Vivo Procedure	45
H. Validation of In Vivo Application	46
V. RESULTS AND DISCUSSION	49
A. Introduction	49
B. Definition of X-Y Plot Formats	50
C. Examination of the Applied Boundary Conditions	56
D. Examination of Mesh Refinement	82
E. Analytical Results for the Three Structural Materials	111

CHAPTER	PAGE
F. Analytical Displacements	111
G. Analytical Stress Distribution	130
H. Experimental Results	141
I. In Vivo Results	141
J. Validation of the Analytical Results	148
VI. CONCLUSIONS AND RECOMMENDATIONS	154
A. Conclusions	154
B. Recommendations	160
REFERENCES	162
APPENDICES	165
A. DATA UNITS	166
B. PAFEC DATA DECKS	168
C. OUTPUT DATA LISTINGS	205
D. X-Y PLOT PROGRAM	263
VITA	269

LIST OF TABLES

TABLE	PAGE
1. Full Model Results Versus Theory Using the 43210 Semi-Loof Quadrilateral	30
2. Boundary Conditions	33
3. Symmetric Results	33
4. Results of In Vivo Testing	48
5. Nodal Displacement Units in Millimeters	128
6. Stress Ratios for the Three Structural Materials	141
7. Experimental Rotations Compared to Analytical Rotations	151

LIST OF FIGURES

FIGURE	PAGE
1. Vertebra Rotation Effect on the Distance between the Purchase Sites of the Harrington Rod Hooks	10
2. Application of Lateral Bend and Oblique Traction by Guerin	11
3. Location of the Degrees of Freedom and Gauss Points for the Semi-Loof Element	19
4. Stress Output for one Gauss Point on the 43210 Semi-Loof Element	21
5. Degrees of Freedom at Each Node of the 41320 Triangle Element	22
6. Stress Output for the 41320 and 44100 Triangular Elements	23
7. Degrees of Freedom at Each Node of the 44100 Triangle Element	24
8. Jacket Mesh of PAFBLOCKS and Two Elements	26
9. Axis System of the Model	27
10. Mesh with Semi-Loof Elements and Element Numbers	28
11. Mesh Consisting of Triangular Elements	29
12. Full Mesh Consisting of Semi-Loof Elements	29
13. Full and Symmetric Thin Wall Box Model	31
14. Examination of Symmetric Nodes for Boundary Conditions	32
15. Mesh with Applied Loads	35
16. Light Lever System Used by Cavendish to Measure the Gravitational Constant	36
17. Geometric Angle of the Light Lever System	38
18. Angles of Incidence and Reflectance in Optics	39

FIGURE	PAGE
19. Determination of the Actual Angle of Rotation	40
20. Hip Locking Device	45
21. Cadaver Support Apparatus	47
22. Unfolded Two-Dimensional View of the Symmetric Semi- Loof Element Mesh Used for x-y Displacement Plots	52
23. Unfolded Two-Dimensional View of the Symmetric Semi- Loof Element Mesh Used for x-y Stress Plots	54
24. Distorted Structural Shapes of the Symmetric Model and Full Model Due to Torsional Loading	58
25. ΔX -Displacements for Strip 1 of the Symmetric Model and Full Model	59
26. ΔX -Displacements for Strip 2 of the Symmetric Model and Full Model	60
27. ΔX -Displacements for Strip 3 of the Symmetric Model and Full Model	61
28. ΔX -Displacements for Strip 4 of the Symmetric Model and Full Model	62
29. ΔY -Displacements for Strip 1 of the Symmetric Model and Full Model	64
30. ΔY -Displacements for Strip 2 of the Symmetric Model and Full Model	65
31. ΔY -Displacements for Strip 3 of the Symmetric Model and Full Model	66
32. ΔY -Displacements for Strip 4 of the Symmetric Model and Full Model	67
33. ΔZ -Displacements for Strip 1 of the Symmetric Model and Full Model	68
34. ΔZ -Displacements for Strip 2 of the Symmetric Model and Full Model	69
35. ΔZ -Displacements for Strip 3 of the Symmetric Model and Full Model	70

FIGURE	PAGE
36. ΔZ -Displacements for Strip 4 of the Symmetric Model and Full Model	71
37. Positive Top Surface Stress for Panel 1 of the Symmetric Model and Full Model	74
38. Positive Top Surface Stress for Panel 2 of the Symmetric Model and Full Model	75
39. Positive Top Surface Stress for Panel 3 of the Symmetric Model and Full Model	76
40. Positive Top Surface Stress for Panel 4 of the Symmetric Model and Full Model	77
41. Positive Bottom Surface Stress for Panel 1 of the Symmetric Model and Full Model	78
42. Positive Bottom Surface Stress for Panel 2 of the Symmetric Model and Full Model	79
43. Positive Bottom Surface Stress for Panel 3 of the Symmetric Model and Full Model	80
44. Positive Bottom Surface Stress for Panel 4 of the Symmetric Model and Full Model	81
45. One Quadrilateral Element Divided into Eight Triangular Elements	84
46. Distorted Structural Shapes of the Symmetric Quadrilateral Model and Symmetric Triangular Model Due to Torsional Loading	85
47. ΔX -Displacements for Strip 1 of the Quadrilateral Model and Triangular Model	87
48. ΔX -Displacements for Strip 2 of the Quadrilateral Model and Triangular Model	88
49. ΔX -Displacements for Strip 3 of the Quadrilateral Model and Triangular Model	89
50. ΔX -Displacements for Strip 4 of the Quadrilateral Model and Triangular Model	90
51. ΔY -Displacements for Strip 1 of the Quadrilateral Model and Triangular Model	91

FIGURE	PAGE
52. ΔY -Displacements for Strip 2 of the Quadrilateral Model and Triangular Model	92
53. ΔY -Displacements for Strip 3 of the Quadrilateral Model and Triangular Model	93
54. ΔY -Displacements for Strip 4 of the Quadrilateral Model and Triangular Model	94
55. ΔZ -Displacements for Strip 1 of the Quadrilateral Model and Triangular Model	96
56. ΔZ -Displacements for Strip 2 of the Quadrilateral Model and Triangular Model	97
57. ΔZ -Displacements for Strip 3 of the Quadrilateral Model and Triangular Model	98
58. ΔZ -Displacements for Strip 4 of the Quadrilateral Model and Triangular Model	99
59. Location of Stress Output for a Subdivided Quadrilateral Element	101
60. Positive Top Surface Stress for Panel 1 of the Quadrilateral Model and Triangular Model	103
61. Positive Top Surface Stress for Panel 2 of the Quadrilateral Model and Triangular Model	104
62. Positive Top Surface Stress for Panel 3 of the Quadrilateral Model and Triangular Model	105
63. Positive Top Surface Stress for Panel 4 of the Quadrilateral Model and Triangular Model	106
64. Positive Bottom Surface Stress for Panel 1 of the Quadrilateral Model and Triangular Model	107
65. Positive Bottom Surface Stress for Panel 2 of the Quadrilateral Model and Triangular Model	108
66. Positive Bottom Surface Stress for Panel 3 of the Quadrilateral Model and Triangular Model	109
67. Positive Bottom Surface Stress for Panel 4 of the Quadrilateral Model and Triangular Model	110
68. Distorted Structural Shapes of the Quadrilateral Model Employing Plaster, Polyethylene and Polypropylene as the Structural Materials	112

FIGURE	PAGE
69. ΔX -Displacements for Strip 1 of the Symmetric Quadrilateral Model Using the Three Structural Materials	114
70. ΔX -Displacements for Strip 2 of the Symmetric Quadrilateral Model Using the Three Structural Materials	115
71. ΔX -Displacements for Strip 3 of the Symmetric Quadrilateral Model Using the Three Structural Materials	116
72. ΔX -Displacements for Strip 4 of the Symmetric Quadrilateral Model Using the Three Structural Materials	117
73. ΔY -Displacements for Strip 1 of the Symmetric Quadrilateral Model Using the Three Structural Materials	118
74. ΔY -Displacements for Strip 2 of the Symmetric Quadrilateral Model Using the Three Structural Materials	119
75. ΔY -Displacements for Strip 3 of the Symmetric Quadrilateral Model Using the Three Structural Materials	120
76. ΔY -Displacements for Strip 4 of the Symmetric Quadrilateral Model Using the Three Structural Materials	121
77. ΔZ -Displacements for Strip 1 of the Symmetric Quadrilateral Model Using the Three Structural Materials	123
78. ΔZ -Displacements for Strip 2 of the Symmetric Quadrilateral Model Using the Three Structural Materials	124
79. ΔZ -Displacements for Strip 3 of the Symmetric Quadrilateral Model Using the Three Structural Materials	125
80. ΔZ -Displacements for Strip 4 of the Symmetric Quadrilateral Model Using the Three Structural Materials	126

FIGURE	PAGE
81. Positive Top Surface Stress for Panel 1 of the Symmetric Quadrilateral Model Using the Three Structural Materials	132
82. Positive Top Surface Stress for Panel 2 of the Symmetric Quadrilateral Model Using the Three Structural Materials	133
83. Positive Top Surface Stress for Panel 3 of the Symmetric Quadrilateral Model Using the Three Structural Materials	134
84. Positive Top Surface Stress for Panel 4 of the Symmetric Quadrilateral Model Using the Three Structural Materials	135
85. Positive Bottom Surface Stress for Panel 1 of the Symmetric Quadrilateral Model Using the Three Structural Materials	136
86. Positive Bottom Surface Stress for Panel 2 of the Symmetric Quadrilateral Model Using the Three Structural Materials	137
87. Positive Bottom Surface Stress for Panel 3 of the Symmetric Quadrilateral Model Using the Three Structural Materials	138
88. Positive Bottom Surface Stress for Panel 4 of the Symmetric Quadrilateral Model Using the Three Structural Materials	139
89. Unrestrained Vertebra Motion Versus Restrained Vertebra Motion Due to the Polypropylene Jacket	143
90. Unrestrained Vertebra Motion Versus Restrained Vertebra Motion Due to the Polypropylene Jacket Equipped with Cowhorns	145
91. Unrestrained Vertebra Motion Versus Restrained Vertebra Motion Due to the Plaster Jacket	146
92. Unrestrained Vertebra Motion Versus Restrained Vertebra Motion Due to the Plaster Jacket Equipped with a Neckpiece	147

FIGURE	PAGE
93. Two-Dimensional View of the Symmetric Quadrilateral Mesh Showing the Areas Removed from the Polypropylene Jacket for in vivo Testing	149
94. Influence of in vivo Modifications to Polypropylene Jacket on the Experimental Rotation Results	152

CHAPTER I

INTRODUCTION

This study was done to determine the feasibility of constructing TLSO jackets from thermal plastic rather than plaster. A finite element analysis was employed along with physically experimental techniques to accomplish this task.

Scoliosis has existed in man since prehistoric times and its description is included in the earliest medical recordings. Clinically, scoliosis is defined as "appreciable deviation in the normally straight vertical line of the spine" [1] when viewed posteriorly. The biomechanical definition states it as "abnormal deformation between and within vertebrae; too much curvature in the frontal plane; too much vertical axis rotation in the wrong direction" [1].

Scoliosis occurring at birth is called congenital. Scoliosis is called acquired when the causes are known. If it occurs from unknown causes, it is called idiopathic, which is the largest category.

The two types of curves are nonstructural, which is nonprogressive and easily straightened, and structural which is progressive and difficult to correct.

There are both nonoperative and operative correction procedures for scoliotic curves. Nonoperative correction requires utilizing one

of many external orthoses. It is restricted to juvenile curves of 45 degrees or less [1]. A recent approach utilizes electrical muscular stimulation. Operative correction is performed using internal bracing, fusion, and fixation devices. It is usually followed by plaster external orthoses.

External orthoses are generally classified as CTLSO (Cervical-Thoracic-Lumbar-Sacral-Orthoses) or TLSO (Thoracic-Lumbar-Sacral-Orthoses). CTLSO devices consist of Milwaukee braces, with modifications if desired, and full contact plastic jackets, both of which are customized. The TLSO devices also consist of either a Milwaukee brace with modifications, total contact plastic braces, or metal and fabric braces [2].

Many of the full contact plastic TLSO devices are used in nonoperative correction. The jacket is used to force the spine to grow straight. In operative corrections, the plaster cast is still widely used as the postoperative technique for maintaining correction. This is needed to allow the forcefully corrected spine to heal in order that correction will be permanent.

It was desirable to replace the plaster jacket because of the weight and, less important, lack of water resistance. A lighter material such as thermal plastic, if sufficient functional strength could be demonstrated, could be a suitable choice.

Thermal plastic is currently being used in construction of TLSO jackets for use in nonoperative correction procedures. These jackets are nearly identical to the plaster jackets used postoperatively.

The primary purpose of the plaster jacket is to prevent torsional movement of the postoperative spinal column. Therefore, torsion was chosen as the loading condition under which evaluation studies were done. To accomplish the task of evaluating the thermal plastic for replacement, two types of analysis methods were chosen.

The first method was an advanced numerical analysis technique called finite elements. In order to use this method, the proper mathematical boundary conditions pertaining to the analysis must be determined. With the boundary conditions, a finite element model of the jacket was constructed.

Three identical models were used differing only in the type of element used in construction. Two elements were used for validation of the one primary elements results.

The second method was based on experimental techniques developed specifically for the jacket. The experimental evaluations were divided into two categories. One was to physically validate the finite element model results. The second was to provide an independent in vivo analysis of the jacket.

With these two types of analysis methods, a balanced view of the functional strength of the thermal plastic is presented. Each method provides an independent assessment of the thermal plastic. The ability to cross check the results of each method was also provided.

CHAPTER II

LITERATURE SURVEY

Today's method of operatively treating scoliosis came together from three separate areas: fusion, internal devices, and external devices. The type of fusion performed is determined by the surgeon. The internal device used today is Harrington distraction rod(s). The external device most often used is a plaster body jacket.

Fusion was the first operative procedure for scoliosis beginning over 65 years ago. The plaster cast, utilized for other problems over 100 years, joined with the surgery soon afterwards. The cast was used preoperatively and postoperatively. In the last 20 years Harrington rod procedures began being used. All have undergone many changes since their inceptions. It was only in the last 5 years that all three were used together compatibly.

A. FUSION

Fusion of the scoliotic spine to maintain correction was first done by Hibbs [3,4,5] in 1914, although not reported until 1924. He inserted bone grafts into the intervertebral joints. The observation that probably led him to this operation was that deformity increased until ankylosis occurred. Albee also did a fusion operation around 1914 using tibial bone struts inserted into split spinal processes [3], but was not as successful as Hibbs. Until 1955, fusion was done

posteriorly on the spine; however, Hodgson had started his pioneering anterior fusion at this time. By 1965 anterior fusion had become a safe method and is now a standard procedure in most orthopedic hospitals.

Normally, fusion can be usually restricted to the curve and the general rule states: Fuse from neutral to neutral (in rotation) vertebrae. Bradford, Moe, and Winter [3] describe the following three principles for obtaining solid fusion: First, "Destroy facets within fusion area and replace articular surfaces with fresh autogenous cancellous or cortico cancellous bone." Second, "Decorticate deeply and completely all of the laminae and transverse processes within the fusion area and place the fragments removed or autogenous cancellous bone into the inter-laminar and inter-transverse process spaces." Third, "Add autogenous bone, preferably iliac, in amounts sufficient to create a deep, even bed of cancellous and cortical bone fragments."

The three principles were to insure that fusion will successfully occur. The type of fusion performed depends on the surgeon's preferences.

In general, it was observed that greater corrections required stronger fusions. Also, immobilization of the spine was of utmost importance in order to prevent fracture of the fusion mass and prevent pseudarthrosis [4,6]. This was the purpose of the postoperative plaster jacket. The jacket was used to immobilize the spine to allow the fusion areas to heal, thus preventing fracture and/or pseudarthrosis.

In the past two decades, though, improved fusion techniques and successful development of spinal instrumentation have occurred. This has significantly improved the operative treatment of scoliosis.

B. HARRINGTON INSTRUMENTATION

A number of devices have been designed and used to straighten the scoliotic spine. In 1891 Hadra wired the spinous process together. From 1921 to 1924 Lange used celluloid strips. Neither of these techniques were successful, but they were the first attempts at straightening the spine internally.

It was not until 1947, when Harrington started his studies [7], when the idea of internal devices were tried again. From 1949 to 1954 there were 35 modifications in Harrington's device. From 1955 to 1960, when the experimental stage ended, saw more modifications. These were principally to the instrumentation but also to the surgical approach. However, Harrington was not alone in his attempt to develop an internal correction device [8]. In 1954, Marino-Zuco tried using steel plates, Novak tried using wires, and Allen tried using a screw jack. In 1958 Gruca tried using a flattened steel spring, and in 1961 Wenger tried a turnbuckle spine jack. All of these techniques proved disastrous and were subsequently abandoned.

The Harrington instrumentation consisted of a distraction rod, compression rod, sacral bar, compression hooks, and universal hooks [7]. The hooks were anchored into the vertebrae and the rods placed

between them, secured to the hooks. The sacral bar was used in the iliac crests if lower stability was needed to be increased. The principle behind the rods was to serve as primary corrective forces on the curve and supply secondary supplementary stabilizing forces [7].

The working principle of the rods was the same as an automobile bumper jack. The top hooks were jacked up or down the rods, which had ridges for the hollow hooks to engage, and force the spine into a corrected position.

Harrington's initial paper stated that fusion was not always done. Also stated was the fact that only log rolling motion was allowed for the patient. This was due to the sensitivity of the lower hook to torsional motion which would cause it to dislodge. He stated that a well-molded plaster cast was worn for 3 months post-operatively. His results showed about 60% of the patients' spines were better and the rest were the same or got worse.

Tamburino et al. started using the Harrington technique in 1960 and reported their findings in 1964 [8]. They used fusion in every case and used a full Risser holding cast. It was stressed that a cast be used to "prevent twisting of the spine." This cast was worn an average of 11.5 months postoperatively. The results were much better with only a few patients losing all of their initial correction. Also stated was a problem with the lower hook dislodging while the patient was in bed. This was attributed to the design of the hook. A new hook design emerged from the study and was being used in place of the old design.

In 1973 Dickson and Harrington [9] presented their modifications to the Harrington instrumentation technique. They revised the purchase site of the hook and increased the time of immobilization. The fusion technique was changed but there was no mention as to the type of cast used. The weak point of the system was the stress concentration placed in the upper laminae at the purchase site. There was no mention of using a preoperative cast.

In 1973, Bradford et al. [3] described their use of a preoperative Risser localizer cast using Cotral straps. They stated that the patient could be ambulatory 12-14 days after surgery wearing a Risser-Cotral cast postoperatively. The use of preoperative traction allowed ambulation without displacement of the rods. They listed the following advantages pertaining to Harrington instrumentation: 1. "Maximal correction of the curve is achieved making Harrington instrumentation easier." 2. "The patient is more comfortable postoperatively, and there is less danger of hook displacement."

They stated that the primary purpose of the Harrington distraction strut bar is to provide maximal safe correction. It also was to provide internal stabilization so the patient may be safely ambulated, without loss of correction, in a snug cast applied 5-10 days postoperatively. They also found the contracting hook assembly useless if a Risser-Cotrel cast was used.

In these medical studies, it was apparent that the postoperative cast had to be snug and worn for at least 6 months.

The purpose of the cast was to keep the spine totally immobile, thus permitting proper fusion of the vertebrae. However, more important was the prevention of hook dislodgement. The Harrington instrumentation is a temporary method of maintaining correction. When the fusion is strong enough, the Harrington instrumentation is then no longer needed.

The effect of rotation on the Harrington instrumentation will cause the distance between the purchase sites to increase (Figure 1).

With the length of the rod remaining stationary, it must now span a greater distance. Either the hook dislodges or it may be easily dislodged from the purchase site.

C. PLASTER OF PARIS CAST

The first attempts at forcefully correcting scoliotic curves was with traction. Various devices were used to apply these traction forces to the body. In 1877 Lewis Sayre applied the first plaster of paris cast on a patient with scoliosis while in traction [3,4,10]. The purpose was to hold the body in its traction oriented position. Thus the patient was free of the traction device. Soon body casts were being applied while the body was in various positions.

In 1927 the first anteroposterior hinge turnbuckle cast was used at the New York Orthopaedic Hospital [10]. The cast was used to apply lateral bending and oblique traction to straighten the spine postoperatively. This made the cast traction applying and holding.

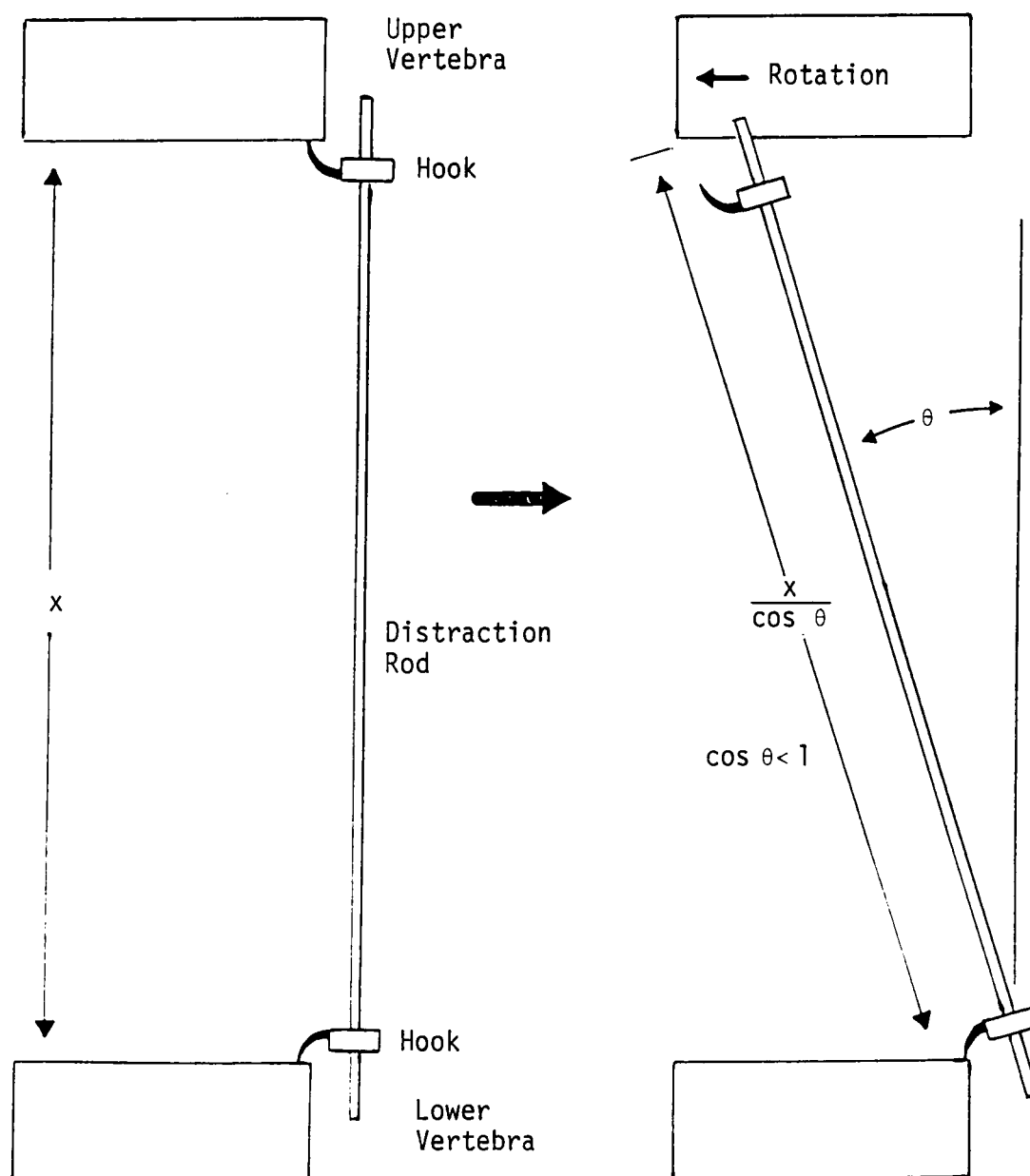


Figure 1. Vertebra rotation effect on the distance between the purchase sites of the Harrington rod hooks.

This was not the initial use of this concept. Guerin in 1842 strapped patients to a hinged board which would apply lateral bending and oblique traction to the spine (Figure 2),

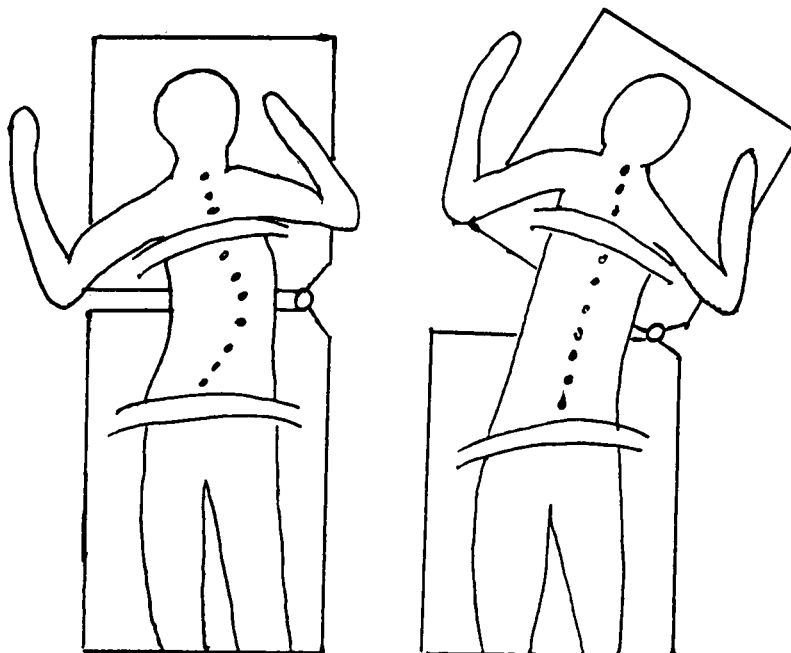


Figure 2. Application of lateral bend and oblique traction by Guerin.

Postoperatively, there were several options. The cast could be left on, changed to a similar type, or a semi-bent cast was applied. In any of these situations, the cast was worn 3 to 15 months. Ambulation was difficult if not impossible. By 1941 this method was used in 80% of the scoliosis cases and was the most effective and popular method [6].

The 1950's brought about a great deal of changes in the plaster cast. After 5 years of experimenting with the traction

device, Risser introduced the localizer cast at the Los Angeles Orthopaedic Hospital in 1952 [10].

The localizer cast made use of a third corrective force in conjunction with the head and pelvic correction forces [5]. This third force was applied to the prominent rib deformity. Postoperatively, a plaster jacket was worn 3 to 15 months. The style was like that of the localizer which would allow ambulation.

By 1955 Carpenter and Fisher were using a postoperative cast that was very similar to Risser's, but still used the turnbuckle postoperatively [11]. A 1958 study by Risser showed the localizer to be superior in maintaining correction and reducing pseudarthroses [5]. By 1964 the Risser localizer and its variations had become the popular style of cast used in scoliosis correction. In 1973 the localizer was modified to use Cotrel straps which produced very good results [3].

D. NONOPERATIVE SCOLIOSIS

The concept of nonoperative treatment was to place forces on the spine that would induce straight growth. Thus the young person was forced to wear a corrective device all through puberty.

Nonoperative scoliosis followed the same path as operative scoliosis in terms of external methods of correction. This changed in the 1940's when the Milwaukee brace appeared. Though there are variations and other types of braces, the Milwaukee remains the standard procedure for nonoperative scoliosis [2].

There has appeared a new type of brace which dates back to the mid-1960's. This brace is a plastic version of the Risser localizer cast, which also has been used in nonoperative scoliosis. In 1972 Risser and Cockrell reported on their 6-year study of a plastic jacket with 70% patient improvement [12]. Park et al. reported that 80% of the patients had satisfactory results in their study with a plastic prenyl jacket in 1977 [12]. In 1980 Bunnell et al. stated in their study on plastic jackets "that when the indications are carefully adhered to, the plastic jacket is as effective as the Milwaukee" [12].

E. SUMMARY

The importance of the plaster jacket postoperatively is evident. With the current success of a plastic jacket in nonoperative scoliosis, it follows that this could be successful in postoperative situations. However, there is no record of this having been done yet. There is also no evidence of a study being done on this idea.

Considering the importance of the fusion and Harrington rods needed for an immobilized spine, it is proposed to do a complementing analytical and experimental evaluation on the shell structure of the cast.

This evaluation will include not only the plaster jacket, but two popular plastic jackets, polyethylene and polypropylene. Furthermore, rotational restraint will be experimentally examined in vivo of the cast when constructed of plaster and plastic.

CHAPTER III

ANALYTICAL ANALYSIS

A. INTRODUCTION

The finite element method was used for the analytical analysis of the Risser jacket to obtain distributions of displacements and stress for the complex shape. The primary objective was to characterize the jacket's torsional stiffness since this reduces spinal rotation which can dislodge the Harrington rods. The distribution of deflection and stress was also useful in detection of potential areas of weakness.

The finite element method has been utilized for over two decades. The words "finite element method" were first used by R. Clough in 1960 [13]. Initially the method was primarily intuitive, lacking a solid theoretical basis. Currently, with the theoretical and mathematical concepts having become better developed, the method is an important tool for numerical analysis [14].

B. THEORY

The method is best described using the minimum of potential energy. It is based on the fact that "of all possible states of displacements, satisfying the geometric boundary conditions, the one that corresponds to the equilibrium state is the one that renders the total potential energy stationary (minimum)" [14].

This can be expressed by the following equation:

$$\pi_{PE} = S.E. - W.D.$$

where

π_{PE} = total potential energy of the system;

S.E. = strain energy stored internally;

W.D. = work done on the structure.

The S.E. term involves an integral of unknown functions.

This casts the problem into a variational form. The corresponding differential equation(s) of this variational form are Euler equation(s). When S.E. is stationary, there Euler equation(s) are the equation(s) of equilibrium [15].

The S.E. can be represented as a sum of the S.E. density of each differential element.

$$\pi_{PE} = \sum_{\text{elements}} (\text{S.E. density}) dv - W.D.$$

When the S.E. density is based on the unknown displacements, its form is:

$$\text{S.E.}_{\text{element } i} = 1/2 \{Ue\}^T [Se_i] \{Ue\}$$

where

$\{Ue\}^T$ = row matrix containing the unknown element nodal displacements;

$[Se_i]$ = square matrix containing the stiffness coefficients of the element;

$\{U_e\}$ = column matrix containing the unknown element nodal displacements.

The nodes are points used to define the element geometry and/or meet mathematical requirements of the interpolation function used to define unknowns. The function used to describe the geometry may or may not be the same function used to describe the geometry may or may not be the same function used to describe the unknowns. The interpolation functions are usually polynomials.

The first theorem of Castigliano "states that the differential of strain energy with respect to a displacement gives the force in the direction of that displacement" [15] or,

$$\{F_e\} = d(S.E.)/d\{U_e\} = [S_e]\{U_e\}.$$

This defines a relation between the forces and displacements at the element level. By assembling the element matrices,

$$\{F_G\} = \sum_{i \text{ element}} [S_{e_i}]\{U_e\}$$

a larger global matrix is formed for the entire region modelled by the elements. At this point the system matrix $[S_G]$ is singular. The application of the boundary conditions modifies the system matrix into a nonsingular form. Solution of the modified system matrix yields the unknown displacements. These displacements may then be used to calculate other quantities such as stresses by using the appropriate relations.

The finite element method can be broken into six basic steps [13,14,15,16]:

1. Discretize the continuum;
2. Select interpolation functions;
3. Find element properties;
4. Assemble the element properties to obtain the system equations;
5. Solve the system equations;
6. Make additional computations if desired.

These steps require a great deal of programming effort in order to use the finite element method. However, there are commercial codes available which alleviate this problem for the potential user.

The code chosen for this study was PAFEC (Programs for Automatic Finite Element Calculations) [17]. This code contains a mesh generator, free format, wide choice of elements, and engineering key words which allow a new user a rapid ability to use the finite element method.

C. INPUT DATA PREPARATION

The steps required for input to a finite element program are as follows:

1. Identify element types;
2. Define mesh and find nodal coordinates of the system to be modelled;
3. Define topology of single elements or blocks of elements;

4. Define boundary conditions;
5. Define loads.

The following sections describe the procedure used to define the input to the PAFEC code.

D. ELEMENT TYPES

The Risser cast falls into the category of three dimensional shell structures. It can be further classified as a thin shell structure. This means that the radii of curvature or typical unsupported lengths of plates are greater than five times the shell thickness. This then limits the size of the elements used to approximate the structure and its boundaries. The following is a description of the elements chosen to model the structure.

Three elements were chosen to independently construct the shell model of the jacket. The 43210 semi-loof quadrilateral element was used as the primary element for the analysis. The two triangular elements, the 41320 and 44100, were used to check the accuracy and limitations of the 43210 semi-loof element.

E. 43210 SEMI-LOOF ELEMENT

The 43210 is an eight node quadrilateral semi-loof element. The word semi-loof comes from the loof nodes, hidden to the user, along the element sides. These hidden nodes allow out-of-plane curvature of the element.

The semi-loof element, based on the minimum potential energy principle, uses the Gauss quadrature procedure for calculating the S.E. density [18]. Gauss quadrature provides the greatest possible accuracy with the minimum numerical cost [14]. The Gauss method subdivides the integration interval symmetrically with respect to the interval's midpoint.

Since the element was a thin shell, 2×2 Gauss integration is employed and required four Gauss points (see Figure 3). The element is based on the Gauss points.

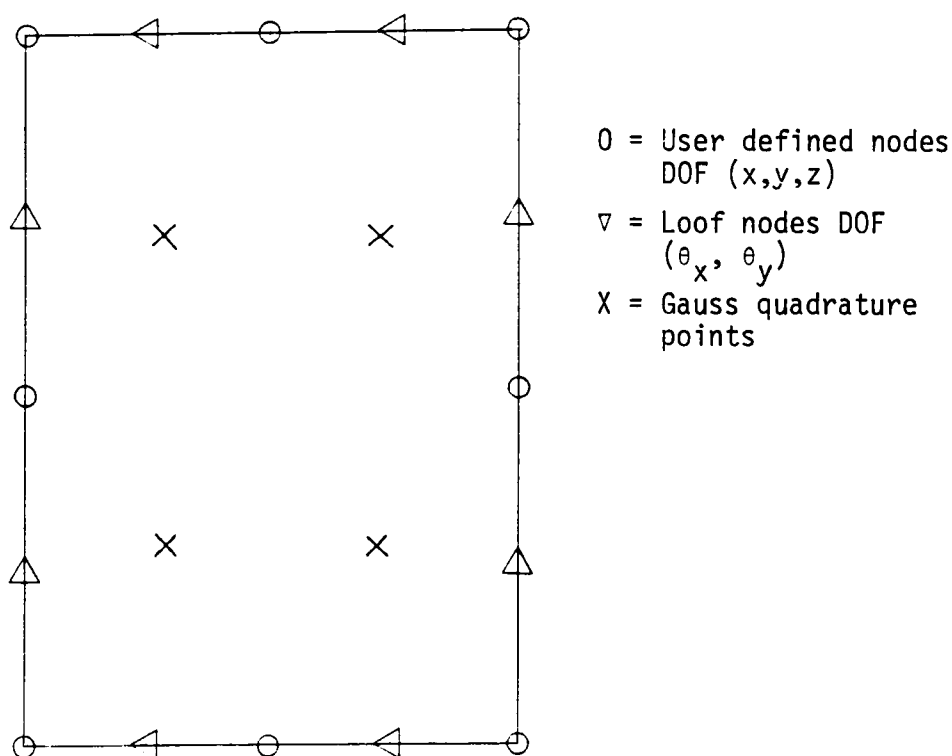


Figure 3. Location of the degrees of freedom and Gauss points for the semi-loof element.

The semi-loof element belongs to a family called delinquent elements. There is little theory behind the development of the semi-loof element but a good amount of intuition [19].

Each user defined node has three translational degrees of freedom: U_x , U_y , and U_z . The rotation of the loof nodes, θ_x , θ_y , are referred to the midside nodes as additional degrees of freedom (Figure 3). These rotations do not represent global rotations, nor are they related to the global axis in any manner. Instead, they represent local rotations of the edges of the element boundaries.

This is the only quadrilateral in the PAFEC element library which may be curved out of plane.

It is ideal for approximating the continuously varying boundaries and surfaces of the Risser jacket.

The stresses are found at the four Gauss points. At each Gauss point, the most positive and most negative principal stresses are given for the top and bottom surfaces (Figure 4).

F. 41320 TRIANGLE ELEMENT

The 41320 triangle is a hybrid element with only three corner nodes. The hybrid method is not based on displacements as in the principle of minimum potential energy. Instead, the Hellinger-Reissner variational principle is used. The element formulation is based on stresses and displacements, both being unknowns [15]. This method yields accurate results for the stresses.

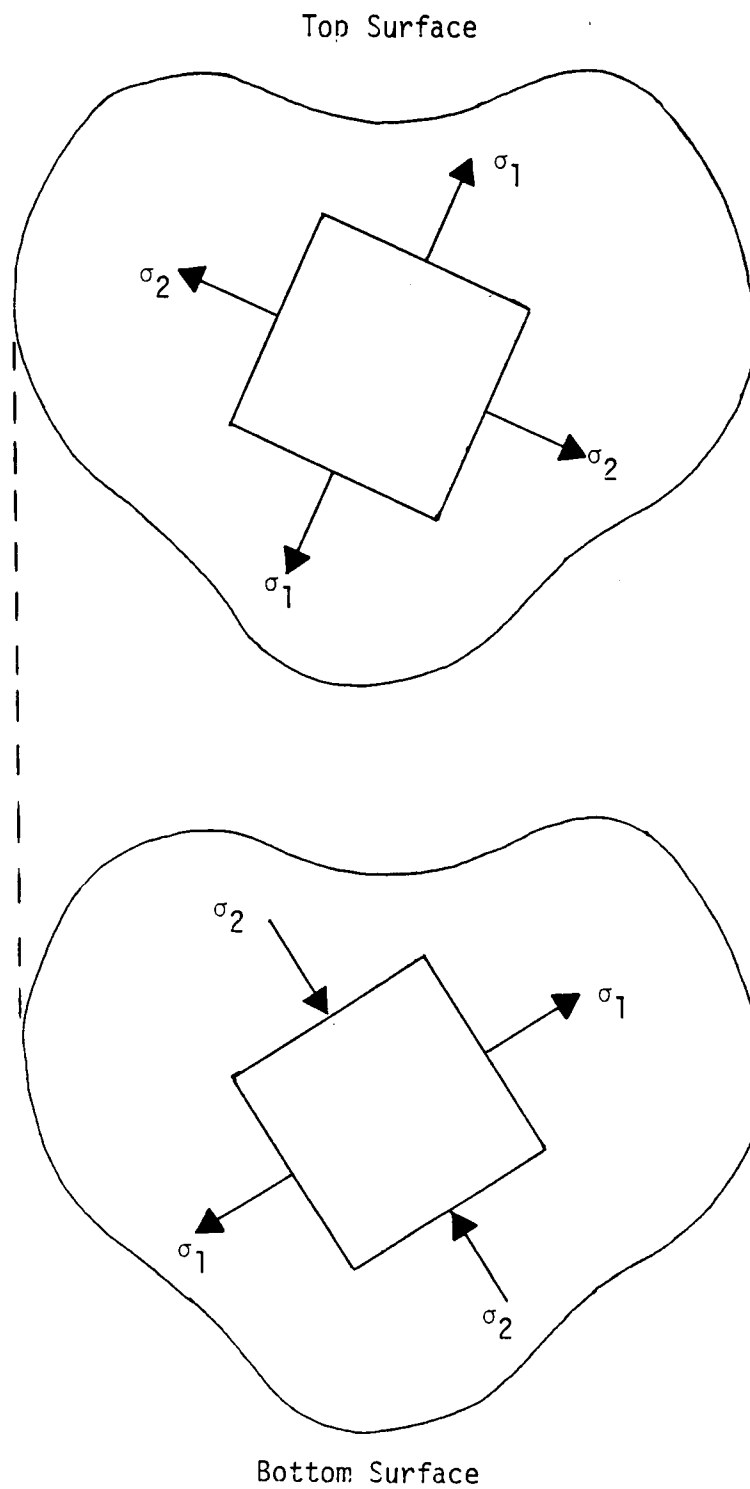


Figure 4. Stress output for one Gauss point on the 43210 semi-loop element.

Because three nodes always form a plane, this element can be used to approximate the curved surfaces of the Risser jacket. The curved surfaces were then approximated by the flat surfaces of the triangles. The curved boundaries would have to be a series of straight lines since there are no midside nodes.

The element is designed for thin shell applications. Each node has the following degrees of freedom: U_x , U_y , U_z , θ_x , and θ_y (Figure 5).

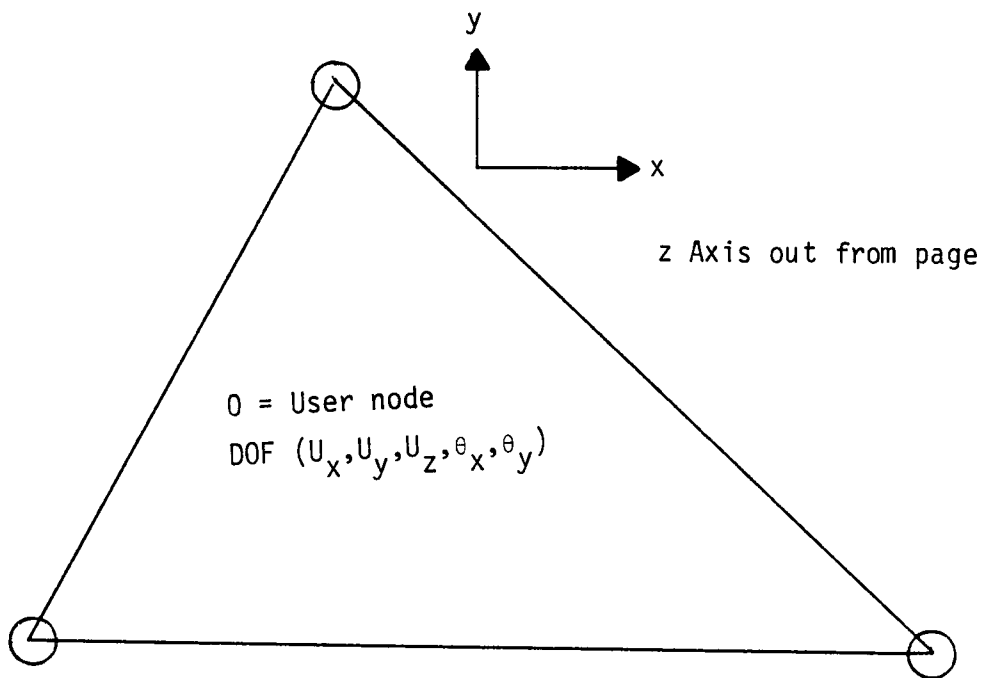


Figure 5. Degrees of freedom at each node of the 41320 triangle element.

The stresses are found at the centroid of the top, middle, and bottom surfaces. The most positive and most negative principal stresses are given (Figure 6).

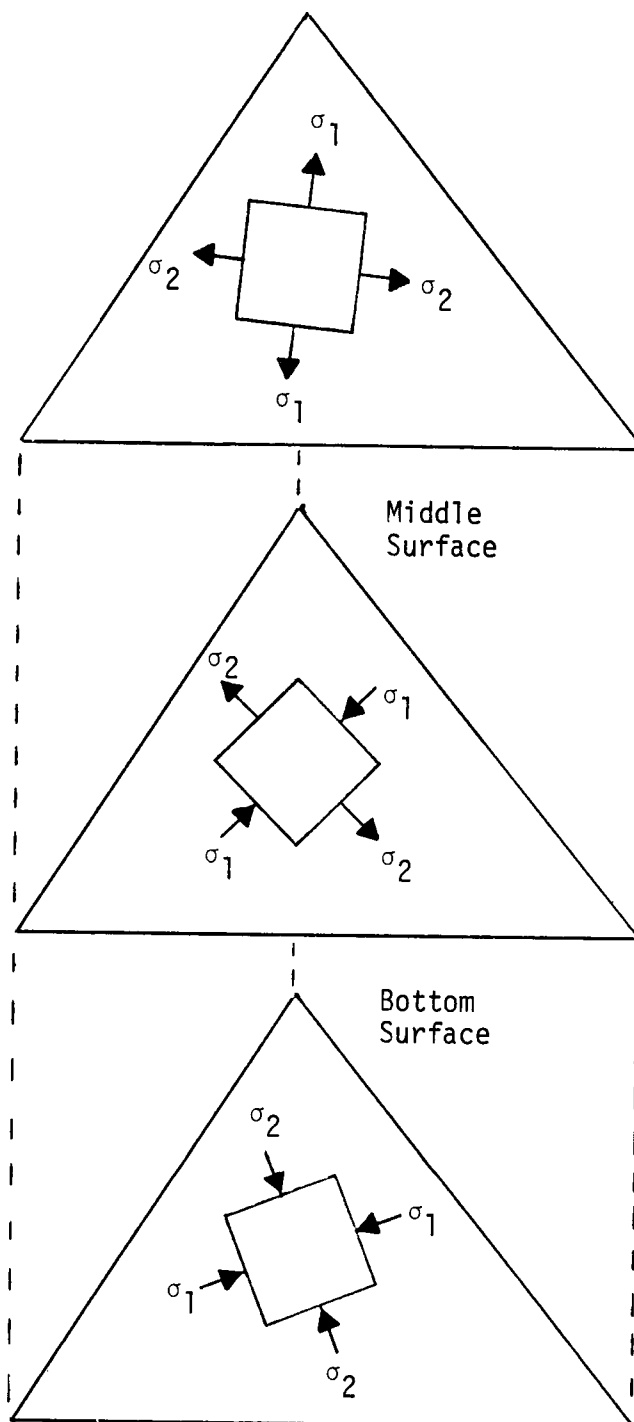


Figure 6. Stress output for the 41320 and 44100 triangular elements.

G. 44100 TRIANGULAR ELEMENT

The 44100 triangle is derived using the isoparametric transformation [15], with only three corner nodes. This is based on the minimum potential energy principle but can also be derived using a direct displacement method. The results of each produce the same [Se] matrix. The displacements are very accurate for isoparametric elements.

As with the 41320 triangle, the three nodes always form a plane. Thus the 44100 triangle approximates the Risser jacket boundaries and surfaces in the same manner as the 41320 triangle.

The element is designed for the shell applications. It has six degrees of freedom at each node: $U_x, U_y, U_z, \theta_x, \theta_y, \theta_z$ (Figure 7).

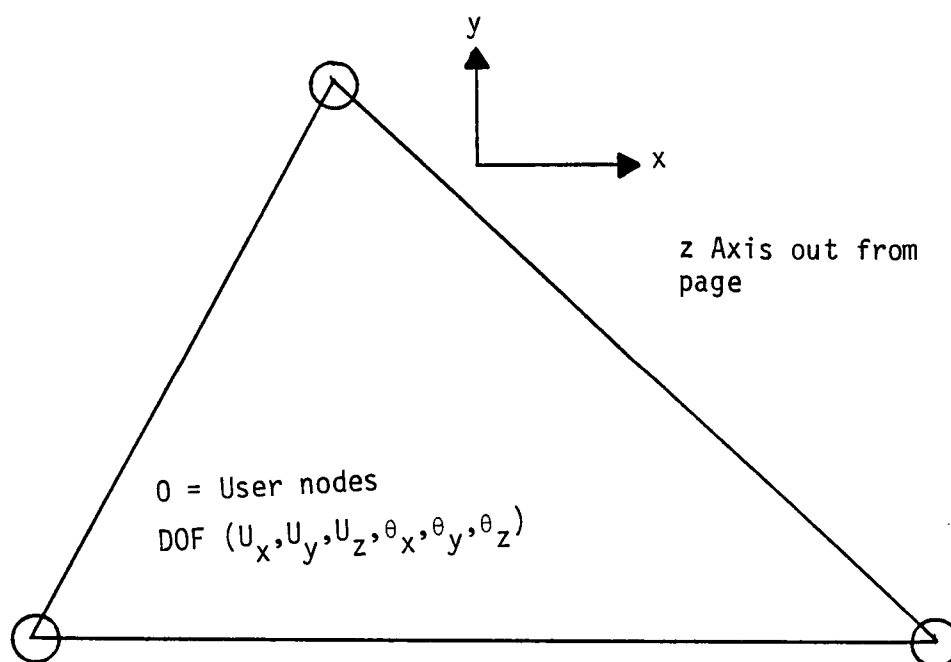


Figure 7. Degrees of freedom at each node of the 44100 triangle element.

Stresses are solved for at the top, middle, and bottom surfaces at the centroid. The most positive and most negative principal stresses are given in Figure 6.

H. MESH GENERATION

The symmetry between the right and left sides of the Risser jacket permitted modelling of one-half of the jacket. Thus, the total number of elements needed for the model was halved. More important is the effect of symmetry on the number of elements in the global stiffness matrix. A full mesh generates a nearly full matrix whereas a symmetric mesh generates a banded matrix. The number of calculations, and thus the computational cost, for solving a full matrix is much greater than for a banded matrix.

Three materials are being employed to manufacture the TLSO, but polypropylene geometrical properties were selected for the model since this was the material used in the physical setting.

Two assumptions were used in creating the mesh. The first assumed that any material overlaps could be considered as a single layer of material. The second was that the closure line, used to put on and remove the jacket, could be taken as nonexistent. This means that the plastic jacket was a solid tubular shape.

An internal plaster mold of the polypropylene jacket was made. The jacket was put on the mold and the boundaries drawn in with a felt tip pen. The jacket was removed and the lines of symmetry were determined.

The PAFBLOCKS facility, the mesh generation portion of the PAFEC program, allows each block to represent a finite number of elements. The number of elements each block can be subdivided into is defined by the user.

Element distortion was also considered. There are limitations as to how distorted an element can be and still produce accurate results.

Using PAFBLOCKS, only 15 blocks and two separate elements were required to adequately model the jacket (Figure 8).

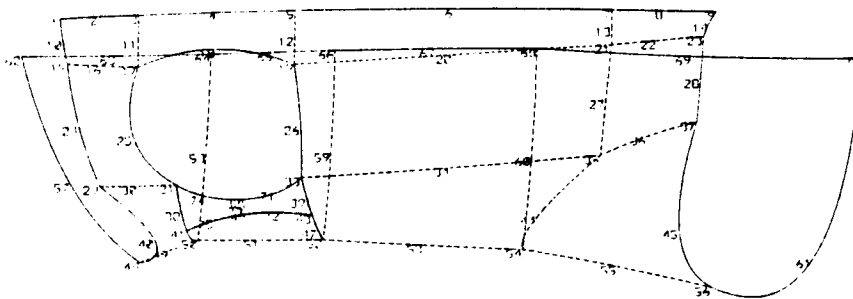


Figure 8. Jacket mesh of PAFBLOCKS and two elements. Node numbers are shown.

These blocks of elements were drawn in on the plaster mold with the corner and midside nodes identified.

I. COORDINATE SYSTEM

A right-handed cylindrical axis was chosen for the coordinate system to allow easy measurement of the nodal coordinates. The axial direction was chosen to run from the top of the jacket to the

bottom. The angular direction started at the anterior line of symmetry, 0 degrees, and stopped at the posterior symmetry line, 180 degrees. The radial direction ran perpendicularly outward from the axial direction (Figure 9).

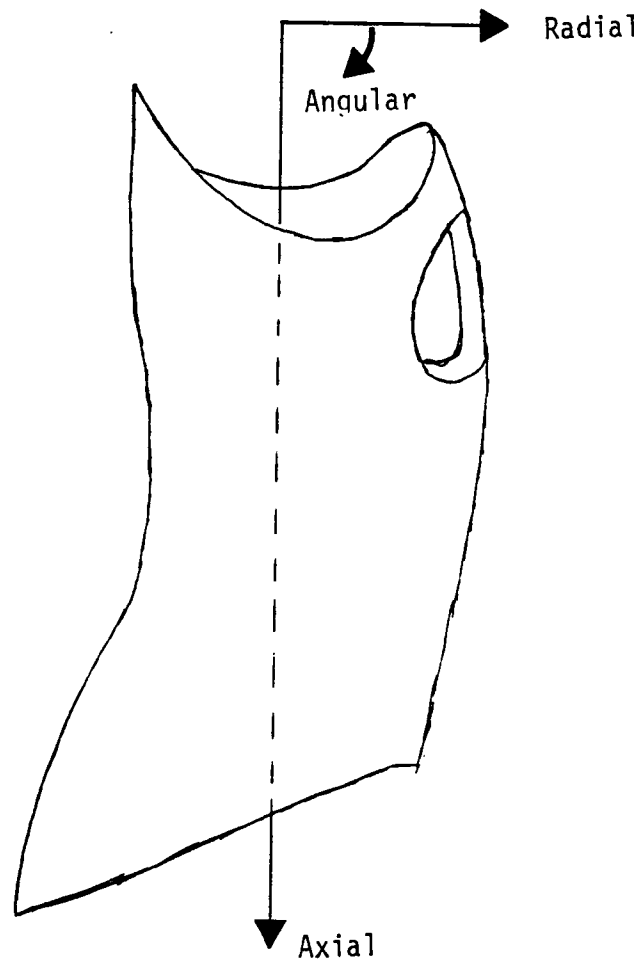


Figure 9. Axis system of the model.

The desired meshes were generated from the nodal coordinates and the PAFBLOCKS. The semi-loof quadrilateral only required 41 elements to model the curved surfaces and boundaries of the Risser jacket. This was the main mesh used in the analysis (Figure 10).

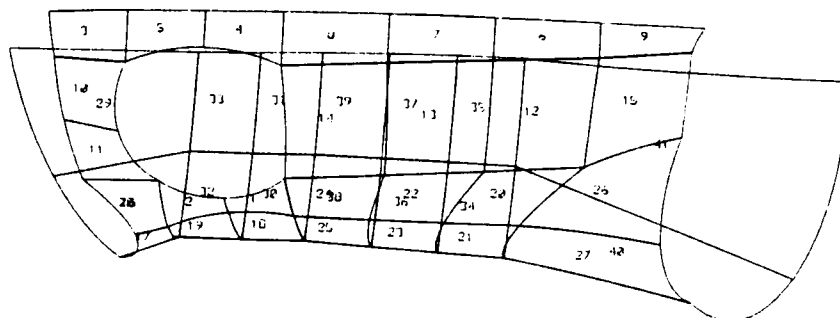


Figure 10. Mesh with semi-loof elements and element numbers.

The 41320 and 44100 triangle elements were used to check the semi-loof results for displacements and stresses. These elements required eight times as many elements, 328, to model the jacket using the 41 semi-loof elements as PAFBLOCKS. These elements have straight sides and remain flat. Therefore, more elements are needed to adequately model the curved surfaces and boundaries of the jacket (Figure 11).

A full mesh of semi-loof elements was generated using the GROUP-OF-SIMILAR elements and SIMILAR NODES facilities (Figure 12). This mesh was used to check the validity of the boundary conditions.

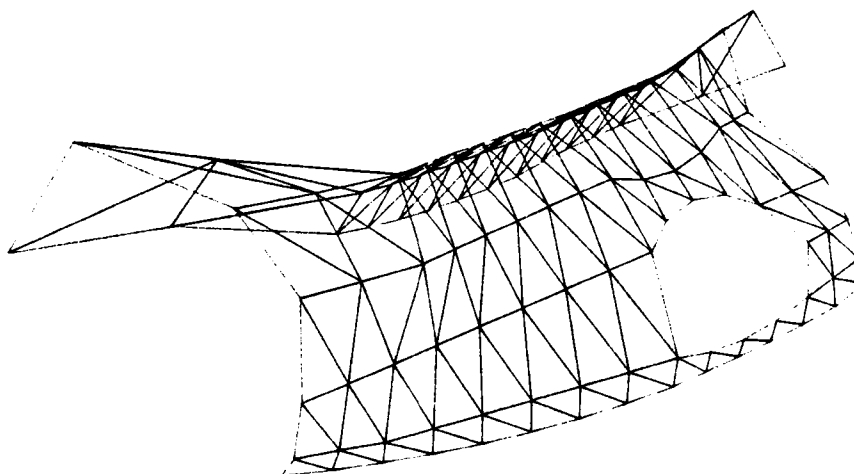


Figure 11. Mesh consisting of triangular elements.

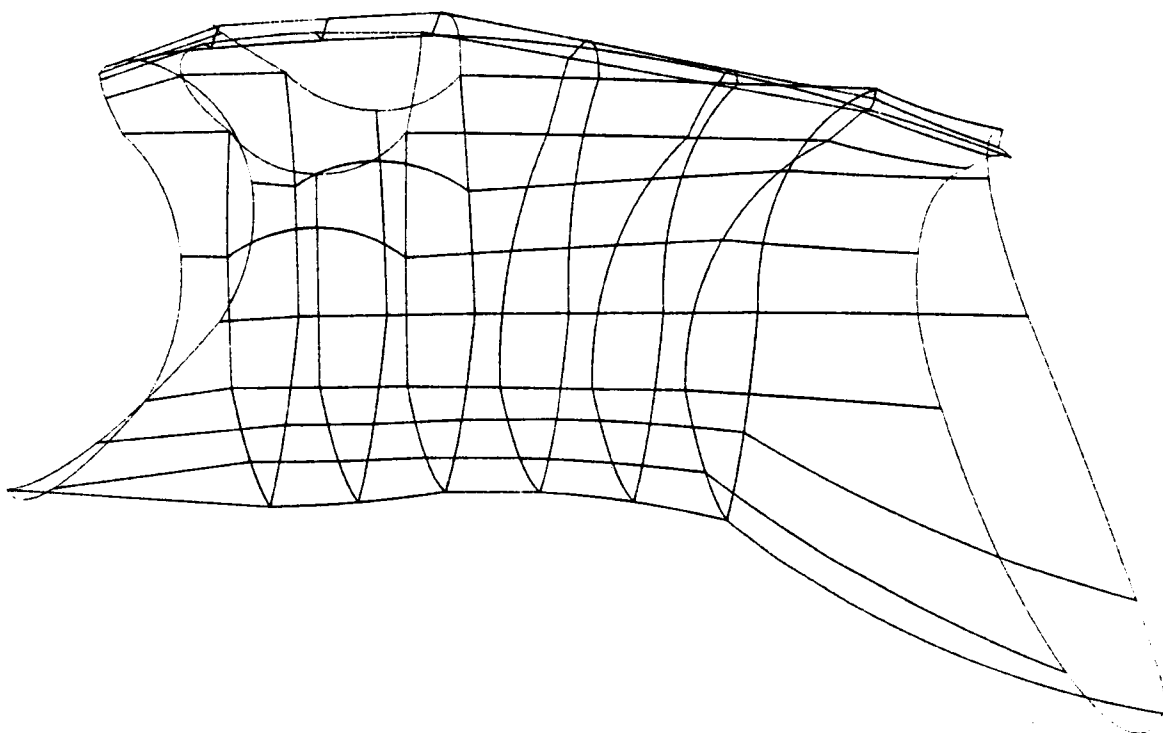


Figure 12. Full mesh consisting of semi-loop elements.

J. BOUNDARY CONDITION DETERMINATION

To insure that the proper boundary conditions were imposed on a symmetric model, a thinwall hollow square beam undergoing torsion was considered. The boundary conditions were derived from this model because of the available theoretical results for comparison.

A full model was first examined using the semi-loop elements. The results were compared to the theoretical predictions to confirm the elements' accuracy (Table 1).

TABLE 1
FULL MODEL RESULTS VERSUS THEORY USING THE
43210 SEMI-LOOP QUADRILATERAL

	Tau	Theta, Rad
Theory	.00222	.0154074
Semi-loop	.00222	.0152120

The model was then split into a symmetric form (Figure 13).

A plane was passed through the symmetric thin wall box model perpendicular to the axial direction. The nodes on the lines of symmetry that lie on this plane were examined during rotation (Figure 14).

Assuming that the nodes A and B are the same distance from the X axis, the following relationships were noted (Table 2).

These conditions were imposed by using the GENERALIZED-CONSTRAINTS facility and the REPEATED-FREEDOMS-FACILITY. These were

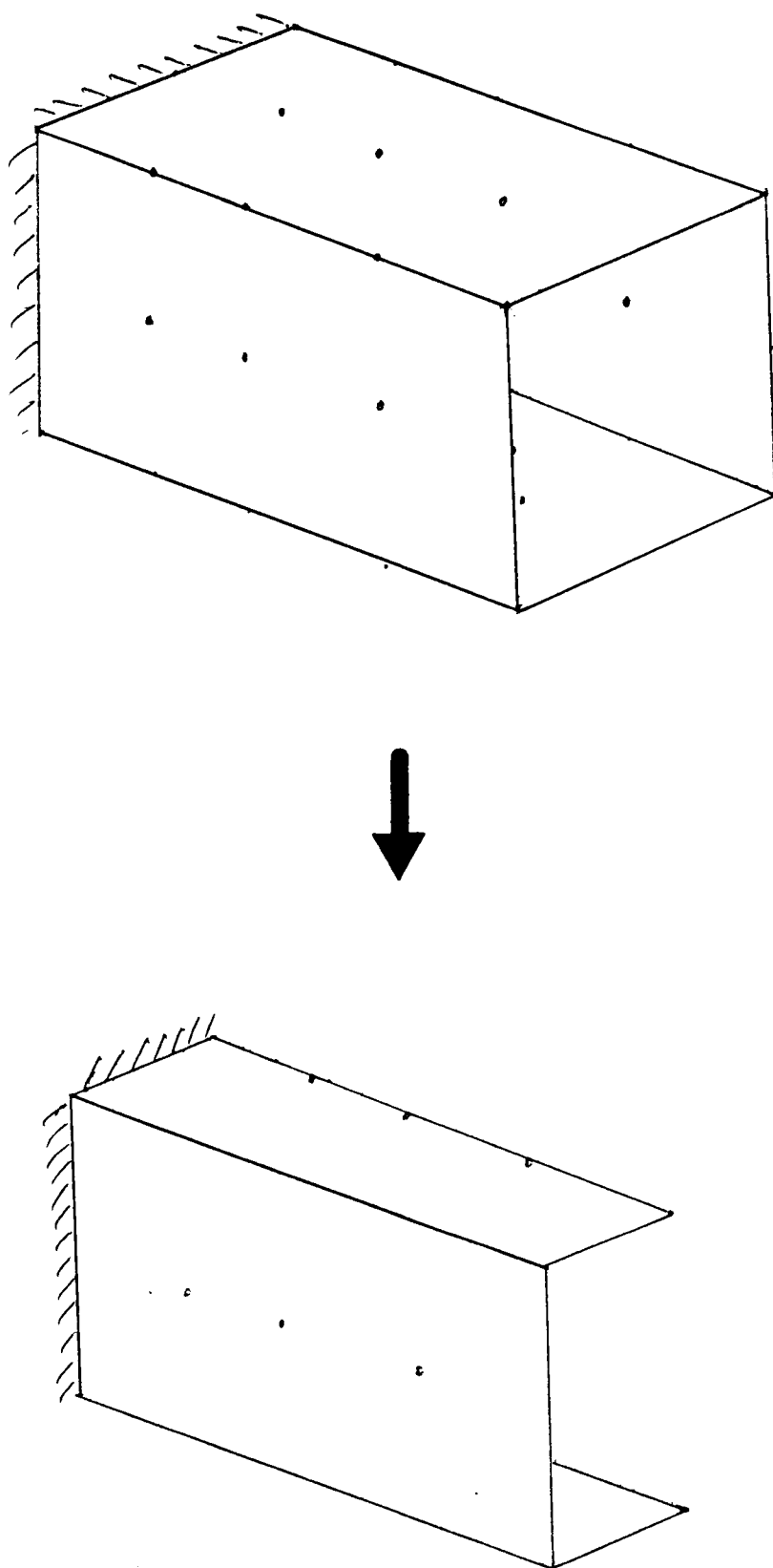


Figure 13. Full and symmetric thin wall box model.

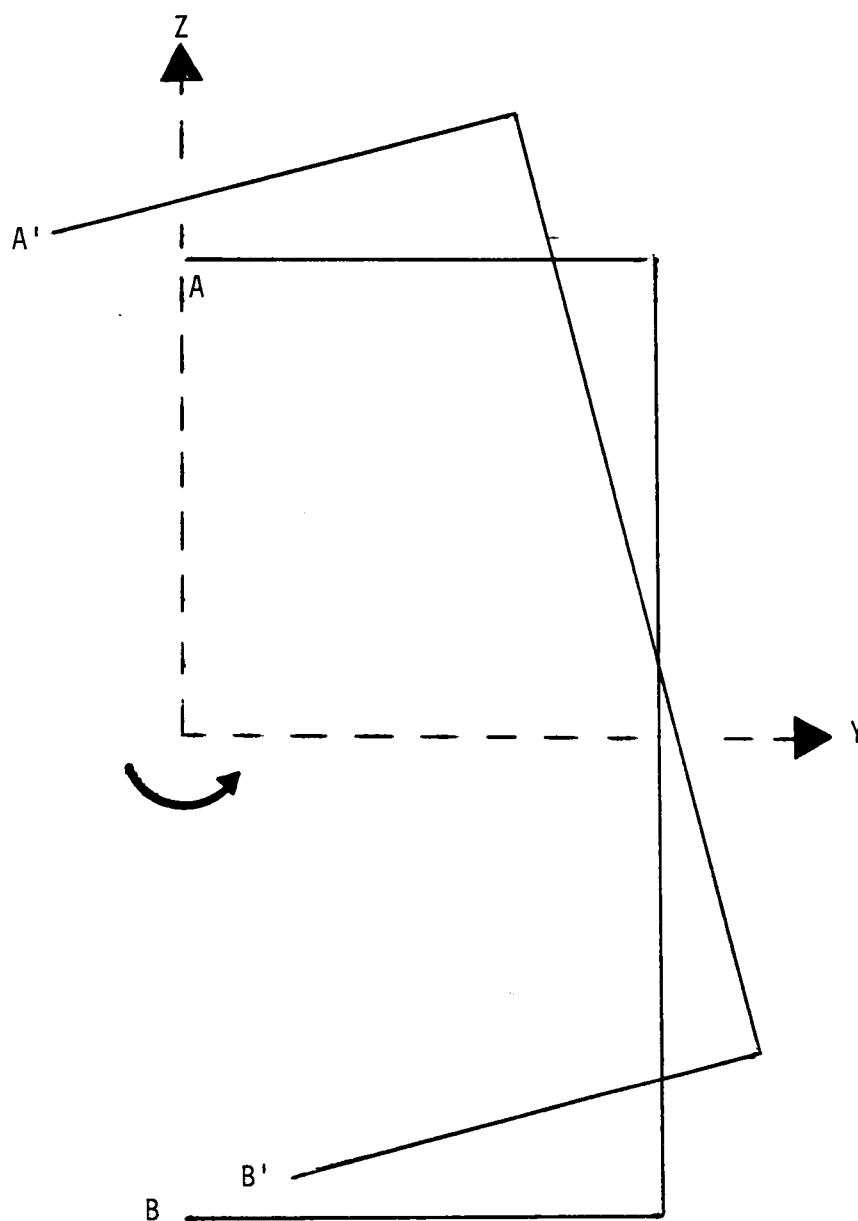


Figure 14. Examination of symmetric nodes for boundary conditions.

TABLE 2
BOUNDARY CONDITIONS

A			B	
	ΔX_A	=	ΔX_B	
	$-\Delta Y_A$	=	ΔY_B	
	ΔZ_A	=	ΔZ_B	
Theta	X_A	=	Theta	X_B
Theta	Y_A	=	Theta	Y_B

applied only to nodes that lie along the lines of symmetry and in the same plane perpendicular to the axial direction.

The symmetric model was examined using the derived boundary conditions. The results were compared against the theoretical predictions and the results of another finite element code (Table 3).

TABLE 3
SYMMETRIC RESULTS

	Tau	Theta, Rad
Theory	.00222	.0154074
SAP 6	.00222	.0154133
PAFEC	.00222	.0154120

The Risser jacket finite element mesh did not exactly meet the boundary node condition criteria along the symmetry lines. Nodes that were on opposite sides of the line of symmetry did not lie in a plane perpendicular to the axial direction. This occurred from the

physical dimensions of the Risser jacket and constraints put on the amount of allowable element distortion. Most of the deviation from the boundary node condition criteria was small. Coupled with simple and low magnitude load, large errors were not expected.

The posterior portion of the Risser mesh had all degrees of freedom restrained. The ENCASTRE facility was used to accomplish this. This boundary condition was also easily duplicated experimentally for validation of the finite element results.

K. LOADS

A simple loading condition was used so that a duplicate physical experiment could be conducted. The loads were two equal and opposite forces. They were applied at the superior end of the jacket mesh, specifically, at the top nodes that lie on the lines of symmetry (Figure 15).

The magnitude of these loads were derived experimentally. A subject was bodily loaded at the same points that corresponded to the mesh loading. There were equal and opposite forces caused by a hanging weight system. The subject was loaded with increasing amounts of weight until body rotation could no longer occur.

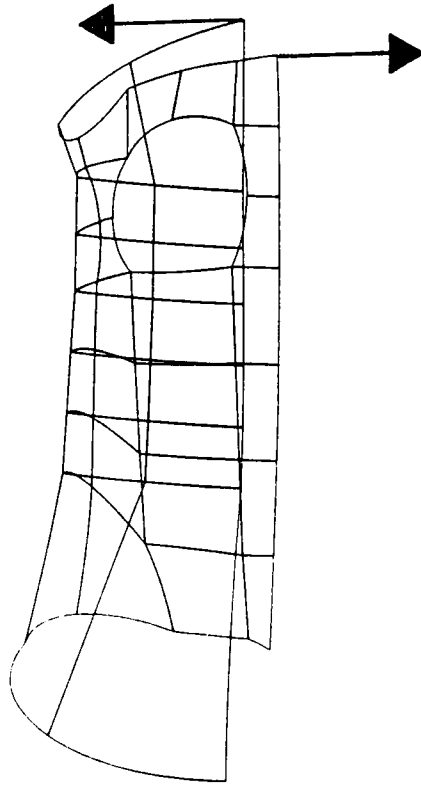


Figure 15. Mesh with applied loads.

CHAPTER IV

EXPERIMENTAL ANALYSIS

The method used in the experimental part of this study employed a light lever system. As an example, this system was used by Henry Cavendish (1731-1780) to construct a sensitive torsional balance to determine the gravitational constant [20] (Figure 16).

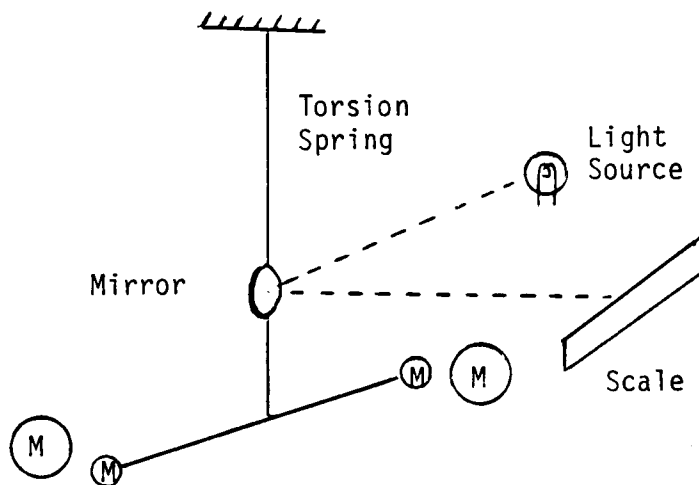


Figure 16. Light lever system used by Cavendish to measure the gravitational constant.

A. KINEMATIC AND GEOMETRIC CONSIDERATIONS

The purpose of the light lever is to amplify very small movements, such as rotations. From geometry and kinematics it is known that the product of a differential angle and a radius yield the

length of the corresponding arc. It is clear that with a constant differential angle, the arc length is directly proportional with the radius.

From Figure 16, small rotations of the mirror will cause a large linear displacement of the reflected light beam on the measurement scale. This linear displacement is a result of the differential angle and the distance between the mirror and scale.

An angle associated with this system can be determined if the following two conditions are met:

1. The mirror, light source, and initial reflected beam lie in a plane perpendicular to the scale.
2. The mirror axis of rotation lies in that perpendicular plane during all rotations.

These conditions are shown in Figure 17. If the distance from the axis of rotation to the scale is known, X in Figure 17, and the horizontal displacement of the reflected beam known, Y in Figure 17, the two legs of a right triangle are described. By using the tangent function the angle may be calculated.

$$\theta = \tan^{-1} Y/X .$$

B. OPTICAL CONSIDERATIONS

It would appear that the angle θ previously calculated would yield the angle of rotation the mirror experienced. This is not the case due to the simple law of optics involving incidence and reflectance.

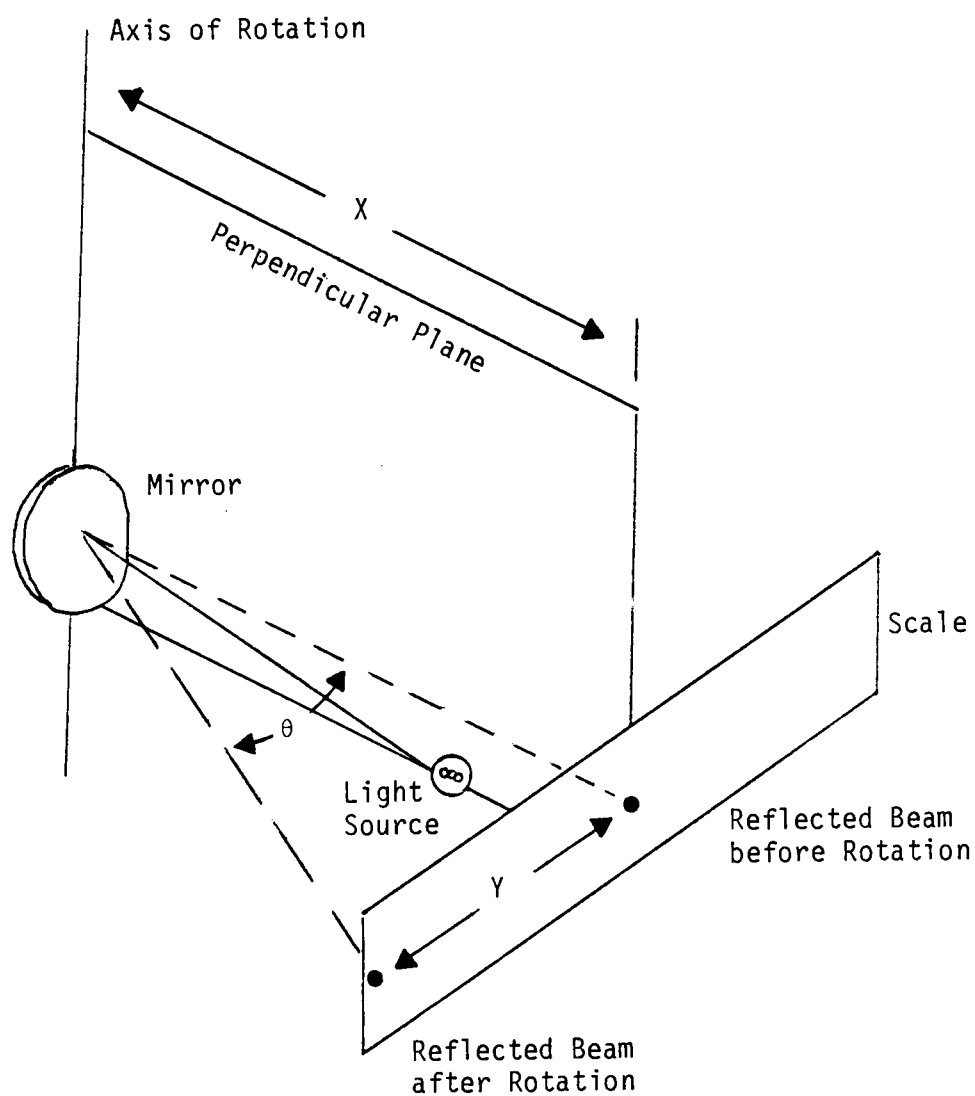


Figure 17. Geometric angle of the light lever system.

Before rotation, the light source is trained directly upon the mirror, thus the angle of incidence and reflectance is 90 degrees. Upon rotation, the mirror turns but the light source remains stationary. The light source no longer strikes the mirror at 90 degrees, but at an angle of incidence. Optics state that the angle of incidence is equal to the angle of reflectance (Figure 18).

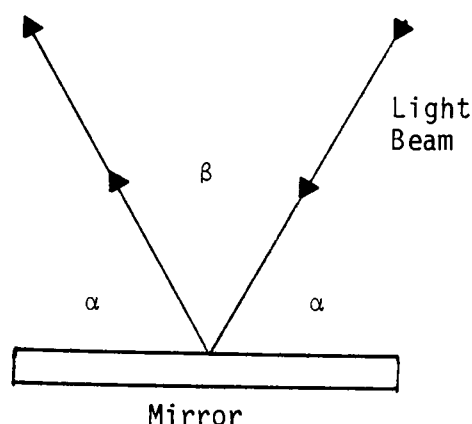


Figure 18. Angles of incidence and reflectance in optics.

Considering this effect allows the calculation of the actual angle of rotation from the geometric angle.

In Figure 19(a), the light strikes the mirror at an angle of 90 degrees before rotation occurs. A normal vector drawn outward from the mirror surface has the same direction as the light beam.

In Figure 19(b) the mirror has been rotated a finite amount around its centroid. The angle B may be calculated as was done in

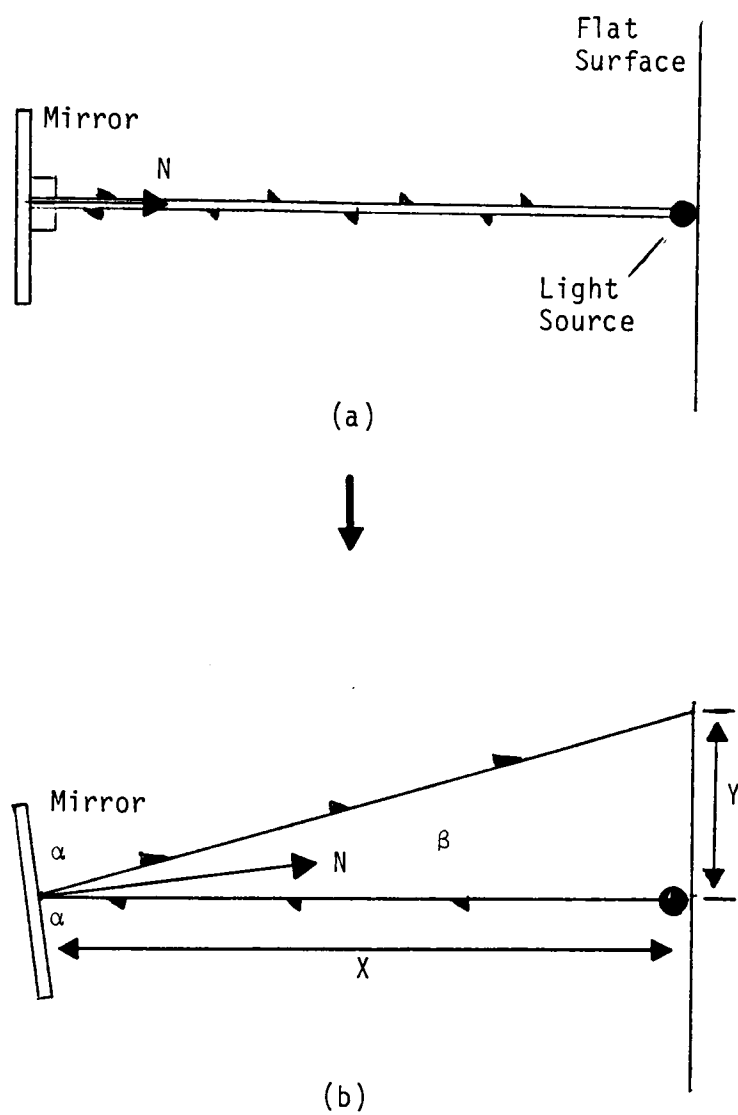


Figure 19. Determination of the actual angle of rotation.

Figure 17. Thus the angle B is actually the geometric angle θ . The normal vector drawn from the surface experiences the same rotation as the mirror. This normal vector will bisect the angle B, the geometric angle. Thus the actual mirror rotation is one-half of the geometric angle.

C. SOURCE OF ERROR

If the mirror's centroid does not correspond to the axis of rotation, there are two translations which will introduce error in the values of X and Y in Figure 19(B). In the experimental portion of the study the mirror's centroid did not correspond to the axis of rotation.

If the mirror's centroid lies at a radius R from the axis of rotation, the translations are:

$$(1) \quad R \sin \theta/2$$

$$(2) \quad R \cos \theta/2$$

The Y measurement in Figure 19(B) is lengthened by (1) and the X measurement in Figure 19(B) is lengthened by (2).

The error in Y and X cannot be subtracted out since θ , the value being sought, is needed to compute the error. The values X, Y and the error depend on θ .

The solution is to make the error negligible when compared to Y or X. Since R is fixed but X can be varied, the answer is to make R negligible when compared to X or Y.

D. APPLICATION TO THE FINITE ELEMENT MODEL

Torsion and rotation are directly coupled in nonrigid body motion. Thus when a structure, such as a TLSO jacket, has torsion applied to it, all points of the structure have rotational components.

Using the light level principle, small 5 mm x 5 mm mirrors were attached to the TLSO jacket using a sticky putty. The points of attachment were at various element nodal coordinates. The jacket was anchored at the posterior end to simulate the analytical boundary conditions. The analytical loads were applied at the same points on the jacket in magnitude and direction.

This method was used to compare against the rotations around the X-axis calculated from the finite element model displacement results. It must be remembered that the semi-loof degrees of freedom θ_x and θ_y are not related to the global axis.

Since the element mesh was taken from the dimensions of the polypropylene jacket, it was chosen for testing. The plaster jacket could not be used because it was partially destroyed during removal after an in vivo test. The polyethylene jacket was not used because its dimensions did not match the element mesh.

It was assumed that the center of the rotation was midway between the front and back of the jacket and midway between the sides. Mirror placement was on the front and side areas. The back was not used due to slight modifications done from previous experimental work. It was assumed that these modifications would not influence the experimental results.

E. IN VIVO APPLICATION

There was another important area of rotation that was checked using the light lever, the rotational restraint that the jacket applies to the body. The vertebrae must not be allowed to rotate to prevent the Harrington rod hooks from being dislocated from their purchase sites on the vertebrae.

Wasserman and McNamee [20] used this method for in vivo evaluation of lumbo-sacral orthoses. The method was named Light Lever Method (LLM) in their paper. The equipment they used was modified slightly but the application was not. The polypropylene TLSO jacket and the plaster Risser jacket were evaluated with the LLM.

F. JACKET CONSTRUCTION AND PREPARATION

The plaster Risser jacket was applied by Dr. Sydney Wallace and a team of surgeons at The University of Tennessee Hospital. The jacket was standard thickness and size; a neck piece was included. After the plaster cured, five slots approximately 2500 mm by 200 mm were cut across the back horizontal to the spine. This was the maximum amount of slots that could be cut so that the cast would retain its rigidity. The lowest slot was at the L5 level and the highest slot was at the T5 level.

The polypropylene jacket was constructed by Karl Fillauer's Orthopedic Clinic in Knoxville. Standard material, thickness, and size in normal construction procedures were followed and the jacket

was fitted to normal limits. A set of aluminum cow horns, for shoulder restraint, was also built for the jacket. Seven slots, 2500 mm by 200 mm, were cut across the back horizontal to the spine. The lowest slot corresponded to L5 and the top slot to T4.

The measurement bars were constructed of flat aluminum stock and measured 2000 mm by 60 mm. A .6 cm diameter steel ball was glued to the center of the bar. It was on this ball that the mirrors, 5 mm by 5 mm, were placed with putty to allow easy adjustment of the mirrors. The bars had elastic straps attached to both ends with a metal loop swivel hinge. The free ends of the straps attached to one another with a pull through friction buckle.

The bars were mounted on the body across the spine and the elastic straps extended around the body where they buckled in the front.

For the plaster jacket, the bars were slipped in place between the body and the jacket. They were placed on the open areas of the body exposed by the slots. They were checked to see that they moved freely with the body and did not bind or touch with the plaster.

Since the plastic jacket was removable without damage, the slots were marked on the skin with a pen. The jacket was removed and the bars placed in accordance with the pen markings. This allowed more separate tests to be done. However, since the jacket is fitted to only one person, the tests were limited to just one subject.

G. IN VIVO PROCEDURE.

The bars were mounted and the mirrors placed on the steel balls with putty. The subject was seated in a chair designed to prevent hip rotation and lifting (Figure 20).

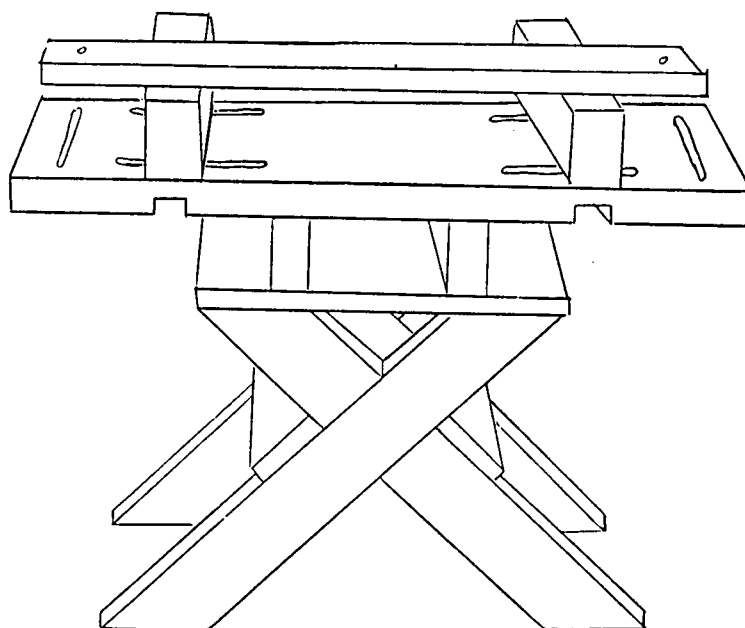


Figure 20. Hip locking device.

The measurement surface was two sheets of standard construction size plywood. They were attached together and covered with tracing paper. The light source was a normal slide projector. A special slide was used to give a rectangular shaped beam of light. The projector was directly in line with the mirrors and measurement surface. This produced the initial 90 degree angles of reflectance and incidence.

The reflected light beams from the mirrors show up as dots on the marking paper. They were aligned in order vertically equally spaced, and marked. The subject was then rotated to a maximum point allowed by physical discomfort. The dots of light were marked again. The rotations were repeated 5-10 times with the top dot always displaced the same distance. The average displacement of a mirror was used as the resultant displacement for that mirror.

The vertical distance from the floor to the trochanter and to each mirror was measured and recorded. This was done so as to determine which vertebrae each bar was riding on. An x-ray of the subject's spine was used to locate the heights of the vertebrae from the trochanter.

The plaster jacket was tested with and without the neck piece. The polypropylene jacket was tested with and without the cow horns.

H. VALIDATION OF IN VIVO APPLICATION

The bars ride on soft tissue and are thus not connected directly to the vertebrae. Since the objective was to measure relative rotations, the error introduced should cancel out. The repeatability of the method had to be known to have valid comparisons.

To examine this, a cadaver was used to measure bar rotation versus vertebrae rotation. To do this, the spinal processes were first exposed and the cadaver hung in an apparatus to support the body vertically (Figure 21).

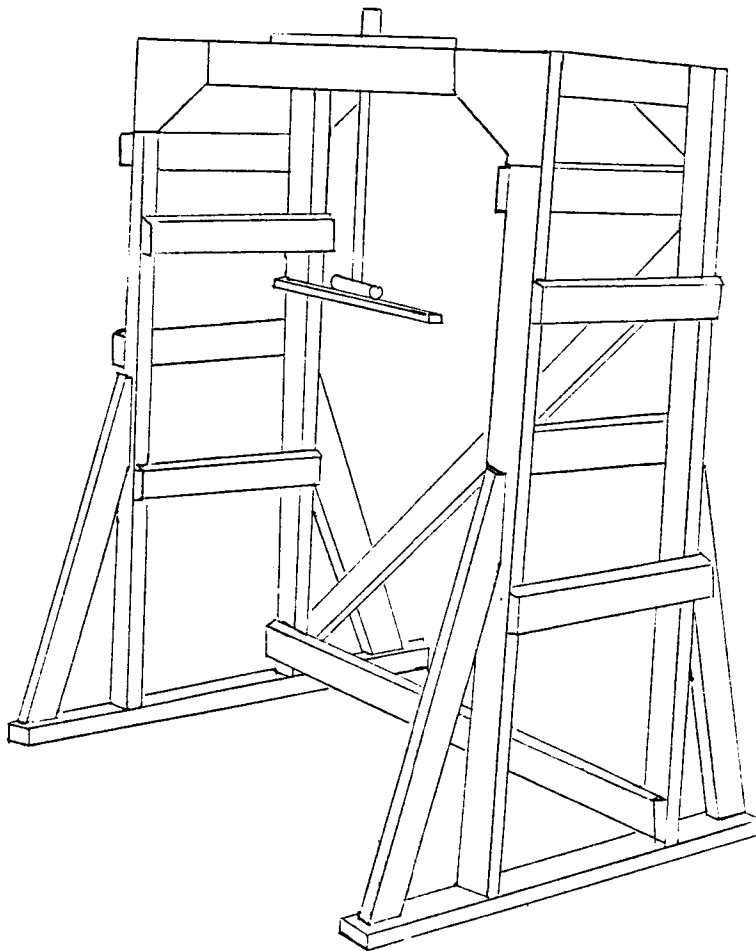


Figure 21. Cadaver support apparatus.

