EXPERIMENTAL AND ANALYTICAL INVESTIGATION ON THE BEHAVIOR OF CONTINUOUS BOX GIRDER BRIDGES

Prepared By

Maroun Ghosn Wakim

A thesis
presented to the University of Ottawa
in partial fulfillment of the
requirements for the degree of
Master of Applied Science
in
Civil Engineering

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF OTTAWA
OTTAWA, ONTARIO

January, 1996

ISBN 0-612-15771-7

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

Abstract

Contiuous curved box girder bridges are increasingly being used in metropolitan large cities particularly as flyovers and as entrance and exit ramps for highspeed freeways. The purpose of this investigation is to examine the static response of continous curved box girder bridges subjected to various specified OHBD loadings.

The prototype structure that was selected for this model study is the Cyrville road Queensway overpass located in the east end of Ottawa. The structure was built in 1973 and designed according to ASHTO design truck load HS20-44 by the Ministry of Transportation and Communication. The bridge is 102.4 meters long, 12.8 meters wide, and consists of two spans with 16.8° horizontal angle of curvature between the end supports. Its cross section consists of four contiguous cells with a depth of 1.83 meters. As for the diaphragms, two prestressed diaphragms are placed at the extreme end supports and one is placed over the middle support.

The bridge model was designed and constructed at the University of Ottawa structures laboratory. A scale of 1/24 was adopted for the bridge model, and the center line radius of curvature of the model was 14.5 m. Longitudinally, and tangent to the center line, the model's span is 4.268 m with an angle of curvature of 16.8°. The bridge model has a width of 0.49 m and a depth 0.133 m.

The model structure is of composite construction, made up of a 20 mm micro concrete deck resting on four aluminum box girders. The model is supported on two reinforced concrete columns at both ends, and a steel shaft at the middle support with a diameter of 80 mm.

For all of the nine load cases employed in this case study, the ADINA model predictions for the maximum displacements and maximum longitudinal normal tensile stresses were in good agreement with their corresponding experimental values. However, for the maximum compressive stresses near the centre support, the experimental values are much less than the ADINA values. This may be due to stress release due to a minor slippage of the centre support or due to less than perfect fixity at the centre support as asumed by the ADINA model. It was further noted, that the ADINA model consistently underestimated the stress values due to the fact that the finite element ADINA model was invariably stiffer than the prototype.

Acknowledgement

The author wishes to express sincere gratitude to Professor S.F.Ng for his constant guidance, encouragement, and support throughout the course of this study.

Sincere thanks are expressed to Dr.M.S. Cheung for his help and support.

Special thanks are due to all the technical staff of the structures laboratory at the University of Ottawa.

Also, the author is greatful to his colleague Mr. G. Xi for all his valuable suggestions and comments in all the problems encountered throughout the experiment.

Finally, special recognitions are given to my parents for their continuous support.

Dedication

This thesis is dedicated to my parents Ghosn and Mary Wakim.

Notations

[c] = Material constitutive law matrix.

D_r = Radial flexural rigidity per unit circumferential length.

D_θ = Angular flexural rigidity per unit radial width.

$D_{r\theta}$ = Radial torsional rigidity per unit circumferential length.

D_x = Bending and twisting rigidity in cartesian coordinate.

D_y = Bending and twisting rigidity in cartesian coordinate.

D_{xy} = Bending and twisting rigidity in cartesian coordinate.

E = Young's modulus.

E_f = Young's modulus scale factor.

E_a = Young's modulus for aluminum.

E_c = Young's modulus for concrete.

E_t = Strain hardening modulus.

E_x = Elastic constant in cartesian coordinates.

E_y = Elastic constant in cartesian coordinates.

E_{xy} = Elastic constant in cartesian coordinates.

F = Equivalent OHBD parallel trucks load.

F^m, F^p = Force scale factor for model and prototype.

F_f = Force scale factor.

F_y = Steel yield stress.

I = Moment of inertia about the beam neutral axis.

I^m, I^p = Moment of inertia scale factor for model and prototype.

I_f = Moment of inertia scale factor.

L_f = Linear scale factor.

M = longitudinal bending moment.

P = Jack force applied on two parallel trucks.

R = Radius of the bridge horizontal curvature.

$\{U\}$ = Nodal displacement vector.

V^k_n = Normal vector for the shell element at node k.

e_s, e_t = Unit vectors along the shell neutral coordinates axes s,t.

e_r, e_s = Unit vectors along the cartesian shell-aligned axes r,s.

F'_c = Concrete compressive strength.

F'_{ct} = Concrete splitting strength.

F'_{cu} = Ultimate strength of concrete.

F_{ult} = Ultimate strength of aluminum.

F_y = Yield strength of aluminum.

l = Length of simply supported beam.

u_k, v_k, w_k = Transnational degree of freedom at node k.

α_k , β_k = Rotational degree of freedom of the shell element at node k.

γ = Shear modulus.

ϵ = Element strain vector.

$\epsilon_L, \epsilon_D, \epsilon_T$ = Strain components of the rosette strain gage.

ϵ^m, ϵ^p = normal strain for the model and the prototype bridge.

υ_a = Poissons's ratio for aluminum.

υ_c = Poissons's ratio for concrete.

$\{\sigma\}$ = Element stress vector.

σ = Longitudinal normal stress.

σ^m, σ^p = Normal stress for the model and the prototype bridge.

σ_{max} = Maximum normal stress at beam mid-span.

σ_y = Yield stress of the material.

$\sigma_{xx}, \sigma_{yy}, \sigma_{zz}$ = Normal stress components in the cartesian coordinate system.

τ = Shear stress.

$\tau_{xy}, \tau_{xz}, \tau_{yz}$ = Shear stress components in the cartesian coordinate system.

$\tau_{\theta r}, \tau_{\theta z}$ = Shear stress components in the cylindrical coordinate system.

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Chapter 1

Introduction

1.1 General

Box girders are becoming increasingly popular and are extensively used in modern populated cities. Due to site or zoning restrictions and other reasons, box girder bridges curved in planform are also commonly found in metropolitan large cities in North America.

A typical box-girder bridge consists of top and bottom plates connected by inclined or vertical webs to form the box-like section. Among the wide range of bridge types, box girder bridges are often preferred by designers due to the following reasons:

1. The final designed bridge is generally lighter and more slender than other types.
2. They are particularly adaptable to prefabrication and prestress sections can be handled easily.
3. Due to the fact that box girders can be fully sealed,

the internal corrosion of such bridges is minimized and therefore, generally the maintenance cost is lower.

4. Due to the high torsional stiffness possessed by box girders, elimination of stiffeners and diaphragms other than at the support can be achieved resulting in lower fabrication and erection cost.
5. Depending on the terrain, the shallower box sections may result in a significant reduction of cost and of earthwork associated with the construction of access roads.

Curved bridges are subjected to high torsional moments, under both eccentric and centric loadings. The load tends to distort and twist the bridge cross section causing some deformations and nonuniform distribution of longitudinal flange stresses as well as secondary plate bending stresses [1]. Hence the use of box girders seems to be of great advantage, not only for their excellent torsional capacity, but also for their low material content and weight.

The extensive use of curved box girder bridges came into existence, not only to overcome geometric restrictions and restrain nonuniform distribution of longitudinal flange stresses as well as secondary plate bending stresses but also for their aesthetically pleasant appearance as elevated freeways and multilevel interchange structures.

1.2 Objectives

The objectives of this thesis are:

1. To study the linear variation of stresses, strains and deflections at five different sections of the bridge model, due to OHBD truck load with different positions of the middle support, using the computer program ADINA.
2. To set up a curved continuous box girder bridge model.
3. To test the model using OHBD truck loading, and to compare the theoretical results obtained from ADINA with those obtained from experiment.

1.3 Outline

Chapter 2 presents a review of methods of analysis for bridges recommended by the Ontario Highway Bridge Design Code. A brief literature review on previous work done on curved girder bridges is given in Chapter 3. In Chapter 4, the manufacture of the bridge model, the testing equipment, the experimental setup are described in detail followed by extensive experimental results. In Chapter 5, the use of the finite element method and ADINA for modelling curved box girder bridges is described along with a detailed comparison between analytical and experimental results. Conclusions and recommendations from this case study are presented in Chapter 6.

Chapter 2

Literature Review

2.1 Review of Methods of Analysis

A wide spectrum of methods of analyzing curved box-bridges have been advanced in the past. In the last two decades, these methods have been revised, modified, and tested. A brief review of these methods for the analysis of horizontally curved box- girder bridges as recommended by the **OHBD** code in Canada are discussed as follows:

1. The Finite Strip Method.
2. The Finite Element Method.
3. The Orthotropic Plate Method.
4. The Grillage Analogy Method.
5. The Folded Plate Method.

2.1.1 Finite Strip Method

The basic procedure of the Finite Strip Method is to divide the prismatic structure into longitudinal strip elements. Then, the behavior of each strip being described by displacement functions are assumed to be polynomial functions in the transverse direction and harmonic functions in the longitudinal direction.

This method is very efficient, due to the fact that for the particular harmonic functions satisfying simply supported end conditions, the stiffness matrices corresponding to the individual harmonics are uncoupled. Hence, the complete solution consists of solutions for individual harmonics that require only a small number of degrees of freedom.

This uncoupling of the solutions for structures with simply-supported ends is of high importance. It is also well known that the higher the number of harmonics involved, the greater will be the solution accuracy.

The basic steps involved are [4]:

1. For each strip, displacement functions are used to describe the strip behavior, these functions being such as to maintain compatibility along the nodal lines between strips and to satisfy the end boundary conditions. The amplitudes of the functions are the local degrees of freedom.

2. Determine the total potential and kinetic energy of the structure in terms of the global degrees of freedom, and their time derivatives.

3. Invoke the principle of virtual work in the form of Lagrange's equation to obtain the equilibrium equations.

The primary difference between the Finite Strip Method and the Finite Element Method is as follows:

In the Finite Strip Method, the displacement functions are assumed to be polynomial functions in the transverse direction and harmonic functions in the longitudinal direction; whereas, in the Finite Element Method, the displacement functions are assumed to take the form of two-way polynomial functions for a plate or shell element.

2.1.2 Finite Element Method

The Finite Element Method is probably the most versatile method for the analysis of general engineering structures. All structural analysis has one important objective in common: to predict the response of a given structure exposed to a predetermined set of loads, so that the structure will serve its intended purpose. Alternatively, for achieving such an objective, one can resort to more expensive experimental techniques such as the testing of structural model or field testing of the actual structure.

To analyze a structure by the finite element method, a complete specification of the structure has to be defined :

a. The geometry of the physical space,

b. The material properties,

c. The boundary and support conditions,

d. The applied loads and other external effects.

In this method, the physical space is defined by the geometric dimensions and is modeled by a number of discrete elements, so called finite elements, which are assumed to be connected to each other at suitably located joints. In case of box girder structures, element types such as plate bending or shell elements are selected so that the structural response in terms of strains and deformation reflects the components of the actual prototype. One also has to take into account the number, size, and arrangement of the elements in the discretized structure.

The location of each node must be specified with its coordinates, based on a given coordinate system. For example if the structure has a two-dimensional geometry, then two coordinates are required. However, the coordinate system can be one of the following: Cartesian, cylindrical, or spherical. All local coordinates must be referred to a global system.

The shapes of the elements depend on the geometry of the physical space. Moreover; one or more of the following types of finite elements can be utilized for discretization.[16]

1. Three-dimensional element for modelling solids, with all three dimensions of the same order of magnitude.
2. Two-dimensional elements for modelling surface structures such as plates and shells, with one dimension very small as compared to the other two.

3. Axisymmetric solid or rings elements to discretize axisymmetric solid structures.
4. Axisymmetric shell or surface elements to discretize axisymmetric shell and plate structures.
5. One-dimensional line element to model beams, columns, rods, bars, stiffeners, ribs, etc. In this case the length is larger than the cross-sectional dimensions. These elements may be straight or curved.

The most common shapes for three-dimensional elements are:

1. Tetrahedra (4 triangular faces)
2. Pentahedra (2 triangular faces)
3. Hexahedra (6 quadrilateral faces)

The material data required in a 3-D finite element analysis is specified by a stress-strain relationships. For the linear elastic material the generalized Hooke's law is:

$$\{\sigma\}=[C]\{\epsilon\} \tag{2-1}$$

Where:

$$\{\sigma\}=\sigma_x,\sigma_y,\sigma_z,\tau_{xy},\tau_{yz},\tau_{zx} \tag{2-2}$$

$$\{\epsilon\}=\epsilon_x,\epsilon_y,\epsilon_z,\nu_{xy},\nu_{yz},\nu_{zx} \tag{2-3}$$

2.1.3. Orthotropic Plate Method

The Orthotropic Plate Method was successfully applied by Massonnet (1950), Morice and Little (1956), Troitsky (1967) [5], and Cusens and Pama (1969) [27]. In the Orthotropic Plate Method, the structure is idealized by an equivalent orthotropic plate, consisting of different structural properties in two orthogonal directions.

In this method the deformations due to shear are neglected, and the applicability of the method is restricted to those structures with sufficient transverse diaphragms to prevent local bending of the flanges and webs.

The Orthotropic Plate Theory assumptions are as follows:[5]

1. The orthotropic plate is assumed to be thin and have uniform thickness.
2. Plate Material is perfectly elastic, homogeneous, and possesses different elastic properties with respect to the two in plane orthogonal directions.
3. Middle plane of plate remains neutral during bending and particles on a plane perpendicular to the neutral plane remain normal to the deflected neutral surface. Furthermore, normal stresses transverse to the plane of the plate are assumed to be small and hence neglected.
4. Plate deflections are small compared to its thickness.

The general differential equation of the orthotropic plate can be written as:

$$D_x \frac{\partial^4 w}{\partial x^4} + 2H \frac{\partial^4 w}{\partial x^2 \partial y^2} + D_y \frac{\partial^4 w}{\partial y^4} = P(x,y) \qquad \textbf{(2-4)}$$

Where

$$2H = D_x \nu_y + D_y \nu_x + 4 D_{xy} \qquad \textbf{(2-5)}$$

and

$$D_x = \frac{E_x t^3}{12(1-\nu_x \nu_y)} \qquad \textbf{(2-6)}$$

$$D_y = \frac{E_y t^3}{12(1-\nu_x \nu_y)} \qquad \textbf{(2-7)}$$

$$D_{xy} = \frac{G_{xy} t^3}{12} \qquad \textbf{(2-8)}$$

A solution of this non-homogeneous equation was suggested by Massonnet and Gandolfi (1967). The solution was obtained by solving the homogeneous and the particular solutions of the general solution, namely $W = W_1 + W_2$

where

W_1 : Is the deflection of a general solution of the homogeneous equation under the initial condition (Unloaded) P(X,Y) = 0.

W_2 : Is the deflection of a particular solution of the non-homogeneous equation under certain condition (loaded) P(X,Y).

To determine the particular solution, the Levy-Nadai type solution employed by considering an infinitely wide bridge deck undergoing a sinusoidal load distribution along the Y-axis, is employed.

$$P(Y)=\sum_{n=1}^{\infty} H_n \sin\alpha_n y \tag{2-9}$$

where

$$\alpha_n=\frac{n\Pi}{L} \tag{2-10}$$

By using Fourier Series, H_n the loading function can be derived for any particular loading along the Y-axis. (See table A1 in Appendix A.)

As for W_2 the particular solution that satisfies the boundary conditions at the sides and parallel to the X-axis, it can be written as:

$$W_2=\sum_{n=1}^{\infty} A e^{\theta_n x} \sin\alpha_n y \tag{2-11}$$

With this form of solution for W_2, the simply supported ends are automatically satisfied with a sine function, and when W_2 is substituted in the general differential equation with P(X,Y)=0, the following characteristic equation can be derived:

$$D_y\alpha_n^4-2H\alpha_n^2\theta_n^2+D_x\theta_n^4=0 \tag{2-12}$$

and its roots are:

$$\theta_{1,2,3,4}=\pm\alpha_n\sqrt{\frac{H}{D_y}\pm\sqrt{\left(\frac{H}{D_y}\right)^2-\left(\frac{D_x}{D_y}\right)}} \tag{2-13}$$

Hence the following cases are possible:

1. $H = D_x = D_y$ Isotropic.
2. $H^2 < D_xD_y$ Torsionally soft/Flexurally stiff.
3. $H^2 > D_xD_y$ Torsionally stiff/Flexurally soft.

Cheung [10], Sawko and Merriman [11] proposed the Equivalent Orthotropic Plate Method for multi-girder curved bridges, in which the stiffness of the girders and flanges are lumped together into one equivalent orthotropic plate. The first difficulty encountered in this method is the determination of the equivalent torsional and flexural stiffness parameters in the Equivalent Orthotropic Plate. The second difficulty encountered in the final results is the evaluation of slab and girder stresses.

2.1.4. Grillage Analogy Methods

In the Grillage Analogy Methods, the structure is idealized as a system of discrete curved I-beams intersected orthogonally with cross beams. In these methods, any support condition can be represented, since at the joints of the grillage, any normal form of restraint to movement may be applied. Furthermore, discrete columns, elastic foundation, fixed supports, skewed, curved, and irregular planforms can be represented with ease.

Typical methods that have been involved in the solutions of grid systems are [12]:

1. The slope deflection method.
2. The usual stiffness method.

Most of the application of the Grillage Analogy Methods was done on curved bridges with open girders. However, these methods can also be applied to multi-spine curved box-girder bridges. OHBD code of Canada restricted the use of Grillage Analogy methods to voided slabs and box-girder bridges with more than two cells.

One of the major difficulties encountered with the Grillage Analogy Methods is the representation of the torsional stiffness of the closed cells. Evans and Shanmugam [13] achieved an approximate method of analysis by modelling the torsional stiffness of a single closed cell with an equivalent I-beam torsional stiffness.

Another difficulty in this approach is to assign the effective width of the slab to counteract the shear lag effects. Hasebe et al. [14] adopted the refined beam theory by Kano et al. [15] and examined the effect of various parameters on the effective width of the curved girders. The study was limited only to those structures with simply supported ends and a single box section. In the analysis, it was obvious that the ratio of the effective width to the flange width was sensitive to many factors, including: the cross section dimensions, distribution of the applied load, ratio of span width to span length, and the bridge horizontal curvature. The worst established scenario of the pre-mentioned parameters occurred with:

1. High girder horizontal curvature.
2. A small ratio of flange width to span length.
3. Deep webs in box sections.
4. Concentrated point loads.

2.1.5. Folded Plate Method

The idealization of the structure in this method is very close to the Finite Strip Method. Goldgerg and Leve (1957) were the first to introduce the Folded Plate Method. The method was applied to box-girder bridges and cellular structures, by Scordelis (1964, 1966). Evans (1982) applied the same method to a continuous structure using the standard force method.

However, this method has been found to be very complicated and time consuming. Furthermore, the method does not allow any changes in the elastic and geometric properties of the structure, and it is limited to those structures with prismatic members and regular planforms.

Chapter 3

Previous Work On Curved Box Girders And Curved Girders.

3.1 Introduction

Curved box girder bridges are becoming very popular and are extensively used in modern populated cities. Thus, a good understanding of the true behavior of such structures is essential. When subjected to gravity load, a horizontally curved box girder does not only endure vertical displacement, but also experience torsion along its longitudinal axis. This mutual action between bending and torsion depends on the girder geometry and the girder's rigidity ratio of flexure and torsion.

3.2 Previous Work

W. Li, L. Tham, and Y.Cheung [6] extented the spline finite strip method to the elasto-static analysis of circular and noncircular box-girder bridges, based on the curvilinear coordinate system. In their investigation, three numerical examples were employed to demonstrate the fast convergence as well as the accuracy of the method. S.Ng, M.Cheung, and H. Hachem [7], studied experimentally and analytically the static response of a curved continuous composite box girder bridge.

In the last two decades, various analytical and numerical methods were developed for the analysis and design of curved box girders. Among the numerical methods used, the finite element approach is the most versatile tool. However, special elements such as the strain-based element by Ashwell and Sabir [8] and the semi-loof element by Irons [9] can also be used in the analysis, to ensure satisfactory convergence. But due to the fact that these elements have a large number of degrees of freedom per element, their applicability is limited due to the requirements of huge input data in the analysis of large structures.

The classical finite-strip method first proposed by Cheung [17], based on the trigonometric series expansion, is simple and inexpensive, but its application is restricted to simple boundary conditions and geometry. Subsequently the method was devised by Cheung et al. [18] for the analysis of right straight plates and box girders.

Gottfeld [19] was the first in presenting a theoretical treatment for curved girders. In his work, he tested two girders with cross-bracing, and the girders were subjected to gravity loads. Dabrowski [20] indicated that the type of problem that Gottfeld worked on, could be regarded as a special case of the combined torsion and moment of curved thin-wall members. Dabrowski also established a wide spectrum of tables, formulas, and influence lines that were very difficult to use in design. Umanskii [21] calculated the bimoments in an I-Beam under gravity load, and established solutions for various loading conditions using the initial parameters, and was the first in presenting a complete treatment for thin-wall curved girders having a doubly symmetrical I-shaped cross section. Dabrowski [22], after Benscoter (1954), presented the fundamental equations for the coupled bending and nonuniform torsion of curved box girders with nondeformable asymmetrical cross sections. The primary contribution of Dabrowski [23] was the publication of his work on curved thin-walled girders with deformable cross-section in the International Association for Bridge and Structural Engineering.

In the mid-sixties, U.S. Steel [24] published the " V-Load Analysis " which is an approximate method for engineers to determine the moments and shears in horizontally curved open framed highway bridges. This procedure was used extensively by designers until early to mid-seventies when highly sophisticated computers and computer software came into the picture. Also at the same time, Shimada and Kuranishi [25], and Watanabe [26] established similar tables and formulas in Japan. Coull and Das [28], Cheung [29], and Sawko and Merriman [30] suggested the application of Equivalent Orthotropic Plate Method for multi-girder curved bridges with high torsional rigidity. Furthermore, Bell and Heins [31] solved the orthotropic plate and beam assembly by the slope deflection method and established their solutions in terms of Fourier series. Tung [32], used similar approach in his analysis of twin box girder bridges and considered the interaction between the two girders while neglecting the interaction between the annular flanges and the cylindrical webs. Tung's solution was proved to be unreliable by [33,34,35] due to the fact that curved box girders are made up of sections of plates and shell elements that interact closely with the top flanges.

In 1986 a computer program BSDI [36] (Bridge Software Development International, Ltd.) was developed to optimize a horizontally curved bridge systems which utilize influence surfaces based on 3-D finite element analysis. Tan and Shore [37] and Komatsu and Nakai et al. [38,39], studied the dynamic behaviors of curved girder bridges. Culver and McManus [40], worked on allowable flexural stresses for the bridge girder, and it appears that AASHTO (American Association of State Highway and Transportation Officials.) adopted their study to establish the 1980 AASHTO Guide Specifications for Horizontally Curved Highway Bridges [41]. Nakai and Kotoguchi [42], analyzed the lateral buckling strength of a curved I girder in the elastoplastic region. Also Nakai, Kitada, and Ohminami [43], based on the results of a series of experimental studies, investigated the web buckling of curved girders.

Boulton et al. [44], and Yoo et. al. [45], studied the plastic collapse loads for circular arc girders based on the kinematic collapse mechanism. Fukumoto et. al. [46], and Yoshida et. al. [47] studied the material and geometric nonlinear response of curved I beams.

Chapter Four

Experimental Set-Up And Results

4.1 Introduction

In general most experimental bridge models lack one or a combination of the following:

1. Multi-Span continuous structures.
2. Multi-Cell Box Girder cross section.
3. Diaphragms.
4. Design truck load.

However, the prototype structure that was selected for this model study satisfied all the above mentioned features, namely the Cyrivlle road Queensway overpass located in the east end of Ottawa. The structure was built in 1973 and designed according to ASHTO design truck load HS20-44 by the Ministry of Transportation and Communication. The bridge is 102.4 meters long, 12.8 meters wide, and consists of two spans with 16.8° horizontal angle of curvature between the end supports. Its cross section consists of four contiguous cells with a depth of 1.83 meters. As for the diaphragms, two prestressed diaphragms are placed at the extreme end supports and one is placed over the middle support.

4.2 Objective

The objectives of this thesis are :

1. To study the linear variation of stresses, strains and deflections at five different sections of the bridge model, due to OHDB truck load with different positions of the middle support, using the computer program ADINA.
2. To set up a curved continuous box girder bridge model.
3. To test the model using OHBD truck loading, and verify the theoretical results obtained from ADINA, with those obtained from the experimental model.

4.3 The Continuous Box Girder Bridge Model

4.3.1 Bridge Model Construction

The bridge model was rebuilt from a model previously used for linear experimental study at the University of Ottawa. A scale of 1/24 was adopted, and the bridge model was a composite of micro-concrete deck and aluminum bottom plate with cylindrical webs. A typical cross section of the model consists of four rectangular box girders. Also, the bridge model consisted of three diaphragms, two of which were placed at the extreme ends and the third was placed at the middle support. These transverse diaphragms were made from Aluminum C-Channels, and in order to generate the box girders, the curved webs were clamped in position and then welded to the bottom plate. Due to the heat release as a result of welding, and to minimize the possible warping of aluminum, spot welding was utilized. However, to allow horizontal movements, rockers were installed in the bridge model's end support system. Aluminum shear connectors 8 mm in diameter were installed to the top flange of the webs at 80 mm c/c spacing, so that the slab would act as an integral part of the box girder.(Figs. 4.2 and 4.3)

4.3.2 Bridge Model Geometry

A scale of 1/24 was adopted for the bridge model, and the center line radius of curvature of the model was 14.554 m. Longitudinally, and tangent to the center line, the model's span is 4.268 m through the small angle of curvature 16.8° . The bridge model width is 0.49 m and depth 0.133 m. (Fig. 4.1)

4.3.3 Bridge Model Re-Construction

The bridge model mentioned above was reconstructed for both linear and nonlinear experimental study in August 1994 at the University of Ottawa.

The model's old micro concrete slab and the stay-in-place false form work were removed. All the strain gauges were checked, the ones that were damaged were replaced, and a number of additional strain gauges where added to the model at sections 1, 4, and 9. (Figs. 4.16 and 4.17) The model was then loaded and all the strain gauges were checked before the casting of the new bridge deck.

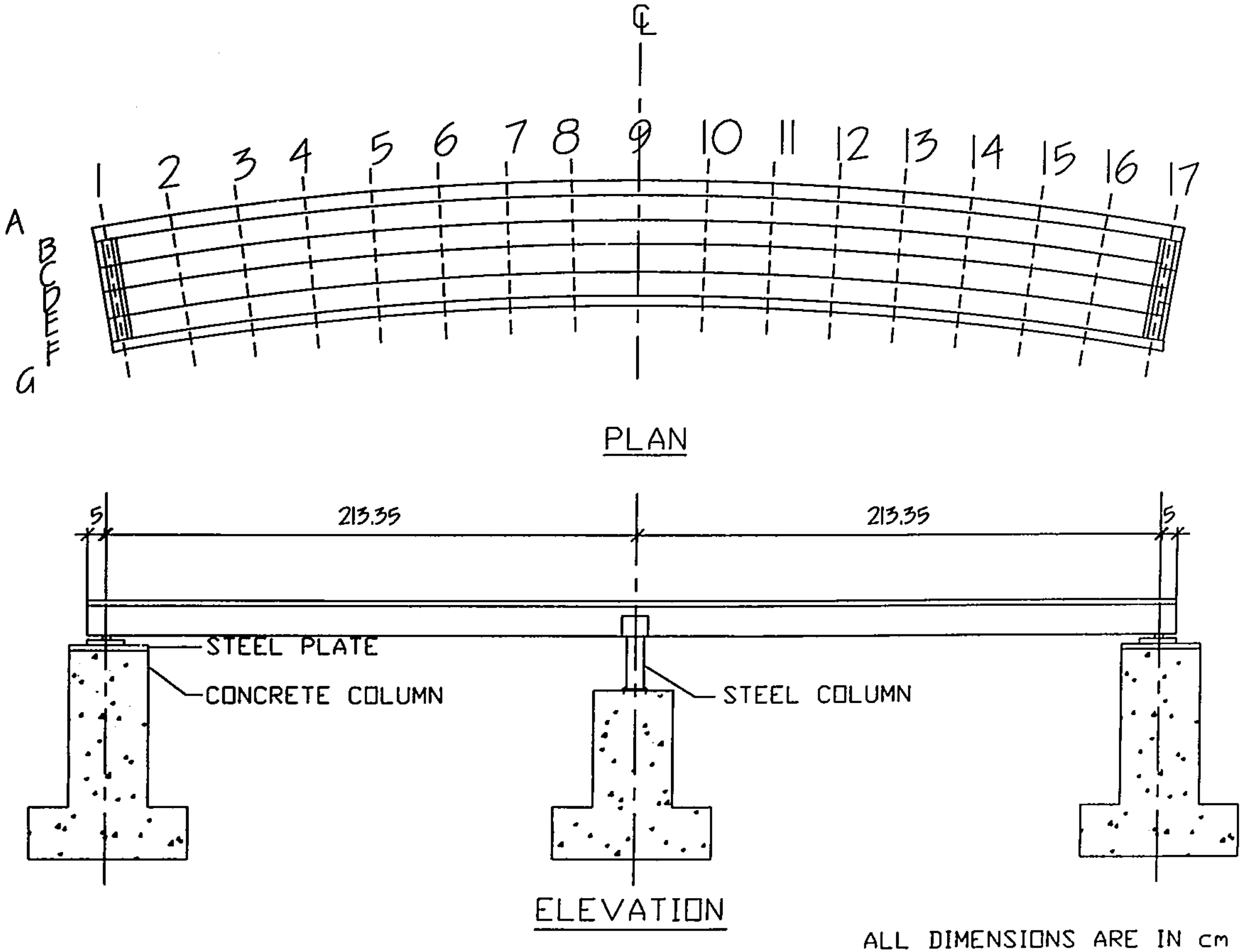
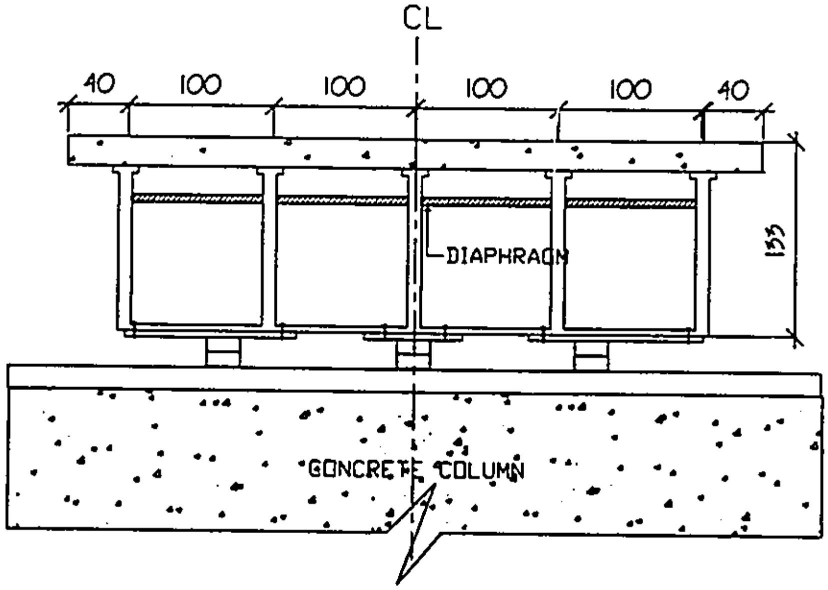
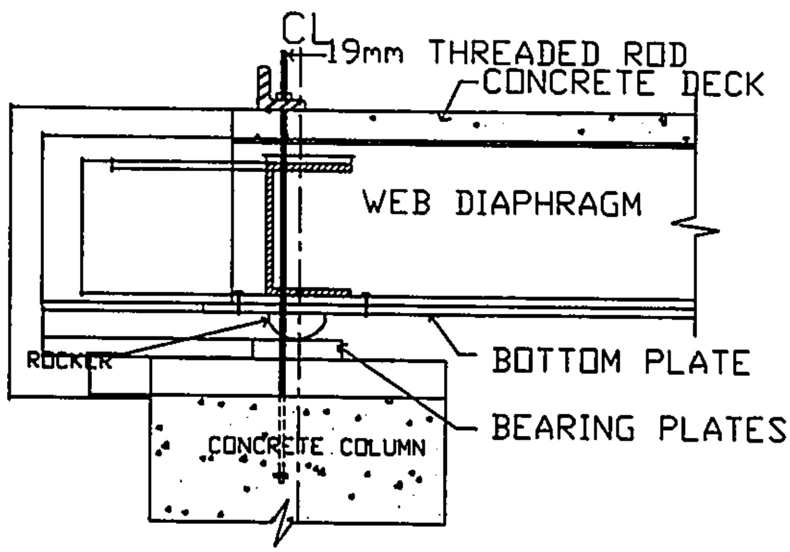


FIGURE 4.1: GEOMETRY OF CURVED BOX GIRDER BRIDGE MODEL.



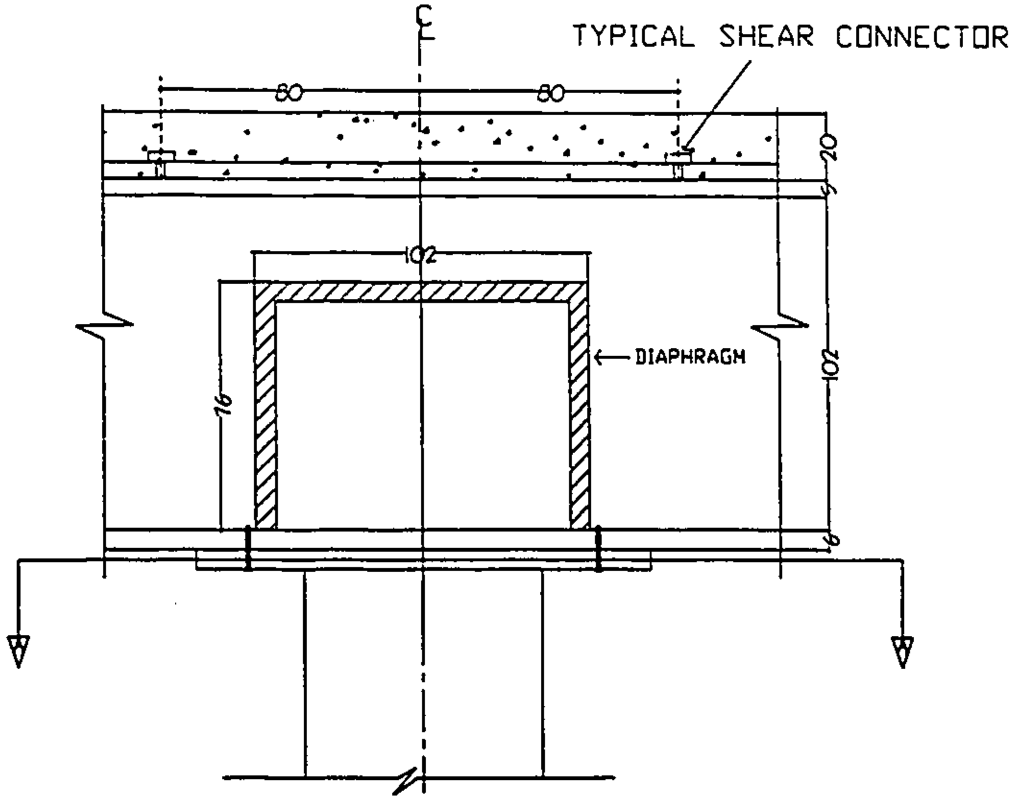
SECTION 1



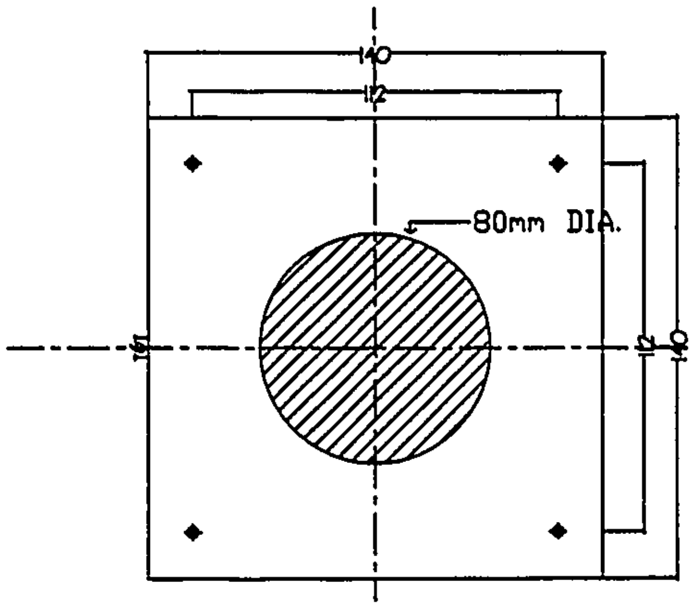
ELEVATION @ END SUPPORT

ALL DIMENSIONS ARE IN mm.

FIGURE 4.2 DETAILS OF BRIDGE MODEL END SUPPORTS.



ELEVATION @ CENTRAL SUPPORT



SECTION A-A

ALL DIMENSIONS ARE IN mm.

FIGURE 4.3 DETAILS OF BRIDGE MODEL @ MIDDLE SUPPORT.

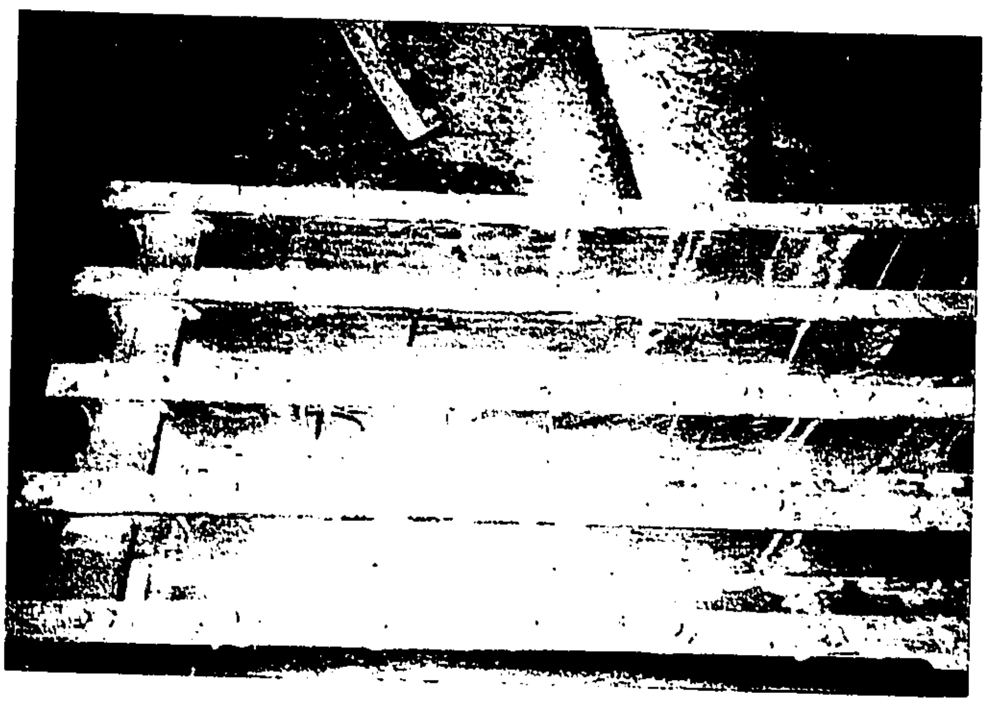


FIGURE 4.4 BRIDGE MODEL RE-CONSTRUCTION.

The same stay-in-place false form work was adopted for the model's surface, except for the side form work. Steel angles (2" x 2" L-Shape) were utilized and bolted to the model itself.

A 1" x 1" x 16 WWF (Welded Wire Fabric) mesh was placed over the false work as temperature and shrinkage reinforcement for the micro concrete deck. A high strength micro concrete with f'_c= 60.0 MPa was prepared at the University of Ottawa Structures Laboratory and the deck of the model was poured with thickness of 20.0 mm and cured for 28 days. (Fig. 4.5)

4.3.4 Material Properties

The model is built in such a way that all its properties are intended to be as close as possible to those of the prototype but on a reduced scale. However, the choice of material for the bridge model also has to follow the simple criteria of ease of fabrication, instrumentation, and test techniques.

A 1/24 model scale was adopted to model the Cyrville road overpass of the Queensway. Preliminary studies showed that only micro concrete could be used for the deck of the model due to the fact that the bridge deck can only have a total thickness of 20.0 mm.

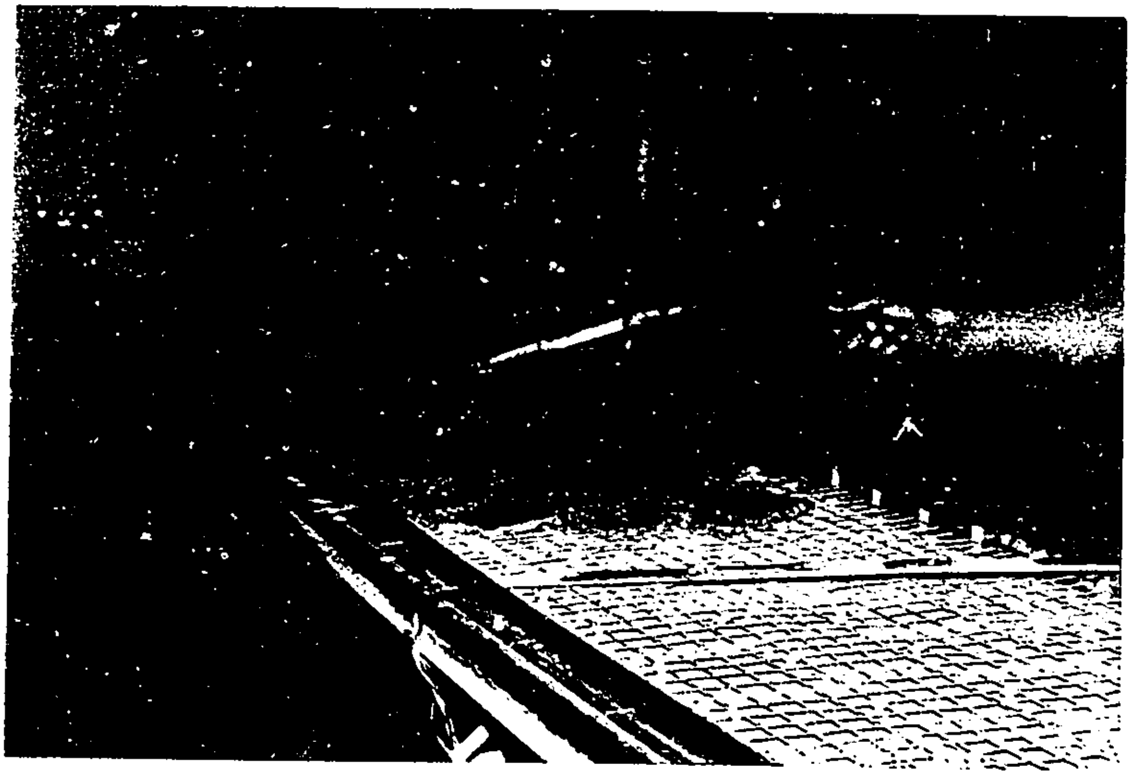


FIGURE 4.5 BRIDGE MODEL'S DECK, POURING & CURING.

Furthermore, to model the webs, the bottom plate, the ends, and the middle diaphragms, the advantages and the disadvantages of various materials such as steel, plexiglass, and aluminum were evaluated. After many considerations, aluminum alloy was selected to model these components of the model for the following reasons:[3]

A. The choice of a plexiglass model is rejected because its material properties are time dependent. This would mean that, strain gauge readings would change with time, while the model is subjected to constant loading.

B. Another distinct disadvantage of plexiglass is the magnification of temperature that rises at the strain gauge location. This phenomenon is due to the combined effect of the low thermal conductivity of plexiglass and the heat generated as a result of the current passing through electrical resistance strain gauges.

C. The problems associated with heat generation in the welding process of aluminum is also a problem but it can be minimized by proper clamping and stabilization using spot welding before complete welding of the components. Also, aluminum is lighter and easier to machine than steel, and has a much lower modulus of elasticity.

4.3.4.1 Micro Concrete

The fact that the thickness of the model deck is limited to 20.0 mm dictates the choice of micro concrete instead of regular concrete. Hence all aggregates passing sieve No. 4 were considered as maximum aggregate size.

An early high strength micro concrete mix design provided from the National Research Council of Canada was adopted as presented in table 4.1, and the model bridge deck was cast along with 30 cylinders (75mm x 150mm) that were utilized to determine the mechanical properties of the micro concrete.

Table 4.1 Micro Concrete Mix Design.

Cement (Kg)	Silica Fume (Kg)	Water (Kg)	Fine Aggregates (Kg)	Super Plasticizer (Liters)	W/C
34.61	1.08	13.32	111.53	1.92	0.35

At 7, 14 and at 28 days three cylinders were tested each time for compressive strength, as presented in table 4.2. In order to determine the Young's modules, the following formula was used: $E_c = 5000 \times (F'_c)^{1/2}$. Hence, the Young's modulus was calculated to be 37.4 MPa.

Table 4.2 Micro concrete Compressive Strength.

Cylinder #	Compressive Strength (MPa)		
	7 Days	14 Days	28 Days
1	46	52	58
2	38	48	53
3	50	45	56
Average	45	48	56

Hence the F'_c for the micro concrete employed is 56 MPa.

The other three cylinders were tested for tensile strength and the results are listed in table 4.3

Table 4.3 Micro concrete Tensile Strength.

Cylinder #	Load Recorded (KN)	F'_{ct}
1	62	3.508
2	99	5.600
3	55	3.110
Average	72	4.074

Hence the F'_{ct} for the micro concrete employed is 4.074 MPa.

In general the mechanical properties of the micro concrete are as listed in table 4.4

Table 4.4 Summary of The Micro Concrete .

Property	Symbol	Magnitude
Compressive Strength (MPa)	F'_c	56.00
Tensile Strength (MPa)	F'_{ct}	4.074
Modules of Elasticity (MPa)	E_c	37.40
Poisson's Ratio	ν_c	0.150

4.3.4.2 Aluminum

The Aluminum alloy (ref.1) No. 6061-T6 was utilized for the webs, bottom plate, ends, and middle diaphragms. [3] Two sets of aluminum were tested, set A representing the bottom plate, and set B representing the webs, ends and middle supports. The results are tabulated in table 4.5

Table 4.5 Aluminum Properties .

Property	Symbol	Magnitude		
		Set A	Set B	Average
Ultimate Strength (MPa)	F_{ult}	327	306	317
Yield Strength (MPa)	F_y	316	285	301
Modules of Elasticity (MPa)	E_a	70277	72000	71100
Poisson's Ratio	ν_a	0.379	0.379	0.379

[1]Magnesium and Silicon wrought alloy.

4.3.5 Support Details

The bridge model was supported under its own dead load by means of three rockers at each end, and by a single steel column support at the middle section.

Two sets, each consists of three rockers, were made up of 25.4 mm thick steel rings having an outer diameter of 108.0 mm. These rockers were welded to 6.5 mm thick steel bearing plates. Then each set of rockers was connected to the bottom plate of the model at the appropriate location, making the rockers a part of the structure. (Fig.4.2)

As for the middle column support, it was made up of a short steel column 80.0 mm in diameter. The column was welded to two bearing plates 140mm x 140 mm and 6.35 mm in thickness at the top and bottom. The top plate of the shaft was connected to the bottom plate of the bridge by means of four screws at a distance of 112.0 mm center to center. The same kind of connection was used for the bottom plate which was, in turn, connected to the concrete pier.

This kind of column connection is intended to simulate a pin type support with some degree of fixity. (Fig. 4.3)

A total of three reinforced concrete columns were constructed at the University of Ottawa Structures laboratory to support the bridge.

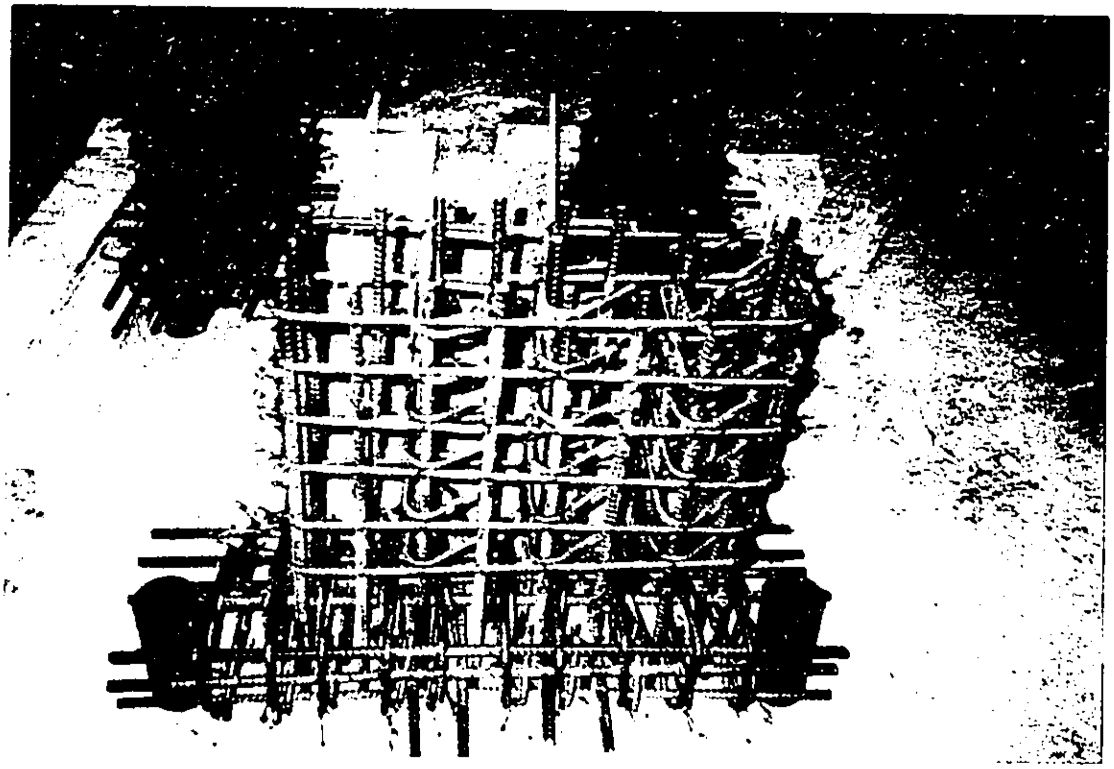
(Figs. 4.6 & 4.7) Two of these columns were identical each having a 700 mm x 300 mm cross section, a total height of 600 mm and a base of 1100 mm x 600 mm. Each column base was bolted to the floor to create total fixity.

As for the middle column, it has the same cross section dimensions as the end columns but with a total height of 450 mm. A typical end and middle support section is shown in Figs. 4.8 and 4.9.

Each end support column has 21 #15 bars as longitudinal reinforcement, with 6 #10 as transverse reinforcement at 100 mm C/C as shown in Fig. 4.10. As for the middle support column it has 32 #15 bars as longitudinal reinforcement, with 5 #10 as transverse reinforcement at 75 mm C/C as shown in Fig. 4.11. Fig. 4.12 shows a typical complete column and footing reinforcement section. All reinforcement for the three columns were designed according to the CSA A23.3-M84 [48].

It is clear that the reinforced concrete support system was over designed, in order to ensure that during experimental testing the support system will not experience any kind of deformation.

The bridge was supported at both ends on 700mm x 300mm x 13mm thick bearing plates resting on the reinforced concrete columns. It was observed that not all rockers were in contact with the bearing plates. As a result, additional thin steel plates were utilized to adjust and level the bridge model, so that all rockers rest on the bearing plates . As for the global stability of the model, both end supports were restrained against torsional movements by bolting a 2" x 2" L shape angle to two 3/4" threaded rods that form part of the end support system for the reinforced concrete columns as shown in (Fig. 4.8.)



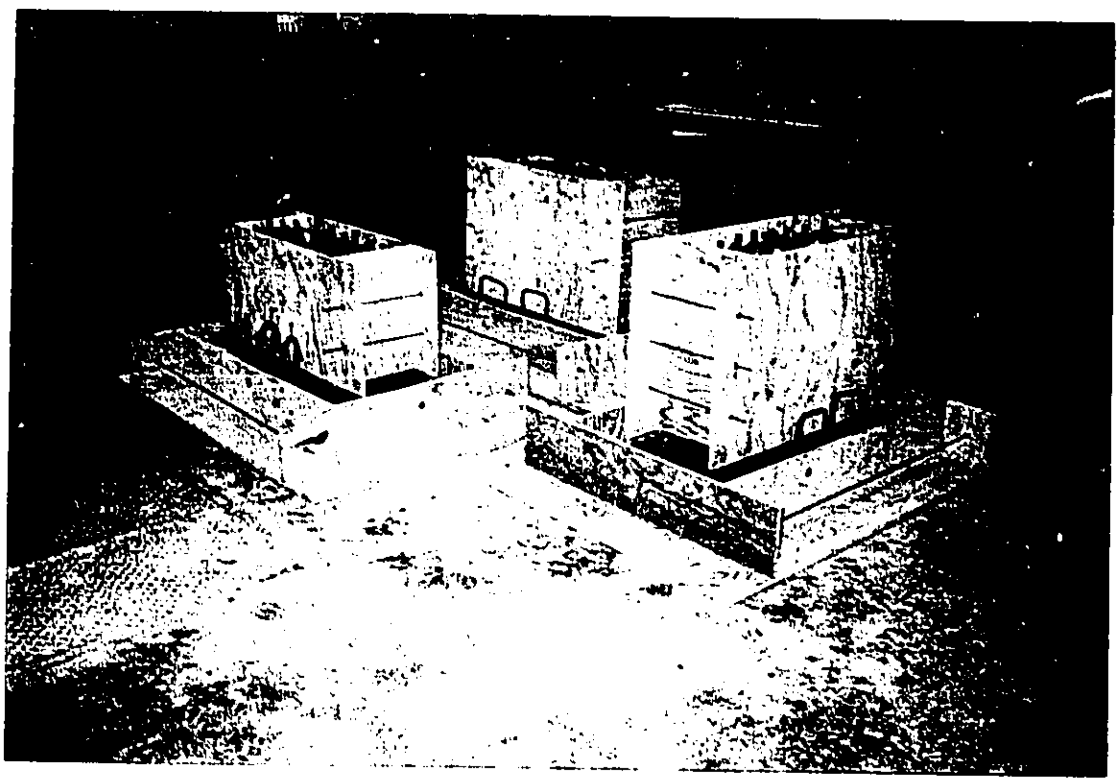
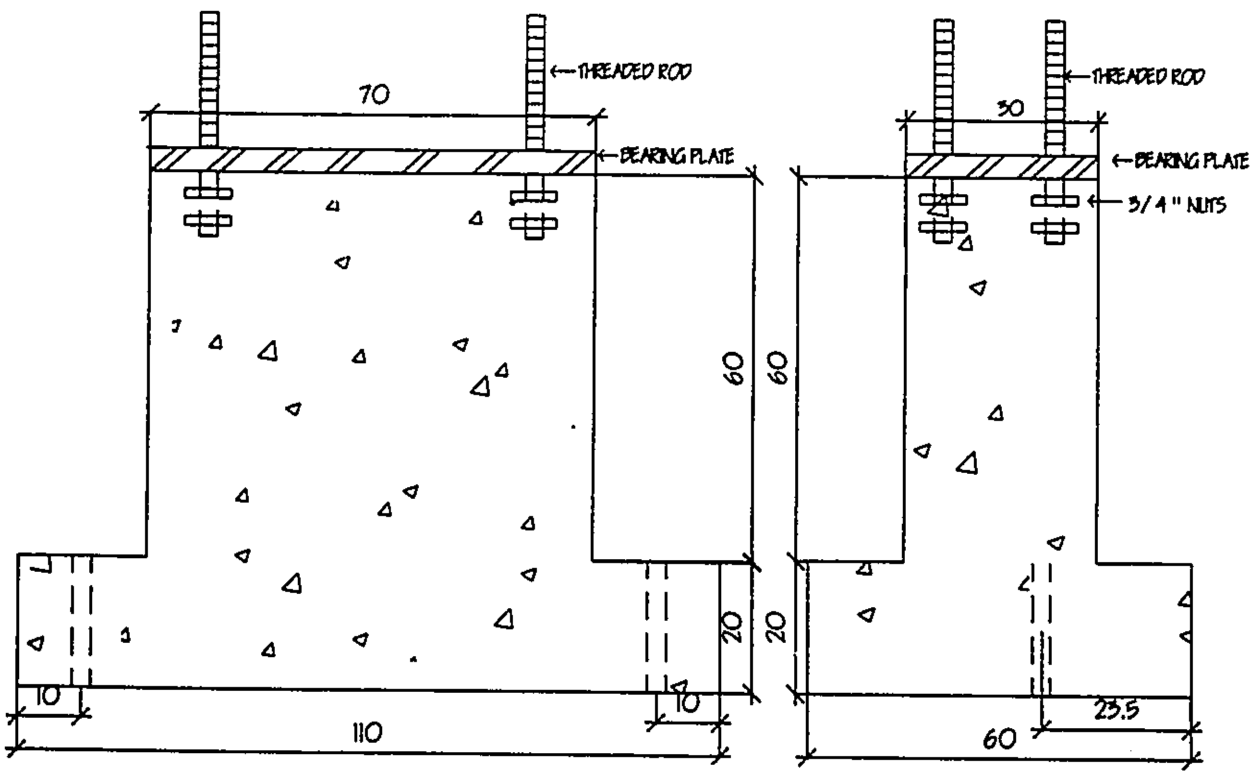


FIGURE 4.6 SUPPORT SYSTEM REINFORCEMENT.

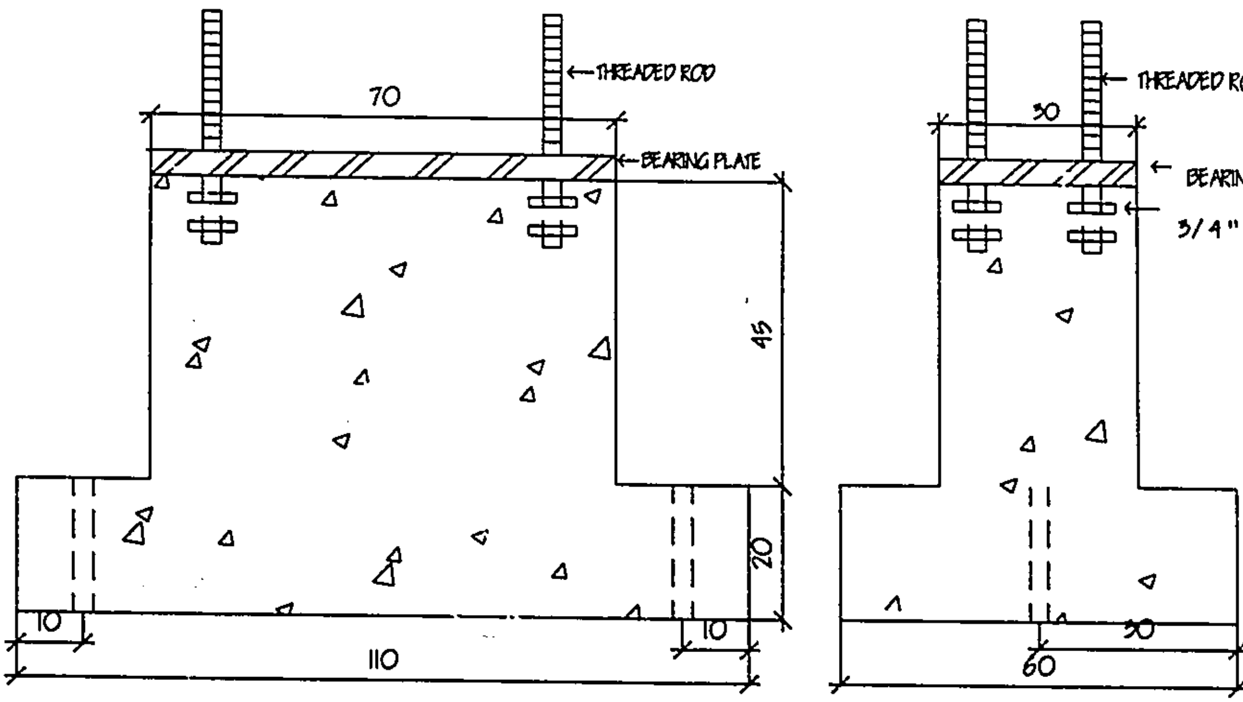
FIGURE 4.7 SUPPORT SYSTEM POURING & CURING.



END SUPPORT

ALL DIMENSIONS ARE IN cm.

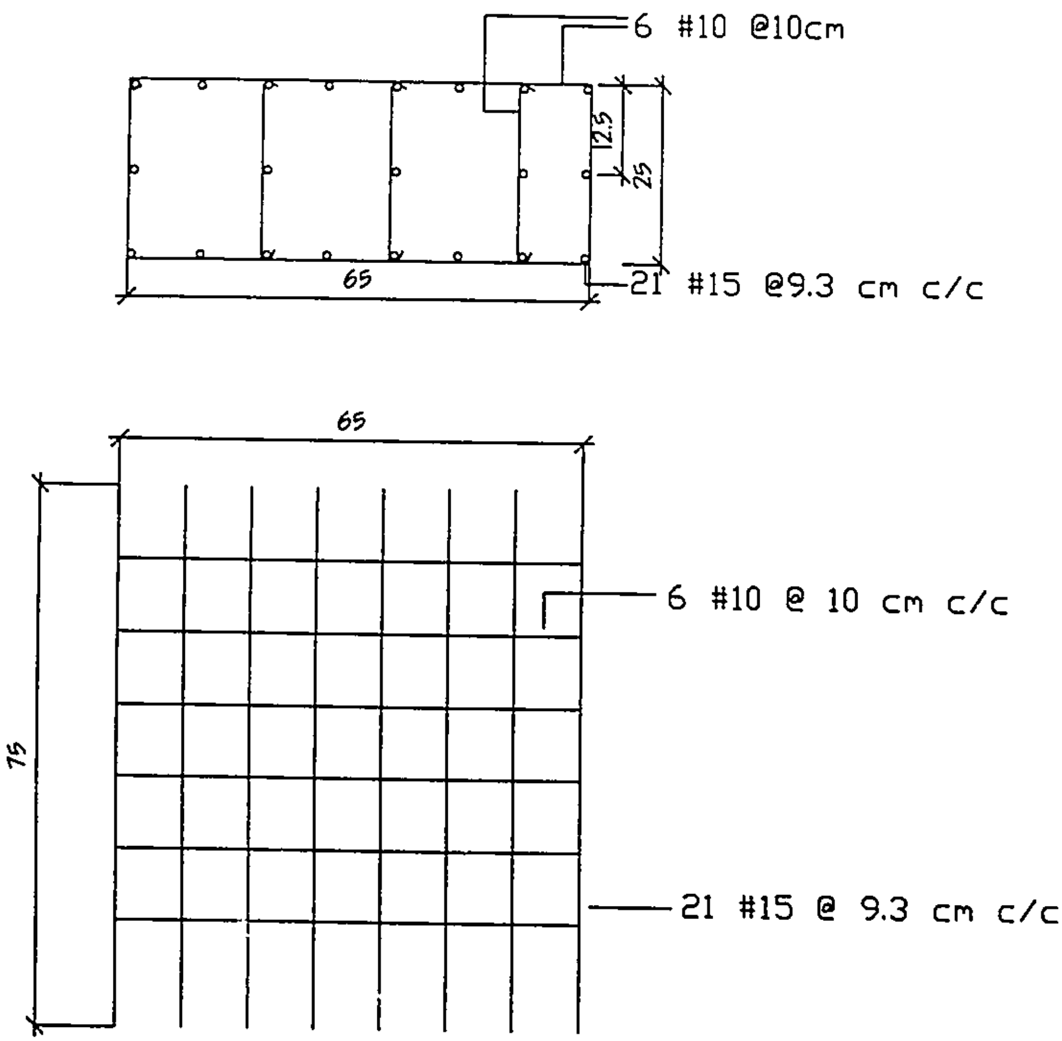
FIGURE 4.8 END R/C COLUMN SUPPORT



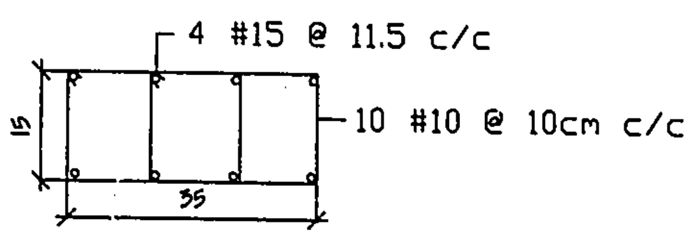
MIDDLE SUPPORT

ALL DIMENSIONS ARE IN cm.

FIGURE 4.9 MIDDLE R/C COLUMN SUPPORT



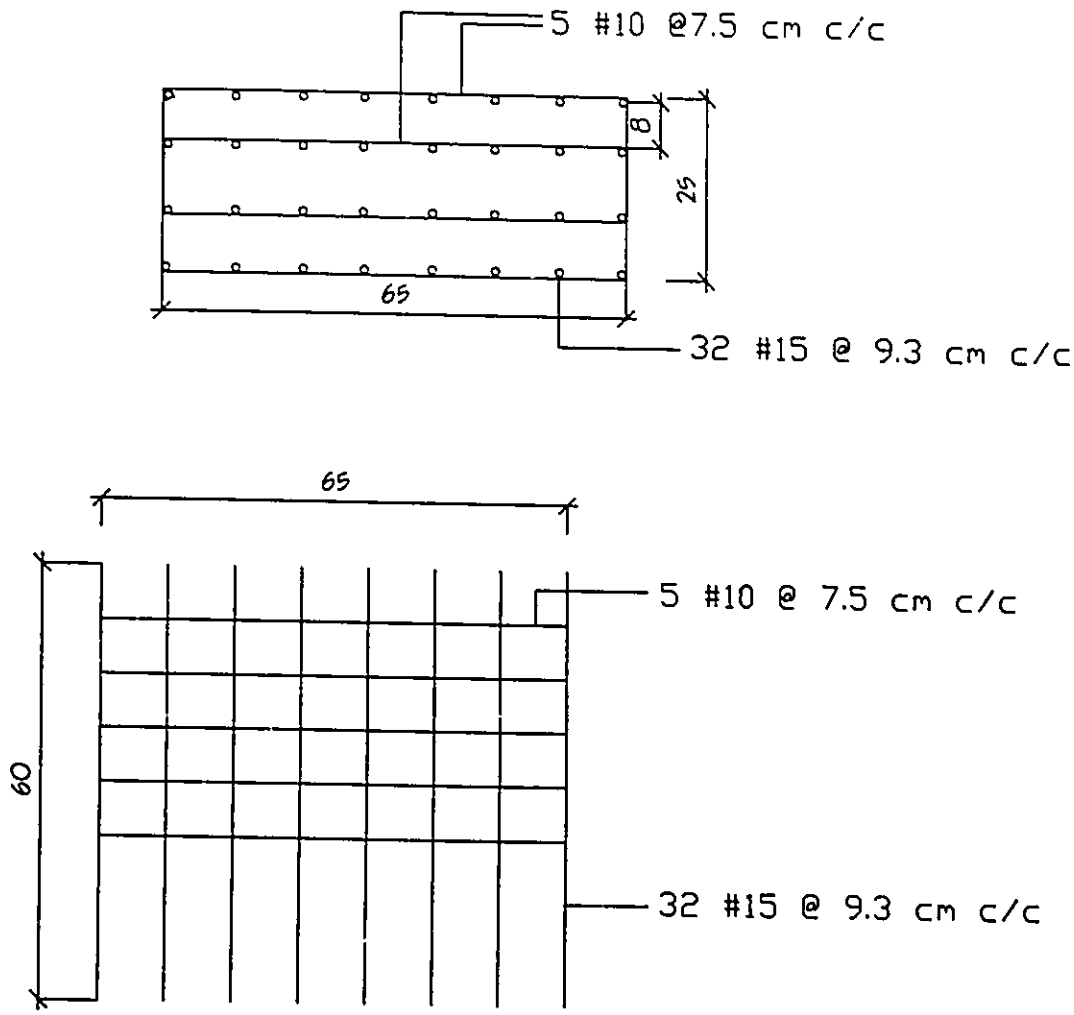
COLUMN REINFORCEMENT



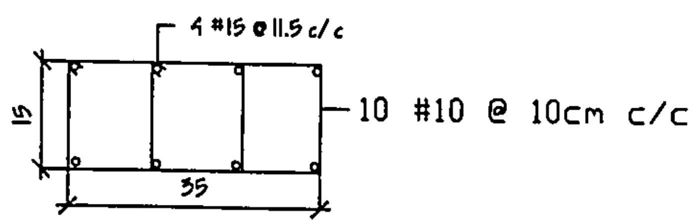
FOOTING REINFORCEMENT

ALL DIMENSIONS ARE IN cm.

FIGURE 4.10 END SUPPORT REINFORCEMENT



COLUMN REINFORCEMENT

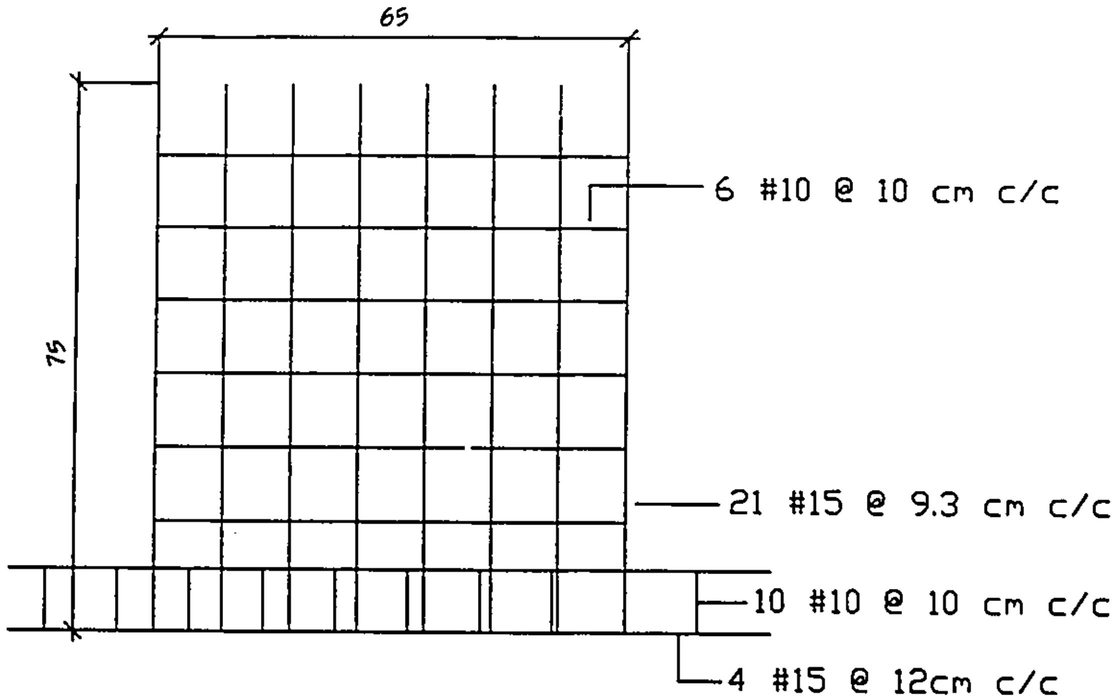


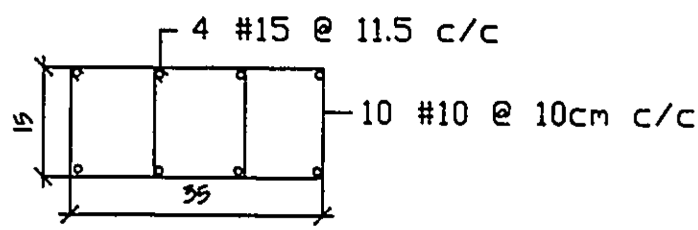
FOOTING REINFORCEMENT

ALL DIMENSIONS ARE IN cm.

FIGURE 4.11 MIDDLE SUPPORT REINFORCEMENT

TYPICAL FOOTING REINFORCEMENT





ALL DIMENSIONS ARE IN cm.

FIGURE 4.12 TYPICAL FOOTING REINFORCEMENT

4.3.6 Model Loading System

An equivalent **OHBD** truck load was adopted to load the bridge model. In all the 9 load cases studied, two parallel loading trucks were always acting at the middle of one or both span, thus yielding the maximum response of the bridge model. However, to establish the equivalent **OHBD** truck, the laws of similitude and dimensional analyses were employed. The basic similitude used in this analysis was the simulation of the longitudinal strains, i.e. the equivalent **OHBD** truck must produce the same normal strains (ε^m) in the model as (ε^p) in the prototype. Hence

$$\varepsilon^m = \varepsilon^p \tag{4-1}$$

Ignoring Poisson's effect,

$$\frac{\sigma^m}{E^m} = \frac{\sigma^p}{E^p} \tag{4-2}$$

Where

E: is young's modules.

σ: is the longitudinal bending stress.

m: denotes the model.

p: denotes the prototype.

However, the normal stress at any section is given by:

$$\sigma=\frac{M*Y}{I} \qquad (4\text{-}3)$$

Where:

M: is the bending moment at the section.

Y: is the distance from the neutral axis.

I: moment of inertia of the section about the neutral axis.

Furthermore; M, the bending moment can be expressed in the form of:

$$M=F*X \qquad (4\text{-}4)$$

Where M is the product of the force (F) and the linear dimension along the longitudinal axis of the structure (X).

After substituting Eq. 4.4 into Eq. 4.3 and Eq. 4.2, the new equation will be:

$$\frac{F^m*X^m*Y^m}{E^m*I^m}=\frac{F^p*X^p*Y^p}{E^p*I^p} \qquad (4\text{-}5)$$

Or,

$$F^m=\frac{E^m*I^m*X^p*Y^p}{E^p*I^p*X^m*Y^m}*F^p \qquad (4\text{-}6)$$

A constant linear scale (L_f) was used for the two linear dimensions X,Y:

$$L_f=\frac{X^p}{X^m}=\frac{Y^p}{Y^m} \tag{4-7}$$

$$I_f=\frac{I^p}{I^m} \tag{4-8}$$

$$E_f=\frac{E^p}{E^m} \tag{4-9}$$

Substituting Eqs. 4.7, 4.8, and 4.9 into Eq. 4.6

$$F^m=\frac{L_f^2}{E_f I_f}*F^p \tag{4-10}$$

Or

$$F^p=F_f*F^m \tag{4-11}$$

Where F_f, the static linear force is given by:

$$F_f=\frac{E_f I_f}{L_f^2} \tag{4-12}$$

Eq. 4.11 shows the relationship between the prototype force (F^p) and the equivalent model force (F^m) that would satisfy the normal strain similarities. The stiffness properties that were used in the calculation of the force scale factor are as follows:

I^p = 310520100 cm^4

I^m = 2871 cm^4

E^p = .7700 MPa

E^m = 71100 MPa

With a linear scale factor L_f = 24, the force scale factor was calculated as:

$$F_f=73 \tag{4-13}$$

Applying this factor, the model truck simulating one **OHBD** truck load [49] was calculated and the results are shown in Table 4.6

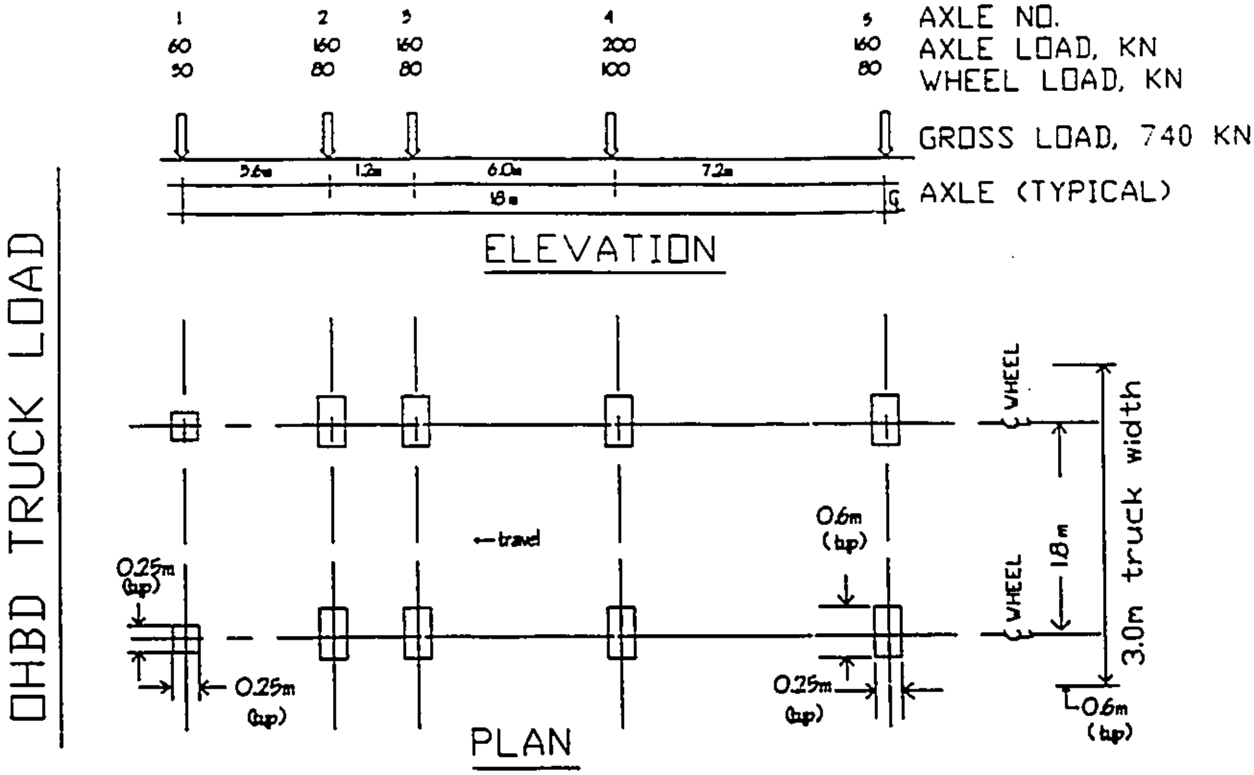
Table 4.6 OHBD Truck Load Vs. Model Load .

Axle Number	Load (KN)	
	Prototype	Model
1	60	0.822
2	160	2.192
3	160	2.192
4	200	2.740
5	160	2.192
Gross Load	740	10.138

In general, the model truck load consists of four axles instead of five due to the fact that, axles number 2 and 3 were lumped together because of the short distance between them. This model truck loading system is made up of a number of steel bars that are assembled on top of each other to form what is called a tree loading system, such that when a concentrated jack load is applied, the load is distributed between the four axles to the wheels as shown in Figs. 4.13 & 4.14. At this stage it is important to note that the wheel loads are located exactly on the webs in order to avoid the damage of the micro concrete deck.

Table 4.7 Single Model Truck Weight .

Beam ID.	Beam Dimension (Cm)	Mass/Beam (Kg)	Number Of Beams	Mass (Kg)
A	10x10x50	39.25	1	39.25
B	5x5x16.5	3.24	2	6.48
C	5x6.4x23.5	5.90	2	11.80
D	5x6.4x36.5	9.17	2	18.34
E	3.2x5x9.5	1.19	8	9.52
Total Mass Of One Model Truck				85.39



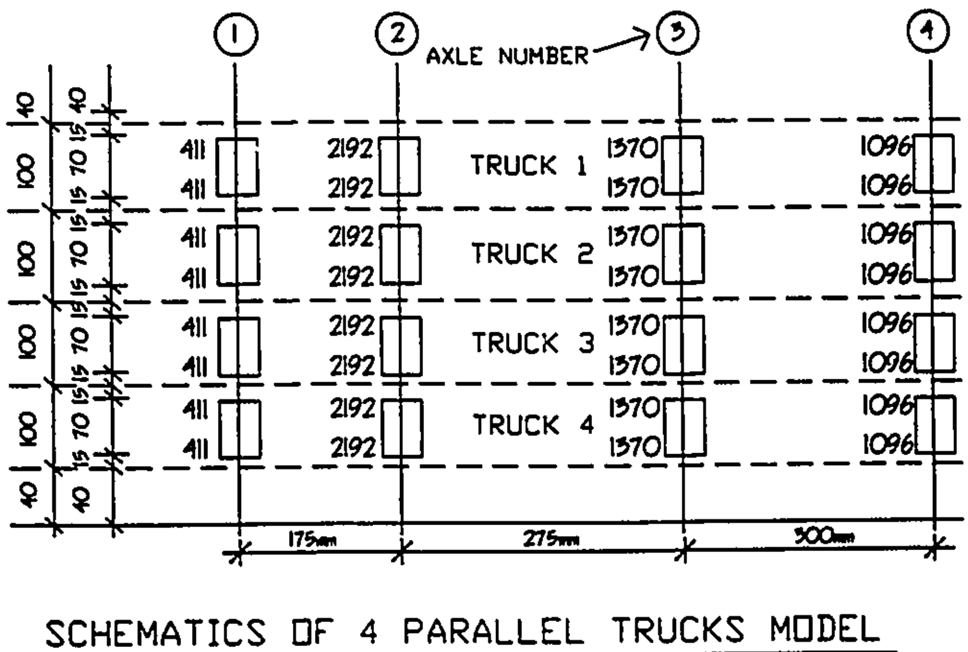
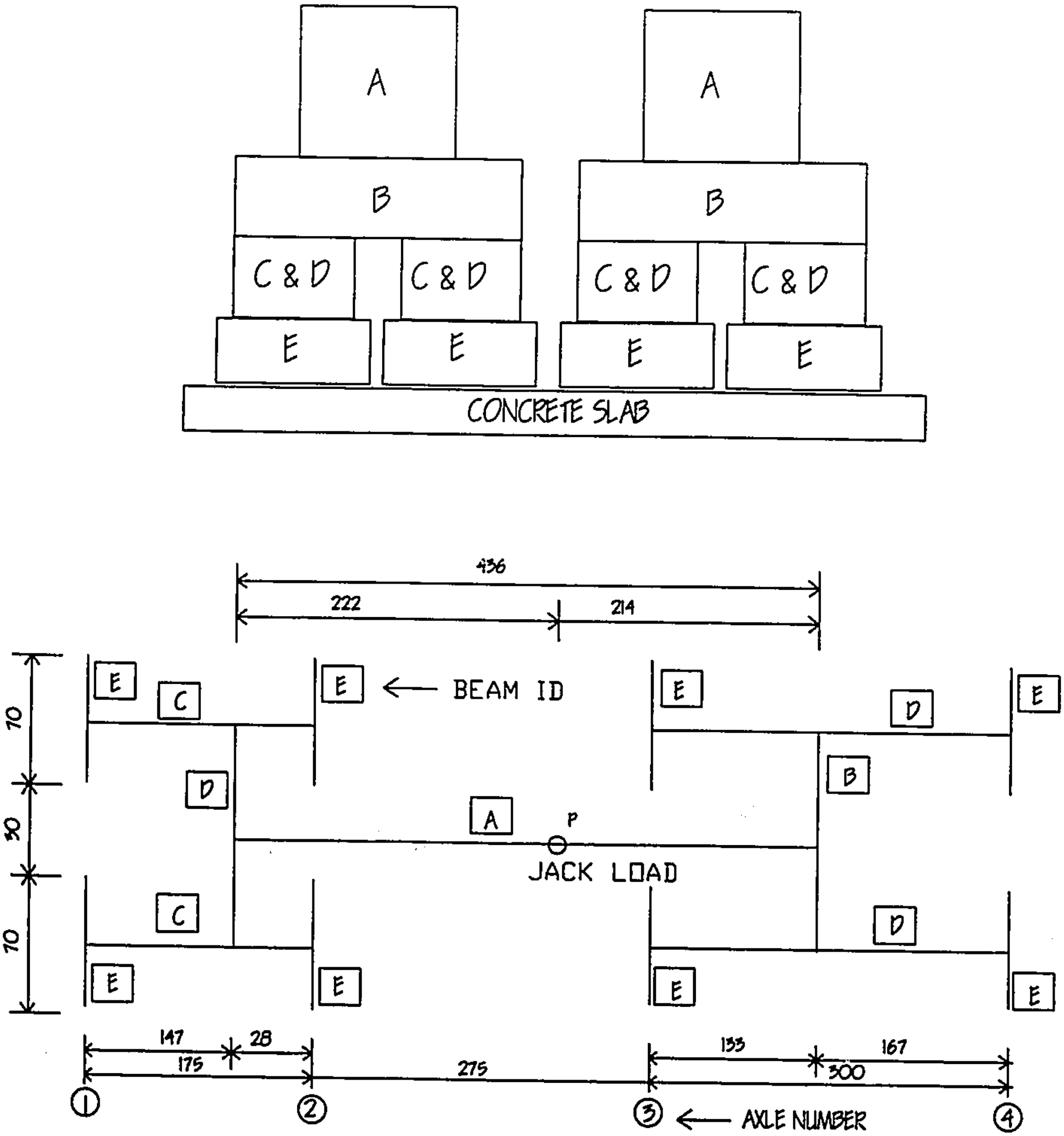


FIGURE 4.13 OHBD & MODEL TRUCKS



ALL DIMENSIONS ARE IN mm.

