**User Manual**

# SKELETON-9

## Linear Elastic Analysis of Plane Frameworks

**by**

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USING SKELETON IN WINDOWS 3.1 AND WINDOWS 9/ 98

Although Skeleton is MS DOS based program of 1988, it works happily in the above two environments.

To use the program,

Switch to the MS DOS PROMPT mode of the windows environment.

Ensure/make the SKELETON program directory as the default DOS directory, and then

Start SKELETON in the usual way i.e. by typing AUTOEXEC. This leads to the MASTER OPTIONS of the program operation.

As explained above, you can send TEXT part of SKELETON output to a disk file for viewing and printing by a word processor.

If you now want to add the frame diagram in the word processor document/output, draw the diagram by using a graphics package e.g. Corel Draw or AutoCAD and copy-paste it into the text output.

# CONTENTS

# *PREFACE TO VERSION 9*

In addition to typesetting the program manual on a laser printer, the following new features have been added:

- Now self weight of members can be included automatically.  The members can be of different material densities.
- The program has been re-compiled using QuickBASIC 4.  All memory up to 640K is now used, allowing analysis of large problems and speeding up analysis.
- Program output can be sent to a disk file for inspection, formatting and printing by a word processor of your choice.
- Use of double precision numbers in setting up stiffness matrix and finding displacements to enhance accuracy.
- Facility to define aspect ratio of diagrams to suit your screen display or printer.
- Default output options for post member analyses.  They appear already selected each time you perform this analysis.
- The program now supports all popular graphic cards e.g. VGA, EGA, CGA, Hercules.
- Facility to start member analysis output of each new loading and/or combination case on a new page.
- Structure data files are now saved in a format which allows editing of its text by a word processor.  Although program monitored editing is recommended, this facility can be useful when only minor changes of data are required.
- Sequence of menu appearance and layout of options have been fully revised to enhance user control.
- Facility to change data drive/directory.  Hard disk users can now store data files in any directory on any drive.

***September 1988***

# *PREFACE TO VERSION 8*

Versions 1 to 7 of this program were written in Applesoft Basic on the APPLE II, IIe computer.  This version has now been written in Microsoft Basic on the IBM PC computer.

***November 1985***

# *PREFACE TO VERSION 1*

Development of this program was initiated at the University of Manchester, Institute of Science & Technology in 1973.  Written in FORTRAN IV, its objective was to analyse non-linear inelastic reinforced concrete frames at all stages of their loading up to collapse. With the availability of micro-computers at a reasonably low cost and in the absence of powerful programs to satisfy everyday needs of designers, relevant parts of this program have been re-written in BASIC and named SKELETON.  The objective has been to cope with routine design office requirements and SKELETON analyses only linear elastic frameworks.

The use of the program does not require any programming experience.  It has specifically been written for designers working in small to medium size firms.  The user is expected to be familiar with the basic elements of structural analysis so that he can appreciate the results produced for him by SKELETON.  To ensure its correct use, a user can therefore be a non-programmer but, preferably, not a non-designer.

Experience of SKELETON's use in design offices suggests that the best course to get started is to use SKELETON rather than continue reading its manual.  To this end analysis of simple problems e.g. simply supported beam with nodal joints in its span and subjected to different types of loads, are suggested.

The manual has been purposely kept concise to serve as a reference rather than a tutorial. In order to illustrate various aspects of its use, however, a worked example has been included with complete details of its input and output.  In addition a set of worked examples is also available separately to help practice and gain familiarity in the use of SKELETON.

***November 1980***

*Section 1*

# INTRODUCTION

SKELETON carries out linear elastic analysis of plane frameworks subjected to static loads. At supports, joints can have full restraints or elastic springs in any combination of the X, Y or Angular direction of the support axes. Joints can therefore be fixed, free to rotate, or be on rollers.

SKELETON analyses any framework be it a truss, a rigid frame, or a truss and rigid frame combined. It also analyses frameworks having joints where some member-ends are pinned and others rigidly connected.

SKELETON combines its ability to analyse complex frameworks with an extremely powerful input system to describe complicated member-end connections with ease and rapidity. To this end, a new term used is HINGED BAR MEMBERS for describing members in the framework with hinges at both ends.

All framework diagrams are displayed on the VDU and can be printed for record purposes. This provides an instant check of data requiring minimum of effort. Incorrect entries concerning joint-coordinates and member-locations in the framework become obvious at a glance.

Structure details, applied loads and results of analyses are stored on user's data disks, which can be floppies.or directories on a hard disk. The stored information can be retrieved for use in an analysis or examined, modified, appended and re-stored for later use.

A set of loads acting simultaneously on the framework joints and members is called a LOAD CASE. After the framework analyses have been completed, various LOAD CASES can be factored and combined as required. The resulting set of loads is called a COMBination CASE. Subject to the storage capacity of the data disk (see section 14 & 17), the number of LOAD and COMB CASES can be as many as desired; a reference number is used for each to store and retrieve its details from the data disk.

LOAD and COMB CASE analyses are carried out using separate programs, the former always being the first. These analyses follow one after the other and are numbered with consecutive integers starting from 1 upwards. The LOAD or COMB CASE numbers in these analyses can be any random selection and order, so long as details pertaining to them exist on the data disk.

After the LOAD and/or COMB CASE analyses, values of axial load, shear, moment and deflection can be determined and plotted along member spans. The analysis can be interactive or automatic. In the interactive analysis, the members are analysed one at a time, giving the structure name, the LOAD or COMB CASE number, and the member number. In the auto analysis, the structure name, the LOAD and or COMB CASE numbers and the member numbers together with their output contents are chosen first. Following this the operation is automatic, the analyses being executed one after the other for all the chosen members in each LOAD and COMB CASE.

No computer knowledge or programming experience is required to use the program. The only requirement is an understanding of the framework behaviour so that program potentials can be exploited in everyday design. The program mainly serves as an analysis tool; validity of the results in relation to the real structure is only as good as the users understanding of the behaviour involved.

### *Section 2*

# USING SKELETON

## *2.1* EQUIPMENT & INSTALLATION

To use SKELETON, the following equipment is required:

| | |
|---|---|
| Either | An IBM PC/XT or PS/2 computer or with at least 512K of random access memory, an optional graphics card, a Hard Disk or Two Floppy Disk Drives and a Printer with graphic print facilities. |
| Or | A Macintosh Plus Computer with 1 Mb RAM, a Hard Disk and an Imagewriter Printer. |

The program is also supplied for Apple IIe computers but the latest version available for this machine is SKELETON 7.

For installation of the program, consult documentation supplied with your disks or read the contents of the text file *"README"* on one of the SKELETON disks.

The program is normally supplied with default settings set for your computer system. If necessary, they can be altered by taking option-6 of menu-1; this leads to menus 87 to 100 for this purpose.

## *2.2* PROGRAM DISKS

The number and contents of supplied SKELETON disks vary, depending upon the type and configuration of your computer. For information relating to your version of SKELETON disks, consult the documents enclosed with your disks; the information is also stored in the *"README"* text file on one of the SKELETON disks.

SKELETON programs are supplied on floppy disks. It is recommended that you make a back-up copy of the original disks and use them as your working copies. Store the originals away safely.

On a computer without a hard disk, you can create a SKELETON system disk, that is, a disk that also includes your operating system. This disk will enable you to boot the system and SKELETON directly. Refer to your system documentation for specific instructions.

## *2.3* DATA DISKS

Frame analysis information can be stored either in a *directory on the hard disk* or on a *floppy disk*. The floppy disk is an ordinary disk, FORMATted and provided by the user. The number of floppy disks can be as many as required e.g. one disk for each job or a disk common to as many jobs as it can manage.

## *2.4* PROGRAM USE

On a system with a hard disk, make the program directory as Default and then type AUTOEXEC (or any other chosen batch filename e.g. SKELERON) and press enter. This leads to the MASTER OPTIONS menu-1 from which the program operation is interactive and self-explanatory.

Broadly speaking, the main MASTER OPTIONS of menu-1 are used for the following:

> the DATA-PREPARATION option to prepare, modify, update, examine and store data for its use later by the analysis disk,
>
> the FRAMEWORK ANALYSIS option to carry out framework analyses using data stored on disk,
>
> the LOAD-COMBINATION ANALYSIS option to factorize and add the loading case results as obtained (*and stored on data disk*) by using the framework analysis option above, and
>
> the POST MEMBER ANALYSIS option to draw and print axial load, shear, bending moment, and deformation values along the length of a framework member after their LOADing case and COMBination case analyses.