The hips were secured between two boards to prevent rotation. These boards were anchored to the legs of the apparatus.

A sheet metal screw was inserted into each exposed dorsal spine. A measurement bar was placed on the body between two dorsal spines. The mirrors were attached to the measurement bar and each screw head on either side of the bar. The apparatus was then used to rotate the cadaver spine by rotating the shoulders.

The same procedure was followed to set up and measure the reflections as in the in vivo testing. The results of these tests are in Table 4.

TABLE 4
RESULTS OF IN VIVO TESTING

Vertebrae	# of Tests	Actual Range of θ (in Degrees)	Measured Range of θ (in Degrees)	% Diff.	S.D.
L1	9	.91 - 4.10	1.9 - 8.05	+47	1.8
L2	6	1.3 - 2.95	2.6 - 6.83	+51	3.7
L3	10	.7 - 3.12	1.2 - 6.17	+47	4.5
T11	17	1.4 - 5.8	1.7 - 8.05	+26	2.7

A large range of rotational values were checked at four vertebrae locations. The actual rotational measurements was 50 to 75% of the rotation indicated by the measurement bar. This states that the LLM is conservative for this particular application. Thus, when used noninvasively, it can be assumed that the actual vertebrae rotation will be less than the in vivo measured vertebrae rotation.

The standard deviation is derived from the percent difference of each test done at a vertebrae location. The small values of standard deviation indicate a high level of confidence in repeatability for the LLM. This means that rotational measurement data from independent tests can be compared. From the comparison, reasonable and meaningful conclusions can be drawn.

CHAPTER V

RESULTS AND DISCUSSION

A. INTRODUCTION

Three types of material were considered in the analytical analysis: plaster, polyethylene, and polypropylene. Plaster is made from calcined gypsum and is also known as "Plaster of Paris." Polyethylene and polypropylene are called thermal plastics. The Risser cast is normally constructed with plaster. The two thermal plastics are primarily used in construction of nonoperative TLSO jackets.

All of the data dimensions in this analysis were International Standard, abbreviated as SI. A complete listing of the units can be found in Appendix A. The PAFEC finite element code was written in a unitless generic format. Definition of compatible input data units was a responsibility assigned to the user. During program execution, data units are not modified or changed in any manner. Output data units are based only on the input data units.

There were separate PAFEC data decks for each type of finite element model used in this study. Each of these data decks are listed in Appendix B. Descriptive comments were included in the data decks to define important sections.

Computer programs are capable of generating vast amounts of data with relative ease. Large dense tables of numbers summarizing the data contribute little to the understanding of the overall final

solution. The decision was made to cast 90% of the data into a unique X-Y plot format. The plots will be kept simple for clarity. A few small tables will be included to highlight specific points.

The complete listing of output data for each analytical execution of PAFEC used in this study can be found in Appendix C. The program used to plot the output data in the X-Y plot format is listed in Appendix D.

The next section of this chapter will describe in detail the X-Y plot format used for displacement and stress comparisons. This will be followed by a section that examines the accuracy of the derived boundary conditions that were applied to the symmetric model. This will be followed by a section containing the verification of the symmetric model's mesh refinement. The analytical results will be concluded with a section containing the comparisons of displacements and stresses for the three materials. Experimental results will be presented in the last section.

B. DEFINITION OF X-Y PLOT FORMATS

The results of a static finite element analysis produces two groups of numbers: displacements and stresses. Displacements can be compared using structural deformation plots. The deformed structure is superimposed as a dotted line on the undeformed structure. Stresses can be compared using structural stress contour plots. The undeformed structural plot has labeled lines of constant stress drawn on the surface. Unfortunately, the semi-loof element only supports structural deformation plots.

Structural deformation plots can provide a visual comparison between two finite element deformed shape models. Normally, numerical tables would be employed to detail the differences in deformed shapes of the two finite element models. To replace these long numerical lists comparing nodal displacements, a unique type of X-Y plot was designed. These plots visually convey the relative differences in displacements occurring between two finite element models. A short explanation follows which describes and defines these X-Y plots.

In Figure 22 the symmetric mesh has been unfolded into a two-dimensional view. The node strips along with the directions of displacement are indicated. Four vertical strips of axially continuous nodes were chosen and are labeled in Figure 22. The axial direction of the strips of nodes present a natural view to the observer. The distribution of the strips relate the greatest amount of information about the model's displacements.

The strips of nodes were plotted in their naturally observed order on the ordinate of the X-Y plot. An individual direction of the three cartesian displacements was plotted along the abscissa of the X-Y plot.

The X-Y plot format was retained for all displacement comparisons in this chapter. The program that generated these plots can be found in Appendix D. Care should be used in reading any displacement X-Y plot produced by this program. Scaling is automatic for the abscissa and can produce different scale values between individual plots. The abscissa numbering may be scaled by a power of

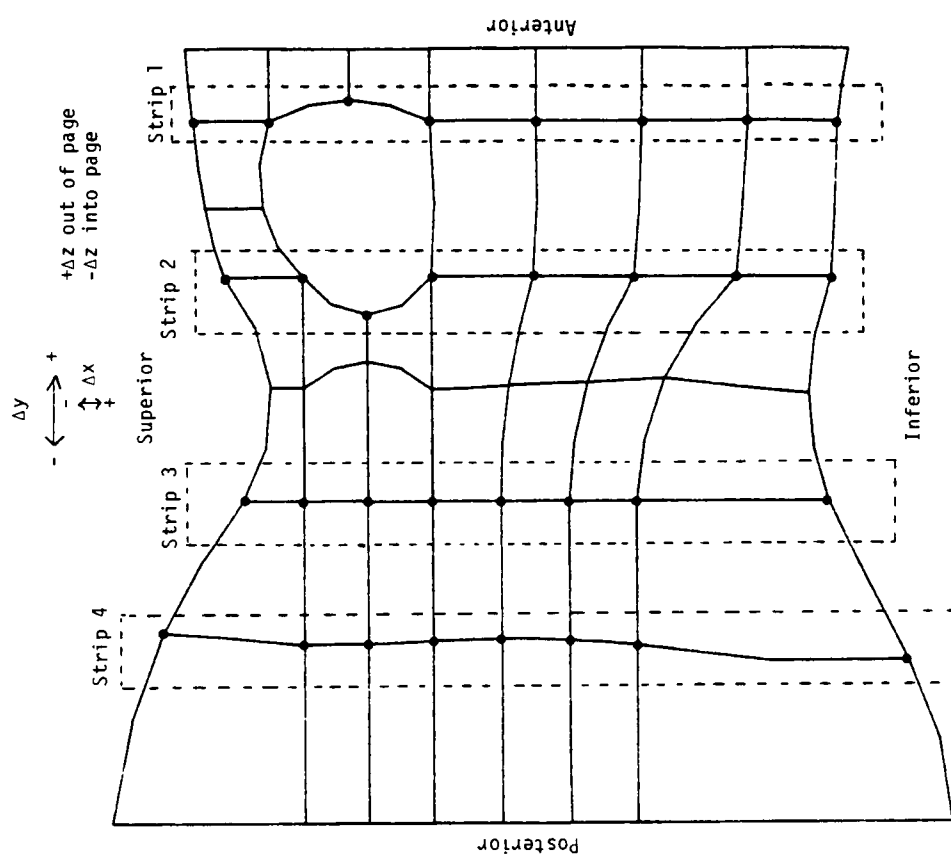


Figure 22. Unfolded two-dimensional view of the symmetric semi-loop element mesh used for x-y displacement plots.

10. Scaling by a power of 10 is noted to the right of the abscissa title when it has occurred.

Automatic scaling was chosen to enhance the comparisons. If a constant scale had been employed, nearly 75% of the plots would have depicted a single line and defeated the purpose of the plot. The drawback of the automatic scaling is that all minor differences tend to appear as major differences. When this occurs, it will be noted in the discussion about the comparisons.

The same four strips of nodes were used for all displacement comparisons in this chapter for continuity. For uniformity among the sets of displacement comparisons throughout this chapter, the order of presentation will be: strip 1, strip 2, strip 3, and strip 4.

As stated before, the semi-loof elements do not support stress contour plots. Numerical tables would be cumbersome in comparing stress between the two finite element models. The X-Y plot format employed in the displacement comparisons was selected for the stress comparisons. The following few paragraphs describe and define the X-Y plots for the stress comparisons.

In Figure 23 the symmetric mesh has been unfolded into a two-dimensional view. Four axially vertical panels of continuous elements were chosen and are labeled in Figure 23. The axial direction of the panels of elements present a natural view to the observer. The distribution of the panels related the greatest amount of information concerning the comparison of stresses.

The panels of elements were plotted in their naturally observed order on the ordinate of the X-Y stress plot. The most positive

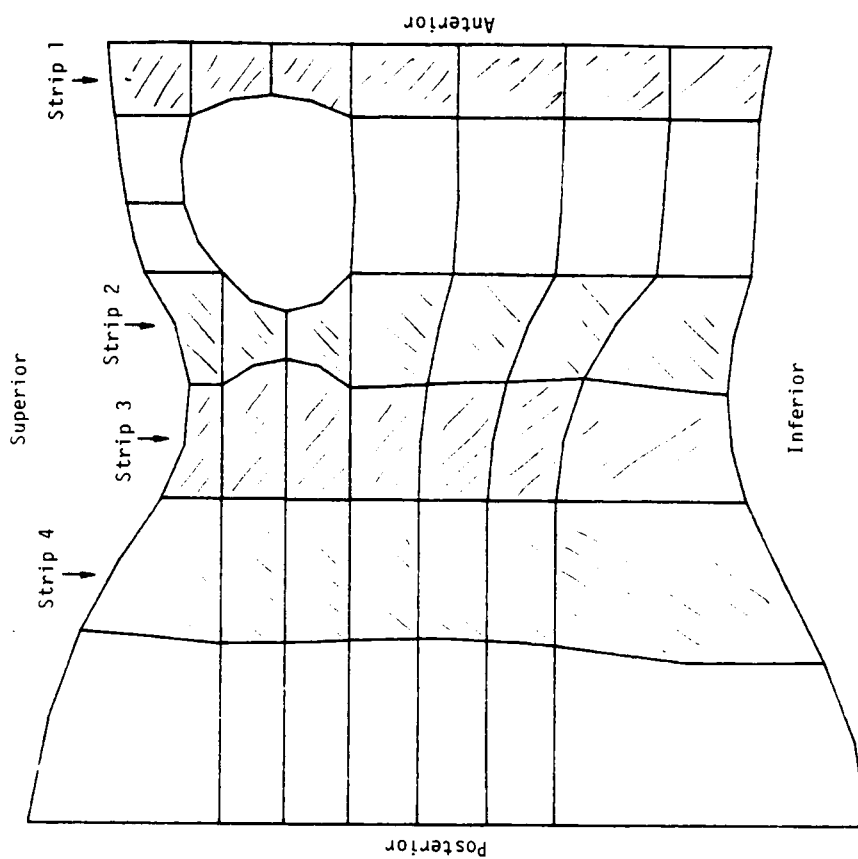


Figure 23. Unfolded two-dimensional view of the symmetric semi-loop element mesh used for x-y stress plots.

principal stress was chosen to be plotted along the abscissa. The top surface and bottom surface for each panel was selected for comparison between two models.

The X-Y plot format was retained for all stress comparisons in this chapter. The program that generated these plots can be found in Appendix D. Care should be used in reading any X-Y plot produced by this program. Scaling is automatic for the abscissa and can produce a different scale value between individual plots. The automatic scaling tends to exaggerate minor differences.

Besides automatic scaling, there is an inherent source of error in the stress results which also must be considered. Stress components are calculated using the directly calculated displacements. This is a valid method in obtaining stress results. However, consideration must be given to the degree of error, if any, in the displacement results.

Stress-displacement relations involve theoretical approximations which are usually insignificant. Error in the displacement comparison between two models is passed directly to the stresses. Comparison of stresses cannot be expected to yield an exact numerical match unless displacements yield an exact numerical match.

The selected four panels of elements were used for all stress comparisons in this chapter for continuity. For uniformity among the sets of stress comparisons in this chapter, the panels will be presented in the following order: panel 1, panel 2, panel 3, and panel 4. The top surface stress will be compared first and followed by the bottom surface comparison.

C. EXAMINATION OF THE APPLIED BOUNDARY CONDITIONS

As noted in Chapter III, the Risser jacket symmetric finite element model did not exactly meet the geometric criteria for nodes along the lines of symmetry. Large errors in the results were not expected due to the low magnitude of the simple loading conditions. To verify this assumption, a full model of the Risser jacket using semi-loof elements was developed. A picture of the full model mesh can be seen in Figure 12, p. 29.

This examination was not intended to verify the accuracy of the semi-loof element. The accuracy had been previously verified with examples in Chapter IV. The only purpose of this section was to show the influence of the applied boundary conditions on the displacements and stresses. This was accomplished by a direct comparison of calculated displacements and stresses between the symmetric and full finite element models. Each model was subjected to identical loading conditions which are described in Chapter IV. In the rest of this section, the two models will be referred to as the symmetric model for the symmetric semi-loof quadrilateral model and full model for the full semi-loof quadrilateral model.

The definition of thin shell theory was applied to the three materials employed in this study. When the Risser jacket is constructed from plaster, the structural thickness is .9525 cm. If the Risser jacket is constructed with a thermal plastic, the structural thickness is .3175 cm, or one-third of the plaster jacket's thickness. By definition, the thickness of a thin shell is less than one-fifth

of the shortest unsupported length. Employing a common element size, a comparison clearly shows that the plaster material represents the greatest approximation to a thin shell.

Plaster was chosen as the material to be used for the two finite element models. The two models would then be considered the greatest approximation to thin shell theory. It follows that errors due to the boundary conditions would be the largest for the finite element models using plaster as the structural material.

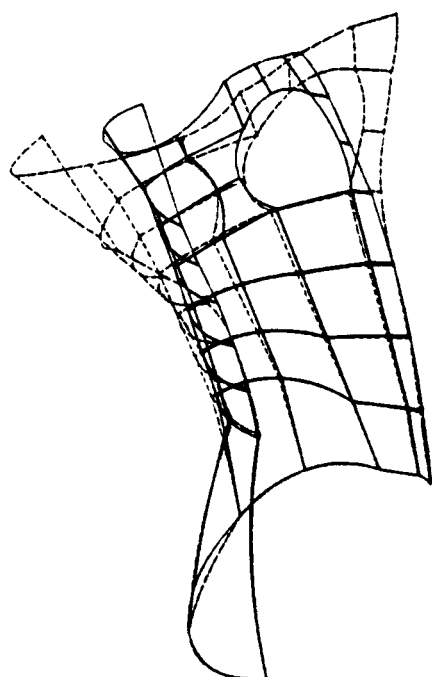
Models using thermal plastics as a structural material would be less of an approximation to thin shell theory. The errors due to the boundary conditions were expected to be the same or less than the errors of the plaster finite element models.

In summary, if the plaster finite element model produced acceptable results, then the thermal plastic finite element models would produce acceptable results. Using this reasoning, only the plaster material was used to verify the boundary conditions.

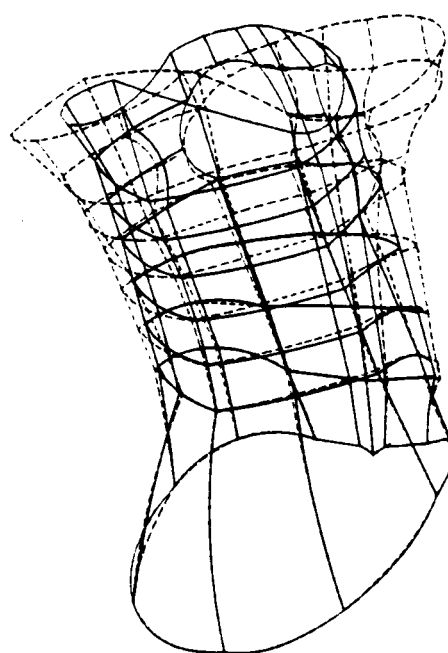
The loading condition described in Chapter III was employed in each finite element model. The overall displaced shapes of each model, full and symmetric, can be seen in Figure 24. The difference between the displaced shapes was seen at the superior end, noted by arrows in Figure 24. The most prominent area of difference was around the breast hole.

The ΔX displacement comparisons between the full model and symmetric model are shown in Figures 25, 26, 27, and 28. The positive direction of the ΔX displacement runs axially from the superior end

Symmetric Semi-Loof Model



Full Semi-Loof Model



Material: Plaster

Figure 24. Distorted structural shapes of the symmetric model and full model due to torsional loading.

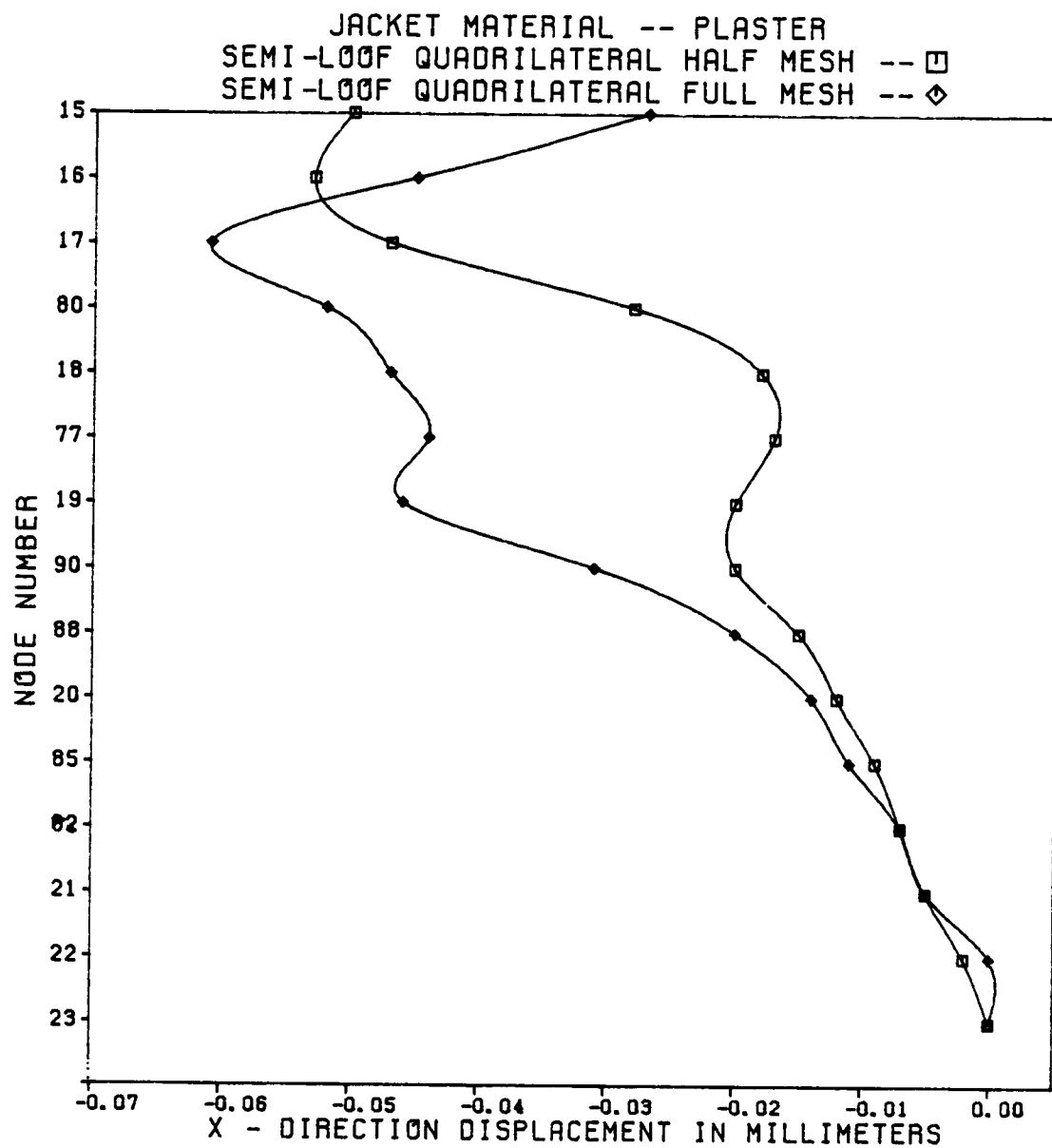


Figure 25. ΔX -displacements for strip 1 of the symmetric model and full model.

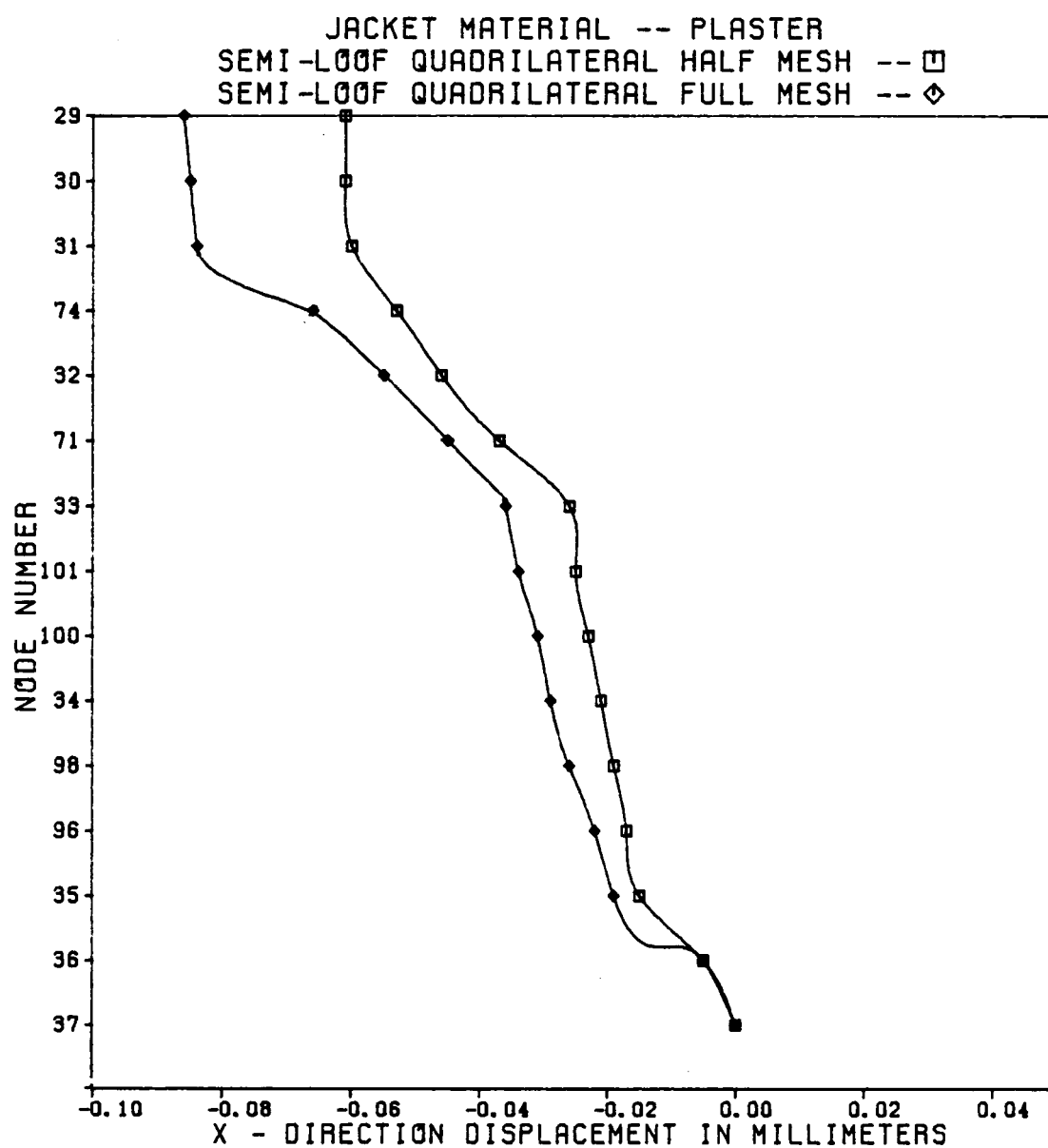


Figure 26. ΔX -displacements for strip 2 of the symmetric model and full model.

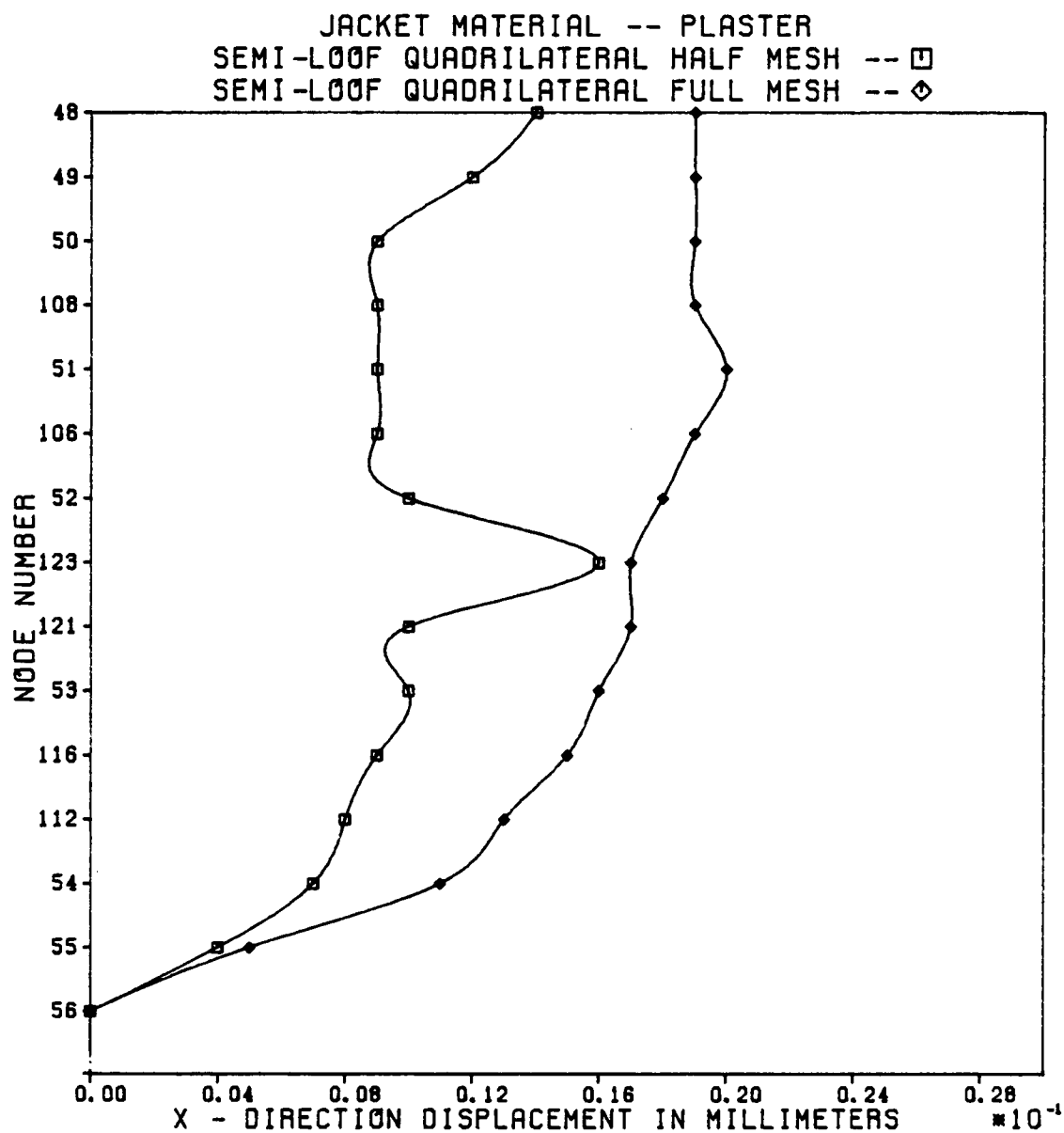


Figure 27. ΔX -displacements for strip 3 of the symmetric model and full model.

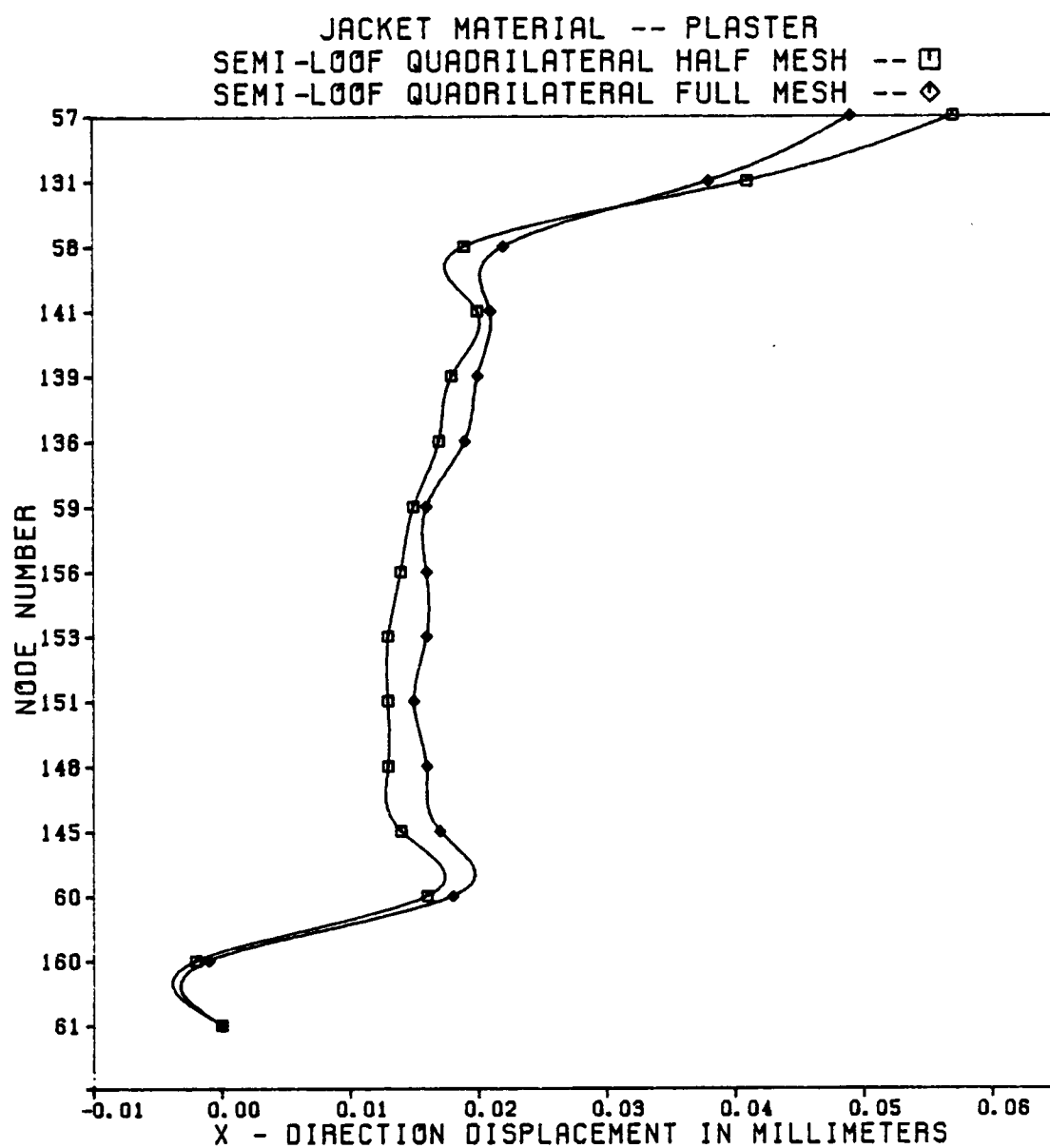


Figure 28. ΔX -displacements for strip 4 of the symmetric model and full model.

to the inferior end of the model (see Figure 22). Figures 25 and 26 demonstrate negative motion with the symmetric model having the lesser displacements. Figures 27 and 28 demonstrate positive motion with the symmetric model having the greater displacements.

In each figure, ΔX displacement comparisons were on the same order of magnitude. Symmetric model displacements followed the same general characteristic curve shape set by the full model displacements. This occurred at nearly every node except for nodes in strip 1 which were near the breast hole. The symmetric model nodes near the breast hole displayed a different displacement curve shape than the exact same nodes of the full model.

The ΔY displacement comparisons between the full model and symmetric model are shown in Figures 29, 30, 31, and 32. The positive direction of the ΔY displacement is defined as movement towards the anterior of the model. The negative direction of the ΔY displacement is defined as movement towards the posterior of the model. These directions are labeled in Figure 22.

In each comparison of the ΔY displacements, the symmetric model displacement curve and full model displacement curve were on the same order of magnitude. For each strip of nodes, the characteristic shape of the symmetric model displacement curve was similar to the shape of the corresponding full model displacement curve. The major difference occurred in strip 1 for nodes near the breast hole. In this area, there was little similarities between the two curves.

The ΔZ displacement comparisons between the full model and symmetric model are shown in Figures 33, 34, 35, and 36. The positive

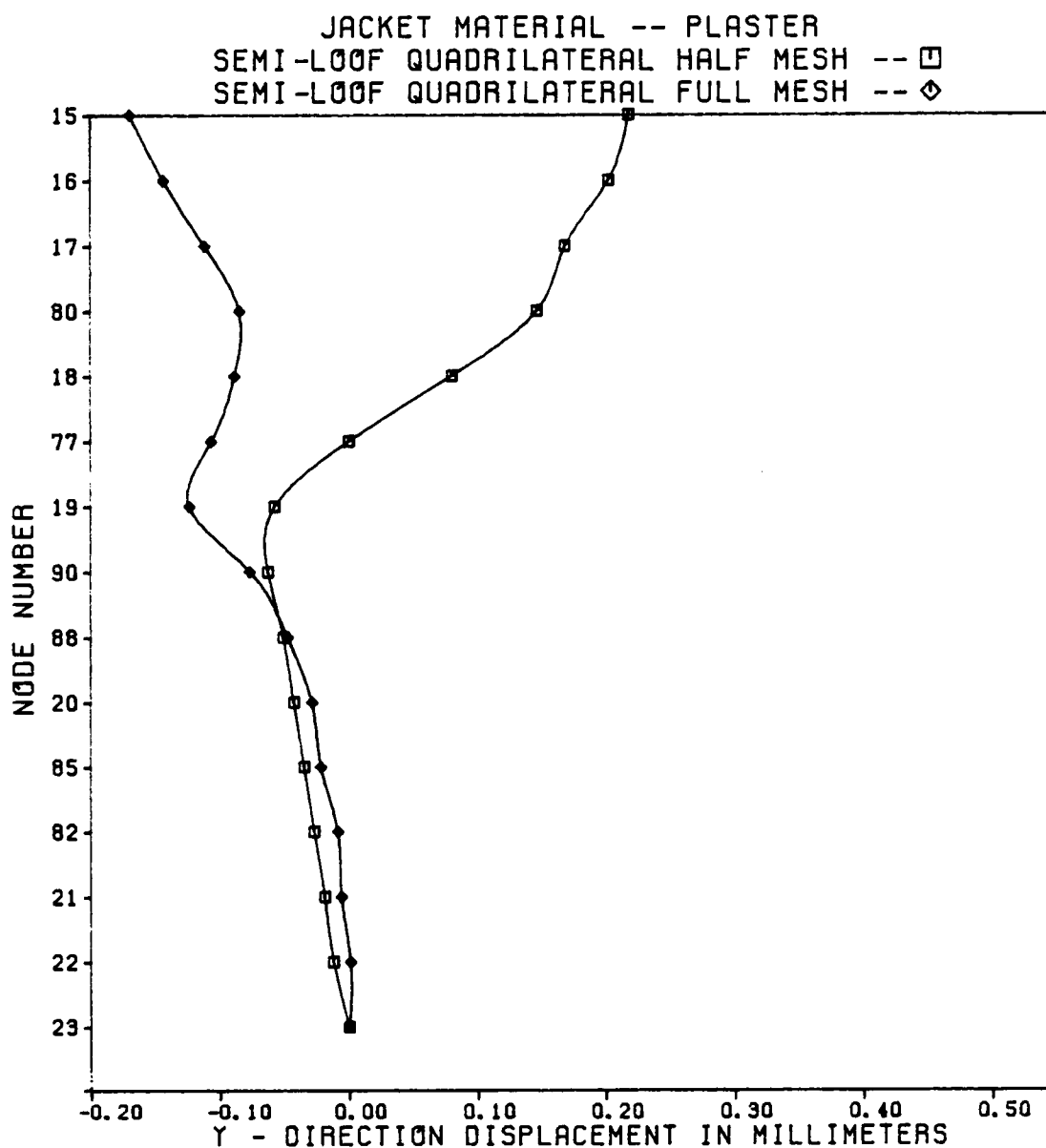


Figure 29. ΔY -displacements for strip 1 of the symmetric model and full model.

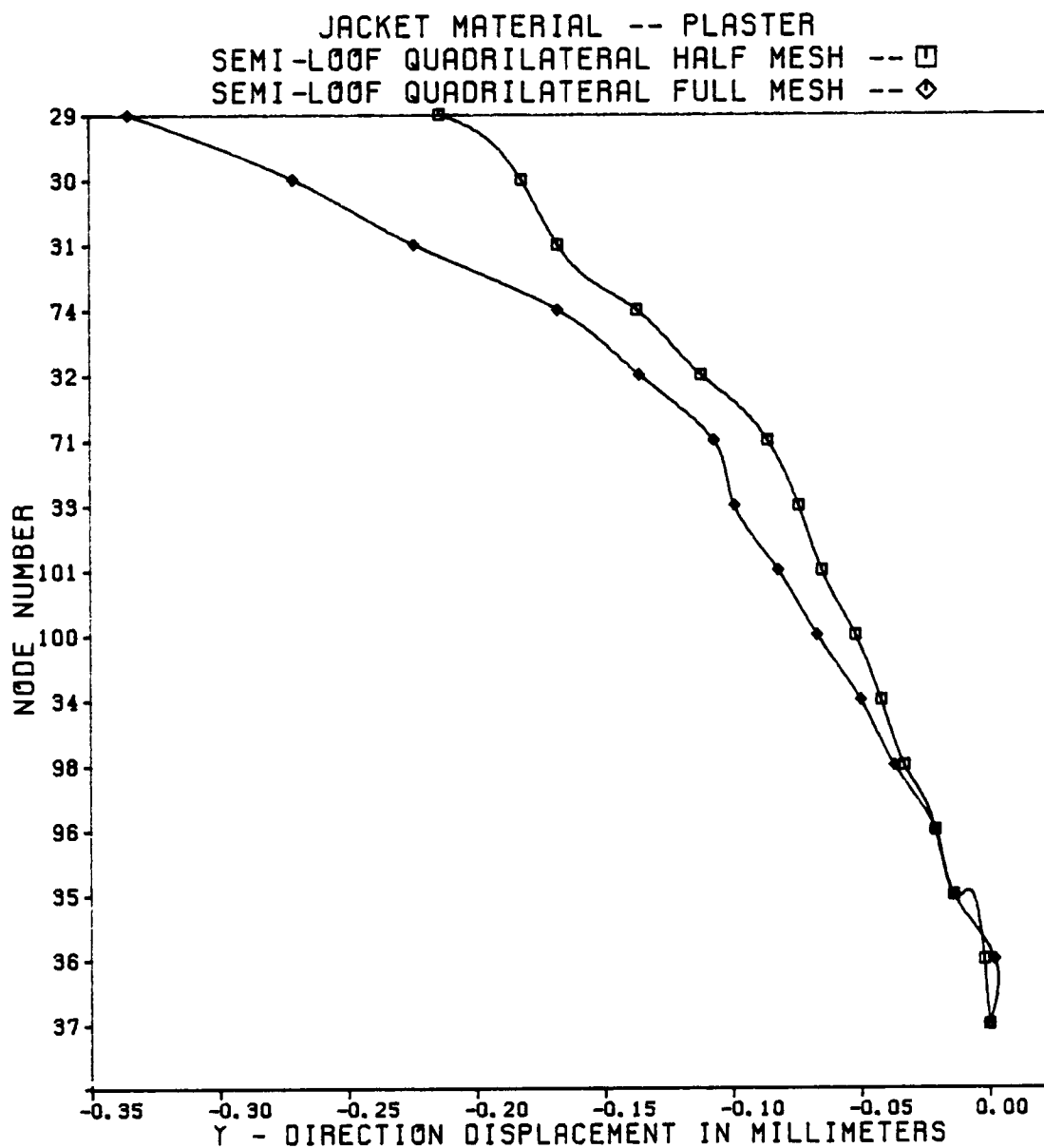


Figure 30. ΔY -displacements for strip 2 of the symmetric model and full model.

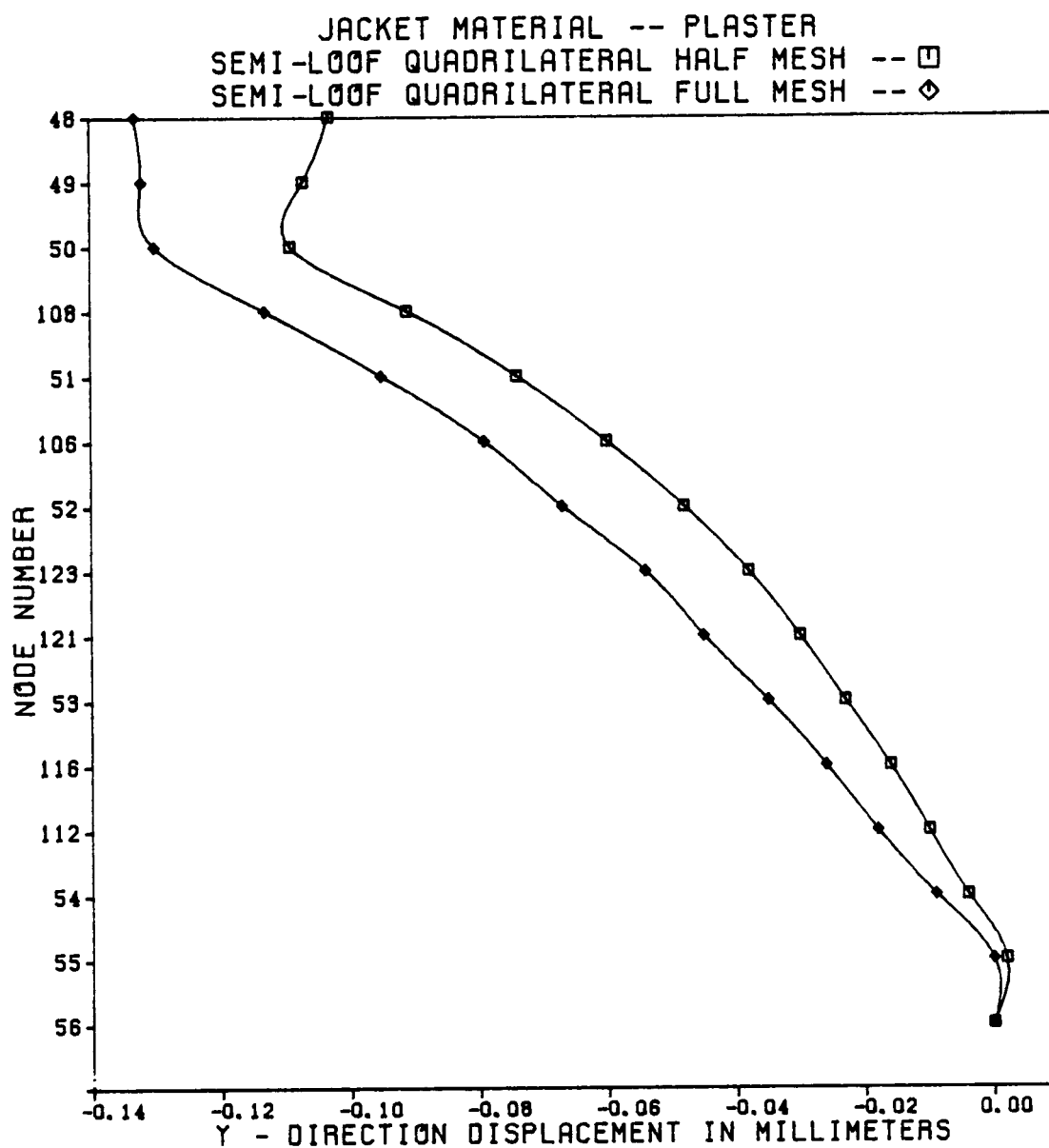


Figure 31. ΔY -displacements for strip 3 of the symmetric model and full model.

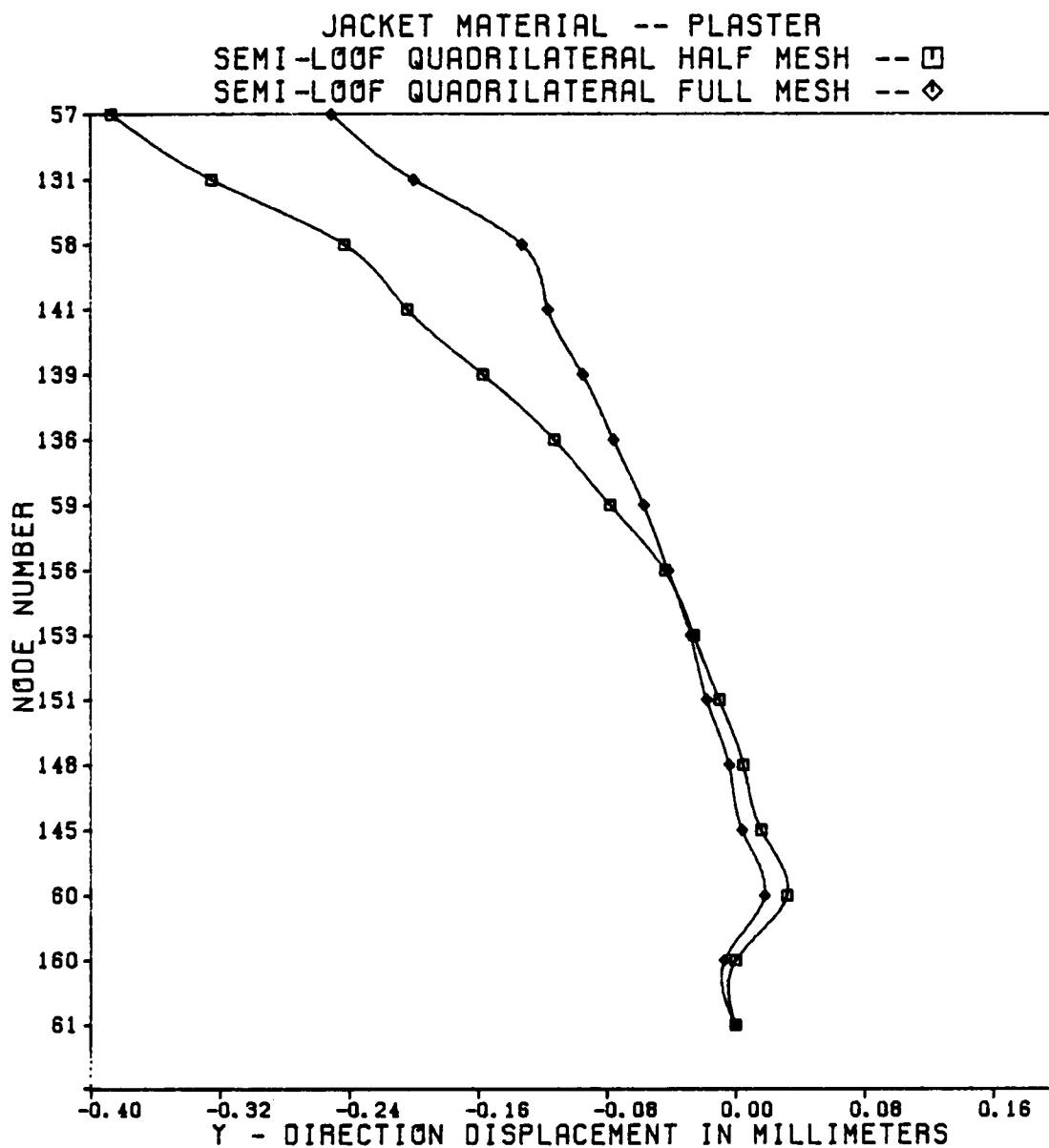


Figure 32. ΔY -displacements for strip 4 of the symmetric model and full model.

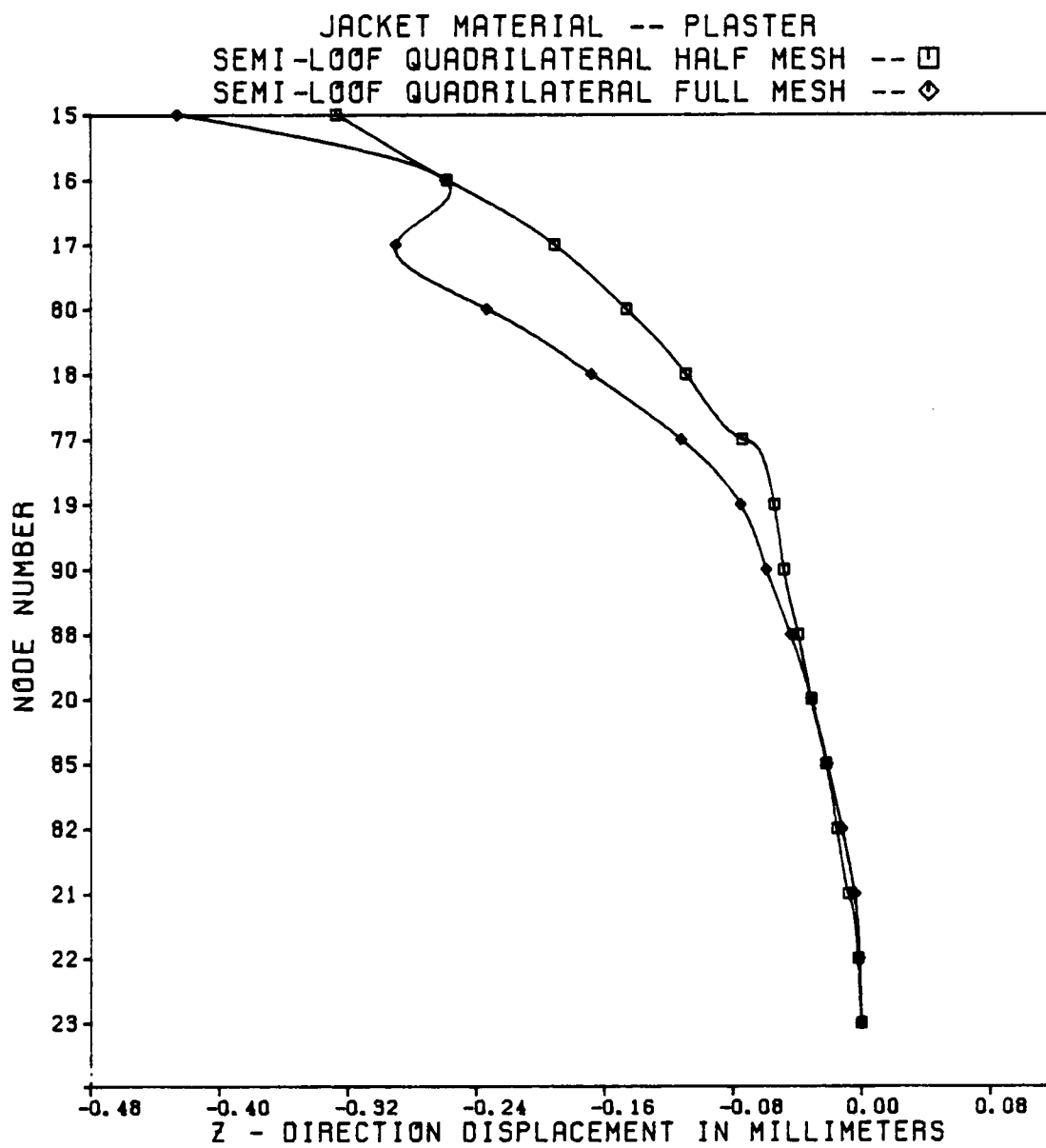


Figure 33. ΔZ -displacements for strip 1 of the symmetric model and full model.

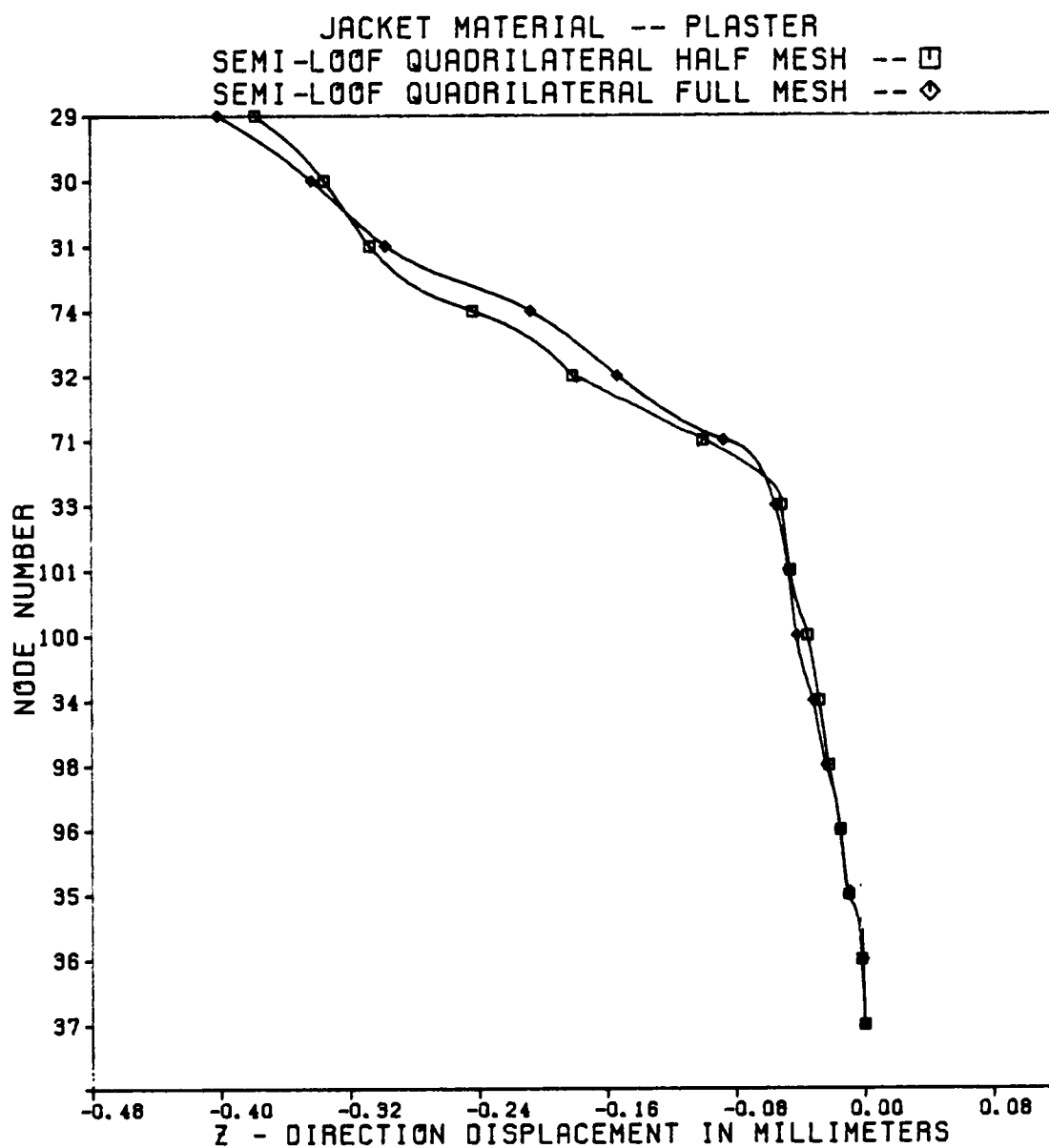


Figure 34. ΔZ -displacements for strip 2 of the symmetric model and full model.

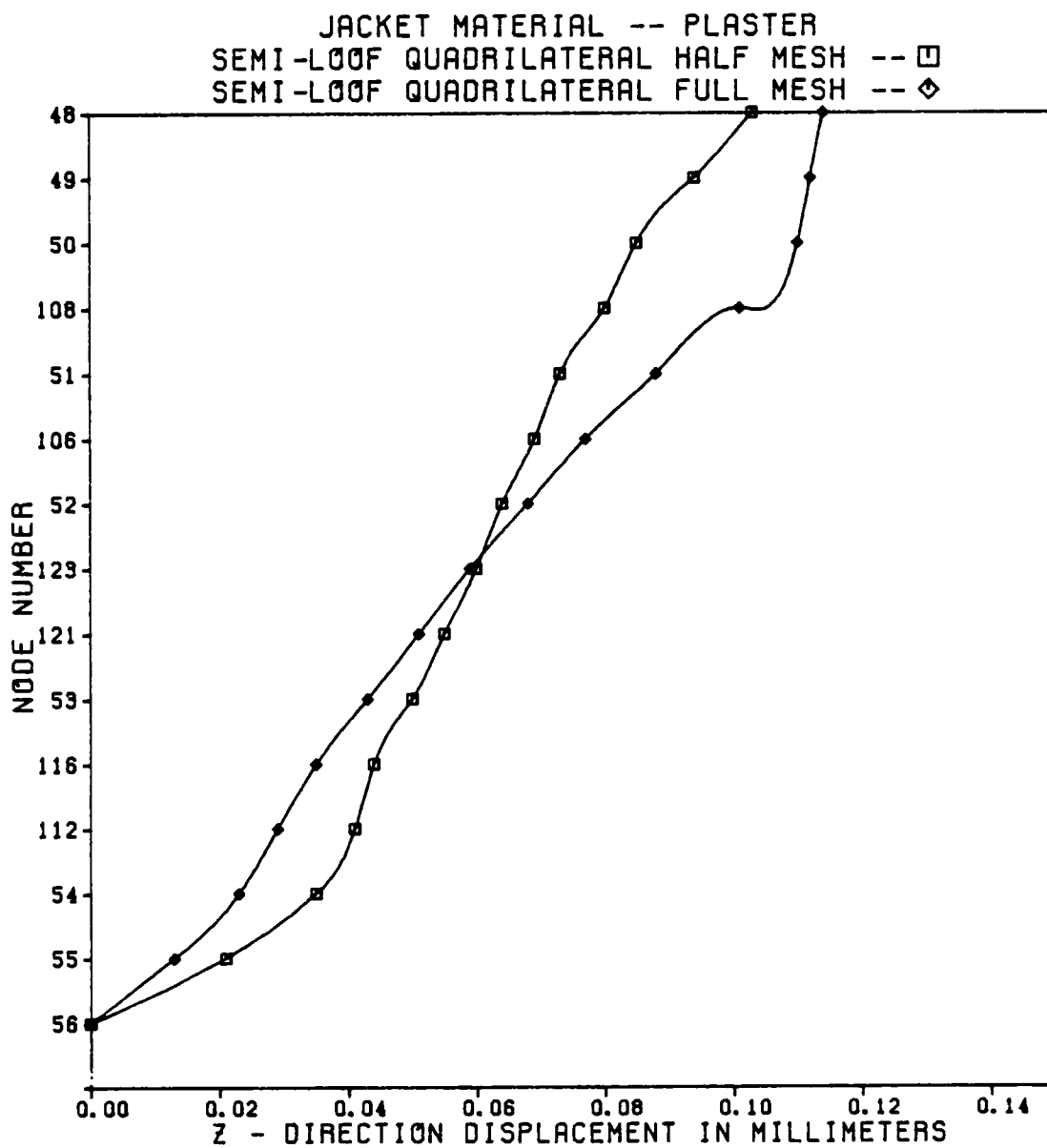


Figure 35. ΔZ -displacements for strip 3 of the symmetric model and full model.

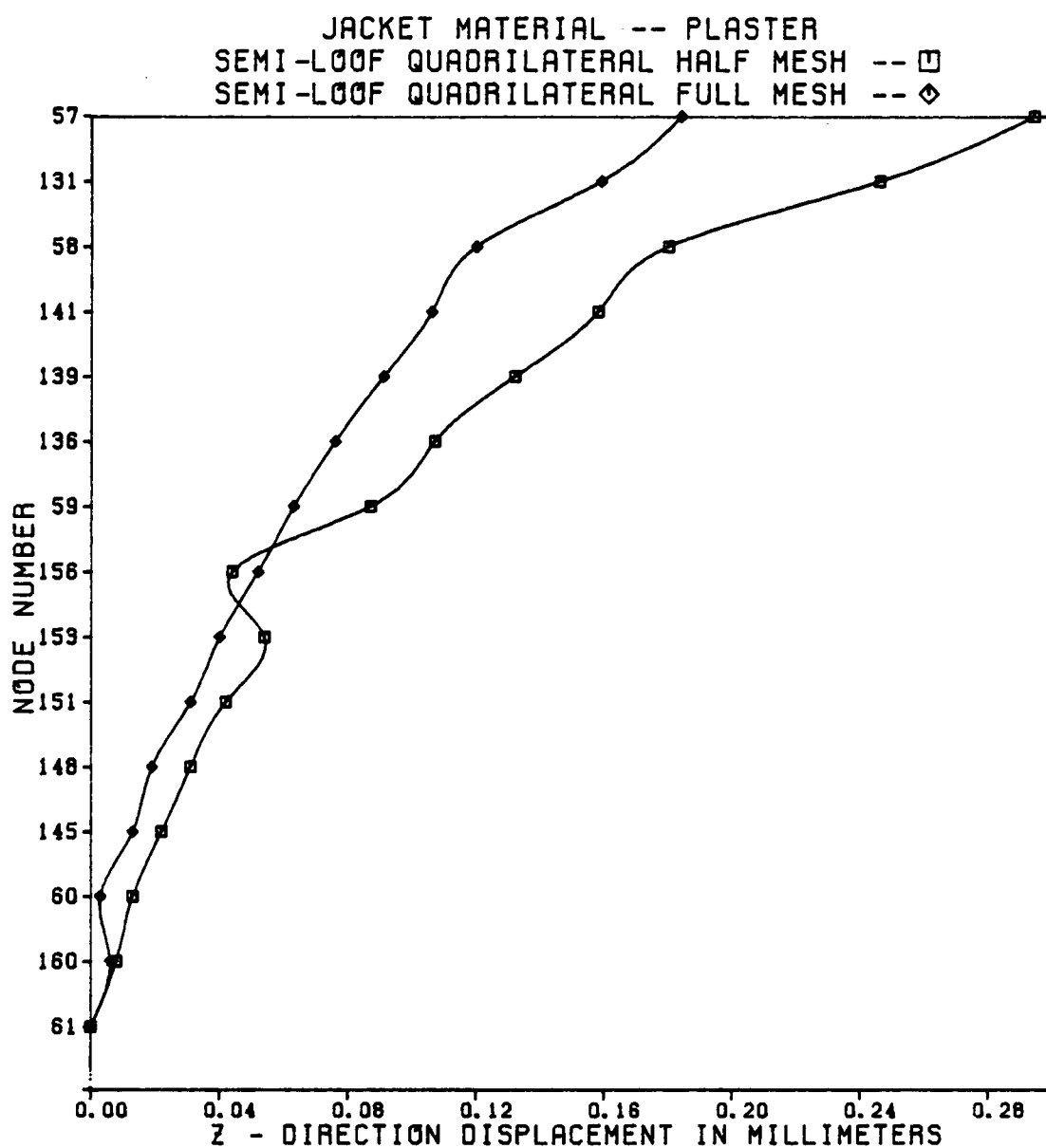


Figure 36. ΔZ -displacements for strip 4 of the symmetric model and full model.

direction of the ΔZ displacement is defined as lateral movement. The negative direction of the ΔZ displacement is defined as medial movement. These definitions are shown in Figure 23 (p. 54).

In each figure, the symmetric model displacement curve and full model displacement curve were on the same order of magnitude. The individual characteristic curve shape of the full model was closely followed by the curve shape of the symmetric model for the ΔZ displacement. Nodes in strip 1 near the breast hole produced similar curves for each model. This was the opposite trend seen in strip 1 for the ΔX displacement comparisons and ΔY displacement comparisons.

The symmetric model displaced shape was similar to the full model displaced shape. This was supported by the nodal displacement comparison curves and the distorted structural shape comparison. The only difficulty in the displacement comparison was found in the set of nodes between the breast hole and symmetric boundary line. In this localized area the ΔX and ΔY displacements did not compare favorably between the two models. This difference was minor and did not appear to affect the rest of the structural displacements.

Overall, the magnitude of every displacement was small with respect to the physical dimensions of the model. All displacements were less than one-half millimeter with roughly 50% less than one-quarter of a millimeter. Therefore, no comparisons were made on a percentage basis. A percentage comparison would provide misleading numbers in which to draw conclusions on the validity of the boundary conditions.

The stress output of the semi-loof element has been previously described in Chapter III. Stresses are calculated at each of the four Gauss points on the top and bottom surfaces. The calculated stress components consist of the most positive principal stress and the most negative principal stress. A picture of the stress output at one Gauss point can be seen in Figure 4 (p. 21). For the X-Y stress plot comparisons, the most positive principal stress of the four Gauss points of a single element was used for comparison on the top and bottom surface.

Figures 37, 38, 39, and 40 contain the top surface positive principal stress comparisons for the symmetric model and full model. The stresses in each figure were on the same order of magnitude. The individual characteristic curve shape of the symmetric model is moderately similar to the curve shape of the full model. The element stresses in panel 1 near the breast hole did not compare as favorably as the other element stresses in panel 1. The element stresses in panel 4 appear only roughly comparable. However, the scale of the abscissa in panel 4 was the smallest among the panels and tends to over-emphasize minor differences. Based on the other panels' larger abscissa scale factor, the stresses in panel 4 compare favorably.

The bottom surface positive principal stress comparisons are contained in Figures 41, 42, 43, and 44. In each figure, the stresses are on the same order of magnitude. The individual stress curve characteristic shape of the symmetric model was similar to the characteristic curve shape of the full model. The element stresses

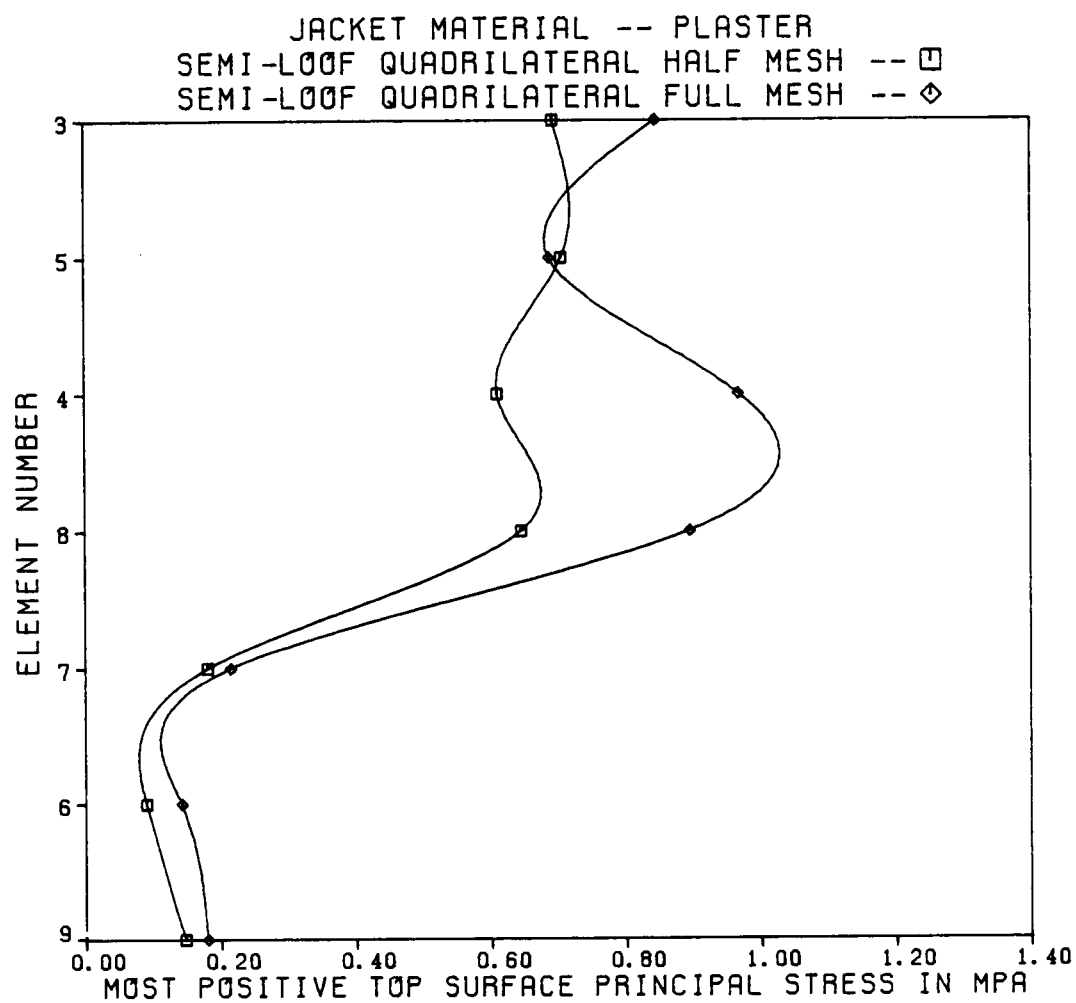


Figure 37. Positive top surface stress for panel 1 of the symmetric model and full model.

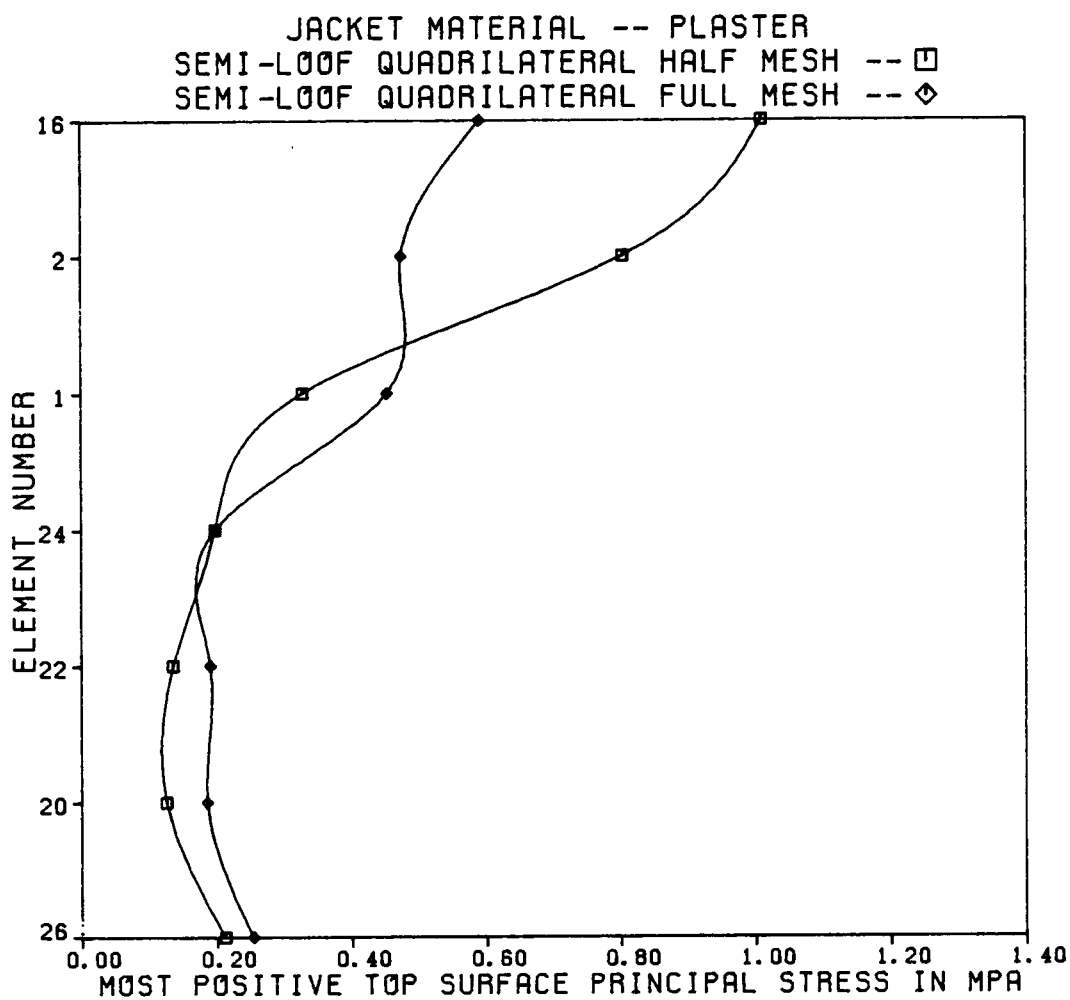


Figure 38. Positive top surface stress for panel 2 of the symmetric model and full model.

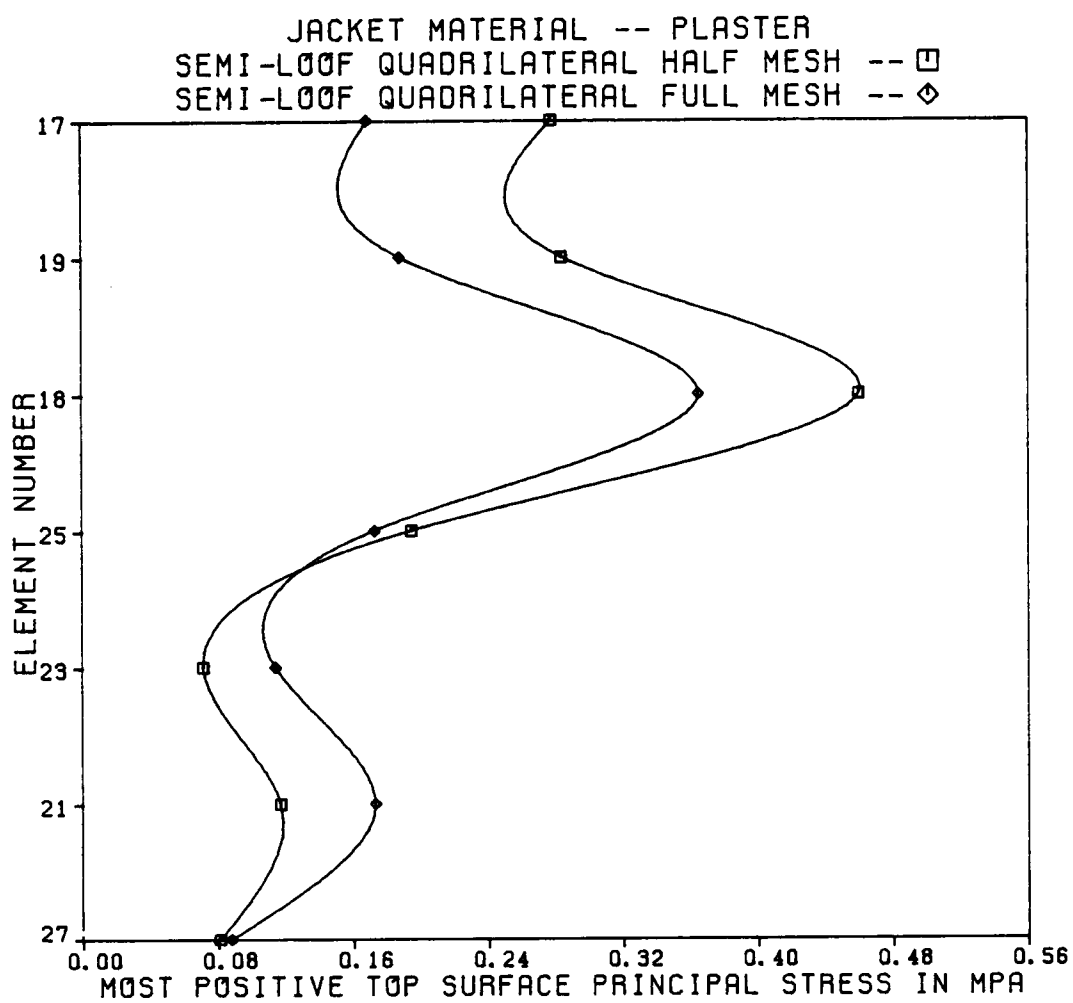


Figure 39. Positive top surface stress for panel 3 of the symmetric model and full model.

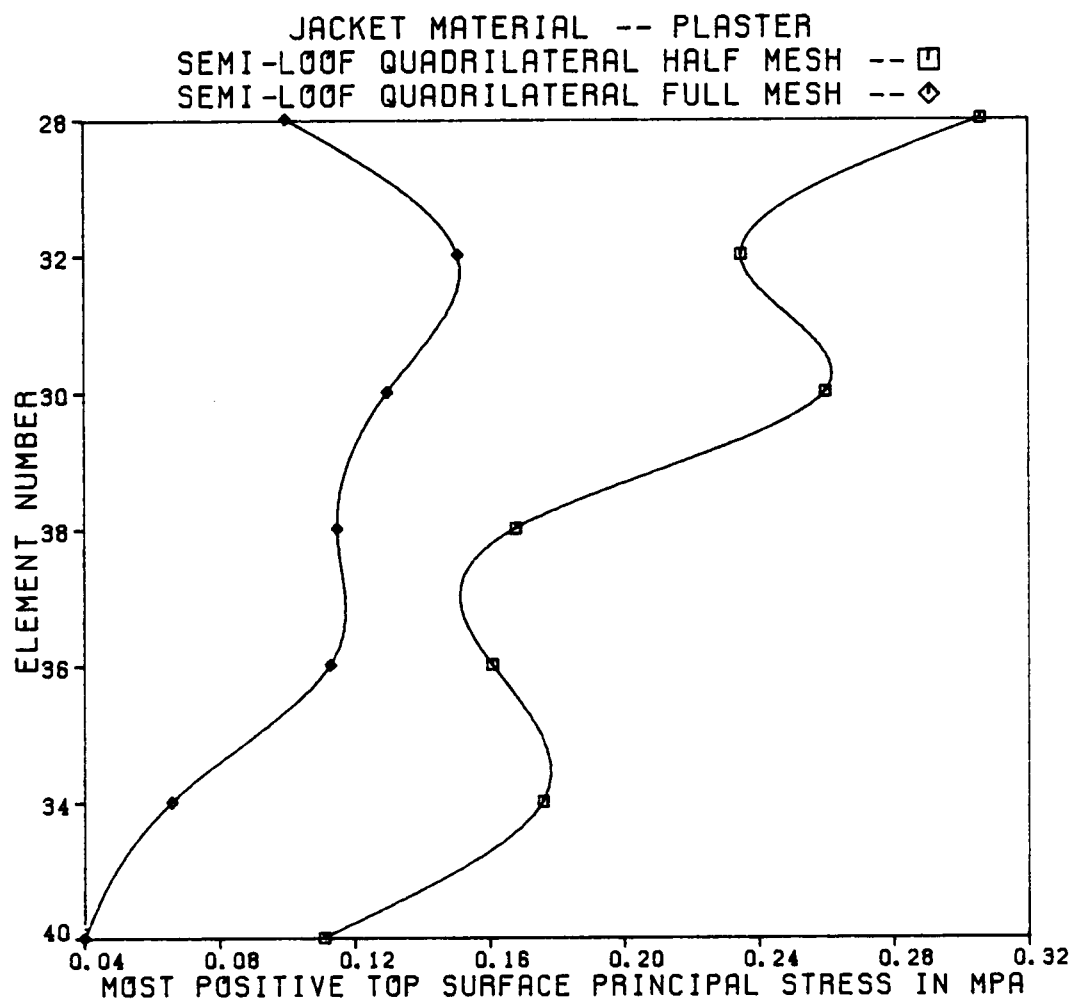


Figure 40. Positive top surface stress for panel 4 of the symmetric model and full model.

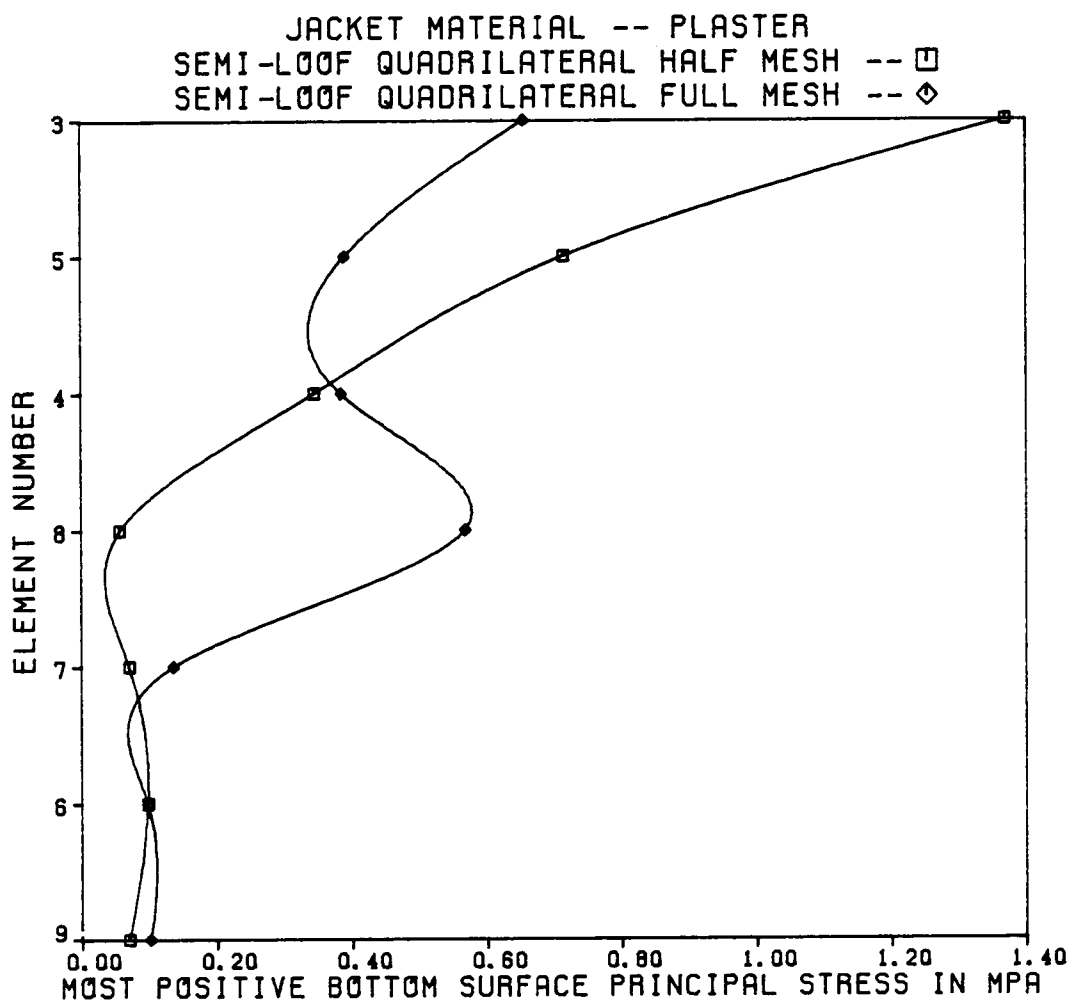


Figure 41. Positive bottom surface stress for panel 1 of the symmetric model and full model.

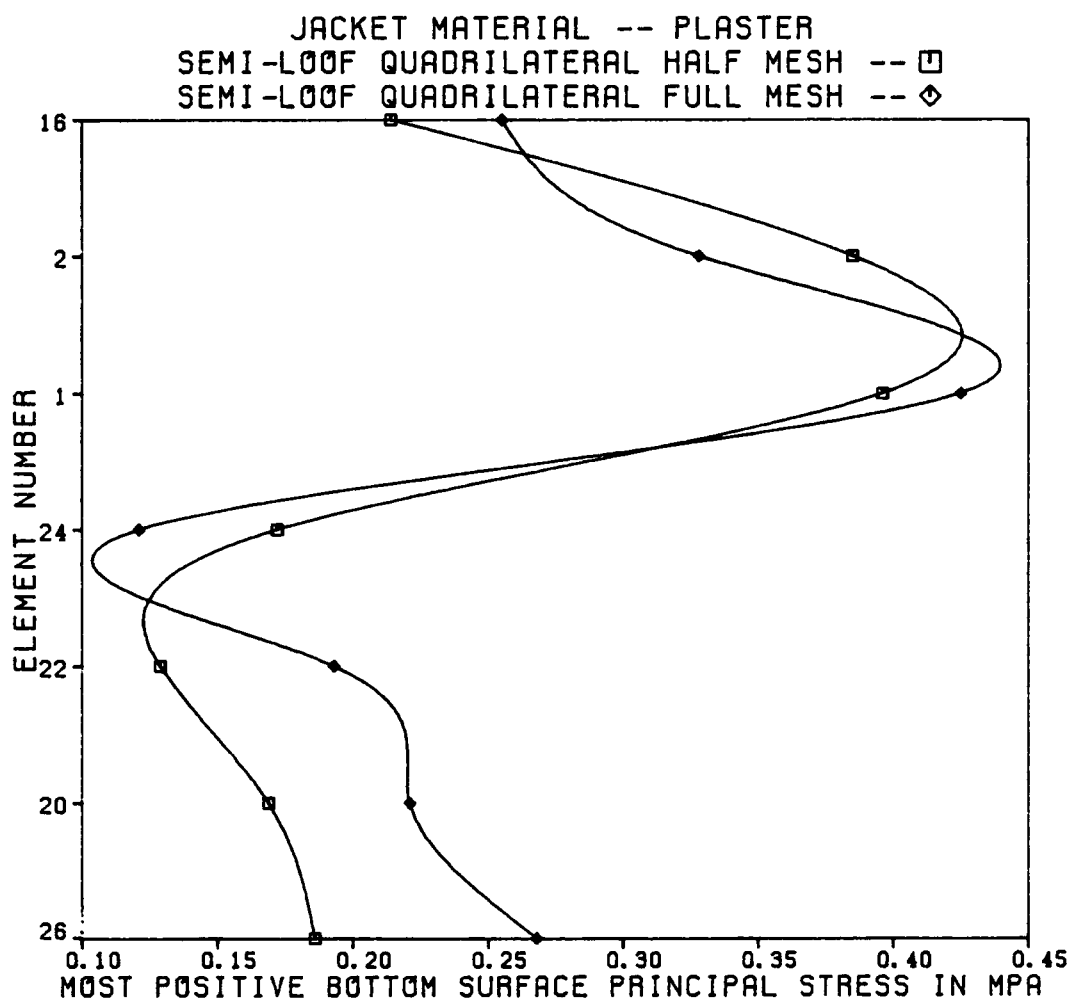


Figure 42. Positive bottom surface stress for panel 2 of the symmetric model and full model.

