A PERFORMANCE ANALYSIS OF THE HI-PLAN STRUCTURAL APPARATUS

by

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ABSTRACT

Visual experience is a powerful pedagogic tool. Extensive use of experimental studies prior to design and construction has made conceptualization of complex structures possible. Experiments on reduced-scale structures and specimens are also vital tools for teaching structural mechanics. As such, the Department of Civil Engineering at Virginia Tech has acquired a new apparatus for use as an educational demonstration tool in the area of structural mechanics. This work presents the results of a detailed study on the performance of this device as related to its accuracy and operation.

To fulfill such objectives, two structural models (a continuous beam and a portal frame) were extensively tested under several loading and support configurations. The models were analysed using STRUDL as well as a computer program developed by the author. The comparison of the results (deformations) obtained in the two phases of the study have indicated that the apparatus is reasonably accurate to meet the requirements of a structural teaching model and adapting to a variety of structural models.

ACKNOWLEDGEMENT

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Special thanks are extended to my parents and parents in-law for their support and help, which will always be remembered.

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CHAPTER I

INTRODUCTION

1.1 Modeling in Structural Engineering

The use of small-scale models by engineers and builders dates back many years. However, these early models were primarily aids for planning and constructing structures rather than a tool for predicting deformations and strength of full scale structure. The development of modeling as a practical tool for design and prediction of prototype's performance has been sharply influenced by advancement in area of experimental stress analysis techniques and introduction of measuring devices such as electrical resistance strain gages, linear variable differential transformers (LVDT), brittle and photelastic coatings and automated data acquisition systems.

Structural models can be defined and classified in a variety of ways. One is according to their intended function, such as strength model that is used to predict behavior of a prototype for all loads up to failure. Such a classification is presented in a text written by G.M. Sabnis, (5).

The type of model that is the concern of this thesis is an instructional or educational model that is used primarily as a complement to a mathematical model.

1.2 Educational Modeling

Barry Hilson in his book Basic Structural Behavior Via Models (2) says, "The concept of structural testing should be presented to the students at an early stage of their course of study so that they may freely apply their imagination and initiative without being too influenced by standard solutions to the problems."

Several other scholars in this field have emphasized the necessity of structural testing as a supplement to the more traditional subjects of theory and design of structures. But cost and availability of space for such a facility is usually a major problem in today's schools of engineering.

Unlike the apparatus used for research activities with a high degree of precision which usually requires a large amount of capital investment, educational model testing equipment should be very simple. This is for two main reasons: (1) no great skill will be necessary in manufacturing the models, (2) the observation and testing will be easier. Such equipment should be accurate enough to demonstrate the different aspects of the concept under study. Therefore similitude distortion that does not markedly influence the desired behavior of the system is usually permissible.

The apparatus used during the course of this study satisfies such requirments, since it is a portable rigid stand that occupies very small space in the laboratory and serves as a universal base for variety of structural experiments. The testing models are easy to manufacture and testing arrangements are very simple to assemble.

1.3 Investigation Goals

The objective of this study is to provide a detailed description on the performance of a new apparatus purchased by the Department of Civil Engineering at Virginia Tech for use as an educational demonstration tool in the area of structural mechanics.

To familiarize the reader with the equipment, Chapter II provides a detailed description of the apparatus and its different fixtures. This chapter contains several pictures which should clarify the assembly process of the testing arrangements. Chapter III explains the testing procedures of several experiments that have been performed.

A FORTRAN computer program has been developed in order to have a quick way of checking the accuracy of experimental results. This program is capable of solving several beam bending problems. In Chapter IV the structural development of this program is presented.

Chapter V provides a brief discussion of the experimental results obtained and their differences with theoretical values. This section draws attention to possible sources of errors involved and in general terms presents the experience the author gained during experimental work with this apparatus. Finally Chapter VI contains the conclusion of this study. Appendixes include tabulated theoretical and experimental results, figures of testing arrangements, samples of hand calculated problems, and a listing of computer programs used for this study.

CHAPTER II

TESTING EQUIPMENT

2.1 Introduction

The major piece of equipment used for experimental testing was a portable rigid frame which served as a foundation for a variety of structural model testing. This frame, structural testing models, and several other related accessaries all have been designed and manufactured by Hi-Tech LTD, of England. The different sets of fixtures designed to be used with this frame for different structural experiments are all standardized and mostly multifunctional which gives a high degree of versatility to the system. For example, the dial gage assembly is so adaptable that it can be used at any point of the structure to monitor the deformation in any desired direction. Also, the apparatus is so simple that additional parts or models can be fabricated in case of future needs with very little cost. A brief description of different parts of the apparatus and their application in experimental work are presented in this chapter. The names used for the parts in the following discussion are according to the manufacturer's catalog (8).

2.2 Universal Frame and Stand

The apparatus shown in Figure 2.1 is an assemblage of two parallel rectangular frames 1.22 m wide by 0.76 m high. It is fabricated from 40 mm square heavy gage mild steel tubing clamped together with four aluminum corner blocks. These frames are bolted to a stand constructed of 25 mm square mild steel tubing with a shelf fitted over the two lower struts and standing on four adjustable mounting feet.

2.3 Model Beam and Its Fixtures

The beam specimen is a mild steel bar 1.21 m long with a rectangular cross section 25 mm wide and 5 mm thick.

The supports for the beam during experimental work are provided by end support brackets (Figure 2.2a) that are made of cast iron and act as rigid columns under the loaded beam. They can be fastened to the stand at any point for desired length of span or spans within the available length of the testing frame. Theoretical beam boundary conditions such as fixed or pin supports are simulated by specially designed devices on top of the end support brackets. These devices actually dictate the movement or degree of freedom of the beam under applied load at the resting point. Some of the devices that were used are as follows:

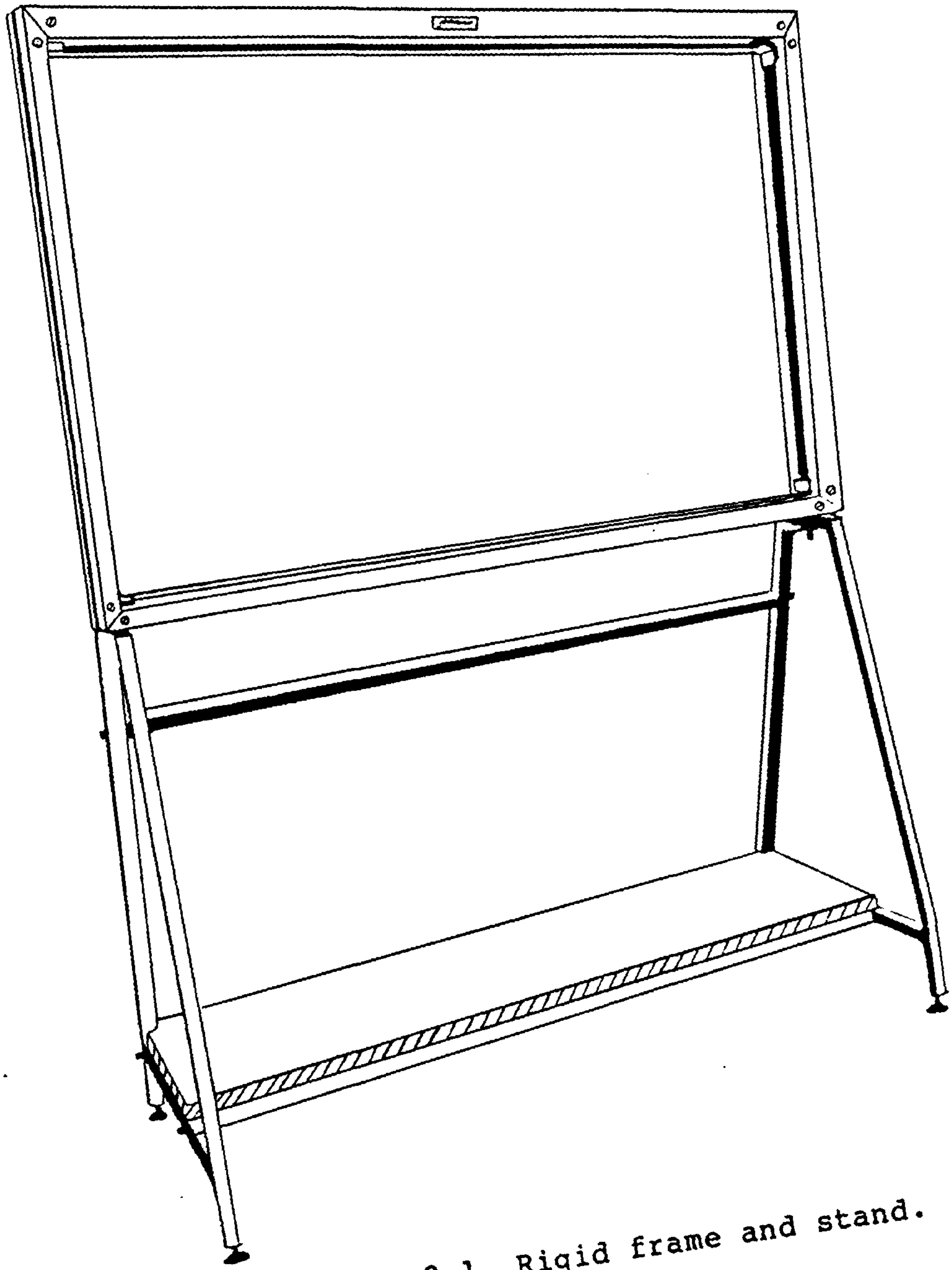
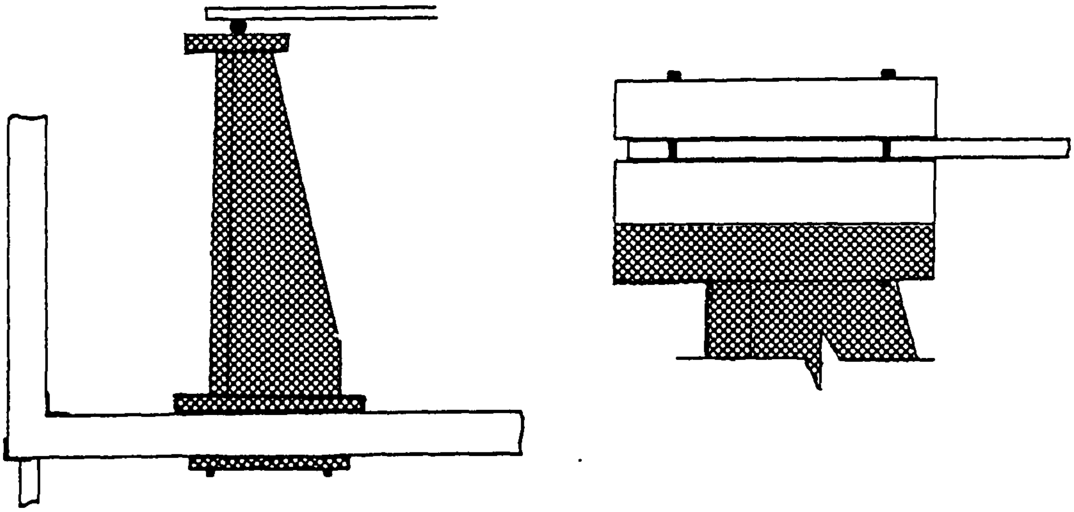
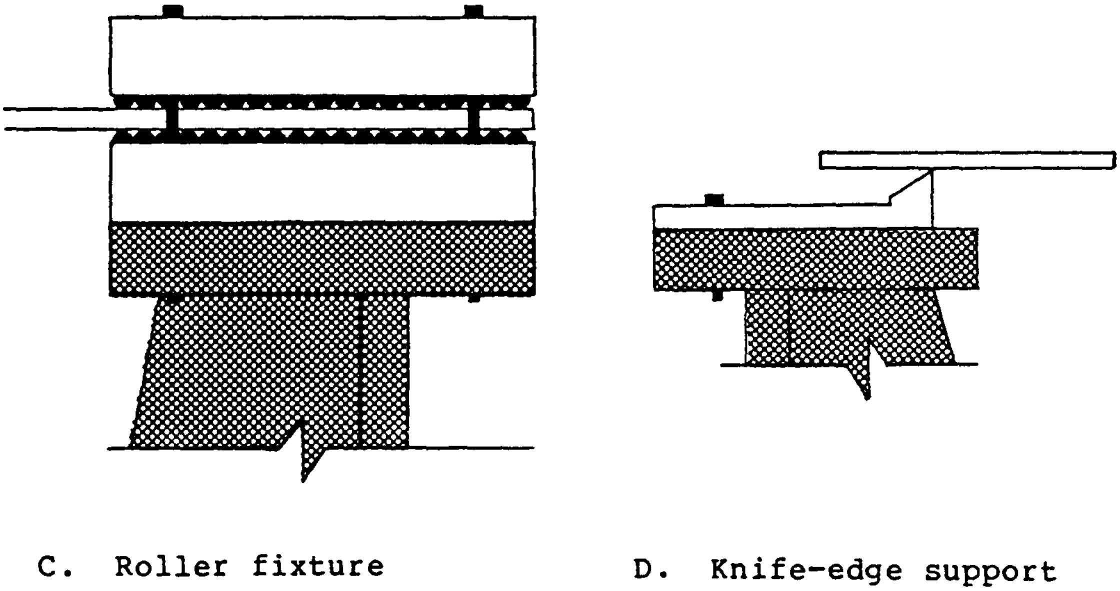


Fig. 2.1 Rigid frame and stand.



B. Clamp plate

A. End support bracket and roller



C. Roller fixture

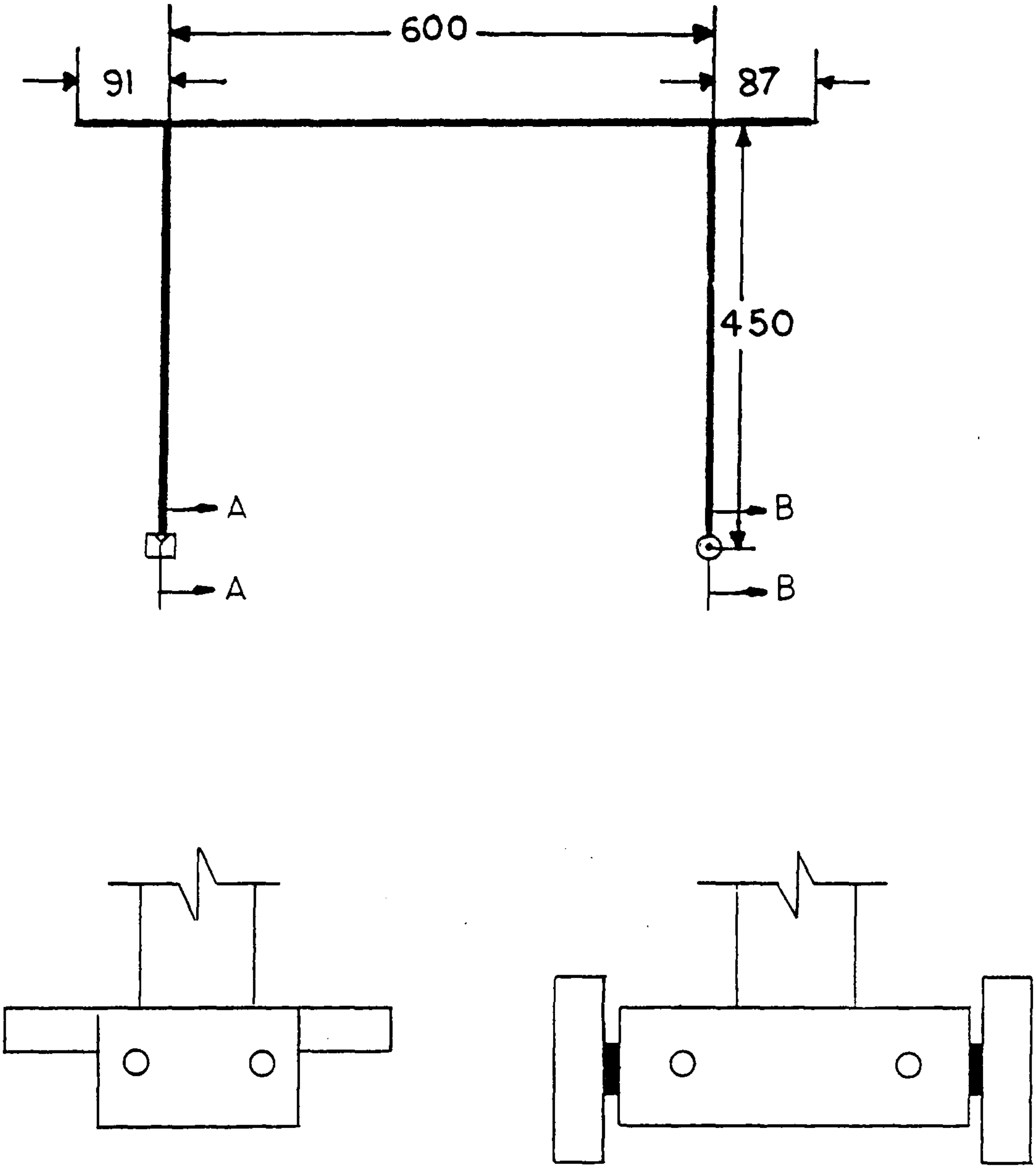
D. Knife-edge support

Fig. 2.2 Beam supporting fixtures

1. Clamped plate used as a built-in (fixed) support condition. It prevents any displacement or rotation of the beam at the supporting point (Figure 2.2b).
2. Roller fixture used as a built-in (fixed) support that allows the beam to move in an axial direction (Figure 2.2c).
3. Knife-edge and roller supports prevent the beam from moving in a vertical direction but allow rotation and movement in its axial direction (Figures 2.2d & 2.2a).

2.4 Model Frame and Its Fixtures

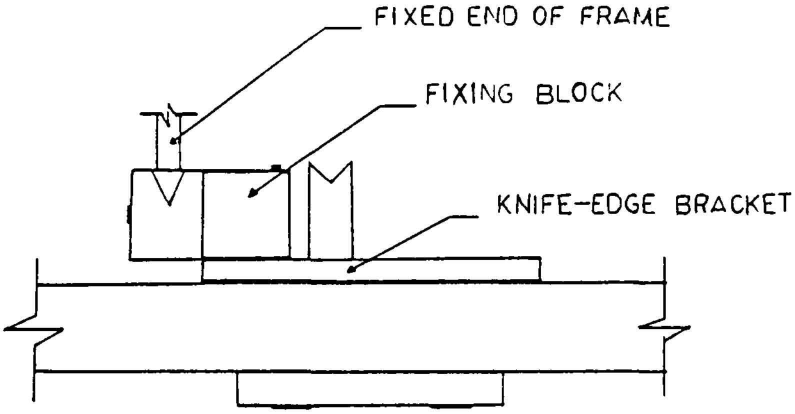
A single bay portal frame was used for experimental testing. It is fabricated from a mild steel 25 mm x 8 mm thick rectangular cross section with 450 mm vertical legs at 600 mm on center. The beam cantilevers 90 mm at each side (Figure 2.3). One end of the frame is welded to an aluminum block which can be used along with the knife-edge bracket as a fixed support (Figure 2.4a) or pin support (Figure 2.4b). The other end is connected to a pair of ball bearing wheels which allows this end to move freely in the horizontal direction on the ground track plate (Figure 2.5a). A hold down device (Figure 2.5b) and a fixing block (Figure 2.5C) were added to the system to be used on the end of the frame with the wheel. The hold down device is



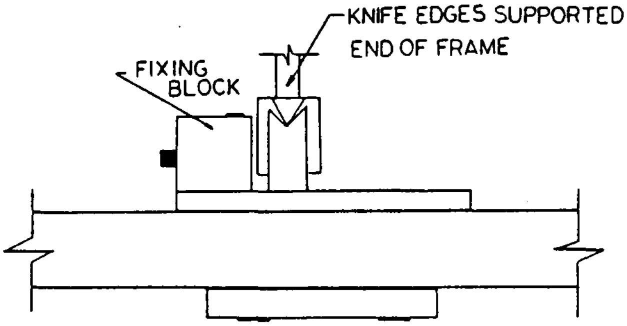
SECTION A-A

SECTION B-B

Fig. 2.3 Portal frame model (Unit = mm)

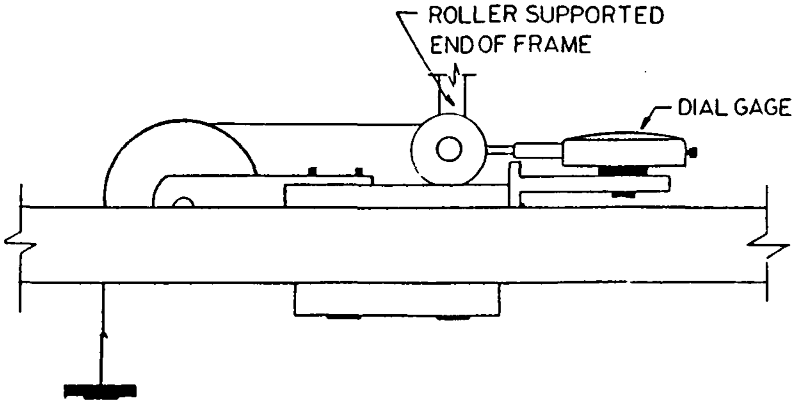


A. Fixed supported end of frame

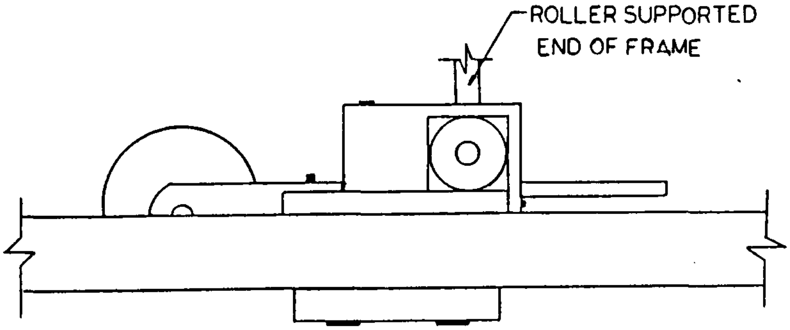


B. Pin supported end of frame

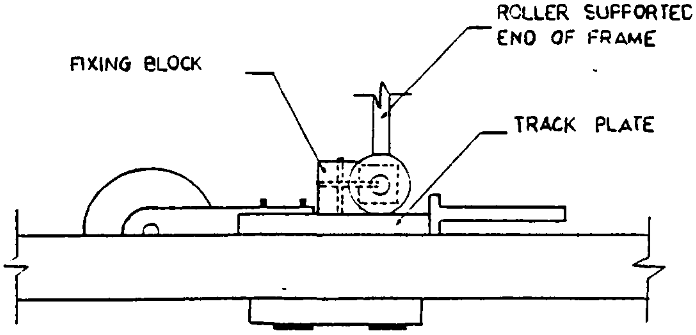
Fig. 2.4 Portal frame supporting fixtures



A. Roller supported end of frame



B. Pin supported end of frame



C. Fix supported end of frame

Fig. 2.5 Portal frame supporting fixtures to prevent horizontal movement of the wheels to simulate a pin support.

2.5 Loading System

2.5.1 Concentrated load.

Cast iron slotted weights were used as concentrated forces. They were applied to the structure by two types of devices. One is knife-edge rigid hangers for concentrated gravity force application and the other is knife-edge stirrup and cord for applying point loads virtually in any direction. This is done by passing the cord through a pulley bracket mounted on the stand. Figure 2.6 shows such a device when it is used to apply sideway load to the model frame.

2.5.2 Distributed loads.

A number of steel blocks all with approximately the same weight (5.048 gr) and dimensions (73 mm x 73 mm x 12mm) were available in the lab. These blocks approximate a uniformly distributed load when placed close together on the beam model structure (Figure 2.7a).

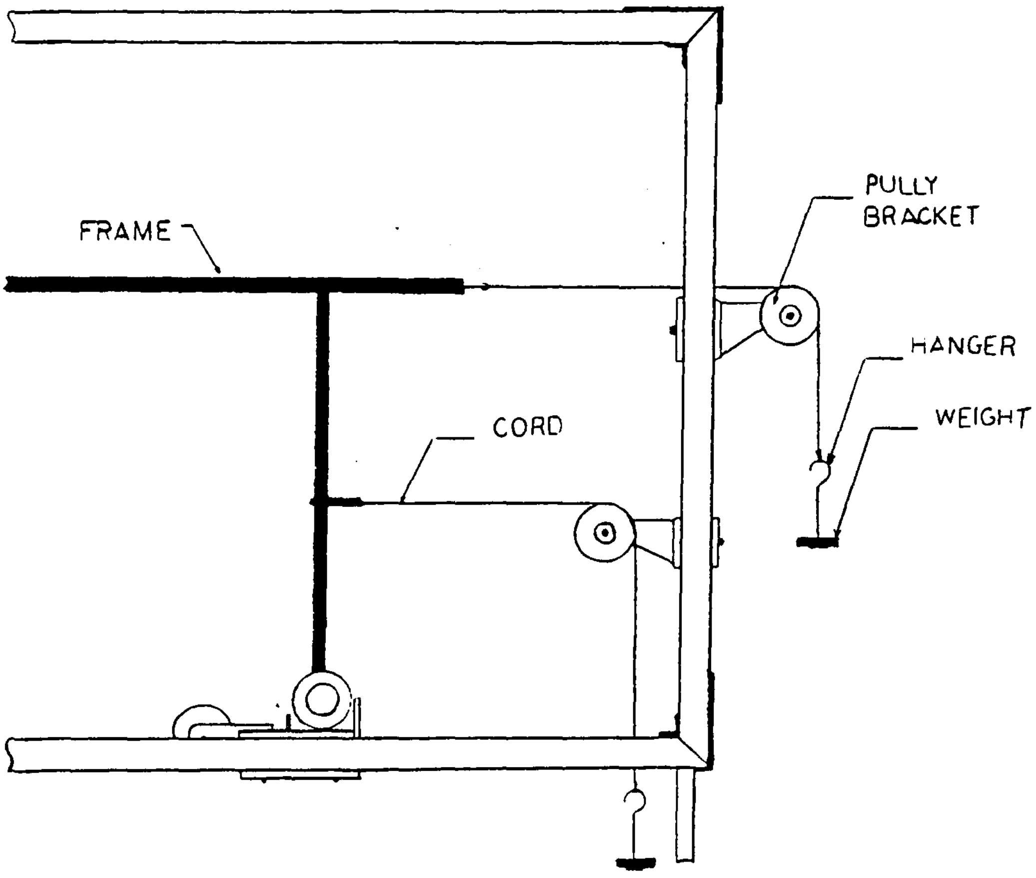
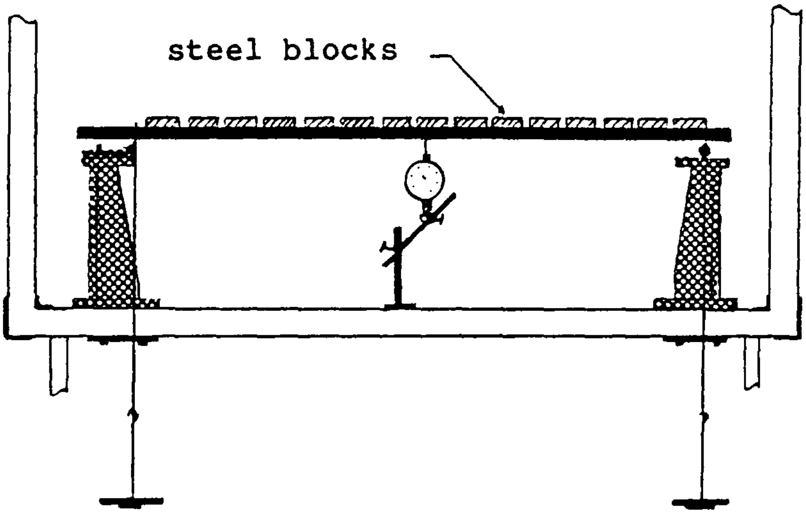
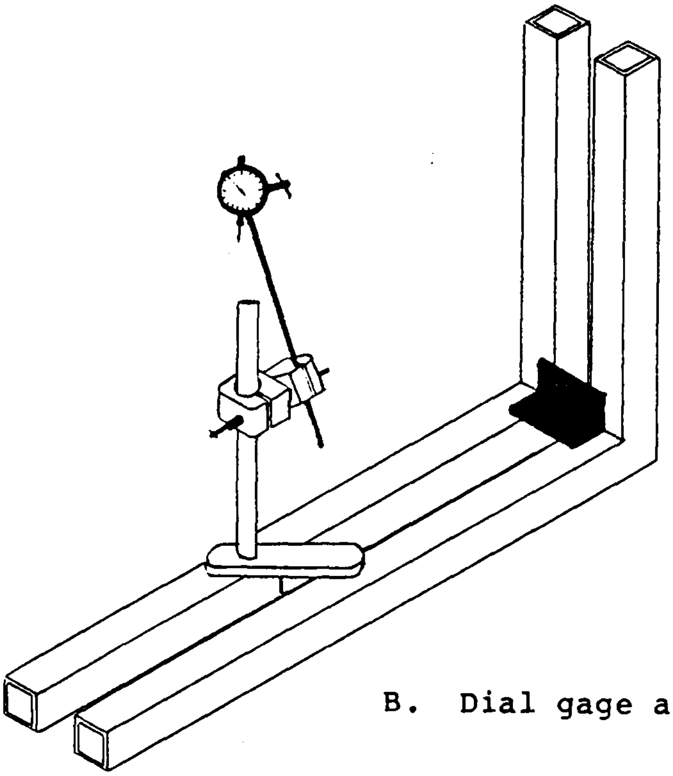


Fig. 2.6 Portal frame subjected to sidesway loading



A. Uniformly distributed loading



B. Dial gage assembly

Fig. 2.7 Loading and measuring devices

2.6 Measuring Device

Three mechanical dial gages were used to measure the deflection of the structures. All three are graduated in 0.01 mm increments. Two of the gages have 12 mm travel and the third one can measure movements up to 25 mm.

The gages are supported on an arm mounted to a rigid post by means of a clamp. The post is fastened to the universal frame by a base plate (Figure 2.7b). By adjusting the clamp and the base plate, direction and the position of the indicators can be changed easily along entire structure.

CHAPTER III

TESTING PROCEDURE

3.1 Introduction

The manufacturer's catalog (8) gives several figures showing set-ups for a variety of experimental tests, but it does not specify any particular testing procedure. To develop a testing technique, several separate tests were conducted on the beam and the frame. During testing, some of the components within the apparatus, particularly supporting fixtures, did not function as intended. Therefore, a few alterations were needed to improve the resulting data. In the following sections, the nature of such malfunctions are emphasized as well as improvements that were made on the apparatus. Due to similarity in testing procedures, just one typical case for each structural model is presented.

3.2 Beam Deflection

Case presented here is a two-span continuous beam fixed at both ends and resting on a roller at the middle (Figure 3.1).

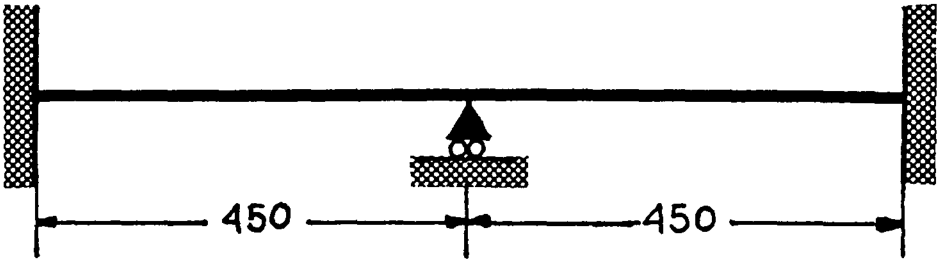


Fig 3.1 Two spans continuous beams (Unit - mm)

3.2.1 Set-up Procedure

Three support brackets were bolted to the rigid frame at equal distances. Beam was clamped to the brackets using clamp plate (Figure 2.2b) at one end and roller fixture (Figure 2.2c) at the other end. Due to the bowed shape of the beam, there was no contact between the beam and the cylindrical shaft used as roller support at the middle. When the beam was inverted, the shaft had to be forced in place at the middle. It was also observed during testing that the roller support can not assume a stable position and it is moving when the beam is subjected to load. To prevent such movement, some forces were applied at the support point to secure the position of the shaft. The technique used, is shown in Figure 3.2. Later on, this method had to be used in almost all experiments with the roller or knife-edge supports since some other problems such as uplifting of the beam at the end were observed. An example is shown in Figure 3.3. In the case under consideration, two dial gages were used to measure the deflection at two midspans of the beam.