FIGURE 4.14 TRUCK LOADING SYSTEM

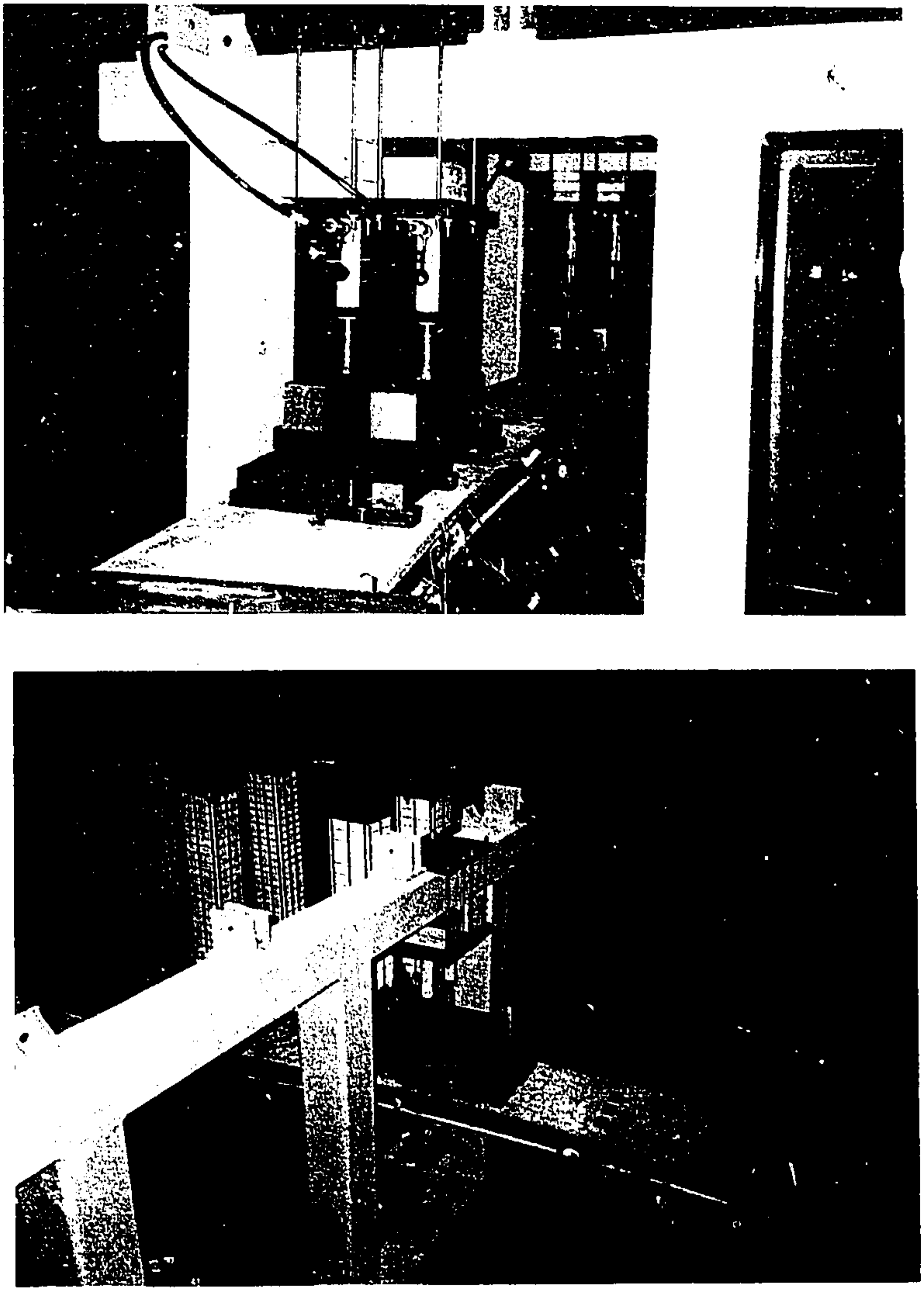


FIGURE 4.15 PARALLEL MODEL TRUCK LOADING SYSTEM

4.3.7 Instruments Used

4.3.7.1 Strain Gauges

A total of three types of foil strain gauges were utilized in this experimental study to measure the strains.

Type:

1. 45° three-gauge rosette strain gauges, aluminum type EA-13-125RA-120.
2. Uniaxial "linear" strain gauge, aluminum type KEC-5-C1-11
3. A linear strain gauge for the micro concrete type EA-06-500GB-120.

All the above mentioned strain gauges have a gauge factor of 2.10 and have been installed and wired as recommended in ref. [50]. Micro-Measurement M-Bond 200 adhesive was used to glue the strain gauges to either the micro concrete or the aluminum.

A total 82 strain gauges were installed, at five chosen sections, namely sections 1,4,5,8, and 9. Eight linear strain gauges type EA-06-500GB-120 were installed at the model's deck surface of sections 4,8, and 9. Ten 45° three-gauge rosette strain gauges type EA-13-125RA-120 were installed on the outer surface of aluminum at sections 1,4,5, and 8. Finally, forty four linear strain gauges type KEC-5-C1-11 were installed on the outer and inner surfaces of aluminum at sections 1,4,5,8 and 9 as shown in Figs. 4.16 & 4.17.

Each strain gauge has an identification symbol as follows:

A^{L}_{ij} : A linear strain gauges type KEC-5-C1-11 located on the outer or inner surfaces of the aluminum at section j, and i refers to the gauge number within section j.

A^{Rx}_{ij} : A 45° three-gauge rosette strain gauge type EA-13-125RA-120 located on the outer surface of the aluminum at section j, and i refers to the gauge number within section j.
x defines the axis in the plane of the rosette as follows:
x = L defines longitudinal axis of the bridge model.
x = T defines perpendicular axis to L in rosette plane.
x = D defines the 45° axis between L and T.

C^{L}_{ij} : A linear strain gauges type EA-06-500GB-120 located on deck surface at section j, and i refers to the gauge number within section j.

For example:

Strain gauge number A^{L}_{39} refers to the 3rd linear strain gauge type KEC-5-C1-11 located on the outer or inner surface of the aluminum at section 9.

Or C^{L}_{18} refers to the 1st linear strain gauge type EA-06-500GB-120 located on the deck surface at section 8.

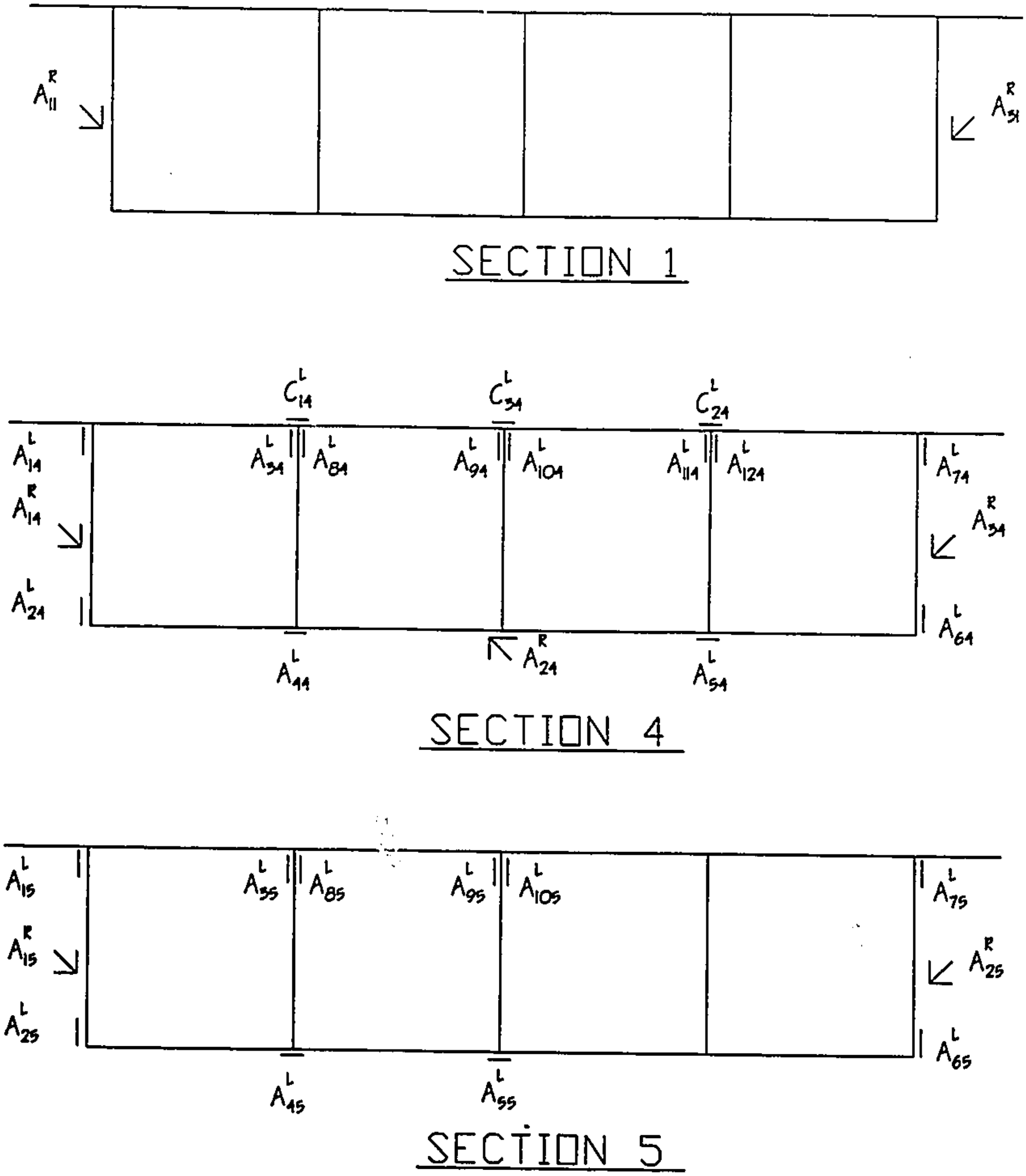
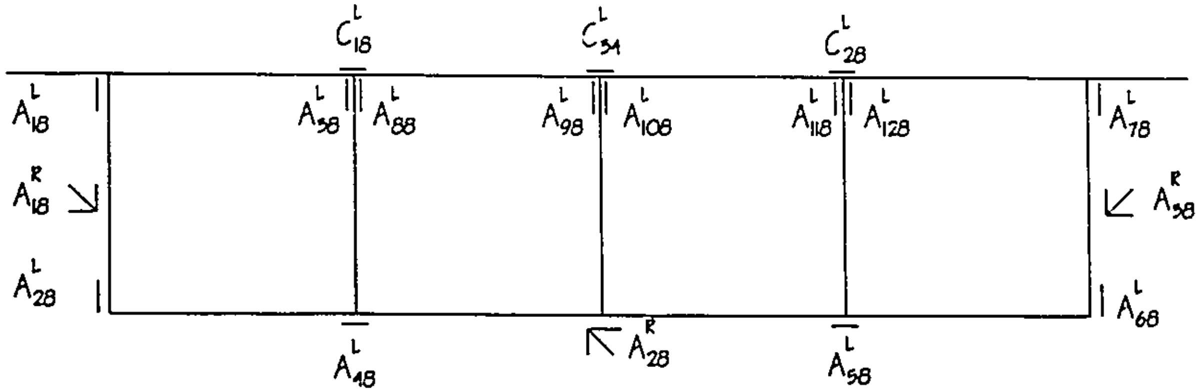
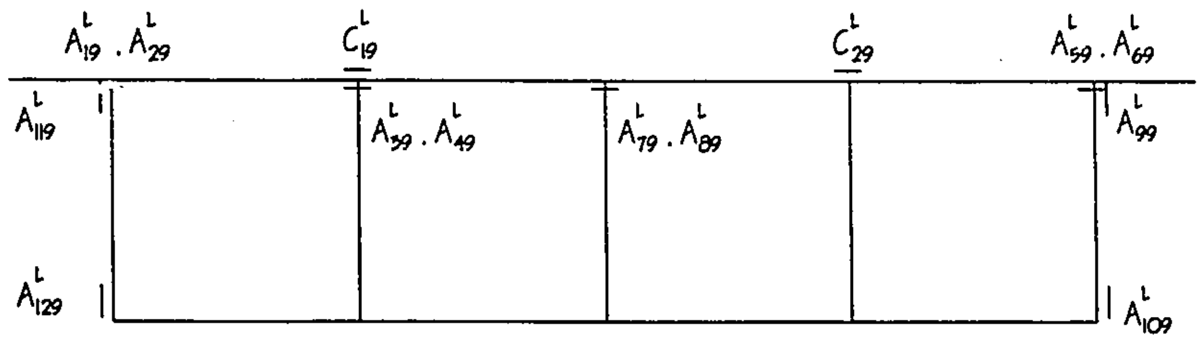


FIGURE 4.16 STRAIN GAUGES LOCATION



SECTION 8



SECTION 9

FIGURE 4.17 STRAIN GAUGES LOCATION

4.3.7.2 COPILOT Software For Data Acquisition

COPILOT is a system of integrated data acquisition and management modules that is designed to collect, display and manage scientific and engineering monitoring data. These integrated modules form a system that allows the collection and analysis of a large amount of data.

COPILOT operates sensors and Electronic Measurement System equipment (EMS Equipment) or Electronic Measurement and Control System equipment (EMCS Equipment) to the exact specification that one defines. Data read by the sensors are automatically processed and stored into a disk for future analysis. With COPILOT one can conduct monitoring over a period of hours or years and for a large number of locations. Once the data acquisition is completed, COPILOT can display on the screen, or print data tables and graphs. Furthermore, COPILOT manages data so it can be exported to other programs for further analysis.

COPILOT consists of three independent programs called modules. The COPILOT module is a program that acts as an entry point to the COPILOT package which consists of the following: [51]

1. CONFIGURE

The configure module allows the user to define a monitoring task that will tell COPILOT what data acquisition equipment and sensors to use, what data to gather, and how to process and save that data.

2. MONITOR

The monitor module performs real-time data acquisition using the monitoring task that was specified using the CONFIGURE module. This module operates the data acquisition system, measures sensors, perform calculations, and displays and stores data.

3. DISPLAY

The display module allows the user to view data, that the MONITOR has stored on a disk, in tables or graphs and export the stored data to a spreadsheet.

COPILOT utilizes pop-up menus that allows the user to get around the program and chooses task configuration, monitoring, and display options. All the available choices are displayed on the screen. However, when configuring a task, COPILOT prompts the user with parameter names and explanations and often offers the user choices of using default parameters values.

A total of 64 sensors were employed as follows:

Eight linear strain gauges type EA-06-500GB-120 were used to record the data at the bridge model's micro concrete deck surface at sections 4,8, and 9.

Eight 45° three-gauge rosette strain gauges type EA-13-125RA-120 were used to record the data on the outer surface of aluminum at sections 1,4,5, and 8.

Forty linear strain gauges type KEC-5-C1-11 were used to record data on the outer and inner surfaces of aluminum at sections 1,4,5,8 and 9.

The last eight were sensors and one of them was used to measure the load imposed by the jacks as shown in Fig. 4.18.

FIGURE 4.18 DATA ACQUISITION SYSTEM & STRAIN GAUGES.

4.3.7.3 Dial Gauges

Dial gauges with a sensitivity of 0.01 mm were employed in this experiment to measure the vertical displacement.

A total of 25 dial gauges were used to measure the vertical displacement of the bridge model and were denoted by V_{ij}. These dial gauges were mounted vertically under each web centerline at sections 2, 4, 5, 8, 9, 10, 13, 14, and 16 , and were supported by 3/8 " threaded rods bolted to steel angles that were clamped onto a separated steel frame underneath the bridge model.

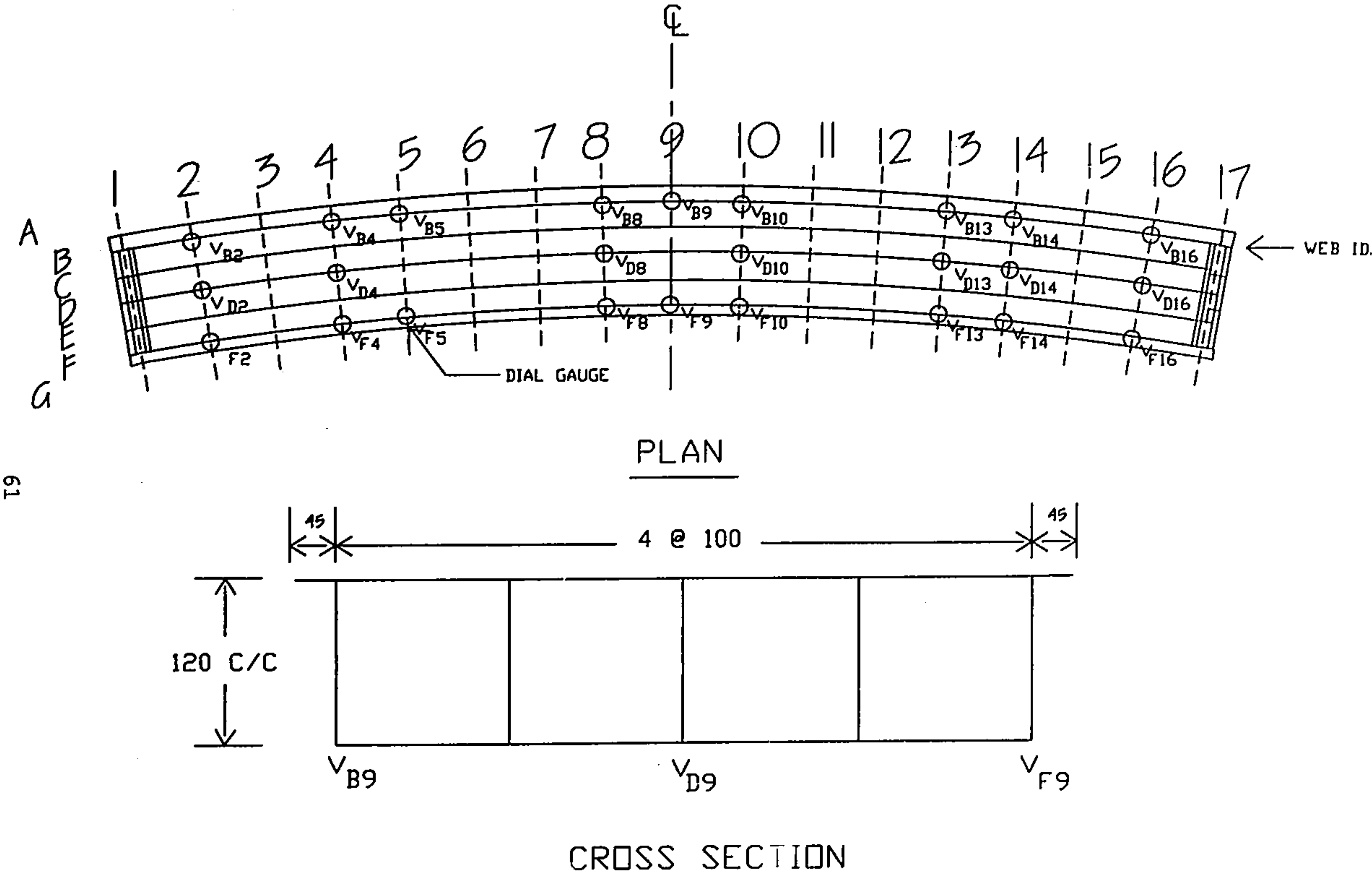
To facilitate the labelling and positioning these dial gauges, the bridge model was divided transversely into seven distinct tangential lines, namely A, B, C, D, E, F, and G. Lines A and G representing the bridge model extreme edges, and the other five line B, C, D, E, and F represent the center lines of the webs. Fig. 4.19 shows the location and identification of each dial gauge.

For example:

Dial gauge number V_{B2} refers to the vertical dial gauge under web B at section 2.

Table 4.8 Identification of Dial Gauge Numbers

Dial Gauge Number	Dial Gauge Identification
1	V_{B2}
2	V_{D2}
3	V_{F2}
4	V_{B4}
5	V_{D4}
6	V_{F4}
7	V_{B5}
8	V_{F5}
9	V_{B8}
10	V_{D8}
11	V_{F8}
12	V_{B9}
13	V_{B10}
14	V_{D10}
15	V_{F10}
16	V_{B13}
17	V_{D13}
18	V_{F13}
19	V_{B14}
20	V_{D14}
21	V_{F14}
22	V_{B16}
23	V_{D16}
24	V_{F16}
25	V_{F9}



ALL DIMENTSONS ARE IN mm

FIGURE 4.19 DIAL GAUGES LOCATIONS.

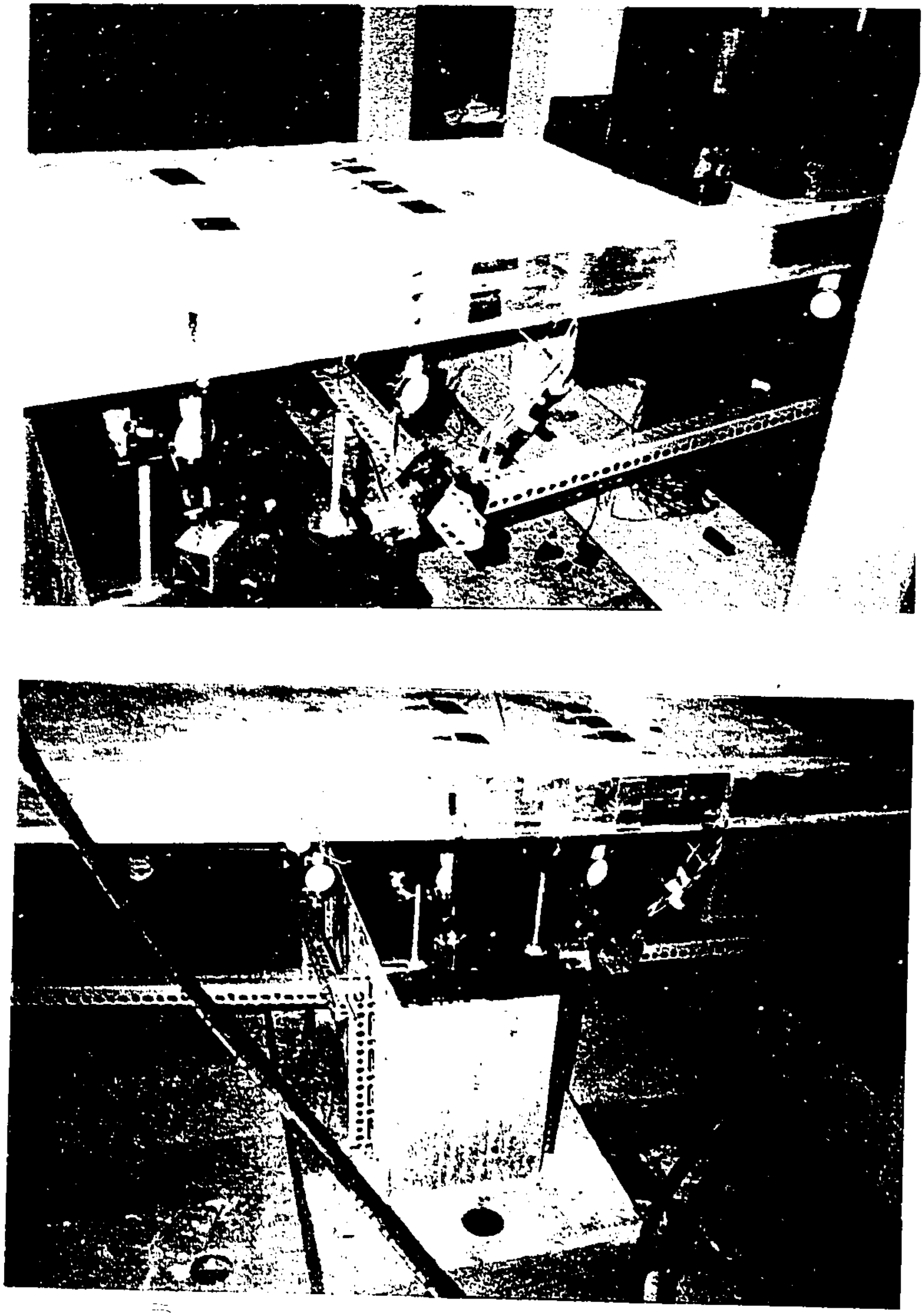


FIGURE 4.20 DIAL GAUGES SETUP.

4.4 Load Cases

A total of 9 load cases were considered in the linear experimental testing of the bridge model. OHBD truck load was adopted in all the load cases, instead of a point load. All the load cases were selected such that maximum stresses, strains, and deflections will occur at critical sections; namely, sections 5, 9, and 13.

In brief, six different load cases were considered with the central support located underneath web D. Another three different load cases were considered with the central support shifted 10 cm underneath web E. Figs. 4.21 to 4.25 show the trucks and central support locations for each load case.

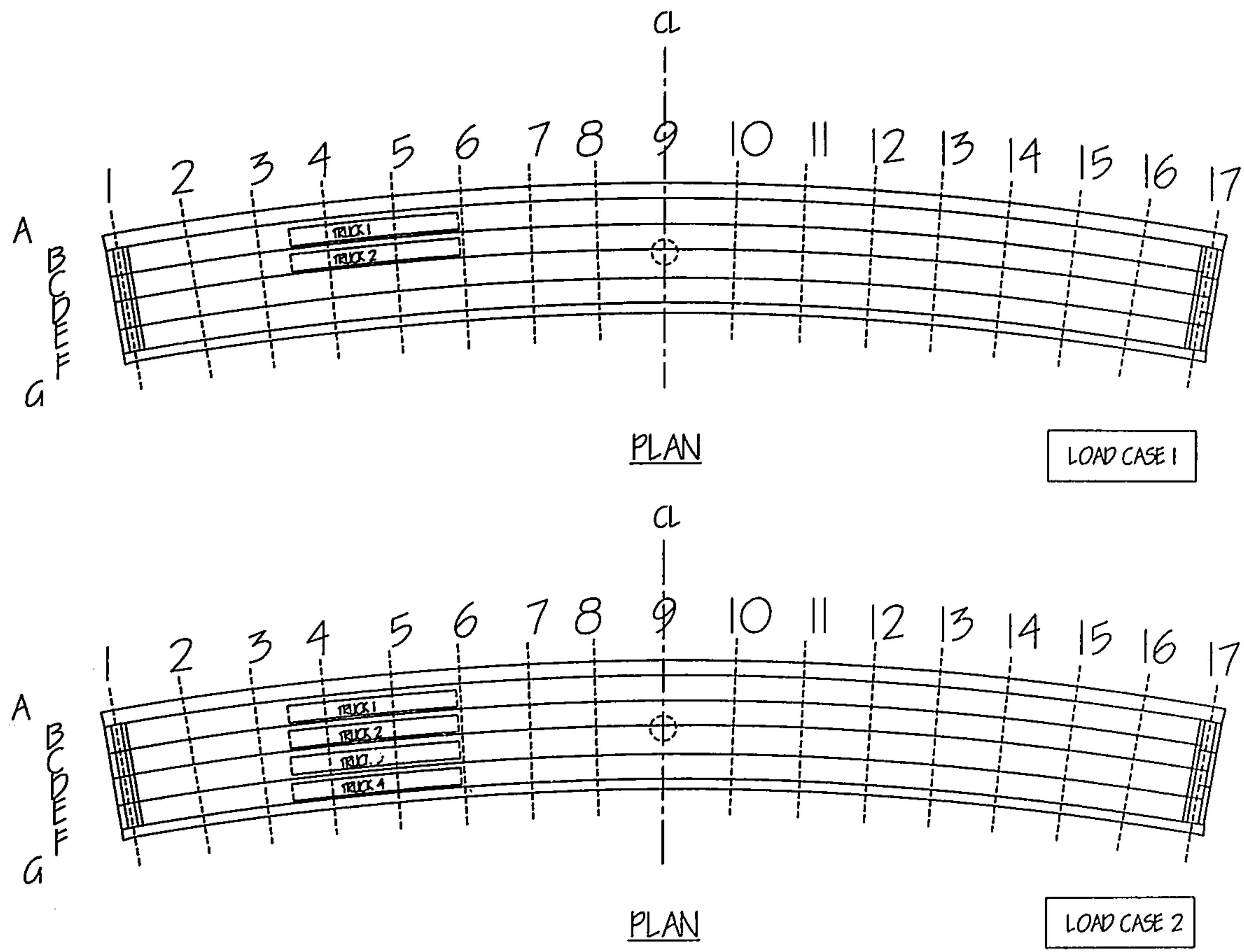


FIGURE 4.21 LINEAR LOAD SEQUENCE

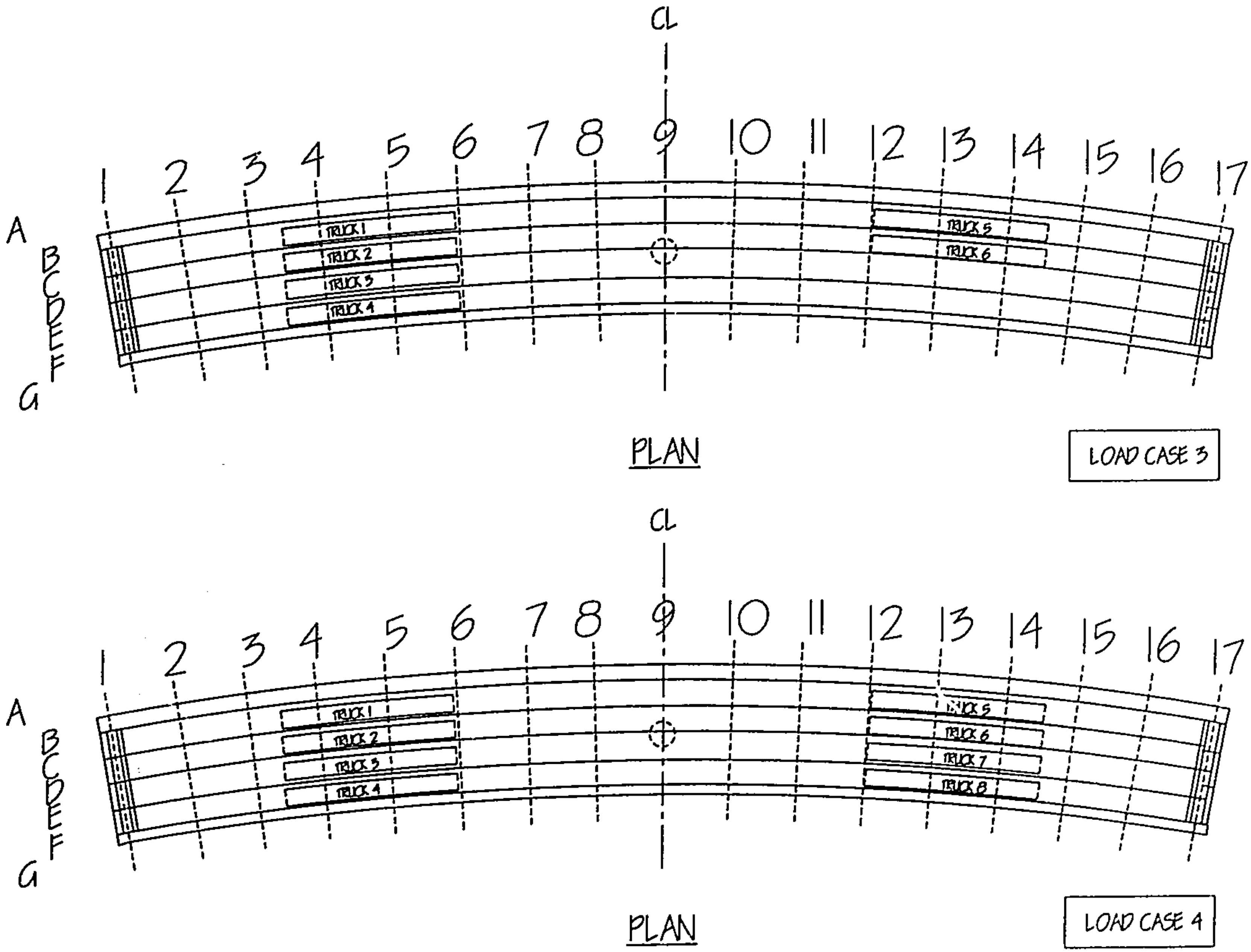
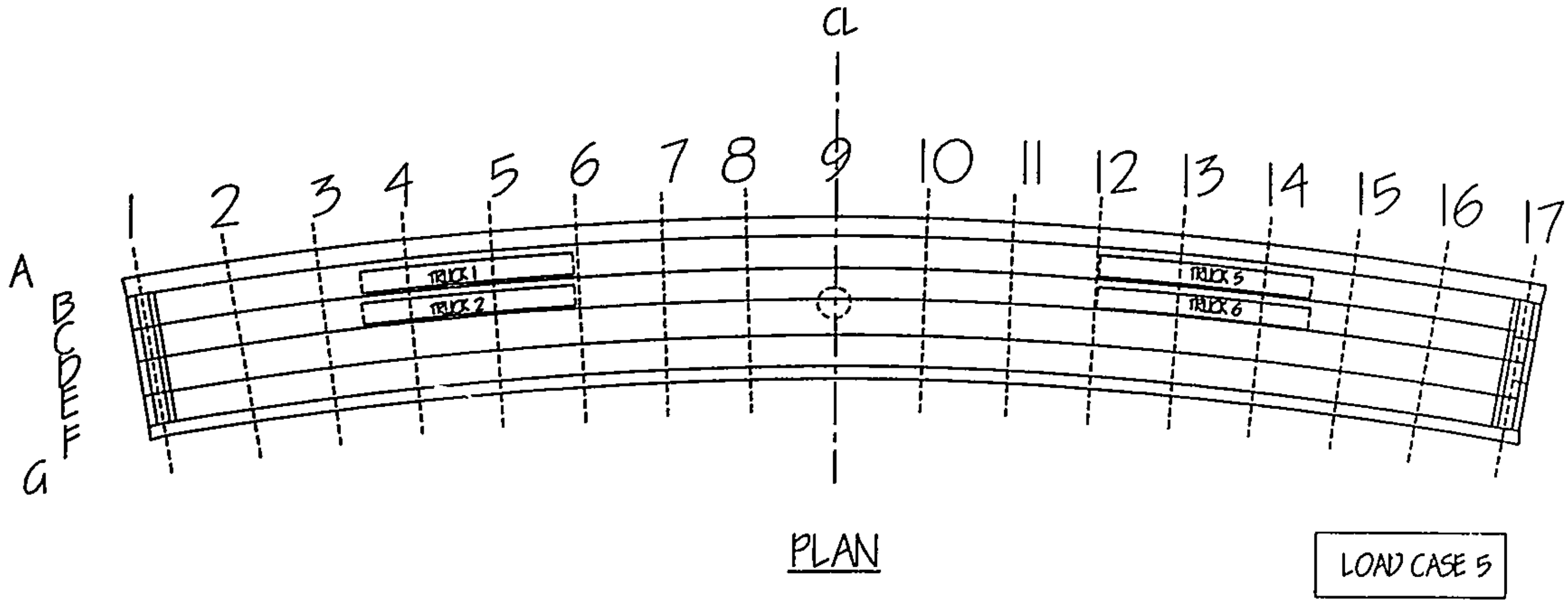


FIGURE 4.22 LINEAR LOAD SEQUENCE



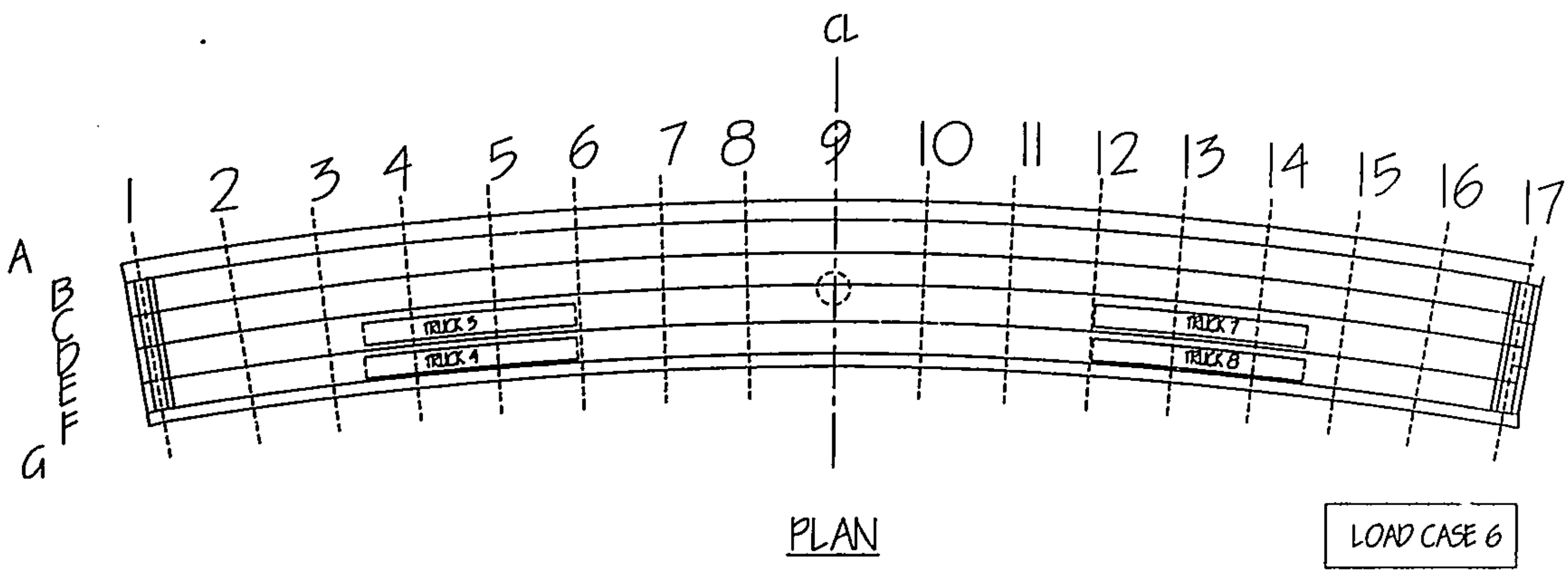
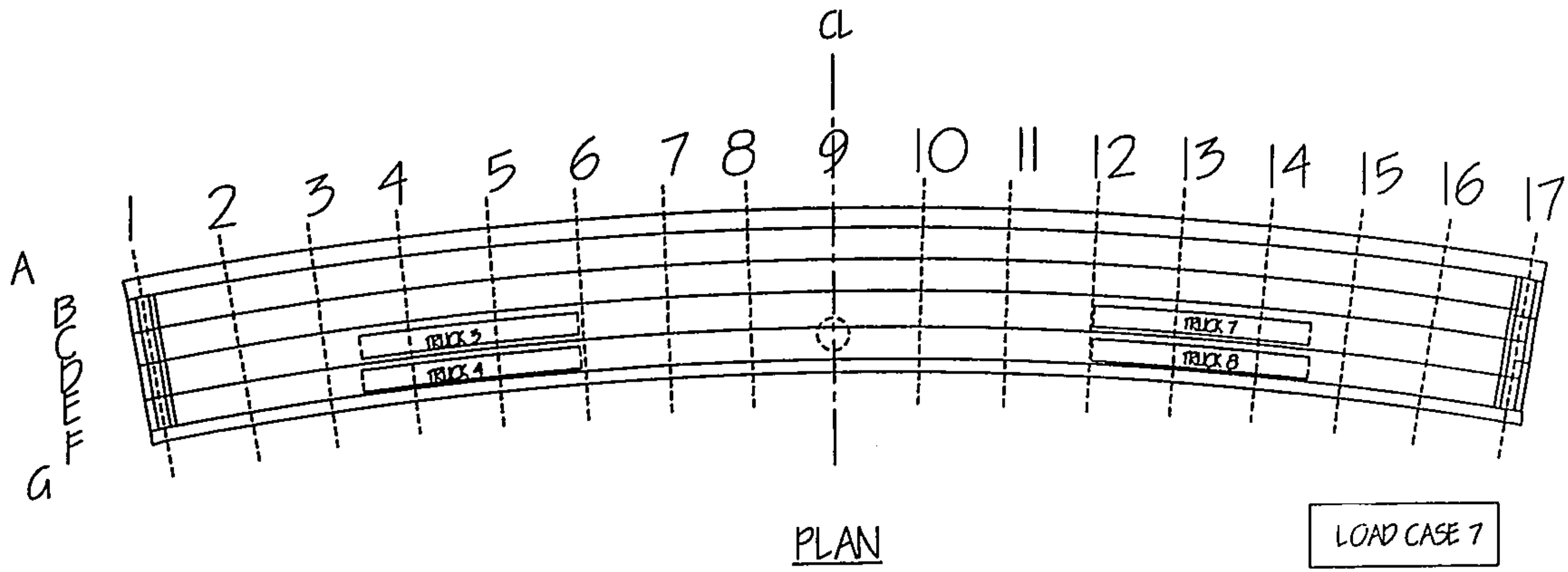


FIGURE 4.23 LINEAR LOAD SEQUENCE



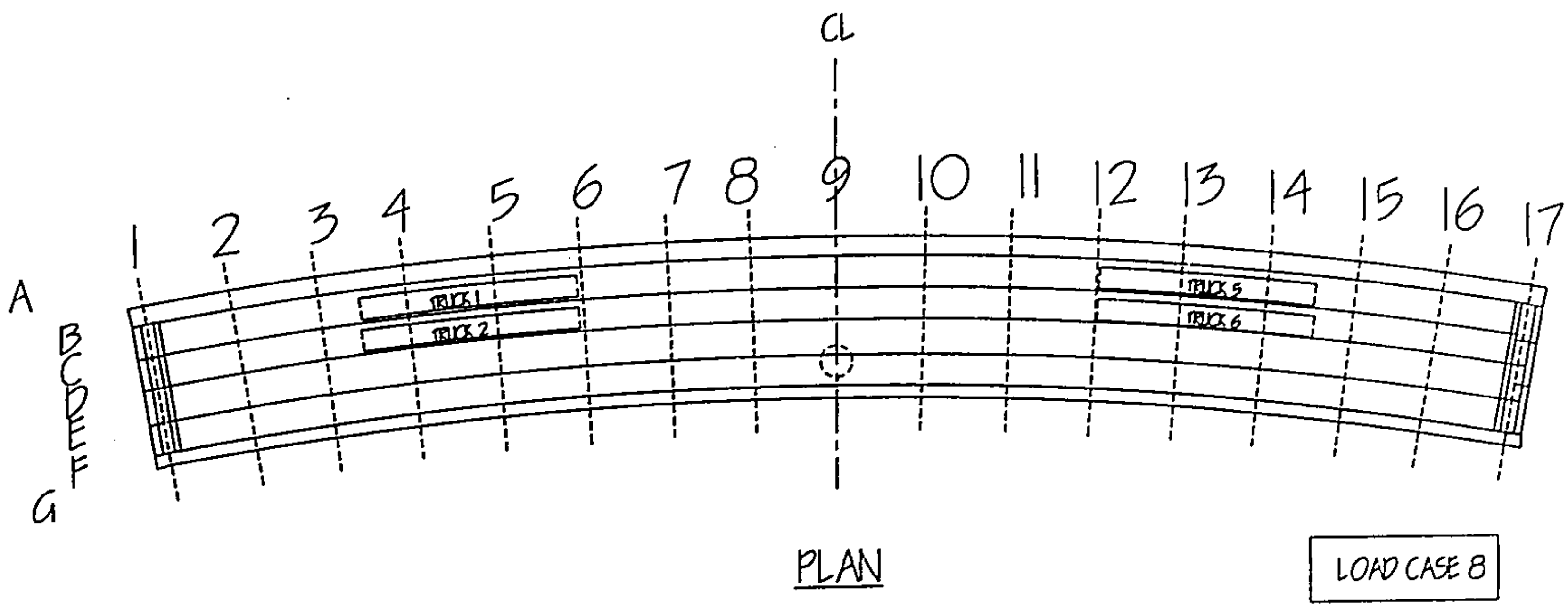


FIGURE 4.24 LINEAR LOAD SEQUENCE

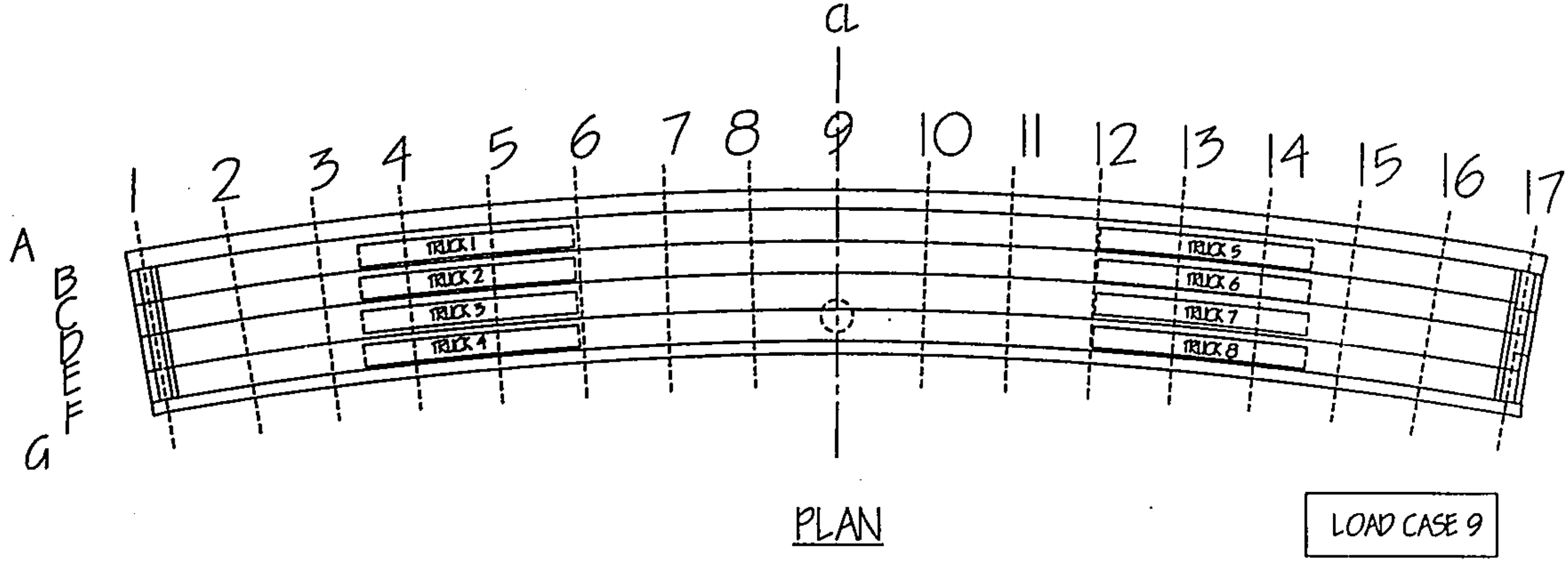


FIGURE 4.25 LINEAR LOAD SEQUENCE

4.5 Test Setup

After the bridge model was supported and leveled on the support system as described in section 4.3.5. Four hydraulic Enerpac jacks type RC 106 with a capacity of 10 ton each were installed, and were connected to a hydraulic Enerpac, 4-way pump, with a flow of 12 in^3/min. Then, the system was tested to insure that there is no oil leakage. Fig.4.26 shows a typical setup.

A total of 82 strain gauges were employed in the experiment, 56 of which were connected to the Data Acquisition COPILOT and remaining 26 strain gauges were connected to two different switch boxes as follows:

17 strain gauges were connected to two 10-channel, switch and balance boxes type BLH model 1225 that were connected in series to a single digital strain indicator type BLH.

The remaining nine strain gauges were connected to a 10-channel, switch and balancing unit type BLH model MINEBEA 7501 that was connected to a digital strain indicator type BLH model MINEBEA PSD-702.

Table 4.9 A. Identification of Strain Gauge Numbers

Strain Gauge #.	Strain Gauge I.D
1	A^{L}_{58}
2	A^{RL}_{38}
3	A^{RD}_{38}
4	A^{RT}_{38}
5	A^{L}_{68}
6	A^{L}_{78}
7	A^{RL}_{18}
8	A^{RD}_{18}
9	A^{RT}_{18}
10	A^{L}_{48}
11	A^{L}_{28}
12	A^{RD}_{35}
13	A^{RL}_{35}
14	A^{RT}_{35}
15	A^{L}_{75}

Table 4.9 B. Identification of Strain Gauge Numbers

Strain Gauge #.	Strain Gauge I.D
16	A^{L}_{65}
17	A^{L}_{18}
18	A^{RD}_{11}
19	A^{RL}_{11}
20	A^{RT}_{11}
21	A^{RD}_{21}
22	A^{RL}_{21}
23	A^{RT}_{21}
24	A^{RD}_{34}
25	A^{RL}_{34}
26	A^{RT}_{34}
27	A^{RD}_{14}
28	A^{RL}_{14}
29	A^{RT}_{14}
30	A^{RD}_{15}
31	A^{RL}_{15}
32	A^{RT}_{15}
33	A^{L}_{15}
34	A^{L}_{25}
35	A^{L}_{69}
36	A^{L}_{59}
37	A^{L}_{118}
38	A^{L}_{128}
39	A^{L}_{124}
40	A^{L}_{114}

Table 4.9 C. Identification of Strain Gauge Numbers

Strain Gauge #.	Strain Gauge I.D
41	A^{L}_{105}
42	A^{L}_{104}
43	A^{L}_{108}
44	A^{L}_{95}
45	A^{L}_{98}
46	A^{L}_{79}
47	A^{L}_{89}
48	A^{L}_{34}
49	A^{L}_{84}
50	A^{L}_{85}
51	A^{L}_{88}
52	A^{L}_{35}
53	A^{L}_{38}
54	A^{L}_{39}
55	A^{L}_{19}
56	A^{L}_{29}
57	C^{L}_{14}
58	C^{L}_{24}
59	C^{L}_{34}
60	A^{L}_{64}
61	A^{L}_{74}
62	A^{L}_{119}
63	A^{L}_{129}
64	A^{L}_{14}
65	A^{RL}_{24}

Table 4.9 D. Identification of Strain Gauge Numbers

Strain Gauge #.	Strain Gauge I.D
66	A^{RT}_{24}
67	A^{RD}_{24}
88	A^{RT}_{44}
69	A^{RD}_{44}
70	A^{RL}_{44}
71	A^{L}_{54}
72	A^{L}_{24}
73	A^{RT}_{28}
74	A^{RD}_{28}
75	A^{RL}_{28}
76	A^{L}_{99}
77	A^{L}_{109}
78	A^{L}_{18}
79	A^{L}_{29}
80	A^{L}_{19}
81	A^{L}_{28}
82	A^{L}_{38}

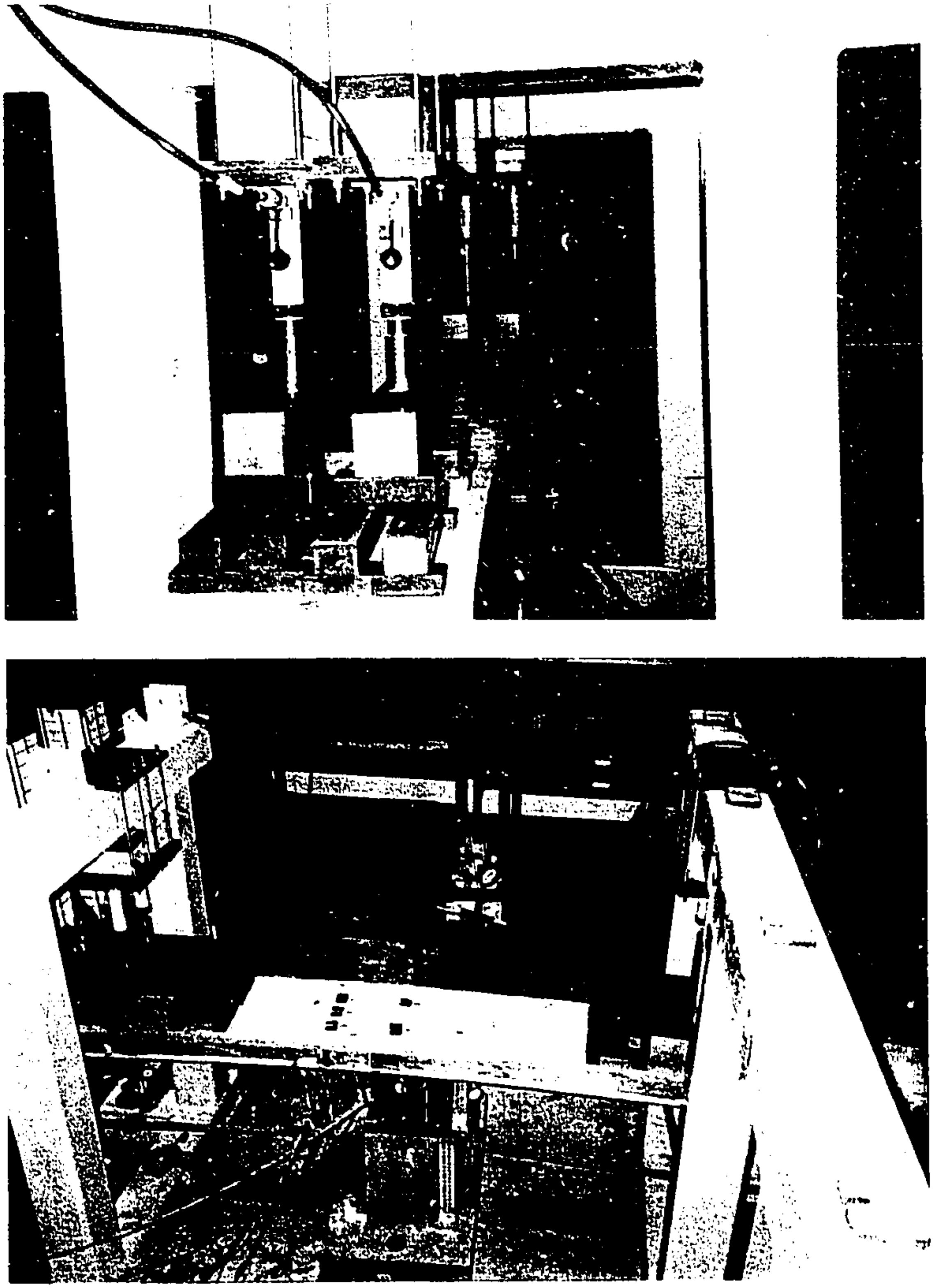


FIGURE 4.26 TYPICAL SETUP.

4.6 Test Procedure

The test procedure for all load cases consisted of three stages;

a. Prior to loading stage.

b. Loading stage.

c. Unloading stage.

1. Prior to loading:

At this stage, all dial gauges were checked and set to zero reading, then according to the load case number, the jacks were hooked to the pump in order to activate them.

2. Loading stage:

During this stage, load increments were applied on the loading system, then the dial gauges readings along with the manual strain gauges were recorded. The strain gauges that were connected to the data acquisition system were recorded every 10 seconds.

3. Unloading stage:

In the unloading stage, load was released in steps until zero load is reached, and the strain and dial gauges readings were recorded. Not all load cases were recorded during the unloading stage, due to the large amount of readings that had to be recorded. After it was checked that, in each loading case, the loading and unloading readings are in agreement, six of the nine load cases readings were recorded in the unloading stage.

The load increments for each load case are as follows:

Table 4.10 Loading Steps For Load Case One

Load #	Total Load (N)
1	3,000
2	5,000
3	7,000
4	10,000

Table 4.11 Loading Steps For Load Case Two

Load #	Total Load (N)
1	3,800
2	6,900
3	9,500
4	15,000
5	10,200
6	6,300
7	0

Table 4.12 Loading Steps For Load Case Three

Load #	Total Load (N)
1	10,700
2	15,500
3	21,600
4	28,000
5	21,900
6	14,500
7	8,200
8	0

Table 4.13 Loading Steps For Load Case Four

Load #	Total Load (N)
1	9,600
2	15,000
3	21,000
4	26,700
5	17,000
6	11,000
7	0

Table 4.14 Loading Steps For Load Case Five

Load #	Total Load (N)
1	4,500
2	7,200
3	11,000
4	15,000
5	10,500
6	7,400
7	4,500
8	0

Table 4.15 Loading Steps For Load case Six

Load #	Total Load (N)
1	6,100
2	9,000
3	12,000
4	15,800

Table 4.16 Loading Steps For Load Case Seven

Load #	Total Load (N)
1	5,000
2	7,000
3	10,000
4	15,000
5	10,000
6	7,000
7	5,000
8	0

Table 4.17 Loading Steps For Load Case Eight

Load #	Total Load (N)
1	2,500
2	5,300
3	8,000
4	10,500

Table 4.18 Loading Steps For Load Case Nine

Load #	Total Load (N)
1	5,000
2	7,500
3	10,000
4	14,000
5	19,500

4.7 Experimental Results

All the experimental data recorded using the data acquisition system COPILOT were exported into a spreadsheet format, and the software Excel version 5.0 for windows were employed to read these exported data.

The fact that the data acquisition system COPILOT was recording data every ten seconds, made the amount of data collected very huge. To overcome the difficulty of working with such a huge amount of data, an average of each load step along with its corresponding strain were calculated using the software Excel, and then Strain Vs Load graphs for each section with respect to each load step were generated showing the linearity of the system during the loading and unloading steps.

As for the deflections, all the dial gauges readings were recorded manually and then entered into a spreadsheet, then the software Quattro Pro. version 6.0 for windows was used to produce the Deflection Vs Load graphs with respect to each dial gauge at certain pre-located sections.

The classical Hook's Law was used for the calculation of the stresses from the experimental strain data namely;

$$\sigma = E\varepsilon \tag{4-14}$$

Where:

E : young's modulus.

ε : experimental strain reading.

As for the calculations of the principal stresses and their directions, the following relations were used [52].

The Principal Strain:

$$\varepsilon=\frac{\varepsilon_a+\varepsilon_c}{2}\pm\frac{1}{\sqrt{2}}\sqrt{(\varepsilon_a-\varepsilon_b)^2+(\varepsilon_b-\varepsilon_c)^2} \tag{4-15}$$

Then to determine the stress, equation 4-14 was used.

The direction of the principal stress:

$$\tan 2\theta=\frac{\varepsilon_a+\varepsilon_c-2\varepsilon_b}{\varepsilon_a-\varepsilon_c} \tag{4-16}$$

Where:

$$\varepsilon_a=A^{RL} \tag{4-17}$$

$$\varepsilon_b=A^{RD} \tag{4-18}$$

$$\varepsilon_c=A^{RT} \tag{4-19}$$

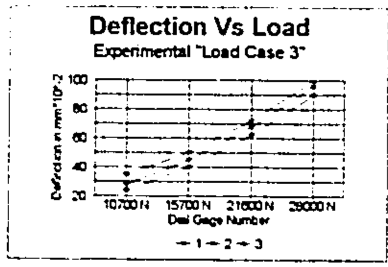
Where ε_a, ε_b, and ε_c denotes the longitudinal, diagonal, and transverse strain component in the rosette plane.

However, in this Chapter and due to the huge amount of data collected during the experiment, only the data and the calculations for load cases 3, 4, and 5 are shown in this Chapter and the rest of the data are included in appendix B of this thesis.

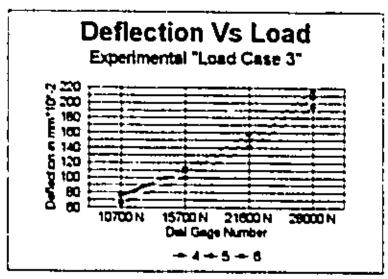
Also, since it was found that most of the rosette readings were small and unstable, the strain recordings were unreliable. Although the principal stresses and their directions were calculated based on the rosette gauge readings (shown in appendex B Tables B15 to B41) no comparison of these values are made with ADINA.

LOADING

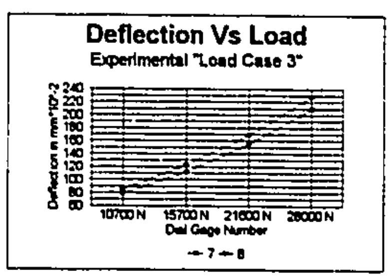
	Dial Gage #	Load "1" 10700 N	Load "2" 15700 N	Load "3" 21600 N	Load "4" 28000 N
Section# 2	1	35	50	72	100
	2	28	45	68	96
	3	24	40	62	90



Section# 4	4	76	112	158	216
	5	75	108	149	208
	6	65	100	141	195



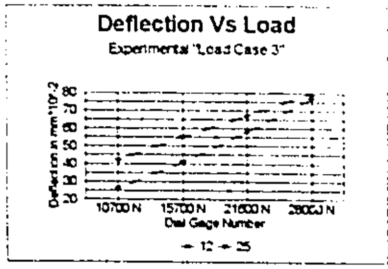
Section# 5	7	85	123	168	228
	8	79	112	155	209



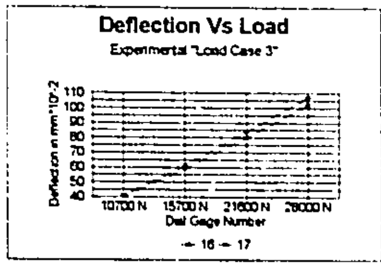
Section# 9	12	42	55	67	80
	25	26	41	58	77

FIGURE 4.27 DEFLECTION VS. LOAD FOR LOAD CASE 3

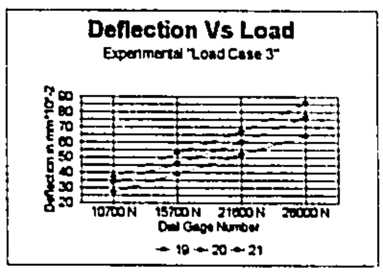
LOADING



Section# 13	16	41	61	84	107
	17	40	59	80	102



Section# 14	19	37	53	67	86
	20	33	46	60	77
	21	27	39	52	64



Section# 16					
	23	16	23	30	38
	24	15	20	25.5	30.5

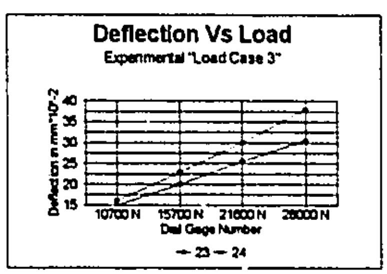
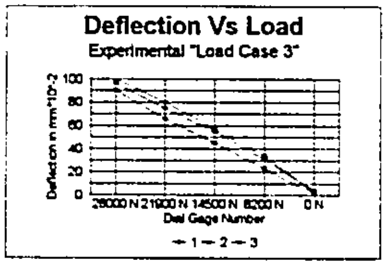


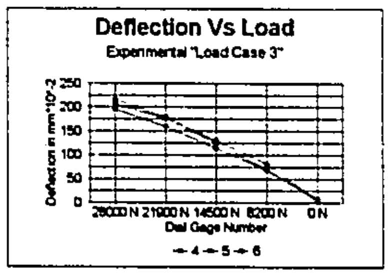
FIGURE 4.28 DEFLECTION VS. LOAD FOR LOAD CASE 3

UNLOADING

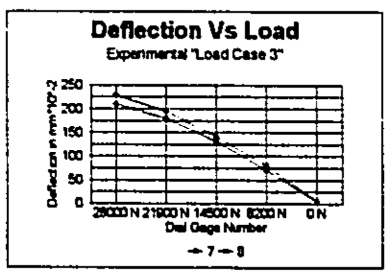
	Dial Gage #	Load "1" 28000 N	Load "2" 21900 N	Load "3" 14500 N	Load "4" 8200 N	Load "5" 0 N
Section# 2	1	100	80	57	34	2
	2	96	75	55	31	4
	3	90	66	45	23	1



Section# 4	4	216	180	130	81	3
	5	208	176	125	69	6
	6	195	160	115	68	8



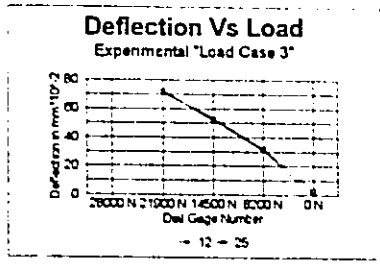
Section# 5	7	228	195	141	80	5
	8	209	180	132	71	5



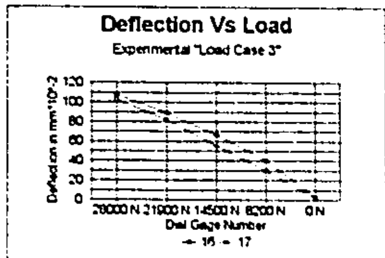
Section# 9	12	80	72	52	31	0
	25	77	71	53	32	3

FIGURE 4.29 DEFLECTION VS. LOAD FOR LOAD CASE 3

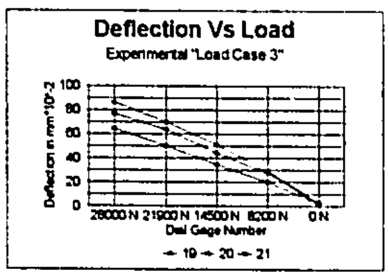
UNLOADING



Section# 13	16	107	89	66	40	3
	17	102	82	55	30	2



Section# 14	19	86	70	51	29	1
	20	77	63.5	44.5	28	3
	21	64	50	35	20	2



Section# 16	23	38	30	23	15	5
	24	30.5	25	19	12	6

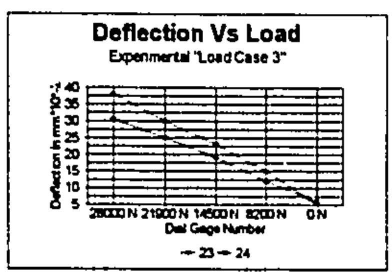
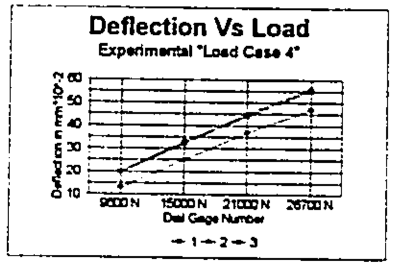


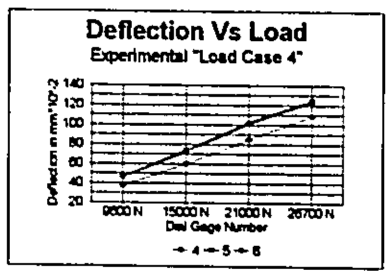
FIGURE 4.30 DEFLECTION VS. LOAD FOR LOAD CASE 3

LOADING

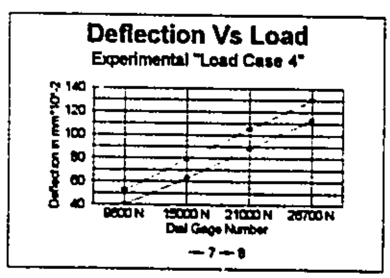
	Dial Gage #	Load "1" 9600 N	Load "2" 15000 N	Load "3" 21000 N	Load "4" 26700 N
Section# 2	1	20	32	45	56
	2	20	33	44	55
	3	13	25	37	47



Section# 4	4	46	74	102	125
	5	46	72	101	123
	6	37	60	85	109



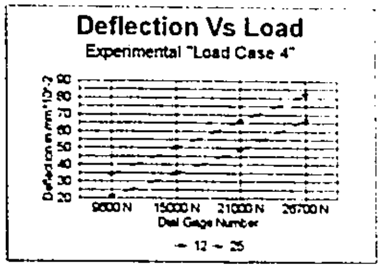
Section# 5	7	52	79	105	130
	8	40	63	88	113



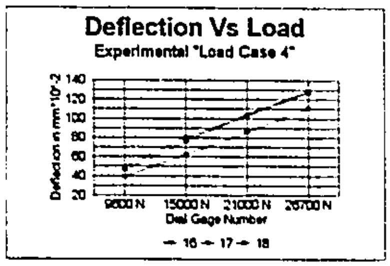
Section# 9	12	34	50	66	82
	25	21	35	49	67

FIGURE 4.31 DEFLECTION VS. LOAD FOR LOAD CASE 4

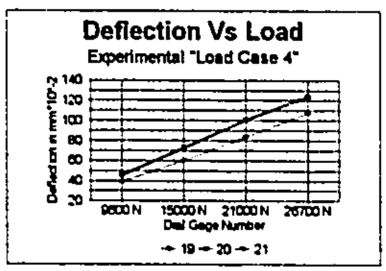
LOADING



Section# 13	16	46	76	104	127
	17	49	80	103	129
	18	39	62	86	111



Section# 14	19	46	73	101	125
	20	45	72	100	123
	21	39	60	84	108



Section# 16

23	20	31	43	54
24	14	25	36	47

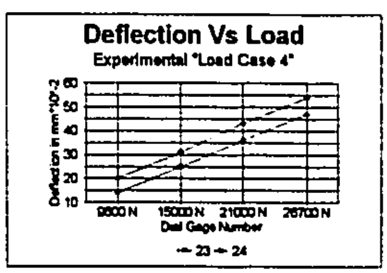
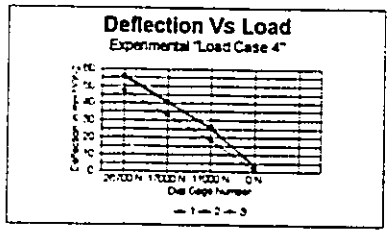


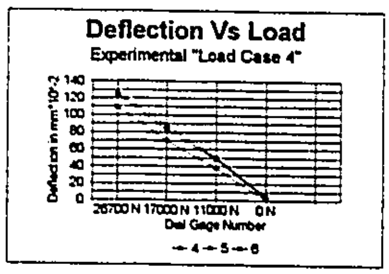
FIGURE 4.32 DEFLECTION VS. LOAD FOR LOAD CASE 4

UNLOADING

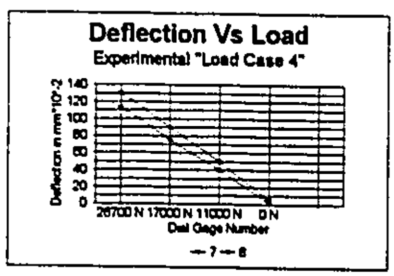
	Dial Gage #	Load "1" 26700 N	Load "2" 17000 N	Load "3" 11000 N	Load "4" 0 N
Section# 2	1	56	41	26	3
	2	55	40	25	4
	3	47	33	18	1



	Dial Gage #	Load "1" 26700 N	Load "2" 17000 N	Load "3" 11000 N	Load "4" 0 N
Section# 4	4	125	88	50	5
	5	123	83	48	3
	6	109	70	38	1



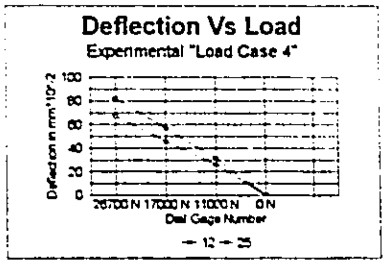
	Dial Gage #	Load "1" 26700 N	Load "2" 17000 N	Load "3" 11000 N	Load "4" 0 N
Section# 5	7	130	90	50	5
	8	113	75	40	2



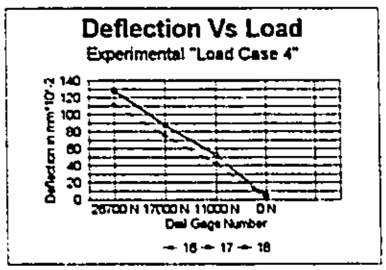
	Dial Gage #	Load "1" 26700 N	Load "2" 17000 N	Load "3" 11000 N	Load "4" 0 N
Section# 9	12	82	57	31	0
	25	67	46	26	0

FIGURE 4.33 DEFLECTION VS. LOAD FOR LOAD CASE 4

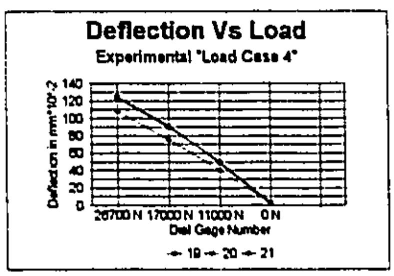
UNLOADING



Section# 13	16	127	87	52	5
	17	129	88	53	1
	18	111	75	42	2



Section# 14	19	125	91	48	1
	20	123	90	50	3
	21	108	75	40	2



Section# 16	23	54	38	21	2
	24	47	30	15	0

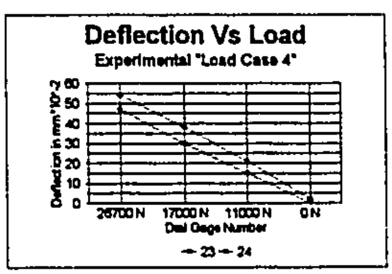
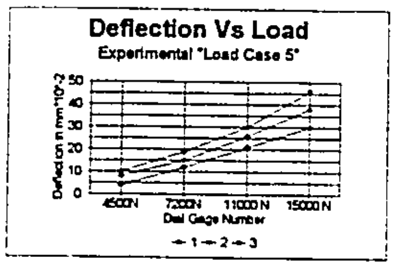


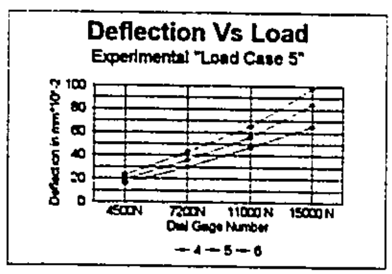
FIGURE 4.34 DEFLECTION VS. LOAD FOR LOAD CASE 4

LOADING

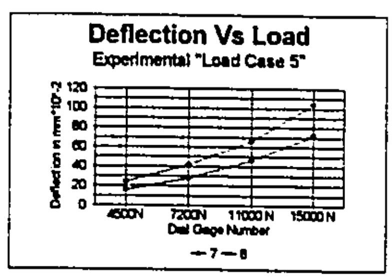
	Dial Gage #	Load "1" 4500N	Load "2" 7200N	Load "3" 11000 N	Load "4" 15000 N
Section# 2	1	10	19	30	46
	2	8	15	26	38
	3	4	12	21	30



Section# 4	4	23	43	65	98
	5	19	36	56	84
	6	16	30	47	65



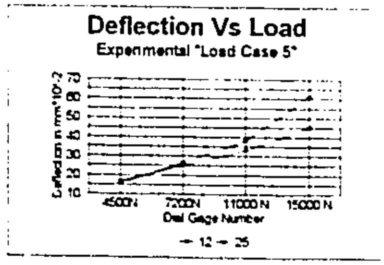
Section# 5	7	24	42	66	104
	8	16	28	46	72



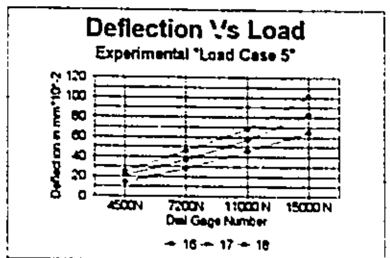
Section# 9	12	15.5	26.5	38	61
	25	16.5	25	33	45

FIGURE 4.35 DEFLECTION VS. LOAD FOR LOAD CASE 5

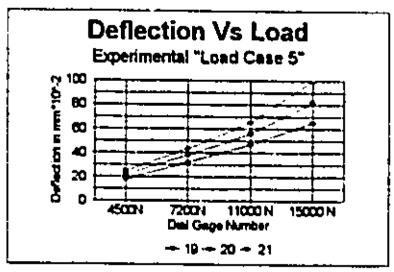
LOADING



Section# 13	16	25	46	68	101
	17	21	37	57	83
	18	14	28	46	65



Section# 14	19	25	43	65	100
	20	22	38	56	82
	21	18	32	47	65



Section# 16	22	13	22	32	47
	23	10	18	26	38
	24	7	13	21.5	30

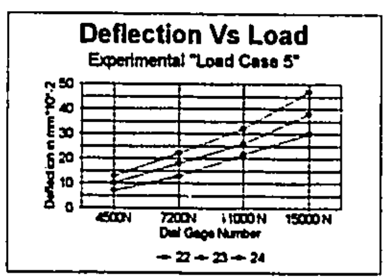
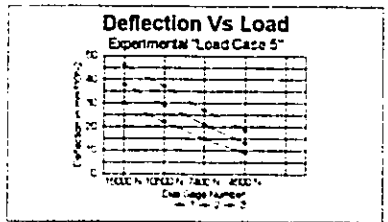


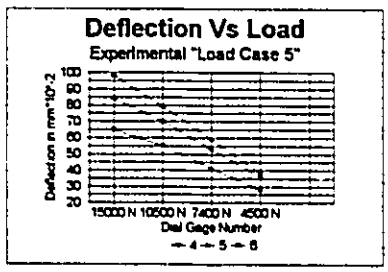
FIGURE 4.36 DEFLECTION VS. LOAD FOR LOAD CASE 5

UNLOADING

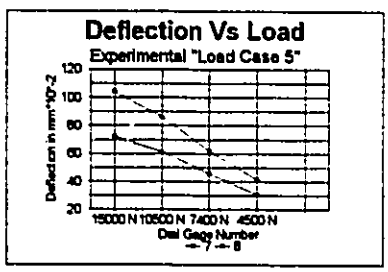
	Dial Gage #	Load "1" 15000 N	Load "2" 10500 N	Load "3" 7400 N	Load "4" 4500 N
Section# 2	1	46	37	27	18.5
	2	38	29	21	13
	3	30	22	15	9



Section# 4	4	98	79	59	38
	5	84	70	53	36
	6	65	55	41	28



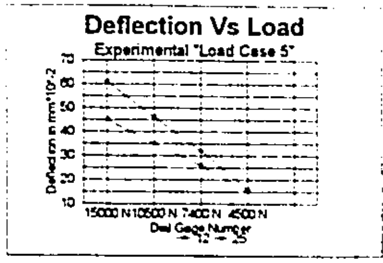
Section# 5	7	104	86	62	41.5
	8	72	61	46	30.5



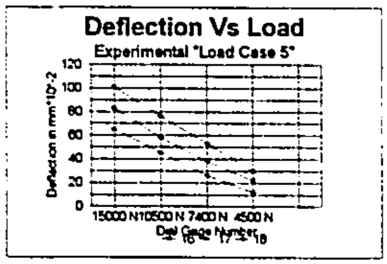
Section# 9	12	61	46	32	16
	25	45	35	26	15

FIGURE 4.37 DEFLECTION VS. LOAD FOR LOAD CASE 5

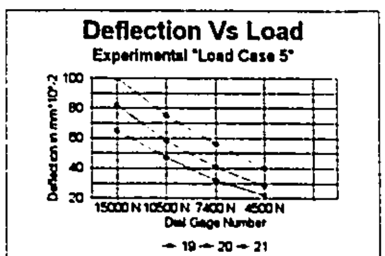
UNLOADING



Section# 13	16	101	76	53	30
	17	83	58	38	22
	18	65	45	26	12



Section# 14	19	100	75	56	40
	20	82	58	41	28
	21	65	47	32	22



Section# 16	23	38	28	20	13
	24	30	23	15	8

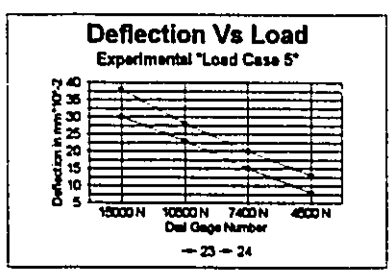
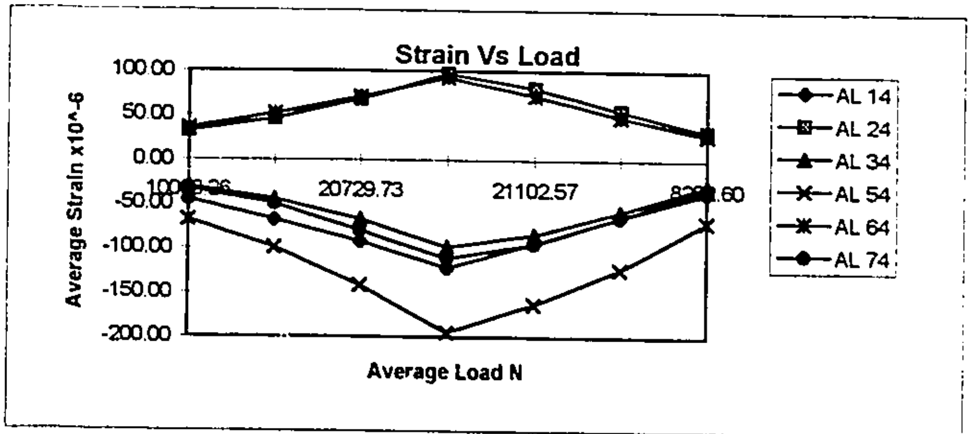


FIGURE 4.38 DEFLECTION VS. LOAD FOR LOAD CASE 5

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	10003.26	-45.00	32.00	-30.57	-68.00	35.00	-33.00
Load 2	14764.93	-68.00	46.00	-45.37	-99.00	52.00	-50.00
Load 3	20729.73	-92.00	68.00	-66.96	-142.00	71.00	-80.00
Load 4	27799.52	-122.00	97.00	-98.24	-195.00	93.00	-111.00
Load 5	21102.57	-94.00	81.00	-84.28	-163.00	72.00	-95.00
Load 6	14549.84	-64.00	55.00	-58.61	-123.00	49.00	-64.00
Load 7	8252.60	-37.00	32.00	-28.46	-70.00	28.00	-32.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain M1 CL 14	Strain M2 CL 24	Strain M3 CL 34
Load 1	10003.26	30.67	37.76	-40.38	-37.00	-38.00	-35.00
Load 2	14764.93	53.36	59.51	-[illegible]0.73	-53.00	-52.00	-54.00
Load 3	20729.73	79.21	85.78	-89.37	-78.00	-79.00	-80.00
Load 4	27799.52	107.77	119.12	-121.40	-106.00	-108.00	-107.00
Load 5	21102.57	88.21	101.64	-100.80	-83.00	-84.00	-82.00
Load 6	14549.84	60.59	70.08	-70.49	-55.00	-55.00	-57.00
Load 7	8252.60	30.61	34.73	-37.58	-29.00	-28.00	-30.00