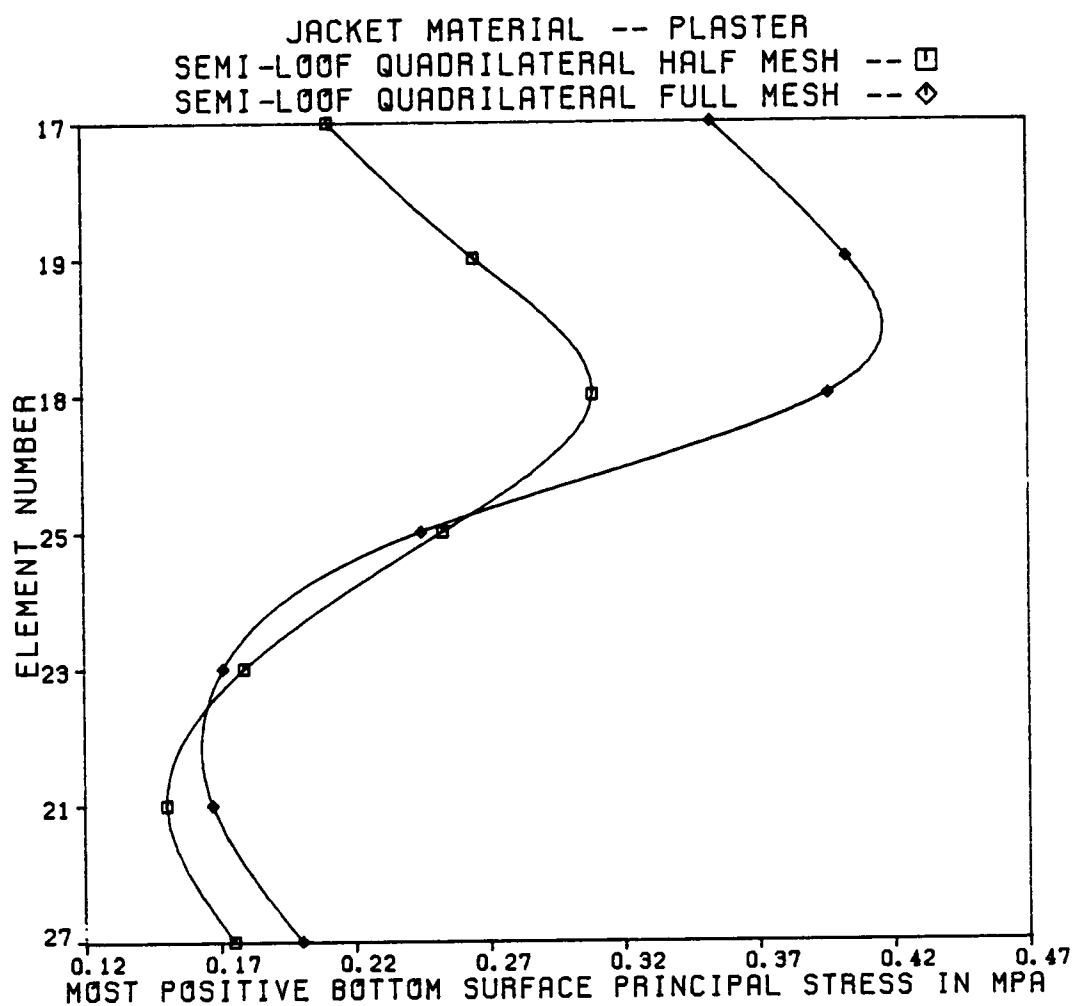


Figure 43. Positive bottom surface stress for panel 3 of the symmetric model and full model.

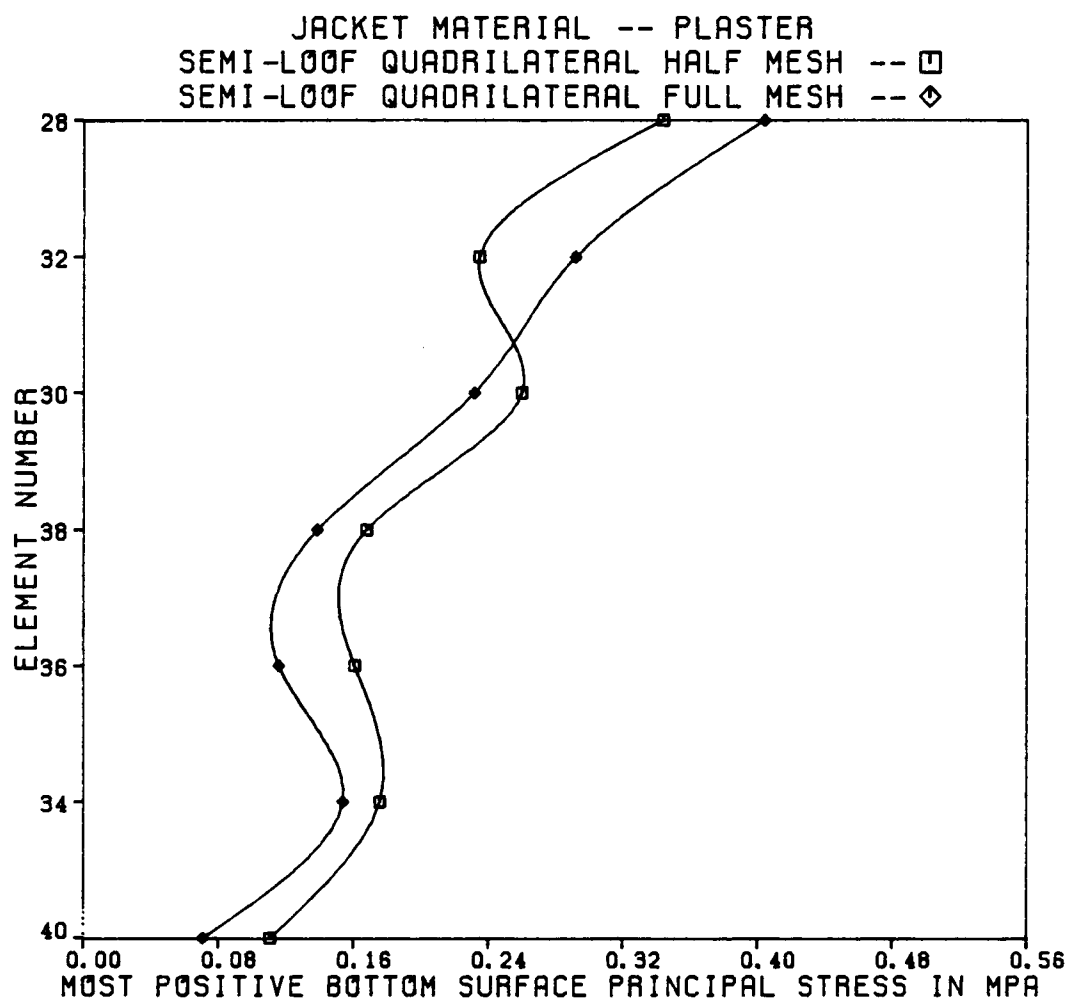


Figure 44. Positive bottom surface stress for panel 4 of the symmetric model and full model.

in panel 1 near the breast hole did not compare as favorably as the other element stresses in panel 1.

The symmetric model stresses were similar to the full model stresses. Bottom surface stress comparisons were superior to the top surface stress comparisons. Difficulty was found in the set of elements between the breast hole and symmetric boundary. Stresses did not compare favorably for either the top or bottom surfaces in this area. The area was limited in size and did not appear to influence the other element stresses.

Displacement and stress results were deemed acceptable for the symmetric model. Thus, the boundary conditions of the symmetric model were considered to be correctly applied. Since the plaster structural material produced acceptable results, it was expected that the two thermal plastic structural materials would produce acceptable results. This is based on the fact that the thermal plastics are more conservative with respect to thin shell theory.

D. EXAMINATION OF MESH REFINEMENT

The mesh discretization of the symmetric Risser jacket was defined in Chapter III. A picture of this mesh can be seen in Figure 10 (p. 28). One guideline for constructing a finite element mesh is to use smaller elements in areas where displacements and stresses are expected to vary rapidly in magnitude. This rapid variation is due to the load configuration, physical dimensions of the structure, and geometric shape of the structure. The mesh used in the symmetric model was constructed using this guideline.

To verify the mesh refinement, a triangular symmetric mesh was generated. A picture of this mesh can be seen in Figure 11 (p. 29). The mesh was generated by splitting each original quadrilateral mesh element into eight triangular mesh elements (see Figure 45). In the rest of this section, the two models will be referred to as the quad model for the semi-loof quadrilateral symmetric model and the triangular model for the refined triangular symmetric model.

This procedure was not intended to verify the accuracy of the semi-loof element. The accuracy had been previously verified with examples in Chapter IV. The purpose of this section was to investigate only the mesh refinement of the quad model. Displacement and stress comparisons will be used in this investigation.

Only the plaster structural material was used by employing the reasoning of the previous section. Briefly, of the three materials, plaster used as the structural material represents the greatest compromise to thin shell theory. If the quad model produces acceptable results using plaster as a structural material, then it follows that the thermal plastics would also produce acceptable results.

The loading condition described in Chapter III was employed in each finite element model. The overall displaced shapes of the quad model and triangular model can be seen in Figure 46. The displaced shapes appear to be identical. The triangular model displays a finer definition of the displaced shape due to the greater number of elements.

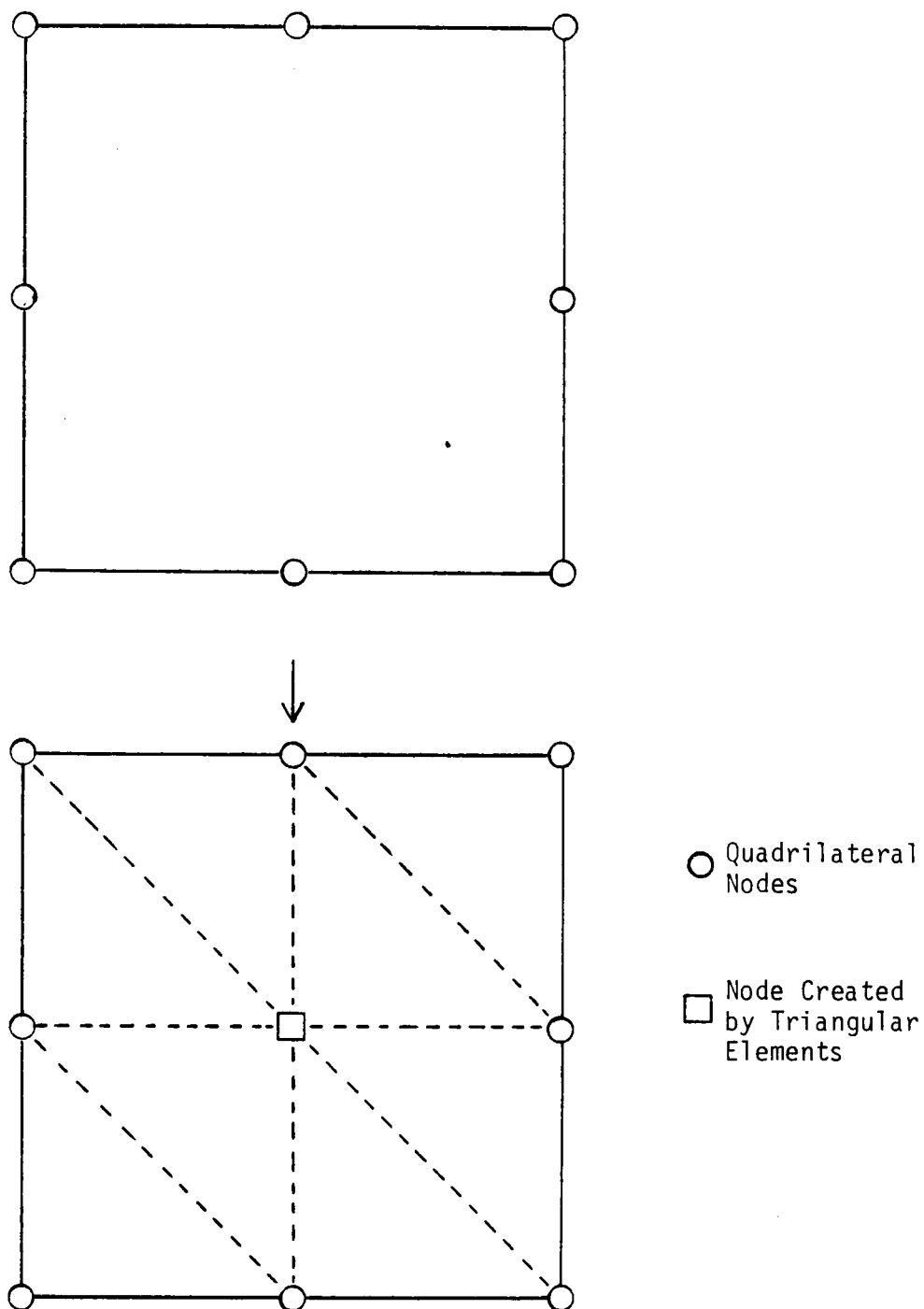
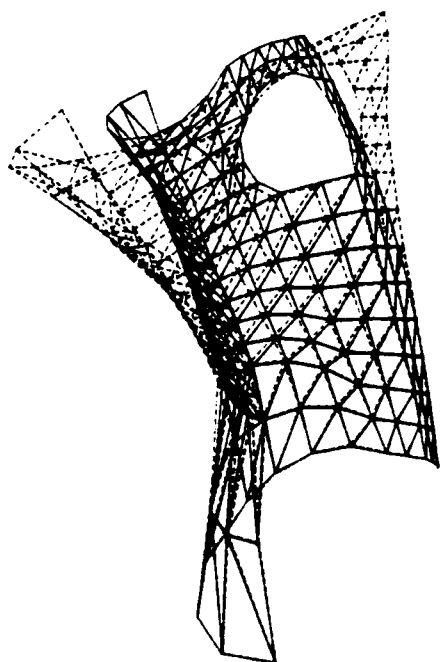
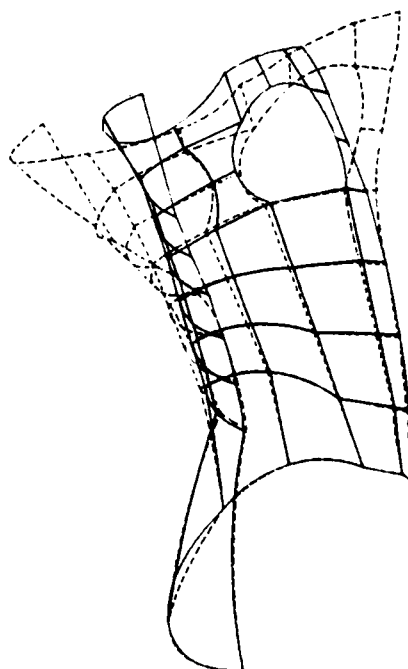


Figure 45. One quadrilateral element divided into eight triangular elements.

Symmetric Triangular Model



Symmetric Quadrilateral Model



Material: Plaster

Figure 46. Distorted structural shapes of the symmetric quadrilateral model and symmetric triangular model due to torsional loading.

Displacement comparisons will be done with the X-Y plot format. This format was defined in a previous section. The definition of the directions of displacement are described in Figure 22 (p. 52). For displacement comparisons, the 44100 triangular element was employed. This isoparametric triangular element is well known and the calculated displacements are very accurate.

The ΔX displacement comparisons for the quad model and triangular model are contained in Figures 47, 48, 49, and 50. In each figure, both curves are observed to have the same order of magnitude. It can also be seen that the characteristic shape of the triangular model displacement curve is replicated by the quad model displacement curve. However, for the nodes in strip 1 near the breast hole, this statement does not hold true. The magnitudes of each quad model nodal ΔX displacement in every figure, except for a few isolated nodes, is greater than the corresponding triangular model ΔX nodal displacements.

In Figures 51, 52, 53, and 54 the ΔX displacements for the quad model and triangular model are compared. For each individual comparison, the two curves are on the same order of magnitude. The characteristic curve shape set by the triangular model was closely followed by the quad model displacement curve. This occurred in each figure except for the nodes in strip 1 which were near the breast hole (see Figure 51). For every ΔY displacement comparison, the magnitude of each quad model nodal displacement was greater than the magnitude of each triangular model nodal displacement.

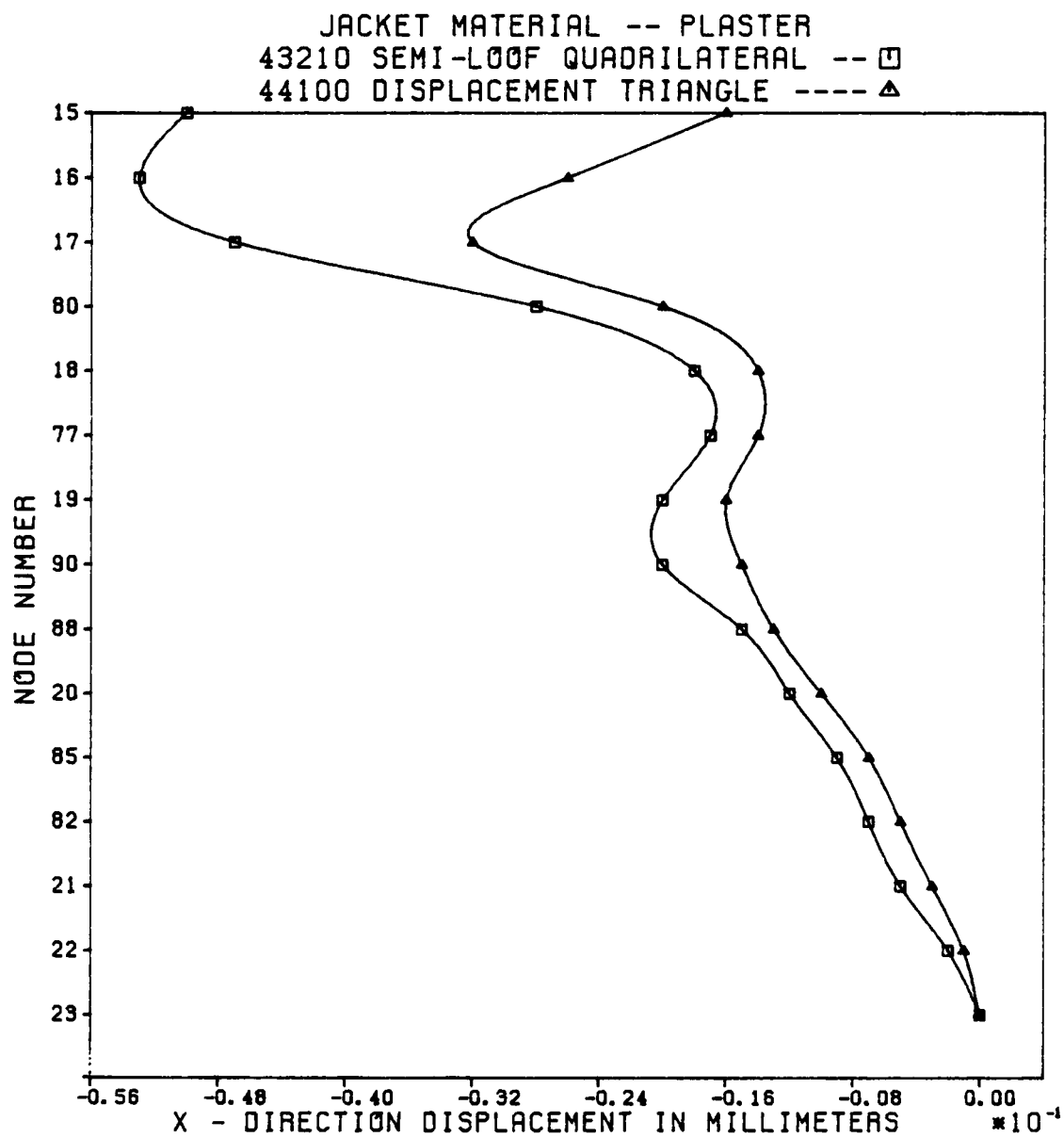


Figure 47. ΔX -displacements for strip 1 of the quadrilateral model and triangular model.

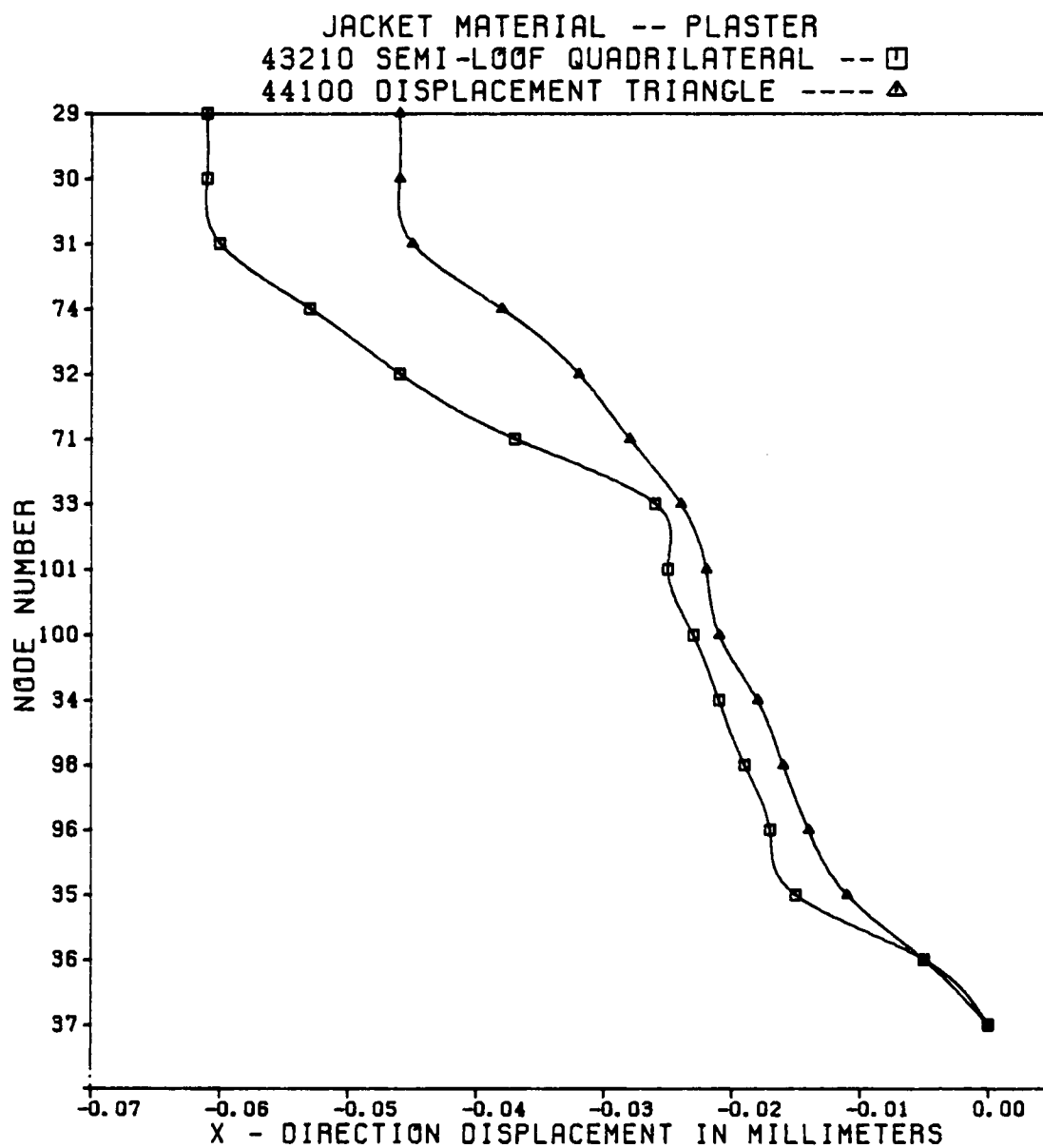


Figure 48. ΔX -displacements for strip 2 of the quadrilateral model and triangular model.

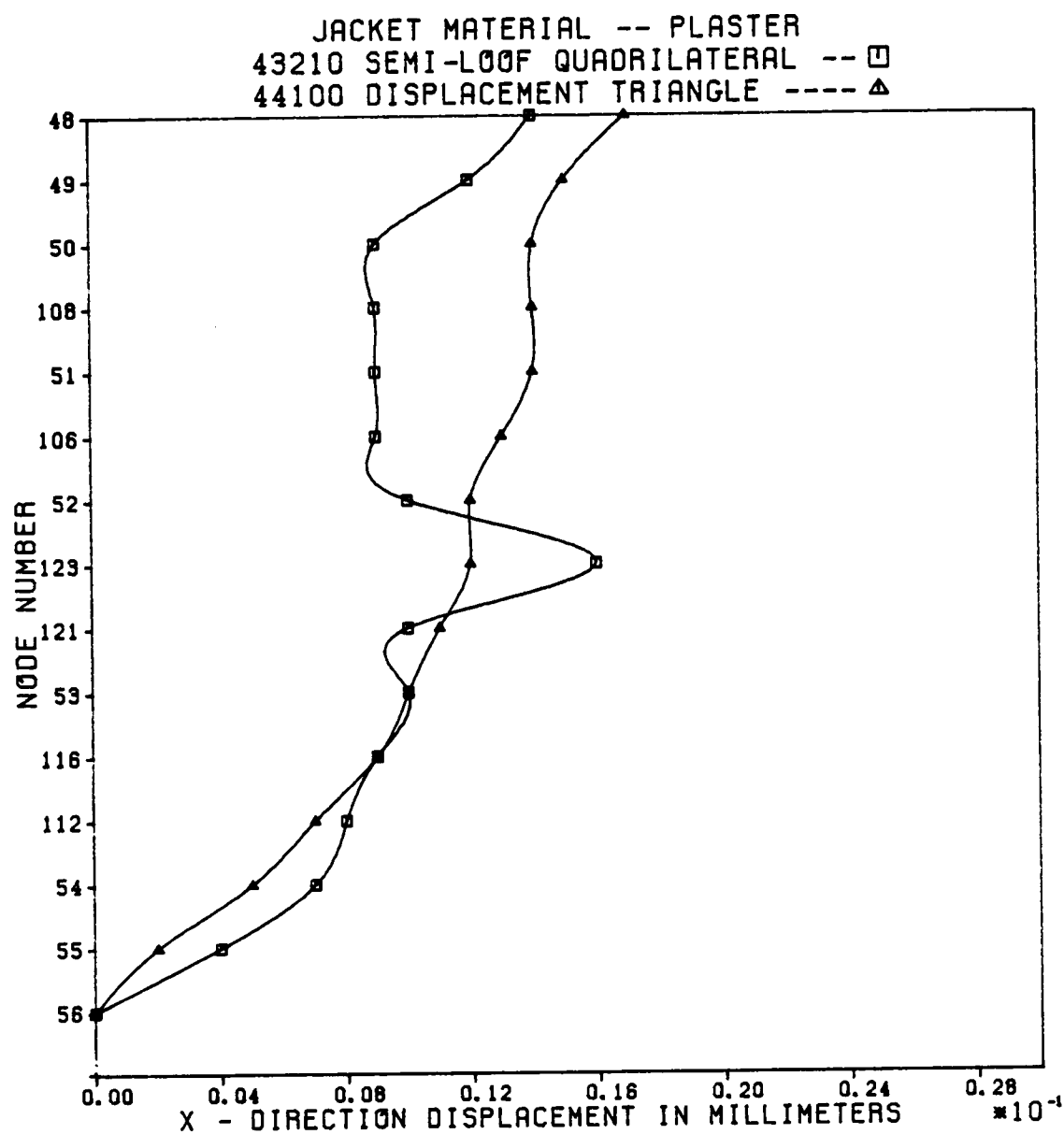


Figure 49. ΔX -displacements for strip 3 of the quadrilateral model and triangular model.

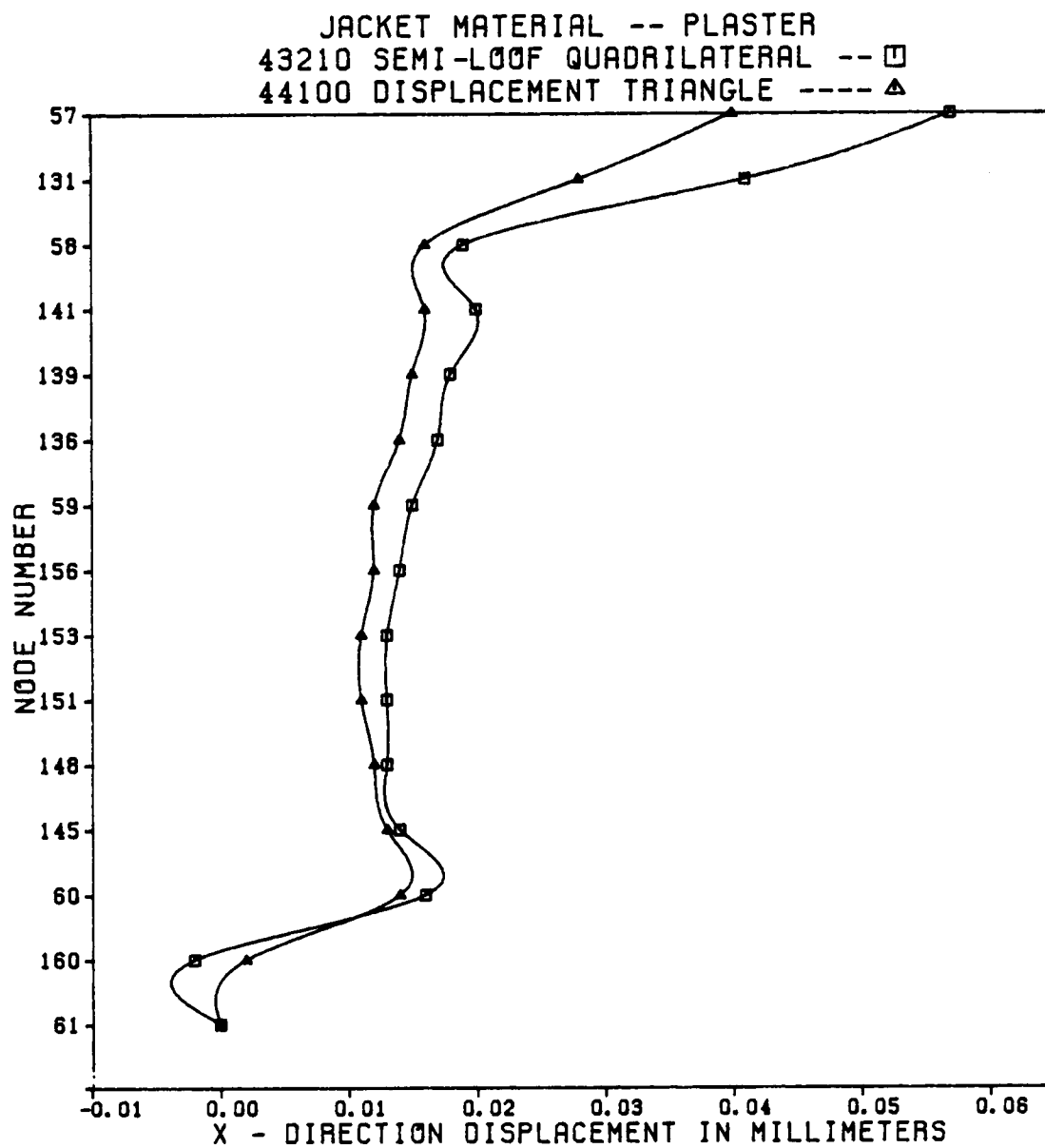


Figure 50. ΔX -displacements for strip 4 of the quadrilateral model and triangular model.

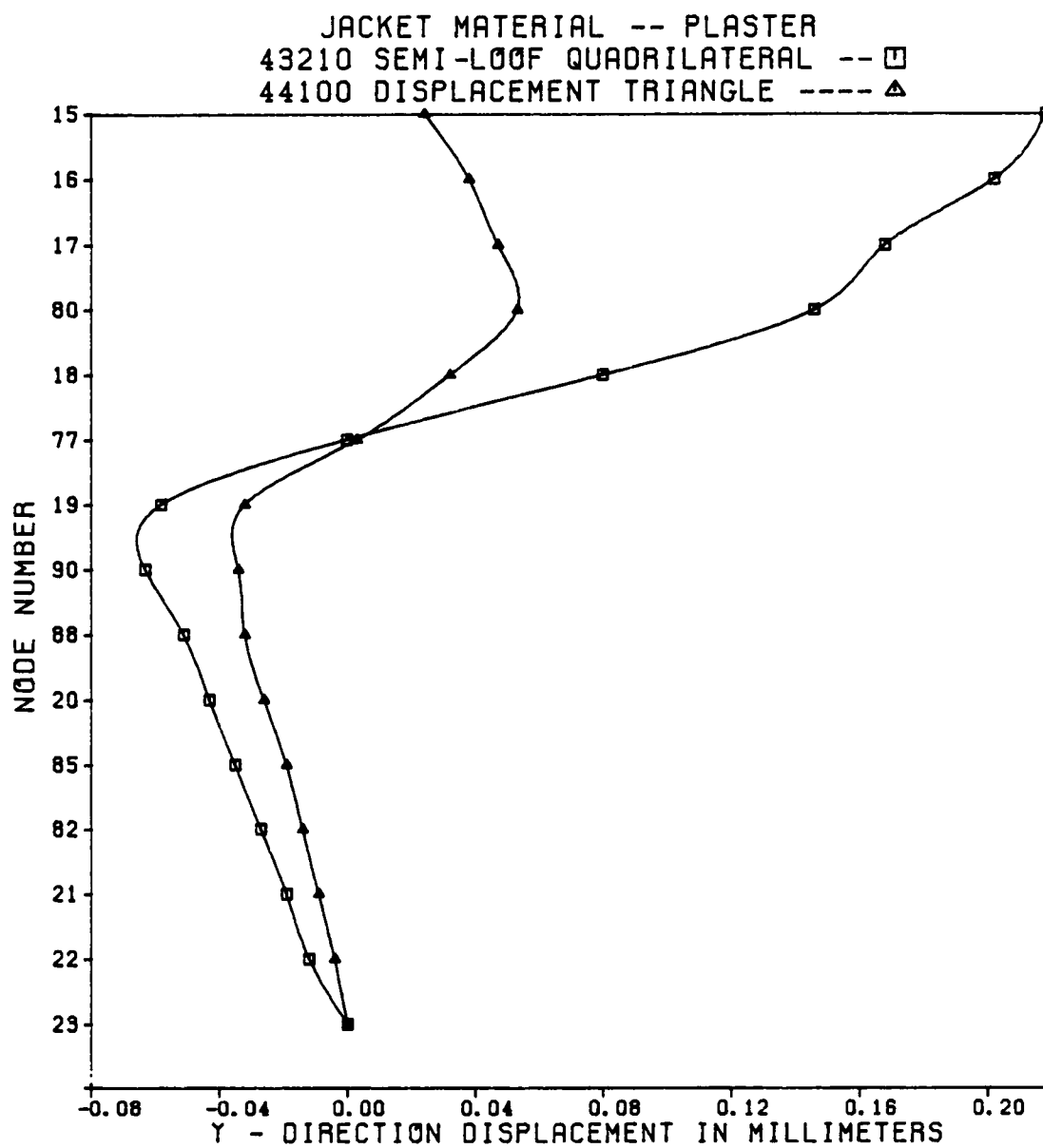


Figure 51. ΔY -displacements for strip 1 of the quadrilateral model and triangular model.

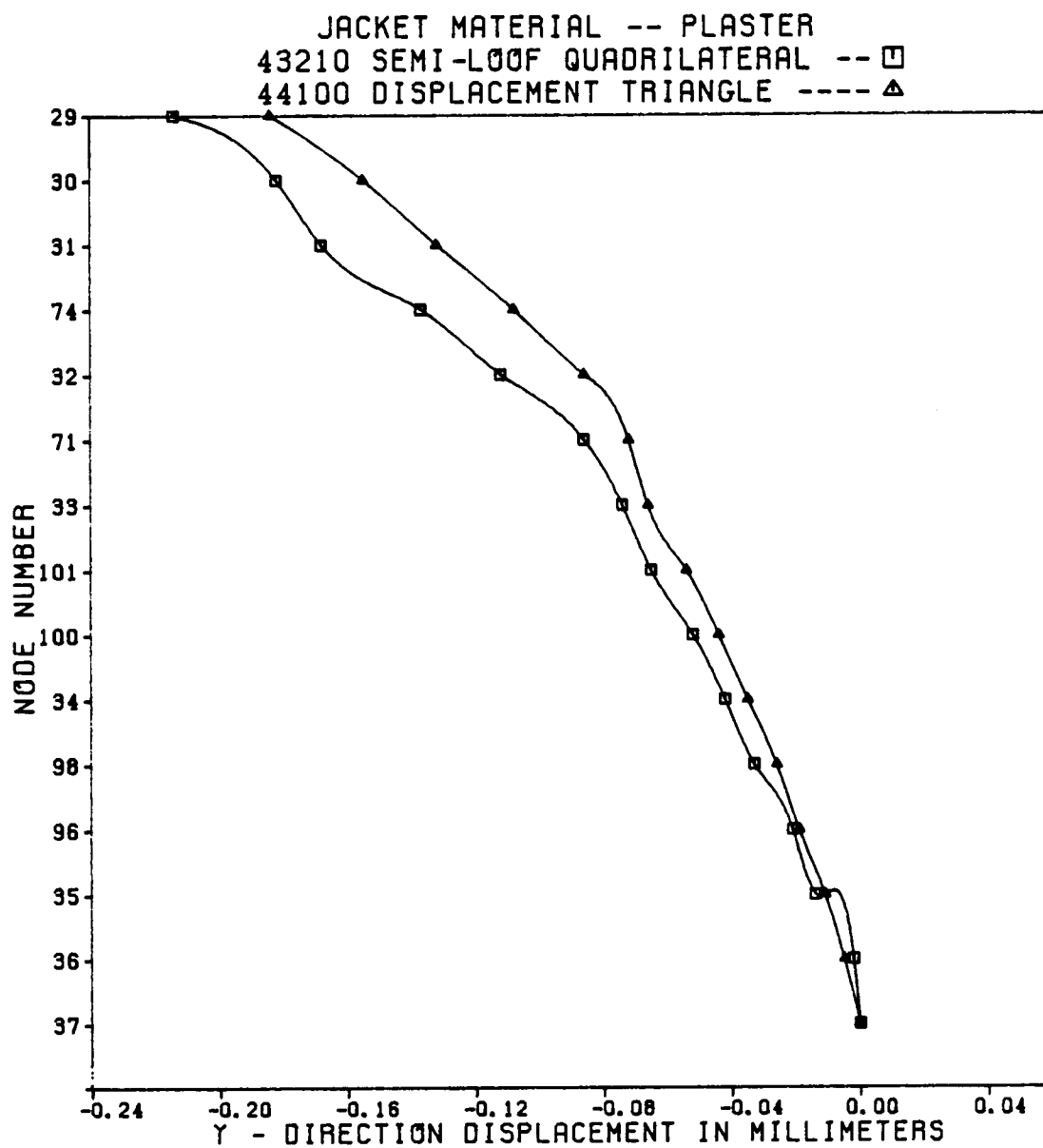


Figure 52. ΔY -displacements for strip 2 of the quadrilateral model and triangular model.

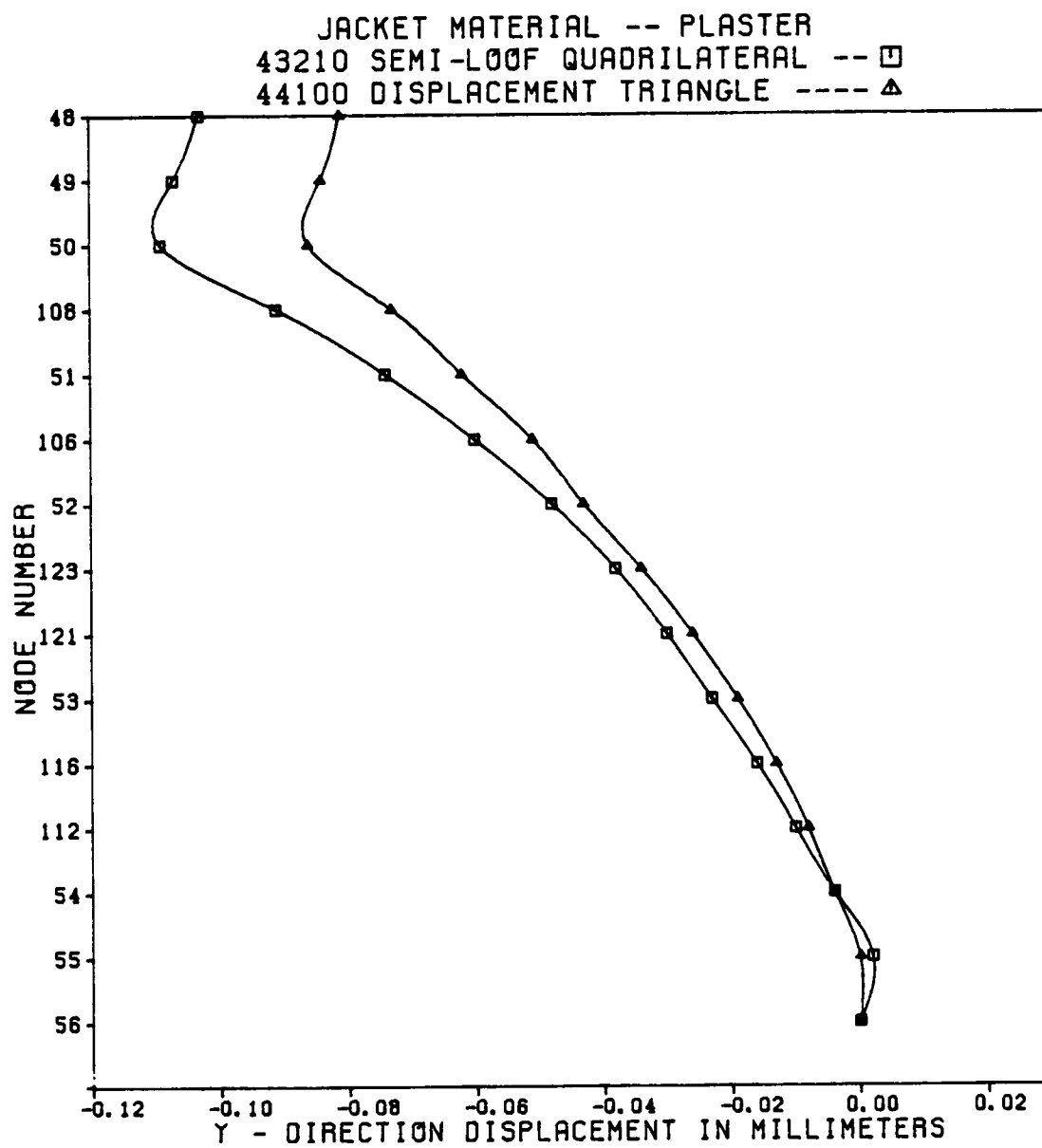


Figure 53. ΔY -displacements for strip 3 of the quadrilateral model and triangular model.

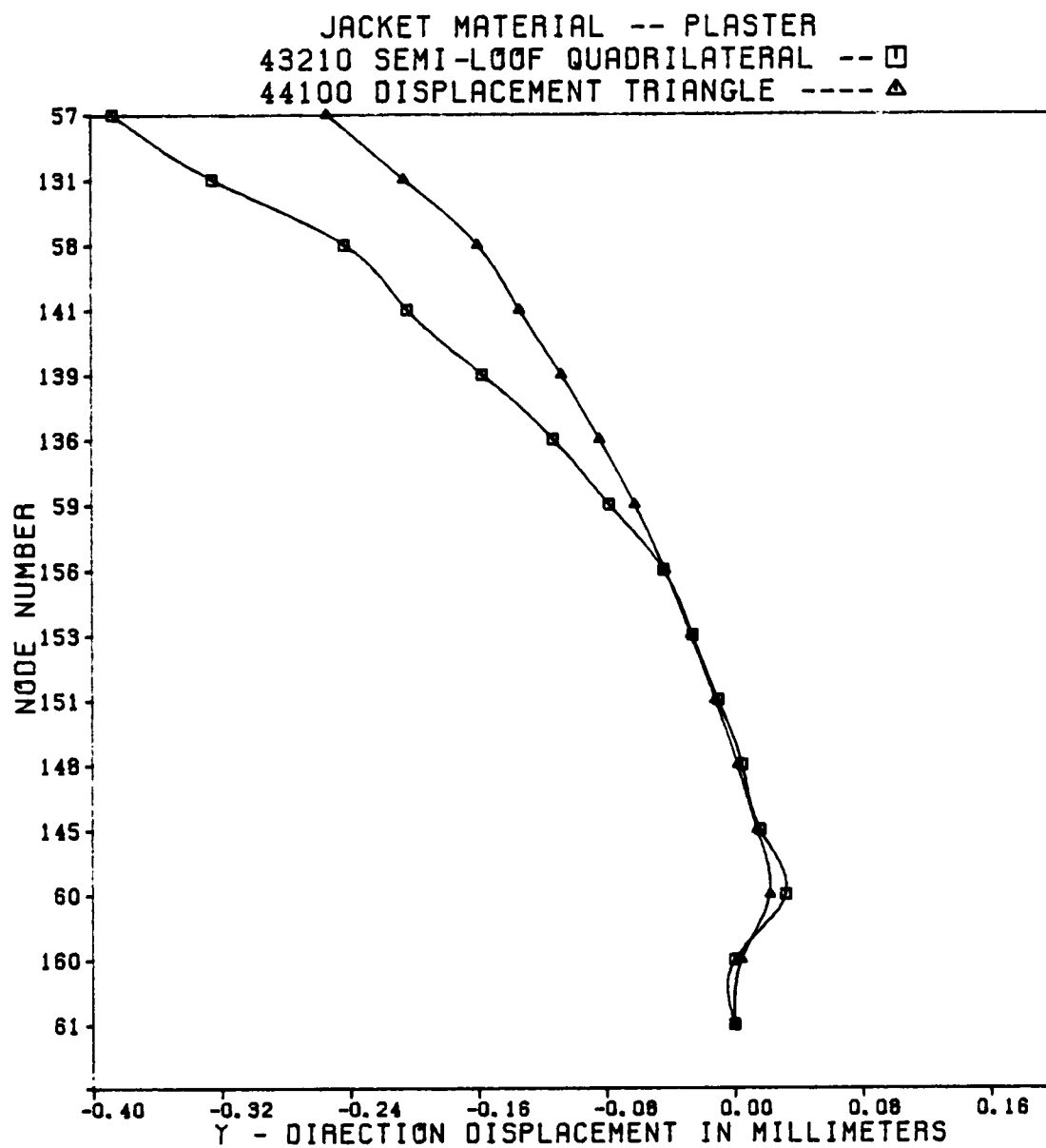


Figure 54. ΔY -displacements for strip 4 of the quadrilateral model and triangular model.

The ΔZ displacement comparisons between the quad model and triangular model are shown in Figures 55, 56, 57, and 58. In each figure, the two displacement curves were of the same order of magnitude. The characteristic curve shape of the triangular model was closely duplicated by the quad model curve shape. There were no difficulties in comparisons for nodes in strip 1 near the breast hole. For nearly every nodal displacement, the magnitude of the quad model was greater than the magnitude of the triangular model.

The quad model displaced shape was similar to the triangular model displaced shape. This was supported by the nodal displacement comparison curves and the distorted structural shape comparison. The only difficulty in the displacement comparisons was found in the set of nodes between the breast hole and symmetric boundary line. In this localized area the ΔX and ΔY displacements did not compare favorably between the two models. This difference was minor and did not appear to affect the rest of the structure.

The quad model can be referred to as being conservative when displacements are considered. This is based on the fact that virtually every nodal absolute displacement of the quad model was greater than the counterpart nodal absolute displacements of the triangular model. Thus, the mesh refinement using quadrilaterals is sufficient for calculating nodal displacements.

Stress comparisons will be done with the X-Y plot format. This format was defined in a previous section. The elements used for comparisons are described in Figure 23 (p. 54). For stress comparisons,

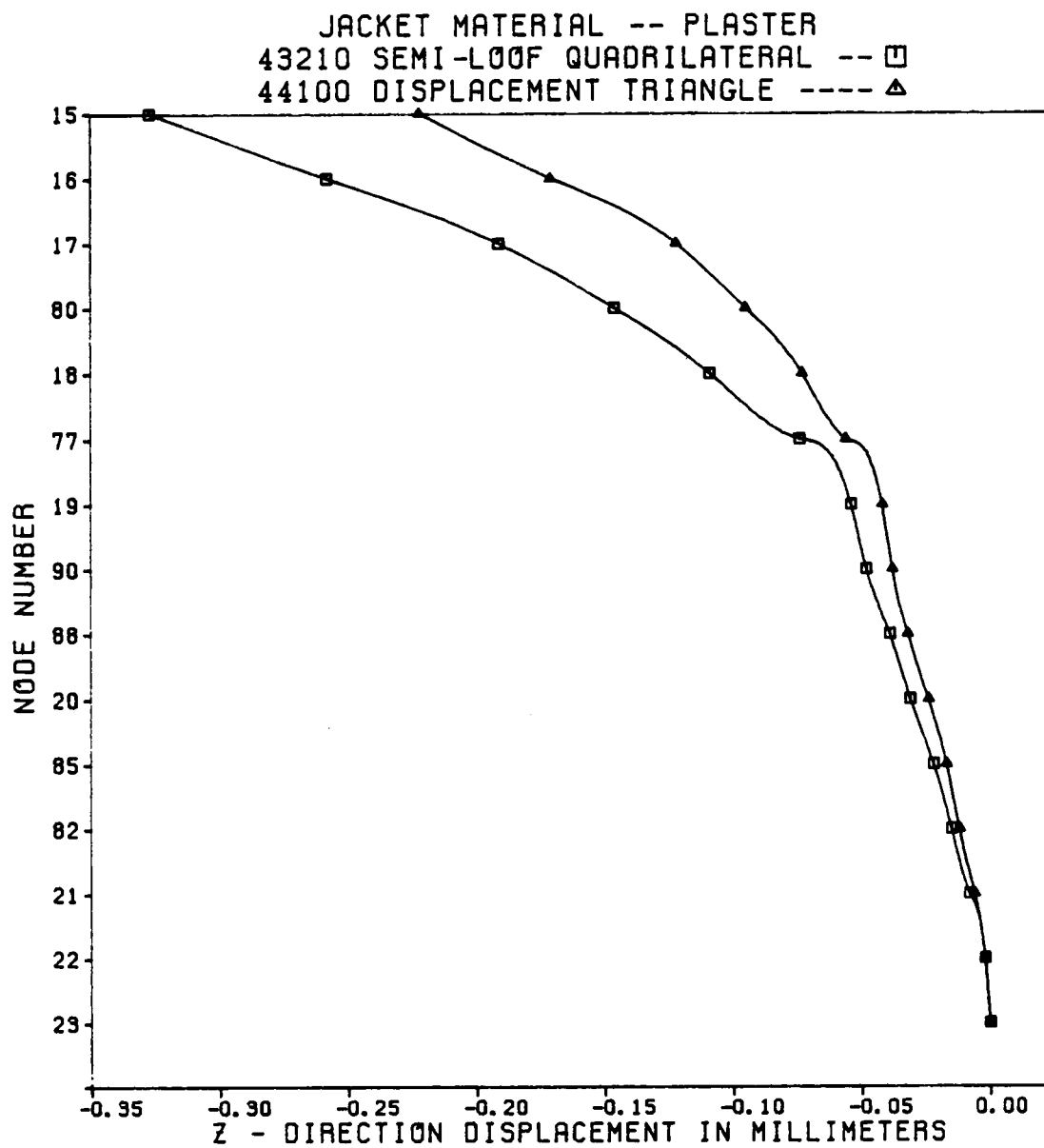


Figure 55. ΔZ -displacements for strip 1 of the quadrilateral model and triangular model.

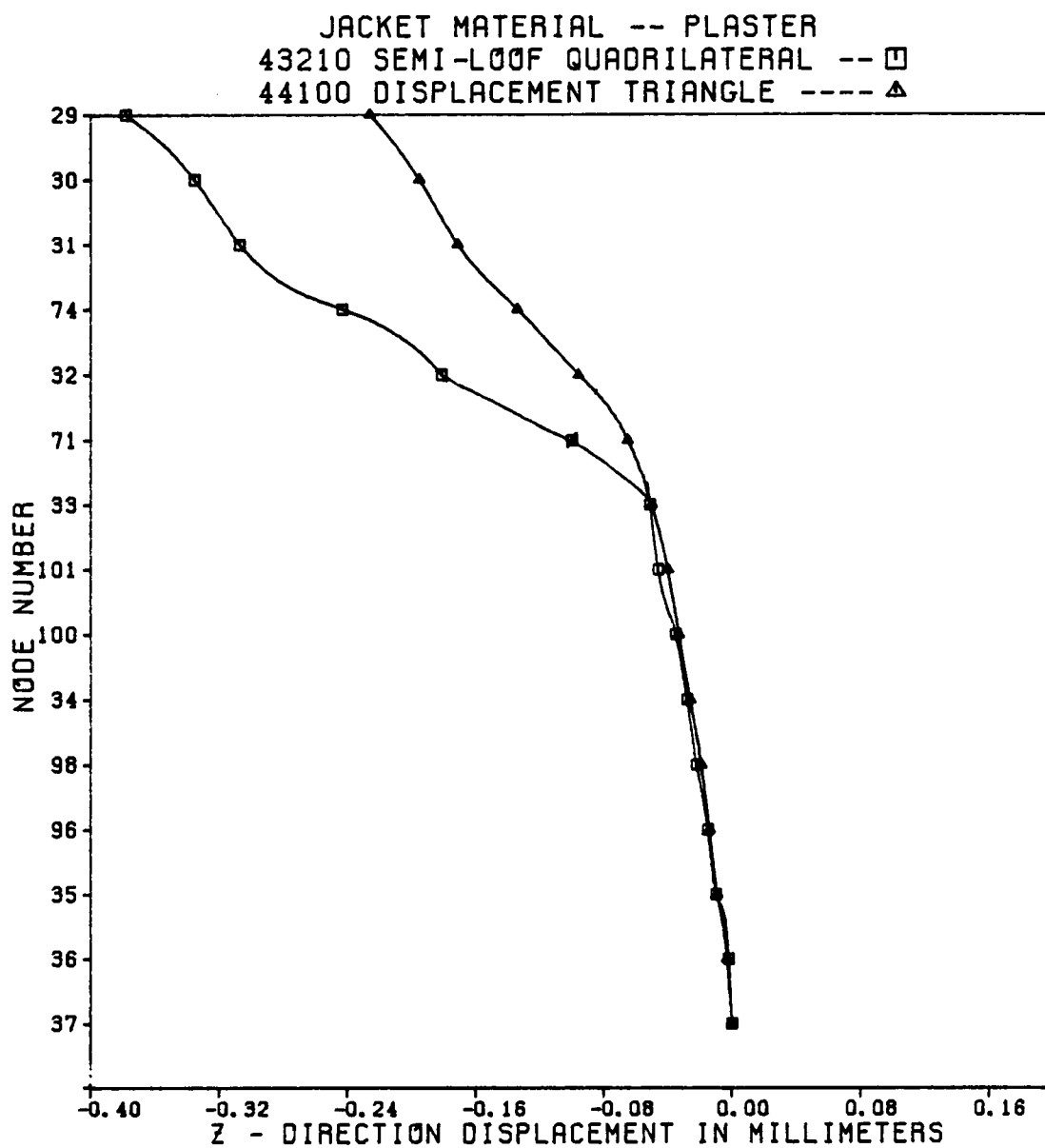


Figure 56. ΔZ -displacements for strip 2 of the quadrilateral model and triangular model.

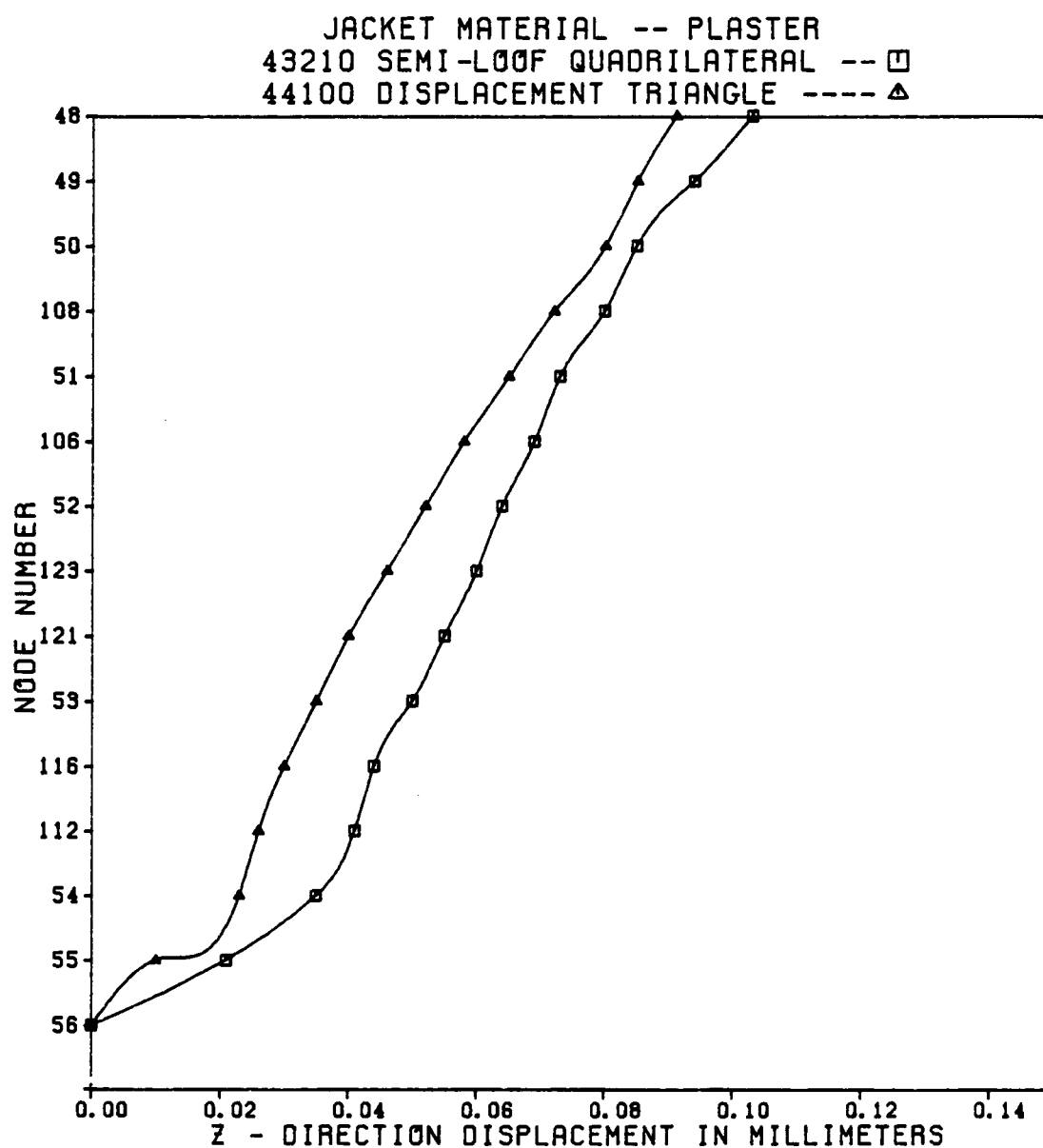


Figure 57. ΔZ -displacements for strip 3 of the quadrilateral model and triangular model.

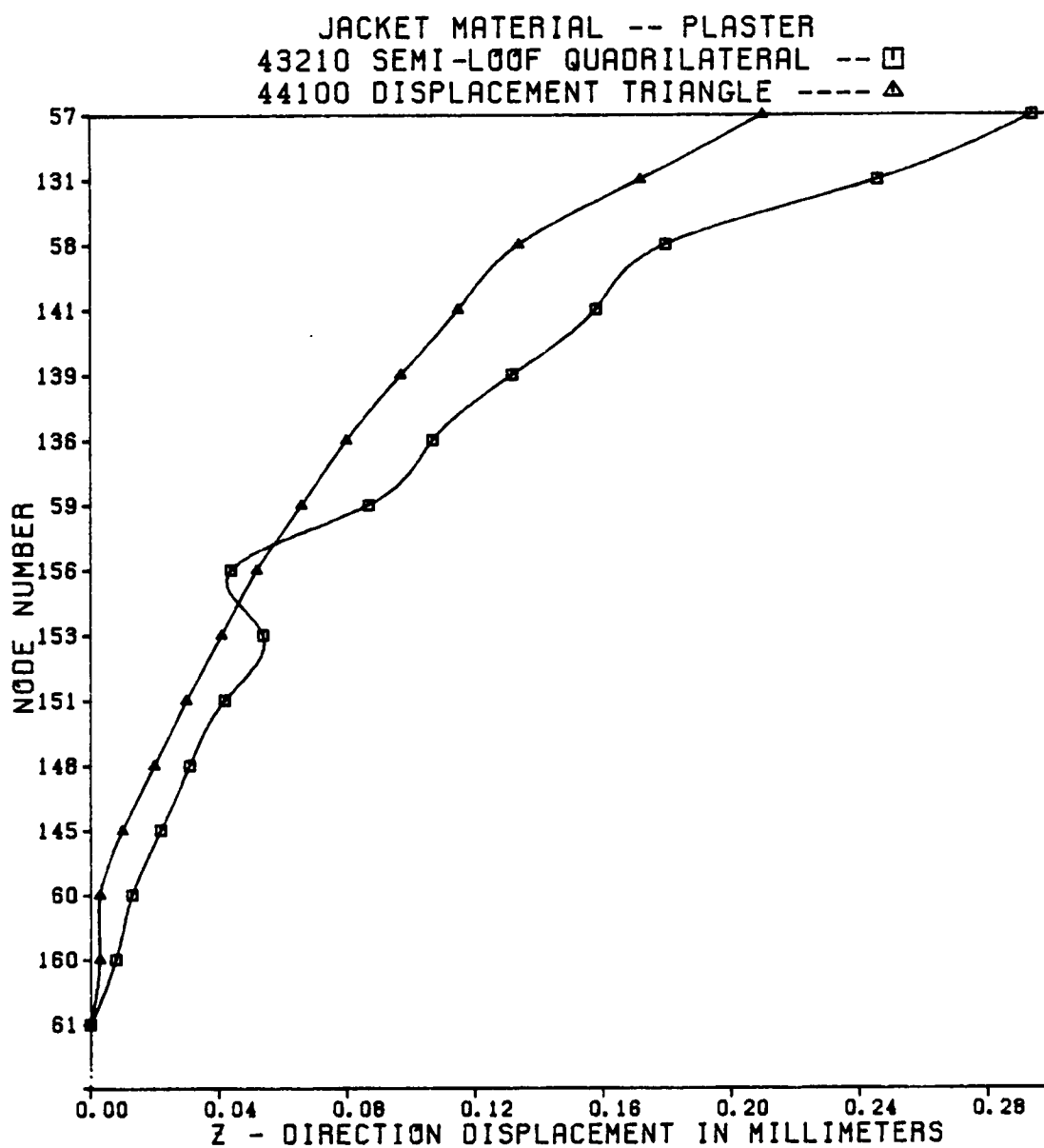


Figure 58. ΔZ -displacements for strip 4 of the quadrilateral model and triangular model.

the 41320 triangular element was employed. This hybrid triangular element calculates stresses directly and not indirectly from the nodal displacements. The calculated stresses are considered superior in accuracy when compared to the isoparametric calculated stresses.

The semi-loof element calculates stresses at the four gauss points for the top and bottom surface (see Figures 3 and 4, pp. 19 and 21). The 41320 triangular element calculates stresses at the centroid of the top, middle, and bottom surfaces (see Figure 6, p. 23). The gauss points of the semi-loof quadrilateral and the centroid of the 41320 triangular element do not coincide (see Figure 59). Stress averaging was used to allow comparisons between the semi-loof element and the 41320 triangular element.

Each quadrilateral element was subdivided into eight triangular elements. From Figure 59, each gauss point was seen to be located very near a common boundary between two unique triangular elements. The stress results for these two unique triangular elements were averaged for each surface, respectively. The four averaged stress results of the triangular element were used in the stress comparisons.

For a defined surface, top or bottom, the most positive principal stress from the four gauss points was chosen for the semi-loof stress. The four corresponding averaged triangular element stress results were examined and the most positive principal stress chosen. Those two chosen stress values were used for the direct stress comparisons.

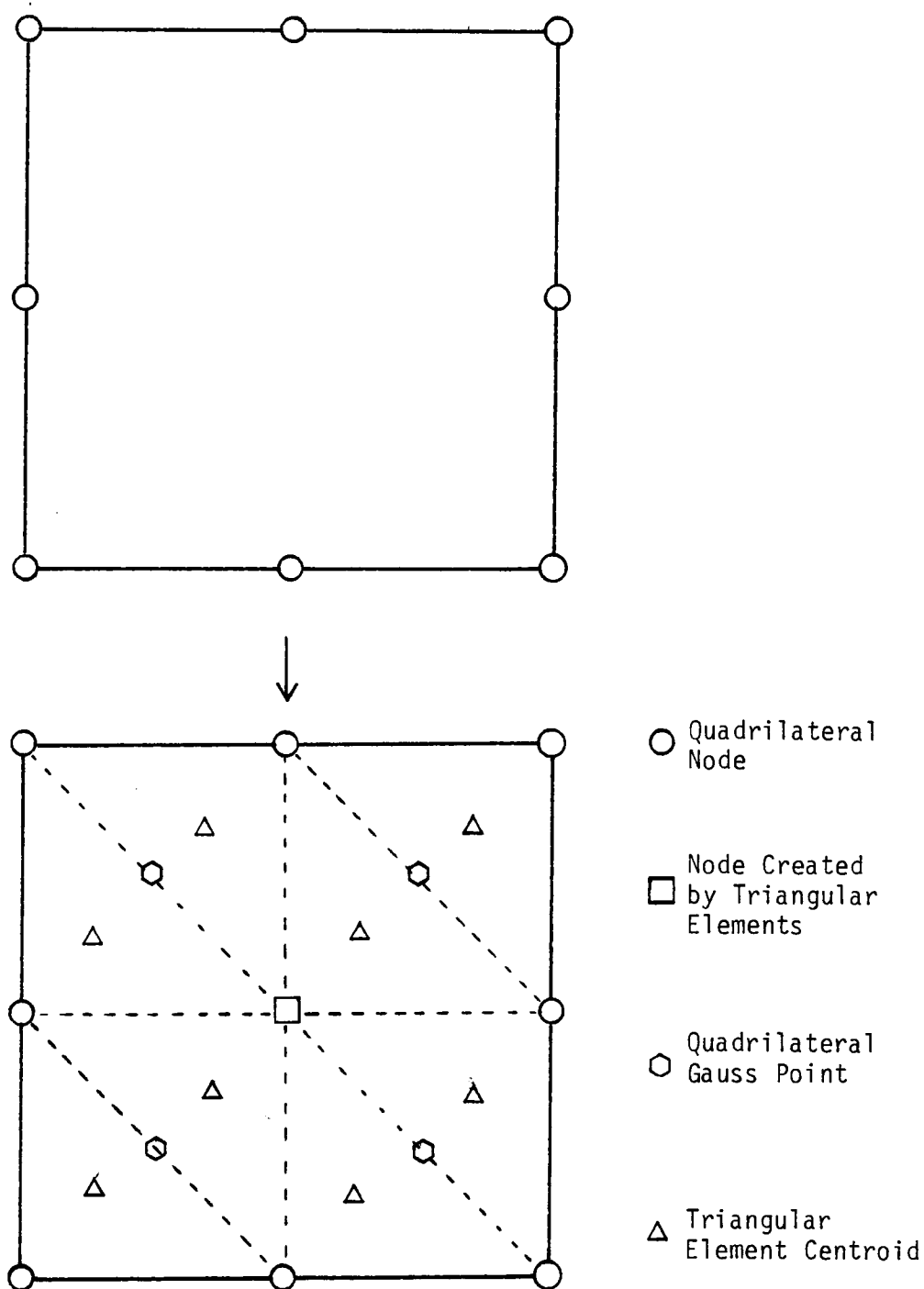


Figure 59. Location of stress output for a subdivided quadrilateral element.

Figures 60, 61, 62, and 63 contain the top surface positive principal stress comparisons for the quad model and triangular model. The stresses in each figure were on the same order of magnitude. Generally, the curve characteristics of the quad model were similar to the triangular model. The quad model did tend to produce higher stresses in most elements.

The bottom surface positive principal stress comparisons are contained in Figures 64, 65, 66, and 67. In the figures, the stresses were on the same order of magnitude. The characteristic curve shape of the triangular model was followed fairly close by the quad model curve. The quad model tended to show higher stresses for about 50% of the elements.

Stress comparisons were generally acceptable between the quad model and triangular model. The bottom surface stresses displayed a higher level of correlation than the top surface stresses. The quadrilateral mesh was considered acceptable based on the displacement and stress comparisons. The results suggest that the quadrilateral mesh is conservative in its present form. This does not cause problems since the quadrilateral mesh is consistently conservative. Since the plaster structural material produced acceptable results, it was expected that the two thermal plastic structural materials would produce acceptable results.

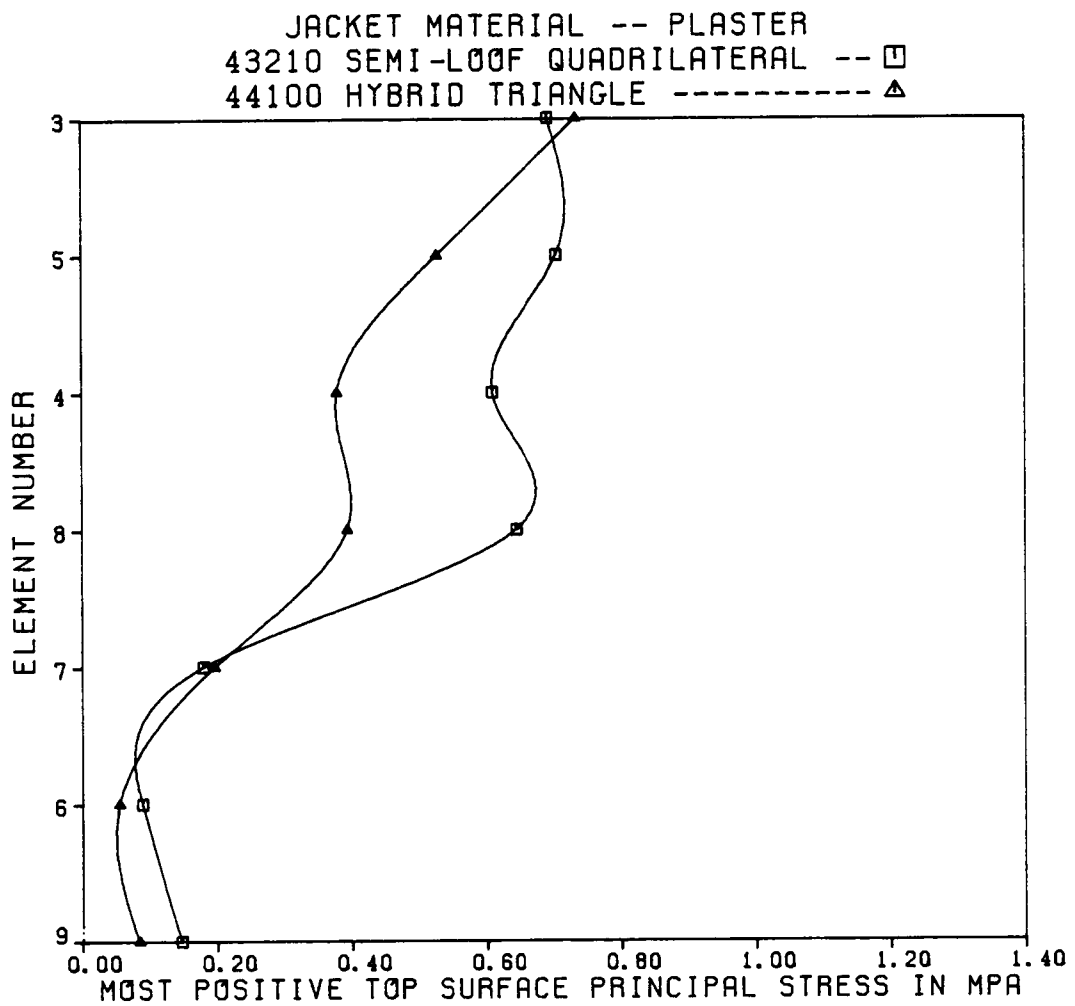


Figure 60. Positive top surface stress for panel 1 of the quadrilateral model and triangular model.

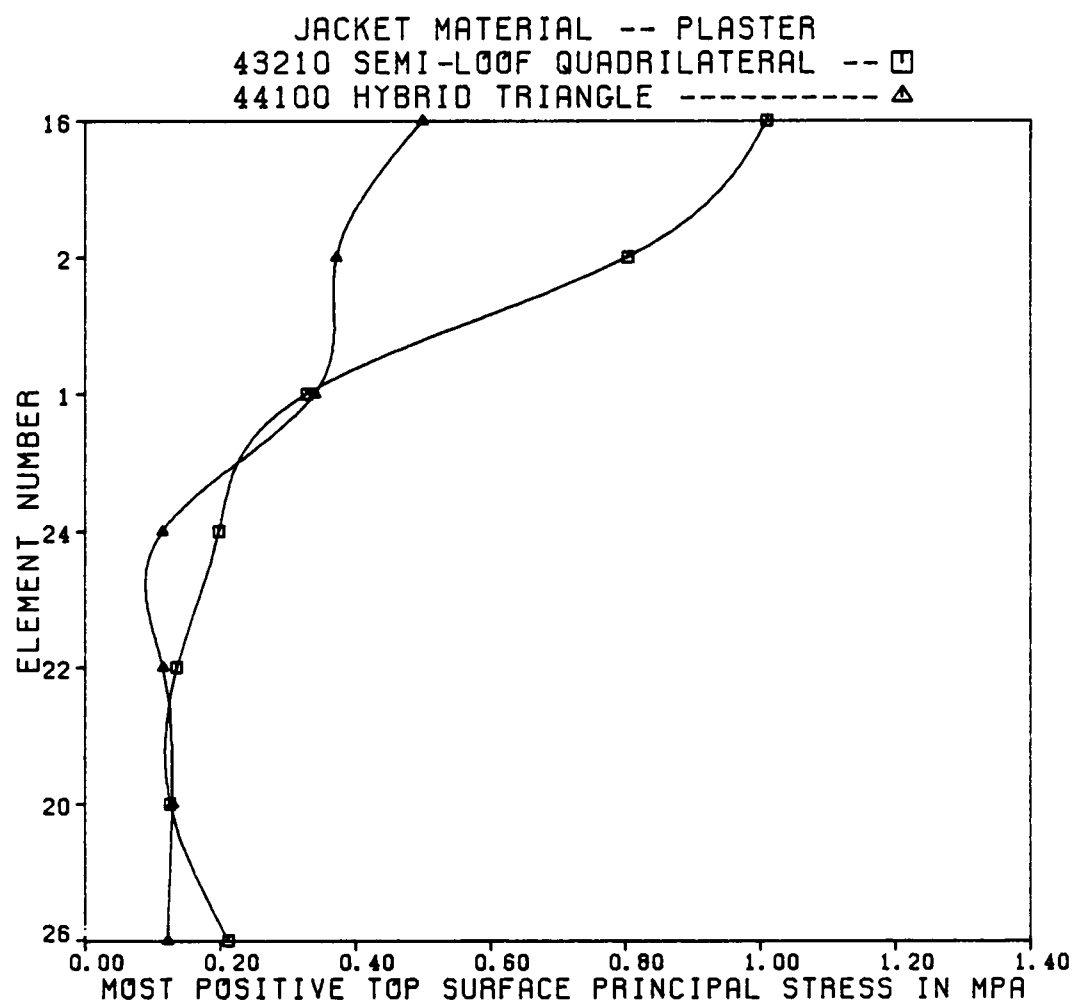


Figure 61. Positive top surface stress for panel 2 of the quadrilateral model and triangular model.

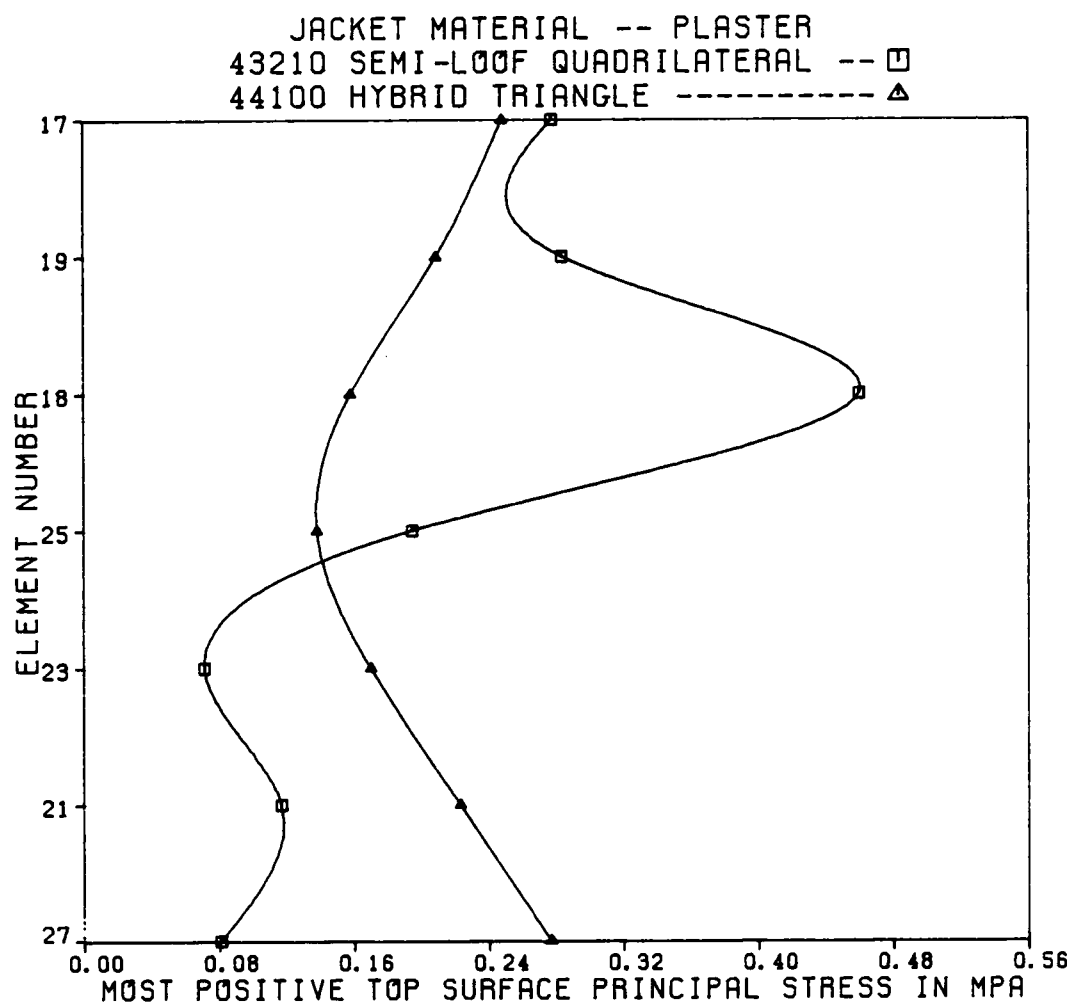


Figure 62. Positive top surface stress for panel 3 of the quadrilateral model and triangular model.

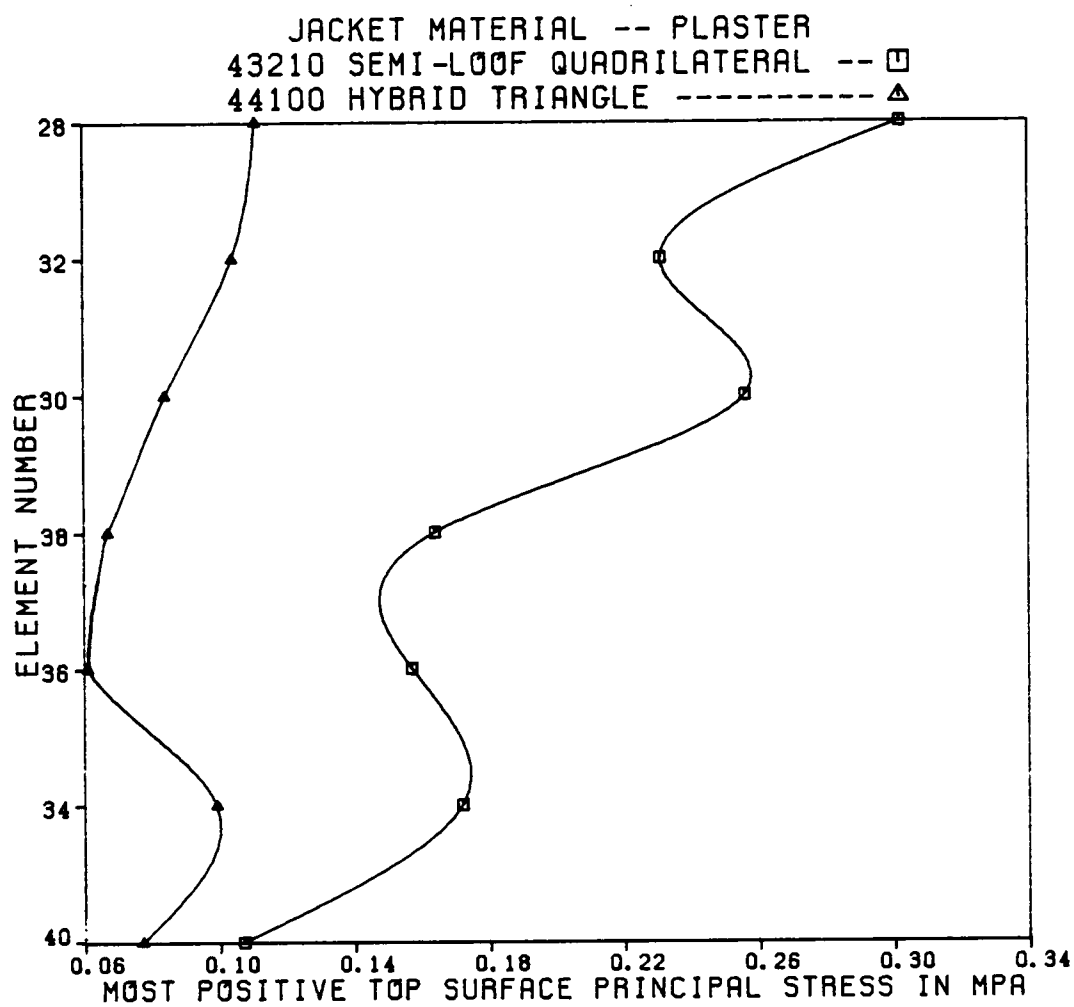


Figure 63. Positive top surface stress for panel 4 of the quadrilateral model and triangular model.

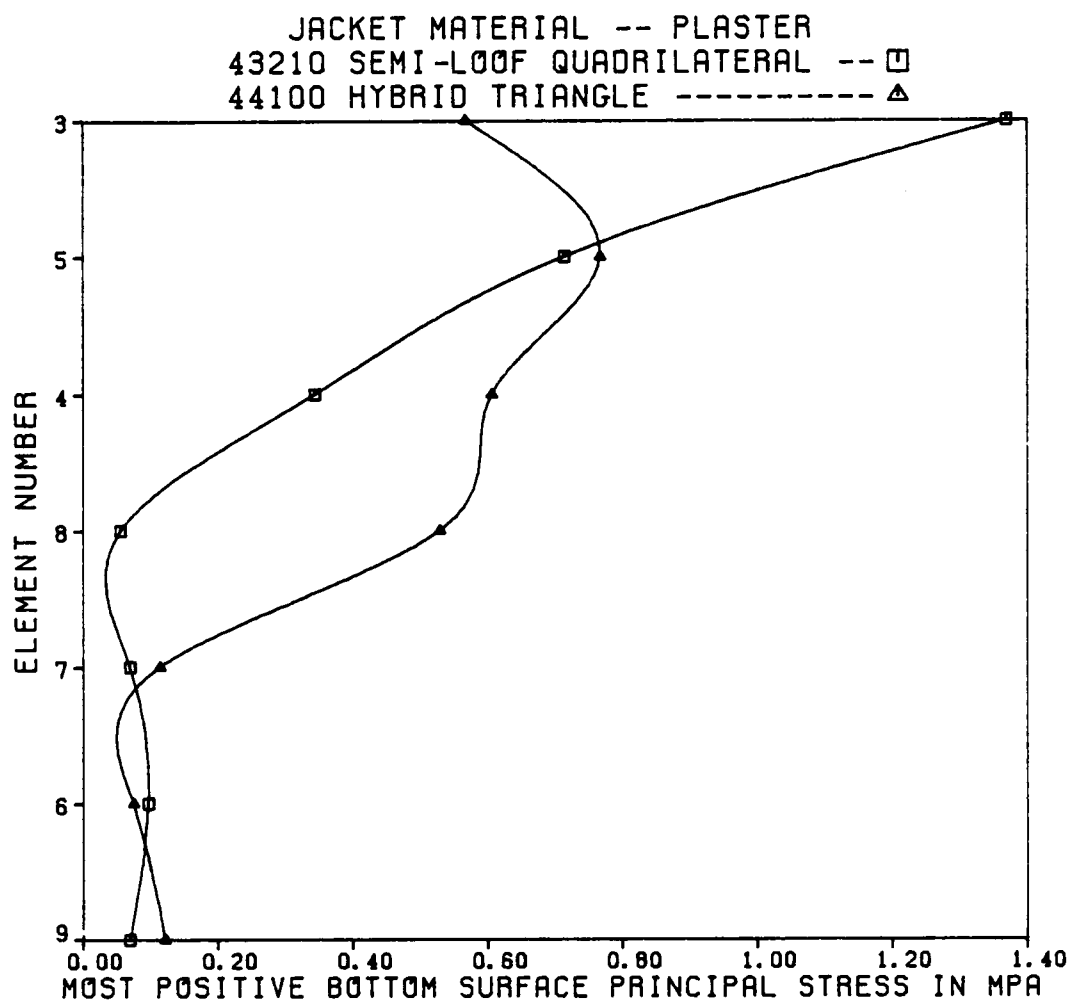


Figure 64. Positive bottom surface stress for panel 1 of the quadrilateral model and triangular model.

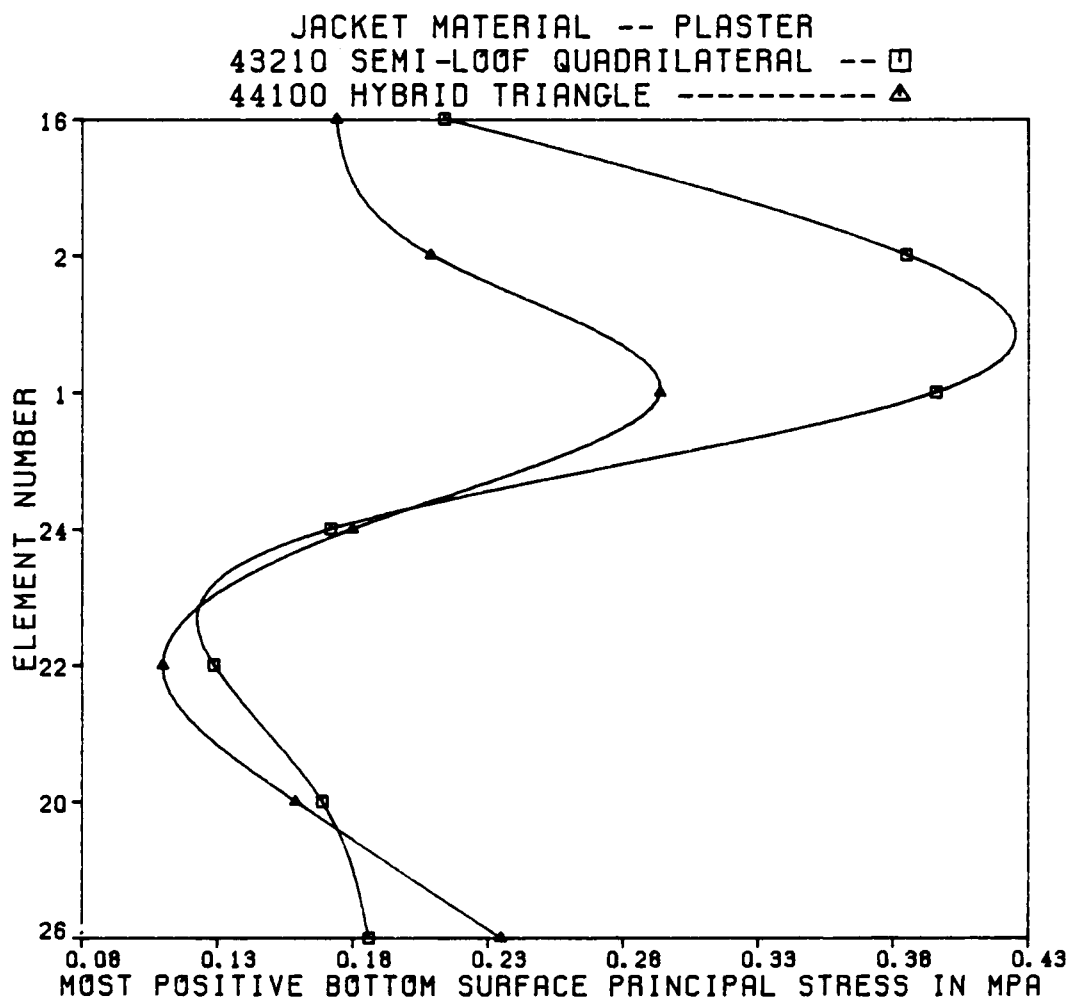


Figure 65. Positive bottom surface stress for panel 2 of the quadrilateral model and triangular model.