## *2.5* INPUT DATA PROMPTS

When entering data, SKELETON input prompts include ?, 2?, 3? or 4?. The numeral next to the question mark indicates the number of data values required; a comma being used to separate the input of more than one value. For example, 3? means that three values of data separated by commas are required.

Some terms of the DOS (Disk Operating System) used freely in the program and this manual are: BOOT, FORMAT, LOAD, SAVE, RETURN, DISK FULL and WRITE PROTECTED. For their definition and explanation, reference should be made to your system documentation.

## *2.6* PAGINATION OF OUTPUT

SKELETON output is printed on continuous paper sheets. The length of pages can be selected to suit varying needs. All pages are numbered. The page numbers appear at top left corner and are intended to disappear into the report binding for presentation purposes. They are meant for the user's reference while the output pages are loose prior to their inclusion in a report. The program assumes that the final page numbers would appear in the top centre later when all design calculations have been completed for the entire project.

The pagination parameters which can be varied or selected are:

1- 1ST PAGE NUMBER
2- LINES PER DIAGRAM
3- LINES PER PAGE
4- LINES PER GAP
5- CHARACTERS FOR LEFT MARGIN

The above items can be defined as MASTER-DEFAULT-OUTPUT-SELECTION by taking option-6 of menu-1. This leads to menu-88 *(via option-1 menu-87)* for Framework Analyses and menu-92 *(via option-2 menu-87)* for Post Member Analyses. These menus display the last chosen output selection, which can be defined/changed and, when satisfactory, saved on to the program disk for future use.

The defined MASTER-DEFAULT-SELECTION items appear as a ready selection prior to each analysis; via menu-29 for the FRAMEWORK ANALYSIS, menu-45 for the LOAD-COMBINATION ANALYSIS, menu-66 for INTERACTIVE POST-MEMBER ANALYSIS, and menu-78 for the POST-MEMBER ANALYSIS. Except for items 2 and 5, these items can be re-defined for each individual analysis.

Typical values of these items are:

1ST PAGE NUMBER: Usually it is "1" but if there are other pages to precede the present analysis, it can be any other number.

LINES PER DIAGRAM: This represents the number of lines the printer takes to print graphics e.g. 31 lines using EPSON FX80 printer, HERCULES graphics card and IBMGRAPH.COM printer driver from Laboratory Software.

LINES PER PAGE: The actual number of lines to be printed on each page e.g. 60.

LINES PER GAP: The number of lines per each gap between successive pages e.g. 6. Total lines per page and gap determine the page length i.e. 66 lines for the values quoted here.

CHARACTERS FOR LEFT MARGIN This defines the left margin width. For an EPSON FX80 printer, the suitable widths are 10 characters for LOAD and COMBINATION analyses and 5 characters for POST MEMBER analyses.

## *2.7* NOTES ON PRINTING STRUCTURE DIAGRAM

Your system should have its own facilities to print graphics from the screen on to the printer. For example, GRAPHICS.COM from the DOS 2.1 disk or GRAFTRAX.COM from the Public Domain library can be loaded via AUTOEXEC.BAT program on the SKELETON disk and graphics can be dumped on to the printer when Shift and Prt Scr Keys are pressed together.

When an option to include structure diagram in the SKELETON output is taken, the program displays the Structure Diagram on the screen and waits for the user to press Shift and Prt Scr keys (or an equivalent of this for your system set up). When the diagram has been printed, the user is required to press the RETURN key as a prompt for the program to continue further and analyse/print rest of the output.

The user can use any suitable Graphics Dump program for his system. Normally this requires copying it on to the the SKELETON disk and, each time SKELETON is run, loading it into the memory via AUTOEXEC.BAT program .

When GRAPHICS.COM program is used (via AUTOEXEC.BAT), the structure diagram is printed sideways on the paper (see IBM PC DOS manual ) and on an Epson FX-80 printer it occupies 54 lines per diagram.

When GRAFTRAX.COM is used (via AUTOEXEC.BAT), the screen can be sent to the printer in two ways. A Small Size 17 lines/diagram by pressing RIGHT-Shift and Prt Scr keys and a Large Size 66 lines/diagram by pressing LEFT-Shift and Prt Scr keys.

For Hercules Card, when IBMGRAPH.COM is used (via AUTOEXEC.BAT), the screen is sent to the printer automatically or as directed by the program on screen. The size is 31 lines/diagram.

To ensure correct pagination of output, count the number of lines your system takes to print the Structure diagram and Re-define/Save them via option-13 of Menu-88. For more details, see Section 2.6.

*Section 3*

# UNITS

Using SKELETON, frameworks can be analysed in any units. The only requirement is that once the data input has begun the units should not be changed or mixed.

The units to be chosen for each framework analysis are the FORCE and LENGTH. The description can be a maximum of 2 characters each; excess characters to the right, if input, are ignored. Units of all other items of input and output are derived by the program itself. For example, if the chosen units are kN for force and ft for length (an improbable combination of units selected here for illustration only), the units of various elements would be:

| | | |
|---|---|---|
| Modulus of elasticity | | kN/ft$^2$ |
| Sectional area | | ft |
| Inertia | | ft$^4$ |
| Length | coordinates of joints, span of members, deflection of joints and members, location of span loads on members from their start-ends | ft |
| Force | horizontal and vertical loads on joints, axial compression or tension in members, shear at member-ends | kN |
| Moment | | kN ft |
| Distributed loads | | kN/ft run of member length |

Rotation at joints, member-ends, member-hinges, and along member lengths is always printed in RADIANS; inclination of member loads and joint supports (unless specified parallel/perpendicular to member lengths) is always described in DEGREES; it is of no matter which units are used.

*Section 4*

# STRUCTURE SIZE

The maximum size of structure that can be analysed depends on the type and joint-numbering of the structure; optimum joint-numbering being when the maximum difference between any two joints connected by a member (JD) is the least possible. To give an idea of what the structure size can be, SKELETON has been used to analyse the following frames on 64K APPLE IIe computer:

a 16-storey 4-bay rigidly-jointed framework with 85 joints and 144 members (JD=5), analysis time 33 minutes,

a 60-bay rigidly-jointed lattice girder with 122 joints and 241 members (JD=2), analysis time 26 minutes, and

a 70-bay pin-jointed lattice girder with 142 joints and 281 members (JD=2), analysis time 20 minutes.

The time durations stated above do not include the time required for printing results and are for analysis of one load case only.

The program checks memory size requirement of an analysis in two stages; firstly when a user begins to input data by describing the number of joints, members and sections in the structure and secondly when the stiffness matrix of the structure is set up.

In terms of when a user would discover that his structure is too large for analysis, the size can fall into one of three categories. For the first category large size, the program will not accept any further data after the numbers of joints, members and sections in the structure have been defined. For the second category large structures, it will be possible to input the structure details but not its loading case data. For the third category large structures, structure details as well as its loading case data would have been defined but actual analysis will not be possible.

In view of the above, a user would feel most disappointed if his structure falls into the third category large size, after having input all the structure details and the loading case data. It is however inevitable since memory size requirements depend upon, among other obvious factors, the member-end connections at joints and are established when all the data has been input. For example, version 7 of SKELETON on Apple IIe can analyse a 70-bay Lattice girder if all of its connections are pinned. The same analysis is however not possible when the joints are all rigidly connected.

In all cases, when memory requirements are found to be excessive, a flashing display appears in the middle of the screen and the user is requested to press SPACE BAR to continue; this leads to the master-options of the program or DOS command level.

*Section 5*

# FRAMEWORK SUPPORTS

At supports, joint restraints can be rigid, elastic springs, or free. The directions in which these restraints can be specified are the X, Y and angular direction of the support axes. Joints can therefore be fixed, free to rotate or be on rollers.

The data required to specify each support is its *Joint No* and *three spring constant numbers* for the restraints in the X, Y and angular direction of the support axes. When support axes of any joint are not parallel to the Global axes, *inclination angle of the support* is also required.

## *5.1* ELASTIC SPRING CONSTANTS

To specify joint restraints, up to 9 spring constants (i.e. the force or moment required to produce a unit displacement in the specified direction) can be specified. The spring constant-1 is however always infinity and cannot be re-defined; it is used to specify restraints which are fully rigid. To describe free restraints, the spring constant-0 is used. Example of data input for various restraints are as shown below:

```
SPRING CONSTANTS

Existing Value; New Value
Nos =1 ; How Many (1 to 9/Return) ? 4
0 (FREE)
1- Infinity (FIXED)
2- 9.9e+09 ; New (VALUE/Return) ? 1000
3- 9.9e+09 ; New (VALUE/Return) ? 1100
4- 9.9e+09 ; New (VALUE/Return) ? 1200

SUPPORTED JOINTS ? 3
         JNT , X-R , Y-R , R-R
1- 4? 4,1,2,0
2- 4? 5,1,1,3
3- 4? 6,2,3,4
```

In the above, Joint-4 is pinned but with spring-2 in its Y-direction. Joint-5 is fixed but with spring-3 in its angular direction. Joint-6 is also fixed but with springs 2, 3 and 4 in its X, Y and angular directions respectively.