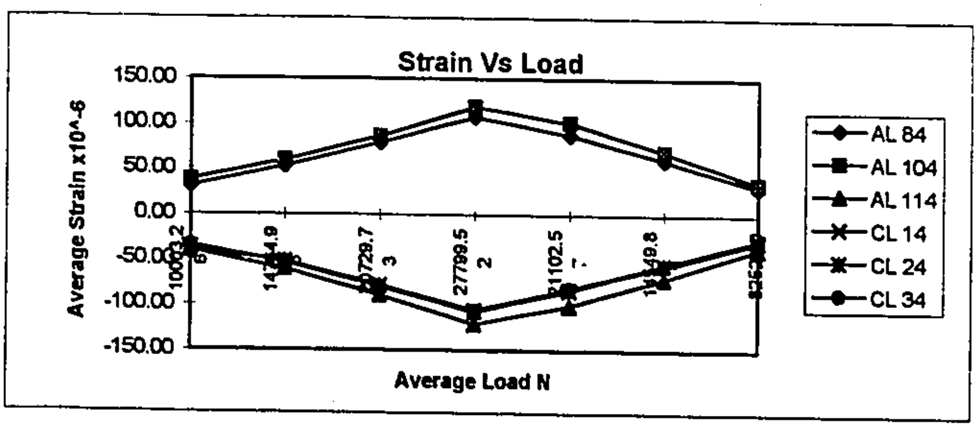


FIGURE 4.39 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 3

SECTION 5

	Average Load N	Strain 33	Strain 52	Strain 16	Strain 15	Strain 50	Strain 44	Strain 41
		AL 15	AL 35	AL 65	AL 75	AL 85	AL 95	AL 105
Load 1	10003.26	-47.34	-33.53	48.13	-68.21	16.45	-11.75	51.03
Load 2	14764.93	-69.90	-56.87	73.02	-89.77	47.60	-16.90	81.53
Load 3	20729.73	-98.23	-78.82	104.62	-115.65	80.42	-24.75	110.43
Load 4	27799.52	-131.35	-105.64	147.85	-144.03	125.35	-35.18	148.46
Load 5	21102.57	-99.43	-84.35	125.36	-119.49	98.11	-26.75	129.39
Load 6	14549.84	-68.33	-60.16	91.26	-90.30	66.96	-17.45	96.84
Load 7	8252.60	-38.57	-32.32	51.16	-56.68	35.22	-9.54	59.77

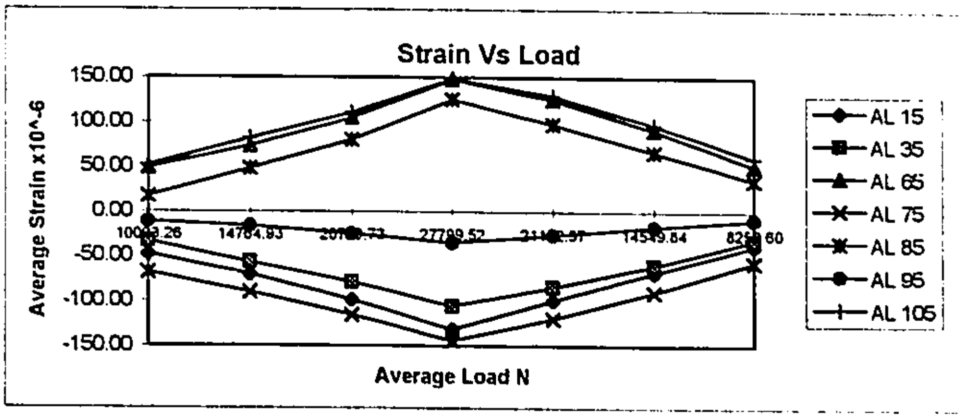
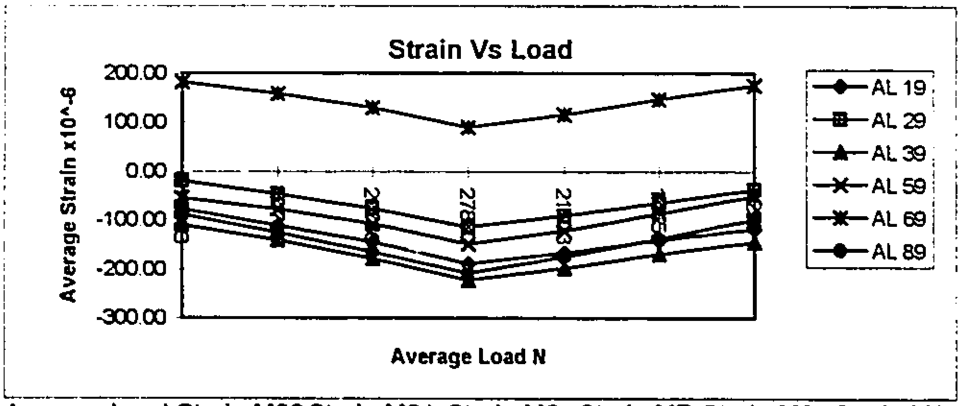


FIGURE 4.40 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 3

SECTION 9

	Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
		AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
Load 1	10003.26	-78.00	-20.00	-110.00	-54.96	181.67	-88.00
Load 2	14764.93	-111.31	-47.07	-141.70	-78.13	158.74	-125.00
Load 3	20729.73	-145.00	-77.00	-178.00	-107.54	130.44	-165.00
Load 4	27799.52	-188.79	-113.65	-221.98	-148.65	90.72	-208.00
Load 5	21102.57	-166.82	-90.15	-197.77	-121.17	115.66	-175.00
Load 6	14549.84	-141.56	-65.00	-169.23	-86.68	147.07	-138.00
Load 7	8252.60	-117.31	-37.62	-144.48	-51.16	175.39	-98.68



	Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
		AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
Load 1	10003.26	35.00	-5.00	18.00	-28.00	-11.00	-19.00
Load 2	14764.93	56.00	-11.00	27.00	-43.00	-17.00	-28.00
Load 3	20729.73	81.00	-19.00	40.00	-61.00	-27.00	-37.00
Load 4	27799.52	114.00	-26.00	52.00	-84.00	-34.00	-50.00
Load 5	21102.57	91.00	-18.00	40.00	-67.00	-26.00	-42.00
Load 6	14549.84	64.00	-10.00	25.00	-45.00	-17.00	-32.00
Load 7	8252.60	35.00	-4.00	13.00	-24.00	-8.00	-22.00

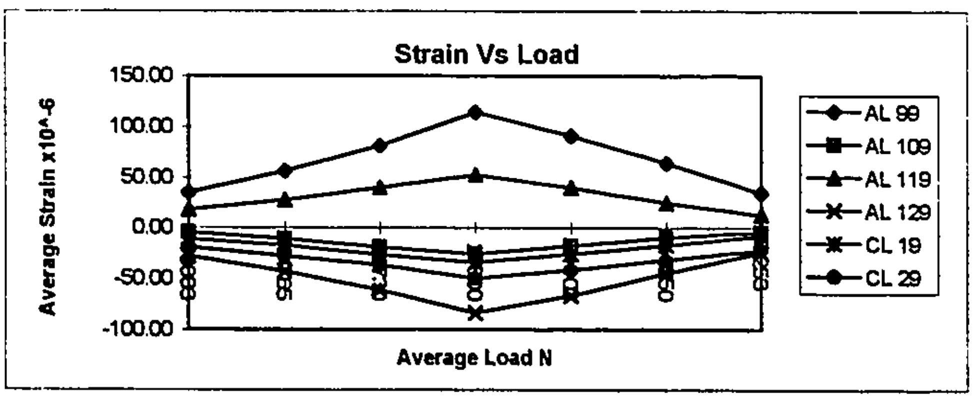
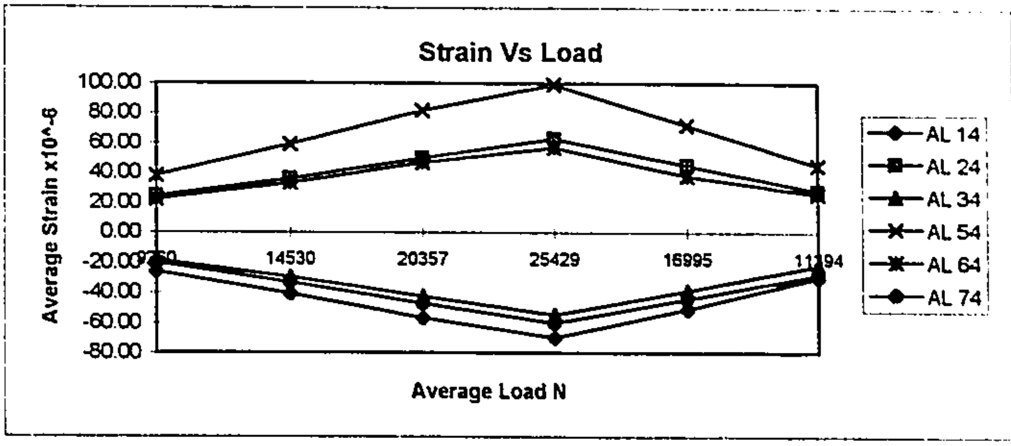


FIGURE 4.41 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 3

Load Case 4

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	9259.80	-26.00	24.00	-18.59	38.00	22.00	-20.00
Load 2	14530.00	-41.00	36.00	-29.97	59.00	33.00	-33.00
Load 3	20356.56	-57.00	50.00	-42.69	82.00	47.00	-47.00
Load 4	25428.73	-70.00	63.00	-54.76	99.00	57.00	-60.00
Load 5	16994.52	-51.00	45.00	-38.74	72.00	38.00	-44.00
Load 6	11394.15	-30.00	28.00	-21.75	45.00	26.00	-28.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain M1 CL 14	Strain M2 CL 24	Strain M3 CL 34
Load 1	9259.80	25.14	25.61	-26.25	-23.00	-24.00	-24.00
Load 2	14530.00	36.90	37.41	-39.13	-36.00	-35.00	-33.00
Load 3	20356.56	51.88	53.94	-55.84	-50.00	-52.00	-51.00
Load 4	25428.73	64.42	67.59	-69.73	-64.00	-66.00	-65.00
Load 5	16994.52	51.26	50.57	-52.41	-44.00	-41.00	-43.00
Load 6	11394.15	32.75	33.38	-35.19	-23.00	-24.00	-23.00

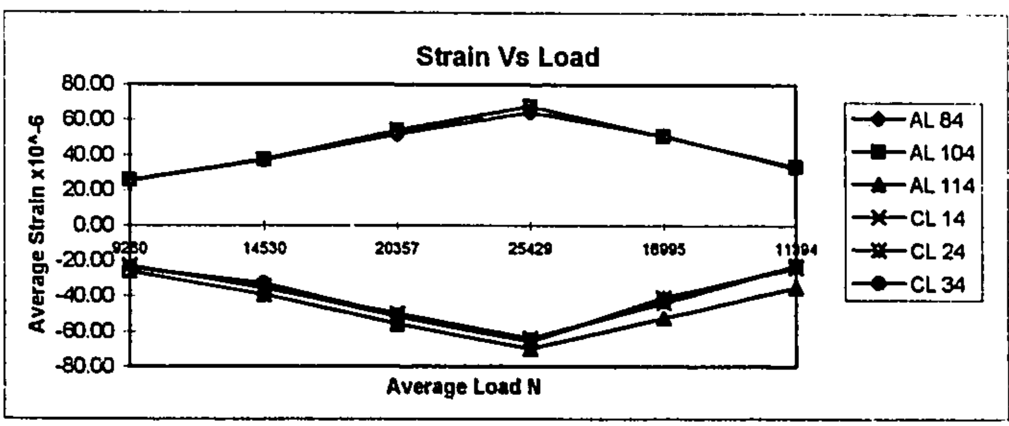


FIGURE 4.42 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 4

Load Case 4

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 52 AL 35	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85	Strain 44 AL 95	Strain 41 AL 105
Load 1	9259.80	-29.50	-20.60	28.59	-50.59	3.74	-18.59	43.57
Load 2	14530.00	-46.23	-33.75	45.51	-66.40	22.63	-22.63	58.37
Load 3	20356.56	-64.88	-47.55	62.83	-87.29	43.98	-30.44	78.26
Load 4	25428.73	-77.82	-60.23	79.38	-102.24	62.76	-37.83	91.65
Load 5	16994.52	-52.03	-46.54	63.23	-82.12	42.28	-26.14	73.94
Load 6	11394.15	-34.87	-30.48	41.88	-62.28	17.10	-17.81	54.60

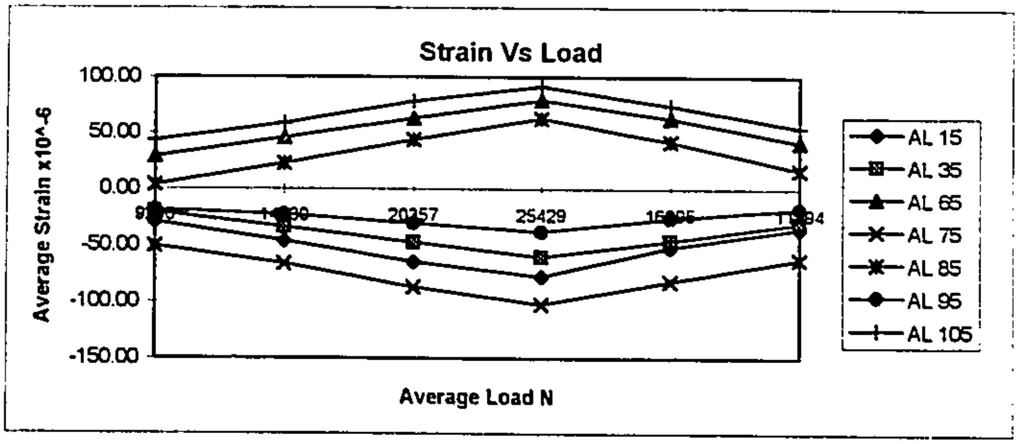
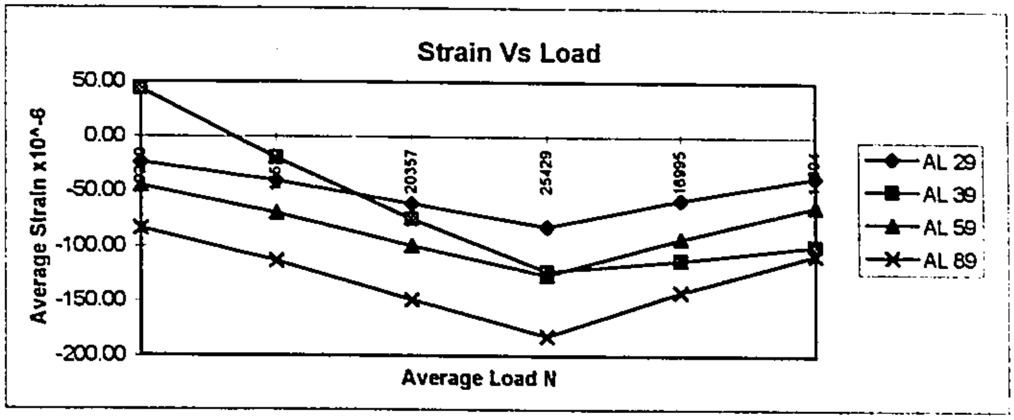


FIGURE 4.43 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 4

Load Case 4

SECTION 9

	Average Load N	Strain 56 AL 29	Strain 54 AL 39	Strain 36 AL 59	Strain 47 AL 89
Load 1	9259.80	-24.03	43.55	-45.21	-83.73
Load 2	14530.00	-40.84	-20.03	-70.03	-113.11
Load 3	20356.56	-61.23	-75.37	-99.59	-148.50
Load 4	25428.73	-82.15	-122.83	-126.07	-182.02
Load 5	16994.52	-57.71	-112.76	-92.99	-141.55
Load 6	11394.15	-37.19	-99.80	-63.63	-107.39



	Average Load N	Strain M20 AL 99	Strain M21 AL 109	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	9259.80	42.00	-4.00	27.00	-23.00	-10.00	-20.00
Load 2	14530.00	66.00	-10.00	33.00	-39.00	-15.00	-26.00
Load 3	20356.56	92.00	-15.00	43.00	-56.00	-21.00	-34.00
Load 4	25428.73	113.00	-20.00	54.00	-68.00	-30.00	-43.00
Load 5	16994.52	88.00	-11.00	41.00	-50.00	-21.00	-33.00
Load 6	11394.15	63.00	-7.00	32.00	-31.00	-14.00	-23.00

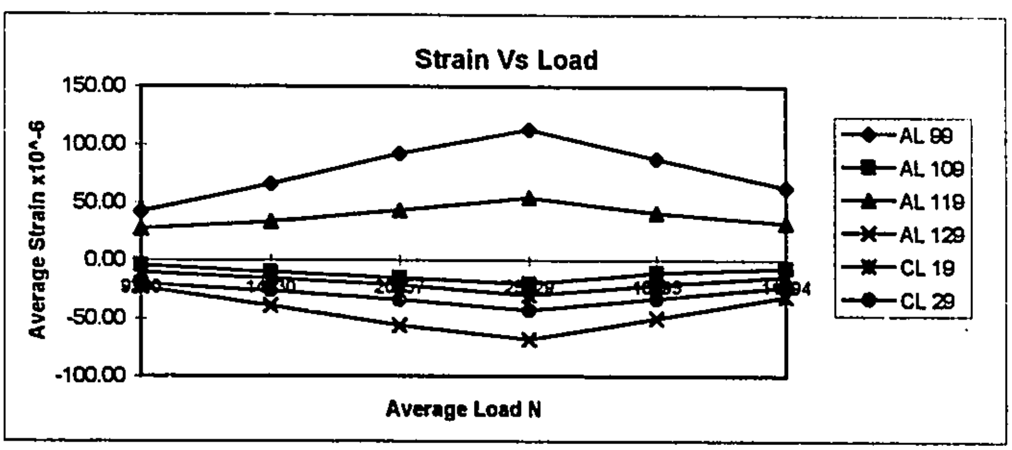
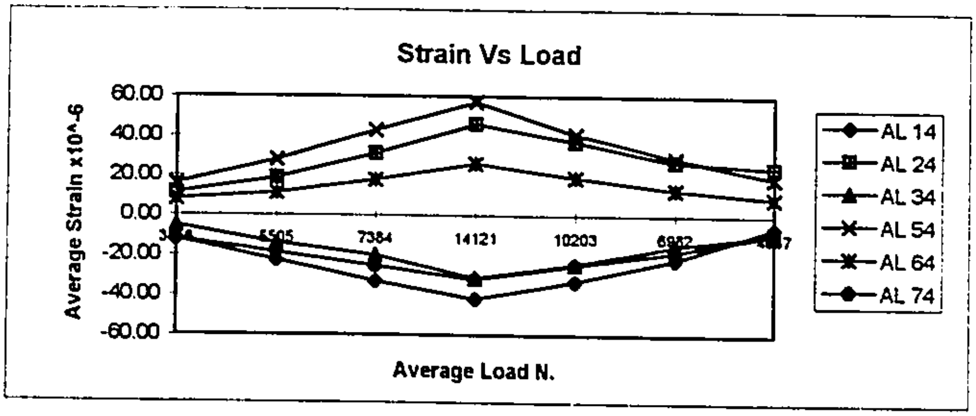


FIGURE 4.44 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 4

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	3856.11	-12.00	11.00	-5.25	16.00	8.00	-12.00
Load 2	5505.21	-22.60	18.70	-13.90	28.00	11.00	-18.70
Load 3	7383.80	-33.10	31.20	-20.00	42.70	17.80	-25.40
Load 4	14120.53	-42.00	46.00	-31.49	57.00	26.00	-32.00
Load 5	10203.29	-33.00	37.00	-24.48	41.00	19.00	-25.00
Load 6	6981.70	-22.00	27.00	-15.27	29.00	13.00	-18.00
Load 7	4637.07	-6.00	24.00	-9.15	19.00	9.00	-9.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain 39 AL 124	Strain M1 CL 14	Strain M2 CL 24
Load 1	3856.11	8.43	11.47	-6.01	10.92	-10.00	-7.00
Load 2	5505.21	15.60	19.32	-12.03	16.31	-16.00	-13.00
Load 3	7383.80	20.56	25.18	-17.51	22.73	-22.00	-20.00
Load 4	14120.53	37.23	44.00	-34.96	39.71	-41.00	-34.00
Load 5	10203.29	29.94	35.61	-27.49	31.06	-29.00	-24.00
Load 6	6981.70	20.65	23.88	-16.28	20.43	-20.00	-17.00
Load 7	4637.07	14.21	16.19	-9.29	13.79	-13.00	-10.00

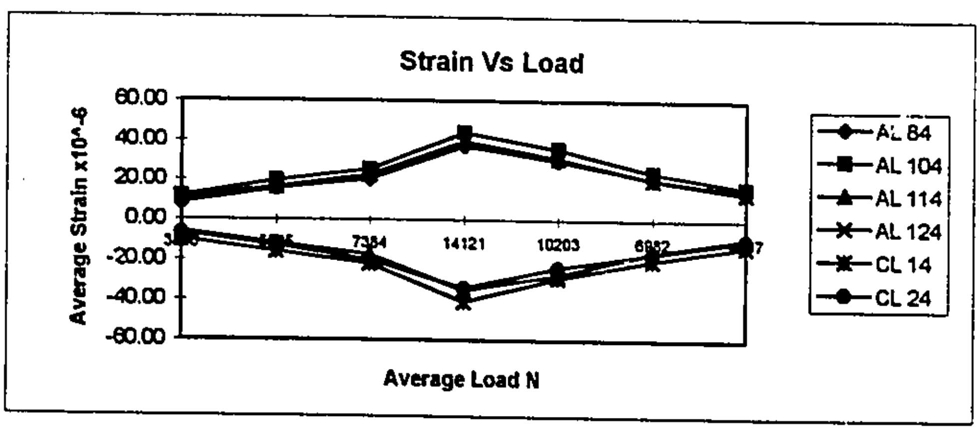


FIGURE 4.45 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 5

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 34 AL 25	Strain 52 AL 35	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85	Strain 44 AL 95
Load 1	3856.11	-15.06	16.03	-3.87	3.66	-7.67	11.05	-8.57
Load 2	5505.21	-20.76	20.82	-9.26	10.77	-14.88	21.06	-12.19
Load 3	7383.80	-35.10	29.52	-14.38	16.02	-23.12	32.93	-14.23
Load 4	14120.53	-51.15	45.50	-30.10	31.38	-40.90	55.50	-24.40
Load 5	10203.29	-36.95	35.12	-20.56	22.13	-31.70	42.59	-20.68
Load 6	6981.70	-25.39	26.60	-9.97	13.34	-21.94	28.95	-16.42
Load 7	4637.07	-16.41	19.70	-0.56	5.63	-14.64	16.89	-14.21

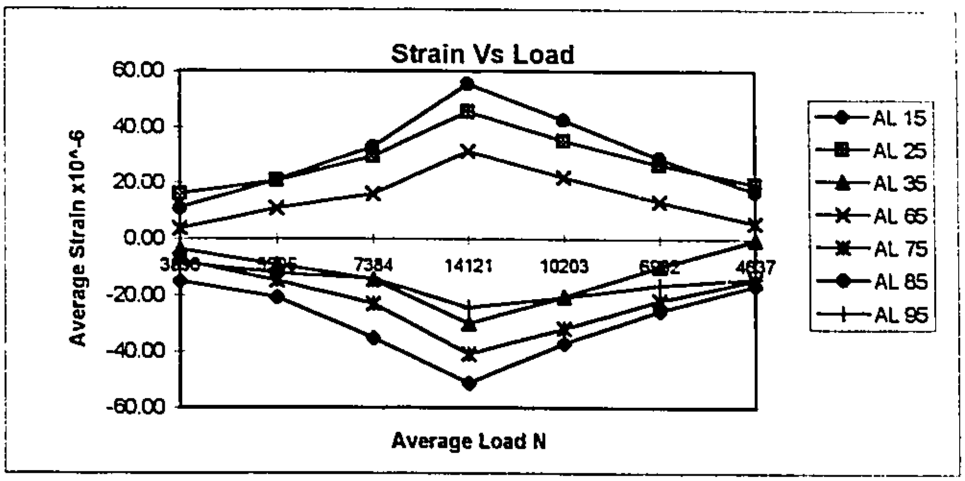
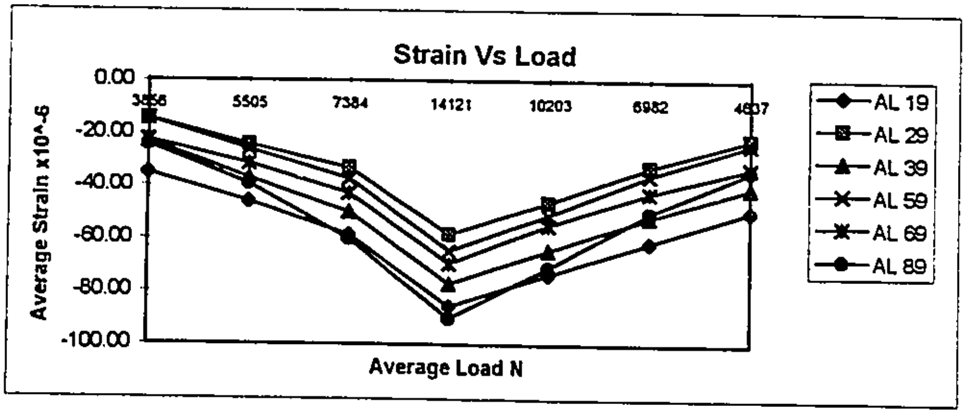


FIGURE 4.46 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 5

SECTION 9

	Average Load N	Strain 55 AL 19	Strain 56 AL 29	Strain 54 AL 39	Strain 36 AL 59	Strain 35 AL 69	Strain 47 AL 89
Load 1	3856.11	-35.08	-14.58	-23.14	-14.58	-22.73	-24.32
Load 2	5505.21	-45.98	-24.46	-37.04	-26.04	-31.62	-39.26
Load 3	7383.80	-58.52	-33.25	-50.00	-37.21	-42.77	-60.00
Load 4	14120.53	-85.70	-58.40	-77.10	-64.60	-69.30	-90.27
Load 5	10203.29	-73.33	-46.28	-64.39	-50.98	-54.89	-70.87
Load 6	6981.70	-61.56	-32.85	-51.81	-35.83	-42.63	-50.23
Load 7	4637.07	-49.44	-22.24	-40.71	-23.93	-33.03	-34.13



	Average Load N	Strain M20 AL 99	Strain M21 AL 109	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	3856.11	12.00	-4.00	3.00	-14.00	-2.00	-5.00
Load 2	5505.21	22.00	-6.00	9.00	-21.00	-5.00	-8.00
Load 3	7383.80	34.00	-10.00	14.00	-29.00	-7.00	-12.00
Load 4	14120.53	50.00	-16.00	26.00	-43.00	-16.00	-20.00
Load 5	10203.29	38.00	-11.00	20.00	-32.00	-12.00	-15.00
Load 6	6981.70	28.00	-7.00	10.00	-25.00	-7.00	-11.00
Load 7	4637.07	19.00	-5.00	9.00	-15.00	-3.00	-7.00

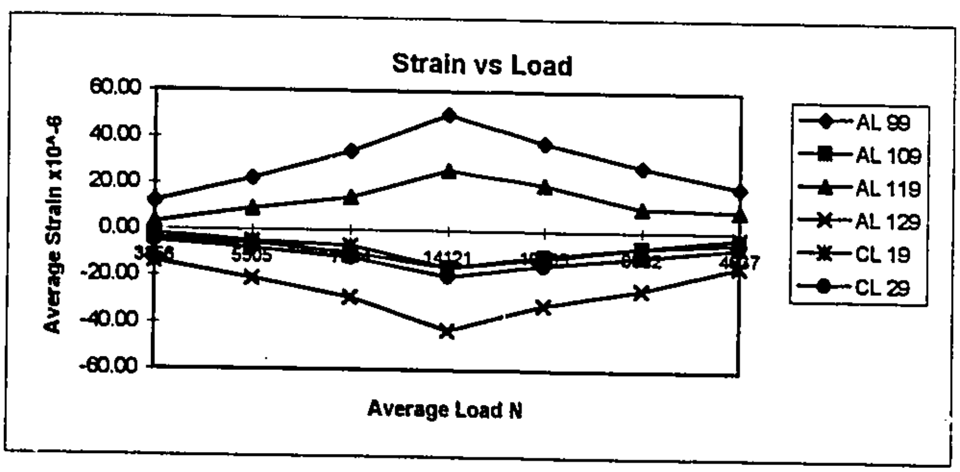


FIGURE 4.47 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 5

Table 4.19 Experimental Strain Results For Load Case 3

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5	
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
10003.26	-45.00	32.00	-30.57	-68.00	35.00	-33.00	
14764.93	-68.00	46.00	-45.37	-99.00	52.00	-50.00	
20729.73	-92.00	68.00	-66.96	-142.00	71.00	-80.00	
27799.52	-122.00	97.00	-98.24	-195.00	93.00	-111.00	
21102.57	-94.00	81.00	-84.28	-163.00	72.00	-95.00	
14549.84	-64.00	55.00	-58.61	-123.00	49.00	-64.00	
8252.60	-37.00	32.00	-28.46	-70.00	28.00	-32.00	
SECTION 4 Average Load N	Strain 49	Strain 42	Strain 40	Strain M1	Strain M2	Strain M3	
	AL 84	AL 104	AL 114	CL 14	CL 24	CL 34	
10003.26	30.67	37.76	-40.38	-37.00	-38.00	-35.00	
14764.93	53.36	59.51	-60.73	-53.00	-52.00	-54.00	
20729.73	79.21	85.78	-89.37	-78.00	-79.00	-80.00	
27799.52	107.77	119.12	-121.40	-106.00	-108.00	-107.00	
21102.57	88.21	101.64	-100.80	-83.00	-84.00	-82.00	
14549.84	60.59	70.08	-70.49	-55.00	-55.00	-57.00	
8252.60	30.61	34.73	-37.58	-29.00	-28.00	-30.00	
SECTION 5 Average Load N	Strain 33	Strain 52	Strain 16	Strain 15	Strain 50	Strain 44	Strain 41
	AL 15	AL 35	AL 65	AL 75	AL 85	AL 95	AL 105
10003.26	-47.34	-33.53	48.13	-68.21	16.45	-11.75	51.03
14764.93	-69.90	-56.87	73.02	-89.77	47.60	-16.90	81.53
20729.73	-98.23	-78.82	104.62	-115.65	80.42	-24.75	110.43
27799.52	-131.35	-105.64	147.85	-144.03	125.35	-35.18	148.46
21102.57	-99.43	-84.35	125.36	-119.49	98.11	-26.75	129.39
14549.84	-68.33	-60.16	91.26	-90.30	66.96	-17.45	96.84
8252.60	-38.57	-32.32	51.16	-56.68	35.22	-9.54	59.77
SECTION 9 Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47	
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
10003.26	-78.00	-20.00	-110.00	-54.96	181.67	-88.00	
14764.93	-111.31	-47.07	-141.70	-78.13	158.74	-125.00	
20729.73	-145.00	-77.00	-178.00	-107.54	130.44	-165.00	
27799.52	-188.79	-113.65	-221.98	-148.65	90.72	-208.00	
21102.57	-166.82	-90.15	-197.77	-121.17	115.66	-175.00	
14549.84	-141.56	-65.00	-169.23	-86.68	147.07	-138.00	
8252.60	-117.31	-37.62	-144.48	-51.16	175.39	-98.68	

Table 4.20 Experimental Strain Results For Load Case 3

SECTION 9 Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
10003.26	35.00	-5.00	18.00	-28.00	-11.00	-19.00
14764.93	56.00	-11.00	27.00	-43.00	-17.00	-28.00
20729.73	81.00	-19.00	40.00	-61.00	-27.00	-37.00
27799.52	114.00	-26.00	52.00	-84.00	-34.00	-50.00
21102.57	91.00	-18.00	40.00	-67.00	-26.00	-42.00
14549.84	64.00	-10.00	25.00	-45.00	-17.00	-32.00
8252.60	35.00	-4.00	13.00	-24.00	-8.00	-22.00

Table 4.21 Experimental Stress Results For Load Case 3

SECTION 4 Average Load N	Stress Values MPa					
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
10003.26	-3.20	2.28	-2.17	-4.83	2.49	-2.35
14764.93	-4.83	3.27	-3.23	-7.04	3.70	-3.56
20729.73	-6.54	4.83	-4.76	-10.10	5.05	-5.69
27799.52	-8.67	6.90	-6.99	-13.86	6.61	-7.89
21102.57	-6.68	5.76	-5.99	-11.59	5.12	-6.75
14549.84	-4.55	3.91	-4.17	-8.75	3.48	-4.55
8252.60	-2.63	2.28	-2.02	-4.98	1.99	-2.28

SECTION 4 Average Load N	Stress Values MPa					
	AL 84	AL 104	AL 114	CL 14	CL 24	CL 34
10003.26	2.18	2.68	-2.87	-1.27	-1.30	-1.20
14764.93	3.79	4.23	-4.32	-1.82	-1.78	-1.85
20729.73	5.63	6.10	-6.35	-2.68	-2.71	-2.74
27799.52	7.66	8.47	-8.63	-3.64	-3.70	-3.67
21102.57	6.27	7.23	-7.17	-2.85	-2.88	-2.81
14549.84	4.31	4.98	-5.01	-1.89	-1.89	-1.96
8252.60	2.18	2.47	-2.67	-0.99	-0.96	-1.03

SECTION 5 Average Load N	Stress Values MPa						
	AL 15	AL 35	AL 65	AL 75	AL 85	AL 95	AL 105
10003.26	-3.37	-2.38	3.42	-4.85	1.17	-0.84	3.63
14764.93	-4.97	-4.04	5.19	-6.38	3.38	-1.20	5.80
20729.73	-6.98	-5.60	7.44	-8.22	5.72	-1.76	7.85
27799.52	-9.34	-7.51	10.51	-10.24	8.91	-2.50	10.56
21102.57	-7.07	-6.00	8.91	-8.50	6.98	-1.90	9.20
14549.84	-4.86	-4.28	6.49	-6.42	4.76	-1.24	6.89
8252.60	-2.74	-2.30	3.64	-4.03	2.50	-0.68	4.25

SECTION 9 Average Load N	Stress Values MPa					
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
10003.26	-5.55	-1.42	-7.82	-3.91	12.92	-6.26
14764.93	-7.91	-3.35	-10.08	-5.55	11.29	-8.89
20729.73	-10.31	-5.47	-12.66	-7.65	9.27	-11.73
27799.52	-13.42	-8.08	-15.78	-10.57	6.45	-14.79
21102.57	-11.86	-6.41	-14.06	-8.61	8.22	-12.44
14549.84	-10.07	-4.62	-12.03	-6.16	10.46	-9.81
8252.60	-8.34	-2.67	-10.27	-3.64	12.47	-7.02

Table 4.22 Experimental Stress Results For Load Case 3

SECTION 9 Average Load N	Stress Values MPa					
10003.25581	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
14764.93	2.49	-0.36	1.28	-1.99	-0.38	-0.65
20729.73	3.98	-0.78	1.92	-3.06	-0.58	-0.96
27799.52	5.76	-1.35	2.84	-4.34	-0.93	-1.27
21102.57	8.11	-1.85	3.70	-5.97	-1.17	-1.72
14549.84	6.47	-1.28	2.84	-4.76	-0.89	-1.44
8252.60	4.55	-0.71	1.78	-3.20	-0.58	-1.10

Table 4.23 Experimental Strain Results For Load Case 4

SECTION 4 Average Load N	Strain M8	Strain M1	Strain 48	Strain M1	Strain M4	Strain M5
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
9259.80	-26.00	24.00	-18.59	38.00	22.00	-20.00
14530.00	-41.00	36.00	-29.97	59.00	33.00	-33.00
20356.56	-57.00	50.00	-42.69	82.00	47.00	-47.00
25428.73	-70.00	63.00	-54.76	99.00	57.00	-60.00
16994.52	-47.00	45.00	-38.74	66.00	38.00	-44.00
11394.15	-30.00	28.00	-21.75	45.00	26.00	-28.00

SECTION 4 Average Load N	Strain 49	Strain 42	Strain 40	Strain M1	Strain M2	Strain M3
	AL 84	AL 104	AL 114	CL 14	CL 24	CL 34
9259.80	25.14	25.61	-26.25	-23.00	-24.00	-24.00
14530.00	36.90	37.41	-39.13	-36.00	-35.00	-33.00
20356.56	51.88	53.94	-55.84	-50.00	-52.00	-51.00
25428.73	64.42	67.59	-69.73	-64.00	-66.00	-65.00
16994.52	51.26	50.57	-52.41	-44.00	-41.00	-43.00
11394.15	32.75	33.38	-35.19	-23.00	-24.00	-23.00

SECTION 5 Average Load N	Strain 33	Strain 52	Strain 16	Strain 15	Strain 50	Strain 44	Strain 41
	AL 15	AL 35	AL 65	AL 75	AL 85	AL 95	AL 105
9259.80	-29.50	-20.60	28.59	-50.59	3.74	-18.59	43.57
14530.00	-46.23	-33.75	45.51	-66.40	22.63	-22.63	58.37
20356.56	-64.88	-47.55	62.83	-87.29	43.98	-30.44	78.26
25428.73	-77.82	-60.23	79.38	-102.24	62.76	-37.83	91.65
16994.52	-52.03	-46.54	63.23	-82.12	42.28	-26.14	73.94
11394.15	-34.87	-30.48	41.88	-62.28	17.10	-17.81	54.60

SECTION 9 Average Load N	Strain 56	Strain 54	Strain 36	Strain 47
	AL 29	AL 39	AL 59	AL 89
9259.80	-24.03	43.55	-45.21	-83.73
14530.00	-40.84	-20.03	-70.03	-113.11
20356.56	-61.23	-75.37	-99.59	-148.50
25428.73	-82.15	-122.83	-126.07	-182.02
16994.52	-57.71	-112.76	-92.90	-141.55
11394.15	-37.19	-99.80	-63.63	-107.39

SECTION 9 Average Load N	Strain M2	Strain M2	Strain M6	Strain M7	Strain M2	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
9259.80	42.00	-4.00	27.00	-23.00	-10.00	-20.00
14530.00	66.00	-10.00	33.00	-39.00	-15.00	-26.00
20356.56	92.00	-15.00	43.00	-56.00	-21.00	-34.00
25428.73	113.00	-20.00	54.00	-68.00	-30.00	-43.00
16994.52	88.00	-11.00	41.00	-50.00	-21.00	-33.00
11394.15	63.00	-7.00	32.00	-31.00	-14.00	-23.00

Table 4.24 Experimental Stress Results For Load Case 4

SECTION 4 Average Load N	Stress Values MPa					
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
9259.80	-1.85	1.71	-1.32	2.70	1.56	-1.42
14530.00	-2.92	2.56	-2.13	4.19	2.35	-2.35
20356.56	-4.05	3.56	-3.04	5.83	3.34	-3.34
25428.73	-4.98	4.48	-3.89	7.04	4.05	-4.27
16994.52	-3.34	3.20	-2.75	4.69	2.70	-3.13
11394.15	-2.13	1.99	-1.55	3.20	1.85	-1.99

SECTION 4 Average Load N	Stress Values MPa					
	AL 84	AL 104	AL 114	CL 14	CL 24	CL 34
9259.80	1.79	1.82	-1.87	-0.79	-0.82	-0.82
14530.00	2.62	2.66	-2.78	-1.23	-1.20	-1.13
20356.56	3.69	3.83	-3.97	-1.72	-1.78	-1.75
25428.73	4.58	4.81	-4.96	-2.20	-2.26	-2.23
16994.52	3.64	3.60	-3.73	-1.51	-1.41	-1.47
11394.15	2.33	2.37	-2.50	-0.79	-0.82	-0.79

SECTION 5 Average Load N	Stress Values MPa						
	AL 15	AL 35	AL 65	AL 75	AL 85	AL 95	AL 105
9259.80	-2.10	-1.46	2.03	-3.60	0.27	-1.32	3.10
14530.00	-3.29	-2.40	3.24	-4.72	1.61	-1.61	4.15
20356.56	-4.61	-3.38	4.47	-6.21	3.13	-2.16	5.56
25428.73	-5.53	-4.28	5.64	-7.27	4.46	-2.69	6.52
16994.52	-3.70	-3.31	4.50	-5.84	3.01	-1.86	5.26
11394.15	-2.48	-2.17	2.98	-4.43	1.22	-1.27	3.88

SECTION 9 Average Load N	Stress Values MPa			
	AL 29	AL 39	AL 59	AL 89
9259.80	-1.71	3.10	-3.21	-5.95
14530.00	-2.90	-1.42	-4.98	-8.04
20356.56	-4.35	-5.36	-7.08	-10.56
25428.73	-5.84	-8.73	-8.96	-12.94
16994.52	-4.10	-8.02	-6.61	-10.06
11394.15	-2.64	-7.10	-4.52	-7.64

SECTION 9 Average Load N	Stress Values MPa					
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
9259.80	2.99	-0.28	1.92	-1.64	-0.34	-0.69
14530.00	4.69	-0.71	2.35	-2.77	-0.51	-0.89
20356.56	6.54	-1.07	3.06	-3.98	-0.72	-1.17
25428.73	8.03	-1.42	3.84	-4.83	-1.03	-1.47
16994.52	6.26	-0.78	2.92	-3.56	-0.72	-1.13
11394.15	4.48	-0.50	2.28	-2.20	-0.48	-0.79

Table 4.25 Experimental Strain Results For Load Case 5

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
3856.11	-12.00	11.00	-5.25	16.00	8.00	-12.00
5505.21	-17.00	13.00	-10.93	23.00	10.00	-14.00
7383.80	-22.00	25.00	-16.75	30.00	14.00	-20.00
14120.53	-42.00	46.00	-31.49	57.00	26.00	-32.00
10203.29	-33.00	37.00	-24.48	41.00	19.00	-25.00
6981.70	-22.00	27.00	-15.27	29.00	13.00	-18.00
4637.07	-6.00	24.00	-9.15	19.00	9.00	-9.00

SECTION 4 Average Load N	Strain 49	Strain 42	Strain 40	Strain 39	Strain M1	Strain M2
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24
3856.11	8.43	11.47	-6.01	10.92	-10.00	-7.00
5505.21	15.60	19.32	-12.03	16.31	-16.00	-13.00
7383.80	20.56	25.18	-17.51	22.73	-22.00	-20.00
14120.53	37.23	44.00	-34.96	39.71	-41.00	-34.00
10203.29	29.94	35.61	-27.49	31.06	-29.00	-24.00
6981.70	20.65	23.88	-16.28	20.43	-20.00	-17.00
4637.07	14.21	16.19	-9.29	13.79	-13.00	-10.00

SECTION 5 Average Load N	Strain 33	Strain 34	Strain 52	Strain 16	Strain 15	Strain 50	Strain 44
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 95
3856.11	-15.06	16.03	-3.87	3.66	-7.67	11.05	-8.57
5505.21	-20.76	20.82	-9.26	10.77	-14.88	21.06	-12.19
7383.80	-27.79	29.52	-14.38	16.02	-23.12	32.93	-14.23
14120.53	-51.15	45.50	-30.10	31.38	-40.90	55.50	-24.40
10203.29	-36.95	35.12	-20.56	22.13	-31.70	42.59	-20.68
6981.70	-25.39	26.60	-9.97	13.34	-21.94	28.95	-16.42
4637.07	-16.41	19.70	-0.56	5.63	-14.64	16.89	-14.21

SECTION 9 Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
3856.11	-35.08	-14.58	-23.14	-14.58	-22.73	-24.32
5505.21	-45.98	-24.46	-37.04	-26.04	-31.62	-39.26
7383.80	-58.52	-33.25	-44.90	-37.21	-42.77	-52.52
14120.53	-85.70	-58.40	-77.10	-64.60	-69.30	-90.27
10203.29	-73.33	-46.28	-64.39	-50.98	-54.89	-70.87
6981.70	-61.56	-32.85	-51.81	-35.83	-42.63	-50.23
4637.07	-49.44	-22.24	-40.71	-23.93	-33.03	-34.13

Table 4.26 Experimental Strain Results For Load Case 5

SECTION 9 Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
3856.11	12.00	-4.00	3.00	-14.00	-2.00	-5.00
5505.21	22.00	-6.00	6.00	-18.00	-5.00	-8.00
7383.80	30.00	-10.00	12.00	-25.00	-7.00	-12.00
14120.53	50.00	-16.00	26.00	-43.00	-16.00	-20.00
10203.29	38.00	-11.00	20.00	-32.00	-12.00	-15.00
6981.70	28.00	-7.00	10.00	-25.00	-7.00	-11.00
4637.07	19.00	-5.00	9.00	-15.00	-3.00	-7.00

Table 4.27 Experimental Stress Results For Load Case 5

SECTION 4 Average Load N	Stress Values MPa						
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
3856.11	-0.85	0.78	-0.37	1.14	0.57	-0.85	
5505.21	-1.21	0.92	-0.78	1.64	0.71	-1.00	
7383.80	-1.56	1.78	-1.19	2.13	1.00	-1.42	
14120.53	-2.99	3.27	-2.24	4.05	1.85	-2.28	
10203.29	-2.35	2.63	-1.74	2.92	1.35	-1.78	
6981.70	-1.56	1.92	-1.09	2.06	0.92	-1.28	
4637.07	-0.43	1.71	-0.65	1.35	0.64	-0.64	
SECTION 4 Average Load N	Stress Values MPa						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	
3856.11	0.60	0.82	-0.43	0.78	-0.34	-0.24	
5505.21	1.11	1.37	-0.86	1.16	-0.50	-0.41	
7383.80	1.46	1.79	-1.24	1.62	-0.69	-0.63	
14120.53	2.65	3.13	-2.49	2.82	-1.28	-1.06	
10203.29	2.13	2.53	-1.95	2.21	-0.91	-0.75	
6981.70	1.47	1.70	-1.16	1.45	-0.63	-0.53	
4637.07	1.01	1.15	-0.66	0.98	-0.41	-0.31	
SECTION 5 Average Load N	Stress Values MPa						
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 95
3856.11	-1.07	1.14	-0.28	0.26	-0.55	0.79	-0.61
5505.21	-1.48	1.48	-0.66	0.77	-1.06	1.50	-0.87
7383.80	-1.98	2.10	-1.02	1.14	-1.64	2.34	-1.01
14120.53	-3.64	3.24	-2.14	2.23	-2.91	3.95	-1.73
10203.29	-2.63	2.50	-1.46	1.57	-2.25	3.03	-1.47
6981.70	-1.81	1.89	-0.71	0.95	-1.56	2.06	-1.17
4637.07	-1.17	1.40	-0.04	0.40	-1.04	1.20	-1.01
SECTION 9 Average Load N	Stress Values MPa						
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
3856.11	-2.49	-1.04	-1.65	-1.04	-1.62	-1.73	
5505.21	-3.27	-1.74	-2.63	-1.85	-2.25	-2.79	
7383.80	-4.16	-2.36	-3.19	-2.65	-3.04	-3.73	
14120.53	-6.09	-4.15	-5.48	-4.59	-4.93	-6.42	
10203.29	-5.21	-3.29	-4.58	-3.62	-3.90	-5.04	
6981.70	-4.38	-2.34	-3.68	-2.55	-3.03	-3.57	
4637.07	-3.52	-1.58	-2.89	-1.70	-2.35	-2.43	

Table 4.28 Experimental Stress Results For Load Case 5

SECTION 9 Average Load N	Stress Values MPa					
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
3856.11	0.85	-0.28	0.21	-1.00	-0.07	-0.17
5505.21	1.56	-0.43	0.43	-1.28	-0.17	-0.27
7383.80	2.13	-0.71	0.85	-1.78	-0.24	-0.41
14120.53	3.56	-1.14	1.85	-3.06	-0.55	-0.69
10203.29	2.70	-0.78	1.42	-2.28	-0.41	-0.51
6981.70	1.99	-0.50	0.71	-1.78	-0.24	-0.38
4637.07	1.35	-0.36	0.64	-1.07	-0.10	-0.24

Chapter Five

Comparison of Analytical And Experimental Results

5.1 Introduction

In this chapter, prior to the analysis of the four box curved girder bridge, a brief description about the software ADINA is presented along with some specific modelling requirements for curved boxed girder bridges. This is followed by a summary about the basic assumptions in the element formulation, and the advantages and disadvantages for the element are given.

The Automatic Dynamic Incremental Nonlinear Analysis program, ADINA, is a Finite Element computer program utilized for displacement and stress analysis of structures. The ADINA program has been used extensively by many researches, and specially in the fields of solid mechanics, soil mechanics, fracture mechanics, and fluid mechanics. The ADINA System Verification Product [53], shows the capability of the program itself in analyzing linear,nonlinear, static, and transient problems.

5.2 ADINA's Modelling Requirements

In modelling curved box girder bridges, the web element could be idealized as conical or cylindrical, while the top and/ or the bottom flange element are annular in shape. The elements should represent in-plane and bending deformations, since the diaphragm's bending action is too small in comparison with its in-plane action. The diaphragms could be idealized by using the in-plane elements only.

ADINA provides a family of isoparametric shell elements that can be classified into three categories namely:

a. Thin plate / shell elements.

b. Thick shell elements.

c. Shell to solid transition elements.

In the modelling of a curved boxed girder structural component, the shell element with 4, 9, or 16 mid-surfaces nodes may be employed depending on the particular application. For the curved box girder model analysis in this thesis, the 4-nodes shell element is employed.

5.3 Thin Shell Isoparametric Element

The shell element is a 4- to 32-node isoparametric element that can be utilized to model thick and thin general shell structures. However, depending on the application, the appropriate number of nodes on the element must be used.

The ADINA program version 6.1 limits the shell element use to the following analysis conditions:[54]

a. Linear analysis, in which case the displacements, rotations, and strains are infinitesimally small and the material is linear elastic.
b. Materially-nonlinear-only analysis in which the displacements and strains are infinitesimally small, but the material behavior is nonlinear.
c. Large displacement formulation, for very large displacements and rotations but small strains, and the material behavior can be linear elastic or nonlinear.

The basic equations used in the formulation of the element are given in [53]. However, the shell element is formulated treating the shell as a three dimensional continuum with the following two assumptions used in the Timoshenko beam theory and the Mindlin /Reissner plate theory:

Assumption 1: Material particles that originally lie on a straight line "normal" to the midsurface of the structure remain on that straight line during deformation.

Assumption 2: The stress in the direction normal to the midsurface of the structure is zero.

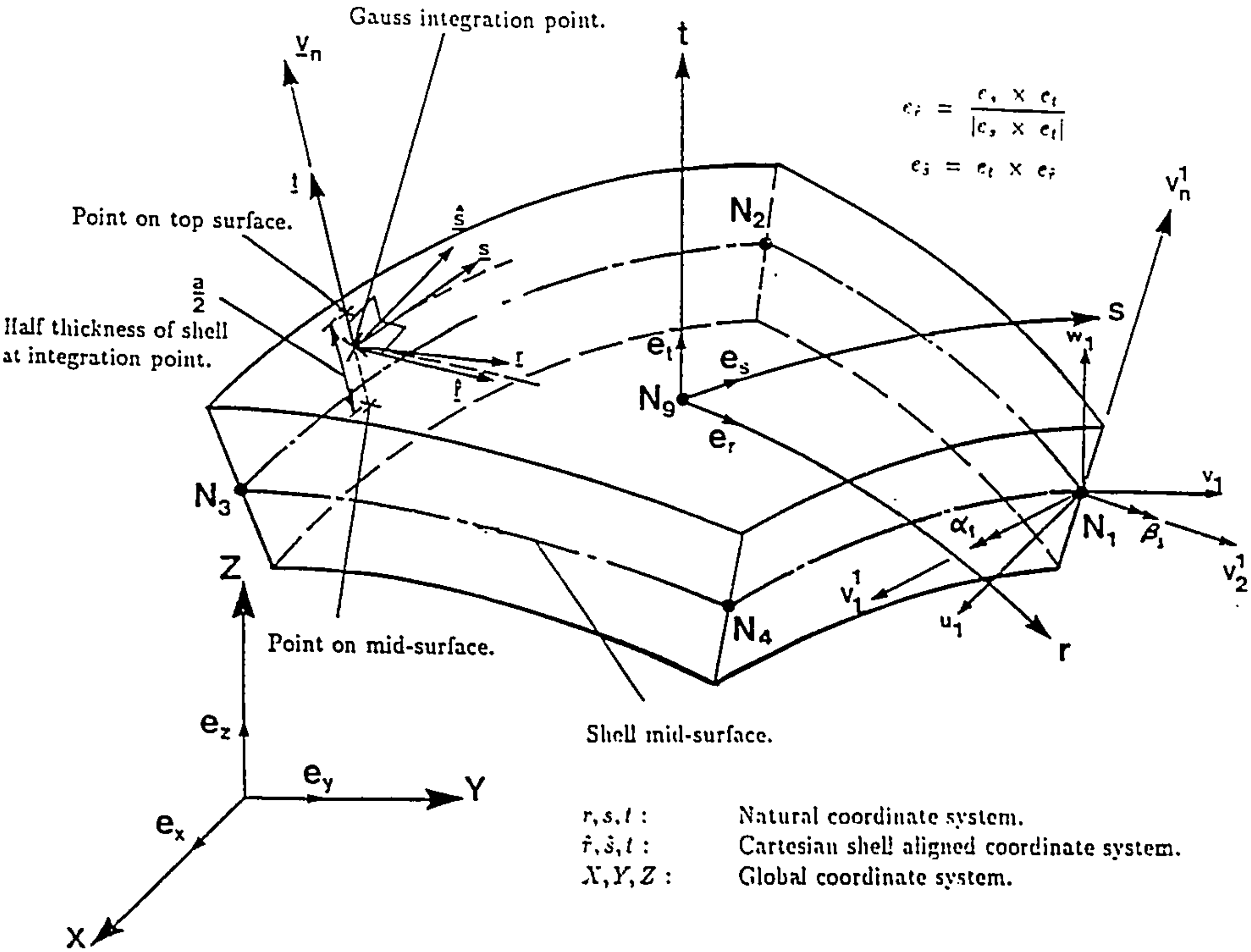
In assumption 1, the straight line originally which is normal to the shell mid surface may or may not be normal to the shell mid-surface during deformation. Therefore, shear deformations are included in the analysis, while the transverse shear deformations are assumed to be constant across the shell thickness.

In assumption two, for the stress situation, the finite element solution imposes a zero stress condition in the direction of the normal vector to the shell mid-surface.

The following coordinate system is employed during the calculations of the shell element matrices:

1. The r,s,t coordinate system is the natural coordinate system for the element. However, this system is established with respect to the element nodal numbering scheme as in figure 5.1 .

2. The $\hat{r}$, $\hat{s}$, $\hat{t}$ coordinate system is the cartesian shell-aligned coordinate system. The axes for this system are orthogonal, and this system is established at any integration point once the shell midsurface normal is defined. The unit vectors along $\hat{r}$ and $\hat{s}$ are as follows:



u_k, v_k, w_k = 3 translational D.O.F. along global X,Y,Z axes respectively.
α_k, β_k = 2 rotational D.O.F. about vectors V_1^k & V_2^k respectively.

$$V_1^k = \frac{e_y \times V_n^k}{|e_y \times V_n^k|}$$

$$V_2^k = V_n^k \times V_1^k$$

when $V_n^k = \pm Y$ then: $V_1^k = \pm Z$, $V_2^k = +X$

FIGURE 5.1 ADINA's 4-NODE THIN SHELL ELEMENT

$$e_r = \frac{e_s * e_t}{|e_s * e_t|} \tag{5.1}$$

$$e_s = e_t * e_r \tag{5.2}$$

Where e_s, e_t are the unit vectors along the s and t directions.

3. The X,Y,Z coordinate system is the global cartesian system or the structure's system.

A typical node on the shell mid-surface can have a maximum five degrees of freedom, 2 rotations and 3 translations. The two rotations α_k and β_k are refered in accordance to the orthogonal vectors V^k_1 and V^k_2 at node k respectively. As for the translational degree of freedom, u_k, v_k, w_k, are refered to the global cartesian coordinate system.
However, the V^k_1 and V^k_2 vectors are defined from the normal vector at node k as follows:

$$V_1^k = \frac{e_y * V_n^k}{|e_y * V_n^k|} \tag{5.3}$$

$$V_2^k = V_n^k * V_1^k \tag{5.4}$$

When the normal vector V^k_n at node k aligns with the global Y axis, the following rule applies:

When $V^k_n = \pm Y$ Then:

$$V_1^k = \pm Z \tag{5.5}$$

$$V_2^k = + X \tag{5.6}$$

Hence a special set of orthogonal vector V^k_1 and V^k_2 at node k is defined for a unique normal vector V^k_n at node k. At this stage a special problem is encountered when the shell elements intersect at a common boundaries; therefore, a unique normal vector can no longer be defined at the intersection node. In fact this is the case in modelling box girder structures where the top and bottom flange elements intersect with the web elements and sometimes with diaphragm elements at one or more common nodes. In ADINA version 6.1 this problem is solved by automatically generating as many normal vectors at the common node K as there are shell elements attached to the node. For each individual intersecting shell element a unique normal vector is defined at node k. The components of the shell element matrices corresponding to the rotational degree of freedom at this node are first formulated in the local mid-surface system defined by the normal vector and then translated to the global cartesian system. [55]

5.4 ADINA's Bridge Model

5.4.1 Finite Element Discretization

The 4-node thin shell element described above, was employed to model the components of the two span, horizontally curved four-box girder bridge. On top of that, the structural components includes the cylindrical webs, the bottom flange, the micro concrete deck, and the three diaphragms.

The basic geometrical features used in preparing the finite element model for the bridge model are as follows:

1. Width of the micro concrete deck = 480 mm.
2. Width of the bottom aluminum flange = 400 mm.
3. Radius of curvature of the central web = 14554 mm.
4. Subtended angle between ends supports = 16.8°.
5. Circumferential distance between end supports along central web = 4268 mm.
6. Depth of the cylindrical webs which are assumed to extend to the mid-surface of the deck and bottom flange elements = 120 mm.

Also, a total number of 2069 nodes and a total number of 2208 elements were used. A 4-node element,cylindrical coordinates and 6 degrees of freedom per node was employed. As for the loading, a concentrated load was used, and for the aluminum C channel diaphragms they were modeled by equivalent plate diaphragms. The depth of these plate diaphragms were assumed to extend to the mid-surface of the bottom flange and the deck plates. In the ADINA model, in order to ensure that the plate diaphragms would provide the same transverse bending as the C channel diaphragms, the thickness used for the end diaphragms was 9.2 mm and for the middle diaphragms 8.3 mm.

Tables 5.1, 5.2, and 5.3 show the finite element discretization of the ADINA bridge model.

Table 5.1 Section Number & Its Angle

Section #	Angle In Degrees.	Section #	Angle In Degrees.
1.0	81.59893	6.5	87.34268
1.5	82.07922	7.0	87.87414
2.0	82.55950	7.5	88.40561
2.5	83.09097	8.0	88.93707
3.0	83.62243	8.25	89.20281
3.5	84.130273	8.5	89.46854
4.0	84.68536	8.75	89.73427
4.5	85.311305	9.0	90.00000
5.0	85.74829	9.25	90.26573
5.5	86.393917	9.5	90.53146
6.0	87.082852	9.75	90.79720

Table 5.2 Section Number & Its Angle

Section #	Angle In Degrees.	Section #	Angle In Degrees.
10.0	91.06290	14.0	95.31464
10.5	91.59440	14.5	95.869727
11.0	92.12586	15.0	96.37757
11.5	92.65733	15.5	96.90904
12.0	92.917148	16.0	97.44050
12.5	93.606083	16.5	97.92079
13.0	94.25171	17.0	98.40107
13.5	94.688695		

Table 5.3 Web Identification & Its Radius

Web I.D.	Radius (m)
A	14.794
B	14.754
C	14.654
D	14.554
E	14.454
F	14.354
G	14.314

The input file for ADINA, and the ADINA node numbers, are enclosed in appendix C. A typical three dimensional view of the ADINA bridge model is shown in figure 5.1.

5.4.2 Material Properties

An elastic, isotropic, homogeneous material behavior is assumed for all the aluminum structural components and the micro concrete deck. Detailed material properties, are discribed in Tables 4.4, 4.5, and 5.4.

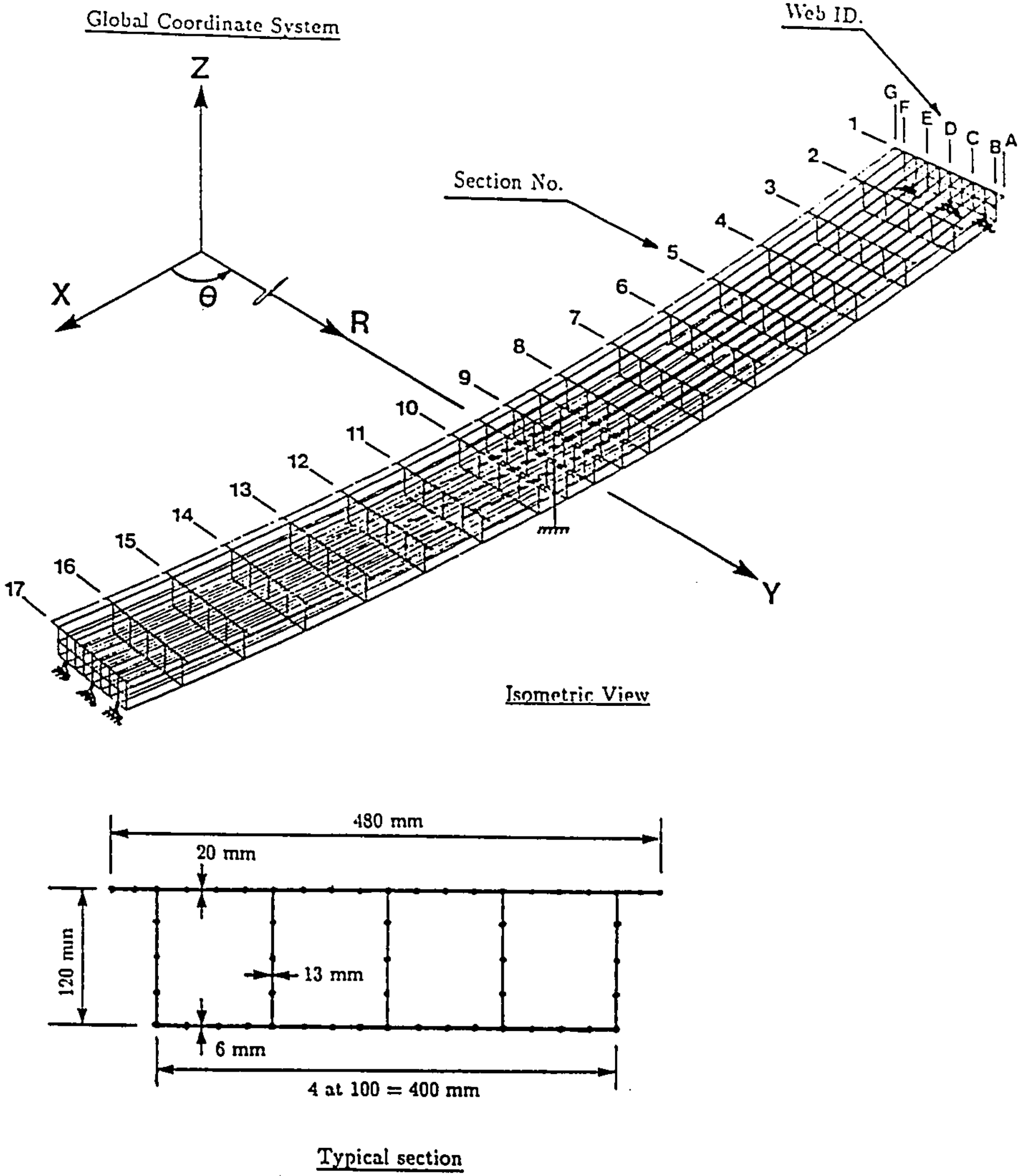


FIGURE 5.2 FINITE ELEMENT DISCRETIZATION OF ADINA BRIDGE MODEL

Table 5.4 Elastic Material Properties For ADINA Model

Structure Element	Material Type	Young Modulus E (MPa)	Poisson's Ratio	Thickness t (mm)
Top Plate	Concrete	37,000	0.150	20.0
Bottom Plate	Aluminum	70,277	0.379	6.00
Cylindrical Web	Aluminum	72,000	0.379	13.0
End Diaphragm	Aluminum	72,000	0.379	9.20
Middle Diaphragm	Aluminum	72,000	0.379	8.30

5.4.3 Boundary Conditions

The boundary conditions imposed on the structure are as follows:

1. End supports: only vertical translation is restrained at the bottom plate nodes.
2. Middle support: total fixity in the X,Y,Z directions in the deflections; fixed rotation in the ZZ direction while free to rotate in the XX and YY directions.

5.5 Experimental Deflection Calibration.

During the experiment, some deflection was noted at the middle support "in the range of 0.5 to 0.9 mm" as compared to complete fixity for the ADINA analysis. Due to this fact, all the experimental deflection data were calibrated by assuming that the deflection at the middle support is equal to zero, and each section of each load case was adjusted in accordance with Tables D1 to D9 in Appendix D.

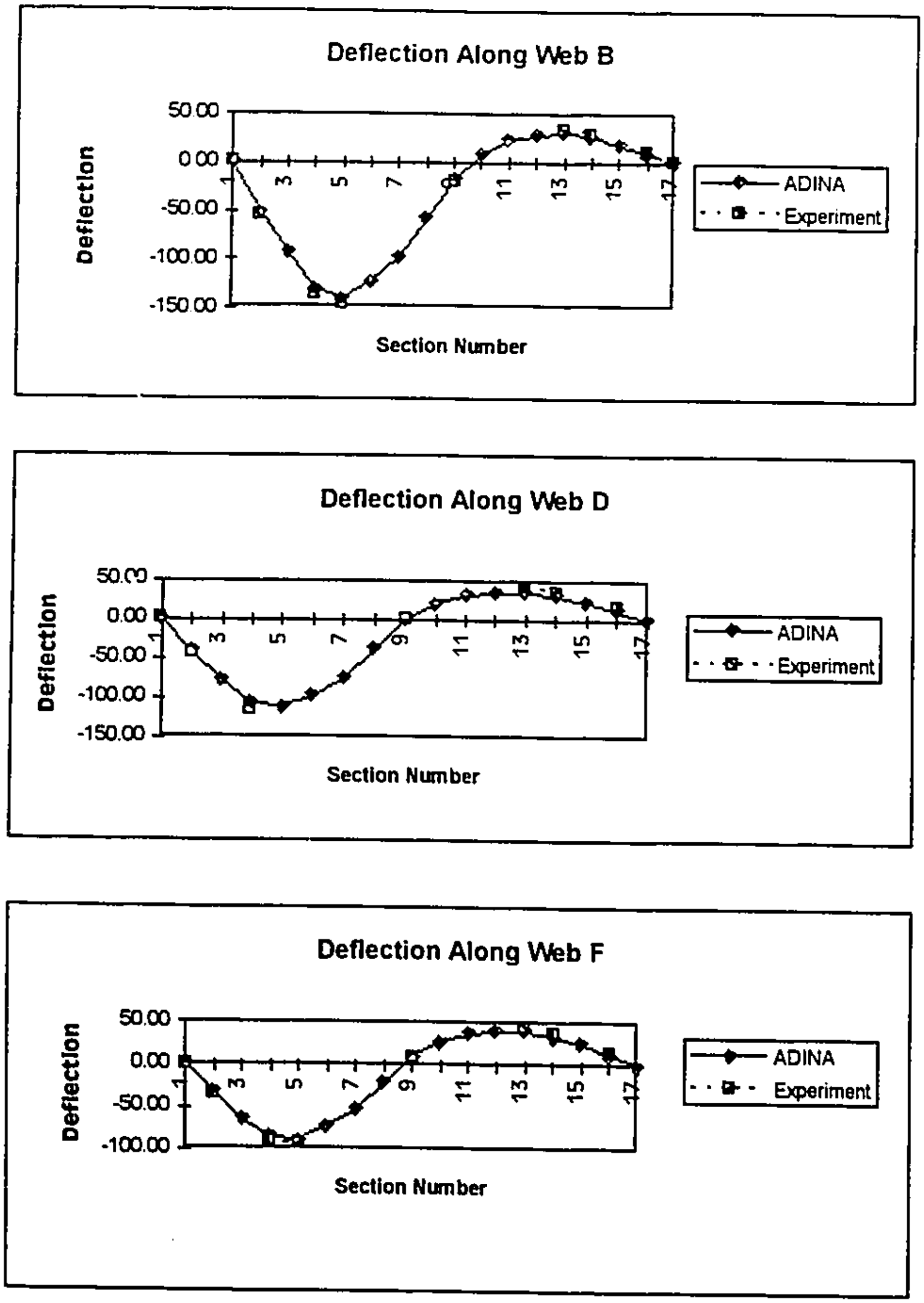
5.6 Comparison of Analytical And Experimental Results.

5.6.1 Load Case 1

In this load case, only one span of the bridge model was loaded with one set of parallel OHBD trucks such that axle number 1 was aligned with the section between sections 3 and 4 i.e (section 3.5). With the central support located at web D, the first truck was located on web B and the second truck on web C as shown in Fig. 4.21

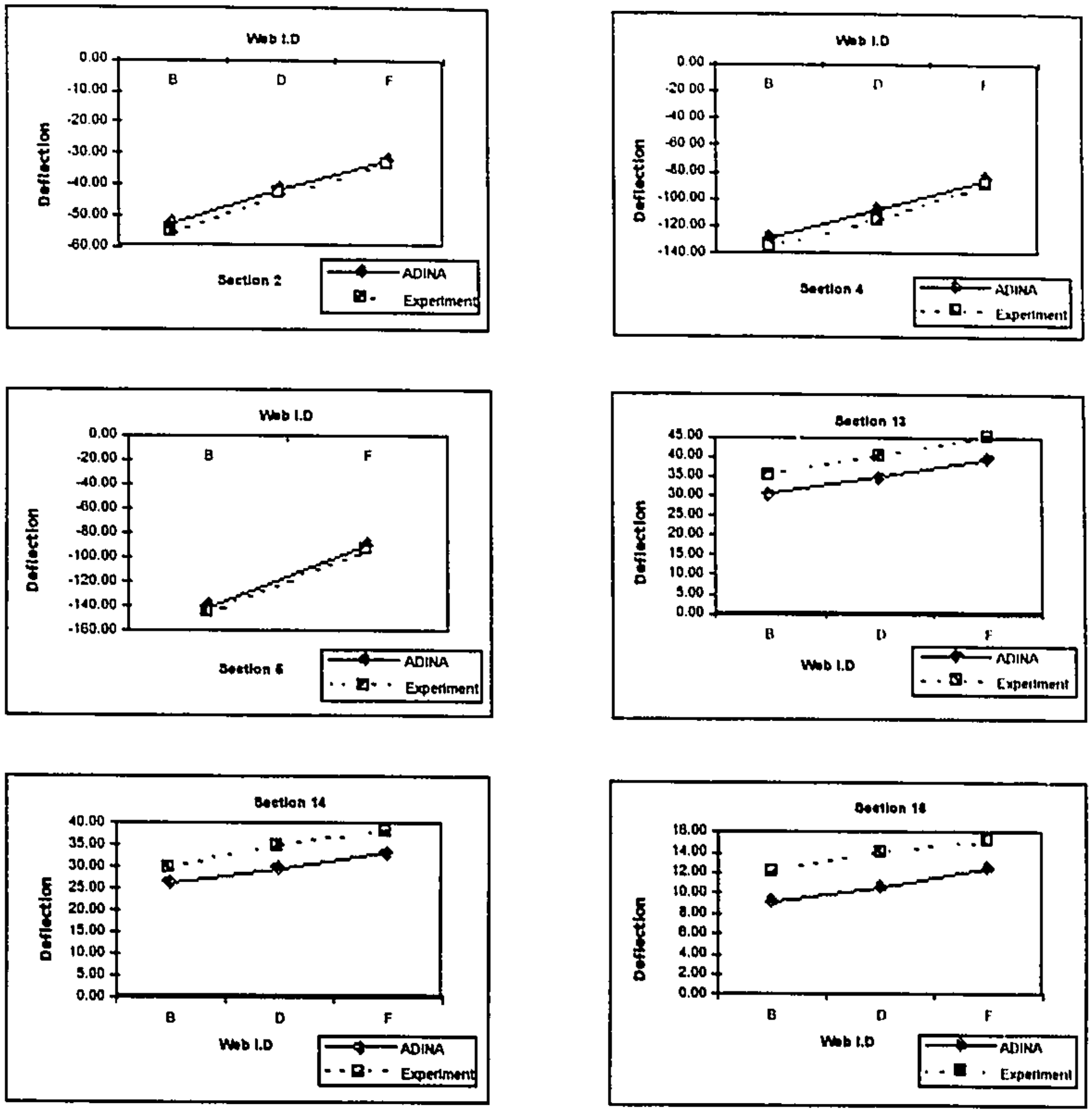
As for the vertical deflection of the bridge model, Fig. 5.3 shows the overall behavior of the model along three webs in the longitudinal direction namely, webs B, D, & F. An uplift is noticed in both ADINA predictions and the experimental results. However, it is clear that the highest deflection occurred underneath the outer web, i.e web B, and that is due to the eccentric nature of the truck loading. Fig.5.4 shows the deflection in the transverse direction of the bridge model. From theses figures, it can be concluded that the ADINA model is stiffer than the experimental model. Both experimental and ADINA results were in good agreement. From table 5.5, the maximum deflection values were 1.46 mm and 1.40 mm in the experimental model and ADINA model respectively. This maximum deflection took place underneath web B and at section 5.

The stress distribution of the bridge model is plotted in Fig. 5.5 for both sections 4 and 5. The ADINA model results were in agreement with the experimental model in terms of the sign of the moments developing at the sections; moreover, for stress field in the instrumented sections, both schemes were also in agreement on the location of the maximum moment at each section. The maximum compressive stress in the concrete deck was recorded at web B in both experimental and ADINA models with values of 3.485 and 4.875 MPA respectively. Table 5.6 compares the ADINA and experimental stress results. It is evident that the ADINA's model underestimated the stress values due to the stiffer structure response already observed in deflection comparisons.



Note: All deflections are x10^-2 mm

FIGURE 5.3 VERTICAL DEFLECTION CURVES FOR LOAD CASE 1



Note: All deflections are x10^-2 mm

FIGURE 5.4 VERTICAL DEFLECTION CURVES FOR LOAD CASE 1

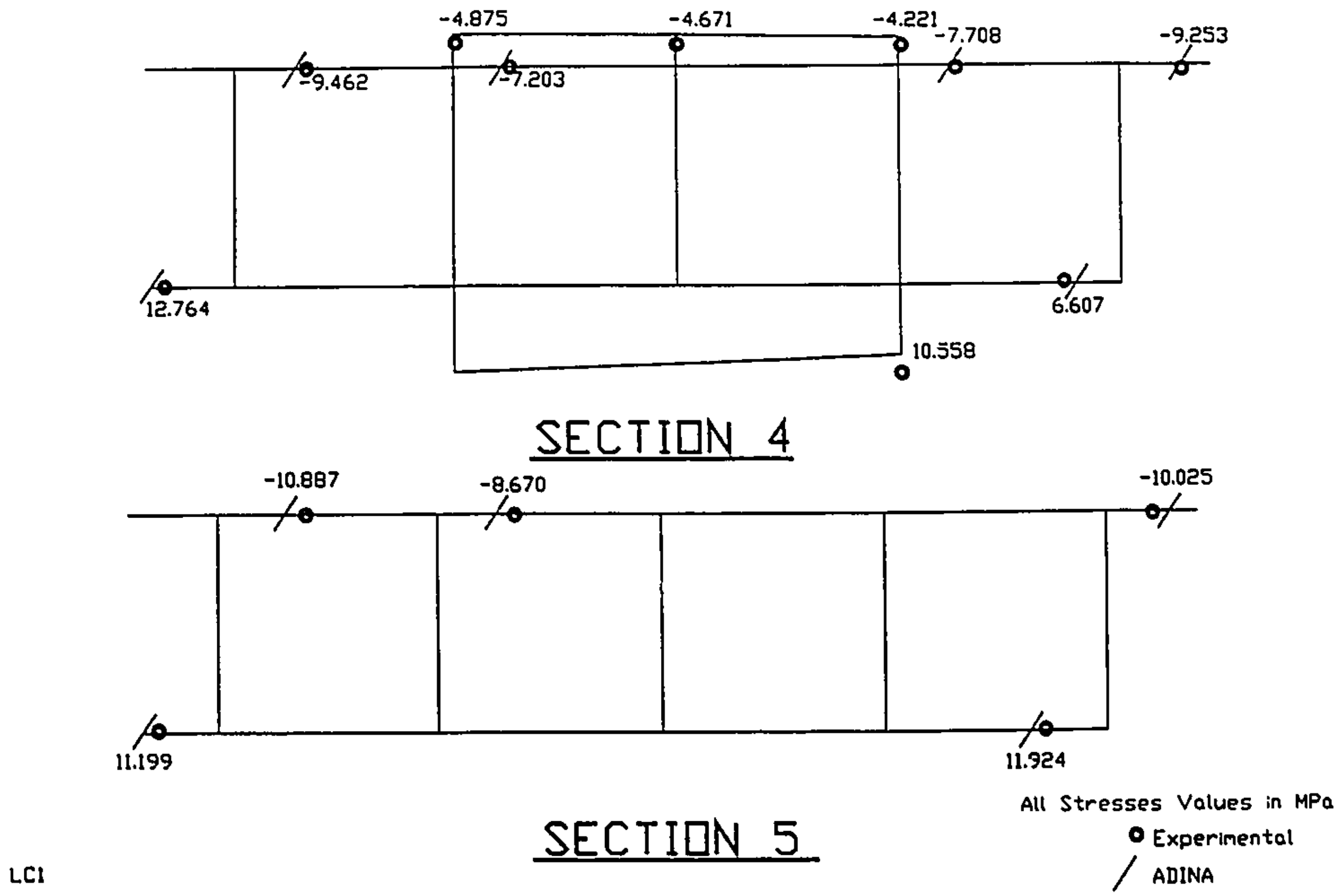


FIGURE 5.5 STRESS DISTRIBUTION FOR LOAD CASE 1

Table 5.5 Deflection Results For Load Case 1

Dial Gage	Experimental 8.384N	Experimental 20,276 N	ADINA 20,276 N	% Error
VB2	23	55.62	52.16	6.6
VD2	18	43.53	41.69	4.4
VF2	14	33.86	32.42	4.4
VB4	56	135.43	129.45	4.6
VD4	48	116.08	107.93	7.6
VF4	37	89.48	85.37	4.8
VB5	60.5	146.31	140.54	4.1
VF5	39	94.32	89.93	4.9

Table 5.6 Stress Results For Load Case # 1

Strain Gage I.D	ADINA Stress @ 20,276 N	Experimental Stress @ 8,384 N	Experimental Stress @ 20,276 N	% Of Error
CL14	-4.875	-1.441	-3.485	28.5
CL24	-4.221	-1.338	-3.236	23.3
CL34	-4.671	-1.372	-3.318	29.0
AL14	-9.462	-4.479	-10.832	-14.5
AL24	12.764	4.906	11.865	7 0
AL34	-7.203	-3.166	-7.657	-6.3
AL54	10.558	4.906	11.865	-12.4
AL64	6.607	3.057	7.393	-11.9
AL74	-9.253	-3.839	-9.284	-0.3
AL114	-7.708	-3.627	-8.772	-13.8
AL15	-10.887	-5.855	-14.160	-30.1
AL25	-11.199	-4.561	-11.030	1.5
AL35	-8.670	-4.020	-9.722	-12.1
AL65	11.924	4.611	11.151	6.5
AL75	-10.025	-3.706	-8.963	10.6

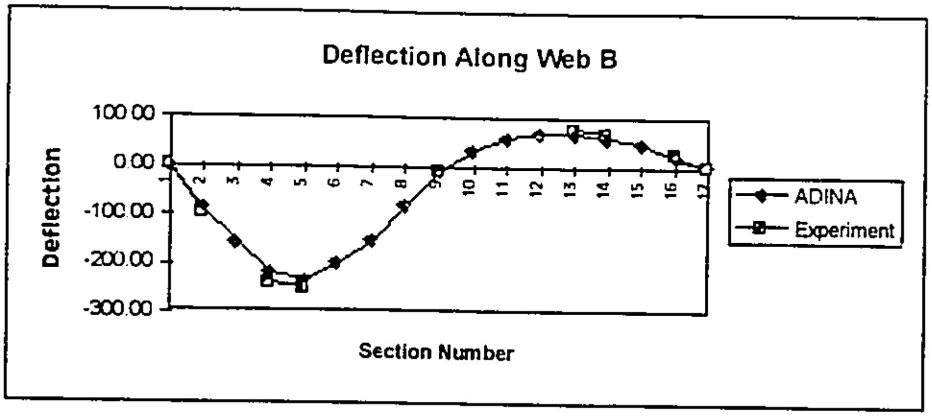
5.6.2 Load Case 2

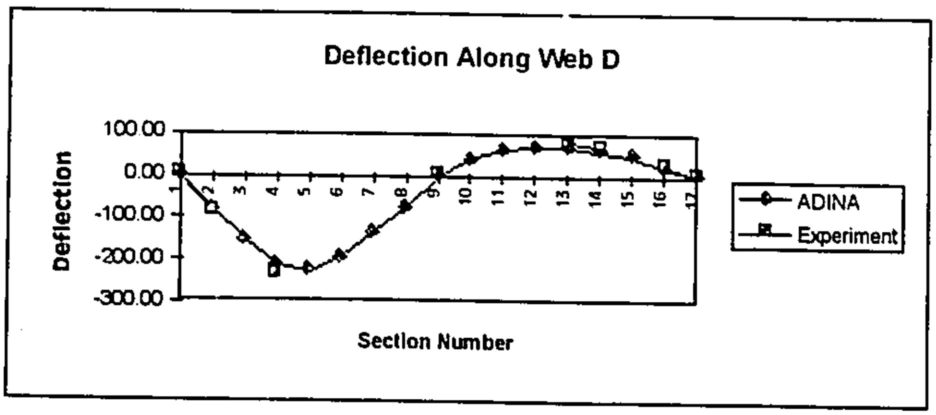
Similar to load case 1, the bridge model was loaded with two sets of OHBD trucks such that the first axle was along section 3.5, and trucks 1, 2, 3, and 4 were located on webs B, C, E, and F respectively as shown in Fig.4.21.

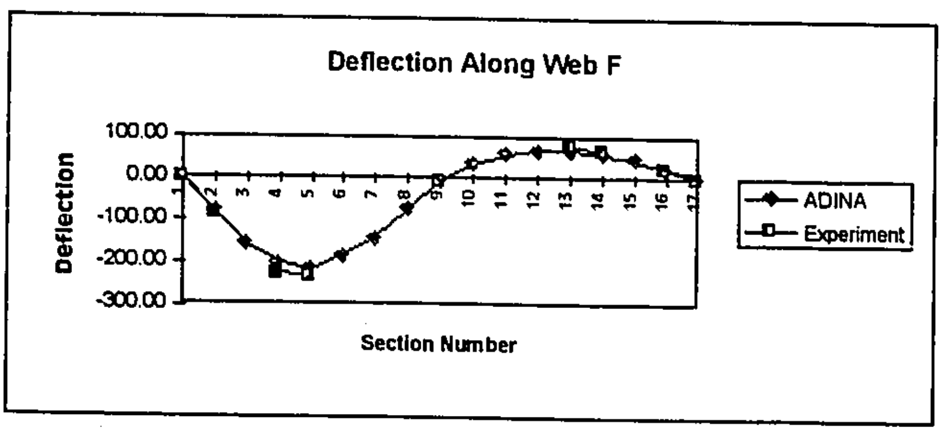
An overall plot for the behavior of the model along three longitudinal webs B, D, & F is presented in Fig.5.6. Again ADINA's model seems to be stiffer than the experimental model in terms of deflection. Both experimental and ADINA results were in good agreement. From Table 5.7 the maximum deflection values were 2.49 mm and 2.34 mm in the experimental model and ADINA model respectively. This maximum deflection took place underneath web B and at section 5. When compared to load case 1, it is noted that the maximum deflection has almost doubled when the total load was doubled showing a general linear behavior of the bridge model. An uplift also was noticed in both ADINA predictions and the experimental results at sections 13, 14, and 16. It is also clear and due to the eccentric nature of the truck loading,that the highest deflection occurred underneath the outer web, i.e web B. Fig.5.7 shows the typical deflection of the bridge model in the transverse direction.