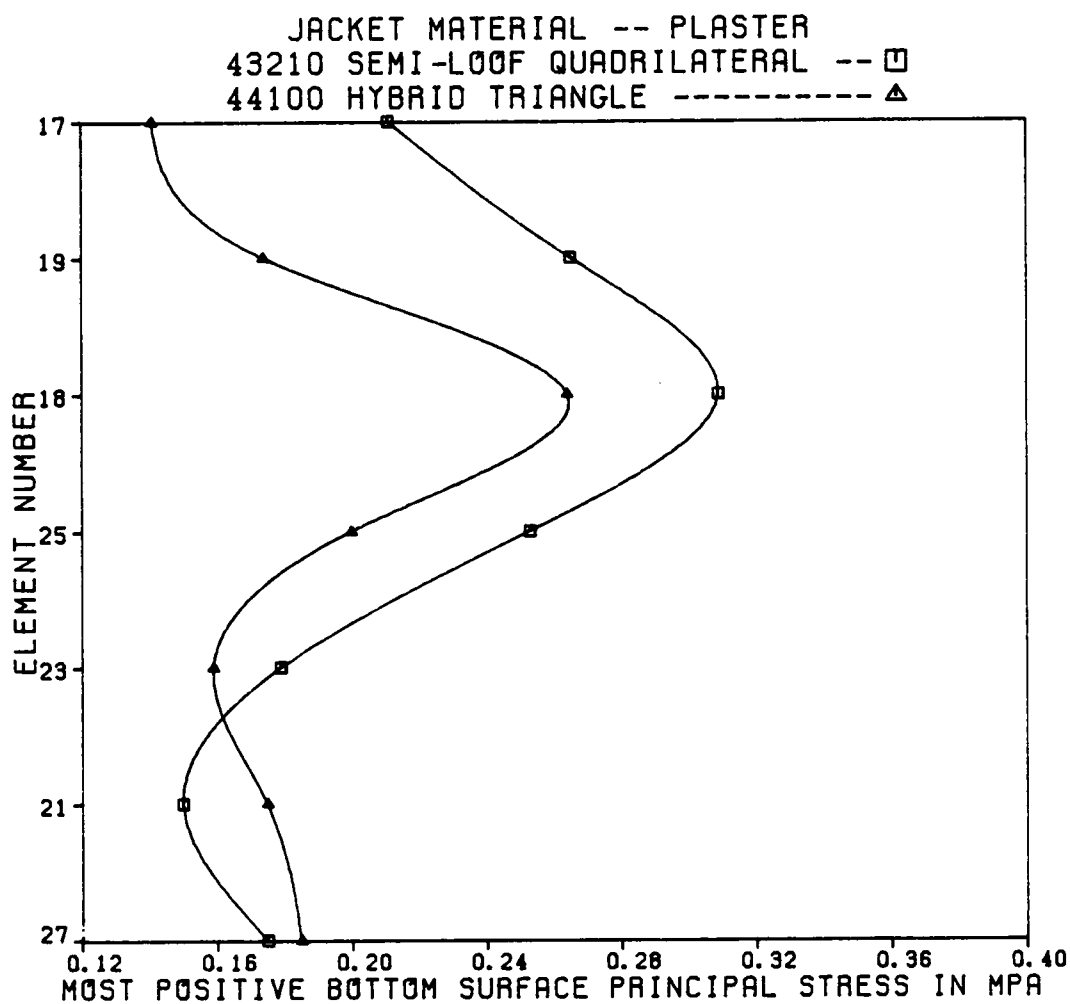


Figure 66. Positive bottom surface stress for panel 3 of the quadrilateral model and triangular model.

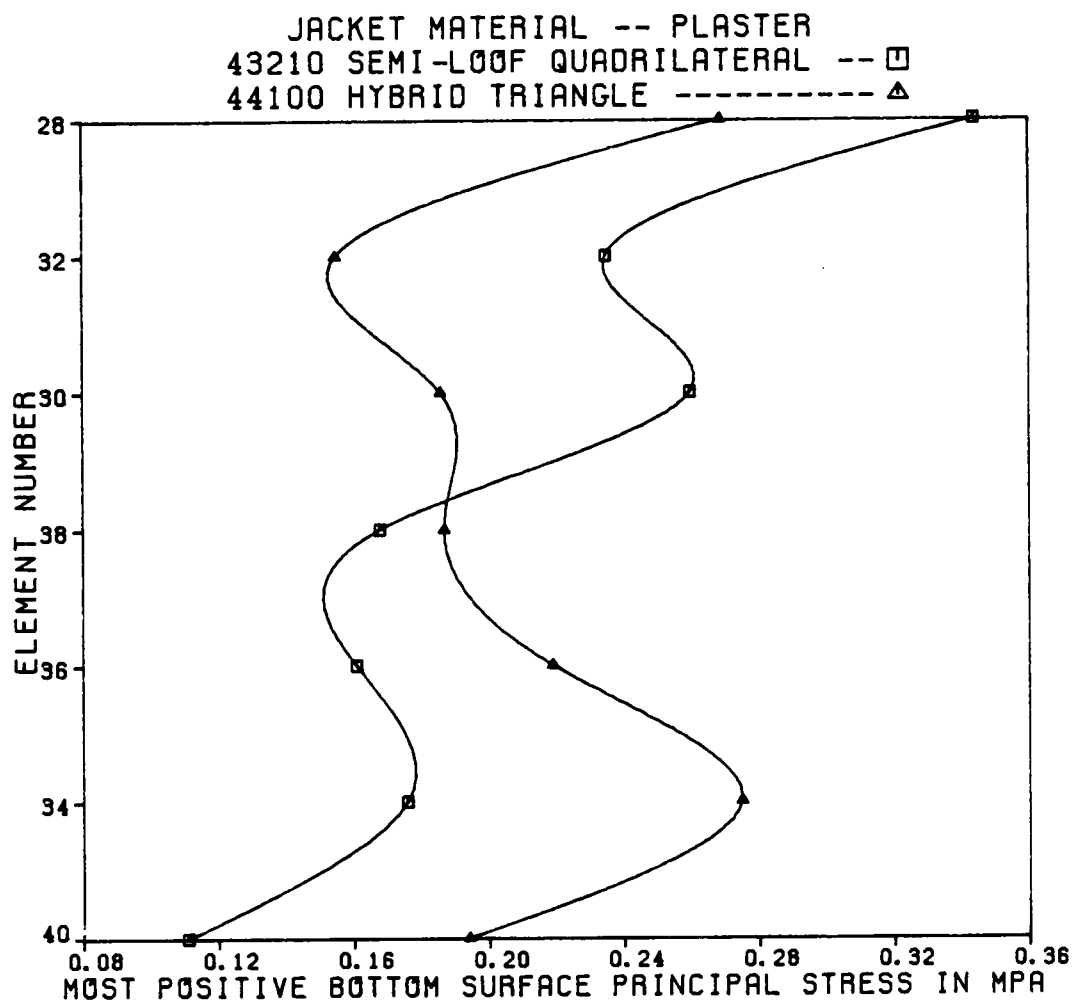


Figure 67. Positive bottom surface stress for panel 4 of the quadrilateral model and triangular model.

E. ANALYTICAL RESULTS FOR THE THREE STRUCTURAL MATERIALS

The boundary conditions and mesh discretization have been verified in the previous two sections of this chapter. In this section, the final analytical results will be presented and compared.

The symmetric quadrilateral mesh was used as the finite element model. The three materials: plaster, polyethylene, and polypropylene, were separately employed as structural materials. The semi-loof element was the only element used in the finite element model. For the remainder of this section, the symmetric quadrilateral semi-loof element model will be referred to as the quad model. The quad model will be qualified with a reference to a structural material when clarification is needed. Polyethylene and polypropylene will be referred to as the thermal plastics when a statement equally applies to both materials.

The loading conditions described in Chapter III were applied to the quad model for each of the three structural materials. Only the verified symmetric boundary conditions were applied to the quad model. The resulting displacements and stresses will be compared using the X-Y plot format. The X-Y plot format was previously defined and discussed in the second section of this chapter.

F. ANALYTICAL DISPLACEMENTS

The overall displaced shapes of each quad model, plaster, polyethylene, and polypropylene, can be seen in Figure 68. The

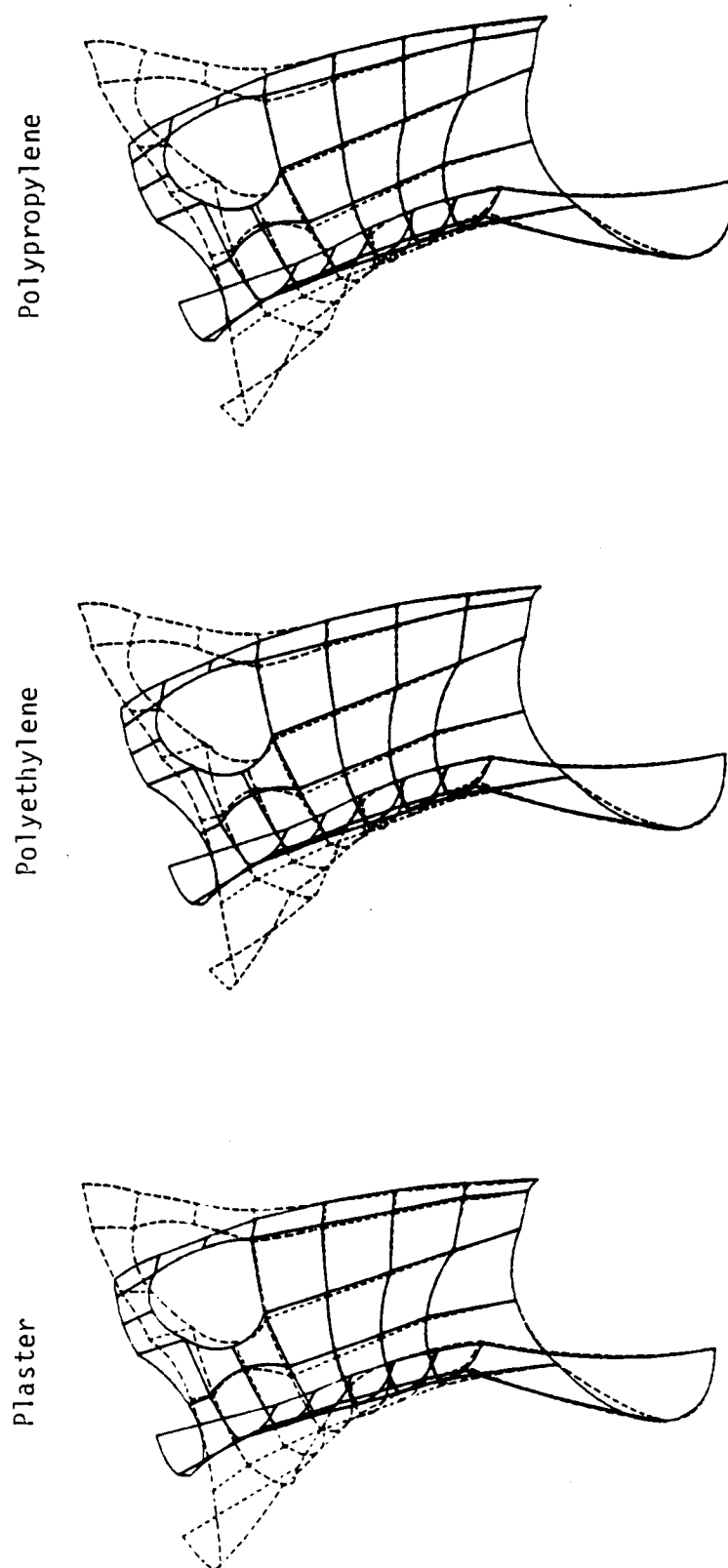


Figure 68. Distorted structural shapes of the quadrilateral model employing plaster, polyethylene and polypropylene as the structural materials.

significant area of distortion was in the upper half of all three quad models.

Differences between the displaced shapes are difficult to discern visually (see Figure 68). Since only the material properties and shell thickness were variables in the quad model, the strong similarity between displaced shapes was expected, however there would be differences in the overall magnitudes of displacements for the three quad models. This was seen in the X-Y plot format.

The ΔX displacement comparisons between the three quad models are shown in Figures 69, 70, 71, and 72. In every figure, polyethylene demonstrates the largest displacement on a node to node level of comparison. The polypropylene magnitudes are roughly 50% less than the polyethylene magnitudes. Plaster displacement curves appear as a nearly straight vertical line. Closer inspection reveals that the characteristic bumps and dips appearing in the thermal plastic displacement curves also occur in the plaster displacement curves. The largest displacements appear in the upper third of strip 1 and strip 4 for the two thermal plastics. Strip 1 is between the breast hole and anterior symmetric boundary line. Strip 4 is near the posterior symmetric boundary line.

The ΔY displacement comparisons between the three quad models are shown in Figures 73, 74, 75, and 76. As was noted in the ΔX comparisons, the polyethylene demonstrates the highest displacement magnitudes in each figure. The polypropylene nodal displacements are roughly 50% less than the polyethylene nodal displacements when compared on a node to node basis. Plaster displacement curves appear

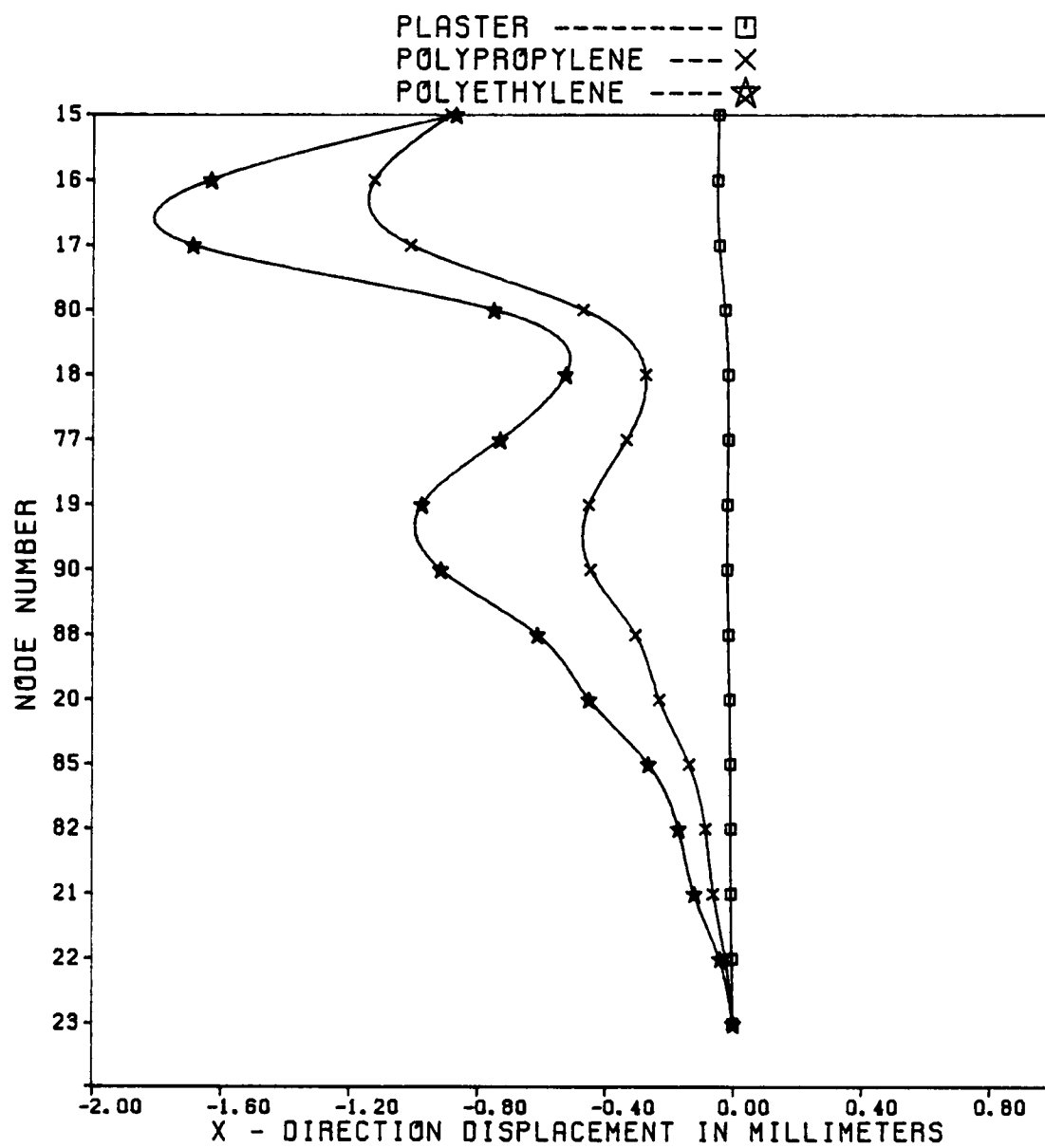


Figure 69. ΔX -displacements for strip 1 of the symmetric quadrilateral model using the three structural materials.

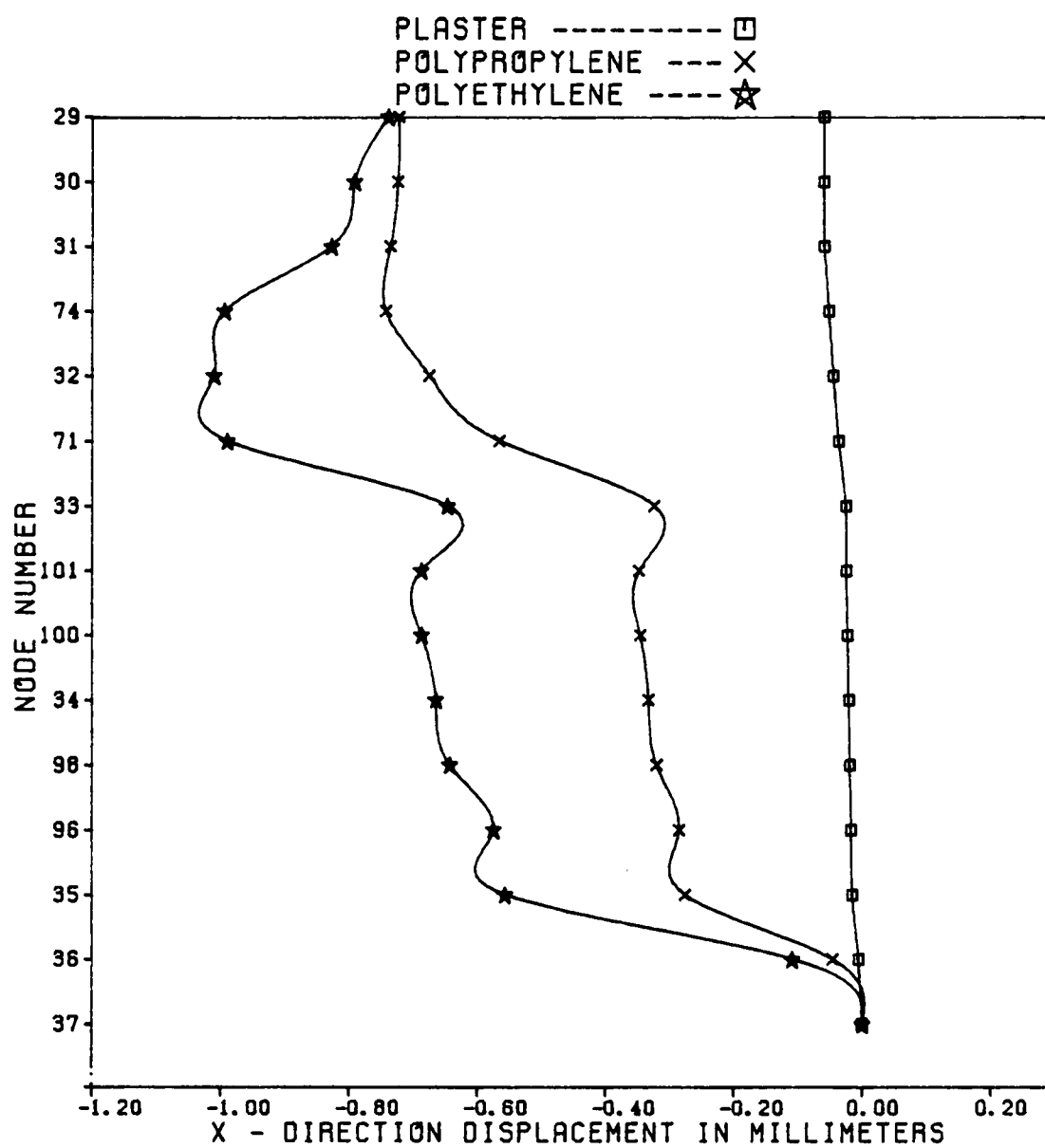


Figure 70. ΔX -displacements for strip 2 of the symmetric quadrilateral model using the three structural materials.

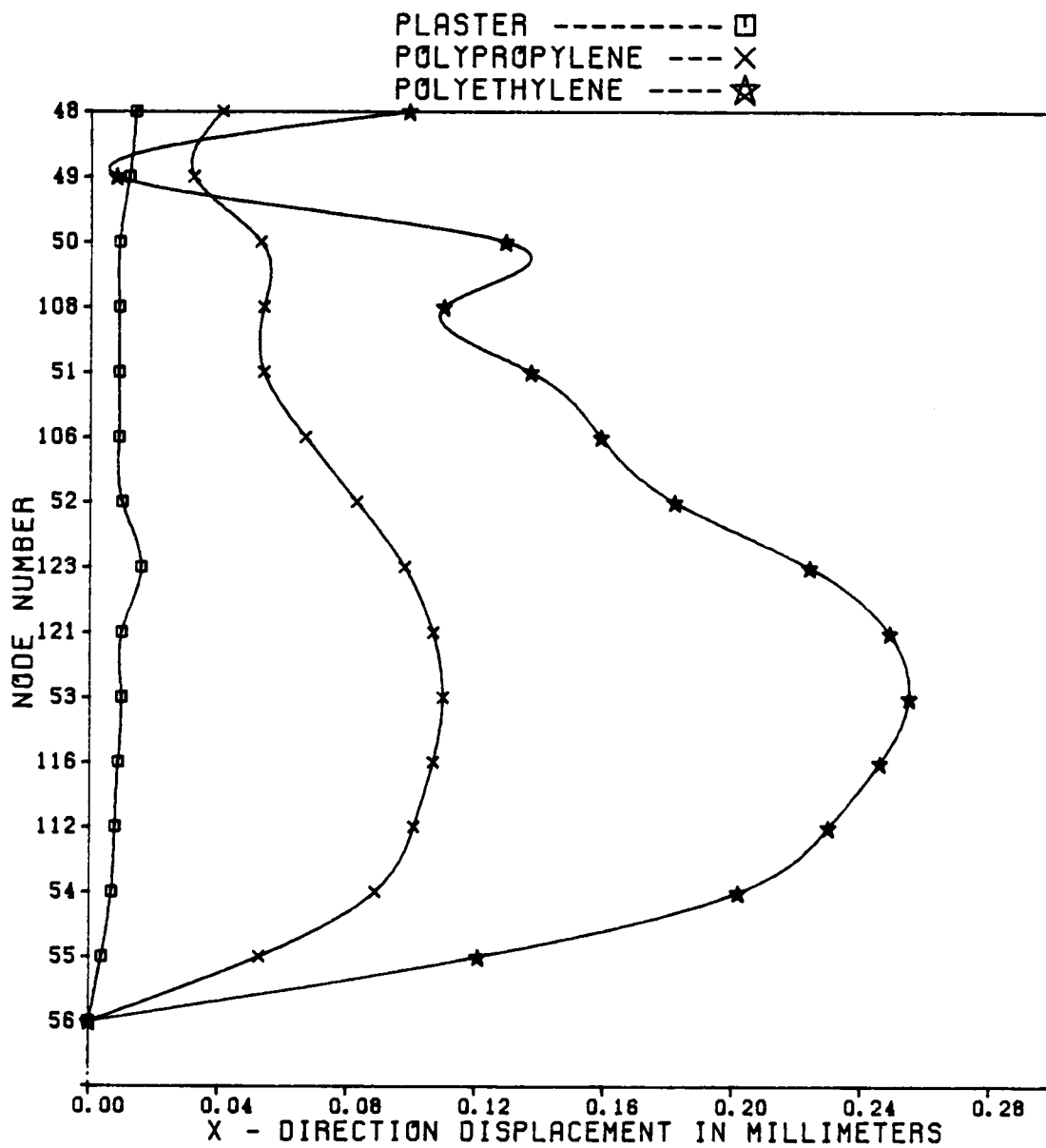


Figure 71. ΔX -displacements for strip 3 of the symmetric quadrilateral model using the three structural materials.

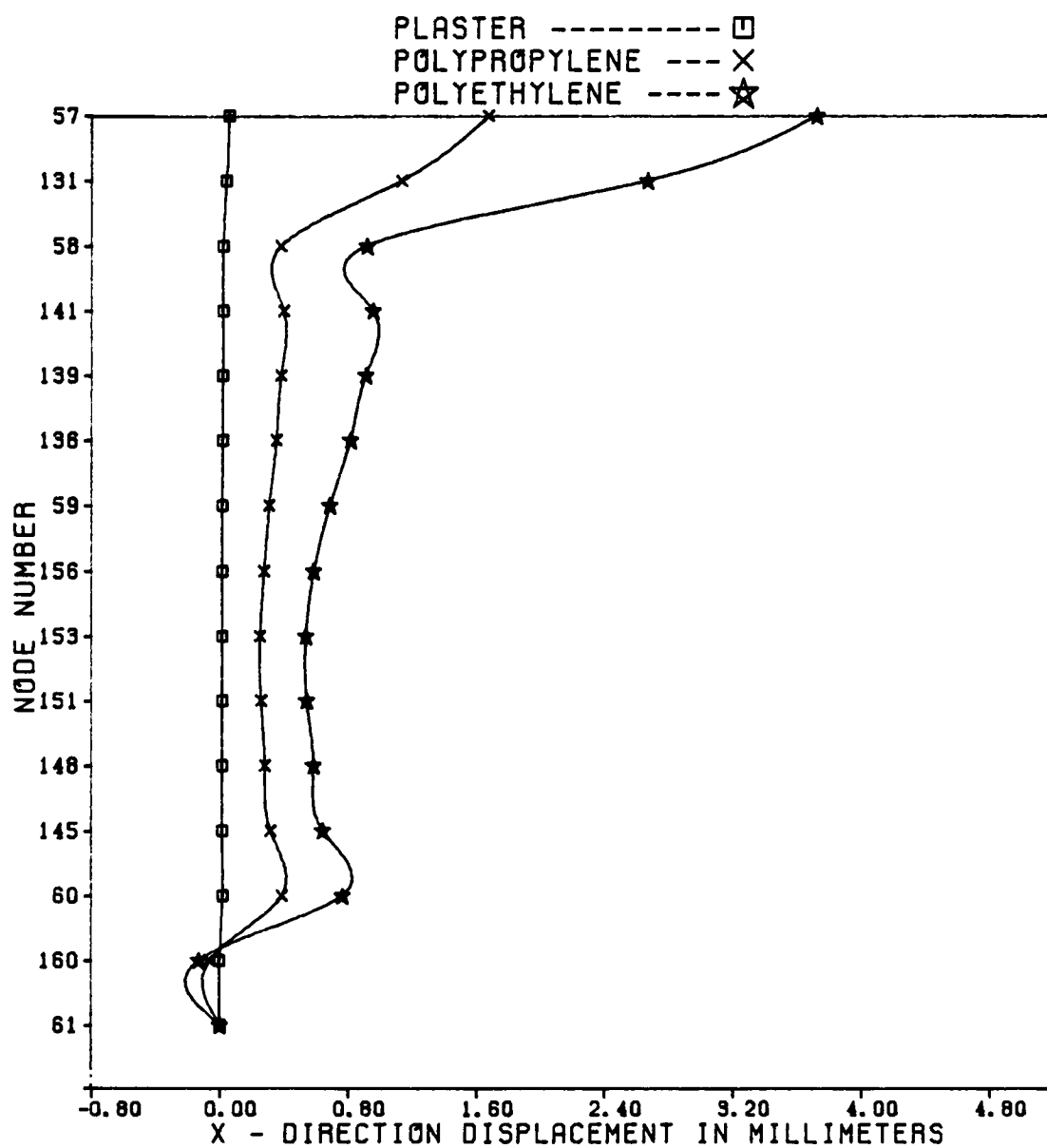


Figure 72. ΔX -displacements for strip 4 of the symmetric quadrilateral model using the three structural materials.

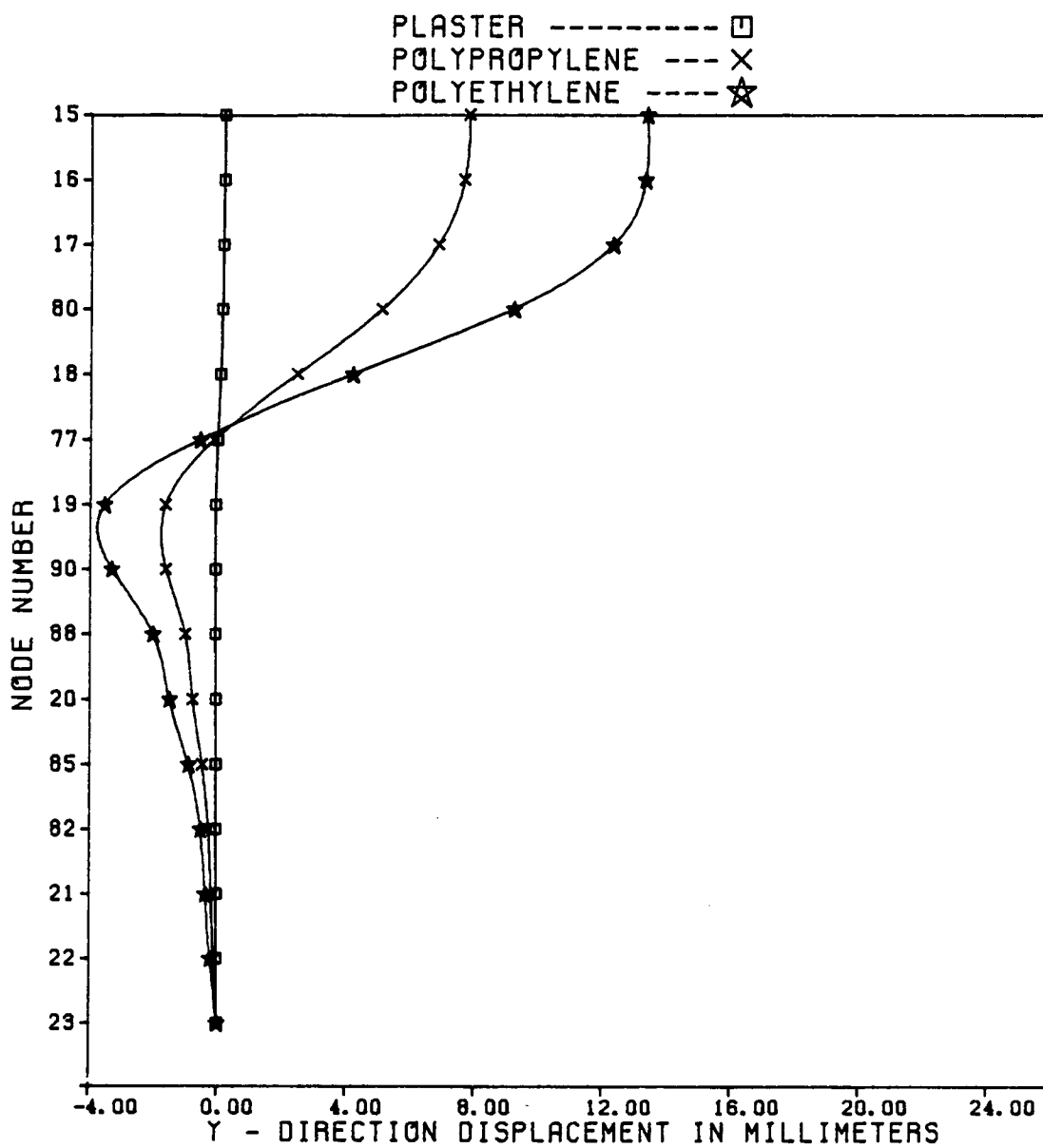


Figure 73. ΔY -displacements for strip 1 of the symmetric quadrilateral model using the three structural materials.

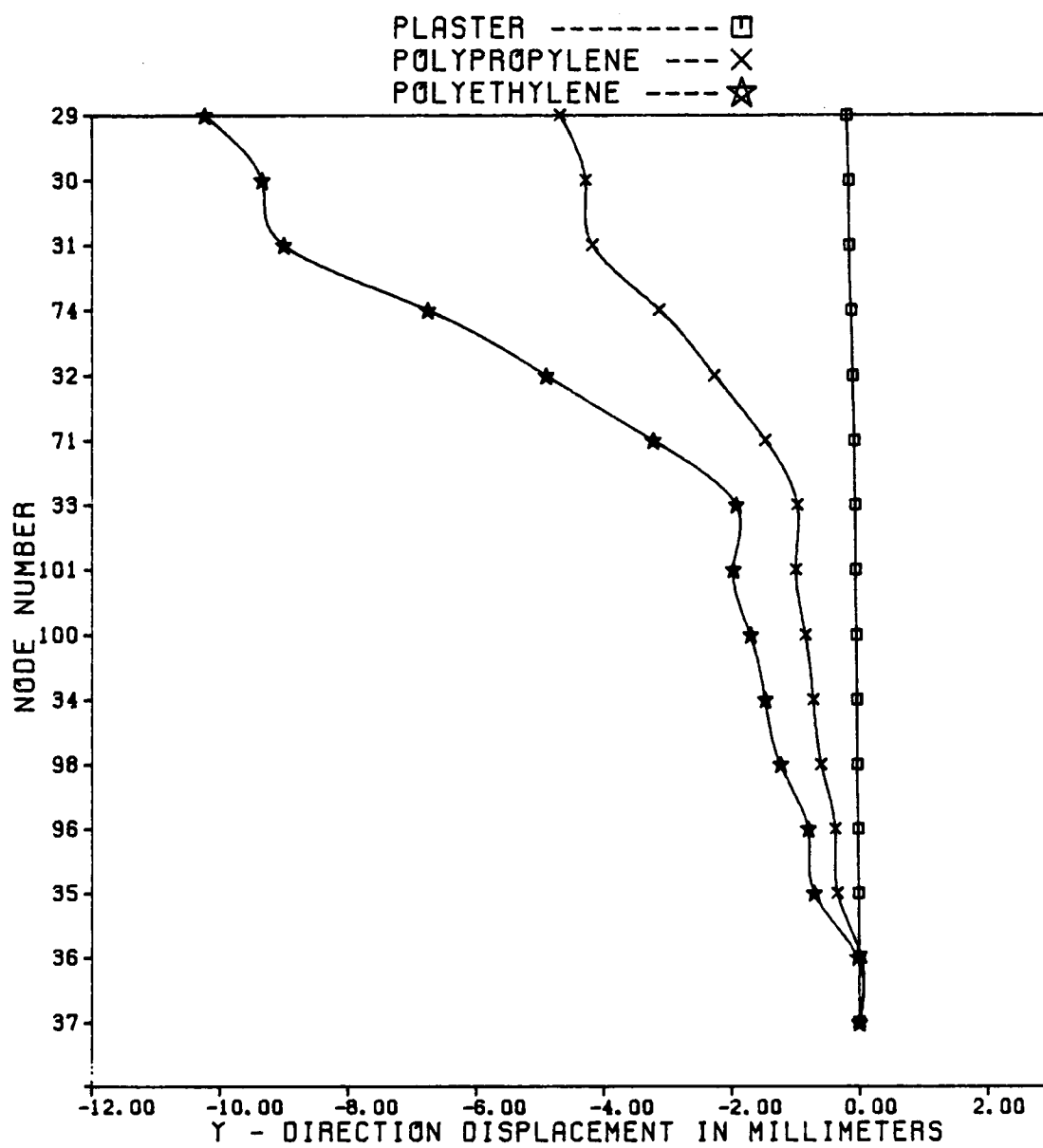


Figure 74. ΔY -displacements for strip 2 of the symmetric quadrilateral model using the three structural materials.

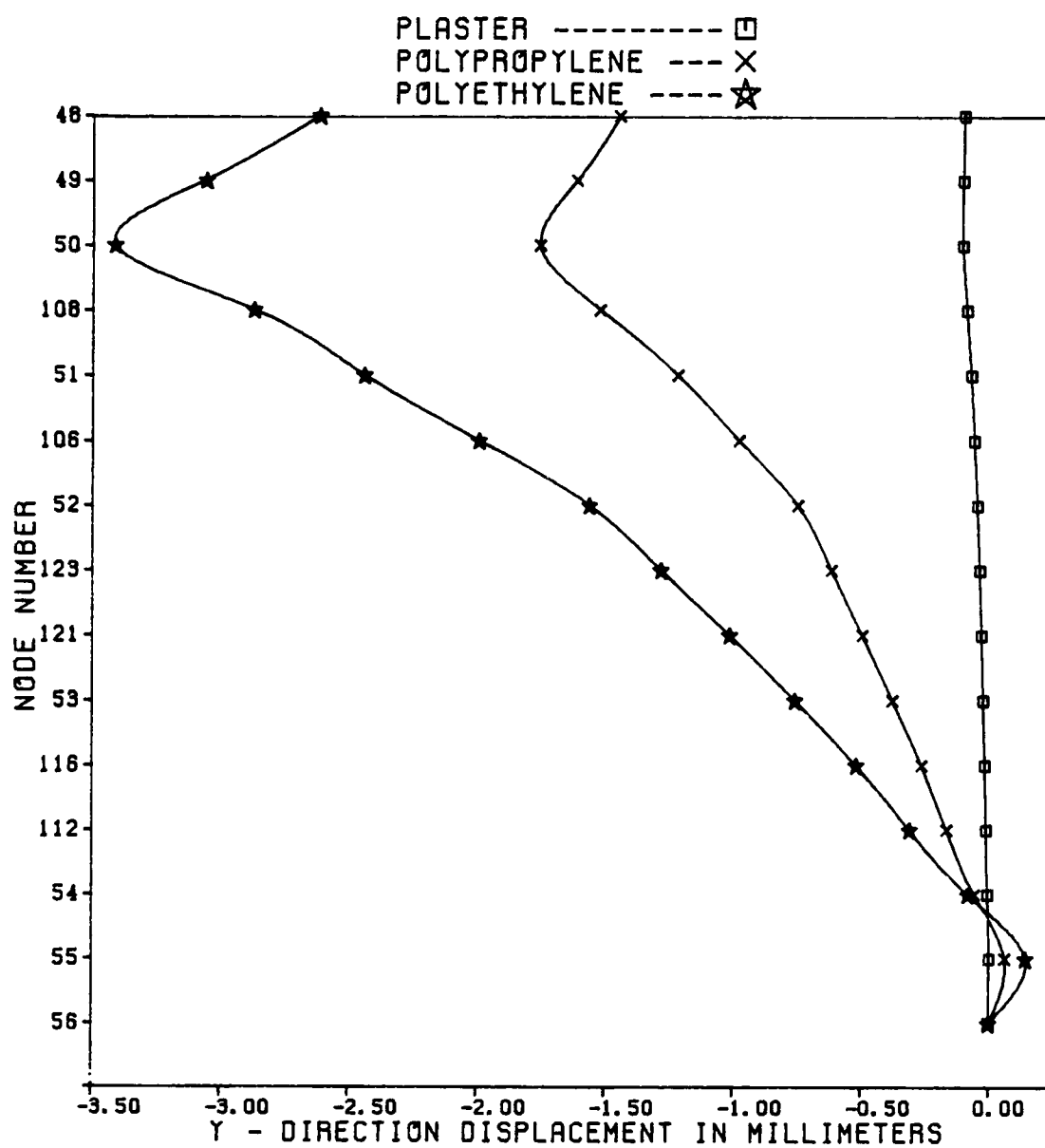


Figure 75. ΔY -displacements for strip 3 of the symmetric quadrilateral model using the three structural materials.

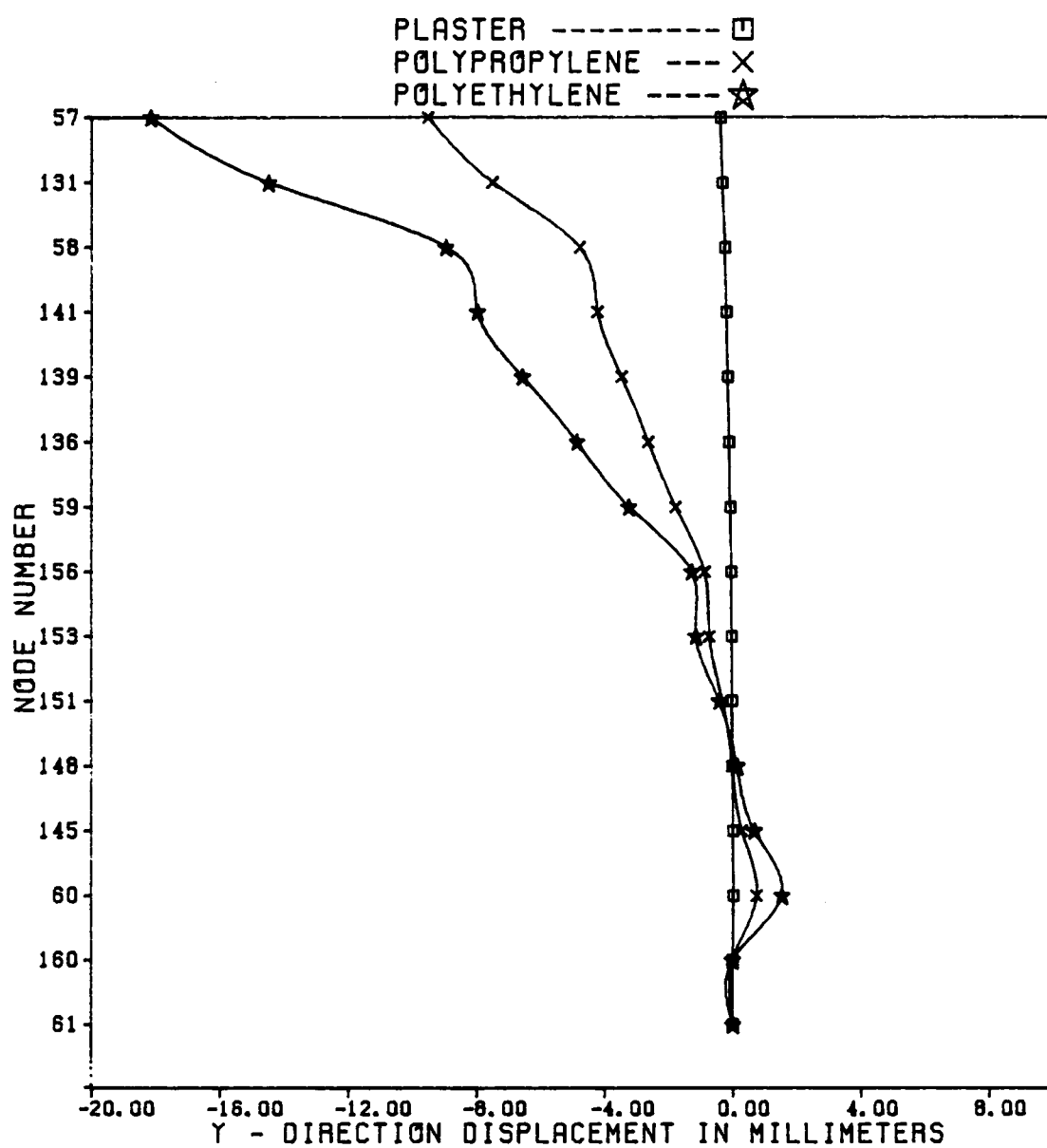


Figure 76. ΔY -displacements for strip 4 of the symmetric quadrilateral model using the three structural materials.

as nearly straight vertical lines. Closer inspection reveals that the characteristic bumps and dips appearing in the thermal plastic quad model curves also appear in the plaster quad model curves.

The ΔY displacement magnitudes are larger than the ΔX displacement magnitudes. This was expected since the Y axis was in the plane of the applied loads. The largest ΔY displacements occur in the upper half of strip 1, strip 2, and strip 4 for the two thermal plastics. Strip 1 and strip 2 straddle the breast hole while strip 4 is near the posterior symmetric boundary line.

The ΔZ displacement comparisons between the three quad models are shown in Figures 77, 78, 79, and 80. The polyethylene quad model demonstrates the highest displacement magnitude in each figure. The polypropylene magnitudes are roughly 50% less than the polyethylene magnitudes when compared on a node to node basis. The plaster displacement curves appear as straight vertical lines. The general shape of the two thermal plastic displacement curves was difficult to see in the plaster displacement curves.

The ΔZ displacement magnitudes are on the same order of magnitude as the ΔY displacement magnitudes. This was expected since the Z axis was in the plane of the applied loads. The largest ΔZ displacements occur in the upper superior end of strip 1, strip 2, and strip 4 for the two thermal plastics. Strip 1 straddles the breast hole and is near the anterior symmetric boundary line. Strip 2 straddles the opposite side of the breast hole while strip 4 is near the posterior symmetric boundary line. The nodes within each strip and location of each strip can be seen in Figure 22 (p. 52).

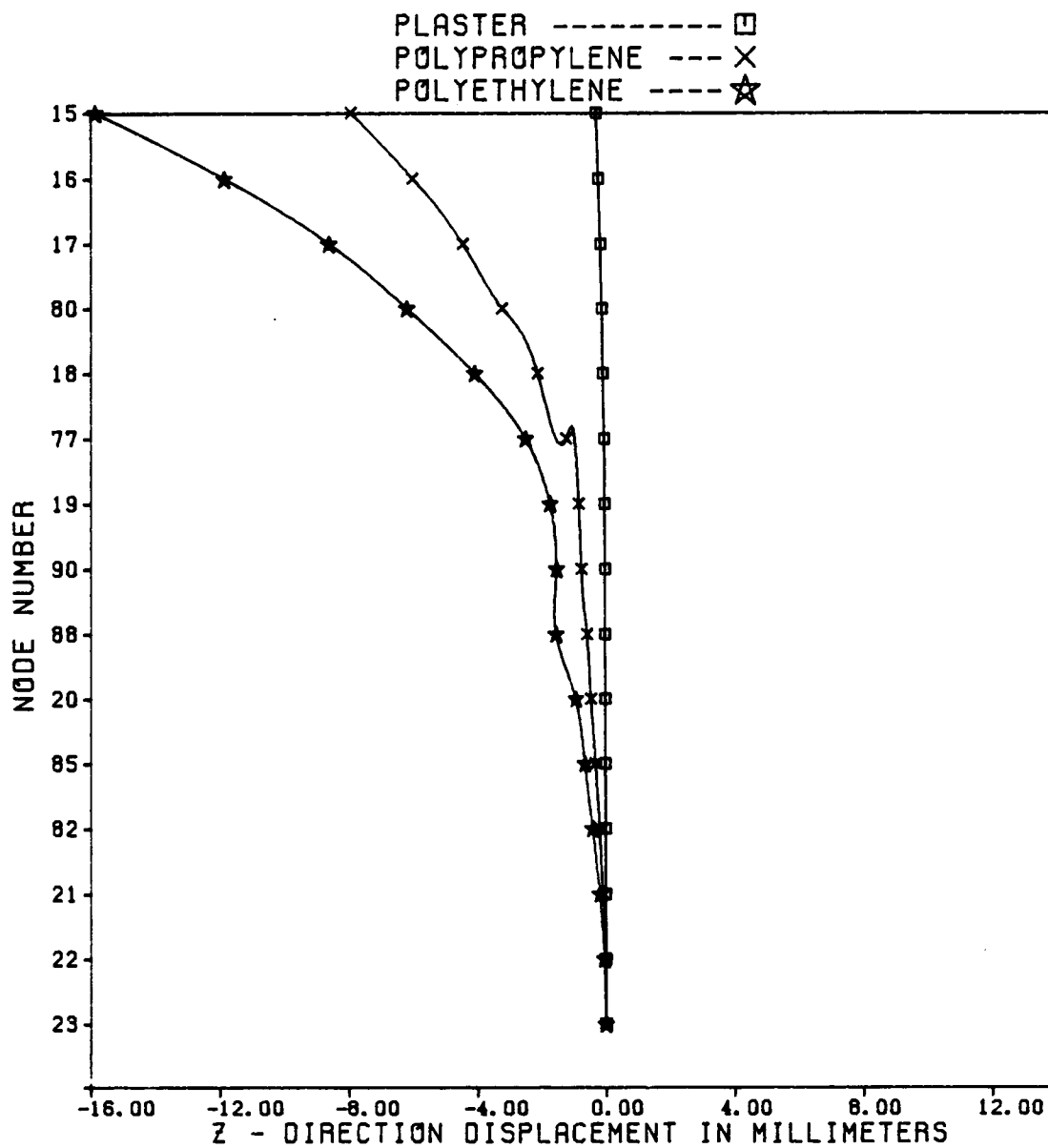


Figure 77. ΔZ -displacements for strip 1 of the symmetric quadrilateral model using the three structural materials.

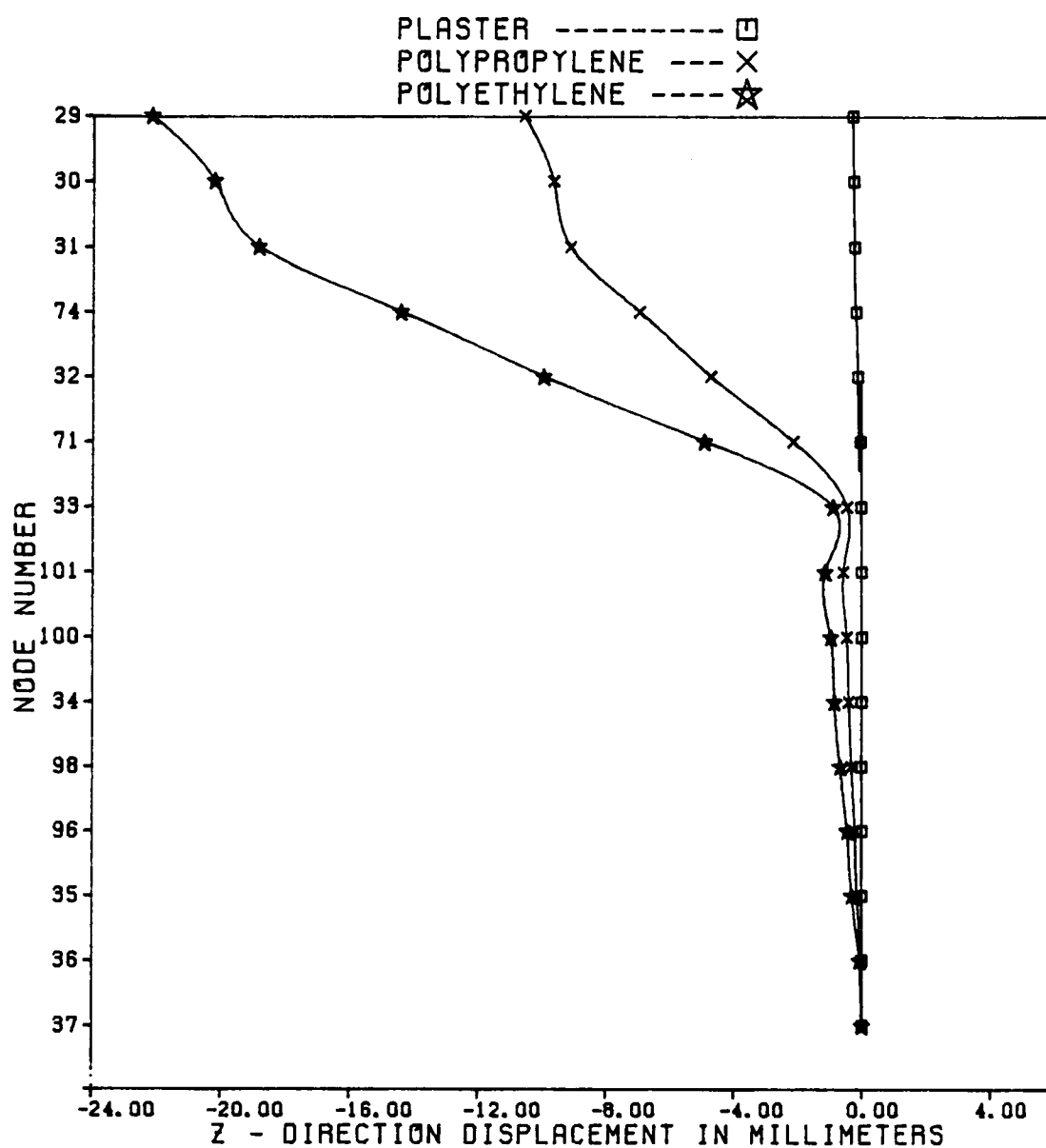


Figure 78. ΔZ -displacements for strip 2 of the symmetric quadrilateral model using the three structural materials.

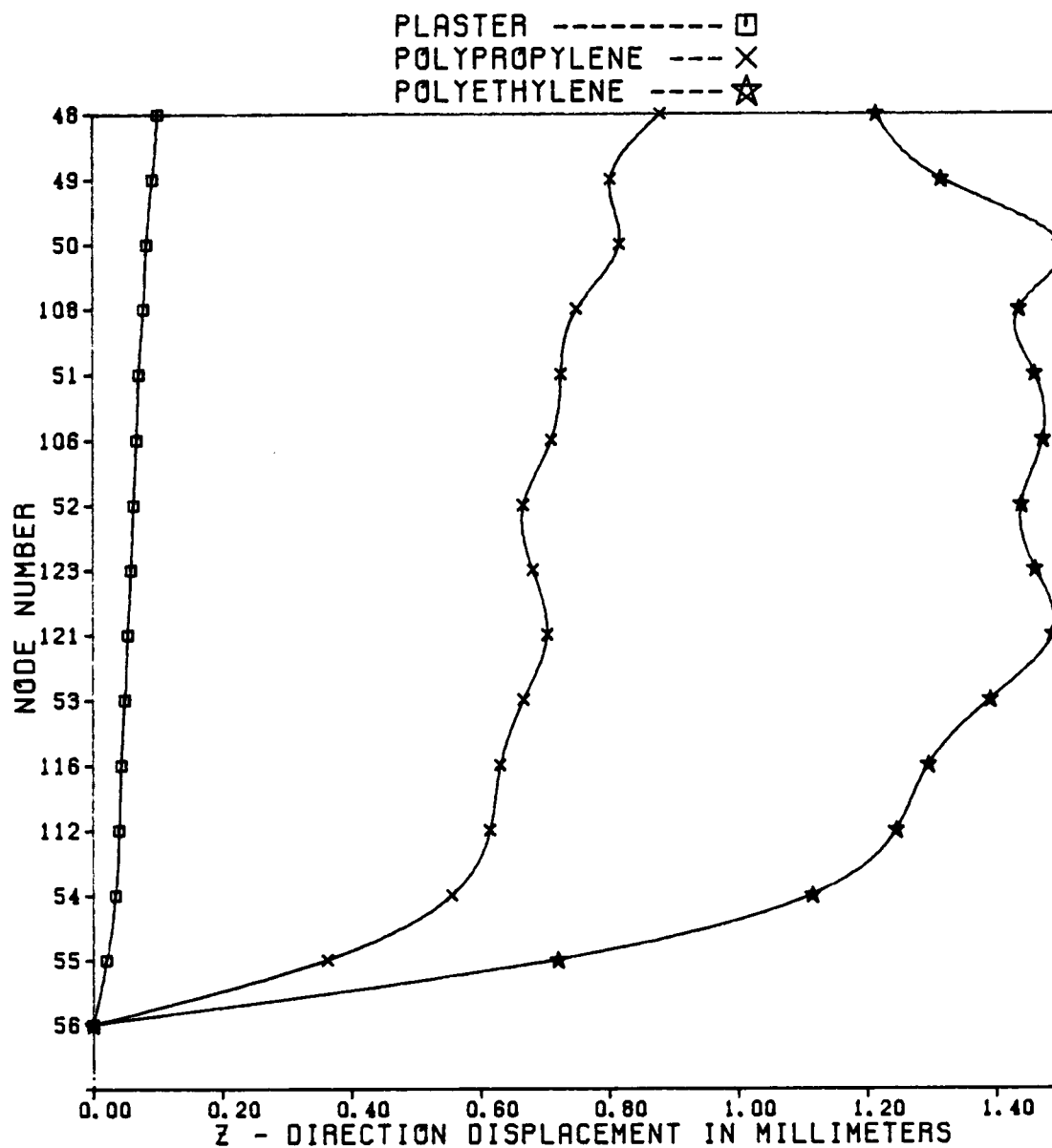


Figure 79. ΔZ -displacements for strip 3 of the symmetric quadrilateral model using the three structural materials.

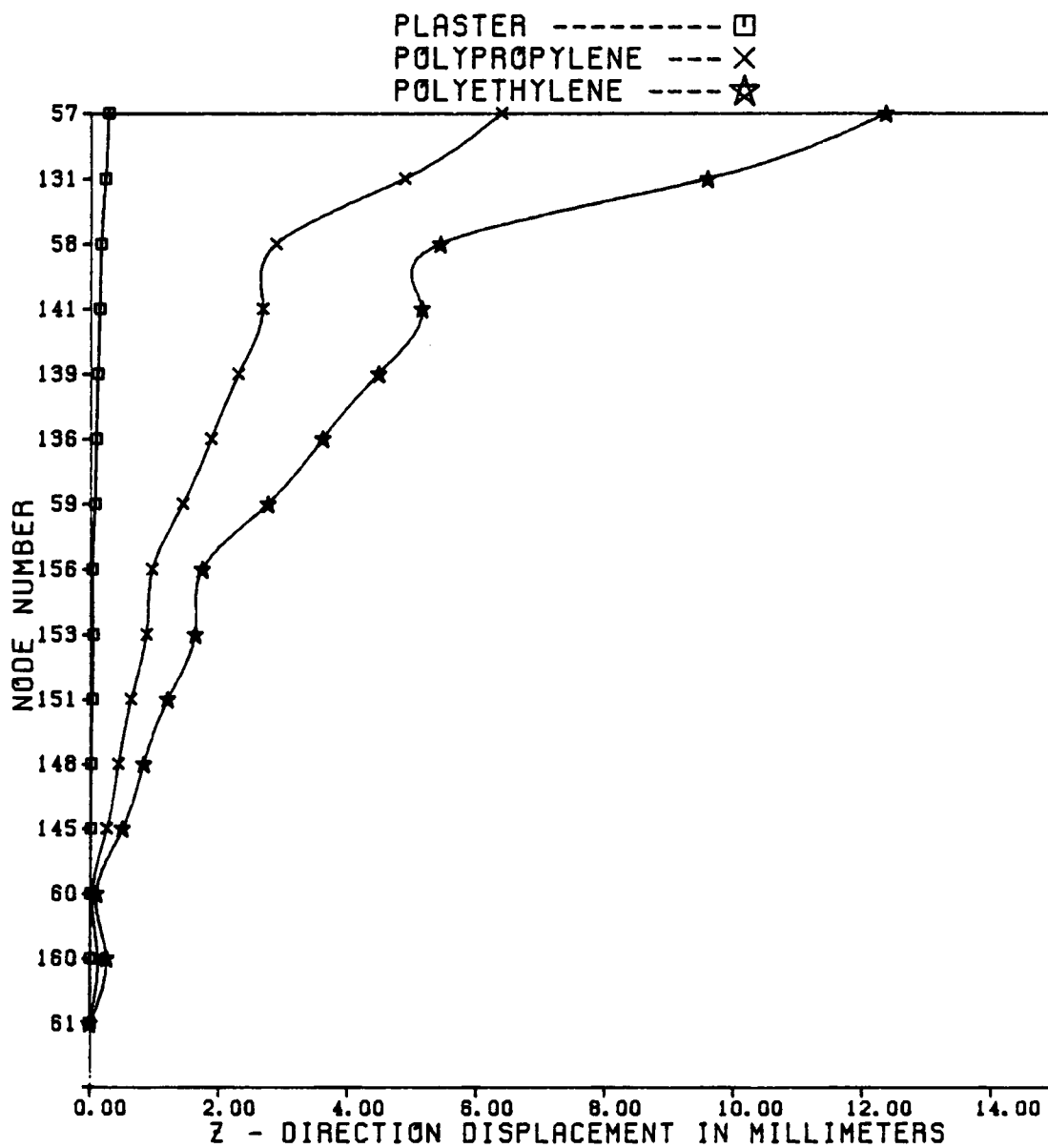


Figure 80. ΔZ -displacements for strip 4 of the symmetric quadrilateral model using the three structural materials.

Strip 1 was selected for a tabular numerical comparison for the three structural materials (Table 5). The magnitudes of the three displacement directions of the plaster quad model were from 10 to 60 times smaller than the magnitudes of the two thermal plastic displacements. The analytical thickness of the two thermal plastic structural materials were exactly one-third of the plaster analytical structural thickness. The larger displacements of the thermal plastic quad models was expected due to the thinner shell thickness.

Displacements in the Y and Z directions will be discussed first. These two directions are directly related to the torsional motion induced by the loading conditions. The prevention of vertebra rotation depends primarily on limiting the magnitude of these two displacements.

As was observed in the X-Y plot displacement comparison of strip 1, the ΔY and ΔZ displacements increase rapidly from node 88 upward to the superior end of the strip. This displacement pattern is more noticeable in the thermal plastic quad models than in the plaster quad model. The displacement pattern is due to the breast hole and not the symmetric boundary line. If the symmetric boundary line was the cause of the large nodal displacements in strip 1, then all of the nodes in strip 1 would have large displacements.

Observing the strip 2 displacement pattern from the X-Y plot comparisons, the ΔY and ΔZ displacements become large from node 33 upwards to the superior end of the strip. Strip 2 borders the opposite side of the breast hole and is not near a symmetric boundary line.

TABLE 5
NODAL DISPLACEMENT UNITS IN MILLIMETERS

Node	Plaster			Polypropylene			Polyethylene		
	ΔX	ΔY	ΔZ	ΔX	ΔY	ΔZ	ΔX	ΔY	ΔZ
15	-.050	.219	-.327	-.886	7.857	-7.940	-.870	13.400	-15.840
17	-.048	.169	-.191	-1.001	6.897	-4.466	-1.690	12.350	-8.612
18	-.018	.080	-.109	-.276	2.504	-2.137	-.530	4.224	-4.088
19	-.020	-.058	-.054	-.453	-1.629	-.850	-.976	-3.524	-1.754
88	-.016	-.051	-.039	-.039	-.305	-1.001	-.601	-2.016	-1.218
85	-.009	-.035	-.023	-.137	-.463	-.329	-.267	-.900	-.663
21	-.006	-.019	-.008	-.061	-.173	-.089	-.123	-.350	-.186
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The breast hole was the only cause of the displacement pattern in strip 2.

Displacements in the ΔY and ΔZ directions of strip 4 are due to the large unsupported superior extension of the model on the posterior side. In Figure 22 (p. 52), the extension can be seen at the superior end of the two-dimensional view of the quad model mesh. The extension is the result of the need for adequate mobility of the human arm. This need was satisfied by the dip cut into the superior border of the jacket (see Figure 22).

The extension is a weak structural area of the model. It cannot handle out of plane loads without displaying large displacements. This is the cause of the large ΔY and ΔZ displacements in strip 4 from node 139 and upwards into the superior-posterior extension.

The ΔY and ΔZ displacements in strip 3 are roughly 3-10 times smaller than ΔY and ΔZ displacements in strip 1, strip 2, or strip 4. This was logical since strip 3 is not near the breast hole or superior-posterior extension.

The ΔX displacements do not play as substantial a role in vertebral rotation as do the ΔY or ΔZ displacements. This does not diminish the importance of the ΔX displacements. They measure the axial changes of the quad model and should complement the ΔY and ΔZ displacement patterns.

Based only on a strip comparison, the ΔX displacements of the thermal plastic quad models are roughly 20 times smaller than the ΔY

and ΔZ displacements. The ΔX displacements of the plaster quad model are roughly 3 times smaller than the ΔX and ΔZ displacements.

The ΔX displacements become large in strip 1 and strip 2 for nodes that are near the breast hole. This displacement pattern is similar to the pattern seen in strip 1 and strip 2 for the ΔY and ΔZ displacements. Strip 4 ΔX displacements begin to increase rapidly for nodes located in the superior-posterior extension. This extension had the same effects on the ΔY and ΔZ displacements of strip 4. The ΔX displacements of strip 3 are nearly one-half the ΔX displacements of the other strips. Since strip 3 is not near the breast hole or superior-posterior extension, this was expected.

The displacements of the plaster quad model were significantly smaller than the displacements of the thermal plastic quad models. The thermal plastic quad models showed displacements at nearly 16 mm. Considering the overall physical dimensions of the quad model, the large displacements of the thermal plastics were less than a 1% change in the physical geometric dimensions.

Areas of concern were the breast hole and superior-posterior extension of the quad model. Displacements were large in the areas local to the breast hole and extension. Although the displacements were not significant, these two areas could be sites of future problems.

G. ANALYTICAL STRESS DISTRIBUTION

The definition of the element panels can be seen in Figure 23 (p. 54). The X-Y stress comparison format has been previously defined in the second section of this chapter.

Stresses for the top surface comparisons are shown in Figures 81, 82, 83, and 84. Stresses in the plaster quad model never get any larger than 1 MPA. The stresses in the thermal plastic quad models are nearly 4 times higher than the plaster quad model. Since the thermal plastic quad models had larger displacements, higher values of stress were expected. The shape of the stress curve for the two thermal plastics can be seen in the plaster curve. This was seen in all four panels. The two thermal plastic quad model stress curves were nearly identical in magnitude at every element.

The same patterns emerged for stress magnitudes, as were seen in the magnitudes of the displacements. Elements bordering the breast hole, panel 1 and panel 2, showed stresses that were double or triple in magnitude in comparison with other elements in the respective panels. Panel 4 elements that were in the superior-posterior extension showed stress magnitudes that were nearly three times greater than other elements in the panel. Panel 3 also contained elements exhibiting high stresses. These elements were close to the breast hole, although not bordering it, and were lower in magnitude than adjacent elements in panel 2.

Stresses for the bottom surface comparisons are shown in Figures 85, 86, 87, and 88. As was seen with the top surface stresses, the plaster quad model stress never exceeds 1 MPA. The thermal plastics have stresses that are, in some cases, ten times larger. As stated before, the large displacements of the thermal plastic quad models will be accompanied by large stresses. The shape of the two

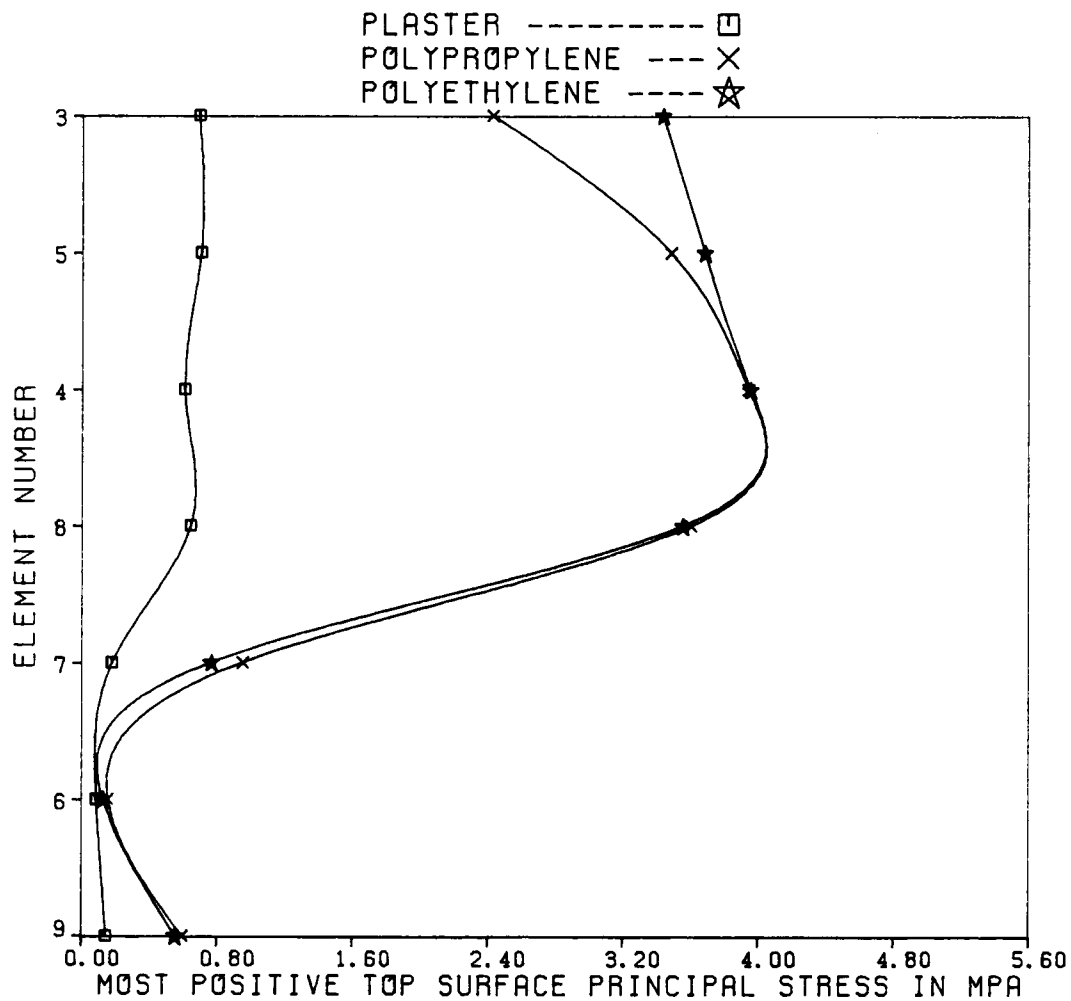


Figure 81. Positive top surface stress for panel 1 of the symmetric quadrilateral model using the three structural materials.

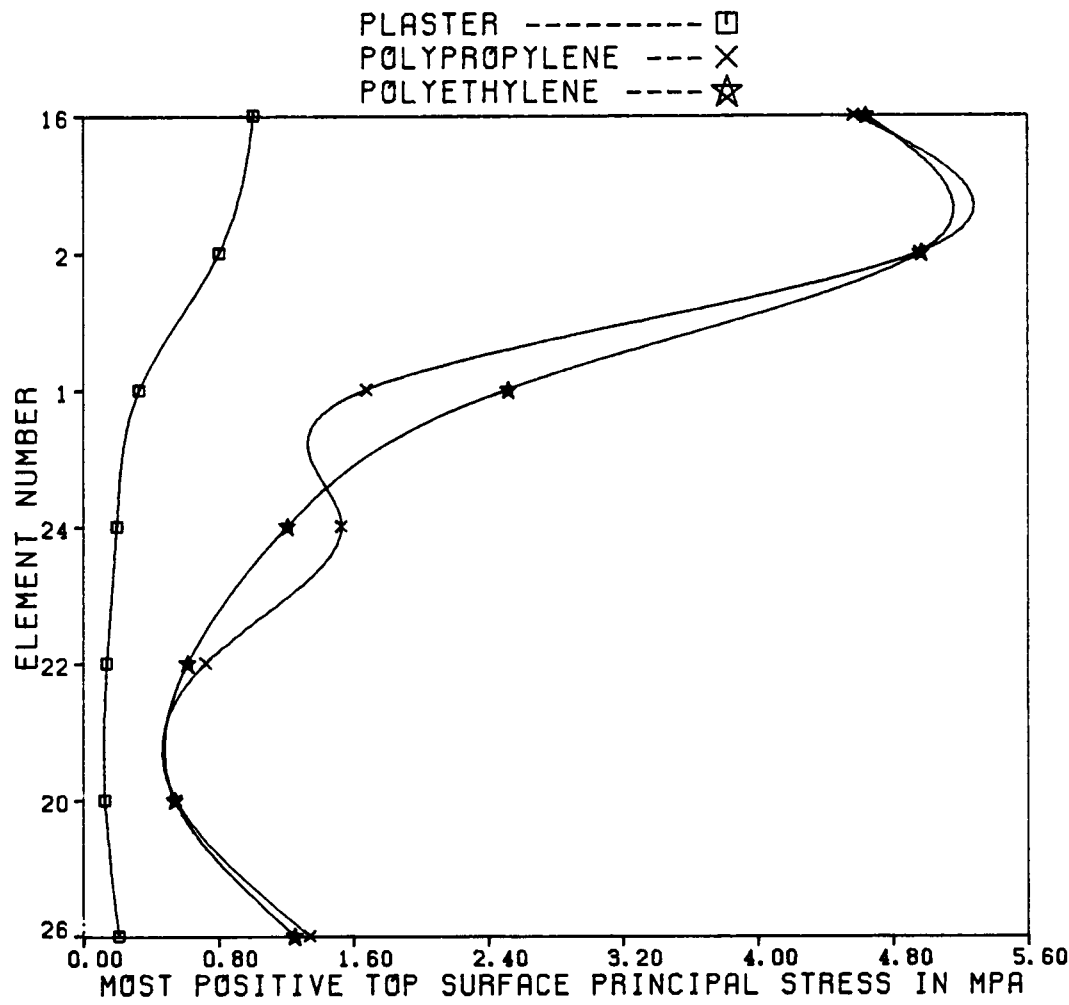


Figure 82. Positive top surface stress for panel 2 of the symmetric quadrilateral model using the three structural materials.

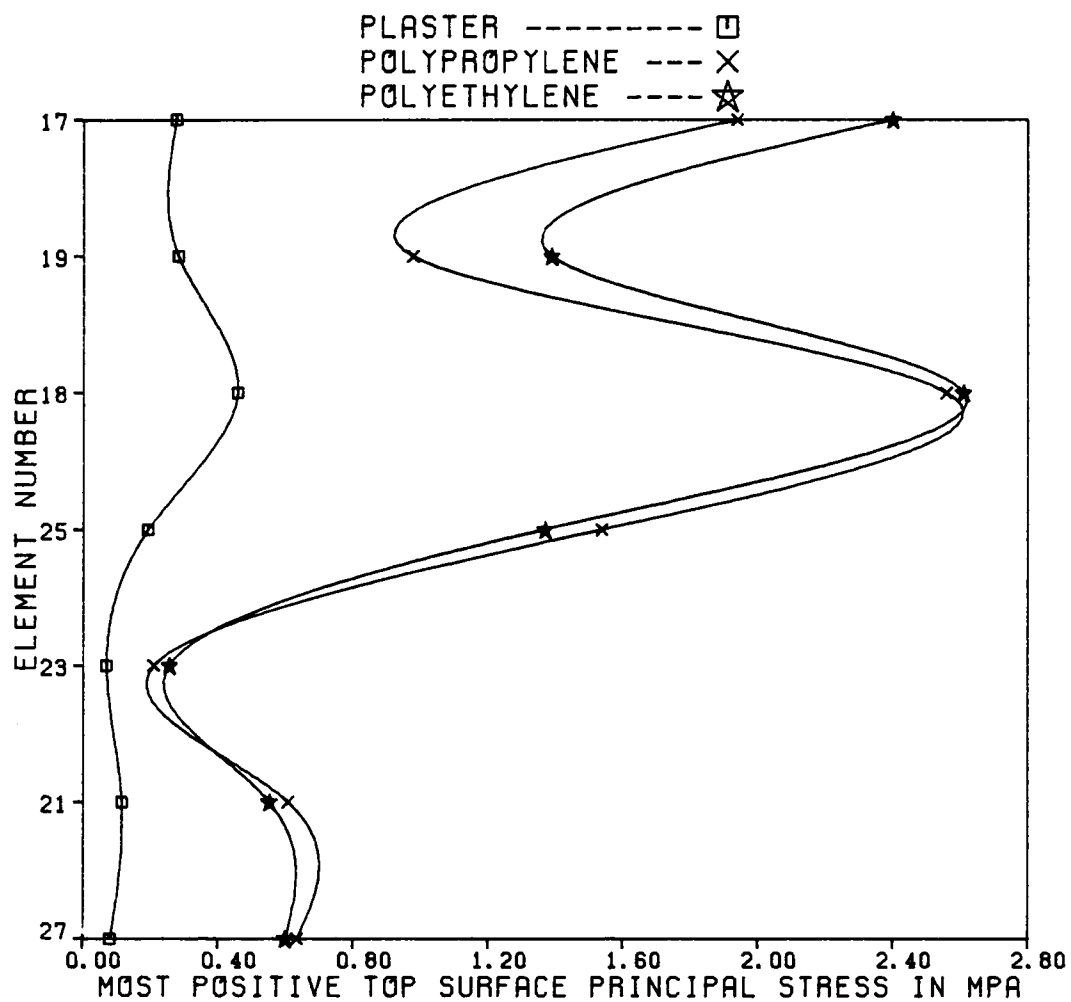


Figure 83. Positive top surface stress for panel 3 of the symmetric quadrilateral model using the three structural materials.

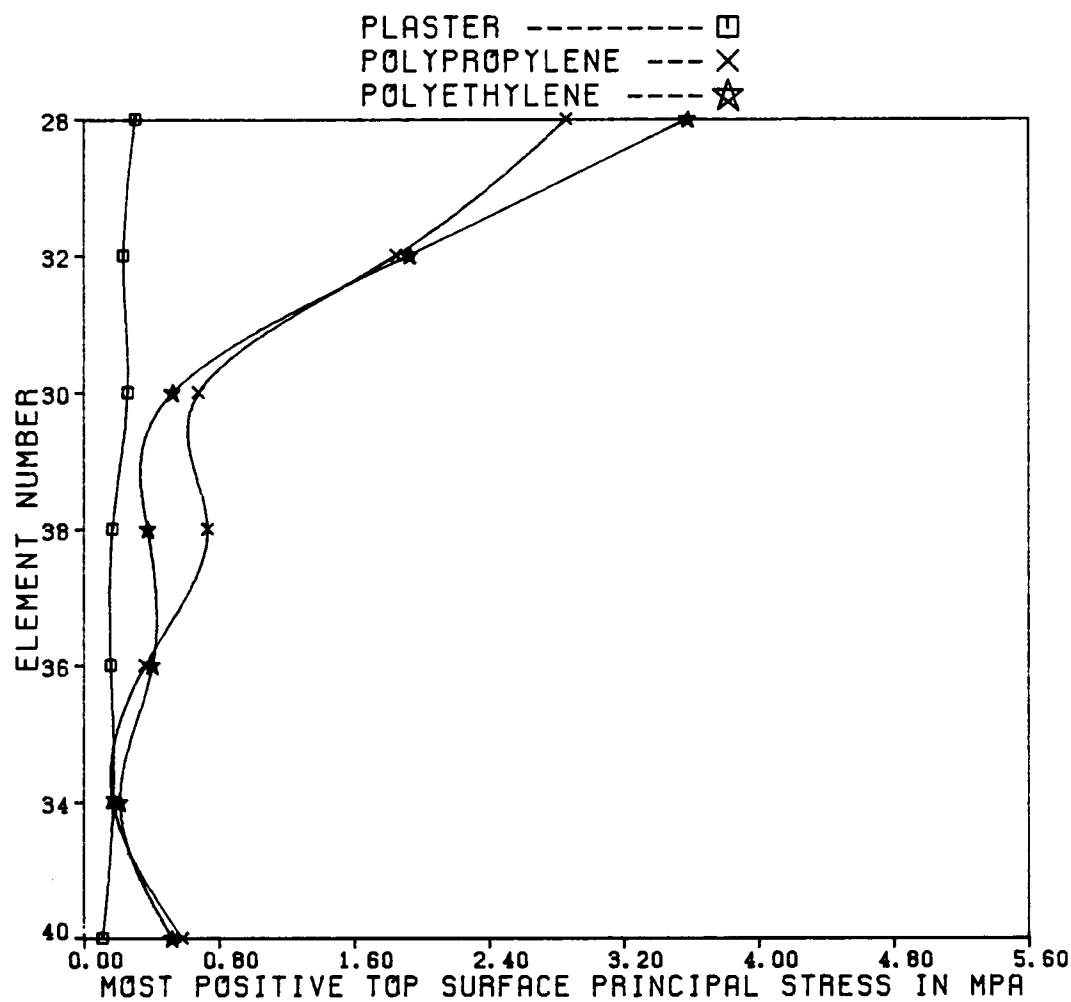


Figure 84. Positive top surface stress for panel 4 of the symmetric quadrilateral model using the three structural materials.

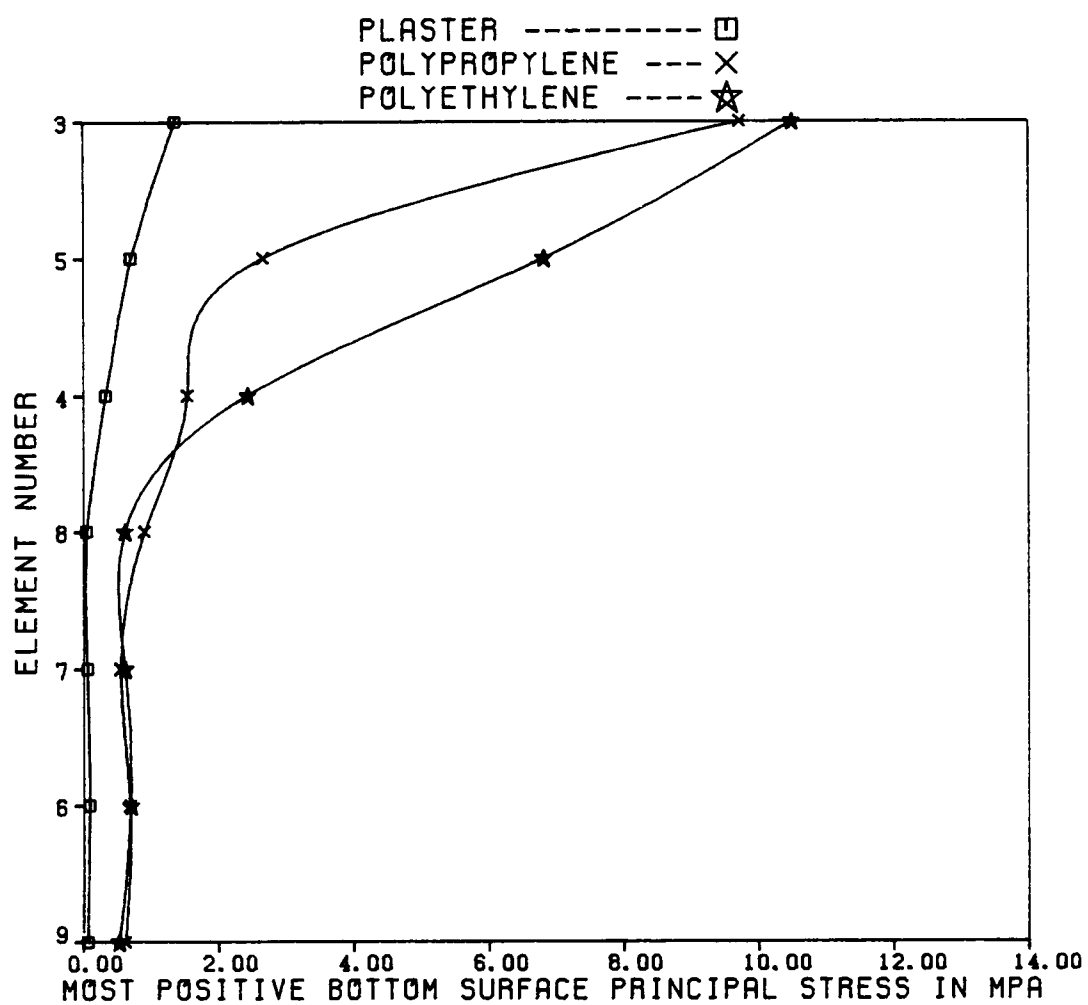


Figure 85. Positive bottom surface stress for panel 1 of the symmetric quadrilateral model using the three structural materials.

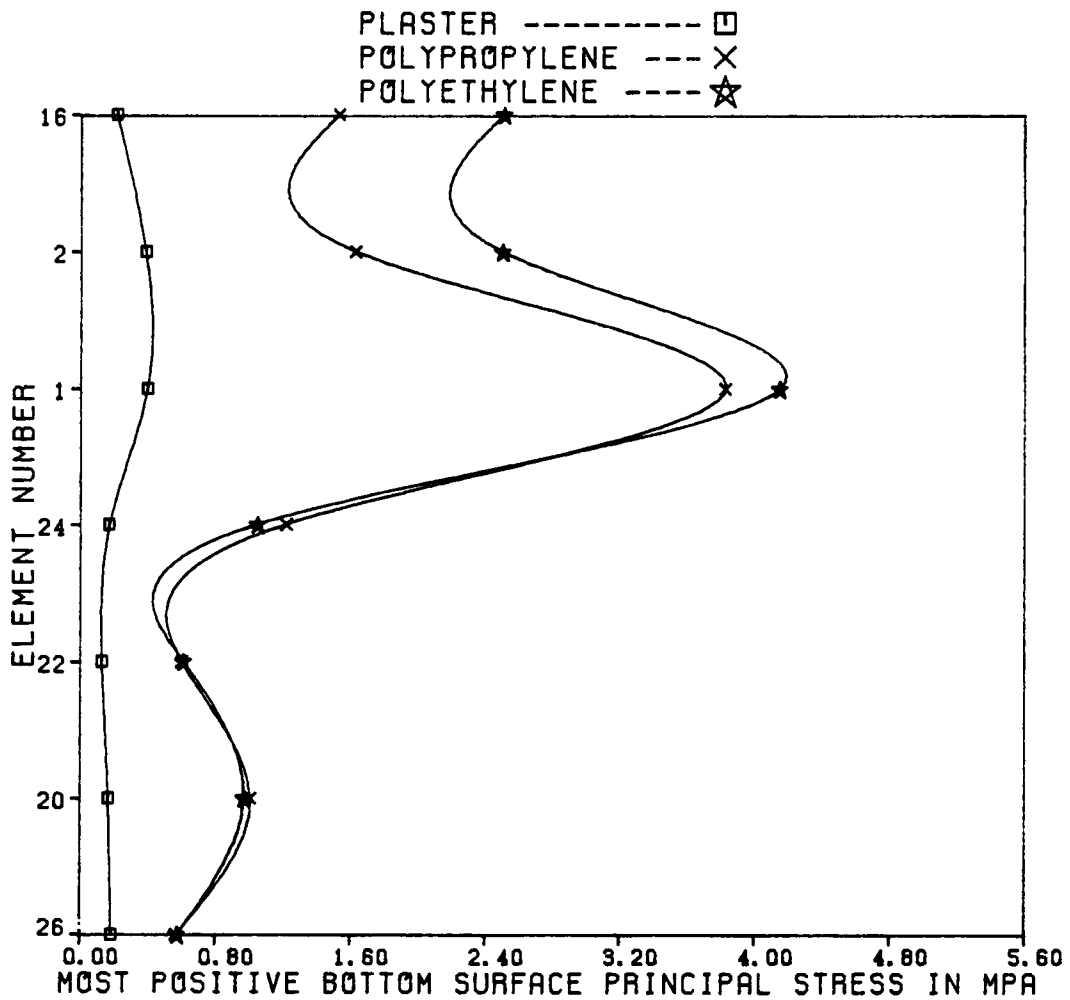


Figure 86. Positive bottom surface stress for panel 2 of the symmetric quadrilateral model using the three structural materials.

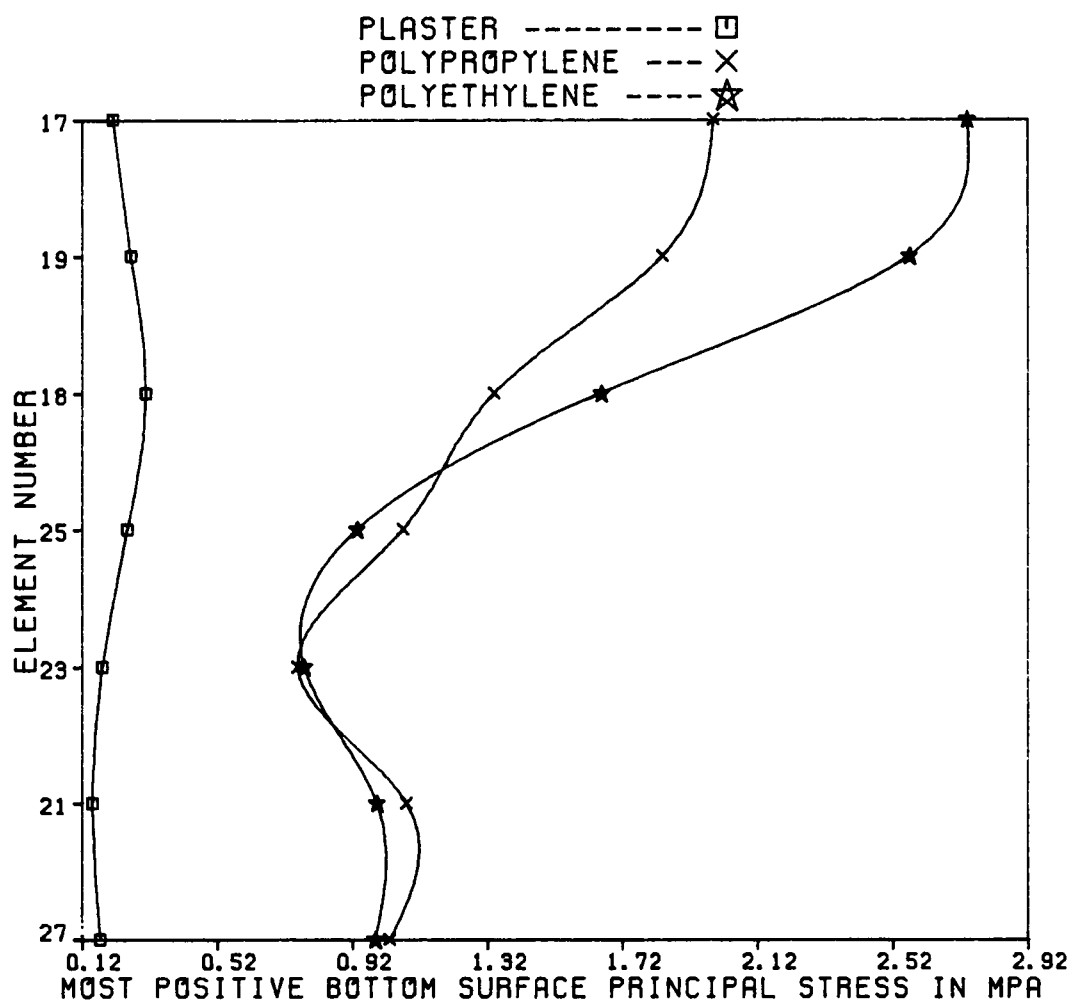


Figure 87. Positive bottom surface stress for panel 3 of the symmetric quadrilateral model using the three structural materials.