3.2.2 Loading Technique

As suggested by the manufacturer, slotted cast iron weights were directly hung on the structure using knife-edge hangers as vertical concentrated forces. A difficulty encountered here was movement of the hangers

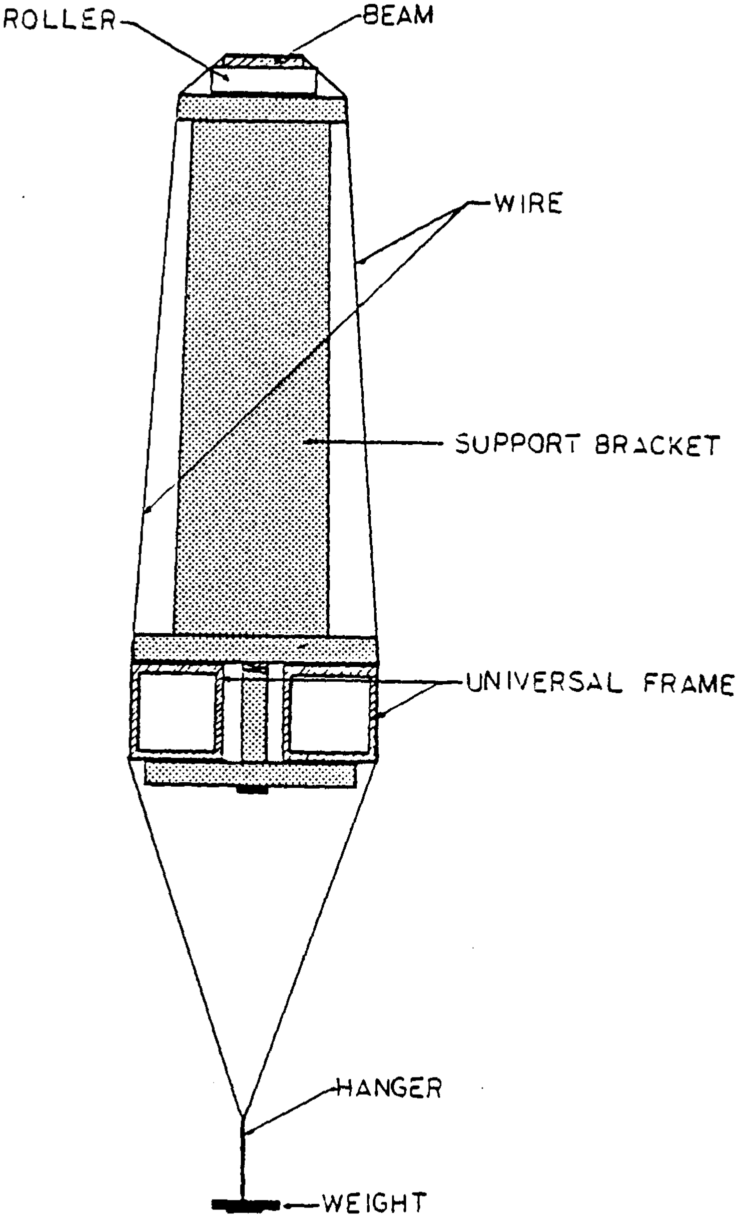
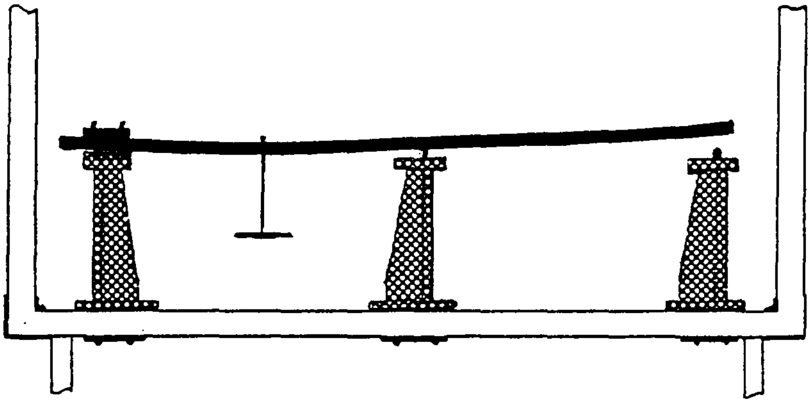
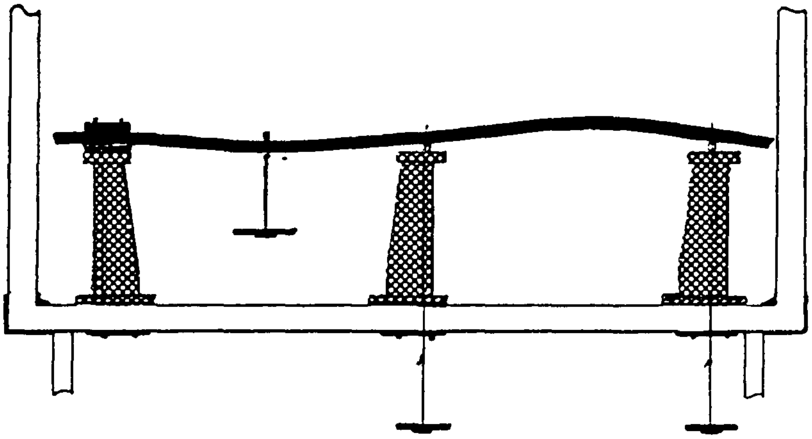


Fig. 3.2 Stablizing force technique



A. Uplift at one end



B. Method to prevent uplift

Fig. 3.3 Continuous beam test set-up

when the weights were placed or removed. This caused inconsistencies in dial gage readings because of the change in application point of the load. This was quite noticeable when dial gages were placed directly on the top of hangers to measure deflection at the loading point. More stable readings were taken when weights were applied indirectly, using a cord attached to the structure at the point of loading. This cord was passed through a double pulley mounted on the testing frame and loads were applied at the lower end of the cord (Figure 3.4).

This method caused less physical dislocation of the loading point. Since just one of these pulley brackets was available it could not be used for the cases with more than one concentrated force.

As mentioned in section 2.5.2, several steel blocks were available in the lab for use as uniformly distributed loads on the structures. These blocks were placed directly on the beam with equal distances between them. The length of these distances was dictated by the length of the beam and the maximum number of blocks that would cover the structure in one row. Besides the length limitation, these spaces between the blocks are necessary since contact between them would add to the rigidity of the structure and prevent the structure from free deformation. Each block was individually weighed, and their weight distribution is shown in Figure 3.5. Their mean value of 5.048 gr. was used in the theoretical analysis.

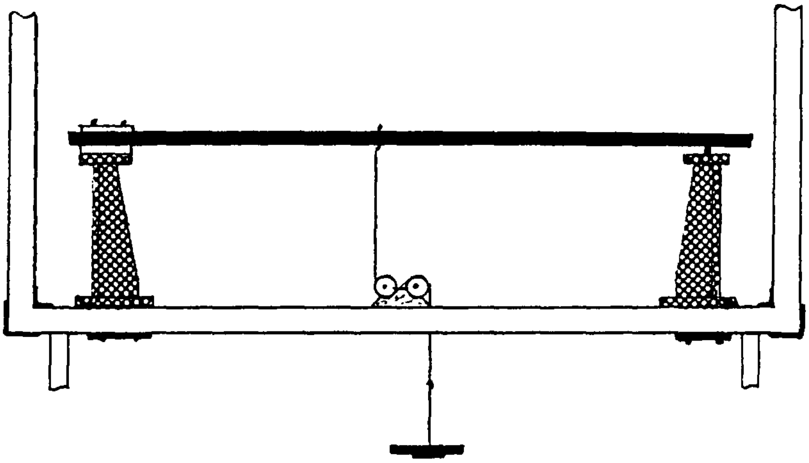


Fig. 3.4 Indirect application of concentrated force

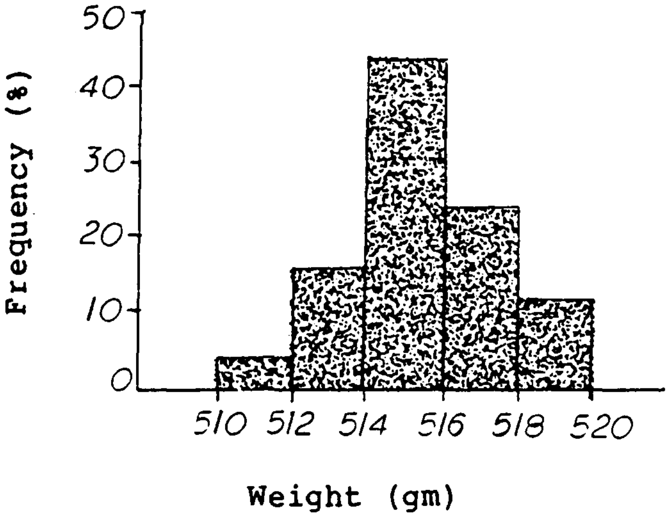


Fig. 3.5 Weight distribution histogram for steel blocks

3.2.3 Data Reading

Each experiment was repeated three times and readings were taken before and after the loads were applied. The difference between the two readings was recorded as deflection at those points. The average of three experimental tests was used as the final result.

Data for all of the tests on the beams are tabulated for each of the structural arrangements in Appendix A.

3.3 Elastic Deflection of Portal Frame

The case to be studied here is a typical portal frame supported on a knife-edge (pinned) at one end and standing on a roller at the other end (Figure 3.6).

3.3.1 Set-up Procedures

The frame was placed on two support fixtures, a knife-edge bracket of Figure 2.4b and a track plate assembly of Figure 2.5a which were mounted on the rigid frame. Due to manufacturing imperfection, the ball bearings on the roller end of the frame did not bear evenly on the track plate. A paper shim placed between the track plate and the rigid frame (Figure 3.7) corrected this problem. Three dial gages were used. One was placed on left end of the beam to measure the amount of sidesway that the frame undergoes. A second one was placed to measure

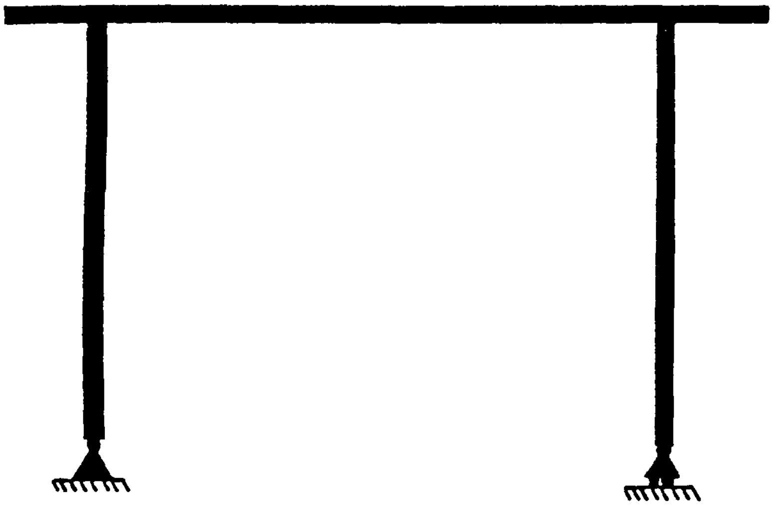


Fig. 3.6 Pin-Roller supported portal frame

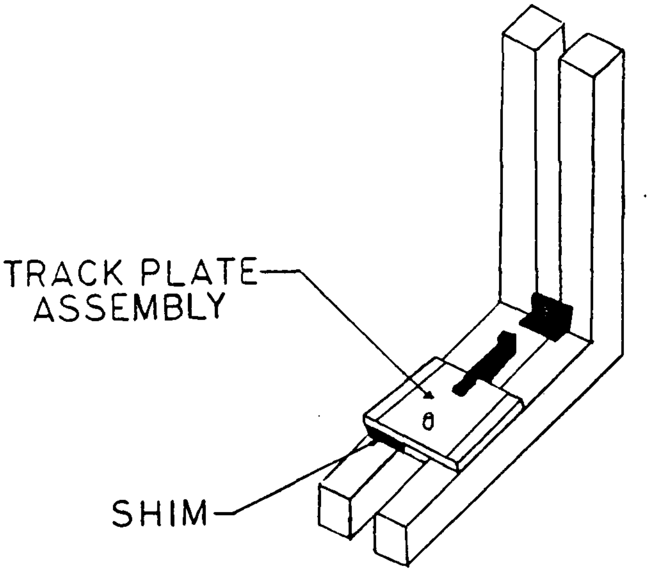


Fig. 3.7 Using shim to obtain even bearing on the support

the deflection of the beam at midspan and the third one was mounted on the track plate to measure the horizontal movement of the frame at the roller support.

3.3.2 Loading Technique

As in the case of the beam, cast iron weights and steel blocks were used as concentrated and uniformly distributed loads. Again a problem occurred when concentrated vertical forces were hung directly on the structure. The contact point between the hanger and the structure moved when the weights were placed and the effect was minimized if the loads were applied indirectly by a cord and pulley bracket. The end of the frame supported on knife-edge brackets lifted upward due to sidesway loads. A similar technique as for the beam was used here to hold the frame intact at its support without inducing any moment in the structure. The arrangement is shown in Figure 3.8.

3.3.3 Data Collection

Each experiment was performed three times and readings were taken before and after application of the forces. The difference of two readings in each experiment was recorded. The average of three test results was taken as the final experimental deflection value. The results of the several tests performed on the frame are presented in Appendix B in tabulated form.

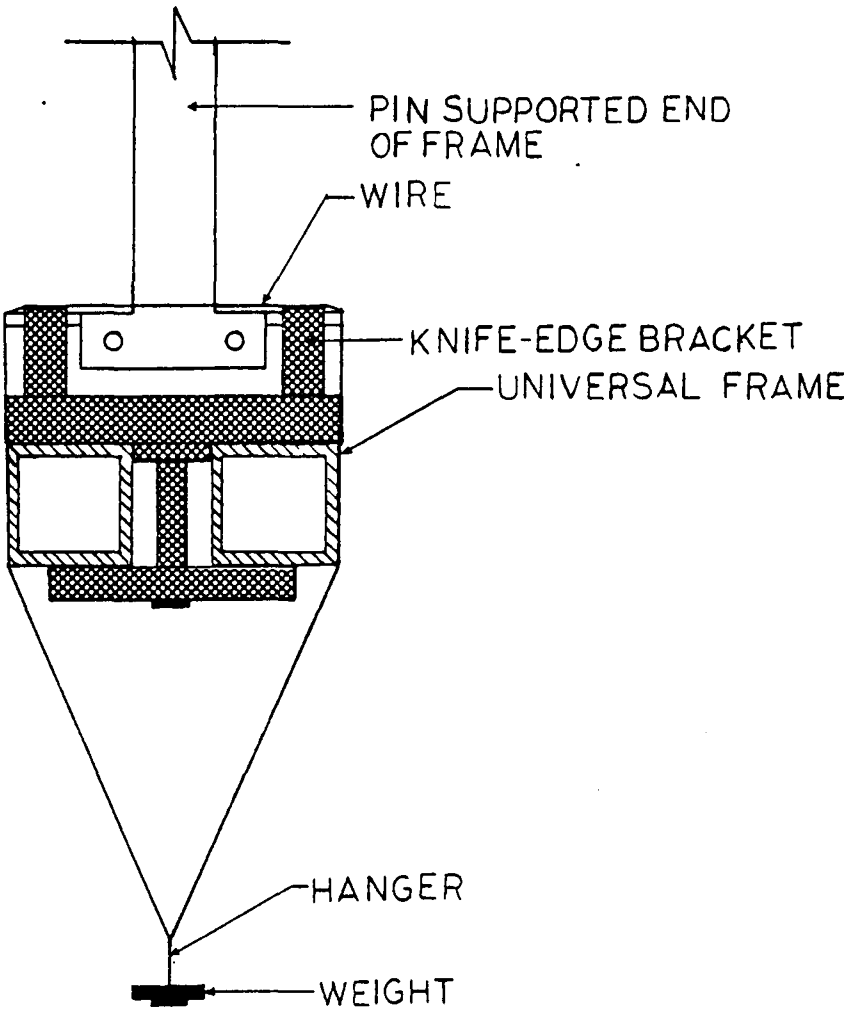


Fig. 3.8 Stablizing force to prevent uplifting of the frame

Two major problems were encountered during testing of the frame: first, poor degree of repeatability and second, relatively large lateral displacements. The main reason for the first was the friction between the ball bearings and the track plate assembly. The instruction manual (7) prepared by the manufacturer suggests adding some stablizing forces to the frame (without specifying any particular point on the frame) and tapping the apparatus to minimize the frictional effects. It was observed that adding such forces along with tapping of the apparatus lightly prior to taking any reading each time, improved the results to a certain degree.

The second problem is caused by the portal frame undergoing some side-sway due to any nonsymmetrical situation, whether this is a nonsymmetrical loading on a symmetrically supported frame or a symmetrical loading of a frame supported nonsymmetrically. Because the position of the dial gages are fixed, the dial indicator that is measuring vertical deflection of the beam is no longer at midspan of the beam after deformation. This was a major contributing factor to errors involved at those points.

CHAPTER IV

PROGRAM DEVELOPMENT

4.1 Introduction

In this chapter, the development of a computer program for the computation of reactions and deflections for a continuous beam with constant cross section is presented.

4.2 Theoretical Background

The computation is based on Clebsch's Method (1862) (4). This method gives an exact solution of the Euler-Bernoulli beam equation which exhibits clearly and concisely the contribution of different types of loading to the deflection curve. In addition to the name, Clebsch's method, the various related forms of this approach are often called singularity or step function methods.

4.3 Mathematical Presentation

Solution for the slope and deflection of an elastic beam with uniform cross section and subjected to sets of uniformly distributed loads $w_i (i = 1, 2, ..., n)$ and concentrated loads $P_j (j = 1, 2, ...,n)$ is readily obtained by direct integration of the Euler- Bernoulli equation if it is written as a continuous function of x in the form of:

$$EIy'' = M \qquad (4.1)$$

where:

$$M = H \langle x,a \rangle,\ f(x,a) \qquad (4.2)$$

$$H \langle x,a \rangle = \begin{matrix} 0 & \text{If } x \leq a \\ 1 & \text{If } x > a \end{matrix}$$

Also M is bending moment due to the different types of loading taken at any point of the beam, E is Young's modulus, and I is the moment of inertia of the cross section about the neutral axis.

Integrals of Equation (4.1) yield the slope and deflection curves while the differential of Equation (4.1), evaluated at any point on the beam gives the shear at that point.

$$EIy' = \int_0^x Mdx + C1 \qquad (4.3)$$

$$EIy = \int_0^x \int_0^x Mdx^2 + C1x + C2 \qquad (4.4)$$

$$EIy''' = V = dM/dx \qquad (4.5)$$

There are two constants of integration that can be evaluated by employing the beam's boundary conditions.

To illustrate the application of the above equations, the following example is presented. The case considered is a n-span beam with constant cross-section and fixed at both ends. It is subjected to k sets of uniformly distributed loads and m concentrated loads (Figure 4.1).

In the following equations L denotes the span length and subscript (j) refers to span number. The first span starts from left end of the beam. To be able to show the equations in general form and have a better analogy with the program, L with the subscript zero in all the following equations is zero.

Bending moment as a function of x is:

$$M = - M1(x)^{o} + \sum_{i=1}^{n} R_i H \langle x - \sum_{j=0}^{i-1} L_j \rangle (x - \sum_{j=0}^{i-1} L_j)$$

$$- \sum_{i=1}^{m} P_i H \langle x-a_i \rangle (x-a) -$$

$$\sum_{i=1}^{k} \frac{W_i}{2} H \langle x-b_i \rangle (x-b_i)^2 + \sum_{i=1}^{k} \frac{W_i}{2} \langle x-e_i \rangle (x - e_i)^2 \qquad (4.6)$$

By Equation (4.1)

$$EI \frac{d^2y}{dx^2} = -M1(x)^{o} + \sum_{i=1}^{n} R_i H \langle x- \sum_{j=0}^{i-1} L_j \rangle (x- \sum_{j=0}^{i-1} L_j) - \sum_{i=1}^{m} P_i H \langle x-a_i \rangle$$

$$(x-a_i) - \sum_{i=1}^{k} \frac{W_i}{2} H \langle x-b_i \rangle (x-b_i)^2 + \sum_{i=1}^{k} \frac{W_i}{2} \langle X-e_i \rangle (x-e_i)^2 \qquad (4.7)$$

First integration of Equation (4.7) gives the slope equation and by second integration the equation of deflected curve is obtained.

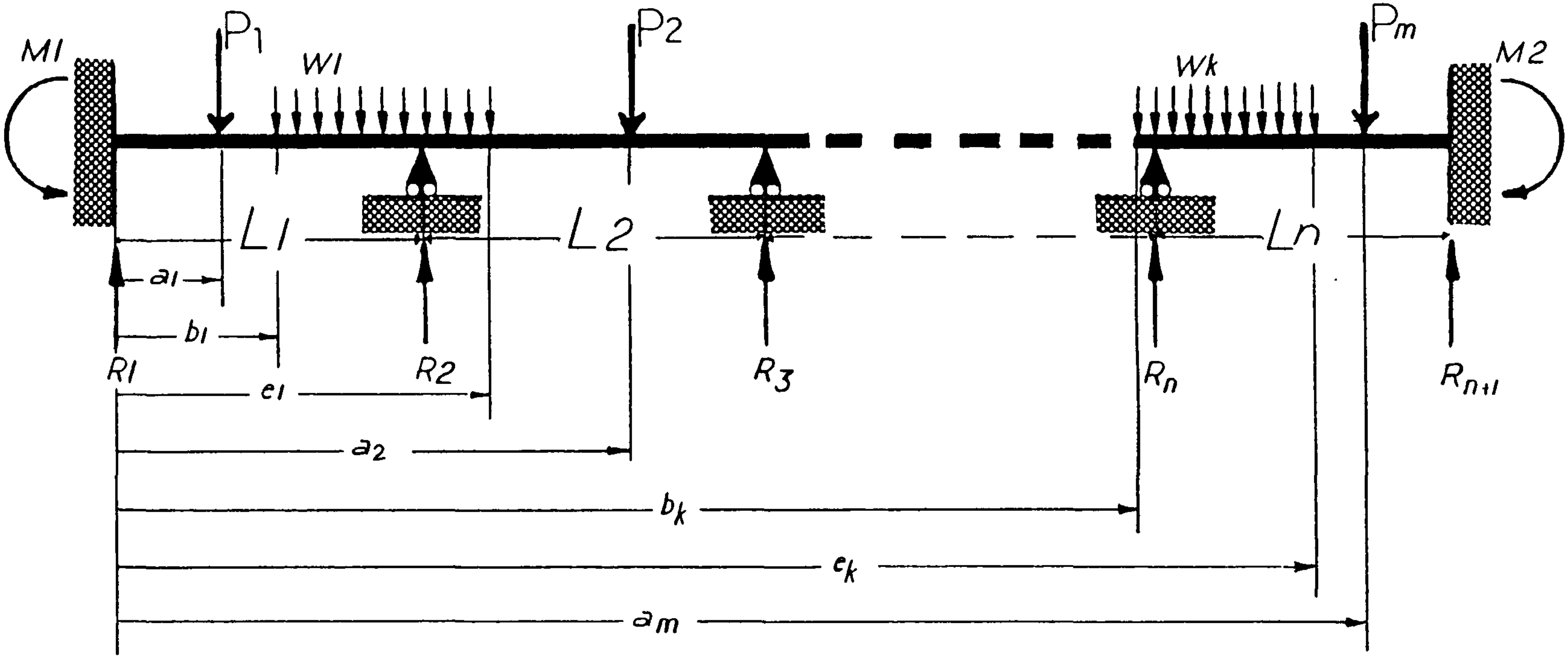


Fig. 4.1 n-spans continuous beam

$$EI\,\frac{dy}{dx} = -M1(x) + \sum_{i=1}^{n} \frac{R_i}{2}\, H\langle x-\sum_{j=0}^{i-1} L_j\rangle\left(x-\sum_{j=0}^{i-1} L_j\right)^2 - \sum_{i=1}^{m} \frac{P_i}{2}\, H\langle x-a_i\rangle(x-a_i)^2 - \sum_{i=1}^{k} \frac{W_i}{6}\, H\langle x-b_i\rangle(x-b_i)^3 + \sum_{i=1}^{k} \frac{W_i}{6}\, H\,\langle x-e_i\rangle(x-e_i)^3 + C1 \qquad (4.8)$$

$$EIy = -\frac{M1}{2}\,(x)^2 + \sum_{i=1}^{n} \frac{R_i}{6}\, H\langle x-\sum_{j=0}^{i-1} L_j\rangle\left(x-\sum_{j=0}^{i-1} L_j\right)^3 - \sum_{i=1}^{m} \frac{P_i}{6}\, H\langle x-a_i\rangle(x-a\ )^3 - \sum_{i=1}^{k} \frac{W_i}{24}\, H\langle x-b_i\rangle(x-b_i)^4 + \sum_{i=1}^{k} \frac{W_i}{24}\, H\langle x-e_i\rangle(x-e_i)^4 + C1X + C2 \qquad (4.9)$$

To solve Equation (4.9) there are (n+3) unknowns:

M1	1
R_i (i=1,2,...n)	n
C1 & C2	2
	(n+3)

Also there are (n+3) boundary conditions for this case:

at x = 0	dy/dx = 0	1
at x = L_i (i=0,1,2...n)	y = 0	n+1
at x = S	dy/dx = 0	1
		(n+3)

where $S = \sum_{i=1}^{n} L_i$

By employing these boundary conditions in Equations (4.8) and (4.9) sufficient equations are in hand to evaluate the unknowns. A program has been written to generate the system of equations from specific loads and boundary condition. These equations are then solved by using a subroutine from CMS called LEQT1F. Finally the values for the unknowns are substituted in Equation (4.9) to get the value of deflection at the desired points.

4.4 Program Design

The program structure is presented in Figure 4.2. The program listing presented in Appendix C uses a WATFIV compiler. Since the program is meant to execute interactively (reads and writes on the terminal on some parts), a three line subprogram is needed to set the read and write statements with device numbers other than 5 and 6 (which reads from the file and writes on listing file). This execute file is listed at the end of the program.

4.5 Specifications

Beams are defined according to cartesian coordinates and the starting point of the beam is at the origin of this coordinate. All the distances are measured from the origin. Moments are positive when the upper fiber of the beam is in compression and upward reactions are positive.

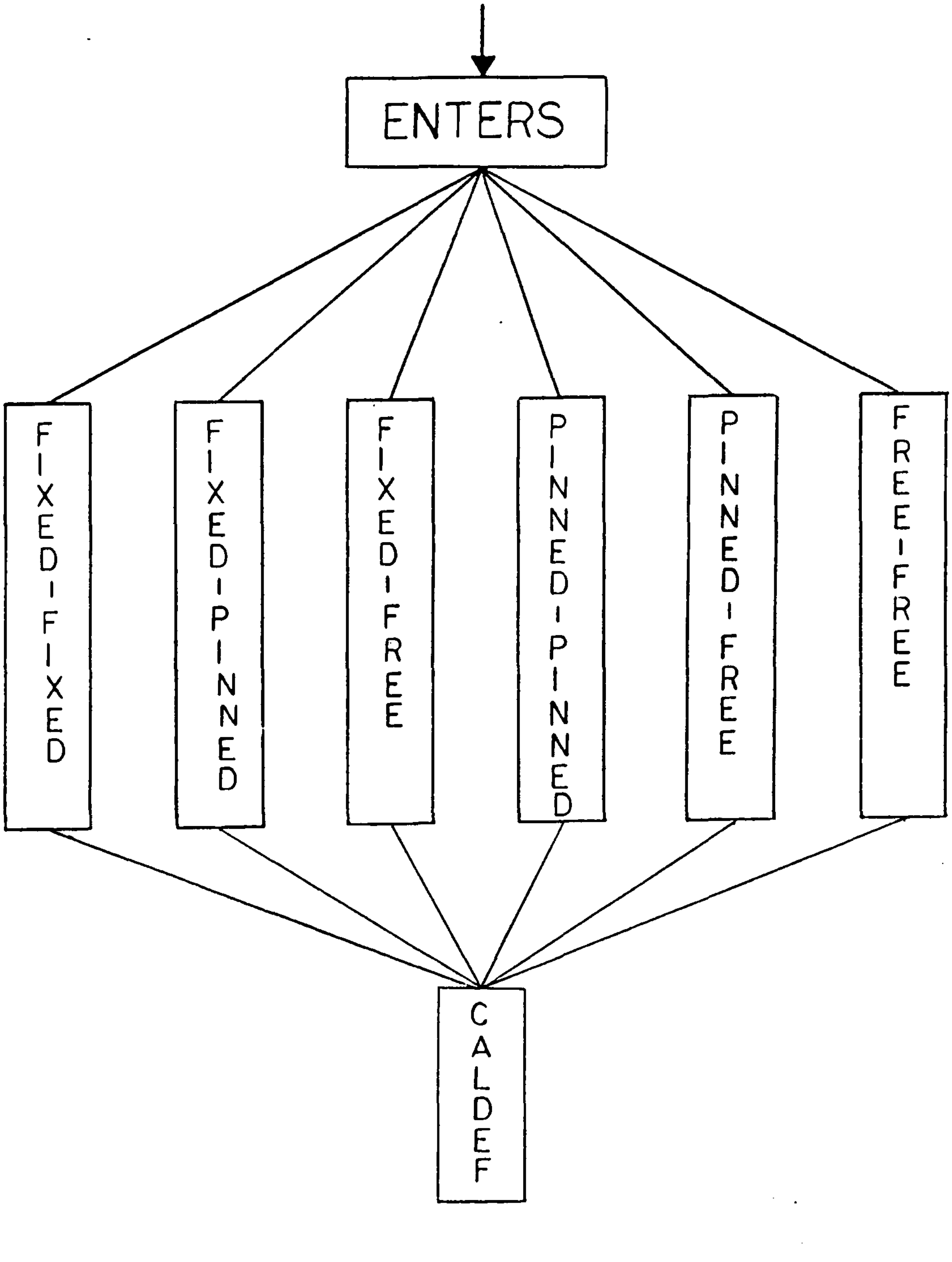


Fig. 4.2 Program structure.

Deflections are positive in the direction of the positive axis.

4.6 Limitations

4.6.1 Beam should have uniform cross section with no hinges or points of discontinuity. Since the solution is based on simple beam theory, the axial deformation is neglected.

4.6.2 Only two types of loads are considered: 1) uniformly distributed loads, and 2) concentrated vertical forces.

4.6.3 The size of arrays in the main program and subroutines are arranged for a maximum of 30 uniform loads and concentrated forces and a maximum of 25 spans. Therefore, for larger sizes the array dimensions have to be increased.

4.7 Units

All the units are in metric system.

Displacements	mm
Length	mm
Force	newton
Uniform loads	newton/mm
Moments	newton*mm

Moment of inertia	$(mm)^4$
Young's modulus	n/mm^2

4.8 Parameters

A(I)	Distance of force (I) from origin
BG(I)	Distance of starting point of W(I) from origin support condition
DELX	The interval on the beam where deflection is computed
E(I)	Distance of ending point of W(I) from origin
EM	Value of Young's modulus
ICONT	Dummy variable to specify the first and last support condition
IM	Moment of inertia
L(I)	Length of span (I)
N	Number of spans in the beam
NP	Number of concentrated loads
NW	Number of uniformly distributed loads
P(I)	Value of force (I)
W(I)	Value of uniformly distributed load (I)

CHAPTER V

DISCUSSION OF RESULTS

5.1 Introduction

In this chapter the basic goal is the comparison of the theoretical data with the experimental results obtained from the structural models tested. The discussion will center around the validity and accuracy of the findings and will draw attention to the major elements which contribute to some of the differences existing between the results found experimentally and mathematically. In general all the experiments have been performed within the elastic range of the material for two reasons: first, to conserve the model for possible future use, and second, to enable the use of conventional beam theory for mathematical analysis. The following discussion has been divided into two main sections. One is devoted to the beam experiments and the second one to the findings from the portal frame.

5.2 Deflection of the Beam

Beams were tested using twelve different supporting arrangements. Theoretically they were analyzed with the use of computer program described in Chapter Four. The results obtained from model structures and the mathematical analysis are compared and given in Appendix A. Generally, it was found that the theoretical values of the deflections were lower than deflections measured on the actual structures and the differences are in the range of 8 to 24 percent.

Theoretically there is an argument that the use of classical beam theory would not consider the contribution of shear to the deflection curve and therefore the theoretical models are stiffer compared to their experimental counterparts. Timoshenko in his book "Theory of Elasticity" (9) examines the effect of both bending and shear to the deflected shape of a simply supported beam subjected to a concentrated force at its midspan. He arrives at the following equation:

$$\Delta = \frac{PL^3}{48EI} + \frac{PL}{4C} \left(\frac{3}{4G} - \frac{3}{10E} - \frac{3\nu}{4E} \right) - .21\frac{P}{E} \qquad (5.1)$$

where,

G = shear modulus = $\frac{E}{2(I + \nu)}$

ν = Poisson's ratio

C = distance between the neutral axes and the extreme fiber

P = value of concentrated force

E = modulus of elasticity

I = moment of inertia

L = length of the span

Using .3 for ν in Equation (5.1) it was found that shear contribution is about 0.2% of total deflection for the simple beam used in the tests.

In another case the effect of the shear was considered on a cantilever beam subjected to a concentrated force at its free end. The following equation is shown to be approximately valid (3):

$$\Delta\nu = 1.6 \left(\frac{L^2}{h}\right) \quad \Delta m \tag{5.2}$$

where

$\Delta\nu$ = deflection due to shear

Δm = deflection due to bending

L = length of the beam

h = height of cross section

Error encountered in deflection value if shear contribution is neglected has been examined for several beams with different (L/h) ratios. The results are presented in Table 5.1. The conclusion is that for the beams with (L/h) ratio greater than 20 the deflection caused by the shear is not

TABLE 5.1:

L/h	$\frac{\Delta \nu}{\Delta m} \times 100$ (Percent)
1	N.A.
3	7
5	2.5
7	1.3
10	0.6
20	0.2

significant. For the cases tested the minimum L/h ratio is 59. Therefore the use of classical beam theory for the purpose of this study is valid.