Fig. 5.8 presents the stress distribution of the bridge model for both sections 4 and 5. The ADINA model results were in a good agreement with the experimental model in terms of the sign of the moments developing at the sections and the location of the maximum moment at each section. The maximum compressive stress in the concrete deck was recorded at web B, in both experimental and ADINA models with values of 7.123 and 9.280 MPA respectively. Also approxomately 100 % of stress increase in the concrete deck was observed when the truck load was doubled, as compared to load case 1. Table 5.8 compares the ADINA and experimental stress results. A particular feature of this load case is that,of the nine load cases considered the highest stress was recorded in this load case.

It is believed that the modeling of the central diaphragm by means of the equivalent single plate diaphragm, plays a significant factor in overstiffening the ADINA model, thus the difference in the stress values between the ADINA and experimental model were underestimated by the ADINA's model.

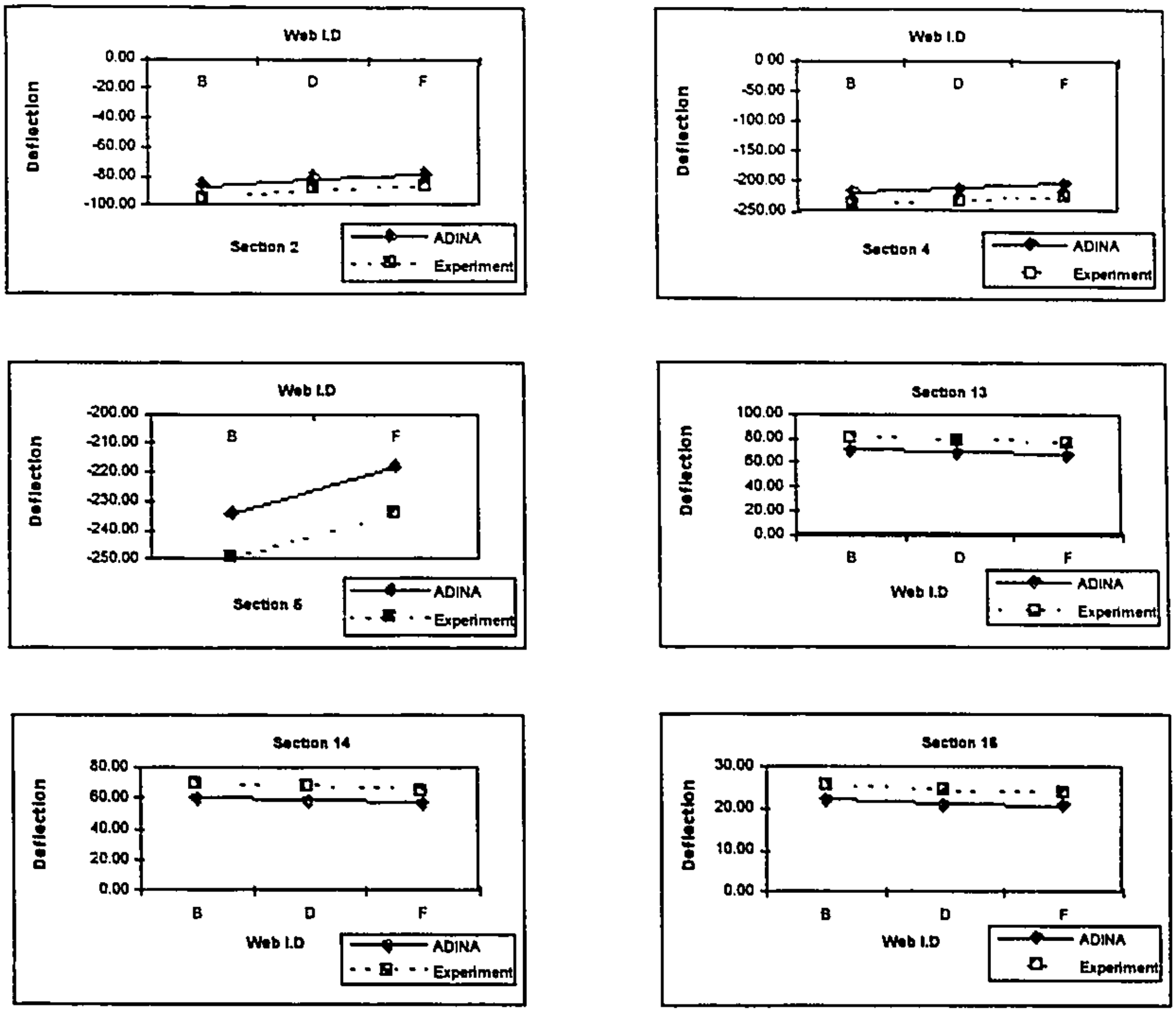






Note: All deflections are x10^-2 mm

FIGURE 5.6 VERTICAL DEFLECTION CURVES FOR LOAD CASE 2



Note: All deflections are x10^-2 mm

FIGURE 5.7 VERTICAL DEFLECTION CURVES FOR LOAD CASE 2

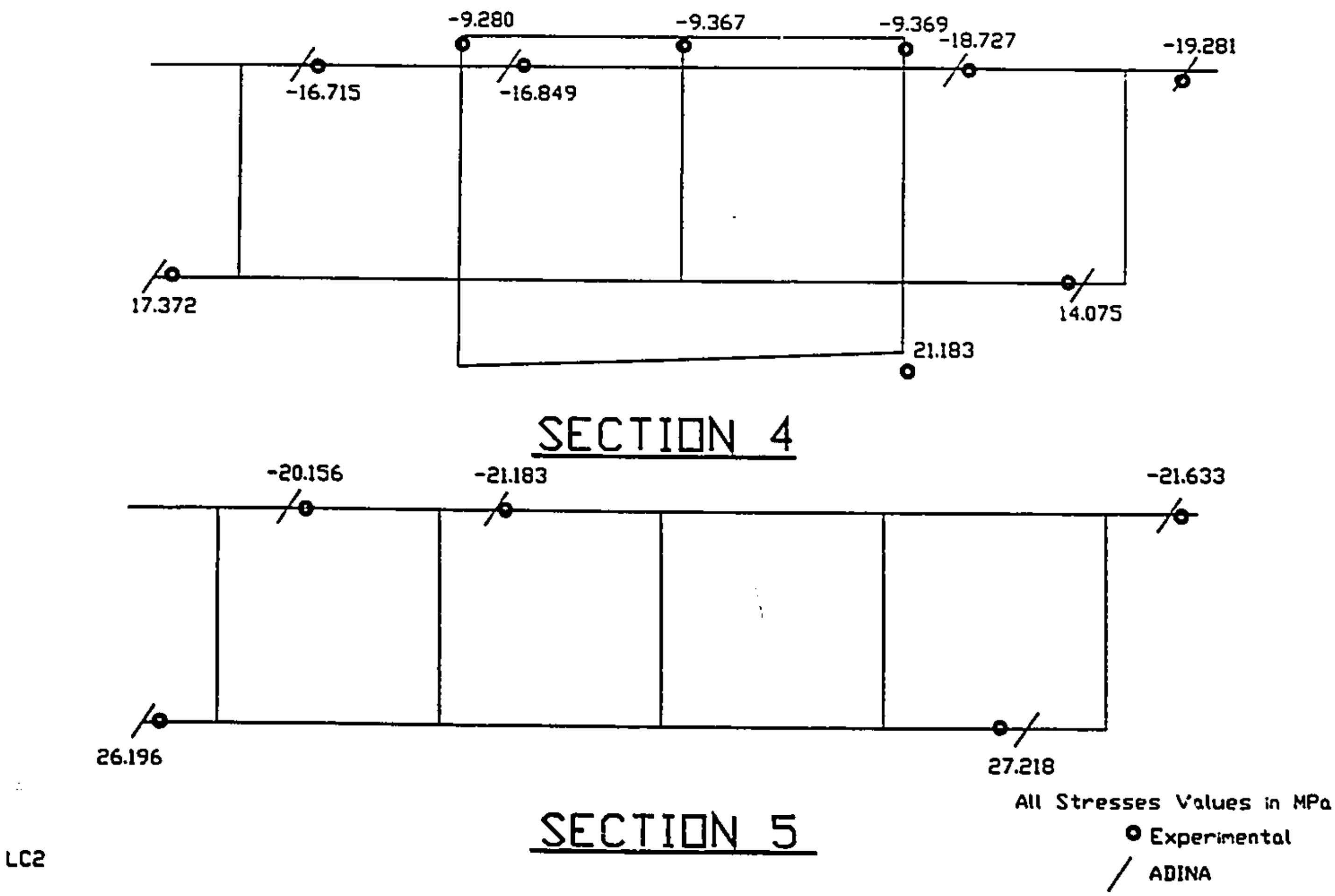


FIGURE 5.8 STRESS DISTRIBUTION FOR LOAD CASE 2

Table 5.7 Deflection Results For Load Case 2

Dial Gage	Experimental 13,476 N	Experimental 40,552 N	ADINA 40,552 N	% Error
VB2	32	96.29	86.82	10.9
VD2	30	90.28	81.81	10.4
VF2	29	87.27	79.32	10.0
VB4	79	237.73	218.56	8.8
VD4	78	234.72	212.03	10.7
VF4	75	225.69	203.33	11.0
VB5	83	249.76	234.61	6.5
VF5	78	234.72	217.99	7.7

Table 5.8 Stress Results For Load Case # 2

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 13,476 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-9.280	-2.357	-7.123	23.2
CL24	-9.369	-2.470	-7.433	20.7
CL34	-9.367	-2.504	-7.535	19.6
AL14	-16.715	-8.959	-26.959	-61.3
AL24	17.372	5.119	15.404	11.3
AL34	-16.849	-6.269	-18.865	-12.0
AL54	21.183	8.374	25.199	-19.0
AL64	14.075	5.312	15.985	-13.6
AL74	-19.281	-6.755	-20.327	-5.4
AL114	-18.727	-7.016	-21.113	-12.7
AL15	-20.156	-8.908	-26.806	-33.0
AL25	26.196	6.790	20.432	22.0
AL35	-21.183	-6.392	-19.235	9.2
AL65	27.218	9.593	28.867	-6.1
AL75	-21.633	-6.860	-20.643	4.6

5.6.3 Load Case 3

In this load case, both spans of the bridge model were loaded with the central support located at web D.

The first span of the bridge model was loaded with two sets of OHBD trucks possessing the same geometric features as load case 2.

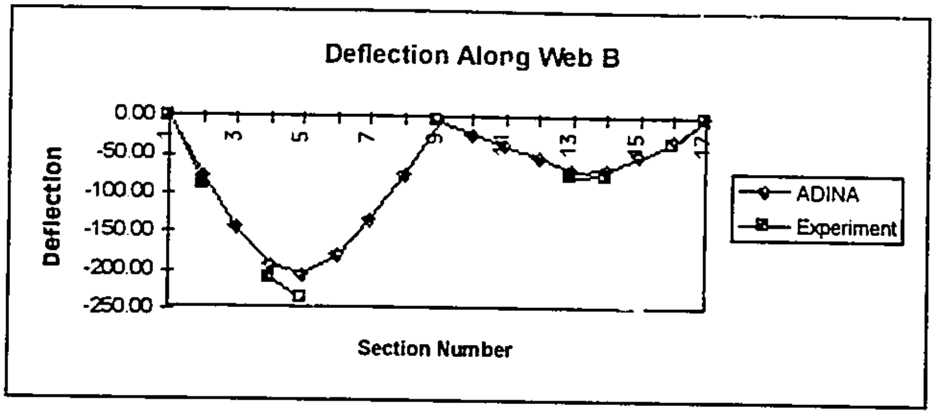
The second span of the bridge model was loaded eccentrically with one set of OHBD truck such that the first axle was aligned with section 12 and trucks number 5 & 6 were located on webs B & C respectively. Details are given on Fig. 4.22

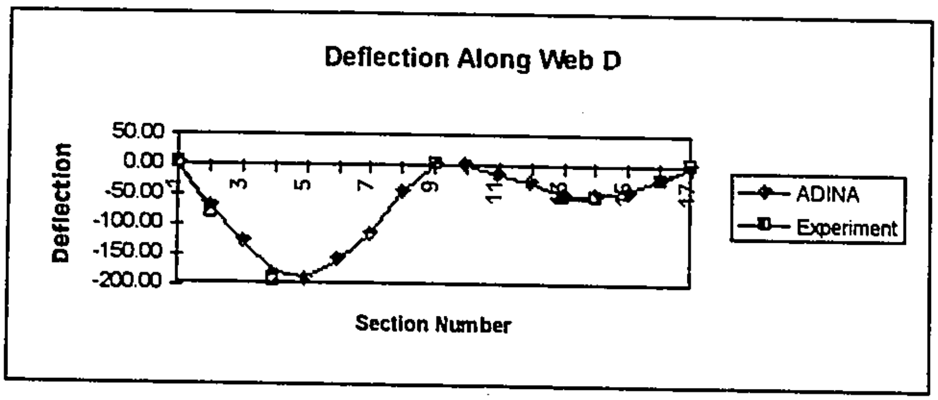
Fig. 5.9 presents an overall view for the behavior of the bottom plate of bridge model along three longitudinal webs B, D, & F in terms of deflections. Still maintaining a stiffer ADINA's model response, the percentage of error is almost the same as in the previous load cases. Table 5.9 shows the maximum deflection vales were 2.36 mm and 2.04 mm in the experimental model and ADINA model respectively. The maximum deflection occurred underneath web B and at section 5.

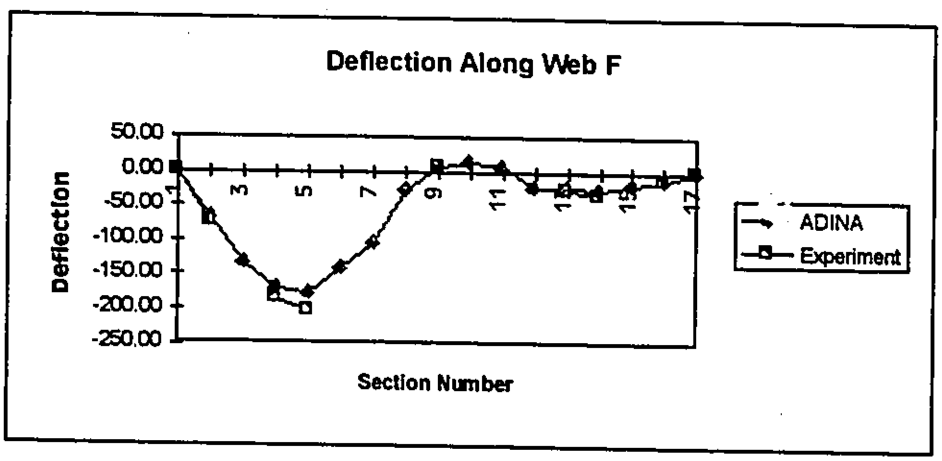
As shown in Fig. 5.9, a minimal deflection was observed from both ADINA predictions and the experimental results at sections 16, 14, and 13 when compared to sections 2, 4, and 5 respectively. It is also clear that the highest deflection took place underneath web B and due to the eccentric nature of the truck loading. Fig.5.10 shows a typical deflection of the bridge model in the transverse direction.

The stress distribution of the bridge model for both sections 4 and 5 is shown in Fig. 5.11. The ADINA model results are in agreement with those of the experimental model in terms of predicting the negative and positive curvatures at the instrumented sections. The maximum compressive stress in the concrete deck was recorded at web C in both experimental and ADINA models with values of 8.030 and 8.457 MPA respectively, giving a percentage of error of 5.0 % . Table 5.10 compares the ADINA and experimental stress results. At this stage, it is important to note that there has been a stress release in the order of 10-15 percent at the outer web B when compared to load case two.

As in the previous load cases, ADINA's model also underestimated the stress values due to the stiffer structure in the ADINA model.

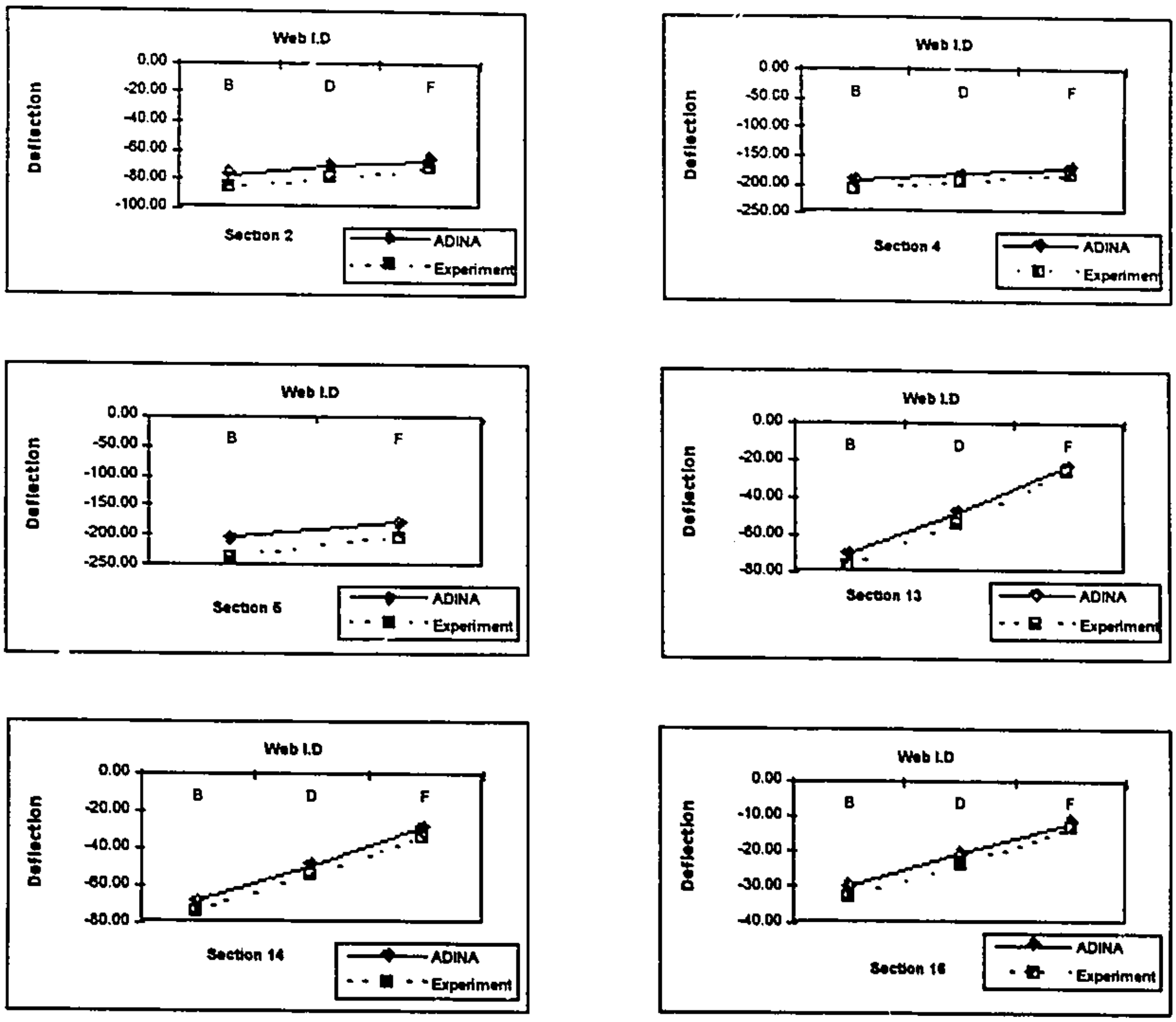






Note: All deflections are x10^-2 mm

FIGURE 5.9 VERTICAL DEFLECTION CURVES FOR LOAD CASE 3



Note: All deflections are x10^-2 mm

FIGURE 5.10 VERTICAL DEFLECTION CURVES FOR LOAD CASE 3

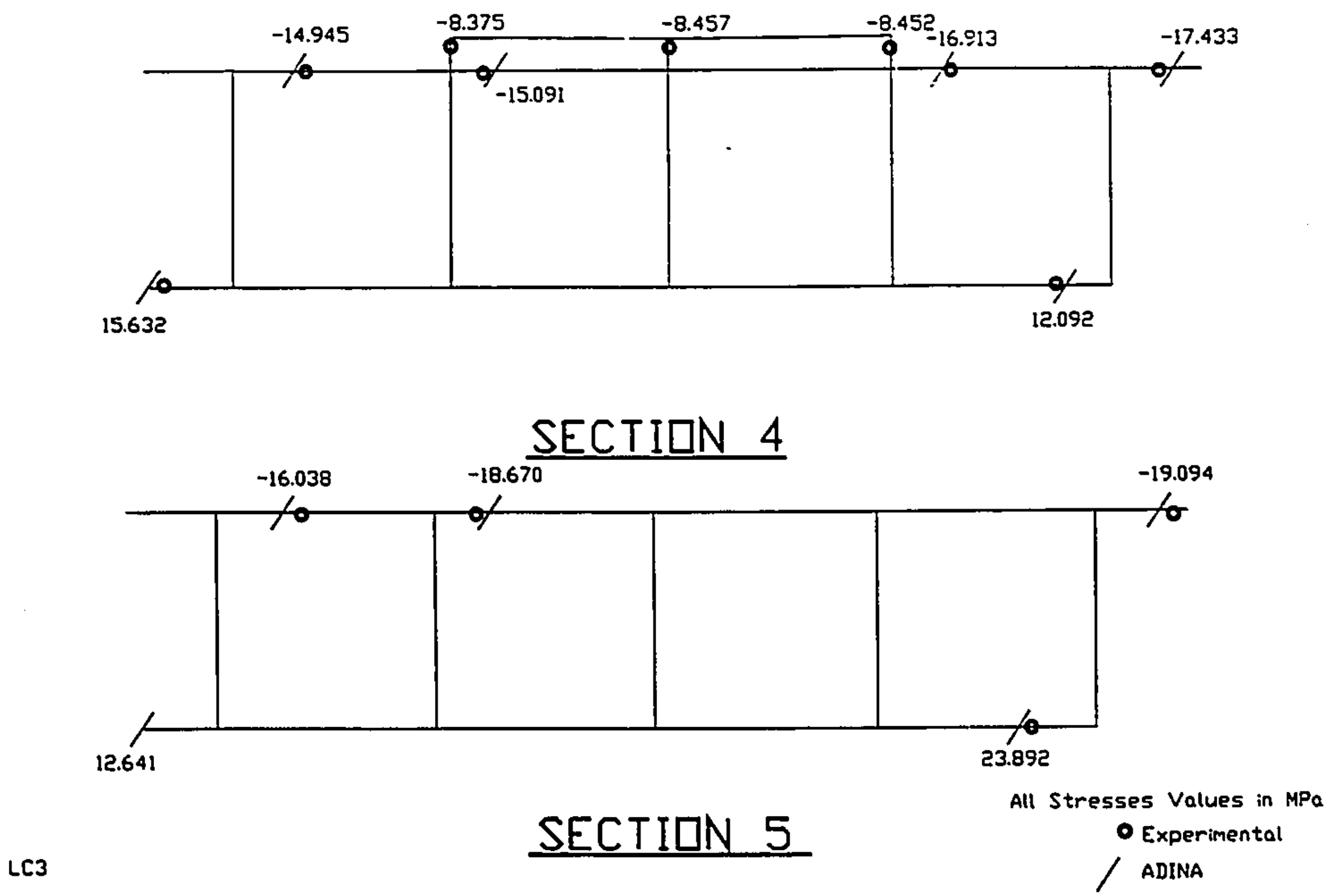


FIGURE 5.11 STRESS DISTRIBUTION FOR LOAD CASE 3

Table 5.9 Deflection Results For Load Case 3

Dial Gage	Experimental 27.799 N	Experimental 60,828 N	ADINA 60,828 N	% Error
VB2	40	87.53	77.59	12.8
VD2	37	80.96	71.22	13.7
VF2	32	70.02	66.95	4.6
VB4	96	210.06	192.24	9.3
VD4	90	196.93	182.41	8.0
VF4	79	172.86	170.00	1.7
VB5	108	236.32	204.32	15.7
VF5	93	203.50	178.58	14.0
VB13	35	76.58	69.81	9.7
VD13	25	54.70	47.65	14.8
VB14	34	74.40	68.79	8.2
VD14	25	54.70	49.48	10.6
VF14	14	30.63	28.37	8.0
VD16	10	21.88	20.77	5.4
VF16	5.5	12.03	11.97	0.5

Table 5.10 Stress Results For Load Case # 3

Strain Gage I.D	ADINA Stress @ 60,828 N	Experimental Stress @ 27,799 N	Experimental Stress @ 60,828 N	% Of Error
CL14	-8.375	-3.636	-7.956	5.0
CL24	-8.452	-3.700	-8.096	4.2
CL34	-8.457	-3.670	-8.030	5.0
AL14	-14.954	-8.674	-18.980	-26.9
AL24	15.632	6.897	15.092	3.5
AL34	-15.091	-6.985	-15.284	-1.3
AL54	N.A	N.A	N.A	N.A
AL64	12.092	6.612	14.468	-19.6
AL74	-17.433	-7.892	-17.269	0.9
AL114	-16.913	-8.632	-18.888	-11.7
AL15	-16.038	-9.339	-20.435	-27.4
AL35	-18.642	-7.511	-16.435	11.8
AL65	23.892	10.512	23.002	3.7
AL75	-19.094	-10.240	-22.407	-17.4

5.6.4 Load Case 4

In load case 4, with the middle support located on web D, both spans of the bridge model were loaded with four sets of OHBD trucks. Span one of the bridge model was loaded with two sets of OHBD trucks possessing the same geometric features as load case 2. Span 2 of the bridge model was loaded with two sets of OHBD trucks such that the first axle was aligned with section 12 and trucks number 5, 6, 7, and 8 were located on webs B, C, E, and F respectively as shown in Fig. 4.22

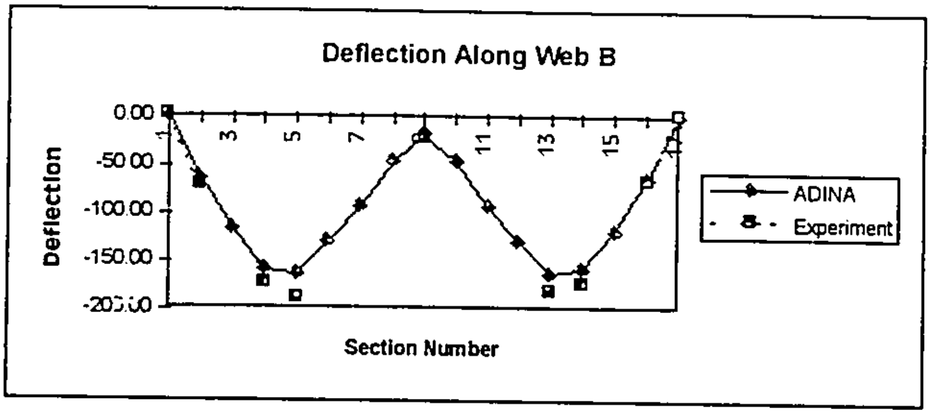
Vertical deflection plots along the three webs in the longitudinal direction namely, webs B, D, & F, for the box girder bridge model are given in Fig. 5.12. Similar to all previous load cases, the ADINA model is stiffer than the physical model. As can be noted from Fig. 5.12, the maximum deflection at the bottom plate occurred under webs B and F with approximately the same magnitude, showing a symmetrical behavior under a symmetrical truck loading.

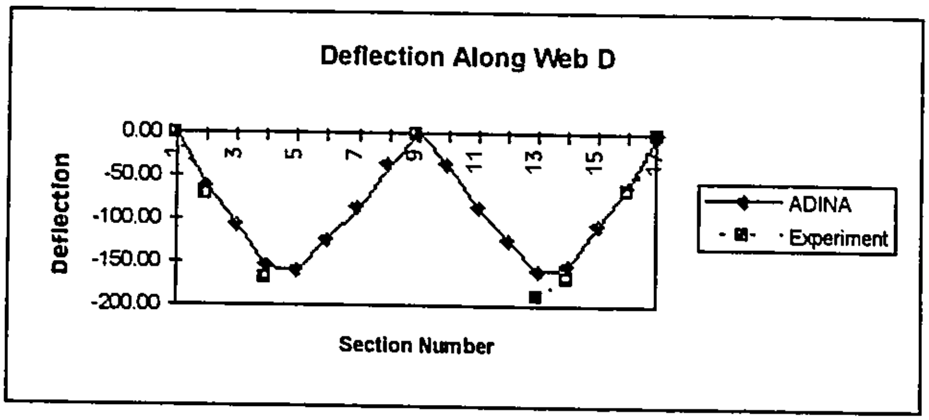
As shown in Table 5.11 the maximum experimental deflections at web B section 5 & 13 the deflections were 1.91 mm, 1.81 mm , respectively and web F section 5 & 13 the values were 1.75 mm, and 1.78 mm respectively. Also from Table 5.11 the maximum vertical deflection at section 5 was underestimated by the ADINA model. Similarly, section 13 was underestimated by ADINA model as well.

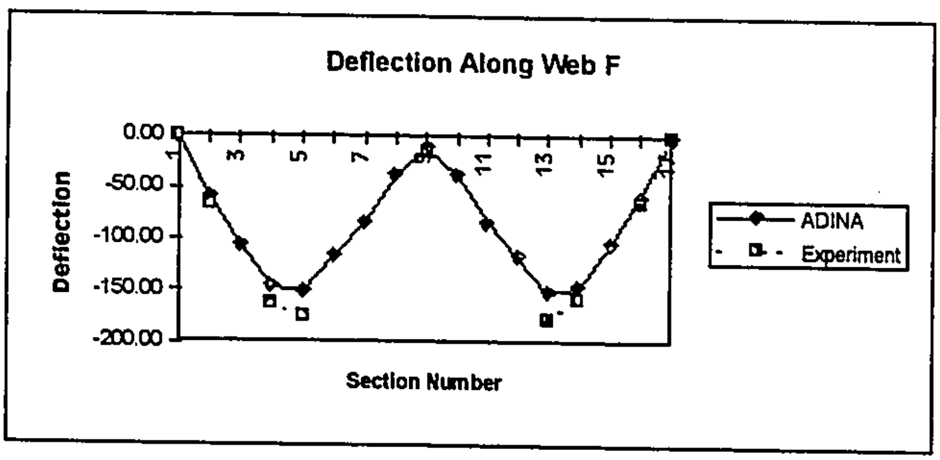
Fig. 5.14 shows the stress distribution of the box girder bridge model for both sections 4 and 5. The ADINA model results gives a good correlation with those of the experimental model in terms of the sign of the moments developing at the sections and for stress field in the instrumented sections. Both schemes were also in agreement on the location of the maximum moment at each section. The compressive stresses at section 4, in the concrete deck was almost uniform along the deck.

At this stage, it is evident from Figs. 5.8 and 5.14 that there has been a stress release at the outer webs B and F in the order of 45-60 percent when comparing this load case to load case 2.

Table 5.12 compares the ADINA predictions and the experimental stress results.

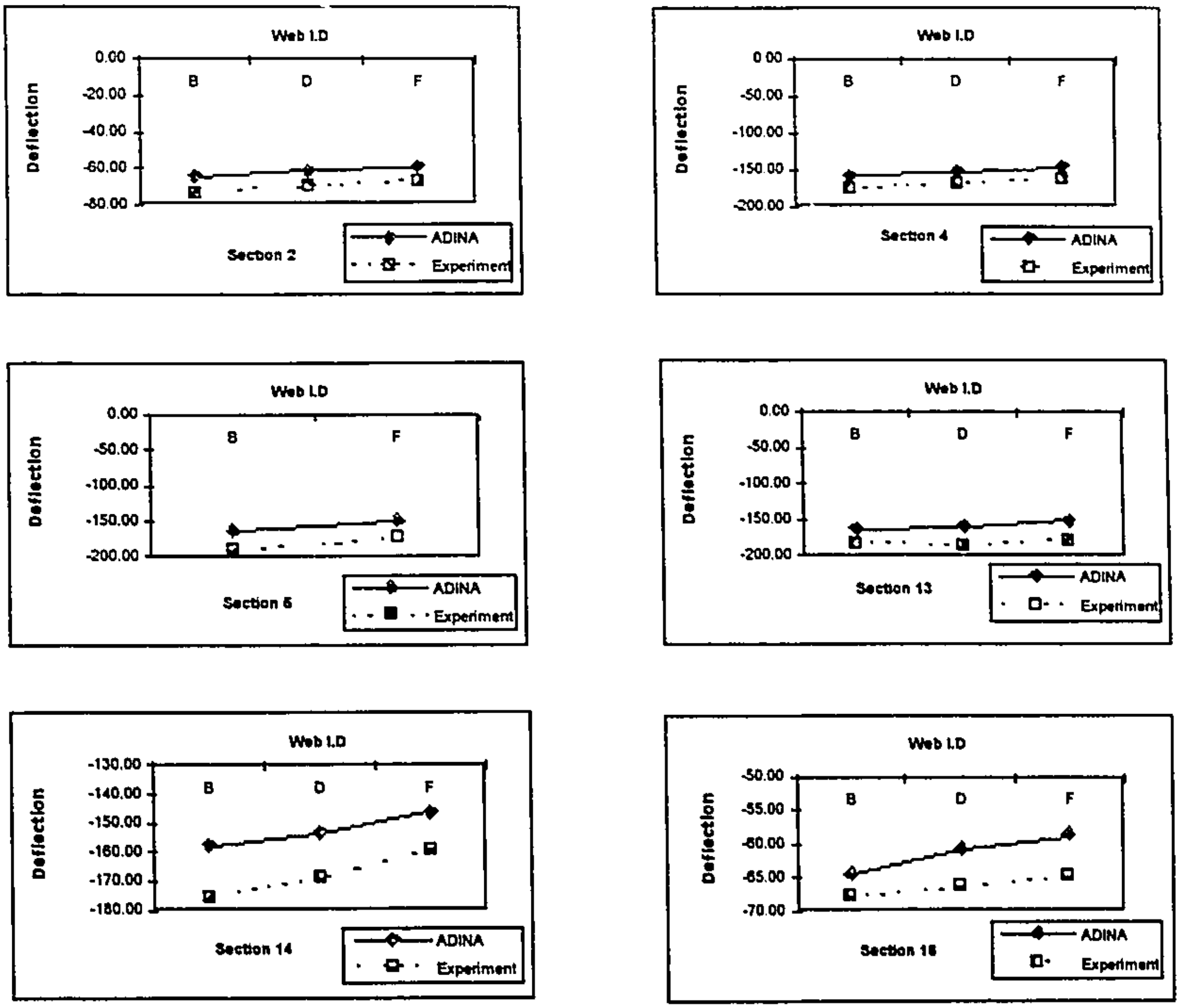






Note: All deflections are x10^-2 mm

FIGURE 5.12 VERTICAL DEFLECTION CURVES FOR LOAD CASE 4



Note: All deflections are x10^-2 mm

FIGURE 5.13 VERTICAL DEFLECTION CURVES FOR LOAD CASE 4

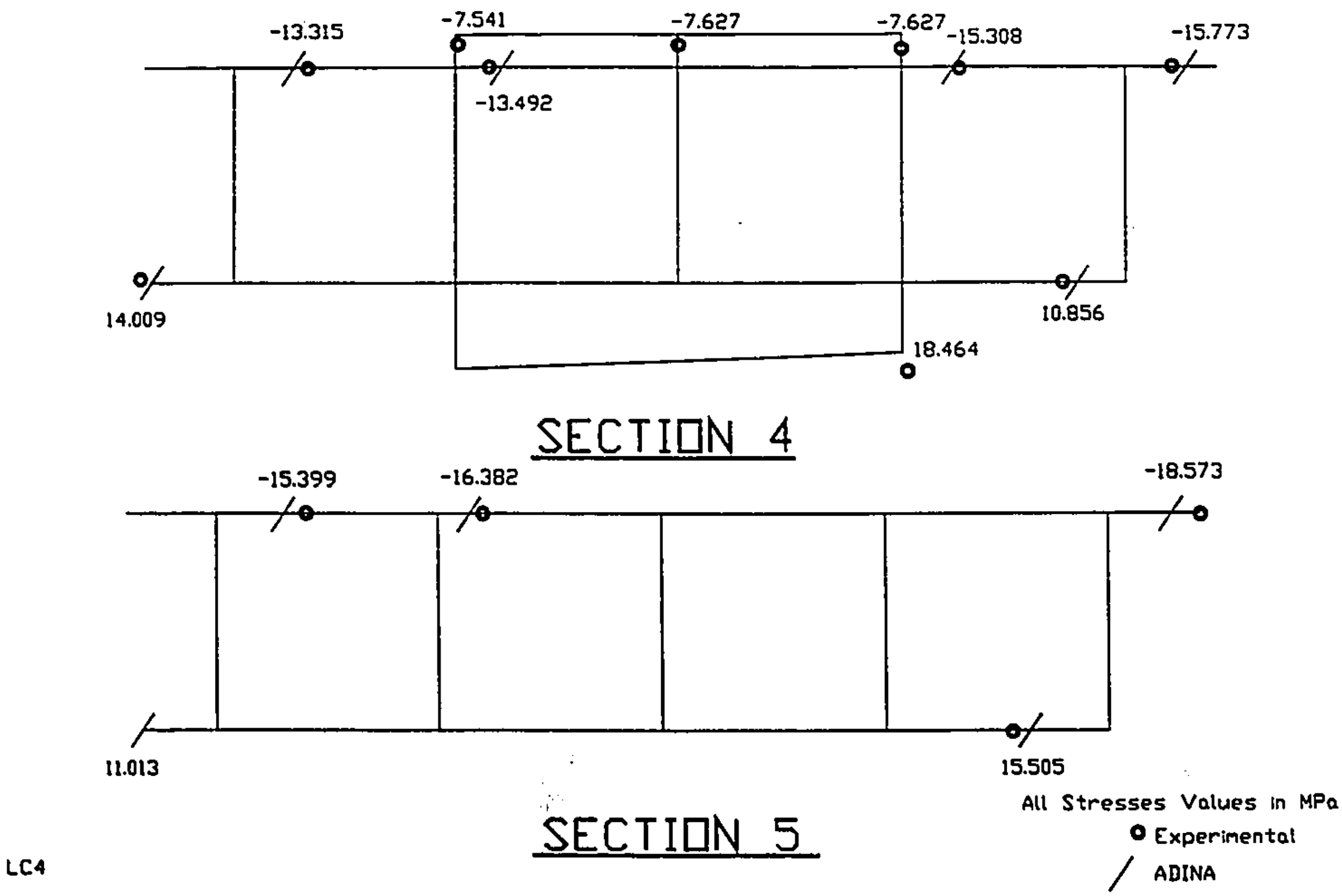


FIGURE 5.14 STRESS DISTRIBUTION FOR LOAD CASE 4

Table 5.11 Deflection Results For Load Case 4

Dial Gage	Experimental 25.429 N	Experimental 81,104 N	ADINA 81,104 N	% Error
VB2	23	73.36	64.66	13.5
VD2	22	70.17	60.89	15.2
VF2	21	66.98	58.87	13.8
VB4	55	175.42	157.90	11.1
VD4	53	169.04	153.58	10.1
VF4	51	162.66	146.33	11.2
VB5	60	191.37	163.88	16.8
VF5	55	175.42	151.33	15.9
VB13	57	181.80	163.88	10.9
VD13	59	188.18	159.60	17.9
VF13	56	178.61	151.33	18.0
VB14	55	175.42	157.90	11.1
VD14	53	169.04	153.56	10.1
VF14	50	159.47	146.33	9.0
VD16	21	66.98	60.89	10.0
VF16	21	66.98	58.87	13.8

Table 5.12 Stress Results For Load Case # 4

Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 25,428 N	Experimental Stress @ 81,104 N	% Of Error
CL14	-7.541	-2.195	-7.001	7.2
CL24	-7.627	-2.264	-7.221	5.3
CL34	-7.627	-2.230	-7.113	6.7
AL14	-13.315	-4.977	-15.874	-19.2
AL24	14.009	4.479	14.286	-2.0
AL34	-13.492	-3.894	-12.420	7.9
AL54	18.464	7.039	22.451	-21.6
AL64	10.856	4.053	12.927	-19.1
AL74	-15.773	-4.266	-13.607	13.7
AL114	-15.308	-4.957	-15.811	-3.3
AL15	-15.399	-5.533	-17.648	-14.6
AL35	-16.382	-4.282	-13.658	16.6
AL65	15.505	5.644	18.002	-16.1
AL75	-18.573	-7.269	-23.185	-24.8

5.6.5 Load Case 5

In this load case, both spans of the bridge model were loaded eccentrically each with one set of OHBD truck. Span one of the bridge model was loaded such that axle 1 of the OHBD truck is along section 3.5 and trucks 1 & 3 were situated on web B. The second span was loaded along section 12 with trucks 2 & 4 situated on web C. The middle support of this load case was located on web D. The loading and support conditions are shown in more detail in Fig.4.23.

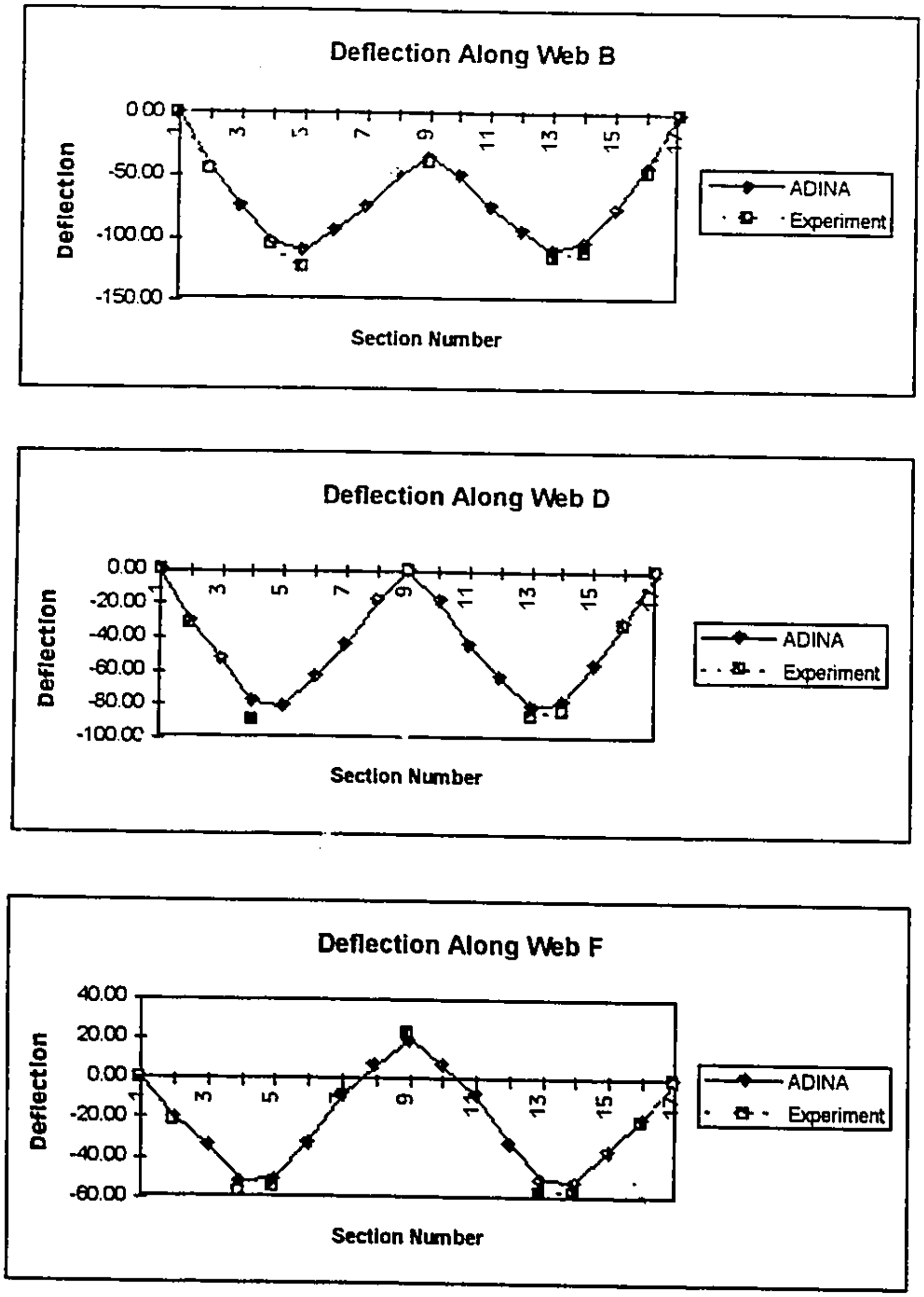
The maximum bottom plate deflection of the box girder bridge model for this load case was at section 5, particularly under web B due to the eccentric nature of the truck loading imposed on the bridge model. Table 5.13, compares the ADINA and experimental deflections for load case 5.

It can be noted from Fig. 5.15, the deflections at the bottom plate under web B were all downwards, whereas at web F and at section 9 some kind of an uplift was noted due to the eccentric nature of the truck loading.

Fig. 5.17 shows the stress distribution of the bridge model for sections 4 and 5. The ADINA model results seem to correlate very well with the experimental model in terms of the sign of the moments developing at the sections and for stress field in the instrumented sections. The maximum compressive stress at section

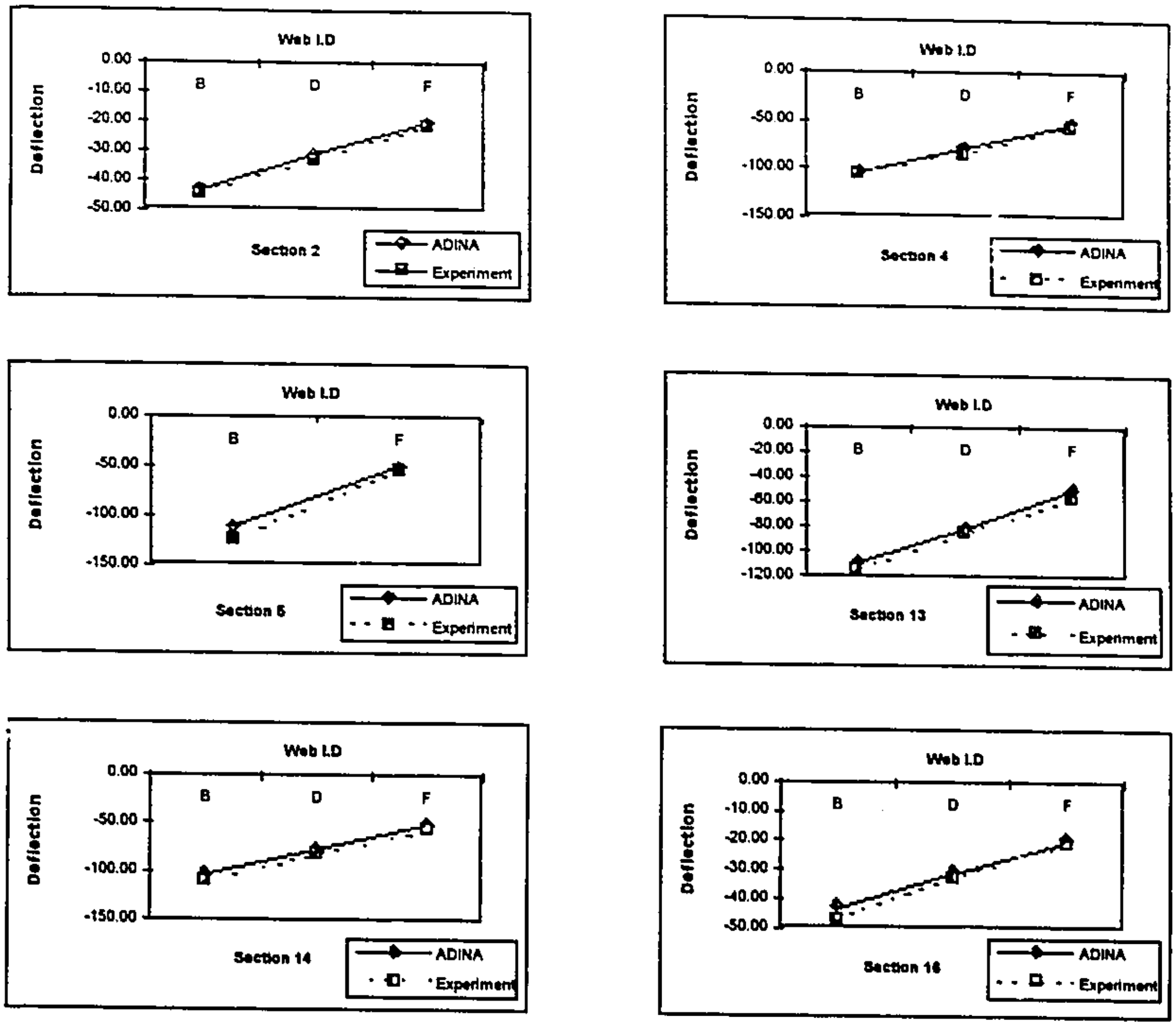
4 in the concrete deck was located at web C with a value of 4.176 MPa, resulting in 11.8 % of error. As for the webs, the maximum stress was at web B at section 5, the bottom of the web was subjected to 11.690 MPa of tension.

As can be seen from Table 5.14 the ADINA predictions compare very well with the experimental stress.



Note: All deflections are x10^-2 mm

FIGURE 5.15 VERTICAL DEFLECTION CURVES FOR LOAD CASE 5



Note: All deflections are x10^-2 mm

FIGURE 5.16 VERTICAL DEFLECTION CURVES FOR LOAD CASE 5

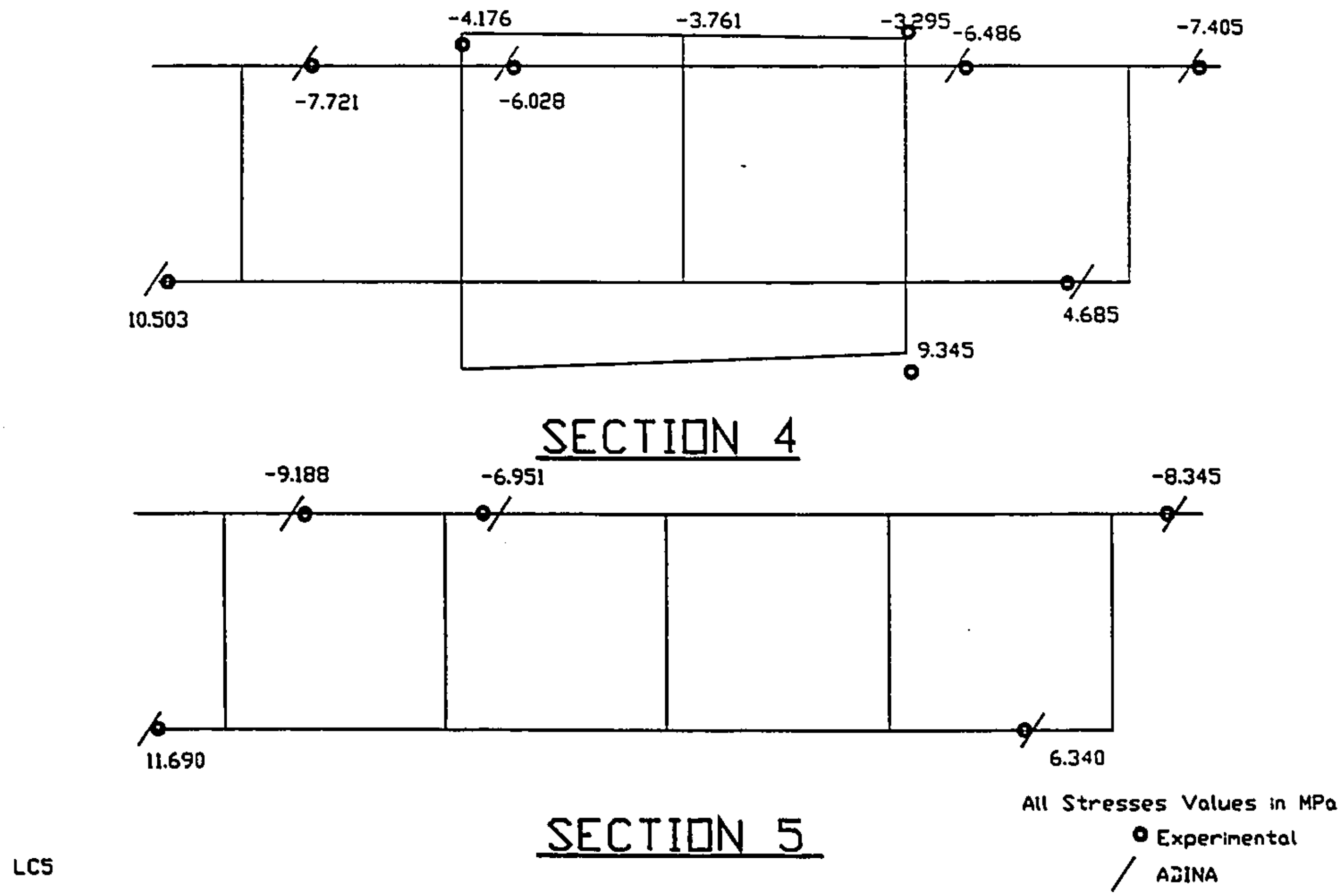


FIGURE 5.17 STRESS DISTRIBUTION FOR LOAD CASE 5

Table 5.13 Deflection Results For Load Case 5

Dial Gage	Experimental 14,120 N	Experimental 40,552 N	ADINA	% Error
VB2	15.5	44.52	42.93	3.7
VD2	11.5	33.03	31.10	6.2
VF2	7.5	21.54	20.06	7.4
VB4	37	106.26	103.12	3.0
VD4	31	89.03	78.31	13.7
VF4	20	57.44	52.04	10.4
VB5	43	123.49	110.25	12.0
VF5	19	54.57	50.52	8.0
VB13	40	114.88	110.25	4.2
VD13	30	86.16	81.37	5.9
VF13	20	57.44	50.52	13.7
VB14	39	112.01	103.12	8.6
VD14	29	83.29	78.31	6.4
VF14	20	57.44	52.04	10.4
VB16	16.5	47.39	42.93	10.4
VD16	11.5	33.03	31.10	6.2
VF16	7.5	21.54	20.06	7.4

Table 5.14 Stress Results For Load Case # 5

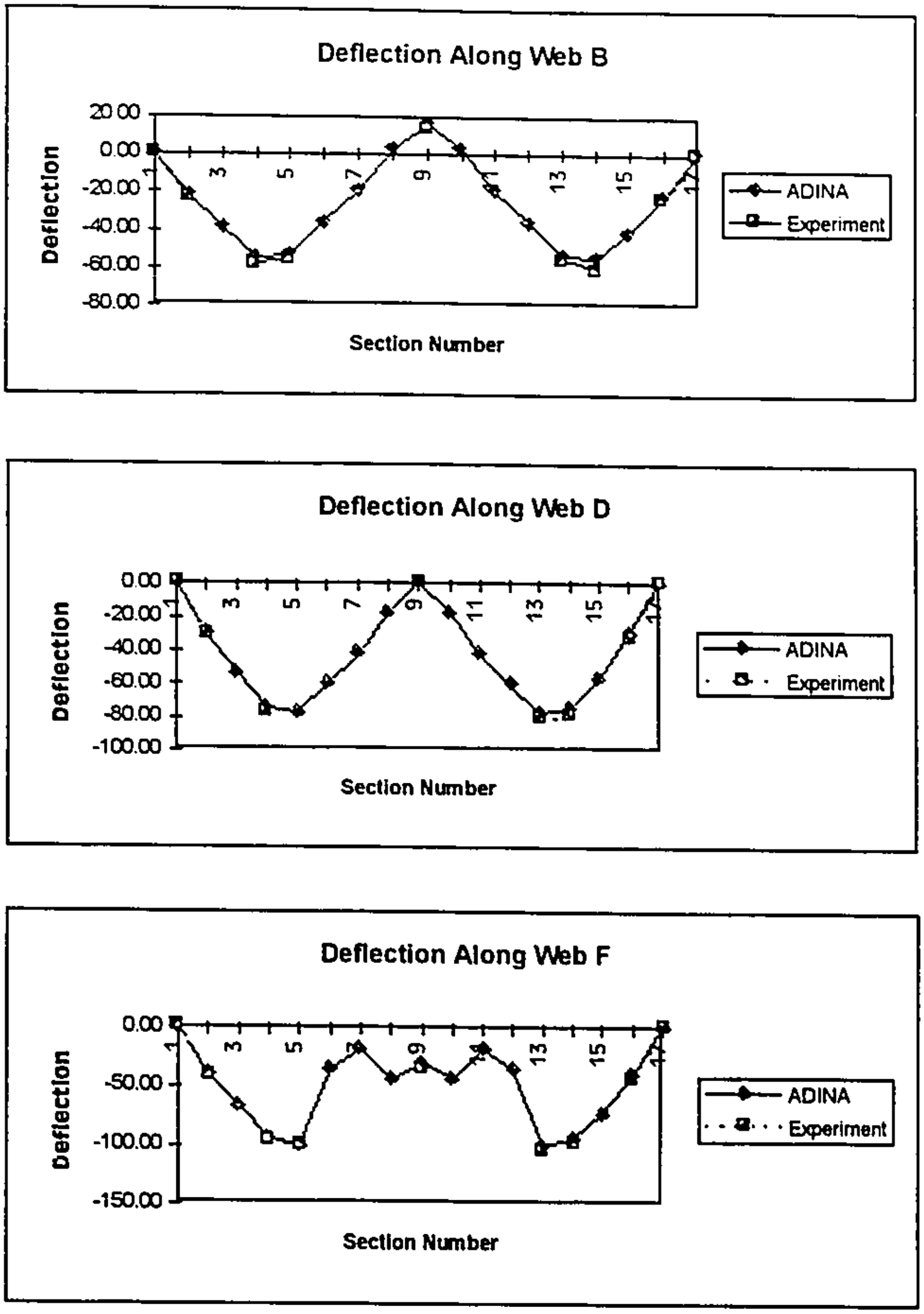
Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 14,120 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-4.176	-1.283	-3.685	11.8
CL24	-3.295	-1.064	-3.056	7.3
CL34	-3.761	N.A	N.A	N.A
AL14	-7.721	-2.986	-8.576	-11.1
AL24	10.503	3.271	9.394	10.6
AL34	-6.028	-2.239	-6.430	-6.7
AL54	9.345	4.053	11.640	-24.6
AL64	4.685	1.849	5.310	-13.3
AL74	-7.405	-2.275	-6.534	11.8
AL114	-6.486	-2.486	-7.140	-10.1
AL15	-9.188	-3.637	-10.445	-13.7
AL25	11.690	3.235	9.291	20.5
AL35	-6.951	-2.140	-6.146	11.6
AL65	6.430	2.231	6.407	0.4
AL75	-8.345	-2.908	-8.352	-0.1

5.6.6 Load Case 6

Similar to load case 5, in load case 6 the bridge model was loaded on both spans eccentrically with two sets of OHBD trucks as in load case 5 but trucks 1 & 3 were located on web E and trucks 2 & 4 on web F. The loading conditions are shown in Fig. 4.23.

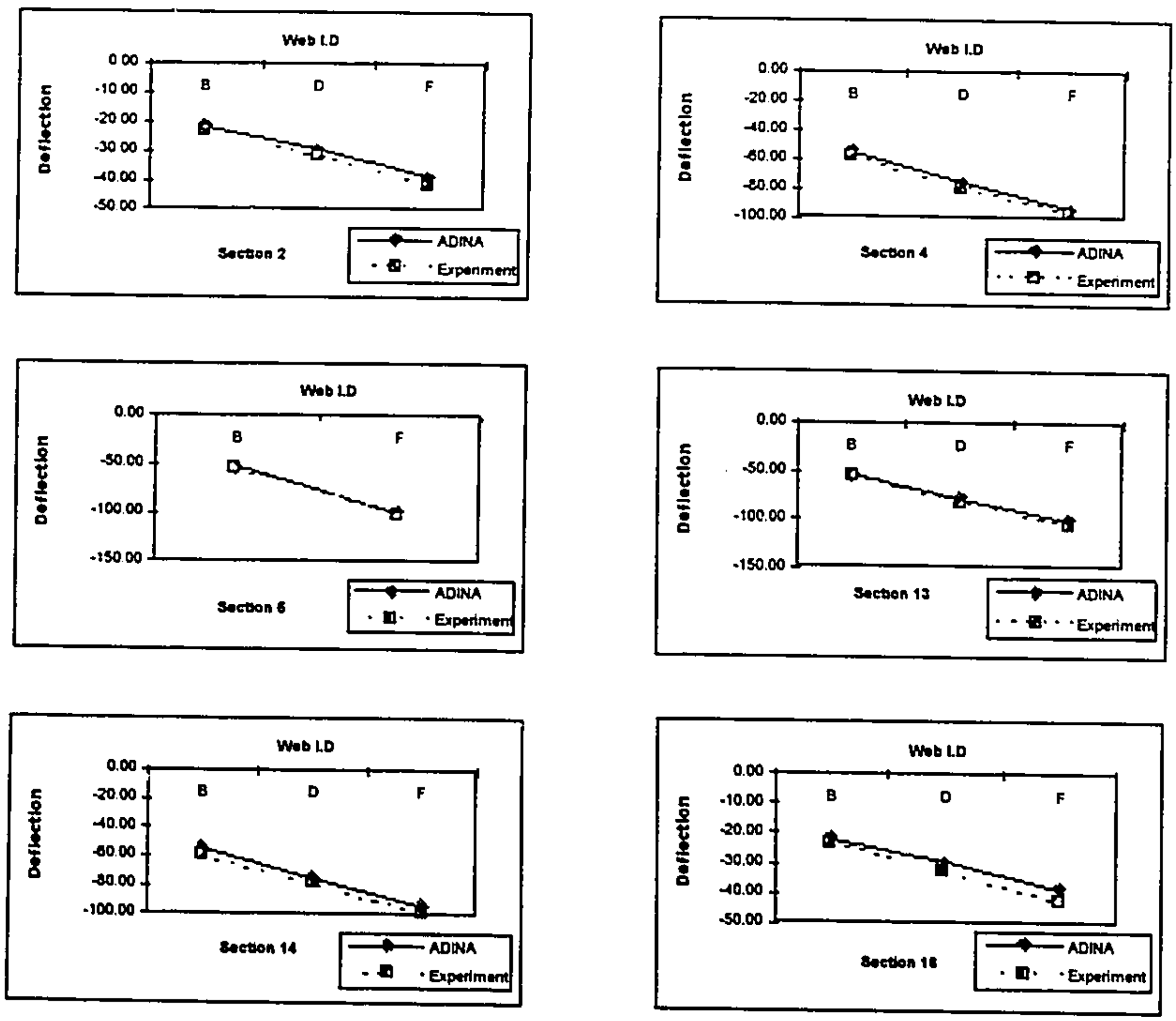
Fig. 5.18 presents an overall view for the behavior of the bottom plate of the box girder bridge model along three longitudinal webs B, D, & F in terms of deflections. The ADINA model response was in a very good agreement with the experimental results; a maximum of 11.0 % error can be noted from Table 5.15. Also Table 5.15 also shows that the maximum deflection values were 1.04 mm and 1.00 mm in the experimental model and ADINA model respectively. Fig.5.19 shows a typical deflection of the bridge model in the transverse direction.

The stress response of the box girder bridge model for sections 4 and 5 is shown in Fig.5.20. The ADINA provides a good correlation with the experimental results as shown in Table 5.16. As for the maximum compressive stresses at section 4 in the concrete deck, in this load case the maximum compressive stress was shifted to web E with a value of 4.318 MPa. As for the webs, the maximum stress was at web F at section 5, where the top of the web was subjected to 10.227 MPa of compression.



Note: All deflections are x10^-2 mm

FIGURE 5.18 VERTICAL DEFLECTION CURVES FOR LOAD CASE 6



Note: All deflections are x10^-2 mm

FIGURE 5.19 VERTICAL DEFLECTION CURVES FOR LOAD CASE 6

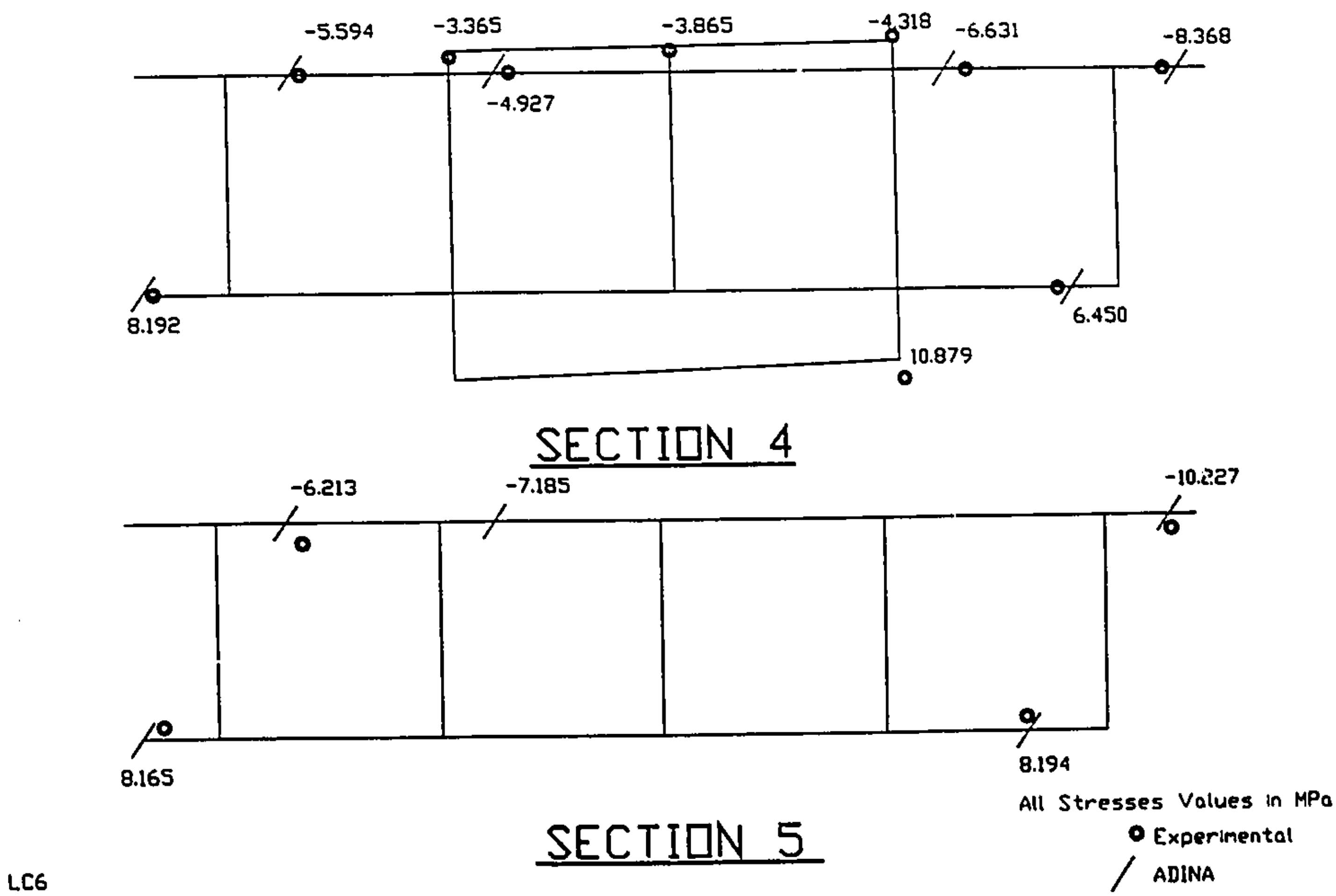


FIGURE 5.20 STRESS DISTRIBUTION FOR LOAD CASE 6

Table 5.15 Deflection Results For Load Case 6

Dial Gage	Experimental 14,727 N	Experimental 40,552 N	ADINA 40,552 N	% Error
VB2	8.5	23.41	21.72	7.7
VD2	11.5	31.67	29.79	6.3
VF2	15	41.30	38.82	6.4
VB4	21	57.93	54.78	5.6
VD4	28.5	78.48	75.27	4.3
VF4	35	36.38	94.29	2.2
VB5	20	55.07	53.63	2.7
VF5	37	101.88	100.80	1.1
VB13	20	55.07	53.63	2.7
VD13	29.5	81.23	78.23	3.8
VF13	38	104.64	100.80	3.8
VB14	22	60.58	54.78	10.6
VF14	36	99.13	94.29	5.1
VB16	8.5	23.41	21.72	7.7
VD16	12	33.04	29.79	10.9
VF16	15.5	42.68	38.82	10.0

Table 5.16 Stress Results For Load Case # 6

Strain Gage I.D -	ADINA Stress @ 40,552 N	Experimental Stress @ 14,727 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-3.365	-1.098	-3.023	10.2
CL24	-4.318	-1.544	-4.252	1.5
CL34	-3.865	-1.338	-3.684	4.7
AL14	-5.594	-2.275	-6.264	-12.0
AL24	8.192	2.506	6.900	15.8
AL34	-4.927	-2.031	-5.593	-13.5
AL54	10.879	4.835	13.314	-22.4
AL64	6.450	2.773	7.636	-18.4
AL74	-8.368	-2.702	-7.440	11.1
AL114	-6.631	-3.091	-8.511	-28.4
AL15	-6.213	-2.804	-7.721	-24.3
AL25	-8.165	-2.320	-6.388	21.8
AL65	8.194	3.289	9.057	-10.5
AL75	-10.227	-3.766	-10.370	-1.4

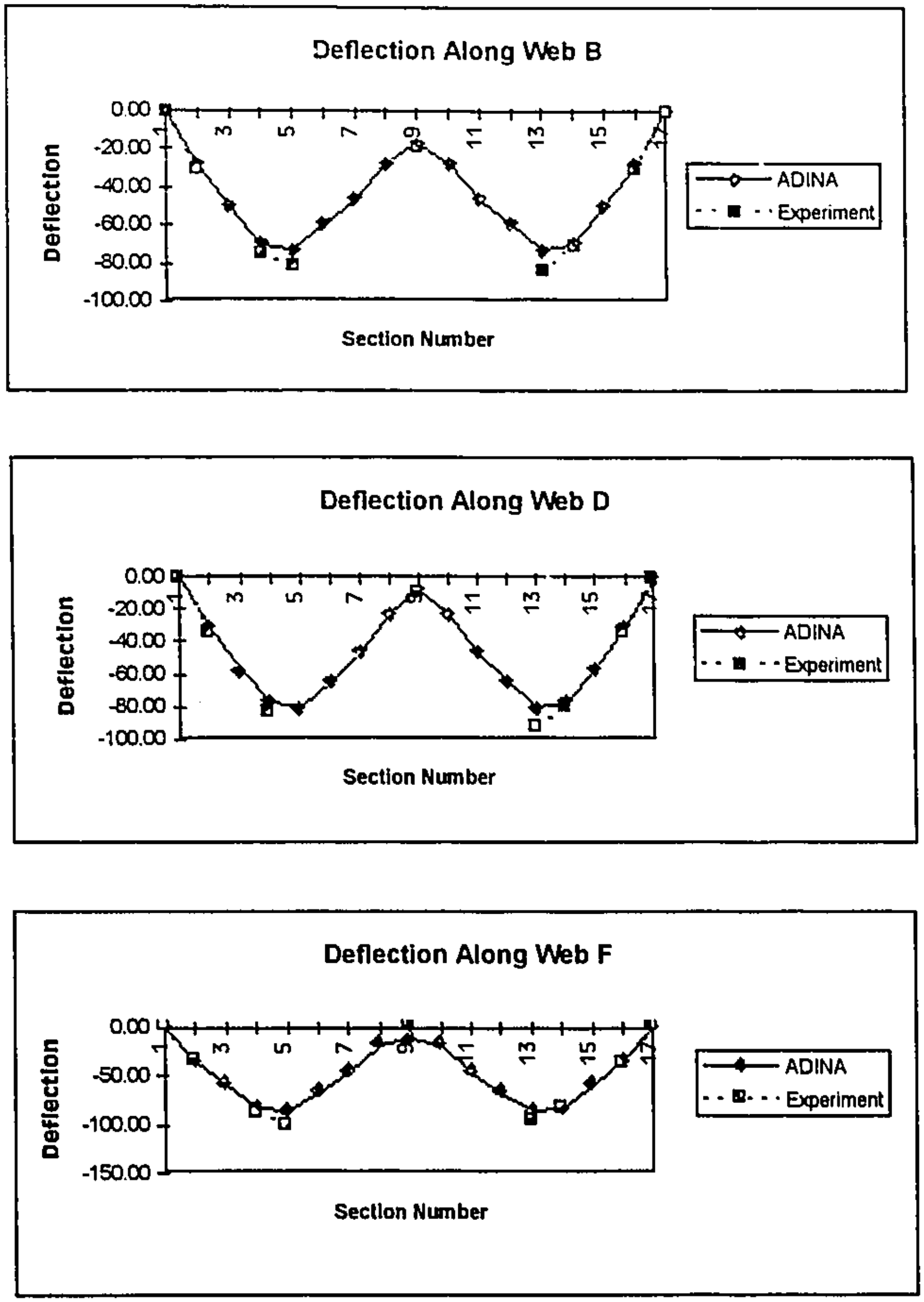
5.6.7 Load Case 7

Unlike all the previous load cases, in load case 7 the bridge model was loaded with the central support situated under web E. The OHBD truck loadings were the same as in load case 6, Fig. 4.24.

The maximum bottom plate deflection of the box girder bridge model for this load case occurred at sections 5 & 13, particularly under web F due to the eccentric nature of the truck loading imposed on the bridge model. Similar to previous load cases and referring to Table 5.17, ADINA's predictions for the deflections consistently lower than the experimental deflections. Comparing the deflection of the bottom plate of this load case to load case 6, it can be seen from Table 5.17A that for sections 5 and 13 where the maximum deflections took place, load case 7 yielded a 45-53 % increase in the deflections on the outer web B.

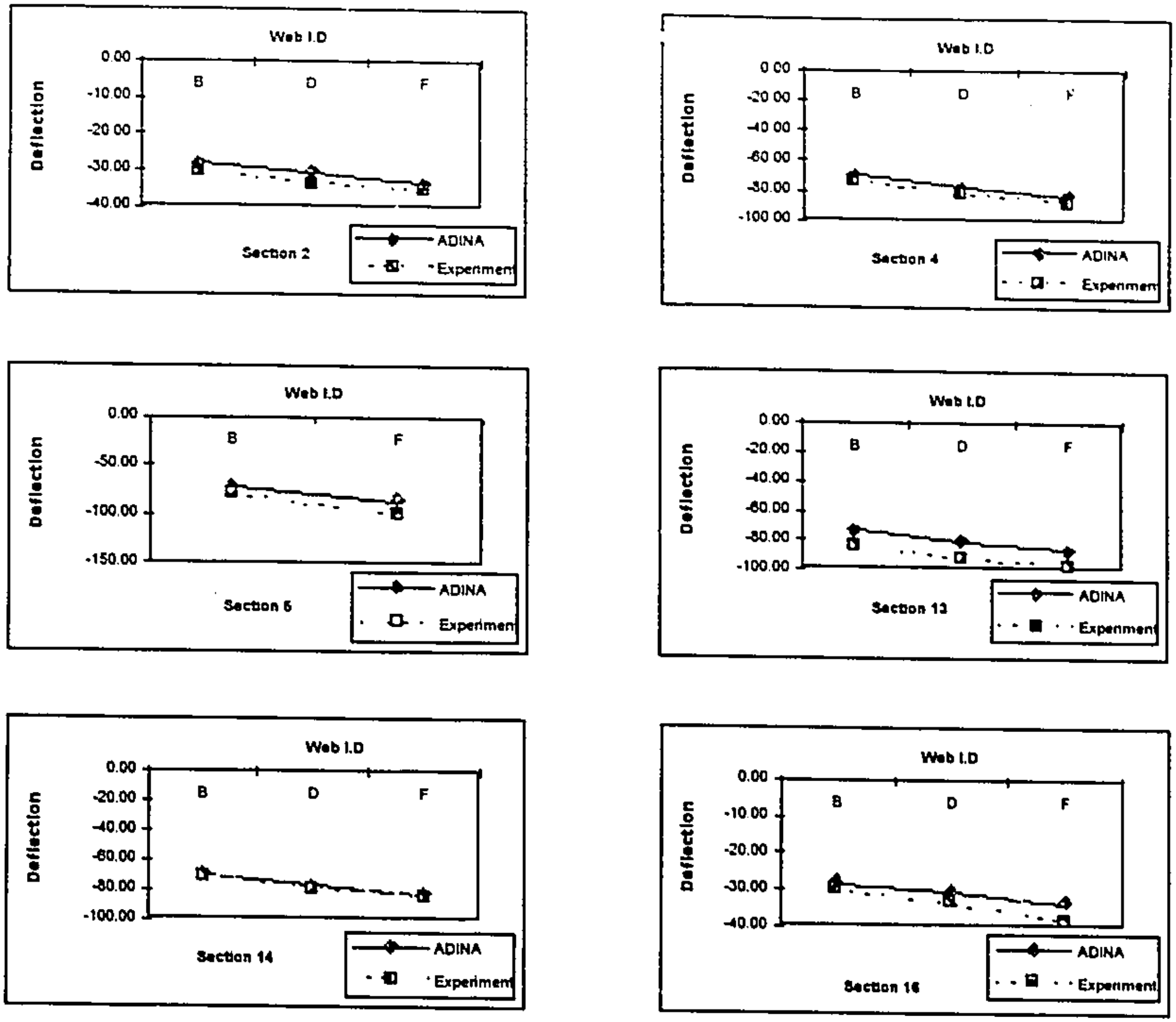
As for the stress response, Fig.5.23 shows the stress distribution of the box girder bridge model for sections 4 and 5. For this load case, ADINA's predictions did not perform as good as in the previous load cases. A higher percentage of errors were noted when comparing the ADINA's response with the experimental results as shown in Table 5.18. A maximum compressive stress at section 4 in the concrete deck, was located at web E with a value of 4.276 MPa (similar to load case 6), resulting in 4.9 % error between ADINA's predictions and experimental results. As for the webs, the maximum stress was at web F at section 5, with the top of the web subjected to 8.321 MPa of compression.

It is interesting to note from Table 5.18A that the stress response was not very much affected by changing the location of the central support as for the case with the deflection response.