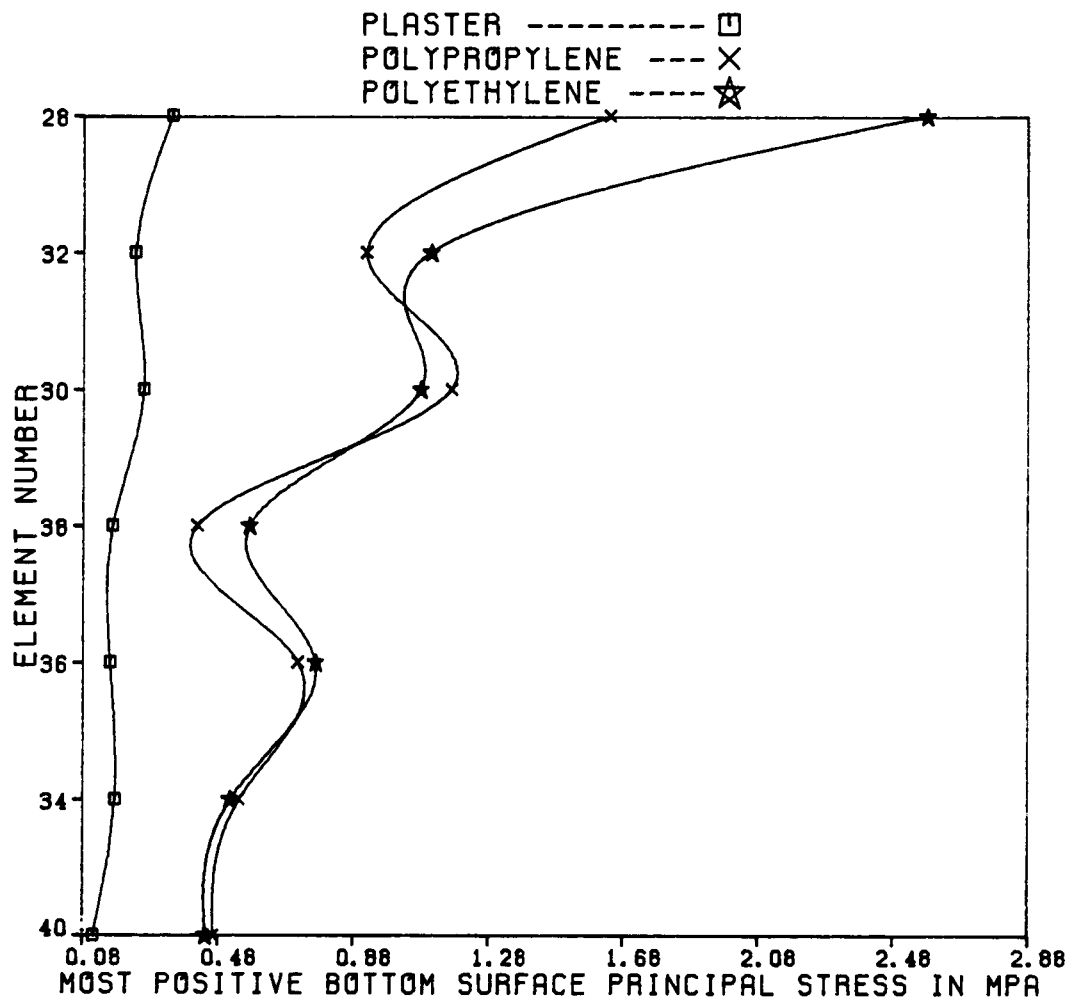


Figure 88. Positive bottom surface stress for panel 4 of the symmetric quadrilateral model using the three structural materials.

thermal plastic stress curves can be seen in the plaster quad model stress curve. The stress magnitudes of the two thermal plastics were roughly the same for nearly all of the compared elements.

Panel 1 and panel 2 show the highest stresses in elements that border the breast hole. Stresses of these elements were 4 to 10 times higher than elements not bordering the breast hole. Panel 4 had elements in the superior-posterior extension which had stress magnitude twice as high as the other elements in the panel. Panel 3 elements that are adjacent to panel 2 elements, which border the breast hole, have nearly twice the magnitudes of stress than other panel 3 elements.

The areas of high stress occurred near and around the breast hole and in the superior-posterior extension. In order to properly evaluate stress levels in the three quad models, a stress ratio was employed. The stress ratio reflects the comparison of the highest numerical stress found in a quad model to the allowable material stress. Compressive and tensile stresses were treated separately.

In Table 6, the stress ratios for the three quad models are shown. The ratios indicate that none of the three materials was overstressed by the applied loads.

None of the stress ratio exceeded .5 which is the same as a factor of safety greater than 2. The high stresses around the breast hole and superior-posterior extension were not critical. Although the thermal plastics exhibited high stress magnitudes, they were well within the allowable material limits.

TABLE 6
STRESS RATIOS FOR THE THREE STRUCTURAL MATERIALS

	Plaster	Polypropylene	Polyethylene
Tensile	.41	.28	.43
Compressive	.08	.14	.27

$$\text{Stress ratio} = \frac{\text{actual}}{\text{allowable}} .$$

H. EXPERIMENTAL RESULTS

When the experimental techniques were being applied, only the polypropylene jacket and plaster Risser cast were available. The polyethylene jacket had not yet been constructed. Experimental data were not taken on the polyethylene jacket.

The polypropylene jacket was removable and could be tested when conditions were convenient. Once the plaster Risser jacket was applied, the experimental testing was immediately conducted. Removal of the plaster jacket resulted in irreparable damage and further testing was not possible.

Modifications to the plaster jacket and polypropylene jacket were previously explained in Chapter IV. The method of measurement and apparatus were also described and detailed in Chapter IV.

I. IN VIVO RESULTS

Each jacket was modified for the experimental results. The polypropylene jacket was modified with removable cowhorns. The cowhorns extend above the superior end of the jacket to provide extra

restraint against the shoulders. The plaster jacket had the neckpiece removed after the first series of rotation tests. Removal of the neckpiece allowed the shoulders to move as freely as would the polypropylene jacket without cowhorns.

Rotation tests were performed on the polypropylene jacket without cowhorns and with cowhorns. Rotation tests were also performed on the plaster jacket without the neckpiece and with the neckpiece. Since the jackets were custom made items, only one subject was used in the rotation testing.

The jacket restrained vertebra rotations were compared against the unrestrained vertebra rotations. This comparison was done with an X-Y plot format. The lumbar and thoracic vertebra were listed in their natural order equally spaced on the ordinate. The vertebra rotations were plotted along the abscissa. The 5% standard deviation of the LLM, determined in Chapter IV, was indicated as a dotted line on both sides of the plotted rotation curves. To prevent cluttering of the plots, single comparisons will only be made.

In Figure 89, vertebra rotations due to the polypropylene jacket without cowhorns is compared against normal vertebra rotations. From the vertebra T-11 and up to vertebra T-5 the polypropylene jacket reduced the normal vertebra rotations. Below vertebra T-11, the polypropylene jacket caused larger than normal vertebra rotations. This condition was called overtwist since vertebra rotations were higher than normal unrestrained rotation. The figure also shows that the polypropylene jacket tends to produce the same amount of rotation

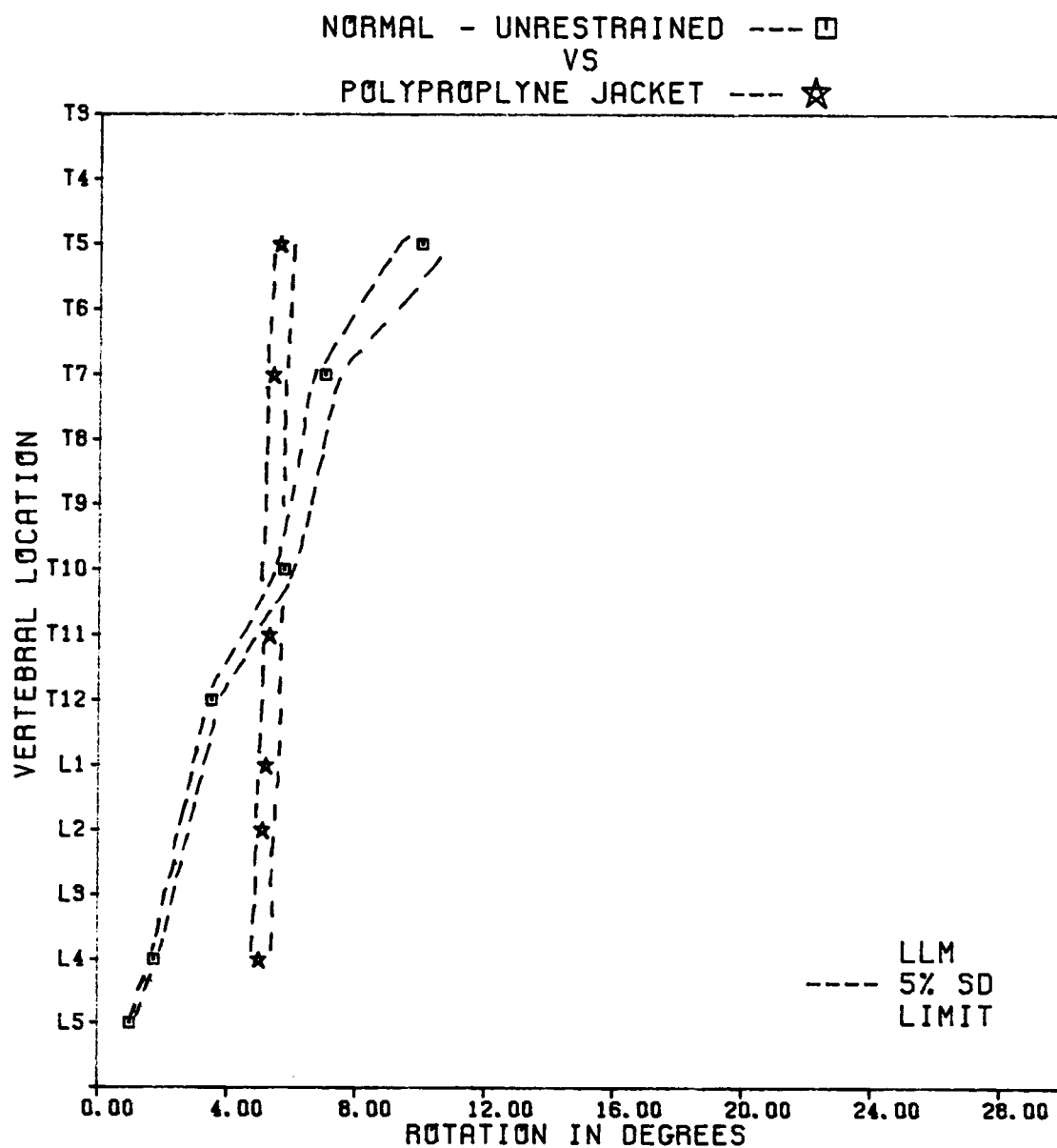


Figure 89. Unrestrained vertebra motion versus restrained vertebra motion due to the polypropylene jacket.

in each vertebra. This causes the slope of the restrained rotation curve to approach infinity. A slope of infinity indicates that the spinal column is moving as a rigid unit instead of as individual elements.

In Figure 90, the vertebra rotations due to the polypropylene jacket equipped with cowhorns is compared against normal vertebra rotations. The cowhorns reduce but do not eliminate the overtwist that exists below the T-11 level. The slope of the restrained rotations has a larger horizontal component than the previous curve in Figure 89. This means that there is more individual rotation of the vertebra. The vertebra elements still have a rigid body rotation, but also a medium amount of relative rotation.

In Figure 91, the vertebra rotations due to the plaster jacket without a neckpiece are compared to the normal unrestrained vertebra rotations. The plaster jacket causes overtwist in all vertebra locations. The magnitude of overtwist is greater than the overtwist caused by the polypropylene jacket (Figure 89). At the T-4 level, the plaster jacket causes an acute overtwist.

In Figure 92, the vertebra rotations due to the plaster jacket with a neckpiece is compared to the normal vertebra rotations. The neckpiece only corrects the acute overtwist at the T-4 level and slightly increases overtwist at the T-7 level. The slope of the restrained curve has a rigid body component and a medium amount of relative rotation.

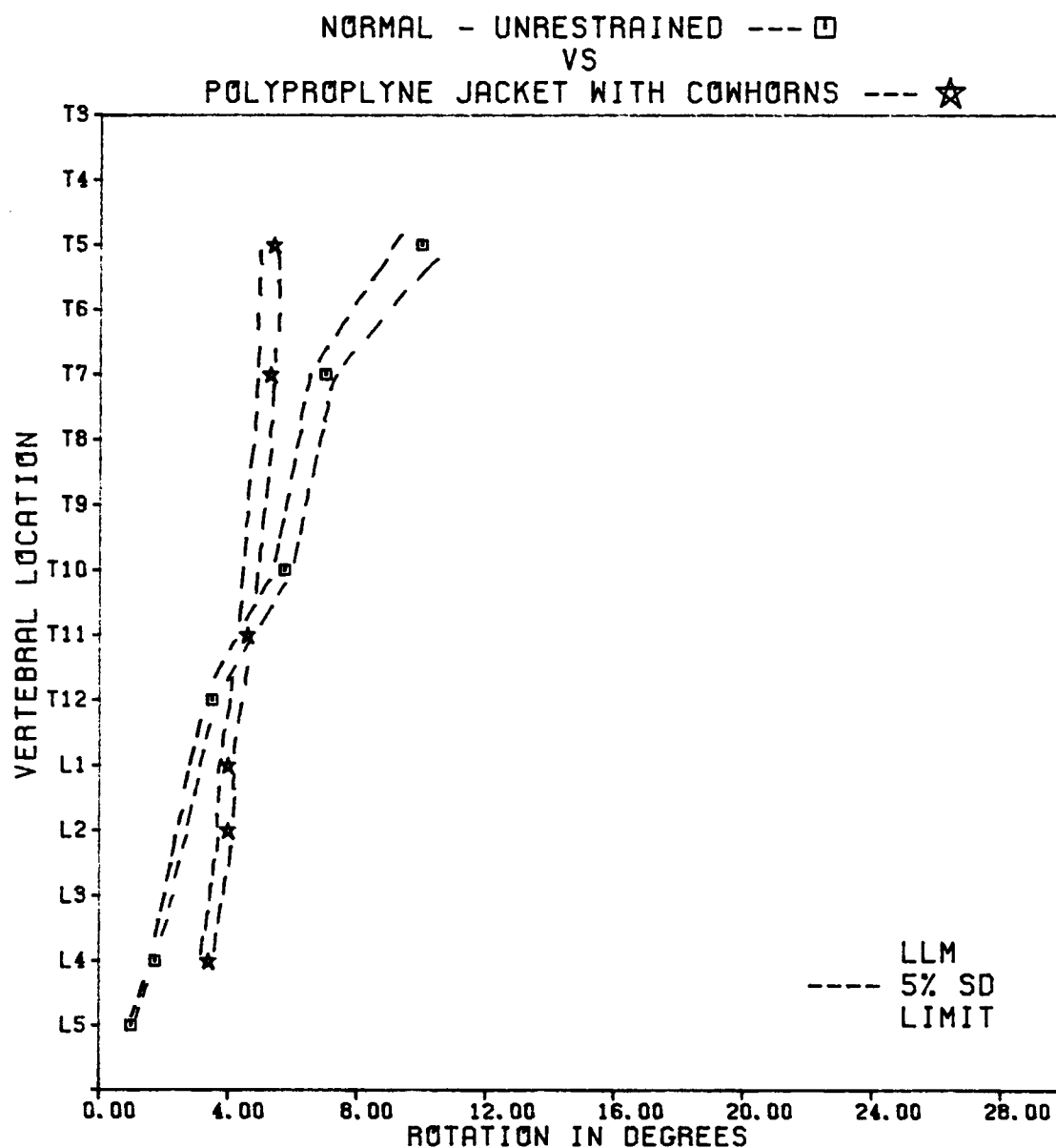


Figure 90. Unrestrained vertebra motion versus restrained vertebra motion due to the polypropylene jacket equipped with cowhorns.

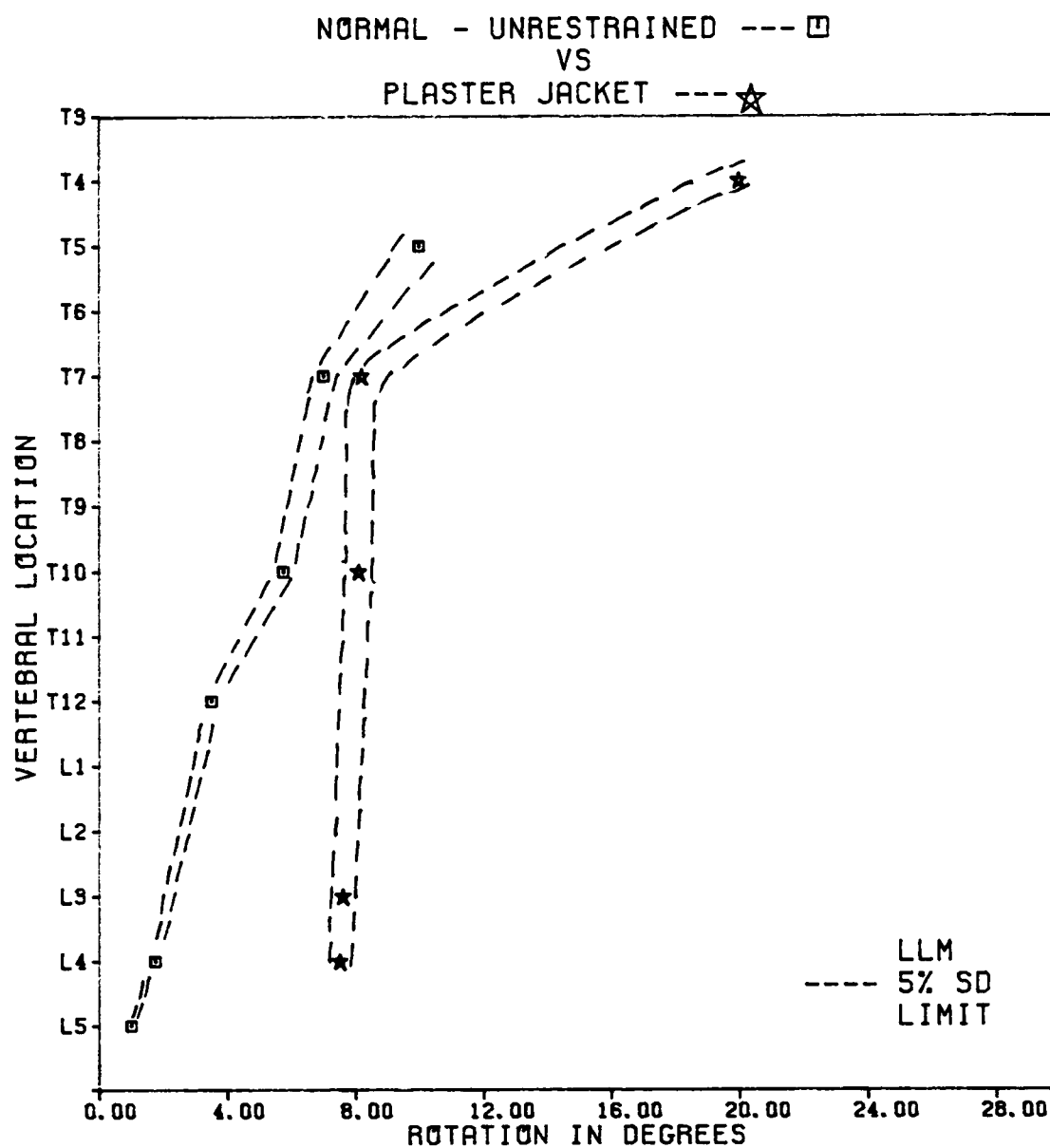


Figure 91. Unrestrained vertebra motion versus restrained vertebra motion due to the plaster jacket.

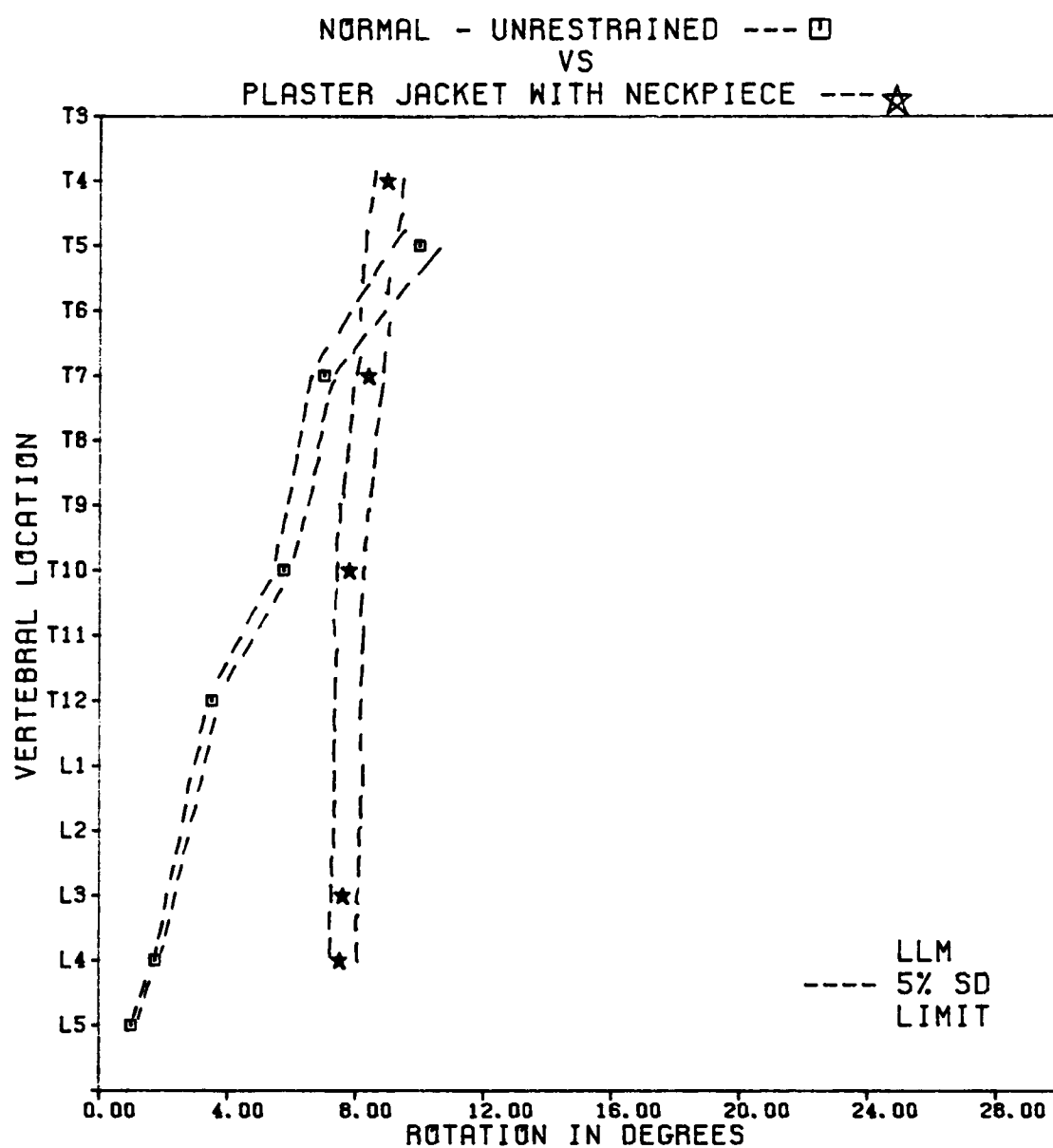


Figure 92. Unrestrained vertebra motion versus restrained vertebra motion due to the plaster jacket equipped with a neckpiece.

The polypropylene jacket produced 50% less overtwist than the plaster jacket. The addition of cowhorns to the polypropylene jacket helped to reduce the overtwist but did not eliminate it. The other item of interest is the relative rotation of the vertebral elements. This motion causes the Harrington rods to loosen from their purchase site. The plaster jacket without the neckpiece produces the worst relative rotation, concentrated in the T-7 to T-4 levels. The addition of a neckpiece eliminates the large relative rotation seen in the plaster jacket.

J. VALIDATION OF THE ANALYTICAL RESULTS

The polypropylene jacket was used in the validation of the analytical results. The plaster jacket was not used since it was partially destroyed during the removal process. The polyethylene jacket's physical dimensions were not the same as the finite element model and was not used in the testing.

The application of the LLM method to the polypropylene jacket was previously described in Chapter IV. The analytical loads and restraints were duplicated in the experimental analysis.

The polypropylene jacket had been modified for in vivo testing. These modifications can be seen in Figure 93 where the symmetric quadrilateral finite element mesh has been unfolded into a 2D image. The modifications of the jacket are shown by the shaded areas. These areas were physically removed for in vivo testing. The assumption was made that these modifications would not affect the experimental testing.

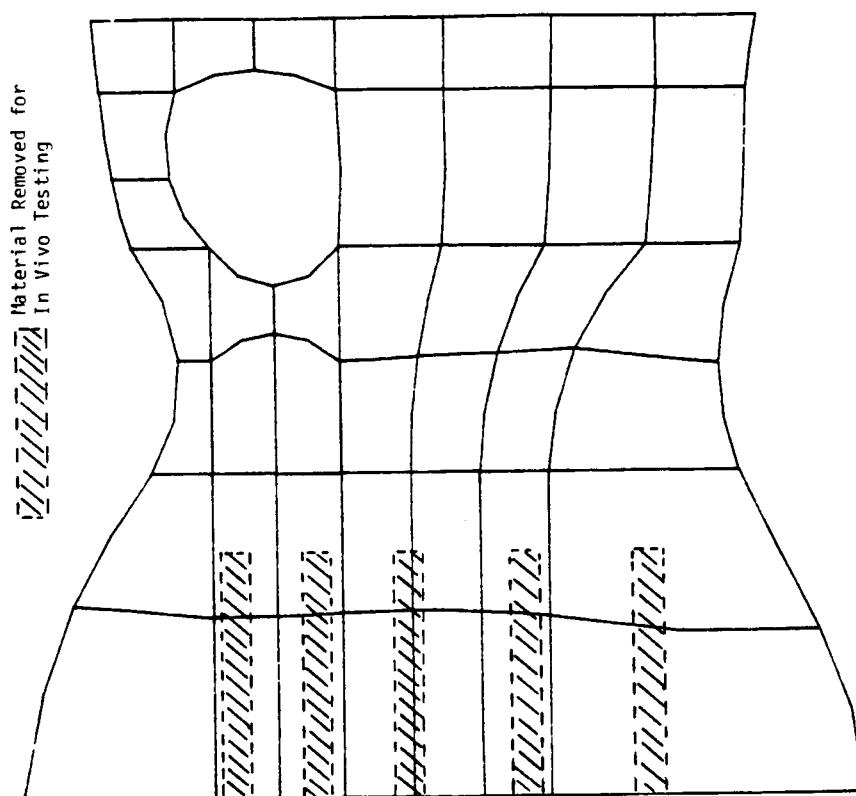


Figure 93. Two-dimensional view of the symmetric quadrilateral mesh showing the areas removed from the polypropylene jacket for in vivo testing.

When the experimental loads were applied, it was easily seen that the in vivo modifications were severely influencing the distortion of the jacket. A sample of rotation comparisons between the experimental rotations and analytical rotations can be seen in Table 7. There was very little similarity between the two sets of rotation. As would be expected, the experimental rotations are higher due to the weakness induced by the in vivo modifications on the jacket.

The in vivo modification effects were better defined with a visual representation. A few of the rotation comparisons in Table 7 were listed on a 2-D image of the symmetric quadrilateral mesh (Figure 94). The figure shows that the closer a node was to the in vivo modifications, the greater the difference became between the nodal rotation comparison. The nodes that were the furthest away from the in vivo modifications showed the best correlation between the analytical and experimental rotations.

The best correlation occurred for a few nodes above the breast hole. For these few nodes, the measured rotations were 25-50% of the analytic rotations. The effects of the in vivo modifications were quite severe for this particular experimental rotational measuring procedure.

The experimental rotation results do not invalidate the in vivo testing results. The conditions under which the in vivo testing was conducted were entirely different from the experimental rotation conditions.

TABLE 7

EXPERIMENTAL ROTATIONS COMPARED TO ANALYTICAL ROTATIONS

Node	Experimental Rotation (Degrees)	Analytical Rotation (Degrees)
24	2.25	3.19
25	1.35	2.06
26	1.35	.01
27	.91	.09
29	9.10	1.06
30	8.07	.97
31	6.82	.87
32	5.97	.09
34	3.02	.12
35	1.24	.07
39	6.95	.62
40	10.3	.29
41	10.4	.44
42	8.1	.32
43	6.95	.62
44	1.35	.07
71	5.43	.07
72	7.47	.35
74	6.61	.33
75	8.39	.34
92	4.66	1.41
93	1.57	2.59
95	4.9	2.0
96	1.57	.06
97	.68	.05
98	2.25	.11

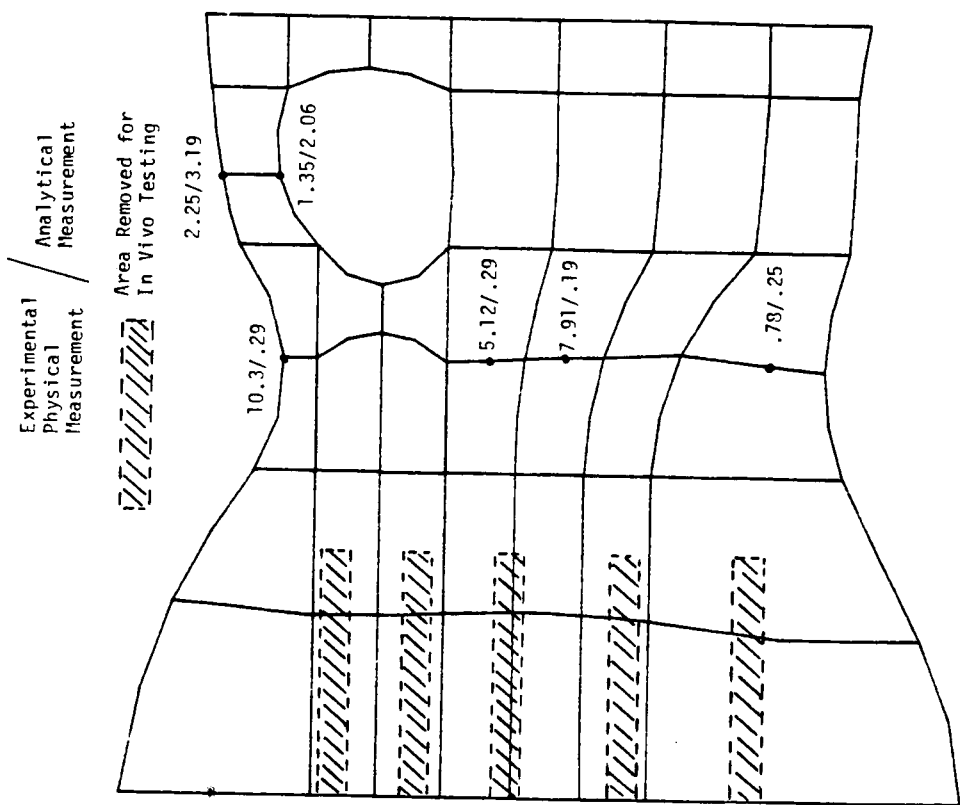


Figure 94. Influence of in vivo modifications to polypropylene jacket on the experimental rotation results.

Internally, the in vivo jacket was supported on nearly 90% of the surface area by the trunk of the human body. The trunk is fairly rigid due to the internal bone structure. This would prevent the jacket from deforming into the shape seen during the experimental rotation testing. This also causes the loading conditions and boundary conditions to be entirely different for the in vivo experiment. There is no basis in which to judge the in vivo results by examining the experimental rotation results.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Boundary conditions derived in Chapter IV were examined with the use of a full quadrilateral finite element model and a symmetric quadrilateral finite element model. Displacements and stresses were compared for evaluation of the validity of the applied boundary conditions. The following points were noted about the comparisons:

1. Visually, the displaced shape of the symmetric model was similar to the displaced shape of the full model (Figure 24, p. 58).
2. Displacement comparisons showed the order of magnitude of displacements were the same for both models.
3. The shape of the individual X-Y plot displacement curves for the symmetric model were similar to their counterpart X-Y plot displacement curves for the full model (see Figures 25 through 36, pp. 59-62, 64-71).
4. All displacements were less than one-half millimeter.
5. Stress comparisons showed the order of magnitude of stresses were the same for both models.
6. The shape of the individual X-Y plot stress curves for the symmetric model were similar to their counterpart X-Y plot

stress curves for the full model (see Figures 37 through 44, pp. 74-81).

7. Comparisons for displacement and stress were mildly poor only for the local area between the breast hole and anterior symmetric boundary line.

Exact numerical matches for displacement and stress were not expected in the comparisons. Boundary conditions were derived for an idealized model. The geometry at the symmetric boundary line of the jacket does not reflect the idealized geometry conditions. Since the comparison did not show drastic differences between the symmetric jacket model and full model, the applied boundary conditions were considered adequate.

The examination of the mesh refinement was considered successful in showing that the quadrilateral mesh was adequate for the analytical model. This examination was performed by using a quadrilateral symmetric finite element model and a triangular symmetric finite element model. Displacements and stresses were compared for evaluation of the quadrilateral symmetric mesh. The following points were noted about the comparisons:

1. Visually, the displaced shape of the quadrilateral model was similar to the displaced shape of the triangular model (Figure 46, p. 85).
2. Displacement comparisons showed the order of magnitude of displacements were the same for both models.
3. The shape of the individual X-Y plot displacement curves of the quadrilateral model were similar to their

counterpart X-Y plot displacement curves for the triangular model (see Figures 47 through 58, pp. 87-94, 96-99).

4. The quadrilateral model consistently had the higher displacement magnitudes.
5. Stress comparisons showed the order of magnitude of stresses were the same for both models.
6. The shape of the individual X-Y plot stress curves for the quadrilateral model were similar to their counterpart X-Y plot stress curves for the triangular model (see Figures 60 through 67, pp. 103-110).
7. Comparisons for displacement and stress were mildly poor only for the local area between the breast hole and anterior symmetric boundary line.

Exact numerical matches for displacement and stress were not expected due to the use of different mesh sizes and element types. Since the comparisons did not show drastic differences between the quadrilateral model and triangular model, the mesh refinement using quadrilateral elements was considered adequate.

The following was noted about the analytical displacements of the symmetric quadrilateral model for the three structural materials:

1. The three structural materials produced a very similar displaced shape (Figure 68, p. 112).
2. Polyethylene always produced the largest displacements.
3. Polypropylene displacements were roughly 50% of the polyethylene displacements.

4. Plaster displacements well less than 10% of the polyethylene displacements.
5. The largest polyethylene displacements were less than 1% of the radius or axial length of the model.
6. The Y and Z components were the major contributors to the nodal displacement vector.
7. The largest displacements for each material occurred near the breast hole and in the superior-posterior extension.

The following was noted about the analytical stresses of the symmetric quadrilateral model for the three structural materials:

1. Stresses in the plaster structural material never exceeded 1 MPa.
2. Stresses in the two thermal plastics exceeded 10 MPa.
3. High stresses occurred near the breast hole and in the superior-posterior extension for all three structural materials.
4. Stress ratios never exceeded 50% for tension or compression (see Table 6, p. 141).

The thermal plastics produced larger displacements (15 mm $\rightarrow$ 7 mm) than the plaster jacket (1.5 mm). Based on that statement only, the thermal plastics would not be adequate replacements for plaster in the construction of the Risser jacket. However, several qualifiers must be taken into account:

1. The loading does reflect a single "real life" loading condition, but does not reflect the overall multiple "real life" loading condition.
2. The experimental in vivo results must also be considered.

Stress ratios showed that none of the structural materials were overstressed. Based on stresses, the thermal plastics would be adequate replacements for plaster in construction of the Risser jacket.

The following points were noted about the in vivo experimental results:

1. The polypropylene jacket equipped with cowhorns provided the best overall vertebral restraint. However, vertebra overtwist existed at the T-11 level and downward and ranged from 0° - 3° .
2. The polypropylene jacket equipped with cowhorns minimized the vertebra overtwist.
3. The plaster jacket without a neckpiece produced overtwist at all vertebra levels, particularly severe at the T-4 level.
4. The plaster jacket with a neckpiece corrected the overtwist at the T-4 level, but still produced overtwist at the T-5 level and downward with a range of 0° - 8° .
5. Both jackets caused the vertebra to move in a semirigid body fashion. With the polyethylene jacket producing the best results.

Based on the in vivo results, the polypropylene jacket was capable of replacing the plaster jacket. The polypropylene jacket

produces less overtwist and caused the vertebra to move in a semirigid body motion. This motion is important because it is the relative motion between the vertebra which dislodges the Harrington rod. Minimizing relative motion causes rigid body motion to occur.

The analytical displacements should not be used to qualify or disqualify the thermal plastics as replacements for plaster. They primarily should be used to evaluate the effect of the loading condition on the geometry of the jacket.

From the displacement results, torsional loading had a negative influence on the area around the breast hole and posterior-superior extension. Since the thermal plastics used a thinner shell thickness, displacements were higher than the plaster structural material. This result was expected and proved by the analytical results. The final conclusion made from the analytical results was that the thermal plastics could replace plaster as the Risser jacket construction material. The thermal plastics produced a displacement pattern that was similar to the plaster displacement pattern.

The experimental validation of the analytical rotations was not completely successful. However, important information was derived from the results. The extensive in vivo modifications severely weakened the polypropylene jacket. This was shown by the large rotations seen in the LLM results (Figure 94, p. 152). This means that any modification done to a Risser jacket should be thoroughly researched before implementation. Although the modifications did not affect the in vivo results, other similar modifications could.

The experimental validation results do not disqualify the *in vivo* testing results. The experiments were carried out under completely different test environments.

B. RECOMMENDATIONS

This study has opened many possibilities for further research into the replacement of the plaster Risser jacket with a thermal plastic Risser jacket. The improvements in this study occur in the analytical area and experimental area.

The first step in the analytical area would be to improve the boundary conditions. This could be done by including an axial term in the dependent generalized constraint equation. The axial term would eliminate the need for opposite boundary line nodes to have the same axial component.

The number of different loading conditions could be increased. These loads could be applied separately or in combinations. Some of the new loadings would be internal pressure, bending, and tension or compression.

Mesh refinement would be a secondary improvement. The current mesh is adequate for most analytical requirements. A finer mesh would possibly be required for single in-depth studies of a particularly complicated loading environment.

Several improvements could be incorporated into the experimental analysis. Experimental validation results should be performed prior to *in vivo* modifications. These irreversible modifications make validation

experiments difficult to execute. The experimental validation should employ both thermal plastics and, if possible, a plaster jacket.

The in vivo testing needs to be performed on several individuals using several structural materials. Overtwist of the lower vertebra might be prevented by the use of leg straps on the inferior end of the jackets. In vivo testing would confirm the results.

Another area of concern is the effect the in vivo modifications have on the in vivo results. This could be investigated with an analytical model, although the model would be complicated.

There are many new avenues of investigation opened up by this study. Each one is equally important and should be evaluated as to the feasibility of follow-up research.

REFERENCES

REFERENCES

1. A. A. White III and M. M. Panjabi, Clinical Biomechanics of the Spine, J. B. Lippincott Company, Philadelphia, 1978.
2. C. L. Nash, Jr., "Current Concepts Review: Scoliosis Bracing," The Journal of Bone and Joint Surgery, Vol. 62-A, No. 5, July 1980.
3. D. S. Bradford, J. H. Moe, and R. B. Winter, The Spine, Vol. I, Chap. 6, W. B. Saunders Company, Philadelphia, 1975.
4. J. C. Risser, "Scoliosis: Past and Present, an Instructional Course Letter," The American Academy of Orthopaedic Surgeons, Vol. 46-A, No. 1, January 1964.
5. J. C. Risser and D. M. Norquist, "A Follow-Up Study on the Treatment of Scoliosis," The Journal of Bone and Joint Surgery, Vol. 40-A, No. 3, June 1955.
6. E. B. Carpenter and R. H. Fisher, "One Stage Plaster Correction of Scoliosis Following Spine Fusion," The Journal of Bone and Joint Surgery, Vol. 37-A, No. 3, June 1955.
7. P. R. Harrington, "Treatment of Scoliosis," The Journal of Bone and Joint Surgery, Vol. 44-A, No. 4, June 1962.
8. J. M. Tamborino, E. N. Armbrust, and J. H. Moe, "Harrington Instrumentation in Correction of Scoliosis, a Comparison with Cast Correction," The Journal of Bone and Joint Surgery, Vol. 46-A, No. 2, March 1964.
9. J. H. Dickson and P. R. Harrington, "The Evolution of the Harrington Instrumentation Techniques in Scoliosis," The Journal of Bone and Joint Surgery, Vol. 55-A, No. 5, July 1973.
10. J. C. Risser, C. H. Lauder, D. M. Norquist, and W. A. Craig, "The Spine," "Instructional Course Letters: Three Types of Body Casts," American Academy of Orthopaedic Surgeons, Vol. 10, 1953.
11. L. A. Goldstein, "Results in the Treatment of Scoliosis with Turnbuckle Plaster Cast Correction and Fusion," The Journal of Bone and Joint Surgery, Vol. 41-A, No. 2, March 1959.
12. W. P. Bunnell, G. D. MacEwen, and S. Jayakumar, "The Use of Plastic Jackets in the Non-Operative Treatment of Idiopathic Scoliosis," The Journal of Bone and Joint Surgery, Vol. 62-A, No. 1, January 1980.

13. K. H. Huebner, The Finite Element Method for Engineers, John Wiley and Sons, New York, 1975.
14. J. E. Akin, Application and Implementation of Finite Element Methods, Academic Press, London, 1982.
15. PAFEC 75 Theory and Results, PAFEC Ltd., London, 1975.
16. O. C. Zienkiewicz, The Finite Element Method, Third Edition, McGraw-Hill, London, 1979.
17. PAFEC 75 Data Preparation, PAFEC Ltd., London, 1975.
18. B. M. Irons, "The Semi-Loof Element," Swansea Report, University College.
19. B. M. Irons, Lecture notes for the International Research Seminar on "The Theory and Application of Finite Element Methods," University of Calgary, Alberta, Canada, 1973.
20. J. F. Wasserman and M. J. McNamee, "Engineering Evaluation of Lumbo-Sacral Orthoses Using In Vivo Noninvasive Testing," 10th Southeast Conference of Theoretical and Applied Mechanics, The University of Tennessee, Knoxville, 1980.

APPENDICES

APPENDIX A

DATA UNITS

<u>Physical Quantity</u>	<u>SI Designation</u>	<u>Abbreviation</u>
Length	meter	M
	centimeter	cm
		100 cm = 1 M
	millimeter	mm
		1000 mm = 1 M
Time	second	s
Mass	kilogram	kg
Force	Newton	N
		$1 \text{ N} = \frac{1 \text{ kg} \cdot \text{m}}{\text{s}}$
Stress	Pascal	P
		$1 \text{ P} = \text{N/m}^2$
	megapascal	MPa
		$1 \text{ MPa} = 1.0 \times 10^6 \text{ P}$

APPENDIX B

PAFEC DATA DECKS

Data Deck for Full Semi-Loof Quadrilateral Mesh

```

CONTROL
FULL.CONTROL
NAME.MIR1
PHASE=7
PHASE=8
SAVE.RESULTS
CONTROL.END
CONTROL
FULL.CONTROL
NAME.MIR1
PHASE=1
PHASE=3
SAVE.RESULTS
PHASE=4
PHASE=5
SAVE.RESULTS
PHASE=6
PHASE=7
SAVE
PHASE=8
SAVE.RESULTS
CONTROL.END

```

```

C ALL NODES MUST BE GIVEN, GENERATED NODES CANNOT
C BE MIRRCRED

```

```

TITLE PLASTER RISSE CAST, FULL MESH CHECK

```

```

NODES

```

NODE	X	Y	Z
1	.1047	.1079	
2	.1343	.1170	
3	.1651	.1206	
4	.2238	.1240	
5	.2825	.1254	
6	.3998	.1116	
7	.5143	.0825	
8	.5518	.0702	
9	.5889	.0565	
10	.1071	.1099	.0167
11	.1651	.1250	.0193
12	.2825	.1282	.0203
13	.5143	.0830	.0131
14	.5839	.0589	.0087
15	.1100	.1090	.0333
16	.1374	.1185	.0363
17	.1651	.1275	.0390
18	.2239	.1316	.0280
19	.2825	.1321	.0404
20	.3985	.1090	.0333
21	.5143	.0851	.0260
22	.5468	.0716	.0219
23	.5800	.0596	.0182
24	.1180	.1050	.0791
25	.1601	.1175	.0887
26	.2857	.1195	.0843
27	.5093	.0825	.0662
28	.5774	.0605	.0497
29	.1317	.0917	.1217
30	.1603	.0919	.1220
31	.1889	.0921	.1222
32	.2355	.0700	.1316
33	.2825	.0895	.1188

34	.3938	.0855	.1134
35	.5050	.0802	.1065
36	.5386	.0690	.0916
37	.5747	.0611	.0811
38	.1889	.0620	.1388
39	.2825	.0584	.1309
40	.1650	.0306	.1550
41	.1889	.0290	.1486
42	.2357	.0428	.1389
43	.2825	.0260	.1390
44	.4520	.0336	.1448
45	.5571	.0260	.1567
46	.1889	-.0053	.1518
47	.2825	-.0066	.1460
48	.1450	-.0435	.1625
49	.1668	-.0414	.1546
50	.1889	-.0394	.1472
51	.2357	-.0398	.1484
52	.2825	-.0399	.1489
53	.3571	-.0414	.1545
54	.4318	-.0427	.1595
55	.5020	-.0465	.1735
56	.5715	-.0509	.1901
57	.0865	-.0973	.0959
58	.1889	-.0870	.0775
59	.2825	-.0862	.0790
60	.4318	-.0955	.0844
61	.6290	-.1970	.1528
62	.0492	-.1095	
63	.1191	-.1150	
64	.1889	-.1206	
65	.2358	-.1190	
66	.2825	-.1143	
67	.3578	-.1175	
68	.4318	-.1315	
69	.5390	-.2000	
70	.6604	-.2381	
71	.2618	.0747	.1277
72	.2604	.0381	.1377
73	.2355	.0567	.1365
74	.2094	.0762	.1296
75	.2110	.0396	.1427
76	.2531	.1249	
77	.2538	.1323	.0313
78	.2238	.1280	.0139
79	.1944	.1225	
80	.1939	.1299	.0306
81	.4766	.0939	
82	.4757	.0932	.0285
83	.4384	.1036	
84	.4378	.1016	.0155
85	.4371	.1011	.0309
86	.3609	.1179	
87	.3604	.1167	.0179
88	.3598	.1168	.0357
89	.3218	.1225	
90	.3212	.1245	.0381
91	.1580	.1251	.0639
92	.1710	.1058	.1093
93	.1390	.1114	.0840

94	.1133	.1082	.0565
95	.1242	.0995	.1010
96	.4680	.0821	.1090
97	.4348	.0953	.0726
98	.4309	.0838	.1113
99	.3603	.1076	.0787
100	.3567	.0869	.1154
101	.3196	.0883	.1172
102	.1889	-.0053	.1515
103	.1769	.0298	.1517
104	.1544	.0657	.1406
105	.1617	-.0079	.1627
106	.2591	-.0399	.1487
107	.2357	.0016	.1467
108	.2123	-.0396	.1479
109	.4755	.0621	.1278
110	.4370	-.0026	.1557
111	.4238	.0325	.1442
112	.4069	-.0423	.1579
113	.4112	.0612	.1292
114	.3956	.0313	.1434
115	.3855	-.0039	.1527
116	.3820	-.0419	.1563
117	.3673	.0301	.1425
118	.3469	.0599	.1300
119	.3390	.0288	.1414
120	.3340	-.0053	.1492
121	.3322	-.0409	.1528
122	.3108	.0274	.1403
123	.3074	-.0404	.1509
124	.2825	.0581	.1301
125	.2825	-.0068	.1453
126	.5621	.0511	.1215
127	.5604	-.0099	.1808
128	.5041	.0291	.1490
129	.1889	-.0649	.1135
130	.1889	-.1056	.0395
131	.1377	-.0921	.0865
132	.1140	-.0749	.1343
133	.0644	-.1091	.0500
134	.2825	-.0652	.1154
135	.2825	-.1027	.0404
136	.2591	-.0870	.0787
137	.2592	-.1170	
138	.2357	-.0655	.1147
139	.2357	-.0874	.0784
140	.2358	-.1053	.0400
141	.2123	-.0874	.0780
142	.2124	-.1202	
143	.4318	-.0711	.1233
144	.4318	-.1157	.0432
145	.4071	-.0925	.0836
146	.4074	-.1257	
147	.3822	-.0680	.1209
148	.3823	-.0901	.0828
149	.3825	-.1078	.0423
150	.3827	-.1210	
151	.3574	-.0882	.0819
152	.3324	-.0660	.1183
153	.3325	-.0870	.0810

154 .3326 -.1035 .0414
 155 .3327 -.1152
 156 .3075 -.0863 .0800
 157 .3076 -.1142
 158 .6000 -.1293 .1919
 159 .6510 -.2367 .0828
 160 .5270 -.1537 .1180

C

C ALL ELEMENTS MUST BE DEFINED, GENERATED

C ELEMENTS CANNOT BE MIRRORED

ELEMENTS

C THIS IS THE SEMI-LOOP ELEMENT

ELEMENT=43210

GROUP=1

PROPERTIES=1

NUMBER	TOPOLOGY
1	33 43 32 42 39 71 72 73
2	32 42 31 41 73 74 75 38
3	3 17 1 15 11 2 16 10
4	5 19 4 18 12 76 77 78
5	4 18 3 17 78 79 80 11
6	7 21 83 85 13 81 82 84
7	83 85 86 88 84 6 20 87
8	86 88 5 19 87 89 90 12
9	9 23 7 21 14 8 22 13
10	17 25 15 24 91 16 93 94
11	25 31 24 29 92 93 30 95
12	21 35 85 98 27 82 96 97
13	85 98 88 100 97 20 34 99
14	88 100 19 33 99 90 101 26
15	23 37 21 35 28 22 36 27
16	31 41 29 40 38 30 103 104
17	41 50 40 48 102 103 49 105
18	43 52 42 51 47 72 106 107
19	42 51 41 50 107 75 108 46
20	35 44 98 114 109 96 111 113
21	44 54 114 116 110 111 112 115
22	98 114 100 119 113 34 117 118
23	114 116 119 121 115 117 53 120
24	100 119 33 43 118 101 122 124
25	119 121 43 52 120 122 123 125
26	37 45 35 44 126 36 128 109
27	45 56 44 54 127 128 55 110
28	50 58 48 57 129 49 131 132
29	58 64 57 62 130 131 63 133
30	52 59 51 139 134 106 136 138
31	59 66 139 65 135 136 137 140
32	51 139 50 58 138 108 141 129
33	139 65 58 64 140 141 142 130
34	54 60 116 148 143 112 145 147
35	60 68 148 150 144 145 146 149
36	116 148 121 153 147 53 151 152
37	148 150 153 155 149 151 67 154
38	121 153 52 59 152 123 156 134
39	153 155 59 66 154 156 157 135
40	56 61 54 60 158 55 160 143
41	61 70 60 68 159 160 69 144

C

C MIRROR THE NODES

C


```

SIMILIAR.NODES
ORIGINAL.NODE=1
NUMBER.OF.NODES=160
COPY.NODE      AXIS.OF.NEW.NODES
161           5
C
C MIRROR THE ELEMENTS
GROUP.OF.SIMILIAR.ELEMENTS
OLD=1
NUMBER=41
NEW  GROUP.NEW  TOPOLOGY.INCREMENTS
42   2          160
C
C MATERIAL IS PLASTER
PLATES.AND.SHELLS
PLATE.# MATERIAL THICKNESS.IN.METERS
1      11      .009525
MATERIALS
MATERIAL.#  E.N/M2  NU
11          2.17E9 .2
C
C ALL POSTERIOR END NODES ARE FULLY
C RESTAINED, INCLUDING THE MIRRORED
C NODES
C
ENCASTRE
LIST
9
14
23
28
37
45
56
61
70
169
174
183
188
197
205
216
221
230
C
C FULL LOADING APPLIED
LOADS
NODE  DIRECTION VALUE
1      3      -111.2
62     3      111.2
END.OF.DATA

```

Data Deck for Symmetric Triangular Element 44100 Mesh

```

CONTROL
FULL CONTROL
NAME.TES2
FAST.READ
SKIP.CHECK
PHASE=1
PHASE=2
SAVE.RESULTS
PHASE=4
SAVE
PHASE=6
BASE=40000
PHASE=7
BASE=40000
SAVE
PHASE=8
BASE=40000
SAVE.RESULTS
PHASE=9
BASE=40000
PHASE=10
BASE=40000
SAVE.RESULTS
CONTROL.END
TITLE PLASTER RISSE CAST, DISPLACEMENTS
NODES

```

NODE	X	Y	Z
1	.1047	.1079	
2	.1343	.1170	
3	.1651	.1206	
4	.2238	.1240	
5	.2825	.1254	
6	.3998	.1116	
7	.5143	.0825	
8	.5518	.0702	
9	.5889	.0565	
10	.1071	.1099	.0167
11	.1651	.1250	.0193
12	.2825	.1282	.0203
13	.5143	.0830	.0131
14	.5839	.0589	.0087
15	.1100	.1090	.0333
16	.1374	.1185	.0363
17	.1651	.1275	.0390
18	.2239	.1316	.0280
19	.2825	.1321	.0404
20	.3985	.1090	.0333
21	.5143	.0851	.0260
22	.5468	.0716	.0219
23	.5800	.0596	.0182
24	.1180	.1050	.0791
25	.1601	.1175	.0887
26	.2857	.1195	.0843
27	.5093	.0825	.0662
28	.5774	.0605	.0497
29	.1317	.0917	.1217
30	.1603	.0919	.1220
31	.1889	.0921	.1222
32	.2355	.0700	.1316
33	.2825	.0895	.1188

34	.3938	.0855	.1134
35	.5050	.0802	.1065
36	.5386	.0690	.0916
37	.5747	.0611	.0811
38	.1889	.0620	.1388
39	.2825	.0584	.1309
40	.1650	.0306	.1550
41	.1889	.0290	.1486
42	.2357	.0428	.1389
43	.2825	.0260	.1390
44	.4520	.0336	.1448
45	.5571	.0260	.1567
46	.1889	-.0053	.1518
47	.2825	-.0066	.1460
48	.1450	-.0435	.1625
49	.1668	-.0414	.1546
50	.1889	-.0394	.1472
51	.2357	-.0398	.1484
52	.2825	-.0399	.1489
53	.3571	-.0414	.1545
54	.4318	-.0427	.1595
55	.5020	-.0465	.1735
56	.5715	-.0509	.1901
57	.0865	-.0973	.0959
58	.1889	-.0870	.0775
59	.2825	-.0862	.0790
60	.4318	-.0955	.0844
61	.6290	-.1970	.1528
62	.0492	-.1095	
63	.1191	-.1150	
64	.1889	-.1206	
65	.2358	-.1190	
66	.2825	-.1143	
67	.3578	-.1175	
68	.4318	-.1315	
69	.5390	-.2000	
70	.6604	-.2381	
71	.2618	.0747	.1277
72	.2604	.0381	.1377
73	.2355	.0567	.1365
74	.2094	.0762	.1296
75	.2110	.0396	.1427
76	.2531	.1249	
77	.2538	.1323	.0313
78	.2238	.1280	.0139
79	.1944	.1225	
80	.1939	.1299	.0306
81	.4766	.0939	
82	.4757	.0932	.0285
83	.4384	.1036	
84	.4378	.1016	.0155
85	.4371	.1011	.0309
86	.3609	.1179	
87	.3604	.1167	.0179
88	.3598	.1168	.0357
89	.3218	.1225	
90	.3212	.1245	.0381
91	.1580	.1251	.0639
92	.1710	.1058	.1093
93	.1390	.1114	.0840

94	.1133	.1082	.0565
95	.1242	.0995	.1010
96	.4680	.0821	.1090
97	.4348	.0953	.0726
98	.4309	.0838	.1113
99	.3603	.1076	.0787
100	.3567	.0869	.1154
101	.3196	.0883	.1172
102	.1889	-.0053	.1515
103	.1769	.0298	.1517
104	.1544	.0657	.1406
105	.1617	-.0079	.1627
106	.2591	-.0399	.1487
107	.2357	.0016	.1467
108	.2123	-.0396	.1479
109	.4755	.0621	.1278
110	.4370	-.0026	.1557
111	.4238	.0325	.1442
112	.4069	-.0423	.1579
113	.4112	.0612	.1292
114	.3956	.0313	.1434
115	.3855	-.0039	.1527
116	.3820	-.0419	.1563
117	.3673	.0301	.1425
118	.3469	.0599	.1300
119	.3390	.0288	.1414
120	.3340	-.0053	.1492
121	.3322	-.0409	.1528
122	.3108	.0274	.1403
123	.3074	-.0404	.1509
124	.2825	.0581	.1301
125	.2825	-.0068	.1453
126	.5621	.0511	.1215
127	.5604	-.0099	.1808
128	.5041	.0291	.1490
129	.1889	-.0649	.1135
130	.1889	-.1056	.0395
131	.1377	-.0921	.0865
132	.1140	-.0749	.1343
133	.0644	-.1091	.0500
134	.2825	-.0652	.1154
135	.2825	-.1027	.0404
136	.2591	-.0870	.0787
137	.2592	-.1170	
138	.2357	-.0655	.1147
139	.2357	-.0874	.0784
140	.2358	-.1053	.0400
141	.2123	-.0874	.0780
142	.2124	-.1202	
143	.4318	-.0711	.1233
144	.4318	-.1157	.0432
145	.4071	-.0925	.0836
146	.4074	-.1257	
147	.3822	-.0680	.1209
148	.3823	-.0901	.0828
149	.3825	-.1078	.0423
150	.3827	-.1210	
151	.3574	-.0882	.0819
152	.3324	-.0660	.1183
153	.3325	-.0870	.0810

154 .3326 -.1035 .0414
 155 .3327 -.1152
 156 .3075 -.0863 .0800
 157 .3076 -.1142
 158 .6000 -.1293 .1919
 159 .6510 -.2367 .0828
 160 .5270 -.1537 .1180

PAFBLOCKS

TYPE=1

C THIS ELEMENT ACCURATE FOR DISPLACEMENTS

ELEMENT=44100

GROUP=1

N1=1

N2=2

PROPERTIES=1

BLOCK

TOPOLOGY

1	33 43 32 42 39 71 72 73
2	32 42 31 41 73 74 75 38
3	3 17 1 15 11 2 16 10
4	5 19 4 18 12 76 77 78
5	4 18 3 17 78 79 80 11
6	7 21 83 85 13 81 82 84
7	83 85 86 88 84 6 20 87
8	86 88 5 19 87 89 90 12
9	9 23 7 21 14 8 22 13
10	17 25 15 24 91 16 93 94
11	25 31 24 29 92 93 30 95
12	21 35 85 98 27 82 96 97
13	85 98 88 100 97 20 34 99
14	88 100 19 33 99 90 101 26
15	23 37 21 35 28 22 36 27
16	31 41 29 40 38 30 103 104
17	41 50 40 48 102 103 49 105
18	43 52 42 51 47 72 106 107
19	42 51 41 50 107 75 108 46
20	35 44 98 114 109 96 111 113
21	44 54 114 116 110 111 112 115
22	98 114 100 119 113 34 117 118
23	114 116 119 121 115 117 53 120
24	100 119 33 43 118 101 122 124
25	119 121 43 52 120 122 123 125
26	37 45 35 44 126 36 128 109
27	45 56 44 54 127 128 55 110
28	50 58 48 57 129 49 131 132
29	58 64 57 62 130 131 63 133
30	52 59 51 139 134 106 136 138
31	59 66 139 65 135 136 137 140
32	51 139 50 58 138 108 141 129
33	139 65 58 64 140 141 142 130
34	54 60 116 148 143 112 145 147
35	60 68 148 150 144 145 146 149
36	116 148 121 153 147 53 151 152
37	148 150 153 155 149 151 67 154
38	121 153 52 59 152 123 156 134
39	153 155 59 66 154 156 157 135
40	56 61 54 60 158 55 160 143
41	61 70 60 68 159 160 69 144

MESH

REFERENCE SPACING

1

2

2 2
 PLATES.AND.SHELLS
 PLATE.# MATERIAL THICKNESS
 1 11 .009525
 MATERIALS
 MATERIAL.# E.N/M2 NU
 11 2.17E9 .2

ENCASTRE

LIST

9
 14
 23
 28
 37
 45
 56
 61
 70

GENERALISED.CONSTRAINTS

NODE DIRECTION LIST

2	2	63,2,-1
63	3	2,3,-1
79	2	142,2,-1
142	3	79,3,-1
76	2	137,2,-1
137	3	76,3,-1
89	2	157,2,-1
157	3	89,3,-1
6	2	67,2,-1
67	3	6,3,-1
81	2	146,2,-1
146	3	81,3,-1
8	2	69,2,-1
69	3	8,3,-1
1	2	62,2,-1
62	3	1,3,-1
3	2	64,2,-1
64	3	3,3,-1
4	2	65,2,-1
65	3	4,3,-1
5	2	66,2,-1
66	3	5,3,-1
86	2	155,2,-1
155	3	86,3,-1
83	2	150,2,-1
150	3	83,3,-1
7	2	68,2,-1
68	3	7,3,-1

REPEATED.FREEDOMS

PLANE=0

DIRECTION=1456

N1	N2
63	2
142	79
137	76
157	89
67	6
146	81
69	8
62	1

64 3
65 4
66 5
155 86
150 83
68 7
LOADS
NODE DIRECTION VALUE
1 3 -55.6
62 3 55.6
OUT.DRAW
PLOT.TYPE
20
1
21
22
IN.DRAW
TYPE.NUMBER INFO
2 3
2 0
END.OF.DATA

Data Deck for Symmetric Triangular Element 41320 Mesh

```

CONTROL
FULL.CONTROL
NAME.TES1
FAST.READ
SKIP.CHECK
PHASE=1
BASE=30000
PHASE=3
BASE=30000
SAVE
PHASE=4
BASE=30000
SAVE.RESULTS
SAVE.FILES
CONTROL.END
TITLE PLASTER RISSEK CAST, STRESSES
NODES

```

NODE	X	Y	Z
1	.1047	.1079	
2	.1343	.1170	
3	.1651	.1206	
4	.2238	.1240	
5	.2825	.1254	
6	.3998	.1116	
7	.5143	.0825	
8	.5518	.0702	
9	.5889	.0565	
10	.1071	.1099	.0167
11	.1651	.1250	.0193
12	.2825	.1282	.0203
13	.5143	.0830	.0131
14	.5839	.0589	.0087
15	.1100	.1090	.0333
16	.1374	.1185	.0363
17	.1651	.1275	.0390
18	.2239	.1316	.0280
19	.2825	.1321	.0404
20	.3985	.1090	.0333
21	.5143	.0851	.0260
22	.5468	.0716	.0219
23	.5800	.0596	.0182
24	.1180	.1050	.0791
25	.1601	.1175	.0887
26	.2857	.1195	.0843
27	.5093	.0825	.0662
28	.5774	.0605	.0497
29	.1317	.0917	.1217
30	.1603	.0919	.1220
31	.1889	.0921	.1222
32	.2355	.0700	.1316
33	.2825	.0895	.1188
34	.3938	.0855	.1134
35	.5050	.0802	.1065
36	.5386	.0690	.0916
37	.5747	.0611	.0811
38	.1889	.0620	.1388
39	.2825	.0584	.1309
40	.1650	.0306	.1550
41	.1889	.0290	.1486
42	.2357	.0428	.1389

43	.2825	.0260	.1390
44	.4520	.0336	.1448
45	.5571	.0260	.1567
46	.1889	-.0053	.1518
47	.2825	-.0066	.1460
48	.1450	-.0435	.1625
49	.1668	-.0414	.1546
50	.1889	-.0394	.1472
51	.2357	-.0398	.1484
52	.2825	-.0399	.1489
53	.3571	-.0414	.1545
54	.4318	-.0427	.1595
55	.5020	-.0465	.1735
56	.5715	-.0509	.1901
57	.0865	-.0973	.0959
58	.1889	-.0870	.0775
59	.2825	-.0862	.0790
60	.4318	-.0955	.0844
61	.6290	-.1970	.1528
62	.0492	-.1095	
63	.1191	-.1150	
64	.1889	-.1206	
65	.2358	-.1190	
66	.2825	-.1143	
67	.3578	-.1175	
68	.4318	-.1315	
69	.5390	-.2000	
70	.6604	-.2381	
71	.2618	.0747	.1277
72	.2604	.0381	.1377
73	.2355	.0567	.1365
74	.2094	.0762	.1296
75	.2110	.0396	.1427
76	.2531	.1249	
77	.2538	.1323	.0313
78	.2238	.1280	.0139
79	.1944	.1225	
80	.1939	.1299	.0306
81	.4766	.0939	
82	.4757	.0932	.0285
83	.4384	.1036	
84	.4378	.1016	.0155
85	.4371	.1011	.0309
86	.3609	.1179	
87	.3604	.1167	.0179
88	.3598	.1168	.0357
89	.3218	.1225	
90	.3212	.1245	.0381
91	.1580	.1251	.0639
92	.1710	.1058	.1093
93	.1390	.1114	.0840
94	.1133	.1082	.0565
95	.1242	.0995	.1010
96	.4680	.0821	.1090
97	.4348	.0953	.0726
98	.4309	.0838	.1113
99	.3603	.1076	.0787
100	.3567	.0869	.1154
101	.3196	.0883	.1172
102	.1889	-.0053	.1515

103	.1769	.0298	.1517
104	.1544	.0657	.1406
105	.1617	-.0079	.1627
106	.2591	-.0399	.1487
107	.2357	.0016	.1467
108	.2123	-.0396	.1479
109	.4755	.0621	.1278
110	.4370	-.0026	.1557
111	.4238	.0325	.1442
112	.4069	-.0423	.1579
113	.4112	.0612	.1292
114	.3956	.0313	.1434
115	.3855	-.0039	.1527
116	.3820	-.0419	.1563
117	.3673	.0301	.1425
118	.3469	.0599	.1300
119	.3390	.0288	.1414
120	.3340	-.0053	.1492
121	.3322	-.0409	.1528
122	.3108	.0274	.1403
123	.3074	-.0404	.1509
124	.2825	.0581	.1301
125	.2825	-.0068	.1453
126	.5621	.0511	.1215
127	.5604	-.0099	.1808
128	.5041	.0291	.1490
129	.1889	-.0649	.1135
130	.1889	-.1056	.0395
131	.1377	-.0921	.0865
132	.1140	-.0749	.1343
133	.0644	-.1091	.0500
134	.2825	-.0652	.1154
135	.2825	-.1027	.0404
136	.2591	-.0870	.0787
137	.2592	-.1170	
138	.2357	-.0655	.1147
139	.2357	-.0874	.0784
140	.2358	-.1053	.0400
141	.2123	-.0874	.0780
142	.2124	-.1202	
143	.4318	-.0711	.1233
144	.4318	-.1157	.0432
145	.4071	-.0925	.0836
146	.4074	-.1257	
147	.3822	-.0680	.1209
148	.3823	-.0901	.0828
149	.3825	-.1078	.0423
150	.3827	-.1210	
151	.3574	-.0882	.0819
152	.3324	-.0660	.1183
153	.3325	-.0870	.0810
154	.3326	-.1035	.0414
155	.3327	-.1152	
156	.3075	-.0863	.0800
157	.3076	-.1142	
158	.6000	-.1293	.1919
159	.6510	-.2367	.0828
160	.5270	-.1537	.1180

PAFBLGCKS

TYPE=1

C THIS ELEMENT ACCURATE FOR STRESSES
ELEMENT=41320

GROUP=1

N1=1

N2=2

PROPERTIES=1

BLOCK	TOPOLOGY
1	33 43 32 42 39 71 72 73
2	32 42 31 41 73 74 75 38
3	3 17 1 15 11 2 16 10
4	5 19 4 18 12 76 77 78
5	4 18 3 17 78 79 80 11
6	7 21 83 85 13 81 82 84
7	83 85 86 88 84 6 20 87
8	86 88 5 19 87 89 90 12
9	9 23 7 21 14 8 22 13
10	17 25 15 24 91 16 93 94
11	25 31 24 29 92 93 30 95
12	21 35 85 98 27 82 96 97
13	85 98 88 100 97 20 34 99
14	88 100 19 33 99 90 101 26
15	23 37 21 35 28 22 36 27
16	31 41 29 40 38 30 103 104
17	41 50 40 48 102 103 49 105
18	43 52 42 51 47 72 106 107
19	42 51 41 50 107 75 108 46
20	35 44 98 114 109 96 111 113
21	44 54 114 116 110 111 112 115
22	98 114 100 119 113 34 117 118
23	114 116 119 121 115 117 53 120
24	100 119 33 43 118 101 122 124
25	119 121 43 52 120 122 123 125
26	37 45 35 44 126 36 128 109
27	45 56 44 54 127 128 55 110
28	50 58 48 57 129 49 131 132
29	58 64 57 62 130 131 63 133
30	52 59 51 139 134 106 136 138
31	59 66 139 65 135 136 137 140
32	51 139 50 58 138 108 141 129
33	139 65 58 64 140 141 142 130
34	54 60 116 148 143 112 145 147
35	60 68 148 150 144 145 146 149
36	116 148 121 153 147 53 151 152
37	148 150 153 155 149 151 67 154
38	121 153 52 59 152 123 156 134
39	153 155 59 66 154 156 157 135
40	56 61 54 60 158 55 160 143
41	61 70 60 68 159 160 69 144

MESH

REFERENCE SPACING

1	2
2	2

PLATES AND SHELLS

PLATE.#	MATERIAL	THICKNESS
1	11	.009525

MATERIALS

MATERIAL.#	E.N/P2	NU
11	2.17E9	.2

ENCASTRE

LIST

```

9
14
23
28
37
45
56
61
70
GENERALISED.CONSTRAINTS
NODE DIRECTION LIST
  2      2      63,2,-1
 63      3      2,3,-1
 79      2      142,2,-1
142      3      79,3,-1
 76      2      137,2,-1
137      3      76,3,-1
 89      2      157,2,-1
157      3      89,3,-1
  6      2      67,2,-1
 67      3      6,3,-1
 81      2      146,2,-1
146      3      81,3,-1
  8      2      69,2,-1
 69      3      8,3,-1
  1      2      62,2,-1
 62      3      1,3,-1
  3      2      64,2,-1
 64      3      3,3,-1
  4      2      65,2,-1
 65      3      4,3,-1
  5      2      66,2,-1
 66      3      5,3,-1
 86      2      155,2,-1
155      3      86,3,-1
 83      2      150,2,-1
150      3      83,3,-1
  7      2      68,2,-1
 68      3      7,3,-1
REPEATED.FREEDOMS
PLANE=0
DIRECTION=1456
N1      N2
 63      2
142      79
137      76
157      89
 67      6
146      81
 69      8
 62      1
 64      3
 65      4
 66      5
155      86
150      83
 68      7
LOADS
NODE      DIRECTION VALUE
  1          3      -55.6
 62          3       55.6
OUT.DRAW
PLOT.TYPE      ORIEN
  1          4
IN.DRAW
TYPE      INFO      ORIEN
  2      0      4
  4      0      4
  3      0      4
END.OF.DATA

```

Data Deck for Symmetric Quadrilateral Mesh

Structural Material: Polyethylene

SYSTEM LEVEL 3.4
JUNE 1981

						777777	555555
						77	7 55
PPPPP	AAAAA	FFFFF	EEEE	CCCCC	77	7	55
P P	A A	FF	E	C CC	77	7	55
P P	A A	FF	E	C		7	55
PPPPP	AAAAA	FFF	EEE	C	777	555555	
PP	AA	A F	EE	C		7	5
PP	AA	A F	EE	C		7	5
PP	AA	A F	EE	C		7	5
PP	AA	A F	EEEE	CCCCC		7	5
						7	5 5
						7	555555

*
* PHASE NUMBER 1 STARTS HERE
*

```
( 1) CONTROL
( 2) NAME.RIS1
( 3) FULL.CONTROL
( 4) LARGE.DISPLACEMENTS
( 5) PHASE=1
( 6) PHASE=2
( 7) PHASE=4
( 8) SAVE.RESULTS
( 9) PHASE=6
(10) SAVE.RESULTS
(11) PHASE=7
(12) SAVE
(13) CONTROL.END
(14) C
(15) TITLE POLYETHYLENE KISSER CAST STRUCTURAL ANALYSIS
-----
(16) C
(17) C COORDINATES OF THE NODES IN RIGHT HANDED CYLINDRICAL AXES
(18) C HALF SYMMETRY MODEL USED
(19) C X.AXIAL AND Y.RADIAL ARE IN METERS
(20) C Z.ANGLE IS IN DEGREES
(21) NODES
(22) AXIS=2
(23) NODE# X.AXIAL Y.RADIAL Z.ANGLE
(24) 1 .1047 .1079
(25) 2 .1343 .1170
(26) 3 .1651 .1206
(27) 4 .2238 .1240
(28) 5 .2825 .1254
(29) 6 .3998 .1116
(30) 7 .5143 .0825
```


(31)	8	.5518	.0702	
(32)	9	.5689	.0565	
(33)	10	.1071	.1111	8.59
(34)	11	.1651	.1265	8.76
(35)	12	.2825	.1298	9.00
(36)	13	.5143	.0840	8.97
(37)	14	.5839	.0595	8.40
(38)	15	.1100	.1140	17
(39)	16	.1375	.1240	17.03
(40)	17	.1651	.1333	17
(41)	18	.2238	.1345	12
(42)	19	.2825	.1381	17
(43)	20	.3984	.1140	17
(44)	21	.5143	.0890	17
(45)	22	.5468	.0749	17.01
(46)	23	.5800	.0623	17
(47)	24	.1180	.1315	36.99
(48)	25	.1601	.1472	37.02
(49)	26	.2857	.1462	35.2
(50)	27	.5093	.1058	38.74
(51)	28	.5774	.0783	39.38
(52)	29	.1317	.1524	53
(53)	30	.1603	.1528	53.01
(54)	31	.1889	.1630	53
(55)	32	.2355	.1490	62
(56)	33	.2825	.1487	53
1				
(57)	34	.3938	.1420	53
(58)	35	.5050	.1333	53
(59)	36	.5386	.1147	53.01
(60)	37	.5747	.1016	53
(61)	38	.1889	.1520	65.93
(62)	39	.2825	.1433	65.95
(63)	40	.1650	.1580	78.83
(64)	41	.1889	.1514	78.96
(65)	42	.2355	.1454	72.89
(66)	43	.2825	.1414	79.40
(67)	44	.4520	.1487	76.97
(68)	45	.5571	.1588	80.57
(69)	46	.1889	.1519	91.99
(70)	47	.2825	.1462	92.60
(71)	48	.1450	.1682	105
(72)	49	.1669	.1600	105
(73)	50	.1889	.1524	105
(74)	51	.2355	.1536	105
(75)	52	.2825	.1542	105
(76)	53	.3571	.1600	105
(77)	54	.4318	.1651	105
(78)	55	.5020	.1796	105
(79)	56	.5715	.1968	105
(80)	57	.0865	.1366	135.41
(81)	58	.1889	.1165	138.32
(82)	59	.2825	.1168	137.78
(83)	60	.4318	.1275	138.53
(84)	61	.6290	.2493	142.2
(85)	62	.0492	.1095	180
(86)	63	.1190	.1150	180
(87)	64	.1889	.1206	180
(88)	65	.2358	.1190	180
(89)	66	.2825	.1143	180

```

( 90) 67 .3577 .1175 180
( 91) 68 .4318 .1315 180
( 92) 69 .5390 .2000 180
( 93) 70 .6604 .2381 180
( 94) C THESE NODES ARE FOR ELEMENTS 1 AND 2
( 95) 71 .2618 .1479 59.67
( 96) 72 .2604 .1429 74.53
( 97) 73 .2355 .1478 67.44
( 98) 74 .2094 .1503 59.55
( 99) 75 .2110 .1481 74.49
(100) C
(101) C
(102) C ELEMENTS MODULE USED TO PRESCRIBE THE
(103) C SEMILOOF CURVATURE FOR THE ELEMENTS
(104) C 1 AND 2 WHICH FORM PART OF THE BOUNDARY
(105) C OF THE BREAST HOLE
(106) ELEMENTS
(107) ELEMENT TYPE=43210
(108) PROPERTIES=1
(109) NUMBER TOPOLOGY
(110) 1 33 43 32 42 39 71 72 73
(111) 2 32 42 31 41 73 74 75 38
(112) C
(113) C
1
(114) PAFBLOCKS
(115) C ELEMENTS ARE SEMILOOF 8 NODE QUADRILATERALS
(116) ELEMENT=43210
(117) TYPE=1
(118) PROPERTIES=1
(119) BLOCK# N1 N2 TOPOLOGY
(120) 1 1 2 3 17 1 15 11 2 16 10
(121) 2 1 4 5 19 3 17 12 4 18 11
(122) 3 1 3 7 21 5 19 13 6 20 12
(123) 4 1 2 9 23 7 21 14 8 22 13
(124) 5 4 2 17 31 15 29 25 16 30 24
(125) 6 1 3 21 35 19 33 27 20 34 26
(126) 7 1 2 23 37 21 35 28 22 36 27
(127) 8 4 2 31 50 29 48 41 30 49 40
(128) 9 1 4 43 52 41 50 47 42 51 46
(129) 10 4 3 35 54 33 52 44 34 53 43
(130) 11 4 2 37 56 35 54 45 36 55 44
(131) 12 4 2 50 64 48 62 58 49 63 57
(132) 13 4 4 52 66 50 64 59 51 65 58
(133) 14 4 3 54 68 52 66 60 53 67 59
(134) 15 4 2 56 70 54 66 61 55 69 60
(135) MESH
(136) REFERENCE SPACING
(137) 1 1
(138) 2 1
(139) 3 3
(140) 4 2
(141) C
(142) C
(143) PLATES AND SHELLS
(144) PLATE# MATERIAL THICKNESS IN METERS
(145) 1 11 .003175
(146) MATERIALS
(147) C PROPERTIES FOR POLYETHYLENE
(148) MATERIAL# E.N/M2 NU

```

```

( 149)      11      4.3E8      .4
( 150) C
( 151) C
( 152) C NODES ALONG THE POSTERIOR END OF THE CAST HAVE
( 153) C ALL DEGREES OF FREEDOM RESTRAINED
( 154) ENCASTRE
( 155) LIST
( 156) 9
( 157) 14
( 158) 23
( 159) 28
( 160) 37
( 161) 45
( 162) 56
( 163) 61
( 164) 70
( 165) C FOR TORSIONAL SYMMETRY, THE V AND W DISPLACEMENTS
( 166) C OF OPPOSITE NODES ALONG THE LINES OF SYMMETRY MUST
( 167) C BE OF OPPOSITE SIGN AND OF THE SAME MAGNITUDE
( 168) GENERALISED.CC.NTRAINTS
( 169) NODE DIRECTION LIST
( 170) C MIDSIDE NODES
1
( 171) 63      2      2,2,-1
( 172) 63      3      2,3,-1
( 173) 142     2      79,2,-1
( 174) 142     3      79,3,-1
( 175) 137     2      76,2,-1
( 176) 137     3      76,3,-1
( 177) 157     2      85,2,-1
( 178) 157     3      89,3,-1
( 179) 67      2      6,2,-1
( 180) 67      3      6,3,-1
( 181) 146     2      81,2,-1
( 182) 146     3      81,3,-1
( 183) 69      2      8,2,-1
( 184) 69      3      8,3,-1
( 185) C CORNER NODES
( 186) 62      2      1,2,-1
( 187) 62      3      1,3,-1
( 188) 64      2      3,2,-1
( 189) 64      3      3,3,-1
( 190) 65      2      4,2,-1
( 191) 65      3      4,3,-1
( 192) 66      2      5,2,-1
( 193) 66      3      5,3,-1
( 194) 155     2      80,2,-1
( 195) 155     3      86,3,-1
( 196) 150     2      83,2,-1
( 197) 150     3      83,3,-1
( 198) 68      2      7,2,-1
( 199) 68      3      7,3,-1
( 200) C FOR TORSIONAL SYMMETRY, THE U, THETA X, AND THETA Y
( 201) C DISPLACEMENTS OF OPPOSITE NODES ALONG THE LINES OF
( 202) C SYMMETRY MUST BE OF THE SAME SIGN AND MAGNITUDE
( 203) REPEATED.FREEDOMS
( 204) PLANE=0
( 205) DIRECTION=145
( 206) N1      N2
( 207) C MIDSIDE NODES

```

```

( 208) 63 2
( 209) 142 79
( 210) 137 76
( 211) 157 89
( 212) 67 6
( 213) 146 81
( 214) 69 8
( 215) C CORNER NODES
( 216) 62 1
( 217) 64 3
( 218) 65 4
( 219) 66 5
( 220) 155 86
( 221) 150 83
( 222) 68 7
( 223) C
( 224) C
( 225) C ONE HALF OF THE LOAD IS USED FOR SYMMETRY
( 226) LCADS
( 227) NODE DIRECTION VALUE,NEWTONS
1
( 228) 1 3 -55.6
( 229) 62 3 55.6
( 230) OUT.DRAW
( 231) PLOT.TYPE
( 232) 1
( 233) END.OF.DATA
OEND OF DATA 0 ERRORS

```


Data Deck for Symmetric Quadrilateral Mesh

Structural Material: Polypropylene

CONTROL
 NAME.RIS2
 FULL.CONTROL
 LARGE.DISPLACEMENTS
 PHASE=1
 PHASE=2
 PHASE=4
 SAVE.RESULTS
 PHASE=6
 SAVE.RESULTS
 PHASE=8
 SAVE
 PHASE=9
 PHASE=10
 SAVE.RESULTS
 CONTROL.END

C

TITLE POLYPROPYLENE RISSE CAST STRUCTURAL ANALYSIS

C

C COORDINATES OF THE NODES IN RIGHT HANDED CYLINDRICAL AXES

C HALF SYMMETRY MODEL USED

C X.AXIAL AND Y.RADIAL ARE IN METERS

C Z.ANGLE IS IN DEGREES

NODES

AXIS=2

NODE#	X.AXIAL	Y.RADIAL	Z.ANGLE
1	.1047	.1079	
2	.1343	.1170	
3	.1651	.1206	
4	.2238	.1240	
5	.2825	.1254	
6	.3998	.1116	
7	.5143	.0825	
8	.5518	.0702	
9	.5889	.0565	
10	.1071	.1111	8.59
11	.1651	.1265	8.76
12	.2825	.1298	9.00
13	.5143	.0840	8.97
14	.5839	.0595	8.40
15	.1100	.1140	17
16	.1375	.1240	17.03
17	.1651	.1333	17
18	.2238	.1345	12
19	.2825	.1381	17
20	.3984	.1140	17
21	.5143	.0890	17
22	.5468	.0749	17.01
23	.5800	.0623	17
24	.1180	.1315	36.99
25	.1601	.1472	37.02
26	.2857	.1462	35.2
27	.5093	.1058	38.74
28	.5774	.0783	39.38
29	.1317	.1524	53
30	.1603	.1528	53.01
31	.1889	.1530	53
32	.2355	.1490	62
33	.2825	.1487	53
34	.3938	.1420	53

35	.5050	.1333	53
36	.5386	.1147	53.01
37	.5747	.1016	53
38	.1889	.1520	65.93
39	.2825	.1433	65.95
40	.1650	.1580	78.83
41	.1889	.1514	78.96
42	.2355	.1454	72.89
43	.2825	.1414	79.40
44	.4520	.1487	76.97
45	.5571	.1588	80.57
46	.1889	.1519	91.99
47	.2825	.1462	92.60
48	.1450	.1682	105
49	.1669	.1600	105
50	.1889	.1524	105
51	.2355	.1536	105
52	.2825	.1542	105
53	.3571	.1600	105
54	.4318	.1651	105
55	.5020	.1796	105
56	.5715	.1968	105
57	.0865	.1366	135.41
58	.1889	.1165	138.32
59	.2825	.1168	137.78
60	.4318	.1275	138.53
61	.6290	.2493	142.2
62	.0492	.1095	180
63	.1190	.1150	180
64	.1889	.1206	180
65	.2358	.1190	180
66	.2825	.1143	180
67	.3577	.1175	180
68	.4318	.1315	180
69	.5390	.2000	180
70	.6604	.2381	180

C THESE NODES ARE FOR ELEMENTS 1 AND 2

71	.2618	.1479	59.67
72	.2604	.1429	74.53
73	.2355	.1478	67.44
74	.2094	.1503	59.55
75	.2110	.1481	74.49

C
C
C ELEMENTS MODULE USED TO PRESCRIBE THE
C SEMILOOF CURVATURE FOR THE ELEMENTS
C 1 AND 2 WHICH FORM PART OF THE BOUNDARY
C OF THE BREAST HOLE
ELEMENTS
ELEMENT TYPE=43210
PROPERTIES=1
NUMBER TOPOLOGY
1 33 43 32 42 39 71 72 73
2 32 42 31 41 73 74 75 38
C
C
PAFBLCKS
C ELEMENTS ARE SEMILOOF 8 NODE QUADRILATERALS
ELEMENT=43210
TYPE=1

PROPERTIES=1

BLOCK#	N1	N2	TOPOLOGY
1	1	2	3 17 1 15 11 2 16 10
2	1	4	5 19 3 17 12 4 18 11
3	1	3	7 21 5 19 13 6 20 12
4	1	2	9 23 7 21 14 8 22 13
5	4	2	17 31 15 29 25 16 30 24
6	1	3	21 35 19 33 27 20 34 26
7	1	2	23 37 21 35 28 22 36 27
8	4	2	31 50 29 48 41 30 49 40
9	1	4	43 52 41 50 47 42 51 46
10	4	3	35 54 33 52 44 34 53 43
11	4	2	37 56 35 54 45 36 55 44
12	4	2	50 64 48 62 58 49 63 57
13	4	4	52 66 50 64 59 51 65 58
14	4	3	54 68 52 66 60 53 67 59
15	4	2	56 70 54 68 61 55 69 60

MESH

REFERENCE	SPACING
1	1
2	1
3	3
4	2

C

C

PLATES AND SHELLS

PLATE#	MATERIAL	THICKNESS, IN. METERS
1	11	.003175

MATERIALS

C PROPERTIES FOR POLYPROPYLENE

MATERIAL #	E.N/P2	NU
11	9.307E8	.46

C

C

C NODES ALONG THE POSTERIOR END OF THE CAST HAVE

C ALL DEGREES OF FREEDOM RESTRAINED

ENCASTRE

LIST

9

14

23

28

37

45

56

61

70

C FOR TORSIONAL SYMMETRY, THE V AND W DISPLACEMENTS

C OF OPPOSITE NODES ALONG THE LINES OF SYMMETRY MUST

C BE OF OPPOSITE SIGN AND OF THE SAME MAGNITUDE

GENERALISED CONSTRAINTS

NODE DIRECTION LIST

C MIDSIDE NODES

63	2	2,2,-1
63	3	2,3,-1
142	2	79,2,-1
142	3	79,3,-1
137	2	76,2,-1
137	3	76,3,-1
157	2	89,2,-1