Another factor that has significance in theoretical computations is the modulus of elasticity of the material. The manufacturer (6) suggests to use 30 X 10^6 psi for the value of E. This value in general has variations and one way to calculate it is to substitute the experimental value of deflection into the bending equation for a simply supported beam. The value comes out to be about 28.8 x 10^6 psi. This value was used in the entire theoretical analysis of the beam.

In order to examine the source of errors the structures were loaded in such a fashion that deflections were computed through the use of superposition. It was found that the summation of the results obtained from the beam subjected to individual loads are approximately the same as those of all loads applied simultaneously (differences are about 1%). This indicates that the errors are related to physical characteristics of the actual structure or to the actual measurements.

5.2.1 Physical Characteristics

Since the percent errors increased significantly when the beam was fixed, there is speculation that fixing brackets fail to prevent the beam from rotation. The effect can be noticed clearly when the beam is supported on a fixed clamp at one end and a roller at the other. The error increases by 6% as the load is applied closer to the fixed support. One of the two fixing brackets supplied by the manufacturer is equipped with internal rollers that is intended to allow axial movement to the beam. This one is even more flexible compared to the previous one and percent error increases to 30% at the points near this support. The above cases show systematic errors that can be accounted for if proper instruments are employed to measure amount of rotation taking place at these supports.

5.2.2 Errors due to Physical Measurements

The components measured physically are the beam dimensions, the weights, and the deflections. The cross sectional dimensions of the beam were measured at ten points along the beam with a caliper. The accuracy of the measuring device was 0.5 mm. The average values were used for calculating cross sectional area and moment of inertia. The cast iron slotted weights were weighed with a scale with an accuracy within 0.1 gram. The actual reading of deflections was taken using a mechanical dial gage with an accuracy within 0.01 mm. The uncertainty in physical measurements using a method

(1) which is explained in Appendix E came out to be about 3% of the theoretical values calculated for the deflections.

5.3 Deflection of the Frame

The portal frame described in Chapter Two was tested with six different support conditions. Frames were theoretically analyzed using STRUDL. The listing of program and its output is given in Appendix F. The experimental data are compared with theoretical results in Appendix B.

In general three dial gages were used to measure the deflections at three points on the frame. Referring to the tables in Appendix B, the letters with the subscript v denotes the vertical deflection and with the subscript h denotes the horizontal movement of the point. The experimental data show that horizontal deflection results are consistently more accurate compared to vertical deflections. This was because the dial gage is not pointed at the same point before and after deformation. Errors involved in horizontal deflections were in the range of zero percent for the fix-fix case to 13 percent for the pin-roller supported frame. As in the case of beams, the loads have been applied consistently at the positions so that the results can be superimposed. The principle of superposition holds for horizontal deformations within 3 percent. Generally, as the supports get stiffer the error percentages decrease. The highest error of 13 percent is obtained from a pin-roller support condition.

Instruction manuals (6 & 7) warn against the friction that might take place between the ball-bearings and the track plate. They suggest using stabilizing forces on the frame or lightly tapping the stand in order to minimize the effect of friction. This was examined in two cases. One was with pin-roller support conditions and a second was with fixed-roller support conditions. In each case several readings were taken with and without stabilizing forces. The dial gages were zeroed and a total of 26 readings were taken just after the stand was lightly tapped.

The pin-roller supported frame was observed to behave in the following manner. After tapping, the roller support did not return to zero. Without any load on the system, the highest deviation from zero was 0.08 mm on one occasion but the most frequent deviation was 0.06 mm from zero (35 percent of the time). When two horizontal stabilizing forces were applied at the right corner and roller abutment, the deviation decreased to 0.04 mm with a frequency of 70 percent.

In the case of fixed-roller supports, without any load on the system, the most frequent deviation of the roller from zero was 0.02 mm (frequency of 46 percent). The roller did not show any deviation when the two horizontal stabilizing forces were added to the frame.

Lack of sensitivity in dial gages had a major role in contributing to the differences between the experimental and theoretical analysis. Although theoretical results were given by the computer to six significant figures, they were rounded off to 2 significant figures because the accuracy of the gages was only 0.01 mm. The experimental results show that small deflections up to order of 0.09 mm are susceptible to high percentage of error. This is to be expected because of the limited accuracy of the dial gages. Other contributing elements to the differences were manufacturing imperfection of the model such as crookedness of welded roller block relative to the frame, difference in length of the overhanging part of the beam, and lack of complete rigidity in brackets.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This study presents the experimental techniques involved with the testing of two model structures and compares the results with theoretical predictions. In general the equipment is easy to use, adaptable to a variety of structural models, and is reasonably accurate. It meets the requirements of a qualitative structural teaching model, but falls short of providing accurate quantitative values for all boundary conditions.

6.1 Conclusions

Results obtained throughout the experimental work and mathematical analysis leads to the following conclusions for each of the two models.

6.1.1 Beam Bending Experiments

1. For beams with simple supports the experimental deflections are about 7 percent higher than the theoretical values.
2. For beams which contain fixed supports, the experimental deflection values are considerably

higher than the theoretical values. The inability of the testing apparatus to duplicate the idealized fixed condition is the main reason for the large difference.

3. The principle of superposition is experimentally demonstrated within an accuracy of about 3 percent.
4. The contribution of shear to the deflection is shown to be negligible and the classical beam theory can be used for the analytical model.
5. Application of vertical stabilizing forces to the beam when it is supported on knife-edge or roller prevents the uplifting and undesired movement of the beam at the supports.

6.1.2 Portal Frame Experiments

1. The percent errors for horizontal deflections are smaller for the fixed-fixed support conditions than for non-fixed supports for pinned-roller supports.
2. For symmetrical loading and boundary conditions (no sidesway), vertical deflections compare reasonably well with the theoretical values.
3. For unsymmetrical loading or boundary conditions, sidesway occurs and vertical deflections read from a fixed position are highly inaccurate.

4. The principle of superposition generally holds for horizontal deflections within 3 percent accuracy.
5. Application of horizontal stabilizing forces to the portal frame minimizes the friction effect by reducing the no-load movement after tapping from 0.06 mm to 0.02 mm. In the case of fixed-roller supported frame, application of the stabilizing force reduces the no-load movement after tapping zero.
6. In general the experimental results show that small deflections up to order of 0.09 mm are susceptible to high percentage of error.

6.2 Recommendations

To improve and expand the testing capability of the experimental apparatus discussed in this study, a number of recommendations are made.

1. Models made of other material, such as aluminum or epoxy glass, should be substituted for the steel models so that larger deflections are produced when subjected to small loads.
2. To overcome the difficulties encountered with the vertical deflections of the portal frame when sidesway occurs, the position of the dial gages should move along with the structure.

6.3 Future Studies

The scope of the work can be extended along the following directions:

1. By using a second parallel testing frame to provide additional support conditions, three dimensional space frame can be tested.
2. With the addition of an instantaneous deflections reading device, the use of the testing apparatus can be extended to problems in structural dynamics.

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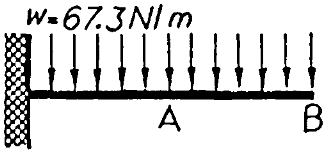
8. Tecquipment, Hi-Plan Structures Apparatus, issue No. 9, England.

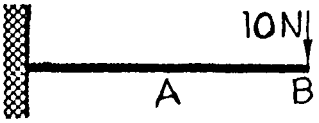
9. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, 3rd Ed. MaGraw-Hill, NY 1970.

APPENDIX A

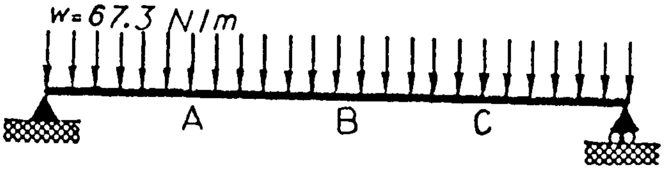
BEAM TESTING RESULTS



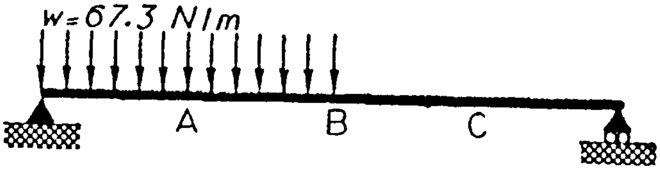
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-2.55	-2.21	15.4
B	-7.05	-6.23	13.2



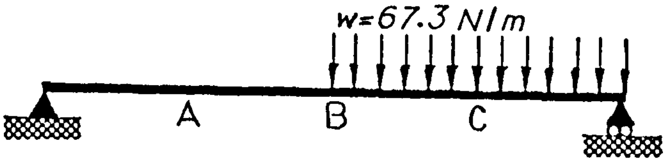
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.96	-1.71	14.6
B	-6.16	-5.48	12.4



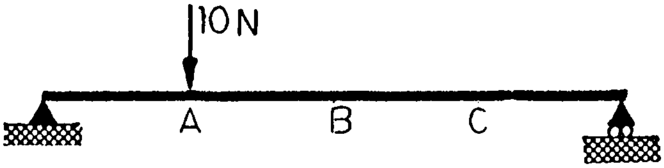
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-8.00	-7.40	8.1
B	-11.17	-10.38	7.6
C	-7.92	-7.40	7.0



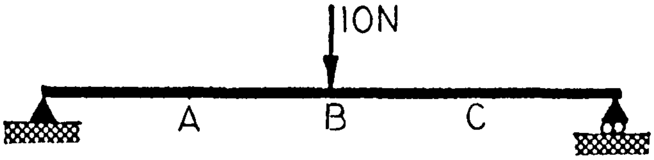
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-4.37	-4.02	8.7
B	-5.59	-5.19	7.7
C	-3.62	-3.37	7.4



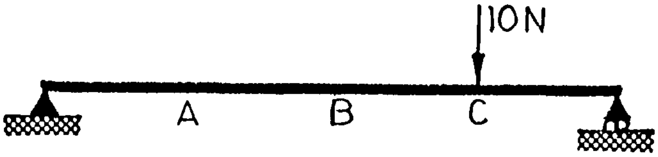
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-3.64	-3.37	8.0
B	-5.58	-5.19	7.5
C	-4.32	-4.02	7.5



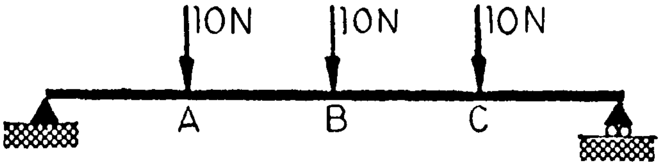
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.67	-1.54	8.4
B	-2.01	-1.88	6.9
C	-1.29	-1.20	7.5



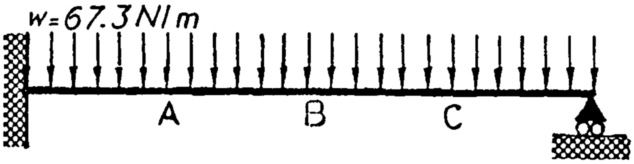
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-2.04	-1.88	8.5
B	-2.93	-2.74	6.9
C	-2.03	-1.88	8.0



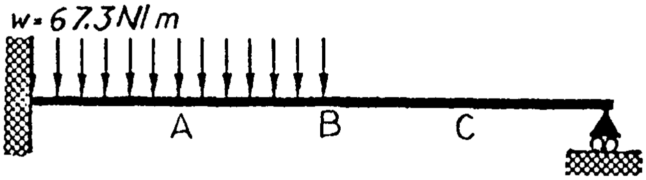
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.28	-1.20	6.7
B	-2.01	-1.88	6.9
C	-1.66	-1.54	7.8



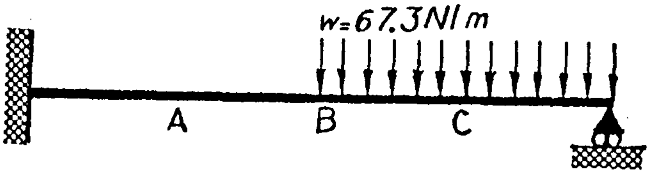
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-5.00	-4.62	8.2
B	-6.96	-6.51	6.9
C	-4.98	-4.62	7.8



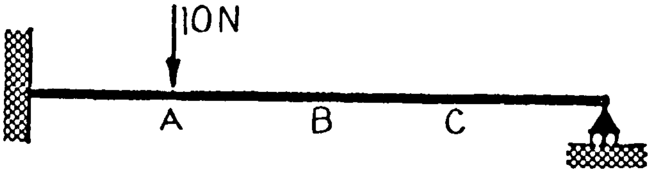
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-2.31	-1.95	18.5
B	-4.68	-4.15	12.8
C	-3.91	-3.50	11.7



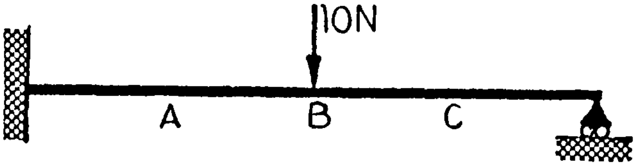
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.14	-0.96	18.7
B	-1.95	-1.69	15.4
C	-1.36	-1.18	15.2



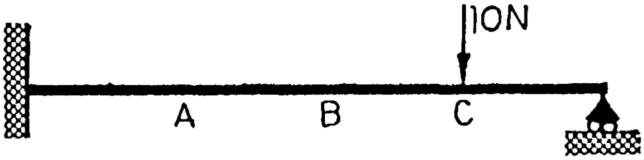
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.14	-0.99	15.1
B	-2.74	-2.46	11.4
C	-2.55	-2.32	9.9



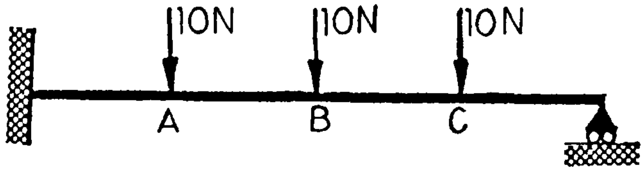
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.43	-0.36	19.4
B	-0.63	-0.53	18.9
C	-0.42	-0.36	16.7



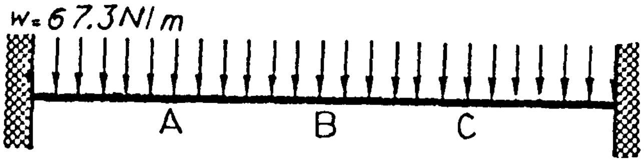
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.63	-0.53	18.9
B	-1.35	-1.20	12.5
C	-1.03	-0.92	11.9



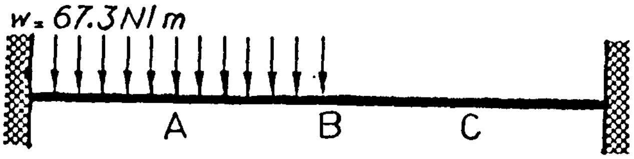
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.41	-0.36	13.9
B	-1.03	-0.92	11.9
C	-1.04	-0.94	10.6



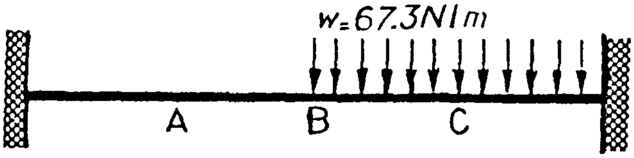
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.49	-1.25	19.2
B	-3.01	-2.66	13.1
C	-2.49	-2.22	12.2



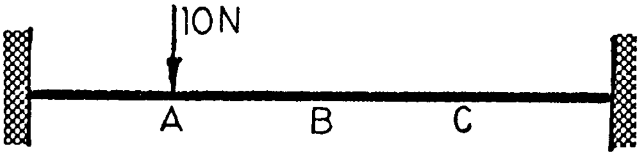
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-1.46	-1.16	25.9
B	-2.52	-2.08	21.1
C	-1.52	-1.16	31.0



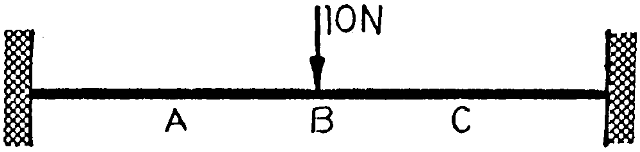
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.87	-0.71	22.5
B	-1.23	-1.03	19.4
C	-0.57	-0.45	26.7



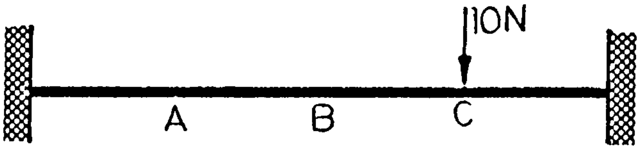
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.57	-0.45	26.7
B	-1.26	-1.03	22.3
C	-0.93	-0.71	31.0



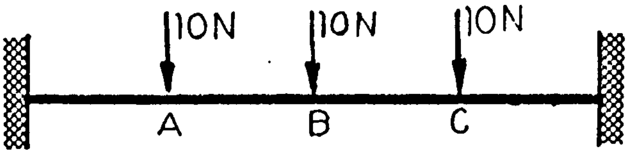
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.35	-0.29	20.7
B	-0.41	-0.34	20.6
C	-0.18	-0.14	28.6



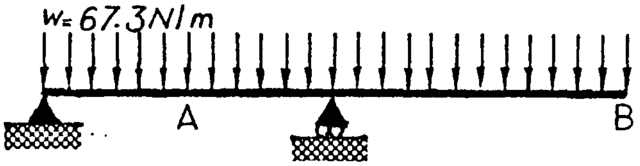
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.41	-0.34	20.6
B	-0.80	-0.69	15.9
C	-0.43	-0.34	26.5



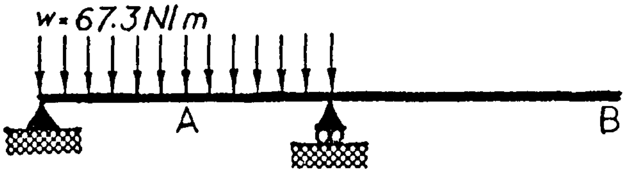
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.18	-0.14	28.6
B	-0.42	-0.34	23.5
C	-0.37	-0.29	27.6



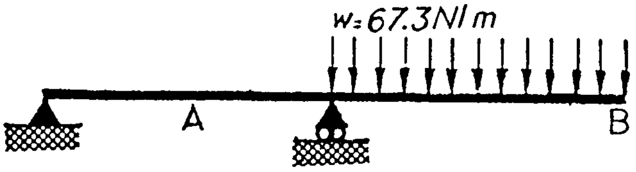
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.95	-0.77	23.4
B	-1.65	-1.37	20.4
C	-0.99	-0.77	28.6



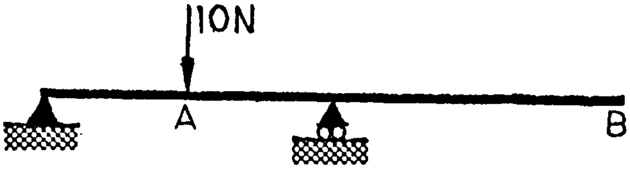
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.97	0.91	6.6
B	-13.51	-12.46	8.4



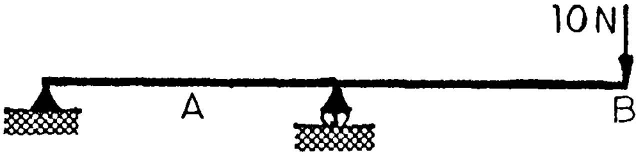
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.71	-0.65	9.2
B	2.10	2.08	1.0



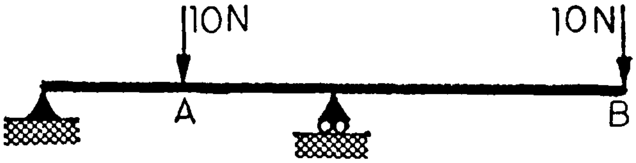
Location	Experimental (mm)	Theoretical (mm)	% Error
A	1.70	1.56	9.0
B	-15.76	-14.53	8.5



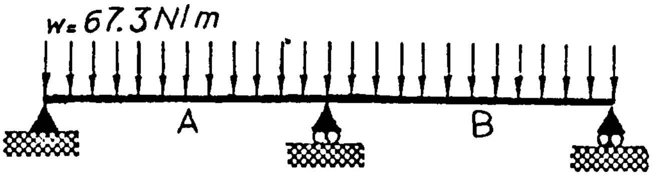
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.38	-0.34	11.8
B	1.0	1.03	2.9



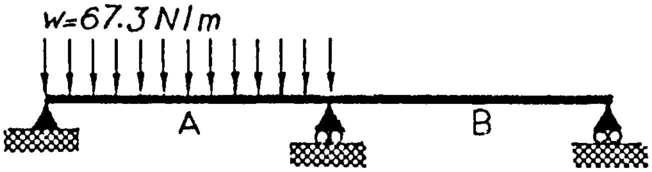
Location	Experimental (mm)	Theoretical (mm)	% Error
A	1.14	1.03	10.7
B	-11.86	-10.97	8.1



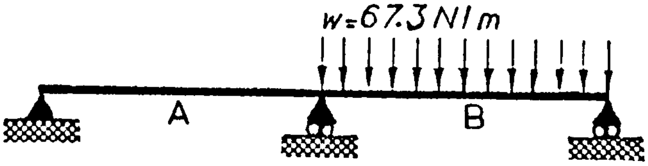
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.76	0.68	11.8
B	-10.82	-9.94	8.8



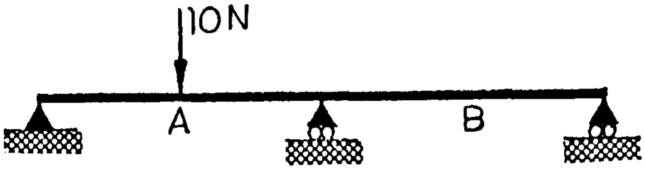
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.29	-0.26	11.5
B	-0.29	-0.26	11.5



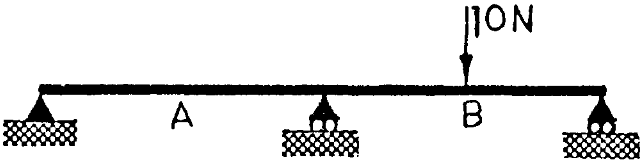
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.49	-0.45	8.9
B	0.21	0.19	10.5



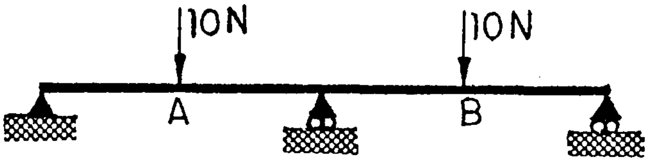
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.22	0.19	15.8
B	-0.50	-0.45	11.1



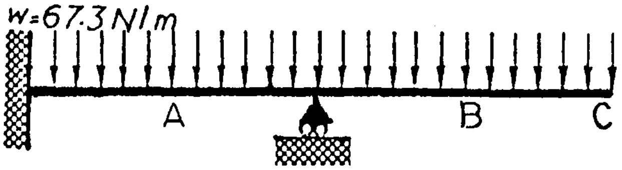
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.27	-0.25	8.0
B	0.10	0.10	0.0



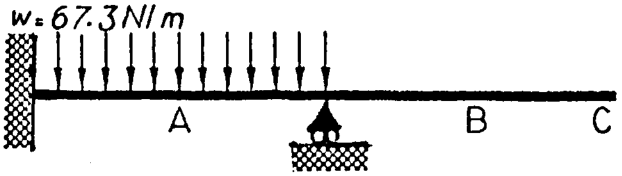
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.11	0.10	10.0
B	-0.26	-0.25	4.0



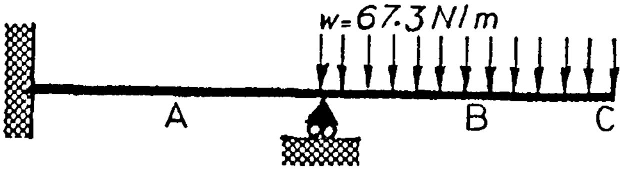
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.16	-0.15	6.7
B	-0.17	-0.15	13.3



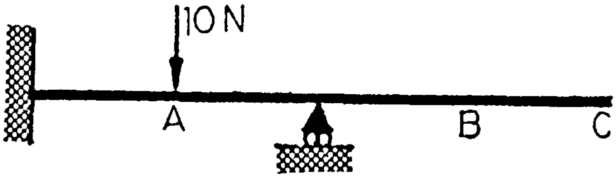
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.56	0.52	7.7
B	-5.24	-4.80	9.2
C	-12.41	-11.42	8.7



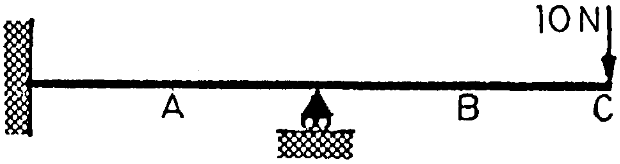
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.31	-0.26	19.2
B	0.53	0.52	1.9
C	1.04	1.04	0.0



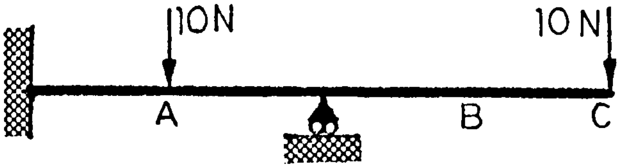
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.87	0.78	11.5
B	-5.81	-5.32	9.2
C	-13.57	-12.46	8.9



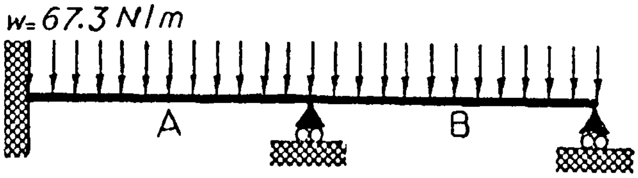
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.17	-0.15	13.3
B	0.24	0.26	7.7
C	0.46	0.51	9.8



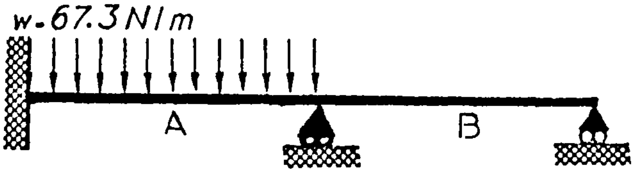
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.56	0.51	9.8
B	-4.09	-3.77	8.5
C	-10.36	-9.60	7.9



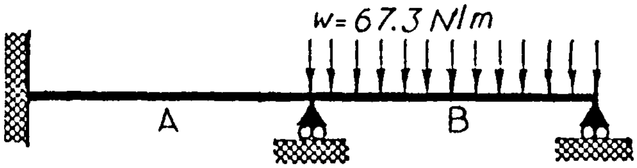
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.39	-0.36	8.3
B	-3.83	-3.51	9.1
C	-9.86	-9.08	8.6



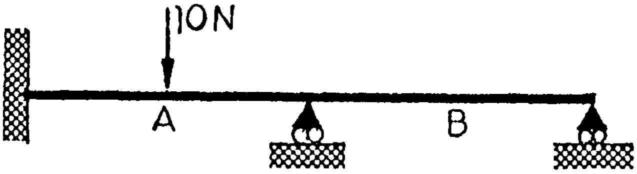
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.13	-0.09	44.4
B	-0.36	-0.31	16.1



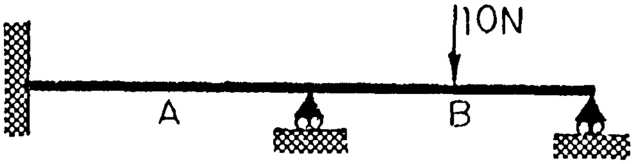
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.25	-0.2	25
B	0.11	0.11	0.0



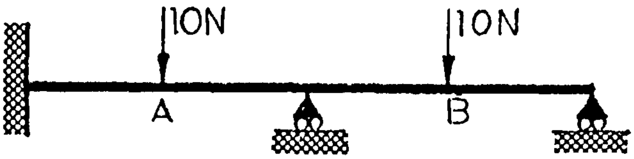
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.11	0.11	0.0
B	-0.49	-0.43	13.9



Location	Experimental (mm)	Theoretical (mm)	% Error *
A	-0.14	-0.12	16.7
B	0.06	0.05	~~20.0~~

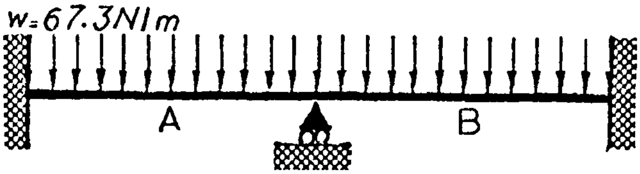


Location	Experimental (mm)	Theoretical (mm)	% Error *
A	0.06	0.05	~~20.0~~
B	-0.27	-0.23	17.4

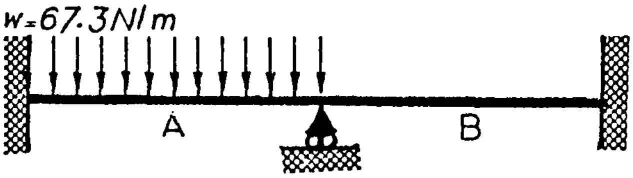


Location	Experimental (mm)	Theoretical (mm)	% Error *
A	-0.08	-0.07	~~14.3~~
B	-0.20	-0.18	11.1

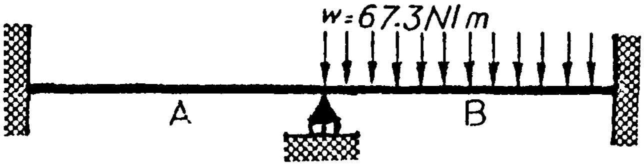
* For measurements less than 0.09 mm, % error not given.