The initial default values for the number of spring constants and their magnitude are 1 and 9.9E+9 respectively. During data input, the default or last-defined values are also displayed alongside and, if correct, they can be accepted by pressing "return".

***FEATURE TO HELP COMPREHEND OUTPUT:***

*The following symbols appear to the right of joint numbers in the output. Their meanings are as follows:*

*A slash "/" signifies that the joint is an Inclined Support.*

*An asterisk "*" signifies that the joint is an hinged support i.e. all member-ends are free to rotate independent of each other.*

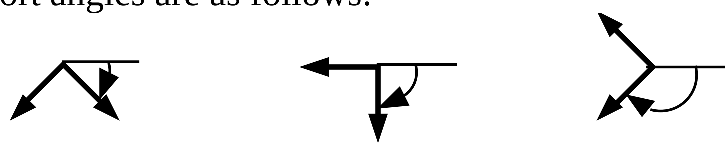
*An "@" signifies that the joint is an elastic spring support.*

## *5.2* INCLINED SUPPORTS

In general, the default angle for all supports is 0 "zero". This implies that the support X-axis is parallel to the GLOBAL X-axis and the support Y-axis is parallel to the GLOBAL Y-axis. For example, if joint 4 in a frame is an X-roller support, the usual data input is:

```
      Jnt , X-res , Y-res , R-res
1- 4?  4,0,1,0
```

When a support is inclined, the support angle is measured from the global X-axis to the support X-axis in the clockwise direction. This angle should always be a +ve value between 0 to 360 degrees (no of decimal places in a value cannot be more than one). Examples of various support angles are as follows:



Ø=0° Ø=47° Ø=91.3° Ø=138°

Ø=180° Ø=240° Ø=271° Ø=306°

Supports can also be specified as being parallel to the axes of any member in the frame. The data input for such supports is the member number followed by the character "M". The support X-axis then becomes parallel to the member X-axis and the support Y-axis parallel to the member Y-axis (to locate the direction of member axes, see Section 9.1 of the manual).

To input the angle of an inclined support, character "A" is typed next to the joint number in the support data. This prompts the program to allow input of the support angle (in degrees ) or inclination parallel to any member in the frame. Examples of the inclined support data is as follows:

```
SUPPORTED JOINTS ? 2
     Jnt , X-res , Y-res , R-res
1- 4? 4A,0,1,0
     Angle (Any-in-deg/Mem) ? 31.2
2- 4? 14A,1,1,0
     Angle (Any-in-deg/Mem) ? 11M
```

The first data is for support at joint-4 which is an X-roller with its X-axis inclined at angle of 31.2 degrees clockwise from the global X-axis.

The second data is for joint-14 which is a pinned support with its axes parallel to the axes of member-11.

## *5.3* UNSTABLE SUPPORT DATA

SKELETON rejects support data when the overall framework supports are unstable. Deemed to be stable support requirements are:

EITHER: The number of pinned joints (i.e. those held in both the X and Y directions) are two or more e.g. a beam pinned at both ends.

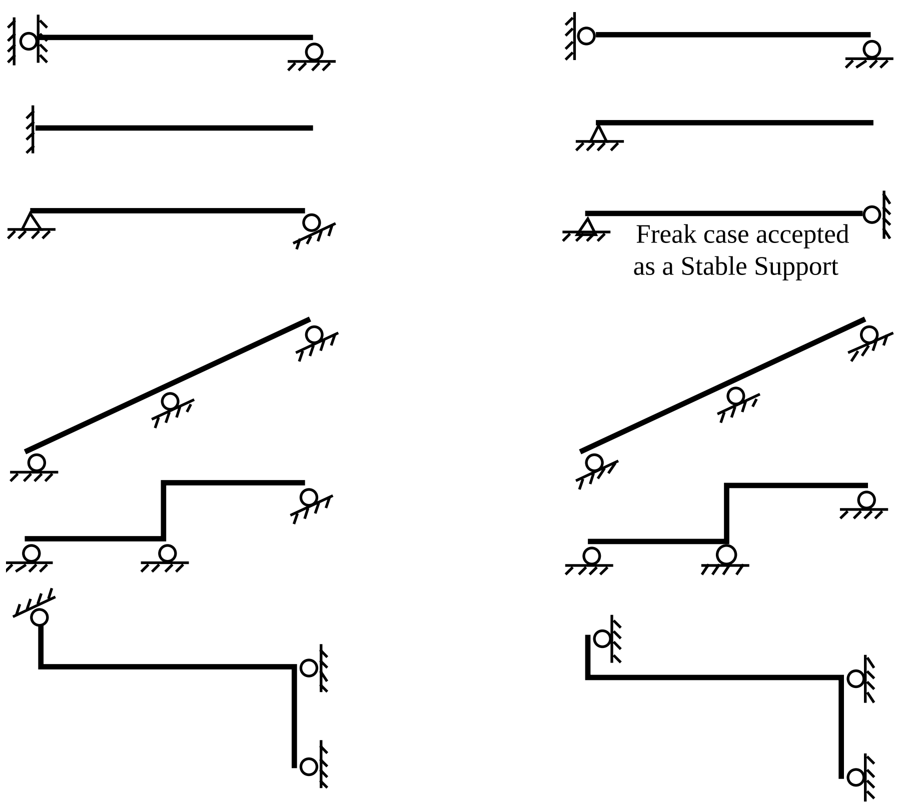
OR: In addition to one joint being pinned, there is also at least one X or Y roller e.g. a beam pinned at one end and with a roller at its other end.

OR: In addition to one joint being held in both the X and Y directions, there is also at least one angular restraint e.g. a cantilever.

OR: The number of joints on rollers are three or more and inclination angle of at least one of them is different than that of the rest.

The above checks will detect all the unstable support data except for one freak case in which, for example, a beam is pinned at one end and has a roller at the other end perpendicular to its length (see diagram below); the program crashes later when the framework is actually analysed. Some examples of stable and unstable supports are shown below.

**STABLE SUPPORTS** **UNSTABLE SUPPORTS**




*Note: At roller supports, movement can occur only along their slope. Movement perpendicular to the slope (e.g. roller up lift) is not permitted.*

*Section 6*

# FRAMEWORK CONNECTIONS

Framework connections can be rigid joints, hinged joints or a combination of rigid and hinged joints.

Hinges can also occur at member ends connected to otherwise rigid joints. Any number of members meeting at a joint can have such hinges. When all members have hinges, the joint becomes a hinged joint.

Unless otherwise specified in the input data, SKELETON considers all joints as rigid. Data to describe rigid joints is therefore not required.

A hinged joint at which all member-ends are pinned is described under the input heading JOINT HINGES and the data required to specify it is the number of the joint.

At joints where some member-ends are pinned and others rigidly connected, input heading MEMBER HINGES is used to describe the connection; data required for each member hinge is the member number and the joint number.

When a framework contains members with both ends pinned (e.g. a lattice girder with top and bottom boom continuous and diagonals with both ends pinned), input heading HINGED-BAR-MEMBERS is used for rapid input. To describe the two hinges of each member, the only data required is the member number.