157	3	89,3,-1
67	2	6,2,-1
67	3	6,3,-1
146	2	81,2,-1
146	3	81,3,-1
69	2	8,2,-1
69	3	8,3,-1

C CORNER NODES

62	2	1,2,-1
62	3	1,3,-1
64	2	3,2,-1
64	3	3,3,-1
65	2	4,2,-1
65	3	4,3,-1
66	2	5,2,-1
66	3	5,3,-1
155	2	86,2,-1
155	3	86,3,-1
150	2	83,2,-1
150	3	83,3,-1
68	2	7,2,-1
68	3	7,3,-1

C FOR TORSIONAL SYMMETRY, THE U, THETA X, AND THETA Y

C DISPLACEMENTS OF OPPOSITE NODES ALONG THE LINES OF

C SYMMETRY MUST BE OF THE SAME SIGN AND MAGNITUDE

REPEATED.FREEDOMS

PLANE=0

DIRECTION=145

N1 N2

C MIDSIDE NODES

63 2

142 79

137 76

157 89

67 6

146 81

69 8

C CORNER NODES

62 1

64 3

65 4

66 5

155 86

150 83

68 7

C

C

C ONE HALF OF THE LOAD IS USED FOR SYMMETRY

LOADS

NODE	DIRECTION	VALUE,NEWTONS
------	-----------	---------------

1	3	-55.6
---	---	-------

62	3	55.6
----	---	------

OUT.DRAW

PLOT.TYPE

1

END.OF.DATA

Data Deck for Symmetric Quadrilateral Mesh

Structural Material: Plaster

CONTROL
 FULL CONTROL'
 NAME.RIS3
 PHASE=1
 PHASE=2
 PHASE=3
 SAVE
 PHASE=4
 PHASE=5
 SAVE
 PHASE=6
 PHASE=7
 PHASE=8
 SAVE
 CONTROL.END

C

TITLE PLASTER RISSE CAST STRUCTURAL ANALYSIS

C

C COORDINATES OF THE NODES IN RIGHT HANDED CYLINDRICAL AXES

C HALF SYMMETRY MODEL USED

C X,AXIAL AND Y,RADIAL ARE IN METERS

C Z,ANGLE IS IN DEGREES

NODES

AXIS=2

NODE#	X,AXIAL	Y,RADIAL	Z,ANGLE
1	.1047	.1079	
2	.1343	.1170	
3	.1651	.1206	
4	.2238	.1240	
5	.2825	.1254	
6	.3998	.1116	
7	.5143	.0825	
8	.5518	.0702	
9	.5889	.0565	
10	.1071	.1111	8.59
11	.1651	.1265	8.76
12	.2825	.1298	9.00
13	.5143	.0840	8.97
14	.5839	.0595	8.40
15	.1100	.1140	17
16	.1375	.1240	17.03
17	.1651	.1333	17
18	.2238	.1345	12
19	.2825	.1381	17
20	.3984	.1140	17
21	.5143	.0890	17
22	.5468	.0749	17.01
23	.5800	.0623	17
24	.1180	.1315	36.99
25	.1601	.1472	37.02
26	.2857	.1462	35.2
27	.5093	.1058	38.74
28	.5774	.0783	39.38
29	.1317	.1524	53
30	.1603	.1528	53.01
31	.1889	.1530	53
32	.2355	.1490	62
33	.2825	.1487	53
34	.3938	.1420	53
35	.5050	.1333	53

36	.5386	.1147	53.01
37	.5747	.1016	53
38	.1889	.1520	65.93
39	.2825	.1433	65.95
40	.1650	.1580	78.83
41	.1889	.1514	78.96
42	.2355	.1454	72.89
43	.2825	.1414	79.40
44	.4520	.1487	76.97
45	.5571	.1588	80.57
46	.1889	.1519	91.99
47	.2825	.1462	92.60
48	.1450	.1682	105
49	.1669	.1600	105
50	.1889	.1524	105
51	.2355	.1536	105
52	.2825	.1542	105
53	.3571	.1600	105
54	.4318	.1651	105
55	.5020	.1796	105
56	.5715	.1968	105
57	.0865	.1366	135.41
58	.1889	.1165	138.32
59	.2825	.1168	137.78
60	.4318	.1275	138.53
61	.6290	.2493	142.2
62	.0492	.1095	180
63	.1190	.1150	180
64	.1889	.1206	180
65	.2358	.1190	180
66	.2825	.1143	180
67	.3577	.1175	180
68	.4318	.1315	180
69	.5390	.2000	180
70	.6604	.2381	180

C THESE NODES ARE FOR ELEMENTS 1 AND 2

71	.2618	.1479	59.67
72	.2604	.1429	74.53
73	.2355	.1478	67.44
74	.2094	.1503	59.55
75	.2110	.1481	74.49

C
C
C ELEMENTS MODULE USED TO PRESCRIBE THE
C SEMILOOF CURVATURE FOR THE ELEMENTS
C 1 AND 2 WHICH FORM PART OF THE BOUNDARY
C OF THE BREAST HOLE
ELEMENTS
ELEMENT.TYPE=43210
PROPERTIES=1
NUMBER TOPOLOGY
1 33 43 32 42 39 71 72 73
2 32 42 31 41 73 74 75 38
C
C
PAFBLOCKS
C ELEMENTS ARE SEMILOOF 8 NODE QUADRILATERALS
ELEMENT=43210
TYPE=1
PROPERTIES=1

BLOCK#	N1	N2	TOPOLOGY
1	1	2	3 17 1 15 11 2 16 10
2	1	4	5 19 3 17 12 4 18 11
3	1	3	7 21 5 19 13 6 20 12
4	1	2	9 23 7 21 14 8 22 13
5	4	2	17 31 15 29 25 16 30 24
6	1	3	21 35 19 33 27 20 34 26
7	1	2	23 37 21 35 28 22 36 27
8	4	2	31 50 29 48 41 30 49 40
9	1	4	43 52 41 50 47 42 51 46
10	4	3	35 54 33 52 44 34 53 43
11	4	2	37 56 35 54 45 36 55 44
12	4	2	50 64 48 62 58 49 63 57
13	4	4	52 66 50 64 59 51 65 58
14	4	3	54 68 52 66 60 53 67 59
15	4	2	56 70 54 68 61 55 69 60

MESH	REFERENCE	SPACING
1	1	1
2	1	1
3	3	3
4	4	2

C
C
PLATES AND SHELLS

PLATE#	MATERIAL	THICKNESS IN METERS
1	11	.009525

MATERIALS
C PROPERTIES FOR PLASTER

MATERIAL#	E.N/M2	NU
11	2.17E9	.2

C
C
C NODES ALONG THE POSTERIOR END OF THE CAST HAVE
C ALL DEGREES OF FREEDOM RESTRAINED
ENCASTRE

LIST

9
14
23
28
37
45
56
61
70

C FOR TORSIONAL SYMMETRY, THE V AND W DISPLACEMENTS
C OF OPPOSITE NODES ALONG THE LINES OF SYMMETRY MUST
C BE OF OPPOSITE SIGN AND OF THE SAME MAGNITUDE
GENERALISED CONSTRAINTS

NODE DIRECTION LIST

C MIDSIDE NODES

2	2	63,2,-1
63	3	2,3,-1
79	2	142,2,-1
142	3	79,3,-1
76	2	137,2,-1
137	3	76,3,-1
89	2	157,2,-1
157	3	89,3,-1

6	2	67,2,-1
67	3	6,3,-1
81	2	146,2,-1
146	3	81,3,-1
8	2	69,2,-1
69	3	8,3,-1

C CORNER NODES

1	2	62,2,-1
62	3	1,3,-1
3	2	64,2,-1
64	3	3,3,-1
4	2	65,2,-1
65	3	4,3,-1
5	2	66,2,-1
66	3	5,3,-1
86	2	155,2,-1
155	3	86,3,-1
83	2	150,2,-1
150	3	83,3,-1
7	2	68,2,-1
68	3	7,3,-1

C FOR TORSIONAL SYMMETRY, THE U, THETA X, AND THETA Y
 C DISPLACEMENTS OF OPPOSITE NODES ALONG THE LINES OF
 C SYMMETRY MUST BE OF THE SAME SIGN AND MAGNITUDE
 REPEATED.FREEDOMS

PLANE=0

DIRECTION=145

N1 N2

C MIDSIDE NODES

63	2
142	79
137	76
157	89
67	6
146	81
69	8

C CORNER NODES

62	1
64	3
65	4
66	5
155	86
150	83
68	7

C

C

C ONE HALF OF THE LOAD IS USED FOR SYMMETRY
 LOADS

NODE	DIRECTION	VALUE.NEWTONS
1	3	-55.6
62	3	55.6

OUT.DRAW

PLOT.TYPE	Orien
1	4

IN.DRAW

TYPE	INFO	Orien
1	0	4
2	3	4
2	0	4
2	5	4

END.OF.DATA

APPENDIX C

OUTPUT DATA LISTINGS

Static Analysis

Full Quadrilateral Semi-Loof Element Model

Structural Material: Plaster

Displacements and Stresses

CASE 1 NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS			RESULTANT TRANSLATION MULTIPLIED BY 1E 6			SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	V	W	X	Y	Z
52	18.038	-67.249	68.540	*	*	*	97.701	**		0.28	-0.04	0.15
53	16.174	-35.544	42.976	-0.041	0.066	*	58.068	*		0.36	-0.04	0.15
54	11.250	-9.355	23.181	*	*	*	27.412	*		0.43	-0.04	0.16
55	5.532	-0.015	13.844	0.159	-0.188	*	14.909	*		0.50	-0.05	0.17
56	*	*	*	*	*	*	*	*		0.57	-0.05	0.19
57	49.281	-251.09	184.00	*	*	*	315.17	*****		0.09	-0.10	0.10
58	22.110	-133.81	120.07	*	*	*	181.13	***		0.19	-0.09	0.08
59	16.924	-57.389	63.363	*	*	*	87.148	**		0.28	-0.09	0.08
60	18.607	18.857	3.506	*	*	*	26.723	*		0.43	-0.10	0.08
61	*	*	*	*	*	*	*	*		0.63	-0.20	0.15
62	-0.000	0.002	195.66	0.000	0.000	0.000	195.66	***		0.05	-0.11	0.00
63	-0.000	0.001	122.57	3.864	3.055	0.000	122.57	**		0.12	-0.12	0.00
64	-0.000	0.001	66.867	0.000	0.000	0.000	66.867	*		0.19	-0.12	0.00
65	-0.000	0.001	53.127	0.000	0.000	0.000	53.127	*		0.24	-0.12	0.00
66	-0.000	0.001	43.257	0.000	0.000	0.000	43.257	*		0.28	-0.11	0.00
67	-0.000	0.000	23.860	0.028	-0.223	0.000	23.860	*		0.36	-0.12	0.00
68	-0.000	0.000	7.511	0.000	0.000	0.000	7.511	*		0.43	-0.13	0.00
69	-0.000	0.000	1.975	-0.207	0.194	0.000	1.975	*		0.54	-0.20	0.00
70	*	*	*	*	*	*	*	*		0.66	-0.24	0.00
71	-45.882	-107.32	-87.049	-2.877	-2.679	*	145.61	***		0.26	0.07	0.13
72	-21.654	-93.507	-20.075	-2.031	-0.651	*	99.556	**		0.26	0.04	0.14
73	-49.795	-126.82	-130.35	2.397	1.661	*	189.56	***		0.24	0.06	0.14
74	-66.457	-168.54	-207.59	-0.643	2.573	*	275.53	*****		0.21	0.08	0.13
75	-36.783	-129.26	-86.237	-3.823	-3.170	*	159.68	***		0.21	0.04	0.14
76	-0.000	-0.001	-138.72	3.338	3.344	0.000	138.72	**		0.25	0.12	0.00
77	-44.783	-107.58	-112.63	3.252	3.180	*	162.07	***		0.25	0.13	0.03
78	-22.329	-43.237	-180.63	-0.704	-0.883	*	187.07	***		0.22	0.13	0.01
79	-0.000	-0.001	-252.85	2.739	2.871	0.000	252.85	***		0.19	0.12	0.00
80	-52.506	-85.813	-233.82	2.390	2.895	*	254.54	***		0.19	0.13	0.03
81	-0.000	-0.000	-11.976	-0.301	-0.586	0.000	11.976	*		0.48	0.09	0.00
82	-1.095	-9.272	-12.878	-0.255	-0.514	*	17.383	*		0.48	0.09	0.00
83	-0.000	-0.000	-19.551	0.000	0.000	0.000	19.551	*		0.44	0.10	0.00
84	-6.139	-13.658	-21.236	0.139	0.195	*	25.984	*		0.44	0.10	0.02
85	-11.273	-22.480	-21.642	*	*	*	33.179	*		0.44	0.10	0.03
86	-0.000	-0.001	-42.028	0.000	0.000	0.000	42.028	*		0.36	0.12	0.00
87	-11.070	-28.969	-44.345	0.064	0.408	*	54.113	*		0.36	0.12	0.02
88	-20.671	-48.264	-44.622	*	*	*	68.905	*		0.36	0.12	0.04
89	-0.000	-0.001	-62.142	3.046	1.868	0.000	62.142	*		0.32	0.12	0.00
90	-31.610	-77.184	-59.636	1.823	1.213	*	102.53	**		0.32	0.12	0.04
91	-88.852	-196.99	-314.95	0.810	2.494	*	381.96	*****		0.17	0.13	0.06
92	-89.434	-216.28	-351.62	2.645	0.085	*	456.04	*****		0.17	0.13	0.06
93	-76.838	-298.29	-377.80	2.721	2.046	*	487.45	*****		0.14	0.11	0.08
94	-41.390	-273.60	-421.19	2.697	3.478	*	503.96	*****		0.11	0.11	0.06
95	-66.575	-369.12	-421.37	3.087	2.287	*	564.12	*****		0.12	0.10	0.10
96	-22.159	-21.083	-15.298	-0.071	0.365	*	34.199	*		0.47	0.08	0.11
97	-23.634	-45.909	-26.193	0.250	0.419	*	57.899	*		0.43	0.10	0.07
98	-26.192	-37.810	-24.859	*	*	*	52.283	*		0.43	0.08	0.11
99	-35.574	-79.599	-49.803	0.512	0.522	*	100.41	**		0.36	0.09	0.08
100	-31.355	-67.265	-41.992	-1.169	-0.684	*	85.271	**		0.36	0.09	0.12
101	-34.493	-82.420	-47.170	1.033	0.415	*	101.03	**		0.32	0.09	0.12
102	-3.860	-125.13	35.329	*	*	*	130.07	**		0.19	-0.01	0.15

CASE NODE NUMBER	TRANSLATIONS MULTIPLIED BY IE 6			ROTATIONS MULTIPLIED BY IE 3			RESULTANT TRANSLATION MULTIPLIED BY IE 6 HISTOGRAM	SCALED COORDINATES MULTIPLIED BY IE 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ		X	Y	Z
103	-34.862	-137.42	-87.354	-4.130	-3.880	*	166.52	0.18	0.03	0.15
104	-70.724	-223.61	-273.01	0.975	0.783	*	359.91	0.15	0.07	0.14
105	-8.383	-115.75	26.381	1.172	1.194	*	119.01	0.16	-0.01	0.16
106	19.368	-79.952	77.859	-0.857	0.368	*	113.27	0.26	-0.04	0.15
107	-6.937	-98.955	17.554	1.086	-0.115	*	100.74	0.24	0.00	0.15
108	19.954	-113.35	101.37	-1.241	-0.998	*	153.57	0.21	-0.04	0.15
109	-16.878	-24.549	-19.408	0.098	0.427	*	35.556	0.48	0.06	0.13
110	0.593	-11.166	14.151	-0.024	-0.175	*	18.035	0.44	-0.00	0.16
111	-10.786	-17.096	11.601	0.264	0.724	*	23.307	0.42	0.03	0.14
112	13.400	-18.312	29.555	-0.212	-0.184	*	37.261	0.41	-0.04	0.16
113	-19.739	-36.349	-17.721	0.441	0.490	*	46.959	0.41	-0.04	0.16
114	-11.197	-28.749	6.717	*	*	*	31.575	0.40	0.03	0.13
115	1.083	-26.412	25.898	0.135	-0.220	*	46.330	0.39	-0.00	0.15
116	15.163	-26.681	36.862	0.697	0.891	*	41.686	0.38	-0.04	0.16
117	-11.358	-39.332	7.859	0.552	0.295	*	67.164	0.37	0.03	0.14
118	-22.508	-59.689	-21.015	*	*	*	52.916	0.35	0.06	0.13
119	-11.569	-50.684	9.872	0.053	-0.230	*	58.839	0.34	-0.01	0.14
120	1.149	-45.579	37.191	*	*	*	70.113	0.33	-0.01	0.15
121	17.015	-45.090	50.924	-0.974	-0.918	*	65.186	0.31	-0.04	0.15
122	-13.582	-61.105	18.191	-0.209	-0.147	*	82.496	0.28	-0.06	0.13
123	17.539	-54.921	59.006	0.120	-0.187	*	87.763	0.28	-0.01	0.15
124	-23.406	-83.179	-15.358	-0.268	-0.319	*	15.009	0.56	0.05	0.12
125	0.466	-67.902	51.963	-0.139	-0.116	*	7.546	0.56	-0.01	0.18
126	-8.192	-11.124	-5.866	-0.098	-0.366	*	14.213	0.50	0.03	0.15
127	5.207	-1.375	5.286	-0.469	-0.180	*	188.29	0.19	-0.06	0.11
128	-5.319	2.999	12.035	-0.768	-0.971	*	132.95	0.19	-0.11	0.04
129	23.363	-141.61	121.88	1.125	-0.619	*	259.33	0.14	-0.09	0.09
130	14.705	-86.154	100.19	0.489	0.461	*	264.48	0.11	-0.07	0.13
131	38.359	-200.70	159.68	0.208	-1.383	*	248.99	0.06	-0.11	0.05
132	43.213	-203.82	162.90	-1.513	-0.739	*	102.11	0.28	-0.07	0.12
133	29.820	-170.22	179.26	-0.782	-0.929	*	61.877	0.28	-0.10	0.04
134	19.592	-70.738	70.986	-0.775	-0.305	*	109.60	0.26	-0.09	0.08
135	10.154	-31.498	52.284	-0.551	-0.719	*	47.587	0.26	-0.12	0.00
136	18.900	-76.067	76.602	-0.902	-1.005	*	146.74	0.24	-0.07	0.11
137	-0.000	0.001	47.587	*	*	0.000	132.84	0.24	-0.09	0.08
138	21.967	-107.15	97.830	1.351	1.029	*	159.55	0.21	-0.09	0.08
139	20.626	-94.921	90.614	0.410	0.965	*	58.672	0.21	-0.12	0.00
140	12.780	-55.955	71.564	0.807	0.661	*	21.60	0.43	-0.07	0.12
141	21.621	-117.06	106.23	2.189	1.836	0.000	22.212	0.43	-0.12	0.04
142	-0.000	0.001	58.672	-0.350	-0.453	*	21.484	0.41	-0.09	0.08
143	17.659	9.791	6.329	-0.331	-0.146	*	12.886	0.41	-0.13	0.00
144	13.298	17.646	2.273	-0.158	-0.208	*	34.068	0.38	-0.07	0.12
145	16.691	4.350	12.808	-0.387	0.165	0.000	26.041	0.38	-0.09	0.08
146	-0.000	0.000	12.886	-0.597	-0.671	*	20.341	0.38	-0.11	0.04
147	17.545	-13.601	25.866	*	*	*	18.061	0.38	-0.12	0.00
148	16.328	-3.866	19.915	-0.560	-0.245	*	39.369	0.36	-0.09	0.08
149	10.825	4.485	16.628	0.000	0.000	0.000	64.415	0.33	-0.07	0.12
150	-0.000	0.000	18.061	-0.274	-0.351	*	51.606	0.33	-0.09	0.08
151	15.579	-18.349	31.153	-0.620	-0.702	*	*	*	*	*
152	18.251	-40.085	47.005	*	*	*	*	*	*	*
153	15.904	-28.105	40.253	*	*	*	*	*	*	*

CASE 1 NODE NUMBER	TRANSLATIONS			ROTATIONS			RESULTANT TRANSLATION MULTIPLIED BY 1E 6			SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	V	W	X	Y	Z
205	*	*	*	*	*	*	*	*	*	*	*	*
206	2.357	121.81	28.973	0.109	-0.565	*	125.23	*	*	0.56	0.03	-0.16
207	0.321	67.157	50.076	1.429	0.076	*	83.772	*	*	0.19	-0.01	-0.15
208	-19.975	133.34	114.45	*	*	*	176.85	***	*	0.28	-0.01	-0.15
209	-19.526	132.00	112.56	-2.275	-1.666	*	174.57	***	*	0.15	-0.04	-0.16
210	-19.012	130.80	110.63	*	*	*	172.36	***	*	0.17	-0.04	-0.15
211	-20.271	95.436	88.386	*	*	*	131.65	***	*	0.19	-0.04	-0.15
212	-18.038	67.248	68.539	*	*	*	97.00	**	*	0.24	-0.04	-0.15
213	-16.174	35.543	42.975	-0.041	0.066	*	58.067	*	*	0.28	-0.04	-0.15
214	-11.250	9.355	23.180	0.159	-0.188	*	27.812	*	*	0.36	-0.04	-0.15
215	-5.532	0.014	13.864	*	*	*	14.909	*	*	0.43	-0.04	-0.16
216	*	*	*	*	*	*	315.17	*****	*	0.50	-0.05	-0.17
217	-49.281	251.09	184.00	*	*	*	181.13	***	*	0.57	-0.05	-0.19
218	-22.110	133.81	120.06	*	*	*	87.148	**	*	0.09	-0.10	-0.10
219	-16.924	57.390	63.362	*	*	*	26.723	*	*	0.19	-0.09	-0.08
220	-18.607	-18.857	3.506	*	*	*	195.66	***	*	0.28	-0.09	-0.08
221	*	*	*	0.000	0.000	0.000	122.57	**	*	0.43	-0.10	-0.08
222	-0.000	0.002	195.66	3.864	3.055	0.000	66.867	*	*	0.63	-0.20	-0.15
223	-0.000	0.001	122.57	0.000	0.000	0.000	43.257	*	*	0.05	-0.11	0.00
224	-0.000	0.001	66.867	0.000	0.000	0.000	23.860	*	*	0.12	-0.12	0.00
225	-0.000	0.001	53.127	0.000	0.000	0.000	7.511	*	*	0.19	-0.12	0.00
226	-0.000	0.001	43.257	0.000	0.000	0.000	1.975	*	*	0.24	-0.12	0.00
227	-0.000	0.000	23.860	0.028	-0.223	0.000	145.61	***	*	0.28	-0.11	0.00
228	-0.000	0.000	7.511	0.000	0.000	0.000	99.556	**	*	0.36	-0.12	0.00
229	-0.000	0.000	1.975	-0.207	0.194	0.000	275.53	*****	*	0.43	-0.13	0.00
230	*	*	*	-2.877	-2.479	*	138.172	**	*	0.54	-0.20	0.00
231	45.882	107.32	-87.050	-2.031	-0.651	*	162.07	***	*	0.66	-0.24	0.00
232	27.654	93.507	-20.076	2.397	1.661	*	254.54	*****	*	0.26	0.07	-0.13
233	49.795	126.82	-130.35	-0.843	-2.573	*	11.976	*	*	0.26	0.04	-0.14
234	66.457	168.54	-207.59	-3.823	-3.170	0.000	17.382	*	*	0.24	0.06	-0.14
235	36.783	129.26	-86.237	3.338	3.344	0.000	19.551	*	*	0.21	0.08	-0.14
236	-0.000	-0.001	-138.72	-0.704	-0.883	*	25.984	*	*	0.21	0.04	-0.14
237	44.783	107.58	-112.63	3.252	3.180	*	33.178	*	*	0.25	0.12	0.00
238	22.329	43.236	-180.63	-2.739	2.871	0.000	54.113	*	*	0.22	0.13	-0.03
239	-0.000	-0.001	-252.85	2.390	2.895	*	68.904	*	*	0.22	0.13	-0.03
240	52.505	85.812	-233.82	-0.301	-0.586	0.000	102.53	**	*	0.19	0.12	0.00
241	-0.000	-0.000	-11.976	-0.255	-0.514	*	381.96	*****	*	0.48	0.09	0.00
242	7.095	9.272	-12.878	0.000	0.000	0.000	456.04	*****	*	0.48	0.09	0.00
243	-0.000	-0.000	-19.551	0.139	0.195	*	487.45	*****	*	0.44	0.10	0.00
244	6.138	13.657	-21.236	0.000	0.000	0.000	503.96	*****	*	0.44	0.10	0.00
245	11.273	22.480	-21.642	0.000	0.000	0.000	564.12	*****	*	0.44	0.10	0.00
246	-0.000	-0.001	-42.028	0.064	0.408	*	*	*	*	0.44	0.10	-0.03
247	11.069	28.968	-44.345	3.046	1.868	0.000	*	*	*	0.36	0.12	0.00
248	20.671	48.263	-44.622	1.823	1.213	*	62.142	*	*	0.36	0.12	-0.02
249	-0.000	-0.001	-62.142	3.046	1.868	0.000	68.904	*	*	0.36	0.12	-0.04
250	31.609	77.183	-59.636	1.823	1.213	*	102.53	**	*	0.32	0.12	0.00
251	88.851	196.99	-314.95	0.810	2.494	*	381.96	*****	*	0.32	0.12	-0.04
252	89.434	276.28	-351.62	2.645	0.085	*	456.04	*****	*	0.16	0.13	0.06
253	76.837	298.29	-371.80	2.721	2.045	*	487.45	*****	*	0.17	0.11	-0.11
254	41.389	273.60	-421.19	2.697	3.478	*	503.96	*****	*	0.11	0.11	-0.08
255	66.575	369.12	-421.37	3.087	2.287	*	564.12	*****	*	0.12	0.10	-0.10

CASE 1 NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS MULTIPLIED BY 1E 3			RESULTANT TRANSLATION MULTIPLIED BY 1E 6		SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	HISTOGRAM	X	Y	Z
256	22.159	21.082	-15.298	-0.071	0.365	*	34.198	*	0.47	0.08	-0.11
257	23.634	45.908	-26.193	-0.250	0.419	*	57.898	*	0.43	0.10	-0.07
258	26.192	37.809	-24.859	*	*	*	52.283	*	0.43	0.08	-0.11
259	35.576	79.599	-49.803	0.512	0.522	*	100.41	**	0.36	0.11	-0.08
260	31.355	67.265	-41.992	*	*	*	85.270	**	0.32	0.09	-0.12
261	34.493	82.419	-47.170	-1.169	-0.684	*	101.03	**	0.32	0.09	-0.12
262	3.860	125.13	35.327	1.033	0.415	*	130.07	**	0.19	0.01	-0.15
263	34.862	137.41	-87.355	-4.130	-3.880	*	166.52	***	0.18	0.03	-0.15
264	70.724	223.61	-273.01	0.975	0.783	*	359.91	*****	0.15	0.07	-0.14
265	8.383	115.75	26.379	1.172	1.194	*	119.01	**	0.16	-0.01	-0.16
266	-19.367	79.952	77.858	-0.857	-0.368	*	113.27	**	0.26	-0.04	-0.15
267	6.937	98.955	17.552	1.086	-0.115	*	100.74	**	0.24	0.00	-0.15
268	-19.954	113.35	101.37	-1.242	-0.998	*	153.37	***	0.21	-0.04	-0.15
269	16.876	24.549	-19.408	-0.098	0.427	*	35.556	*	0.48	0.06	-0.13
270	-0.592	11.166	14.150	-0.024	-0.175	*	18.035	*	0.44	-0.00	-0.16
271	10.786	17.096	11.601	0.264	0.724	*	23.306	*	0.42	0.03	-0.14
272	-13.400	18.312	29.555	-0.212	-0.184	*	37.260	*	0.41	-0.04	-0.16
273	19.739	36.349	-17.722	0.441	0.490	*	44.999	*	0.41	0.06	-0.13
274	11.197	28.749	6.717	*	*	*	31.575	*	0.40	0.03	-0.14
275	-1.083	26.412	25.898	0.135	-0.220	*	37.006	*	0.39	-0.00	-0.15
276	-15.163	26.481	34.862	*	*	*	46.330	*	0.38	-0.04	-0.16
277	11.358	39.332	7.858	0.697	0.891	*	41.686	*	0.37	0.03	-0.14
278	22.508	59.688	-21.015	0.552	0.295	*	67.163	*	0.35	0.06	-0.13
279	11.569	50.684	9.872	*	*	*	52.916	*	0.34	0.03	-0.14
280	-1.149	45.579	37.191	0.053	-0.230	*	58.838	*	0.33	-0.01	-0.15
281	-17.015	45.089	50.923	*	*	*	70.112	*	0.33	0.03	-0.15
282	13.582	61.105	18.190	-0.974	-0.918	*	65.185	*	0.31	-0.04	-0.15
283	-17.539	54.920	59.006	-0.209	-0.147	*	82.495	*	0.31	0.04	-0.15
284	23.406	83.178	-15.359	0.120	-0.187	*	87.763	**	0.28	0.06	-0.13
285	-0.466	67.902	51.962	-0.268	-0.319	*	85.504	**	0.28	-0.01	-0.15
286	8.192	11.124	-5.866	0.139	0.116	*	15.009	*	0.26	0.05	-0.12
287	-5.207	1.375	-5.286	-0.098	-0.366	*	7.546	*	0.56	-0.01	-0.18
288	5.319	-2.999	12.834	-0.469	-0.180	*	14.213	*	0.50	0.03	-0.15
289	-23.363	141.61	121.88	-0.768	-0.971	*	188.29	***	0.19	-0.06	-0.11
290	-14.706	86.157	100.19	-1.125	-0.619	*	132.96	**	0.19	-0.11	-0.04
291	-38.359	200.70	159.68	0.489	0.461	*	259.33	*****	0.14	-0.09	-0.09
292	-43.213	203.82	162.90	0.208	-1.383	*	264.47	*****	0.11	-0.07	-0.13
293	-29.820	170.22	179.26	-1.513	-0.739	*	248.99	*****	0.06	-0.11	-0.05
294	-19.592	70.738	70.986	-0.782	-0.929	*	102.11	**	0.28	-0.07	-0.12
295	-10.154	31.499	52.284	-0.775	-0.305	*	61.878	*	0.28	-0.10	-0.04
296	-18.900	76.067	76.602	-0.551	-0.719	*	109.60	**	0.26	-0.09	-0.08
297	-0.000	0.001	47.587	-0.551	-0.719	0.000	47.587	*	0.26	-0.09	-0.08
298	-21.967	107.15	97.830	-0.902	-1.005	*	146.74	***	0.24	-0.07	-0.11
299	-20.626	94.922	90.614	*	*	*	132.84	**	0.24	-0.09	-0.08
300	-12.780	55.956	71.664	0.410	0.965	*	91.816	**	0.24	-0.11	-0.04
301	-21.621	117.06	106.23	0.807	0.661	*	159.55	***	0.21	-0.09	-0.08
302	-0.000	0.001	58.672	2.189	1.836	0.000	58.672	*	0.21	-0.12	0.00
303	-17.659	-9.791	6.328	-0.350	-0.453	*	21.160	*	0.43	0.07	-0.12
304	-13.298	-7.647	2.273	-0.331	-0.146	*	22.213	*	0.43	-0.12	-0.04
305	-16.692	-4.350	12.808	-0.158	-0.208	*	21.484	*	0.41	-0.09	-0.08
306	-0.000	0.000	12.886	0.387	0.165	0.000	12.886	*	0.41	-0.13	0.00

CASE 1 NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS MULTIPLIED BY 1E 3			RESULTANT TRANSLATION MULTIPLIED BY 1E 6			SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	V	W	X	Y	Z
307	-17.545	13.601	25.842	-0.597	-0.671	*	34.068	*		0.38	-0.07	-0.12
308	-16.328	3.866	19.914	*	*	*	26.041	*		0.38	-0.09	-0.08
309	-10.825	-4.484	16.628	-0.560	-0.245	*	20.341	*		0.38	-0.11	-0.04
310	-0.000	0.000	18.061	0.000	0.000	0.000	18.061	*		0.38	-0.12	0.00
311	-15.579	18.350	31.153	-0.274	-0.351	*	39.369	*		0.36	-0.09	-0.08
312	-18.251	40.085	47.004	-0.620	-0.702	*	64.415	*		0.33	-0.07	-0.12
313	-15.904	28.106	40.253	*	*	*	51.606	*		0.33	-0.09	-0.08
314	-9.573	12.472	33.703	-0.581	-0.235	*	37.190	*		0.33	-0.10	-0.04
315	-0.000	0.000	30.260	0.000	0.000	0.000	30.260	*		0.33	-0.12	0.00
316	-16.158	42.301	51.538	0.506	0.431	*	68.605	*		0.31	-0.09	-0.08
317	-0.000	0.001	36.763	0.708	0.390	0.000	36.763	*		0.31	-0.11	0.00
318	-24.553	-16.154	-25.926	-0.417	-0.211	*	39.191	*		0.60	-0.13	-0.19
319	-3.744	-4.691	-2.040	0.250	-0.036	*	6.339	*		0.65	-0.24	-0.08
320	0.624	7.143	6.530	0.068	-0.110	*	9.698	*		0.53	-0.15	-0.12

 *
 * 0 ERRORS IN THIS PHASE *
 *
 * 56 WARNINGS IN THIS PHASE *
 *

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 30498 WORDS ****

*** END OF PHASE 7 ***

 *
 * TITLE PLASTER RISSE CAST, FULL MESH CHECK *
 * PHASE NUMBER 9 STARTS HERE *

DEFAULT STRESS ELEMENTS MODULE CREATED.

STRESSES FOR ELEMENT 43210
 SIGMA1 IS THE MOST POSITIVE PRINCIPAL STRESS.
 SIGMA2 IS THE MOST NEGATIVE PRINCIPAL STRESS.
 ANGLE ALPHA1 IS THE ANGLE BETWEEN THE GLOBAL
 X-AXIS AND PRINCIPAL STRESS SIGMA1
 ANGLE ALPHA2 IS THE ANGLE BETWEEN THE GLOBAL
 Y-AXIS AND PRINCIPAL STRESS SIGMA1

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
1	1	0.274	0.718E-01	0.128	0.352E+06	-0.987E+05	127	135	0.757E+05	-0.296E+06	25	115
1	1	0.274	0.430E-01	0.136	0.162E+06	0.978E+04	154	113	0.425E+06	-0.224E+06	48	138
1	1	0.247	0.481E-01	0.137	0.296E+06	-0.211E+06	145	123	0.368E+06	-0.407E+06	49	139
1	1	0.247	0.649E-01	0.133	0.453E+06	-0.489E+05	141	124	0.383E+06	-0.200E+06	36	124
2	1	0.224	0.657E-01	0.144	0.452E+06	0.443E+05	173	92	0.328E+06	-0.173E+06	30	119
2	1	0.225	0.489E-01	0.140	0.284E+06	0.418E+05	145	122	0.318E+06	-0.263E+06	49	139
2	1	0.197	0.457E-01	0.144	0.335E+06	-0.227E+06	132	133	0.230E+06	-0.164E+06	42	132
2	1	0.197	0.745E-01	0.132	0.474E+06	0.153E+06	33	120	0.235E+06	-0.519E+05	48	133
3	1	0.152	0.121	0.791E-02	0.964E+05	-0.391E+06	46	77	0.391E+06	-0.655E+06	142	90
3	1	0.153	0.124	0.298E-01	0.232E+05	-0.625E+06	49	78	0.355E+06	-0.324E+06	149	102
3	1	0.120	0.114	0.273E-01	0.684E+06	-0.170E+05	60	86	0.380E+06	-0.175E+06	121	106
3	1	0.118	0.113	0.731E-02	0.845E+06	-0.110E+06	51	75	0.434E+06	-0.277E+06	124	97
4	1	0.270	0.126	0.761E-02	0.301E+06	0.118E+05	26	86	0.463E+04	-0.805E+05	37	84
4	1	0.270	0.131	0.283E-01	0.967E+06	0.653E+05	25	88	0.215E+06	-0.481E+05	170	84
4	1	0.237	0.130	0.226E-01	0.554E+06	0.910E+05	8	88	0.281E+06	-0.345E+05	22	84
4	1	0.236	0.126	0.602E-02	0.151E+06	-0.437E+04	29	81	0.312E+06	-0.384E+06	43	79
5	1	0.211	0.125	0.592E-02	0.624E+05	-0.252E+05	21	81	0.389E+06	-0.311E+06	43	76
5	1	0.211	0.130	0.223E-01	0.217E+05	-0.715E+05	19	82	0.229E+06	-0.182E+06	35	79
5	1	0.177	0.123	0.273E-01	-0.233E+05	-0.687E+06	74	79	0.173E+06	-0.424E+05	11	82
5	1	0.177	0.123	0.722E-02	0.129E+06	-0.296E+06	65	74	0.241E+06	0.198E+05	32	78
6	1	0.498	0.872E-01	0.578E-02	0.891E+05	-0.689E+05	42	103	0.148E+05	-0.321E+05	40	103
6	1	0.498	0.878E-01	0.214E-01	0.863E+05	-0.135E+05	27	99	0.382E+05	-0.794E+05	29	98
6	1	0.454	0.977E-01	0.236E-01	0.142E+06	-0.873E+05	46	99	0.980E+05	-0.638E+05	145	80
6	1	0.454	0.988E-01	0.636E-02	0.100E+06	-0.130E+06	49	104	0.904E+05	-0.777E+05	141	83
7	1	0.422	0.106	0.678E-02	0.810E+05	-0.260E+05	49	104	0.206E+05	-0.408E+05	140	85
7	1	0.421	0.105	0.252E-01	0.103E+06	0.131E+05	48	99	0.275E+05	-0.761E+05	166	78
7	1	0.376	0.113	0.274E-01	0.208E+06	-0.323E+05	55	97	0.122E+06	-0.136E+06	164	79
7	1	0.377	0.115	0.736E-02	0.215E+06	-0.113E+06	47	100	0.117E+06	-0.118E+06	139	86
8	1	0.344	0.120	0.780E-02	0.205E+06	-0.123E+06	45	97	0.200E+06	-0.218E+06	149	84
8	1	0.344	0.120	0.290E-01	0.397E+06	0.463E+05	53	94	0.265E+06	-0.314E+06	165	79

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGNAL	SIGMA2	ALPHA1	ALPHA2	SIGNAL	SIGMA2	ALPHA1	ALPHA2
8	1	0.299	0.128	0.312E-01	0.895E+06	0.126E+06	50	89	0.142E+06	-0.568E+06	159	78
8	1	0.299	0.125	0.839E-02	0.405E+06	-0.487E+05	45	90	0.220E+06	-0.274E+06	144	82
9	1	0.571	0.632E-01	0.397E-02	0.382E+05	-0.450E+05	50	102	0.134E+05	-0.106E+05	20	109
9	1	0.567	0.644E-01	0.154E-01	0.365E+05	-0.259E+05	115	84	0.101E+06	-0.909E+05	35	108
9	1	0.528	0.785E-01	0.191E-01	0.180E+06	-0.519E+05	47	100	0.887E+05	-0.339E+05	150	69
9	1	0.530	0.775E-01	0.511E-02	0.165E+06	-0.123E+06	48	102	0.731E+05	-0.428E+05	136	76
10	1	0.150	0.123	0.493E-01	0.808E+05	-0.699E+06	44	75	0.144E+06	-0.314E+06	151	107
10	1	0.149	0.118	0.765E-01	0.275E+06	-0.135E+06	103	113	0.133E+06	-0.834E+06	23	73
10	1	0.125	0.110	0.715E-01	0.951E+06	-0.107E+06	73	98	0.443E+05	-0.155E+06	158	110
10	1	0.122	0.113	0.446E-01	0.747E+06	-0.286E+06	66	84	0.467E+06	-0.290E+06	122	104
11	1	0.155	0.111	0.963E-01	0.902E+06	0.156E+05	91	123	0.390E+05	-0.111E+07	17	78
11	1	0.169	0.976E-01	0.117	0.110E+07	0.119E+06	67	130	0.128E+06	-0.857E+06	171	98
11	1	0.139	0.959E-01	0.114	0.112E+07	0.163E+06	82	117	0.535E+05	-0.108E+07	174	94
11	1	0.130	0.105	0.906E-01	0.126E+07	0.179E+06	76	107	-0.811E+05	-0.794E+06	18	77
12	1	0.496	0.873E-01	0.642E-01	0.197E+06	0.218E+05	18	103	0.634E+04	-0.771E+05	26	103
12	1	0.491	0.830E-01	0.906E-01	0.224E+06	-0.141E+05	11	98	147.	-0.111E+06	153	86
12	1	0.448	0.878E-01	0.937E-01	0.174E+06	0.964E+05	48	105	0.175E+06	-0.138E+06	14	99
12	1	0.452	0.962E-01	0.473E-01	0.115E+06	0.466E+04	49	103	0.920E+05	-0.752E+05	167	78
13	1	0.420	0.103	0.496E-01	0.144E+06	0.430E+05	54	103	0.126E+06	-0.117E+06	12	102
13	1	0.417	0.912E-01	0.959E-01	0.207E+06	0.629E+05	55	111	0.171E+06	-0.122E+06	9	98
13	1	0.374	0.957E-01	0.980E-01	0.237E+06	0.196E+06	88	118	0.108E+06	-0.187E+06	24	106
13	1	0.377	0.111	0.529E-01	0.272E+06	0.862E+05	54	104	0.825E+05	-0.155E+06	11	101
14	1	0.345	0.118	0.554E-01	0.309E+06	0.756E+05	73	103	0.157E+06	-0.304E+06	20	104
14	1	0.343	0.988E-01	0.101	0.186E+06	0.940E+05	100	121	0.592E+05	-0.150E+06	21	106
14	1	0.300	0.103	0.104	0.893E+05	-0.303E+05	97	129	727.	-0.192E+06	6	96
14	1	0.301	0.126	0.589E-01	0.579E+06	0.602E+05	94	101	0.221E+06	-0.569E+06	19	104
15	1	0.564	0.645E-01	0.335E-01	0.429E+05	-0.982E+05	54	102	0.156E+06	0.901E+05	18	107
15	1	0.561	0.642E-01	0.712E-01	0.897E+05	-0.400E+05	128	82	0.446E+06	0.111E+06	19	103
15	1	0.521	0.759E-01	0.837E-01	0.204E+06	0.111E+06	23	111	0.168E+06	-0.107E+06	21	111
15	1	0.526	0.783E-01	0.401E-01	0.207E+06	-0.157E+06	46	111	0.102E+06	-0.423E+05	147	72
16	1	0.179	0.802E-01	0.130	0.518E+06	0.744E+05	78	146	0.218E+06	-0.455E+06	11	100
16	1	0.183	0.440E-01	0.146	0.744E+05	-0.369E+06	130	132	0.142E+06	-0.386E+05	36	126
16	1	0.168	0.459E-01	0.149	0.749E+05	-0.476E+06	138	122	0.138E+06	-0.169E+06	20	110
16	1	0.153	0.814E-01	0.130	0.591E+06	-0.286E+06	88	143	0.255E+06	-0.838E+06	173	94
17	1	0.184	0.144E-01	0.152	0.680E+05	-0.383E+06	150	110	0.281E+06	0.262E+05	87	173
17	1	0.181	-0.258E-01	0.153	0.623E+05	-0.588E+06	155	106	0.317E+06	-0.510E+05	71	155
17	1	0.161	-0.280E-01	0.161	0.169E+06	-0.176E+06	149	115	0.353E+06	-0.236E+05	87	166

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
17	1	0.170	0.141E-01	0.157	0.322E+05	-0.394E+06	150	107	0.347E+06	-0.439E+05	75	164
18	1	0.273	0.170E-01	0.142	0.333E+06	-0.264E+06	152	116	0.341E+06	-0.131E+05	55	144
18	1	0.273	-0.245E-01	0.148	0.115E+06	-0.245E+06	137	132	0.277E+06	-0.185E+06	63	152
18	1	0.246	-0.225E-01	0.148	0.187E+06	-0.410E+06	146	123	0.324E+06	-0.155E+06	62	151
18	1	0.246	0.246E-01	0.142	0.365E+06	-0.232E+06	151	116	0.396E+06	-0.278E+06	52	142
19	1	0.225	0.250E-01	0.144	0.188E+06	-0.210E+06	153	114	0.270E+06	-0.182E+06	63	152
19	1	0.226	-0.233E-01	0.149	0.743E+05	-0.382E+06	158	111	0.326E+06	-0.355E+04	82	172
19	1	0.199	-0.239E-01	0.150	0.818E+05	-0.500E+06	160	109	0.403E+06	-0.247E+05	70	159
19	1	0.198	0.187E-01	0.149	0.114E+06	-0.454E+06	149	117	0.244E+06	-0.183E+06	60	150
20	1	0.477	0.741E-01	0.117	0.186E+06	0.447E+05	12	100	0.167E+06	-0.127E+06	38	117
20	1	0.449	0.664E-01	0.138	0.112E+06	-0.116E+06	36	120	0.191E+06	-0.749E+05	14	101
20	1	0.414	0.450E-01	0.138	0.711E+05	-0.345E+05	1	89	0.133E+06	0.231E+05	29	115
20	1	0.437	0.746E-01	0.119	0.155E+06	0.939E+05	140	117	0.221E+06	-0.128E+06	19	106
21	1	0.433	0.184E-01	0.150	0.198E+05	-0.103E+06	173	96	0.136E+06	-0.279E+05	27	115
21	1	0.422	-0.253E-01	0.158	-0.173E+06	-0.212E+06	12	101	0.454E+05	-0.184E+06	109	160
21	1	0.393	-0.254E-01	0.156	-0.132E+06	-0.163E+06	128	141	0.137E+06	-0.106E+06	78	167
21	1	0.402	0.172E-01	0.149	0.397E+05	-0.213E+06	156	113	0.167E+06	0.199E+05	52	138
22	1	0.407	0.750E-01	0.120	0.118E+06	0.999E+05	148	113	0.193E+06	-0.132E+06	22	109
22	1	0.389	0.439E-01	0.138	0.530E+05	-0.433E+05	1	89	0.102E+06	-0.250E+04	3	92
22	1	0.355	-0.425E-01	0.137	0.127E+06	-0.566E+05	162	106	0.692E+05	-0.140E+05	27	114
22	1	0.367	0.754E-01	0.122	0.191E+06	0.819E+05	130	130	0.701E+05	-0.101E+06	7	97
23	1	0.379	0.163E-01	0.147	0.153E+05	-0.146E+06	157	111	0.106E+06	0.932E+04	48	134
23	1	0.372	-0.255E-01	0.155	-0.114E+06	-0.158E+06	173	94	0.130E+06	-0.831E+05	79	167
23	1	0.343	-0.256E-01	0.153	-0.100E+06	-0.147E+06	22	111	0.171E+06	-0.625E+05	72	161
23	1	0.348	0.151E-01	0.146	0.446E+05	-0.154E+06	164	105	0.889E+05	0.161E+05	65	151
24	1	0.337	0.157E-01	0.123	0.198E+06	0.629E+05	135	127	0.384E+05	-0.110E+06	8	98
24	1	0.329	0.514E-01	0.137	0.140E+06	-0.821E+05	157	111	0.405E+05	0.134E+05	166	103
24	1	0.295	0.401E-01	0.136	0.188E+06	-0.147E+06	152	117	0.121E+06	0.348E+05	131	136
24	1	0.297	0.762E-01	0.124	0.991E+05	-0.589E+05	152	114	0.706E+05	-0.143E+06	31	119
25	1	0.325	0.141E-01	0.145	0.966E+05	-0.139E+06	3	88	0.838E+05	0.550E+05	133	135
25	1	0.322	-0.257E-01	0.151	-0.762E+05	-0.163E+06	30	119	0.134E+06	0.866E+05	71	160
25	1	0.293	-0.258E-01	0.149	-0.704E+05	-0.996E+05	169	99	0.137E+06	-0.846E+05	77	165
25	1	0.294	0.127E-01	0.143	0.173E+06	-0.615E+05	15	103	0.245E+06	0.895E+05	56	143
26	1	0.552	0.609E-01	0.101	0.254E+06	-0.105E+05	148	90	0.146E+06	0.661E+05	159	86
26	1	0.538	0.596E-01	0.140	0.148E+06	0.560E+04	31	109	0.268E+06	-0.409E+05	47	118
26	1	0.482	0.445E-01	0.138	0.128E+06	0.225E+05	175	90	0.131E+06	0.658E+05	25	112
26	1	0.507	0.697E-01	0.111	0.176E+06	0.581E+05	111	127	0.160E+06	-0.148E+06	24	113

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
27	1	0.534	0.126E-01	0.164	0.455E+05	-0.824E+05	20	101	0.114E+06	0.297E+05	29	109
27	1	0.538	-0.313E-01	0.181	0.445E+05	-0.180E+06	89	172	-0.229E+05	-0.145E+06	106	163
27	1	0.461	-0.268E-01	0.164	-0.504E+05	-0.126E+06	76	163	0.340E+05	-0.128E+06	83	169
27	1	0.468	0.169E-01	0.153	0.877E+05	-0.883E+06	174	89	0.200E+06	0.555E+05	50	133
28	1	0.177	-0.521E-01	0.137	0.306E+05	-0.513E+06	150	117	0.404E+06	-0.752E+05	60	113
28	1	0.170	-0.803E-01	0.972E-01	-0.706E+05	-0.330E+06	167	101	0.262E+06	-0.133E+06	70	113
28	1	0.117	-0.866E-01	0.109	0.129E+05	-0.321E+06	14	83	0.396E+06	-0.652E+05	102	115
28	1	0.144	-0.563E-01	0.148	0.902E+05	-0.166E+06	459	110	0.258E+06	-0.219E+05	99	129
29	1	0.165	-0.970E-01	0.648E-01	-0.155E+06	-0.524E+06	35	97	0.374E+06	-0.530E+05	94	113
29	1	0.161	-0.114	0.179E-01	-0.402E+05	-0.416E+06	40	100	0.222E+06	-0.760E+05	108	104
29	1	0.832E-01	-0.112	0.206E-01	-0.768E+05	-0.422E+06	33	93	0.244E+06	0.196E+05	60	93
29	1	0.100	-0.102	0.736E-01	-0.165E+06	-0.550E+06	22	90	0.492E+06	0.661E+05	97	105
30	1	0.273	-0.512E-01	0.135	-0.750E+05	-0.152E+06	135	115	0.145E+06	-0.168E+06	71	125
30	1	0.273	-0.781E-01	0.946E-01	-0.606E+05	-0.145E+06	42	109	0.935E+05	-0.165E+06	79	119
30	1	0.246	-0.786E-01	0.942E-01	-0.120E+06	-0.227E+06	46	111	0.169E+06	-0.989E+05	75	119
30	1	0.246	-0.512E-01	0.135	-0.130E+06	-0.253E+06	167	97	0.232E+06	-0.801E+05	81	127
31	1	0.273	-0.943E-01	0.628E-01	0.105E+05	-0.160E+06	42	104	0.787E+05	-0.151E+06	97	114
31	1	0.273	-0.111	0.174E-01	0.123E+06	-0.140E+06	42	96	0.110E+06	-0.110E+06	126	105
31	1	0.246	-0.113	0.171E-01	0.982E+05	-0.161E+06	40	99	0.952E+05	-0.119E+06	126	106
31	1	0.246	-0.953E-01	0.625E-01	-0.209E+05	-0.186E+06	47	107	0.138E+06	-0.133E+06	98	115
32	1	0.226	-0.510E-01	0.134	-0.141E+06	-0.282E+06	173	92	0.292E+06	-0.476E+05	74	126
32	1	0.226	-0.786E-01	0.939E-01	-0.136E+06	-0.229E+06	56	115	0.144E+06	-0.935E+05	81	120
32	1	0.199	-0.783E-01	0.933E-01	-0.151E+06	-0.284E+06	169	93	0.163E+06	-0.142E+06	86	118
32	1	0.199	-0.507E-01	0.134	-0.147E+06	-0.405E+06	11	98	0.287E+06	0.774E+05	102	126
33	1	0.226	-0.956E-01	0.622E-01	-0.569E+05	-0.285E+06	36	104	0.181E+06	-0.101E+06	95	115
33	1	0.226	-0.114	0.171E-01	0.874E+05	-0.217E+06	38	100	0.182E+06	-0.123E+06	121	107
33	1	0.199	-0.115	0.169E-01	0.166E+06	-0.212E+06	40	102	0.221E+06	-0.149E+06	114	108
33	1	0.199	-0.955E-01	0.618E-01	-0.137E+06	-0.368E+06	9	95	0.101E+06	-0.173E+06	75	115
34	1	0.421	-0.548E-01	0.144	0.333E+04	-0.776E+05	76	127	0.145E+06	-0.300E+06	68	126
34	1	0.421	-0.846E-01	0.101	0.659E+05	-0.498E+05	28	108	-0.154E+06	-0.192E+06	21	105
34	1	0.393	-0.820E-01	0.996E-01	0.548E+05	-0.111E+06	59	117	-0.331E+05	-0.138E+06	54	116
34	1	0.393	-0.538E-01	0.142	-0.474E+05	-0.166E+06	68	125	0.639E+05	-0.167E+06	71	126
35	1	0.421	-0.103	0.670E-01	0.166E+06	0.741E+05	58	116	-0.328E+05	-0.127E+06	127	105
35	1	0.421	-0.123	0.184E-01	0.116E+06	0.592E+04	49	111	0.573E+05	-0.102E+06	132	95
35	1	0.393	-0.118	0.182E-01	0.334E+05	0.854E+04	43	108	0.407E+05	-0.851E+05	140	93
35	1	0.393	-0.993E-01	0.662E-01	0.565E+05	-0.985E+04	60	114	-0.510E+05	-0.911E+05	154	94

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE			BOTTOM SURFACE			ALPHA1	ALPHA2
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	SIGMA1	SIGMA2	ALPHA1		
36	1	0.372	-0.531E-01	0.141	-0.113E+06	-0.165E+06	101	125	0.116E+06	-0.187E+06	63	123
36	1	0.372	-0.805E-01	0.988E-01	0.406E+05	-0.112E+06	66	118	-0.126E+05	-0.102E+06	73	119
36	1	0.343	-0.790E-01	0.975E-01	0.971E+04	-0.135E+06	62	116	0.401E+04	-0.138E+06	77	118
36	1	0.343	-0.523E-01	0.139	-0.862E+05	-0.160E+06	62	123	0.108E+06	-0.141E+06	74	125
37	1	0.372	-0.971E-01	0.656E-01	0.509E+05	-0.783E+05	58	112	-0.515E+05	-0.725E+05	152	96
37	1	0.372	-0.115	0.180E-01	0.825E+05	-0.717E+05	50	107	0.856E+05	-0.130E+06	137	95
37	1	0.343	-0.112	0.179E-01	0.518E+05	-0.466E+05	49	104	0.462E+05	-0.721E+05	137	97
37	1	0.343	-0.950E-01	0.644E-01	0.268E+05	-0.760E+05	59	111	-0.273E+05	-0.766E+05	98	112
38	1	0.322	-0.518E-01	0.138	-0.115E+06	-0.129E+06	96	125	0.139E+06	-0.165E+06	68	124
38	1	0.322	-0.783E-01	0.966E-01	-0.211E+05	-0.124E+06	57	115	0.213E+05	-0.147E+06	78	118
38	1	0.293	-0.779E-01	0.952E-01	-0.308E+05	-0.135E+06	43	110	0.492E+05	-0.187E+06	84	119
38	1	0.293	-0.513E-01	0.136	-0.106E+06	-0.120E+06	99	126	0.114E+06	-0.198E+06	72	126
39	1	0.322	-0.942E-01	0.641E-01	0.289E+05	-0.975E+05	55	110	-0.153E+05	-0.111E+06	100	112
39	1	0.322	-0.110	0.176E-01	0.763E+05	-0.100E+06	47	102	0.544E+05	-0.113E+06	132	99
39	1	0.293	-0.110	0.174E-01	0.923E+05	-0.986E+05	43	100	0.552E+05	-0.975E+05	127	102
39	1	0.293	-0.937E-01	0.632E-01	0.326E+05	-0.121E+06	42	106	0.271E+05	-0.140E+06	98	113
40	1	0.551	-0.799E-01	0.184	-0.187E+04	-0.129E+06	90	170	0.119E+05	-0.788E+05	40	128
40	1	0.576	-0.156	0.158	-0.401E+05	-0.111E+06	139	94	0.719E+05	-0.904E+05	120	113
40	1	0.469	-0.107	0.116	0.128E+06	-0.280E+05	62	139	0.457E+05	-0.844E+05	106	115
40	1	0.464	-0.625E-01	0.145	-0.294E+05	-0.199E+06	81	147	-364.	-0.257E+06	100	139
41	1	0.593	-0.200	0.112	-0.131E+05	-0.652E+05	46	126	0.143E+05	-0.469E+05	80	120
41	1	0.606	-0.227	0.327E-01	0.474E+04	-0.134E+05	29	108	0.203E+05	0.216E+04	36	107
41	1	0.475	-0.159	0.222E-01	0.250E+05	0.109E+05	56	124	0.222E+05	-0.308E+05	54	125
41	1	0.473	-0.135	0.791E-01	0.110E+06	0.333E+05	122	90	0.184E+05	-0.819E+05	57	134
42	1	0.274	0.718E-01	-0.128	0.296E+06	-0.757E+05	113	146	0.987E+05	-0.352E+06	38	127
42	1	0.274	0.430E-01	-0.136	0.224E+06	-0.425E+06	138	129	-0.978E+04	-0.162E+06	65	153
42	1	0.247	0.481E-01	-0.137	0.407E+06	-0.368E+06	139	129	0.211E+06	-0.296E+06	55	145
42	1	0.247	0.649E-01	-0.133	0.200E+06	-0.383E+06	126	137	0.489E+05	-0.453E+06	51	138
43	1	0.224	0.657E-01	-0.134	0.173E+06	-0.328E+06	120	139	-0.443E+05	-0.452E+06	84	155
43	1	0.225	0.489E-01	-0.140	0.263E+06	-0.318E+06	138	128	-0.418E+05	-0.284E+06	56	145
43	1	0.198	0.457E-01	-0.144	0.164E+06	-0.230E+06	131	134	0.227E+06	-0.335E+06	43	133
43	1	0.197	0.745E-01	-0.132	0.519E+05	-0.235E+06	138	122	-0.153E+06	-0.474E+06	122	134
44	1	0.152	0.121	-0.791E-02	0.654E+06	-0.391E+06	53	77	0.391E+06	-0.964E+05	135	88
44	1	0.153	0.124	-0.298E-01	0.324E+06	-0.355E+06	64	81	0.625E+06	-0.232E+05	135	99
44	1	0.120	0.114	-0.273E-01	0.175E+06	-0.380E+06	38	78	0.170E+05	-0.684E+06	143	102
44	1	0.118	0.113	-0.731E-02	0.277E+06	-0.434E+06	39	73	0.110E+06	-0.845E+06	136	100

ELEM NO. LOAD CASE GLOBAL CO-ORDINATES X Y Z TOP SURFACE SIGMA1 SIGMA2 ALPHA1 ALPHA2 BOTTOM SURFACE SIGMA1 SIGMA2 ALPHA1 ALPHA2

45	1	0.270	0.126	-0.761E-02	0.805E+05	-0.463E+04	127	81	-0.118E+05	-0.301E+06	116	81
45	1	0.270	0.131	-0.283E-01	0.481E+05	-0.215E+06	81	78	-0.653E+05	-0.967E+06	114	76
45	1	0.237	0.130	-0.226E-01	0.345E+05	-0.281E+06	112	76	-0.910E+05	-0.554E+06	98	75
45	1	0.236	0.126	-0.602E-02	0.384E+06	-0.312E+06	133	79	0.437E+04	-0.151E+06	119	77
46	1	0.211	0.125	-0.592E-02	0.311E+06	-0.389E+06	133	79	0.253E+05	-0.624E+05	110	75
46	1	0.211	0.130	-0.223E-01	0.182E+06	-0.229E+06	125	81	0.715E+05	-0.217E+05	109	78
46	1	0.177	0.128	-0.273E-01	0.424E+05	-0.173E+06	99	82	0.687E+06	0.233E+05	163	93
46	1	0.177	0.123	-0.722E-02	-0.198E+05	-0.241E+06	121	79	0.296E+06	-0.129E+06	154	87
47	1	0.498	0.872E-01	-0.578E-02	0.321E+05	-0.148E+05	126	81	0.689E+05	-0.891E+05	127	81
47	1	0.498	0.878E-01	-0.214E-01	0.794E+05	-0.382E+05	116	79	0.135E+05	-0.863E+05	113	79
47	1	0.454	0.977E-01	-0.236E-01	0.638E+05	-0.980E+05	58	97	0.873E+05	-0.142E+06	133	82
47	1	0.454	0.988E-01	-0.636E-02	0.777E+05	-0.904E+05	54	104	0.130E+06	-0.100E+06	136	84
48	1	0.422	0.106	-0.678E-02	0.408E+05	-0.206E+05	53	103	0.260E+05	-0.810E+05	136	86
48	1	0.421	0.105	-0.252E-01	0.761E+05	-0.275E+05	82	93	-0.131E+05	-0.103E+06	135	83
48	1	0.376	0.113	-0.274E-01	0.136E+06	-0.122E+06	79	93	0.323E+05	-0.208E+06	143	81
48	1	0.377	0.115	-0.736E-02	0.118E+06	-0.117E+06	51	100	0.113E+06	-0.215E+06	136	87
49	1	0.344	0.120	-0.780E-02	0.218E+06	-0.200E+06	61	95	0.123E+06	-0.205E+06	134	86
49	1	0.344	0.120	-0.240E-01	0.314E+06	-0.265E+06	79	89	-0.463E+05	-0.397E+06	141	80
49	1	0.299	0.128	-0.312E-01	0.568E+06	-0.142E+06	71	84	-0.126E+06	-0.895E+06	138	77
49	1	0.299	0.125	-0.839E-02	0.274E+06	-0.220E+06	55	89	0.487E+05	-0.405E+06	135	82
50	1	0.571	0.632E-01	-0.397E-02	0.106E+05	-0.134E+05	96	86	0.450E+05	-0.382E+05	134	75
50	1	0.567	0.644E-01	-0.154E-01	0.909E+05	-0.101E+06	118	83	0.259E+05	-0.365E+05	32	109
50	1	0.528	0.785E-01	-0.191E-01	0.339E+05	-0.887E+05	70	92	0.519E+05	-0.180E+06	130	72
50	1	0.530	0.775E-01	-0.511E-02	0.428E+05	-0.731E+05	52	101	0.123E+06	-0.165E+06	132	77
51	1	0.150	0.123	-0.483E-01	0.314E+06	-0.144E+06	70	82	0.699E+06	-0.808E+05	128	102
51	1	0.149	0.118	-0.765E-01	0.834E+06	-0.133E+06	99	112	0.135E+06	-0.275E+06	25	75
51	1	0.125	0.110	-0.715E-01	0.155E+06	-0.443E+05	90	105	0.107E+06	-0.951E+06	152	114
51	1	0.122	0.113	-0.446E-01								

Static Analysis

Symmetric 44100 Triangular Element Model

Structural Material: Plaster

Displacements

CASE NUMBER	TRANSLATIONS			ROTATIONS			RESULTANT TRANSLATION MULTIPLIED BY IE 6 HISTOGRAM			SCALED COORDINATES MULTIPLIED BY IE 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	V	W	X	Y	Z
1	-8.853	175.90	-236.15	3.045	4.787	-0.184	294.60	*****		0.10	0.11	0.00
2	-7.275	171.08	-178.53	1.849	5.973	-0.565	247.38	*****		0.13	0.12	0.00
3	-5.491	149.09	-135.60	0.379	12.83	-3.635	201.61	*****		0.17	0.12	0.00
4	-5.371	78.046	-86.108	0.485	22.18	-6.458	116.34	***		0.22	0.12	0.00
5	-5.443	23.558	-53.023	1.084	6.002	-0.943	58.276	**		0.28	0.13	0.00
6	-2.085	-11.659	-23.015	0.519	0.294	0.064	25.884	*		0.40	0.11	0.00
7	-0.119	-11.652	-7.111	-0.134	0.180	0.020	13.651			0.51	0.08	0.00
8	-0.350	-7.553	-1.385	-0.317	-0.534	0.059	7.687			0.55	0.07	0.00
9										0.59	0.06	0.00
10	-13.310	97.662	-222.51	5.614	-3.235	-0.610	243.36	*****		0.11	0.11	0.02
11	-18.769	104.93	-127.87	2.619	0.059	-0.600	166.48	*****		0.17	0.13	0.02
12	-10.679	-0.255	-49.140	1.508	-1.753	-0.339	50.287	*		0.28	0.13	0.02
13	-1.432	-9.983	-6.900	0.006	-0.096	0.069	12.220			0.51	0.08	0.01
14										0.58	0.06	0.01
15	-16.228	24.831	-222.96	4.418	*	1.099	224.92	*****		0.11	0.11	0.03
16	-26.446	38.692	-171.29	3.657	*	0.840	177.59	*****		0.14	0.12	0.04
17	-32.521	47.612	-122.19	3.074	-1.202	0.264	135.11	***		0.17	0.13	0.04
18	-14.980	32.439	-73.454	1.856	0.068	-0.888	81.684	**		0.22	0.13	0.03
19	-16.634	-32.202	-42.535	1.492	-0.524	-0.389	55.883	*		0.28	0.13	0.04
20	-10.353	-26.388	-24.841	0.769	-0.425	0.165	37.691			0.40	0.11	0.03
21	-3.197	-9.899	-6.746	-0.008	-0.231	0.141	12.398			0.51	0.09	0.03
22	-1.033	-4.964	-2.007	-0.118	-0.043	0.169	5.453			0.55	0.07	0.02
23										0.58	0.06	0.02
24	-22.824	-154.20	-230.30	3.299	-0.482	1.679	278.09	*****		0.12	0.11	0.08
25	-50.607	-111.72	-161.86	2.903	-0.856	1.320	203.07	*****		0.16	0.12	0.09
26	-25.980	-68.645	-51.083	0.321	-0.287	0.154	89.423	***		0.29	0.12	0.08
27	-7.846	-13.273	-7.797	0.082	-0.023	0.263	17.278	*		0.51	0.08	0.07
28										0.58	0.08	0.05
29	-46.535	-184.54	-226.38	-0.745	-0.556	1.632	295.75	*****		0.13	0.09	0.12
30	-46.661	-155.09	-195.05	-0.787	-1.520	0.291	253.52	*****		0.16	0.09	0.12
31	-45.988	-132.27	-171.82	-0.931	0.625	2.736	221.65	*****		0.19	0.09	0.12
32	-32.625	-86.742	-95.598	-1.468	-1.461	*	133.14	***		0.24	0.07	0.13
33	-24.301	-66.806	-50.203	-0.419	-0.901	-0.187	87.028	**		0.28	0.09	0.12
34	-18.754	-34.804	-25.804	-0.387	-0.176	0.226	47.211	*		0.39	0.09	0.11
35	-11.953	-11.667	-8.982	-0.156	-0.121	0.252	18.965	*		0.51	0.08	0.11
36	-5.495	-4.733	-3.397	-0.063	-0.150	0.248	8.008			0.54	0.07	0.09
37										0.57	0.06	0.08
38	-35.732	-107.57	-126.57	-2.104	-0.548	1.295	169.91	*****		0.19	0.06	0.14
39	-22.618	-57.312	-28.512	-0.748	-0.712	1.866	67.891	**		0.28	0.06	0.13
40	-22.830	-86.450	-88.686	-2.401	-0.330	0.901	112.77	***		0.17	0.03	0.16
41	-18.889	-85.776	-54.505	-2.209	-0.348	1.191	103.37	***		0.19	0.03	0.15
42	-21.161	-75.509	-53.711	-1.662	-0.876	*	95.049	***		0.24	0.04	0.14
43	-10.123	-50.307	-0.153	-0.984	-0.427	0.206	51.315	*		0.28	0.03	0.14
44	-5.905	-6.213	6.471	-0.499	0.072	0.050	10.740			0.55	0.03	0.14
45										0.56	0.03	0.16
46	-0.658	-77.902	18.972	-1.954	-0.011	0.450	80.181	**		0.19	-0.01	0.15
47	0.645	-44.428	28.540	-0.832	-0.116	0.508	52.809	*		0.28	-0.01	0.15
48	16.970	-81.472	91.370	-1.982	0.102	0.745	123.59	***		0.15	-0.04	0.16
49	15.257	-84.141	85.502	-1.790	0.048	0.538	120.93	***		0.17	-0.04	0.15
50	13.800	-86.111	79.879	-1.536	0.216	0.504	118.26	***		0.19	-0.04	0.15
51	13.986	-61.559	65.216	-1.106	0.294	0.473	90.765	***		0.24	-0.04	0.15

CASE 1 NODE NUMBER	TRANSLATIONS			ROTATIONS			RESULTANT TRANSLATION MULTIPLIED BY IE 6 U HISTOGRAM			SCALED COORDINATES MULTIPLIED BY IE 0 X Y Z		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U			X	Y	Z
52	12.602	-42.708	52.146	-0.590	0.232	0.388	68.571	**		0.28	-0.04	0.15
53	10.267	-19.701	35.127	-0.058	0.197	0.286	41.562	*		0.36	-0.04	0.15
54	4.852	-3.648	23.524	0.255	0.051	0.157	24.295	*		0.43	-0.04	0.16
55	2.487	-0.066	9.911	0.031	0.179	-0.216	10.219	*		0.50	-0.05	0.17
56	*	*	*	*	*	*	*	*		0.57	-0.05	0.19
57	40.619	-254.86	210.31	-1.076	2.144	0.585	332.92	*****		0.09	-0.10	0.10
58	16.283	-160.35	134.05	-0.702	0.995	0.957	209.63	*****		0.19	-0.09	0.08
59	12.341	-62.607	66.159	0.019	0.330	0.963	91.919	***		0.28	-0.09	0.08
60	14.129	22.349	3.724	0.148	0.232	0.038	26.702	*		0.43	-0.10	0.08
61	*	*	*	*	*	*	*	*		0.63	-0.20	0.15
62	-8.853	-175.90	236.15	3.045	4.787	-0.184	294.60	*****		0.05	-0.11	0.00
63	-7.275	-171.08	178.53	1.849	5.973	-0.565	247.38	*****		0.12	-0.11	0.00
64	-5.491	-149.09	135.60	0.379	12.83	-3.635	201.61	*****		0.19	-0.12	0.00
65	-5.371	-78.046	86.108	0.465	22.18	-6.435	116.34	***		0.24	-0.12	0.00
66	-5.463	-23.558	53.023	1.084	6.002	-0.943	58.276	**		0.28	-0.11	0.00
67	-2.085	11.659	23.015	0.519	0.294	0.064	25.884	*		0.36	-0.12	0.00
68	-0.119	11.652	7.111	-0.134	0.180	0.020	13.651	*		0.43	-0.13	0.00
69	-0.350	7.553	1.385	-0.317	-0.534	0.059	7.687	*		0.54	-0.20	0.00
70	*	*	*	*	*	*	*	*		0.66	-0.24	0.00
71	-28.500	-72.342	-65.755	-0.915	-1.516	*	101.83	***		0.26	0.07	0.13
72	-16.640	-62.902	-27.212	-1.280	-0.926	*	70.527	**		0.26	0.04	0.14
73	-28.225	-79.376	-76.052	-1.483	-0.775	1.439	113.50	***		0.24	0.06	0.14
74	-38.395	-108.60	-134.29	-1.609	-0.497	1.709	177.05	***		0.21	0.08	0.13
75	-22.256	-83.911	-64.966	-1.991	-0.685	0.359	108.43	***		0.21	0.04	0.14
76	-5.423	47.198	-67.380	0.889	10.64	-2.543	82.444	**		0.25	0.12	0.00
77	-14.275	3.644	-56.568	1.732	*	-0.979	58.455	*		0.25	0.13	0.03
78	-9.899	58.527	-80.157	1.794	*	-0.883	99.742	***		0.22	0.13	0.01
79	-5.451	116.29	-110.32	0.428	28.85	-9.161	160.39	***		0.19	0.12	0.00
80	-20.856	53.018	-95.194	2.124	*	-1.144	110.94	***		0.19	0.13	0.03
81	-0.691	-12.412	-11.571	-0.016	-0.144	-0.056	16.984	*		0.48	0.09	0.00
82	-5.012	-14.568	-11.888	0.106	-0.261	0.102	19.459	*		0.48	0.09	0.03
83	-1.314	-12.523	-16.791	0.219	0.033	0.078	20.988	*		0.44	0.10	0.00
84	-4.266	-15.734	-17.457	0.301	0.112	0.115	23.885	*		0.44	0.10	0.02
85	-7.338	-19.606	-17.861	0.185	-0.495	0.112	21.518	*		0.44	0.10	0.03
86	-3.090	-7.604	-30.683	0.880	1.263	0.002	31.762	*		0.36	-0.12	0.00
87	-8.502	-20.001	-31.918	0.786	*	-0.042	38.613	*		0.36	-0.12	0.02
88	-13.492	-32.582	-32.224	0.650	-0.276	0.051	47.770	*		0.36	-0.12	0.04
89	-4.265	3.133	-40.292	1.209	-0.347	-0.236	40.638	*		0.32	-0.12	0.00
90	-15.805	-34.815	-38.536	0.923	-0.418	0.013	54.286	**		0.32	-0.12	0.04
91	-47.551	-36.313	-137.47	3.334	-0.720	1.285	149.92	*****		0.16	0.13	0.06
92	-50.455	-140.97	-177.82	1.167	-0.644	1.295	232.46	*****		0.17	0.11	0.11
93	-37.575	-132.14	-195.04	2.875	-0.466	1.884	149.92	*****		0.14	0.11	0.08
94	-18.859	-75.511	-222.64	4.220	0.018	1.508	238.57	*****		0.11	0.11	0.06
95	-33.470	-194.94	-235.74	1.368	0.138	1.988	235.55	*****		0.11	0.11	0.10
96	-14.055	-18.882	-13.885	-0.187	-0.090	0.182	307.72	*****		0.47	0.08	0.11
97	-13.828	-28.317	-19.674	0.120	-0.109	0.252	27.329	*		0.43	0.10	0.07
98	-16.367	-26.470	-19.513	-0.286	-0.104	0.253	37.150	*		0.43	0.08	0.11
99	-21.063	-50.106	-35.876	0.142	-0.194	0.281	36.733	*		0.36	0.11	0.08
100	-20.938	-44.481	-39.876	-0.453	-0.155	0.300	59.102	**		0.36	0.09	0.12
101	-22.717	-54.524	-39.894	-0.485	-0.184	0.316	71.278	**		0.32	0.09	0.12
102	-0.691	-79.576	20.067	-2.000	-0.290	0.473	82.072	**		0.19	-0.01	0.15

CASE NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS MULTIPLIED BY 1E 3			RESULTANT TRANSLATION MULTIPLIED BY 1E 6			SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	V	W	X	Y	Z
103	-20.855	-86.579	-61.779	-2.508	-0.514	0.425	108.39	***	***	0.18	0.03	0.15
104	-40.396	-130.94	-160.35	-2.151	-0.684	1.085	210.94	*****	*****	0.15	0.07	0.14
105	-2.339	-70.659	19.175	-2.082	-0.166	1.085	73.252	**	**	0.16	-0.01	0.16
106	13.454	-51.407	58.388	-0.852	0.257	0.441	78.948	**	**	0.26	0.04	0.15
107	-3.378	-63.563	10.833	-1.427	-0.122	1.030	64.568	**	**	0.24	0.00	0.15
108	14.096	-73.234	72.617	-1.332	0.295	0.584	104.09	***	***	0.21	-0.00	0.15
109	-10.264	-11.936	7.551	-0.387	0.139	0.054	17.460	*	*	0.48	0.06	0.13
110	-0.984	-2.908	22.562	-0.277	0.117	0.129	22.770	*	*	0.44	-0.00	0.16
111	-6.979	-9.967	8.141	-0.588	0.015	0.239	14.640	*	*	0.42	0.03	0.16
112	7.198	-7.999	26.053	0.233	0.133	0.268	28.188	*	*	0.41	-0.04	0.16
113	-12.987	-21.855	-10.197	-0.634	-0.143	0.154	27.392	*	*	0.41	0.06	0.13
114	-7.724	-15.679	8.108	-0.656	-0.129	0.027	19.268	*	*	0.40	0.03	0.14
115	-0.376	-12.848	25.778	-0.372	0.003	0.164	28.805	*	*	0.39	-0.00	0.15
116	8.977	-13.504	30.208	0.109	0.167	0.274	34.285	*	*	0.38	-0.04	0.16
117	-8.229	-22.979	6.775	-0.702	-0.019	0.466	25.331	*	*	0.37	0.03	0.16
118	-15.175	-37.946	-17.048	-0.739	-0.211	0.131	44.281	*	*	0.34	0.03	0.14
119	-8.673	-31.302	5.417	-0.772	-0.074	0.324	32.930	*	*	0.33	-0.01	0.15
120	0.370	-27.195	27.378	-0.542	0.060	0.418	38.734	*	*	0.33	0.04	0.15
121	11.260	-26.553	40.586	-0.221	0.212	0.301	49.790	*	*	0.31	0.03	0.14
122	-9.223	-40.281	3.936	-0.835	-0.189	*	41.511	*	*	0.31	-0.04	0.15
123	12.011	-34.137	46.262	-0.389	0.230	0.309	58.735	*	*	0.28	0.06	0.13
124	-16.176	-58.641	29.141	-0.785	-0.406	0.080	67.451	**	**	0.28	-0.01	0.15
125	0.784	-45.007	29.689	-0.743	-0.033	*	53.923	**	**	0.56	0.05	0.12
126	-4.984	1.140	-0.644	0.014	0.306	0.322	5.153	*	*	0.56	-0.01	0.18
127	2.114	-0.557	-2.117	-0.069	-0.037	0.490	3.043	*	*	0.50	0.03	0.15
128	-3.013	-1.392	2.839	-0.189	0.275	0.312	4.368	*	*	0.19	-0.06	0.11
129	17.084	-128.69	113.12	-1.066	0.470	0.839	172.19	*****	*****	0.19	-0.11	0.06
130	9.298	-168.09	139.71	0.511	-1.442	2.131	218.17	*****	*****	0.14	-0.03	0.09
131	28.492	-206.80	172.96	-0.430	-1.280	1.927	271.09	*****	*****	0.11	-0.07	0.13
132	37.270	-169.52	164.06	-1.983	1.309	0.730	238.83	*****	*****	0.06	-0.11	0.05
133	21.072	-276.21	225.44	0.814	-3.137	1.290	357.15	*****	*****	0.28	-0.07	0.12
134	14.101	-57.479	63.213	-0.266	0.043	0.923	86.594	**	**	0.28	-0.10	0.04
135	5.766	-55.931	63.057	0.381	0.777	0.921	84.485	**	**	0.26	-0.09	0.08
136	14.128	-84.286	80.934	-0.084	0.425	1.143	117.70	***	***	0.26	-0.12	0.00
137	-5.423	-47.198	67.380	-0.889	10.64	-2.543	82.444	*	*	0.24	-0.07	0.11
138	16.354	-91.662	87.991	-0.670	0.306	0.941	128.11	***	***	0.24	-0.09	0.08
139	15.551	-108.48	97.638	-0.243	0.652	1.095	146.78	***	***	0.24	-0.11	0.04
140	9.151	-106.98	96.271	0.435	-0.384	1.777	144.21	***	***	0.21	-0.09	0.08
141	16.310	-134.10	115.59	-0.452	0.949	1.014	177.79	***	***	0.21	-0.12	0.00
142	-5.451	-116.29	110.32	0.428	28.85	-9.161	160.39	***	***	0.21	-0.09	0.08
143	11.916	13.456	9.788	-0.650	0.288	-0.030	20.466	*	*	0.43	-0.07	0.12
144	8.721	19.882	4.386	-0.078	0.400	-0.040	22.149	*	*	0.43	-0.12	0.04
145	13.292	14.710	10.405	0.226	1.151	0.015	22.391	*	*	0.41	-0.09	0.08
146	-0.691	12.412	11.571	-0.016	-0.144	0.056	16.984	*	*	0.41	-0.13	0.00
147	12.280	-6.125	24.537	0.273	-0.084	0.784	28.114	*	*	0.38	-0.07	0.12
148	12.334	2.194	19.900	0.166	0.213	0.643	23.515	*	*	0.38	-0.09	0.08
149	6.940	6.432	18.306	0.132	0.815	0.176	20.606	*	*	0.38	-0.11	0.04
150	-1.314	12.523	16.791	0.219	0.033	0.078	34.988	*	*	0.36	-0.12	0.00
151	11.654	-12.018	30.369	0.196	0.931	0.534	30.678	*	*	0.33	-0.09	0.08
152	12.928	-30.040	42.873	0.010	0.124	0.654	53.923	**	**	0.33	-0.07	0.12
153	11.507	-27.075	41.268	0.146	0.219	0.740	50.681	*	*	0.33	-0.09	0.08

CASE NODE NUMBER	TRANSLATIONS MULTIPLIED BY IE 6			ROTATIONS MULTIPLIED BY IE 3			RESULTANT TRANSLATION MULTIPLIED BY IE 6		SCALED COORDINATES MULTIPLIED BY IE 0		
	UX	UY	UZ	PHIX	PHIY	PHIZ	U	HISTOGRAM	X	Y	Z
154	5.420	-16.781	37.214	0.395	0.392	0.597	41.207	*	0.33	-0.10	0.04
155	-3.050	7.604	30.683	0.880	1.263	0.002	31.762	*	0.33	-0.12	0.00
156	11.701	-43.556	52.956	0.094	0.549	0.668	69.558	**	0.31	-0.09	0.08
157	-4.265	-3.133	40.292	1.209	3.347	0.236	40.638	*	0.31	-0.11	0.00
158	1.453	-2.480	6.330	-0.148	0.080	0.411	6.953		0.60	-0.13	0.19
159	-2.606	-2.008	-0.013	0.093	0.225	-0.072	3.290		0.65	-0.24	0.08
160	2.311	4.634	3.256	0.500	0.364	0.596	6.117		0.53	-0.15	0.12
161	-25.322	-66.402	-49.193	-1.131	-1.094	0.475	86.432	**	0.26	0.06	0.13
162	-32.438	-92.761	-103.01	-1.915	-0.882	0.594	142.36	****	0.21	0.06	0.14
163	-18.523	106.72	-170.40	3.461	0.267	0.377	201.91	*****	0.14	0.12	0.02
164	-9.674	30.799	-63.394	1.366	-5.536	0.107	71.140	****	0.25	0.13	0.02
165	-12.324	86.003	-101.57	2.059	*	-1.365	133.66	****	0.19	0.13	0.02
166	-2.691	-12.971	-11.769	0.125	0.048	0.085	17.720		0.48	0.09	0.01
167	-6.319	-19.007	-24.249	0.582	0.443	0.114	31.451	*	0.40	0.11	0.02
168	-10.164	-14.392	-40.166	0.876	-1.633	0.261	43.860	*	0.32	0.12	0.02
169	-0.700	-6.137	-1.721	-0.150	*	0.167	6.412		0.55	0.07	0.01
170	-33.844	-56.603	-178.57	4.031	-1.112	1.435	190.36	*****	0.14	0.12	0.06
171	-42.818	-165.05	-205.58	1.348	-1.037	1.475	267.10	*****	0.15	0.10	0.11
172	-10.710	-20.116	-13.382	-0.023	-0.681	0.102	26.428	*	0.47	0.09	0.07
173	-17.416	-38.594	-27.255	0.046	-0.562	0.198	50.355	*	0.40	0.10	0.07
174	-23.964	-60.063	-44.081	0.109	-0.469	0.135	78.262	**	0.32	0.11	0.08
175	-2.171	-3.669	-2.457	0.024	0.038	0.256	4.921	****	0.54	0.07	0.06
176	-38.057	-118.96	-143.09	-2.196	-0.823	0.593	189.93	****	0.17	0.06	0.14
177	-1.790	-75.608	19.107	-2.036	-0.226	0.561	78.006	**	0.18	-0.01	0.16
178	-1.918	-53.842	18.853	-1.123	-0.176	0.557	57.080	**	0.26	-0.00	0.15
179	-2.977	-72.144	10.231	-1.756	-0.121	0.556	72.927	**	0.21	0.00	0.15
180	-11.632	-16.187	-8.364	-0.323	-0.023	0.291	21.616	*	0.44	0.06	0.13
181	-0.767	-7.134	24.603	-0.299	0.051	0.219	25.628	*	0.41	-0.00	0.15
182	-14.192	-29.209	-13.148	-0.681	-0.116	0.304	35.035	*	0.38	0.06	0.13
183	0.060	-19.695	26.345	-0.450	0.063	0.500	32.893	*	0.36	-0.00	0.15
184	-15.868	-47.521	-21.205	-0.782	-0.221	0.152	54.403	**	0.31	0.06	0.13
185	0.544	-35.524	28.790	-0.651	0.066	0.474	45.728	*	0.31	-0.01	0.15
186	-6.485	-5.115	-2.532	-0.189	-0.035	0.213	8.639	*	0.52	0.06	0.12
187	-0.666	0.273	7.994	-0.107	0.281	0.110	8.026	*****	0.50	-0.01	0.17
188	26.683	-147.37	137.57	-1.218	-0.570	1.621	203.36	*****	0.15	0.07	0.12
189	14.788	-223.00	183.45	0.709	-3.094	1.677	289.14	*****	0.13	-0.11	0.04
190	15.344	-73.762	75.143	-0.459	0.372	0.842	106.41	***	0.26	-0.07	0.12
191	7.846	-80.660	78.418	0.339	-0.304	1.485	112.77	***	0.26	-0.10	0.04
192	16.913	-110.15	100.84	-0.871	0.549	0.758	150.29	***	0.21	-0.07	0.11
193	9.734	-137.64	117.47	0.309	-2.901	3.070	181.22	*****	0.21	-0.11	0.04
194	12.172	5.321	15.842	0.495	1.277	-0.200	20.675	*	0.41	-0.07	0.12
195	7.958	14.784	10.486	-0.016	0.722	0.122	19.796	*	0.41	-0.11	0.04
196	12.489	-18.011	33.660	0.155	0.277	0.535	40.167	*	0.36	-0.07	0.12
197	6.132	-3.819	27.161	0.281	0.534	0.403	28.105	*	0.36	-0.11	0.04
198	13.470	-42.837	52.485	-0.116	0.368	0.555	69.073	**	0.31	-0.07	0.12
199	5.421	-33.780	48.942	0.442	0.435	0.815	59.714	**	0.31	-0.10	0.04
200	-1.808	-1.398	11.146	0.171	-0.127	-0.200	11.378	**	0.51	-0.10	0.16
201	1.323	7.978	1.000	-0.091	-0.320	-0.151	8.149		0.54	-0.19	0.06

NO ERRORS OR WARNINGS IN THIS PHASE
*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 39410 WORDS ***
*** END OF PHASE 7 ***

*
* TITLE PLASTER RISSE CAST, STRESSES
*
* PHASE NUMBER 9 STARTS HERE
*

DEFAULT STRESS-ELEMENTS MODULE CREATED.