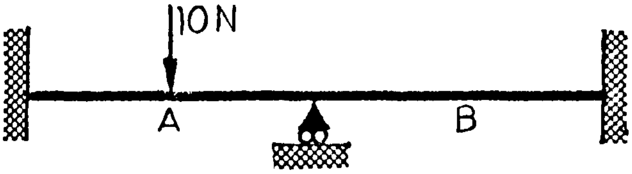
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.16	-0.13	23.1
B	-0.17	-0.13	30.8



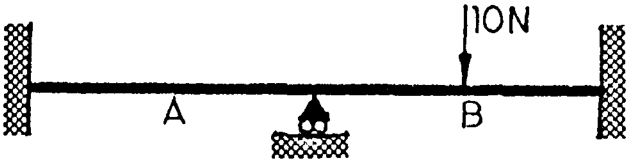
Location	Experimental (mm)	Theoretical (mm)	% Error *
A	-0.24	-0.19	26.3
B	0.08	0.06	~~33.3~~



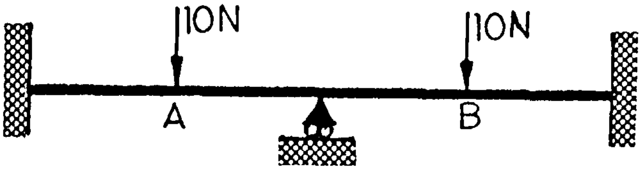
Location	Experimental (mm)	Theoretical (mm)	% Error *
A	0.08	0.06	~~33.3~~
B	-0.25	-0.19	31.6



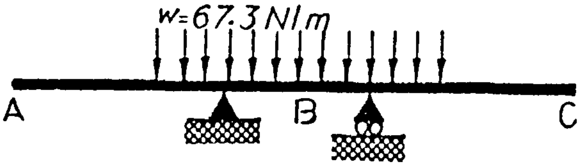
Location	Experimental (mm)	Theoretical (mm)	% Error*
A	-0.10	-0.12	16.7
B	0.04	0.03	~~33.3~~



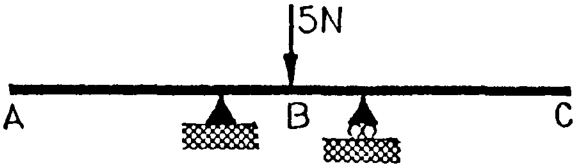
Location	Experimental (mm)	Theoretical (mm)	% Error*
A	0.04	0.03	~~33.3~~
B	-0.15	-0.12	25.0



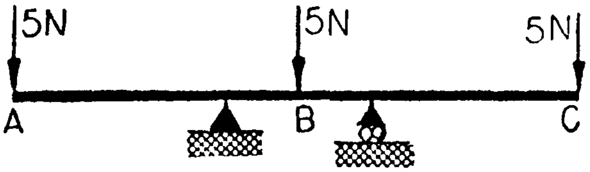
Location	Experimental (mm)	Theoretical (mm)	% Error*
A	-0.10	-0.08	~~25~~
B	-0.10	-0.08	~~25~~



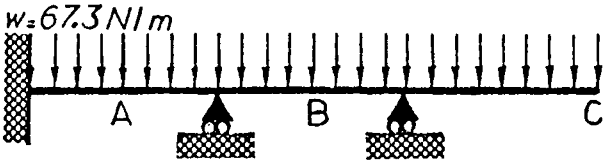
Location	Experimental (mm)	Theoretical (mm)	% Error *
A	-1.46	-1.34	8.9
B	0.08	0.09	~~11.1~~
C	-1.43	-1.34	6.7



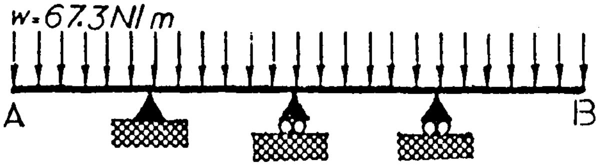
Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.55	0.53	3.8
B	-0.19	-0.18	5.5
C	0.50	0.53	5.7



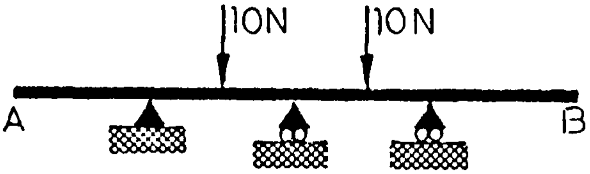
Location	Experimental (mm)	Theoretical (mm)	% Error
A	-7.01	-6.57	6.7
B	-0.96	-0.89	7.9
C	-7.00	-6.57	6.5



Location	Experimental (mm)	Theoretical (mm)	% Error
A	-0.25	-0.22	13.6
B	0.60	0.55	9.1
C	-9.40	-8.4	11.9



Location	Experimental (mm)	Theoretical (mm)	% Error
A	-2.93	-2.49	17.7
B	-2.78	-2.49	11.6

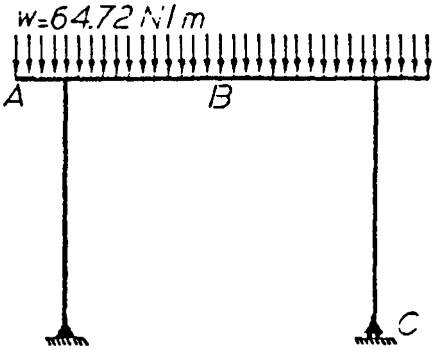


Location	Experimental (mm)	Theoretical (mm)	% Error
A	0.26	0.22	18.2
B	0.26	0.22	18.2

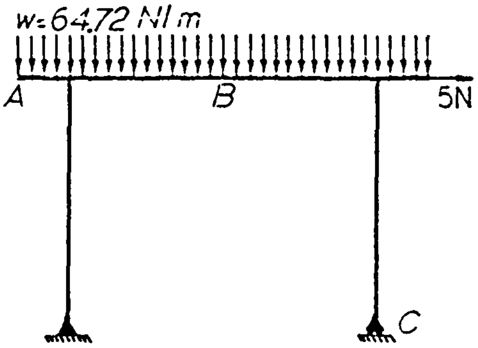
APPENDIX B

PORTAL FRAME TESTING RESULTS

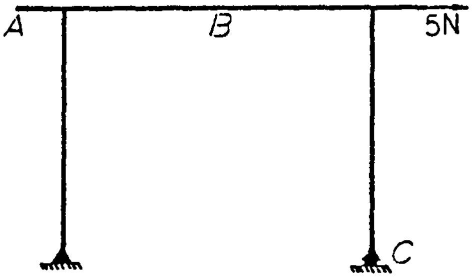
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	1.08	1.03	5
B_V	-0.5	-0.44	14
C_H	2.11	2.07	2



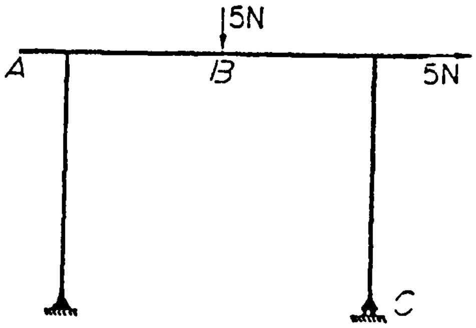
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	2.67	2.64	1
B_V	-0.70	-0.68	3
C_H	4.22	4.14	2



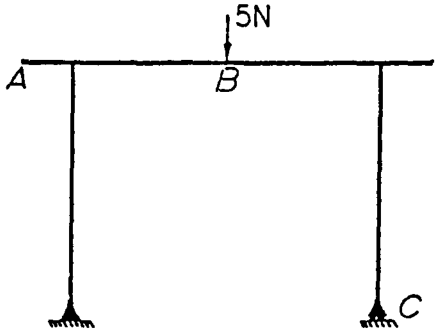
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	1.59	1.61	1.24
B_V	-0.21	-0.23	8.7
C_H	2.06	2.07	0.5



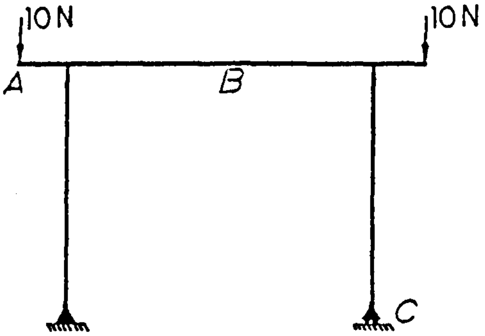
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	1.79	1.84	2.7
B_V	-0.34	-0.33	3
C_H	2.48	2.53	2



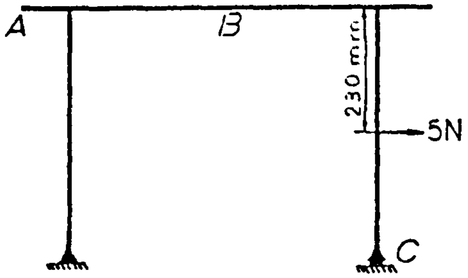
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.2	0.23	13
B_V	-0.11	-0.1	10
C_H	0.44	0.46	4



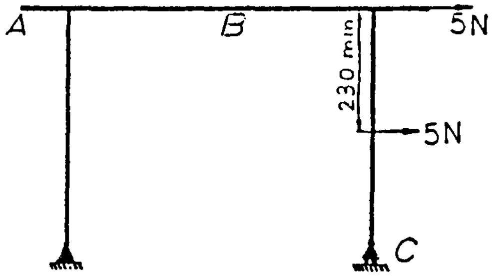
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.55	-0.55	0
B_V	0.163	0.183	11
C_H	-1.05	-1.1	4.5



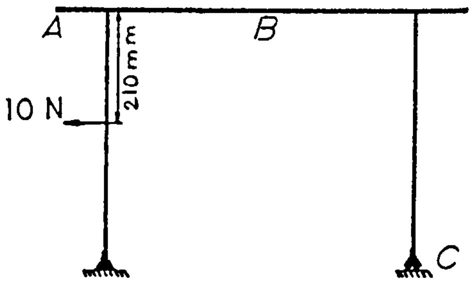
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	1.71	1.84	7
B_V	-0.33	-0.35	6
C_H	2.79	2.98	6



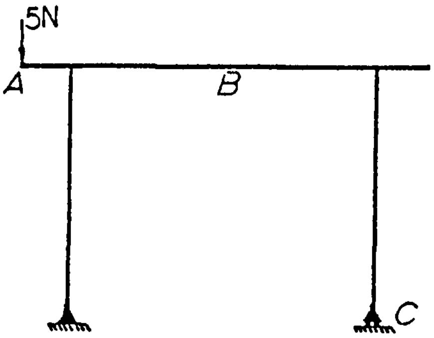
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	3.3	3.4	3
B_V	-0.56	-0.58	3
C_H	4.84	5.05	4



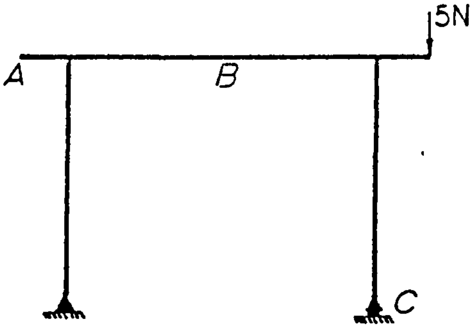
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-1.99	-2.01	0.1
B_V	0.23	0.25	8
C_H	-2.47	-2.51	1.6



Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	-0.18	-0.19	5
B_V	0.045	0.046	~~2~~
C_H	-0.27	-0.28	3.6

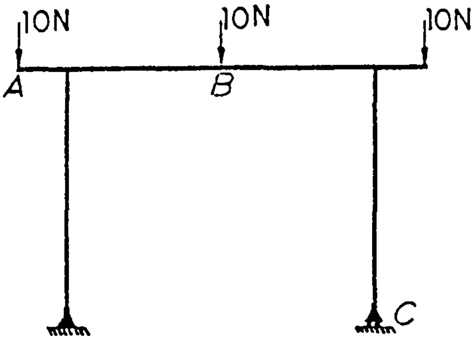


Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	-0.08	-0.09	~~11~~
B_V	0.04	0.04	0
C_H	-0.25	-0.27	7

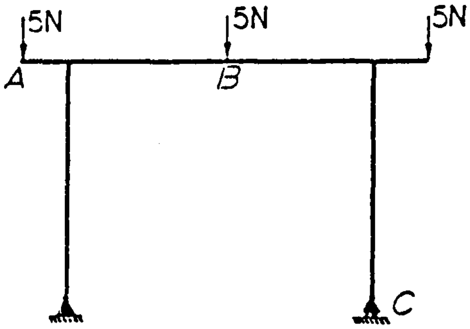


* For measurements less than 0.09 mm, % error not given.

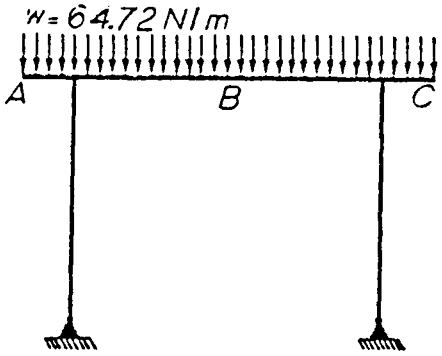
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.09	-0.09	0
B_V	-0.02	-0.02	0
C_H	-0.17	-0.18	5.5



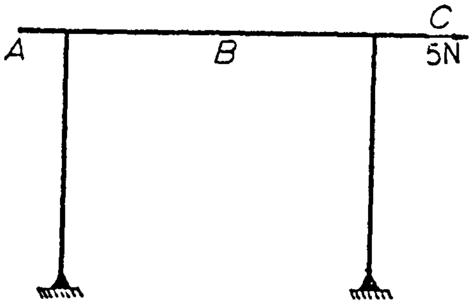
Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	-0.045	-0.046	~~2~~
B_V	-0.01	-0.01	0
C_H	-0.08	-0.09	~~11~~



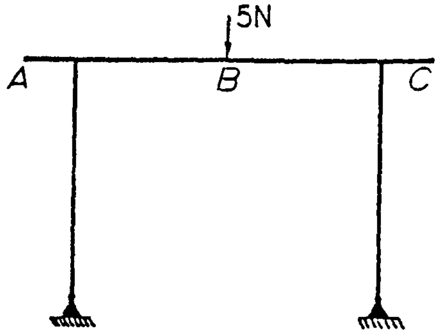
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0	0	0
B_V	-0.22	-0.21	5
C_V	0.05	0.06	~~17~~



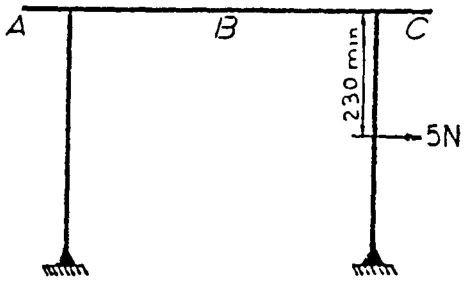
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.56	0.57	2
B_V	0	0	0
C_V	-0.04	-0.04	0



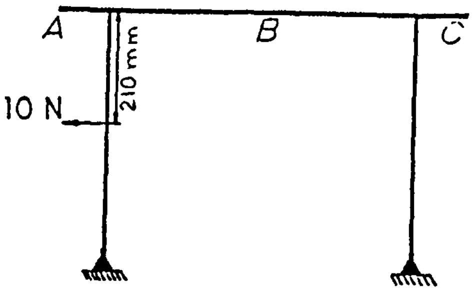
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
B_V	-0.05	-0.05	0
C_V	0.01	0.01	0



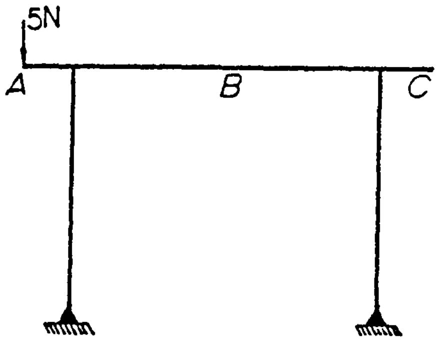
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.32	0.35	8.6
B_V	-0.03	-0.014	~~114~~
C_V	-0.01	-0.01	0



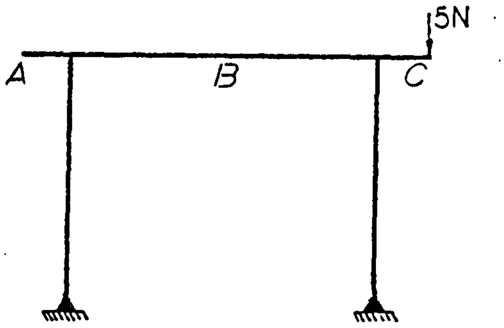
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.74	-0.75	1
B_V	-0.09	-0.03	~~200~~
C_V	0.02	0.07	~~71~~



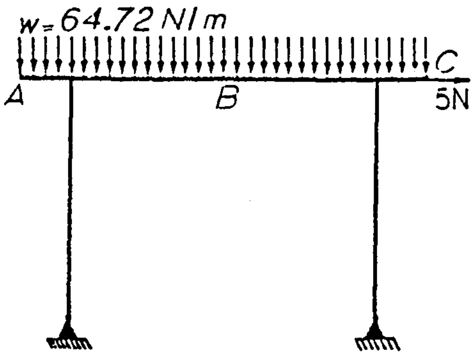
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.04	-0.05	~~20~~
B_V	0.015	0.015	0
C_V	0	0	0



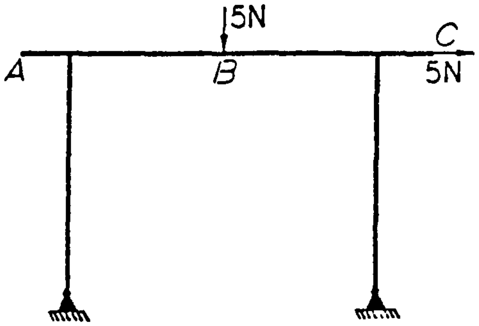
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.04	0.04	0
B_V	0.01	0.01	0
C_V	-0.03	-0.02	~~50~~



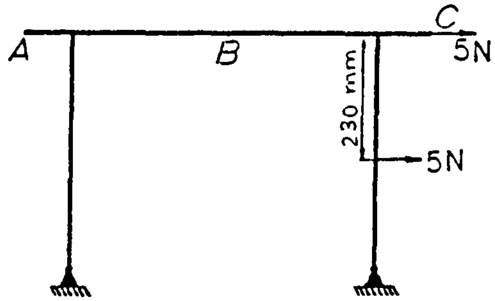
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.54	0.57	5
B_V	-0.26	-0.21	24
C_V	0.02	0.02	0



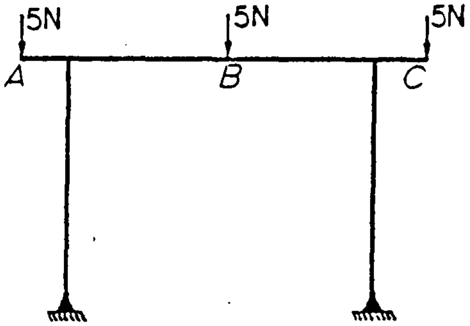
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.56	0.57	2
B_V	-0.05	-0.05	0
C_V	-0.02	-0.03	~~33~~



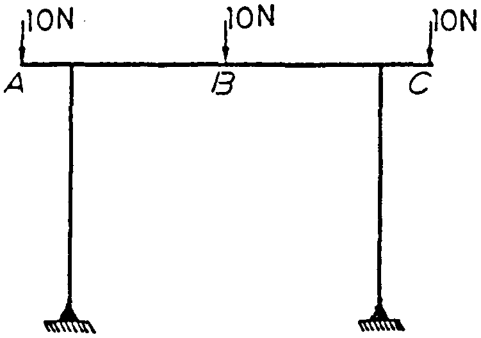
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.89	0.92	3
B_V	-0.06	-0.01	~~500~~
C_V	-0.12	-0.06	~~100~~



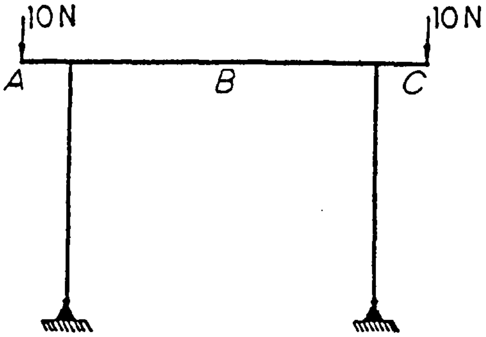
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
B_V	-0.02	-0.02	0
C_V	0	0	0



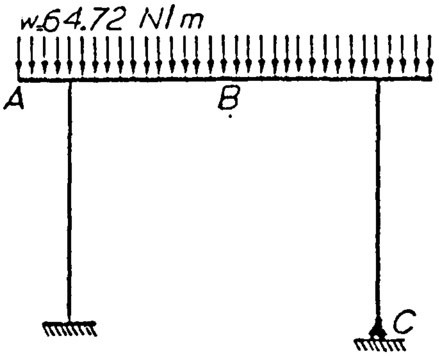
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0	0	0
B_V	-0.04	-0.04	0
C_V	-0.02	-0.01	~~100~~



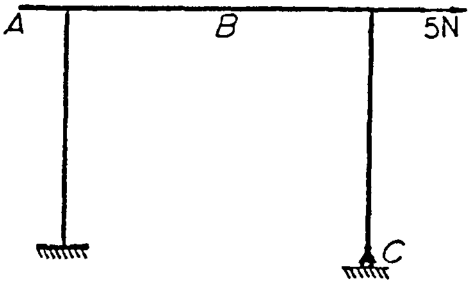
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0	0	0
B_V	0.05	0.06	~~17~~
C_V	-0.03	-0.04	~~25~~



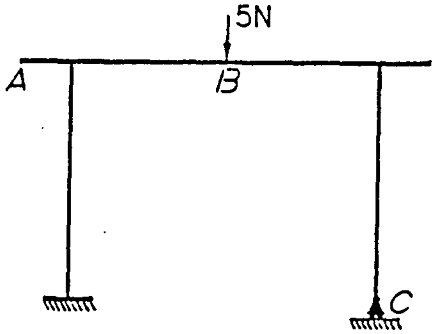
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.37	0.36	3
B_V	-0.39	-0.37	5.4
C_H	1.32	1.23	7



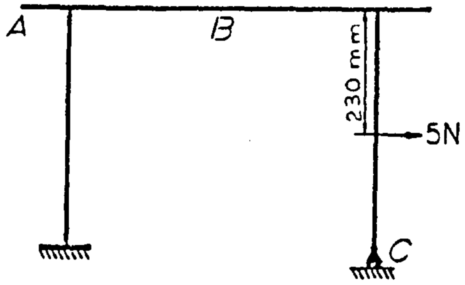
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.32	0.33	3
B_V	-0.09	-0.08	~~12.5~~
C_H	0.49	0.49	0



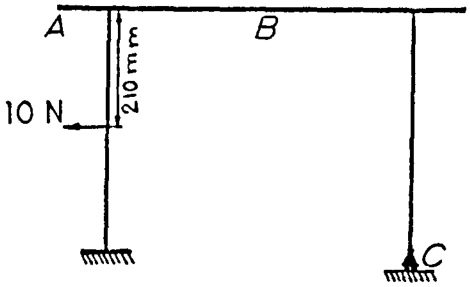
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.07	0.08	~~12.5~~
B_V	-0.09	-0.08	~~12~~
C_H	0.27	0.27	0



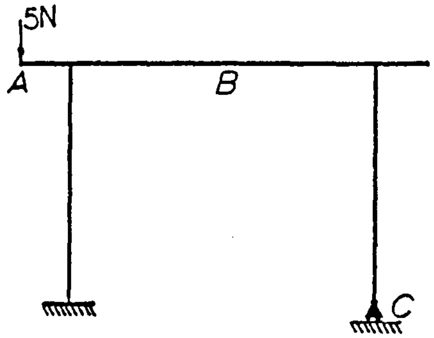
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.41	0.41	0
B_V	-0.19	-0.18	5.5
C_H	1.2	1.2	0



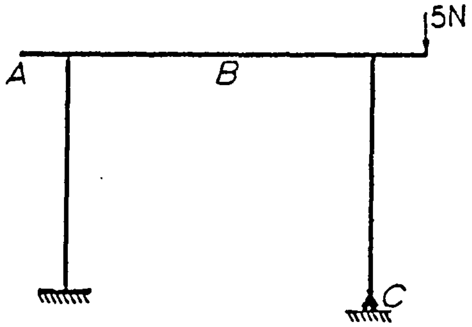
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.30	-0.29	3.4
B_V	0.05	0.05	0
C_H	-0.34	-0.38	10.5



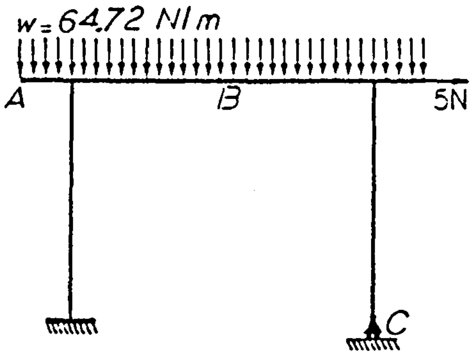
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.06	-0.06	0
B_V	0.03	0.03	0
C_H	-0.12	-0.13	8



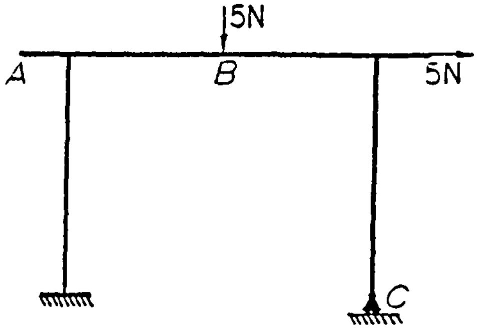
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.03	-0.03	0
B_V	0.04	0.04	0
C_H	-0.19	-0.20	5



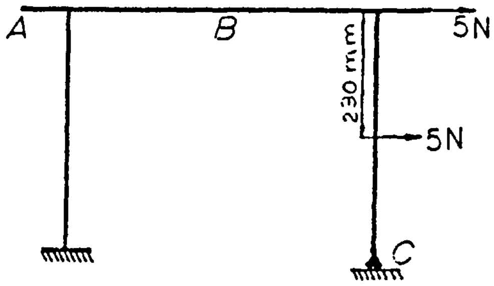
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.71	0.69	3
B_V	-0.47	-0.44	7
C_H	1.80	1.73	4



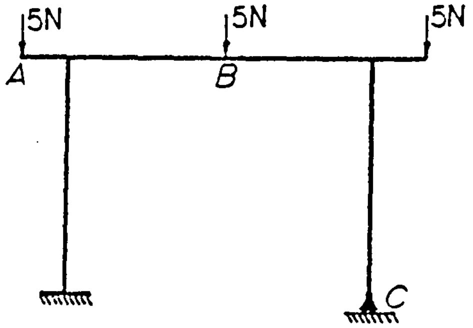
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.40	0.41	2.4
B_V	-0.20	-0.16	25
C_H	0.76	0.76	0



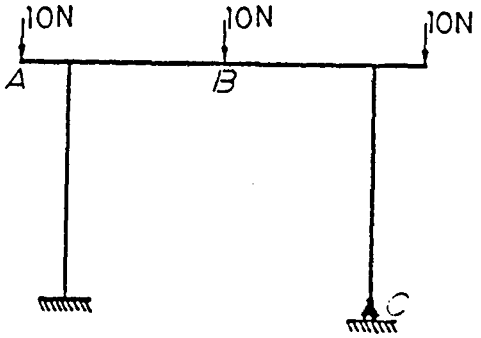
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.74	0.74	0
B_V	-0.32	-0.26	23
C_H	1.67	1.70	2



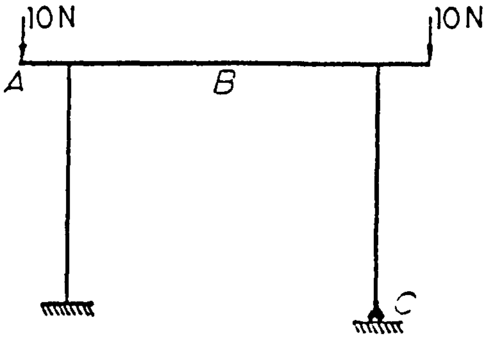
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.01	-0.01	0
B_V	-0.03	-0.01	~~200~~
C_H	-0.05	-0.05	0



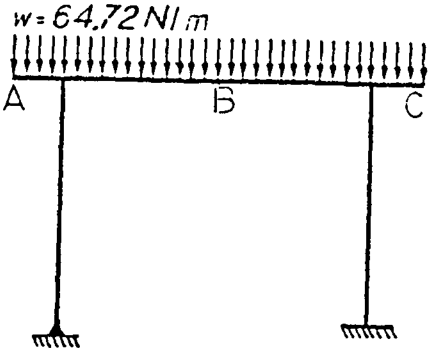
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.03	-0.03	0
B_V	-0.04	-0.03	~~100~~
C_H	-0.10	-0.10	0



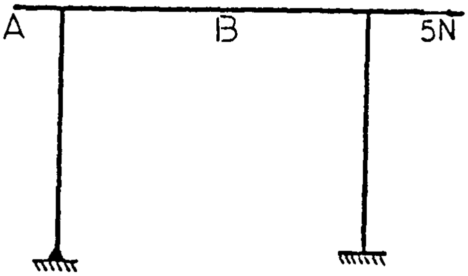
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.19	-0.19	0
B_V	0.16	0.14	14
C_H	-0.65	-0.65	0



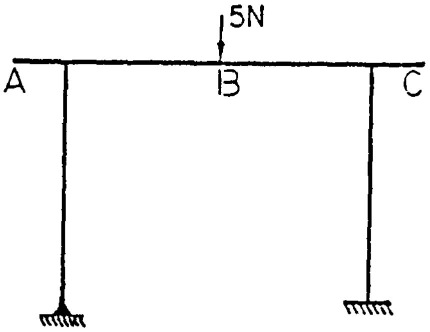
Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	-0.09	-0.08	~~12.5~~
B_V	-0.2	-0.2	0
C_V	0.06	0.07	~~14~~



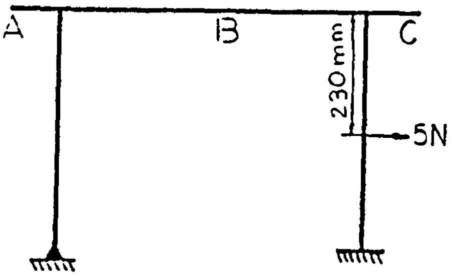
Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	0.22	0.22	0
B_V	0.02	0.02	0
C_V	-0.04	-0.03	~~33~~



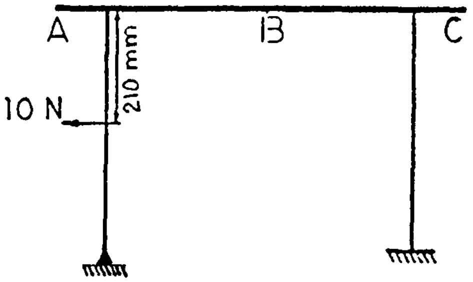
Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	-0.01	-0.02	~~50~~
B_V	-0.05	-0.05	0
C_V	0.01	0.01	0



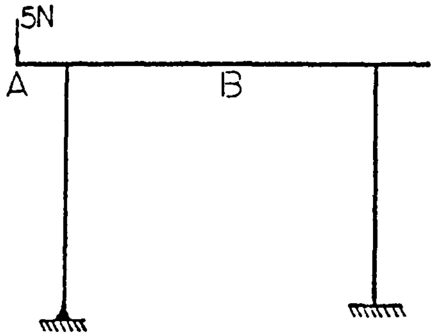
Location	Experimental (mm)	Theoretical (mm)	% Error*
A_H	0.08	0.09	~~11~~
B_V	0	0	0
C_V	0	0.01	~~100~~



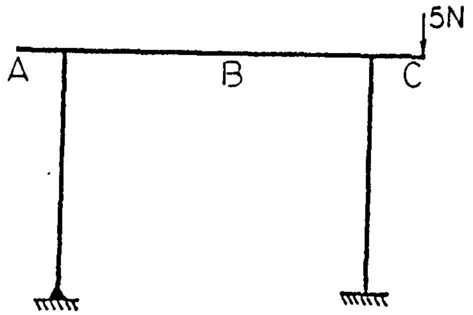
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.29	-0.30	3
B_V	-0.04	-0.05	~~20~~
C_V	0.19	0.05	~~280~~



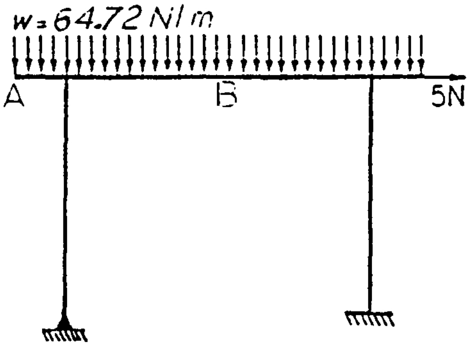
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.01	-0.01	0
A_V	-0.02	-0.02	0
B_V	0.01	0.01	0



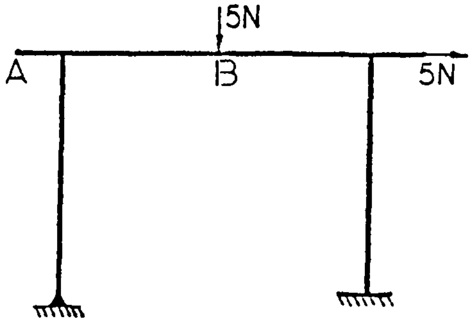
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.03	0.03	0
B_V	0.01	0.01	0
C_V	-0.02	-0.02	0



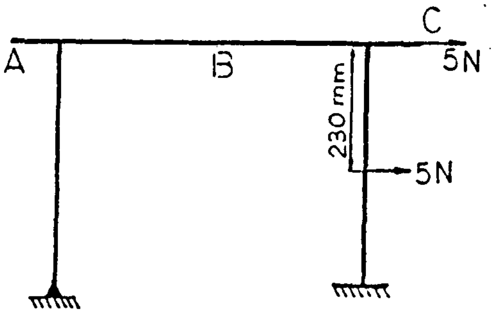
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.12	0.14	14
A_V	0.04	0.07	~~43~~
B_V	-0.2	-0.2	0



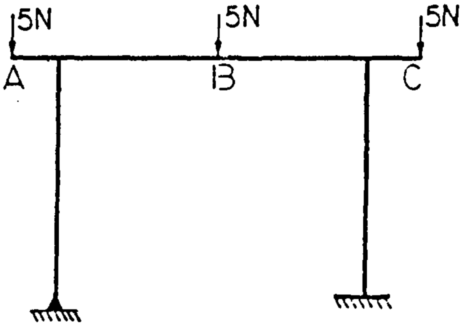
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.2	0.2	0
A_V	0.02	0.03	~~33~~
B_V	-0.03	-0.03	0



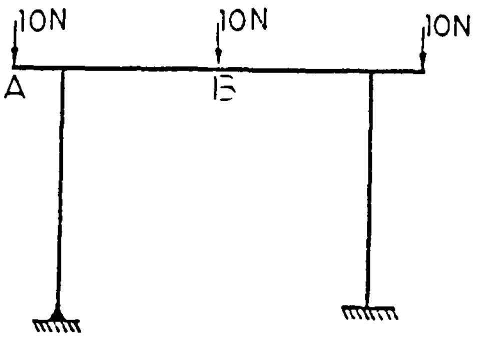
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.31	0.31	0
B_V	0.02	0.02	0
C_V	-0.04	-0.04	0



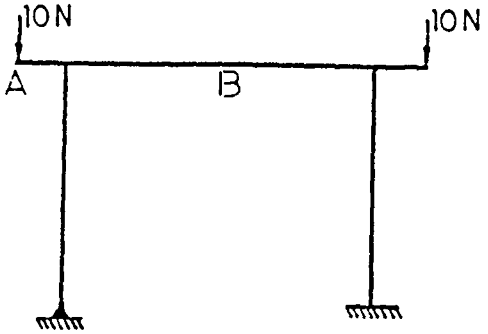
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
B_V	-0.02	-0.02	0
C_V	-0.01	-0.01	0



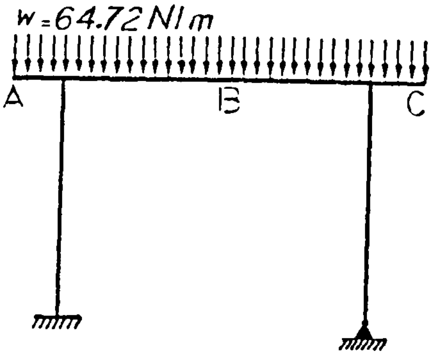
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.01	0.005	~~100~~
A_V	-0.02	-0.02	0
B_V	-0.05	-0.04	~~25~~