Using the above provisions, a framework with all of its joints pinned (i.e. a truss) is described in one of the following ways:

JOINT HINGES = No. of joints in the framework

HINGED-BAR-MEMBERS = No. of members in the framework

MEMBER HINGES = 2 x No. of members in the structure

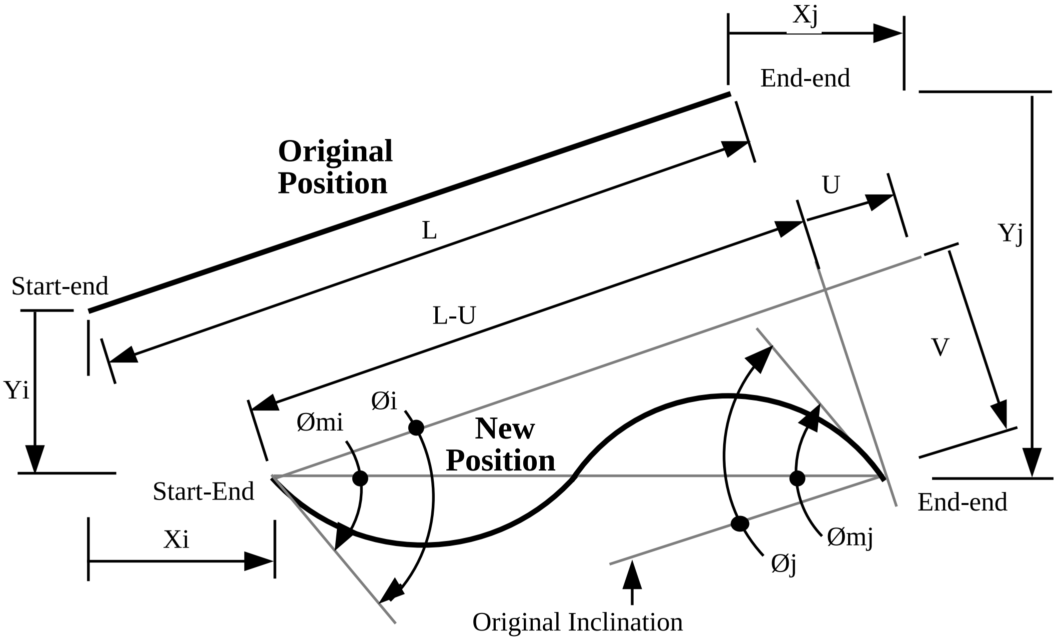
Since the descriptions imply that all joints/member-ends are pinned, no further information (joint/member numbers) is required in the data to describe location of these hinges in the framework.

***FEATURE TO HELP COMPREHEND OUTPUT***

*An asterisk "*" printed to the right of a joint or a member number signifies a hinged connection or a cantilever end. Irrespective of how the user has described the framework connections, all hinged joints, and pinned and cantilever member ends are indicated this way in the entire output.*

# JOINT AND MEMBER DEFORMATIONS

The joint and member deformations calculated by the program are as shown in the following sketch:




In accordance with the program sign convention, all displacements shown in the sketch are positive. The dot and arrow in each measurement line indicate the start and the end of the measurement respectively. The meaning of other symbols used in the sketch are as follows:

L Original (undeformed) member length

U Member axial deformation

V Member sway

Xi Displacement of joint-i along the global X-axis

Xj Displacement of joint-j along the global X-axis

Yi Displacement of joint-i along the global Y-axis

Yj Displacement of joint-j along the global Y-axis

Øi Rotation of joint-i (at start-end of the member)

Øj Rotation of joint-j (at end-end of the member)

Ømi Rotation of member at its start-end

Ømj Rotation of member at its end-end

***Section 8***

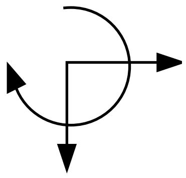
# SIGN CONVENTION FOR LOADS AND DISPLACEMENTS

## *8.1* JOINT LOADS AND DISPLACEMENTS (ALSO IMPOSED DISPLACEMENTS)

Global X-axis *+ve to the right*

Global Y-axis *+ve downwards*

Moment *+ve clockwise*



When support axes are inclined, the +ve direction of X and Y loads/ displacements also becomes inclined relative to the global axes. The angle of inclination is +ve clockwise from the global to the support axes.

## *8.2* APPLIED MEMBER LOADS

Loads 1-9 *perpendicular to member span, +ve acting downwards (member length being viewed with its start end to LHS of the user)*

Loads 11-19 *parallel to member span, +ve acting to the right i.e. from start-end towards end-end*

Loads 21-29 *inclined at an angle O which is +ve clockwise from the load direction to the member span (see Section 9.2 for detailed description)*

Loads 31-39 *parallel to the global X-axis, +ve if acting to the right (Global Horizontal)*

Loads 41-49 *parallel to the global Y-axis, +ve if acting downwards (Global Vertical)*

Moment *+ve clockwise (load types 8,18,28,38,48 & 52)*

Special Effects Temperature Change: *Rise +ve & Fall -ve*

Lack-of-fit: *Long +ve & Short -ve*

Axial strain: *Elongation +ve & Shortening -ve*

## *8.3* MEMBER END FORCES

| | |
|---|---|
| Axial | *+ve compression & -ve tension* |
| Perpendicular | *+ve acting upwards (in the negative direction of local Y-axis)* |
| | ***N.B.*** ***For member analysis results, the sign convention is different, see Section 22.7.*** |
| Moment | *sagging +ve and hogging -ve* |

## *8.4* MEMBER DEFORMATIONS

| | |
|---|---|
| Axial Force | *+ve compression & -ve tension* |
| Sway | *+ve upwards (in the +ve direction of local Y-axis and measured relative to the original member position)* |
| Rotation | *+ve clockwise* |

## *8.5* SUPPORT REACTIONS *(ACTING ON TO THE FRAMEWORK)*

The sign convention is as that for joint loads and displacements, described in Section 8.1.

*Section 9*

# APPLIED LOADS ON FRAMEWORK JOINTS AND MEMBERS

Loads can be applied on both framework joints and on member spans.

Joint loads can be a horizontal load, a vertical load and a moment. The positive direction of these loads is described in Section 8.1.

Member loads can be a single point load, a series of equi-spaced equal-magnitude point loads, uniformly distributed loads, linearly varying distributed loads and moments; the distributed loads can act over a part member length as either a total load or a load per unit length.

Inclination of loads on the member span can be any defined angle from 0 to 360 degrees.

In all 45 types of loads are allowed on the member span; this minimises the user's effort to describe a given set of applied loads. These loads have been subdivided into the following six categories:

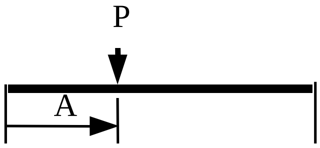
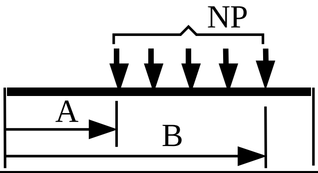
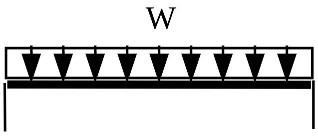
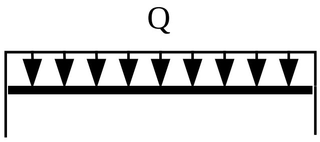
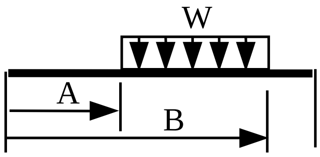
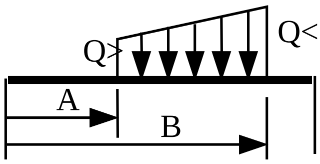
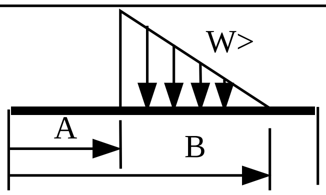
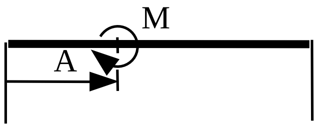
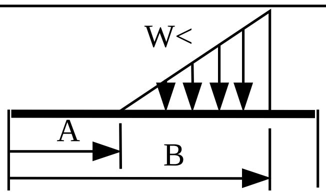
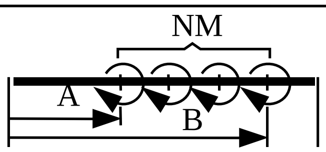
> loads perpendicular to member spans *(load types 1-9)*,
>
> loads acting axially along the member length *(load types 11-19)*,
>
> loads inclined at any general angle from 0 to 360 degrees relative to the member span *(load types 21-29)*,
>
> loads parallel to the global X-axis *(load types 31-39)*, and
>
> loads parallel to the global Y-axis (*load types 41-49)*.
>
> Special effects loads *(load types 51-54)*

The data required to describe the above loads is shown on page 25.