Note: All deflections are x10^-2 mm

FIGURE 5.21 VERTICAL DEFLECTION CURVES FOR LOAD CASE 7



Note: All deflections are x10^-2 mm

FIGURE 5.22 VERTICAL DEFLECTION CURVES FOR LOAD CASE 7

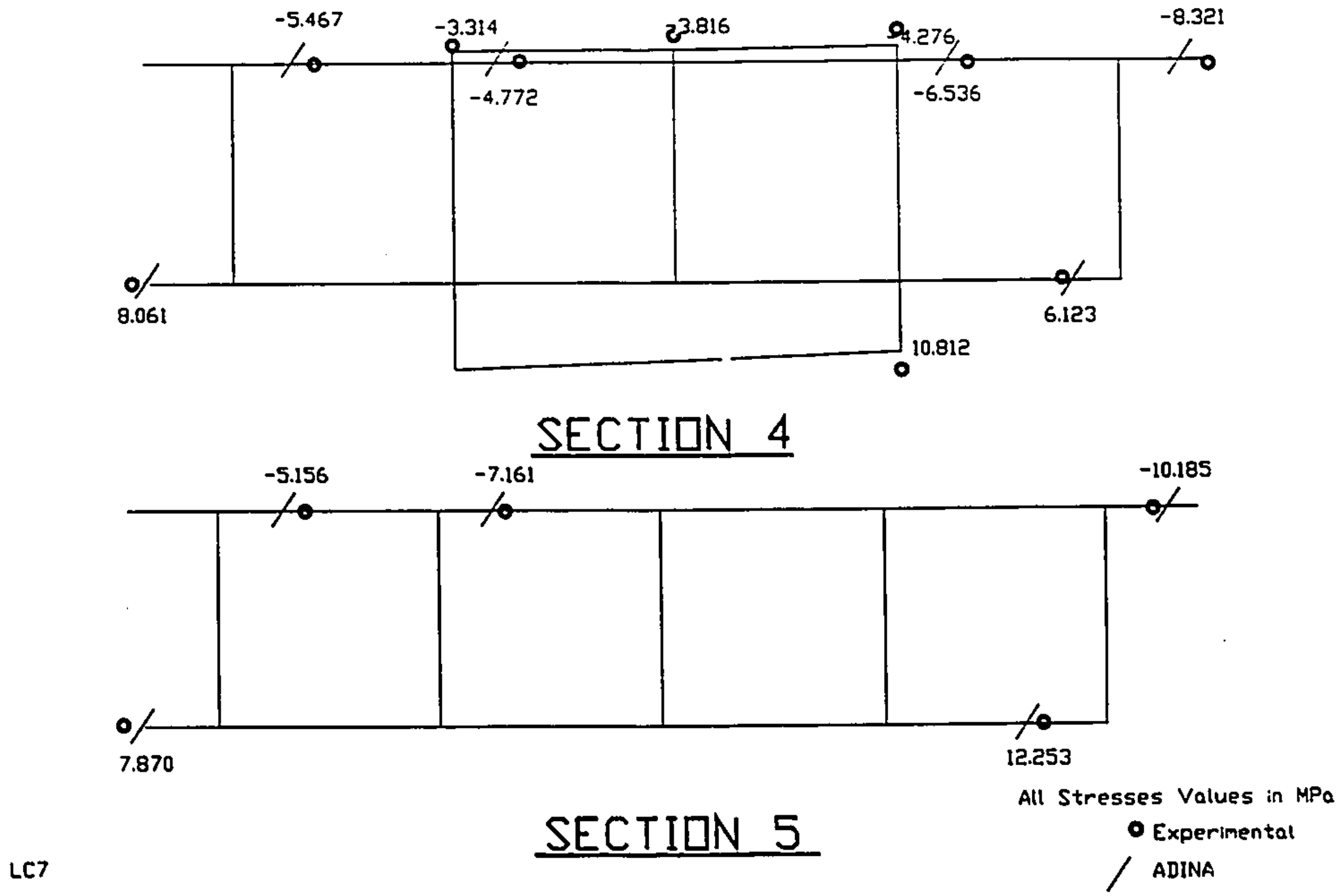


FIGURE 5.23 STRESS DISTRIBUTION FOR LOAD CASE 7

Table 5.17 Deflection Results For Load Case 7

Dial Gage	Experimental 12,036 N	Experimental 40,552 N	ADINA 40,552 N	% Error
VB2	9	30.32	28.31	7.1
VD2	10	33.69	30.58	10.2
VF2	10.5	35.38	33.72	4.9
VB4	22	74.12	69.93	6.0
VF4	26	87.60	83.43	5.0
VB5	24	80.86	72.81	11.1
VF5	30	101.08	86.81	16.4
VB13	25	84.23	72.81	15.7
VD13	27.5	92.65	81.08	14.3
VF13	29	97.71	86.81	12.6
VB14	21	70.75	69.93	1.2
VD14	23.5	79.18	77.54	2.1
VF14	25	84.23	83.43	1.0
VB16	9	30.32	28.31	7.1
VD16	10	33.69	30.58	10.2
VF16	11.5	38.75	33.72	14.9

Table 5.18 Stress Results For Load Case # 7

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 12,036 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-3.314	-1.269	-4.276	-29.0
CL24	-4.276	-1.681	-5.664	-32.4
CL34	-3.816	-1.338	-4.508	-18.1
AL14	-5.467	-1.920	-6.469	-18.3
AL24	8.061	3.200	10.782	-33.7
AL34	-4.772	-1.610	-5.424	-13.7
AL54	10.812	3.911	13.177	-21.9
AL64	6.123	2.346	7.904	-29.1
AL74	-8.321	-3.413	-11.499	-38.2
AL114	-6.536	-2.372	-7.992	-22.3
AL15	-5.156	-1.912	-6.443	-25.0
AL25	7.870	3.030	10.209	-29.7
AL35	-7.161	-2.356	-7.938	-10.9
AL65	12.253	4.250	14.319	-16.9
AL75	-10.185	-4.111	-13.851	-36.0

Table 5. 17A Experimental Deflection Comparison Between Load Cases 6 & 7

	Load Case # 6		Load Case # 7		
Dial Gage I.D	Adjusted Experimental Deflection mmx10^ -2 @ 14,727 N	Adjusted Experimental Deflection mmx10^ -2 @ 40,552 N	Adjusted Experimental Deflection mmx10^ -2 @ 12,036 N	Adjusted Experimental Deflection mmx10^ -2 @ 40,552 N	% Of Difference @ 40,552 N
VB2	8.50	23.41	9.00	30.32	29.56
VD2	11.50	31.67	10.00	33.69	6.40
VF2	15.00	41.30	10.50	35.38	-14.35
VB4	21.00	57.83	22.00	74.12	28.18
VF4	35.00	96.38	26.00	87.60	-9.11
VB5	20.00	55.07	24.00	80.86	46.83
VF5	37.00	101.88	30.00	101.08	-0.79
VB13	20.00	55.07	25.00	84.23	52.95
VD13	29.50	81.23	27.50	92.65	14.06
VF13	38.00	104.64	29.00	97.71	-6.62
VB14	22.00	60.58	21.00	70.75	16.80
VF14	36.00	99.13	25.00	84.23	-15.03
VB16	8.50	23.41	9.00	30.32	29.56
VD16	12.00	33.04	10.00	33.69	1.96
VF16	15.50	42.68	11.50	38.75	-9.22

Table 5.18A Experimental And ADINA Stresses Comparison Between Load Cases 6 & 7

	Load Case # 6		Load Case # 7		% Difference	
Strain Gage I.D	ADINA Stress @ 40.552 N	Experimental Stress @ 40.552 N	ADINA Stress @ 40.552 N	Experimental Stress @ 40.552 N	Experimental	ADINA
CL14	-3.365	-3.023	-3.314	-4.276	41.41	-1.51
CL24	-4.318	-4.252	-4.276	-5.664	33.21	-0.97
CL34	-3.865	-3.684	-3.816	-4.508	22.36	-1.25
AL14	-5.594	-6.264	-5.467	-6.469	3.26	-2.26
AL24	8.192	6.900	8.061	10.782	56.24	-1.60
AL34	-4.927	-5.593	-4.772	-5.424	-3.01	-3.16
AL54	10.879	13.314	10.812	13.177	-1.03	-0.62
AL64	6.450	7.636	6.123	7.904	3.52	-5.08
AL74	-8.368	-7.440	-8.321	-11.499	54.55	-0.56
AL114	-6.631	-8.511	-6.536	-7.992	-6.10	-1.43
AL15	-6.213	-7.721	-5.156	-6.443	-16.55	-17.01
AL25	8.165	6.388	7.870	10.209	59.80	-3.62
AL65	8.194	9.057	12.253	14.319	58.11	49.53
AL75	-10.227	-10.370	-10.185	-13.851	33.57	-0.41

5.6.8 Load Case 8

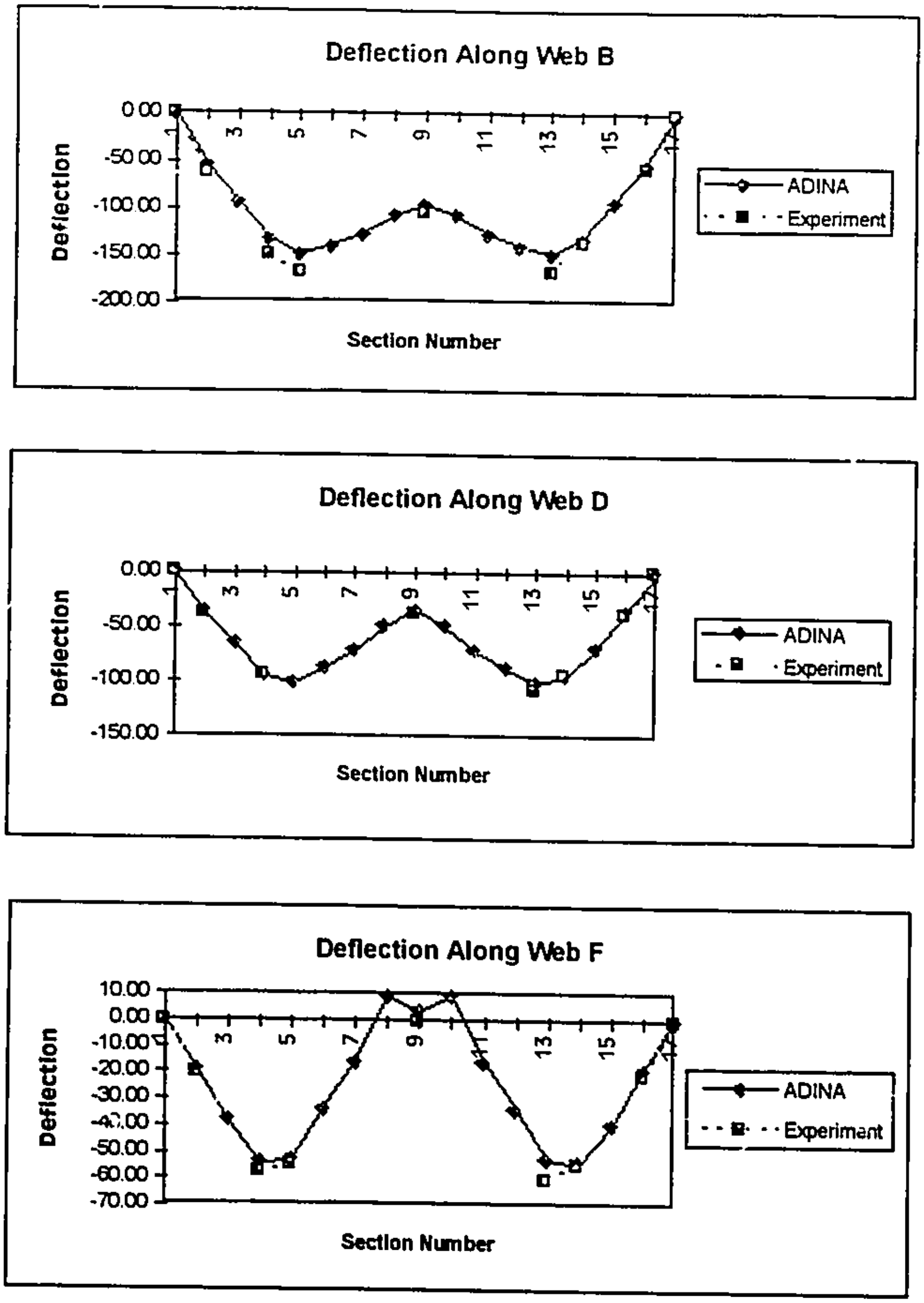
In this load case, the bridge model was loaded with two sets of OHBD trucks, with the central support remaining the same as in load case 7. However, trucks 1 & 3 were located on web B and trucks 2 & 4 on web C. Details are given in Fig. 4.24.

Vertical deflection plots along the three webs in the longitudinal direction namely, webs B, D, & F, for the box girder bridge model are given in Fig. 5.24. Similar to the previous load cases, the ADINA model is stiffer than the physical model, and it is clear from Fig. 5.24 that the maximum deflection at the bottom plate occurred under web B at sections 5 & 13 with approximately the same magnitude, showing a symmetrical behavior under the eccentric, symmetric truck loading.

Referring to Table 5.19, ADINA's predictions for the deflections were in close agreement with the experimental values. The maximum deflection occurred at section 5 and was underestimated by 18.4 % . Comparing the deflection of the bottom plate results of load case 8 with load case 5, it can be seen from Table 5.19A that at sections 5 and 13 where the maximum deflections occurred, an increase in the deflections in load case 8 took place at the outer web B in the order of 44% whereas 63% increase in deflection was noted at web B under section 13.

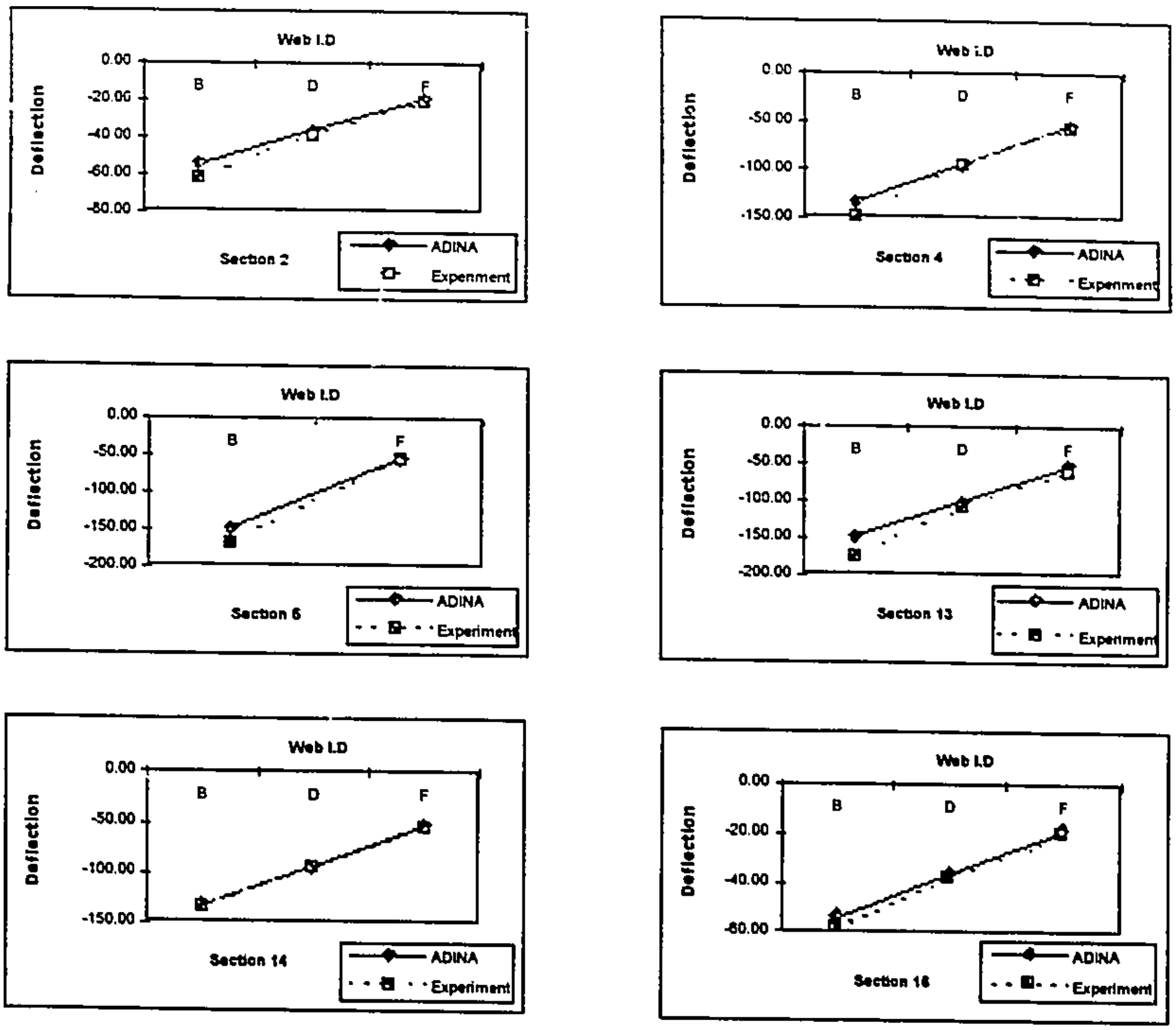
Fig. 5.26 presents the stress response of the box girder bridge model for sections 4 and 5. In this load case, ADINA's predictions performed better than in the previous load case. Table 5.20 shows a comparison of the ADINA and experimental deflections. The maximum compressive stress in the concrete deck at section 4 was located at web C with a value of 4.227 MPa resulting in 16.8 % difference between ADINA's predictions and the experimental results. As for the webs, the maximum stress was at web F at section 5, the bottom of the web was subjected to 12.977 MPa of tension.

It is evident from Table 5.20A, unlike load cases 6 & 7, the stress response changes appreciately by moving the central support from web D to web E.



Note: All deflections are x10^-2 mm

FIGURE 5.24 VERTICAL DEFLECTION CURVES FOR LOAD CASE 8



Note: All deflections are x10^-2 mm

FIGURE 5.25 VERTICAL DEFLECTION CURVES FOR LOAD CASE 8

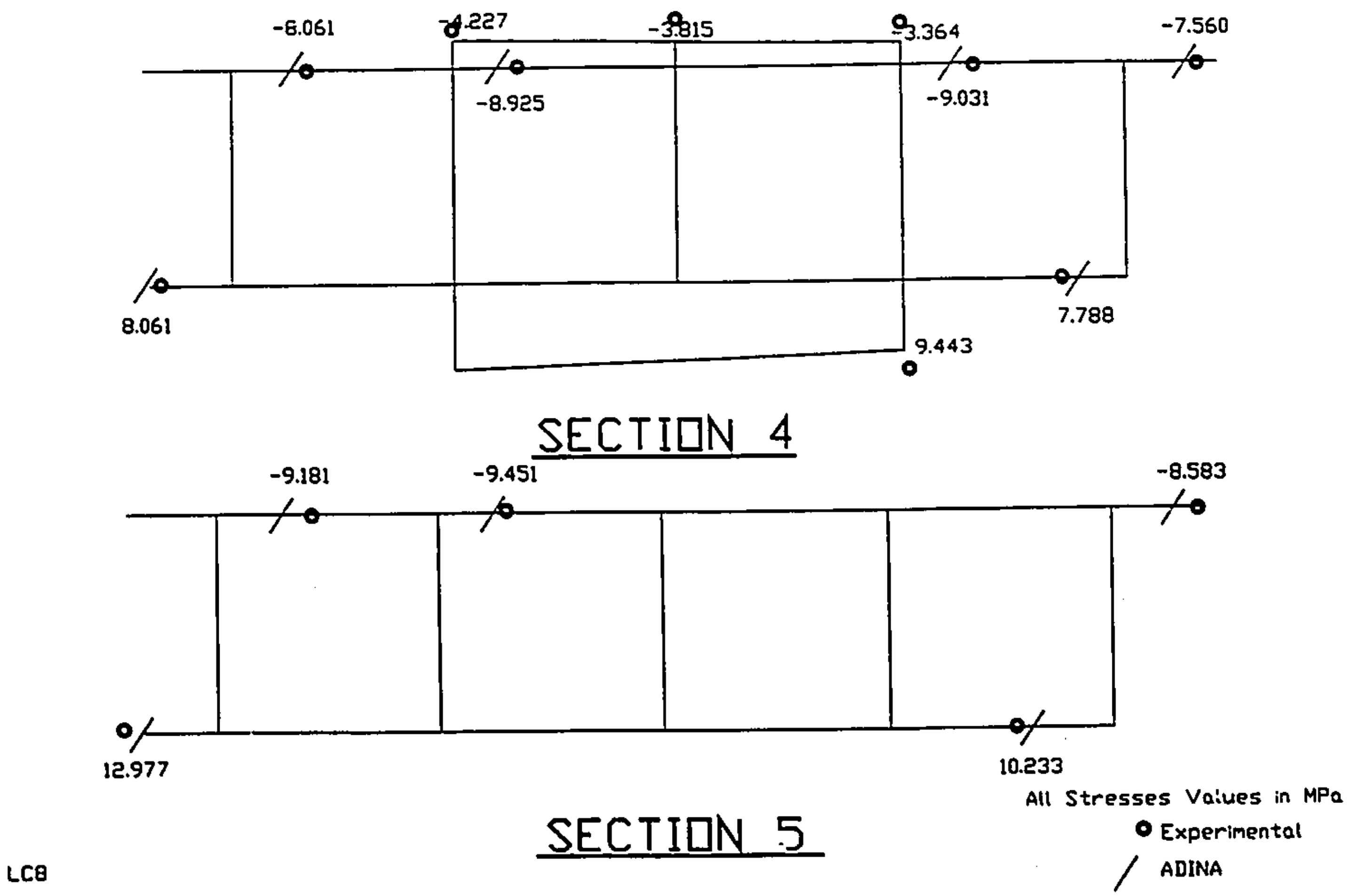


FIGURE 5.26 STRESS DISTRIBUTION FOR LOAD CASE 8

Table 5.19 Deflection Results For Load Case 8

Dial Gage	Experimental 14,145 N	Experimental 40,552 N	ADINA 40,552 N	% Error
VB2	21.5	61.64	54.16	13 8
VD2	13.5	38.70	36.22	6 8
VB4	52	149 08	132 35	12 6
VD4	33	94.61	93.94	0.7
VF4	20	57.34	53.89	6 4
VB5	58	166.28	147.67	12 6
VF5	19	54 47	53.05	2 7
VB13	61	174.88	147 67	18 4
VD13	38	108.94	101.56	7 3
VF13	21	60.20	53.05	13.5
VB14	47	134 74	132.35	1 8
VD14	33	94.61	93.94	0 7
VF14	19	54.47	53.89	1.1
VB16	20 5	58.77	54.16	8.5
VD16	13 5	38 70	36 22	6 8

Table 5.20 Stress Results For Load Case # 8

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 10,144 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-4.227	-1.235	-4.937	-16.8
CL24	-3.364	-1.029	-4.114	-22.3
CL34	-3.815	-1.201	-4.801	-25.9
AL14	-8.042	-2.295	-9.175	-14.1
AL24	8.061	1.849	7.392	8.3
AL34	-8.925	-2.279	-9.111	-2.1
AL54	9.443	2.773	11.085	-17.4
AL64	7.788	2.204	8.811	-13.1
AL74	-7.560	-1.920	-7.675	-1.5
AL114	-9.031	-2.655	-10.614	-17.5
AL15	-9.181	-2.838	-11.345	-23.6
AL25	12.977	3.412	13.640	-5.1
AL35	-9.451	-2.322	-9.283	1.8
AL65	10.233	3.031	12.117	-18.4
AL75	-8.583	-2.695	-10.774	-25.5

Table 5. 19A Experimental Deflection Comparison Between Load Cases 5 & 8

	Load Case # 5		Load Case # 8		
Dial Gage I.D	Adjusted Experimental Deflection mmx10^ -2 @ 14,120 N	Adjusted Experimental Deflection mmx10^ -2 @ 40,552 N	Adjusted Experimental Deflection mmx10^ -2 @ 14,145 N	Adjusted Experimental Deflection mmx10^ -2 @ 40,552 N	% Of Difference @ 40,552 N
VB2	15.50	41.57	21.50	61.64	48.27
VD2	11.50	30.84	13.50	38.70	25.48
VB4	37.00	99.23	52.00	149.08	50.23
VD4	31.00	83.14	33.00	94.61	13.79
VF4	20.00	53.64	20.00	57.34	6.89
VB5	43.00	115.33	58.00	166.28	44.18
VF5	19.00	50.96	19.00	54.47	6.89
VB13	40.00	107.28	61.00	174.88	63.01
VD13	30.00	80.46	38.00	108.94	35.40
VF13	20.00	53.64	21.00	60.20	12.24
VB14	39.00	104.60	47.00	134.74	28.82
VD14	29.00	77.78	33.00	94.61	21.64
VF14	20.00	53.64	19.00	54.47	1.55
VB16	16.50	44.25	20.50	58.77	32.81
VD16	11.50	30.84	13.50	38.70	25.48

Table 5.20A Experimental And ADINA Stresses Comparison Between Load Cases 5 & 8

	Load Case # 5		Load Case # 8		% Difference	
Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 40,552 N	ADINA Stress @ 40,552 N	Experimental Stress @ 40,552 N	Experimental	ADINA
CL14	-4.176	-3.685	-4.227	-4.937	33.99	1.21
CL24	-3.295	-3.056	-3.364	-4.114	34.62	2.11
AL14	-7.721	-8.576	-8.042	-9.175	6.98	4.16
AL24	10.503	9.394	8.061	7.392	-21.32	-23.25
AL34	-6.028	-6.430	-8.925	-9.111	41.68	48.07
AL54	9.345	11.640	9.443	11.085	-4.76	1.05
AL64	4.685	5.310	7.788	8.811	65.92	66.24
AL74	-7.405	-6.534	-7.560	-7.675	17.47	2.09
AL114	-6.486	-7.140	-9.031	-10.614	48.66	39.23
AL15	-9.188	-10.445	-9.181	-11.345	8.62	-0.08
AL25	11.690	9.291	12.977	13.640	46.81	11.01
AL35	-6.951	-6.146	-9.451	-9.283	51.03	35.96
AL65	6.430	6.407	10.233	12.117	89.12	59.14
AL75	-8.345	-8.352	-8.583	-10.774	29.00	2.85

5.6.9 Load Case 9

Load case 9 have the same loading features as in load case 4, apart from the fact that the middle support was moved to web E, Fig. 4.25.

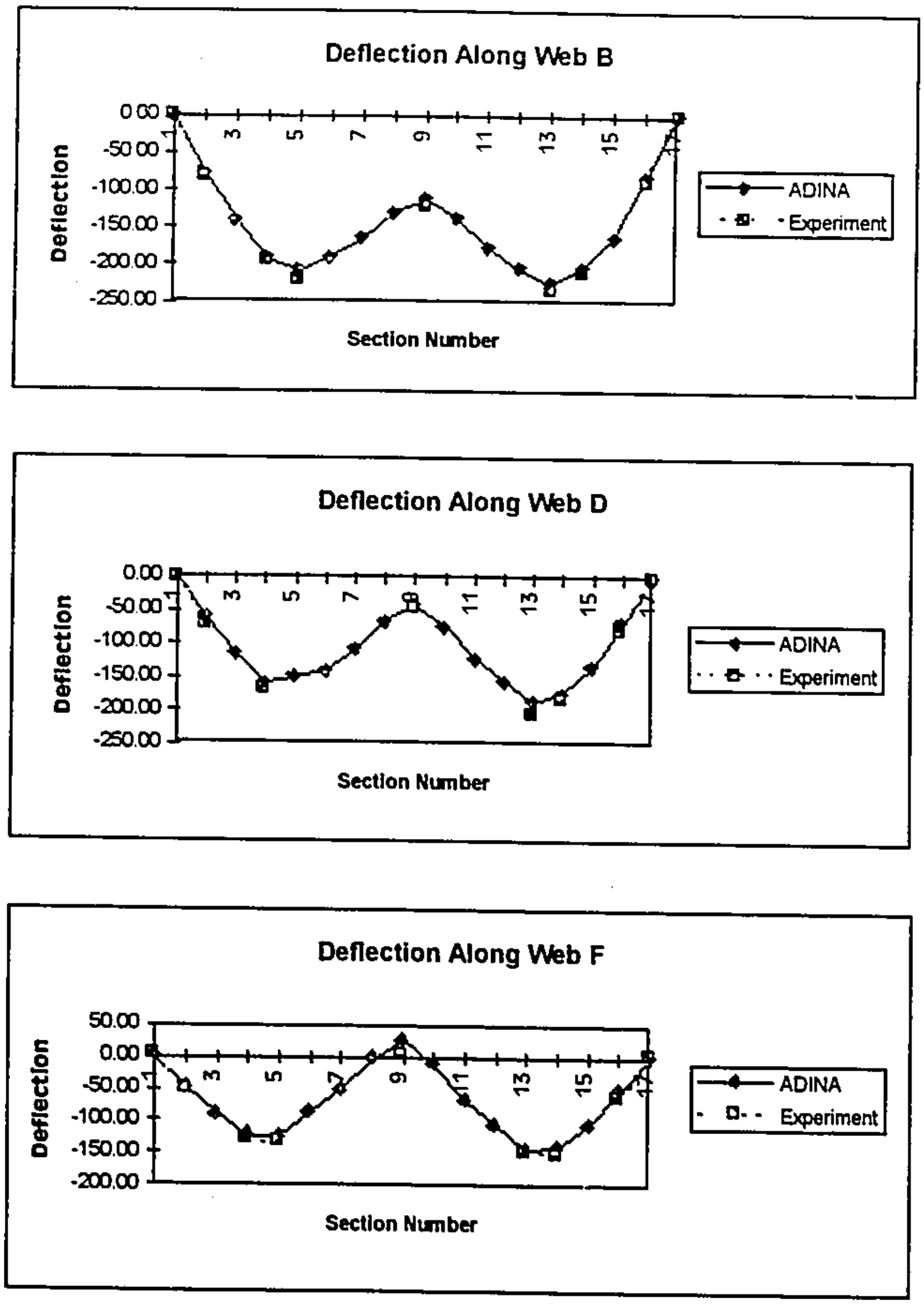
With reference to Fig. 5.27, an overall view for the behavior of the vertical displacement of the bridge model along three longitudinal webs B, D, & F is presented. The ADINA's model response was generally in good correlation with the experimental results; as shown in Table 5.21. Also from Table 5.21 it can be seen that the maximum deflection values were 2.32 mm and 2.24 mm in the experimental model and ADINA model respectively. Fig. 5.22 shows a typical deflection of the bridge model in the transverse direction for six sections.

The maximum experimental vertical displacement occurred at section 13 and was underestimated by only 3.7 % when compared to the ADINA's model as presented in Table 5.21.

Comparing the vertical displacement of the bottom plate response of load case 4 to load case 9, it is clear from table 5.21A that at sections 5 and 13 where the maximum deflections occurred, an increase in the deflections in load case 9 was experienced at the outer web B in section 5 in the order of 14% whereas 27% of increase was experienced at web B section 13.

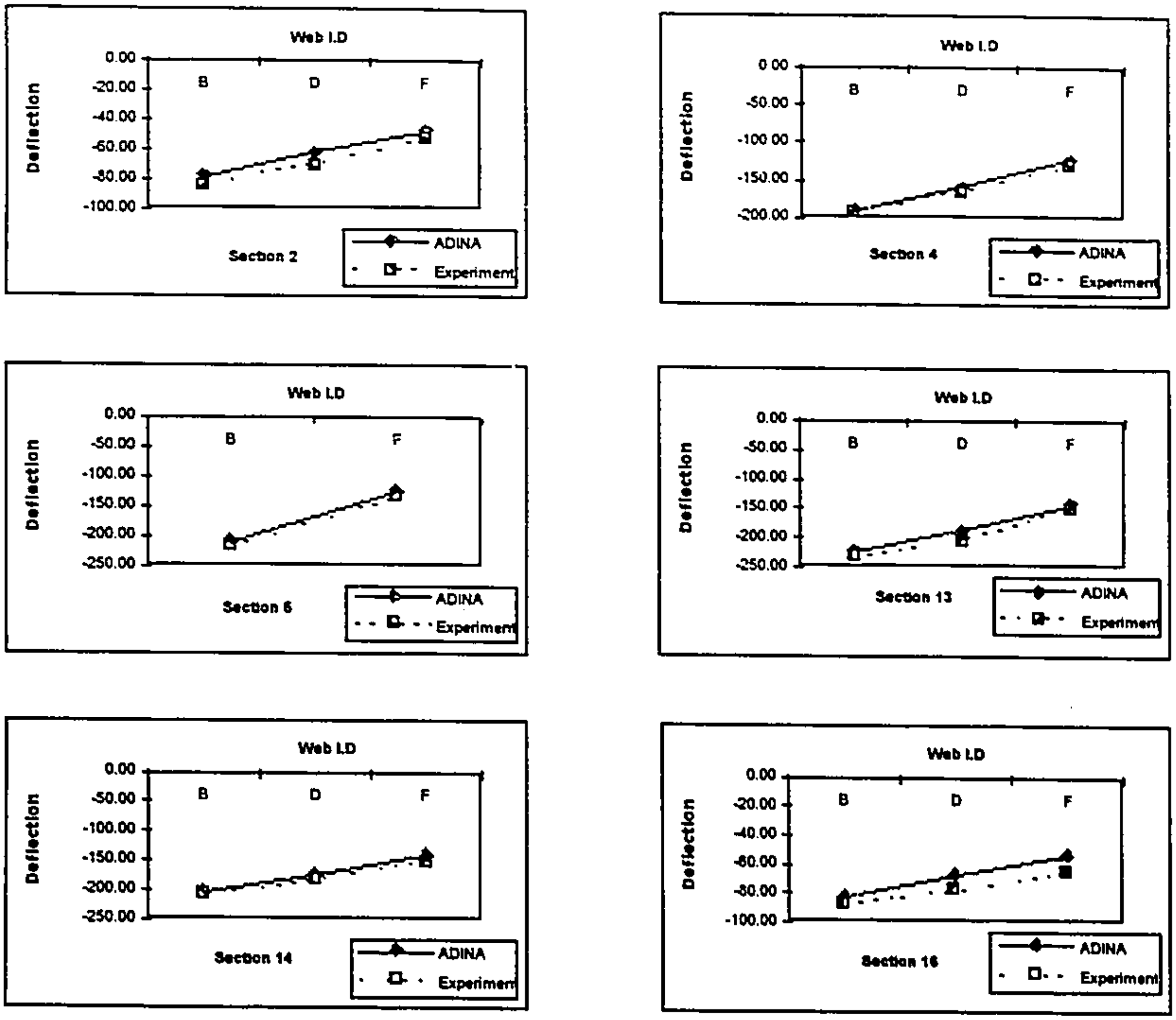
The stress response of the box girder bridge model for sections 4 and 5 is shown in Fig.5.29. ADINA's model response provides a good correlation with the experimental results as presented in Table 5.22. As for the compressive stresses in the concrete deck at section 4, it was uniformly distributed throughout the section with a average value of 7.05 MPa as was the case in load case 4. The percentage error between the experimental results and ADINA's model predictions for the concrete deck was less than 9.00 % . As for the webs, the maximum stress was at web F section 5, the bottom of the web was subjected to 20.8 MPa tension.

Similar to the vertical deflection comparison between load cases 4 & 9 of the box girder bridge model, the ADINA and experimental stress comparison was in close agreement. From Table 5.22A it was noted that the stress response was not affected by changing the location of the central support as was the case in load case 7.



Note: All deflections are x10^-2 mm

FIGURE 5.27 VERTICAL DEFLECTION CURVES FOR LOAD CASE 9



Note: All deflections are x10^-2 mm

FIGURE 5.28 VERTICAL DEFLECTION CURVES FOR LOAD CASE 9

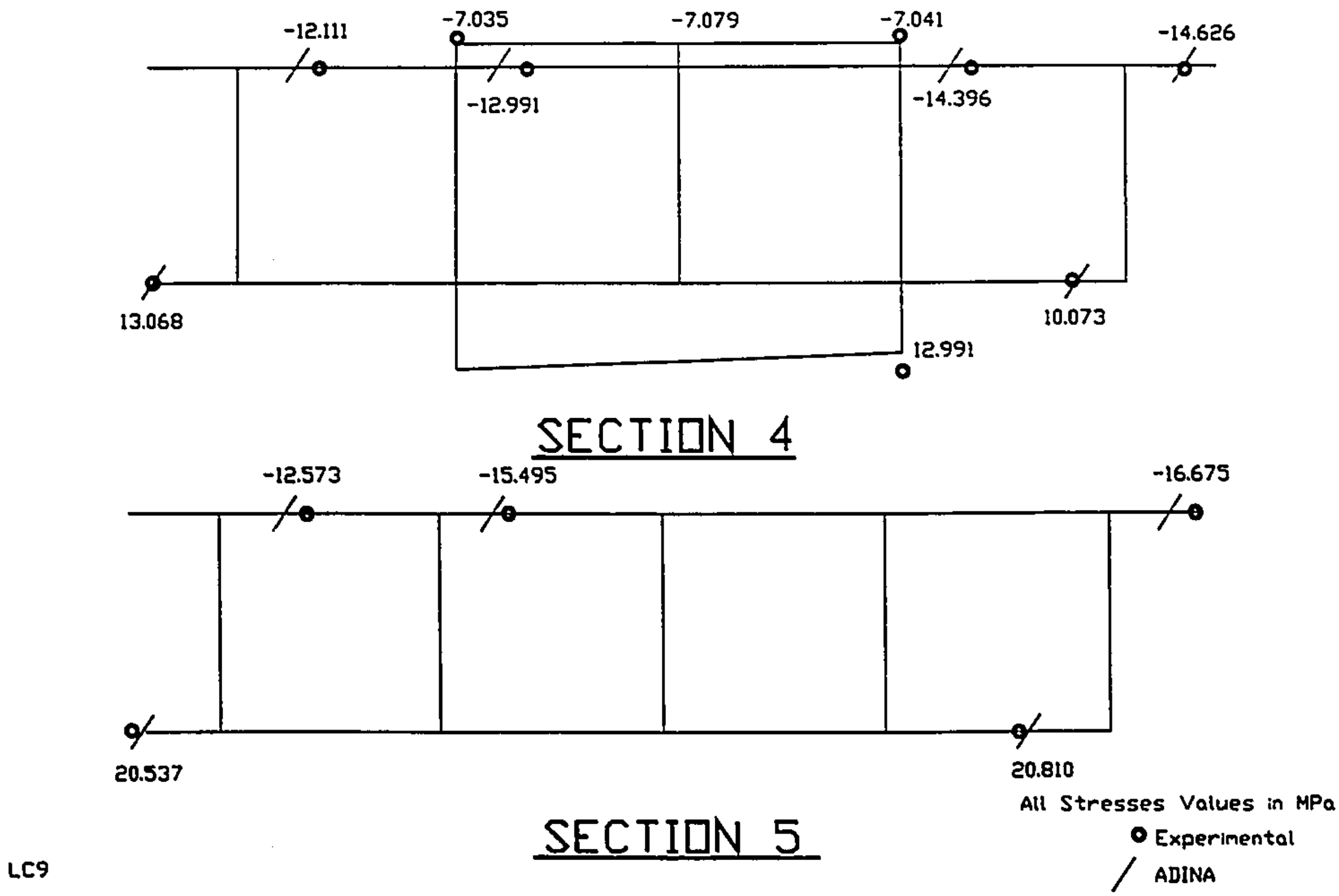


FIGURE 5.29 STRESS DISTRIBUTION FOR LOAD CASE 9

Table 5.21 Deflection Results For Load Case 9

Dial Gage	Experimental 18.527 N	Experimental 81.104 N	ADINA 81.104 N	% Error
VB2	19	83.17	77.9	6.8
VD2	16	70.04	61.92	13.1
VB4	44	192.61	190.52	1.1
VD4	38	166.35	158.55	4.9
VF4	30	131.33	123.31	6.5
VB5	50	218.88	207.83	5.3
VF5	31	135.71	124.52	9.0
VB13	53	232.01	223.82	3.7
VD13	47	205.75	186.23	10.5
VF13	34	148.84	143.71	3.6
VB14	48	210.13	205.10	2.4
VD14	42	183.86	174.47	5.4
VF14	35	153.22	140.51	9.0
VB16	20	87.55	83.44	4.9
VD16	18	78.80	67.85	16.1
VF16	15	65.66	53.89	21.9

Table 5.22 Stress Results For Load Case # 9

Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 18,527 N	Experimental Stress @ 81,104 N	% Of Error
CL14	-7.035	-1.681	-7.359	-4.6
CL24	-7.041	-1.749	-7.656	-8.7
CL34	-7.079	N.A	N.A	N.A
AL14	-12.111	-3.271	-14.319	-18.2
AL24	13.068	2.986	13.072	0.0
AL34	-12.991	-3.579	-15.667	-20.6
AL54	12.991	3.626	15.873	-22.2
AL64	10.073	2.631	11.517	-14.3
AL74	-14.626	-3.342	-14.630	0.0
AL114	-14.396	-3.982	-17.432	-21.1
AL15	-12.573	-3.456	-15.129	-20.3
AL25	20.537	5.132	22.466	-9.4
AL35	-15.495	-3.791	-16.596	-7.1
AL65	20.810	4.973	21.770	-4.6
AL75	-16.675	-4.533	-19.844	-19.0

Table 5. 21A Experimental Deflection Comparison Between Load Cases 4 & 9

	Load Case # 4		Load Case # 9		
Dial Gage I.D	Adjusted Experimental Deflection mmx10^ -2 @ 25,429 N	Adjusted Experimental Deflection mmx10^ -2 @ 81,104 N	Adjusted Experimental Deflection mmx10^ -2 @ 18,527 N	Adjusted Experimental Deflection mmx10^ -2 @ 81,104 N	% Of Difference @ 81,104 N
VB2	23.00	73.36	19.00	83.17	13.38
VD2	22.00	70.17	16.00	70.04	-0.18
VB4	55.00	175.42	44.00	192.61	9.80
VD4	53.00	169.04	38.00	166.35	-1.59
VF4	51.00	162.66	30.00	131.33	-19.26
VB5	60.00	191.37	50.00	218.88	14.38
VF5	55.00	175.42	31.00	135.71	-22.64
VB13	57.00	181.80	53.00	232.01	27.62
VD13	59.00	188.18	47.00	205.75	9.34
VF13	56.00	178.61	34.00	148.84	-16.67
VB14	55.00	175.42	48.00	210.13	19.79
VD14	53.00	169.04	42.00	183.86	8.77
VF14	50.00	159.47	35.00	153.22	-3.92
VD16	21.00	66.98	18.00	78.80	17.65
VF16	21.00	66.98	15.00	65.66	-1.96

Table 5.22A Experimental And ADINA Stresses Comparison Between Load Cases 4 & 9

	Load Case # 4		Load Case # 9		% Difference	
Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 81,104 N	ADINA Stress @ 81,104 N	Experimental Stress @ 81,104 N	Experimental	ADINA
CL14	-7.541	-7.001	-7.035	-7.359	5.11	-6.72
CL24	-7.627	-7.221	-7.041	-7.656	6.03	-7.69
AL14	-13.315	-15.874	-12.111	-14.319	-9.80	-9.04
AL24	14.009	14.286	13.068	13.072	-8.50	-6.72
AL34	-13.492	-12.420	-12.991	-15.667	26.15	-3.71
AL54	18.464	22.451	12.991	15.873	-29.30	-29.64
AL64	10.856	12.927	10.073	11.517	-10.91	-7.21
AL74	-15.773	-13.607	-14.626	-14.630	7.52	-7.27
AL114	-15.308	-15.811	-14.396	-17.432	10.25	-5.96
AL15	-15.399	-17.648	-12.573	-15.129	-14.27	-18.36
AL35	-16.382	-13.658	-15.495	-16.596	21.51	-5.41
AL65	15.505	18.002	20.810	21.770	20.93	34.22
AL75	-18.573	-23.185	-16.675	-19.844	-14.41	-10.22

As can be concluded, the ADINA's model was always stiffer than the experimental bridge model. Figs. 5.30 to 5.35 provide a statistical study on the number of occurance verses the percentage error that occurred in the stress and deflection values. It is clear that the percentage of error in the deflection values was always shifting to the lower zone of % of error. Most of the time the pecentage error in the deflection values was between (10 - 15%) , as for the stress value the percentage of error was in a higher range (25 -30%).

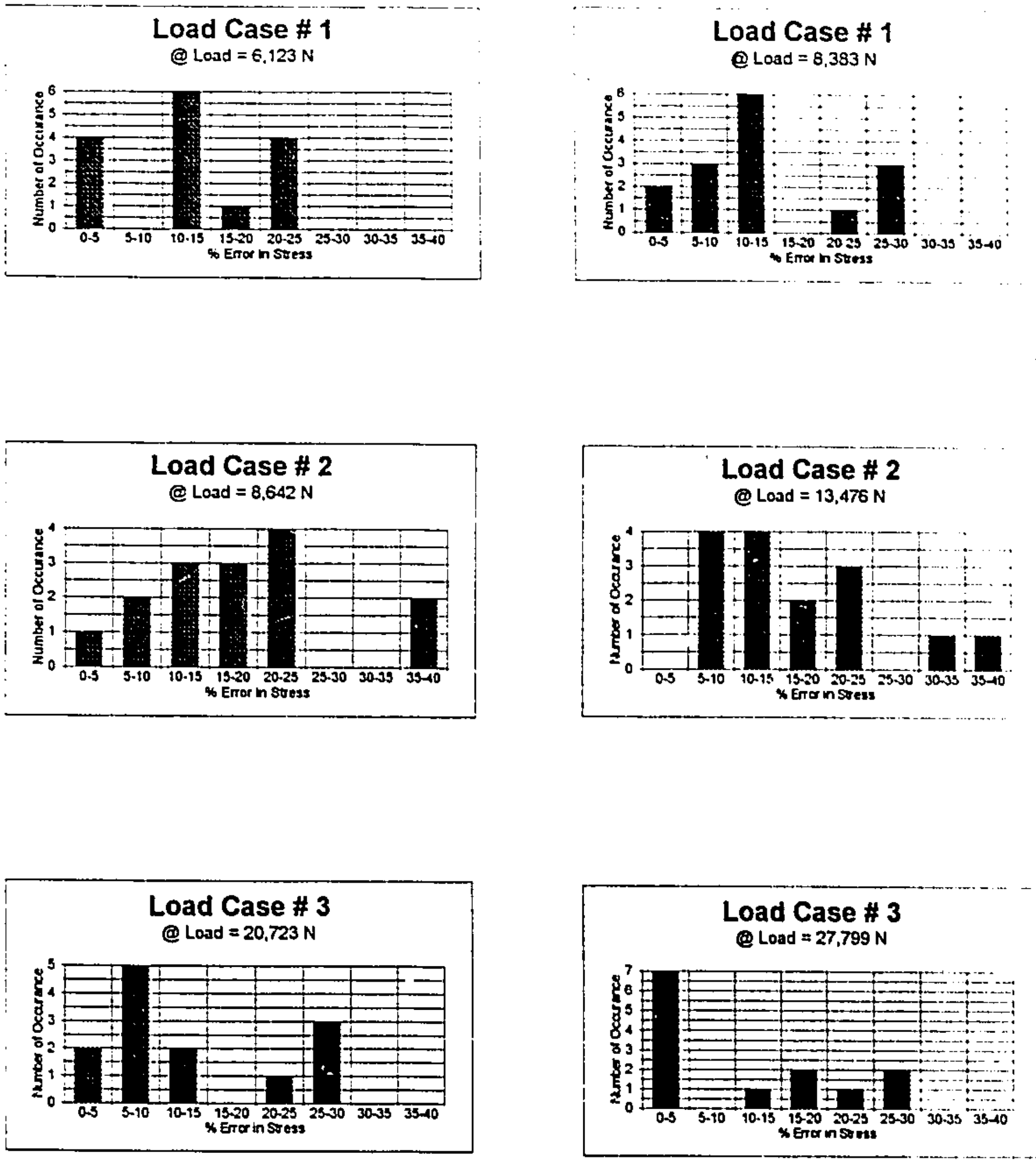


FIGURE 5.30 PERCENTAGE ERROR IN STRESSES

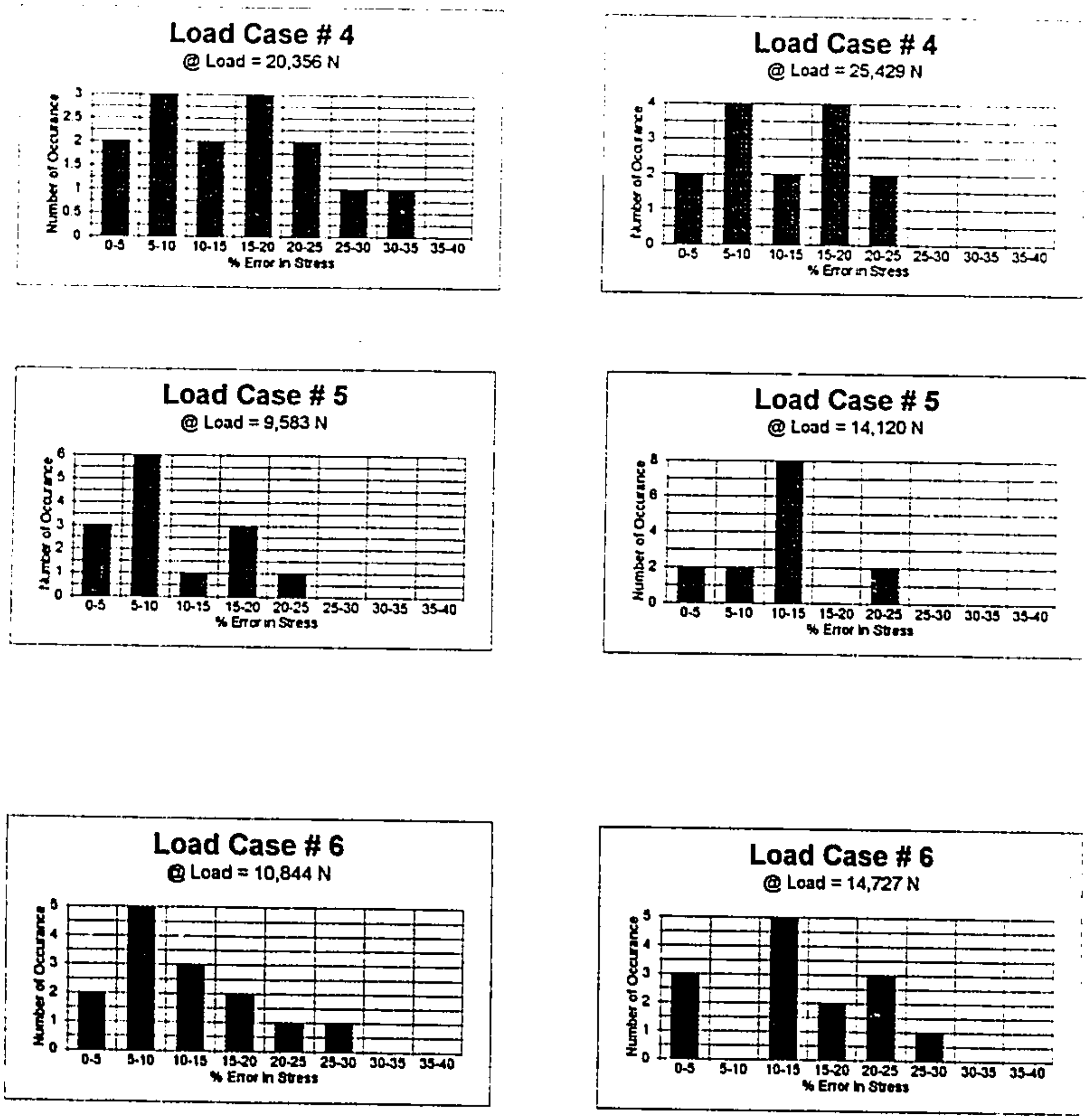


FIGURE 5.31 PERCENTAGE ERROR IN STRESSES

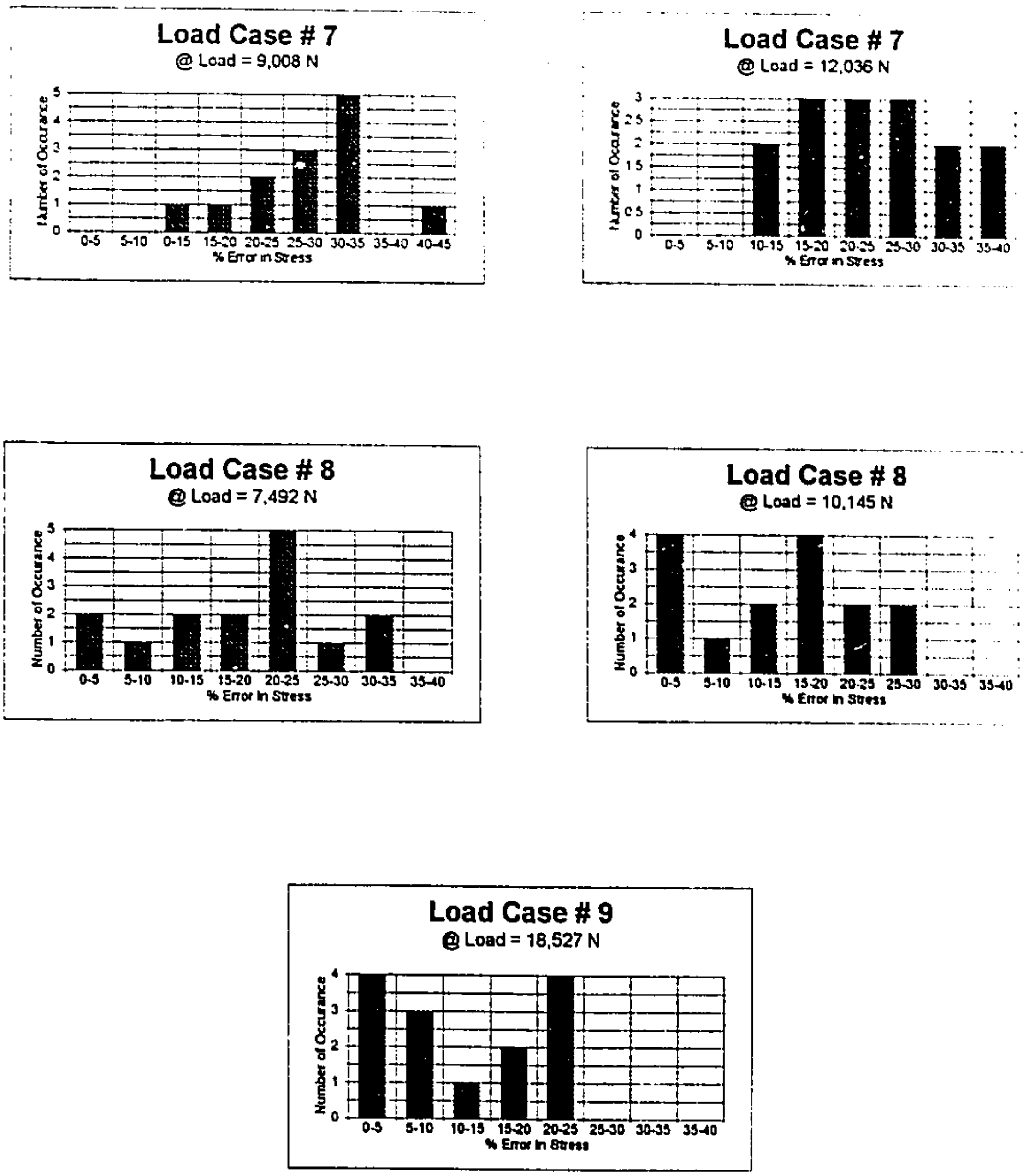


FIGURE 5.32 PERCENTAGE ERROR IN STRESSES

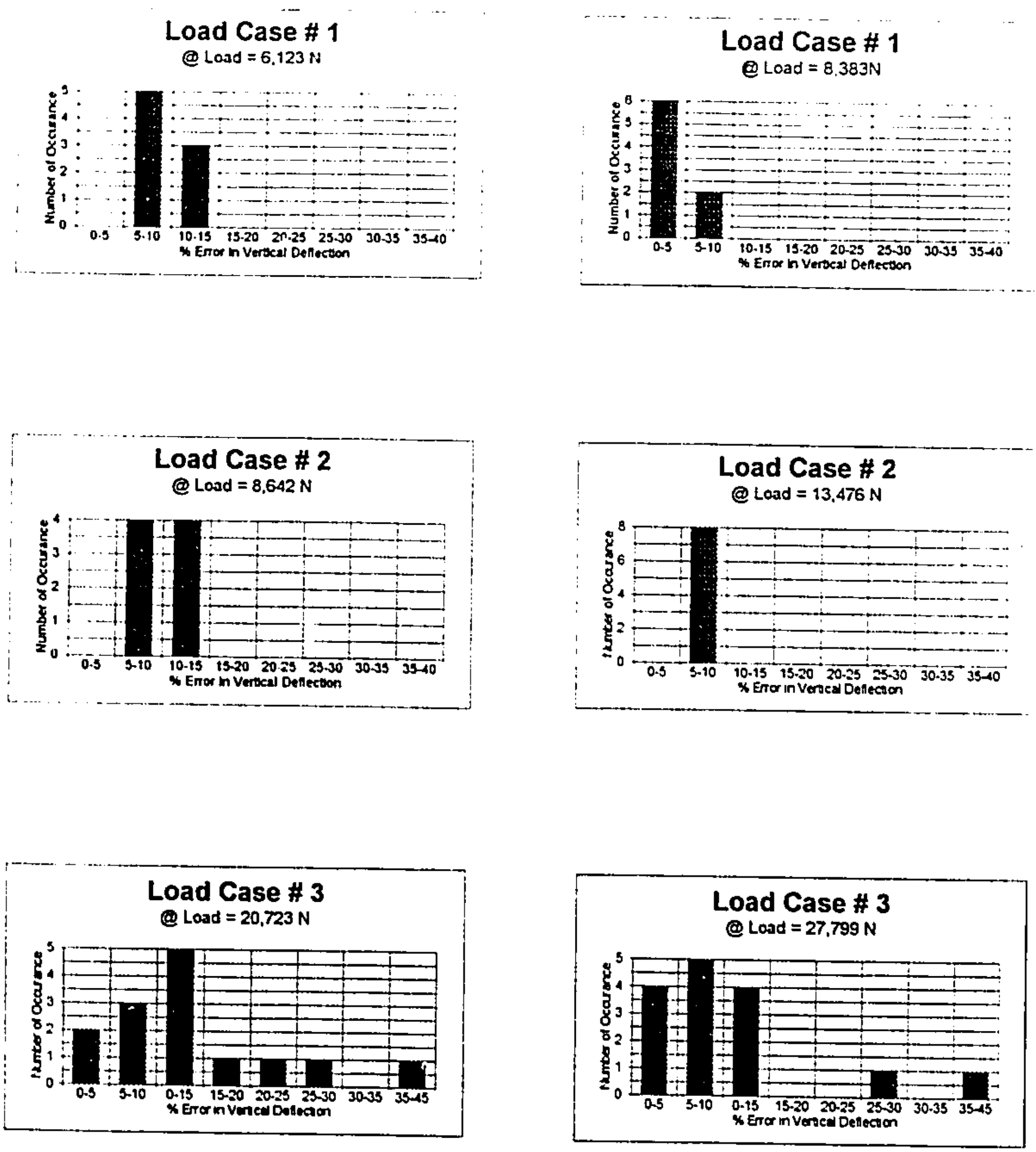


FIGURE 5.33 PERCENTAGE ERROR IN DEFLECTIONS

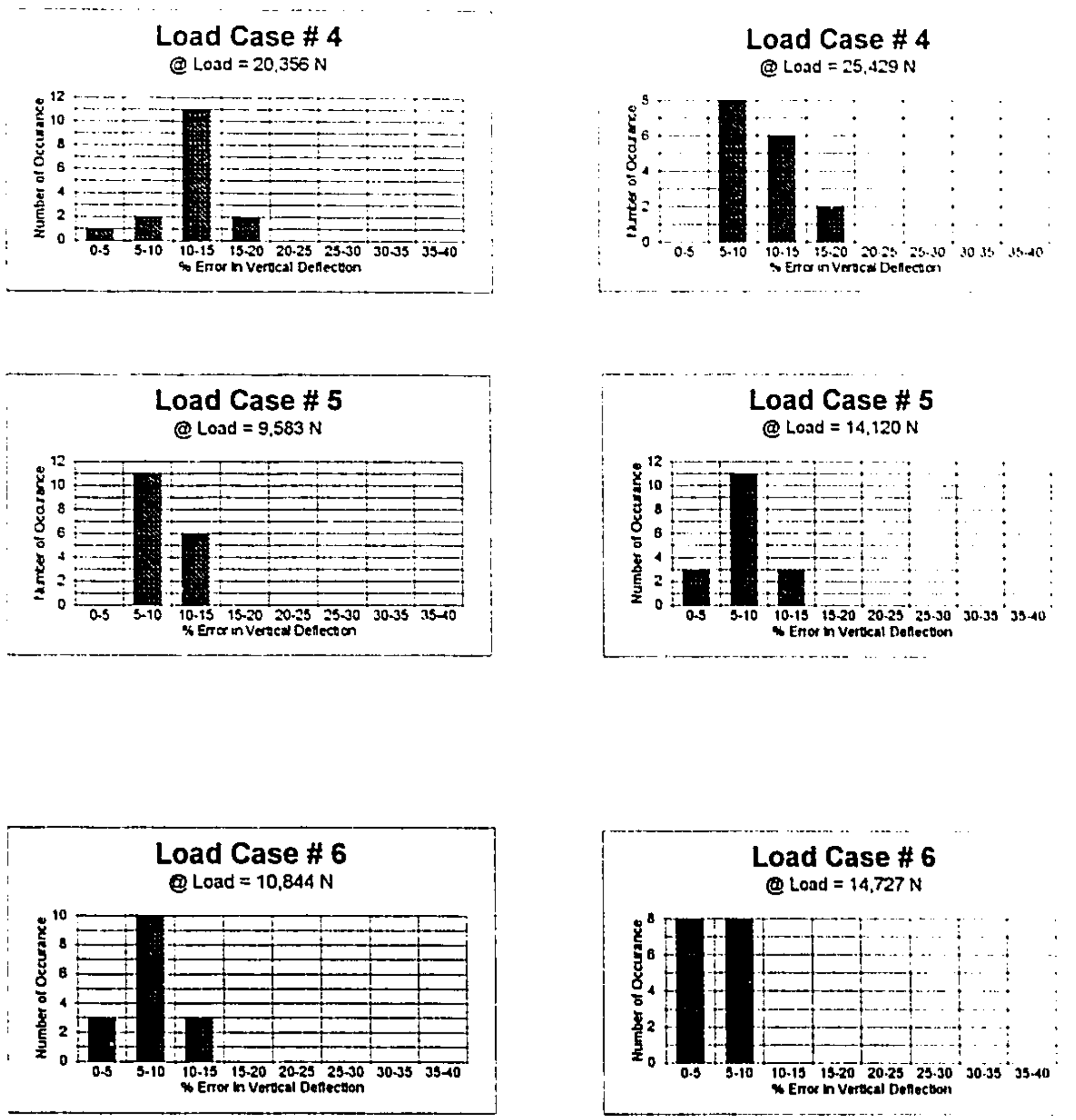


FIGURE 5.34 PERCENTAGE ERROR IN DEFLECTIONS

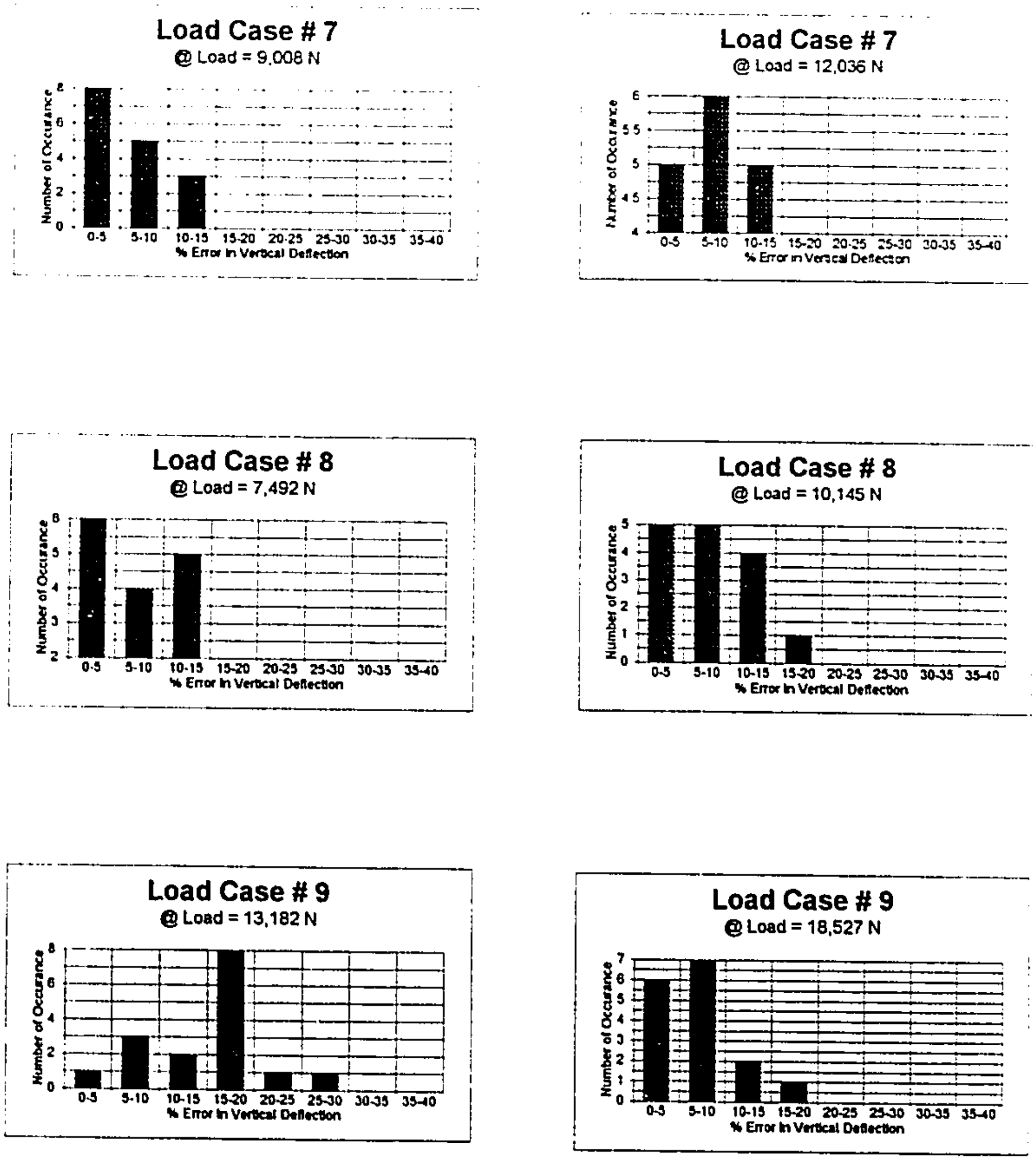


FIGURE 5.35 PERCENTAGE ERROR IN DEFLECTIONS

5.7 Negative Moment

Because of the unexpected deflection at the middle support and subsequent stress release during the experimntal testing, the experimental negative moments near the centre support do not compare well with the ADINA values. Tables 5.23 to 5.26 show the percentage error for load cases 1,2,3, and 4 respectively. Complete experimental data for the negative moment recorded can be found in appendex B Tables B1 to B14.

Table 6.23 Stress Result at Section 9 For Load Case 1

Strain Gage I.D	ADINA Stress @ 20,276 N	Experimental Stress @ 6,123 N	Experimental Stress @ 20,276 N	% Of Error	Experimental Stress @ 8,384 N	Experimental Stress @ 20,276 N	% Of Error
AL19	15.569	2.79	9.239	40.7	3.61	8.730	43.9
AL39	16.439	1.46	4.835	70.6	3.02	7.304	55.6
AL69	9.989	2.00	6.623	33.7	2.73	6.602	33.9
AL89	15.270	2.30	7.616	50.1	3.29	7.957	47.9
AL109	-2.565	-0.64	-2.119	17.4	-0.92	-2.225	13.2
AL129	-10.178	-1.49	-4.934	51.5	-2.03	-4.909	51.8

Table 6.24 Stress Result at Section 9 For Load Case 2

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 8,642 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 13,476 N	Experimental Stress @ 40,552 N	% Of Error
AL19	33.148	3.23	15.2	54.3	4.17	12.546	62.1
AL39	35.310	2.84	13.3	62.3	3.85	11.585	67.2
AL69	27.190	3.45	16.2	40.5	4.46	13.421	50.6
AL89	34.287	2.96	13.9	59.5	4.5	13.541	60.5
AL109	-5.252	-0.28	-1.3	75.0	-0.71	-2.137	59.3
AL129	-18.766	-2.20	-10.3	45.0	-3.2	-9.629	48.7

Table 6.25 Stress Result at Section 9 For Load Case 3

Strain Gage I.D	ADINA Stress @ 60,828 N	Experimental Stress @ 20,730 N	Experimental Stress @ 60,828 N	% Of Error	Experimental Stress @ 27,799 N	Experimental Stress @ 60,828 N	% Of Error
AL19	52.437	10.31	30.253	42.3	13.420	29.365	44.0
AL39	56.025	12.66	37.148	33.7	15.78	34.529	38.4
AL69	45.154	9.27	27.201	39.8	6.45	14.113	68.7
AL89	54.435	11.73	34.419	36.8	14.79	32.363	40.5
AL109	-24.479	-0.78	-2.289	90.7	-1.35	-2.954	87.9
AL129	-27.85	-3.06	-8.979	67.8	-4.34	-9.497	65.9

Table 6.26 Stress Result at Section 9 For Load Case 4

Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 20,356 N	Experimental Stress @ 81,104 N	% Of Error	Experimental Stress @ 25,428 N	Experimental Stress @ 81,104 N	% Of Error
AL29	64.647	4.350	17.332	73.2	5.840	18.627	71.2
AL39	69.484	5.36	21.356	69.3	8.73	27.845	59.9
AL59	55.112	7.08	28.209	48.8	8.96	28.578	48.1
AL89	67.569	10.56	42.074	37.7	12.94	41.273	38.9
AL109	-31.958	-1.07	-4.263	86.7	-1.42	-4.529	85.8
AL129	-35.683	-3.98	-15.857	55.6	-4.83	-15.406	56.8

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

This investigation on the behaviour of horizontally curved box girder bridges has led to many important results. Based on these results, the following conclusions can be drawn:

1. The isoparametric thin shell elements used by ADINA to predict the analytical response of curved box girder bridges provided moderately accurate comparison of results of the various components of the bridge model.

2. The experimental results and the ADINA model were in close agreement in predicting the maximum deflection of the bridge model.

3. The ADINA results seem to correlate very well with the experimental results in terms of the sign and maximum positive moments developed at the instrumented sections.

4. The ADINA model was always stiffer than the experimental model. This was clear throughout the discussions for each load case in the previous Chapter. As a result, the ADINA bridge model sometimes overestimated the stresses and underestimated the deflection values at the instrumented sections.

5. ADINA's model predictions for the deflection values correlated better than those of the stress values.

6. Special attention should be given in modeling the middle support. During the experiment, the middle support was clearly noticed to experience deflection sufficient to cause higher deflection response of the bridge model and a stress release at section 9. However,to overcome this problem, the experimental deflections were recalibrated as discussed in Chapter 5.

7. Despite the small amount of deflection of the middle support, the positive moment values were not affected to as much as the deflection values.

8. While the normal stresses carried by the concrete deck are linear and relatively small as evidenced from the concrete gauges, the webs of the box girder carry significantly higher stresses as evidenced from the aluminum gauges placed in the webs.

6.2 Recommendations

Due to increased usage of horizantally curved box girder bridges in modern highway systems, it is desirable to further extend the invistigations on this type of girder bridges to include research on the following:

1. It is recommended to conduct dynamic analysis on such structures in order to determine their dynamic properties, due to external excitations such as winds, earthquakes, and the moving vehicles.

2. Great attention should be given for the modelling of the end and central diaphragms. When the bridge model is subjected to eccentric loads, the requirement of stiff end and central diaphragms is very important.

3. Research should be extended for curved box girder bridges to the inelastic range to predict the ultimate strength of such bridges.

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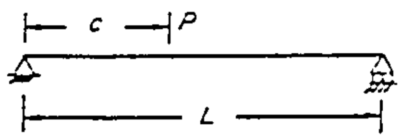
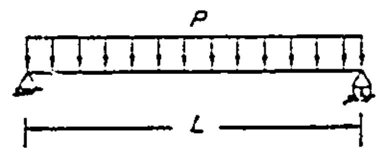
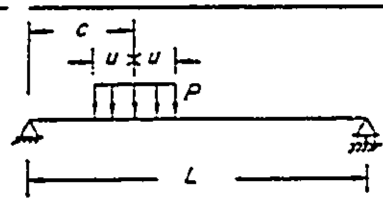
Appendix A



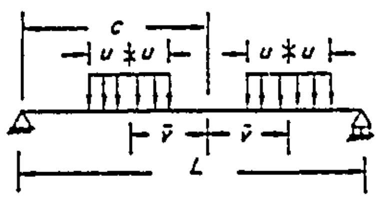
$$H_n = \frac{2P}{L} \sin\left(\frac{n\pi c}{L}\right)$$



$$H_n = \frac{4P}{L} \sin^2\left(\frac{n\pi}{2}\right)$$



$$H_n = \frac{4P}{n\pi} \sin\left(\frac{n\pi c}{L}\right) \sin\left(\frac{n\pi u}{L}\right)$$



$$H_n = \frac{8P}{n\pi} \sin\left(\frac{n\pi c}{L}\right) \sin\left(\frac{n\pi u}{L}\right) \cos\left(\frac{n\pi \bar{v}}{L}\right)$$

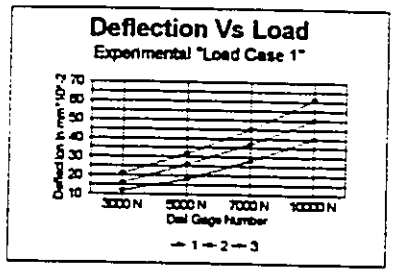
TABLE A.1 TYPICAL LOAD FUNCTION

Appendix B

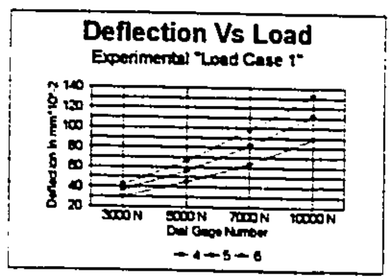
Experimental Deflections & Strain Results

LOADING

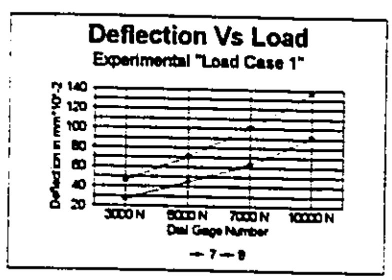
	Dial Gage #	Load "1" 3000 N	Load "2" 5000 N	Load "3" 7000 N	Load "4" 10000 N
Section# 2	1	21	32	45	61
	2	16	26	37	50
	3	12	18	28	40



Section# 4	4	42	66	98	132
	5	37	56	82	112
	6	30	45	63	89



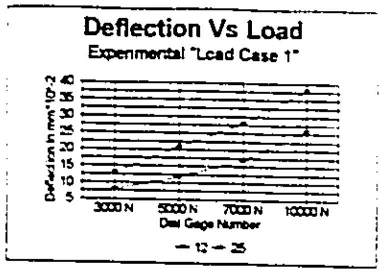
Section# 5	7	46	71	101	136.5
	8	27	45	63	91



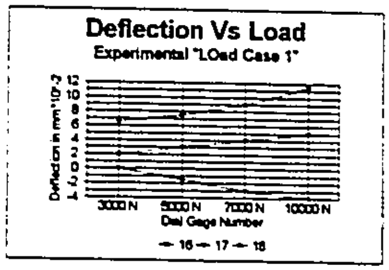
Section# 9	12	13	21	28	38
	25	8	12	17	26

FIGURE B.1 DEFLECTION VS. LOAD FOR LOAD CASE 1

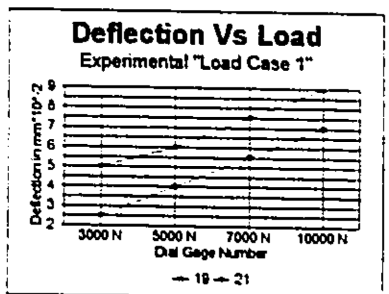
LOADING



Section# 13	16	6.5	7.5	9	11.5
	17	2	3	4	5
	18	0	-1.5	-3	-4



Section# 14	19	5	6	7.5	9
	21	2.5	4	5.5	7



Section# 16	22	2	3	4	5
	23	0	0	1	2.5
	24	0	2	4	7

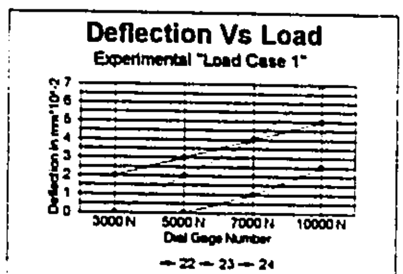
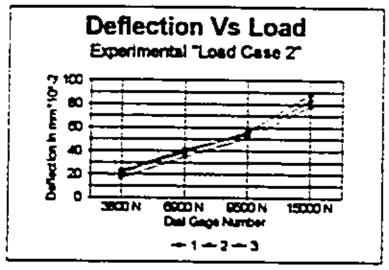


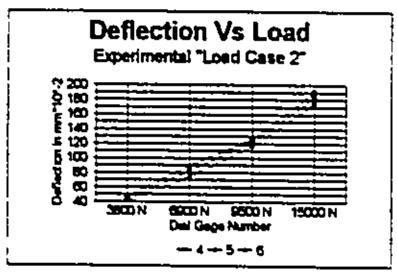
FIGURE B.2 DEFLECTION VS. LOAD FOR LOAD CASE 1

LOADING

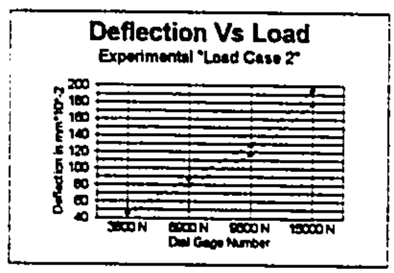
	Dial Gage #	Load "1" 3800 N	Load "2" 6900 N	Load "3" 9500 N	Load "4" 15000 N
Section# 2	1	21	39	56	88
	2	23	41	54	83
	3	17	35	51.5	78



Section# 4	4	47	89	126	191
	5	42.5	83	121	184
	6	40	75	116	175



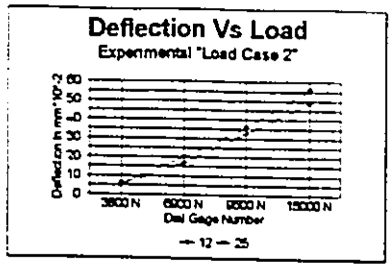
Section# 5	7	47.5	88	128	195
	8	44	80	117	178



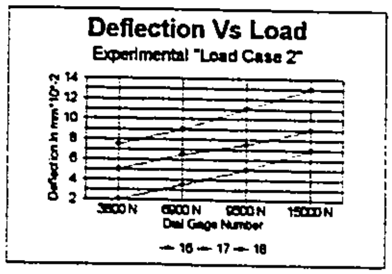
Section# 9	12	6	20	36	56
	25	5	17	33	49

FIGURE B.3 DEFLECTION VS. LOAD FOR LOAD CASE 2

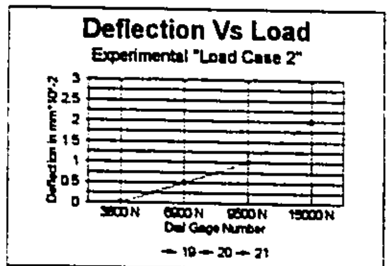
LOADING



Section# 13	16	7.5	9	11	13
	17	5	6.5	7.5	9
	18	2	3.5	5	7



Section# 14	19	0	0.5	1	2
	20	3	3	3	3
	21				



Section# 16	22	0	-1.5	-3.5	-5
	23	0	-0.5	-1	-1.5
	24	0.5	1	1.5	2

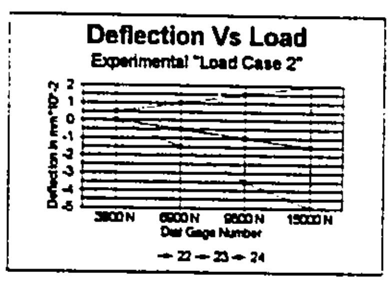
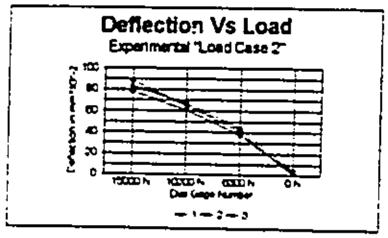


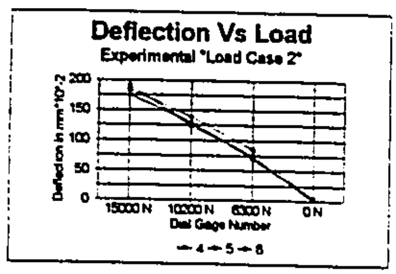
FIGURE B.4 DEFLECTION VS. LOAD FOR LOAD CASE 2

UNLOADING

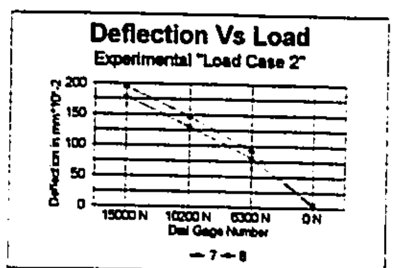
	Dial Gage #	Load "1" 15000 N	Load "2" 10200 N	Load "3" 6300 N	Load "4" 0 N
Section# 2	1	88	65	41	1
	2	83	67	44	5
	3	78	61	38	3



	Dial Gage #	Load "1" 15000 N	Load "2" 10200 N	Load "3" 6300 N	Load "4" 0 N
Section# 4	4	191	124	75	0
	5	184	139	85	0
	6	175	130	70	4



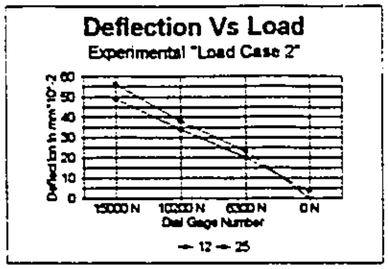
	Dial Gage #	Load "1" 15000 N	Load "2" 10200 N	Load "3" 6300 N	Load "4" 0 N
Section# 5	7	195	146.5	91	1.5
	8	178	130	80	5



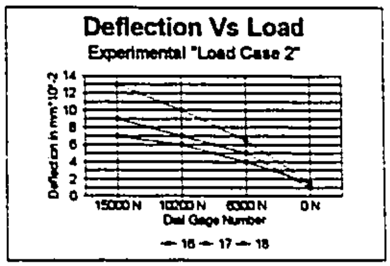
	Dial Gage #	Load "1" 15000 N	Load "2" 10200 N	Load "3" 6300 N	Load "4" 0 N
Section# 9	12	56	38	23	0
	25	49	34	20	3

FIGURE B.5 DEFLECTION VS. LOAD FOR LOAD CASE 2

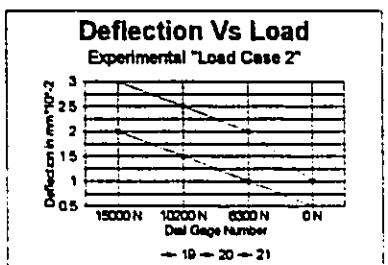
UNLOADING



Section# 13	16	13	10	6.5	1.5
	17	9	7	5	1
	18	7	6	4	1.5



Section# 14	19	2	1.5	1	0.5
	20	3	2.5	2	1
	21				



Section# 16	22	-5	-3	-1.5	0
	23	-1.5	-1	-0.5	0
	24	2	1.5	1	1

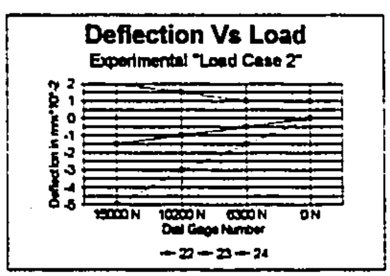
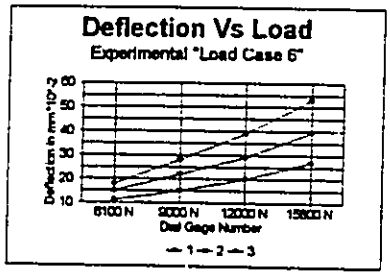


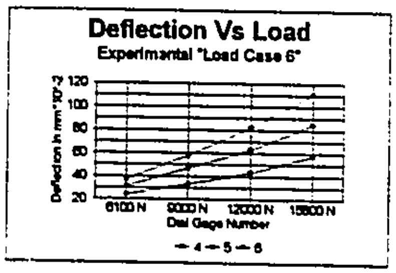
FIGURE B.6 DEFLECTION VS. LOAD FOR LOAD CASE 2

LOADING

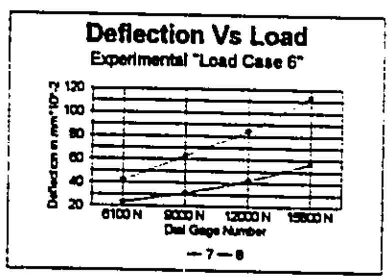
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 2	1	11	15	20	27
	2	15	22	29	39.5
	3	18	28	39	53



	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 4	4	24	33	43	58
	5	31	47	63	85
	6	37	58	82	111



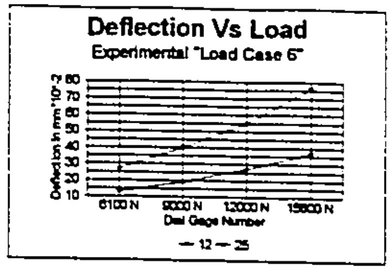
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 5	7	23	31	42	57
	8	42	63	84	113



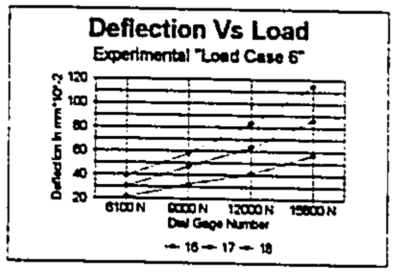
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 9	12	13	19	27	37
	25	27	40	55	76

FIGURE B.7 DEFLECTION VS. LOAD FOR LOAD CASE 6

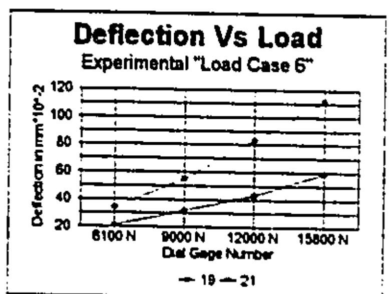
LOADING



Section# 13	16	21	32	41	57
	17	30	47	63	86
	18	39	58	83	114



Section# 14	19	21	32	43	59
	21	34	55	83	112



Section# 16	22	10	15	20	27
	23	13	20.5	29	40
	24	20	29	39	53.5

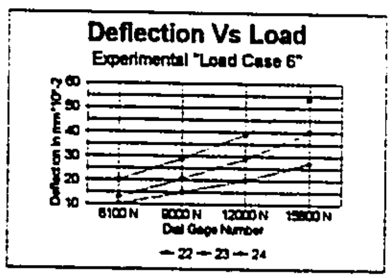
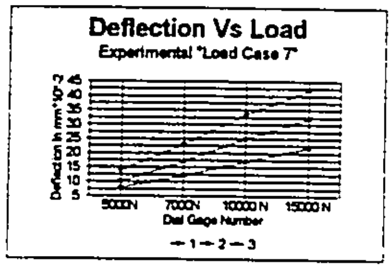


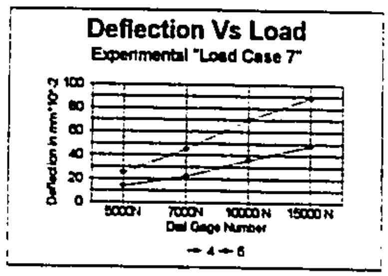
FIGURE B.8 DEFLECTION VS. LOAD FOR LOAD CASE 6