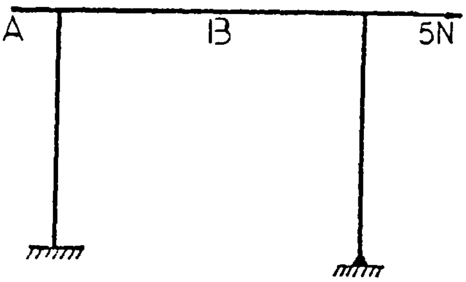
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.04	0.04	0
A_V	-0.05	-0.04	~~25~~
B_V	0.05	0.06	~~17~~



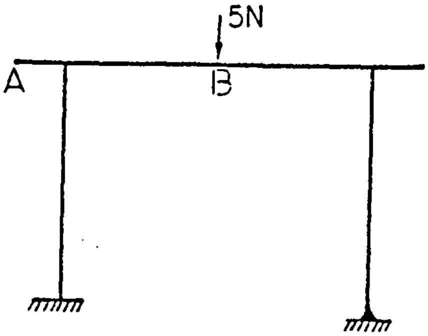
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.08	0.08	0
B_V	-0.2	-0.2	0
C_V	0.04	0.06	~~33~~



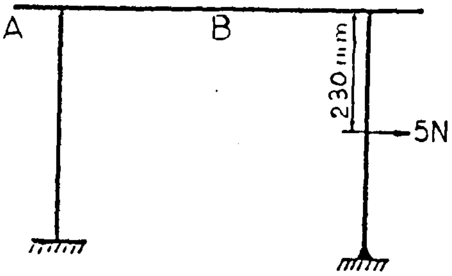
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.22	0.22	0
A_V	0.02	0.03	~~33~~
B_V	-0.03	-0.02	~~50~~



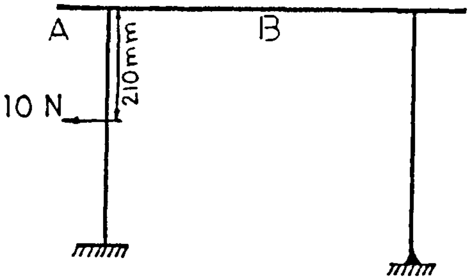
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.02	0.02	0
A_V	0.01	0.02	~~50~~
B_V	-0.05	-0.05	0



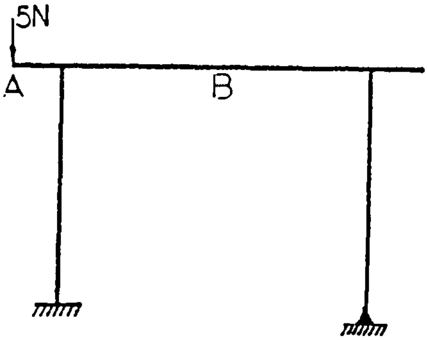
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.14	0.14	0
A_V	0.02	0.02	0
B_V	-0.025	-0.025	0



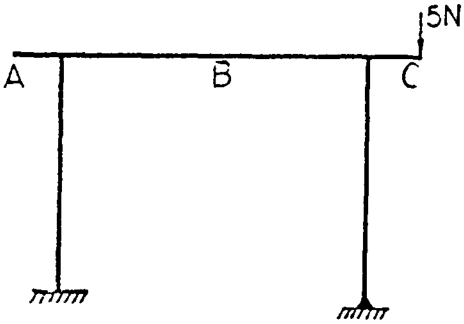
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.2	-0.2	0
A_V	-0.01	-0.01	0
B_V	0	0	0



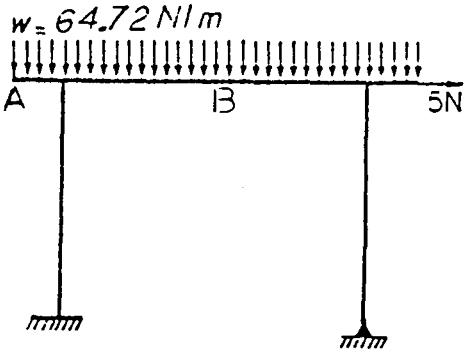
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.03	-0.03	0
A_V	-0.02	-0.02	0
B_V	0.01	0.02	~~50~~



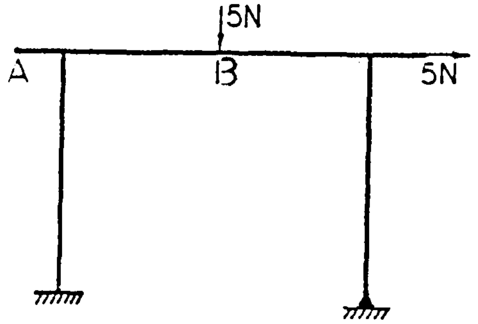
Location	Experimental (mm)	Theoretical (mm)	% Error
A_V	0.01	0.01	0
B_V	0.01	0.01	0
C_H	-0.02	-0.02	0



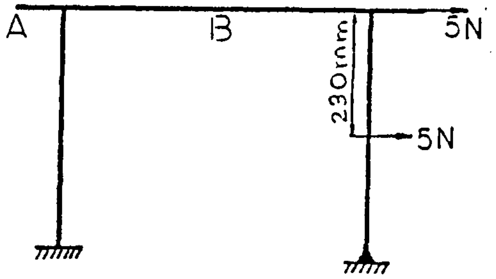
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.29	0.30	3
A_V	0.08	0.1	~~20~~
B_V	-0.24	-0.23	4



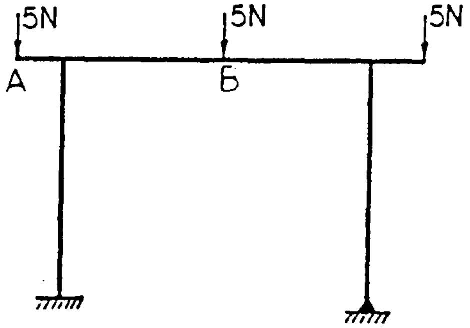
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.23	0.24	4
A_V	0.03	0.05	~~40~~
B_V	-0.09	-0.07	~~28~~



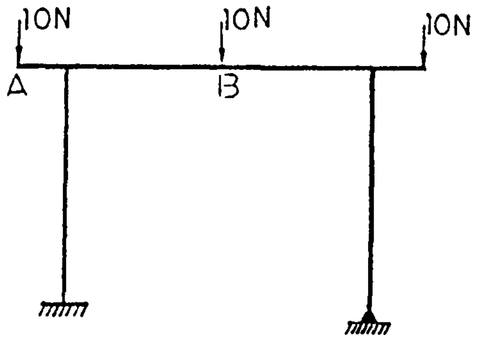
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.35	0.36	3
A_V	0.03	0.06	~~50~~
B_V	-0.07	-0.04	~~75~~



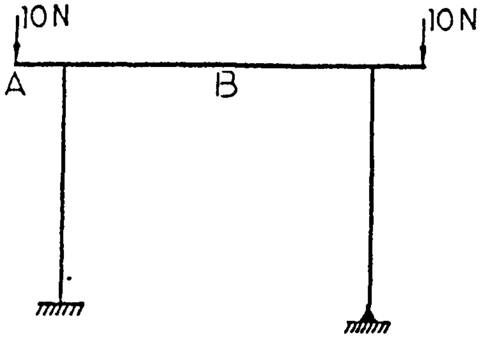
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
A_V	-0.01	-0.01	0
B_V	-0.02	-0.02	0



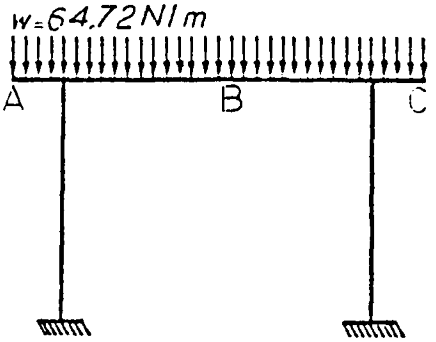
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0	0	0
A_V	-0.02	-0.02	0
B_V	-0.05	-0.04	~~25~~



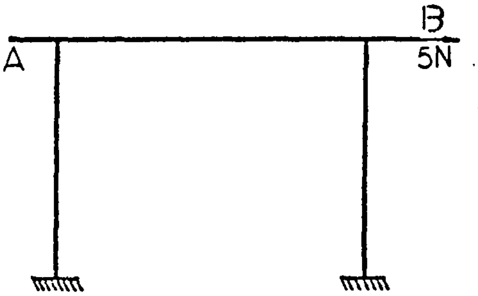
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	-0.04	-0.04	0
A_V	-0.05	-0.05	0
B_V	0.05	0.06	~~17~~



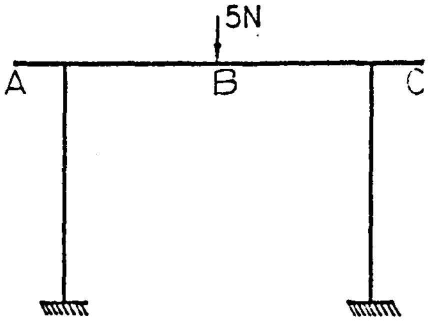
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
B_V	-0.2	-0.2	0
C_V	0.05	0.05	0



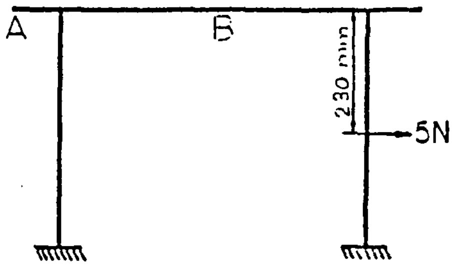
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.13	0.13	0
A_V	0.02	0.02	0
B_V	0	0	0



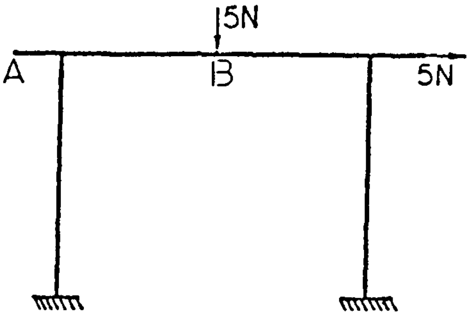
Location	Experimental (mm)	Theoretical (mm)	% Error
A_V	0.01	0.01	0
B_V	-0.05	-0.05	0
C_V	0.01	0.01	0



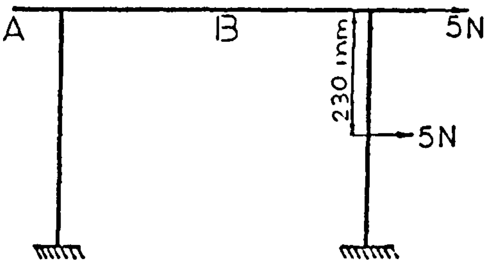
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.05	0.05	0
A_V	0	0.01	~~100~~
B_V	0	-0.01	~~100~~



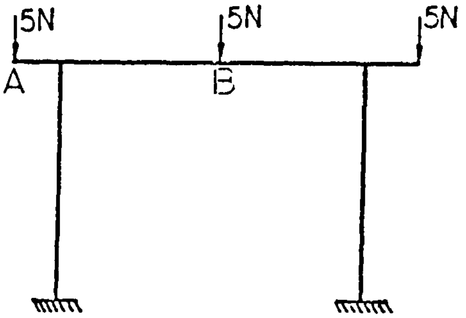
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.13	0.13	0
A_V	0.03	0.03	0
B_V	-0.05	-0.05	0



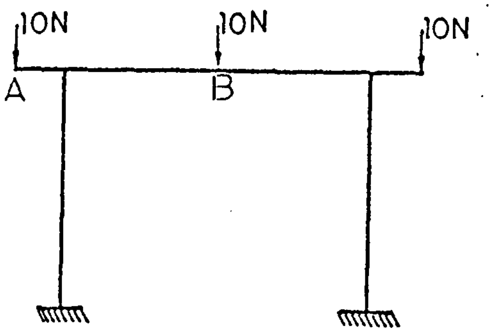
Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0.18	0.19	5
A_V	0.02	0.03	~~33~~
B_V	0	-0.01	~~100~~



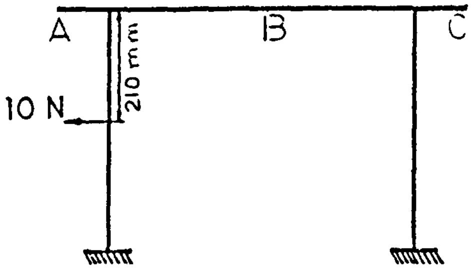
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
A_V	-0.01	-0.01	0
B_V	-0.02	-0.02	0



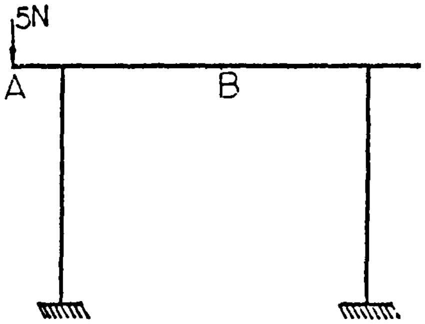
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0	0	0
A_V	-0.02	-0.02	0
B_V	-0.04	-0.04	0



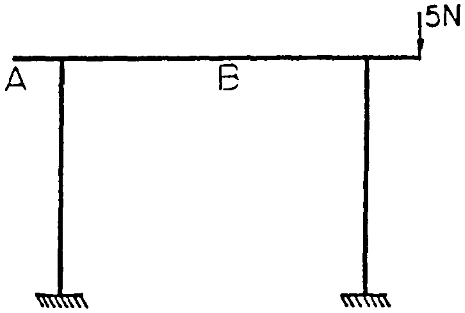
Location	Experimental (mm)	Theoretical (mm)	* % Error
A_H	-0.12	-0.12	0
B_V	-0.02	-0.02	0
C_V	0.01	0.02	~~50~~



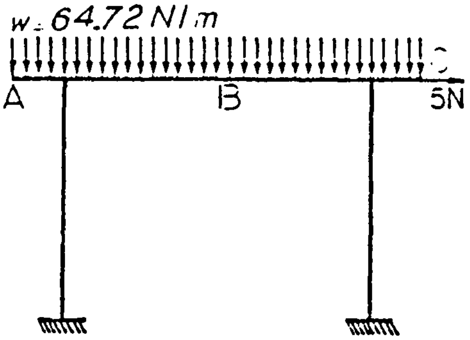
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	-0.02	-0.02	0
A_V	-0.02	-0.02	0
B_V	0.01	0.01	0



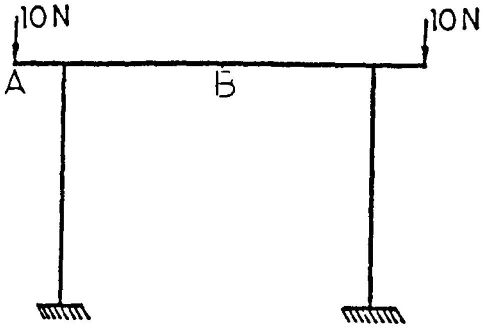
Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.02	0.02	0
A_V	0	0	0
B_V	0.01	0.01	0



Location	Experimental (mm)	Theoretical (mm)	% Error
A_H	0.13	0.13	0
B_V	-0.2	-0.2	0
C_V	0.03	0.03	0



Location	Experimental (mm)	Theoretical (mm)	% Error *
A_H	0	0	0
A_V	-0.04	-0.04	0
B_V	0.04	0.05	~~20~~



APPENDIX C

BEAM ANALYSIS PROGRAM

```
$JOB
C     **********************************************************
C     *                        MAIN PROGRAM                    *
C     **********************************************************
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      DATA M/1/,IA/25/,IDGT/3/
      REAL L(30)
      WRITE(9,10)
 10   FORMAT('THE DATA REQUIRED HERE IS TO DESIGNATE THE BOUNDARY',/,
     $'CONDITION OF THE BEAM AT THE FIRST AND LAST SUPPORT.THERE ARE',/,
     $'SIX CONDITIONS THAT THIS PROGRAM IS DESIGNED TO ANALYZE.',/,
     $'1-(FIX-FIX)',9X,'2-(FIX-PIN)',/,'3-(FIX-FREE)',8X,'4-(PIN-PIN)'
     $,/,'5-(PINNED-FREE)',5X,'6-(FREE-FREE)',/,
     $'THE CONDITIONS MENTIONED IN THE PARENTHESIS ARE REFERED TO THE',/
     $,'FIRST AND LAST SUPPORT IN THE BEAM.ENTER THE NUMBER TO THE',/,
     $'LEFT OF PARENTHESIS FOR THE CONDITION APPLICABLE TO THE BEAM',/
     $,'YOU ARE ANALYZING....???')
      READ (8,*)ICONT
      WRITE(9,15)
 15   FORMAT('ENTER THE NUMBER OF SPANS IN THE BEAM....???')
      READ(8,*)N
      WRITE(9,20)
 20   FORMAT('ENTER LENGTH OF EACH SPAN ONE PER LINE...???')
      TSP=0
      DO 22 I=1,N
      READ(8,*)L(I)
      WRITE(6,23)I,L(I)
 23   FORMAT(/,5X,'L(',I2,') =',F6.2)
      TSP=L(I)+TSP
 22   CONTINUE
      WRITE(9,25)
 25   FORMAT('ENTER THE TOTAL NUMBER OF CONCENTRATED VERTICAL FORCE',/,
     $'TO BE APPLIED ON THE BEAM....???/')
      READ(8,*)NP
      IF(NP.EQ.0)GO TO 42
      WRITE(9,30)
 30   FORMAT('ENTER THE VALUE OF EACH CONCENTRATED FORCE AND ITS',/,
     $'DISTANCE FROM FIRST SUPPORT...???')
                DO 35 I=1,NP
                READ(8,*)P(I),A(I)
                  IF(A(I).GT.TSP)GO TO 37
                  WRITE(6,34)I,P(I),A(I)
 34               FORMAT(//,10X,'P(',I2,')=',F6.2,'(N)',5X,'AT X =',
     $            F6.2,'(MM)',//)
                  GO TO 35
 37               WRITE(9,40)I
 40               FORMAT(/,5X,'P(',I2,')ACTING BEYOND RANGE OF THE BEAM')
                  STOP
 35             CONTINUE
      GO TO 42
 42   WRITE(9,45)
 45   FORMAT(,5X,'ENTER TOTAL NUMBER OF VERTICAL UNIFORM LOAD TO BE'
     $,/,'APPLIED ON THE BEAM...???')
      READ(8,*)NW
      IF(NW.EQ.0)GO TO 46
      WRITE(9,50)
 50   FORMAT('ENTER THE DISTANCE OF STARTING POINT,VALUE AND DISTANCE
     $OF END POINT OF THE UNIFORM LOAD.ONE LINE PER EACH SET OF LOAD.
     $',/,' NOTE,ALL THE DISTANCES MEASURED FROM FIRST SUPPORT...???')
              DO 57 I=1,NW
              READ(8,*)BG(I),W(I),E(I)
              IF(BG(I).GT.TSP.OR.E(I).GT.TSP)GO TO 59
              WRITE(6,58)I,W(I),BG(I),E(I)
 58   FORMAT(/,10X,'W(',I2,')=',F10.8,5X,'  (N/MM)',5X,'STARTS AT
     $X=',F6.2,//,42X,'AND ENDS AT',7X,'X=',F6.2,'   (MM)')
      GO TO 57
```

```
  59  WRITE(9,60)I
  60  FORMAT('W(',I2,')ACTING BEYOND RANGE OF THE BEAM')
      STOP
  57         CONTINUE
  46  GO TO(51,52,53,54,55,56),ICONT
  51  CALL FF(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      GO TO 65
  52  CALL FP(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      GO TO 65
  53  CALL FFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      GO TO 65
  54  CALL PP(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      GO TO 65
  55  CALL PFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      GO TO 65
  56  CALL FRFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
  65  STOP
      END
C   ********************************************************************
C   *                             FIXED-FIXED                          *
C   ********************************************************************
      SUBROUTINE FF(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,35X,15X,'BEAM FIXED AT BOTH ENDS (',I2,'SPANS)',//)
      K=N+2
      NS=N
      CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      S=L(1)
          DO 20 I=1,N
             MD=K-1
             AU(I,MD)=S**2/(-2)
             J=I+1
              IF(J.GT.N)GO TO 25
             S=L(J)+S
  20      CONTINUE
  25            DO 30 I=1,N
                 AU(I,K)=0
  30            CONTINUE
      CALL SLOPE(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(MD,MD)=-TSP
      AU(MD,K)=0
      CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(K,MD)=-1
      AU(K,K)=1
      CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
      AM1=BU(MD)
      AM2=BU(K)
      CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
      R(MD)=RL
      Z1=0
      Z2=0
      CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $AM1,AM2,Z1,Z2)
      RETURN
      END
C   ********************************************************************
C   *                             FIXED-PINNED                         *
C   ********************************************************************
      SUBROUTINE FP(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,30X,'BEAM FIXED AT THE FIRST AND PINNED AT THE LAST
```

```
     $SUPPORT (',I2,' SPANS)',//)
      K=N+1
      NS=N
      CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      S=L(1)
           DO 100 I=1,N
            AU(I,K)=S**2/(-2)
            IC=I+1
              IF(IC.GT.N)GO TO 20
            S=L(IC)+S
 100       CONTINUE
  20  CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(K,K)=-1
      CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
      CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
      AM1=BU(K)
      R(K)=RL
      Z1=0
      Z2=0
      CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $AM1,AM2,Z1,Z2)
      RETURN
      END
C     ******************************************************************
C     *                           FIXED-FREE                           *
C     ******************************************************************
      SUBROUTINE FFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,30X,'BEAM FIXED AT THE FIRST AND FREE AT THE LAST SUPPOR
     $T (',I2,' SPANS)',//)
      K=N+1
      NS=N-1
      IF(N.EQ.1)GO TO 15
      CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      SP=L(1)
            DO 12 I=1,NS
              AU(I,K)=-SP**2/2
              J=I+1
              SP=SP+L(J)
  12        CONTINUE
  15  CALL SHEAR(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(N,K)=0.
      CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(K,K)=-1
      CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
      NS=N
      CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
      AM1=BU(K)
      Z1=0
      Z2=0
      CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $AM1,AM2,Z1,Z2)
      RETURN
      END
C     ******************************************************************
C     *                         PINNED-PINNED                          *
C     ******************************************************************
      SUBROUTINE PP(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,35X,'BEAM PINNED AT BOTH ENDS (',I2,' SPANS)',//)
      K=N+1
```

```
      NS=N
      CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      S=L(1)
            DO 12 I=1,N
              AU(I,K)=S
              IO=I+1
                IF(IO.GT.N)GO TO 20
              S=S+L(IO)
  12        CONTINUE
  20  CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      AU(K,K)=0
      CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
      CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
      IN=N+1
      R(IN)=RL
      Z1=BU(K)
      Z2=0
      AM1=0
      CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $AM1,AM2,Z1,Z2)
      RETURN
      END
C   ********************************************************************
C   *                             PINNED-FREE                          *
C   ********************************************************************
      SUBROUTINE PFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,30X,'BEAM PINNED AT THE FIRST AND FREE AT THE LAST SUPPO
     $S (',I2,' SPANS)',//)
          IF(N.GT.1)THEN DO
            K=N+1
            NS=N-1
            CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
            S=L(1)
              DO 12 I=1,NS
               AU(I,K)=S
               IC=I+1
               S=S+L(IC)
  12          CONTINUE
            CALL SHEAR(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
            AU(N,K)=0
            CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
            AU(K,K)=0
            CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
            NS=N
            CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
            Z1=BU(K)
            AM1=0
            Z2=0
            CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $      AM1,AM2,Z1,Z2)
               ELSE DO
                 WRITE(9,25)
  25             FORMAT(//,25X,'SYSTEM IS UNSTABLE',//)
                 STOP
               END IF
      RETURN
      END
C   ********************************************************************
C   *                             FREE-FREE                            *
C   ********************************************************************
      SUBROUTINE FRFR(N,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP,IA,M,IDGT)
      DOUBLE PRECISION AU(25,25),BU(25),WKAREA(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
```

```
      REAL L(30)
      WRITE(6,10)N
  10  FORMAT(//,35X,'BEAM IS FREE AT BOTH ENDS (',I2,' SPANS)',//)
      K=N+1
      IF(N.GT.2)THEN DO
      NS=N-1
      CALL DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      S=L(1)
           DO 12 I=1,NS
            AU(I,N)=S
            MD=I+1
            S=S+L(MD)
  12       CONTINUE
          DO 20 I=1,NS
           AU(I,K)=1
  20      CONTINUE
      CALL SHEAR(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
          DO 30 I=N,K
            AU(N,I)=0
  30      CONTINUE
      CALL MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
          DO 40 I=N,K
             AU(K,I)=0.
  40      CONTINUE
        CALL LEQT1F(AU,M,K,IA,BU,IDGT,WKAREA,IER)
        CALL EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
        Z1=BU(N)
        Z2=BU(K)
        AM1=0
            CALL CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $      AM1,AM2,Z1,Z2)
           ELSE DO
            WRITE(9,35)
  35        FORMAT(//,'SYSTEM IS UNSTABLE',//)
            STOP
           END IF
      RETURN
      END
C   *******************************************************************
C   *                  DEFLECTION BOUNDARY CONDITION                  *
C   *******************************************************************
      SUBROUTINE DEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT)
      DOUBLE PRECISION AU(25,25),BU(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30)
      REAL L(30)
      X=L(1)
          DO 10 I=1,NS
            IF(ICONT.EQ.6)GO TO 15
            SP=0
              DO 20 J=1,N
                AU(I,J)=(X-SP)**3/6
                IF((X-SP).LT.0.)AU(I,J)=0.
                SP=SP+L(J)
 20           CONTINUE
            GO TO 17
 15         SP=L(1)
              DO 16 J=1,NS
                AU(I,J)=(X-SP)**3/6
                JJ=J+1
                IF(JJ.GT.N)GO TO 17
                SP=SP+L(J+1)
                IF((X-SP).LT.0)AU(I,J)=0
 16           CONTINUE
 17         CA1=0
            IF(NP.EQ.0)GO TO 26
              DO 25 NL=1,NP
                CA=(X-A(NL))**3/6*P(NL)
```

```
                IF((X-A(NL)).LT.0)CA=0
                CA1=CA+CA1
  25          CONTINUE
  26         US1=0
             IF(NW.EQ.0)GO TO 29
                DO 30 LL=1,NW
                 UB=(X-BG(LL))**4/24*W(LL)
                 UE=-(X-E(LL))**4/24*W(LL)
                 IF((X-BG(LL)).LT.0)UB=0
                 IF((X-E(LL)).LT.0)UE=0
                 US1=UB+UE+US1
  30           CONTINUE
  29       BU(I)=CA1+US1
           IC=I+1
           IF(IC.GT.NS)GO TO 35
           X=X+L(IC)
  10      CONTINUE
  35  RETURN
      END
C   ********************************************************************
C   *                     SLOPE BOUNDARY CONDITION                     *
C   ********************************************************************
      SUBROUTINE SLOPE(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      DOUBLE PRECISION AU(25,25),BU(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30)
      REAL L(30)
      SPL=0
        DO 10 I=1,NS
          J=K-1
          AU(J,I)=(TSP-SPL)**2/2
          SPL=SPL+L(I)
  10    CONTINUE
      CB1=0
      IF(NP.EQ.0)GO TO 21
          DO 20 I=1,NP
            CB=(TSP-A(I))**2/2*P(I)
            CB1=CB1+CB
  20      CONTINUE
  21  UB1=0
      UE1=0
      IF(NW.EQ.0)GO TO 31
          DO 30 I=1,NW
          UB=(TSP-BG(I))**3/6*W(I)
          UE=-(TSP-E(I))**3/6*W(I)
          UB1=UB+UB1
          UE1=UE+UE1
  30    CONTINUE
  31  BU(K-1)=CB1+UB1+UE1
      RETURN
      END
C   ********************************************************************
C   *                    MOMENT BOUNDARY CONDITION
C   ********************************************************************
      SUBROUTINE MOM(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
      DOUBLE PRECISION AU(25,25),BU(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30)
      REAL L(30)
      IF(ICONT.EQ.6)GO TO 15
      SPL=0
          DO 10 I=1,N
            AU(K,I)=(TSP-SPL)
            SPL=SPL+L(I)
  10      CONTINUE
      GO TO 16
  15  SPL=L(1)
          DO 12 I=1,NS
            AU(K,I)=TSP-SPL
```

```
            J=I+1
            SPL=SPL+L(J)
  12      CONTINUE
  16    CB1=0
        IF(NP.EQ.0)GO TO 21
             DO 20 I=1,NP
               CB=(TSP-A(I))*P(I)
               CB1=CB1+CB
  20         CONTINUE
  21    UB1=0
        UE1=0
        IF(NW.EQ.0)GO TO 31
              DO 30 I=1,NW
                UB=(TSP-BG(I))**2/2*W(I)
                UE=-(TSP-E(I))**2/2*W(I)
                UB1=UB+UB1
                UE1=UE+UE1
  30          CONTINUE
  31    BU(K)=CB1+UB1+UE1
        RETURN
        END
C     ***********************************************************************
C     *                           SHEAR BOUNDARY CONDITION                  *
C     ***********************************************************************
        SUBROUTINE SHEAR(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,ICONT,TSP)
        DOUBLE PRECISION AU(25,25),BU(25)
        DIMENSION P(30),A(30),W(30),BG(30),E(30)
        REAL L(30)
        IF(ICONT.EQ.6)GO TO 15
        SPL=0
             DO 10 I=1,N
               J=K-1
               IF((TSP-SPL).EQ.0.)GO TO 8
               AU(J,I)=(TSP-SPL)**0
                GO TO 9
   8           AU(J,I)=1.
   9           SPL=SPL+L(I)
  10         CONTINUE
        GO TO 16
  15    SPL=L(1)
             DO 12 I=1,NS
               IF((TSP-SPL).EQ.0.)GO TO 211
               AU(N,I)=(TSP-SPL)**0
               J=I+1
               GO TO 23
 211           AU(N,I)=1
  23           SPL=SPL+L(J)
  12         CONTINUE
  16    CB1=0
        IF(NP.EQ.0)GO TO 21
             DO 20 I=1,NP
              IF((TSP-A(I)).EQ.0.)GO TO 28
              CB=(TSP-A(I))**0*P(I)
              GO TO 29
  28          CB=P(I)
  29          CB1=CB1+CB
  20         CONTINUE
  21    UB1=0
        UE1=0
        IF(NW.EQ.0)GO TO 31
             DO 30 I=1,NW
                UB=(TSP-BG(I))*W(I)
                UE=-(TSP-E(I))*W(I)
                UB1=UB+UB1
                UE1=UE+UE1
  30         CONTINUE
  31    BU(K-1)=CB1+UB1+UE1
```

```
      RETURN
      END
C     ******************************************************************
C     *                          EQUILIBRIUM                           *
C     ******************************************************************
      SUBROUTINE EQU(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,RL)
      DOUBLE PRECISION AU(25,25),BU(25)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),R(26)
      REAL L(30)
            DO 10 I=1,NS
              R(I)=BU(I)
   10       CONTINUE
      RE=0
            DO 20 I=1,NS
              CO=R(I)
              RE=CO+RE
   20       CONTINUE
      PE=0
      IF(NP.EQ.0)GO TO 31
            DO 30 I=1,NP
              EO=P(I)
              PE=EO+PE
   30       CONTINUE
   31 WE=0
      IF(NW.EQ.0)GO TO 41
            DO 40 I=1,NW
              FO=W(I)*(E(I)-BG(I))
              WE=FO+WE
   40       CONTINUE
   41 AP=PE+WE
      RL=AP-RE
      RETURN
      END
C     ******************************************************************
C     *                             CALDEF                             *
C     ******************************************************************
      SUBROUTINE CALDEF(N,K,NS,NP,NW,P,A,W,BG,E,L,AU,BU,R,ICONT,TSP,
     $AM1,AM2,Z1,Z2)
      DIMENSION P(30),A(30),W(30),BG(30),E(30),AU(25,25),BU(25),
     $R(26)
      REAL L(30),EM,IM
      WRITE(9,15)
   15 FORMAT(15X,'ENTER FRACTION OF THE BEAM THAT DISPLACEMENT' ,/,
     $'NEEDED...???')
      READ(8,*)DELX
      WRITE(9,10)
   10 FORMAT('ENTER VALUE OF MODULUS OF ELASTICITY AND MOMENT OF INERTIA
     $OF THE BEAM...???')
      READ(8,*)EM,IM
      WRITE(6,20)EM,IM
   20 FORMAT(/,10X,'YOUNG'S MODULUS=' ,F12.3,2X,'(N/MM**2)' ,3X,'MOMENT OF
     $INERTIA=' ,F12.2,2X,'(MM**4)')
      IF(ICONT.EQ.4)GO TO 77
      IF(ICONT.EQ.5)GO TO 104
      IF(ICONT.EQ.6)GO TO 105
      WRITE(6,101)AM1
  101 FORMAT(/,10X,'M1 =' ,F10.2,2X,'N.MM')
      IF(ICONT.EQ.2)GO TO 77
      IF(ICONT.EQ.3)GO TO 104
      WRITE(6,103)AM2
  103 FORMAT(/,10X,'M2 =' ,F10.2,2X,'N.MM')
   77 J=N+1
      GO TO 78
  104 J=N
      GO TO 78
  105 J=N-1
   78 DO 120 I=1,J
```

```
      WRITE(6,130)I,R(I)
  130 FORMAT(/,10X,'R(',I2,') =',F10.2,2X,'(N)')
  120 CONTINUE
      WRITE(6,30)
   30 FORMAT(//,5X,'DISTANCE',20X,'DEFLECTION',/,7X,'(MM)',24X,'(MM)',//
     $)
      X=0
   40 SUM=0
      IF(ICONT.EQ.6)GO TO 45
      RE=0
              DO 50 I=1,N
                 TERM=(X-RE)**3/6*R(I)
                 IF((X-RE).LT.0)TERM=0
                 RE=L(I)+RE
                 SUM=TERM+SUM
   50         CONTINUE
                      GO TO 60
   45 RE=L(1)
            DO 70 I=1,NS
               TERM=(X-RE)**3/6*R(I)
               IF((X-RE).LT.0)TERM=0
               J=I+1
               RE=RE+L(J)
               SUM=TERM+SUM
   70       CONTINUE
   60 SUM1=0
      IF(NP.EQ.0)GO TO 85
            DO 80 I=1,NP
               TERM1=-(X-A(I))**3/6*P(I)
               IF((X-A(I)).LT.0)TERM1=0
               SUM1=TERM1+SUM1
   80       CONTINUE
   85 SUM2=0
      IF(NW.EQ.0)GO TO 95
         DO 90 I=1,NW
            TERM2=-(X-BG(I))**4/24*W(I)
            TERM3=(X-E(I))**4/24*W(I)
            IF((X-BG(I)).LT.0)TERM2=0
            IF((X-E(I)).LT.0)TERM3=0
            SUM2=TERM2+TERM3+SUM2
   90    CONTINUE
   95 SUM3=-AM1*X**2/2
      SUM4=Z1*X+Z2
      Y=(SUM+SUM1+SUM2+SUM3+SUM4)/(EM*IM)
      WRITE(6,100)X,Y
  100 FORMAT(3X,'X=',2X,F8.3,15X,'Y=',F12.7)
      X=X+DELX
      IF(X.GT.TSP)GO TO 110
              GO TO 40
  110 RETURN
      END
$ENTRY
```

```
               *****************************************
               *              EXECUTE FILE             *
               *****************************************
```

```
GLOBAL MACLIB IMSLDP WATLIB
FI 8 TERMINAL
FI 9 TERMINAL
WATFIV GENERAL
```

APPENDIX D

HAND CALCULATION OF SAMPLE PROBLEMS

As a sample hand calculation a typical portal frame subjected to a concentrated force of 5N (Figure D-1) is analyzed. Castigliano's Theorem based on the principle of minimum potential energy is used to calculate the horizontal deflection (side-sway) of the frame.