## *9.1* ESTABLISHING POSITIVE DIRECTION OF LOAD TYPES 1 TO 9

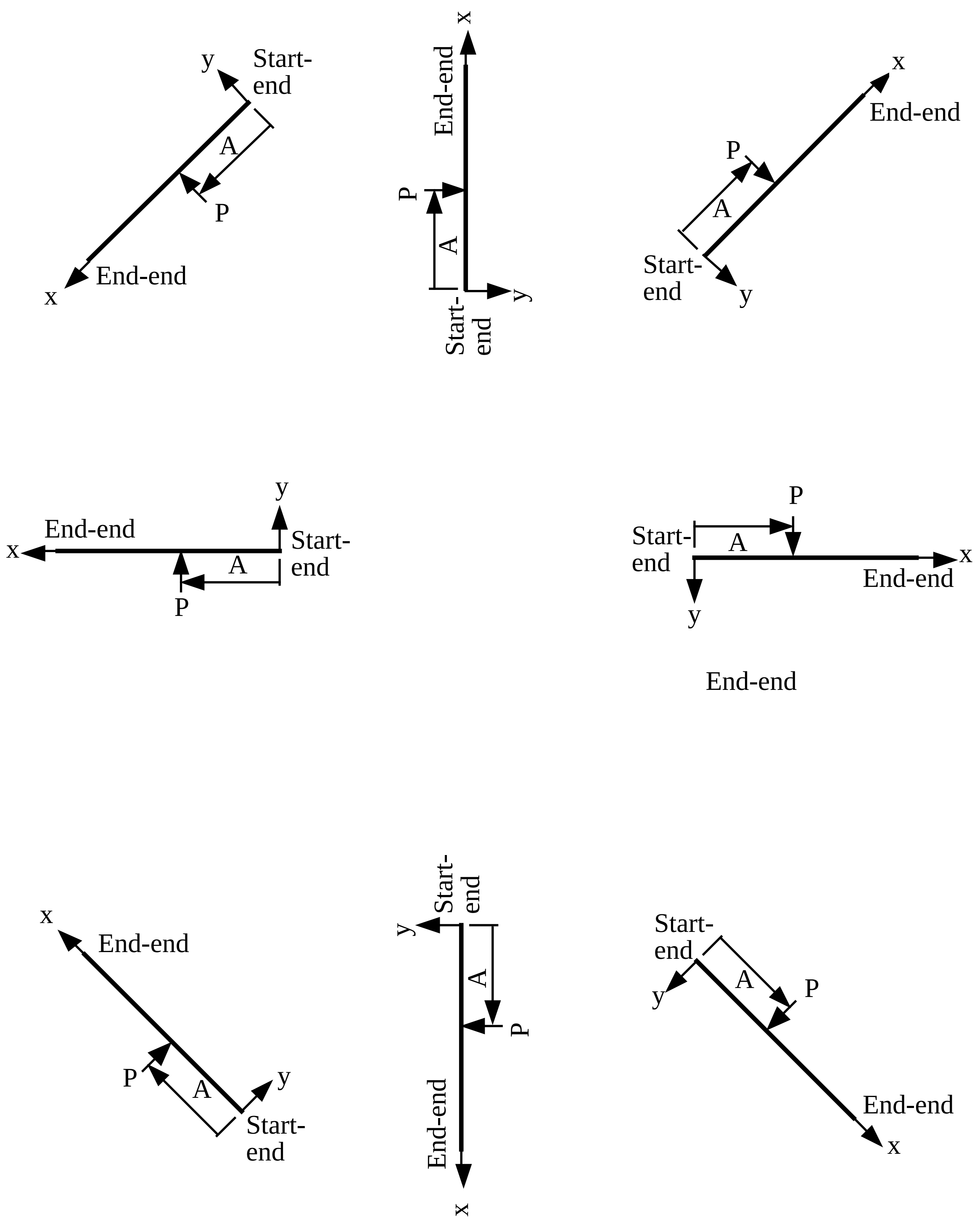
The positive direction of these loads perpendicular to member spans *(load types 1 to 9, except load type 8 which is a moment and +ve when clockwise)* depends upon not only the member orientation and the direction in which these loads act but also on the **THE USER'S CHOICE TO SELECT ONE OF THE TWO MEMBER-ENDS AS THE START-END.** To describe member loads correctly in all general situations (see example page 26), it is necessary to appreciate fully the implication of this point.

# INPUT INFORMATION TO SPECIFY MEMBER LOADS

| Load Description | | Load Type | Required Values for Load Definition |
|---|---|---|---|
| Point load at distance A |  | 1*<br>11<br>21<br>31<br>41 | P , A<br>Also Ø if Load Type 21 |
| N point loads spaced equi-distant over member length from A to B |  | 2*<br>12<br>22<br>32<br>42 | N , P , A , B<br>Also Ø if Load Type 22 |
| Uniform total load over entire member length |  | 3*<br>13<br>23<br>33<br>43 | W<br>Also Ø if Load Type 23 |
| Uniform load per unit length over entire member length |  | 4*<br>14<br>24<br>34<br>44 | Q<br>Also Ø if Load Type 24 |
| Uniform total load over part member length from A to B |  | 5*<br>15<br>25<br>35<br>45 | W , A , B<br>Also Ø if Load Type 25 |
| Linearly varying load per unit length: Q> at distance A to Q< at distance B |  | 6*<br>16<br>26<br>36<br>46 | Q> , Q< , A , B<br>Also Ø if Load Type 26 |
| Linearly varying total load with an intensity maximum at distance A to zero at distance B |  | 7*<br>17<br>27<br>37<br>47 | W> , A , B<br>Also Ø if Load Type 27 |
| Moment at distance A |  | 8<br>18<br>28<br>38<br>48 | M , A |
| Linearly varying total load with an intensity zero at distance A to maximum at distance B |  | 9*<br>19<br>29<br>39<br>49 | W< , A , B<br>Also Ø if Load Type 29 |
| Member temperature change(Rise +ve) | | 51 | TEMP , COEFF. |
| N moments spaced equi-distant over member length from A to B |  | 52 | N , M , A , B |
| Lack -of-fit (Long +ve) | | 53 | Lack-of-fit |
| Member axial-strain (Elongation +ve) | | 54 | Strain |

** the above sketch shows only this load type; forthe description of otherloads see section 9*

# Positive Directions of Member Axes and Load Types 1-9 for Various Member Orientations and Choices of Start-end and End-end



To establish the correct sign of these loads, it is first necessary to locate the member axes. Origin being at the start-end, the member X-axis is always along the member length, with its positive direction from the start-end to the end-end of the member. The member Y-axis is perpendicular to the X-axis with its positive direction at 90 degrees clockwise from the member length (or the member X-axis).

To help specify member loads and locate their member-axes, various member orientations and different choices of start-ends are shown on page 26, together with the member-axes and the positive directions of loads.

Once the member-axes have been located, the member is viewed with its start-end to the left hand side of the user. As described in Section 8, these loads are +ve when acting downwards.

## *9.2* INCLINATION-ANGLE OF MEMBER LOAD TYPES 21 TO 29

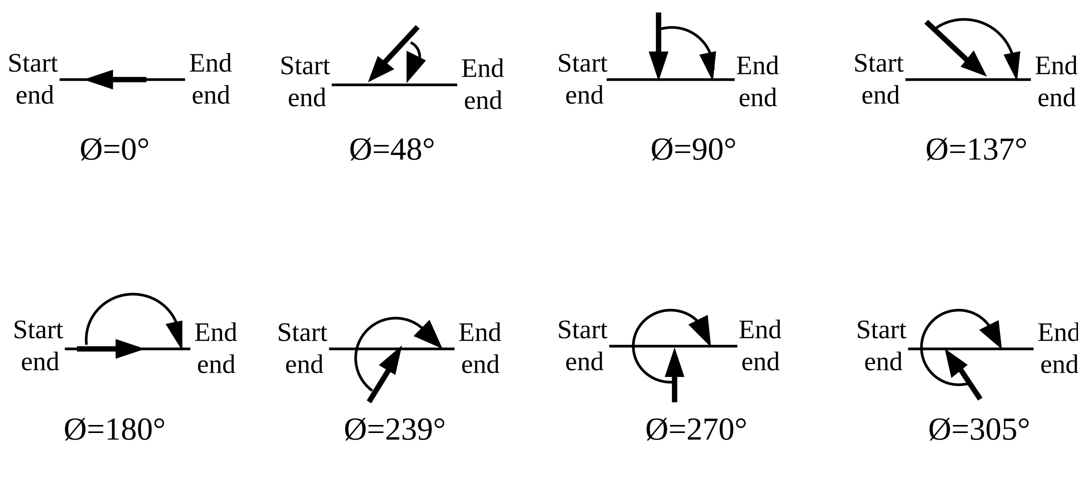
To measure inclination-angle of loads on member spans (load types 21 to 29):

(a) view the member so that its start-end is to the left and the end-end to the right of the user,

(b) place the arrow-tip of the load direction on the member-span, and

(c) measure the angle CLOCKWISE, starting from the load direction and up to the member span on to the right hand side of the load-direction.

Examples of various load inclinations are shown below:



## *9.3* CAUTION ON LOAD-DISTANCES ALONG MEMBER-SPAN

All distances in the description of member loads are ALWAYS along the member-length and are measured from the start-end. This is so irrespective of the category of loads.