LOADING

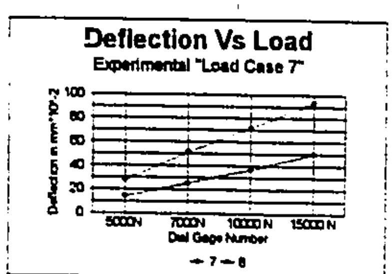
Section	Dial Gage #	Load "1" 5000N	Load "2" 7000N	Load "3" 10000 N	Load "4" 15000 N
Section# 2	1	8	12	17	22
	2	10	17	25	32
	3	14	23	33.5	42



Section# 4	4	14	22	36	48
	6	25	45	70	89



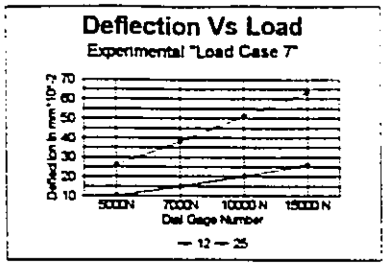
Section# 5	7	14	25	37	50
	8	28	51	72	93



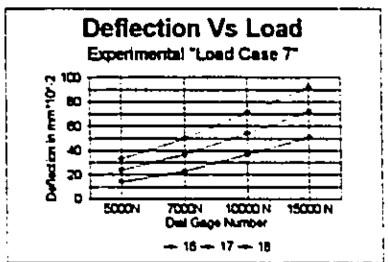
Section# 9	12	10	15	20	26
	25	26	38	51	63

FIGURE B.9 DEFLECTION VS. LOAD FOR LOAD CASE 7

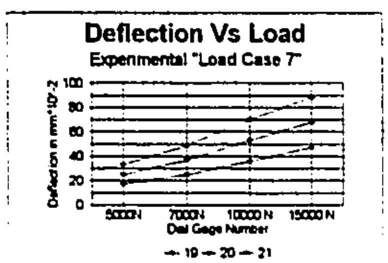
LOADING



Section# 13	16	14	23	37	51
	17	24	37	54	72
	18	33	50	71	92



Section# 14	19	17	25	36	47
	20	25	37	53	68
	21	33	49	70	88



Section# 16	22	7	12	17	22
	23	12	18	25	32
	24	16	25	34	43

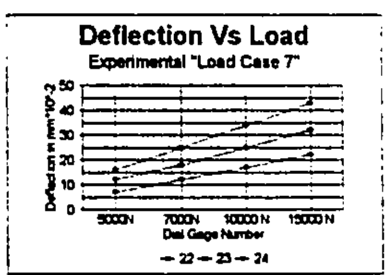
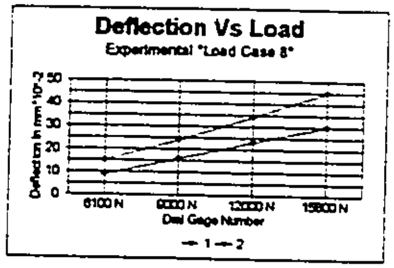


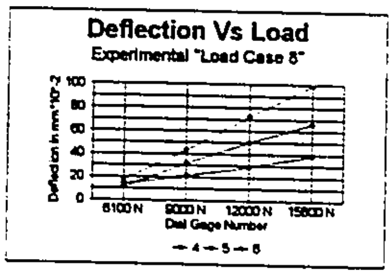
FIGURE B.10 DEFLECTION VS. LOAD FOR LOAD CASE 7

LOADING

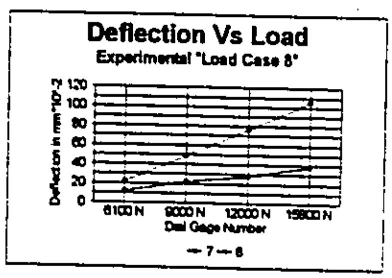
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 2	1	15	24	34	45
	2	9	16	23	30



	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 4	4	18	43	72	99
	5	11	32	50	66
	6	14	21	29	39



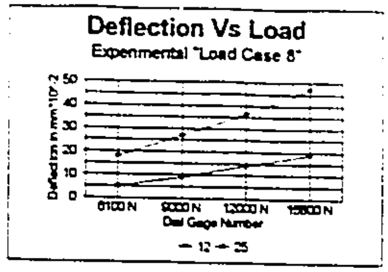
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 5	7	22	49	76	105
	8	12	22	28	38



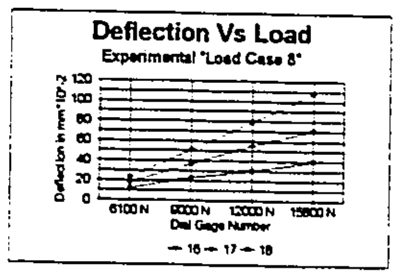
	Dial Gage #	Load "1" 6100 N	Load "2" 9000 N	Load "3" 12000 N	Load "4" 15800 N
Section# 9	12	18	27	36	47
	25	5	9	14	19

FIGURE B.11 DEFLECTION VS. LOAD FOR LOAD CASE 8

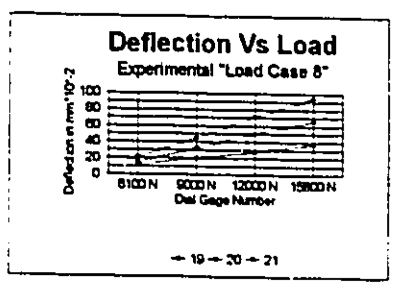
LOADING



Section# 13	16	23	51	79	108
	17	18	37	55	71
	18	12	23	30	40



Section# 14	19	21	45	71	94
	20	15	33	50	66
	21	13	20	28	38



Section# 16	22	16	25	34	44
	23	12	17	23	30

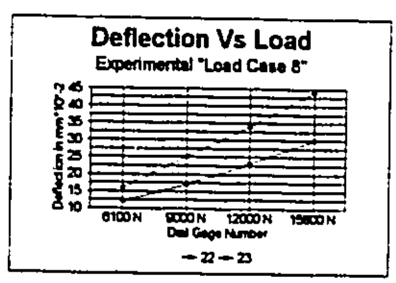
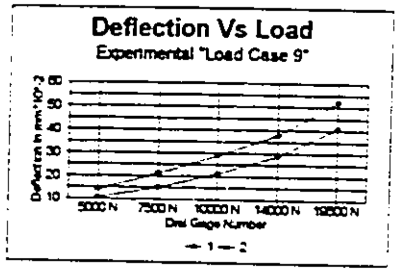


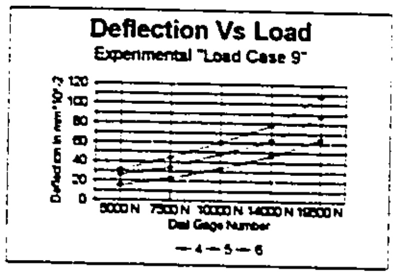
FIGURE B.12 DEFLECTION VS. LOAD FOR LOAD CASE 8

LOADING

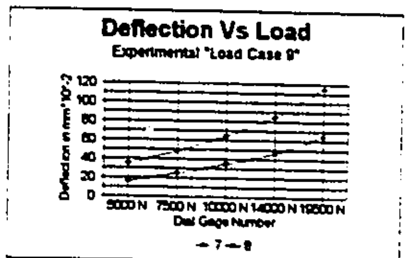
	Dial Gage #	Load "1" 5000 N	Load "2" 7500 N	Load "3" 10000 N	Load "4" 14000 N	Load "5" 19500 N
Section# 2	1	14	21	29	38	52
	2	10.5	15	21	29	41



	Dial Gage #	Load "1" 5000 N	Load "2" 7500 N	Load "3" 10000 N	Load "4" 14000 N	Load "5" 19500 N
Section# 4	4	31	44	60	78	109
	5	26	34	48	62	88
	6	15	23	33	46	64



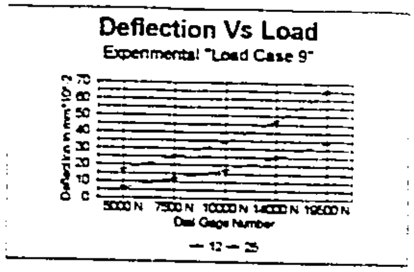
	Dial Gage #	Load "1" 5000 N	Load "2" 7500 N	Load "3" 10000 N	Load "4" 14000 N	Load "5" 19500 N
Section# 5	7	35	48	64	85	115
	8	16	25	35	46	65



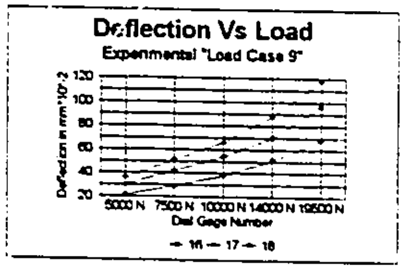
	Dial Gage #	Load "1" 5000 N	Load "2" 7500 N	Load "3" 10000 N	Load "4" 14000 N	Load "5" 19500 N
Section# 9	12	17	25	34	47	65
	25	6	12	17	25	34

FIGURE B.13 DEFLECTION VS. LOAD FOR LOAD CASE 9

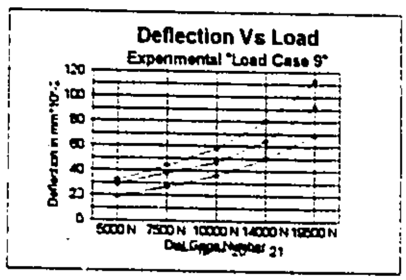
LOADING



Section# 13	16	36	51	66	88	118
	17	30	42	54	70	97
	18	21	29	38	51	68



Section# 14	19	32	44	58	80	113
	20	29	38	47	64	92
	21	19	27	36	50	69



Section# 16	22	15	22	30	40	53
	23	12	18	24	33	43
	24	11.5	14	18	25	32

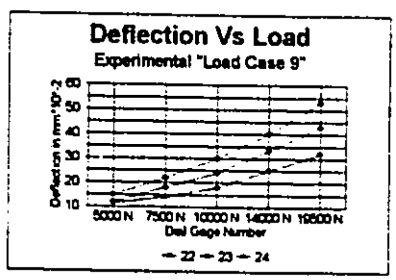
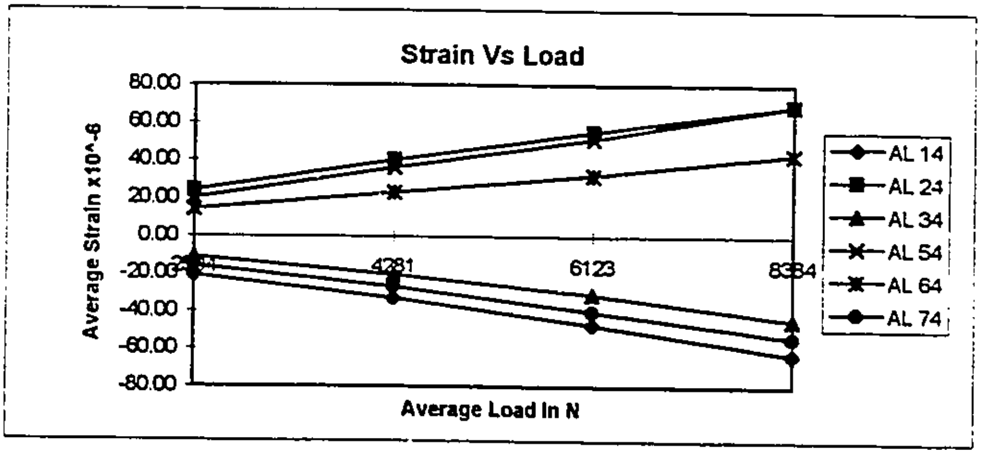


FIGURE B.14 DEFLECTION VS. LOAD FOR LOAD CASE 9

SECTION 4

	Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5
		AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
Load 1	2504.30	-21.00	24.00	-11.32	20.00	14.00	-16.00
Load 2	4281.47	-33.00	40.00	-20.52	36.00	23.00	-27.00
Load 3	6123.03	-47.00	55.00	-31.13	51.00	32.00	-40.00
Load 4	8384.05	-63.00	69.00	-44.53	69.00	43.00	-54.00



	Average Load N	Strain 49	Strain 42	Strain 40	Strain 39	Strain M1	Strain M2	Strain M3
		AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
Load 1	2504.30	13.80	19.50	-14.04	17.35	-11.00	-13.00	-15.00
Load 2	4281.47	24.32	30.40	-26.09	29.76	-18.00	-21.00	-20.00
Load 3	6123.03	35.73	44.77	-36.99	41.39	-33.00	-28.00	-31.00
Load 4	8384.05	54.51	64.32	-51.02	58.40	-42.00	-39.00	-40.00

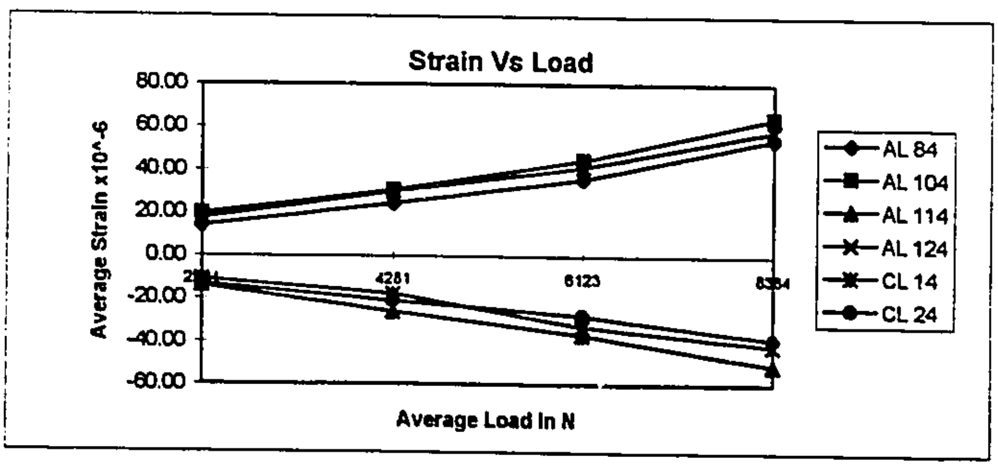


FIGURE B.15 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 1

SECTION 5

	Average Load N	Strain 33	Strain 34	Strain 52	Strain 16	Strain 15	Strain 50	Strain 44
		AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
Load 1	2504.30	-22.47	-17.02	-10.86	15.45	-11.23	20.32	4.54
Load 2	4281.47	-38.81	-31.87	-25.22	30.52	-24.05	36.66	17.86
Load 3	6123.03	-57.32	-45.71	-41.67	44.67	-36.02	56.06	32.39
Load 4	8384.05	-82.35	-64.15	-56.54	64.85	-52.13	80.50	51.69

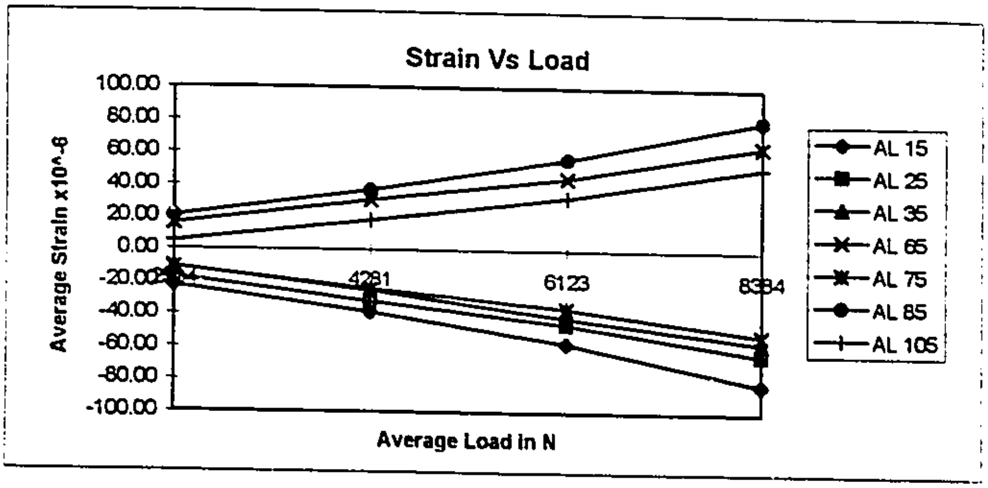
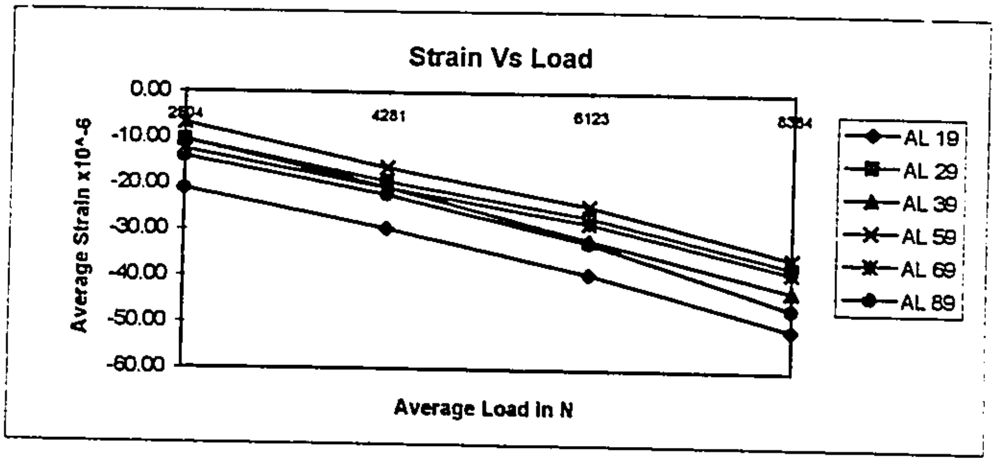


FIGURE B.16 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 1

SECTION 9

	Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
		AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
Load 1	2504.30	-21.15	-10.49	-10.41	-6.86	-12.56	-14.13
Load 2	4281.47	-29.62	-19.25	-20.52	-16.34	-20.65	-22.17
Load 3	6123.03	-39.18	-26.81	-31.82	-24.38	-28.07	-32.35
Load 4	8384.05	-50.80	-37.20	-42.50	-35.36	-38.35	-46.30



	Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
		AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
Load 1	2504.30	7.00	-4.00	5.00	-8.00	-2.00	-4.00
Load 2	4281.47	14.00	-7.00	9.00	-14.00	-4.00	-6.00
Load 3	6123.03	22.00	-9.00	13.00	-21.00	-5.00	-9.00
Load 4	8384.05	30.00	-13.00	18.00	-28.50	-8.00	-13.00

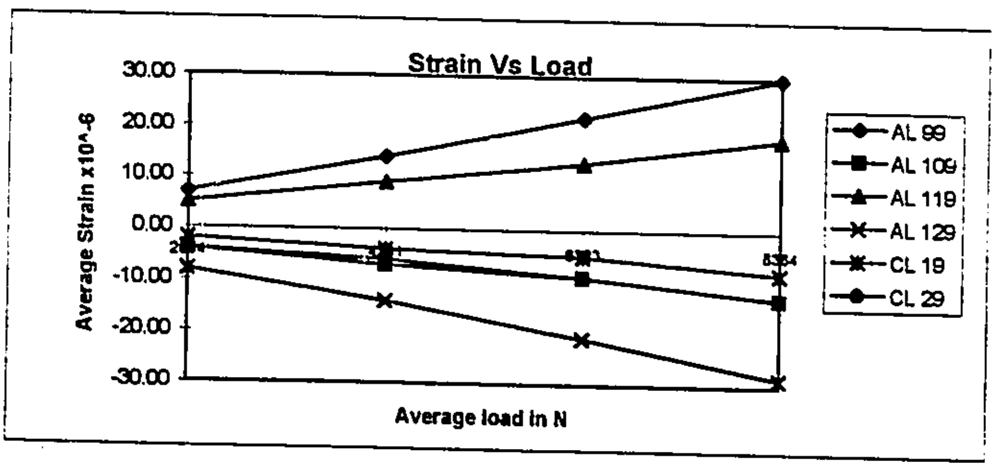
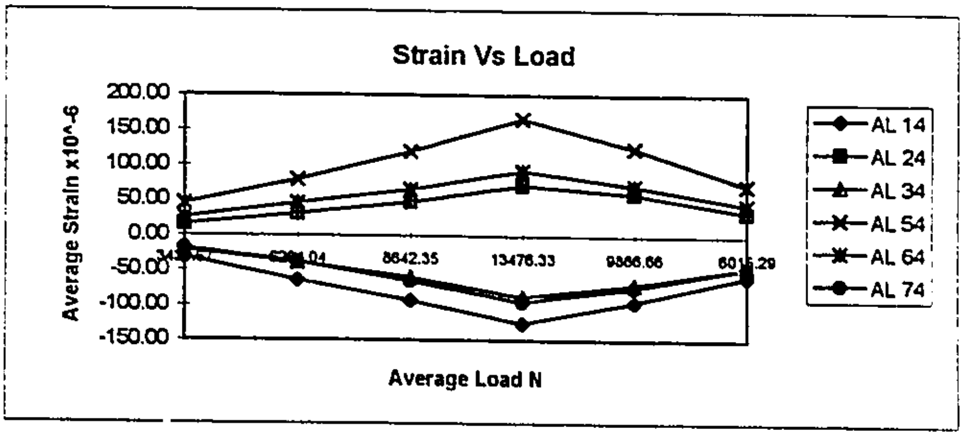


FIGURE B.17 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 1

SECTION 4

	Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5
		AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
Load 1	3431.67	-32.00	15.00	-21.00	45.00	25.00	-19.00
Load 2	6264.04	-64.00	30.00	-39.35	79.00	46.00	-38.00
Load 3	8642.35	-93.00	48.00	-59.94	120.00	66.00	-65.00
Load 4	13476.33	-126.00	72.00	-88.17	167.00	93.00	-95.00
Load 5	9866.66	-95.00	60.00	-70.02	125.00	72.00	-74.00
Load 6	6015.29	-58.00	34.00	-44.92	73.00	45.00	-45.00



	Average Load N	Strain 49	Strain 42	Strain 40	Strain 39	Strain M1	Strain M2	Strain M3
		AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
Load 1	3431.67	22.04	31.78	-26.54	23.51	-19.00	-20.00	-22.00
Load 2	6264.04	44.66	55.72	-46.34	41.96	-29.00	-31.00	-32.00
Load 3	8642.35	69.87	84.36	-71.00	67.88	-45.00	-46.00	-48.00
Load 4	13476.33	95.93	113.90	-98.68	94.80	-69.00	-72.00	-73.00
Load 5	9866.66	75.93	91.16	-71.77	75.16	-56.00	-57.00	-57.00
Load 6	6015.29	49.30	60.07	-45.07	46.61	-31.00	-33.00	-34.00

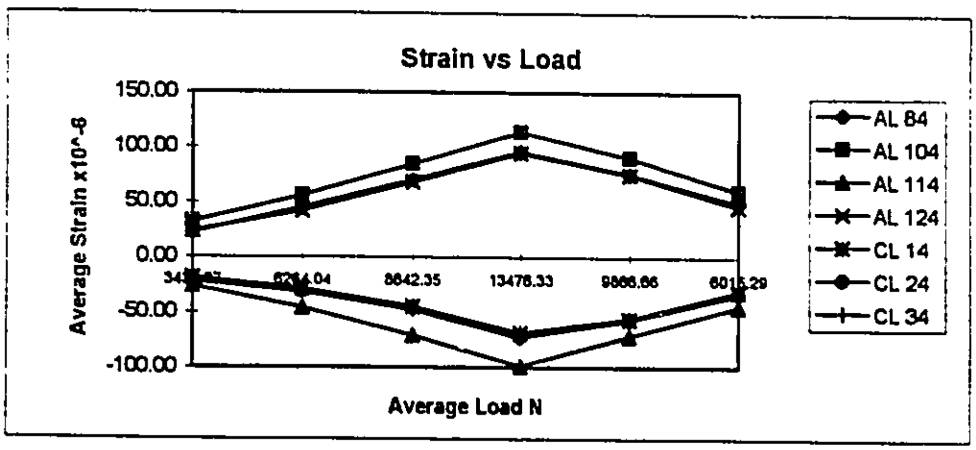


FIGURE B.18 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 2

SECTION 5

	Average Load N	Strain 33	Strain 34	Strain 52	Strain 16	Strain 15	Strain 50	Strain 41
		AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
Load 1	3431.67	-33.83	25.71	-26.42	36.53	-22.00	34.24	38.19
Load 2	6264.04	-62.98	44.32	-44.49	68.41	-46.09	66.13	62.30
Load 3	8642.35	-93.67	68.57	-68.62	99.84	-67.00	97.05	92.36
Load 4	13476.33	-125.29	95.50	-89.91	134.93	-96.48	131.96	124.14
Load 5	9866.66	-95.26	75.23	-68.48	108.03	-75.90	103.42	96.80
Load 6	6015.29	-62.02	50.04	-41.91	69.09	-45.18	65.31	64.29

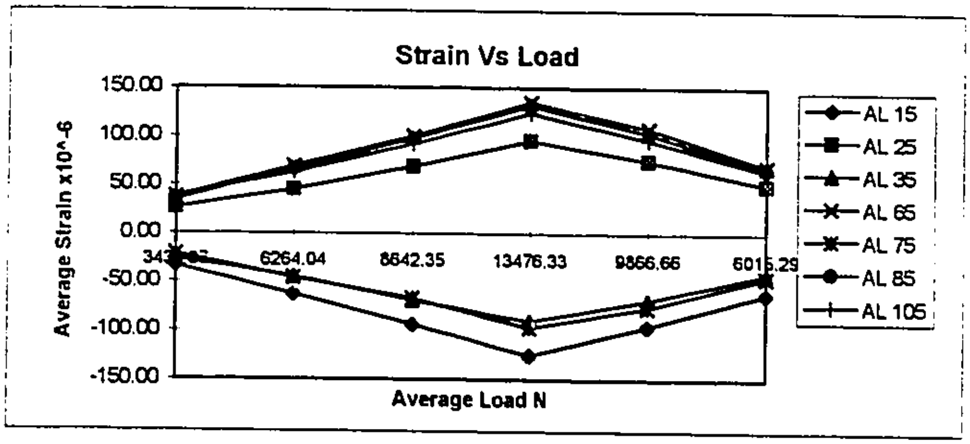
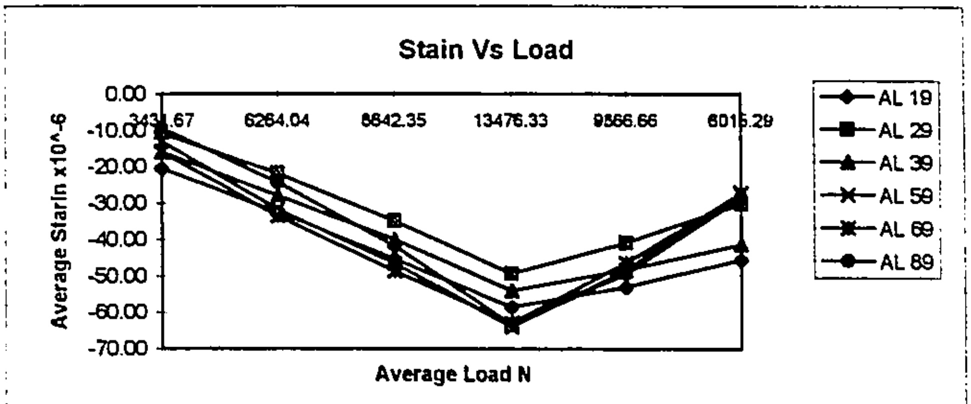


FIGURE B.19 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 2

·SECTION 9

	Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
		AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
Load 1	3431.67	-20.48	-10.79	-15.92	-13.08	-16.00	-9.46
Load 2	6264.04	-32.54	-21.96	-28.02	-31.79	-33.46	-24.23
Load 3	8642.35	-45.37	-34.93	-40.00	-46.55	-48.59	-41.70
Load 4	13476.33	-58.61	-49.36	-54.09	-63.92	-62.79	-63.34
Load 5	9866.66	-52.92	-40.84	-48.36	-48.32	-46.42	-49.36
Load 6	6015.29	-45.55	-30.25	-41.39	-27.07	-27.44	-28.48



	Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
		AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
Load 1	3431.67	17.00	-1.00	3.00	-10.00	-5.00	-6.00
Load 2	6264.04	27.00	-2.00	6.00	-19.00	-6.00	-9.00
Load 3	8642.35	40.00	-4.00	9.00	-31.00	-9.00	-14.00
Load 4	13476.33	56.00	-10.00	17.00	-45.00	-15.00	-19.00
Load 5	9866.66	42.00	-7.00	13.00	-35.00	-12.00	-15.00
Load 6	6015.29	25.00	-5.00	6.00	-24.00	-7.00	-9.00

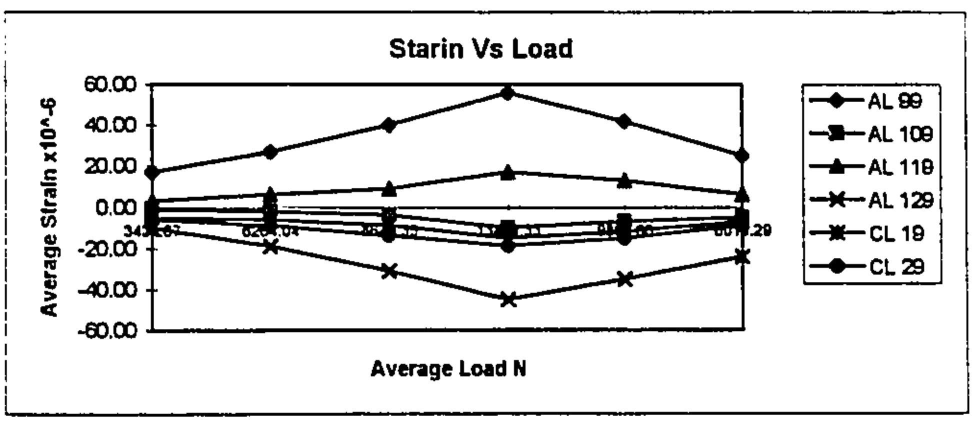
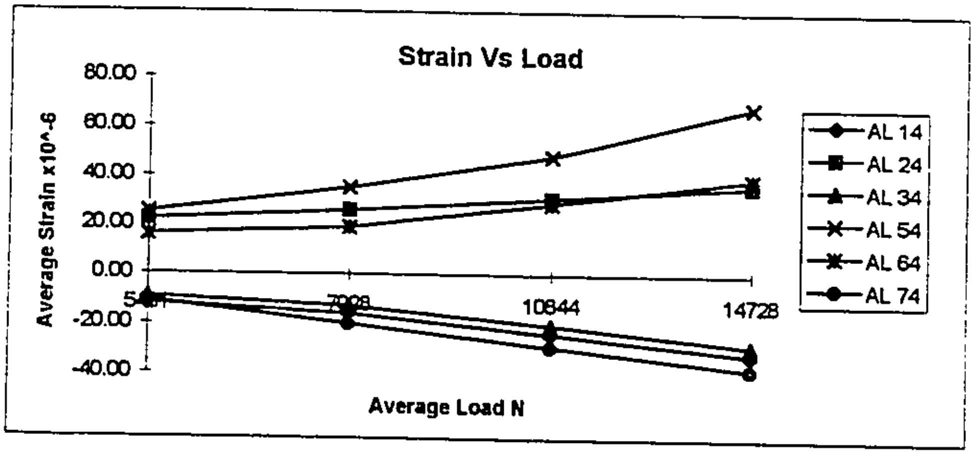


FIGURE B.20 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 2

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	5480.91	-12.00	22.00	-9.34	25.00	16.00	-11.00
Load 2	7028.06	-16.00	26.00	-12.83	35.00	19.00	-20.00
Load 3	10843.71	-24.00	31.00	-20.23	48.00	29.00	-29.00
Load 4	14727.63	-32.00	36.00	-28.57	68.00	39.00	-38.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain 39 AL 124	Strain M1 CL 14	Strain M2 CL 24	Strain M3 CL 34
Load 1	5480.91	12.49	16.18	-12.59	12.92	-12.00	-15.00	-13.50
Load 2	7028.06	16.56	20.72	-18.00	16.78	-15.00	-24.00	-19.00
Load 3	10843.71	26.76	32.06	-30.47	27.23	-24.00	-35.00	-27.00
Load 4	14727.63	36.67	43.10	-43.48	38.29	-32.00	-45.00	-39.00

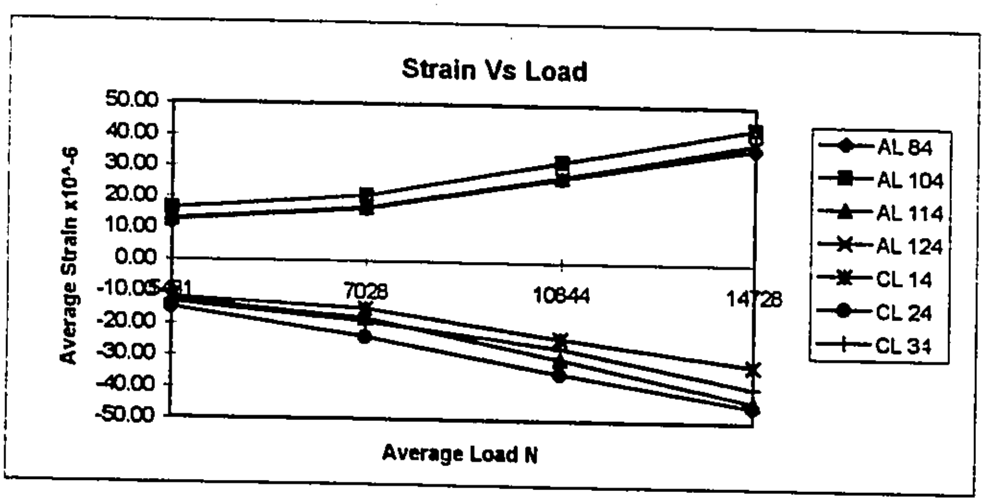


FIGURE B.21 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 6

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 34 AL 25	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85
Load 1	5480.91	-14.55	-17.05	12.38	-21.06	14.77
Load 2	7028.06	-24.65	-19.72	20.42	-28.79	22.78
Load 3	10843.71	-29.96	-26.68	32.44	-40.59	36.19
Load 4	14727.63	-39.44	-32.63	46.26	-52.97	50.06

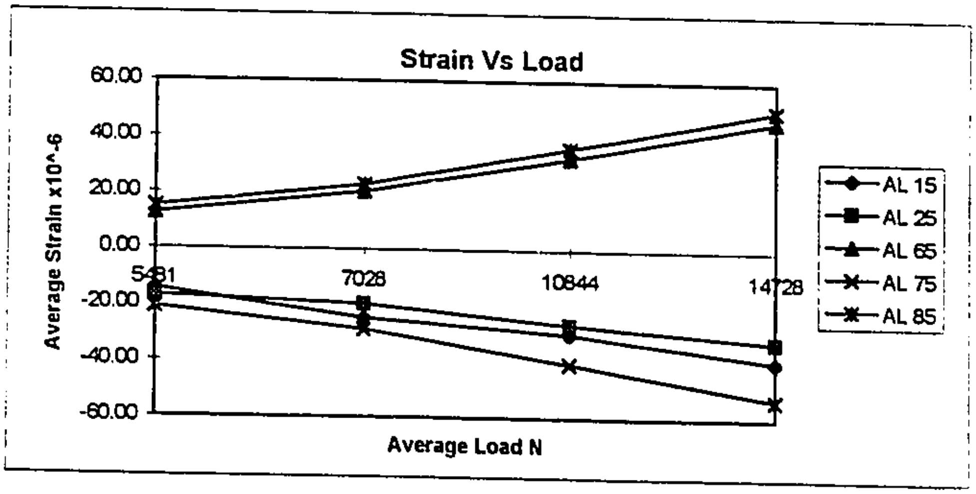
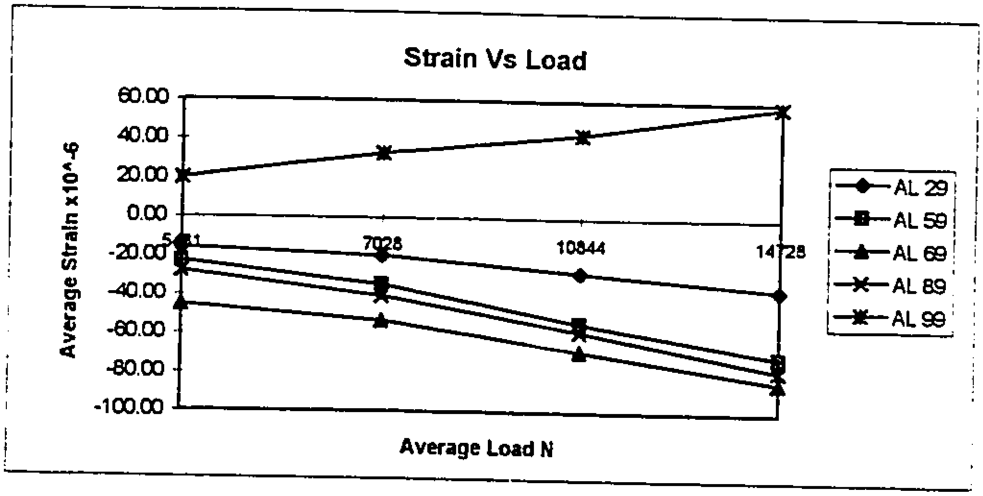


FIGURE B.22 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 6

SECTION 9

	Average Load N	Strain 56 AL 29	Strain 36 AL 59	Strain 35 AL 69	Strain 47 AL 89	Strain M20 AL 99
Load 1	5480.91	-16.07	-22.89	-45.17	-28.00	20.00
Load 2	7028.06	-19.65	-34.50	-53.09	-40.50	33.00
Load 3	10843.71	-27.94	-54.13	-68.54	-58.25	43.00
Load 4	14727.63	-36.52	-70.96	-83.88	-77.93	58.00



	Average Load N	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	5480.91	6.00	-12.00	4.00	6.00
Load 2	7028.06	7.00	-23.00	5.00	10.00
Load 3	10843.71	7.00	-32.00	8.00	12.00
Load 4	14727.63	12.00	-42.00	13.00	16.00

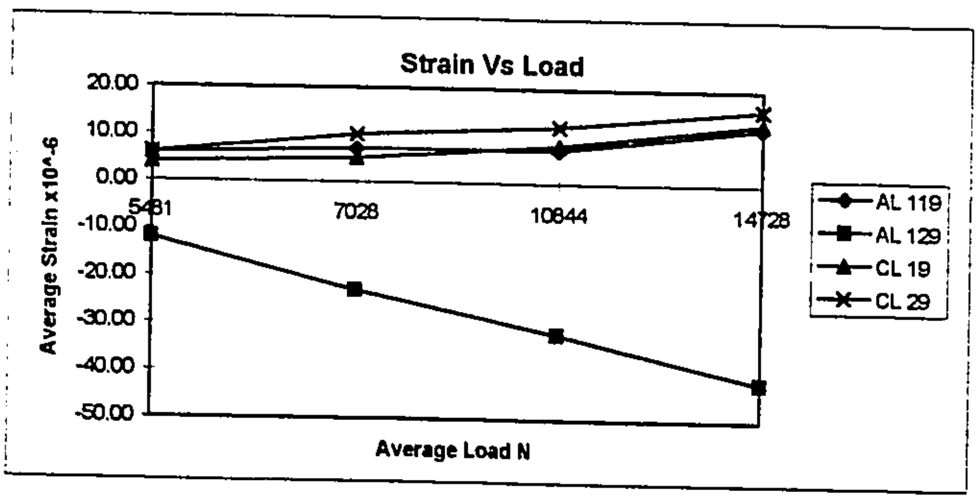
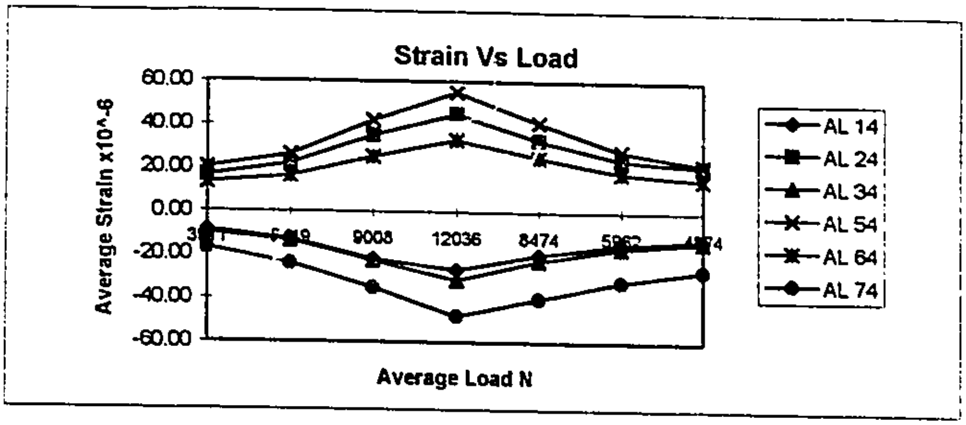


FIGURE B.23 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 6

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	3910.91	-9.00	16.00	-9.97	20.00	13.00	-17.00
Load 2	5419.36	-13.00	22.00	-13.63	26.00	16.00	-24.00
Load 3	9008.24	-22.00	35.00	-22.64	42.00	25.00	-35.00
Load 4	12036.12	-27.00	45.00	-31.41	55.00	33.00	-48.00
Load 5	8474.19	-20.00	33.00	-22.41	41.00	25.00	-40.00
Load 6	5961.69	-15.00	24.00	-16.83	28.00	18.00	-32.00
Load 7	4874.23	-13.00	21.00	-13.77	22.00	15.00	-27.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain 39 AL 124	Strain M1 CL 14	Strain M2 CL 24	Strain M3 CL 34
Load 1	3910.91	19.12	21.76	-12.73	23.03	-13.00	-18.00	-16.00
Load 2	5419.36	22.39	25.77	-16.74	27.55	-17.00	-23.00	-21.00
Load 3	9008.24	34.68	37.52	-25.20	37.02	-29.00	-37.00	-34.00
Load 4	12036.12	40.67	46.77	-33.36	45.04	-37.00	-49.00	-39.00
Load 5	8474.19	33.23	36.83	-23.63	36.60	-26.00	-35.00	-31.00
Load 6	5961.69	26.01	29.81	-16.69	29.93	-19.00	-26.00	-23.00
Load 7	4874.23	24.26	27.04	-13.78	28.06	-16.00	-21.00	-19.00

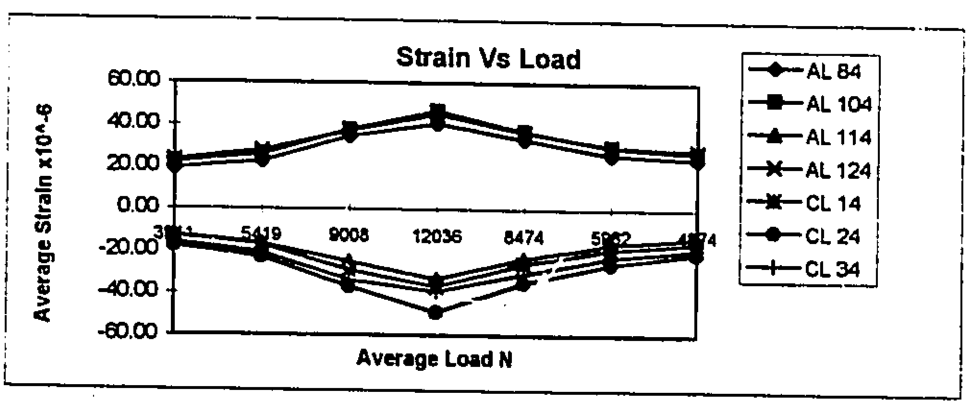
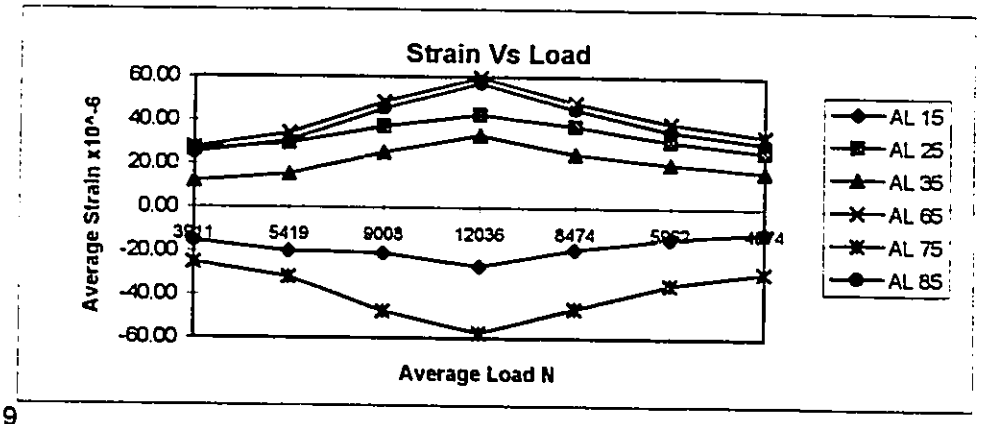


FIGURE B.24 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 7

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 34 AL 25	Strain 52 AL 35	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85
Load 1	3910.91	-15.22	26.25	11.86	27.29	-25.09	24.87
Load 2	5419.36	-19.94	29.16	15.20	33.90	-31.85	30.39
Load 3	9008.24	-20.97	36.99	25.16	48.38	-47.45	45.50
Load 4	12036.12	-26.89	42.62	33.14	59.78	-57.82	57.02
Load 5	8474.19	-19.13	37.44	24.70	48.20	-46.29	45.18
Load 6	5961.69	-14.08	30.37	20.11	38.91	-35.31	35.19
Load 7	4874.23	-11.29	25.75	16.52	32.99	-29.63	29.80



SECTION 9

	Average Load N	Strain 35 AL 69	Strain M20 AL 99	Strain M21 AL109	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	3910.91	-16.01	5.00	16.00	-22.00	-4.00	0.00	-1.00
Load 2	5419.36	-27.29	11.00	15.00	-21.00	-9.00	0.00	-3.00
Load 3	9008.24	-47.25	25.00	11.00	-18.00	-19.00	0.00	-5.00
Load 4	12036.12	-64.16	41.00	6.00	-13.00	-32.00	-8.00	-8.00
Load 5	8474.19	-45.82	30.00	9.00	-18.00	-23.00	-6.00	-6.00
Load 6	5961.69	-29.13	19.00	13.00	-22.00	-12.00	-4.00	-4.00
Load 7	4874.23	-17.98	13.00	15.00	-23.00	-7.00	-3.00	-3.00

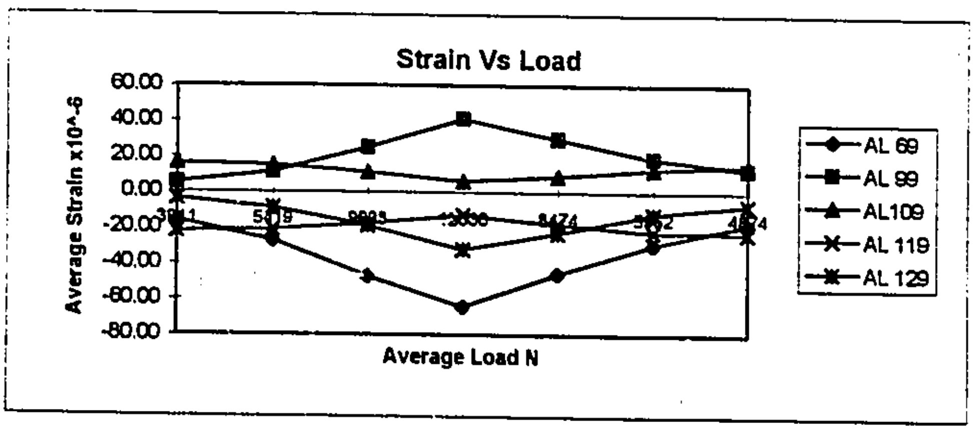
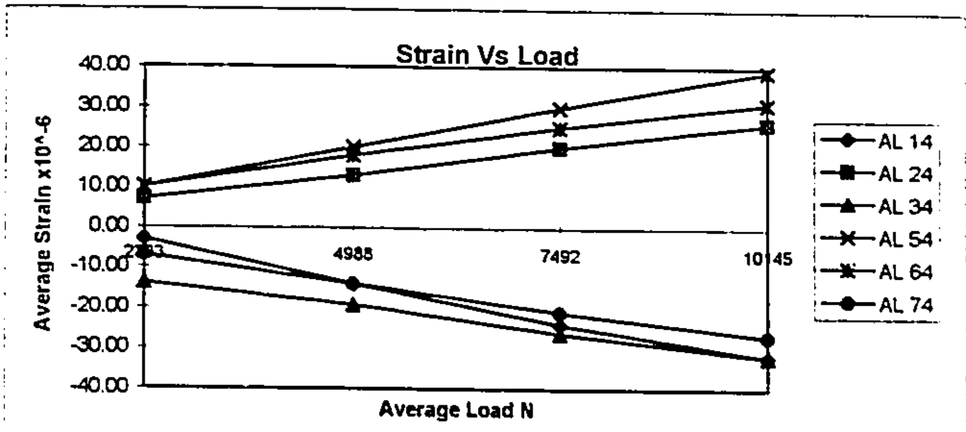


FIGURE B.25 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 7

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	2392.96	-3.00	7.00	-13.98	10.00	10.00	-7.00
Load 2	4988.04	-14.00	13.00	-19.28	20.00	18.00	-14.00
Load 3	7491.67	-24.00	20.00	-26.22	30.00	25.00	-21.00
Load 4	10144.56	-32.00	26.00	-32.05	39.00	31.00	-27.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain 39 AL 124	Strain M1 CL 14	Strain M2 CL 24	Strain M3 CL 34
Load 1	2392.96	14.29	16.42	-15.05	19.46	-11.00	-7.00	-9.00
Load 2	4988.04	21.53	24.49	-23.08	27.58	-20.00	-19.00	-23.00
Load 3	7491.67	27.99	31.91	-29.13	34.17	-27.00	-23.00	-27.00
Load 4	10144.56	35.34	41.00	-37.34	41.23	-36.00	-30.00	-35.00

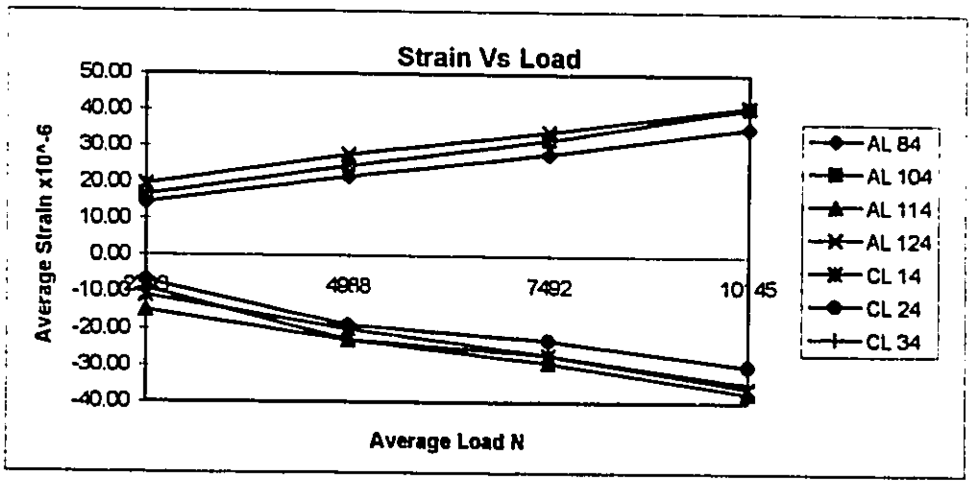


FIGURE B.26 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 8

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 34 AL 25	Strain 52 AL 35	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85
Load 1	2392.96	-10.03	23.86	-11.25	10.42	-14.74	19.46
Load 2	4988.04	-19.73	32.59	-19.14	21.73	-21.92	30.94
Load 3	7491.67	-29.89	39.80	-25.21	32.57	-30.00	40.69
Load 4	10144.56	-39.92	47.99	-32.65	44.57	-37.90	51.20

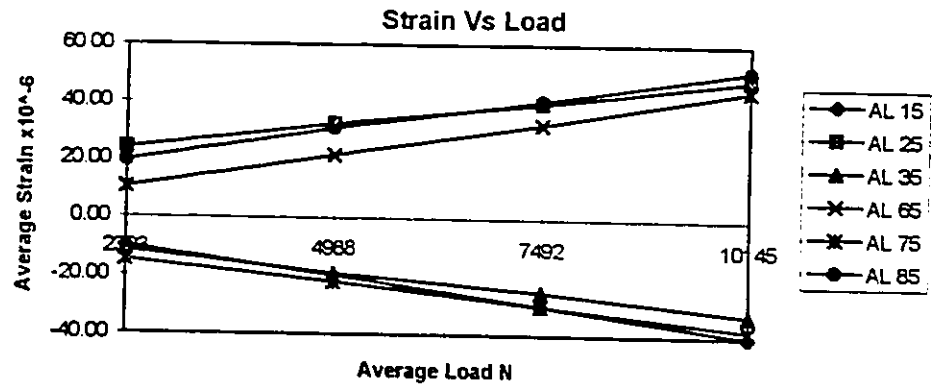
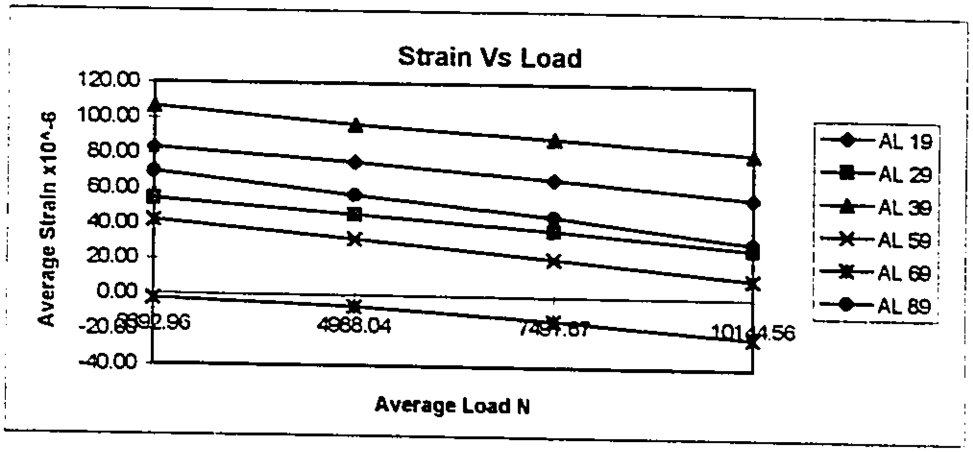


FIGURE B.27 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 8

SECTION 9

	Average Load N	Strain 55 AL 19	Strain 56 AL 29	Strain 54 AL 39	Strain 36 AL 59	Strain 35 AL 69	Strain 47 AL 89
Load 1	2392.96	83.04	54.32	106.56	41.85	-2.43	69.67
Load 2	4988.04	75.48	46.06	96.87	31.94	-6.47	56.90
Load 3	7491.67	66.78	37.68	89 45	21.41	-13.68	45.37
Load 4	10144.56	56.54	28.14	81.84	10.81	-22.51	31.34



	Average Load N	Strain M20 AL 99	Strain M21 AL 109	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	2504.30	15.00	-3.00	-3.00	-6.00	-2.00	-3.00
Load 2	4281.47	20.00	-7.00	-7.00	-11.00	-4.00	-4.00
Load 3	6123.03	25.00	-11.00	-12.00	-17.00	-7.00	-6.00
Load 4	8384.05	31.00	-18.00	-18.00	-23.00	-10.00	-8.00

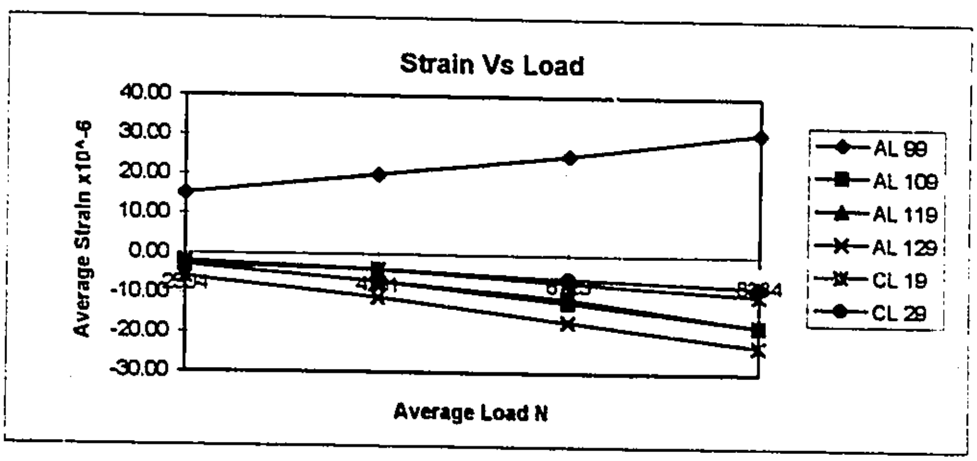
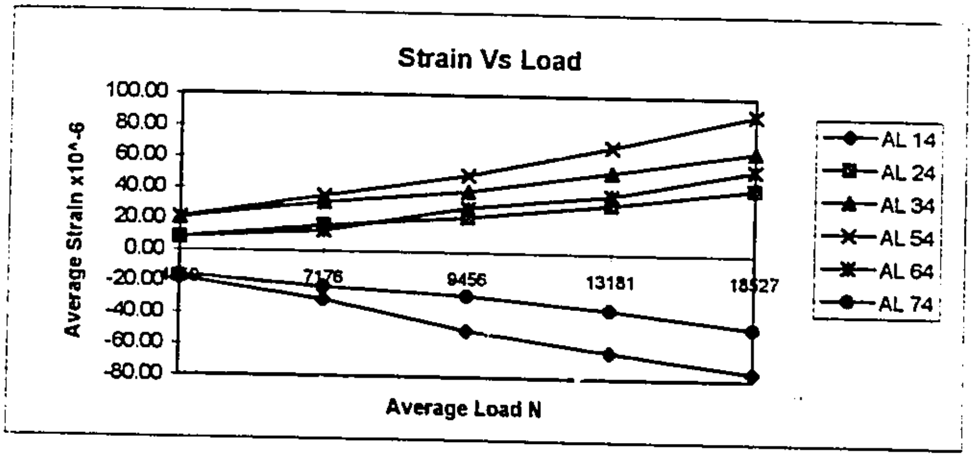


FIGURE B.28 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 8

SECTION 4

	Average Load N	Strain M8 AL 14	Strain M16 AL 24	Strain 48 AL 34	Strain M15 AL 54	Strain M4 AL 64	Strain M5 AL 74
Load 1	4858.56	-18.00	8.00	20.48	21.00	8.00	-16.00
Load 2	7176.40	-31.00	16.00	30.98	35.00	13.00	-23.00
Load 3	9455.61	-50.00	22.00	38.69	49.00	28.00	-28.00
Load 4	13181.49	-63.00	31.00	51.79	68.00	37.00	-36.00
Load 5	18527.00	-75.00	42.00	65.80	89.00	54.00	-47.00



	Average Load N	Strain 49 AL 84	Strain 42 AL 104	Strain 40 AL 114	Strain 39 AL 124	Strain M1 CL 14	Strain M2 CL 24
Load 1	4858.56	20.79	24.48	23.25	25.48	-13.00	-52.00
Load 2	7176.40	27.96	31.99	30.15	33.88	-21.00	-82.00
Load 3	9455.61	35.51	40.46	38.06	42.65	-28.00	-112.00
Load 4	13181.49	43.65	48.79	46.84	51.59	-36.00	-156.00
Load 5	18527.00	53.42	58.00	56.00	62.00	-49.00	-215.00

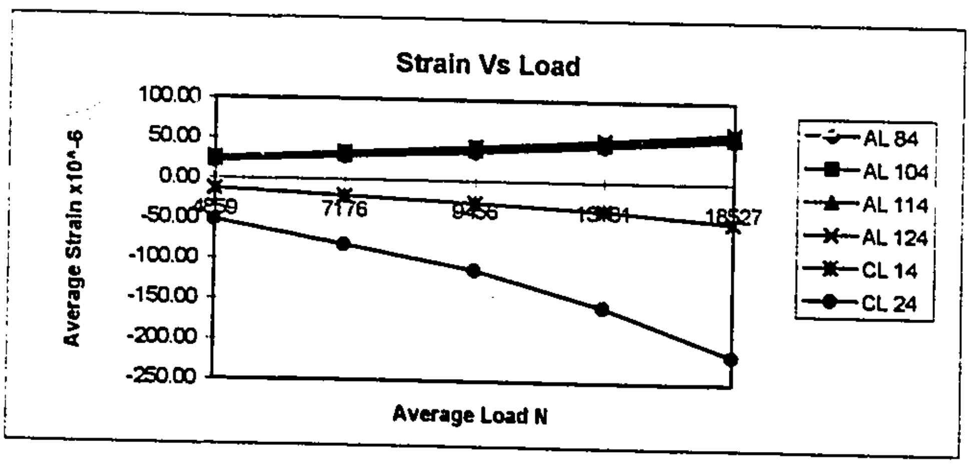


FIGURE B.29 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 9

SECTION 5

	Average Load N	Strain 33 AL 15	Strain 34 AL 25	Strain 52 AL 35	Strain 16 AL 65	Strain 15 AL 75	Strain 50 AL 85	Strain 41 AL 105
Load 1	4858.56	33.96	-27.94	17.55	27.46	-21.79	30.16	-7.26
Load 2	7176.40	43.39	-38.22	23.64	37.09	-31.95	41.89	1.86
Load 3	9455.61	54.65	-49.33	30.85	45.76	-41.67	53.14	9.34
Load 4	13181.49	68.09	-60.07	40.28	57.62	-52.07	65.03	21.16
Load 5	18527.00	83.77	-72.18	53.32	69.94	-63.75	79.96	31.65

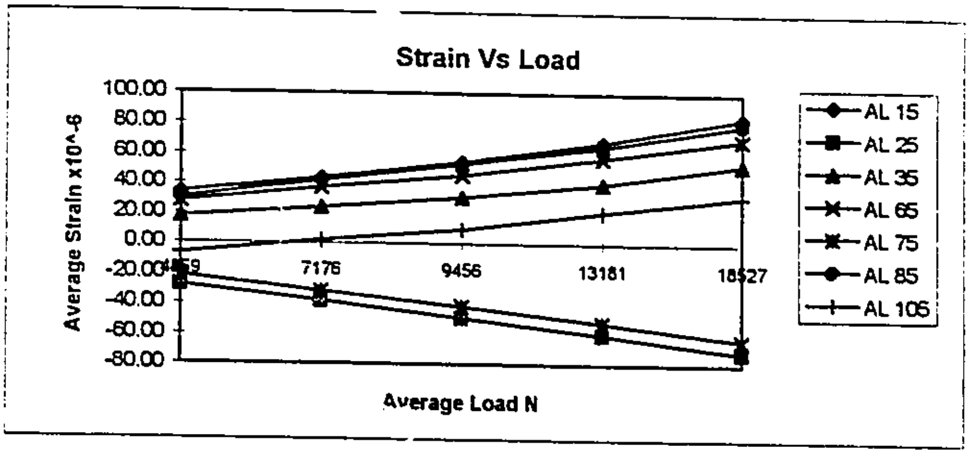
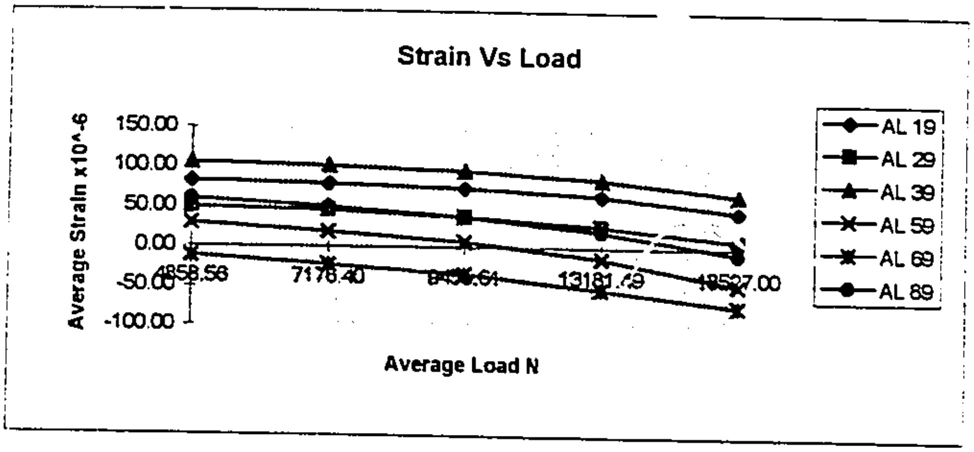


FIGURE B.30 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 9

SECTION 9

	Average Load N	Strain 55 AL 19	Strain 56 AL 29	Strain 54 AL 39	Strain 36 AL 59	Strain 35 AL 69	Strain 47 AL 89
Load 1	4858.56	81.71	48.85	105.26	29.17	-12.18	59.36
Load 2	7176.40	79.02	45.76	100.98	18.24	-22.80	49.72
Load 3	9455.61	73.52	37.93	95.29	6.89	-34.58	37.67
Load 4	13181.49	64.91	26.80	85.35	-13.35	-52.48	20.54
Load 5	18527.00	45.51	8.79	66.67	-46.16	-73.89	-6.95



	Average Load N	Strain M20 AL 99	Strain M21 AL 109	Strain M6 AL 119	Strain M7 AL 129	Strain M24 CL 19	Strain M23 CL 29
Load 1	4858.56	12.00	-7.00	1.00	-11.00	-2.00	-4.00
Load 2	7176.40	26.00	-11.00	4.00	-18.00	-4.00	-5.00
Load 3	9455.61	40.00	-14.00	11.00	-24.00	-5.00	-8.00
Load 4	13181.49	55.00	-19.00	17.00	-31.00	-8.00	-12.00
Load 5	18527.00	70.00	-27.00	24.00	-40.50	-11.00	-17.00

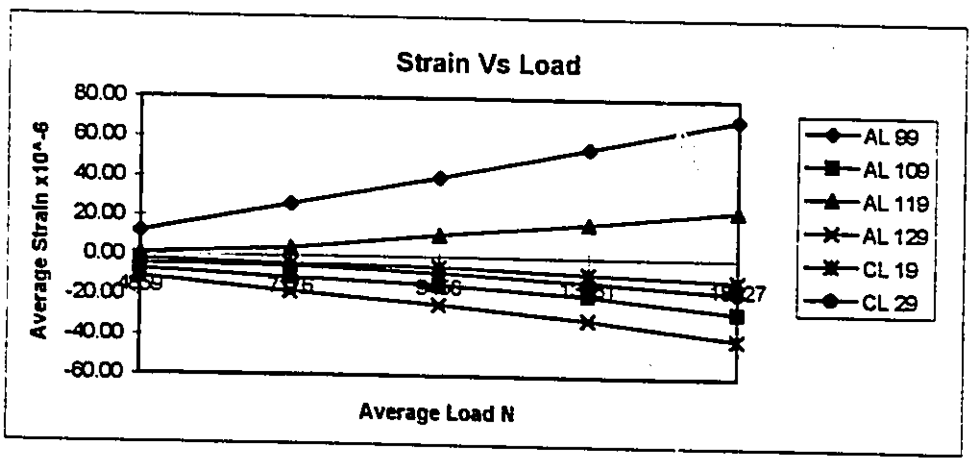


FIGURE B.31 STRAIN VS. AVERAGE LOAD FOR LOAD CASE 9

Table B.1 Experimental Strain Results For Load Case 1

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5	
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
2504.30	-21.00	24.00	-11.32	20.00	14.00	-16.00	
4281.47	-33.00	40.00	-20.52	36.00	23.00	-27.00	
6123.03	-47.00	55.00	-31.13	51.00	32.00	-40.00	
8384.05	-63.00	69.00	-44.53	69.00	43.00	-54.00	
SECTION 4 Average Load N	**Strain 49**	**Strain 42**	**Strain 40**	**Strain 39**	**Strain M1**	**Strain M2**	**Strain M3**
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
2504.30	13.80	19.50	-14.04	17.35	-11.00	-13.00	-15.00
4281.47	24.32	30.40	-26.09	29.76	-18.00	-21.00	-20.00
6123.03	35.73	44.77	-36.99	41.39	-33.00	-28.00	-31.00
8384.05	54.51	64.32	-51.02	58.40	-42.00	-39.00	-40.00
SECTION 5 Average Load N	**Strain 33**	**Strain 34**	**Strain 52**	**Strain 16**	**Strain 15**	**Strain 50**	**Strain 44**
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
2504.30	-22.47	-17.02	-10.86	15.45	-11.23	20.32	4.54
4281.47	-38.81	-31.87	-25.22	30.52	-24.05	36.66	17.86
6123.03	-57.32	-45.71	-41.67	44.67	-36.02	56.06	32.39
8384.05	-82.35	-64.15	-56.54	64.85	-52.13	80.50	51.69
SECTION 9 Average Load N	**Strain 55**	**Strain 56**	**Strain 54**	**Strain 36**	**Strain 35**	**Strain 47**	
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
2504.30	-21.15	-10.49	-10.41	-6.86	-12.56	-14.13	
4281.47	-29.62	-19.25	-20.52	-16.34	-20.65	-22.17	
6123.03	-39.18	-26.81	-31.82	-24.38	-28.07	-32.35	
8384.05	-50.80	-37.20	-42.50	-35.36	-38.35	-46.30	
SECTION 9 Average Load N	**Strain M20**	**Strain M21**	**Strain M6**	**Strain M7**	**Strain M24**	**Strain M23**	
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29	
2504.30	7.00	-4.00	5.00	-8.00	-2.00	-4.00	
4281.47	14.00	-7.00	9.00	-14.00	-4.00	-6.00	
6123.03	22.00	-9.00	13.00	-21.00	-5.00	-9.00	
8384.05	30.00	-13.00	18.00	-28.50	-8.00	-13.00	

Table B.2 Experimental Stress Results For Load Case 1

SECTION 4 Average Load N	Stress Values MPa						
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
2504.30	-1.49	1.71	-0.80	1.42	1.00	-1.14	
4281.47	-2.35	2.84	-1.46	2.56	1.64	-1.92	
6123.03	-3.34	3.91	-2.21	3.63	2.28	-2.84	
8384.05	-4.48	4.91	-3.17	4.91	3.06	-3.84	
SECTION 4 Average Load N	**Stress Values MPa**						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
2504.30	0.98	1.39	-1.00	1.23	-0.38	-0.45	-0.51
4281.47	1.73	2.16	-1.86	2.12	-0.62	-0.72	-0.69
6123.03	2.54	3.18	-2.63	2.94	-1.13	-0.96	-1.06
8384.05	3.88	4.57	-3.63	4.15	-1.44	-1.34	-1.37
SECTION 5 Average Load N	**Stress Values MPa**						
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
2504.30	-1.60	-1.21	-0.77	1.10	-0.80	1.44	0.32
4281.47	-2.76	-2.27	-1.79	2.17	-1.71	2.61	1.27
6123.03	-4.08	-3.25	-2.96	3.18	-2.56	3.99	2.30
8384.05	-5.86	-4.56	-4.02	4.61	-3.71	5.72	3.67
SECTION 9 Average Load N	**Stress Values MPa**						
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
2504.30	-1.50	-0.75	-0.74	-0.49	-0.89	-1.00	
4281.47	-2.11	-1.37	-1.46	-1.16	-1.47	-1.58	
6123.03	-2.79	-1.91	-2.26	-1.73	-2.00	-2.30	
8384.05	-3.61	-2.65	-3.02	-2.51	-2.73	-3.29	
SECTION 9 Average Load N	**Stress Values MPa**						
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29	
2504.30	0.50	-0.28	0.36	-0.57	-0.07	-0.14	
4281.47	1.00	-0.50	0.64	-1.00	-0.14	-0.21	
6123.03	1.56	-0.64	0.92	-1.49	-0.17	-0.31	
8384.05	2.13	-0.92	1.28	-2.03	-0.27	-0.45	

Table B.3 Experimental Strain Results For Load Case 2

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5	
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
3431.67	-32.00	15.00	-21.00	45.00	25.00	-19.00	
6264.04	-64.00	30.00	-39.35	79.00	46.00	-38.00	
8642.35	-85.00	48.00	-59.94	120.00	66.00	-65.00	
13476.33	-126.00	72.00	-88.17	167.00	93.00	-95.00	
9866.66	-95.00	60.00	-70.02	125.00	72.00	-74.00	
6015.29	-58.00	34.00	-44.92	73.00	45.00	-45.00	
SECTION 4 Average Load N	**Strain 49**	**Strain 42**	**Strain 40**	**Strain 39**	**Strain M1**	**Strain M2**	**Strain M3**
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
3431.67	22.04	31.78	-26.54	23.51	-19.00	-20.00	-22.00
6264.04	44.66	55.72	-46.34	41.96	-29.00	-31.00	-32.00
8642.35	69.87	84.36	-64.40	67.88	-45.00	-46.00	-48.00
13476.33	95.93	113.90	-98.68	94.80	-69.00	-72.00	-73.00
9866.66	75.93	91.16	-71.77	75.16	-56.00	-57.00	-57.00
6015.29	49.30	60.07	-45.07	46.61	-31.00	-33.00	-34.00
SECTION 5 Average Load N	**Strain 33**	**Strain 34**	**Strain 52**	**Strain 16**	**Strain 15**	**Strain 50**	**Strain 41**
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
3431.67	-33.83	25.71	-26.42	36.53	-22.00	34.24	38.19
6264.04	-62.98	44.32	-44.49	68.41	-46.09	66.13	62.30
8642.35	-93.67	68.57	-68.62	99.84	-67.00	97.05	92.36
13476.33	-125.29	95.50	-89.91	134.93	-96.48	131.96	124.14
9866.66	-95.26	75.23	-68.48	108.03	-75.90	103.42	96.80
6015.29	-62.02	50.04	-41.91	69.09	-45.18	65.31	64.29
SECTION 9 Average Load N	**Strain 55**	**Strain 56**	**Strain 54**	**Strain 36**	**Strain 35**	**Strain 47**	
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
3431.67	-20.48	-10.79	-15.92	-13.08	-16.00	-9.46	
6264.04	-32.54	-21.96	-28.02	-31.79	-33.46	-24.23	
8642.35	-45.37	-34.93	-40.00	-46.55	-48.59	-41.70	
13476.33	-58.61	-49.36	-54.09	-63.92	-62.79	-63.34	
9866.66	-52.92	-40.84	-48.36	-48.32	-46.42	-49.36	
6015.29	-45.55	-30.25	-41.39	-27.07	-27.44	-28.48	

Table B.4 Experimental Strain Results For Load Case 2

SECTION 9 Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
3431.67	17.00	-1.00	3.00	-10.00	-5.00	-6.00
6264.04	27.00	-2.00	6.00	-19.00	-6.00	-9.00
8642.35	40.00	-4.00	9.00	-31.00	-9.00	-14.00
13476.33	56.00	-10.00	17.00	-45.00	-15.00	-19.00
9866.66	42.00	-7.00	13.00	-35.00	-12.00	-15.00
6015.29	25.00	-5.00	6.00	-24.00	-7.00	-9.00

Table B.5 Experimental Stress Results For Load Case 2

SECTION 4 Average Load N	Stress Values MPa						
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
3431.67	-2.28	1.07	-1.49	3.20	1.78	-1.35	
6264.04	-4.55	2.13	-2.80	5.62	3.27	-2.70	
8642.35	-6.04	3.41	-4.26	8.53	4.69	-4.62	
13476.33	-8.96	5.12	-6.27	11.87	6.61	-6.75	
9866.66	-6.75	4.27	-4.98	8.89	5.12	-5.26	
6015.29	-4.12	2.42	-3.19	5.19	3.20	-3.20	
SECTION 4 Average Load N	**Stress Values MPa**						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
3431.67	1.57	2.26	-1.89	1.67	-0.65	-0.69	-0.75
6264.04	3.18	3.96	-3.29	2.98	-0.99	-1.06	-1.10
8642.35	4.97	6.00	-4.58	4.83	-1.54	-1.58	-1.65
13476.33	6.82	8.10	-7.02	6.74	-2.37	-2.47	-2.50
9866.66	5.40	6.48	-5.10	5.34	-1.92	-1.96	-1.96
6015.29	3.51	4.27	-3.20	3.31	-1.06	-1.13	-1.17
SECTION 5 Average Load N	**Stress Values MPa**						
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
3431.67	-2.40	1.83	-1.88	2.60	-1.56	2.43	2.72
6264.04	-4.48	3.15	-3.16	4.86	-3.28	4.70	4.43
8642.35	-6.66	4.88	-4.88	7.10	-4.76	6.90	6.57
13476.33	-8.91	6.79	-6.39	9.59	-6.86	9.38	8.83
9866.66	-6.77	5.35	-4.87	7.68	-5.40	7.35	6.88
6015.29	-4.41	3.56	-2.98	4.91	-3.21	4.64	4.57
SECTION 9 Average Load N	**Stress Values MPa**						
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89	
3431.67	-1.46	-0.77	-1.13	-0.93	-1.14	-0.67	
6264.04	-2.31	-1.56	-1.99	-2.26	-2.38	-1.72	
8642.35	-3.23	-2.48	-2.84	-3.31	-3.45	-2.96	
13476.33	-4.17	-3.51	-3.85	-4.54	-4.46	-4.50	
9866.66	-3.76	-2.90	-3.44	-3.44	-3.30	-3.51	
6015.29	-3.24	-2.15	-2.94	-1.92	-1.95	-2.03	

Table B.6 Experimental Stress Results For Load Case 2

SECTION 9 Average Load N	Stress Values MPa					
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
3431.67	1.21	-0.07	0.21	-0.71	-0.17	-0.21
6264.04	1.92	-0.14	0.43	-1.35	-0.21	-0.31
8642.35	2.84	-0.28	0.64	-2.20	-0.31	-0.48
13476.33	3.98	-0.71	1.21	-3.20	-0.51	-0.65
9866.66	2.99	-0.50	0.92	-2.49	-0.41	-0.51
6015.29	1.78	-0.36	0.43	-1.71	-0.24	-0.31

Table B.7 Experimental Strain Results For Load Case 6

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5	
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
5480.91	-12.00	22.00	-9.34	25.00	16.00	-11.00	
7028.06	-16.00	26.00	-12.83	31.00	19.00	-20.00	
10843.71	-24.00	31.00	-20.23	48.00	29.00	-29.00	
14727.63	-32.00	36.00	-28.57	68.00	39.00	-38.00	
SECTION 4 Average Load N	**Strain 49**	**Strain 42**	**Strain 40**	**Strain 39**	**Strain M1**	**Strain M2**	**Strain M3**
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
5480.91	12.49	16.18	-12.59	12.92	-12.00	-15.00	-13.50
7028.06	16.56	20.72	-18.00	16.78	-15.00	-22.00	-19.00
10843.71	26.76	32.06	-30.47	27.23	-24.00	-35.00	-27.00
14727.63	36.67	43.10	-43.48	38.29	-32.00	-45.00	-39.00
SECTION 5 Average Load N	**Strain 33**	**Strain 34**	**Strain 16**	**Strain 15**	**Strain 50**		
	AL 15	AL 25	AL 65	AL 75	AL 85		
5480.91	-14.55	-17.05	12.38	-21.06	14.77		
7028.06	-24.65	-19.72	20.42	-28.79	22.78		
10843.71	-29.96	-26.68	32.44	-40.59	36.19		
14727.63	-39.44	-32.63	46.26	-52.97	50.06		
SECTION 9 Average Load N	**Strain 56**	**Strain 36**	**Strain 35**	**Strain 47**	**Strain M20**		
	AL 29	AL 59	AL 69	AL 89	AL 99		
5480.91	-16.07	-22.89	-45.17	-28.00	20.00		
7028.06	-19.65	-34.50	-53.09	-40.50	33.00		
10843.71	-27.94	-54.13	-68.54	-58.25	43.00		
14727.63	-36.52	-70.96	-83.88	-77.93	58.00		
SECTION 9 Average Load N	**Strain M6**	**Strain M7**	**Strain M24**	**Strain M23**			
	AL 119	AL 129	CL 19	CL 29			
5480.91	6.00	-12.00	4.00	6.00			
7028.06	7.00	-23.00	5.00	10.00			
10843.71	7.00	-32.00	8.00	12.00			
14727.63	12.00	-42.00	13.00	16.00			

Table B.8 Experimental Stress Results For Load Case 6

SECTION 4 Average Load N	Stress Values MPa					
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
5480.91	-0.85	1.56	-0.66	1.78	1.14	-0.78
7028.06	-1.14	1.85	-0.91	2.20	1.35	-1.42
10843.71	-1.71	2.20	-1.44	3.41	2.06	-2.06
14727.63	-2.28	2.56	-2.03	4.83	2.77	-2.70

SECTION 4 Average Load N	Stress Values MPa						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
5480.91	0.89	1.15	-0.90	0.92	-0.41	-0.51	-0.46
7028.06	1.18	1.47	-1.28	1.19	-0.51	-0.75	-0.65
10843.71	1.90	2.28	-2.17	1.94	-0.82	-1.20	-0.93
14727.63	2.61	3.06	-3.09	2.72	-1.10	-1.54	-1.34

SECTION 5 Average Load N	Stress Values MPa				
	AL 15	AL 25	AL 65	AL 75	AL 85
5480.91	-1.03	-1.21	0.88	-1.50	1.05
7028.06	-1.75	-1.40	1.45	-2.05	1.62
10843.71	-2.13	-1.90	2.31	-2.89	2.57
14727.63	-2.80	-2.32	3.29	-3.77	3.56

SECTION 9 Average Load N	Stress Values MPa				
	AL 29	AL 59	AL 69	AL 89	AL 99
5480.91	-1.14	-1.63	-3.21	-1.99	1.42
7028.06	-1.40	-2.45	-3.78	-2.88	2.35
10843.71	-1.99	-3.85	-4.87	-4.14	3.06
14727.63	-2.60	-5.05	-5.96	-5.54	4.12

SECTION 9 Average Load N	Stress Values MPa			
	AL 119	AL 129	CL 19	CL 29
5480.91	0.43	-0.85	0.14	0.21
7028.06	0.50	-1.64	0.17	0.34
10843.71	0.50	-2.28	0.27	0.41
14727.63	0.85	-2.99	0.45	0.55