Strain energy of a structural element under pure bending is:

$$U = \int_0^L \frac{M^2}{2EI}\, dx \qquad \text{(D-1)}$$

where,

M = bending moment

E = modulus of elasticity

I = moment of inertia

L = total length of the element

using the free-body diagram presented in Figure (D-1), potential energy for each member is as follows:

$$u_1 = \frac{1}{2EI} \int_0^L (M_1 + vx_1)^2\, dx_1 \qquad \text{(D-2)}$$

$$u_2 = \frac{1}{2EI} \int_0^a (M_1 + vL - Fx_2)^2 dx_2 \qquad \text{(D-3)}$$

$$u_3 = \frac{1}{2EI} \int_0^L [M_2 + (Q-v)x_3]^2\, dx_3 \qquad \text{(D-4)}$$

Using the equilibrium equation, F is found as a function of M_1 , M_2 and Q, namely,

$$F = \frac{M_1 + M_2 + QL}{a} \qquad \text{(D-5)}$$

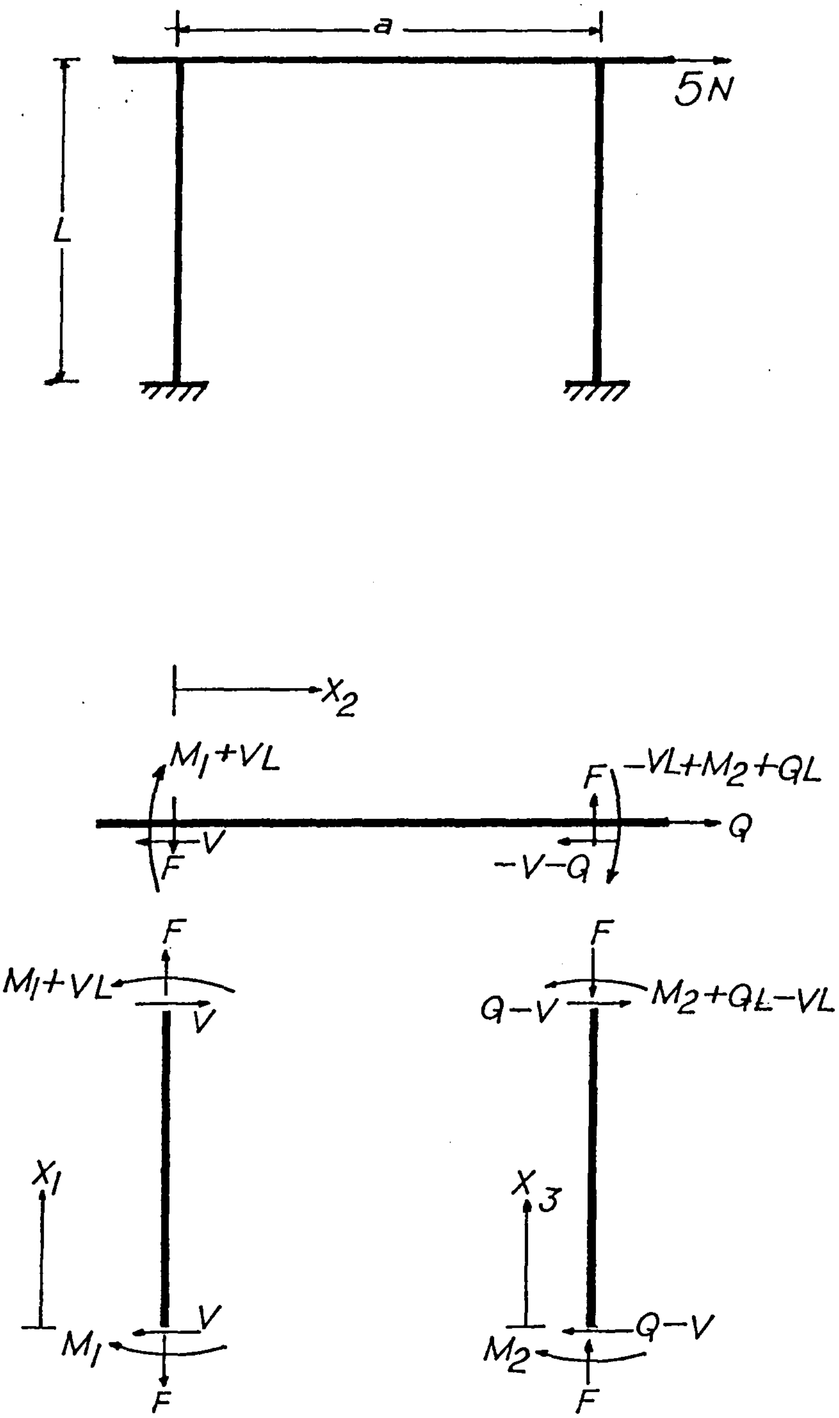


Fig. D-1. A Typical Frame and Its Free-body Diagram.

Substituting (D-5) in equation (D-3) and by adding the three equations (D-2), (D-3) and (D-4) the total strain energy of the frame is found:

$$U = \frac{1}{2EI} \int_0^L (M_1+vx_1)^2 dx_1 + \int_0^a [M_1+vL-(M_1+M_2+QL) \frac{x_2}{a}]^2 \ dx_2$$

$$+ \int_0^L [M_2 +(Q-v)x]^2 \ dx_3 \qquad (D-6)$$

According to Castigliano's Theorem, the partial derivative of total strain energy (D-6) with respect to horizontal force Q yields the horizontal deflection (side-sway) of the frame.

$$\frac{\partial U}{\partial Q} = \Delta_H \qquad (D-7)$$

The above procedure is used for a typical case when the frame is supported on pins at both ends. Since rotation is allowed at both ends of the frame, M_1 and M_2 in equation (D-6) are zero. Therefore,

$$U = \frac{1}{2EI} \left[\int_0^L (vx_1)^2 dx_1 + \int_0^a (vL - QL \frac{x_2}{a})^2 \ dx_2 + \right.$$

$$\left. + \int_0^L (Q-v)^2 \quad x_3^2 \ dx_3 \right] \qquad (D-8)$$

To calculate horizontal reaction v at the supports:

$$\frac{\partial U}{\partial v} = \Delta_v = 0 \qquad (D-9)$$

which results:

$$v = \frac{1}{2} Q \qquad (D-10)$$

Horizontal deflection (side-sway) of the frame is found by taking the partial derivative of U in (D-8) with respect to Q after substituting for v in terms of Q from (D-10). This yields,

$$\frac{\partial U}{\partial Q} = \Delta_H = .5734 \text{ mm} \qquad \text{(D-11)}$$

which is compared to the STRUDL result Δ_H = 0.5744 mm.

APPENDIX E

UNCERTAINTY ANALYSIS

APPENDIX E

UNCERTAINTY ANALYSIS

A precise method of estimating uncertainty in experimental results is based on a careful specification of the uncertainties in the various primary experimental measurements. Suppose we wish to estimate the uncertainty in the calculated result on the basis of the uncertainties in the primary measurements. The result R is a given function of the independent variables x_1, x_2.......x_n

$$R = R\ (x_1,\ x_2,\ .....x_n)$$

let W_R be the uncertainty in the result and W_1, W_2, ...,W_i be the uncertainties in the independent variables. If the uncertainties in the independent variables are all given with the same odds, then the uncertainty in the result having these odds is given as:

$$W_R = [(\frac{\partial R}{\partial x_1} W_1)^2 + (\frac{\partial R}{\partial x_2} W_2)^2 + ... + (\frac{\partial R}{\partial x_n} W_n)^2]^{1/2}$$

EXAMPLE: The area of a rectangle is given as A = bh. The base b, and height, h, are measured with a ruler marked in millimeters. The uncertainty in its measuring ability is

±0.5 mm. B is measured as 10 mm and h as 22mm. Find the uncertainty in the area measurement using the measurements for b and h.

$$W_A = [(\frac{\partial A}{\partial b} W_b)^2 + (\frac{\partial A}{\partial h} W_h)^2]^{1/2}$$

$$\frac{\partial A}{\partial b} = h \quad , \qquad \frac{\partial A}{\partial b} = b, \qquad W_b = W_h = 0.5 \text{ mm}$$