Static Analysis
Symmetric 41320 Triangular Element Model
Structural Material: Plaster
Stresses

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE
 SIGMA1 IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE
 THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS

ELEM.	LOAD	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE
1	1	0.109E+06	-0.807E+05	17.3	0.131E+06	-0.592E+05	71.1	0.294E+06	-0.179E+06	82.3
2	1	0.224E+06	-0.759E+05	23.5	0.281E+05	-0.119E+05	34.7	0.561E+05	-0.172E+06	70.3
3	1	0.432E+05	-0.483E+05	35.9	0.790E+05	-0.571E+05	49.9	0.206E+06	-0.157E+06	51.0
4	1	0.821E+05	-0.419E+05	33.6	0.851E+05	-0.123E+05	51.7	0.212E+06	-0.106E+06	53.5
5	1	0.339E+06	-0.189E+04	46.4	0.196E+06	-0.410E+05	74.6	0.223E+06	-0.859E+05	72.0
6	1	0.106E+06	0.614E+04	35.3	0.102E+06	-0.367E+05	31.0	0.186E+06	-0.167E+06	37.0
7	1	0.152E+06	0.656E+04	41.5	0.910E+05	-0.152E+05	63.1	0.171E+06	-0.117E+06	56.0
8	1	0.124E+06	-0.289E+04	53.4	0.847E+05	-0.781E+04	25.8	0.170E+06	-0.137E+06	30.2
9	1	0.371E+06	0.591E+05	77.8	0.265E+06	0.344E+05	87.1	0.209E+06	-0.356E+05	67.5
10	1	0.176E+06	0.890E+05	59.6	0.157E+06	-0.447E+05	53.2	0.140E+06	-0.180E+06	51.5
11	1	0.210E+06	0.244E+05	56.3	0.104E+06	0.340E+05	81.6	0.130E+06	-0.895E+05	53.2
12	1	0.132E+06	0.164E+05	62.5	0.791E+05	-0.193E+05	57.7	0.122E+06	-0.151E+06	46.9
13	1	0.296E+06	0.111E+06	33.3	0.198E+06	0.330E+05	72.8	0.201E+06	-0.145E+06	88.5
14	1	0.300E+06	0.139E+06	59.3	0.116E+06	-0.343E+05	28.4	-0.479E+04	-0.271E+06	12.3
15	1	0.143E+06	-0.849E+04	48.7	0.933E+05	0.161E+05	83.6	0.130E+06	-0.453E+05	69.3
16	1	0.146E+06	-0.283E+05	17.1	0.459E+05	-0.129E+05	41.3	0.993E+05	-0.151E+06	60.5
17	1	0.537E+05	-0.879E+06	52.5	0.613E+05	-0.441E+06	54.0	0.769E+05	-0.120E+05	70.8
18	1	0.209E+06	-0.614E+06	37.9	0.142E+06	-0.365E+05	50.1	0.568E+06	0.479E+05	60.3
19	1	0.683E+05	-0.685E+06	46.9	0.108E+06	-0.246E+06	62.6	0.369E+06	-0.287E+05	77.2
20	1	0.259E+06	-0.404E+06	36.3	0.145E+06	-0.290E+05	57.5	0.423E+06	-0.459E+05	68.7
21	1	0.490E+06	-0.475E+06	37.8	0.193E+06	-0.166E+06	43.3	0.166E+06	-0.128E+06	66.1
22	1	0.734E+06	-0.121E+06	56.0	0.486E+06	0.803E+05	73.3	0.509E+06	-0.112E+05	68.0
23	1	0.303E+06	-0.451E+06	38.4	0.143E+06	-0.172E+06	43.0	0.128E+06	-0.367E+05	70.0
24	1	0.524E+06	-0.607E+05	58.2	0.391E+06	0.664E+05	73.8	0.395E+06	0.570E+05	74.3
25	1	0.379E+06	-0.170E+06	75.1	0.111E+06	-0.220E+05	37.7	-0.390E+05	-0.331E+06	15.9
26	1	0.305E+06	-0.485E+06	70.2	0.122E+06	0.412E+05	74.6	0.574E+06	-0.562E+06	44.4
27	1	0.180E+06	-0.129E+06	68.9	0.129E+06	0.441E+05	64.9	0.219E+06	0.764E+05	16.2
28	1	0.253E+06	0.158E+06	23.0	0.153E+06	0.211E+05	76.6	0.146E+06	-0.209E+06	74.1
29	1	0.385E+06	0.118E+06	72.6	0.644E+05	-0.466E+05	37.8	-0.932E+05	-0.374E+06	6.5
30	1	-0.252E+06	-0.394E+06	50.1	0.108E+06	0.468E+05	25.7	0.607E+06	0.350E+06	33.3
31	1	0.109E+06	-0.293E+06	86.7	0.909E+05	0.985E+04	74.1	0.325E+06	0.602E+05	4.3
32	1	0.559E+04	-0.107E+06	62.2	0.178E+06	0.234E+05	20.4	0.465E+06	0.119E+06	3.6
33	1	0.528E+06	0.327E+05	60.9	0.318E+05	-0.921E+05	18.2	-0.726E+05	-0.608E+06	15.3
34	1	0.373E+06	0.177E+06	70.2	0.126E+06	-0.276E+05	49.3	0.443E+05	-0.398E+06	38.1
35	1	0.391E+06	-0.229E+05	81.3	0.710E+05	0.485E+04	72.3	0.373E+05	-0.254E+06	4.7
36	1	0.463E+06	0.916E+05	86.4	0.286E+06	-0.471E+05	64.7	0.198E+06	-0.274E+06	48.3
37	1	-0.128E+06	-0.255E+06	22.0	-0.313E+04	-0.145E+06	2.7	0.155E+06	-0.679E+05	15.4
38	1	-0.314E+06	-0.425E+06	49.4	0.754E+05	-0.281E+06	13.0	0.555E+06	-0.226E+06	16.3
39	1	0.117E+06	-0.290E+06	52.5	0.136E+06	-0.170E+05	74.6	0.347E+06	0.624E+05	61.8
40	1	-0.105E+06	-0.294E+06	43.8	0.284E+06	-0.150E+06	1.9	0.168E+06	-0.998E+05	4.4
41	1	0.342E+05	-0.438E+05	73.6	0.585E+05	0.261E+05	38.5	0.156E+06	-0.231E+05	26.4
42	1	0.205E+05	-0.686E+05	70.4	0.225E+05	-0.714E+04	86.7	0.715E+05	0.739E+04	40.5
43	1	0.555E+05	-0.228E+05	64.8	0.335E+05	-0.259E+05	50.0	0.758E+05	-0.103E+05	21.9
44	1	0.423E+05	-0.365E+05	70.0	0.278E+05	-0.776E+04	89.9	0.430E+05	-0.864E+04	51.0
45	1	0.371E+05	-0.754E+05	68.9	0.299E+05	-0.732E+04	78.5	0.641E+05	0.175E+05	36.1
46	1	0.416E+05	-0.555E+05	19.9	0.383E+05	-0.117E+05	2.4	0.709E+05	-0.379E+04	35.3
47	1	0.521E+05	-0.490E+05	65.1	0.446E+05	-0.794E+04	76.3	0.553E+05	0.150E+05	67.2
48	1	0.547E+05	-0.321E+05	27.3	0.486E+05	-0.948E+04	7.5	0.648E+05	-0.913E+04	16.6
49	1	0.794E+05	-0.680E+05	64.8	0.536E+05	-0.123E+05	76.8	0.656E+05	0.542E+04	56.9
50	1	0.763E+05	-0.647E+05	67.7	0.608E+05	-0.118E+05	87.3	0.913E+05	-0.505E+04	58.6

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE										
SIGNAL IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE										
THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS										
ELEM. NO.	LOAD CASE	***POSITIVE***SURFACE***			***NEUTRAL***SURFACE***			***NEGATIVE***SURFACE***		
		SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE
51	1	0.104E+06	-0.462E+05	-61.3	0.717E+05	-0.125E+05	-74.0	0.662E+05	-0.609E+04	74.2
52	1	0.115E+06	-0.222E+05	-57.8	0.720E+05	-0.128E+05	-75.8	0.624E+05	-0.370E+05	77.1
53	1	0.163E+06	-0.262E+05	-68.1	0.970E+05	-0.116E+05	-76.4	0.489E+05	-0.154E+05	75.3
54	1	0.130E+06	-0.111E+06	23.5	0.985E+05	-0.120E+05	14.2	0.115E+06	0.384E+05	-33.4
55	1	0.186E+06	-0.223E+05	-61.2	0.108E+06	-0.107E+05	-73.7	0.650E+05	-0.353E+05	75.5
56	1	0.197E+06	-0.215E+05	44.2	0.105E+06	-0.228E+05	28.9	0.597E+05	-0.707E+05	-6.4
57	1	0.237E+06	0.363E+04	-72.2	0.145E+06	-0.112E+05	-74.3	0.537E+05	-0.272E+05	-80.3
58	1	0.107E+06	-0.234E+06	-69.2	0.144E+06	-0.449	-69.2	0.233E+06	0.181E+06	20.9
59	1	0.271E+06	-0.202E+05	-61.6	0.136E+06	-0.645E+04	-73.3	0.622E+05	-0.540E+05	66.0
60	1	0.319E+06	0.149E+05	-43.6	0.137E+06	-0.250E+05	-58.3	0.255E+05	-0.135E+06	87.6
61	1	0.288E+06	-61.1	-77.2	0.170E+06	-0.282E+04	-67.9	0.817E+05	-0.352E+05	-41.8
62	1	-0.608E+05	-0.422E+06	26.2	0.182E+06	-0.350E+05	37.6	0.530E+06	0.385E+06	-89.6
63	1	0.278E+06	-0.756E+05	-58.9	0.135E+06	0.108E+05	-69.9	0.122E+06	-0.322E+05	49.7
64	1	0.394E+06	0.695E+05	57.0	0.146E+06	-0.149E+05	45.6	-0.367E+05	-0.164E+06	5.8
65	1	0.515E+05	-0.166E+06	-24.5	0.411E+05	-0.914E+05	-37.7	0.665E+05	-0.526E+05	-64.7
66	1	-0.673E+05	-0.164E+06	35.5	-0.404E+05	-0.951E+05	16.2	0.146E+05	-0.545E+05	-14.1
67	1	0.194E+05	-0.135E+06	-16.7	0.262E+05	-0.650E+05	-36.8	0.781E+05	-0.403E+05	-65.2
68	1	-0.845E+05	-0.138E+06	52.5	-0.355E+05	-0.533E+05	10.6	0.522E+05	-0.110E+05	-18.2
69	1	0.328E+05	-0.964E+05	-51.2	0.286E+05	-0.110E+06	-42.8	0.293E+05	-0.129E+06	-36.1
70	1	-292.	-0.858E+05	39.2	0.312E+05	-0.407E+05	87.7	0.122E+06	-0.545E+05	-77.9
71	1	0.500E+05	-0.119E+06	-58.2	0.486E+05	-0.857E+05	-48.7	0.583E+05	-0.636E+05	-35.3
72	1	0.450E+05	-0.729E+05	48.1	0.387E+05	-0.244E+05	68.7	0.711E+05	-0.148E+05	-79.2
73	1	0.710E+05	-0.592E+06	-68.4	0.880E+05	-0.225E+06	89.3	0.368E+06	-0.121E+06	53.5
74	1	0.156E+06	-0.162E+06	-42.7	0.357E+05	960.	75.9	0.220E+06	-0.141E+06	52.0
75	1	0.872E+05	-0.133E+06	-47.3	0.281E+05	-0.198E+06	-61.9	-0.625E+04	-0.288E+06	-73.2
76	1	0.386E+06	0.304E+05	11.3	0.546E+05	-0.314E+05	21.2	0.340E+05	-0.278E+06	-80.1
77	1	0.327E+06	-0.285E+06	-43.9	0.142E+06	-0.127E+06	-46.8	0.411E+05	-0.518E+05	63.5
78	1	0.509E+06	-0.212E+05	60.1	0.321E+06	0.492E+05	78.0	0.291E+06	-0.390E+05	-67.1
79	1	0.419E+06	-0.116E+06	-18.1	0.128E+06	-0.160E+06	-35.3	-0.184E+05	-0.348E+06	-68.4
80	1	0.688E+06	-177.	71.4	0.238E+06	0.323E+05	68.2	0.681E+05	-0.196E+06	-13.6
81	1	0.516E+06	-0.120E+06	21.8	0.491E+05	-0.116E+06	-33.5	0.142E+06	-0.672E+06	-57.0
82	1	0.761E+06	0.276E+04	21.9	0.868E+05	0.391E+05	-10.1	0.105E+06	-0.617E+06	-64.7
83	1	0.725E+06	-0.120E+06	28.6	0.104E+06	-0.609E+05	-8.6	0.151E+06	-0.670E+06	-50.0
84	1	0.746E+06	0.414E+05	24.8	0.111E+06	0.233E+05	-24.5	0.117E+06	-0.634E+06	-58.5
85	1	0.614E+06	-0.270E+05	11.6	0.108E+06	-0.135E+06	-26.4	0.308E+05	-0.672E+06	-57.5
86	1	0.778E+06	-0.738E+05	78.5	0.146E+06	-0.201E+05	50.4	0.134E+06	-0.587E+06	-0.3
87	1	0.760E+06	0.146E+05	28.5	0.892E+05	-0.456E+05	-14.2	0.421E+05	-0.730E+06	-51.3
88	1	0.599E+06	-0.607E+05	87.2	0.793E+05	-0.633E+05	37.4	0.127E+06	-0.633E+06	8.0
89	1	0.830E+05	-0.294E+05	-68.1	0.449E+05	-0.143E+05	-68.8	0.714E+04	565.	-80.5
90	1	0.101E+06	0.173E+05	-74.0	0.734E+05	-0.711E+04	-83.7	0.507E+05	-0.361E+05	87.0
91	1	0.117E+06	0.204E+05	-74.3	0.758E+05	-0.282E+05	-81.1	0.369E+05	-0.794E+05	-86.8
92	1	0.108E+06	0.690E+05	-70.4	0.831E+05	-0.283E+04	-85.2	0.610E+05	-0.780E+05	-89.2
93	1	0.720E+05	-0.180E+05	-59.2	0.611E+05	-0.158E+05	-73.5	0.616E+05	-0.249E+05	-88.6
94	1	0.830E+05	0.158E+05	39.8	0.760E+05	-574.	16.1	0.852E+05	-0.332E+05	3.8
95	1	0.108E+06	0.323E+05	-50.2	0.877E+05	-0.109E+05	-73.4	0.840E+05	-0.708E+05	-83.8
96	1	0.126E+06	0.923E+05	61.2	0.104E+06	-0.128E+05	18.0	0.988E+05	-0.838E+05	12.8
97	1	0.123E+06	-0.347E+04	-52.3	0.855E+05	-0.132E+05	-67.5	0.667E+05	-0.421E+05	-85.5
98	1	0.132E+06	0.271E+05	-46.1	0.895E+05	-0.588E+04	-67.4	0.708E+05	-0.626E+05	-83.5
99	1	0.136E+06	0.565E+05	-37.5	0.947E+05	-0.207E+04	-68.0	0.812E+05	-0.888E+05	-80.2
100	1	0.153E+06	0.995E+05	-33.0	0.113E+06	0.123E+05	-75.5	0.100E+06	-0.103E+06	-83.2

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE
 SIGNAL IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE
 THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS
 ELEM. LOAD ***POSITIVE***SURFACE***
 NUMB. CASE SIGMA 1 SIGMA 2 ANGLE
 101 1 0.182E+06 0.157E+05 -46.9 0.104E+06 -0.137E+05 -63.7 0.585E+05 -0.752E+05 -85.4
 102 1 0.191E+06 0.360E+05 54.4 0.984E+05 -0.171E+05 34.0 0.440E+05 -0.108E+06 13.3
 103 1 0.152E+06 0.657E+05 -29.0 0.819E+05 -0.230E+04 -66.6 0.550E+05 -0.113E+06 -81.4
 104 1 0.161E+06 0.102E+06 69.1 0.980E+05 0.108E+05 22.0 0.713E+05 -0.117E+06 13.0
 105 1 0.240E+06 0.484E+05 -41.6 0.105E+06 -0.113E+05 -60.0 0.188E+05 -0.121E+06 -87.9
 106 1 0.256E+06 0.574E+05 -29.7 0.933E+05 -0.169E+05 -47.9 -0.143E+05 -0.147E+06 -79.4
 107 1 0.168E+06 0.630E+05 -23.0 0.575E+05 0.628E+04 -62.3 0.975E+04 -0.139E+06 -84.3
 108 1 0.172E+06 0.841E+05 -17.2 0.727E+05 0.187E+05 -74.3 0.458E+05 -0.119E+06 -88.9
 109 1 0.293E+06 0.200E+05 -28.9 0.889E+05 -103. 51.3 0.288E+05 -0.164E+06 81.4
 110 1 0.310E+06 0.330E+05 70.7 0.830E+05 -0.174E+05 54.6 -0.303E+05 -0.181E+06 3.2
 111 1 0.179E+06 0.114E+05 -16.2 0.209E+05 12.9 -43.7 -401. -0.148E+06 80.5
 112 1 0.150E+06 0.417E+05 72.2 0.486E+05 -0.234E+05 16.0 0.346E+05 -0.176E+06 1.8
 113 1 0.245E+04 -0.925E+05 -21.4 0.368E+05 -0.636E+05 -39.9 0.870E+05 -0.504E+05 -52.2
 114 1 -0.103E+05 -0.627E+05 -67.3 0.525E+05 -0.102E+05 -79.7 0.119E+06 0.384E+05 -87.6
 115 1 0.726E+05 -0.537E+05 -47.6 0.115E+06 -0.147E+05 -60.5 0.168E+06 0.130E+05 -70.9
 116 1 0.124E+06 291. 88.2 0.193E+06 0.865E+04 85.1 0.263E+06 0.165E+05 83.5
 117 1 0.630E+05 -0.117E+06 -52.1 0.600E+05 -0.694E+05 -50.4 0.575E+05 -0.224E+05 -46.7
 118 1 0.105E+06 -0.320E+05 43.3 0.829E+05 -0.113E+05 40.8 0.814E+05 -0.847E+04 34.4
 119 1 0.824E+05 -0.118E+05 -63.1 0.844E+05 -0.253E+05 -71.1 0.896E+05 -0.419E+05 -76.8
 120 1 0.136E+06 0.239E+05 31.2 0.119E+06 -0.173E+05 31.3 0.102E+06 -0.585E+05 31.4
 121 1 0.379E+06 -0.332E+05 -12.9 0.926E+05 0.627E+04 -67.2 0.174E+06 -0.322E+06 86.8
 122 1 0.378E+06 0.102E+06 14.8 0.712E+05 -0.721E+05 -39.0 -0.140E+05 -0.468E+06 -56.7
 123 1 0.158E+06 -0.931E+05 31.8 0.686E+05 -0.238E+05 65.5 0.136E+06 0.111E+06 -79.9
 124 1 0.981E+05 -0.112E+06 52.2 -0.804E+04 -0.517E+05 -78.6 0.864E+05 -0.172E+06 -48.4
 125 1 0.499E+06 -0.240E+04 18.7 0.684E+05 0.150E+05 59.7 0.841E+05 -0.414E+06 -77.4
 126 1 0.344E+06 -0.110E+06 82.8 0.187E+04 -0.739E+05 12.4 0.101E+06 -0.479E+06 -2.5
 127 1 0.225E+06 -0.106E+06 39.8 0.778E+05 -0.740E+05 61.5 0.617E+05 -0.174E+06 -81.2
 128 1 0.651E+05 -0.186E+06 -42.3 -0.422E+04 -0.104E+06 -7.8 0.815E+05 -0.177E+06 24.7
 129 1 0.442E+05 -0.175E+06 50.5 0.675E+05 -0.466E+05 44.8 0.109E+06 0.637E+05 8.0
 130 1 0.256E+05 -0.172E+06 58.4 0.305E+05 -0.331E+05 52.4 0.110E+06 0.317E+05 -21.7
 131 1 0.450E+05 -0.218E+06 67.0 0.748E+04 -0.683E+05 87.2 0.114E+06 -0.629E+05 -39.8
 132 1 0.165E+05 -0.248E+06 38.4 0.455E+05 -0.543E+05 40.8 0.141E+06 0.731E+05 -58.7
 133 1 0.647E+05 -0.179E+06 57.4 0.444E+05 -0.421E+05 51.5 0.101E+06 0.184E+05 -19.9
 134 1 0.333E+05 -0.178E+06 -18.7 0.228E+05 -0.449E+05 -28.8 0.982E+05 -0.188E+04 86.0
 135 1 0.570E+05 -0.807E+05 54.3 0.171E+05 0.801E+04 -76.6 0.108E+06 -0.337E+05 -39.3
 136 1 0.104E+06 -0.111E+06 -36.2 0.644E+05 -0.195E+05 -47.1 0.918E+05 0.502E+04 76.9
 137 1 0.108E+06 -0.956E+05 52.6 0.141E+06 0.387E+05 78.8 0.264E+06 0.837E+05 -69.5
 138 1 0.697E+05 -0.106E+06 46.5 0.199E+05 0.457E+04 -36.7 0.146E+06 -0.602E+05 -42.5
 139 1 0.926E+05 -0.119E+06 53.2 0.519E+05 0.715E+04 46.7 0.135E+06 0.920E+04 -32.2
 140 1 -0.689E+04 -0.158E+06 42.9 -76.6 -0.911E+05 -6.6 0.118E+06 -0.136E+06 -24.6
 141 1 0.144E+06 -0.866E+05 53.0 0.759E+05 0.263E+05 81.4 0.171E+06 -0.238E+05 -49.6
 142 1 0.101E+06 -0.104E+06 -45.1 0.216E+05 0.120E+05 65.1 0.146E+06 -0.753E+05 46.5
 143 1 0.101E+06 -0.144E+06 51.9 0.468E+05 -0.740E+04 44.2 0.132E+06 -0.110E+05 -32.4
 144 1 0.143E+05 -0.171E+06 -41.2 0.313E+04 -0.671E+05 -83.9 0.126E+06 -0.971E+05 68.2
 145 1 0.153E+06 -0.972E+05 50.8 0.481E+05 0.126E+05 53.7 0.123E+06 -0.575E+05 -40.4
 146 1 0.981E+05 -0.120E+06 54.7 0.951E+04 0.496E+04 60.2 0.130E+06 -0.792E+05 -35.5
 147 1 0.945E+05 -0.166E+06 53.2 0.463E+05 -0.256E+05 40.2 0.129E+06 -0.164E+05 -23.9
 148 1 0.238E+05 -0.189E+06 55.5 0.988E+04 -0.466E+05 24.6 0.140E+06 -0.681E+05 -18.5
 149 1 0.102E+06 -0.170E+06 49.1 0.248E+05 -0.359E+05 38.0 0.106E+06 -0.601E+05 -32.8
 150 1 0.541E+05 -0.200E+06 -15.1 0.548E+04 -0.547E+05 6.4 0.116E+06 -0.688E+05 61.8

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE										
SIGNAL IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE										
THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS										
ELEM. LOAD										
NUMB. CASE										
POSITIVESURFACE***										
NEUTRALSURFACE***										
NEGATIVESURFACE***										
SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE		
151	1	0.717E+05	-0.164E+06	57.7	0.321E+05	-0.196E+05	42.8	0.136E+06	-0.188E+05	-22.6
152	1	-0.507E+05	-0.209E+06	-31.1	0.108E+05	-0.232E+05	-49.6	0.174E+06	-0.617E+05	69.6
153	1	0.129E+06	0.593E+05	71.7	0.101E+06	-0.147E+05	68.5	0.736E+05	-0.890E+05	67.1
154	1	0.115E+06	0.756E+05	77.1	0.116E+06	-0.725E+04	71.2	0.117E+06	-0.906E+05	70.1
155	1	0.880E+05	0.352E+04	66.1	0.119E+06	-0.174E+05	78.2	0.156E+06	-0.435E+05	83.2
156	1	0.498E+05	-0.180E+05	71.0	0.103E+06	-0.454E+04	81.8	0.159E+06	-0.550E+04	86.5
157	1	0.117E+06	0.766E+05	-76.3	0.115E+06	-0.338E+04	73.6	0.125E+06	-0.949E+05	69.0
158	1	0.115E+06	0.853E+05	45.7	0.114E+06	-0.987E+04	24.9	0.118E+06	-0.698E+05	21.9
159	1	0.653E+05	-0.299E+04	67.7	0.102E+06	-0.993E+04	76.1	0.140E+06	-0.189E+05	79.6
160	1	0.550E+05	-0.124E+05	5.0	0.761E+05	-265.	19.3	0.104E+06	0.500E+04	28.9
161	1	0.281E+05	-0.929E+05	64.6	0.835E+05	-0.150E+05	76.7	0.151E+06	0.511E+05	-88.4
162	1	-0.659E+05	-0.117E+06	61.0	-0.932E+04	-0.270E+05	-54.2	0.942E+05	0.160E+05	-39.1
163	1	-0.707E+05	-0.153E+06	62.3	0.627E+04	-0.430E+05	32.8	0.120E+06	0.299E+05	7.2
164	1	-0.144E+06	-0.223E+06	13.0	-0.270E+05	-0.215E+06	-5.2	0.995E+05	-0.217E+06	-9.5
165	1	0.231E+05	-0.101E+06	63.3	0.635E+05	-0.139E+05	72.1	0.115E+06	0.622E+05	-85.0
166	1	-0.467E+05	-0.113E+06	-16.7	-0.165E+05	-0.335E+05	82.4	0.799E+05	-0.197E+05	76.4
167	1	-0.506E+05	-0.146E+06	56.2	0.115E+05	-0.374E+05	16.4	0.134E+06	0.107E+05	-8.3
168	1	-0.124E+06	-0.195E+06	-73.4	-0.177E+05	-0.179E+06	84.9	0.100E+06	-0.175E+06	79.8
169	1	0.115E+06	0.893E+05	-68.9	0.105E+06	-0.209E+04	73.4	0.107E+06	-0.938E+05	69.8
170	1	0.107E+06	0.871E+05	-75.7	0.974E+05	0.107E+05	82.0	0.905E+05	-0.690E+05	79.4
171	1	0.626E+05	-0.100E+05	60.6	0.841E+05	-0.793E+04	71.8	0.110E+06	-0.102E+05	78.5
172	1	0.544E+05	-0.149E+05	62.3	0.572E+05	-696.	78.2	0.706E+05	0.287E+04	-85.4
173	1	0.972E+05	0.848E+05	-34.3	0.846E+05	0.254E+04	73.9	0.832E+05	-0.910E+05	72.7
174	1	0.909E+05	0.872E+05	-52.3	0.770E+05	0.831E+04	12.7	0.661E+05	-0.736E+05	13.2
175	1	0.602E+05	-0.150E+05	53.6	0.696E+05	-0.948E+04	67.3	0.864E+05	-0.113E+05	77.7
176	1	0.741E+05	-0.189E+05	-18.7	0.563E+05	-0.235E+04	-5.2	0.555E+05	-923.	20.2
177	1	0.298E+05	-0.970E+05	62.5	0.534E+05	-0.116E+05	70.1	0.925E+05	0.585E+05	-71.4
178	1	-0.396E+05	-0.110E+06	61.9	-0.174E+05	-0.350E+05	-30.7	0.751E+05	-0.304E+05	-29.0
179	1	-0.302E+05	-0.132E+06	58.1	0.831E+04	-0.312E+05	9.1	0.126E+06	-0.103E+05	-14.5
180	1	-0.115E+06	-0.170E+06	17.6	-0.160E+05	-0.157E+06	-12.5	0.994E+05	-0.159E+06	-17.8
181	1	0.433E+05	-0.944E+05	64.7	0.540E+05	-0.130E+05	71.8	0.834E+05	0.497E+05	-63.6
182	1	-0.295E+05	-0.105E+06	-13.9	-0.162E+05	-0.322E+05	51.9	0.685E+05	-0.310E+05	69.1
183	1	-0.208E+05	-0.116E+06	61.3	0.339E+04	-0.210E+05	-3.8	0.117E+06	-0.152E+06	71.1
184	1	-0.104E+06	-0.147E+06	-69.5	-0.112E+05	-0.142E+06	75.7	0.973E+05	-0.152E+06	71.1
185	1	0.103E+06	0.765E+05	0.8	0.614E+05	0.261E+04	76.8	0.450E+05	-0.961E+05	79.3
186	1	0.102E+06	0.730E+05	0.6	0.556E+05	0.106E+05	84.8	0.380E+05	-0.810E+05	86.2
187	1	0.644E+05	-0.227E+05	46.5	0.559E+05	-0.132E+05	61.3	0.597E+05	-0.160E+05	78.6
188	1	0.104E+06	-0.243E+05	55.9	0.788E+05	-0.465E+04	62.0	0.588E+05	-0.957E+04	78.5
189	1	0.776E+05	-0.291E+05	-10.8	0.507E+05	0.130E+04	67.4	0.128E+06	-0.728E+05	73.6
190	1	0.114E+06	-0.153E+05	-69.0	0.272E+05	-0.344E+05	8.8	0.669E+05	-0.180E+06	15.1
191	1	0.496E+05	-0.725E+05	29.3	0.539E+05	-0.260E+05	50.7	0.937E+05	-0.150E+05	75.6
192	1	0.934E+05	-0.674E+05	-33.4	0.124E+06	-0.272E+05	-21.2	0.168E+06	-949.	-9.6
193	1	0.440E+05	-0.927E+05	70.5	0.667E+05	-0.102E+05	78.7	0.103E+06	0.585E+05	-71.5
194	1	-0.194E+05	-0.866E+05	67.9	-0.268E+04	-0.315E+05	-54.1	0.718E+05	-0.342E+05	-36.7
195	1	-0.143E+05	-0.102E+06	63.3	0.808E+04	-0.130E+05	-26.0	0.118E+06	-0.119E+05	-26.5
196	1	-0.981E+05	-0.138E+06	11.3	-0.269E+04	-0.135E+06	-18.2	0.104E+06	-0.144E+06	-22.1
197	1	0.293E+05	-0.847E+05	75.9	0.108E+06	0.249E+04	-89.5	0.200E+06	0.759E+05	-76.2
198	1	0.254E+05	-0.668E+05	-46.0	0.362E+05	-0.180E+05	60.4	0.135E+06	-0.572E+05	52.9
199	1	-0.624E+04	-0.104E+06	58.0	0.893E+04	-0.894E+04	-16.9	0.120E+06	-0.982E+04	-28.0
200	1	-0.790E+05	-0.128E+06	-66.8	-0.293E+04	-0.130E+06	70.5	0.979E+05	-0.157E+06	65.0

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE										
SIGNAL IS THE MAXIMUM VALUE OF STRESS IN THE PLANE. SIGMA2 IS THE MINIMUM IN THE PLANE										
THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS										
ELEM.	LOAD	***POSITIVE***SURFACE***			***NEUTRAL***SURFACE***			***NEGATIVE***SURFACE***		
NUMB.	CASE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE
201	1	0.116E+06	-0.187E+05	50.8	0.174E+06	-0.170E+04	57.5	0.235E+06	0.124E+05	61.6
202	1	0.122E+06	-0.292E+05	12.1	0.771E+05	0.450E+04	18.0	0.506E+05	0.199E+05	65.5
203	1	0.669E+05	0.260E+04	-49.7	0.111E+06	-0.957E+04	-48.2	0.155E+06	-0.218E+05	-47.7
204	1	0.785E+05	0.223E+05	88.0	0.122E+06	0.995E+04	-74.4	0.172E+06	-0.901E+04	-69.3
205	1	0.130E+06	0.324E+05	7.6	0.925E+05	0.493E+05	32.2	0.994E+05	0.223E+05	68.5
206	1	0.107E+06	0.111E+05	9.2	0.107E+06	-0.289E+05	17.7	0.110E+06	-0.720E+05	22.1
207	1	0.947E+05	0.119E+05	64.0	0.112E+06	0.177E+05	89.8	0.153E+06	458.	-77.6
208	1	0.745E+05	-0.210E+05	-5.4	0.956E+05	-0.169E+05	22.4	0.146E+06	-0.421E+05	34.8
209	1	0.115E+06	-0.128E+05	81.3	0.934E+05	-0.588E+04	-87.1	0.840E+05	-0.113E+05	-71.2
210	1	0.248E+05	-0.526E+05	-34.7	0.440E+05	-0.604E+05	-35.2	0.632E+05	-0.682E+05	-35.5
211	1	0.240E+05	-0.314E+05	59.7	0.288E+05	-0.509E+05	54.4	0.344E+05	-0.711E+05	51.6
212	1	0.200E+05	-0.114E+06	-9.4	0.150E+05	-0.149E+06	-7.6	0.102E+05	-0.185E+06	-6.4
213	1	0.105E+06	-0.233E+05	62.7	0.875E+05	-0.286E+05	77.4	0.107E+06	0.437E+05	-60.5
214	1	-0.493E+05	-0.109E+06	56.5	0.414E+05	-0.772E+05	55.6	0.132E+06	-0.454E+05	55.3
215	1	0.330E+05	-0.526E+05	29.4	0.512E+05	-0.362E+05	23.8	0.710E+05	-0.214E+05	18.6
216	1	-0.809E+05	-0.277E+06	54.8	0.497E+04	-0.184E+06	66.9	0.107E+06	-0.107E+06	78.0
217	1	0.119E+05	-0.215E+06	65.5	0.153E+05	-0.447E+05	89.8	0.158E+06	-0.144E+05	-40.3
218	1	0.287E+05	-0.208E+06	35.8	0.111E+05	-0.411E+05	20.6	0.138E+06	-0.184E+05	-44.2
219	1	-0.651E+05	-0.183E+06	87.3	-0.186E+05	-0.121E+06	-51.8	0.948E+05	-0.127E+06	-35.9
220	1	-0.107E+06	-0.218E+06	79.7	-0.877E+04	-0.450E+05	-47.4	0.183E+06	0.350E+05	-24.4
221	1	0.105E+06	-0.122E+06	49.3	0.231E+05	-0.527E+04	44.3	0.133E+06	-0.590E+05	-39.8
222	1	0.115E+06	-0.133E+06	-28.4	0.635E+05	-0.242E+05	-53.9	0.145E+06	-0.484E+05	84.0
223	1	-0.396E+04	-0.193E+06	76.1	0.354E+04	-0.283E+05	-67.3	0.164E+06	-0.169E+05	-23.7
224	1	0.182E+05	-0.208E+06	-5.6	0.363E+05	-0.149E+05	-72.3	0.269E+06	-0.367E+05	-88.5
225	1	-0.137E+06	-0.348E+06	-64.4	-0.135E+05	-0.159E+06	-52.4	0.135E+06	0.570E+04	-31.5
226	1	-0.718E+05	-0.327E+06	-81.2	0.437E+04	-0.621E+05	-61.1	0.229E+06	0.536E+05	-5.8
227	1	-0.189E+06	-0.349E+06	-71.2	-0.444E+05	-0.158E+06	-79.3	0.109E+06	0.230E+05	84.9
228	1	0.113E+06	-0.116E+06	-45.6	0.613E+04	-0.424E+05	43.2	0.129E+06	-0.198E+06	44.1
229	1	-0.278E+05	-0.277E+06	-88.2	-0.183E+04	-0.651E+05	-58.8	0.192E+06	-0.210E+05	-13.4
230	1	-0.100E+06	-0.333E+06	13.9	0.121E+05	-0.458E+05	71.5	0.333E+06	0.326E+05	-86.3
231	1	-0.476E+05	-0.416E+06	-68.2	0.539E+05	-0.102E+06	-43.0	0.331E+06	0.375E+05	-5.5
232	1	0.102E+06	-0.286E+06	34.0	0.487E+05	-0.959E+05	33.2	0.946E+05	-0.472E+04	-53.7
233	1	-0.430E+05	-0.125E+06	50.1	-0.133E+04	-0.102E+06	-18.2	0.114E+06	-0.152E+06	-24.4
234	1	-0.642E+05	-0.129E+06	41.1	-0.242E+04	-0.122E+06	-16.1	0.109E+06	-0.163E+06	-22.4
235	1	-0.656E+05	-0.776E+05	-27.9	0.716E+04	-0.133E+06	-22.7	0.800E+05	-0.189E+06	-22.5
236	1	-0.596E+05	-0.613E+05	-3.5	0.145E+05	-0.113E+06	-18.3	0.887E+05	-0.166E+06	-18.4
237	1	-0.276E+05	-0.125E+06	56.8	0.761E+04	-0.768E+05	-20.2	0.137E+06	-0.123E+06	-24.9
238	1	-0.801E+05	-0.139E+06	-49.1	508.	-0.119E+06	70.9	0.129E+06	-0.139E+06	66.2
239	1	-0.788E+05	-0.971E+05	-1.1	0.244E+05	-0.124E+06	-23.0	0.130E+06	-0.154E+06	-24.3
240	1	-0.786E+05	-0.897E+05	33.6	0.241E+05	-0.123E+06	67.2	0.130E+06	-0.159E+06	-18.0
241	1	-0.110E+05	-0.994E+05	-47.1	0.296E+05	-0.128E+06	-24.9	0.865E+05	-0.172E+06	-18.0
242	1	-0.256E+04	-0.802E+05	-51.2	0.466E+05	-0.455E+05	-22.0	0.121E+06	-0.365E+05	-9.7
243	1	0.452E+05	-0.290E+06	-59.2	0.109E+06	-0.102E+06	-36.1	0.283E+06	-0.238E+05	-10.2
244	1	0.238E+06	-0.406E+06	-85.9	0.247E+06	0.525E+05	-72.9	0.553E+06	-0.213E+06	-10.9
245	1	0.165E+04	-0.129E+06	-51.5	0.558E+05	-0.128E+06	-25.6	0.144E+06	-0.161E+06	-15.8
246	1	0.613E+05	-0.114E+06	25.3	0.705E+05	-0.636E+05	54.6	0.149E+06	-0.828E+05	74.7
247	1	0.266E+05	-0.257E+06	-64.0	0.899E+05	-0.856E+05	-39.1	0.256E+06	-0.173E+05	-13.0
248	1	0.378E+05	-0.443E+06	10.4	0.203E+06	-0.309E+05	19.2	0.529E+06	0.344E+06	83.2
249	1	-0.145E+05	-0.121E+06	66.5	0.145E+05	-0.513E+05	-27.6	0.150E+06	-0.878E+05	-25.8
250	1	-0.113E+06	-0.130E+06	59.7	770.	-0.120E+06	-27.1	0.132E+06	-0.128E+06	-27.3

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE
 SIGMA1 IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE
 THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS

ELEM.	LOAD	SIGMA 1	SIGMA 2	ANGLE	***POSITIVE***SURFACE***	***NEUTRAL***SURFACE***	SIGMA 1	SIGMA 2	ANGLE	***NEGATIVE***SURFACE***
251	1	-0.921E+05	-0.115E+06	22.0	0.242E+05	0.112E+06	-24.0	0.153E+06	-0.122E+06	-26.4
252	1	-0.104E+06	-0.135E+06	-72.1	0.190E+05	-0.136E+06	-32.8	0.155E+06	-0.150E+06	-29.9
253	1	-0.305E+05	-0.156E+06	64.7	-0.110E+04	-0.155E+05	-40.8	0.152E+06	-0.120E+06	-28.2
254	1	-0.106E+06	-0.163E+06	-11.3	-0.195E+05	-0.128E+06	50.5	0.113E+06	-0.139E+06	55.9
255	1	-0.857E+05	-0.135E+06	57.9	-0.352E+04	-0.943E+05	-27.8	0.128E+06	-0.103E+06	-28.7
256	1	-0.108E+06	-0.214E+06	16.9	-0.149E+04	-0.166E+06	44.6	0.135E+06	-0.148E+06	53.6
257	1	-0.622E+05	-0.170E+06	-60.5	0.482E+05	-0.123E+06	-28.6	0.196E+06	-0.113E+06	-19.5
258	1	-0.218E+05	-0.213E+06	-71.2	0.679E+05	-0.106E+06	-45.5	0.194E+06	-0.790E+05	-24.3
259	1	0.180E+06	-0.202E+06	-74.9	0.729E+05	-0.789E+05	-41.3	0.197E+06	-0.187E+06	-8.2
260	1	0.195E+06	-0.261E+06	-86.8	0.159E+06	-0.344E+05	-66.1	0.304E+06	-0.583E+04	-27.0
261	1	-0.142E+06	-0.237E+06	-77.7	0.116E+05	-0.113E+06	-35.8	0.217E+06	-0.407E+05	-25.0
262	1	-0.143E+06	-0.314E+06	18.7	0.490E+05	-0.164E+06	35.2	0.263E+06	-0.356E+05	44.3
263	1	0.209E+06	-0.145E+06	83.5	0.426E+05	-0.888E+05	-51.1	0.144E+06	-0.300E+06	-24.7
264	1	-0.104E+06	-0.536E+06	65.3	0.884E+05	-0.225E+06	31.0	0.492E+06	-0.126E+06	10.7
265	1	-0.695E+05	-0.267E+06	-27.4	402.	-0.246E+06	-22.8	0.724E+05	-0.228E+06	-19.8
266	1	0.493E+05	-0.135E+05	-27.8	0.198E+05	-0.133E+06	-26.7	-0.965E+04	-0.253E+06	-26.4
267	1	0.126E+06	0.157E+05	-38.2	0.171E+05	-0.125E+06	-24.8	-0.824E+05	-0.275E+06	-17.3
268	1	0.142E+06	0.318E+05	-52.4	0.293E+05	-0.929E+05	-39.0	-0.725E+05	-0.208E+06	-28.4
269	1	-0.761E+05	-0.146E+06	-11.5	0.263E+04	-0.201E+06	-21.7	0.840E+05	-0.259E+06	-23.7
270	1	-0.241E+05	-0.117E+06	83.4	0.143E+04	-0.128E+06	66.3	0.640E+05	-0.150E+06	59.2
271	1	0.529E+05	-0.776E+05	-25.5	0.305E+04	-0.139E+06	-28.3	-0.462E+05	-0.202E+06	-30.6
272	1	0.626E+05	-0.344E+05	54.7	0.145E+05	-0.862E+05	54.8	-0.337E+05	-0.138E+06	54.9
273	1	0.113E+06	-0.809E+05	-71.0	0.112E+05	-0.287E+05	-3.6	-0.621E+05	-0.167E+06	2.7
274	1	0.943E+05	0.691E+04	-52.8	0.239E+04	-0.366E+05	-36.8	-0.616E+05	-0.108E+06	5.7
275	1	0.596E+05	0.311E+04	-51.5	0.748E+04	-0.206E+05	-19.1	-0.143E+05	-0.747E+05	9.8
276	1	0.631E+05	-0.104E+06	-65.4	0.685E+05	-0.206E+04	-84.0	0.137E+06	-0.361E+05	53.4
277	1	0.606E+05	-0.267E+05	-40.4	-0.807E+04	-0.630E+05	-24.8	-0.594E+05	-0.116E+06	1.3
278	1	0.673E+05	-0.427E+05	38.9	-0.296E+04	-0.423E+05	49.2	-0.347E+05	-0.804E+05	-69.7
279	1	0.611E+05	-0.940E+05	-50.5	0.832E+04	-0.385E+05	-38.8	0.210E+05	-0.810E+05	32.7
280	1	0.103E+06	-0.869E+05	18.1	0.640E+05	-0.466E+04	-3.9	0.114E+06	-0.188E+05	-47.1
281	1	-0.628E+05	-0.125E+06	-1.9	0.485E+04	-0.168E+06	-20.9	0.804E+05	-0.219E+06	-24.6
282	1	-0.498E+05	-0.129E+06	-5.1	0.108E+05	-0.128E+06	-22.2	0.805E+05	-0.136E+06	-28.2
283	1	0.407E+04	-0.112E+06	-17.6	-0.140E+04	-0.137E+06	-26.2	-0.233E+04	-0.166E+06	-32.4
284	1	0.124E+05	-0.721E+05	-24.3	0.722E+04	-0.910E+05	-28.5	0.283E+04	-0.111E+06	-31.7
285	1	-0.653E+05	-0.121E+06	-0.9	0.584E+04	-0.147E+06	-20.6	0.846E+05	-0.180E+06	-24.5
286	1	-0.594E+05	-0.123E+06	86.0	0.833E+04	-0.130E+06	70.0	0.822E+05	-0.142E+06	65.7
287	1	-0.237E+05	-0.110E+06	-13.5	-0.419E+04	-0.134E+06	-23.1	0.188E+05	-0.161E+06	-27.7
288	1	-0.191E+05	-0.817E+05	70.7	0.223E+04	-0.965E+05	66.2	0.241E+05	-0.112E+06	64.2
289	1	0.189E+05	-0.780E+05	-37.0	-0.134E+05	-0.834E+05	-25.8	-0.360E+05	-0.986E+05	-7.6
290	1	0.353E+05	-0.676E+05	-52.8	-0.631E+04	-0.470E+05	-33.0	-0.434E+04	-0.700E+05	11.1
291	1	0.618E+05	-0.122E+06	-53.8	-0.113E+05	-0.340E+05	-39.6	0.227E+05	-0.932E+05	25.9
292	1	0.116E+06	-0.979E+05	-65.8	0.581E+05	-0.972E+04	89.7	0.120E+06	-0.416E+05	43.8
293	1	-0.203E+05	-0.990E+05	-37.7	0.157E+05	-0.947E+05	-23.1	-0.218E+04	-0.993E+05	-11.4
294	1	0.114E+05	-0.673E+05	22.3	-0.718E+04	-0.474E+05	64.8	0.271E+05	-0.803E+05	88.2
295	1	0.641E+05	-0.141E+06	-60.8	-0.709E+04	-0.666E+05	-38.4	0.385E+05	-0.109E+06	11.9
296	1	0.147E+06	-0.106E+06	17.9	0.542E+05	-0.270E+04	-0.5	0.119E+06	-0.566E+05	-60.6
297	1	-0.702E+05	-0.115E+06	9.0	0.402E+04	-0.132E+06	-19.2	0.895E+05	-0.160E+06	-23.4
298	1	-0.689E+05	-0.113E+06	2.1	0.318E+04	-0.131E+06	-20.1	0.826E+05	-0.157E+06	-23.8
299	1	-0.404E+05	-0.978E+05	-9.8	-0.607E+04	-0.132E+06	-20.5	0.308E+05	-0.169E+06	-23.5
300	1	-0.383E+05	-0.749E+05	-18.0	-0.126E+04	-0.103E+06	-20.8	0.359E+05	-0.131E+06	-21.4

SUBROUTINE R91320 TRIANGULAR HYBRID ELEMENT STRESSING ROUTINE
 SIGNAL IS THE MAXIMUM VALUE OF STRESS IN THE PLANE, SIGMA2 IS THE MINIMUM IN THE PLANE
 THE ANGLE IS THAT OF SIGNAL MEASURED +IVE TO THE ELEMENT Y-AXIS FROM THE ELEMENT X-AXIS

ELEM. NUMB.	LOAD CASE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE	SIGMA 1	SIGMA 2	ANGLE
301	1	-0.643E+05	-0.117E+06	33.4	-0.987E+05	-0.122E+06	-17.4	0.963E+05	-0.161E+06	-23.1
302	1	-0.699E+05	-0.108E+06	-56.1	-0.347E+04	-0.130E+06	73.7	0.867E+05	-0.176E+06	69.6
303	1	-0.533E+05	-0.788E+05	-10.0	-0.386E+04	-0.133E+06	-20.4	0.465E+05	-0.187E+06	-21.5
304	1	-0.475E+05	-0.585E+05	61.5	0.104E+04	-0.110E+06	72.7	0.500E+05	-0.162E+06	73.2
305	1	-0.453E+05	-0.979E+05	-41.0	-0.127E+05	-0.104E+06	-21.1	0.281E+05	-0.117E+06	-14.3
306	1	0.385E+04	-0.592E+05	-86.7	372.	-0.441E+05	-14.5	0.565E+05	-0.885E+05	-7.1
307	1	0.400E+05	-0.181E+06	-66.9	0.987E+04	-0.770E+05	-37.6	0.102E+06	-0.954E+05	-1.3
308	1	0.170E+06	-0.134E+06	-81.0	0.700E+05	-0.251E+05	88.4	0.188E+06	-0.343E+05	13.2
309	1	-0.371E+05	-0.886E+05	-47.4	0.237E+04	-0.114E+06	-21.8	0.534E+05	-0.151E+06	-16.2
310	1	0.676E+04	-0.503E+05	5.8	0.183E+05	-0.435E+05	75.5	0.820E+05	-0.889E+05	81.8
311	1	-0.132E+05	-0.228E+06	-65.0	0.499E+05	-0.857E+05	-35.9	0.206E+06	-0.362E+05	-11.3
312	1	0.640E+05	-0.193E+06	2.0	0.129E+06	-0.669E+05	4.4	0.327E+06	-0.193E+06	89.9
313	1	-0.134E+04	-0.919E+05	-19.9	0.398E+05	-0.157E+06	2.0	0.269E+05	-0.194E+06	4.4
314	1	-0.430E+04	-0.569E+05	22.2	0.153E+05	-0.381E+05	29.7	0.366E+05	-0.210E+05	36.6
315	1	0.850E+04	-0.511E+05	24.3	0.219E+05	-0.275E+05	36.2	0.410E+05	-0.950E+04	50.5
316	1	-0.190E+04	-0.176E+06	-11.0	-0.307E+04	-0.154E+06	3.6	0.182E+05	-0.154E+06	18.4
317	1	0.634E+04	-0.677E+05	45.3	-0.935E+04	-0.774E+05	-80.4	0.311E+05	-0.143E+06	-68.5
318	1	0.104E+05	-0.104E+06	-15.4	-0.706E+04	-0.948E+05	-12.8	-0.239E+05	-0.863E+05	-8.2
319	1	0.804E+05	-0.491E+05	-65.8	0.119E+05	-0.193E+05	-73.3	0.556E+05	-0.888E+05	-80.3
320	1	0.159E+05	-0.511E+05	-23.5	0.655E+04	-0.384E+05	-22.4	-0.273E+04	-0.258E+05	-19.4
321	1	0.170E+05	-0.205E+04	-6.2	0.482E+04	-0.167E+04	-29.7	0.262E+04	-0.113E+05	-74.8
322	1	0.250E+05	-0.111E+05	-46.1	0.241E+05	-0.155E+05	-44.5	0.232E+05	-0.200E+05	-43.2
323	1	0.571E+05	-0.360E+05	73.4	0.349E+05	-0.170E+04	-88.5	0.155E+05	-0.421E+05	-82.3
324	1	0.335E+05	-0.153E+05	2.4	0.631E+04	-0.321E+05	-27.0	-0.172E+04	-0.681E+05	-46.5
325	1	0.755E+05	-0.443E+05	-50.0	0.193E+05	-0.617E+04	-78.4	-0.204E+05	-0.482E+05	66.6
326	1	0.124E+05	-0.417E+04	-22.5	0.198E+05	-0.268E+05	-51.0	0.315E+05	-0.537E+05	-55.7
327	1	0.745E+05	-0.875E+04	-24.5	0.549E+05	-0.125E+05	-31.6	0.448E+05	0.240E+05	-71.0
328	1									

NO STRESS AVERAGING AVAILABLE WITH THE ELEMENTS USED IN THIS JOB

NO ERRORS OR WARNINGS IN THIS PHASE

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 12867 WORDS ****

*** END OF PHASE 9 ***

Static Analysis

Symmetric Quadrilateral Semi-Loof Element

Structural Material: Polyethylene

Displacements and Stresses

NODE NUMBER	T U A L			D I S P L A C E M E N T			C U R R E N T			I N C R E M E N T			D I S P L A C E M E N T		
	U-X	U-Y	U-Z	U-X	U-Y	U-Z	U-X	U-Y	U-Z	U-X	U-Y	U-Z	PHI-X	PHI-Y	PHI-Z
1	0.4456L-03	0.2174E-01	-0.1538E-01	0.3249E-03	0.2938E-02	-0.2398E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.4456L-03	0.1977E-01	-0.1184E-01	0.2973E-03	0.2745E-02	-0.1818E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3	0.3465E-03	0.1516E-01	-0.8760E-02	0.2917E-03	0.2227E-02	-0.1347E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.1814E-03	0.0602E-02	-0.4627E-02	0.7415E-04	0.9248E-03	-0.7200E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5	-0.2309E-03	0.2934E-03	-0.2226E-02	-0.4224E-04	-0.3108E-04	-0.3705E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	-0.9342E-04	0.7245E-03	-0.8409E-03	-0.1684E-04	-0.1232E-03	-0.1439E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7	-0.5918E-04	0.6403E-03	-0.1671E-03	-0.1237E-04	-0.1242E-03	-0.1388E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8	-0.1059E-03	-0.7477E-03	-0.3903E-04	-0.1596E-04	-0.9117E-04	-0.7481E-05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	-0.2802E-04	0.1076E-01	-0.1536E-01	0.2291E-03	0.2132E-02	-0.2498E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
11	-0.2874E-03	0.1191E-01	-0.1879E-02	0.7803E-04	0.1949E-02	-0.1338E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
12	-0.6219E-04	-0.1547E-02	-0.2337E-02	-0.1206E-03	-0.3439E-03	-0.3521E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	-0.8277E-04	0.4674E-03	-0.1664E-03	-0.1470E-04	-0.8503E-04	-0.3178E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	-0.0300E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	-0.0702E-03	0.1349E-01	-0.1584E-01	0.1402E-03	0.1428E-02	-0.2664E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
16	-0.1033E-02	0.1135E-01	-0.1186E-01	-0.7149E-04	0.1500E-02	-0.1929E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
17	-0.1090E-02	0.1235E-01	-0.8612E-02	-0.1773E-03	0.1531E-02	-0.1337E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
18	-0.5249E-03	0.4224E-02	-0.4084E-02	-0.8512E-04	0.4355E-03	-0.6314E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
19	-0.7676E-01	-0.3524E-02	-0.1754E-02	-0.1926E-03	-0.6983E-03	-0.3181E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	-0.5514E-01	-0.1504E-02	-0.9391E-03	-0.7204E-04	-0.2383E-03	-0.1603E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
21	-0.1229E-03	-0.3582E-03	-0.1861E-03	-0.2271E-04	-0.6787E-04	-0.3505E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
22	-0.5227E-04	0.2144E-03	-0.4666E-04	-0.9215E-05	-0.4419E-04	-0.9673E-05	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
23	0.0300E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24	-0.1711E-03	-0.2552E-02	-0.1925E-01	0.2780E-03	0.1051E-02	-0.3625E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
25	-0.1216E-03	-0.1423E-02	-0.1553E-01	0.1174E-03	-0.1154E-02	-0.2960E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
26	-0.0015E-03	-0.2344E-02	-0.1503E-01	-0.1420E-03	-0.4361E-03	-0.2513E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
27	-0.4178E-03	0.5249E-03	-0.2482E-03	-0.6934E-04	-0.1582E-03	-0.5147E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
29	-0.7396E-03	-0.1022E-01	-0.2215E-01	0.1288E-03	-0.2040E-02	-0.4096E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	-0.7924E-03	-0.9326E-02	-0.2021E-01	0.1337E-03	-0.1488E-02	-0.3708E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
31	-0.0240E-03	-0.8994E-02	-0.1884E-01	0.5324E-04	-0.1771E-02	-0.3409E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
32	-0.1011E-02	-0.4898E-02	-0.9991E-02	-0.4757E-04	-0.9821E-03	-0.1908E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
33	-0.6475E-03	-0.1926E-02	-0.9456E-03	-0.1104E-03	-0.3236E-03	-0.1474E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
34	-0.6652E-03	-0.1408E-02	-0.8440E-03	-0.1124E-03	-0.2579E-03	-0.1544E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
35	-0.5572E-03	-0.7053E-03	-0.3300E-03	-0.9547E-04	-0.1243E-03	-0.5895E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
36	-0.1095E-03	0.2647E-04	-0.6702E-04	-0.0000E+00	-0.9762E-05	-0.1444E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
37	0.0000E+00	0.0000E+00	0.0000E+00	-0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
38	-0.1373E-02	-0.6298E-02	-0.1453E-01	-0.6810E-04	0.1242E-02	-0.2670E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
39	-0.3946E-03	-0.2037E-02	-0.1278E-02	-0.1334E-03	-0.4004E-03	-0.3643E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	-0.1768E-02	-0.1897E-02	-0.1697E-01	-0.2145E-03	-0.7484E-03	-0.2095E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
41	-0.1188E-02	-0.4147E-02	-0.8705E-02	-0.1244E-03	-0.7905E-03	-0.1677E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
42	-0.3600E-01	-0.3911E-02	-0.6904E-02	-0.7713E-04	-0.7763E-03	-0.1370E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

L A R G E D I S P L A C E M E N T S A N A L Y S I S
C U M U L A T I V E L U A D = 100.00 P E R C E N T

WARNING FREEDOM NO= 5 AT NODE 62 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 14 AT NODE 64 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 15 AT NODE 64 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 19 AT NODE 65 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 24 AT NODE 66 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 25 AT NODE 66 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 306 AT NODE 155 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 307 AT NODE 155 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 293 AT NODE 83 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 294 AT NODE 83 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 34 AT NODE 7 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20
 WARNING FREEDOM NO= 35 AT NODE 7 DIAGONAL TERM= 0.0000000E+00 CHANGED TO 1.0E20

43	-0.5118E-03	-0.1671E-02	0.3162E-03	-0.7434E-04	-0.3427E-03	-0.1316E-03	-0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
44	-0.2818E-03	-0.2459E-03	0.5227E-03	-0.4740E-04	-0.3427E-04	0.1049E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
45	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
46	-0.4843E-03	-0.3041E-02	-0.2562E-02	-0.5850E-04	-0.5074E-03	-0.5609E-03	0.1234E-01	0.3532E-02	0.0000E+00	0.0000E+00
47	-0.3300E-03	-0.1654E-02	0.6311E-03	-0.3597E-04	-0.2972E-03	0.1255E-03	0.1398E-01	0.2771E-02	0.0000E+00	0.0000E+00
48	-0.9985E-04	-0.2612E-02	0.1214E-02	-0.9134E-04	-0.3343E-03	0.6474E-06	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
49	0.8558E-05	-0.3056E-02	0.315E-02	-0.2450E-04	-0.5510E-03	0.1178E-03	-0.3544E-01	-0.2241E-01	0.0000E+00	0.0000E+00
50	0.1292E-03	-0.3410E-02	0.1500E-02	-0.2631E-04	-0.5387E-03	0.2070E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
51	0.1379E-03	-0.2443E-02	0.1460E-02	0.3010E-04	-0.4073E-03	0.2530E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
52	0.1828E-03	-0.1500E-02	0.1439E-02	0.3356E-04	-0.2764E-03	0.2862E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
53	0.2553E-03	-0.7581E-03	0.1391E-02	0.5326E-04	-0.1260E-03	0.2612E-03	0.6849E-04	0.1189E-02	0.0000E+00	0.0000E+00
54	0.2025E-03	-0.8196E-04	0.1115E-02	0.4129E-04	-0.2914E-05	0.1921E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
55	0.1218E-03	-0.1446E-03	0.7238E-03	0.2476E-04	-0.3030E-04	0.1221E-03	0.1705E-02	0.1024E-02	0.0000E+00	0.0000E+00
56	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
57	0.3714E-04	-0.1816E-01	0.1235E-01	0.7055E-03	-0.2776E-02	0.1941E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
58	0.9181E-03	-0.3952E-02	0.5444E-02	0.1095E-03	-0.1307E-02	0.8127E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
59	0.6842E-03	-0.3238E-02	0.2771E-02	0.1401E-03	-0.4020E-03	0.4128E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
60	0.7049E-03	-0.1523E-02	0.1042E-03	0.1247E-03	-0.2634E-03	0.2815E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
61	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
62	0.4456E-03	-0.2174E-01	0.1538E-01	0.3249E-03	-0.2938E-02	0.2398E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
63	0.6155E-03	-0.1977E-01	0.1184E-01	0.2973E-03	-0.2745E-02	0.1818E-02	0.2108E-01	0.4006E-02	0.0000E+00	0.0000E+00
64	0.8465E-03	-0.1516E-01	0.8760E-02	0.2917E-03	-0.2227E-02	0.1367E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
65	0.1014E-03	-0.6602E-02	0.4627E-02	0.7415E-04	-0.9248E-03	0.7200E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
66	-0.2309E-04	-0.2944E-04	0.2226E-02	-0.4224E-04	-0.3108E-04	0.3705E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
67	-0.9342E-04	0.7245E-03	0.8409E-03	-0.1684E-04	0.1232E-03	0.1439E-03	-0.2419E-02	-0.4485E-02	0.0000E+00	0.0000E+00
68	-0.5918E-04	0.6440E-03	0.1671E-03	-0.1237E-04	0.1242E-03	0.3188E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
69	-0.1059E-03	0.4787E-03	0.3903E-04	-0.1998E-04	0.9137E-04	0.7481E-05	-0.2935E-02	-0.7121E-03	0.0000E+00	0.0000E+00
70	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
71	-0.9909E-03	-0.3224E-02	0.4953E-02	-0.1139E-03	-0.4567E-03	-0.1083E-02	-0.1970E-01	-0.2193E-01	0.0000E+00	0.0000E+00
72	-0.7410E-03	-0.2730E-02	0.3024E-02	-0.8163E-04	-0.5008E-03	-0.7647E-03	-0.1470E-01	0.9894E-03	0.0000E+00	0.0000E+00
73	-0.1187E-02	-0.4330E-02	0.8653E-02	-0.9154E-04	-0.6300E-03	-0.1660E-02	0.3048E-01	0.2253E-01	0.0000E+00	0.0000E+00
74	-0.9947E-03	-0.6748E-02	-0.1434E-01	0.9405E-05	-0.1334E-02	-0.2644E-02	-0.1140E-01	-0.1658E-01	0.0000E+00	0.0000E+00
75	-0.1121E-02	-0.4533E-02	0.8472E-02	-0.9186E-04	-0.8761E-03	-0.1120E-02	-0.3318E-01	-0.2746E-01	0.0000E+00	0.0000E+00
76	-0.7118E-04	0.2916E-02	-0.3152E-02	0.9031E-07	0.3675E-03	-0.5068E-03	0.1493E-01	0.1429E-01	0.0000E+00	0.0000E+00
77	-0.7323E-03	-0.5428E-03	-0.2510E-02	-0.1476E-03	-0.2220E-03	-0.4277E-03	0.1847E-01	0.1720E-01	0.0000E+00	0.0000E+00
78	-0.9113E-04	0.5760E-02	-0.4377E-02	0.1642E-04	0.7257E-03	-0.6702E-03	-0.2432E-01	-0.2618E-01	0.0000E+00	0.0000E+00
79	0.592E-03	0.1683E-01	-0.6527E-02	0.1899E-03	0.1582E-02	-0.1013E-02	0.1020E-01	0.1082E-01	0.0000E+00	0.0000E+00
80	-0.7218E-03	0.9236E-02	-0.4206E-02	-0.6425E-04	0.1177E-02	-0.9487E-03	0.1768E-01	0.1908E-01	0.0000E+00	0.0000E+00
81	-0.1617E-04	-0.5989E-03	-0.134E-03	-0.3923E-05	-0.1099E-03	-0.7508E-04	0.2264E-02	-0.1540E-03	0.0000E+00	0.0000E+00
82	-0.1715E-03	-0.5141E-03	-0.134E-03	-0.3068E-04	-0.9730E-04	-0.7376E-04	0.7532E-03	-0.1809E-03	0.0000E+00	0.0000E+00
83	-0.1244E-04	-0.5167E-03	-0.6165E-03	-0.1369E-05	-0.8888E-04	-0.1066E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
84	-0.1391E-03	-0.6988E-03	-0.6472E-03	-0.2242E-04	-0.1153E-03	-0.1119E-03	0.9695E-03	0.1569E-02	0.0000E+00	0.0000E+00
85	-0.2668E-03	-0.8995E-03	-0.6636E-03	-0.4434E-04	-0.1527E-03	-0.1152E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
86	-0.1609E-03	-0.6983E-03	-0.1140E-02	-0.2491E-04	-0.1585E-03	-0.1924E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
87	-0.3988E-03	-0.1503E-02	-0.1212E-02	-0.6727E-04	-0.2692E-03	-0.2063E-03	0.2239E-02	0.3618E-02	0.0000E+00	0.0000E+00
88	-0.6140E-03	-0.2016E-02	-0.1214E-02	-0.1035E-03	-0.3357E-03	-0.2100E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
89	-0.2389E-03	-0.1057E-02	-0.1564E-02	-0.4773E-04	-0.2401E-03	-0.2663E-03	0.1341E-01	0.7298E-02	0.0000E+00	0.0000E+00
90	-0.9167E-03	-0.3306E-02	-0.1577E-02	-0.1624E-03	-0.5834E-03	-0.2791E-03	0.8485E-02	0.2904E-02	0.0000E+00	0.0000E+00
91	-0.2086E-02	0.5840E-02	-0.1025E-01	-0.2469E-03	0.2732E-03	-0.1779E-02	0.7722E-02	-0.1805E-01	0.0000E+00	0.0000E+00
92	-0.3232E-03	-0.8774E-02	-0.1918E-01	0.1809E-03	-0.1774E-02	-0.3538E-02	0.1457E-01	-0.2196E-02	0.0000E+00	0.0000E+00
93	-0.6056E-03	0.2931E-02	-0.1721E-01	0.1727E-03	-0.1088E-02	-0.3257E-02	0.5370E-01	0.5436E-01	0.0000E+00	0.0000E+00
94	-0.7565E-03	0.4903E-02	-0.1719E-01	0.1675E-03	0.9306E-04	-0.3115E-02	0.2668E-01	0.4230E-01	0.0000E+00	0.0000E+00
95	0.5759E-03	-0.8272E-02	-0.2154E-01	-0.3020E-03	-0.1812E-02	-0.4039E-02	0.2946E-01	0.2130E-01	0.0000E+00	0.0000E+00
96	-0.5485E-03	-0.1304E-02	-0.7301E-03	-0.9927E-04	-0.1507E-03	-0.8722E-04	0.1568E-02	0.2522E-02	0.0000E+00	0.0000E+00
97	-0.6432E-03	-0.1232E-02	-0.7046E-03	-0.1091E-04	-0.2291E-03	-0.1286E-03	-0.1153E-02	0.1174E-02	0.0000E+00	0.0000E+00
98	-0.6827E-03	-0.1820E-02	-0.142E-02	-0.1091E-04	-0.2204E-03	-0.1264E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
99	-0.6877E-03	-0.1702E-02	-0.958E-03	-0.1231E-03	-0.3379E-03	-0.2065E-03	0.8238E-03	0.8607E-03	0.0000E+00	0.0000E+00
100	-0.6877E-03	-0.1702E-02	-0.958E-03	-0.1141E-04	-0.2939E-03	-0.1722E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
101	-0.6877E-03	-0.1702E-02	-0.958E-03	-0.1141E-04	-0.2939E-03	-0.1722E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
102	-0.7294E-03	-0.3172E-02	-0.2637E-02	-0.1144E-03	-0.2833E-03	-0.1850E-03	-0.3752E-02	-0.2944E-02	0.0000E+00	0.0000E+00
				-0.1124E-03	-0.5350E-03	-0.6228E-03	-0.1684E-01	0.1330E-01	0.0000E+00	0.0000E+00


```
*****
*
* 0 ERRORS IN THIS PHASE
*
* 71 WARNINGS IN THIS PHASE
*
*****
```

```
*** MAXIMUM SIZE OF CASE IN THIS PHASE WAS 16914 WORDS ***
```

```
*** END OF PHASE 1 ***
```

```
*****
*
* TITLE POLYETHYLENE RISSEN LAST STRUCTURAL ANALYSIS
*
* PHASE NUMBER 9 STARTS HERE
*
*****
```

```
DEFAULT STRESS-ELEMENTS MODULE CREATED.
```

```
STRESSES FOR ELEMENT 43210
SIGMA1 IS THE MOST POSITIVE PRINCIPAL STRESS.
SIGMA2 IS THE MOST NEGATIVE PRINCIPAL STRESS.
ANGLE ALPHA1 IS THE ANGLE BETWEEN THE GLOBAL
X-AXIS AND PRINCIPAL STRESS SIGNAL
ANGLE ALPHA2 IS THE ANGLE BETWEEN THE GLOBAL
Y-AXIS AND PRINCIPAL STRESS SIGNAL
```

ELEM LOAD NO. CASE	GLOBAL CO-ORDINATES			TOP SURFACE			BOTTOM SURFACE				
	X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
1 1	0.274	0.706E-01	0.126	0.165E+07	0.635E+06	120	142	0.172E+07	-0.164E+07	24	113
1 1	0.273	0.418E-01	0.135	0.211E+07	0.129E+07	52	140	0.290E+07	0.172E+06	39	127
1 1	0.246	0.463E-01	0.134	0.262E+07	0.711E+06	19	108	0.276E+07	-0.927E+06	35	124
1 1	0.246	0.629E-01	0.129	0.243E+07	0.139E+07	160	108	0.415E+07	-0.140E+07	35	121
2 1	0.224	0.610E-01	0.129	0.442E+07	0.152E+07	173	83	0.250E+07	-0.548E+06	34	119
2 1	0.224	0.466E-01	0.135	0.281E+07	0.190E+07	58	146	0.206E+07	-0.156E+07	50	138
2 1	0.197	0.432E-01	0.138	0.265E+07	0.894E+06	100	157	0.151E+07	-0.123E+07	61	146

ITEM NO.	GLOBAL CO-ORDINATES	-----TOP SURFACE-----			-----BOTTOM SURFACE-----							
		Z	X	Y	Z	X	Y					
3	1	0.152	0.109E-01	0.124	0.497E+07	0.165E+07	155	68	0.170E+07	-0.220E+06	77	144
3	1	0.152	0.130	0.294E-02	0.167E+07	-0.669E+07	30	83	0.802E+07	0.566E+07	127	87
3	1	0.152	0.131	0.248E-01	-0.130E+07	-0.627E+07	33	79	0.728E+07	0.456E+07	119	98
3	1	0.120	0.121	0.203E-01	0.218E+07	-0.703E+06	23	73	0.756E+07	0.298E+07	101	105
3	1	0.118	0.123	0.416E-03	0.344E+07	-0.129E+07	39	78	0.105E+08	0.211E+07	98	95
4	1	0.270	0.127	0.636E-02	0.177E+07	0.163E+06	33	88	0.108E+07	-0.114E+07	82	83
4	1	0.270	0.130	0.272E-01	0.396E+07	0.868E+06	164	86	0.907E+06	0.720E+05	110	79
4	1	0.236	0.132	0.209E-01	0.744E+07	0.923E+06	11	92	0.244E+07	0.592E+06	32	87
4	1	0.236	0.128	0.413E-02	0.700E+06	-0.188E+06	18	89	0.179E+07	-0.200E+07	60	80
5	1	0.211	0.129	0.329E-02	0.944E+06	-0.799E+06	112	74	0.290E+07	-0.113E+07	76	75
5	1	0.211	0.133	0.198E-01	0.369E+07	0.132E+07	4	91	0.327E+07	0.146E+07	20	88
5	1	0.177	0.134	0.235E-01	0.906E+06	-0.110E+07	55	83	0.683E+07	0.143E+07	3	87
5	1	0.178	0.130	0.337E-02	-0.300E+07	-0.432E+07	106	76	0.305E+07	0.113E+07	134	80
6	1	0.498	0.869E-01	0.564E-02	-0.129E+06	-0.448E+06	50	101	0.381E+06	-0.217E+06	95	90
6	1	0.498	0.876E-01	0.213E-01	0.565E+05	-0.329E+06	45	94	0.223E+06	0.327E+05	84	85
6	1	0.454	0.749E-01	0.214E-01	0.717E+05	-0.343E+06	42	99	0.437E+06	0.173E+06	125	83
6	1	0.454	0.985E-01	0.610E-02	-0.464E+05	-0.393E+06	32	105	0.710E+06	0.101E+06	137	84
7	1	0.422	0.106	0.644E-02	0.317E+06	-0.847E+05	168	78	0.577E+06	0.340E+05	153	83
7	1	0.421	0.104	0.249E-01	0.592E+06	0.182E+05	27	101	0.426E+06	-0.263E+06	163	79
7	1	0.376	0.113	0.269E-01	0.768E+06	0.618E+06	104	89	0.408E+06	-0.438E+06	10	100
7	1	0.377	0.114	0.687E-02	0.676E+06	0.405E+05	34	101	0.628E+06	0.981E+05	156	83
8	1	0.364	0.119	0.715E-02	0.114E+07	0.228E+06	15	98	0.621E+06	-0.643E+06	159	84
8	1	0.343	0.118	0.283E-01	0.199E+07	0.642E+06	44	96	0.315E+06	-0.128E+07	168	80
8	1	0.298	0.126	0.302E-01	0.356E+07	0.171E+07	41	93	-0.612E+06	-0.156E+07	155	78
8	1	0.299	0.124	0.743E-02	0.310E+07	0.839E+06	19	95	0.379E+06	0.155E+06	9	96
9	1	0.571	0.631E-01	0.346E-02	0.423E+06	-0.761E+06	105	83	0.912E+05	-0.802E+06	53	101
9	1	0.567	0.643E-01	0.154E-01	-0.554E+06	-0.854E+06	89	93	-0.532E+06	-0.727E+06	34	108
9	1	0.528	0.784E-01	0.190E-01	0.146E+06	-0.721E+05	47	100	0.601E+06	-0.235E+06	75	90
9	1	0.530	0.772E-01	0.506E-02	-0.121E+06	-0.737E+06	82	92	-0.979E+05	-0.111E+07	101	86
10	1	0.149	0.129	0.432E-01	0.244E+07	-0.298E+07	44	79	0.948E+07	0.291E+07	117	105
10	1	0.148	0.119	0.995E-01	0.128E+08	0.295E+07	103	127	0.902E+07	0.664E+07	69	111
10	1	0.124	0.110	0.610E-01	0.109E+08	0.429E+07	100	121	0.814E+07	0.524E+07	100	121
10	1	0.121	0.118	0.373E-01	0.545E+07	0.327E+07	93	104	0.115E+08	0.413E+07	101	108
11	1	0.154	0.108	0.873E-01	0.106E+08	0.199E+07	89	130	0.139E+07	-0.158E+07	162	101
11	1	0.169	0.929E-01	0.107	0.712E+07	0.141E+07	67	130	0.792E+05	-0.586E+07	163	105
11	1	0.139	0.911E-01	0.103	0.642E+07	0.125E+07	85	120	-0.376E+06	-0.588E+07	172	96
11	1	0.130	0.102	0.898E-01	0.107E+08	0.402E+07	89	121	0.153E+07	-0.745E+05	140	121

FIG. CASE	X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
12 1	0.490	0.869E-01	0.441E-01	0.510E+06	-0.424E+05	19	103	0.175E+06	-0.209E+06	63	101
12 1	0.491	0.825E-01	0.905E-01	0.503E+06	-0.191E+06	13	98	-0.298E+06	-0.402E+06	58	99
12 1	0.448	0.871E-01	0.938E-01	0.707E+06	0.266E+06	53	105	0.241E+06	-0.365E+06	14	99
12 1	0.452	0.957E-01	0.474E-01	0.157E+06	0.295E+05	60	102	0.349E+06	0.102E+06	34	103
13 1	0.420	0.102	0.497E-01	0.228E+06	-0.193E+05	38	104	0.395E+06	-0.336E+06	19	103
13 1	0.417	0.503E-01	0.961E-01	0.356E+06	0.134E+06	70	111	0.196E+06	-0.357E+06	30	105
13 1	0.374	0.947E-01	0.990E-01	0.657E+06	0.158E+06	60	117	-0.101E+06	-0.255E+06	72	119
13 1	0.376	0.110	0.529E-01	0.876E+06	0.694E+06	14	102	0.111E+06	-0.618E+06	32	104
14 1	0.344	0.116	0.551E-01	0.745E+06	0.588E+06	72	103	0.357E+06	-0.792E+06	24	103
14 1	0.343	0.977E-01	0.101	-0.424E+05	-0.213E+06	164	92	0.218E+06	-0.227E+06	49	118
14 1	0.300	0.102	0.104	-0.304E+06	-0.517E+06	65	128	0.171E+06	0.131E+06	78	130
14 1	0.300	0.124	0.581E-01	0.145E+07	-0.149E+06	88	102	0.385E+06	-0.129E+07	12	102
15 1	0.564	0.644E-01	0.335E-01	-0.431E+06	-0.706E+06	95	90	0.485E+06	0.352E+05	61	100
15 1	0.561	0.642E-01	0.712E-01	0.309E+05	-0.285E+06	159	77	0.129E+07	0.735E+06	20	103
15 1	0.520	0.756E-01	0.836E-01	0.615E+06	0.100E+06	21	110	0.755E+06	-0.577E+05	24	111
15 1	0.526	0.780E-01	0.401E-01	0.256E+06	-0.109E+07	45	111	0.101E+06	0.460E+05	82	99
16 1	0.179	0.762E-01	0.121	0.464E+07	0.133E+07	66	138	-0.569E+04	-0.171E+07	176	92
16 1	0.182	0.115E-01	0.140	0.173E+07	0.644E+06	88	157	0.251E+07	0.613E+06	64	148
16 1	0.167	0.432E-01	0.142	0.165E+07	0.773E+06	56	140	0.175E+07	0.124E+07	109	144
16 1	0.152	0.770E-01	0.120	0.411E+07	-0.262E+05	75	138	0.134E+07	-0.336E+07	168	99
17 1	0.183	0.126E-01	0.149	0.153E+07	0.637E+06	39	128	0.199E+07	0.115E+07	73	162
17 1	0.181	-0.273E-01	0.152	0.123E+07	-0.348E+06	143	122	0.216E+07	-0.203E+06	56	142
17 1	0.161	-0.292E-01	0.160	0.240E+07	0.109E+07	113	156	0.190E+07	0.172E+06	62	147
17 1	0.169	0.126E-01	0.153	0.186E+07	0.742E+06	62	151	0.274E+07	0.572E+06	68	156
18 1	0.275	0.160E-01	0.142	0.261E+07	-0.459E+06	150	118	0.155E+07	0.542E+06	47	135
18 1	0.273	-0.254E-01	0.149	0.103E+07	-0.727E+06	133	136	0.894E+06	-0.102E+07	44	134
18 1	0.246	-0.236E-01	0.148	0.140E+07	-0.765E+06	137	132	0.630E+06	-0.228E+05	66	156
18 1	0.246	0.231E-01	0.140	0.238E+07	0.870E+05	150	118	0.166E+07	-0.125E+07	47	136
19 1	0.225	0.233E-01	0.141	0.944E+06	0.438E+06	140	127	0.186E+07	-0.423E+06	54	142
19 1	0.226	-0.236E-01	0.149	0.781E+06	-0.942E+06	145	124	0.136E+07	0.539E+06	43	133
19 1	0.199	-0.254E-01	0.150	0.229E+06	-0.570E+06	151	117	0.178E+07	0.743E+06	86	176
19 1	0.198	0.169E-01	0.146	0.139E+07	0.491E+06	126	139	0.257E+07	0.419E+06	54	144
20 1	0.477	0.737E-01	0.116	0.746E+06	0.212E+05	11	99	0.668E+06	-0.689E+06	41	119
20 1	0.448	0.462E-01	0.138	0.195E+06	-0.743E+06	35	119	0.972E+06	-0.362E+06	16	103
20 1	0.414	0.449E-01	0.138	0.386E+06	0.716E+05	160	107	0.706E+06	0.519E+06	54	135
20 1	0.437	0.744E-01	0.118	0.539E+06	0.270E+06	115	132	0.455E+06	-0.322E+06	9	98
21 1	0.433	0.183E-01	0.150	0.905E+05	-0.558E+06	2	88	0.993E+06	0.154E+06	2	90
21 1	0.422	-0.254E-01	0.159	-0.553E+06	-0.609E+06	110	158	-0.184E+05	-0.308E+06	69	160
21 1	0.393	-0.256E-01	0.157	-0.151E+06	-0.290E+06	95	173	0.408E+06	0.754E+05	62	151
21 1	0.402	0.170E-01	0.149	0.711E+05	-0.794E+06	162	107	0.846E+06	0.618E+06	173	95

ELEM NO.	LUMI CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
22	1	0.407	0.741E-01	0.120	0.615E+06	0.408E+06	7	97	0.299E+06	-0.375E+06	28	114
22	1	0.389	0.439E-01	0.138	0.184E+06	-0.278E+06	19	106	0.612E+06	-0.170E+05	158	109
22	1	0.354	0.423E-01	0.137	0.331E+06	-0.236E+06	163	105	0.535E+06	0.632E+05	2	87
22	1	0.367	0.751E-01	0.121	0.366E+06	0.120E+06	75	146	0.337E+06	-0.217E+06	169	98
23	1	0.379	0.160E-01	0.148	0.257E+06	-0.381E+06	168	101	0.686E+06	0.299E+06	176	92
23	1	0.372	-0.258E-01	0.155	-0.612E+05	-0.266E+06	4	90	0.256E+06	-0.733E+05	47	136
23	1	0.363	-0.261E-01	0.153	0.922E+05	-0.141E+06	160	108	0.777E+06	-0.285E+05	36	125
23	1	0.348	0.145E-01	0.146	0.189E+06	-0.507E+06	3	88	0.608E+06	0.123E+06	168	101
24	1	0.337	0.752E-01	0.122	0.492E+06	-0.281E+05	143	121	-0.282E+06	-0.595E+06	146	118
24	1	0.329	0.411E-01	0.137	0.931E+06	-0.195E+06	175	94	0.539E+06	-0.277E+06	169	100
24	1	0.295	0.395E-01	0.136	0.121E+07	0.560E+06	152	117	0.105E+07	-0.842E+05	128	138
24	1	0.297	0.754E-01	0.123	0.374E+06	0.900E+05	58	162	0.260E+06	-0.610E+06	90	157
25	1	0.425	0.135E-01	0.145	0.641E+06	-0.228E+06	12	100	0.294E+06	0.835E+05	18	106
25	1	0.322	-0.263E-01	0.152	0.225E+06	-0.234E+06	48	137	0.146E+06	-0.248E+06	64	153
25	1	0.293	-0.266E-01	0.149	0.790E+06	0.216E+06	133	136	0.163E+06	0.211E+05	109	159
25	1	0.294	0.119E-01	0.143	0.137E+07	0.284E+06	33	121	0.935E+06	0.145E+06	45	133
26	1	0.551	0.607E-01	0.101	0.125E+07	0.363E+06	151	90	0.275E+06	-0.163E+06	149	90
26	1	0.547	0.393E-01	0.140	0.104E+07	0.264E+06	22	104	0.577E+06	-0.306E+06	42	115
26	1	0.481	0.443E-01	0.138	0.733E+06	0.574E+06	157	105	0.483E+06	0.130E+06	142	117
26	1	0.507	0.654E-01	0.111	0.103E+07	0.368E+06	107	130	0.109E+06	-0.757E+06	22	109
27	1	0.533	0.128E-01	0.164	0.338E+06	-0.370E+06	13	96	0.627E+06	0.401E+06	12	94
27	1	0.538	-0.312E-01	0.181	0.163E+06	-0.109E+07	93	172	-0.346E+05	-0.840E+06	98	169
27	1	0.461	-0.249E-01	0.165	-0.106E+06	-0.490E+06	67	155	0.116E+06	-0.251E+06	79	167
27	1	0.468	0.170E-01	0.154	0.600E+06	-0.505E+06	174	89	0.987E+06	0.577E+06	26	111
28	1	0.177	-0.544E-01	0.138	0.190E+07	-0.442E+06	135	126	0.123E+07	-0.617E+06	66	119
28	1	0.170	-0.851E-01	0.100	0.358E+07	0.797E+06	143	118	0.146E+07	0.270E+06	76	117
28	1	0.118	-0.932E-01	0.114	0.142E+07	0.885E+06	141	117	0.258E+07	0.553E+06	113	121
28	1	0.144	-0.589E-01	0.150	0.221E+07	0.771E+06	122	132	0.154E+07	0.665E+05	84	129
29	1	0.166	-0.104	0.690E-01	0.120E+07	0.447E+06	74	112	0.212E+07	0.439E+06	113	117
29	1	0.161	-0.122	0.228E-01	-0.209E+07	-0.237E+07	139	101	0.250E+07	0.126E+07	141	101
29	1	0.839E-01	-0.122	0.275E-01	0.573E+05	-0.209E+07	25	91	0.219E+07	0.832E+06	91	93
29	1	0.102	-0.111	0.798E-01	0.306E+06	-0.827E+06	13	85	0.182E+07	0.247E+06	119	109
30	1	0.273	-0.525E-01	0.136	0.524E+06	-0.305E+04	119	123	0.590E+06	0.363E+06	136	115
30	1	0.273	-0.801E-01	0.962E-01	-0.331E+06	-0.133E+07	136	111	0.670E+06	-0.117E+07	57	113
30	1	0.246	-0.812E-01	0.961E-01	-0.335E+06	-0.151E+07	122	117	0.108E+07	-0.339E+05	48	112
30	1	0.246	-0.527E-01	0.136	0.278E+06	-0.714E+06	145	110	0.613E+06	0.547E+06	114	125

LILM LUNJ NO. CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
	X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
31 1 0.273	-0.966E-01	0.645E-01	0.341E+06	-0.125E+07	54	107		0.492E+06	-0.169E+07	101	114
31 1 0.273	-0.113	0.187E-01	0.271E+07	0.405E+06	171	98		0.255E+07	-0.709E+06	51	95
31 1 0.246	-0.116	0.192E-01	0.358E+07	-0.321E+06	171	98		0.229E+07	-0.661E+05	44	96
31 1 0.246	-0.984E-01	0.646E-01	-0.693E+06	-0.121E+07	98	115		0.588E+06	-0.152E+07	74	113
32 1 0.226	-0.524E-01	0.135	0.649E+06	-0.635E+06	144	111		0.538E+06	0.333E+06	123	121
32 1 0.226	-0.817E-01	0.959E-01	-0.959E+05	-0.125E+07	127	115		0.475E+06	-0.300E+05	67	119
32 1 0.199	-0.819E-01	0.955E-01	0.193E+07	0.449E+06	145	107		-0.131E+06	-0.317E+06	116	119
32 1 0.199	-0.528E-01	0.135	0.474E+06	-0.221E+05	137	114		0.111E+07	-0.293E+06	107	127
33 1 0.226	-0.946E-01	0.648E-01	0.180E+06	-0.839E+06	125	113		0.163E+07	-0.165E+07	58	110
33 1 0.226	-0.118	0.148E-01	0.367E+07	0.267E+06	7	83		0.345E+07	0.103E+07	38	96
33 1 0.199	-0.121	0.208E-01	0.111E+07	-0.173E+07	174	95		0.567E+07	0.247E+07	37	98
33 1 0.199	-0.101	0.649E-01	0.336E+06	-0.118E+07	125	113		0.863E+06	-0.218E+07	48	110
34 1 0.421	-0.546E-01	0.144	0.105E+06	-0.791E+06	63	124		0.516E+06	-0.114E+07	66	125
34 1 0.422	-0.842E-01	0.101	0.469E+05	-0.438E+06	20	103		-0.737E+05	-0.107E+07	43	113
34 1 0.393	-0.820E-01	0.100	0.211E+06	-0.899E+06	58	117		0.435E+06	-0.891E+06	58	117
34 1 0.393	-0.539E-01	0.143	0.273E+05	-0.768E+06	73	126		0.416E+06	-0.838E+06	65	124
35 1 0.422	-0.102	0.671E-01	0.173E+07	0.109E+07	77	116		0.355E+06	-0.769E+06	121	107
35 1 0.422	-0.123	0.185E-01	0.766E+06	0.263E+06	113	102		0.374E+06	-0.732E+06	102	106
35 1 0.393	-0.117	0.184E-01	0.706E+06	-0.111E+06	145	92		0.163E+06	-0.792E+06	121	100
35 1 0.393	-0.989E-01	0.665E-01	0.876E+06	0.358E+06	24	104		-0.592E+06	-0.905E+06	130	104
36 1 0.372	-0.534E-01	0.142	-0.136E+06	-0.625E+06	51	119		0.289E+06	-0.931E+06	60	122
36 1 0.372	-0.807E-01	0.994E-01	0.404E+06	-0.420E+06	56	115		0.260E+06	-0.718E+06	56	115
36 1 0.343	-0.796E-01	0.984E-01	-0.139E+06	-0.930E+06	54	114		-0.828E+05	-0.954E+06	73	117
36 1 0.343	-0.529E-01	0.140	-0.102E+06	-0.472E+06	89	126		0.768E+06	-0.705E+06	55	120
37 1 0.372	-0.970E-01	0.660E-01	0.147E+06	-0.403E+06	123	107		-0.297E+06	-0.102E+07	68	113
37 1 0.372	-0.114	0.184E-01	0.410E+06	-0.396E+06	28	102		0.949E+06	-0.757E+06	133	97
37 1 0.343	-0.112	0.184E-01	0.709E+06	-0.506E+06	35	101		0.124E+07	-0.807E+06	131	98
37 1 0.343	-0.956E-01	0.655E-01	0.270E+06	-0.390E+06	114	110		0.399E+06	-0.944E+06	65	112
38 1 0.322	-0.525E-01	0.139	-0.151E+05	-0.593E+06	27	108		0.383E+06	-0.870E+05	41	115
38 1 0.322	-0.740E-01	0.975E-01	0.223E+06	-0.838E+06	54	113		0.168E+05	-0.928E+06	66	116
38 1 0.293	-0.791E-01	0.965E-01	-0.355E+06	-0.547E+06	100	118		0.876E+05	-0.139E+07	62	114
38 1 0.293	-0.523E-01	0.137	0.376E+06	-0.925E+06	141	111		0.573E+06	-0.863E+06	40	115
39 1 0.322	-0.949E-01	0.650E-01	-0.873E+06	-0.155E+07	103	112		-0.271E+06	-0.106E+07	86	113
39 1 0.322	-0.110	0.184E-01	0.174E+06	-0.730E+06	5	93		0.796E+06	0.236E+06	134	97
39 1 0.293	-0.110	0.185E-01	0.129E+07	-0.108E+07	24	92		0.103E+07	0.236E+06	99	103
39 1 0.293	-0.451E-01	0.645E-01	-0.355E+06	-0.969E+06	144	105		0.246E+06	-0.295E+06	84	113

40	1	0.551	-0.797E-01	0.184	-0.152E+06	-0.657E+06	81	169	-0.918E+04	-0.208E+06	44	133
40	1	0.576	-0.156	0.158	-0.517E+05	-0.481E+06	149	79	0.443E+06	-0.246E+04	130	104
40	1	0.469	-0.107	0.116	0.520E+06	0.122E+06	54	138	0.347E+06	-0.391E+05	109	113
40	1	0.464	-0.623E-01	0.155	-0.831E+05	-0.124E+07	80	146	0.200E+05	-0.123E+07	87	145
41	1	0.593	-0.201	0.112	0.151E+06	-0.217E+06	45	124	-0.511E+05	-0.191E+06	88	117
41	1	0.606	-0.227	0.327E-01	0.148E+06	0.732E+05	85	93	0.738E+05	-0.212E+06	33	108
41	1	0.475	-0.159	0.223E-01	0.113E+06	-0.777E+05	96	100	-0.710E+05	-0.228E+06	45	127
41	1	0.473	-0.134	0.791E-01	0.489E+06	0.263E+06	125	86	0.503E+05	-0.295E+06	40	130