Table B.9 Experimental Strain Results For Load Case 7

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5	
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
3910.91	-9.00	16.00	-9.97	20.00	13.00	-17.00	
5419.36	-13.00	22.00	-13.63	26.00	16.00	-24.00	
9008.24	-22.00	35.00	-22.64	42.00	25.00	-35.00	
12036.12	-27.00	45.00	-31.41	55.00	33.00	-48.00	
8474.19	-20.00	33.00	-22.41	41.00	25.00	-40.00	
5961.69	-15.00	24.00	-16.83	28.00	18.00	-32.00	
4874.23	-13.00	21.00	-13.77	22.00	15.00	-27.00	
SECTION 4 Average Load N	**Strain 49**	**Strain 42**	**Strain 40**	**Strain 39**	**Strain M1**	**Strain M2**	**Strain M3**
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
3910.91	19.12	21.76	-12.73	23.03	-13.00	-18.00	-16.00
5419.36	22.39	25.79	-16.74	27.55	-17.00	-23.00	-21.00
9008.24	34.68	37.52	-25.20	37.02	-29.00	-37.00	-34.00
12036.12	40.67	46.77	-33.36	45.04	-37.00	-49.00	-39.00
8474.19	33.23	36.83	-23.63	36.60	-26.00	-35.00	-31.00
5961.69	26.01	29.81	-16.69	29.93	-19.00	-26.00	-23.00
4874.23	24.26	27.04	-13.78	28.06	-13.00	-21.00	-19.00
SECTION 5 Average Load N	**Strain 33**	**Strain 34**	**Strain 52**	**Strain 16**	**Strain 15**	**Strain 50**	
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	
3910.91	-15.22	26.25	11.86	27.29	-25.09	24.87	
5419.36	-19.94	29.16	15.20	33.90	-31.85	30.39	
9008.24	-20.97	36.99	25.16	48.38	-47.45	45.50	
12036.12	-26.89	42.62	33.14	59.78	-57.82	57.02	
8474.19	-19.13	37.44	24.70	48.20	-46.29	45.18	
5961.69	-14.08	30.37	20.11	38.91	-35.31	35.19	
4874.23	-11.29	25.75	16.52	32.99	-29.63	29.80	
SECTION 9 Average Load N	**Strain 35**	**Strain M20**	**Strain M21**	**Strain M6**	**Strain M7**	**Strain M24**	**Strain M23**
	AL 69	AL 99	AL109	AL 119	AL 129	CL 19	CL 29
3910.91	-16.01	5.00	16.00	-22.00	-4.00	0.00	-1.00
5419.36	-27.29	11.00	15.00	-21.00	-9.00	0.00	-3.00
9008.24	-47.25	25.00	11.00	-18.00	-19.00	0.00	-5.00
12036.12	-64.16	41.00	6.00	-13.00	-32.00	-8.00	-8.00
8474.19	-45.82	30.00	9.00	-18.00	-23.00	-6.00	-6.00
5961.69	-29.13	19.00	13.00	-22.00	-12.00	-4.00	-4.00
4874.23	-17.98	13.00	15.00	-23.00	-7.00	-3.00	-3.00

Table B.10 Experimental Stress Results For Load Case 7

SECTION 4 Average Load N	Stress Values MPa						
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74	
3910.91	-0.64	1.14	-0.71	1.42	0.92	-1.21	
5419.36	-0.92	1.56	-0.97	1.85	1.14	-1.71	
9008.24	-1.56	2.49	-1.61	2.99	1.78	-2.49	
12036.12	-1.92	3.20	-2.23	3.91	2.35	-3.41	
8474.19	-1.42	2.35	-1.59	2.92	1.78	-2.84	
5961.69	-1.07	1.71	-1.20	1.99	1.28	-2.28	
4874.23	-0.92	1.49	-0.98	1.56	1.07	-1.92	
SECTION 4 Average Load N	**Stress Values MPa**						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
3910.91	1.36	1.55	-0.90	1.64	-0.45	-0.62	-0.55
5419.36	1.59	1.83	-1.19	1.96	-0.58	-0.79	-0.72
9008.24	2.47	2.67	-1.79	2.63	-0.99	-1.27	-1.17
12036.12	2.89	3.33	-2.37	3.20	-1.27	-1.68	-1.34
8474.19	2.36	2.62	-1.68	2.60	-0.89	-1.20	-1.06
5961.69	1.85	2.12	-1.19	2.13	-0.65	-0.89	-0.79
4874.23	1.72	1.92	-0.98	2.00	-0.55	-0.72	-0.65
SECTION 5 Average Load N	**Stress Values MPa**						
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	
3910.91	-1.08	1.87	0.84	1.94	-1.78	1.77	
5419.36	-1.42	2.07	1.08	2.41	-2.26	2.16	
9008.24	-1.49	2.63	1.79	3.44	-3.37	3.24	
12036.12	-1.91	3.03	2.36	4.25	-4.11	4.05	
8474.19	-1.36	2.66	1.76	3.43	-3.29	3.21	
5961.69	-1.00	2.16	1.43	2.77	-2.51	2.50	
4874.23	-0.80	1.83	1.17	2.35	-2.11	2.12	
SECTION 9 Average Load N	**Stress Values MPa**						
	AL 69	AL 99	AL109	AL 119	AL 129	CL 19	CL 29
3910.91	-1.14	0.36	1.14	-1.56	-0.28	0.00	-0.03
5419.36	-1.94	0.78	1.07	-1.49	-0.64	0.00	-0.10
9008.24	-3.36	1.78	0.78	-1.28	-1.35	0.00	-0.17
12036.12	-4.56	2.92	0.43	-0.92	-2.28	-0.27	-0.27
8474.19	-3.26	2.13	0.64	-1.28	-1.64	-0.21	-0.21
5961.69	-2.07	1.35	0.92	-1.56	-0.85	-0.14	-0.14
4874.23	-1.28	0.92	1.07	-1.64	-0.50	-0.10	-0.10

Table B.11 Experimental Strain Results For Load Case 8

SECTION 4 Average Load N	Strain M8	Strain M16	Strain 48	Strain M15	Strain M4	Strain M5
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
2392.96	-3.00	7.00	-13.98	10.00	10.00	-7.00
4988.04	-14.00	13.00	-19.28	20.00	18.00	-14.00
7491.67	-24.00	20.00	-26.22	30.00	25.00	-21.00
10144.56	-32.00	26.00	-32.05	39.00	31.00	-27.00

SECTION 4 Average Load N	Strain 49	Strain 42	Strain 40	Strain 39	Strain M1	Strain M2	Strain M3
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
2392.96	14.29	16.42	-15.05	19.46	-11.00	-7.00	-9.00
4988.04	21.53	24.49	-23.08	27.58	-20.00	-19.00	-23.00
7491.67	27.99	31.91	-29.13	34.17	-27.00	-23.00	-27.00
10144.56	35.34	41.00	-37.34	41.23	-36.00	-30.00	-35.00

SECTION 5 Average Load N	Strain 33	Strain 34	Strain 52	Strain 16	Strain 15	Strain 50
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85
2392.96	-10.03	23.86	-11.25	10.42	-14.74	19.46
4988.04	-19.73	32.59	-19.14	21.73	-21.92	30.94
7491.67	-29.89	39.80	-25.21	32.57	-30.00	40.69
10144.56	-39.92	47.99	-32.65	44.57	-37.90	51.20

SECTION 9 Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
2392.96	83.04	54.32	106.56	41.85	-2.43	69.67
4988.04	75.48	46.06	96.87	31.94	-6.47	56.90
7491.67	66.78	37.68	89.45	21.41	-13.68	45.37
10144.56	56.54	28.14	81.84	10.81	-22.51	31.34

SECTION 9 Average Load N	Strain M20	Strain M21	Strain M6	Strain M7	Strain M24	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
2504.30	15.00	-3.00	-3.00	-6.00	-2.00	-3.00
4281.47	20.00	-7.00	-7.00	-11.00	-4.00	-4.00
6123.03	25.00	-11.00	-12.00	-17.00	-7.00	-6.00
8384.05	31.00	-18.00	-18.00	-23.00	-10.00	-8.00

Table B.12 Experimental Stress Results For Load Case 8

SECTION 4 Average Load N	Stress Values MPa					
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
2392.96	-0.21	0.50	-0.99	0.71	0.71	-0.50
4988.04	-1.00	0.92	-1.37	1.42	1.28	-1.00
7491.67	-1.71	1.42	-1.86	2.13	1.78	-1.49
10144.56	-2.28	1.85	-2.28	2.77	2.20	-1.92

SECTION 4 Average Load N	Stress Values MPa						
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24	CL 34
2392.96	1.02	1.17	-1.07	1.38	-0.38	-0.24	-0.31
4988.04	1.53	1.74	-1.64	1.96	-0.69	-0.65	-0.79
7491.67	1.99	2.27	-2.07	2.43	-0.93	-0.79	-0.93
10144.56	2.51	2.92	-2.65	2.93	-1.23	-1.03	-1.20

SECTION 5 Average Load N	Stress Values MPa					
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85
2392.96	-0.71	1.70	-0.80	0.74	-1.05	1.38
4988.04	-1.40	2.32	-1.36	1.55	-1.56	2.20
7491.67	-2.12	2.83	-1.79	2.32	-2.13	2.89
10144.56	-2.84	3.41	-2.32	3.17	-2.69	3.64

SECTION 9 Average Load N	Stress Values MPa					
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
2392.96	5.90	3.86	7.58	2.98	-0.17	4.95
4988.04	5.37	3.28	6.89	2.27	-0.46	4.05
7491.67	4.75	2.68	6.36	1.52	-0.97	3.23
10144.56	4.02	2.00	5.82	0.77	-1.60	2.23

SECTION 9 Average Load N	Stress Values MPa					
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
2392.96	1.07	-0.21	-0.21	-0.43	-0.07	-0.10
4988.04	1.42	-0.50	-0.50	-0.78	-0.14	-0.14
7491.67	1.78	-0.78	-0.85	-1.21	-0.24	-0.21
10144.56	2.20	-1.28	-1.28	-1.64	-0.34	-0.27

Table B.13 Experimental Strain Results For Load Case 9

SECTION 4 Average Load N	Strain M8	Strain M1	Strain 48	Strain M1	Strain M4	Strain M5
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
4858.56	-13.00	8.00	-13.55	15.00	8.00	-16.00
7176.40	-18.00	16.00	-19.35	21.00	13.00	-23.00
9455.61	-24.00	22.00	-26.26	27.00	20.00	-28.00
13181.49	-33.00	31.00	-35.93	35.00	27.00	-36.00
18527.00	-46.00	42.00	-50.34	51.00	37.00	-47.00

SECTION 4 Average Load N	Strain 49	Strain 42	Strain 40	Strain 39	Strain M1	Strain M2
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24
4858.56	20.79	24.48	-23.25	25.48	-13.00	-15.00
7176.40	27.96	31.99	-30.15	33.88	-21.00	-22.00
9455.61	35.51	40.46	-38.06	42.65	-28.00	-29.00
13181.49	43.65	48.79	-46.84	51.59	-36.00	-37.00
18527.00	53.42	58.00	-56.00	62.00	-49.00	-51.00

SECTION 5 Average Load N	Strain 33	Strain 34	Strain 52	Strain 16	Strain 15	Strain 50	Strain 41
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
4858.56	-12.75	27.94	17.55	27.46	-21.79	30.16	-7.26
7176.40	-18.83	38.22	23.64	37.09	-31.95	41.89	1.86
9455.61	-24.81	49.33	30.85	45.76	-41.67	53.14	9.34
13181.49	-34.58	60.07	40.28	57.62	-52.07	65.03	21.16
18527.00	-48.61	72.18	53.32	69.94	-63.75	79.96	31.65

SECTION 9 Average Load N	Strain 55	Strain 56	Strain 54	Strain 36	Strain 35	Strain 47
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
4858.56	81.71	48.85	105.26	29.17	-12.18	59.36
7176.40	79.02	45.76	100.98	18.24	-22.80	49.72
9455.61	73.52	37.93	95.29	6.89	-34.58	37.67
13181.49	64.91	26.80	85.35	-13.35	-52.48	20.54
18527.00	45.51	8.79	66.67	-46.16	-73.89	-6.95

SECTION 9 Average Load N	Strain M2	Strain M2	Strain M6	Strain M7	Strain M2	Strain M23
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
4858.56	12.00	-7.00	1.00	-11.00	-2.00	-4.00
7176.40	26.00	-11.00	4.00	-18.00	-4.00	-5.00
9455.61	40.00	-14.00	11.00	-24.00	-5.00	-8.00
13181.49	55.00	-19.00	17.00	-31.00	-8.00	-12.00
18527.00	70.00	-27.00	24.00	-40.50	-11.00	-17.00

Table B.14 Experimental Stress Results For Load Case 9

SECTION 4 Average Load N	Stress Values MPa					
	AL 14	AL 24	AL 34	AL 54	AL 64	AL 74
4858.56	-0.92	0.57	-0.96	1.07	0.57	-1.14
7176.40	-1.28	1.14	-1.38	1.49	0.92	-1.64
9455.61	-1.71	1.56	-1.87	1.92	1.42	-1.99
13181.49	-2.35	2.20	-2.55	2.49	1.92	-2.56
18527.00	-3.27	2.99	-3.58	3.63	2.63	-3.34

SECTION 4 Average Load N	Stress Values MPa					
	AL 84	AL 104	AL 114	AL 124	CL 14	CL 24
4858.56	1.48	1.74	-1.65	1.81	-0.45	-0.51
7176.40	1.99	2.27	-2.14	2.41	-0.72	-0.75
9455.61	2.52	2.88	-2.71	3.03	-0.96	-0.99
13181.49	3.10	3.47	-3.33	3.67	-1.23	-1.27
18527.00	3.80	4.12	-3.98	4.41	-1.68	-1.75

SECTION 5 Average Load N	Stress Values MPa						
	AL 15	AL 25	AL 35	AL 65	AL 75	AL 85	AL 105
4858.56	-0.91	1.99	1.25	1.95	-1.55	2.14	-0.52
7176.40	-1.34	2.72	1.68	2.64	-2.27	2.98	0.13
9455.61	-1.76	3.51	2.19	3.25	-2.96	3.78	0.66
13181.49	-2.46	4.27	2.86	4.10	-3.70	4.62	1.50
18527.00	-3.46	5.13	3.79	4.97	-4.53	5.68	2.25

SECTION 9 Average Load N	Stress Values MPa					
	AL 19	AL 29	AL 39	AL 59	AL 69	AL 89
4858.56	5.81	3.47	7.48	2.07	-0.87	4.22
7176.40	5.62	3.25	7.18	1.30	-1.62	3.54
9455.61	5.23	2.70	6.77	0.49	-2.46	2.68
13181.49	4.62	1.91	6.07	-0.95	-3.73	1.46
18527.00	3.24	0.63	4.74	-3.28	-5.25	-0.49

SECTION 9 Average Load N	Stress Values MPa					
	AL 99	AL 109	AL 119	AL 129	CL 19	CL 29
4858.56	0.85	-0.50	0.07	-0.78	-0.07	-0.14
7176.40	1.85	-0.78	0.28	-1.28	-0.14	-0.17
9455.61	2.84	-1.00	0.78	-1.71	-0.17	-0.27
13181.49	3.91	-1.35	1.21	-2.20	-0.27	-0.41
18527.00	4.98	-1.92	1.71	-2.88	-0.38	-0.58

Table B .15 Experimental Rosette Results For Load Case 1

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
2504.30	-1.65	4.05	7.93	7.19	-0.17	-6.44
4281.47	0.13	4.31	6.84	6.21	-1.39	-8.11
6123.03	2.53	4.22	9.08	4.54	-2.01	-10.77
8384.05	5.48	4.60	9.37	5.66	-1.24	-11.40
SECTION 4 Average Load N	**Strain 27 ARD 14**	**Strain 28 ARL 14**	**Strain 29 ART 14**	**Strain M11 ARD 24**	**Strain M9 ARL 24**	**Strain M10 ART 24**
2504.30	20.62	4.21	-1.32	6.00	20.00	-13.00
4281.47	-20.22	5.07	-1.65	31.00	77.00	-6.00
6123.03	-82.20	8.87	-4.22	36.00	90.00	-17.00
8384.05	-134.08	15.20	-4.51	35.00	120.00	-40.00
SECTION 4 Average Load N	**Strain 24 ARD 34**	**Strain 25 ARL 34**	**Strain 26 ART 34**	**Strain M13 ARD 44**	**Strain M14 ARL 44**	**Strain M12 ART 44**
2504.30	-4.13	-2.73	0.91	-3.00	22.00	5.00
4281.47	-4.94	-3.80	0.51	2.00	67.00	28.00
6123.03	-5.81	-2.74	-0.32	-5.00	86.00	30.00
8384.05	-4.42	-3.00	0.35	-27.00	111.00	32.00
SECTION 5 Average Load N	**Strain 30 ARD 15**	**Strain 31 ARL 15**	**Strain 32 ART 15**	**Strain 12 ARD 35**	**Strain 13 ARL 35**	**Strain 14 ART 35**
2504.30	-7.27	2.89	-6.86	-4.63	5.12	7.43
4281.47	-9.50	7.47	-10.77	-4.18	7.22	6.84
6123.03	-12.98	12.24	-11.93	-4.22	9.08	7.28
8384.05	-16.08	20.06	-15.29	-3.98	11.93	7.42

Table B .16 Experimental Rosette Results For Load Case 1

SECTION 1 Average Load N		AR11 Principal Stress MPa	AR11 Direction Degrees		AR21 Principal Stress MPa	AR21 Direction Degrees
2504.30		0.99	-37.87		0.54	-36.67
4281.47		0.79	-38.45		0.48	-36.48
6123.03		0.81	-29.74		0.38	-34.08
8384.05		0.70	-16.11		0.48	-33.51
SECTION 4 Average Load N		AR14 Principal Stress MPa	AR14 Direction Degrees		AR24 Principal Stress MPa	AR24 Direction Degrees
2504.30		1.48	-40.89		1.44	-4.32
4281.47		1.70	40.65		5.49	3.08
6123.03		6.19	42.79		6.40	0.26
8384.05		10.32	42.98		8.54	1.80
SECTION 4 Average Load N		AR34 Principal Stress MPa	AR34 Direction Degrees		AR44 Principal Stress MPa	AR44 Direction Degrees
2504.30		0.20	-30.29		2.28	31.37
4281.47		0.16	-28.41		6.90	33.40
6123.03		0.21	-37.08		9.03	33.02
8384.05		0.16	-30.75		12.63	34.76
SECTION 5 Average Load N		AR15 Principal Stress MPa	AR15 Direction Degrees		AR35 Principal Stress MPa	AR35 Direction Degrees
2504.30		0.37	23.67		1.23	-41.97
4281.47		0.74	20.36		1.30	44.51
6123.03		1.28	23.69		1.47	42.93
8384.05		1.99	23.13		1.67	40.31

Table B .17 Experimental Rosette Results For Load Case 1

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2504.30	0.29	0.56	1.09	-0.01	-0.46	-1.49
4281.47	0.31	0.49	0.77	-0.10	-0.58	-1.56
6123.03	0.30	0.65	0.59	-0.14	-0.77	-1.55
8384.05	0.33	0.67	0.21	-0.09	-0.81	-1.70
SECTION 4	AR14			AR24		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2504.30	0.30	-0.09	-2.73	1.42	-0.92	-0.36
4281.47	0.36	-0.12	3.12	5.47	-0.43	0.64
6123.03	0.63	-0.30	12.02	6.40	-1.21	0.07
8384.05	1.08	-0.32	19.83	8.53	-2.84	0.71
SECTION 4	AR34			AR44		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2504.30	-0.19	0.06	0.46	1.56	0.36	2.35
4281.47	-0.27	0.04	0.47	4.76	1.99	6.47
6123.03	-0.20	-0.02	0.61	6.11	2.13	8.96
8384.05	-0.21	0.03	0.44	7.89	2.28	14.01
SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2504.30	0.21	-0.49	0.75	0.36	0.53	1.55
4281.47	0.53	-0.77	1.12	0.51	0.49	1.59
6123.03	0.87	-0.85	1.87	0.65	0.52	1.76
8384.05	1.43	-1.09	2.63	0.85	0.53	1.94

Table B .18 Experimental Rosette Results For Load Case 2

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
3431.67	4.33	3.71	-0.71	12.90	11.84	9.81
6264.04	5.49	3.97	-1.27	12.41	12.16	8.95
8642.35	7.52	5.20	-0.70	13.73	12.80	10.08
13476.33	9.40	4.35	-1.61	13.49	11.88	8.69
SECTION 4 Average Load N	Strain 27 ARD 14	Strain 28 ARL 14	Strain 29 ART 14	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24
3431.67	-233.77	12.46	5.92	28.00	47.00	-1.00
6264.04	-200.63	16.47	4.39	36.00	72.00	-18.00
8642.35	-51.86	22.41	3.80	51.00	106.00	-22.00
13476.33	-2802.81	29.62	2.19	61.00	151.00	62.00
SECTION 4 Average Load N	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
3431.67	14.32	5.83	5.21	1.00	42.00	23.00
6264.04	16.55	5.07	5.57	-11.00	81.00	31.00
8642.35	17.76	4.81	6.28	-16.00	99.00	39.00
13476.33	20.74	8.79	6.22	-45.00	147.00	43.00
SECTION 5 Average Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
3431.67	-2.12	17.32	-3.45	8.93	9.01	5.48
6264.04	-3.04	25.84	-6.00	9.80	12.84	5.24
8642.35	-4.34	33.86	-8.38	10.08	15.74	5.20
13476.33	-9.15	45.85	-13.17	11.92	25.67	3.54

Table B .19 Experimental Rosette Results For Load Case 2

SECTION 1 Average Load N	AR11 Principal Stress MPa	AR11 Direction Degrees	AR21 Principal Stress MPa	AR21 Direction Degrees
3431.67	0.36	-26.00	0.93	-31.96
6264.04	0.44	-28.84	0.93	-24.59
8642.35	0.59	-30.40	1.00	-29.66
13476.33	0.71	-34.83	0.99	-31.78
SECTION 4 Average Load N	**AR14 Principal Stress MPa**	**AR14 Direction Degrees**	**AR24 Principal Stress MPa**	**AR24 Direction Degrees**
3431.67	17.93	44.62	3.38	-5.88
6264.04	15.75	44.18	5.18	-5.66
8642.35	5.60	40.92	7.58	-4.01
13476.33	201.54	44.86	12.10	22.81
SECTION 4 Average Load N	**AR34 Principal Stress MPa**	**AR34 Direction Degrees**	**AR44 Principal Stress MPa**	**AR44 Direction Degrees**
3431.67	1.02	-43.99	4.65	36.61
6264.04	1.18	44.35	9.07	34.77
8642.35	1.26	43.27	11.31	35.28
13476.33	1.48	-42.22	17.37	34.81
SECTION 5 Average Load N	**AR15 Principal Stress MPa**	**AR15 Direction Degrees**	**AR35 Principal Stress MPa**	**AR35 Direction Degrees**
3431.67	1.47	20.54	0.69	-21.77
6264.04	2.17	19.57	0.92	-5.66
8642.35	2.84	19.49	1.12	2.12
13476.33	3.93	20.41	1.85	6.83

Table B .20 Experimental Rosette Results For Load Case 2

SECTION 1 Average Load N	AR11			AR21		
	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	0.26	-0.05	-0.40	0.84	0.70	-0.30
6264.04	0.28	-0.09	-0.59	0.86	0.64	-0.26
8642.35	0.37	-0.05	-0.75	0.91	0.72	-0.33
13476.33	0.31	-0.11	-1.14	0.84	0.62	-0.46
SECTION 4 Average Load N	**AR14**			**AR24**		
	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	0.89	0.42	34.55	3.34	-0.07	-0.71
6264.04	1.17	0.31	30.01	5.12	-1.28	-1.28
8642.35	1.59	0.27	9.24	7.54	-1.56	-1.28
13476.33	2.11	0.16	400.82	10.74	4.41	6.47
SECTION 4 Average Load N	**AR34**			**AR44**		
	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	0.41	0.37	-1.25	2.99	1.64	4.48
6264.04	0.36	0.40	-1.60	5.76	2.20	9.53
8642.35	0.34	0.45	-1.74	7.04	2.77	12.09
13476.33	0.63	0.44	-1.88	10.45	3.06	19.91
SECTION 5 Average Load N	**A15**			**AR35**		
	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	1.23	-0.25	1.29	0.64	0.39	-0.24
6264.04	1.84	-0.43	1.84	0.91	0.37	-0.11
8642.35	2.41	-0.60	2.43	1.12	0.37	0.06
13476.33	3.26	-0.94	3.62	1.82	0.25	0.38

Table B .21 Experimental Rosette Results For Load Case 3

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
10003.26	-2.92	-1.33	0.27	15.11	0.62	2.03
14764.93	-2.75	-3.14	-1.83	14.02	-0.66	0.92
20729.73	-0.92	-1.64	-1.03	13.76	-0.62	0.00
27799.52	4.33	-2.05	1.29	14.82	0.46	-0.91
SECTION 4 Average Load N	**Strain 27 ARD 14**	**Strain 28 ARL 14**	**Strain 29 ART 14**	**Strain M11 ARD 24**	**Strain M9 ARL 24**	**Strain M10 ART 24**
10003.26	-18830.63	6.01	-4.95	31.00	64.00	-12.00
14764.93	-18886.28	10.61	-6.42	42.00	107.00	-21.00
20729.73	-19005.24	16.23	-7.29	59.00	136.00	-34.00
27799.52	-18996.84	21.96	-7.90	79.00	189.00	-52.00
SECTION 4 Average Load N	**Strain 24 ARD 34**	**Strain 25 ARL 34**	**Strain 26 ART 34**	**Strain M13 ARD 44**	**Strain M14 ARL 44**	**Strain M12 ART 44**
10003.26	3.89	-2.83	-20.77	-5.00	57.00	21.00
14764.93	4.06	-4.59	-21.23	-12.00	84.00	26.00
20729.73	4.72	-2.57	-20.34	-23.00	125.00	38.00
27799.52	6.69	2.43	-21.28	-30.00	178.00	52.00
SECTION 5 Average Load N	**Strain 30 ARD 15**	**Strain 31 ARL 15**	**Strain 32 ART 15**	**Strain 12 ARD 35**	**Strain 13 ARL 35**	**Strain 14 ART 35**
10003.26	-0.27	46.38	68.57	-11.49	-4.86	-11.49
14764.93	-3.01	53.49	64.11	-13.89	-3.93	-12.58
20729.73	-5.24	63.88	62.14	-15.51	0.00	-13.45
27799.52	-9.20	73.77	60.40	-17.56	10.56	-16.34

Table B .22 Experimental Rosette Results For Load Case 3

SECTION 1 Average Load N		AR11 Principal Stress MPa	AR11 Direction Degrees		AR21 Principal Stress MPa	AR21 Direction Degrees
10003.26		0.14	-35.78		1.08	43.53
14764.93		-0.13	-10.90		1.00	43.38
20729.73		-0.06	26.56		0.98	44.37
27799.52		0.33	35.23		1.05	-43.70
SECTION 4 Average Load N		AR14 Principal Stress MPa	AR14 Direction Degrees		AR24 Principal Stress MPa	AR24 Direction Degrees
10003.26		1338.93	44.99		4.57	-3.76
14764.93		1343.11	44.99		7.61	0.46
20729.73		1351.91	44.98		9.70	-2.69
27799.52		1351.68	44.98		13.47	-2.49
SECTION 4 Average Load N		AR34 Principal Stress MPa	AR34 Direction Degrees		AR44 Principal Stress MPa	AR44 Direction Degrees
10003.26		0.45	30.12		6.15	33.87
14764.93		0.43	-31.94		9.10	33.30
20729.73		0.50	-30.61		13.84	33.70
27799.52		0.75	-26.83		19.42	33.26
SECTION 5 Average Load N		AR15 Principal Stress MPa	AR15 Direction Degrees		AR35 Principal Stress MPa	AR35 Direction Degrees
10003.26		8.27	-39.56		-0.25	22.50
14764.93		8.59	-42.55		-0.08	26.25
20729.73		9.33	44.63		0.31	26.27
27799.52		10.21	42.50		1.21	23.73

Table B .23 Experimental Rosette Results For Load Case 3

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
10003.26	-0.09	0.02	0.34	0.04	0.14	-1.96
14764.93	-0.22	-0.13	0.04	-0.05	0.07	-1.98
20729.73	-0.12	-0.07	-0.06	-0.04	0.00	-2.00
27799.52	-0.15	0.09	-0.67	0.03	-0.06	-2.14

SECTION 4	AR14			AR24		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
10003.26	0.43	-0.35	2677.79	4.55	-0.85	-0.71
14764.93	0.75	-0.46	2685.93	7.61	-1.49	0.14
20729.73	1.15	-0.52	2703.18	9.67	-2.42	-1.14
27799.52	1.56	-0.56	2702.35	13.44	-3.70	-1.49

SECTION 4	AR34			AR44		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
10003.26	-0.20	-1.48	-2.23	4.05	1.49	6.26
14764.93	-0.33	-1.51	-2.41	5.97	1.85	9.53
20729.73	-0.18	-1.45	-2.30	8.89	2.70	14.86
27799.52	0.17	-1.51	-2.29	12.66	3.70	20.62

SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
10003.26	3.30	4.87	8.21	-0.35	-0.82	0.47
14764.93	3.80	4.56	8.79	-0.28	-0.89	0.80
20729.73	4.54	4.42	9.70	0.00	-0.96	1.25
27799.52	5.25	4.29	10.85	0.75	-1.16	2.09

Table B .24 Experimental Rosette Results For Load Case 4

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
9259.80	-3.62	-0.99	-1.23	11.17	-2.05	2.57
14530.00	-2.59	-0.95	-1.38	12.00	-1.30	3.45
20356.56	-2.96	-1.98	-2.58	13.15	-0.23	4.94
25428.73	-1.50	-1.11	-0.95	13.22	-0.63	3.25

SECTION 4 Average Load N	Strain 27 ARD 14	Strain 28 ARL 14	Strain 29 ART 14	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24
9259.80	32.14	4.85	-3.45	25.00	54.00	-4.00
14530.00	-202.61	8.20	-3.97	39.00	83.00	-5.00
20356.56	-667.31	12.92	-5.24	50.00	108.00	-14.00
25428.73	-1571.24	16.70	-7.44	52.00	123.00	-31.00

SECTION 4 Average Load N	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
9259.80	4.50	0.58	-21.10	-4.00	46.00	21.00
14530.00	5.79	-2.16	-19.52	-5.00	68.00	31.00
20356.56	6.76	-3.88	-17.10	-10.00	94.00	39.00
25428.73	6.49	-4.43	-15.68	-22.00	117.00	32.00

SECTION 5 Average Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
9259.80	-0.53	37.75	69.94	-10.46	-5.73	-10.00
14530.00	-2.33	44.64	66.66	-11.49	-5.01	-9.93
20356.56	-4.94	53.02	64.96	-13.53	-6.23	-11.32
25428.73	-7.20	59.28	63.31	-14.65	-5.86	-11.16

Table B .25 Experimental Rosette Results For Load Case 4

SECTION 1 Average Load N	AR11 Principal Stress MPa	AR11 Direction Degrees	AR21 Principal Stress MPa	AR21 Direction Degrees
9259.80	0.10	43.67	0.81	39.02
14530.00	0.02	40.69	0.87	38.87
20356.56	-0.11	33.02	0.96	38.27
25428.73	-0.04	-40.27	0.95	40.38
SECTION 4 Average Load N	**AR14 Principal Stress MPa**	**AR14 Direction Degrees**	**AR24 Principal Stress MPa**	**AR24 Direction Degrees**
3431.67	2.30	-41.24	3.84	0.00
6264.04	14.71	44.15	5.90	0.00
8642.35	48.00	44.61	7.68	-1.40
13476.33	112.38	44.78	8.76	-2.23
SECTION 4 Average Load N	**AR34 Principal Stress MPa**	**AR34 Direction Degrees**	**AR44 Principal Stress MPa**	**AR44 Direction Degrees**
3431.67	0.57	-26.85	5.19	35.78
6264.04	0.56	-31.21	7.61	35.63
8642.35	0.57	-34.51	10.51	35.11
13476.33	0.53	-35.62	12.79	33.12
SECTION 5 Average Load N	**AR15 Principal Stress MPa**	**AR15 Direction Degrees**	**AR35 Principal Stress MPa**	**AR35 Direction Degrees**
3431.67	7.86	-36.76	-0.32	25.32
6264.04	8.15	-39.62	-0.20	29.25
8642.35	8.76	-42.33	-0.24	30.91
13476.33	9.23	-44.16	-0.13	33.31

Table B .26 Experimental Rosette Results For Load Case 4

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
9259.80	-0.07	-0.09	0.36	-0.15	0.18	-1.55
14530.00	-0.07	-0.10	0.20	-0.09	0.25	-1.55
20356.56	-0.14	-0.18	0.10	-0.02	0.35	-1.53
25428.73	-0.08	-0.07	0.07	-0.05	0.23	-1.69
SECTION 4	AR14			AR24		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	0.34	-0.25	-4.47	3.84	-0.28	0.00
6264.04	0.58	-0.28	29.11	5.90	-0.36	0.00
8642.35	0.92	-0.37	95.44	7.68	-1.00	-0.43
13476.33	1.19	-0.53	224.09	8.75	-2.20	-0.85
SECTION 4	AR34			AR44		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	0.04	-1.50	-2.10	3.27	1.49	5.33
6264.04	-0.15	-1.39	-2.36	4.83	2.20	7.75
8642.35	-0.28	-1.22	-2.45	6.68	2.77	10.88
13476.33	-0.32	-1.11	-2.35	8.32	2.28	13.72
SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3431.67	2.68	4.97	7.73	-0.41	-0.71	0.37
6264.04	3.17	4.74	8.24	-0.36	-0.71	0.57
8642.35	3.77	4.62	9.09	-0.44	-0.81	0.68
13476.33	4.21	4.50	9.74	-0.42	-0.79	0.87

Table B .27 Experimental Rosette Results For Load Case 5

SECTION 1 Average Loa N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
3856.11	-1.87	4.84	8.22	6.91	-0.69	-6.63
5505.21	0.08	5.70	9.34	6.57	-0.63	-7.05
7383.80	1.04	5.59	9.16	5.22	-0.75	-7.90
14120.53	4.20	4.30	9.50	5.50	-1.30	-11.60

SECTION 4 Average Loa N	Strain 27 ARD 14	Strain 28 ARL 14	Strain 29 ART 14	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24
3856.11	1180.69	4.63	-2.69	6.00	20.00	-10.00
5505.21	4498.87	7.28	-2.61	8.00	29.00	-12.00
7383.80	4142.25	7.75	-3.50	11.00	50.00	-16.00
14120.53	3968.26	12.80	-5.40	28.00	90.00	-21.00

SECTION 4 verage Load N	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
3856.11	-6.63	-5.39	-4.84	-5.00	20.00	3.00
5505.21	-7.92	-5.62	-5.38	-7.00	24.00	5.00
7383.80	-9.09	-5.89	-7.67	-8.00	34.00	8.00
14120.53	-11.90	-7.60	-9.50	-13.00	79.00	23.00

SECTION 5 verage Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
3856.11	-6.70	0.48	12.30	-5.94	1.52	7.67
5505.21	-7.20	4.04	13.54	-6.81	1.66	8.39
7383.80	-9.31	6.26	12.07	-7.38	2.16	9.54
14120.53	-13.00	15.70	9.90	-11.40	1.10	8.20

Table B .28 Experimental Rosette Results For Load Case 5

SECTION 1 Average Load N		AR11 Principal Stress MPa	 Direction Degrees		AR21 Principal Stress MPa	 Direction Degrees
3856.11		1.07	-39.30		0.52	-37.15
5505.21		1.08	-38.13		0.50	-36.44
7383.80		0.99	-37.12		0.42	-34.72
14120.53		0.76	-23.03		0.47	-33.34
SECTION 4 Average Load N		**AR14 Principal Stress MPa**	** Direction Degrees**		**AR24 Principal Stress MPa**	** Direction Degrees**
3856.11		83.95	-44.91		1.42	-1.92
5505.21		319.87	-44.97		2.06	0.69
7383.80		294.51	-44.96		3.59	5.16
14120.53		282.14	-44.93		6.43	3.34
SECTION 4 Average Load N		**AR34 Principal Stress MPa**	** Direction Degrees**		**AR44 Principal Stress MPa**	** Direction Degrees**
3856.11		-0.25	-39.85		2.14	31.37
5505.21		-0.22	-43.59		2.70	33.08
7383.80		-0.31	34.42		3.75	32.93
14120.53		-0.36	37.08		8.59	33.19
SECTION 5 Average Load N		**AR15 Principal Stress MPa**	** Direction Degrees**		**AR35 Principal Stress MPa**	** Direction Degrees**
3856.11		1.48	-32.86		1.11	-36.87
5505.21		1.81	-36.73		1.23	-37.07
7383.80		1.98	-40.53		1.39	-37.21
14120.53		2.76	41.79		1.50	-38.76

Table B .29 Experimental Rosette Results For Load Case 5

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3856.11	0.34	0.58	1.19	-0.05	-0.47	-1.50
5505.21	0.41	0.66	1.06	-0.05	-0.50	-1.48
7383.80	0.40	0.65	0.90	-0.05	-0.56	-1.36
14120.53	0.31	0.68	0.38	-0.09	-0.82	-1.70

SECTION 4	AR14			AR24		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3856.11	0.33	-0.19	-167.76	1.42	-0.71	-0.14
5505.21	0.52	-0.19	-639.41	2.06	-0.85	0.07
7383.80	0.55	-0.25	-588.73	3.56	-1.14	0.85
14120.53	0.91	-0.38	-563.76	6.40	-1.49	0.92

SECTION 4	AR34			AR44		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3856.11	-0.38	[illegible]	0.22	1.42	0.21	2.35
5505.21	-0.40	-0.38	0.34	1.71	0.36	3.06
7383.80	-0.42	-0.55	0.33	2.42	0.57	4.12
14120.53	-0.54	-0.68	0.48	5.62	1.64	9.10

SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3856.11	0.03	0.87	1.86	0.11	0.55	1.50
5505.21	0.29	0.96	2.27	0.12	0.60	1.68
7383.80	0.45	0.86	2.63	0.15	0.68	1.88
14120.53	1.12	0.70	3.67	0.08	0.58	2.28

Table B .30 Experimental Rosette Results For Load Case 6

SECTION 1 Average Loa N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
5480.91	-6.84	3.15	3.91	8.03	-0.98	-1.30
7028.06	-7.67	2.51	2.22	9.39	0.44	0.43
10843.71	-7.68	2.93	2.22	11.95	0.71	2.53
14727.63	-7.85	3.55	0.89	15.33	2.91	6.21
SECTION 4 Average Loa N	Strain 27 ARD 14	Strain 28 ARL 14	Strain 29 ART 14	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24
5480.91	2946.82	5.32	-3.37	43.00	52.00	25.00
7028.06	2896.62	6.31	-3.44	51.00	60.00	21.00
10843.71	2916.17	10.61	-3.01	55.00	75.00	16.00
14727.63	2915.22	14.19	-2.41	69.00	88.00	24.00
SECTION 4 verage Load N	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
5480.91	-3.91	-8.47	-17.05	18.00	38.00	36.00
7028.06	-2.94	-8.68	-16.28	17.00	49.00	42.00
10843.71	0.40	-9.03	-13.30	11.00	53.00	48.00
14727.63	3.17	-8.87	-11.65	15.00	71.00	55.00
SECTION 5 verage Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
5480.91	-6.08	-0.43	20.52	-5.10	1.74	6.08
7028.06	-7.24	1.43	21.65	-6.02	0.50	5.16
10843.71	-7.52	6.41	20.74	-6.25	1.58	5.62
14727.63	-6.71	11.40	20.39	-6.59	2.79	6.08

Table B .31 Experimental Rosette Results For Load Case 6

SECTION 1 Average Load N		AR11 Principal Stress MPa	AR11 Direction Degrees		AR21 Principal Stress MPa	AR21 Direction Degrees
5480.91		0.99	-43.95		0.57	-44.49
7028.06		0.88	44.59		0.67	-44.98
10843.71		0.91	44.00		0.85	42.48
14727.63		0.88	41.24		1.10	40.65
SECTION 4 Average Load N		**AR14 Principal Stress MPa**	**AR14 Direction Degrees**		**AR24 Principal Stress MPa**	**AR24 Direction Degrees**
5480.91		209.52	-44.96		3.75	-9.21
7028.06		205.95	-44.95		4.45	-14.14
10843.71		207.34	-44.93		5.44	-8.92
14727.63		207.27	-44.92		6.44	-11.05
SECTION 4 Average Load N		**AR34 Principal Stress MPa**	**AR34 Direction Degrees**		**AR44 Principal Stress MPa**	**AR44 Direction Degrees**
5480.91		-0.21	-32.07		3.98	43.49
7028.06		-0.16	-34.14		5.28	41.50
10843.71		0.04	-39.76		6.40	43.19
14727.63		0.23	-42.04		7.94	40.27
SECTION 5 Average Load N		**AR15 Principal Stress MPa**	**AR15 Direction Degrees**		**AR35 Principal Stress MPa**	**AR35 Direction Degrees**
5480.91		2.08	-28.49		0.94	-38.23
7028.06		2.34	-30.86		0.85	-37.63
10843.71		2.55	-35.62		0.97	-39.21
14727.63		2.77	-39.38		1.11	-40.75

Table B .32 Experimental Rosette Results For Load Case 6

SECTION 1	AR11			AR21		
	Sigma X	Sigma Y	Shear Stress	Sigma X	Sigma Y	Shear Stress
Average Load N	Mpa	Mpa	Mpa	Mpa	Mpa	Mpa
5480.91	0.22	0.28	1.47	-0.07	-0.09	-1.30
7028.06	0.18	0.16	1.43	0.03	0.03	-1.27
10843.71	0.21	0.16	1.46	0.05	0.18	-1.47
14727.63	0.25	0.06	1.43	0.21	0.44	-1.53
SECTION 4	AR14			AR24		
Average Load	Sigma X	Sigma Y	Shear Stress	Sigma X	Sigma Y	Shear Stress
N	Mpa	Mpa	Mpa	Mpa	Mpa	Mpa
5480.91	0.38	-0.24	-418.90	3.70	1.78	-0.64
7028.06	0.45	-0.24	-411.70	4.27	1.49	-1.49
10843.71	0.75	-0.21	-414.14	5.33	1.14	-1.35
14727.63	1.01	-0.17	-413.71	6.26	1.71	-1.85
SECTION 4	AR34			AR44		
Average Load	Sigma X	Sigma Y	Shear Stress	Sigma X	Sigma Y	Shear Stress
N	Mpa	Mpa	Mpa	Mpa	Mpa	Mpa
5480.91	-0.60	-1.21	-1.26	2.70	2.56	2.70
7028.06	-0.62	-1.16	-1.36	3.48	2.99	4.05
10843.71	-0.64	-0.95	-1.64	3.77	3.41	5.62
14727.63	-0.63	-0.83	-1.91	5.05	3.91	6.83
SECTION 5	AR15			AR35		
Average Load	Sigma X	Sigma Y	Shear Stress	Sigma X	Sigma Y	Shear Stress
N	Mpa	Mpa	Mpa	Mpa	Mpa	Mpa
5480.91	-0.03	1.46	2.29	0.12	0.43	1.28
7028.06	0.10	1.54	2.67	0.04	0.37	1.26
10843.71	0.46	1.47	3.00	0.11	0.40	1.40
14727.63	0.81	1.45	3.22	0.20	0.43	1.57

Table B .33 Experimental Rosette Results For Load Case 7

SECTION 1 Average Loa N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
3910.91	2.65	2.53	7.72	6.22	1.50	-0.23
5419.36	4.07	4.75	9.50	3.39	-0.54	-3.12
9008.24	4.83	2.77	8.22	4.52	0.21	-3.49
12036.12	4.95	1.96	7.37	7.48	3.57	0.58

SECTION 4 Average Loa N	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34
3910.91	44.00	62.00	22.00	-2.99	-5.64	-19.35
5419.36	46.00	72.00	19.00	-6.79	-5.70	-19.54
9008.24	48.00	82.00	15.00	-7.60	-5.55	-20.23
12036.12	65.00	109.00	22.00	-4.38	-6.56	-19.23

SECTION 4 verage Load N	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
3910.91	15.00	49.00	37.00
5419.36	14.00	51.00	37.00
9008.24	13.00	64.00	38.00
12036.12	15.00	87.00	50.00

SECTION 5 verage Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
3910.91	-2.42	0.92	22.22	-2.88	4.95	6.91
5419.36	-1.63	1.22	23.75	-6.65	3.94	4.61
9008.24	1.23	6.26	21.88	-9.55	5.14	3.80
12036.12	2.99	10.48	20.84	-11.17	6.91	4.03

Table B .34 Experimental Rosette Results For Load Case 7

Average Load N		Principal Stress MPa	Direction Degrees		Principal Stress MPa	Direction Degrees
SECTION 1		AR11			AR21	
3910.91		0.62	-21.86		0.45	-40.61
5419.36		0.78	-26.07		0.25	-38.07
9008.24		0.59	-6.88		0.34	-36.65
12036.12		0.53	3.03		0.55	-37.27
SECTION 4		AR24			AR34	
3910.91		4.42	-2.86		-0.06	-27.11
5419.36		5.12	-0.54		-0.25	-20.07
9008.24		5.83	0.43		-0.27	-17.88
12036.12		7.75	0.32		-0.16	-26.69
SECTION 4		AR44				
3910.91		5.09	38.95			
5419.36		5.32	38.43			
9008.24		6.48	35.56			
12036.12		8.90	35.46			
SECTION 5		AR15			AR35	
3910.91		2.07	-26.36		1.05	-41.83
5419.36		2.17	-25.70		1.08	-44.11
9008.24		2.07	-29.35		1.32	43.64
12036.12		2.09	-33.87		1.58	42.53

Table B .35 Experimental Rosette Results For Load Case 7

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3910.91	0.18	0.55	0.35	0.11	-0.02	-0.79
5419.36	0.34	0.68	0.43	-0.04	-0.22	-0.74
9008.24	0.20	0.58	0.09	0.01	-0.25	-0.88
12036.12	0.14	0.52	-0.04	0.25	0.04	-0.77

SECTION 4	AR24			AR34		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3910.91	4.41	1.56	-0.28	-0.40	-1.38	-1.35
5419.36	5.12	1.35	-0.07	-0.41	-1.39	-0.83
9008.24	5.83	1.07	0.07	-0.39	-1.44	-0.75
12036.12	7.75	1.56	0.07	-0.47	-1.37	-1.21

SECTION 4	AR44		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3910.91	3.48	2.63	3.98
5419.36	3.63	2.63	4.27
9008.24	4.55	2.70	5.40
12036.12	6.19	3.56	7.61

SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
3910.91	0.07	1.58	1.99	0.35	0.49	1.25
5419.36	0.09	1.69	2.01	0.28	0.33	1.55
9008.24	0.45	1.56	1.83	0.37	0.27	1.99
12036.12	0.75	1.48	1.80	0.49	0.29	2.37

Table B .36 Experimental Rosette Results For Load Case 8

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
2392.96	4.10	4.86	9.73	5.78	0.00	-1.37
4988.04	4.36	3.52	10.41	7.46	2.81	0.14
7491.67	6.97	3.17	9.75	7.60	1.65	-2.41
10144.56	9.98	5.11	12.71	5.82	0.36	-4.39
SECTION 4 Average Load N	**Strain M11 ARD 24**	**Strain M9 ARL 24**	**Strain M10 ART 24**	**Strain 24 ARD 34**	**Strain 25 ARL 34**	**Strain 26 ART 34**
2392.96	5.00	15.00	-3.00	-4.71	-5.17	-20.98
4988.04	6.00	29.00	-13.00	-2.25	-5.07	-20.55
7491.67	7.00	40.00	-18.00	-3.17	-5.19	-21.15
10144.56	9.00	53.00	-25.00	-5.82	-5.58	-21.38
SECTION 4 Average Load N	**Strain M13 ARD 44**	**Strain M14 ARL 44**	**Strain M12 ART 44**			
2392.96	-2.00	13.00	4.00			
4988.04	-9.00	24.00	4.00			
7491.67	-11.00	35.00	6.00			
10144.56	-19.00	46.00	6.00			
SECTION 5 Average Load N	**Strain 30 ARD 15**	**Strain 31 ARL 15**	**Strain 32 ART 15**	**Strain 12 ARD 35**	**Strain 13 ARL 35**	**Strain 14 ART 35**
2392.96	-6.99	-2.28	18.09	-0.30	3.95	8.97
4988.04	-7.74	1.69	19.84	-0.99	4.08	8.59
7491.67	-8.74	4.18	20.27	-0.89	5.07	8.87
10144.56	-9.62	9.14	19.00	-2.61	6.06	8.43

Table B .37 Experimental Rosette Results For Load Case 8

SECTION 1 Average Load N		AR11 Principal Stress MPa	AR11 Direction Degrees		AR21 Principal Stress MPa	AR21 Direction Degrees
2392.96		0.80	-26.35		0.41	-41.98
4988.04		0.80	-18.53		0.54	-38.70
7491.67		0.70	4.38		0.56	-37.88
10144.56		0.91	7.85		0.44	-36.57
SECTION 4 Average Load N		**AR14 Principal Stress MPa**	**AR14 Direction Degrees**		**AR24 Principal Stress MPa**	**AR24 Direction Degrees**
2392.96		1.07	3.17		-0.11	-23.31
4988.04		2.07	2.71		0.02	-26.88
7491.67		2.86	3.93		-0.03	-25.71
10144.56		3.79	3.65		-0.18	-22.06
SECTION 4 Average Load N		**AR44 Principal Stress MPa**	**AR44 Direction Degrees**			
2392.96		1.42	33.40			
4988.04		2.78	33.25			
7491.67		3.92	32.64			
10144.56		5.35	33.02			
SECTION 5 Average Load N		**AR15 Principal Stress MPa**	**AR15 Direction Degrees**		**AR35 Principal Stress MPa**	**AR35 Direction Degrees**
2392.96		1.84	-27.82		0.97	-34.83
4988.04		2.23	-31.94		0.99	-36.45
7491.67		2.47	-34.50		1.07	-38.20
10144.56		2.72	-39.12		1.22	-41.57

Table B .38 Experimental Rosette Results For Load Case 8

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2392.96	0.35	0.69	0.45	0.00	-0.10	-0.92
4988.04	0.25	0.74	0.37	0.20	0.01	-0.85
7491.67	0.23	0.69	-0.07	0.12	-0.17	-1.13
10144.56	0.36	0.90	-0.15	0.03	-0.31	-1.11
SECTION 4	AR24			AR34		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2392.96	1.07	-0.21	0.14	-0.37	-1.49	-1.19
4988.04	2.06	-0.92	0.28	-0.36	-1.46	-1.50
7491.67	2.84	-1.28	0.57	-0.37	-1.50	-1.42
10144.56	3.77	-1.78	0.71	-0.40	-1.52	-1.09
SECTION 4	AR44					
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa			
2392.96	0.92	0.28	1.49			
4988.04	1.71	0.28	3.27			
7491.67	2.49	0.43	4.48			
10144.56	3.27	0.43	6.40			
SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
2392.96	-0.16	1.29	2.12	0.28	0.64	0.96
4988.04	0.12	1.41	2.63	0.29	0.61	1.04
7491.67	0.30	1.44	2.98	0.36	0.63	1.12
10144.56	0.65	1.35	3.37	0.43	0.60	1.40

Table B .39 Experimental Rosette Results For Load Case 9

SECTION 1 Average Load N	Strain 18 ARD11	Strain 19 ARL11	Strain 20 ART11	Strain 21 ARD21	Strain 22 ARL21	Strain 23 ART21
4858.56	4.81	4.14	9.50	5.81	0.67	-1.34
7176.40	4.90	2.36	8.53	7.94	3.12	-0.25
9455.61	5.99	0.97	9.92	7.02	1.87	-1.03
13181.49	8.42	2.36	9.14	6.88	1.85	-1.85
18527.00	8.251	2.171	8.360	9.229	2.714	-1.194

SECTION 4 Average Load N	Strain M11 ARD 24	Strain M9 ARL 24	Strain M10 ART 24	Strain 24 ARD 34	Strain 25 ARL 34	Strain 26 ART 34
4858.56	2.00	16.00	-15.00	-3.58	-6.15	-21.68
7176.40	11.00	33.00	-11.00	-2.62	-6.25	-21.03
9455.61	3.00	45.00	-26.00	-4.77	-6.18	-21.38
13181.49	20	62	-18	-5.03	-6.37	-21.57
18527.00	28	88	-26	-6.62	-7.38	-21.82

SECTION 4 Average Load N	Strain M13 ARD 44	Strain M14 ARL 44	Strain M12 ART 44
4858.56	-10.00	15.00	-4.00
7176.40	-8.00	28.00	3.00
9455.61	-21.00	30.00	7.00
13181.49	-12.00	58.00	9.00
18527.00	-17.00	79.00	11.00

SECTION 5 Average Load N	Strain 30 ARD 15	Strain 31 ARL 15	Strain 32 ART 15	Strain 12 ARD 35	Strain 13 ARL 35	Strain 14 ART 35
4858.56	-4.47	-1.12	23.14	-2.01	4.58	8.49
7176.40	-3.46	2.36	22.88	-4.22	4.48	7.26
9455.61	-3.22	6.38	24.80	-5.73	4.51	6.57
13181.49	-2.36	10.89	23.31	-6.98	6.88	7.91
18527.00	-2.61	18.46	21.93	-11.18	5.54	5.56

Table B .40 Experimental Rosette Results For Load Case 9

SECTION 1 Average Load N	AR11 Principal Stress MPa	AR11 Direction Degrees	AR21 Principal Stress MPa	AR21 Direction Degrees
4858.56	0.723	-18.435	0.419	-40.353
7176.40	0.610	-10.093	0.580	-37.719
9455.61	0.708	3.478	0.510	-77.621
13181.49	0.716	19.119	0.507	-37.481
18527.00	0.680	21.991	0.672	-38.502
SECTION 4 Average Load N	**AR24 Principal Stress MPa**	**AR24 Direction Degrees**	**AR34 Principal Stress MPa**	**AR34 Direction Degrees**
4858.56	1.143	-2.771	-0.070	-26.251
7176.40	2.346	0	-0.026	-28.075
9455.61	3.241	5.185	-0.142	-24.932
13181.49	4.412	1.431	-0.159	-24.812
18527.00	6.262	1.517	-0.273	-23.928
SECTION 4 Average Load N	**AR44 Principal Stress MPa**	**AR44 Direction Degrees**		
4858.56	1.684	29.251		
7176.40	2.995	30.995		
9455.61	4.240	36.884		
13181.49	6.056	30.849		
18527.00	8.227	30.633		
SECTION 5 Average Load N	**AR15 Principal Stress MPa**	**AR15 Direction Degrees**	**AR25 Principal Stress MPa**	**AR25 Direction Degrees**
4858.56	2.181	-25.957	1.088	-38.557
7176.40	2.254	-28.736	1.142	-41.069
9455.61	2.597	-31.954	1.199	-42.388
13181.49	2.668	-36.146	1.549	-43.977
18527.00	3.062	-42.822	1.584	-44.98

Table B .41 Experimental Rosette Results For Load Case 9

SECTION 1	AR11			AR21		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
4858.56	0.294	0.675	0.286	0.048	-0.095	-0.874
7176.40	0.168	0.606	0.078	0.222	-0.018	-0.925
9455.61	0.069	0.705	-0.078	0.133	-0.073	-0.939
13181.49	0.168	0.650	-0.380	0.131	-0.131	-0.978
18527.00	0.154	0.594	-0.425	0.193	-0.085	-1.204
SECTION 4	AR24			AR34		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
4858.56	1.138	-1.067	-0.213	-0.437	-1.542	-1.470
7176.40	2.346	-0.782	0.000	-0.444	-1.495	-1.567
9455.61	3.200	-1.849	0.924	-0.440	-1.520	-1.282
13181.49	4.408	-1.280	0.284	-0.453	-1.533	-1.271
18527.00	6.257	-1.849	0.427	-0.525	-1.552	-1.135
SECTION 4	AR44					
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa			
4858.56	1.067	-0.284	2.204			
7176.40	1.991	0.213	3.342			
9455.61	2.133	0.498	5.617			
13181.49	4.124	0.640	6.470			
18527.00	5.617	0.782	8.816			
SECTION 5	AR15			AR35		
Average Load N	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa	Sigma X Mpa	Sigma Y Mpa	Shear Stress Mpa
4858.56	-0.079	1.645	2.201	0.326	0.604	1.216
7176.40	0.168	1.627	2.288	0.318	0.516	1.435
9455.61	0.453	1.763	2.674	0.321	0.467	1.603
13181.49	0.774	1.658	2.768	0.489	0.562	2.045
18527.00	1.312	1.559	3.242	0.394	0.395	2.379