$$W_A = [(hW_b)^2 + (bW_h)^2]^{1/2}$$

$$W_A = ([22)(0.5)]^2 + [(10)(0.5)]^2)^{1/2}$$

$$W_A = 12.1 \text{ mm}^2$$

$$A = bh = (10)(22) = 220$$

$$A = 220 \pm 12 \text{ mm}^2$$

APPENDIX F

LISTING OF STRUDL INPUT AND OUTPUT FOR PORTAL FRAME TESTS

```
************************************************************************
*                                                                      *
*              INTEGRATED CIVIL ENGINEERING SYSTEM - V1 M3 NOV 1969    *
*                                    - ICES -                          *
*               NOV 05, 1984              TIME=21.35.44                *
*                                                                      *
************************************************************************
STRUDL 'FRAME' 'ANALYSIS'
           ***********************************************
           *                                             *
           *              ICES STRUDL-II                 *
           *      THE STRUCTURAL DESIGN LANGUAGE         *
           *                                             *
           *     CIVIL ENGINEERING SYSTEMS LABORATORY    *
           *     MASSACHUSETTS INSTITUTE OF TECHNOLOGY   *
           *           CAMBRIDGE, MASSACHUSETTS          *
           *             V2 M2       JUNE, 1972          *
           *            21:35:49      11/05/84           *
           *                                             *
           ***********************************************
TYPE PLANE FRAME
UNIT CM KGS
JOINT COORDS.
1  X  0.0    Y  45.0   F
2  X  9.1    Y  45.0
3  X 39.15   Y  45.0
4  X 69.20   Y  45.0
5  X 78.0    Y  45.0   F
6  X  9.1    Y   0.    S
7  X 69.2    Y   0.    S
$
MEM INC
1  1  2
2  2  3
3  3  4
4  4  5
5  6  2
6  7  4
$ PIN-ROLLER SUPPORT CONDITION
JOINT RELEASES
6 MOM Z
7 FORCE X MOM Z
UNIT CM KGS
MEM 1 TO 6 PROP PRI AX 2.0  IZ 0.10667 YD .8 YC .4
UNIT CM KGS
CONSTANT  E 2.1093E6 ALL
UNIT CM KGS
ACTIVE MEM ALL
LOADING 1 'UNIFORM LOAD ON BEAM'
MEMB LOADS
1 TO 4 F Y GLO UNI W -6.60387E-2
LOADING 2 'SIDESWAY CONC.LOAD ON JOINT 5'
JOINT 5 LOAD FORCE X .5102
LOADING 3 'CONC. LOAD ON MIDSPAN OF BEAM'
JOINT 3 LOAD FORCE Y -.5102
LOADING 4 'SIDESWAY LOAD ALONG THE COLUMN 6'
MEM LOAD
6 FORCE X GLO CON P .5102 L 22.4
LOADING 5 'SIDESWAY LOAD ALONG THE COLUMN 5'
MEM LOAD
5 FORCE X GLO CON  P -1.0204 L 24.4
LOADING 6 'CON VERTICAL LOAD ON JOINT 1'
JOINT 1 LOAD FORCE Y -.5102
LOADING 7 'CONC VERTICAL LOAD ON JOINT 5'
JOINT 5 LOAD FORCE Y -.5102
LOADING LIST ALL
STIFFNES ANALYSIS
LOADING COMB 10 'UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5'
COMBINE 10 1 1. 2 1.
LOADING COMB 15 'VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5'
COMBINE 15 2 1. 3 1.
LOADING COMB 20 'SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6'
COMBINE 20 2 1. 4 1.
LOADING COMB 25 '3 CONCENTRATED LOADS ON J 1&3&5'
COMBINE 25 6 1. 3 1. 7 1.
```

```
*****************************************************************
*                                                               *
*          INTEGRATED CIVIL ENGINEERING SYSTEM - V1 M3 NOV 1969 *
*                              - ICES -                         *
*           NOV 05, 1984                     TIME=21.35.44      *
*                                                               *
*****************************************************************
STRUDL 'FRAME' 'ANALYSIS'
          *****************************************
          *                                       *
          *             ICES STRUDL-II            *
          *      THE STRUCTURAL DESIGN LANGUAGE   *
          *                                       *
          *   CIVIL ENGINEERING SYSTEMS LABORATORY *
          *   MASSACHUSETTS INSTITUTE OF TECHNOLOGY *
          *        CAMBRIDGE, MASSACHUSETTS       *
          *        V2 M2        JUNE, 1972        *
          *        21:35:49      11/05/84         *
          *                                       *
          *****************************************
TYPE PLANE FRAME
UNIT CM KGS
JOINT COORDS.
1  X  0.0    Y  45.0   F
2  X   9.1   Y  45.0
3  X 39.15   Y  45.0
4  X 69.20   Y  45.0
5  X 78.0    Y  45.0   F
6  X   9.1   Y   0.    S
7  X 69.2    Y   0.    S
$
MEM INC
1  1  2
2  2  3
3  3  4
4  4  5
5  6  2
6  7  4
$ PIN-ROLLER SUPPORT CONDITION
JOINT RELEASES
6 MOM Z
7 FORCE X MOM Z
UNIT CM KGS
MEM 1 TO 6 PROP PRI AX 2.0  IZ 0.10667 YD .8 YC .4
UNIT CM KGS
CONSTANT  E 2.1093E6 ALL
UNIT CM KGS
ACTIVE MEM ALL
LOADING 1 'UNIFORM LOAD ON BEAM'
MEMB LOADS
1 TO 4 F Y GLO UNI W -6.60387E-2
LOADING 2 'SIDESWAY CONC.LOAD ON JOINT 5'
JOINT 5 LOAD FORCE X .5102
LOADING 3 'CONC. LOAD ON MIDSPAN OF BEAM'
JOINT 3 LOAD FORCE Y -.5102
LOADING 4 'SIDESWAY LOAD ALONG THE COLUMN 6'
MEM LOAD
6 FORCE X GLO CON P .5102 L 22.4
LOADING 5 'SIDESWAY LOAD ALONG THE COLUMN 5'
MEM LOAD
5 FORCE X GLO CON  P -1.0204 L 24.4
LOADING 6 'CON VERTICAL LOAD ON JOINT 1'
JOINT 1 LOAD FORCE Y -.5102
LOADING 7 'CONC VERTICAL LOAD ON JOINT 5'
JOINT 5 LOAD FORCE Y -.5102
LOADING LIST ALL
STIFFNES ANALYSIS
LOADING COMB 10 'UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5'
COMBINE 10 1 1. 2 1.
LOADING COMB 15 'VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5'
COMBINE 15 2 1. 3 1.
LOADING COMB 20 'SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6'
COMBINE 20 2 1. 4 1.
LOADING COMB 25 '3 CONCENTRATED LOADS ON J 1&3&5'
COMBINE 25 6 1. 3 1. 7 1.
```

```
LOADING COMB 30 '3 10N CONCENTRATED LOADS ON JOINTS 1&3&5'
COMBINE 30 6 2. 3 2. 7 2.
LOADING COMB 35 '2 10N CONCENTRATED LOADS ON JOINTS 1&5'
COMBINE 35 6 2. 7 2.
UNIT IN
PLOT DEVI PRIN  COL 10 ROWS 10
PLOT FORMAT ORIEN NONSTANDARD
PLOT PLAN



PLANE IDENTIFIED BY - PLANE
                                          Z EQUALS      0.0


IN PLANE JOINTS
   JOINT                        COORDINATES
                     X                 Y            Z
   1                0.0             17.7165        0.0
   2                3.5827          17.7165        0.0
   3               15.4134          17.7165        0.0
   4               27.2440          17.7165        0.0
   5               30.7086          17.7165        0.0
   6                3.5827           0.0           0.0
   7               27.2440           0.0           0.0


IN PLANE MEMBERS
   MEMBER INCIDENCES

 MEMBER     START       END
  1          1          2
  2          2          3
  5          6          2
  3          3          4
  4          4          5
  6          7          4
```

```
                                   Y          HORIZONTAL SCALE    5.0000 UNITS PER IN
                                   *
                                   *
                                   *
                                   *          VERTICAL   SCALE    5.0000 UNITS PER IN
                  ORIENTATION      *****X



     X*1**2*X*********************3*X********************4*X****5*X
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
0015 +      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
0010 +      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
0005 +      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
     -      *                                              *
   0 +    6 X                                            7 X
     -

     +---------+---------+---------+---------+---------+---------+---
     0      0005      0010      0015      0020      0025      0030
```

```
UNIT CM KGS
PRINT JOINT STATUS

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  FRAME        JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH         WEIGHT         ANGLE        TEMPERATURE      TIME
                  CM             KG             RAD            DEGF           SEC
                                                                STATUS---/
JOINT

JOINT
```

```
1                                                     ACTIVE
2                                                     ACTIVE
3                                                     ACTIVE
4                                                     ACTIVE
5                                                     ACTIVE
6                                                     ACTIVE
7                                                     ACTIVE


    RELEASES------------------------------------/
JOINT                                             ELASTIC SUPPORT RELEASES------------------------------------------
JOINT
      FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                   KFX          KFY          KFZ          KMX          KMY
6
               Z        0.0      0.0      0.0
                                                    0.0          0.0          0.0          0.0          0.0
7
      X        Z        0.0      0.0      0.0
                                                    0.0          0.0          0.0          0.0          0.0

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
LIST DISP ALL


   ****************************
   *RESULTS OF LATEST ANALYSES*
   ****************************


    PROBLEM - FRAME      TITLE - ANALYSIS

    ACTIVE UNITS  CM   KG   RAD  DEGF SEC
    ACTIVE STRUCTURE TYPE  PLANE   FRAME
    ACTIVE COORDINATE AXES  X Y

    LOADING - 1            UNIFORM LOAD ON BEAM

    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS
```

```
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                             X DISP.          Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

 6          GLOBAL          0.0              0.0                                                            -0.0022975
 7          GLOBAL          0.2071300        0.0                                                             0.0023054

    RESULTANT JOINT
                       DISPLACEMENTS -  FREE JOINTS

JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                             X DISP.          Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

 1          GLOBAL          0.1033872        0.0206280                                                      -0.0022606
 2          GLOBAL          0.1033872       -0.0000276                                                      -0.0022975
 3          GLOBAL          0.1033872       -0.0445787                                                      -0.0000020
 4          GLOBAL          0.1033872       -0.0000273                                                       0.0023054
 5          GLOBAL          0.1033872        0.0200401                                                       0.0022721

    LOADING - 2            SIDESWAY CONC.LOAD ON JOINT 5

    RESULTANT JOINT
                       DISPLACEMENTS -  SUPPORTS

JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                             X DISP.          Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

 6          GLOBAL          0.0              0.0                                                            -0.0043403
 7          GLOBAL          0.2068685        0.0                                                             0.0010220

    RESULTANT JOINT
                       DISPLACEMENTS -  FREE JOINTS

JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                             X DISP.          Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

 1          GLOBAL          0.1608725        0.0186076                                                      -0.0020443
 2          GLOBAL          0.1608725        0.0000041                                                      -0.0020443
 3          GLOBAL          0.1608762       -0.0230357                                                       0.0002554
 4          GLOBAL          0.1608798       -0.0000041                                                       0.0010220
 5          GLOBAL          0.1608809        0.0089892                                                       0.0010220

    LOADING - 3            CONC. LOAD ON MIDSPAN OF BEAM

    RESULTANT JOINT
                       DISPLACEMENTS -  SUPPORTS

JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                             X DISP.          Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

 6          GLOBAL          0.0              0.0                                                            -0.0005119
 7          GLOBAL          0.0460714        0.0                                                             0.0005119
```

```
    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                  /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                          X ROT.           Y ROT.          Z ROT.
                         X DISP.          Y DISP.          Z DISP.

1          GLOBAL       0.0230357        0.0046556                                                       -0.0005119
2          GLOBAL       0.0230357       -0.0000027                                                       -0.0005119
3          GLOBAL       0.0230357       -0.0102579                                                       -0.0000000
4          GLOBAL       0.0230357       -0.0000027                                                        0.0005119
5          GLOBAL       0.0230357        0.0045020                                                        0.0005119

    LOADING - 4            SIDESWAY LOAD ALONG THE COLUMN 6

    RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                  /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                          X ROT.           Y ROT.          Z ROT.
                         X DISP.          Y DISP.          Z DISP.

6          GLOBAL       0.0              0.0                                                             -0.0048535
7          GLOBAL       0.2978636        0.0                                                              0.0026278

    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                  /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                          X ROT.           Y ROT.          Z ROT.
                         X DISP.          Y DISP.          Z DISP.

1          GLOBAL       0.1839691        0.0232762                                                       -0.0025576
2          GLOBAL       0.1839691        0.0000020                                                       -0.0025576
3          GLOBAL       0.1839727       -0.0346047                                                        0.0001271
4          GLOBAL       0.1839764       -0.0000020                                                        0.0020487
5          GLOBAL       0.1839764        0.0180264                                                        0.0020487
    LOADING - 5            SIDESWAY LOAD ALONG THE COLUMN 5

    RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                  /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                          X ROT.           Y ROT.          Z ROT.
                         X DISP.          Y DISP.          Z DISP.

6          GLOBAL       0.0              0.0                                                              0.0058465
7          GLOBAL      -0.2506961        0.0                                                             -0.0011083

    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                  /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                          X ROT.           Y ROT.          Z ROT.
                         X DISP.          Y DISP.          Z DISP.
```

```
1        GLOBAL       -0.2008240     -0.0201789                                                                0.0022170
2        GLOBAL       -0.2008240     -0.0000044                                                                0.0022170
3        GLOBAL       -0.2008240      0.0249809                                                               -0.0002770
4        GLOBAL       -0.2008240      0.0000044                                                               -0.0011083
5        GLOBAL       -0.2008240     -0.0097483                                                               -0.0011083

    LOADING - 6            CON VERTICAL LOAD ON JOINT 1

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                   /----------------DISPLACEMENT----------------/
                                                                      /-----------------ROTATION-----------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.        Z DISP.

6        GLOBAL        0.0            0.0                                                                      0.0004135
7        GLOBAL       -0.0279034      0.0                                                                     -0.0002066

    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                   /----------------DISPLACEMENT----------------/
                                                                      /-----------------ROTATION-----------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.        Z DISP.

1        GLOBAL       -0.0186076     -0.0043387                                                                0.0005074
2        GLOBAL       -0.0186076     -0.0000063                                                                0.0004135
3        GLOBAL       -0.0186076      0.0046556                                                               -0.0000516
4        GLOBAL       -0.0186076      0.0000008                                                               -0.0002066
5        GLOBAL       -0.0186076     -0.0018170                                                               -0.0002066

    LOADING - 7            CONC VERTICAL LOAD ON JOINT 5

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                   /----------------DISPLACEMENT----------------/
                                                                      /-----------------ROTATION-----------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.        Z DISP.

6        GLOBAL        0.0            0.0                                                                      0.0001998
7        GLOBAL       -0.0269835      0.0                                                                     -0.0003999

    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                   /----------------DISPLACEMENT----------------/
                                                                      /-----------------ROTATION-----------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.        Z DISP.

1        GLOBAL       -0.0089892     -0.0018170                                                                0.0001998
2        GLOBAL       -0.0089892      0.0000008                                                                0.0001998
3        GLOBAL       -0.0089892      0.0045020                                                                0.0000499
4        GLOBAL       -0.0089892     -0.0000062                                                               -0.0003999
5        GLOBAL       -0.0089892     -0.0040402                                                               -0.0004877

    LOADING - 10           UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5
```

```
    RESULTANT JOINT
                          SUPPORTS
              DISPLACEMENTS -
JOINT                /-----------------DISPLACEMENT-----------------/
                                                                     /-------------------ROTATION-------------------/
                         X DISP.       Y DISP.       Z DISP.            X ROT.         Y ROT.         Z ROT.

6         GLOBAL        0.0           0.0                                                           -0.0066377
7         GLOBAL        0.4139984     0.0                                                            0.0033274

    RESULTANT JOINT
                          FREE JOINTS
              DISPLACEMENTS -
JOINT                /-----------------DISPLACEMENT-----------------/
                                                                     /-------------------ROTATION-------------------/
                         X DISP.       Y DISP.       Z DISP.            X ROT.         Y ROT.         Z ROT.

1         GLOBAL        0.2642597     0.0392356                                                     -0.0043050
2         GLOBAL        0.2642597    -0.0000235                                                     -0.0043418
3         GLOBAL        0.2642633    -0.0676144                                                      0.0002534
4         GLOBAL        0.2642670    -0.0000314                                                      0.0033274
5         GLOBAL        0.2642680     0.0290293                                                      0.0032940

    LOADING - 15          VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                          SUPPORTS
              DISPLACEMENTS -
JOINT                /-----------------DISPLACEMENT-----------------/
                                                                     /-------------------ROTATION-------------------/
                         X DISP.       Y DISP.       Z DISP.            X ROT.         Y ROT.         Z ROT.

6         GLOBAL        0.0           0.0                                                           -0.0048522
7         GLOBAL        0.2529398     0.0                                                            0.0015339

    RESULTANT JOINT
                          FREE JOINTS
              DISPLACEMENTS -
JOINT                /-----------------DISPLACEMENT-----------------/
                                                                     /-------------------ROTATION-------------------/
                         X DISP.       Y DISP.       Z DISP.            X ROT.         Y ROT.         Z ROT.

1         GLOBAL        0.1839082     0.0232632                                                     -0.0025562
2         GLOBAL        0.1839082     0.0000014                                                     -0.0025562
3         GLOBAL        0.1839119    -0.0332935                                                      0.0002554
4         GLOBAL        0.1839155    -0.0000068                                                      0.0015339
5         GLOBAL        0.1839165     0.0134913                                                      0.0015339

    LOADING - 20          SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6

    RESULTANT JOINT
                          SUPPORTS
              DISPLACEMENTS -
JOINT                /-----------------DISPLACEMENT-----------------/
                                                                     /-------------------ROTATION-------------------/
```

```
                                        FREE JOINTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                             X ROT.             Y ROT.             Z ROT.
                             X DISP.          Y DISP.          Z DISP.

1          GLOBAL         -0.0091223       -0.0030003                                                           0.0003905
2          GLOBAL         -0.0091223       -0.0000164                                                           0.0002027
3          GLOBAL         -0.0091223       -0.0022004                                                          -0.0000034
4          GLOBAL         -0.0091223       -0.0000163                                                          -0.0001891
5          GLOBAL         -0.0091223       -0.0027104                                                          -0.0003647

     LOADING - 35             2 10N CONCENTRATED LOADS ON JOINTS 1&5


     RESULTANT JOINT
                                        SUPPORTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                             X ROT.             Y ROT.             Z ROT.
                             X DISP.          Y DISP.          Z DISP.

6          GLOBAL           0.0              0.0                                                                0.0012265
7          GLOBAL         -0.1097739         0.0                                                               -0.0012129


     RESULTANT JOINT
                                        FREE JOINTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                             X ROT.             Y ROT.             Z ROT.
                             X DISP.          Y DISP.          Z DISP.

1          GLOBAL         -0.0551937       -0.0123115                                                           0.0014143
2          GLOBAL         -0.0551937       -0.0000109                                                           0.0012265
3          GLOBAL         -0.0551937        0.0183153                                                          -0.0000034
4          GLOBAL         -0.0551937       -0.0000108                                                          -0.0012129
5          GLOBAL         -0.0551937       -0.0117145                                                          -0.0013885
$ FIXED-ROLLER SUPPORT CONDITION
DELETIONS
JOINT RELEASES
6 MOM Z
STIFFNES ANALYSIS
PRINT JOINT STATUS

***************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
***************************************

JOB ID -  FRAME         JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH          WEIGHT          ANGLE          TEMPERATURE       TIME
                  CM              KG              RAD             DEGF            SEC
                                                                    STATUS---/
JOINT

JOINT


1
                                                                    ACTIVE

2
                                                                    ACTIVE

3
```

```
                                                                          X ROT.          Y ROT.          Z ROT.
                                X DISP.          Y DISP.          Z DISP.
 6          GLOBAL             0.0              0.0                                                       -0.0091938
 7          GLOBAL             0.5047321        0.0                                                        0.0036497

     RESULTANT JOINT
                             DISPLACEMENTS - FREE JOINTS

 JOINT                         /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                                X DISP.          Y DISP.          Z DISP.

 1          GLOBAL             0.3448417        0.0418838                                                 -0.0046019
 2          GLOBAL             0.3448417        0.0000061                                                 -0.0046019
 3          GLOBAL             0.3448489       -0.0576404                                                  0.0003825
 4          GLOBAL             0.3448561       -0.0000061                                                  0.0030707
 5          GLOBAL             0.3448572        0.0270156                                                  0.0030707

     LOADING - 25           3 CONCENTRATED LOADS ON J 1&3&5

     RESULTANT JOINT
                             DISPLACEMENTS - SUPPORTS

 JOINT                         /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                                X DISP.          Y DISP.          Z DISP.

 6          GLOBAL             0.0              0.0                                                        0.0001014
 7          GLOBAL            -0.0088156        0.0                                                       -0.0000945

     RESULTANT JOINT
                             DISPLACEMENTS - FREE JOINTS

 JOINT                         /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                                X DISP.          Y DISP.          Z DISP.

 1          GLOBAL            -0.0045612       -0.0015002                                                  0.0001952
 2          GLOBAL            -0.0045612       -0.0000082                                                  0.0001014
 3          GLOBAL            -0.0045612       -0.0011002                                                 -0.0000017
 4          GLOBAL            -0.0045612       -0.0000081                                                 -0.0000945
 5          GLOBAL            -0.0045612       -0.0013552                                                 -0.0001823

     LOADING - 30           3 10N CONCENTRATED LOADS ON JOINTS 1&3&5

     RESULTANT JOINT
                             DISPLACEMENTS - SUPPORTS

 JOINT                         /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                                X DISP.          Y DISP.          Z DISP.

 6          GLOBAL             0.0              0.0                                                        0.0002027
 7          GLOBAL            -0.0176312        0.0                                                       -0.0001891

     RESULTANT JOINT
```

```
                                                                                  X ROT.        Y ROT.        Z ROT.
                       X DISP.         Y DISP.        Z DISP.
6        GLOBAL        0.0             0.0                                                                    -0.0091938
7        GLOBAL        0.5047321       0.0                                                                     0.0036497


    RESULTANT JOINT
                                       FREE JOINTS
                   DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.        Y ROT.        Z ROT.
                       X DISP.         Y DISP.        Z DISP.

1        GLOBAL        0.3448417       0.0418838                                                      -0.0046019
2        GLOBAL        0.3448417       0.0000061                                                      -0.0046019
3        GLOBAL        0.3448489      -0.0576404                                                       0.0003825
4        GLOBAL        0.3448561      -0.0000061                                                       0.0030707
5        GLOBAL        0.3448572       0.0270156                                                       0.0030707

    LOADING - 25            3 CONCENTRATED LOADS ON J 1&3&5


    RESULTANT JOINT
                                       SUPPORTS
                   DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.        Y ROT.        Z ROT.
                       X DISP.         Y DISP.        Z DISP.

6        GLOBAL        0.0             0.0                                                             0.0001014
7        GLOBAL       -0.0088156       0.0                                                            -0.0000945


    RESULTANT JOINT
                                       FREE JOINTS
                   DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.        Y ROT.        Z ROT.
                       X DISP.         Y DISP.        Z DISP.

1        GLOBAL       -0.0045612      -0.0015002                                                       0.0001952
2        GLOBAL       -0.0045612      -0.0000082                                                       0.0001014
3        GLOBAL       -0.0045612      -0.0011002                                                      -0.0000017
4        GLOBAL       -0.0045612      -0.0000081                                                      -0.0000945
5        GLOBAL       -0.0045612      -0.0013552                                                      -0.0001823

    LOADING - 30            3 10N CONCENTRATED LOADS ON JOINTS 1&3&5


    RESULTANT JOINT
                                       SUPPORTS
                   DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.        Y ROT.        Z ROT.
                       X DISP.         Y DISP.        Z DISP.

6        GLOBAL        0.0             0.0                                                             0.0002027
7        GLOBAL       -0.0176312       0.0                                                            -0.0001891


    RESULTANT JOINT
```

```
                                                    ACTIVE
4
                                                    ACTIVE
5
                                                    ACTIVE
6
                                                    ACTIVE
7
                                                    ACTIVE


     RELEASES-----------------------------------/
JOINT                                            ELASTIC SUPPORT RELEASES------------------------------------------
JOINT
       FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                   KFX           KFY           KFZ           KMX           KMY
7
        X          Z      0.0      0.0      0.0
                                                    0.0           0.0           0.0           0.0           0.0

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
LIST DISP ALL


    ****************************
    *RESULTS OF LATEST ANALYSES*
    ****************************


     PROBLEM - FRAME     TITLE - ANALYSIS

     ACTIVE UNITS  CM   KG   RAD  DEGF SEC
     ACTIVE STRUCTURE TYPE  PLANE   FRAME
     ACTIVE COORDINATE AXES  X Y

     LOADING - 1            UNIFORM LOAD ON BEAM


     RESULTANT JOINT
                                     SUPPORTS
                      DISPLACEMENTS -
JOINT                   /----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION------------------/
                                                                           X ROT.         Y ROT.          Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                          0.0
7         GLOBAL          0.1235899       0.0                                                          0.0019516


     RESULTANT JOINT
                                      FREE JOINTS
```

```
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                                                                          X ROT.         Y ROT.          Z ROT.
                        X DISP.         Y DISP.        Z DISP.

1        GLOBAL       0.0357688       0.0141859                                                          -0.0015529
2        GLOBAL       0.0357668      -0.0000290                                                          -0.0015897
3        GLOBAL       0.0357688      -0.0366036                                                          -0.0000904
4        GLOBAL       0.0357688      -0.0000259                                                           0.0019516
5        GLOBAL       0.0357688       0.0169279                                                           0.0019182

    LOADING - 2             SIDESWAY CONC.LOAD ON JOINT 5

    RESULTANT JOINT
                                  SUPPORTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                                                                          X ROT.         Y ROT.          Z ROT.
                        X DISP.         Y DISP.        Z DISP.

6        GLOBAL       0.0             0.0                                                                 0.0
7        GLOBAL       0.0490509       0.0                                                                 0.0003536

    RESULTANT JOINT
                                  FREE JOINTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                                                                          X ROT.         Y ROT.          Z ROT.
                        X DISP.         Y DISP.        Z DISP.

1        GLOBAL       0.0331330       0.0064377                                                          -0.0007073
2        GLOBAL       0.0331330       0.0000014                                                          -0.0007073
3        GLOBAL       0.0331367      -0.0079696                                                           0.0000884
4        GLOBAL       0.0331403      -0.0000014                                                           0.0003536
5        GLOBAL       0.0331414       0.0031100                                                           0.0003536

    LOADING - 3             CONC. LOAD ON MIDSPAN OF BEAM

    RESULTANT JOINT
                                  SUPPORTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                                                                          X ROT.         Y ROT.          Z ROT.
                        X DISP.         Y DISP.        Z DISP.

6        GLOBAL       0.0             0.0                                                                 0.0
7        GLOBAL       0.0274578       0.0                                                                 0.0004331

    RESULTANT JOINT
                                  FREE JOINTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                                                                          X ROT.         Y ROT.          Z ROT.
                        X DISP.         Y DISP.        Z DISP.

1        GLOBAL       0.0079696       0.0032202                                                          -0.0003542
2        GLOBAL       0.0079696      -0.0000030                                                          -0.0003542
```

```
3          GLOBAL        0.0079696     -0.0084809                                                          -0.0000197
4          GLOBAL        0.0079696     -0.0000024                                                           0.0004331
5          GLOBAL        0.0079696      0.0038086                                                           0.0004331

   LOADING - 4           SIDESWAY LOAD ALONG THE COLUMN 6

   RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION------------------/
                           X DISP.        Y DISP.        Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL        0.0            0.0                                                                  0.0
7          GLOBAL        0.1213834      0.0                                                                  0.0018803

   RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION------------------/
                           X DISP.        Y DISP.        Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL        0.0411237      0.0096671                                                           -0.0010624
2          GLOBAL        0.0411237     -0.0000010                                                           -0.0010624
3          GLOBAL        0.0411273     -0.0177570                                                           -0.0000597
4          GLOBAL        0.0411310      0.0000010                                                            0.0013012
5          GLOBAL        0.0411310      0.0114519                                                            0.0013012

   LOADING - 5           SIDESWAY LOAD ALONG THE COLUMN 5

   RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION------------------/
                           X DISP.        Y DISP.        Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL        0.0            0.0                                                                  0.0
7          GLOBAL       -0.0381083      0.0                                                                 -0.0002079

   RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION------------------/
                           X DISP.        Y DISP.        Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL       -0.0287527     -0.0037854                                                            0.0004159
2          GLOBAL       -0.0287527     -0.0000008                                                            0.0004159
3          GLOBAL       -0.0287527      0.0046862                                                           -0.0000520
4          GLOBAL       -0.0287527      0.0000008                                                           -0.0002079
5          GLOBAL       -0.0287527     -0.0018287                                                           -0.0002079

   LOADING - 6           CON VERTICAL LOAD ON JOINT 1
```

```
    RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                       /-----------------DISPLACEMENT-----------------/
                                                                            /-------------------ROTATION-------------------/
                               X DISP.         Y DISP.          Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL            0.0             0.0                                                                 0.0
7          GLOBAL          -0.0128679        0.0                                                                -0.0001429

    RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                       /-----------------DISPLACEMENT-----------------/
                                                                            /-------------------ROTATION-------------------/
                               X DISP.         Y DISP.          Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL          -0.0064377      -0.0031793                                                            0.0003800
2          GLOBAL          -0.0064377      -0.0000060                                                            0.0002861
3          GLOBAL          -0.0064377       0.0032202                                                           -0.0000356
4          GLOBAL          -0.0064377       0.0000006                                                           -0.0001429
5          GLOBAL          -0.0064377      -0.0012569                                                           -0.0001429

    LOADING - 7             CONC VERTICAL LOAD ON JOINT 5

    RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                       /-----------------DISPLACEMENT-----------------/
                                                                            /-------------------ROTATION-------------------/
                               X DISP.         Y DISP.          Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL            0.0             0.0                                                                 0.0
7          GLOBAL          -0.0197199        0.0                                                                -0.0003691

    RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                       /-----------------DISPLACEMENT-----------------/
                                                                            /-------------------ROTATION-------------------/
                               X DISP.         Y DISP.          Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL          -0.0031100      -0.0012569                                                            0.0001382
2          GLOBAL          -0.0031100       0.0000009                                                            0.0001382
3          GLOBAL          -0.0031100       0.0038086                                                            0.0000575
4          GLOBAL          -0.0031100      -0.0000064                                                           -0.0003691
5          GLOBAL          -0.0031100      -0.0037696                                                           -0.0004569

    LOADING - 10            UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                       /-----------------DISPLACEMENT-----------------/
                                                                            /-------------------ROTATION-------------------/
                               X DISP.         Y DISP.          Z DISP.         X ROT.          Y ROT.          Z ROT.
```

```
  6         GLOBAL        0.0            0.0                                                                        0.0
  7         GLOBAL        0.1726407      0.0                                                                        0.0023052


     RESULTANT JOINT
                              DISPLACEMENTS - FREE JOINTS

  JOINT                         /----------------DISPLACEMENT----------------/
                                                                                /------------------ROTATION------------------/
                                                                                     X ROT.           Y ROT.           Z ROT.
                                   X DISP.        Y DISP.         Z DISP.

  1         GLOBAL        0.0689018      0.0206235                                                                 -0.0022601
  2         GLOBAL        0.0689018     -0.0000276                                                                 -0.0022970
  3         GLOBAL        0.0689054     -0.0445732                                                                 -0.0000020
  4         GLOBAL        0.0689090     -0.0000273                                                                  0.0023052
  5         GLOBAL        0.0689101      0.0200379                                                                  0.0022718

     LOADING - 15            VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5


     RESULTANT JOINT
                              DISPLACEMENTS - SUPPORTS

  JOINT                         /----------------DISPLACEMENT----------------/
                                                                                /------------------ROTATION------------------/
                                                                                     X ROT.           Y ROT.           Z ROT.
                                   X DISP.        Y DISP.         Z DISP.

  6         GLOBAL        0.0            0.0                                                                        0.0
  7         GLOBAL        0.0765087      0.0                                                                        0.0007866


     RESULTANT JOINT
                              DISPLACEMENTS - FREE JOINTS

  JOINT                         /----------------DISPLACEMENT----------------/
                                                                                /------------------ROTATION------------------/
                                                                                     X ROT.           Y ROT.           Z ROT.
                                   X DISP.        Y DISP.         Z DISP.

  1         GLOBAL        0.0411027      0.0096579                                                                 -0.0010615
  2         GLOBAL        0.0411027     -0.0000016                                                                 -0.0010615
  3         GLOBAL        0.0411063     -0.0164506                                                                  0.0000687
  4         GLOBAL        0.0411099     -0.0000038                                                                  0.0007866
  5         GLOBAL        0.0411110      0.0069186                                                                  0.0007866

     LOADING - 20            SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6


     RESULTANT JOINT
                              DISPLACEMENTS - SUPPORTS

  JOINT                         /----------------DISPLACEMENT----------------/
                                                                                /------------------ROTATION------------------/
                                                                                     X ROT.           Y ROT.           Z ROT.
                                   X DISP.        Y DISP.         Z DISP.

  6         GLOBAL        0.0            0.0                                                                        0.0
  7         GLOBAL        0.1704342      0.0                                                                        0.0022339


     RESULTANT JOINT
                              DISPLACEMENTS - FREE JOINTS
```

```
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL          0.0742567       0.0161047                                                           -0.0017697
2         GLOBAL          0.0742567       0.0000005                                                           -0.0017697
3         GLOBAL          0.0742640      -0.0257266                                                            0.0000287
4         GLOBAL          0.0742713      -0.0000005                                                            0.0016548
5         GLOBAL          0.0742723       0.0145619                                                            0.0016548

    LOADING - 25            3 CONCENTRATED LOADS ON J 1&3&5

    RESULTANT JOINT
                                     SUPPORTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                                  0.0
7         GLOBAL         -0.0051300       0.0                                                                 -0.0000789

    RESULTANT JOINT
                                     FREE JOINTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL         -0.0015780      -0.0012159                                                            0.0001640
2         GLOBAL         -0.0015780      -0.0000081                                                            0.0000701
3         GLOBAL         -0.0015780      -0.0014521                                                            0.0000022
4         GLOBAL         -0.0015780      -0.0000082                                                           -0.0000789
5         GLOBAL         -0.0015780      -0.0012179                                                           -0.0001667
    LOADING - 30            3 10N CONCENTRATED LOADS ON JOINTS 1&3&5

    RESULTANT JOINT
                                     SUPPORTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                                  0.0
7         GLOBAL         -0.0102601       0.0                                                                 -0.0001579

    RESULTANT JOINT
                                     FREE JOINTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL         -0.0031561      -0.0024319                                                            0.0003280
2         GLOBAL         -0.0031561      -0.0000163                                                            0.0001403
3         GLOBAL         -0.0031561      -0.0029041                                                            0.0000044
```

```
4         GLOBAL        -0.0031561       -0.0000164                                                                   -0.0001579
5         GLOBAL        -0.0031561       -0.0024358                                                                   -0.0003335

    LOADING - 35            2 10N CONCENTRATED LOADS ON JOINTS 1&5


    RESULTANT JOINT
                                     SUPPORTS
                    DISPLACEMENTS -

JOINT                 /------------------DISPLACEMENT------------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                                        0.0
7         GLOBAL          -0.0651757      0.0                                                                        -0.0010240


    RESULTANT JOINT
                                     FREE JOINTS
                    DISPLACEMENTS -

JOINT                 /------------------DISPLACEMENT------------------/
                                                                        /-------------------ROTATION-------------------/
                                                                            X ROT.         Y ROT.         Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL         -0.0190953      -0.0088724                                                                   0.0010365
2         GLOBAL         -0.0190953      -0.0000102                                                                   0.0008487
3         GLOBAL         -0.0190953       0.0140577                                                                   0.0000438
4         GLOBAL         -0.0190953      -0.0000116                                                                  -0.0010240
5         GLOBAL         -0.0190953      -0.0100530                                                                  -0.0011996
$ PIN-PIN SUPPORT CONDITION
CHANGES
JOINT RELEASES
6 MOM Z
7 MOM Z
STIFFNES ANALYSIS
PRINT JOINT STATUS

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  FRAME         JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE         TEMPERATURE      TIME
                  CM            KG           RAD             DEGF          SEC
                                                               STATUS---/
JOINT

JOINT


1
                                                               ACTIVE

2
                                                               ACTIVE

3
                                                               ACTIVE

4
                                                               ACTIVE

5
                                                               ACTIVE

6
                                                               ACTIVE
```

```
7                                                                   ACTIVE


      RELEASES-----------------------------------/
JOINT                                             ELASTIC SUPPORT RELEASES-------------------------------------------
JOINT
       FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                     KFX          KFY          KFZ          KMX          KMY
6
               Z        0.0      0.0      0.0
                                                      0.0          0.0          0.0          0.0          0.0
7
               Z        0.0      0.0      0.0
                                                      0.0          0.0          0.0          0.0          0.0

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
LIST DISP ALL


   ****************************
   *RESULTS OF LATEST ANALYSES*
   ****************************

    PROBLEM - FRAME     TITLE - ANALYSIS

    ACTIVE UNITS  CM   KG   RAD  DEGF SEC
    ACTIVE STRUCTURE TYPE  PLANE   FRAME
    ACTIVE COORDINATE AXES   X Y

    LOADING - 1             UNIFORM LOAD ON BEAM

    RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-----------------ROTATION-------------------/
                          X DISP.        Y DISP.         Z DISP.          X ROT.          Y ROT.          Z ROT.

6          GLOBAL        0.0            0.0                                                               0.0003871
7          GLOBAL        0.0            0.0                                                              -0.0003792

    RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-----------------ROTATION-------------------/
                          X DISP.        Y DISP.         Z DISP.          X ROT.          Y ROT.          Z ROT.
```

```
1        GLOBAL      -0.0001760     0.0066584                                                         
2        GLOBAL      -0.0001760    -0.0000276                                                          -0.0007255
3        GLOBAL      -0.0001778    -0.0215135                                                          -0.0007624
4        GLOBAL      -0.0001796    -0.0000273                                                          -0.0000020
5        GLOBAL      -0.0001796     0.0065310                                                           0.0007703
                                                                                                        0.0007369
    LOADING - 2            SIDESWAY CONC.LOAD ON JOINT 5

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS
JOINT
                         /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                            X DISP.         Y DISP.        Z DISP.        X ROT.          Y ROT.         Z ROT.
6        GLOBAL        0.0            0.0
7        GLOBAL        0.0            0.0                                                                 -0.0016591
                                                                                                          -0.0016592
    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS
JOINT
                         /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                            X DISP.         Y DISP.        Z DISP.        X ROT.          Y ROT.         Z ROT.
1        GLOBAL        0.0574402      0.0046556
2        GLOBAL        0.0574402      0.0000041                                                           -0.0005112
3        GLOBAL        0.0574420      0.0000004                                                           -0.0005112
4        GLOBAL        0.0574438     -0.0000041                                                            0.0002554
5        GLOBAL        0.0574449     -0.0045028                                                           -0.0005112
                                                                                                          -0.0005112
    LOADING - 3            CONC. LOAD ON MIDSPAN OF BEAM

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS
JOINT
                         /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                            X DISP.         Y DISP.        Z DISP.        X ROT.          Y ROT.         Z ROT.
6        GLOBAL        0.0            0.0
7        GLOBAL        0.0            0.0                                                                  0.0000852
                                                                                                          -0.0000852
    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS
JOINT
                         /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                            X DISP.         Y DISP.        Z DISP.        X ROT.          Y ROT.         Z ROT.
1        GLOBAL        0.0000004      0.0015484
2        GLOBAL        0.0000004     -0.0000027                                                           -0.0001705
3        GLOBAL       -0.0000000     -0.0051275                                                           -0.0001705
4        GLOBAL       -0.0000004     -0.0000027                                                           -0.0000000
5        GLOBAL       -0.0000004      0.0014972                                                            0.0001705
                                                                                                           0.0001705
    LOADING - 4            SIDESWAY LOAD ALONG THE COLUMN 6
```

```
    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                      /-----------------DISPLACEMENT-----------------/
                                                                            /------------------ROTATION------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.          Y ROT.          Z ROT.

6           GLOBAL           0.0              0.0                                                               -0.0009930
7           GLOBAL           0.0              0.0                                                               -0.0012327

    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                      /-----------------DISPLACEMENT-----------------/
                                                                            /------------------ROTATION------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.          Y ROT.          Z ROT.

1           GLOBAL           0.0350399        0.0031872                                                         -0.0003500
2           GLOBAL           0.0350399        0.0000020                                                         -0.0003500
3           GLOBAL           0.0350409       -0.0014357                                                          0.0001271
4           GLOBAL           0.0350419       -0.0000020                                                         -0.0001589
5           GLOBAL           0.0350419       -0.0014004                                                         -0.0001589

    LOADING - 5              SIDESWAY LOAD ALONG THE COLUMN 5

    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                      /-----------------DISPLACEMENT-----------------/
                                                                            /------------------ROTATION------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.          Y ROT.          Z ROT.

6           GLOBAL           0.0              0.0                                                                0.0025973
7           GLOBAL           0.0              0.0                                                                0.0021409

    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                      /-----------------DISPLACEMENT-----------------/
                                                                            /------------------ROTATION------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.          Y ROT.          Z ROT.

1           GLOBAL          -0.0754782       -0.0032711                                                          0.0003590
2           GLOBAL          -0.0754782       -0.0000044                                                          0.0003590
3           GLOBAL          -0.0754760       -0.0029356                                                         -0.0002770
4           GLOBAL          -0.0754738        0.0000044                                                          0.0007497
5           GLOBAL          -0.0754738        0.0066021                                                          0.0007497

    LOADING - 6              CON VERTICAL LOAD ON JOINT 1

    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                      /-----------------DISPLACEMENT-----------------/
                                                                            /------------------ROTATION------------------/
```

```
                                                                   X ROT.         Y ROT.         Z ROT.
                        X DISP.          Y DISP.          Z DISP.
 6        GLOBAL       0.0              0.0                                                       0.0000519
 7        GLOBAL       0.0              0.0                                                       0.0001551

    RESULTANT JOINT
                   DISPLACEMENTS -  FREE JOINTS
JOINT                 /----------------DISPLACEMENT----------------/
                                                                 /------------------ROTATION------------------/
                                                                   X ROT.         Y ROT.         Z ROT.
                        X DISP.          Y DISP.          Z DISP.

 1        GLOBAL      -0.0046561       -0.0024568                                                 0.0003006
 2        GLOBAL      -0.0046561       -0.0000063                                                 0.0002067
 3        GLOBAL      -0.0046559        0.0015484                                                -0.0000516
 4        GLOBAL      -0.0046556        0.0000008                                                 0.0000002
 5        GLOBAL      -0.0046556        0.0000028                                                 0.0000002

    LOADING - 7            CONC VERTICAL LOAD ON JOINT 5

    RESULTANT JOINT
                   DISPLACEMENTS -  SUPPORTS
JOINT                 /----------------DISPLACEMENT----------------/
                                                                 /------------------ROTATION------------------/
                                                                   X ROT.         Y ROT.         Z ROT.
                        X DISP.          Y DISP.          Z DISP.

 6        GLOBAL       0.0              0.0                                                      -0.0001500
 7        GLOBAL       0.0              0.0                                                      -0.0000501

    RESULTANT JOINT
                   DISPLACEMENTS -  FREE JOINTS
JOINT                 /----------------DISPLACEMENT----------------/
                                                                 /------------------ROTATION------------------/
                                                                   X ROT.         Y ROT.         Z ROT.
                        X DISP.          Y DISP.          Z DISP.

 1        GLOBAL       0.0045023        0.0000028                                                -0.0000002
 2        GLOBAL       0.0045023        0.0000008                                                -0.0000002
 3        GLOBAL       0.0045025        0.0014972                                                 0.0000499
 4        GLOBAL       0.0045028       -0.0000062                                                -0.0001999
 5        GLOBAL       0.0045028       -0.0022803                                                -0.0002877

    LOADING - 10           UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                   DISPLACEMENTS -  SUPPORTS
JOINT                 /----------------DISPLACEMENT----------------/
                                                                 /------------------ROTATION------------------/
                                                                   X ROT.         Y ROT.         Z ROT.
                        X DISP.          Y DISP.          Z DISP.

 6        GLOBAL       0.0              0.0                                                      -0.0012720
 7        GLOBAL       0.0              0.0                                                      -0.0020383

    RESULTANT JOINT
```

```
                                             FREE JOINTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL           0.0572642       0.0113140                                                        -0.0012367
2          GLOBAL           0.0572642      -0.0000235                                                        -0.0012735
3          GLOBAL           0.0572642      -0.0215131                                                         0.0002534
4          GLOBAL           0.0572642      -0.0000314                                                         0.0002591
5          GLOBAL           0.0572653       0.0020283                                                         0.0002257

    LOADING - 15          VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                                             SUPPORTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL           0.0             0.0                                                              -0.0015739
7          GLOBAL           0.0             0.0 .                                                            -0.0017444

    RESULTANT JOINT
                                             FREE JOINTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.          Y ROT.          Z ROT.

1          GLOBAL           0.0574406       0.0062040                                                        -0.0006816
2          GLOBAL           0.0574406       0.0000014                                                        -0.0006816
3          GLOBAL           0.0574420      -0.0051271                                                         0.0002554
4          GLOBAL           0.0574434      -0.0000068                                                        -0.0003408
5          GLOBAL           0.0574445      -0.0030055                                                        -0.0003408