**CAUTION**

> **When the loads specified are parallel to the Global X or Y Axis *(Load Types 31 to 39 and 41 to 49)* caution is necessary; the distances "A" and "B" would be along the Member length, NOT parallel to the Global Axes if the member is inclined.**
>
> **Extreme caution is needed when specifying Distributed Loads *(Load Types 34,36,44, AND 46)*. Here again the Distance per Unit Length in magnitude of the distributed loads is parallel to the member length, NOT the Global Axes if the member is inclined. To avoid the somewhate tedious conversion of load intensities, a possible re-course is to specify the loads as Total Distributed Loads *(Load Types 33,35,37,39,43,45,47, and 49)*.**

Examples of the TOTAL loads being specified rather than the DISTRIBUTED loads are members 19 and 26 in loading case-2 of Sample Problem-1. Although the two members have the same distributed load per unit length of their vertical projection as members 1, 2, 21 and 22 (i.e. 0.015 kN/cm), the loads specified on them are distributed TOTAL loads of 1.395 kN and 2.25 kN respectively.

# DESCRIBING FRAMEWORK DETAILS AND APPLIED LOADS

As a first step, joints are chosen at various points on the framework. These joints must occur at supports, intersection of members and at changes of member directions. Joints can also be introduced optionally at various points along member lengths where values of displacements, axial load, shear and moment are to be obtained. The chosen joints are numbered with consecutive integers from 1 upwards and henceforth referred to by them. Framework dimensions are specified via joint coordinates in the global X and Y directions. Length, orientation and position of members in the framework are specified by the two numbers of the joints to which they connect; the first specified joint for a member becomes its START-END and the second END-END for reference purposes in the analysis. A group of loads applied simultaneously is referred to as a LOADing CASE or COMBination CASE. These loads can occur either at joints or on member spans. Number of LOADing or COMBination CASES can be as many as required.

Before the use of SKELETON, full data preparation is recommended to ensure optimum use of computer time and to minimise mistakes in the input. This requires having all the answers ready to the questions asked by SKELETON during data input. Since the questions asked follow a set order, it helps to write the data-answers in the same sequence. To this end, a complete list of data-questions in the sequence in which they appear on the TV screen is shown in Section 25.

In the course of analysis, the data-questions which become unnecessary are automatically omitted by SKELETON. For example if the answer to LOADED MEMBERS ? is 0 then all the data-questions until SAME-LOAD MEMBER-SETS ? do not appear on the screen.

Most of the data-questions are self explanatory but some which may require explanation or caution in their use are as follows:

**UNITS 2?** A two-word answer (separated by a comma) is required here and is for reference purposes only in the output to describe the units of force and length. The user can type in any desired words here since they have no effect on the analysis results.

**JOINTS ?, MEMBERS ?, SECTIONS ?** Response to these questions is the total number of elements in the framework.

**SECTION DETAILS:** Under this heading, modulus of elasticity, area and inertia are defined for each section size in the framework.

**JOINT COORDINATES:** All joint positions are specified by the global X and Y coordinates. The origin is chosen arbitrarily by the user at a convenient position to define these coordinates. The positive directions are to the right along the X-axis and upwards along the Y-axis.

**MEMBER DETAILS:** For each member, the data required is the joint number at the start-end, the joint number at the end-end and the section number. This establishes the position of members in the framework and their sectional properties. It should be noted that the first described joint number becomes the START-END of the member. Which of the two member ends is chosen as the START-END affects the sign of the member load types 1 to 29 (except the moments 8,18 and 28) and ALL distances in their description are measured from this end.

**JOINT RESTRAINTS ?** To describe restraints (external supports), the answer-code is "0"= free; "1"= fixed; "2" to "9" elastic springs. When there is only one member at a joint, R-R of "0" also means that it is a hinged joint. When there is more than one member at a joint, R-R of "0" means that member-ends are connected to each other rigidly and they rotate together the same amount. If all member ends are pinned at a joint, a joint hinge should be specified through the heading JOINT HINGES ?; if some members are pinned and others rigidly connected to each other at a joint, member hinges should be specified through the heading MEMBER HINGES ? or HINGED BAR-MEMBERS ?

**HINGED BAR MEMBERS ?** Here a hinged bar member is one which has hinges at both ends. Thus all members in a truss are hinged bar members. The data question is nevertheless meant for frameworks in which member-end connections are rigid as well as hinged. Such frameworks can be described easily and rapidly by the use of this heading. An example of its application is a lattice girder in which top and bottom booms act continuously and diagonals have their ends pinned. By describing the diagonals as HINGED BAR MEMBERS, all connection details of the framework can be defined.

**LOADED MEMBERS ?** The answer to this question (i.e. the number of members which have span loads) should include only those members which will be loaded individually under this heading. Members which are later specified as having repetitive loads through the heading SAME-LOAD MEMBER-SETS ? are not to be included here.

**SAME-LOAD MEMBER-SETS ?** When grouping members in a SAME-LOAD MEMBER-SET, the description of span loads (as required by this manual of SKELETON) for each member in the set should exactly be the same. The length and end connections of members (e.g. both ends rigidly connected, or one rigidly connected and the other pinned or both pinned) , however, can be different. Thus members with different fixed end reactions can belong to the same set (e.g. members of different span lengths but with a distributed load per unit length of the same magnitude).

**NUMBER OF MEMBERS IN SET n ARE ?** Here the count (n) should also include the member which has already been loaded through the heading LOADED MEMBERS ? Later when set members are specified through this heading, the first member specified must be the one already loaded.

**LOADED JOINTS ?** As in the case of LOADED MEMBERS ? above, the count should include only those joints which are loaded individually through this heading. For each loaded joint the loads to be described are a
horizontal force FX, a vertical force FY and a moment M.

**NUMBER OF JOINTS IN SET n ARE ?** As in the case of members, the count (n) should include the joint already loaded through LOADED JOINTS ? Later this joint must appear first in the set.

**INPUT OK (return/N) ?** This question appears at the end of every input stage. BY answering "N", data can be modified at any stage of input. If used at the very last stage of the input, it also allows the printing of part or all of the data. If the convenient to modify the data after reaching the last stage of the input.input details are to be checked/ examined prior to the analysis, it may be

*Section 11*

# FRAMEWORK ANALYSIS INVOLVING SPECIAL EFFECTS

In any framework analysis, various special effects can be included. These are described in the following sections.

## *11.1* IMPOSED DISPLACEMENTS (SUPPORT SETTLEMENTS)

Imposed displacements may be specified only at the restrained joints. Their direction can be: support X-axis, support Y-axis and angular. When the joint restraint is free or an elastic spring in any of these three directions, no imposed displacement can be specified in that direction.

The sign of imposed displacements is determined relative to the positive direction of X and Y axes. The imposed rotation is positive when clockwise (from original to the new position).

The imposed joint displacements are input together with the applied joint loads. To distinguish that a value being input is an impose displacement and not an applied load, character "D" is typed to the right side of the value being input. Examples of this data input are as follows:

```
HOW MANY LOADED/DISPLACED JOINTS ?  3
      Jnt , Fx , Fy , M
1-   4? 3,4D,0,0
2-   4? 7,12,-3.1D,0
3-   4? 9,0,0,.15D
```

The above data describes that joint 3 is displaced 4 mm in the positive direction of the support X-axis; joint 7 has an applied load of 12 kN in the support X-axis direction (this means that the joint is free to move in this direction) and is displaced 3.1 mm in the negative direction of the support Y-axis; joint 9 has an imposed rotation of .15 radians in the clockwise direction. The unit of force and length for the frame being considered is kN and mm respectively.

## *11.2* MEMBER TEMPERATURE CHANGE (LOAD TYPE 51)

When a framework member undergoes a temperature change, load type 51 is used to describe the loading. For example if member-15 undergoes a temperature rise of 15.7 degrees and its coefficient of expansion is .00000067, the data input (assuming it has no other span loads) would be:

```
n- Mem No , No of Loads 2? 15,1
   1- Load Type ? 51
      Temp , Coeff  2?  15.7,.00000067
```

The temperature change is specified in degrees Centigrade or Fahrenheit (it matters not which so long as consistent units are used) and the coefficient in change per unit-length per degree.  The sign convention for temperature change is: RISE +VE and FALL -VE.