NO STRESS AVERAGING AVAILABLE WITH THE ELEMENTS USED IN THIS JOB

NO ERRORS OR WARNINGS IN THIS PHASE

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 4563 WORDS ***

*** END OF PHASE 9 ***

Static Analysis

Symmetric Quadrilateral Semi-Loof Element

Structural Material: Polypropylene

Displacements and Stresses

LARGE DISPLACEMENTS ANALYSIS
CUMULATIVE LOAD = 100.00 PERCENT

NODE NUMBER	TOTAL DISPLACEMENT			CURRENT INCREMENT			DISPLACEMENT		
	U-X	U-Y	U-Z	U-X	U-Y	U-Z	PHI-X	PHI-Y	PHI-Z
1	-0.1503E-03	0.1191E-01	-0.7984E-02	0.5018E-04	0.2026E-02	-0.1405E-02	0.0000E+00	0.0000E+00	0.0000E+00
2	-0.1858E-04	0.1068E-01	-0.6165E-02	0.6703E-04	0.1832E-02	-0.1084E-02	0.7702E-02	-0.1683E-02	0.0000E+00
3	0.2075E-03	0.7978E-02	-0.4520E-02	0.8469E-04	0.1384E-02	-0.8027E-03	0.0000E+00	0.0000E+00	0.0000E+00
4	0.2646E-04	0.3562E-02	-0.2405E-02	0.1904E-04	0.6046E-03	-0.4249E-03	0.0000E+00	0.0000E+00	0.0000E+00
5	-0.1124E-03	0.2530E-03	0.1120E-02	-0.2174E-04	0.2092E-04	-0.2041E-03	0.0000E+00	0.0000E+00	0.0000E+00
6	-0.4716E-04	0.3686E-03	0.4179E-03	-0.9193E-05	-0.6916E-04	-0.7691E-04	0.1639E-02	-0.2977E-02	0.0000E+00
7	-0.2781E-04	0.3085E-03	0.1166E-04	-0.5642E-05	-0.5953E-04	-0.1541E-04	0.0000E+00	0.0000E+00	0.0000E+00
8	-0.5072E-04	0.2289E-03	0.1935E-04	-0.9778E-05	-0.4374E-04	-0.3668E-05	-0.1476E-02	-0.2970E-03	0.0000E+00
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	-0.3445E-03	0.9143E-02	-0.7821E-02	0.4171E-03	0.1556E-02	-0.1408E-02	-0.8168E-02	-0.591E-03	0.0000E+00
11	-0.3326E-03	0.7666E-02	-0.4503E-02	0.1818E-04	0.1312E-02	-0.7979E-03	-0.8601E-02	-0.4057E-02	0.0000E+00
12	-0.2888E-03	0.6494E-03	0.1011E-02	-0.5770E-05	-0.1457E-03	-0.1873E-03	0.5681E-02	-0.2998E-02	0.0000E+00
13	-0.4172E-04	0.2284E-03	0.8007E-04	-0.7717E-05	-0.4272E-04	-0.1526E-04	0.2153E-03	0.5531E-03	0.0000E+00
14	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	-0.8559E-03	0.7857E-02	-0.7940E-02	-0.7914E-04	0.1272E-02	-0.1449E-02	0.0000E+00	0.0000E+00	0.0000E+00
16	-0.1124E-02	0.7705E-02	-0.6033E-02	-0.1434E-03	0.1255E-02	-0.1084E-02	0.2707E-01	0.1910E-01	0.0000E+00
17	-0.1010E-02	0.6897E-02	-0.4461E-02	-0.1471E-03	0.1165E-02	-0.7933E-03	0.0000E+00	0.0000E+00	0.0000E+00
18	-0.2767E-03	0.2504E-02	-0.2137E-02	-0.4537E-04	0.3816E-03	-0.3732E-03	0.0000E+00	0.0000E+00	0.0000E+00
19	-0.4533E-03	0.1629E-02	-0.8502E-03	-0.9088E-04	-0.3966E-03	-0.1416E-04	-0.1408E-02	-0.1518E-02	0.0000E+00
20	-0.2317E-03	0.7713E-03	-0.4674E-03	-0.4171E-04	-0.1388E-03	-0.8606E-04	0.0000E+00	0.0000E+00	0.0000E+00
21	-0.6100E-04	0.1735E-03	-0.8950E-04	-0.1135E-04	-0.3252E-04	-0.1705E-04	0.0000E+00	0.0000E+00	0.0000E+00
22	-0.2177E-04	0.1046E-03	-0.2243E-04	-0.4328E-05	-0.2046E-04	-0.4348E-05	-0.1258E-02	-0.1241E-02	0.0000E+00
23	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24	-0.5019E-03	0.4297E-03	-0.9112E-02	-0.1894E-04	-0.2016E-03	-0.1773E-02	0.0000E+00	0.0000E+00	0.0000E+00
25	-0.6961E-03	0.1184E-02	-0.7285E-02	-0.5432E-04	-0.3457E-03	-0.1466E-02	0.0000E+00	0.0000E+00	0.0000E+00
26	-0.3922E-03	0.1188E-02	-0.6845E-03	-0.7240E-04	-0.2111E-03	-0.1265E-03	0.9111E-02	0.9249E-03	0.0000E+00
27	-0.2109E-03	0.4658E-03	-0.1409E-03	-0.3789E-04	-0.8457E-04	-0.2635E-04	0.1553E-02	0.2193E-02	0.0000E+00
28	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
29	-0.7222E-03	0.4688E-02	-0.1058E-01	-0.6438E-04	-0.9289E-03	-0.2061E-02	0.0000E+00	0.0000E+00	0.0000E+00
30	-0.7248E-03	0.4280E-02	-0.9692E-02	-0.7187E-04	-0.8606E-03	-0.1894E-02	0.0000E+00	0.0000E+00	0.0000E+00
31	-0.7361E-03	0.4173E-02	-0.9151E-02	-0.9016E-04	-0.4514E-03	-0.9279E-03	0.0000E+00	0.0000E+00	0.0000E+00
32	-0.6757E-03	0.2262E-02	-0.4764E-02	-0.5785E-04	-0.1740E-03	-0.8542E-04	0.0000E+00	0.0000E+00	0.0000E+00
33	-0.3249E-03	0.9722E-03	-0.4970E-03	-0.4077E-04	-0.1351E-03	-0.8219E-04	0.1358E-02	0.1587E-02	0.0000E+00
34	-0.3330E-03	0.7195E-03	-0.4352E-03	-0.5087E-04	-0.1351E-03	-0.8219E-04	0.0000E+00	0.0000E+00	0.0000E+00
35	-0.2761E-03	0.3457E-03	-0.1627E-03	-0.9945E-05	-0.2043E-04	-0.6309E-05	-0.1122E-02	0.7960E-03	0.0000E+00
36	-0.4600E-04	0.3235E-04	-0.3002E-04	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
37	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
38	-0.9100E-03	0.2909E-02	-0.6999E-02	-0.1250E-03	-0.5818E-03	-0.1361E-02	0.3129E-02	0.8495E-02	0.0000E+00
39	-0.4748E-03	0.9388E-03	-0.4194E-03	-0.8197E-04	-0.1882E-03	-0.1254E-03	0.1585E-01	0.1171E-01	0.0000E+00
40	-0.1003E-02	0.1824E-02	-0.5178E-02	-0.1654E-03	-0.3568E-03	-0.1030E-02	0.0000E+00	0.0000E+00	0.0000E+00
41	-0.7051E-03	0.1954E-02	-0.4101E-02	-0.1097E-03	-0.3804E-03	-0.8146E-03	0.0000E+00	0.0000E+00	0.0000E+00
42	-0.549E-03	0.1803E-02	-0.3202E-02	-0.8757E-04	-0.3590E-03	-0.6405E-03	0.0000E+00	0.0000E+00	0.0000E+00
43	-0.2735E-03	0.7346E-03	0.4708E-03	-0.4791E-04	-0.1544E-03	-0.1719E-04	0.0000E+00	0.0000E+00	0.0000E+00
44	-0.1399E-03	0.1369E-03	0.2269E-03	-0.2597E-04	-0.2334E-04	0.4628E-04	0.0000E+00	0.0000E+00	0.0000E+00
45	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
46	-0.2816E-03	0.1526E-02	-0.1131E-02	-0.4348E-04	-0.2769E-03	-0.2335E-03	0.3418E-02	0.5478E-02	0.0000E+00
47	-0.1995E-03	0.7829E-03	0.3387E-03	-0.2949E-04	-0.1541E-03	-0.5572E-04	0.9503E-02	0.1740E-02	0.0000E+00
48	0.4103E-04	-0.1445E-02	0.8007E-03	-0.1093E-04	-0.2371E-03	0.1081E-03	0.0000E+00	0.0000E+00	0.0000E+00
49	0.3261E-04	-0.1613E-02	0.8036E-03	-0.3077E-04	-0.2767E-03	0.1181E-03	-0.1760E-01	-0.1193E-01	0.0000E+00
50	0.5340E-04	-0.1755E-02	0.8174E-03	-0.1178E-04	-0.1314E-03	0.1370E-03	0.0000E+00	0.0000E+00	0.0000E+00
51	0.549E-04	-0.1216E-02	0.7259E-03	0.1253E-04	-0.2243E-03	0.1342E-03	0.0000E+00	0.0000E+00	0.0000E+00
52	0.815E-04	-0.7484E-03	0.6678E-03	0.1686E-04	-0.1444E-03	0.1326E-03	0.0000E+00	0.0000E+00	0.0000E+00
53	0.1109E-03	-0.3767E-03	0.6674E-03	0.1819E-04	-0.1444E-03	0.1326E-03	0.0000E+00	0.0000E+00	0.0000E+00
54	0.8899E-04	-0.5639E-04	0.5569E-03	0.1821E-04	-0.7454E-05	0.1030E-03	0.0000E+00	0.0000E+00	0.0000E+00
55	0.5337E-04	0.6427E-04	0.3637E-03	0.1097E-04	0.1357E-04	0.6686E-04	0.7572E-03	-0.7191E-03	0.0000E+00


```

116 0.1076E-03 -0.2635E-03 0.6313E-03
117 -0.1860E-03 -0.4365E-03 0.2684E-03
118 -0.2763E-03 -0.7535E-03 0.2915E-03
119 -0.1868E-03 -0.5746E-03 0.1971E-03
120 -0.6910E-04 -0.5180E-03 0.4442E-03
121 0.1073E-03 -0.4951E-03 0.7042E-03
122 -0.2318E-03 -0.6454E-03 0.3388E-03
123 0.9810E-04 -0.6167E-03 0.6826E-03
124 -0.2835E-03 -0.8362E-03 0.4651E-04
125 -0.5499E-04 -0.7632E-03 0.4302E-03
126 -0.1547E-03 -0.4437E-03 0.2305E-03
127 0.7018E-04 -0.2969E-04 0.4185E-04
128 0.1000E-03 -0.7428E-04 0.3482E-03
129 0.2260E-03 -0.3055E-02 0.1790E-02
130 0.5151E-03 -0.6893E-02 0.4039E-02
131 0.1134E-02 -0.7483E-02 0.4887E-02
132 0.1104E-02 -0.4971E-02 0.3909E-02
133 0.2100E-03 -0.1636E-02 0.1355E-02
134 0.1788E-03 -0.2035E-02 0.1570E-02
135 0.3517E-03 -0.2622E-02 0.1886E-02
136 -0.5343E-04 -0.1634E-02 0.1617E-02
137 0.2339E-03 -0.2303E-02 0.1600E-02
138 0.3794E-03 -0.3450E-02 0.2307E-02
139 0.3693E-03 -0.3748E-02 0.2430E-02
140 0.3977E-03 -0.4213E-02 0.2683E-02
141 0.1412E-03 -0.5719E-02 0.3380E-02
142 0.2245E-03 -0.2880E-03 0.2814E-03
143 0.2533E-03 -0.6156E-03 0.2354E-04
144 0.3153E-03 -0.2854E-03 0.2726E-03
145 0.8766E-05 -0.2932E-03 0.2055E-03
146 -0.8876E-05 -0.1751E-03 0.5592E-03
147 0.2262E-03 -0.1751E-03 0.5592E-03
148 0.2811E-03 -0.1451E-04 0.4515E-03
149 0.2290E-03 -0.4100E-03 0.2691E-03
150 -0.9462E-05 -0.2644E-03 0.3053E-03
151 0.2568E-03 -0.3214E-03 0.6460E-03
152 0.2186E-03 -0.8498E-03 0.9516E-03
153 0.3244E-04 -0.1282E-03 0.8830E-03
154 0.1698E-03 -0.7583E-03 0.8849E-03
155 -0.7895E-04 -0.4433E-03 0.5495E-03
156 0.2746E-03 -0.8751E-03 0.9748E-03
157 -0.1107E-03 -0.4537E-03 0.7781E-03
158 0.4171E-03 -0.3092E-03 -0.4696E-03
159 -0.2520E-03 -0.2978E-03 0.5569E-04
160 -0.6538E-04 -0.1330E-04 0.1335E-03

```

```

*****
*
* 0 ERRORS IN THIS PHASE
*
* 71 WARNINGS IN THIS PHASE
*
*****

```

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS

16914 WORDS ****

```

0.2233E-04 -0.4719E-04 0.1192E-03 0.0000E+00 0.0000E+00 0.0000E+00
-0.3447E-04 -0.8183E-04 0.4552E-04 0.1979E-02 0.2525E-02 0.0000E+00
-0.5057E-04 -0.1401E-03 -0.5584E-04 0.1599E-02 0.1715E-02 0.0000E+00
-0.3616E-04 -0.1093E-03 0.2699E-04 0.0000E+00 0.0000E+00 0.0000E+00
-0.1205E-04 -0.9897E-04 0.7225E-04 0.1539E-02 0.7449E-03 0.0000E+00
-0.2278E-04 -0.9294E-04 0.1368E-03 0.0000E+00 0.0000E+00 0.0000E+00
-0.4208E-04 -0.1289E-03 0.2961E-04 -0.1536E-02 0.2228E-02 0.0000E+00
-0.2060E-04 -0.1180E-03 0.1340E-03 -0.1768E-02 0.1058E-02 0.0000E+00
-0.5144E-04 -0.1633E-03 -0.3969E-04 -0.1832E-02 0.9499E-03 0.0000E+00
-0.7380E-05 -0.1521E-03 -0.4162E-04 -0.2311E-03 0.7247E-04 0.0000E+00
-0.2890E-04 -0.7990E-04 -0.7136E-05 -0.2496E-03 0.1617E-02 0.0000E+00
-0.1417E-04 0.6070E-05 0.6300E-04 -0.2469E-02 0.1470E-02 0.0000E+00
-0.1814E-04 0.1311E-04 0.3128E-03 -0.2342E-02 0.4754E-02 0.0000E+00
-0.9888E-04 -0.5378E-03 0.128E-03 -0.8630E-02 0.1528E-01 0.0000E+00
-0.1298E-03 -0.1175E-02 0.7078E-03 -0.1245E-01 0.1081E-01 0.0000E+00
-0.2545E-03 -0.1317E-02 0.8726E-03 -0.5137E-02 0.5514E-02 0.0000E+00
-0.1981E-03 -0.8299E-03 0.6513E-03 -0.9541E-02 -0.5721E-02 0.0000E+00
-0.2627E-03 -0.2023E-02 0.1318E-02 -0.1895E-02 -0.3797E-02 0.0000E+00
-0.4489E-04 -0.2980E-03 0.2539E-03 -0.5005E-02 0.2858E-02 0.0000E+00
-0.4246E-04 -0.3594E-03 0.2842E-03 0.6580E-03 0.8022E-02 0.0000E+00
-0.5955E-05 -0.4473E-03 0.3334E-03 0.7549E-02 -0.3624E-02 0.0000E+00
-0.5955E-05 -0.2632E-03 0.2961E-03 -0.1098E-02 -0.3624E-02 0.0000E+00
-0.4963E-04 -0.4189E-03 0.4129E-03 0.0000E+00 0.0000E+00 0.0000E+00
-0.8418E-04 -0.6027E-03 0.4331E-03 -0.1437E-01 0.7556E-02 0.0000E+00
-0.8281E-04 -0.6517E-03 0.4734E-03 -0.7381E-02 -0.4431E-02 0.0000E+00
-0.8880E-04 -0.7276E-03 0.5989E-03 -0.2753E-02 0.1745E-02 0.0000E+00
-0.5565E-04 -0.9911E-03 0.5205E-04 -0.7369E-03 -0.1973E-02 0.0000E+00
-0.4280E-04 0.1144E-03 0.5485E-05 -0.2362E-03 0.1034E-02 0.0000E+00
-0.5920E-04 0.5923E-04 0.4892E-04 -0.1742E-02 -0.1340E-02 0.0000E+00
-0.1708E-05 0.5521E-04 0.3840E-04 0.1124E-02 -0.2739E-02 0.0000E+00
-0.4407E-04 -0.2600E-04 0.1030E-03 -0.1549E-02 0.0000E+00 0.0000E+00
-0.5384E-04 0.9846E-05 0.7912E-04 0.0000E+00 0.0000E+00 0.0000E+00
-0.4327E-04 0.8837E-04 0.4572E-04 -0.3642E-02 -0.1912E-02 0.0000E+00
-0.1463E-05 0.4832E-04 0.5648E-04 0.0000E+00 0.0000E+00 0.0000E+00
-0.5009E-04 -0.4015E-04 0.1122E-03 -0.7034E-03 -0.1109E-02 0.0000E+00
-0.4408E-04 -0.1506E-03 0.1763E-03 -0.2022E-02 -0.3347E-02 0.0000E+00
-0.4962E-04 -0.1083E-03 0.1530E-03 0.0000E+00 0.0000E+00 0.0000E+00
-0.3524E-04 0.1282E-03 0.1592E-03 -0.5347E-02 -0.3289E-02 0.0000E+00
-0.1561E-04 0.8649E-04 0.1046E-03 0.0000E+00 0.0000E+00 0.0000E+00
-0.5478E-04 -0.1176E-03 0.1611E-03 0.1544E-03 0.6920E-03 0.0000E+00
-0.2278E-04 0.1036E-03 0.1433E-03 0.7852E-02 0.4948E-02 0.0000E+00
-0.7809E-04 0.5862E-04 -0.8963E-04 -0.2889E-02 -0.6142E-03 0.0000E+00
-0.4925E-04 -0.5796E-04 0.1095E-04 -0.2025E-02 -0.7431E-03 0.0000E+00
-0.1298E-04 -0.2242E-05 0.2515E-04 0.1162E-02 0.5062E-03 0.0000E+00

```


ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
5	1	0.211	0.128	0.456E-02	0.112E+07	-0.174E+07	108	74	0.264E+07	-0.194E+07	77	73
5	1	0.211	0.132	0.210E-01	0.260E+07	0.913E+06	167	87	0.212E+07	0.122E+07	21	85
5	1	0.177	0.131	0.253E-01	-0.453E+05	-0.176E+07	66	81	0.666E+07	0.924E+06	4	86
5	1	0.177	0.127	0.523E-02	-0.349E+07	-0.576E+07	104	76	0.267E+07	0.517E+06	129	80
6	1	0.498	0.870E-01	0.571E-02	-0.158E+06	-0.502E+06	53	101	0.377E+06	-0.215E+06	95	90
6	1	0.498	0.877E-01	0.213E-01	0.438E+05	-0.347E+06	46	94	0.223E+06	0.449E+05	76	87
6	1	0.454	0.875E-01	0.235E-01	0.798E+05	-0.386E+06	42	99	0.436E+06	0.177E+06	122	84
6	1	0.454	0.986E-01	0.624E-02	-0.317E+05	-0.412E+06	36	105	0.700E+06	0.885E+05	138	84
7	1	0.422	0.106	0.663E-02	0.324E+06	-0.417E+05	168	78	0.530E+06	-0.104E+05	153	82
7	1	0.421	0.104	0.251E-01	0.670E+06	0.274E+05	29	101	0.400E+06	-0.354E+06	162	79
7	1	0.377	0.113	0.272E-01	0.954E+06	0.749E+06	98	89	0.296E+06	-0.533E+06	10	100
7	1	0.377	0.114	0.713E-02	0.756E+06	0.148E+06	33	101	0.557E+06	-0.728E+04	160	82
8	1	0.344	0.119	0.748E-02	0.134E+07	0.361E+06	19	98	0.464E+06	-0.894E+06	159	83
8	1	0.344	0.119	0.287E-01	0.220E+07	0.715E+06	45	96	-0.180E+05	-0.156E+07	168	79
8	1	0.299	0.127	0.307E-01	0.361E+07	0.186E+07	39	92	-0.991E+06	-0.196E+07	153	78
8	1	0.299	0.125	0.791E-02	0.331E+07	0.89E+06	17	94	0.155E+06	-0.284E+06	14	95
9	1	0.571	0.631E-01	0.396E-02	0.454E+06	-0.749E+06	105	83	0.526E+05	-0.824E+06	53	101
9	1	0.567	0.643E-01	0.154E-01	-0.596E+06	-0.914E+06	89	93	-0.619E+06	-0.777E+06	31	108
9	1	0.528	0.784E-01	0.191E-01	0.138E+06	-0.451E+05	52	98	-609.	-0.246E+06	72	91
9	1	0.530	0.774E-01	0.508E-02	-0.166E+06	-0.813E+06	82	92	-0.900E+05	-0.117E+07	101	86
10	1	0.150	0.127	0.457E-01	0.130E+07	-0.593E+07	40	76	0.848E+07	0.154E+07	121	103
10	1	0.149	0.119	0.732E-01	0.729E+07	0.121E+07	108	121	0.634E+07	0.320E+07	43	90
10	1	0.124	0.111	0.674E-01	0.646E+07	0.240E+07	96	113	0.490E+07	0.414E+07	91	111
10	1	0.121	0.116	0.410E-01	0.223E+07	0.630E+06	62	86	0.898E+07	0.265E+07	100	102
11	1	0.154	0.110	0.920E-01	0.911E+07	0.150E+07	89	126	0.413E+06	-0.369E+07	17	79
11	1	0.169	0.954E-01	0.112	0.795E+07	0.164E+07	66	129	-0.168E+06	-0.683E+07	161	106
11	1	0.139	0.938E-01	0.109	0.710E+07	0.129E+07	84	119	-0.614E+06	-0.662E+07	173	95
11	1	0.129	0.104	0.860E-01	0.917E+07	0.334E+07	85	115	0.130E+06	-0.193E+07	156	112
12	1	0.496	0.871E-01	0.442E-01	0.559E+06	-0.139E+05	18	102	0.141E+06	-0.247E+06	62	100
12	1	0.491	0.827E-01	0.906E-01	0.580E+06	-0.181E+06	12	98	-0.354E+06	-0.491E+06	61	99
12	1	0.448	0.874E-01	0.940E-01	0.778E+06	0.325E+06	55	106	0.217E+06	-0.375E+06	13	99
12	1	0.452	0.959E-01	0.475E-01	0.167E+06	0.331E+05	64	101	0.352E+06	0.655E+05	37	103
13	1	0.420	0.102	0.499E-01	0.255E+06	-0.160E+05	41	104	0.366E+06	-0.425E+06	20	103
13	1	0.417	0.907E-01	0.963E-01	0.316E+06	0.128E+06	68	111	0.163E+06	-0.381E+06	30	106
13	1	0.374	0.951E-01	0.993E-01	0.727E+06	0.165E+06	61	118	-0.157E+06	-0.341E+06	91	118
13	1	0.376	0.111	0.532E-01	0.101E+07	0.878E+06	13	102	-0.141E+05	-0.735E+06	35	105

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE			BOTTOM SURFACE				
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
14	1	0.344	0.117	0.555E-01	0.795E+06	0.655E+06	75	103	0.198E+06	-0.873E+06	22	104
14	1	0.343	0.982E-01	0.101	-0.204E+05	-0.210E+06	162	93	0.196E+06	-0.227E+06	46	117
14	1	0.300	0.102	0.104	-0.199E+06	-0.579E+06	74	130	0.164E+06	0.315E+05	172	86
14	1	0.300	0.125	0.586E-01	0.149E+07	-0.222E+06	87	102	0.344E+06	-0.140E+07	11	101
15	1	0.564	0.644E-01	0.335E-01	-0.494E+06	-0.781E+06	95	90	0.525E+06	0.932E+05	60	100
15	1	0.561	0.642E-01	0.712E-01	-0.244E+05	-0.324E+06	154	78	0.144E+07	0.866E+06	21	103
15	1	0.521	0.758E-01	0.836E-01	0.609E+06	0.817E+05	21	111	0.769E+06	-0.564E+05	23	111
15	1	0.526	0.782E-01	0.401E-01	0.256E+06	-0.113E+07	46	111	0.110E+06	0.722E+05	64	106
16	1	0.179	0.784E-01	0.126	0.457E+07	0.136E+07	65	139	-0.484E+06	-0.271E+07	171	96
16	1	0.183	0.428E-01	0.143	0.939E+06	0.154E+06	109	149	0.153E+07	0.261E+06	69	153
16	1	0.167	0.446E-01	0.145	0.666E+06	0.227E+06	44	132	0.129E+07	0.195E+06	132	128
16	1	0.152	0.794E-01	0.125	0.420E+07	-0.227E+06	76	140	0.110E+07	-0.428E+07	166	100
17	1	0.184	0.136E-01	0.151	0.750E+06	-0.698E+05	19	101	0.117E+07	0.715E+06	87	171
17	1	0.181	-0.286E-01	0.153	0.103E+07	-0.800E+06	143	123	0.155E+07	-0.557E+06	53	138
17	1	0.161	-0.286E-01	0.160	0.194E+07	0.483E+06	125	143	0.120E+07	-0.274E+06	58	140
17	1	0.170	0.134E-01	0.156	0.715E+06	0.455E+06	67	156	0.199E+07	0.220E+06	68	158
18	1	0.273	0.166E-01	0.142	0.282E+07	-0.706E+06	151	117	0.134E+07	0.394E+06	59	147
18	1	0.273	-0.249E-01	0.148	0.141E+07	-0.433E+06	128	141	-0.174E+06	-0.151E+07	42	132
18	1	0.246	-0.230E-01	0.148	0.198E+07	-0.424E+05	137	132	-0.275E+06	-0.464E+06	60	150
18	1	0.246	0.239E-01	0.141	0.256E+07	-0.273E+06	151	116	0.123E+07	-0.150E+07	49	138
19	1	0.225	0.242E-01	0.143	0.966E+06	-0.409E+06	146	120	0.139E+07	-0.694E+06	52	141
19	1	0.226	-0.230E-01	0.149	0.772E+06	-0.112E+07	147	122	0.864E+06	0.382E+06	36	126
19	1	0.199	-0.247E-01	0.150	0.959E+05	-0.791E+06	153	116	0.137E+07	0.583E+06	90	176
19	1	0.198	0.179E-01	0.147	0.980E+06	-0.424E+06	142	124	0.184E+07	0.794E+05	47	137
20	1	0.477	0.739E-01	0.117	0.475E+06	-0.418E+05	11	99	0.696E+06	-0.709E+06	41	119
20	1	0.449	0.463E-01	0.138	0.128E+06	-0.882E+06	34	118	0.101E+07	-0.433E+06	16	104
20	1	0.414	0.451E-01	0.138	0.386E+06	-0.117E+05	158	109	0.777E+06	0.583E+06	56	137
20	1	0.437	0.747E-01	0.119	0.547E+06	0.245E+06	121	129	0.506E+06	-0.312E+06	7	97
21	1	0.433	0.183E-01	0.150	0.403E+05	-0.607E+06	2	88	0.108E+07	0.160E+06	2	89
21	1	0.422	-0.254E-01	0.158	-0.608E+06	-0.644E+06	102	166	0.377E+05	-0.317E+06	115	153
21	1	0.393	-0.255E-01	0.156	-0.133E+06	-0.279E+06	94	173	0.407E+06	0.125E+06	65	154
21	1	0.402	0.171E-01	0.149	0.281E+05	-0.889E+06	161	108	0.869E+06	0.659E+06	169	100
22	1	0.407	0.750E-01	0.120	0.723E+06	0.414E+06	2	92	0.309E+06	-0.385E+06	29	114
22	1	0.389	0.441E-01	0.138	0.136E+06	-0.355E+06	19	106	0.602E+06	-0.104E+06	159	109
22	1	0.355	0.424E-01	0.137	0.390E+06	-0.351E+06	161	107	0.545E+06	0.576E+05	1	89
22	1	0.367	0.755E-01	0.121	0.398E+06	0.179E+06	76	147	0.399E+06	-0.242E+06	170	96

23	1	0.379	0.161E-01	0.148	0.212E+06	-0.450E+06	167	102	0.757E+06	0.342E+06	175	94
23	1	0.372	-0.257E-01	0.155	-0.600E+05	-0.298E+06	5	92	0.219E+06	-0.582E+05	41	130
23	1	0.343	-0.259E-01	0.153	0.147E+06	-0.459E+05	4	91	0.717E+06	515.	33	122
23	1	0.348	0.148E-01	0.146	0.133E+06	-0.689E+06	175	93	0.577E+06	0.149E+06	168	101
24	1	0.337	0.757E-01	0.122	0.718E+06	-0.635E+05	142	122	-0.481E+06	-0.723E+06	151	114
24	1	0.329	0.415E-01	0.137	0.106E+07	-0.355E+06	173	96	0.442E+06	-0.340E+06	168	101
24	1	0.295	0.399E-01	0.136	0.153E+07	0.69E+06	153	115	0.122E+07	0.716E+05	120	146
24	1	0.297	0.758E-01	0.123	0.512E+06	0.245E+06	83	156	0.808E+05	-0.764E+06	87	157
25	1	0.325	0.138E-01	0.145	0.769E+06	-0.412E+06	15	104	0.303E+06	0.161E+06	3	88
25	1	0.322	-0.260E-01	0.151	0.437E+06	-0.169E+06	53	142	-0.778E+05	-0.410E+06	53	142
25	1	0.293	-0.262E-01	0.149	0.954E+06	0.361E+06	113	156	-0.442E+05	-0.227E+06	153	116
25	1	0.294	0.124E-01	0.143	0.154E+07	-0.246E+05	31	119	0.107E+07	0.403E+06	60	147
26	1	0.552	0.608E-01	0.101	0.134E+07	0.354E+06	151	89	0.237E+06	-0.197E+06	148	91
26	1	0.537	0.395E-01	0.140	0.112E+07	-0.252E+06	22	104	0.569E+06	-0.334E+06	41	115
26	1	0.481	0.444E-01	0.138	0.762E+06	0.568E+06	161	102	0.476E+06	0.369E+05	145	116
26	1	0.507	0.695E-01	0.111	0.115E+07	0.443E+06	107	130	0.561E+05	-0.862E+06	22	109
27	1	0.533	0.127E-01	0.164	0.386E+06	-0.360E+06	13	95	0.640E+06	0.411E+06	172	92
27	1	0.538	-0.312E-01	0.181	0.190E+06	-0.113E+07	94	172	-0.692E+05	-0.872E+06	97	170
27	1	0.461	-0.268E-01	0.164	-0.137E+06	-0.377E+06	70	157	0.997E+05	-0.257E+06	82	169
27	1	0.468	0.170E-01	0.153	0.634E+06	-0.532E+06	174	90	0.103E+07	0.589E+06	24	109
28	1	0.177	-0.533E-01	0.138	0.176E+07	-0.917E+06	139	124	0.910E+06	-0.973E+06	62	116
28	1	0.170	-0.828E-01	0.987E-01	0.286E+07	0.842E+06	147	115	0.108E+07	-0.257E+06	72	115
28	1	0.118	-0.900E-01	0.111	0.865E+06	-0.367E+06	185	104	0.164E+07	0.178E+06	114	118
28	1	0.144	-0.577E-01	0.149	0.169E+07	0.474E+06	132	127	0.877E+06	-0.305E+06	76	123
29	1	0.165	-0.101	0.670E-01	0.880E+06	-0.123E+06	74	111	0.165E+07	0.218E+06	106	116
29	1	0.161	-0.118	0.204E-01	-0.222E+07	-0.274E+07	138	100	0.271E+07	0.148E+07	147	98
29	1	0.833E-01	-0.117	0.242E-01	-0.639E+06	-0.228E+07	25	92	0.234E+07	0.983E+06	97	93
29	1	0.101	-0.107	0.769E-01	0.189E+06	-0.906E+06	13	86	0.158E+07	0.212E+06	114	108
30	1	0.273	-0.518E-01	0.136	0.678E+06	0.179E+06	117	123	0.417E+06	0.790E+05	146	110
30	1	0.273	-0.792E-01	0.954E-01	-0.399E+06	-0.164E+07	137	110	0.786E+06	-0.113E+07	59	114
30	1	0.246	-0.799E-01	0.952E-01	-0.410E+06	-0.163E+07	124	115	0.117E+07	0.209E+05	53	114
30	1	0.246	-0.519E-01	0.135	0.197E+06	-0.730E+06	144	111	0.424E+06	0.254E+06	135	115
31	1	0.273	-0.955E-01	0.637E-01	-0.521E+06	-0.140E+07	53	107	0.525E+06	-0.179E+07	99	114
31	1	0.273	-0.112	0.180E-01	0.285E+07	0.298E+06	112	97	0.225E+07	-0.103E+07	50	97
31	1	0.246	-0.115	0.182E-01	0.367E+07	-0.233E+06	170	97	0.207E+07	-0.500E+06	46	98
31	1	0.246	-0.970E-01	0.636E-01	-0.757E+06	-0.123E+07	99	115	0.615E+06	-0.186E+07	74	113
32	1	0.226	-0.519E-01	0.135	0.753E+06	-0.633E+06	143	111	0.242E+06	0.144E+06	137	114
32	1	0.224	-0.802E-01	0.949E-01	-0.180E+06	-0.132E+07	129	113	0.394E+06	-0.190E+06	71	120
32	1	0.199	-0.802E-01	0.944E-01	0.185E+07	0.428E+06	146	106	-0.280E+06	-0.595E+06	64	119
32	1	0.199	-0.518E-01	0.134	0.637E+06	0.149E+06	139	112	0.919E+06	-0.506E+06	108	125

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
33	1	0.226	-0.977E-01	0.636E-01	0.109E+06	-0.863E+06	125	111	0.159E+07	-0.191E+07	59	111
33	1	0.226	-0.116	0.185E-01	0.318E+07	0.211E+06	5	86	0.293E+07	0.583E+06	41	98
33	1	0.199	-0.118	0.189E-01	0.263E+06	-0.216E+07	3	87	0.551E+07	0.212E+07	40	100
33	1	0.199	-0.982E-01	0.634E-01	0.290E+06	-0.127E+07	127	111	0.104E+07	-0.228E+07	48	110
34	1	0.421	-0.548E-01	0.144	0.767E+05	-0.791E+06	63	124	0.542E+06	-0.117E+07	66	125
34	1	0.422	-0.844E-01	0.101	0.459E+05	-0.405E+06	17	102	-0.156E+06	-0.126E+07	43	114
34	1	0.393	-0.820E-01	0.999E-01	0.170E+06	-0.952E+06	58	117	0.461E+06	-0.958E+06	58	117
34	1	0.393	-0.538E-01	0.143	0.400E+05	-0.757E+06	75	126	0.459E+06	-0.855E+06	64	124
35	1	0.422	-0.103	0.670E-01	0.191E+07	0.124E+07	76	116	0.287E+06	-0.924E+06	121	107
35	1	0.422	-0.123	0.184E-01	0.783E+06	-0.330E+06	111	103	0.333E+06	-0.825E+06	103	105
35	1	0.393	-0.117	0.183E-01	0.745E+06	-0.542E+05	146	91	0.140E+06	-0.899E+06	124	99
35	1	0.393	-0.991E-01	0.663E-01	0.914E+06	0.382E+06	24	104	-0.639E+06	-0.991E+06	126	105
36	1	0.372	-0.533E-01	0.141	-0.126E+06	-0.580E+06	53	120	0.276E+06	-0.981E+06	58	122
36	1	0.372	-0.807E-01	0.991E-01	0.360E+06	-0.478E+06	57	116	0.334E+06	-0.736E+06	57	116
36	1	0.343	-0.794E-01	0.980E-01	-0.296E+06	-0.100E+07	56	115	0.363E+05	-0.971E+06	74	118
36	1	0.343	-0.526E-01	0.140	-0.540E+05	-0.436E+06	91	126	0.716E+06	-0.829E+06	52	120
37	1	0.372	-0.971E-01	0.658E-01	0.306E+05	-0.551E+06	121	107	-0.311E+06	-0.108E+07	73	113
37	1	0.372	-0.114	0.182E-01	0.462E+06	-0.361E+06	28	103	0.101E+07	-0.794E+06	133	97
37	1	0.343	-0.112	0.181E-01	0.769E+06	-0.471E+06	33	101	0.116E+07	-0.951E+06	132	98
37	1	0.343	-0.953E-01	0.652E-01	0.832E+05	-0.511E+06	111	110	0.466E+06	-0.968E+06	69	112
38	1	0.322	-0.522E-01	0.138	0.175E+05	-0.480E+06	29	109	0.419E+06	-0.121E+06	35	112
38	1	0.322	-0.787E-01	0.971E-01	-0.128E+06	-0.104E+07	55	114	0.209E+06	-0.933E+06	65	116
38	1	0.293	-0.786E-01	0.959E-01	-0.731E+06	-0.882E+06	101	118	0.870E+05	-0.135E+07	65	116
38	1	0.293	-0.518E-01	0.136	0.536E+06	-0.761E+06	138	112	0.392E+06	-0.104E+07	37	113
39	1	0.322	-0.946E-01	0.646E-01	-0.114E+07	-0.168E+07	104	111	-0.927E+05	-0.893E+06	89	113
39	1	0.322	-0.110	0.180E-01	0.233E+06	-0.804E+06	6	93	0.710E+06	0.197E+06	139	97
39	1	0.293	-0.110	0.180E-01	0.107E+07	-0.126E+07	20	93	0.722E+06	0.543E+05	103	104
39	1	0.293	-0.945E-01	0.639E-01	-0.825E+06	-0.148E+07	141	105	0.347E+06	-0.418E+06	78	113
40	1	0.551	-0.797E-01	0.184	-0.206E+06	-0.725E+06	82	169	-0.580E+04	-0.183E+06	48	137
40	1	0.576	-0.156	0.158	-0.913E+05	-0.548E+06	148	81	0.466E+06	-0.368E+04	130	104
40	1	0.469	-0.107	0.116	0.582E+06	0.149E+06	54	138	0.328E+06	-0.807E+05	109	113
40	1	0.464	-0.624E-01	0.155	-0.146E+06	-0.133E+07	81	147	0.522E+05	-0.126E+07	87	145
41	1	0.593	-0.201	0.112	0.160E+06	-0.226E+06	46	126	-0.585E+05	-0.198E+06	86	117
41	1	0.606	-0.227	0.327E-01	0.149E+06	0.693E+05	82	94	0.844E+05	-0.221E+06	32	108
41	1	0.475	-0.159	0.222E-01	0.119E+06	-0.664E+05	95	101	-0.868E+05	-0.235E+06	47	127
41	1	0.473	-0.135	0.791E-01	0.576E+06	0.326E+06	126	85	-0.278E+05	-0.371E+06	40	130

NO STRESS AVERAGING AVAILABLE WITH THE ELEMENTS USED IN THIS JOB

Static Analysis

Symmetric Quadrilateral Semi-Loof Element

Structural Material: Plaster

Displacements and Stresses

CASE 1 NODE NUMBER	TRANSLATIONS			ROTATIONS		RESULTANT TRANSLATION		SCALED COORDINATES		
	UX	UY	UZ	PHIX	PHIY	U	HISTOGRAM	X	Y	Z
1	-17.158	373.47	-352.19	0.000	0.000	513.63	*****	0.10	0.11	0.00
2	-10.854	333.73	-266.47	2.358	1.284	427.20	*****	0.13	0.12	0.00
3	-3.371	263.74	-201.33	0.000	0.000	331.82	*****	0.17	0.12	0.00
4	-5.365	126.36	-121.34	0.000	0.000	175.27	***	0.22	0.12	0.00
5	-6.495	9.825	-66.821	0.000	0.000	67.851	*	0.28	0.13	0.00
6	-3.328	-29.801	-29.263	-0.383	-0.675	41.899	*	0.40	0.11	0.00
7	-1.944	-24.541	-8.787	0.000	0.000	26.186	*	0.51	0.08	0.00
8	-2.542	-15.220	-1.895	-0.223	-0.019	15.546	*	0.55	0.07	0.00
9	-33.641	242.12	-132.28	-1.336	-0.252	437.31	*****	0.59	0.06	0.00
10	-23.307	221.13	-195.46	-1.769	-1.068	296.05	*****	0.17	0.13	0.02
11	-13.654	-22.114	-61.584	-1.288	-1.049	86.844	*	0.28	0.13	0.02
12	-3.047	-19.442	-8.292	0.090	0.073	21.355	*	0.51	0.08	0.01
13	-50.776	218.95	-327.28	4.729	3.769	397.03	*****	0.58	0.06	0.01
14	-53.890	202.02	-258.07	*	*	332.14	*****	0.11	0.11	0.03
15	-47.978	168.98	-191.44	*	*	259.82	*****	0.14	0.12	0.04
16	-18.069	80.396	-109.30	*	*	136.88	**	0.17	0.13	0.04
17	-20.191	-58.393	-54.013	*	*	82.066	*	0.22	0.13	0.03
18	-12.638	-43.882	-31.048	-0.273	-0.440	55.221	*	0.28	0.13	0.04
19	-5.643	-19.239	-8.135	-0.222	-0.239	21.637	*	0.40	0.11	0.03
20	-2.836	-12.340	-2.581	*	*	12.923	*	0.51	0.09	0.03
21	-53.829	-56.443	-337.62	*	*	346.51	*****	0.55	0.07	0.02
22	-60.721	-81.433	-264.89	*	*	283.70	*****	0.58	0.06	0.02
23	-27.204	-75.038	-55.561	0.354	0.463	97.251	**	0.12	0.11	0.08
24	-10.993	-21.673	-9.478	0.448	0.507	26.084	*	0.16	0.12	0.09
25	-61.949	-214.07	-378.17	*	*	438.95	*****	0.29	0.12	0.08
26	-61.317	-182.91	-335.21	1.406	-0.315	386.76	*****	0.51	0.08	0.07
27	-60.162	-168.72	-307.35	*	*	355.74	*****	0.58	0.06	0.05
28	-46.661	-112.89	-181.24	*	*	218.57	***	0.13	0.09	0.12
29	-26.175	-74.401	-51.985	*	*	94.462	**	0.16	0.09	0.12
30	-21.545	-42.184	-28.298	0.409	0.509	55.176	*	0.24	0.07	0.13
31	-15.965	-14.823	-10.624	*	*	24.237	*	0.28	0.09	0.12
32	-4.902	-1.662	-2.568	-0.447	-0.059	5.778	*	0.39	0.09	0.11
33	-57.131	-140.91	-254.29	1.647	1.728	296.28	*****	0.51	0.08	0.11
34	-30.663	-64.762	-31.070	3.036	2.330	78.101	*	0.54	0.07	0.09
35	-50.632	-107.25	-182.43	*	*	438.95	*****	0.57	0.06	0.08
36	-37.942	-109.66	-145.01	*	*	386.76	*****	0.19	0.06	0.14
37	-36.014	-96.278	-117.27	*	*	355.74	*****	0.28	0.06	0.13
38	-15.814	-54.527	-11.888	*	*	218.57	***	0.19	0.03	0.16
39	-7.389	-8.812	8.452	*	*	94.462	**	0.19	0.03	0.16
40	-12.550	-96.101	-26.128	0.794	-0.169	58.005	*	0.24	0.04	0.14
41	-7.765	-49.996	34.301	1.936	0.387	14.272	*	0.28	0.03	0.14
42	14.321	-103.85	103.98	*	*	100.38	**	0.45	0.03	0.14
43	11.819	-107.62	94.146	-3.883	-3.160	61.126	*	0.56	0.03	0.16
44	9.310	-109.66	85.540	*	*	147.66	***	0.28	-0.01	0.15
45	9.445	-74.399	73.487	*	*	143.47	***	0.17	-0.04	0.16
46				*	*	139.38	**	0.19	-0.04	0.15
47				*	*	105.02	**	0.24	-0.04	0.15
48				*	*					
49				*	*					
50				*	*					
51				*	*					

CASE MODE NUMBER	TRANSLATIONS			ROTATIONS		RESULTANT TRANSLATION		SCALED COORDINATES		
	UX	UY	UZ	PHIX	PHIY	U	HISTOGRAM	X	Y	Z
52	4.817	-48.124	64.309	*	*	80.919	*	0.28	-0.04	0.15
53	10.158	-23.030	50.254	0.096	0.271	56.206	*	0.36	-0.04	0.15
54	7.290	-3.983	35.630	*	*	36.586	*	0.43	-0.04	0.16
55	3.925	2.581	21.545	0.033	-0.306	22.051	*	0.50	-0.05	0.17
56	*	*	*	*	*	*	*	0.57	-0.05	0.19
57	57.362	-387.91	244.52	*	*	490.41	*****	0.09	-0.10	0.10
58	19.647	-243.68	180.31	*	*	303.77	*****	0.19	-0.09	0.08
59	15.274	-18.387	87.007	*	*	118.10	**	0.28	-0.09	0.08
60	16.205	32.333	13.597	*	*	38.638	*	0.43	-0.10	0.08
61	*	*	*	*	*	*	*	0.63	-0.20	0.15
62	-17.158	-373.47	352.19	0.000	0.000	513.63	*****	0.05	-0.11	0.00
63	-10.854	-333.73	266.47	2.358	1.284	427.20	*****	0.12	-0.12	0.00
64	-3.371	-243.74	201.33	0.000	0.000	331.82	*****	0.19	-0.12	0.00
65	-5.365	-126.36	121.34	0.000	0.000	175.27	***	0.24	-0.12	0.00
66	-6.495	-9.825	66.821	0.000	0.000	67.851	*	0.28	-0.11	0.00
67	-3.328	29.801	29.263	-0.383	-0.675	41.899	*	0.36	-0.12	0.00
68	-1.944	24.591	8.787	0.000	0.000	26.186	*	0.53	-0.13	0.00
69	-2.542	15.220	1.895	-0.223	-0.019	15.546	*	0.54	-0.20	0.00
70	*	*	*	*	*	*	*	0.66	-0.24	0.00
71	-17.413	-86.404	-100.57	-2.545	-2.496	137.77	**	0.26	-0.07	0.13
72	-26.088	-74.617	-45.173	-1.706	-0.297	91.043	**	0.26	-0.04	0.14
73	-45.866	-104.85	-162.18	2.808	2.287	198.50	***	0.24	-0.06	0.14
74	-53.659	-137.23	-243.31	-0.107	-1.867	284.45	*****	0.21	0.08	0.13
75	-39.268	-107.27	-145.40	-3.682	-2.920	184.91	***	0.21	0.04	0.14
76	-5.796	56.712	-88.117	1.519	1.589	104.95	*	0.25	0.12	-0.00
77	-17.018	0.750	-74.846	1.500	1.336	76.760	*	0.25	0.13	0.03
78	-11.147	107.06	-115.50	-2.722	-2.710	157.94	***	0.22	0.13	0.01
79	-3.837	197.18	-159.99	1.483	1.351	253.95	*****	0.19	0.12	0.00
80	-24.056	146.24	-146.78	2.453	1.781	209.09	*****	0.19	0.13	0.03
81	-1.910	-27.338	-15.493	0.091	-0.166	31.481	*	0.48	0.09	0.00
82	-7.193	-27.517	-15.523	0.098	-0.147	32.447	*	0.48	0.09	0.03
83	-2.286	-28.343	-21.925	0.000	0.000	35.906	*	0.44	0.10	0.00
84	-5.811	-31.674	-22.546	0.146	0.206	39.319	*	0.44	0.10	0.02
85	-9.420	-35.420	-22.810	*	*	43.170	*	0.44	0.10	0.03
86	-4.450	-28.586	-38.352	0.000	0.000	48.040	*	0.36	0.12	0.00
87	-10.509	-41.957	-39.329	-0.016	0.184	58.460	*	0.36	0.12	0.02
88	-15.882	-51.741	-39.340	*	*	66.910	*	0.32	0.12	0.04
89	-5.828	-23.607	-49.039	1.486	0.941	54.737	*	0.32	0.12	0.00
90	-20.126	-63.541	-48.484	1.191	0.612	82.421	*	0.32	0.12	0.04
91	-64.417	51.320	-21.75	-1.283	0.892	230.94	*****	0.16	0.13	0.06
92	-53.491	-117.46	-324.16	2.455	0.678	373.46	*****	0.17	0.11	0.11
93	-62.980	-57.183	-293.64	5.730	4.619	305.72	*****	0.14	0.11	0.08
94	-51.738	67.262	-326.03	1.004	1.984	336.90	*****	0.11	0.11	0.06
95	-47.924	-174.98	-366.28	2.206	1.543	400.74	*****	0.12	0.10	0.10
96	-17.232	-21.649	-15.298	0.079	0.400	31.617	*	0.47	0.08	0.11
97	-17.418	-41.279	-24.119	0.223	0.309	50.883	*	0.43	0.10	0.07
98	-19.491	-33.164	-22.038	*	*	44.333	*	0.43	0.08	0.11
99	-22.845	-58.065	-40.020	0.175	0.331	74.128	*	0.36	0.11	0.08
100	-23.465	-52.744	-35.403	*	*	67.712	*	0.36	0.09	0.12
101	-25.330	-65.424	-46.262	-0.129	-0.602	84.036	**	0.32	0.09	0.12
102	-19.371	-99.111	-26.428	1.132	0.214	104.39	**	0.19	-0.01	0.15

CASE NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS MULTIPLIED BY 1E 3		RESULTANT TRANSLATION MULTIPLIED BY 1E 6		SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY	U	HISTOGRAM	X	Y	Z
103	-64.226	-108.75	-160.47	-3.804	-3.581	198.93	***	0.18	0.03	0.15
104	-63.362	-174.03	-323.31	1.877	1.096	372.71	*****	0.15	0.07	0.14
105	-23.600	-81.481	-34.345	1.416	1.753	91.519	**	0.16	-0.01	0.16
106	9.736	-60.445	69.104	-1.623	-0.897	92.324	**	0.26	-0.04	0.15
107	-13.857	-78.667	-20.660	1.582	0.212	82.507	*	0.24	0.00	0.15
108	9.470	-91.688	80.215	-2.580	-2.048	122.19	**	0.21	-0.04	0.15
109	-13.112	-20.599	-14.740	0.173	0.366	28.522	*	0.48	0.06	0.13
110	-0.762	-5.817	22.272	0.034	-0.143	23.037	*	0.44	-0.00	0.16
111	-8.916	-12.387	13.426	0.406	0.742	20.328	*	0.42	0.03	0.14
112	8.551	-10.205	41.215	-0.086	-0.007	43.312	*	0.41	-0.04	0.16
113	-15.394	-28.887	-13.129	0.428	0.453	35.268	*	0.40	0.06	0.13
114	-9.659	-20.860	9.774	0.198	-0.128	24.979	*	0.39	0.03	0.14
115	-0.991	-17.018	30.943	*	*	35.328	*	0.38	-0.00	0.15
116	9.498	-16.138	44.725	0.729	0.858	48.487	*	0.37	0.03	0.14
117	-10.097	-28.868	9.109	0.515	0.359	31.911	*	0.35	0.06	0.13
118	-18.057	-45.973	-18.503	*	*	52.744	*	0.34	0.03	0.14
119	-10.518	-37.597	8.195	0.190	-0.093	39.891	*	0.33	-0.01	0.15
120	-1.795	-31.928	36.000	*	*	48.152	*	0.33	-0.01	0.15
121	10.492	-30.666	55.678	-0.982	-0.930	64.425	*	0.33	0.04	0.15
122	-12.658	-46.246	9.131	-0.548	-0.378	48.861	*	0.31	0.03	0.14
123	10.192	-38.542	59.811	0.187	-0.014	71.880	*	0.31	-0.04	0.15
124	-18.888	-62.491	-19.976	-0.064	-0.137	68.271	*	0.28	0.06	0.13
125	-2.011	-49.963	42.345	0.213	0.114	65.524	*	0.28	-0.01	0.15
126	-6.694	-8.792	-4.679	-0.192	-0.502	12.000	*	0.56	0.05	0.12
127	5.441	-0.139	-3.366	-0.513	-0.185	6.400	*	0.56	-0.01	0.18
128	-4.241	1.324	10.981	-1.041	-1.741	11.846	****	0.50	0.03	0.15
129	17.206	-179.68	139.49	-2.247	-2.760	228.23	*****	0.19	-0.06	0.11
130	14.405	-276.43	202.12	-1.758	-1.686	342.74	*****	0.19	-0.11	0.04
131	40.948	-329.79	240.05	0.834	-0.785	410.31	*****	0.14	-0.09	0.09
132	48.246	-244.73	219.98	-1.391	-1.026	332.59	*****	0.11	-0.07	0.13
133	33.629	-446.59	331.59	-0.726	-1.403	551.57	*****	0.06	-0.11	0.05
134	14.417	-74.003	83.562	-0.726	-1.403	112.55	**	0.28	-0.07	0.12
135	7.303	-66.646	82.527	-1.691	-1.816	106.33	**	0.28	-0.10	0.04
136	17.506	-113.44	107.02	-0.057	0.273	156.93	***	0.26	-0.12	0.00
137	-5.796	-56.712	48.117	1.519	1.589	104.95	**	0.26	-0.12	0.00
138	16.787	-123.55	111.57	-0.872	-1.728	167.31	***	0.24	-0.09	0.11
139	18.982	-157.43	132.09	*	*	206.43	****	0.24	-0.07	0.08
140	14.749	-162.07	131.72	3.133	2.420	210.63	****	0.24	-0.11	0.04
141	20.171	-204.36	158.69	-1.196	-0.655	258.53	*****	0.21	-0.09	0.08
142	-3.837	-197.18	159.99	1.483	1.351	253.95	*****	0.21	-0.12	0.00
143	12.247	13.580	21.432	-0.239	-0.427	28.173	*	0.43	-0.07	0.12
144	11.119	31.294	8.128	-0.296	-0.013	36.076	*	0.43	-0.12	0.04
145	14.171	15.999	22.685	-0.324	-0.358	31.167	*	0.41	-0.09	0.08
146	-1.910	27.338	15.493	0.091	-0.166	31.481	*	0.41	-0.13	0.00
147	13.003	-7.129	38.558	-0.504	-0.711	41.311	*	0.38	-0.07	0.12
148	13.542	5.155	30.925	*	*	34.151	*	0.38	-0.09	0.08
149	9.047	20.757	24.424	-0.705	-0.283	33.305	*	0.38	-0.11	0.04
150	-2.286	28.343	21.925	0.000	0.000	35.906	*	0.38	-0.12	0.00
151	13.005	-10.376	42.666	-0.327	-0.379	45.795	*	0.36	-0.09	0.08
152	13.616	-35.414	59.145	-0.552	-0.893	70.268	*	0.33	-0.07	0.12
153	13.203	-26.939	54.863	*	*	62.530	*	0.33	-0.09	0.08

CASE 1 NODE NUMBER	TRANSLATIONS MULTIPLIED BY 1E 6			ROTATIONS MULTIPLIED BY 1E 3			RESULTANT TRANSLATION MULTIPLIED BY 1E 6			SCALED COORDINATES MULTIPLIED BY 1E 0		
	UX	UY	UZ	PHIX	PHIY		U	V	W	X	Y	Z
154	7.233	-9.400	48.007	-1.013	-0.626		49.450	*		0.33	-0.10	0.04
155	-4.450	28.586	38.352	0.000	0.000		48.040	*		0.33	-0.12	0.00
156	14.174	-44.061	66.554	0.242	0.414		81.066	*		0.31	-0.09	0.08
157	-5.828	23.607	49.039	1.486	0.941		54.737	*		0.31	-0.11	0.00
158	24.999	17.172	-25.369	-0.649	-0.252		39.553	*		0.60	-0.13	0.19
159	-12.134	-13.760	2.445	0.460	0.082		18.506			0.65	-0.24	0.08
160	-1.811	0.170	8.317	0.277	0.065		8.514			0.53	-0.15	0.12

```
*****
*
* 0 ERRORS IN THIS PHASE
*
* 14 WARNINGS IN THIS PHASE
*
*****
```

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 16263 WORDS ***

*** END OF PHASE 7 ***

```
*****
*
* TITLE PLASTER RISER CAST STRUCTURAL ANALYSIS
* PHASE NUMBER 9 STARTS HERE
*
*****
```

DEFAULT STRESS-ELEMENTS MODULE CREATED.

STRESSES FOR ELEMENT 43210
 SIGMA1 IS THE MOST POSITIVE PRINCIPAL STRESS.
 SIGMA2 IS THE MOST NEGATIVE PRINCIPAL STRESS.
 ANGLE ALPHA1 IS THE ANGLE BETWEEN THE GLOBAL
 X-AXIS AND PRINCIPAL STRESS SIGNAL

ANGLE ALPHA2 IS THE ANGLE BETWEEN THE GLOBAL
Y-AXIS AND PRINCIPAL STRESS SIGNAL

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TIP SURFACE			BOTTOM SURFACE		
		X	Y	Z	SIGNAL	ALPHA1	ALPHA2	SIGNAL	SIGMA2	ALPHA1
1	1	0.274	0.718E-01	0.128	0.319E+06	-0.114E+06	119	0.732E+05	-0.383E+06	29
1	1	0.274	0.430E-01	0.136	0.186E+06	0.750E+05	135	0.396E+06	-0.202E+06	44
1	1	0.247	0.481E-01	0.137	0.257E+06	-0.833E+05	146	0.283E+06	-0.350E+06	41
1	1	0.247	0.644E-01	0.133	0.328E+06	-0.668E+05	140	0.309E+06	-0.319E+06	38
2	1	0.224	0.656E-01	0.134	0.499E+06	0.153E+06	174	0.100E+06	-0.178E+06	32
2	1	0.225	0.489E-01	0.140	0.271E+06	0.226E+06	156	0.704E+05	-0.321E+06	44
2	1	0.198	0.457E-01	0.144	0.470E+06	0.518E+05	124	0.416E+05	-0.385E+06	39
2	1	0.197	0.766E-01	0.132	0.804E+06	0.193E+06	44	-0.732E+05	-0.214E+06	150
3	1	0.192	0.121	0.791E-02	0.521E+05	-0.147E+07	26	0.836E+06	0.134E+06	125
3	1	0.153	0.124	0.290E-01	-0.824E+05	-0.133E+07	25	0.751E+06	0.310E+06	122
3	1	0.120	0.114	0.271E-01	0.225E+06	-0.368E+06	29	0.109E+07	0.123E+06	91
3	1	0.118	0.113	0.729E-02	0.406E+06	-0.693E+06	37	0.137E+07	-0.169E+06	100
4	1	0.270	0.127	0.761E-02	0.326E+06	0.388E+05	12	0.907E+05	-0.345E+06	82
4	1	0.270	0.131	0.283E-01	0.610E+06	0.351E+05	168	0.356E+05	-0.234E+06	92
4	1	0.237	0.130	0.224E-01	0.264E+06	-0.752E+05	178	0.433E+05	-0.128E+06	43
4	1	0.236	0.126	0.605E-02	0.534E+05	-0.105E+06	16	0.950E+05	-0.284E+06	74
5	1	0.211	0.125	0.594E-02	-0.526E+04	-0.254E+06	90	0.317E+06	-0.174E+06	90
5	1	0.211	0.130	0.223E-01	0.882E+05	-0.159E+05	125	0.249E+06	0.935E+05	144
5	1	0.177	0.128	0.273E-01	0.603E+05	-0.437E+06	47	0.715E+06	0.224E+05	159
5	1	0.177	0.124	0.724E-02	-0.511E+06	-0.705E+06	52	0.439E+06	-0.117E+06	131
6	1	0.498	0.872E-01	0.570E-02	0.382E+05	-0.889E+05	57	0.962E+05	-0.889E+05	119
6	1	0.498	0.878E-01	0.214E-01	0.458E+05	-0.612E+05	67	0.339E+05	-0.392E+04	106
6	1	0.454	0.977E-01	0.236E-01	0.474E+05	-0.200E+05	53	0.294E+05	-0.412E+05	137
6	1	0.454	0.988E-01	0.637E-02	0.445E+05	-0.587E+05	45	0.986E+05	-0.615E+05	135
7	1	0.422	0.106	0.641E-02	0.835E+05	-0.234E+05	35	0.589E+05	-0.760E+05	145
7	1	0.421	0.105	0.252E-01	0.110E+06	0.110E+05	38	0.222E+05	-0.678E+05	162
7	1	0.376	0.113	0.274E-01	0.157E+06	0.375E+05	54	0.658E+05	-0.894E+05	167
7	1	0.377	0.115	0.734E-02	0.181E+06	0.407E+04	40	0.708E+05	-0.526E+05	152
8	1	0.344	0.120	0.781E-02	0.211E+06	-0.142E+05	22	0.588E+05	-0.152E+06	155
8	1	0.344	0.120	0.290E-01	0.294E+06	-0.704E+04	41	0.412E+05	-0.201E+06	162
8	1	0.299	0.128	0.311E-01	0.645E+06	0.129E+06	36	-0.475E+05	-0.364E+06	131
8	1	0.299	0.125	0.838E-02	0.517E+06	0.111E+05	22	-0.147E+05	-0.101E+06	111
9	1	0.571	0.632E-01	0.496E-02	0.147E+06	-0.307E+06	110	0.698E+05	-0.277E+06	39
9	1	0.567	0.644E-01	0.154E-01	-0.815E+05	-0.258E+06	71	0.518E+04	-0.836E+05	144
9	1	0.528	0.785E-01	0.191E-01	0.847E+05	-0.403E+05	42	0.904E+04	-0.146E+06	76

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
9	1	0.530	0.775E-01	0.511E-02	0.729E+05	-0.855E+05	67	97	-0.135E+05	-0.257E+06	89	90
10	1	0.150	0.123	0.483E-01	-0.279E+04	-0.121E+07	34	72	0.671E+06	-0.804E+05	127	101
10	1	0.149	0.118	0.765E-01	0.785E+05	-0.157E+06	112	115	0.194E+06	-0.560E+06	24	75
10	1	0.125	0.110	0.715E-01	0.598E+06	-0.115E+06	66	94	0.237E+06	-0.125E+06	83	102
10	1	0.122	0.113	0.446E-01	0.262E+06	-0.482E+06	51	78	0.931E+06	-0.414E+05	103	98
11	1	0.155	0.111	0.943E-01	0.922E+06	0.391E+05	90	122	-0.317E+05	-0.113E+07	17	78
11	1	0.169	0.976E-01	0.117	0.141E+07	0.223E+06	61	127	-0.742E+04	-0.111E+07	162	106
11	1	0.139	0.959E-01	0.114	0.139E+07	0.205E+06	76	116	-0.590E+05	-0.125E+07	173	96
11	1	0.130	0.105	0.906E-01	0.116E+07	0.178E+06	73	106	-0.208E+06	-0.641E+06	162	104
12	1	0.496	0.873E-01	0.443E-01	0.112E+06	-0.105E+05	28	103	0.559E+04	-0.641E+05	68	99
12	1	0.491	0.829E-01	0.907E-01	0.117E+06	-0.111E+05	7	96	-0.164E+05	-0.324E+05	26	99
12	1	0.448	0.877E-01	0.941E-01	0.127E+06	0.667E+05	48	105	0.739E+05	-0.869E+05	12	99
12	1	0.452	0.961E-01	0.477E-01	0.794E+05	0.387E+04	51	103	0.306E+05	-0.389E+05	164	79
13	1	0.420	0.103	0.501E-01	0.891E+05	0.299E+05	56	103	0.413E+05	-0.737E+05	13	102
13	1	0.417	0.910E-01	0.965E-01	0.123E+06	0.549E+05	59	111	0.624E+05	-0.892E+05	14	101
13	1	0.374	0.955E-01	0.995E-01	0.186E+06	0.589E+05	68	118	0.213E+05	-0.822E+05	8	98
13	1	0.377	0.111	0.534E-01	0.152E+06	0.818E+05	55	104	0.745E+04	-0.114E+06	18	103
14	1	0.344	0.117	0.558E-01	0.195E+06	0.575E+05	58	105	0.148E+05	-0.170E+06	16	103
14	1	0.343	0.986E-01	0.102	0.122E+06	0.522E+05	71	124	0.199E+05	-0.134E+06	12	101
14	1	0.300	0.103	0.104	0.157E+06	-0.284E+05	75	130	-21.6	-0.181E+06	171	88
14	1	0.301	0.126	0.590E-01	0.347E+06	0.375E+04	72	105	0.184E+05	-0.250E+06	11	100
15	1	0.564	0.645E-01	0.335E-01	-0.473E+05	-0.201E+06	104	87	0.184E+06	0.612E+04	44	104
15	1	0.561	0.642E-01	0.712E-01	0.158E+05	-0.387E+05	140	80	0.322E+06	0.742E+05	21	103
15	1	0.521	0.759E-01	0.837E-01	0.141E+06	0.362E+05	32	111	0.116E+06	-0.625E+05	22	111
15	1	0.526	0.783E-01	0.401E-01	0.111E+06	-0.149E+06	48	110	0.312E+05	-0.208E+05	114	85
16	1	0.179	0.802E-01	0.130	0.948E+06	0.649E+05	63	140	0.319E+05	-0.683E+06	170	96
16	1	0.183	0.440E-01	0.146	0.275E+06	-0.539E+05	107	153	-0.694E+05	-0.252E+06	169	84
16	1	0.168	0.459E-01	0.149	0.322E+06	-0.235E+06	118	140	0.112E+06	-0.530E+06	12	100
16	1	0.153	0.314E-01	0.130	0.101E+07	-0.181E+06	77	142	0.214E+06	-0.118E+07	167	99
17	1	0.184	0.144E-01	0.152	0.209E+06	-0.217E+06	135	129	0.109E+06	-0.859E+05	36	124
17	1	0.181	-0.258E-01	0.153	0.108E+06	-0.404E+06	146	119	0.179E+06	-0.163E+06	54	137
17	1	0.161	-0.280E-01	0.160	0.278E+06	-0.108E+06	140	127	0.211E+06	-0.931E+05	70	151
17	1	0.170	0.141E-01	0.157	0.136E+06	-0.229E+06	128	134	0.126E+06	-0.195E+06	49	139
18	1	0.273	0.170E-01	0.142	0.439E+06	-0.269E+06	149	119	0.298E+06	-0.480E+05	46	136
18	1	0.273	-0.245E-01	0.148	0.214E+06	-0.197E+06	134	135	0.252E+06	-0.271E+06	52	142
18	1	0.246	-0.225E-01	0.149	0.317E+06	-0.319E+06	141	128	0.303E+06	-0.247E+06	53	143
18	1	0.246	0.246E-01	0.142	0.460E+06	-0.149E+06	146	122	0.309E+06	-0.345E+06	49	138

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
19	1	0.225	0.251E-01	0.144	0.284E+06	-0.701E+05	144	123	0.198E+06	-0.288E+06	51	140
19	1	0.226	-0.223E-01	0.149	0.232E+06	-0.289E+06	146	123	0.219E+06	-0.495E+05	60	150
19	1	0.199	-0.239E-01	0.150	0.169E+06	-0.361E+06	148	121	0.265E+06	-0.708E+05	59	148
19	1	0.198	0.187E-01	0.149	0.230E+06	-0.241E+06	137	129	0.140E+06	-0.280E+06	42	132
20	1	0.477	0.742E-01	0.117	0.118E+06	0.285E+05	176	89	0.119E+06	-0.117E+06	41	118
20	1	0.449	0.465E-01	0.138	0.866E+05	-0.496E+05	34	118	0.169E+06	-0.607E+05	16	103
20	1	0.414	0.453E-01	0.138	0.606E+05	-0.120E+05	6	94	0.135E+06	0.118E+05	20	107
20	1	0.437	0.749E-01	0.119	0.126E+06	0.603E+05	121	129	0.132E+06	-0.100E+06	19	106
21	1	0.433	0.184E-01	0.150	0.276E+05	-0.795E+05	171	98	0.132E+06	-0.141E+05	25	112
21	1	0.422	-0.253E-01	0.158	-0.117E+06	-0.195E+06	21	110	0.762E+05	-0.793E+05	100	168
21	1	0.453	-0.256E-01	0.156	-0.957E+05	-0.135E+06	175	92	0.142E+06	-0.449E+05	71	160
21	1	0.402	0.172E-01	0.149	0.380E+05	-0.143E+06	158	110	0.150E+06	0.367E+05	39	126
22	1	0.407	0.754E-01	0.120	0.102E+06	0.409E+05	138	120	0.129E+06	-0.101E+06	19	106
22	1	0.389	0.443E-01	0.133	0.552E+05	-0.168E+05	1	89	0.109E+06	-0.986E+04	2	90
22	1	0.355	0.429E-01	0.137	0.102E+06	-0.148E+05	165	103	0.836E+05	-0.248E+05	10	99
22	1	0.367	0.758E-01	0.121	0.136E+06	0.813E+05	112	142	0.899E+05	-0.840E+05	3	93
23	1	0.379	0.163E-01	0.147	0.334E+05	-0.100E+06	162	107	0.126E+06	0.114E+05	32	120
23	1	0.372	-0.255E-01	0.155	-0.715E+05	-0.156E+06	6	94	0.140E+06	-0.299E+05	70	159
23	1	0.343	-0.256E-01	0.153	-0.476E+05	-0.112E+06	6	95	0.179E+06	-0.198E+05	61	150
23	1	0.348	0.150E-01	0.146	0.623E+05	-0.954E+05	166	103	0.879E+05	0.245E+05	27	115
24	1	0.438	0.761E-01	0.122	0.164E+06	0.308E+05	130	132	0.548E+06	-0.115E+06	18	106
24	1	0.430	0.418E-01	0.137	0.152E+06	-0.312E+05	163	106	0.771E+05	-0.236E+05	2	90
24	1	0.295	0.403E-01	0.136	0.198E+06	-0.290E+05	151	117	0.172E+06	-0.124E+05	142	126
24	1	0.297	0.763E-01	0.124	0.102E+06	0.254E+05	106	152	0.182E+06	-0.151E+06	23	111
25	1	0.325	0.141E-01	0.145	0.104E+06	-0.780E+05	175	92	0.985E+05	0.347E+05	23	112
25	1	0.322	-0.257E-01	0.151	-0.550E+05	-0.116E+06	19	108	0.136E+06	-0.511E+05	65	154
25	1	0.293	-0.258E-01	0.149	-0.181E+05	-0.579E+05	155	114	0.665E+05	-0.258E+05	84	171
25	1	0.294	0.127E-01	0.143	0.195E+06	-0.286E+05	21	109	0.255E+06	0.422E+05	44	132
26	1	0.552	0.609E-01	0.101	0.212E+06	-0.184E+05	149	90	0.923E+05	0.565E+05	156	87
26	1	0.537	0.497E-01	0.140	0.108E+06	0.219E+05	22	104	0.186E+06	-0.430E+05	46	118
26	1	0.481	0.446E-01	0.138	0.114E+06	0.244E+05	159	104	0.956E+05	0.317E+05	25	112
26	1	0.507	0.697E-01	0.111	0.128E+06	0.202E+05	114	125	0.107E+06	-0.993E+05	26	116
27	1	0.533	0.127E-01	0.164	0.301E+05	-0.495E+05	12	94	0.117E+06	-0.108E+04	34	114
27	1	0.538	-0.313E-01	0.181	0.609E+05	-0.185E+06	91	172	-0.350E+05	-0.135E+06	103	165
27	1	0.461	-0.268E-01	0.164	-0.492E+05	-0.114E+06	65	153	0.848E+05	-0.780E+05	75	162
27	1	0.468	0.164E-01	0.151	0.810E+05	-0.595E+05	174	89	0.175E+06	0.521E+05	43	127

ELEM NO.	LOAD CASE	GLOBAL CO-ORDINATES			TOP SURFACE				BOTTOM SURFACE			
		X	Y	Z	SIGMA1	SIGMA2	ALPHA1	ALPHA2	SIGMA1	SIGMA2	ALPHA1	ALPHA2
28	1	0.177	-0.521E-01	0.137	0.206E+06	-0.398E+06	147	118	0.298E+06	-0.202E+06	60	113
28	1	0.170	-0.803E-01	0.972E-01	-0.177E+05	-0.254E+06	165	104	0.306E+06	-0.104E+06	65	111
28	1	0.117	-0.866E-01	0.109	-0.180E+05	-0.291E+06	165	96	0.344E+06	-0.635E+05	104	115
28	1	0.144	-0.563E-01	0.148	0.154E+06	-0.114E+06	154	114	0.163E+06	-0.709E+05	87	125
29	1	0.165	-0.971E-01	0.648E-01	-0.207E+06	-0.367E+06	34	97	0.382E+06	0.934E+05	90	113
29	1	0.161	-0.114	0.179E-01	-0.405E+06	-0.548E+06	23	97	0.501E+06	0.112E+06	133	100
29	1	0.831E-01	-0.112	0.206E-01	-0.385E+05	-0.514E+06	23	92	0.448E+06	0.119E+06	90	93
29	1	0.100	-0.102	0.737E-01	-0.719E+05	-0.470E+06	14	87	0.424E+06	573.	96	105
30	1	0.273	-0.512E-01	0.135	0.757E+05	-0.149E+06	136	114	0.120E+06	-0.149E+06	62	122
30	1	0.273	-0.781E-01	0.946E-01	-0.199E+05	-0.239E+06	152	103	0.170E+06	-0.288E+06	68	117
30	1	0.246	-0.786E-01	0.942E-01	0.769E+04	-0.334E+06	139	109	0.260E+06	-0.219E+06	62	116
30	1	0.246	-0.511E-01	0.135	0.478E+05	-0.282E+06	142	111	0.201E+06	-0.122E+06	62	123
31	1	0.273	-0.943E-01	0.628E-01	-0.400E+05	-0.202E+06	176	93	0.151E+06	-0.355E+06	86	113
31	1	0.273	-0.111	0.172E-01	0.471E+06	-0.450E+05	5	85	0.208E+06	-0.265E+06	65	102
31	1	0.246	-0.113	0.172E-01	0.367E+06	-0.109E+06	174	94	0.326E+06	-0.109E+06	62	104
31	1	0.246	-0.953E-01	0.625E-01	-0.572E+05	-0.223E+06	153	101	0.281E+06	-0.342E+06	68	112
32	1	0.226	-0.510E-01	0.134	0.446E+05	-0.294E+06	143	110	0.235E+06	-0.137E+06	61	123
32	1	0.226	-0.786E-01	0.938E-01	-0.474E+05	-0.356E+06	135	110	0.229E+06	-0.206E+06	65	118
32	1	0.199	-0.783E-01	0.932E-01	0.265E+05	-0.301E+06	142	107	0.216E+06	-0.154E+06	55	116
32	1	0.199	-0.507E-01	0.134	0.379E+04	-0.268E+06	159	101	0.185E+06	-0.562E+05	77	126
33	1	0.226	-0.956E-01	0.622E-01	-0.847E+05	-0.229E+06	168	94	0.372E+06	-0.193E+06	60	112
33	1	0.226	-0.114	0.171E-01	0.144E+06	-0.194E+06	2	88	0.446E+06	-32.0	55	104
33	1	0.199	-0.115	0.170E-01	-0.285E+06	-0.597E+06	12	94	0.691E+06	0.858E+05	48	104
33	1	0.199	-0.955E-01	0.618E-01	-0.173E+06	-0.442E+06	157	98	0.350E+06	-0.148E+06	43	108
34	1	0.421	-0.548E-01	0.144	-0.337E+05	-0.115E+06	41	116	0.176E+06	-0.265E+06	69	126
34	1	0.421	-0.846E-01	0.101	0.219E+05	-0.544E+05	12	101	-0.130E+06	-0.259E+06	46	115
34	1	0.393	-0.820E-01	0.997E-01	0.449E+05	-0.127E+06	59	118	0.222E+05	-0.192E+06	60	118
34	1	0.393	-0.538E-01	0.142	-0.891E+05	-0.141E+06	60	123	0.139E+06	-0.164E+06	68	125
35	1	0.421	-0.103	0.669E-01	0.274E+06	-0.101E+06	67	116	0.432E+05	-0.166E+06	115	109
35	1	0.421	-0.123	0.184E-01	0.168E+06	0.199E+05	41	110	0.944E+05	-0.638E+05	118	100
35	1	0.393	-0.118	0.182E-01	0.869E+05	-0.839E+04	24	104	0.720E+05	-0.922E+05	130	97
35	1	0.393	-0.993E-01	0.662E-01	0.103E+06	-0.103E+05	48	112	-0.698E+05	-0.115E+06	94	114
36	1	0.372	-0.531E-01	0.141	-0.121E+06	-0.146E+06	154	102	0.156E+06	-0.186E+06	60	123
36	1	0.372	-0.405E-01	0.988E-01	0.402E+05	-0.113E+06	62	117	0.302E+05	-0.163E+06	65	118
36	1	0.343	-0.790E-01	0.976E-01	-0.500E+06	-0.127E+06	52	114	0.507E+05	-0.212E+06	69	118
36	1	0.343	-0.528E-01	0.139	-0.114E+06	-0.126E+06	139	110	0.161E+06	-0.150E+06	62	123

37	1	0.372	-0.971E-01	0.658E-01	0.154E+05	-0.913E+05	48	111	-0.353E+05	-0.136E+06	80	114
37	1	0.372	-0.115	0.180E-01	0.125E+06	-0.827E+05	35	105	0.142E+06	-0.156E+06	133	97
37	1	0.343	-0.112	0.178E-01	0.191E+06	-0.114E+06	30	101	0.898E+05	-0.220E+06	130	98
37	1	0.343	-0.950E-01	0.648E-01	-0.233E+05	-0.818E+05	18	100	0.291E+05	-0.192E+06	76	113
38	1	0.322	-0.518E-01	0.138	-0.558E+05	-0.130E+06	158	99	0.160E+06	-0.135E+06	58	122
38	1	0.322	-0.783E-01	0.966E-01	-0.497E+05	-0.157E+06	33	107	0.583E+05	-0.230E+06	74	116
38	1	0.293	-0.779E-01	0.953E-01	-0.361E+05	-0.200E+06	152	101	0.106E+06	-0.337E+06	68	117
38	1	0.293	-0.513E-01	0.136	0.578E+05	-0.162E+06	138	111	0.168E+06	-0.240E+06	55	121
39	1	0.322	-0.941E-01	0.641E-01	-0.397E+05	-0.150E+06	5	94	0.655E+04	-0.240E+06	85	113
39	1	0.322	-0.110	0.176E-01	0.237E+06	-0.115E+06	22	97	0.386E+04	-0.212E+06	121	101
39	1	0.293	-0.110	0.174E-01	0.338E+06	-0.147E+06	12	92	0.613E+05	-0.286E+06	97	105
39	1	0.293	-0.937E-01	0.632E-01	0.130E+05	-0.220E+06	166	94	0.875E+05	-0.288E+06	78	112
40	1	0.551	-0.798E-01	0.184	-0.304E+05	-0.150E+06	83	170	0.400E+05	-0.573E+05	41	129
40	1	0.576	-0.156	0.158	-0.228E+05	-0.118E+06	29	114	0.111E+06	-0.323E+05	119	114
40	1	0.469	-0.107	0.116	0.113E+06	-0.432E+05	57	139	0.683E+05	-0.638E+05	107	115
40	1	0.464	-0.624E-01	0.155	-0.508E+05	-0.226E+06	69	146	0.621E+05	-0.189E+06	92	143
41	1	0.593	-0.200	0.112	0.417E+05	-0.658E+05	43	125	0.199E+05	-0.585E+05	109	105
41	1	0.606	-0.227	0.327E-01	0.387E+05	0.166E+05	110	84	0.432E+05	-0.815E+05	30	108
41	1	0.475	-0.159	0.222E-01	0.564E+05	0.416E+05	142	62	0.170E+05	-0.335E+05	35	125
41	1	0.473	-0.135	0.790E-01	0.117E+06	0.294E+05	121	91	-0.210E+05	-0.107E+06	51	134

NO STRESS AVERAGING AVAILABLE WITH THE ELEMENTS USED IN THIS JOB

NO ERRORS OR WARNINGS IN THIS PHASE

*** MAXIMUM SIZE OF BASE IN THIS PHASE WAS 4083 WORDS ***

*** END OF PHASE 9 ***

APPENDIX D

X-Y PLOT PROGRAM

```

      K=0
      DO 20 I=1,5
      DO 10 J=1,7
      ST(I,J)=AT1(J+K)
      ST(I+5,J)=AT2(J+K)
      ST(I+10,J)=AT3(J+K)
      ST(I+15,J)=AT3(J+K)
      SB(I,J)=AB1(J+K)
      SB(I+5,J)=AB2(J+K)
      SB(I+10,J)=AB3(J+K)
      SB(I+15,J)=AB4(J+K)
10    CONTINUE
      K=K+7
      CONTINUE
      K1=0
      DO 50 I=1,4
      DO 40 J=1,5
      DO 30 K=1,7
      S(J,K)=ST(J+K1,K)
30    CONTINUE
40    CONTINUE
      K1=K1+5
      CALL SUBSTS(XM,S,I)
50    CONTINUE
      K1=0
      DO 80 I=5,8
      DO 70 J=1,5
      DO 60 K=1,7
      S(J,K)=SB(J+K1,K)
60    CONTINUE
70    CONTINUE
      CALL SUBSTS(XM,S,I)
80    CONTINUE
      STOP
      END

```

```

SUBROUTINE SUBSTS(X,Y,IPASS)
  DIMENSION X(9),Y1(9),Y2(9),Y3(9),Y(5,7)
  DO 10 J=1,7
  Y1(J)=Y(1,J)
  Y2(J)=Y(2,J)
  Y3(J)=Y(3,J)
10  CONTINUE
  CALL PLOT1(Y1,Y2,Y3,X,IPASS)
  DO 20 J=1,7
  Y2(J)=Y(4,J)
20  CONTINUE
  CALL PLOT2(Y1,Y2,X,IPASS)

```

```

DO 30 J=1,7
Y2(J)=Y(5,7)
30 CONTINUE
CALL PLOT3(Y1,Y2,X,IPASS)
RETURN
END

SUBROUTINE PLCT1(Y1,Y2,Y3,X,IPASS)
DIMENSION Y1(9), Y2(9),Y3(9),X(9),XLABEL(6)
INTEGER XLABEL
CALL HEAD(XLABEL,IPASS)
FAC=8./7.
CALL PLOTS(53,0,3)
CALL FACTOR(FAC)
AMX=0.0
AMY=1.5
CALL ORIGIN(AMX,AMY,0)
CALL SCALE(X,Y.,7,1)
CALL SCALE(Y1,7.,7,1)
CALL SCALE(Y2,7.,7,1)
CALL SCALE(Y3,7.,7,1)
H2=AMIN1(Y1(8),Y2(8),Y3(8))
H3=AMAX1(Y1(9),Y2(9),Y3(9))
Y1(9)=H3
Y2(9)=H3
Y3(9)=H3
CALL AXID(IPASS)
CALL SYM1
CALL AXIS(0.,0.0,XLABEL,-60.7.,0.0,H2,H3)
CALL FLINE(Y1,X,-7,1,1,0)
CALL FLINE(Y2,X,-7,1,14)
CALL FLINE(Y3,X,-7,1,1,14)
CALL ORIGIN(AMX+9.,0.,0)
CALL PLOT(0.,0.,3)
CALL PLOT(0.,0.,999)
END FILE 3
RETURN
END

```

```
SUBROUTINE PLCT2(Y1,Y2,X,IPASS)
DIMENSION Y1(9),Y2(9),X(9),XLABEL(6)
INTEGER XLABEL
CALL HEAD(XLABEL,IPASS)
FAC=8./7.
CALL PLOTS(53,0,3)
CALL FACTOR(FAC)
AMX=0.0
AMY=1.5
CALL ORIGIN(AMX,AMY,0)
CALL SCALE(X,7.,7,1)
CALL SCALE(Y1,7.,7,1)
CALL SCALE(Y2,7.,7,1)
H2=AMIN1(Y1(8),Y2(8))
H3=AMAX1(Y1(9),Y2(9))
Y1(9)=H3
Y2(9)=H3
CALL AXID(IPASS)
CALL SYM2
CALL AXIS(0.,0.0,XLABEL,-60,7.,0.0,H2,H3)
CALL FLINE(Y1,X,-7,1,1,0)
CALL FLINE(Y2,X,-7,1,1,5)
CALL ORIGIN(AMX+9.,0.,0)
CALL PLOT(0.,0.,3)
CALL PLOT(0.,0.,999)
END FILE 3
RETURN
END
```

```
SUBROUTINE PLOT3(Y1,Y2,X,IPASS)
DIMENSION Y1(9),Y2(9),X(9),XLABEL(6)
INTEGER XLABEL
CALL HEAD(XLABEL,IPASS)
FAC=8./7.
CALL PLOTS(53,0,3)
CALL FACTOR(FAC)
AMX=0.0
AMY=1.5
CALL ORIGIN(AMX,AMY,0)
CALL SCALE(X,7.,7,1)
CALL SCALE(Y1,7.,7,1)
CALL SCALE(Y2,7.,7,1)
H2=AMIN1(Y1(8),Y2(8))
H3=AMAX1(Y1(9),Y2(9))
Y1(9)=H3
Y2(9)=H3
CALL AXID(IPASS)
CALL SYM3
CALL AXIS(0.,0.0,XLABEL,-60,7.,0.0,H2,H3)
CALL FLINE(Y1,X,-7,1,1,0)
CALL FLINE(Y2,X,-7,1,1,2)
CALL ORIGIN(AMX+9.,0.,0)
CALL PLOT(0.,0.,3)
CALL PLOT(0.,0.,999)
END FILE 3
RETURN
END
```

```

SUBROUTINE AXID(IPASS)
  DIMENSION N1(7)
  IF(IPASS.EQ.1.OR.IPASS.EQ.5) ENCODE(70,100,N1)
  IF(IPASS.EQ.2.OR.IPASS.EQ.6) ENCODE(70,200,N1)
  IF(IPASS.EQ.3.OR.IPASS.EQ.7) ENCODE(70,300,N1)
  IF(IPASS.EQ.4.OR.IPASS.EQ.8) ENCODE(70,400,N1)
  CALL PLOT(0.,0.,3)
  CALL PLOT(0.,6.,2)
  CALL PLOT(7.,6.,2)
  CALL PLOT(7.,0.,2)
  CALL PLOT(0.,0.,3)
  CALL PLOT(-.06,0.,2)
  CALL PLOT(0.,1.,3)
  CALL PLOT(-.06,1.,2)
  CALL PLOT(0.,2.,3)
  CALL PLOT(-.06,2.,2)
  CALL PLOT(0.,3.,3)
  CALL PLOT(-.06,3.,2)
  CALL PLOT(0.,4.,3)
  CALL PLOT(-.06,4.,2)
  CALL PLOT(0.,5.,3)
  CALL PLOT(-.06,5.,2)
  CALL PLOT(0.,6.,3)
  CALL PLOT(-.06,6.,2)
  CALL SYMBOL(-.5,1.98.,15,14HELEMENT NUMBER,90.,14)
  CALL SYMBOL(-.3,0.,.11,N1(7),0.,10)
  CALL SYMBOL(-.3,1.,.11,N1(6),0.,10)
  CALL SYMBOL(-.3,2.,.11,N1(5),0.,10)
  CALL SYMBOL(-.3,3.,.11,N1(4),0.,10)
  CALL SYMBOL(-.3,4.,.11,N1(3),0.,10)
  CALL SYMBOL(-.3,5.,.11,N1(2),0.,10)
  CALL SYMBOL(-.3,6.,.11,N1(1),0.,10)
100  FORMAT(* 3*,8X,* 5*,8X,* 4*,8X,* 8*,8X,* 7*,8X,
    $* 6*,8X,* 9*,8X)
200  FORMAT(*17*,8X,*19*,8X,*18*,8X,*25*,8X,
    $*23*,8X,*21*,8X,*27*,8X)
300  FORMAT(*16*,8X,* 2*,8X,* 1*,8X,*24*,8X,
    $*22*,8X,*20*,8X,*26*,8X)
400  FORMAT(*28*,8X,*32*,8X,*38*,8X,*38*,8X,
    $*36*,8X,*34*,8X,*40*,8X)
  END

```

VITA

Martin James McNamee was born in Cleveland, Ohio, in the year 1956. He graduated from North Olmsted High School in June 1974. The following September he entered the University of Cincinnati, and in June 1979 he received a Bachelor of Science degree in Mechanical Engineering. In the Fall of 1979 he accepted a teaching assistantship at The University of Tennessee, Knoxville, and began study toward a Master's degree. This degree was awarded in June 1985.

The author is currently employed by Patel Engineering in Huntsville, Alabama.