Appendix C

ADINA Input File & Nodes Number

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*     A D I N A - I N    6 . 1    I N P U T    F I L E
*
* LINEAR RESPONSE OF COMPOSITE CURVED BOX GIRDER BRIDGE MODEL
*      (4-NODES SHELL ELEMENTS)
*
FILEUNITS LIST=8 LOG=7 ECHO=7
FCONTROL HEADING=UPPER ORIGIN=UPPERLEFT
CONTROL PLOTUNIT=PERCENT HEIGHT=1.25
*
DATABASE CREATE
*
HEAD  'LINEAR RESPONSE OF CURVED BOX GIRDER BRIDGE MODEL
 (4-NODES SHELL ELEMENTS)'
*
MASTER  000000  REACTION=YES
PRINTOUT  MAX IPRIC=0 IPRIT=0 IPDATA=4 CARDIMAGE=NO
PORTHOLE FORMATTED=YES FILE=60
*
SYSTEM 1 CYLINDRICAL
COORDINATES
ENTRIES  NODE R THETA XL
  1       14.314  81.59893  0.12  TO
  3       14.354  81.59893  0.12
  3       14.354  81.59893  0.12  TO
 19       14.754  81.59893  0.12
 19       14.754  81.59893  0.12  TO
 21       14.794  81.59893  0.12
 22       14.354  81.59893  0.09  TO
 38       14.754  81.59893  0.09
 39       14.354  81.59893  0.06  TO
 55       14.754  81.59893  0.06
 56       14.354  81.59893  0.03  TO
 72       14.754  81.59893  0.03
 73       14.354  81.59893  0.0   TO
 75       14.404  81.59893  0.0
 76       14.429  81.59893  0.0
 77       14.454  81.59893  0.0  TO
 80       14.529  81.59893  0.0
 81       14.554  81.59893  0.0
 82       14.579  81.59893  0.0  TO
 85       14.654  81.59893  0.0
 86       14.679  81.59893  0.0
 87       14.704  81.59893  0.0  TO
 89       14.754  81.59893  0.0
 90       14.314  82.07922   0.12  TO
 92       14.354  82.07922   0.12
 92       14.354  82.07922   0.12  TO
108        14.754  82.07922   0.12
108        14.754  82.07922   0.12  TO
110        14.794  82.07922   0.12
111        14.354  82.07922   0.09  TO
115        14.754  82.07922   0.09
116        14.354  82.07922   0.06  TO
120        14.754  82.07922   0.06
121        14.354  82.07922   0.03  TO
125        14.754  82.07922   0.03
126        14.354  82.07922   0.0  TO
142        14.754  82.07922   0.0
143        14.314  82.55950   0.12  TO
145        14.354  82.55950   0.12
145        14.354  82.55950   0.12  TO
161        14.754  82.55950   0.12
161        14.754  82.55950   0.12  TO
163        14.794  82.55950   0.12
164        14.354  82.55950   0.09  TO
168        14.754  82.55950   0.09
169        14.354  82.55950   0.06  TO
173        14.754  82.55950   0.06
174        14.354  82.55950   0.03  TO
178        14.754  82.55950   0.03
179        14.354  82.55950   0.0    TO
195        14.754  82.55950   0.0
196        14.314  83.09097   0.12   TO
198        14.354  83.09097,  0.12
198        14.354  83.09097   0.12  TO
214        14.754  83.09097   0.12
214        14.754  83.09097   0.12  TO
216        14.794  83.09097   0.12
217        14.354  83.09097   0.09   TO
221        14.754  83.09097   0.09
222        14.354  83.09097   0.06   TO
226        14.754  83.09097   0.06
227        14.354  83.09097   0.03   TO
231        14.754  83.09097   0.03
232        14.354  83.09097   0.0   TO
248        14.754  83.09097   0.0
249        14.314  83.62243   0.12  TO
251        14.354  83.62243   0.12
```

251	14.354	83.62243	0.12	TO
267	14.754	83.62243	0.12	
267	14.754	83.62243	0.12	TC
269	14.794	83.62243	0.12	
270	14.354	83.62243	0.09	TO
274	14.754	83.62243	0.09	
275	14.354	83.62243	0.06	TO
279	14.754	83.62243	0.06	
280	14.354	83.62243	0.03	TO
284	14.754	83.62243	0.03	
285	14.354	83.62243	0.0	TO
301	14.754	83.62243	0.0	
302	14.314	84.130273	0.12	TO
304	14.354	84.130273	0.12	
304	14.354	84.130273	0.12	TO
320	14.754	84.130273	0.12	
320	14.754	84.130273	0.12	TO
322	14.794	84.130273	0.12	
323	14.354	84.130273	0.09	TO
327	14.754	84.130273	0.09	
328	14.354	84.130273	0.06	TO
332	14.754	84.130273	0.06	
333	14.354	84.130273	0.03	TO
337	14.754	84.130273	0.03	
338	14.354	84.130273	0.0	TO
354	14.754	84.130273	0.0	
355	14.314	84.68536	0.12	TO
357	14.354	84.68536	0.12	
357	14.354	84.68536	0.12	TO
373	14.754	84.68536	0.12	
373	14.754	84.68536	0.12	TO
375	14.794	84.68536	0.12	
376	14.354	84.68536	0.09	TO
380	14.754	84.68536	0.09	
381	14.354	84.68536	0.06	TO
385	14.754	84.68536	0.06	
386	14.354	84.68536	0.03	TO
390	14.754	84.68536	0.03	
391	14.354	84.68536	0.0	TO
407	14.754	84.68536	0.0	
408	14.314	85.311305	0.12	TO
410	14.354	85.311305	0.12	
410	14.354	85.311305	0.12	TO
426	14.754	85.311305	0.12	
426	14.754	85.311305	0.12	TO
428	14.794	85.311305	0.12	
429	14.354	85.311305	0.09	TO
433	14.754	85.311305	0.09	
434	14.354	85.311305	0.06	TO
438	14.754	85.311305	0.06	
439	14.354	85.311305	0.03	TO
443	14.754	85.311305	0.03	
444	14.354	85.311305	0.0	TO
460	14.754	85.311305	0.0	
461	14.314	85.74829	0.12	TO
463	14.354	85.74829	0.12	
463	14.354	85.74829	0.12	TO
479	14.754	85.74829	0.12	
479	14.754	85.74829	0.12	TO
481	14.794	85.74829	0.12	
482	14.354	85.74829	0.09	TO
486	14.754	85.74829	0.09	
487	14.354	85.74829	0.06	TO
491	14.754	85.74829	0.06	
492	14.354	85.74829	0.03	TO
496	14.754	85.74829	0.03	
497	14.354	85.74829	0.0	TO
513	14.754	85.74829	0.0	
514	14.314	86.393917	0.12	TO
516	14.354	86.393917	0.12	
516	14.354	86.393917	0.12	TO
532	14.754	86.393917	0.12	
532	14.754	86.393917	0.12	TO
534	14.794	86.393917	0.12	
535	14.354	86.393917	0.09	TO
539	14.754	86.393917	0.09	
540	14.354	86.393917	0.06	TO
544	14.754	86.393917	0.06	
545	14.354	86.393917	0.03	TO
549	14.754	86.393917	0.03	
550	14.354	86.393917	0.0	TO'
566	14.754	86.393917	0.0	
567	14.314	87.082852	0.12	TO
569	14.354	87.082852	0.12	
569	14.354	87.082852	0.12	TO
585	14.754	87.082852	0.12	
585	14.784	87.082852	0.12	TO
587	14.794	87.082852	0.12	
588	14.354	87.082852	0.09	TO
592	14.754	87.082852	0.09	

593	14.354	87.082852	0.06	TO
597	14.754	87.082852	0.06	
598	14.354	87.082852	0.03	TO
602	14.754	87.082852	0.03	
603	14.354	87.082852	0.0	TO
619	14.754	87.082852	0.0	
620	14.314	87.34268	0.12	TO
622	14.354	87.34268	0.12	
622	14.354	87.34268	0.12	TO
638	14.754	87.34268	0.12	
638	14.754	87.34268	0.12	TO
640	14.794	87.34268	0.12	
641	14.354	87.34268	0.09	TO
645	14.754	87.34268	0.09	
646	14.354	87.34268	0.06	TO
650	14.754	87.34268	0.06	
651	14.354	87.34268	0.03	TO
655	14.754	87.34268	0.03	
656	14.354	87.34268	0.0	TO
672	14.754	87.34268	0.0	
673	14.314	87.87414	0.12	TO
675	14.354	87.87414	0.12	
675	14.354	87.87414	0.12	TO
691	14.754	87.87414	0.12	
691	14.754	87.87414	0.12	TO
693	14.794	87.87414	0.12	
694	14.354	87.87414	0.09	TO
698	14.754	87.87414	0.09	
699	14.354	87.87414	0.06	TO
703	14.754	87.87414	0.06	
704	14.354	87.87414	0.03	TO
708	14.754	87.87414	0.03	
709	14.354	87.87414	0.0	TO
725	14.754	87.87414	0.0	
726	14.314	88.40561	0.12	TO
728	14.354	88.40561	0.12	
728	14.354	88.40561	0.12	TO
744	14.754	88.40561	0.12	
744	14.754	88.40561	0.12	TO
746	14.794	88.40561	0.12	
747	14.354	88.40561	0.09	TO
751	14.754	88.40561	0.09	
752	14.354	88.40561	0.06	TO
756	14.754	88.40561	0.06	
757	14.354	88.40561	0.03	TO
761	14.754	88.40561	0.03	
762	14.354	88.40561	0.0	TO
778	14.754	88.40561	0.0	
779	14.314	88.93707	0.12	TO
781	14.354	88.93707	0.12	
781	14.354	88.93707	0.12	TO
797	14.754	88.93707	0.12	
797	14.754	88.93707	0.12	TO
799	14.794	88.93707	0.12	
800	14.354	88.93707	0.09	TO
804	14.754	88.93707	0.09	
805	14.354	88.93707	0.06	TO
809	14.754	88.93707	0.06	
810	14.354	88.93707	0.03	TO
814	14.754	88.93707	0.03	
815	14.354	88.93707	0.0	TO
831	14.754	88.93707	0.0	
832	14.314	89.20281	0.12	TO
834	14.354	89.20281	0.12	
834	14.354	89.20281	0.12	TO
850	14.754	89.20281	0.12	
850	14.754	89.20281	0.12	TO
852	14.794	89.20281	0.12	
853	14.354	89.20281	0.09	TO
857	14.754	89.20281	0.09	
858	14.354	89.20281	0.06	TO
862	14.754	89.20281	0.06	
863	14.354	89.20281	0.03	TO
867	14.754	89.20281	0.03	
868	14.354	89.20281	0.0	TO
884	14.754	89.20281	0.0	
885	14.314	89.46854	0.12	TO
887	14.354	89.46854	0.12	
887	14.354	89.46854	0.12	TO
903	14.754	89.46854	0.12	
903	14.754	89.46854	0.12	TO
905	14.794	89.46854	0.12	
906	14.354	89.46854	0.09	TO
910	14.754	89.46854	0.09	
911	14.354	89.46854	0.06	TO
915	14.754	89.46854	0.06	
916	14.354	89.46854	0.03	TO
920	14.754	89.46854	0.03	
921	14.354	89.46854	0.0	TO
937	14.754	89.46854	0.0	

938	14.314	89.73427	0.12	TO
940	14.354	89.73427	0.12	
940	14.354	89.73427	0.12	TO
956	14.754	89.73427	0.12	
956	14.754	89.73427	0.12	TO
958	14.794	89.73427	0.12	
959	14.354	89.73427	0.09	TO
963	14.754	89.73427	0.09	
964	14.354	89.73427	0.06	TO
968	14.754	89.73427	0.06	
969	14.354	89.73427	0.03	TO
973	14.754	89.73427	0.03	
974	14.354	89.73427	0.0	TO
990	14.754	89.73427	0.0	
991	14.314	90.00000	0.12	TO
993	14.354	90.00000	0.12	
993	14.354	90.00000	0.12	TO
1009	14.754	90.00000	0.12	
1009	14.754	90.00000	0.12	TO
1011	14.794	90.00000	0.12	
1012	14.354	90.00000	0.09	TO
1028	14.754	90.00000	0.09	
1029	14.354	90.00000	0.06	TO
1045	14.754	90.00000	0.06	
1046	14.354	90.00000	0.03	TO
1062	14.754	90.00000	0.03	
1063	14.354	90.00000	0.0	TO
1070	14.529	90.00000	0.0	
1071	14.554	90.00000	0.0	
1072	14.579	90.00000	0.0	TO
1079	14.754	90.00000	0.0	
1080	14.314	90.26573	0.12	TO
1082	14.354	90.26573	0.12	
1082	14.354	90.26573	0.12	TO
1098	14.754	90.26573	0.12	
1098	14.754	90.26573	0.12	TO
1100	14.794	90.26573	0.12	
1101	14.354	90.26573	0.09	TO
1105	14.754	90.26573	0.09	
1106	14.354	90.26573	0.06	TO
1110	14.754	90.26573	0.06	
1111	14.354	90.26573	0.03	TO
1115	14.754	90.26573	0.03	
1116	14.354	90.26573	0.0	TO
1132	14.754	90.26573	0.0	
1133	14.314	90.53146	0.12	TO
1135	14.354	90.53146	0.12	
1135	14.354	90.53146	0.12	TO
1151	14.754	90.53146	0.12	
1151	14.754	90.53146	0.12	TO
1153	14.794	90.53146	0.12	
1154	14.354	90.53146	0.09	TO
1158	14.754	90.53146	0.09	
1159	14.354	90.53146	0.06	TO
1163	14.754	90.53146	0.06	
1164	14.354	90.53146	0.03	TO
1168	14.754	90.53146	0.03	
1169	14.354	90.53146	0.0	TO
1185	14.754	90.53146	0.0	
1186	14.314	90.79720	0.12	TO
1188	14.354	90.79720	0.12	
1188	14.354	90.79720	0.12	TO
1204	14.754	90.79720	0.12	
1204	14.754	90.79720	0.12	TO
1206	14.794	90.79720	0.12	
1207	14.354	90.79720	0.09	TO
1211	14.754	90.79720	0.09	
1212	14.354	90.79720	0.06	TO
1216	14.754	90.79720	0.06	
1217	14.354	90.79720	0.03	TO
1221	14.754	90.79720	0.03	
1222	14.354	90.79720	0.0	TO
1238	14.754	90.79720	0.0	
1239	14.314	91.06293	0.12	TO
1241	14.354	91.06293	0.12	
1241	14.354	91.06293	0.12	TO
1257	14.754	91.06293	0.12	
1257	14.754	91.06293	0.12	TO
1259	14.794	91.06293	0.12	
1260	14.354	91.06293	0.09	TO
1264	14.754	91.06293	0.09	
1265	14.354	91.06293	0.06	TO
1269	14.754	91.06293	0.06	
1270	14.354	91.06293	0.03	TO
1274	14.754	91.06293	0.03	
1275	14.354	91.06293	0.0	TO
1291	14.754	91.06293	0.0	
1292	14.314	91.59440	0.12	TO
1294	14.354	91.59440	0.12	
1294	14.354	91.59440	0.12	TO

1310	14.794	91.59440	0.12	
1310	14.754	91.59440	0.12	TO
1312	14.794	91.59440	0.12	
1313	14.354	91.59440	0.09	TO
1317	14.754	91.59440	0.09	
1318	14.354	91.59440	0.06	TO
1322	14.754	91.59440	0.06	
1323	14.354	91.59440	0.03	TO
1327	14.754	91.59440	0.03	
1328	14.354	91.59440	0.0	TO
1344	14.754	91.59440	0.0	
1345	14.314	92.12586	0.12	TO
1347	14.354	92.12586	0.12	
1347	14.354	92.12586	0.12	TO
1363	14.754	92.12586	0.12	
1363	14.754	92.12586	0.12	TO
1365	14.794	92.12586	0.12	
1366	14.354	92.12586	0.09	TO
1370	14.754	92.12586	0.09	
1371	14.354	92.12586	0.06	TO
1375	14.754	92.12586	0.06	
1376	14.354	92.12586	0.03	TO
1380	14.754	92.12586	0.03	
1381	14.354	92.12586	0.0	TO
1397	14.754	92.12586	0.0	
1398	14.314	92.65733	0.12	TO
1400	14.354	92.65733	0.12	
1400	14.354	92.65733	0.12	TO
1416	14.754	92.65733	0.12	
1416	14.754	92.65733	0.12	TO
1418	14.794	92.65733	0.12	
1419	14.354	92.65733	0.09	TO
1423	14.754	92.65733	0.09	
1424	14.354	92.65733	0.06	TO
1428	14.754	92.65733	0.06	
1429	14.354	92.65733	0.03	TO
1433	14.754	92.65733	0.03	
1434	14.354	92.65733	0.0	TO
1450	14.754	92.65733	0.0	
1451	14.314	92.917148	0.12	TO
1453	14.354	92.917148	0.12	
1453	14.354	92.917148	0.12	TO
1469	14.754	92.917148	0.12	
1469	14.754	92.917148	0.12	TO
1471	14.794	92.917148	0.12	
1472	14.354	92.917148	0.09	TO
1476	14.754	92.917148	0.09	
1477	14.354	92.917148	0.06	TO
1481	14.754	92.917148	0.06	
1482	14.354	92.917148	0.03	TO
1486	14.754	92.917148	0.03	
1487	14.354	92.917148	0.0	TO
1503	14.754	92.917148	0.0	
1504	14.314	93.606083	0.12	TO
1506	14.354	93.606083	0.12	
1506	14.354	93.606083	0.12	TO
1522	14.754	93.606083	0.12	
1522	14.754	93.606083	0.12	TO
1524	14.794	93.606083	0.12	
1525	14.354	93.606083	0.09	TO
1529	14.754	93.606083	0.09	
1530	14.354	93.606083	0.06	TO
1534	14.754	93.606083	0.06	
1535	14.354	93.606083	0.03	TO
1539	14.754	93.606083	0.03	
1540	14.354	93.606083	0.0	TO
1556	14.754	93.606083	0.0	
1557	14.314	94.25171	0.12	TO
1559	14.354	94.25171	0.12	
1559	14.354	94.25171	0.12	TO
1575	14.754	94.25171	0.12	
1575	14.754	94.25171	0.12	TO
1577	14.794	94.25171	0.12	
1578	14.354	94.25171	0.09	TO
1582	14.754	94.25171	0.09	
1583	14.354	94.25171	0.06	TO
1587	14.754	94.25171	0.06	
1588	14.354	94.25171	0.03	TO
1592	14.754	94.25171	0.03	
1593	14.354	94.25171	0.0	TO
1609	14.754	94.25171	0.0	
1610	14.314	94.688695	0.12	TO
1612	14.354	94.688695	0.12	
1612	14.354	94.688695	0.12	TO
1628	14.754	94.688695	0.12	
1628	14.754	94.688695	0.12	TO
1630	14.794	94.688695	0.12	
1631	14.354	94.688695	0.09	TO
1635	14.794	94.688695	0.09	
1636	14.354	94.688695	0.06	TO

1640	14.754	94.688695	0.06	
1641	14.354	94.688695	0.03	TO
1645	14.754	94.688695	0.03	
1646	14.354	94.688695	0.0	TO
1662	14.754	94.688695	0.0	
1663	14.3?4	95.31464	0.12	TO
1665	14.354	95.31464	0.12	
1665	14.354	95.31464	0.12	TO
1681	14.754	95.31464	0.12	
1681	14.754	95.31464	0.12	TO
1683	14.794	95.31464	0.12	
1684	14.354	95.31464	0.09	TO
1688	14.754	95.31464	0.09	
1689	14.354	95.31464	0.06	TO
1693	14.754	95.31464	0.06	
1694	14.354	95.31464	0.03	TO
1698	14.754	95.31464	0.03	
1699	14.354	95.31464	0.0	TO
1715	14.754	95.31464	0.0	
1716	14.314	95.869727	0.12	TO
1718	14.354	95.869727	0.12	
1718	14.354	95.869727	0.12	TO
1734	14.754	95.869727	0.12	
1734	14.754	95.869727	0.12	TO
1736	14.794	95.869727	0.12	
1737	14.354	95.869727	0.09	TO
1741	14.754	95.869727	0.09	
1742	14.354	95.869727	0.06	TO
1746	14.754	95.869727	0.06	
1747	14.354	95.869727	0.03	TO
1751	14.754	95.869727	0.03	
1752	14.354	95.869727	0.0	TO
1768	14.754	95.869727	0.0	
1769	14.314	96.37757	0.12	TO
1771	14.354	96.37757	0.12	
1771	14.354	96.37757	0.12	TO
1787	14.754	96.37757	0.12	
1787	14.754	96.37757	0.12	TO
1789	14.794	96.37757	0.12	
1790	14.354	96.37757	0.09	TO
1794	14.754	96.37757	0.09	
1795	14.354	96.37757	0.06	TO
1799	14.754	96.37757	0.06	
1800	14.354	96.37757	0.03	TO
1804	14.754	96.37757	0.03	
1805	14.354	96.37757	0.0	TO
1821	14.754	96.37757	0.0	
1822	14.314	96.90904	0.12	TO
1824	14.354	96.90904	0.12	
1824	14.354	96.90904	0.12	TO
1840	14.754	96.90904	0.12	
1840	14.754	96.90904	0.12	TO
1842	14.794	96.90904	0.12	
1843	14.354	96.90904	0.09	TO
1847	14.754	96.90904	0.09	
1848	14.354	96.90904	0.06	TO
1852	14.754	96.90904	0.06	
1853	14.354	96.90904	0.03	TO
1857	14.754	96.90904	0.03	
1858	14.354	96.90904	0.0	TO
1874	14.754	96.90904	0.0	
1875	14.314	97.44050	0.12	TO
1877	14.354	97.44050	0.12	
1877	14.354	97.44050	0.12	TO
1893	14.754	97.44050	0.12	
1893	14.754	97.44050	0.12	TO
1895	14.794	97.44050	0.12	
1896	14.354	97.44050	0.09	TO
1900	14.754	97.44050	0.09	
1901	14.354	97.44050	0.06	TO
1905	14.754	97.44050	0.06	
1906	14.354	97.44050	0.03	TO
1910	14.754	97.44050	0.03	
1911	14.354	97.44050	0.0	TO
1927	14.754	97.44050	0.0	
1928	14.314	97.92079	0.12	TO
1930	14.354	97.92079	0.12	
1930	14.354	97.92079	0.12	TO
1946	14.754	97.92079	0.12	
1946	14.754	97.92079	0.12	TO
1948	14.794	97.92079	0.12	
1949	14.354	97.92079	0.09	TO
1953	14.754	97.92079	0.09	
1954	14.354	97.92079	0.06	TO
1958	14.754	97.92079	0.06	
1959	14.354	97.92079	0.03	TO
1963	14.754	97.92079	0.03	
1964	14.354	97.92078	0.0	TO
1980	14.754	97.92079	0.0	
1981	14.314	98.40107	0.12	TO

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1983        14.354  98.40107    0.12
1983        14.354  98.40107    0.12    TO
1999        14.754  98.40107    0.12
1999        14.754  98.40107    0.12    TO
2001        14.754  98.40107    0.12
2002        14.354  98.40107    0.09    TO
2018        14.754  98.40107    0.09
2019        14.354  98.40107    0.06    TO
2035        14.754  98.40107    0.06
2036        14.354  98.40107    0.03    TO
2052        14.754  98.40107    0.03
2053        14.354  98.40107    0.0     TO
2055        14.404  98.40107    0.0
2056        14.429  98.40107    0.0
2057        14.454  98.40107    0.0   TO
2060        14.529  98.40107    0.0
2061        14.554  98.40107    0.0
2062        14.579  98.40107    0.0   TO
2065        14.654  98.40107    0.0
2066        14.679  98.40107    0.0
2067        14.704  98.40107    0.0   TO
2069        14.754  98.40107    0.0
*
MATERIAL  1 ELASTIC E=7.2E10 NU=.379
MATERIAL  2 ELASTIC E=7.0277E10 NU=.379
MATERIAL  3 ELASTIC E=3.13E10 NU=.15
*
EGROUP  1 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=3
THICKNESS  1 0.02
ENODES
ENTRIES  EL N1 N2 N3 N4/ 1  1 2 91 90
STEP 1 TO 20  20 21 110 109
ENODES
ENTRIES  EL N1 N2 N3 N4/ 21  90 91 144 143
STEP 1 TO 40  109 110 163 162
ENODES
ENTRIES EL N1 N2 N3 N4/ 41 143 144 197 196
STEP 1 TO  60 162 163 216 215
ENODES
ENTRIES EL N1 N2 N3 N4/ 61 196 197 250 249
STEP 1 TO  80 215 216 269 268
ENODES
ENTRIES  EL N1 N2 N3 N4/ 81 249 250 303 302
STEP 1 TO  100 268 269 322 321
ENODES
ENTRIES   EL N1 N2 N3 N4/ 101 302 303 356 355
STEP 1 TO  120 321 322 375 374
ENODES
ENTRIES  EL N1 N2 N3 N4/ 121 355 356 409 408
STEP 1 TO  140 374 375 428 427
ENODES
ENTRIES  EL N1 N2 N3 N4/ 141 408 409 462 461
STEP 1 TO  160 427 428 481 480
ENODES
ENTRIES   EL N1 N2 N3 N4/ 161 461 462 515 514
STEP 1 TO  180 480 481 534 533
STRESSTABLE  1 1 2 3 4
*
EGROUP . 2 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=3
THICKNESS  1 0.02
ENODES
ENTRIES EL N1 N2 N3 N4/ 181 514 515 568 567
STEP 1 TO  200 533 534 587 586
ENODES
ENTRIES  EL N1 N2 N3 N4/ 201 567 568 621 620
STEP 1 TO  220 586 587 640 639
ENODES
ENTRIES EL N1 N2 N3 N4/  221 620 621 674 673
STEP 1 TO  240 639 640 693 692
ENODES
ENTRIES EL N1 N2 N3 N4/  241 673 674 727 726
STEP 1 TO  260 692 693 746 745
ENODES
ENTRIES EL N1 N2 N3 N4/  261 726 727 780 779
STEP 1 TO  280 745 746 799 798
ENODES
ENTRIES EL N1 N2 N3 N4/  281 779 780 833 832
STEP 1 TO  300 798 799 852 851
ENODES
ENTRIES EL N1 N2 N3 N4/  301 832 833 886 885
STEP 1 TO  320 851 852 905 904
ENODES
ENTRIES EL N1 N2 N3 N4/  321 885 886 939 938
STEP 1 TO  340 904 905 958 957
*ENODES
*ENTRIES EL N1 N2 N3 N4/  341 938 939 992 991
*STEP 1 TO  360 957 958 1011 1010
STRESSTABLE  1 1 2 3 4
*
EGROUP  3 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=3
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THICKNESS  1 0.02
*ENODES
*ENTRIES EL N1 N2 N3 N4/  361 991 992 1081 1080
*STEP 1 TO  380 1010 1011 1100 1099
ENODES
ENTRIES EL N1 N2 N3 N4/  381 1080 1081 1134 1133
STEP 1 TO  400 1099 1100 1153 1152
ENODES
ENTRIES EL N1 N2 N3 N4/  401 1133 1134 1187 1186
STEP 1 TO  420 1152 1153 1206 1205
ENODES
ENTRIES EL N1 N2 N3 N4/  421 1186 1187 1240 1239
STEP 1 TO  440 1205 1206 1259 1258
ENODES
ENTRIES EL N1 N2 N3 N4/  441 1239 1240 1293 1292
STEP 1 TO  460 1258 1259 1312 1311
ENODES
ENTRIES EL N1 N2 N3 N4/  461 1292 1293 1346 1345
STEP 1 TO  480 1311 1312 1365 1364
ENODES
ENTRIES EL N1 N2 N3 N4/  481 1345 1346 1399 1398
STEP 1 TO  500 1364 1365 1418 1417
ENODES
ENTRIES EL N1 N2 N3 N4/  501 1398 1399 1452 1451
STEP 1 TO  520 1417 1418 1471 1470
ENODES
ENTRIES EL N1 N2 N3 N4/  521 1451 1452 1505 1504
STEP 1 TO  540 1470 1471 1524 1523
STRESSTABLE  1 1 2 3 4
*
EGROUP  4 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=3
THICKNESS  1 0.02
ENODES
ENTRIES EL N1 N2 N3 N4/  541 1504 1505 1558 1557
STEP 1 TO  560 1523 1524 1577 1576
ENODES
ENTRIES EL N1 N2 N3 N4/  561 1557 1558 1611 1610
STEP 1 TO  580 1576 1577 1630 1629
ENODES
ENTRIES EL N1 N2 N3 N4/  581 1610 1611 1664 1663
STEP 1 TO  600 1629 1630 1683 1682
ENODES
ENTRIES EL N1 N2 N3 N4/  601 1663 1664 1717 1716
STEP 1 TO  620 1682 1683 1736 1735
ENODES
ENTRIES EL N1 N2 N3 N4/  621 1716 1717 1770 1769
STEP 1 TO  640 1735 1736 1789 1788
ENODES
ENTRIES EL N1 N2 N3 N4/  641 1769 1770 1823 1822
STEP 1 TO  660 1788 1789 1842 1841
ENODES
ENTRIES EL N1 N2 N3 N4/  661 1822 1823 1876 1875
STEP 1 TO  680 1841 1842 1895 1894
ENODES
ENTRIES EL N1 N2 N3 N4/  681 1875 1876 1929 1928
STEP 1 TO  700 1894 1895 1948 1947
ENODES
ENTRIES EL N1 N2 N3 N4/  701 1928 1929 1982 1981
STEP 1 TO  720 1947 1948 2001 2000
*EDATA
* ENTRIES EL PRINT
*        1  YES TO
*       720 YES
STRESSTABLE  1 1 2 3 4
*
EGROUP  5 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=1
THICKNESS  1 0.013
ENODES
ENTRIES EL N1 N2 N3 N4/  721 3 22 111 92
STEP 1 TO  725 19 38 115 108
ENODES
ENTRIES EL N1 N2 N3 N4/  726 22 39 116 111
STEP 1 TO  730 38 55 120 115
ENODES
ENTRIES EL N1 N2 N3 N4/  731 39 56 121 116
STEP 1 TO  735 55 72 125 120
ENODES
ENTRIES EL N1 N2 N3 N4/  736 56 73 126 121
STEP 1 TO  740 72 89 142 125
ENODES
ENTRIES EL N1 N2 N3 N4/  741 92 111 164 145
STEP 1 TO  745 108 115 168 161
ENODES
ENTRIES EL N1 N2 N3 N4/  746 111 116 169 164
STEP 1 TO  750 115 120 173 168
ENODES
ENTRIES EL N1 N2 N3 N4/  751 116 121 174 169
STEP 1 TO  755 120 125 178 173
ENODES
ENTRIES EL N1 N2 N3 N4/  756 121 126 179 174
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STEP 1 TO  760 125 142 195 178
ENODES
ENTRIES EL N1 N2 N3 N4/  761 145 164 217 198
STEP 1 TO  765 161 168 221 214
ENODES
ENTRIES EL N1 N2 N3 N4/  766 164 169 222 217
STEP 1 TO  770 168 173 226 221
ENODES
ENTRIES EL N1 N2 N3 N4/  771 169 174 227 222
STEP 1 TO  775 173 178 231 226
ENODES
ENTRIES EL N1 N2 N3 N4/  776 174 179 232 227
STEP 1 TO  780 178 195 248 231
ENODES
ENTRIES EL N1 N2 N3 N4/  781 198 217 270 251
STEP 1 TO  785 214 221 274 267
ENODES
ENTRIES EL N1 N2 N3 N4/  786 217 222 275 270
STEP 1 TO  790 221 226 279 274
ENODES
ENTRIES EL N1 N2 N3 N4/  791 222 227 280 275
STEP 1 TO  795 226 231 284 279
ENODES
ENTRIES EL N1 N2 N3 N4/  796 227 232 285 280
STEP 1 TO  800 231 248 301 284
ENODES
ENTRIES EL N1 N2 N3 N4/  801 251 270 323 304
STEP 1 TO  805 267 274 327 320
ENODES
ENTRIES EL N1 N2 N3 N4/  806 270 275 328 323
STEP 1 TO  810 274 279 332 327
ENODES
ENTRIES EL N1 N2 N3 N4/  811 275 280 333 328
STEP 1 TO  815 279 284 337 332
ENODES
ENTRIES EL N1 N2 N3 N4/  816 280 285 338 333
STEP 1 TO  820 284 301 354 337
ENODES
ENTRIES EL N1 N2 N3 N4/  821 304 323 376 357
STEP 1 TO  825 320 327 380 373
ENODES
ENTRIES EL N1 N2 N3 N4/  826 323 328 381 376
STEP 1 TO  835 332 337 390 385
ENODES
ENTRIES EL N1 N2 N3 N4/  836 333 338 391 386
STEP 1 TO  840 337 354 407 390
ENODES
ENTRIES EL N1 N2 N3 N4/  841 357 376 429 410
STEP 1 TO  845 373 380 433 426
ENODES
ENTRIES EL N1 N2 N3 N4/  846 376 381 434 429
STEP 1 TO  855 385 390 443 438
ENODES
ENTRIES EL N1 N2 N3 N4/  856 386 391 444 439
STEP 1 TO  860 390 407 460 443
ENODES
ENTRIES EL N1 N2 N3 N4/  861 410 429 482 463
STEP 1 TO  865 426 433 486 479
ENODES
ENTRIES EL N1 N2 N3 N4/  866 429 434 487 482
STEP 1 TO  875 438 443 496 491
ENODES
ENTRIES EL N1 N2 N3 N4/  876 439 444 497 492
STEP 1 TO  880 443 460 513 496
ENODES
ENTRIES EL N1 N2 N3 N4/  881 463 482 535 516
STEP 1 TO  885 479 486 539 532
ENODES
ENTRIES EL N1 N2 N3 N4/  886 482 487 540 535
STEP 1 TO  895 491 496 549 544
ENODES
ENTRIES EL N1 N2 N3 N4/  896 492 497 550 545
STEP 1 TO  900 496 513 566 549
STRESSTABLE  1 1 2 3 4
*
EGROUP  6 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL N=1
THICKNESS  1 0.013
ENODES
ENTRIES EL N1 N2 N3 N4/  901 516 535 588 569
STEP 1 TO  905 532 539 592 585
ENODES
ENTRIES EL N1 N2 N3 N4/  906 535 540 593 588
STEP 1 TO  915 544 549 602 597
ENODES
ENTRIES EL N1 N2 N3 N4/  916 545 550 603 598
STEP 1 TO  920 549 566 619 602
ENODES
ENTRIES EL N1 N2 N3 N4/  921 569 588 641 622
STEP 1 TO  925 585 592 645 638
ENODES
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ENTRIES EL N1 N2 N3 N4/  926 588 593 646 641
STEP 1 TO  935 597 602 655 650
ENODES
ENTRIES EL N1 N2 N3 N4/  936 598 603 656 651
STEP 1 TO  940 602 619 672 655
ENODES
ENTRIES EL N1 N2 N3 N4/  941 622 641 694 675
STEP 1 TO  945 638 645 698 691
ENODES
ENTRIES EL N1 N2 N3 N4/  946 641 646 699 694
STEP 1 TO  955 650 655 708 703
ENODES
ENTRIES EL N1 N2 N3 N4/  956 651 656 709 704
STEP 1 TO  960 655 672 725 708
ENODES
ENTRIES EL N1 N2 N3 N4/  961 675 694 747 728
STEP 1 TO  965 691 698 751 744
ENODES
ENTRIES EL N1 N2 N3 N4/  966 694 699 752 747
STEP 1 TO  975 703 708 761 756
ENODES
ENTRIES EL N1 N2 N3 N4/  976 704 709 762 757
STEP 1 TO  980 708 725 778 761
ENODES
ENTRIES EL N1 N2 N3 N4/  981 728 747 800 781
STEP 1 TO  985 744 751 804 797
ENODES
ENTRIES EL N1 N2 N3 N4/  986 747 752 805 800
STEP 1 TO  995 756 761 814 809
ENODES
ENTRIES EL N1 N2 N3 N4/  996 757 762 815 810
STEP 1 TO  1000 761 778 831 814
ENODES
ENTRIES EL N1 N2 N3 N4/  1001 781 800 853 834
STEP 1 TO  1005 797 804 857 850
ENODES
ENTRIES EL N1 N2 N3 N4/  1006 800 805 858 853
STEP 1 TO  1015 809 814 867 862
ENODES
ENTRIES EL N1 N2 N3 N4/  1016 810 815 868 863
STEP 1 TO  1020 814 831 884 867
ENODES
ENTRIES EL N1 N2 N3 N4/  1021 834 853 906 887
STEP 1 TO  1025 850 857 910 903
ENODES
ENTRIES EL N1 N2 N3 N4/  1026 853 858 911 906
STEP 1 TO  1035 862 867 920 915
ENODES
ENTRIES EL N1 N2 N3 N4/  1036 863 868 921 916
STEP 1 TO  1040 867 884 937 920
ENODES
ENTRIES EL N1 N2 N3 N4/  1041 887 906 959 940
STEP 1 TO  1045 903 910 963 956
ENODES
ENTRIES EL N1 N2 N3 N4/  1046 906 911 964 959
STEP 1 TO  1055 915 920 973 968
ENODES
ENTRIES EL N1 N2 N3 N4/  1056 916 921 974 969
STEP 1 TO  1060 920 937 990 973
ENODES
ENTRIES EL N1 N2 N3 N4/  1061 940 959 1012 993
STEP 1 TO  1065 956 963 1028 1009
ENODES
ENTRIES EL N1 N2 N3 N4/  1066 959 964 1029 1012
STEP 1 TO  1070 963 968 1045 1028
ENODES
ENTRIES EL N1 N2 N3 N4/  1071 964 969 1046 1029
STEP 1 TO  1075 968 973 1062 1045
ENODES
ENTRIES EL N1 N2 N3 N4/  1076 969 974 1063 1046
STEP 1 TO  1080 973 990 1079 1062
STRESSTABLE  1 1 2 3 4
*
EGROUP  7 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=1
THICKNESS  1 0.013
ENODES
ENTRIES EL N1 N2 N3 N4/  1081 993 1012 1101 1082
STEP 1 TO  1085 1009 1028 1105 1098
ENODES
ENTRIES EL N1 N2 N3 N4/  1086 1012 1029 1106 1101
STEP 1 TO  1090 1028 1045 1110 1105
ENODES
ENTRIES EL N1 N2 N3 N4/  1091 1029 1046 1111 1106
STEP 1 TO  1095 1045 1062 1115 1110
ENODES
ENTRIES EL N1 N2 N3 N4/  1096 1046 1063 1116 1111
STEP 1 TO  1100 1062 1079 1132 1115
ENODES
ENTRIES EL N1 N2 N3 N4/  1101 1082 1101 1154 1135
STEP 1 TO  1105 1098 1105 1158 1151
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*
ENODES
ENTRIES EL N1 N2 N3 N4/  1106 1101 1106 1159 1154
STEP 1 TO  1115 1110 1115 1168 1163
ENODES
ENTRIES EL N1 N2 N3 N4/  1116 1111 1116 1169 1164
STEP 1 TO  1120 1115 1132 1185 1168
ENODES
ENTRIES EL N1 N2 N3 N4/  1121 1135 1154 1207 1188
STEP 1 TO  1125 1151 1158 1211 1204
ENODES
ENTRIES EL N1 N2 N3 N4/  1126 1154 1159 1212 1207
STEP 1 TO  1135 1163 1168 1221 1216
ENODES
ENTRIES EL N1 N2 N3 N4/  1136 1164 1169 1222 1217
STEP 1 TO  1140 1168 1185 1238 1221
ENODES
ENTRIES EL N1 N2 N3 N4/  1141 1188 1207 1260 1241
STEP 1 TO  1145 1204 1211 1264 1257
ENODES
ENTRIES EL N1 N2 N3 N4/  1146 1207 1212 1265 1260
STEP 1 TO  1155 1216 1221 1274 1269
ENODES
ENTRIES EL N1 N2 N3 N4/  1156 1217 1222 1275 1270
STEP 1 TO  1160 1221 1238 1291 1274
ENODES
ENTRIES EL N1 N2 N3 N4/  1161 1241 1260 1313 1294
STEP 1 TO  1165 1257 1264 1317 1310
ENODES
ENTRIES EL N1 N2 N3 N4/  1166 1260 1265 1318 1313
STEP 1 TO  1175 1269 1274 1327 1322
ENODES
ENTRIES EL N1 N2 N3 N4/  1176 1270 1275 1328 1323
STEP 1 TO  1180 1274 1291 1344 1327
ENODES
ENTRIES EL N1 N2 N3 N4/  1181 1294 1313 1366 1347
STEP 1 TO  1185 1310 1317 1370 1363
ENODES
ENTRIES EL N1 N2 N3 N4/  1186 1313 1318 1371 1366
STEP 1 TO  1195 1322 1327 1380 1375
ENODES
ENTRIES EL N1 N2 N3 N4/  1196 1323 1328 1381 1376
STEP 1 TO  1200 1327 1344 1397 1380
ENODES
ENTRIES EL N1 N2 N3 N4/  1201 1347 1366 1419 1400
STEP 1 TO  1205 1363 1370 1423 1416
ENODES
ENTRIES EL N1 N2 N3 N4/  1206 1366 1371 1424 1419
STEP 1 TO  1215 1375 1380 1433 1428
ENODES
ENTRIES EL N1 N2 N3 N4/  1216 1376 1381 1434 1429
STEP 1 TO  1220 1380 1397 1450 1433
ENODES
ENTRIES EL N1 N2 N3 N4/  1221 1400 1419 1472 1453
STEP 1 TO  1225 1416 1423 1476 1469
ENODES
ENTRIES EL N1 N2 N3 N4/  1226 1419 1424 1477 1472
STEP 1 TO  1235 1428 1433 1486 1481
ENODES
ENTRIES EL N1 N2 N3 N4/  1236 1429 1434 1487 1482
STEP 1 TO  1240 1433 1450 1503 1486
ENODES
ENTRIES EL N1 N2 N3 N4/  1241 1453 1472 1525 1506
STEP 1 TO  1245 1469 1476 1529 1522
ENODES
ENTRIES EL N1 N2 N3 N4/  1246 1472 1477 1530 1525
STEP 1 TO  1255 1481 1486 1539 1534
ENODES
ENTRIES EL N1 N2 N3 N4/  1256 1482 1487 1540 1535
STEP 1 TO  1260 1486 1503 1556 1539
STRESSTABLE  1 1 2 3 4
*
EGROUP  8 SHELL RINT=4 RESULTS=TABLES STRESS=LOCAL M=1
THICKNESS  1 0.013
ENODES
ENTRIES EL N1 N2 N3 N4/  1261 1506 1525 1578 1559
STEP 1 TO  1265 1522 1529 1582 1575
ENODES
ENTRIES EL N1 N2 N3 N4/  1266 1525 1530 1583 1578
STEP 1 TO  1275 1534 1539 1592 1587
ENODES
ENTRIES EL N1 N2 N3 N4/  1276 1535 1540 1593 1588
STEP 1 TO  1280 1539 1556 1609 1592
ENODES
ENTRIES EL N1 N2 N3 N4/  1281 1559 1578 1631 1612
STEP 1 TO  1285 1575 1582 1635 1628
ENODES
ENTRIES EL N1 N2 N3 N4/  1286 1578 1583 1636 1631
STEP 1 TO  1295 1587 1592 1645 1640
ENODES
ENTRIES EL N1 N2 N3 N4/  1296 1588 1593 1646 1641
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STEP 1 TO  1300 1592 1609 1662 1645
ENODES
ENTRIES EL N1 N2 N3 N4/  1301 1612 1631 1684 1665
STEP 1 TO  1305 1628 1635 1688 1681
ENODES
ENTRIES EL N1 N2 N3 N4/  1306 1631 1636 1689 1684
STEP 1 TO  1315 1640 1645 1698 1693
ENODES
ENTRIES EL N1 N2 N3 N4/  1316 1641 1646 1699 1694
STEP 1 TO  1320 1645 1662 1715 1698
ENODES
ENTRIES EL N1 N2 N3 N4/  1321 1665 1684 1737 1718
STEP 1 TO  1325 1681 1688 1741 1734
ENODES
ENTRIES EL N1 N2 N3 N4/  1326 1684 1689 1742 1737
STEP 1 TO  1335 1693 1698 1751 1746
ENODES
ENTRIES EL N1 N2 N3 N4/  1336 1694 1699 1752 1747
STEP 1 TO  1340 1698 1715 1768 1751
ENODES
ENTRIES EL N1 N2 N3 N4/  1341 1718 1737 1790 1771
STEP 1 TO  1345 1734 1741 1794 1787
ENODES
ENTRIES EL N1 N2 N3 N4/  1346 1737 1742 1795 1790
STEP 1 TO  1355 1746 1751 1804 1799
ENODES
ENTRIES EL N1 N2 N3 N4/  1356 1747 1752 1805 1800
STEP 1 TO  1360 1751 1768 1821 1804
ENODES
ENTRIES EL N1 N2 N3 N4/  1361 1771 1790 1843 1824
STEP 1 TO  1365 1787 1794 1847 1840
ENODES
ENTRIES EL N1 N2 N3 N4/  1366 1790 1795 1848 1843
STEP 1 TO  1375 1799 1804 1857 1852
ENODES
ENTRIES EL N1 N2 N3 N4/  1376 1800 1805 1858 1853
STEP 1 TO  1380 1804 1821 1874 1857
ENODES
ENTRIES EL N1 N2 N3 N4/  1381 1824 1843 1896 1877
STEP 1 TO  1385 1840 1847 1900 1893
ENODES
ENTRIES EL N1 N2 N3 N4/  1386 1843 1848 1901 1896
STEP 1 TO  1395 1852 1857 1910 1905
ENODES
ENTRIES EL N1 N2 N3 N4/  1396 1853 1858 1911 1906
STEP 1 TO  1400 1857 1874 1927 1910
ENODES
ENTRIES EL N1 N2 N3 N4/  1401 1877 1896 1949 1930
STEP 1 TO  1405 1893 1900 1953 1946
ENODES
ENTRIES EL N1 N2 N3 N4/  1406 1896 1901 1954 1949
STEP 1 TO  1415 1905 1910 1963 1958
ENODES
ENTRIES EL N1 N2 N3 N4/  1416 1906 1911 1964 1959
STEP 1 TO  1420 1910 1927 1980 1963
ENODES
ENTRIES EL N1 N2 N3 N4/  1421 1930 1949 2002 1983
STEP 1 TO  1425 1946 1953 2010 1999
ENODES
ENTRIES EL N1 N2 N3 N4/  1426 1949 1954 2019 2002
STEP 1 TO  1430 1953 1958 2035 2018
.ENODES
ENTRIES EL N1 N2 N3 N4/  1431 1954 1959 2036 2019
STEP 1 TO  1435 1958 1963 2052 2035
ENODES
ENTRIES EL N1 N2 N3 N4/  1436 1959 1964 2053 2036
STEP 1 TO  1440 1963 1980 2069 2052
*EDATA
*ENTRIES EL PRINT
*              721 YES TO
*              1440 YES
STRESSTABLE  1 1 2 3 4
*
EGROUP  9 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL N=2
THICKNESS  1 0.006
ENODES
ENTRIES EL N1 N2 N3 N4/  1441 73 74 127 126
STEP 1 TO  1456 88 89 142 141
ENODES
ENTRIES EL N1 N2 N3 N4/  1457 126 127 180 179
STEP 1 TO  1472 141 142 195 194
ENODES
ENTRIES EL N1 N2 N3 N4/  1473 179 180 233 232
STEP 1 TO  1488 194 195 248 247
ENODES
ENTRIES EL N1 N2 N3 N4/  1489 232 233 286 285
STEP 1 TO  1504 247 248 301 300
ENODES
ENTRIES EL N1 N2 N3 N4/  1505 285 286 339 338
STEP 1 TO  1520 300 301 354 353
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ENODES
ENTRIES EL N1 N2 N3 N4/  1521 338 339 392 391
STEP 1 TO  1536 353 354 407 406
ENODES
ENTRIES EL N1 N2 N3 N4/  1537 391 392 445 444
STEP 1 TO  1552 406 407 460 459
ENODES
ENTRIES EL N1 N2 N3 N4/  1553 444 445 498 497
STEP 1 TO  1568 459 460 513 512
ENODES
ENTRIES EL N1 N2 N3 N4/  1569 497 498 551 550
STEP 1 TO  1584 512 513 566 565
STRESSTABLE  1 1 2 3 4
*
EGROUP  10 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=2
THICKNESS  1 0.006
ENODES
ENTRIES EL N1 N2 N3 N4/  1585 550 551 604 603
STEP 1 TO  1600 565 566 619 618
ENODES
ENTRIES EL N1 N2 N3 N4/  1601 603 604 657 656
STEP 1 TO  1616 618 619 672 671
ENODES
ENTRIES EL N1 N2 N3 N4/  1617 656 657 710 709
STEP 1 TO  1632 671 672 725 724
ENODES
ENTRIES EL N1 N2 N3 N4/  1633 709 710 763 762
STEP 1 TO  1648 724 725 778 777
ENODES
ENTRIES EL N1 N2 N3 N4/  1649 762 763 816 815
STEP 1 TO  1664 777 778 831 830
ENODES
ENTRIES EL N1 N2 N3 N4/  1665 815 816 869 868
STEP 1 TO  1680 830 831 884 883
ENODES
ENTRIES EL N1 N2 N3 N4/  1681 868 869 922 921
STEP 1 TO  1696 883 884 937 936
ENODES
ENTRIES EL N1 N2 N3 N4/  1697 921 922 975 974
STEP 1 TO  1712 936 937 990 989
ENODES
ENTRIES EL N1 N2 N3 N4/  1713 974 975 1064 1063
STEP 1 TO  1728 989 990 1079 1078
STRESSTABLE  1 1 2 3 4
*
EGROUP  11 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=2
THICKNESS  1 0.006
ENODES
ENTRIES EL N1 N2 N3 N4/  1729 1063 1064 1117 1116
STEP 1 TO  1744 1078 1079 1132 1131
ENODES
ENTRIES EL N1 N2 N3 N4/  1745 1116 1117 1170 1169
STEP 1 TO  1760 1131 1132 1185 1184
ENODES
ENTRIES EL N1 N2 N3 N4/  1761 1169 1170 1223 1222
STEP 1 TO  1776 1184 1185 1238 1237
ENODES
ENTRIES EL N1 N2 N3 N4/  1777 1222 1223 1276 1275
STEP 1 TO  1792 1237 1238 1291 1290
ENODES
ENTRIES EL N1 N2 N3 N4/  1793 1275 1276 1329 1328
STEP 1 TO  1808 1290 1291 1344 1343
ENODES
ENTRIES EL N1 N2 N3 N4/  1809 1328 1329 1382 1381
STEP 1 TO  1824 1343 1344 1397 1396
ENODES
ENTRIES EL N1 N2 N3 N4/  1825 1381 1382 1435 1434
STEP 1 TO  1840 1396 1397 1450 1449
ENODES
ENTRIES EL N1 N2 N3 N4/  1841 1434 1435 1488 1487
STEP 1 TO  1856 1449 1450 1503 1502
ENODES
ENTRIES EL N1 N2 N3 N4/  1857 1487 1488 1541 1540
STEP 1 TO  1872 1502 1503 1556 1555
STRESSTABLE  1 1 2 3 4
*
EGROUP  12 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=2
THICKNESS  1 0.006
ENODES
ENTRIES EL N1 N2 N3 N4/  1873 1540 1541 1594 1593
STEP 1 TO  1888 1555 1556 1609 1608
ENODES
ENTRIES EL N1 N2 N3 N4/  1889 1593 1594 1647 1646
STEP 1 TO  1904 1608 1609 1662 1661
ENODES
ENTRIES EL N1 N2 N3 N4/  1905 1646 1647 1700 1699
STEP 1 TO  1920 1661 1662 1715 1714
ENODES
ENTRIES EL N1 N2 N3 N4/  1921 1699 1700 1753 1752
STEP 1 TO  1936 1714 1715 1768 1767
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ENODES
ENTRIES EL N1 N2 N3 N4/  1937 1752 1753 1806 1805
STEP 1 TO  1952 1767 1768 1821 1820
ENODES
ENTRIES EL N1 N2 N3 N4/  1953 1805 1806 1859 1858
STEP 1 TO  1968 1820 1821 1874 1873
ENODES
ENTRIES EL N1 N2 N3 N4/  1969 1858 1859 1912 1911
STEP 1 TO  1984 1873 1874 1927 1926
ENODES
ENTRIES EL N1 N2 N3 N4/  1985 1911 1912 1965 1964
STEP 1 TO  2000 1926 1927 1980 1979
ENODES
ENTRIES EL N1 N2 N3 N4/  2001 1964 1965 2054 2053
STEP 1 TO  2016 1979 1980 2069 2068
*EDATA
*ENTRIES EL PRINT
*              1441 YES TO
*              2016 YES
STRESSTABLE  1 1 2 3 4
*
EGROUP 13 SHELL RINT=4 RESULT=TABLES STRESS=LOCAL M=1
THICKNESS  1 0.003
ENODES
ENTRIES EL N1 N2 N3 N4/  2017 3 4 23 22
STEP 1 TO  2032 18 19 38 37
ENODES
ENTRIES EL N1 N2 N3 N4/  2033 22 23 40 39
STEP 1 TO  2048 37 38 55 54
ENODES
ENTRIES EL N1 N2 N3 N4/  2049 39 40 57 56
STEP 1 TO  2064 54 55 72 71
ENODES
ENTRIES EL N1 N2 N3 N4/  2065 56 57 74 73
STEP 1 TO  2080 71 72 89 88
ENODES
ENTRIES EL N1 N2 N3 N4/  2081 993 994 1013 1012
STEP 1 TO  2096 1008 1009 1028 1027
ENODES
ENTRIES EL N1 N2 N3 N4/  2097 1012 1013 1030 1029
STEP 1 TO  2112 1027 1028 1045 1044
ENODES
ENTRIES EL N1 N2 N3 N4/  2113 1029 1030 1047 1046
STEP 1 TO  2128 1044 1045 1062 1061
ENODES
ENTRIES EL N1 N2 N3 N4/  2129 1046 1047 1064 1063
STEP 1 TO  2144 1061 1062 1079 1078
ENODES
ENTRIES EL N1 N2 N3 N4/  2145 1983 1984 2003 2002
STEP 1 TO  2160 1998 1999 2018 2017
ENODES
ENTRIES EL N1 N2 N3 N4/  2161 2002 2003 2020 2019
STEP 1 TO  2176 2017 2018 2035 2034
ENODES
ENTRIES EL N1 N2 N3 N4/  2177 2019 2020 2037 2036
STEP 1 TO  2192 2034 2035 2052 2051
ENODES
ENTRIES EL N1 N2 N3 N4/  2193 2036 2037 2054 2053
STEP 1 TO  2208 2051 2052 2069 2068
*EDATA
*ENTRIES EL PRINT
*              2017 YES  TO
*              2208 YES
STRESSTABLE  1 1 2 3 4
*
SHELLDIR E
    1   0.0  -8.40107
    2   0.0  -7.92078
    3   0.0  -7.44050
    4   0.0  -6.90903
    5   0.0  -6.37757
    6   0.0  -5.869727
    7   0.0  -5.31464
    8   0.0  -4.688695
    9   0.0  -4.25171
   10   0.0  -3.606083
   11   0.0  -2.917148
   12   0.0  -2.65732
   13   0.0  -2.12586
   14   0.0  -1.59439
   15   0.0  -1.06293
   16   0.0  -0.79719
   17   0.0  -0.53146
   18   0.0  -0.26573
   19   0.0   0.0
   20   0.0   0.26573
   21   0.0   0.53146
   22   0.0   0.79719
   23   0.0   1.06293
   24   0.0   1.59439
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     25   0.0   2.12586
     26   0.0   2.65732
     27   0.0   2.917148
     28   0.0   3.606083
     29   0.0   4.25171
     30   0.0   4.688695
     31   0.0   5.31464
     32   0.0   5.869727
     33   0.0   6.37757
     34   0.0   6.90903
     35   0.0   7.44050
     36   0.0   7.92078
     37   0.0   8.40107
     38   0.0  81.59893
     39   0.0       90.0
     40   0.0  98.40107
     41  90.0       90.0
*
SHELLNODES DOF-DEFAULT=SIX TYPE=NODES
1 41 TO
21 41
90 41 TO
110 41
143 41 TO
163 41
196 41 TO
216 41
249 41 TO
269 41
302 41 TO
322 41
355 41 TO
375 41
408 41 TO
428 41
461 41 TO
481 41
514 41 TO
534 41
567 41 TO
587 41
620 41 TO
640 41
673 41 TO
693 41
726 41 TO
746 41
779 41 TO
799 41
832 41 TO
852 41
885 41 TO
905 41
938 41 TO
958 41
*991 41 TO
*1011 41
993 39 TO
1009 39
*
1080 41 TO
1100 41
1133 41 TO
1153 41
1186 41 TO
1206 41
1239 41 TO
1259 41
1292 41 TO
1312 41
1345 41 TO
1365 41
1398 41 TO
1418 41
1451 41 TO
1471 41
1504 41 TO
1524 41
1557 41 TO
1577 41
1610 41 TO
1630 41
1663 41 TO
1683 41
1716 41 TO
1736 41
1769 41 TO
1789 41
1822 41 TO
1842 41
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1875 41 TO
1895 41
1928 41 TO
1948 41
1981 41 TO
2001 41
73 41 TO
89 41
126 41 TO
142 41
179 41 TO
195 41
232 41 TO
248 41
285 41 TO
301 41
338 41 TO
354 41
391 41 TO
407 41
444 41 TO
460 41
497 41 TO
513 41
550 41 TO
566 41
603 41 TO
619 41
656 41 TO
672 41
709 41 TO
725 41
762 41 TO
778 41
815 41 TO
831 41
868 41 TO
884 41
921 41 TO
937 41
974 41 TO
990 41
1063 41 TO
1079 41
1116 41 TO
1132 41
1169 41 TO
1185 41
1222 41 TO
1238 41
1275 41 TO
1291 41
1328 41 TO
1344 41
1381 41 TO
1397 41
1434 41 TO
1450 41
1487 41 TO
1503 41
1540 41 TO
1556 41
1593 41 TO
1609 41
1646 41 TO
1662 41
1699 41 TO
1715 41
1752 41 TO
1768 41
1805 41 TO
1821 41
1858 41 TO
1874 41
1911 41 TO
1927 41
1964 41 TO
1980 41
2053 41 TO
2069 41
22 1 STEP 4 TO
38 1
39 1 STEP 4 TO
55 1
56 1 STEP 4 TO
72 1
23 38 STEP 4 TO
35 38
24 38 STEP 4 TO
36 38
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25 38 STEP 4 TO
37 38
40 38 STEP 4 TO
52 38
41 38 STEP 4 TO
53 38
42 38 STEP 4 TO
54 38
57 38 STEP 4 TO
69 38
58 38 STEP 4 TO
70 38
59 38 STEP 4 TO
71 38
111 2 TO
125 2
164 3 TO
178 3
217 4 TO
231 4
270 5 TO
284 5
323 6 TO
337 6
376 7 TO
390 7
429 8 TO
443 8
482 9 TO
496 9
535 10 TO
549 10
588 11 TO
602 11
641 12 TO
655 12
694 13 TO
708 13
747 14 TO
761 14
800 15 TO
814 15
853 16 TO
867 16
906 17 TO
920 17
959 18 TO
973 18
1012 19 STEP 4 TO
1028 19
1029 19 STEP 4 TO
1045 19
1046 19 STEP 4 TO
1062 19
1013 39 STEP 4 TO
1025 39
1014 39 STEP 4 TO
1026 39
1015 39 STEP 4 TO
1027 39
1030 39 STEP 4 TO
1042 39
1031 39 STEP 4 TO
1043 39
1032 39 STEP 4 TO
1044 39
1047 39 STEP 4 TO
1059 39
1048 39 STEP 4 TO
1060 39
1049 39 STEP 4 TO
1061 39
1101 20 TO
1115 20
1154 21 TO
1168 21
1207 22 TO
1221 22
1260 23 TO
1274 23
1313 24 TO
1327 24
1366 25 TO
1380 25
1419 26 TO
1433 26
1472 27 TO
1486 27
1525 28 TO
1539 28
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1578 29 TO
1592 29
1631 30 TO
1645 30
1684 31 TO
1698 31
1737 32 TO
1751 32
1790 33 TO
1804 33
1843 34 TO
1857 34
1896 35 TO
1910 35
1949 36 TO
1963 36
2002 37 STEP 4 TO
2018 37
2019 37 STEP 4 TO
2035 37
2036 37 STEP 4 TO
2052 37
2003 40 STEP 4 TO
2015 40
2004 40 STEP 4 TO
2016 40
2005 40 STEP 4 TO
2017 40
2020 40 STEP 4 TO
2032 40
2021 40 STEP 4 TO
2033 40
2022 40 STEP 4 TO
2034 40
2037 40 STEP 4 TO
2049 40
2038 40 STEP 4 TO
2050 40
2039 40 STEP 4 TO
2051 40
DELETE 3 STEP 1 TO 19
DELETE 22 STEP 4 TO 38
DELETE 39 STEP 4 TO 55
DELETE 56 STEP 4 TO 72
DELETE 73 STEP 1 TO 89
DELETE 92 STEP 4 TO 108
DELETE 126 STEP 4 TO 142
DELETE 145 STEP 4 TO 161
DELETE 179 STEP 4 TO 195
DELETE 198 STEP 4 TO 214
DELETE 232 STEP 4 TO 248
DELETE 251 STEP 4 TO 267
DELETE 285 STEP 4 TO 301
DELETE 304 STEP 4 TO 320
DELETE 338 STEP 4 TO 354
DELETE 357 STEP 4 TO 373
DELETE 391 STEP 4 TO 407
DELETE 410 STEP 4 TO 426
DELETE 444 STEP 4 TO 460
DELETE 463 STEP 4 TO 479
DELETE 497 STEP 4 TO 513
DELETE 516 STEP 4 TO 532
DELETE 550 STEP 4 TO 566
DELETE 569 STEP 4 TO 585
DELETE 603 STEP 4 TO 619
DELETE 622 STEP 4 TO 638
DELETE 656 STEP 4 TO 672
DELETE 675 STEP 4 TO 691
DELETE 709 STEP 4 TO 725
DELETE 728 STEP 4 TO 744
DELETE 762 STEP 4 TO 778
DELETE 781 STEP 4 TO 797
DELETE 815 STEP 4 TO 831
DELETE 834 STEP 4 TO 850
DELETE 868 STEP 4 TO 884
DELETE 887 STEP 4 TO 903
DELETE 921 STEP 4 TO 937
DELETE 940 STEP 4 TO 956
DELETE 974 STEP 4 TO 990
*DELETE 993 STEP 1 TO 1009
DELETE 993 STEP 4 TO 1009
*
DELETE 1012 STEP 4 TO 1028
DELETE 1029 STEP 4 TO 1045
DELETE 1046 STEP 4 TO 1062
DELETE 1063 STEP 1 TO 1079
DELETE 1082 STEP 4 TO 1098
DELETE 1116 STEP 4 TO 1132
DELETE 1135 STEP 4 TO 1151
DELETE 1169 STEP 4 TO 1185
```

```
DELETE 1188 STEP 4 TO 1204
DELETE 1222 STEP 4 TO 1238
DELETE 1241 STEP 4 TO 1257
DELETE 1275 STEP 4 TO 1291
DELETE 1294 STEP 4 TO 1310
DELETE 1328 STEP 4 TO 1344
DELETE 1347 STEP 4 TO 1363
DELETE 1381 STEP 4 TO 1397
DELETE 1400 STEP 4 TO 1416
DELETE 1434 STEP 4 TO 1450
DELETE 1453 STEP 4 TO 1469
DELETE 1487 STEP 4 TO 1503
DELETE 1506 STEP 4 TO 1522
DELETE 1540 STEP 4 TO 1556
DELETE 1559 STEP 4 TO 1575
DELETE 1593 STEP 4 TO 1609
DELETE 1612 STEP 4 TO 1628
DELETE 1646 STEP 4 TO 1662
DELETE 1665 STEP 4 TO 1681
DELETE 1699 STEP 4 TO 1715
DELETE 1718 STEP 4 TO 1734
DELETE 1752 STEP 4 TO 1768
DELETE 1771 STEP 4 TO 1787
DELETE 1805 STEP 4 TO 1821
DELETE 1824 STEP 4 TO 1840
DELETE 1858 STEP 4 TO 1874
DELETE 1877 STEP 4 TO 1893
DELETE 1911 STEP 4 TO 1927
DELETE 1930 STEP 4 TO 1946
DELETE 1964 STEP 4 TO 1980
DELETE 1983 STEP 1 TO 1999
DELETE 2002 STEP 4 TO 2018
DELETE 2019 STEP 4 TO 2035
DELETE 2036 STEP 4 TO 2052
DELETE 2053 STEP 1 TO 2069
*
BOUNDARIES  100000  TYPE=NODES / 76 81 86
BOUNDARIES  100000  TYPE=NODES / 2056 2061 2066
BOUNDARIES  111100  TYPE=NODES / 1071
*
LOADS  CONCENTRATED
304 1 -274.
305 1 -548. STEP 1 TO
311 1 -548.
312 1 -274.
410 1 -342.5
411 1 -685. STEP 1 TO
417 1 -685.
418 1 -342.5
516 1 -548.
517 1 -1096. STEP 1 TO
523 1 -1096.
524 1 -548.
569 1 -102.75
570 1 -205.5 STEP 1 TO
576 1 -205.5
577 1 -102.75
1453 1 -102.75
1454 1 -205.5 STEP 1 TO
1460 1 -205.5
1461 1 -102.75
1506 1 -548.
1507 1 -1096. STEP 1 TO
1513 1 -1096.
1514 1 -548.
1612 1 -342.5
1613 1 -685. STEP 1 TO
1619 1 -685.
1620 1 -342.5
1718 1 -274.
1719 1 -548. STEP 1 TO
1725 1 -548.
1726 1 -274.
*
FRAME
DEPICTION SHELL=MIDSURFACE
EGROUP NAME=SHELL
       1 2 3 4 5 6 7 8 9 10 11 12 13
MESH  NODES=31 ELEMENT=1 BCODE=ALL HIDDEN=DASHED
EVECTOR VAR=FORCE OUTPUT=ALL
*
ADINA
*
END
*
```

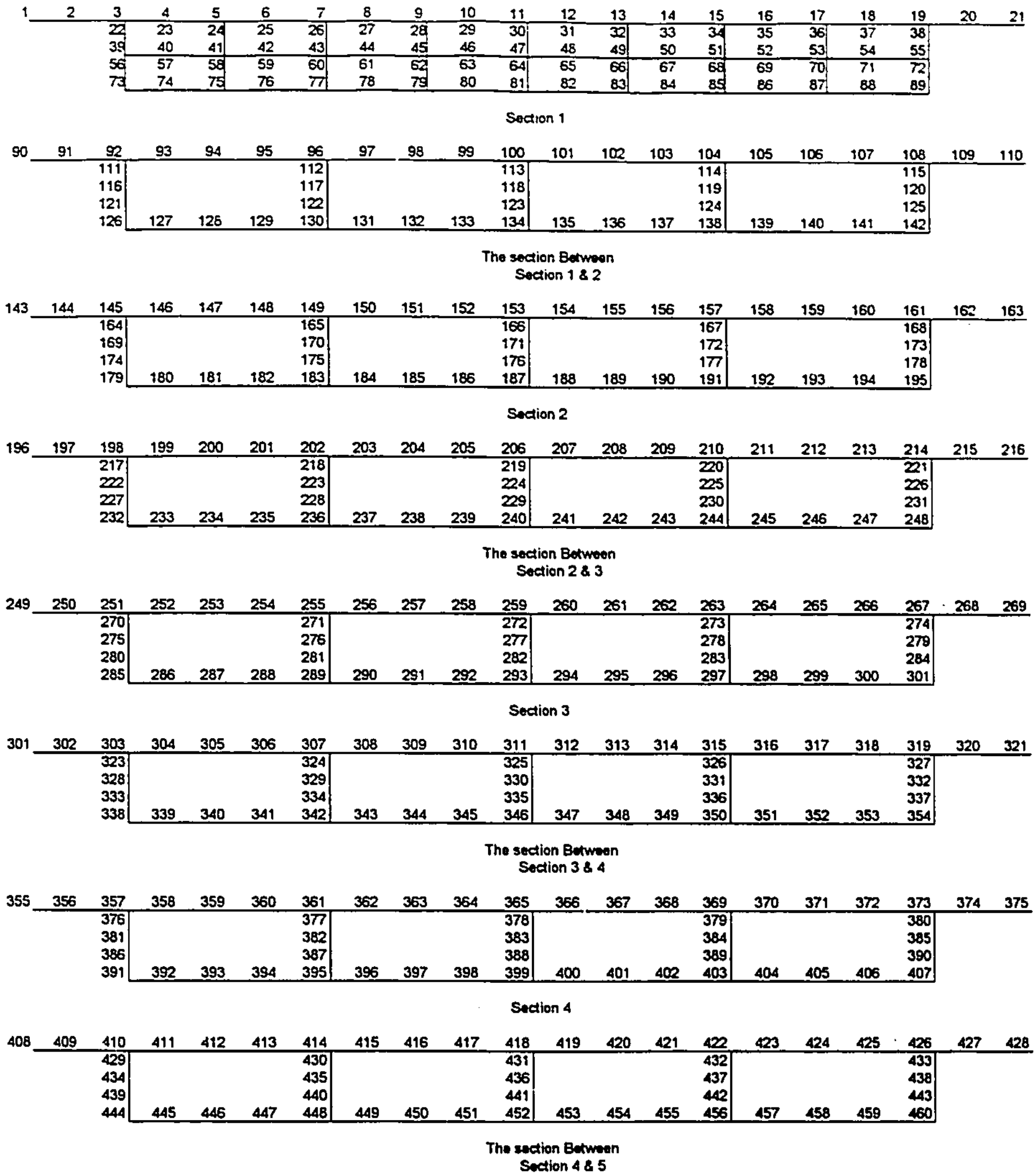

FIGURE C.1 ADINA NODES NUMBER

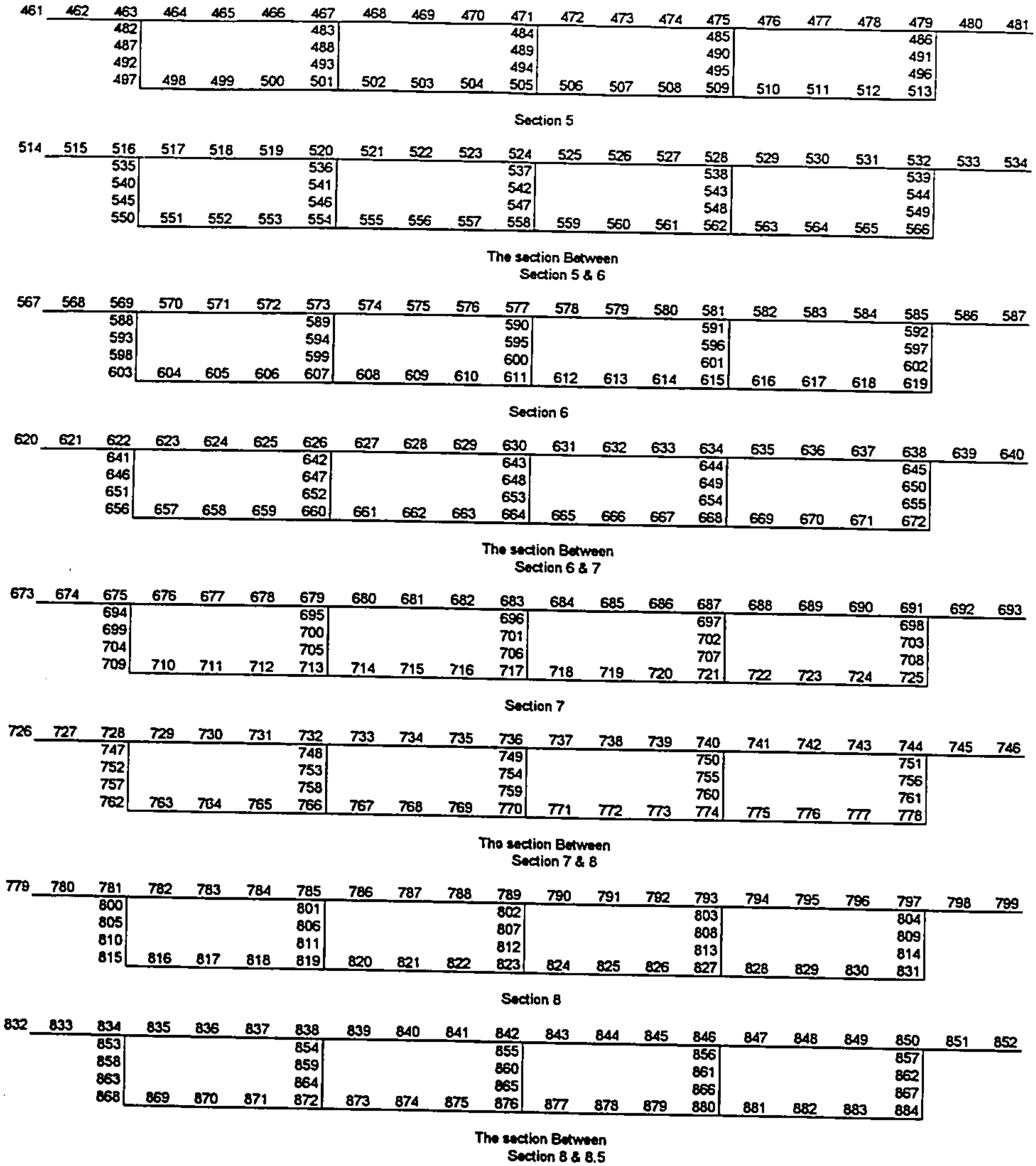

FIGURE C.2 ADINA NODES NUMBER

885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905
		906				907				908				909				910		
		911				912				913				914				915		
		916				917				918				919				920		
		921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937		

Section 8.5

938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958
		959				960				961				962				963		
		964				965				966				967				968		
		969				970				971				972				973		
		974	975	976	977	978	979	980	981	982	983	984	965	986	987	988	989	990		

The section Between
Section 8.5 & 9

991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011
		1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028		
		1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045		
		1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062		
		1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079		

Section 9

1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100
		1101				1102				1103				1104				1105		
		1106				1107				1108				1109				1110		
		1111				1112				1113				1114				1115		
		1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132		

The section Between
Section 9 & 9.5

1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153
		1154				1155				1156				1157				1158		
		1159				1160				1161				1162				1163		
		1164				1165				1166				1169				1168		
		1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185		

Section 9.5

1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206
		1207				1208				1209				1210				1264		
		1212				1213				1214				1215				1269		
		1217				1218				1219				1220				1274		
		1222	1223	1224	1225	1226	1227	1228	1229	1230	1231	1232	1233	1234	1235	1236	1237	1238		

The section Between
Section 9.5 & 10

1239	1240	1241	1242	1243	1244	1245	1246	1247	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259
		1260				1261				1262				1263				1264		
		1265				1266				1267				1268				1269		
		1270				1271				1272				1273				1274		
		1275	1276	1277	1278	1279	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291		

Section 10

1292	1293	1294	1295	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311	1312
		1313				1314				1315				1316				1317		
		1318				1319				1320				1321				1322		
		1323				1324				1325				1326				1327		
		1328	1329	1330	1331	1332	1333	1334	1335	1336	1337	1338	1339	1340	1341	1342	1343	1344		

The section Between
Section 10 & 11

FIGURE C.3 ADINA NODES NUMBER

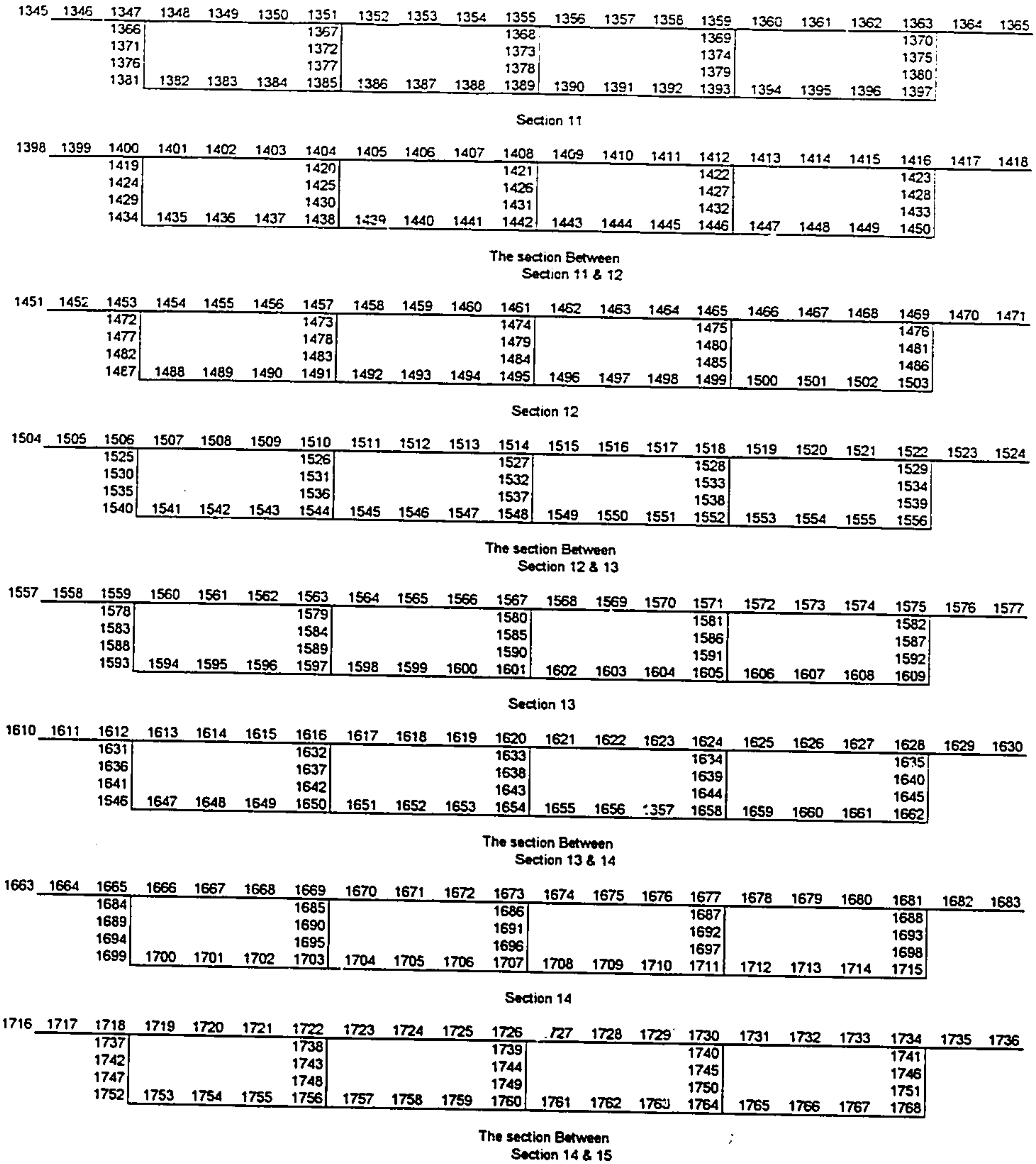

FIGURE C.4 ADINA NODES NUMBER

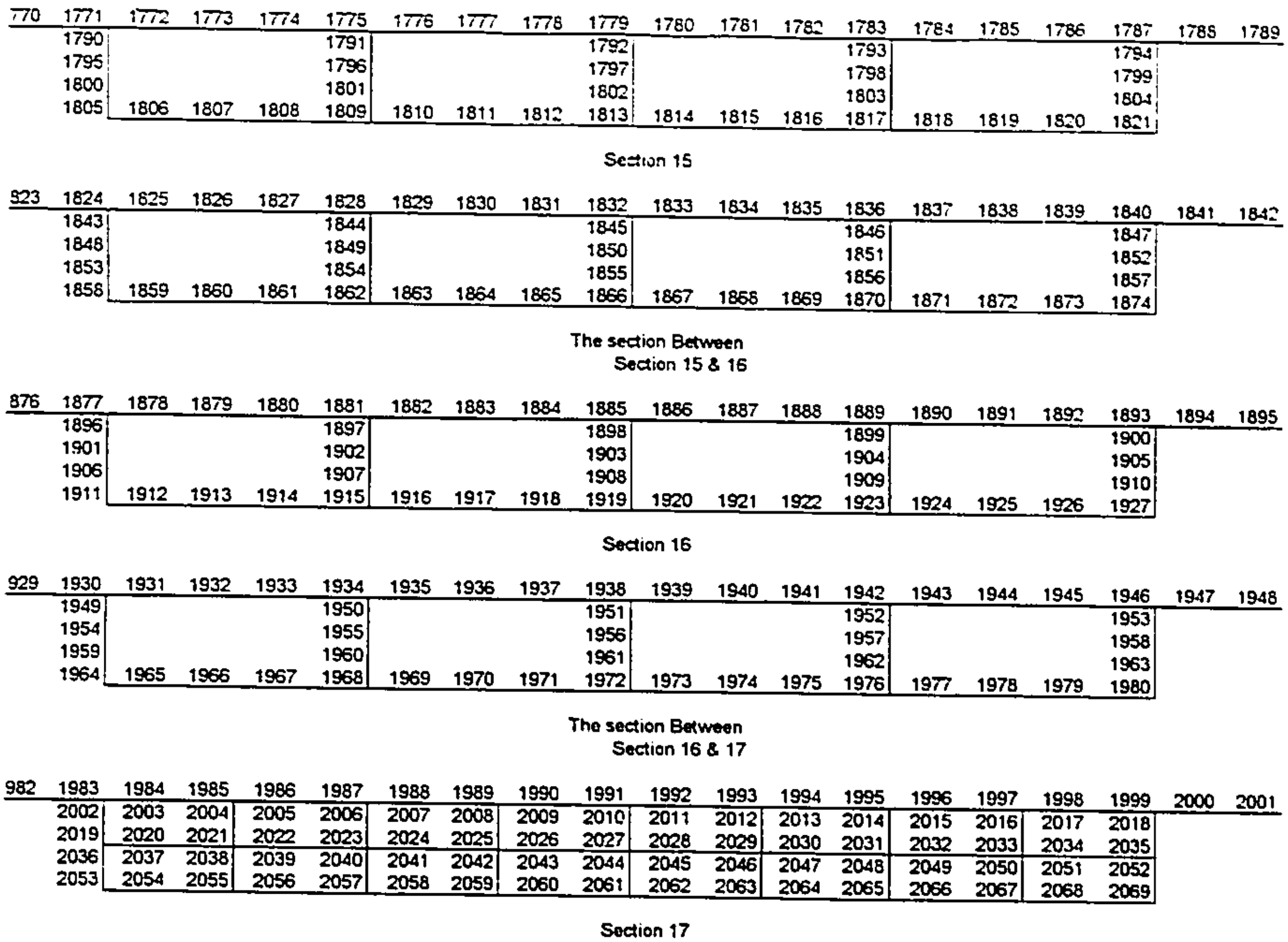

FIGURE C.5 ADINA NODES NUMBER

Appendix D

Experimental Deflections &

Srtresses Results Vs. ADINA'S

Table D.1 ADINA Deflection Vs. Experimental For Load Case # 1

Load Case # 1					Load = 6,123 N			Load = 8,383 N		
Dial Gage I.D	Load 1 2,504 N	Load 2 4,281 N	Load 3 6,123 N	Load 4 8,384 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	21.00	32.00	45.00	61.00	17.00	15.75	7.35	23.00	21.57	6.23
VD2	16.00	26.00	37.00	50.00	14.00	12.59	10.08	18.00	17.24	4.23
VF2	12.00	18.00	28.00	40.00	11.00	9.79	10.99	14.00	13.41	4.24
VB4	42.00	66.00	98.00	132.00	42.00	39.09	6.92	56.00	53.53	4.42
VD4	37.00	56.00	82.00	112.00	36.00	32.59	9.46	48.00	44.63	7.02
VF4	35.00	49.00	63.00	89.00	29.00	25.78	11.10	37.00	35.30	4.60
VB5	46.00	71.00	101.00	136.50	45.00	42.44	5.69	60.50	58.11	3.95
VF5	29.00	51.00	63.00	91.00	29.00	27.16	6.36	39.00	37.19	4.65

Table D.2 ADINA Deflection Vs. Experimental For Load Case # 2

Load Case # 2					Load = 8,642 N			Load = 13,476 N		
Dial Gage I.D	3,431 N	6,264 N	8,642 N	13,476 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	21.00	39.00	56.00	88.00	20.00	18.50	7.49	32.00	28.85	9.84
VD2	23.00	41.00	54.00	83.00	19.00	17.43	8.24	30.00	27.19	9.38
VF2	17.00	35.00	51.50	78.00	18.50	16.90	8.63	29.00	26.36	9.11
VB4	47.00	89.00	126.00	191.00	54.00	46.58	13.74	79.00	72.63	8.06
VD4	42.50	83.00	121.00	184.00	52.00	45.19	13.10	78.00	70.46	9.66
VF4	40.00	75.00	116.00	175.00	50.00	43.33	13.34	75.00	67.57	9.91
VB5	47.50	88.00	128.00	195.00	56.00	50.00	10.72	83.00	77.96	6.07
VF5	47.00	89.00	117.00	178.00	51.00	46.45	8.91	78.00	72.44	7.13

Table D.3 ADINA Deflection Vs. Experimental For Load Case # 3

Load Case # 3					Load = 20,729 N			Load = 27,799 N		
Dial Gage I.D	10,003 N	14,764 N	20,729 N	27,799 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	35.00	50.00	72.00	100.00	28.00	26.44	5.57	40.00	35.46	11.35
VD2	28.00	45.00	68.00	96.00	28.00	24.27	13.32	37.00	32.55	12.03
VF2	24.00	40.00	62.00	90.00	24.00	22.82	4.94	32.00	30.60	4.38
VB4	76.00	112.00	158.00	216.00	70.00	65.51	6.41	96.00	87.85	8.49
VD4	75.00	108.00	149.00	208.00	69.00	62.16	9.91	90.00	83.36	7.38
VF4	65.00	100.00	141.00	195.00	65.00	57.93	10.87	79.00	77.69	1.66
VB5	85.00	123.00	168.00	228.00	80.00	69.63	12.96	108.00	93.38	13.54
VF5	79.00	112.00	155.00	209.00	79.00	60.86	22.97	93.00	81.61	12.25
VB13	41.00	61.00	84.00	107.00	24.00	23.79	0.88	35.00	31.90	8.85
VD13	40.00	59.00	80.00	102.00	20.00	16.24	18.82	31.00	21.77	29.76
VB14	37.00	53.00	67.00	86.00	27.00	23.44	13.18	34.00	31.44	7.54
VD14	33.00	46.00	60.00	77.00	23.00	16.86	26.70	25.00	22.61	9.56
VF14	27.00	39.00	52.00	64.00	17.00	9.67	43.13	25.00	12.96	48.14
VD16	15.00	21.00	30.00	38.00	8.00	7.08	11.54	10.00	9.49	5.10
VF16	15.00	20.00	25.50	30.50	4.50	4.08	9.32	5.50	5.47	0.55

Table D.4 ADINA Deflection Vs. Experimental For Load Case # 4

Load Case # 4					Load = 20,356 N			Load = 25,429 N		
Dial Gage I.D	9,260 N	14,530 N	20,356 N	25,429 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	20.00	32.00	45.00	56.00	18.00	16.23	9.85	23.00	20.27	11.86
VD2	20.00	33.00	44.00	55.00	17.00	15.28	10.11	22.00	19.09	13.23
VF2	13.00	25.00	37.00	47.00	17.00	14.78	13.08	21.00	18.46	12.10
VB4	46.00	74.00	102.00	125.00	46.00	39.63	13.85	55.00	49.51	9.99
VD4	46.00	72.00	101.00	123.00	45.00	38.55	14.34	53.00	48.15	9.15
VF4	37.00	60.00	85.00	109.00	43.00	36.73	14.59	51.00	45.88	10.04
VB5	52.00	79.00	105.00	130.00	49.00	41.13	16.06	60.00	51.38	14.36
VF5	40.00	63.00	88.00	113.00	46.00	37.98	17.43	55.00	47.45	13.73
VB13	46.00	76.00	104.00	127.00	48.00	41.13	14.31	57.00	51.38	9.85
VD13	49.00	80.00	103.00	129.00	47.00	40.06	14.77	59.00	50.04	15.19
VF13	39.00	62.00	86.00	111.00	44.00	37.98	13.68	56.00	47.45	15.28
VB14	46.00	73.00	101.00	125.00	45.00	39.63	11.93	55.00	49.51	9.99
VD14	41.00	66.00	100.00	123.00	44.00	38.55	12.40	53.00	48.15	9.15
VF14	39.00	60.00	84.00	108.00	42.00	36.73	12.56	50.00	45.88	8.24
VD16	20.00	31.00	43.00	54.00	16.00	15.28	4.49	21.00	19.09	9.10
VF16	14.00	25.00	36.00	47.00	16.00	14.78	7.65	21.00	18.46	12.10

Table D.5 ADINA Deflection Vs. Experimental For Load Case # 5

Load Case # 5					Load = 9,583 N			Load = 14,120 N		
Dial Gage I.D	3,856 N	5,505 N	9,583 N	14,120 N	Adjusted Experimental Deflection mmx10^-2	ADINA Deflection mmx10^-2	% Of Error	Adjusted Experimental Deflection mmx10^-2	ADINA Deflection mmx10^-2	% Of Error
VB2	10.00	19.00	30.00	46.00	11.00	10.15	7.77	15.50	14.95	3.55
VD2	8.00	15.00	26.00	38.00	8.00	7.35	8.13	11.50	10.83	5.83
VF2	4.00	12.00	22.00	30.00	5.50	4.74	13.83	7.50	6.98	6.89
VB4	23.00	43.00	65.00	98.00	27.00	24.37	9.74	37.00	35.91	2.96
VD4	19.00	36.00	56.00	84.00	20.50	18.50	9.73	31.00	27.27	12.05
VF4	16.00	30.00	47.00	65.00	14.00	12.30	12.16	20.00	18.12	9.40
VB5	24.00	42.00	66.00	104.00	28.00	26.05	6.95	43.00	38.39	10.72
VF5	16.00	28.00	46.00	72.00	13.00	11.94	8.16	19.00	17.59	7.41
VB13	25.00	46.00	68.00	101.00	30.00	26.05	13.15	40.00	38.39	4.03
VD13	21.00	37.00	57.00	83.00	21.50	19.23	10.57	30.00	28.33	5.56
VF13	14.00	28.00	46.00	65.00	13.00	11.94	8.16	20.00	17.59	12.04
VB14	25.00	46.00	65.00	100.00	27.00	24.37	9.74	39.00	35.91	7.93
VD14	22.00	38.00	56.00	82.00	20.50	18.50	9.73	29.00	27.27	5.98
VF14	18.00	32.00	47.00	65.00	14.00	12.30	12.16	20.00	18.12	9.40
VB16	13.00	22.00	32.00	47.00	12.00	10.15	15.45	16.50	14.95	9.40
VD16	10.00	18.00	26.00	38.00	8.00	7.35	8.13	11.50	10.83	5.83
VF16	7.00	13.00	21.50	30.00	5.00	4.74	5.21	7.50	6.98	6.89

Table D.6 ADINA Deflection Vs. Experimental For Load Case # 6

Load Case # 6					Load = 10,844 N			Load = 14,727 N		
Dial Gage I.D	5,481 N	7,028 N	10,844 N	14,727 N	Adjusted Experimental Deflection mmx10^-2	ADINA Deflection mmx10^-2	% Of Error	Adjusted Experimental Deflection mmx10^-2	ADINA Deflection mmx10^-2	% Of Error
VB2	11.00	15.00	20.00	27.00	6.50	5.81	10.64	8.50	7.89	7.19
VD2	15.00	22.00	29.00	39.50	8.50	7.97	6.29	11.50	10.82	5.94
VF2	18.00	28.00	39.00	53.00	11.50	10.38	9.74	15.00	14.10	6.03
VB4	24.00	33.00	43.00	58.00	16.00	14.65	8.45	21.00	19.89	5.27
VD4	31.00	47.00	63.00	85.00	22.00	20.13	8.51	28.50	27.33	4.09
VF4	37.00	58.00	82.00	111.00	27.00	25.21	6.62	35.00	34.24	2.17
VB5	23.00	31.00	42.00	57.00	15.00	14.34	4.39	20.00	19.48	2.61
VF5	42.00	63.00	84.00	113.00	29.00	26.96	7.05	37.00	36.61	1.06
VB13	21.00	32.00	41.00	57.00	16.00	14.34	10.36	20.00	19.48	2.61
VD13	30.00	47.00	63.00	86.00	22.00	20.92	4.91	29.50	28.41	3.69
VF13	39.00	58.00	83.00	114.00	28.00	26.96	3.73	38.00	36.61	3.66
VB14	21.00	32.00	43.00	59.00	16.00	14.65	8.45	22.00	19.89	9.57
VF14	34.00	55.00	83.00	112.00	28.00	25.21	9.95	36.00	34.24	4.88
VB16	10.00	15.00	20.00	27.00	6.50	5.81	10.64	8.50	7.89	7.19
VD16	13.00	20.50	29.00	40.00	8.50	7.97	6.29	12.00	10.82	9.86
VF16	20.00	29.00	39.00	53.50	11.50	10.38	9.74	15.50	14.10	9.03

Table D.7 ADINA Deflection Vs. Experimental For Load Case # 7

Load Case # 7					Load = 9,008 N			Load = 12,036 N		
Dial Gage I.D	3,911N	5,419 N	9,008 N	12,036 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	8.00	12.00	17.00	22.00	7.00	6.29	10.17	9.00	8.40	6.65
VD2	10.00	17.00	25.00	32.00	7.50	6.79	9.42	10.00	9.08	9.23
VF2	14.00	23.00	33.50	42.00	8.00	7.49	6.38	10.50	10.01	4.69
VB4	14.00	22.00	36.00	48.00	16.00	15.53	2.91	22.00	20.76	5.66
VF4	25.00	45.00	70.00	89.00	19.00	18.53	2.46	26.00	24.76	4.76
VB5	14.00	25.00	37.00	50.00	17.00	16.17	4.86	24.00	21.61	9.95
VF5	28.00	51.00	72.00	93.00	21.00	19.28	8.17	30.00	25.77	14.11
VB13	14.00	23.00	37.00	51.00	17.00	16.17	4.86	25.00	21.61	13.56
VD13	24.00	37.00	54.00	72.00	19.00	18.01	5.21	27.50	24.07	12.49
VF13	33.00	50.00	71.00	92.00	20.00	19.28	3.58	29.00	25.77	11.15
VB14	17.00	25.00	36.00	47.00	16.00	15.53	2.91	21.00	20.76	1.17
VD14	25.00	37.00	53.00	68.00	18.00	17.22	4.31	23.50	23.01	2.07
VF14	33.00	49.00	70.00	88.00	19.00	18.53	2.46	25.00	24.76	0.95
VB16	7.00	12.00	17.00	22.00	7.00	6.29	10.17	9.00	8.40	6.65
VD16	12.00	18.00	25.00	32.00	7.50	6.79	9.42	10.00	9.08	9.23
VF16	16.00	25.00	34.00	43.00	8.50	7.49	11.89	11.50	10.01	12.98

Table D.8 ADINA Deflection Vs. Experimental For Load Case # 8

Load Case # 8					Load = 10,492 N			Load = 14,145 N		
Dial Gage I.D	6100 N	9000 N	12000 N	15800 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -2	% Of Error
VB2	15.00	24.00	34.00	45.00	16.00	14.01	12.44	21.50	18.89	12.14
VD2	9.00	16.00	23.00	30.00	10.00	9.37	6.30	13.50	12.63	6.44
VB4	18.00	43.00	72.00	99.00	36.00	34.24	4.89	52.00	46.16	11.23
VD4	11.00	32.00	50.00	66.00	25.00	24.31	2.76	33.00	32.77	0.70
VF4	14.00	21.00	29.00	39.00	15.00	13.94	7.07	20.00	18.80	6.00
VB5	22.00	49.00	76.00	105.00	40.00	38.21	4.47	58.00	51.51	11.19
VF5	12.00	22.00	28.00	38.00	14.00	12.72	9.14	19.00	18.50	2.63
VB13	23.00	51.00	79.00	108.00	43.00	38.21	11.14	61.00	51.51	15.56
VD13	18.00	37.00	55.00	71.00	30.00	26.28	12.40	38.00	35.43	6.76
VF13	12.00	23.00	30.00	40.00	16.00	13.72	14.25	21.00	18.50	11.90
VB14	21.00	43.00	71.00	94.00	35.00	34.24	2.17	47.00	46.16	1.79
VD14	15.00	33.00	50.00	66.00	25.00	24.31	2.76	33.00	32.77	0.70
VF14	13.00	20.00	28.00	38.00	14.00	13.94	0.43	19.00	18.80	1.05
VB16	11.00	22.00	34.00	44.00	16.00	14.01	12.44	20.50	18.89	7.85
VD16	12.00	17.00	23.00	30.00	10.00	9.37	6.30	13.50	12.63	6.44

Table D.9 ADINA Deflection Vs. Experimental For Load Case # 9

Load Case # 9					Load = 13,182 N			Load = 18,527 N		
Dial Gage I.D	7,176 N	9,455 N	13,182 N	18,527 N	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -	% Of Error	Adjusted Experimental Deflection mmx10^ -2	ADINA Deflection mmx10^ -	% Of Error
VB2	21.00	29.00	38.00	52.00	15.50	12.66	18.32	19.00	17.79	6.37
VD2	15.00	21.00	29.00	41.00	12.00	10.06	16.14	16.00	14.14	11.62
VB4	44.00	60.00	78.00	109.00	33.00	30.97	6.17	44.00	43.52	1.09
VD4	34.00	48.00	62.00	88.00	28.00	25.77	7.97	38.00	36.22	4 69
VF4	23.00	33.00	46.00	64.00	23.00	20.04	12.86	30.00	28.17	6.11
VB5	48.00	64.00	85.00	115.00	40.00	33.78	15.55	50.00	47.48	5.05
VF5	25.00	35.00	46.00	65.00	23.00	20.24	12.01	31.00	28.44	8.25
VB13	51.00	66.00	88.00	118.00	43.00	36.38	15.40	53.00	51.13	3.53
VD13	42.00	54.00	70.00	97.00	36.00	30.27	15.92	47.00	42.54	9.49
VF13	29.00	38.00	51.00	68.00	28.00	23.36	16.58	34.00	32.83	3.45
VB14	44.00	56.00	80.00	113.00	35.00	33.34	4.76	48.00	46.85	2.39
VD14	38.00	47.00	64.00	92.00	30.00	28.36	5.48	42.00	39.85	5.11
VF14	27.00	36.00	50.00	69.00	27.00	22.84	15.42	35.00	32.10	8.29
VB16	21.00	28.00	40.00	53.00	17.50	13.56	22.50	20.00	19.06	4.70
VD16	18.00	24.00	33.00	43.00	16.00	11.03	31.08	18.00	15.50	13 89
VF16	13.00	17.00	22.00	32.00	10.50	8.76	16.59	15.00	12.31	17 94

Table D.10 ADINA Stresses Vs Experimental For Load Case # 1

Strain Gage I.D	ADINA Stress @ 20,276 N	Experimental Stress @ 6,123 N	Experimental Stress @ 20,276 N	% Of Error	Experimental Stress @ 8,384 N	Experimental Stress @ 20,276 N	% Of Error
CL14	-4.875	-1.132	-3.749	23.1	-1.441	-3.485	28.5
CL24	-4.221	-0.960	-3.179	24.7	-1.338	-3.236	23.3
CL34	-4.671	-1.063	-3.520	24.6	-1.372	-3.318	29.0
AL14	-9.462	-3.342	-11.066	-16.9	-4.479	-10.832	-14.5
AL24	12.764	3.911	12.949	-1.4	4.906	11.865	7.0
AL34	-7.203	-2.213	-7.329	-1.7	-3.166	-7.657	-6.3
AL54	10.558	3.626	12.007	-13.7	4.906	11.865	-12.4
AL64	6.607	2.275	7.534	-14.0	3.057	7.393	-11.9
AL74	-9.253	-2.844	-9.418	-1.8	-3.839	-9.284	-0.3
AL114	-7.708	-2.630	-8.709	-13.0	-3.627	-8.772	-13.8
AL15	-10.887	-4.076	-13.496	-24.0	-5.855	-14.160	-30.1
AL25	-11.199	-3.250	-10.763	3.9	-4.561	-11.030	1.5
AL35	-8.670	-2.963	-9.812	-13.2	-4.020	-9.722	-12.1
AL65	11.924	3.176	10.517	11.8	4.611	11.151	6.5
AL75	-10.025	-2.561	-8.481	15.4	-3.706	-8.963	10.6

Table D.11 ADINA Stresses Vs Experimental For Load Case # 2

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 8,642 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 13,476 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-9.280	-1.544	-7.245	21.9	-2.367	-7.123	23.2
CL24	-9.369	-1.578	-7.405	21.0	-2.470	-7.433	20.7
CL34	-9.367	-1.646	-7.724	17.5	-2.504	-7.535	19.6
AL14	-16.715	-6.044	-28.361	-69.7	-8.959	-26.959	-61.3
AL24	17.372	3.413	16.015	7.8	5.119	15.404	11.3
AL34	-16.849	-4.262	-19.999	-18.7	-6.269	-18.865	-12.0
AL54	21.183	5.532	25.959	-22.5	8.374	25.199	-19.0
AL64	14.075	3.493	16.391	-16.5	5.312	15.985	-13.6
AL74	-19.281	-4.622	-21.688	-12.5	-6.755	-20.327	-5.4
AL114	-18.727	-4.579	-21.487	-14.7	-7.016	-21.113	-12.7
AL15	-20.156	-6.660	-31.252	-55.0	-8.908	-26.806	-33.0
AL25	26.196	4.875	22.876	12.7	6.790	20.432	22.0
AL35	-21.183	-4.879	-22.894	-8.1	-6.392	-19.235	9.2
AL65	27.218	7.099	33.312	-22.4	9.593	28.867	-6.1
AL75	-21.633	-4.764	-22.355	-3.3	-6.860	-20.643	4.6

Table D.12 ADINA Stresses Vs Experimental For Load Case # 3

Strain Gage I.D	ADINA Stress @ 60,828 N	Experimental Stress @ 20,730 N	Experimental Stress @ 60,828 N	% Of Error	Experimental Stress @ 27,799 N	Experimental Stress @ 60,828 N	% Of Error
CL14	-8.375	-2.675	-7.849	6.3	-3.636	-7.956	5.0
CL24	-8.452	-2.710	-7.952	5.9	-3.700	-8.096	4.2
CL34	-8.457	-2.744	-8.052	4.8	-3.670	-8.030	5.0
AL14	-14.954	-6.541	-19.193	-28.4	-8.674	-18.980	-26.9
AL24	15.632	4.835	14.187	9.2	6.897	15.092	3.5
AL34	-15.091	-4.761	-13.970	7.4	-6.985	-15.284	-1.3
AL54	N.A	N.A	N.A	N.A	N.A	N.A	N.A
AL64	12.092	5.048	14.812	-22.5	6.612	14.468	-19.6
AL74	-17.433	-5.688	-16.690	4.3	-7.892	-17.269	0.9
AL114	-16.913	-6.354	-18.645	-10.2	-8.632	-18.888	-11.7
AL15	-16.038	-6.984	-20.493	-27.8	-9.339	-20.435	-27.4
AL35	-18.642	-5.604	-16.444	11.8	-7.511	-16.435	11.8
AL65	23.892	7.439	21.828	8.6	10.512	23.002	3.7
AL75	-19.094	-8.223	-24.129	-26.4	-10.240	-22.407	-17.4

Table D.13 ADINA Stresses Vs Experimental For Load Case # 4

Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 20,356 N	Experimental Stress @ 81,104 N	% Of Error	Experimental Stress @ 25,428 N	Experimental Stress @ 81,104 N	% Of Error
CL14	-7.541	-1.715	-6.833	9.4	-2.195	-7.001	7.2
CL24	-7.627	-1.784	-7.108	6.8	-2.264	-7.221	5.3
CL34	-7.627	-1.749	-6.969	8.6	-2.230	-7.113	6.7
AL14	-13.315	-4.053	-16.148	-21.3	-4.977	-15.874	-19.2
AL24	14.009	3.555	14.164	-1.1	4.479	14.286	-2.0
AL34	-13.492	-3.035	-12.092	10.4	-3.894	-12.420	7.9
AL54	18.464	5.830	23.228	-25.8	7.039	22.451	-21.6
AL64	10.856	3.342	13.315	-22.7	4.053	12.927	-19.1
AL74	-15.773	-3.342	-13.315	15.6	-4.266	-13.607	13.7
AL114	-15.308	-3.970	-15.818	-3.3	-4.957	-15.811	-3.3
AL15	-15.399	-4.613	-18.379	-19.4	-5.533	-17.648	-14.6
AL35	-16.382	-3.381	-13.471	17.8	-4.282	-13.658	16.6
AL65	15.505	4.467	17.798	-14.8	5.644	18.002	-16.1
AL75	-18.573	-6.206	-24.726	-33.1	-7.269	-23.185	-24.8

Table D.14 ADINA Stresses Vs Experimental For Load Case # 5

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 7,384 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 14,120 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-4.176	-0.689	-3.784	9.4	-1.283	-3.685	11.8
CL24	-3.295	-0.626	-3.438	-4.3	-1.064	-3.056	7.3
CL34	-3.761	N.A	N.A	N.A	N.A	N.A	N.A
AL14	-7.721	-1.564	-8.589	-11.2	-2.986	-8.576	-11.1
AL24	10.503	1.778	9.765	7.0	3.271	9.394	10.6
AL34	-6.028	-1.191	-6.541	-8.5	-2.239	-6.430	-6.7
AL54	9.345	2.133	11.714	-25.4	4.053	11.640	-24.6
AL64	4.685	0.995	5.464	-16.6	1.849	5.310	-13.3
AL74	-7.405	-1.422	-7.809	-5.5	-2.275	-6.534	11.8
AL114	-6.486	-1.245	-6.837	-5.4	-2.486	-7.140	-10.1
AL15	-9.188	-1.976	-10.852	-18.1	-3.637	-10.445	-13.7
AL25	11.690	2.099	11.527	1.4	3.235	9.291	20.5
AL35	-6.951	-1.022	-5.613	19.3	-2.140	-6.146	11.6
AL65	6.430	1.139	6.255	2.7	2.231	6.407	0.4
AL75	-8.345	-1.644	-9.029	-8.2	-2.908	-8.352	-0.1

Table D.15 ADINA Stresses Vs Experimental For Load Case # 6

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 10,843 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 14,727 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-3.365	-0.823	-3.078	8.5	-1.098	-3.023	10.2
CL24	-4.318	-1.201	-4.492	-4.0	-1.544	-4.252	1.5
CL34	-3.865	-0.926	-3.463	10.4	-1.338	-3.684	4.7
AL14	-5.594	-1.706	-6.380	-14.1	-2.275	-6.264	-12.0
AL24	8.192	2.204	8.243	-0.6	2.506	6.900	15.8
AL34	-4.927	-1.438	-5.378	-9.2	-2.031	-5.593	-13.5
AL54	10.879	3.413	12.764	-17.3	4.835	13.314	-22.4
AL64	6.450	2.062	7.712	-19.6	2.773	7.636	-18.4
AL74	-8.368	-2.062	-7.712	7.8	-2.702	-7.440	11.1
AL114	-6.631	-2.166	-8.101	-22.2	-3.091	-8.511	-28.4
AL15	-6.213	-2.130	-7.966	-28.2	-2.804	-7.721	-24.3
AL25	-8.165	-1.897	-7.095	13.1	-2.320	-6.388	21.8
AL65	8.194	2.306	8.624	-5.2	3.289	9.057	-10.5
AL75	-10.227	-2.886	-10.793	-5.5	-3.766	-10.370	-1.4

Table D.16 ADINA Stresses Vs Experimental For Load Case # 7

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 9,008 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 12,036 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-3.314	-0.995	-4.479	-35.1	-1.269	-4.276	-29.0
CL24	-4.276	-1.269	-5.713	-33.6	-1.681	-5.664	-32.4
CL34	-3.816	-1.066	-4.799	-25.7	-1.338	-4.508	-18.1
AL14	-5.467	-1.564	-7.041	-28.8	-1.920	-6.469	-18.3
AL24	8.061	2.560	11.525	-43.0	3.200	10.782	-33.7
AL34	-4.772	-1.226	-5.519	-15.7	-1.610	-5.424	-13.7
AL54	10.812	2.986	13.442	-24.3	3.911	13.177	-21.9
AL64	6.123	1.778	8.004	-30.7	2.346	7.904	-29.1
AL74	-8.321	-2.489	-11.205	-34.7	-3.413	-11.499	-38.2
AL114	-6.536	-1.792	-8.067	-23.4	-2.372	-7.992	-22.3
AL15	-5.156	-1.491	-6.712	-30.2	-1.912	-6.443	-25.0
AL25	7.870	2.630	11.840	-50.4	3.030	10.209	-29.7
AL35	-7.161	-1.789	-8.054	-12.5	-2.356	-7.938	-10.9
AL65	12.253	3.440	15.486	-26.4	4.250	14.319	-16.9
AL75	-10.185	-4.111	-18.507	-81.7	-4.111	-13.851	-36.0

Table D.17 ADINA Stresses Vs Experimental For Load Case # 8

Strain Gage I.D	ADINA Stress @ 40,552 N	Experimental Stress @ 7,491 N	Experimental Stress @ 40,552 N	% Of Error	Experimental Stress @ 10,144 N	Experimental Stress @ 40,552 N	% Of Error
CL14	-4.227	-0.926	-5.013	-18.6	-1.235	-4.937	-16.8
CL24	-3.364	-0.789	-4.271	-27.0	-1.029	-4.114	-22.3
CL34	-3.815	-0.926	-5.013	-31.4	-1.201	-4.801	-25.9
AL14	-8.042	-1.706	-9.235	-14.8	-2.295	-9.175	-14.1
AL24	8.061	1.422	7.698	4.5	1.849	7.392	8.3
AL34	-8.925	-1.864	-10.091	-13.1	-2.279	-9.111	-2.1
AL54	9.443	2.133	11.547	-22.3	2.773	11.085	-17.4
AL64	7.788	1.778	9.625	-23.6	2.204	8.811	-13.1
AL74	-7.560	-1.493	-8.082	-6.9	-1.920	-7.675	-1.5
AL114	-9.031	-2.071	-11.211	-24.1	-2.655	-10.614	-17.5
AL15	-9.181	-2.125	-11.504	-25.3	-2.838	-11.345	-23.6
AL25	12.977	2.830	15.320	-18.1	3.412	13.640	-5.1
AL35	-9.451	-1.792	-9.701	-2.6	-2.322	-9.283	1.8
AL65	10.233	2.316	12.538	-22.5	3.031	12.117	-18.4
AL75	-8.583	-2.133	-11.547	-34.5	-2.695	-10.774	-25.5

Table D.18 ADINA Stresses Vs Experimental For Load Case # 9

Strain Gage I.D	ADINA Stress @ 81,104 N	Experimental Stress @ 18,527 N	Experimental Stress @ 81,104 N	% Of Error
CL14	-7.035	-1.681	-7.359	-4.6
CL24	-7.041	-1.749	-7.656	-8.7
CL34	-7.079	N.A	N.A	N.A
AL14	-12.111	-3.271	-14.319	-18.2
AL24	13.068	2.986	13.072	0.0
AL34	-12.991	-3.579	-15.667	-20.6
AL54	12.991	3.626	15.873	-22.2
AL64	10.073	2.631	11.517	-14.3
AL74	-14.626	-3.342	-14.630	0.0
AL114	-14.396	-3.982	-17.432	-21.1
AL15	-12.573	-3.456	-15.129	-20.3
AL25	20.537	5.132	22.466	-9.4
AL35	-15.495	-3.791	-16.596	-7.1
AL65	20.810	4.973	21.770	-4.6
AL75	-16.675	-4.533	-19.844	-19.0