### *11.3* LACK OF FIT (LOAD TYPE 53)

A member may be too long or short before being fixed between its joints. To describe this lack of fit, load type 53 is used.  An example of data input for member-16, which is 5.7 mm too long and has no other span loads, is as follows:

```
n- Mem No , No of Loads 2? 16,1
   1- Load Type ? 53
      Lack of Fit ? 5.7
```

The sign convention for the lack of fit is: LONG +VE and SHORT -VE.

### *11.4* MEMBER AXIAL STRAIN (LOAD TYPE 54)

Member axial strains (e.g. shrinkage of concrete or expansion of wet timber) are specified as LOAD TYPE 54.  An example of data input for member-17, which undergoes a shrinkage strain of .0015, is as follows:

```
n- Load Type 2? 17,1
   1- Load Type ? 54
      Strain ? -.0015
```

The sign convention for member strains (change of length per unit length) is: ELONGATION +VE and CONTRACTION -VE.

*Section 12*

# TEMPORARY FILES
# CREATED BY SKELETON ON THE DATA-DISK

In the course of operation, SKELETON creates various files on the user's data disk for temporary use. The presence of these files can be seen in the file directory of the data-disk. When storing data or when using the data-disk for some other needs, it is advised not to use these filenames; if used accidentally, they would be over-written and lost. The files created by the program are as follows:

| **File** | **Purpose** |
|---|---|
| S | stores structure-name for analysis using ANALYSIS DISK |
| SO | is created only when printing a copy of structure and its loading case data-files using DATA-PREPARATION program; creation of SO signifies that structure-details are to be printed; absence of SO means that only loading case data is to be printed. |
| S1 | stores name of the data-file and the loading case number for analysis-1 of the framework using FRAMEWORK ANALYSIS program. |
| S2 | stores information as above for analysis-2. |
| Sn | stores information as above for analysis-n. Absence of file Sn+1 indicates that program operation is to stop after the n'th analysis; if a file Sn+1 exists as a result of previous program use, it is deleted prior to the start of analysis-1. |
| C | stores structure-name for load-combination analysis |
| C1 | stores the following information for analysis-1 using the LOAD-COMBINATION program to factorize and combine loading cases: COMBination CASE no, the number of loading cases to be combined, number and factor for each loading case being combined, and title for the COMBination CASE as defined by the user. |
| C2 | stores information as above for analysis-2. |
| Cn | stores information as above for analysis-n. Absence of file Cn+1 indicates that program operation is to stop after the n'th analysis; if a file Cn+1 exists as a result of previous program use,it is deleted prior to the start of analysis-1. |
| PRNOUT | stores information about the output contents selected by the user. Each time an analysis is carried out (or a copy of output is made), the contents of this file are over-written. |
| AUTO)( | stores structure name and output selection data for the auto analysis along member lengths by the POST MEMBER ANALYSIS program. |

*Section 13*

# ANALYSIS FILES
# CREATED BY SKELETON ON THE DATA DISK

Details of each framework are stored using the STRUCTURE-NAME chosen by the user. The name should conform to DOS conventions e.g. it cannot be more than 8 characters long. Filename Extension, i.e. an additional up to 3 character long name starting with a period ".", is added by the program itself and is not to be input by the user.

Structure details are saved on to the user's data disk by using the filename exactly as typed by the user. This happens when either data is input for a new framework or modified for an existing one. Structure detail files are also created when saving an existing framework data in different names; option-6 of menu-2 leads to menus 21 and 22 for this purpose.

Details of each loading case are saved by adding an extension to the filename. This extension contains a period ".", character "A" and the loading case number (in numeric form ). For example, if the structure name chosen by the user is ILLUSTRA, the filename for the above loading case would be:

ILLUSTRA.A23

As mentioned above, the user only gives the loading case number; the filename with its extension is derived by the program itself.

In all, eight different types of files are created for saving details of the framework, its loading and analysis results. The filenames used are all derived from the structure name. For example, the results of framework analysis (joint displacements) are stored by adding a period ".", the character "B" and the loading case number to the immediate right of the structure name. Thus the filename for the analysis results of loading case-23, would be

ILLUSTRA.B23

In view of the above method of deriving names and the DOS limitation that the filename extension is a maximum of 3 characters long, a loading case number cannot be in more than two figures, i.e. not greater than 99. An attempt to use a number greater than this limit, gives an UNACCEPTABLE DATA; REENTER message.

A complete list of all the data files together with the symbols used to derive their names is as follows:

| | FILE CONTENTS | SYMBOLS USED | EXAMPLE |
|---|---|---|---|
| 1 | structure details | *none* | ILLUSTRA |
| 2 | member details | M | ILLUSTRA.M |
| 3 | LOADing CASE data | A | ILLUSTRA.A23 |
| 4 | LOADing CASE results | B | ILLUSTRA.B23 |
| 5 | LOADing CASE member loads | C | ILLUSTRA.C23 |
| 6 | COMBination CASE data | D | ILLUSTRA.D23 |
| 7 | COMBination CASE results | E | ILLUSTRA.E23 |
| 8 | COMBination CASE member loads | F | ILLUSTRA.F23 |
| 9 | Output File for Frame Analysis | STR | ILLUSTRA.STR |
| 10 | Output File for Load Combinations | MIX | ILLUSTRA.MIX |
| 11 | Output File for Auto Member Analyses | MEM | ILLUSTRA.MEM |

*Section 14*

# STORAGE CAPACITY ON USER'S DATA DISKS

When analysing large size structures and/or having very many LOAD and COMBination cases, the disk capacity to store data becomes important. The list of filenames and the amount of free storage available on a disk can be displayed on the screen by taking one of the option (e.g.option-5, menu-1) during interactive program use. Conversely DOS DIR statement can also be used to obtain this information when SKELETON is not in use.

To give an idea of how much data a disk can store, the list of files created for analysing seven sample problems of this manual is shown below:

```
B:\
SPBLMA1 .A1  SPBLMA1 .A2  SPBLMA1 .B1  SPBLM2  .A1
SPBLM2  .A2  SPBLM2  .A3  SPBLM2       SPBLM7
SPBLM3  .A1  SPBLM3  .A2  SPBLM3       SPBLM4  .A1
SPBLM4  .A2  SPBLM4       SPBLM5  .A1  SPBLM5
SPBLM6  .A1  SPBLM5  .B1  SPBLM7  .A1  SPBLMA1 .B2
SPBLM6       SPBLM2  .B1  SPBLM2  .B2  SPBLM2  .B3
SPBLM3  .B1  SPBLM3  .B2  SPBLM4  .B1  SPBLM4  .B2
SPBLM6  .B1  SPBLM7  .B1  SPBLMA1 .M   SPBLMA1
SPBLMA1 .D1  SPBLM2  .D1  SPBLM2  .C1  SPBLM2  .D2
SPBLM2  .C2  SPBLM2  .D3  SPBLM2  .C3  SPBLM5  .M
SPBLMA1 .C1  SPBLMA1 .E1  SPBLMA1 .E2  SPBLMA1 .C2
SPBLM2  .M   SPBLM2  .E1  SPBLM2  .E2  SPBLM2  .E3
SPBLM3  .M   SPBLM2  .F1  SPBLM2  .F2  SPBLM2  .F3
SPBLM3  .C1  SPBLM3  .C2  SPBLM4  .M   SPBLM4  .C1
SPBLM4  .C2  SPBLM5  .C1  SPBLM7  .M   SPBLM7  .C1
SPBLM6  .M   SPBLM6  .C1  PRNOUT       S
S1           C            C1           C2
C3           AUTO)(
 285696 Bytes free

PRESS SPACE BAR TO CONTINUE
```

Out of a total storage capacity of 362496 bytes, 76800 bytes have been used and 285696 bytes are free. The total number of files created in the above are 70.

*Section 15*

# MODIFICATION OF DATA

## *15.1* MODIFYING DATA AND RETAINING ITS EXISTING VERSION

Frequently a user may wish to modify data and retain its existing version. This need arises when in the course of design a probe analysis is attempted by modifying existing/temporarily-finalised structure details. Option-6 of menu-2 helps to fulfil this requirement.

Using this option (via menus 21 and 22), further copies of the structure and its loading case data can be created, using new filenames. The newly created files can then be modified for use in the analysis, keeping the original data files intact.

## *15.2* ADDING NEW SECTIONS/MEMBERS/JOINTS

Before modification of an existing framework begins, the number of joints, members and or sections to be added can be specified via menu-5. Following this, options 4, 5 and 6 of menu-6 leads to menus 8,9 and 10 respectively to add these elements.

New sections and members can be added with their numbers starting one after the last entered section/member in the framework. This does not affect the working efficiency of the program in any way.