    LOADING - 20          SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6

    RESULTANT JOINT
                                             SUPPORTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.          Y ROT.          Z ROT.

6          GLOBAL           0.0             0.0                                                              -0.0026521
7          GLOBAL           0.0             0.0                                                              -0.0028919

    RESULTANT JOINT
                                             FREE JOINTS
                        DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.          Y ROT.          Z ROT.
```

```
  1        GLOBAL      0.0924801      0.0078428                                                              -0.0008612
  2        GLOBAL      0.0924801      0.0000061                                                              -0.0008612
  3        GLOBAL      0.0924829     -0.0014353                                                               0.0003825
  4        GLOBAL      0.0924857     -0.0000061                                                              -0.0006701
  5        GLOBAL      0.0924868     -0.0059031                                                              -0.0006701

     LOADING - 25              3 CONCENTRATED LOADS ON J 1&3&5

     RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

  JOINT                  /-----------------DISPLACEMENT-----------------/ /------------------ROTATION-------------------/
                            X DISP.         Y DISP.         Z DISP.            X ROT.          Y ROT.          Z ROT.

  6        GLOBAL      0.0            0.0                                                                    -0.0000129
  7        GLOBAL      0.0            0.0                                                                     0.0000197

     RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS

  JOINT                  /-----------------DISPLACEMENT-----------------/ /------------------ROTATION-------------------/
                            X DISP.         Y DISP.         Z DISP.            X ROT.          Y ROT.          Z ROT.

  1        GLOBAL     -0.0001534     -0.0009056                                                               0.0001299
  2        GLOBAL     -0.0001534     -0.0000082                                                               0.0000360
  3        GLOBAL     -0.0001534     -0.0020819                                                              -0.0000017
  4        GLOBAL     -0.0001533     -0.0000081                                                              -0.0000292
  5        GLOBAL     -0.0001533     -0.0007602                                                              -0.0001170

     LOADING - 30              3 10N CONCENTRATED LOADS ON JOINTS 1&3&5

     RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

  JOINT                  /-----------------DISPLACEMENT-----------------/ /------------------ROTATION-------------------/
                            X DISP.         Y DISP.         Z DISP.            X ROT.          Y ROT.          Z ROT.

  6        GLOBAL      0.0            0.0                                                                    -0.0000258
  7        GLOBAL      0.0            0.0                                                                     0.0000394

     RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS

  JOINT                  /-----------------DISPLACEMENT-----------------/ /------------------ROTATION-------------------/
                            X DISP.         Y DISP.         Z DISP.            X ROT.          Y ROT.          Z ROT.

  1        GLOBAL     -0.0003069     -0.0018112                                                               0.0002598
  2        GLOBAL     -0.0003069     -0.0000164                                                               0.0000720
  3        GLOBAL     -0.0003067     -0.0041638                                                              -0.0000034
  4        GLOBAL     -0.0003066     -0.0000163                                                              -0.0000584
  5        GLOBAL     -0.0003066     -0.0015605                                                              -0.0002340

     LOADING - 35              2 @ 10N CONCENTRATED LOADS ON JOINTS 1&5
```

```
    RESULTANT JOINT
                                SUPPORTS
                    DISPLACEMENTS -

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

6          GLOBAL       0.0              0.0                                                              -0.0001962
7          GLOBAL       0.0              0.0                                                               0.0002099

    RESULTANT JOINT
                                FREE JOINTS
                    DISPLACEMENTS -

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                       /-------------------ROTATION-------------------/
                                                                          X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

1          GLOBAL      -0.0003077       -0.0049080                                                         0.0006007
2          GLOBAL      -0.0003077       -0.0000109                                                         0.0004129
3          GLOBAL      -0.0003067        0.0060913                                                        -0.0000034
4          GLOBAL      -0.0003058       -0.0000108                                                        -0.0003993
5          GLOBAL      -0.0003058       -0.0045550                                                        -0.0005749
$ FIXED-PIN SUPPORT CONDITION
DELETIONS
JOINT RELEASES
6 MOM Z
STIFFNES ANALYSIS
PRINT JOINT STATUS

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  FRAME         JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE      TIME
                  CM            KG            RAD            DEGF          SEC
                                                              STATUS---/
JOINT

JOINT

1
                                                              ACTIVE
2
                                                              ACTIVE
3
                                                              ACTIVE
4
                                                              ACTIVE
5
                                                              ACTIVE
6
                                                              ACTIVE
7
                                                              ACTIVE
```

```
        RELEASES------------------------------------/
JOINT                                                 ELASTIC SUPPORT RELEASES-----------------------------------------
JOINT
         FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                        KFX          KFY          KFZ          KMX          KMY
7
                    Z       0.0      0.0      0.0
                                                         0.0          0.0          0.0          0.0          0.0

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************
LIST DISP ALL


   ****************************
   *RESULTS OF LATEST ANALYSES*
   ****************************

    PROBLEM - FRAME      TITLE - ANALYSIS

    ACTIVE UNITS  CM   KG   RAD  DEGF SEC
    ACTIVE STRUCTURE TYPE  PLANE   FRAME
    ACTIVE COORDINATE AXES  X Y

    LOADING - 1            UNIFORM LOAD ON BEAM

    RESULTANT JOINT
                         DISPLACEMENTS - SUPPORTS

JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION------------------/
                              X DISP.         Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

6          GLOBAL          0.0             0.0                                                                0.0
7          GLOBAL          0.0             0.0                                                               -0.0006114

    RESULTANT JOINT
                         DISPLACEMENTS - FREE JOINTS

JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION------------------/
                              X DISP.         Y DISP.          Z DISP.      X ROT.          Y ROT.          Z ROT.

1          GLOBAL          0.0080602       0.0069158                                                         -0.0007537
2          GLOBAL          0.0080602      -0.0000272                                                         -0.0007906
3          GLOBAL          0.0080582      -0.0210905                                                          0.0000262
4          GLOBAL          0.0080561      -0.0000278                                                          0.0006857
5          GLOBAL          0.0080561       0.0057866                                                          0.0006524

    LOADING - 2            SIDESWAY CONC.LOAD ON JOINT 5
```

```
    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /----------------DISPLACEMENT----------------/ /------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.         Z ROT.
                           X DISP.          Y DISP.          Z DISP.

6          GLOBAL          0.0              0.0                                                             0.0
7          GLOBAL          0.0              0.0                                                            -0.0006636

    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                    /----------------DISPLACEMENT----------------/ /------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.         Z ROT.
                           X DISP.          Y DISP.          Z DISP.

1          GLOBAL          0.0221359        0.0035523                                                      -0.0003901
2          GLOBAL          0.0221359        0.0000021                                                      -0.0003901
3          GLOBAL          0.0221388       -0.0018127                                                       0.0001346
4          GLOBAL          0.0221416       -0.0000021                                                      -0.0001488
5          GLOBAL          0.0221426       -0.0013118                                                      -0.0001488

    LOADING - 3               CONC. LOAD ON MIDSPAN OF BEAM

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /----------------DISPLACEMENT----------------/ /------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.         Z ROT.
                           X DISP.          Y DISP.          Z DISP.

6          GLOBAL          0.0              0.0                                                             0.0
7          GLOBAL          0.0              0.0                                                            -0.0001363

    RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                    /----------------DISPLACEMENT----------------/ /------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.         Z ROT.
                           X DISP.          Y DISP.          Z DISP.

1          GLOBAL          0.0018137        0.0016051                                                      -0.0001767
2          GLOBAL          0.0018137       -0.0000026                                                      -0.0001767
3          GLOBAL          0.0018132       -0.0050344                                                       0.0000062
4          GLOBAL          0.0018127       -0.0000028                                                       0.0001518
5          GLOBAL          0.0018127        0.0013334                                                       0.0001518

    LOADING - 4               SIDESWAY LOAD ALONG THE COLUMN 6

    RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /----------------DISPLACEMENT----------------/ /------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.         Z ROT.
                           X DISP.          Y DISP.          Z DISP.
```

```
 6         GLOBAL         0.0            0.0                                                                      0.0
 7         GLOBAL         0.0            0.0                                                                     -0.0006369

     RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /--------------------ROTATION--------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.           Y ROT.          Z ROT.

 1         GLOBAL         0.0139098       0.0025268                                                          -0.0002776
 2         GLOBAL         0.0139098       0.0000009                                                          -0.0002776
 3         GLOBAL         0.0139114      -0.0025209                                                           0.0000549
 4         GLOBAL         0.0139131      -0.0000009                                                           0.0000580
 5         GLOBAL         0.0139131       0.0005095                                                           0.0000580

     LOADING - 5              SIDESWAY LOAD ALONG THE COLUMN 5

     RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /--------------------ROTATION--------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.           Y ROT.          Z ROT.

 6         GLOBAL         0.0            0.0                                                                  0.0
 7         GLOBAL         0.0            0.0                                                                  0.0005824

     RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /--------------------ROTATION--------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.           Y ROT.          Z ROT.

 1         GLOBAL        -0.0202089      -0.0015437                                                           0.0001695
 2         GLOBAL        -0.0202089      -0.0000014                                                           0.0001695
 3         GLOBAL        -0.0202082      -0.0000971                                                          -0.0000879
 4         GLOBAL        -0.0202076       0.0000014                                                           0.0001824
 5         GLOBAL        -0.0202076       0.0016067                                                           0.0001824

     LOADING - 6              CON VERTICAL LOAD ON JOINT 1

     RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /--------------------ROTATION--------------------/
                              X DISP.         Y DISP.         Z DISP.         X ROT.           Y ROT.          Z ROT.

 6         GLOBAL         0.0            0.0                                                                  0.0
 7         GLOBAL         0.0            0.0                                                                  0.0001240

     RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS
```

```
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /-------------------ROTATION-------------------/
                                                                         X ROT.          Y ROT.          Z ROT.
                         X DISP.         Y DISP.         Z DISP.

1        GLOBAL       -0.0035527      -0.0024223                                                           0.0002968
2        GLOBAL       -0.0035527      -0.0000062                                                           0.0002029
3        GLOBAL       -0.0035525       0.0016051                                                          -0.0000478
4        GLOBAL       -0.0035523       0.0000008                                                          -0.0000111
5        GLOBAL       -0.0035523      -0.0000969                                                          -0.0000111

    LOADING - 7            CONC VERTICAL LOAD ON JOINT 5

    RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /-------------------ROTATION-------------------/
                                                                         X ROT.          Y ROT.          Z ROT.
                         X DISP.         Y DISP.         Z DISP.

6        GLOBAL        0.0             0.0                                                                 0.0
7        GLOBAL        0.0             0.0                                                                 0.0000398

    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /-------------------ROTATION-------------------/
                                                                         X ROT.          Y ROT.          Z ROT.
                         X DISP.         Y DISP.         Z DISP.

1        GLOBAL        0.0013112      -0.0000969                                                           0.0000107
2        GLOBAL        0.0013112       0.0000006                                                           0.0000107
3        GLOBAL        0.0013115       0.0013334                                                           0.0000389
4        GLOBAL        0.0013118      -0.0000061                                                          -0.0001671
5        GLOBAL        0.0013118      -0.0019919                                                          -0.0002549

    LOADING - 10           UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                      DISPLACEMENTS - SUPPORTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /-------------------ROTATION-------------------/
                                                                         X ROT.          Y ROT.          Z ROT.
                         X DISP.         Y DISP.         Z DISP.

6        GLOBAL        0.0             0.0                                                                 0.0
7        GLOBAL        0.0             0.0                                                                -0.0012750

    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /-------------------ROTATION-------------------/
                                                                         X ROT.          Y ROT.          Z ROT.
                         X DISP.         Y DISP.         Z DISP.

1        GLOBAL        0.0301961       0.0104681                                                          -0.0011439
2        GLOBAL        0.0301961      -0.0000250                                                          -0.0011807
3        GLOBAL        0.0301969      -0.0229033                                                           0.0001608
```

```
4         GLOBAL          0.0301977      -0.0000299                                                                    0.0005369
5         GLOBAL          0.0301987       0.0044748                                                                    0.0005036

    LOADING - 15          VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5

    RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                                          0.0
7         GLOBAL          0.0             0.0                                                                         -0.0008000

    RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL          0.0239496       0.0051573                                                                   -0.0005668
2         GLOBAL          0.0239496      -0.0000005                                                                   -0.0005668
3         GLOBAL          0.0239519      -0.0068472                                                                    0.0001408
4         GLOBAL          0.0239543      -0.0000050                                                                    0.0000030
5         GLOBAL          0.0239554       0.0000215                                                                    0.0000030

    LOADING - 20          SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6

    RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.         Z DISP.

6         GLOBAL          0.0             0.0                                                                          0.0
7         GLOBAL          0.0             0.0                                                                         -0.0013005

    RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                             X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.         Z DISP.

1         GLOBAL          0.0360458       0.0060791                                                                   -0.0006677
2         GLOBAL          0.0360458       0.0000030                                                                   -0.0006677
3         GLOBAL          0.0360502      -0.0043337                                                                    0.0001895
4         GLOBAL          0.0360546      -0.0000030                                                                   -0.0000908
5         GLOBAL          0.0360557      -0.0008024                                                                   -0.0000908

    LOADING - 25          3 CONCENTRATED LOADS ON J 1&3&5

    RESULTANT JOINT
```

```
                                  SUPPORTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

6        GLOBAL         0.0              0.0                                                                 0.0
7        GLOBAL         0.0              0.0                                                                 0.0000275

    RESULTANT JOINT
                                  FREE JOINTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

1        GLOBAL        -0.0004279       -0.0009142                                                           0.0001309
2        GLOBAL        -0.0004279       -0.0000082                                                           0.0000370
3        GLOBAL        -0.0004278       -0.0020960                                                          -0.0000026
4        GLOBAL        -0.0004277       -0.0000081                                                          -0.0000264
5        GLOBAL        -0.0004277       -0.0007554                                                          -0.0001142

    LOADING - 30             3 10N CONCENTRATED LOADS ON JOINTS 1&3&5

    RESULTANT JOINT
                                  SUPPORTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

6        GLOBAL         0.0              0.0                                                                 0.0
7        GLOBAL         0.0              0.0                                                                 0.0000549

    RESULTANT JOINT
                                  FREE JOINTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

1        GLOBAL        -0.0008558       -0.0018283                                                           0.0002617
2        GLOBAL        -0.0008558       -0.0000164                                                           0.0000739
3        GLOBAL        -0.0008556       -0.0041920                                                          -0.0000053
4        GLOBAL        -0.0008554       -0.0000162                                                          -0.0000528
5        GLOBAL        -0.0008554       -0.0015109                                                          -0.0002284

    LOADING - 35             2 10N CONCENTRATED LOADS ON JOINTS 1&5

    RESULTANT JOINT
                                  SUPPORTS
                     DISPLACEMENTS -
JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.
```

```
6          GLOBAL        0.0            0.0                                                                       0.0
7          GLOBAL        0.0            0.0                                                                       0.0003276


    RESULTANT JOINT
                      DISPLACEMENTS - FREE JOINTS

JOINT                  /-----------------DISPLACEMENT-----------------/
                                                                       /------------------ROTATION------------------/
                         X DISP.        Y DISP.         Z DISP.           X ROT.         Y ROT.          Z ROT.

1          GLOBAL     -0.0044831     -0.0050384                                                          0.0006150
2          GLOBAL     -0.0044831     -0.0000112                                                          0.0004273
3          GLOBAL     -0.0044820      0.0058768                                                         -0.0000177
4          GLOBAL     -0.0044809     -0.0000106                                                         -0.0003565
5          GLOBAL     -0.0044809     -0.0041776                                                         -0.0005321
$ PIN-FIXED SUPPORT CONDITION
CHANGES
JOINT RELEASES
6 MOM Z
DELETIONS
JOINT RELEASES
7 MOM Z
STIFFNES ANALYSIS
PRINT JOINT STATUS

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE   *
****************************************

JOB ID -  FRAME        JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE      TIME
                  CM            KG            RAD            DEGF           SEC
                                                              STATUS---/
JOINT

JOINT


1
                                                            ACTIVE
2
                                                            ACTIVE
3
                                                            ACTIVE
4
                                                            ACTIVE
5
                                                            ACTIVE
6
                                                            ACTIVE
7
                                                            ACTIVE



      RELEASES-------------------------------------/
 JOINT                                              ELASTIC SUPPORT RELEASES------------------------------------------

 JOINT
        FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                       KFX          KFY          KFZ          KMX          KMY
```

```
6
                    Z      0.0      0.0      0.0
                                                      0.0          0.0          0.0          0.0          0.0

***************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
***************************************
LIST DISP ALL


   ***************************
   *RESULTS OF LATEST ANALYSES*
   ***************************


    PROBLEM - FRAME      TITLE - ANALYSIS

    ACTIVE UNITS  CM   KG   RAD  DEGF SEC
    ACTIVE STRUCTURE TYPE  PLANE   FRAME
    ACTIVE COORDINATE AXES  X Y

    LOADING - 1            UNIFORM LOAD ON BEAM


    RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.          X ROT.         Y ROT.         Z ROT.

6         GLOBAL            0.0            0.0                                                           0.0006146
7         GLOBAL            0.0            0.0                                                           0.0


    RESULTANT JOINT
                        DISPLACEMENTS - FREE JOINTS

JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.          X ROT.         Y ROT.         Z ROT.

1         GLOBAL           -0.0082435      0.0059043                                                    -0.0006427
2         GLOBAL           -0.0082435     -0.0000281                                                    -0.0006796
3         GLOBAL           -0.0082456     -0.0210991                                                    -0.0000296
4         GLOBAL           -0.0082476     -0.0000269                                                     0.0007979
5         GLOBAL           -0.0082476      0.0067749                                                     0.0007646
    LOADING - 2            SIDESWAY CONC.LOAD ON JOINT 5


    RESULTANT JOINT
                        DISPLACEMENTS - SUPPORTS

JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /------------------ROTATION-------------------/
                                                                             X ROT.         Y ROT.         Z ROT.
```

```
                          X DISP.        Y DISP.          Z DISP.
 6          GLOBAL      0.0            0.0                                                                      -0.0006635
 7          GLOBAL      0.0            0.0                                                                        0.0


     RESULTANT JOINT
                               FREE JOINTS
                     DISPLACEMENTS -

 JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                              X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.          Z DISP.

 1          GLOBAL      0.0221359      0.0013558                                                                -0.0001488
 2          GLOBAL      0.0221359      0.0000021                                                                -0.0001488
 3          GLOBAL      0.0221367      0.0018137                                                                 0.0001346
 4          GLOBAL      0.0221376     -0.0000021                                                                -0.0003902
 5          GLOBAL      0.0221386     -0.0034356                                                                -0.0003902

     LOADING - 3              CONC. LOAD ON MIDSPAN OF BEAM


     RESULTANT JOINT
                               SUPPORTS
                     DISPLACEMENTS -

 JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                              X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.          Z DISP.

 6          GLOBAL      0.0            0.0                                                                       0.0001363
 7          GLOBAL      0.0            0.0                                                                       0.0


     RESULTANT JOINT
                               FREE JOINTS
                     DISPLACEMENTS -

 JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                              X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.          Z DISP.

 1          GLOBAL     -0.0018127      0.0013789                                                                -0.0001518
 2          GLOBAL     -0.0018127     -0.0000028                                                                -0.0001518
 3          GLOBAL     -0.0018132     -0.0050344                                                                -0.0000062
 4          GLOBAL     -0.0018137     -0.0000026                                                                 0.0001767
 5          GLOBAL     -0.0018137      0.0015521                                                                 0.0001767

     LOADING - 4              SIDESWAY LOAD ALONG THE COLUMN 6


     RESULTANT JOINT
                               SUPPORTS
                     DISPLACEMENTS -

 JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                                                                              X ROT.          Y ROT.          Z ROT.
                          X DISP.        Y DISP.          Z DISP.

 6          GLOBAL      0.0            0.0                                                                      -0.0002533
 7          GLOBAL      0.0            0.0                                                                        0.0


     RESULTANT JOINT
                               FREE JOINTS
```

```
                       DISPLACEMENTS -
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                          X DISP.        Y DISP.        Z DISP.            X ROT.          Y ROT.          Z ROT.

1         GLOBAL        0.0088095      0.0007354                                                        -0.0000808
2         GLOBAL        0.0088095      0.0000006                                                        -0.0000808
3         GLOBAL        0.0088098     -0.0000885                                                         0.0000374
4         GLOBAL        0.0088101     -0.0000006                                                        -0.0000690
5         GLOBAL        0.0088101     -0.0006075                                                        -0.0000690

    LOADING - 5              SIDESWAY LOAD ALONG THE COLUMN 5

    RESULTANT JOINT
                                  SUPPORTS
                       DISPLACEMENTS -
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                          X DISP.        Y DISP.        Z DISP.            X ROT.          Y ROT.          Z ROT.

6         GLOBAL        0.0            0.0                                                               0.0013127
7         GLOBAL        0.0            0.0                                                               0.0

    RESULTANT JOINT
                                  FREE JOINTS
                       DISPLACEMENTS -
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                          X DISP.        Y DISP.        Z DISP.            X ROT.          Y ROT.          Z ROT.

1         GLOBAL       -0.0299235      0.0009869                                                        -0.0001087
2         GLOBAL       -0.0299235     -0.0000019                                                        -0.0001087
3         GLOBAL       -0.0299200     -0.0052754                                                        -0.0001211
4         GLOBAL       -0.0299165      0.0000019                                                         0.0005936
5         GLOBAL       -0.0299165      0.0052252                                                         0.0005936

    LOADING - 6              CON VERTICAL LOAD ON JOINT 1

    RESULTANT JOINT
                                  SUPPORTS
                       DISPLACEMENTS -
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                          X DISP.        Y DISP.        Z DISP.            X ROT.          Y ROT.          Z ROT.

6         GLOBAL        0.0            0.0                                                              -0.0000412
7         GLOBAL        0.0            0.0                                                               0.0

    RESULTANT JOINT
                                  FREE JOINTS
                       DISPLACEMENTS -
JOINT                   /-----------------DISPLACEMENT-----------------/
                                                                        /-------------------ROTATION-------------------/
                          X DISP.        Y DISP.        Z DISP.            X ROT.          Y ROT.          Z ROT.

1         GLOBAL       -0.0013565     -0.0021484                                                         0.0002667
2         GLOBAL       -0.0013565     -0.0000061                                                         0.0001728
```

```
3        GLOBAL       -0.0013561      0.0013789                                                          -0.0000403
4        GLOBAL       -0.0013558      0.0000006                                                          -0.0000111
5        GLOBAL       -0.0013558     -0.0000969                                                          -0.0000111

    LOADING - 7              CONC VERTICAL LOAD ON JOINT 5


    RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                        /-----------------DISPLACEMENT-----------------/
                                                                             /-------------------ROTATION-------------------/
                                X DISP.        Y DISP.         Z DISP.           X ROT.            Y ROT.           Z ROT.

6        GLOBAL               0.0            0.0                                                                 -0.0001199
7        GLOBAL               0.0            0.0                                                                  0.0


    RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                        /-----------------DISPLACEMENT-----------------/
                                                                             /-------------------ROTATION-------------------/
                                X DISP.        Y DISP.         Z DISP.           X ROT.            Y ROT.           Z ROT.

1        GLOBAL               0.0034352     -0.0000969                                                            0.0000107
2        GLOBAL               0.0034352      0.0000007                                                            0.0000107
3        GLOBAL               0.0034354      0.0015521                                                            0.0000462
4        GLOBAL               0.0034356     -0.0000062                                                           -0.0001962
5        GLOBAL               0.0034356     -0.0022481                                                           -0.0002840

    LOADING - 10             UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5


    RESULTANT JOINT
                           DISPLACEMENTS - SUPPORTS

JOINT                        /-----------------DISPLACEMENT-----------------/
                                                                             /-------------------ROTATION-------------------/
                                X DISP.        Y DISP.         Z DISP.           X ROT.            Y ROT.           Z ROT.

6        GLOBAL               0.0            0.0                                                                 -0.0000489
7        GLOBAL               0.0            0.0                                                                  0.0


    RESULTANT JOINT
                           DISPLACEMENTS - FREE JOINTS

JOINT                        /-----------------DISPLACEMENT-----------------/
                                                                             /-------------------ROTATION-------------------/
                                X DISP.        Y DISP.         Z DISP.           X ROT.            Y ROT.           Z ROT.

1        GLOBAL               0.0138924      0.0072601                                                           -0.0007914
2        GLOBAL               0.0138924     -0.0000259                                                           -0.0008283
3        GLOBAL               0.0138911     -0.0192855                                                            0.0001051
4        GLOBAL               0.0138899     -0.0000290                                                            0.0004078
5        GLOBAL               0.0138910      0.0033393                                                            0.0003744

    LOADING - 15             VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5
```

```
   RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                              X ROT.         Y ROT.         Z ROT.
                            X DISP.         Y DISP.          Z DISP.

6          GLOBAL           0.0             0.0                                                           -0.0005271
7          GLOBAL           0.0             0.0                                                            0.0

   RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                              X ROT.         Y ROT.         Z ROT.
                            X DISP.         Y DISP.          Z DISP.

1          GLOBAL           0.0203232       0.0027347                                                     -0.0003006
2          GLOBAL           0.0203232      -0.0000007                                                     -0.0003006
3          GLOBAL           0.0203235      -0.0032208                                                      0.0001284
4          GLOBAL           0.0203239      -0.0000048                                                     -0.0002135
5          GLOBAL           0.0203250      -0.0018836                                                     -0.0002135

   LOADING - 20           SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6

   RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                              X ROT.         Y ROT.         Z ROT.
                            X DISP.         Y DISP.          Z DISP.

6          GLOBAL           0.0             0.0                                                           -0.0009168
7          GLOBAL           0.0             0.0                                                            0.0

   RESULTANT JOINT
                       DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                              X ROT.         Y ROT.         Z ROT.
                            X DISP.         Y DISP.          Z DISP.

1          GLOBAL           0.0309455       0.0020912                                                     -0.0002295
2          GLOBAL           0.0309455       0.0000027                                                     -0.0002295
3          GLOBAL           0.0309465       0.0017251                                                      0.0001720
4          GLOBAL           0.0309476      -0.0000027                                                     -0.0004591
5          GLOBAL           0.0309487      -0.0040432                                                     -0.0004591

   LOADING - 25           3 CONCENTRATED LOADS ON J 1&3&5

   RESULTANT JOINT
                       DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/ /-------------------ROTATION-------------------/
                                                                              X ROT.         Y ROT.         Z ROT.
                            X DISP.         Y DISP.          Z DISP.
```

```
6          GLOBAL       0.0              0.0                                                                        -0.0000247
7          GLOBAL       0.0              0.0                                                                         0.0


    RESULTANT JOINT
                         DISPLACEMENTS - FREE JOINTS

JOINT                     /-----------------DISPLACEMENT-----------------//-------------------ROTATION-------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.           Y ROT.           Z ROT.

1          GLOBAL       0.0002660       -0.0008664                                                               0.0001256
2          GLOBAL       0.0002660       -0.0000082                                                               0.0000317
3          GLOBAL       0.0002661       -0.0021034                                                              -0.0000003
4          GLOBAL       0.0002662       -0.0000082                                                              -0.0000306
5          GLOBAL       0.0002662       -0.0007929                                                              -0.0001184

    LOADING - 30            3 10N CONCENTRATED LOADS ON JOINTS 1&3&5


    RESULTANT JOINT
                         DISPLACEMENTS - SUPPORTS

JOINT                     /-----------------DISPLACEMENT-----------------//-------------------ROTATION-------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.           Y ROT.           Z ROT.

6          GLOBAL       0.0              0.0                                                                        -0.0000495
7          GLOBAL       0.0              0.0                                                                         0.0


    RESULTANT JOINT
                         DISPLACEMENTS - FREE JOINTS

JOINT                     /-----------------DISPLACEMENT-----------------//-------------------ROTATION-------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.           Y ROT.           Z ROT.

1          GLOBAL       0.0005320       -0.0017328                                                               0.0002512
2          GLOBAL       0.0005320       -0.0000163                                                               0.0000634
3          GLOBAL       0.0005322       -0.0042069                                                              -0.0000005
4          GLOBAL       0.0005324       -0.0000163                                                              -0.0000613
5          GLOBAL       0.0005324       -0.0015859                                                              -0.0002369

    LOADING - 35            2 10N CONCENTRATED LOADS ON JOINTS 1&5


    RESULTANT JOINT
                         DISPLACEMENTS - SUPPORTS

JOINT                     /-----------------DISPLACEMENT-----------------//-------------------ROTATION-------------------/
                              X DISP.          Y DISP.          Z DISP.        X ROT.           Y ROT.           Z ROT.

6          GLOBAL       0.0              0.0                                                                        -0.0003221
7          GLOBAL       0.0              0.0                                                                         0.0


    RESULTANT JOINT
                         DISPLACEMENTS - FREE JOINTS
```

```
JOINT                 /-----------------DISPLACEMENT----------------/
                                                                     /-------------------ROTATION------------------/
                           X DISP.        Y DISP.        Z DISP.        X ROT.          Y ROT.          Z ROT.

1         GLOBAL        0.0041575     -0.0044906                                                        0.0005549
2         GLOBAL        0.0041575     -0.0000107                                                        0.0003671
3         GLOBAL        0.0041586      0.0058619                                                        0.0000119
4         GLOBAL        0.0041597     -0.0000111                                                       -0.0004146
5         GLOBAL        0.0041597     -0.0046900                                                       -0.0005902
$ FIXED-FIXED SUPPORT CONDITION
DELETIONS
JOINT RELEASES
6 MOM Z
STIFFNES ANALYSIS
PRINT JOINT STATUS

****************************************
*  PROBLEM DATA FROM INTERNAL STORAGE  *
****************************************

JOB ID -  FRAME        JOB TITLE - ANALYSIS

ACTIVE UNITS -  LENGTH        WEIGHT        ANGLE        TEMPERATURE      TIME
                  CM            KG           RAD            DEGF           SEC
JOINT                                                         STATUS---/

JOINT

1
                                                            ACTIVE
2
                                                            ACTIVE
3
                                                            ACTIVE
4
                                                            ACTIVE
5
                                                            ACTIVE
6
                                                            ACTIVE
7
                                                            ACTIVE


      RELEASES-------------------------------------/
JOINT                                               ELASTIC SUPPORT RELEASES-------------------------------------------
JOINT
       FORCE  MOMENT   THETA 1  THETA 2  THETA 3
                                                       KFX          KFY          KFZ          KMX          KMY

****************************************
*  END OF DATA FROM  INTERNAL STORAGE  *
****************************************

LIST DISP ALL
```

```
**************************
*RESULTS OF LATEST ANALYSES*
**************************

 PROBLEM - FRAME     TITLE - ANALYSIS

 ACTIVE UNITS  CM   KG   RAD  DEGF SEC
 ACTIVE STRUCTURE TYPE  PLANE   FRAME
 ACTIVE COORDINATE AXES  X Y

 LOADING - 1            UNIFORM LOAD ON BEAM

 RESULTANT JOINT
                 DISPLACEMENTS - SUPPORTS

JOINT                     /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                             X DISP.         Y DISP.         Z DISP.

6          GLOBAL           0.0             0.0                                                             0.0
7          GLOBAL           0.0             0.0                                                             0.0

 RESULTANT JOINT
                 DISPLACEMENTS - FREE JOINTS

JOINT                     /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                             X DISP.         Y DISP.         Z DISP.

1          GLOBAL          -0.0000697       0.0053969                                                     -0.0005869
2          GLOBAL          -0.0000697      -0.0000276                                                     -0.0006237
3          GLOBAL          -0.0000727      -0.0194198                                                     -0.0000016
4          GLOBAL          -0.0000757      -0.0000273                                                      0.0006302
5          GLOBAL          -0.0000757       0.0052985                                                      0.0005969
 LOADING - 2            SIDESWAY CONC.LOAD ON JOINT 5

 RESULTANT JOINT
                 DISPLACEMENTS - SUPPORTS

JOINT                     /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                             X DISP.         Y DISP.         Z DISP.

6          GLOBAL           0.0             0.0                                                             0.0
7          GLOBAL           0.0             0.0                                                             0.0

 RESULTANT JOINT
                 DISPLACEMENTS - FREE JOINTS

JOINT                     /----------------DISPLACEMENT----------------/
                                                                        /------------------ROTATION------------------/
                                                                           X ROT.          Y ROT.          Z ROT.
                             X DISP.         Y DISP.         Z DISP.
```

```
1          GLOBAL        0.0133114      0.0019036                                                                      -0.0002090
2          GLOBAL        0.0133114      0.0000017                                                                      -0.0002090
3          GLOBAL        0.0133132      0.0000007                                                                       0.0001044
4          GLOBAL        0.0133150     -0.0000017                                                                      -0.0002091
5          GLOBAL        0.0133161     -0.0018417                                                                      -0.0002091

    LOADING - 3              CONC. LOAD ON MIDSPAN OF BEAM


    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /-------------------ROTATION-------------------/
                             X DISP.         Y DISP.         Z DISP.        X ROT.          Y ROT.          Z ROT.

6          GLOBAL        0.0            0.0                                                                             0.0
7          GLOBAL        0.0            0.0                                                                             0.0


    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /-------------------ROTATION-------------------/
                             X DISP.         Y DISP.         Z DISP.        X ROT.          Y ROT.          Z ROT.

1          GLOBAL        0.0000007      0.0012663                                                                      -0.0001395
2          GLOBAL        0.0000007     -0.0000027                                                                      -0.0001395
3          GLOBAL       -0.0000000     -0.0046618                                                                      -0.0000000
4          GLOBAL       -0.0000007     -0.0000027                                                                       0.0001395
5          GLOBAL       -0.0000007      0.0012245                                                                       0.0001395

    LOADING - 4              SIDESWAY LOAD ALONG THE COLUMN 6


    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /-------------------ROTATION-------------------/
                             X DISP.         Y DISP.         Z DISP.        X ROT.          Y ROT.          Z ROT.

6          GLOBAL        0.0            0.0                                                                             0.0
7          GLOBAL        0.0            0.0                                                                             0.0


    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                    /-----------------DISPLACEMENT-----------------/
                                                                         /-------------------ROTATION-------------------/
                             X DISP.         Y DISP.         Z DISP.        X ROT.          Y ROT.          Z ROT.

1          GLOBAL        0.0054409      0.0009446                                                                      -0.0001038
2          GLOBAL        0.0054409      0.0000004                                                                      -0.0001038
3          GLOBAL        0.0054416     -0.0007806                                                                       0.0000259
4          GLOBAL        0.0054422     -0.0000004                                                                       0.0000002
5          GLOBAL        0.0054422      0.0000010                                                                       0.0000002

    LOADING - 5              SIDESWAY LOAD ALONG THE COLUMN 5
```

```
    RESULTANT JOINT
                                    SUPPORTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION-------------------/
                                                                         X ROT.         Y ROT.         Z ROT.
                          X DISP.         Y DISP.         Z DISP.

6         GLOBAL         0.0             0.0                                                                 0.0
7         GLOBAL         0.0             0.0                                                                 0.0

    RESULTANT JOINT
                                    FREE JOINTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION-------------------/
                                                                         X ROT.         Y ROT.         Z ROT.
                          X DISP.         Y DISP.         Z DISP.

1         GLOBAL        -0.0124649      -0.0000969                                                           0.0000105
2         GLOBAL        -0.0124649      -0.0000010                                                           0.0000105
3         GLOBAL        -0.0124633      -0.0016885                                                          -0.0000614
4         GLOBAL        -0.0124618       0.0000010                                                           0.0002353
5         GLOBAL        -0.0124618       0.0020716                                                           0.0002353

    LOADING - 6            CON VERTICAL LOAD ON JOINT 1

    RESULTANT JOINT
                                    SUPPORTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION-------------------/
                                                                         X ROT.         Y ROT.         Z ROT.
                          X DISP.         Y DISP.         Z DISP.

6         GLOBAL         0.0             0.0                                                                 0.0
7         GLOBAL         0.0             0.0                                                                 0.0

    RESULTANT JOINT
                                    FREE JOINTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION-------------------/
                                                                         X ROT.         Y ROT.         Z ROT.
                          X DISP.         Y DISP.         Z DISP.

1         GLOBAL        -0.0019044      -0.0021144                                                           0.0002630
2         GLOBAL        -0.0019044      -0.0000061                                                           0.0001691
3         GLOBAL        -0.0019040       0.0012663                                                          -0.0000421
4         GLOBAL        -0.0019036       0.0000007                                                           0.0000002
5         GLOBAL        -0.0019036       0.0000021                                                           0.0000002

    LOADING - 7            CONC VERTICAL LOAD ON JOINT 5

    RESULTANT JOINT
                                    SUPPORTS
                    DISPLACEMENTS -
JOINT                 /-----------------DISPLACEMENT-----------------/
                                                                      /------------------ROTATION-------------------/
                                                                         X ROT.         Y ROT.         Z ROT.
```

```
                          X DISP.          Y DISP.          Z DISP.

 6         GLOBAL        0.0              0.0                                                                     0.0
 7         GLOBAL        0.0              0.0                                                                     0.0


    RESULTANT JOINT
                                FREE JOINTS
                   DISPLACEMENTS -

JOINT                  /----------------DISPLACEMENT----------------/
                                                                     /------------------ROTATION------------------/
                                                                        X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

 1         GLOBAL        0.0018409        0.0000021                                                      -0.0000002
 2         GLOBAL        0.0018409        0.0000007                                                      -0.0000002
 3         GLOBAL        0.0018413        0.0012245                                                       0.0000407
 4         GLOBAL        0.0018417       -0.0000061                                                      -0.0001635
 5         GLOBAL        0.0018417       -0.0019601                                                      -0.0002513

    LOADING - 10          UNIF.LOAD ON BEAM+SIDESWAY LOAD ON JOINT 5


    RESULTANT JOINT
                                SUPPORTS
                   DISPLACEMENTS -

JOINT                  /----------------DISPLACEMENT----------------/
                                                                     /------------------ROTATION------------------/
                                                                        X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

 6         GLOBAL        0.0              0.0                                                                     0.0
 7         GLOBAL        0.0              0.0                                                                     0.0


    RESULTANT JOINT
                                FREE JOINTS
                   DISPLACEMENTS -

JOINT                  /----------------DISPLACEMENT----------------/
                                                                     /------------------ROTATION------------------/
                                                                        X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

 1         GLOBAL        0.0132417        0.0073005                                                      -0.0007959
 2         GLOBAL        0.0132417       -0.0000259                                                      -0.0008328
 3         GLOBAL        0.0132405       -0.0194192                                                       0.0001028
 4         GLOBAL        0.0132393       -0.0000290                                                       0.0004211
 5         GLOBAL        0.0132404        0.0034568                                                       0.0003878

    LOADING - 15          VERTICAL LOAD ON BEAM MIDSPAN+SIDESWAY LOAD ON JOINT 5


    RESULTANT JOINT
                                SUPPORTS
                   DISPLACEMENTS -

JOINT                  /----------------DISPLACEMENT----------------/
                                                                     /------------------ROTATION------------------/
                                                                        X ROT.          Y ROT.          Z ROT.
                          X DISP.          Y DISP.          Z DISP.

 6         GLOBAL        0.0              0.0                                                                     0.0
 7         GLOBAL        0.0              0.0                                                                     0.0


    RESULTANT JOINT
                                FREE JOINTS
```

```
                         DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.           X ROT.          Y ROT.          Z ROT.

1          GLOBAL          0.0133120       0.0031699                                                       -0.0003485
2          GLOBAL          0.0133120      -0.0000011                                                       -0.0003485
3          GLOBAL          0.0133132      -0.0046612                                                        0.0001044
4          GLOBAL          0.0133144      -0.0000044                                                       -0.0000696
5          GLOBAL          0.0133154      -0.0006172                                                       -0.0000696

    LOADING - 20            SIDESWAY LOAD ON J 5+SIDESWAY LOAD ON COLUMN #6

    RESULTANT JOINT
                                       SUPPORTS
                         DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.           X ROT.          Y ROT.          Z ROT.

6          GLOBAL          0.0             0.0                                                              0.0
7          GLOBAL          0.0             0.0                                                              0.0

    RESULTANT JOINT
                                       FREE JOINTS
                         DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.           X ROT.          Y ROT.          Z ROT.

1          GLOBAL          0.0187523       0.0028482                                                       -0.0003128
2          GLOBAL          0.0187523       0.0000021                                                       -0.0003128
3          GLOBAL          0.0187548      -0.0007800                                                        0.0001303
4          GLOBAL          0.0187573      -0.0000021                                                       -0.0002089
5          GLOBAL          0.0187583      -0.0018407                                                       -0.0002089

    LOADING - 25            3 CONCENTRATED LOADS ON J 1&3&5

    RESULTANT JOINT
                                       SUPPORTS
                         DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.           X ROT.          Y ROT.          Z ROT.

6          GLOBAL          0.0             0.0                                                              0.0
7          GLOBAL          0.0             0.0                                                              0.0

    RESULTANT JOINT
                                       FREE JOINTS
                         DISPLACEMENTS -
JOINT                     /-----------------DISPLACEMENT-----------------/
                                                                          /-------------------ROTATION-------------------/
                              X DISP.        Y DISP.        Z DISP.           X ROT.          Y ROT.          Z ROT.

1          GLOBAL         -0.0000628      -0.0008460                                                        0.0001234
2          GLOBAL         -0.0000628      -0.0000082                                                        0.0000295
```

```
3          GLOBAL       -0.0000627      -0.0021710                                                          -0.0000014
4          GLOBAL       -0.0000626      -0.0000081                                                          -0.0000239
5          GLOBAL       -0.0000626      -0.0007335                                                          -0.0001117

    LOADING - 30            3 @ 10N CONCENTRATED LOADS ON JOINTS 1&3&5


    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                      /-----------------DISPLACEMENT-----------------/ /------------------ROTATION------------------/
                                                                               X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.          Z DISP.

6          GLOBAL          0.0             0.0                                                                  0.0
7          GLOBAL          0.0             0.0                                                                  0.0


    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                      /-----------------DISPLACEMENT-----------------/ /------------------ROTATION------------------/
                                                                               X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.          Z DISP.

1          GLOBAL       -0.0001257      -0.0016919                                                           0.0002467
2          GLOBAL       -0.0001257      -0.0000164                                                           0.0000589
3          GLOBAL       -0.0001254      -0.0043420                                                          -0.0000028
4          GLOBAL       -0.0001252      -0.0000163                                                          -0.0000478
5          GLOBAL       -0.0001252      -0.0014671                                                          -0.0002234

    LOADING - 35            2 10N CONCENTRATED LOADS ON JOINTS 1&5


    RESULTANT JOINT
                          DISPLACEMENTS - SUPPORTS

JOINT                      /-----------------DISPLACEMENT-----------------/ /------------------ROTATION------------------/
                                                                               X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.          Z DISP.

6          GLOBAL          0.0             0.0                                                                  0.0
7          GLOBAL          0.0             0.0                                                                  0.0


    RESULTANT JOINT
                          DISPLACEMENTS - FREE JOINTS

JOINT                      /-----------------DISPLACEMENT-----------------/ /------------------ROTATION------------------/
                                                                               X ROT.          Y ROT.          Z ROT.
                           X DISP.         Y DISP.          Z DISP.

1          GLOBAL       -0.0001270      -0.0042246                                                           0.0005256
2          GLOBAL       -0.0001270      -0.0000109                                                           0.0003379
3          GLOBAL       -0.0001254       0.0049817                                                          -0.0000028
4          GLOBAL       -0.0001239      -0.0000108                                                          -0.0003267
5          GLOBAL       -0.0001239      -0.0039161                                                          -0.0005023
FINISH


GOOD-BYE
```