When adding new joints, consideration should however be given to keeping the maximum number difference between any two joints connected by a member to a minimum. For large frameworks, this may require a new joint number to be inserted between the existing joint numbers. In such a case, it would be necessary to re-define all the member and joint details which involve joint numbers greater than the one being added.

To add sections, members and joints (via menus 8, 9 & 10 respectively), the numbers to be added must be specified beforehand via menu-5. The order in which the newly added elements are described/added is also important. Section and joint details should be described/added before the member details; otherwise UNACCEPTABLE DATA; RE-ENTER message can result if member details refer to a section or joint not yet added.

## *15.3* DELETING MEMBER LOADS

To delete member loads, the number of loads on the span are re-defined equal to zero.

If the member is a set-leader of a SAME-LOAD MEMBER-SET, the whole set is deleted; the set however remains intact if the re-defined number of loads on the span are greater than zero.

If the member is a set-follower in a SAME-LOAD MEMBER-SET, the number of members in that set become one less.

## *15.4* DELETING JOINT LOADS

To delete joint loads, the loads FX, FY and M on the joint are redefined equal to zero.

If the joint is a set-leader or a set-follower, then the effect on its SAME-LOAD JOINT-SET is the same as that described in the above regarding SAME-LOAD MEMBER-SETS.

## *15.5* EDITING DATA FILES USING A WORD PROCESSOR

SKELETON now stores structure and loading data files in a text form. Although these files are somewhat cryptic (being brief in pursuit of saving your disk space), it is possible to load and edit them by using a word processor. This kind of editing is, however, without program supervision and is not recommended for routine use. When only minor changes of data are required, some expert users of SKELETON may find this option useful at their own risk.

When editing by a word processor, always make a copy of your data files (use different structure name if using the same floppy/directory as for the original files) and do not operate on their original version.

Also remember that the structure data filenames have no extension, the loading filenames have an extension with first character as alphabet "A" followed by a numeric load case number - refer to Section 13 for more details on filenames.

*Section 16*

# NAMING DATA FILES

The user is free to choose any desired filename when saving framework data. It is however helpful if the chosen name is also meaningful so that retrieval of data becomes an easier task at a later date. To this end, the following items of information could be considered for inclusion in a filename:

- code characters for the program (i.e. SKELETON)
- data-disk number
- user's initials
- job number
- job name/location
- client's name
- structure name
- data-file number for the structure

Since only 8 characters are permitted in a chosen name, it is not possible to include most of the above items. However, a typical filename can be:

A2341D56

In the above, first character "A", which can be any of the 26 characters A to Z, represents the structure name for the job number 2341. The last three characters D99 signify that the data disk number is 56; this number helps at a later date when it is necessary to retrieve the stored information - which disk to use for this purpose would then be readily known.

Filenaming rules of the DOS do not give much room to the user for choosing comprehensively meaningful names. This section is an attempt to describe what is desirable and the thoughts behind the filenames chosen by the writer in practical situations.

# USE OF DIRECTORIES AND SUB-DIRECTORIES FOR FILE MANAGEMENT

When DOS formats a disk, it creates a directory that describes each of the files on the disk. There is a limit to the number of files a directory can hold; 64 on single-sided diskette, 112 on a double-sided diskette, 224 on a high-capacity diskette, and 512 or more on a fixed disk.

To store more number of data files and to be able to retrieve data efficiently, it is recommended that you create additional directories, call sub-directories, on a disk. The sub-directories divide the disk into different storage areas, each of which you can use as if it were a different disk. If necessary, you can also have further directories within sub-directories i.e. a multi-level directory structure. For detailed information on how to create and use directories, consult your DOS manual

In a routine design use of SKELEON, the writer finds it helpful to create a sub-directory for each separate job e.g. J3231, J4343 and J4365 for Job Numbers 3231, 4343 and 4365 respectively. Within in each job directory, the structure names can then be A3131D88, B3231D88, C3231D88 for frames A, B and C of Job No 3231 whose data files have been saved on disk no 88.

To retrieve data files, the directories/sub-directories are specified by a path name. In all main program menus, a choice *`Change/Display-Filenames-in Data Drive/Dir`* allows changing this path. For example, to retrieve the file for frame **`C3231D88`** in Sub-directory **`BLDG1`** in Directory **`J3231`** in **`Drive C:`** the path description will be:

**C:\J321\BLDG1**

Other path specifications can be:

| | |
|---|---|
| **A:** | Data Files are in the Root Directory of disk Drive-A |
| **C:\STR\J4341** | Data Files are in Sub Directory **J4341** in Sub-Directory **STR** of disk Drive-C |
| **B:\J4344** | Data Files are in Sub-Directory **J4344** of disk Drive-B |

It is to be noted that in all retrievals of SKELETON data files, the path name is not typed attached to structure filenames. The data file path is always specified/changed separately, described as above. Hence the filename for retrieving the above frame data will always be **C3231D88**, no matter which data drive/directory the file is kept in.

*Section 18*

# OUTPUT OF RESULTS

## *18.1* MASTER SELECTION OF OUTPUT ITEMS

To minimise the user's effort in selecting the output items, a MASTER SELECTION is saved on the program disk. This selection is chosen to satisfy the most frequent needs of the user's firm and can be changed at any time by the options available i.e. options 1 and 2 of menu-87. Before each analysis, this selection appears on the screen as a ready choice of output contents.

## *18.2* SELECTIVE OUTPUT OPTIONS

Depending upon his needs, a user can choose to print all, none or only a part of the analysis results. The output elements to choose from are:

1- HEADING
2- STRUCTURE DIAGRAM
3- STRUCTURE REFERENCE
4- STRUCTURE DETAILS
5- LOADING REFERENCE
6- MEMBER & JOINT LOADS
7- JOINT DISPLACEMENTS
8- MEMBER FORCES
9- MEMBER DEFORMATIONS
10- SUPPORT REACTIONS

Before each analysis begins, menu-35 allows the above items can be selected for printing via menu-35 for Frame Analyses and menu-45 for Load Combination Analyses. Initially the menus appears with a ready MASTER-OUTPUT-SELECTION. If it matches the user's output needs, he only needs to take option-18 of the menus. When the output needs differ, the selection can be changed via switches: Y=print and N=do-not-print, displayed next to each item. The switches are set by taking options 1 to 10 for individual items or option 16 and 17 for the entire group. Option-18 of the menu concludes the selection; option-19 provides an exit and leads to master-options of the program.

## *18.3* HEADING DETAILS

If the heading switch is on via option-1 of menus 29 and 45, the output is titled with the user's organization name and details pertaining to the present analysis (JOB NO, DATE, PAGE NO, DESIGNER, & PROJECT). The organization name is permanently built into the program. Heading details regarding the analysis are defined during the selection of output items via option-20 (displayed next to option-1 in brackets) of menus 29 and 45.

Each heading includes the program version reference printed at its top right end.

## *18.4* DECIMAL PLACES IN THE NUMERIC OUTPUT

Real numbers in the output of MICROSOFT BASIC are normally displayed and printed with up to seven decimal digits of accuracy. In practical applications, however, this number of digits may not be required. To this end, SKELETON enables the user to select the number of places to the right of the decimal point, each time the program is used for analysis.

Since numbers are rounded off just prior to their printing (without changing the memory contents), the accuracy of results is not affected by selecting lesser number of digits for the output.

Option-2 of menu-23 displays the MASTER-SELECTION of decimals for loads and displacements prior to the start of each analysis. If taken, this option leads to menu-36 for re-selecting the decimal places required in the analysis. The chosen number of decimal places can be between 1 to 7.

## *18.5* FURTHER COPIES OF OUTPUT

At the end of each SKELETON analysis and until the use of the data disk for next analysis, further copies of the output can be obtained even when the computer has been switched off.

As many sets of output as required can be obtained (option-2, menu-29). Before the printing of each copy, the previous selection of output items is displayed on the screen via menu-29; this allows the contents of each output to be re-selected, if so desired.

## *18.6* SENDING OUTPUT TO DISK FILES

If desired, the printer output can be diverted to a disk file. This creates a text file which can be examined/formatted/printed by using a word processor or, if necessary, can be sent to other locations via modem links.. All SKELEON output included in this manual has been processed by a word processor using this facility. It is to be noted, however, that only textural output is sent to the disk file; the graphic output is ignored.

The names of output files are chosen by the program itself. They are derived from the original structure name by adding an extension. Various output filenames and corresponding menu options to create them are:

| | | |
|---|---|---|
| *structure*.STR | Framework Analyses | (Option-15 of menu-29) |
| *structure*.MIX | Load Combination Analyses | (Option-15 of menu-45) |
| *structure*.MEM | Auto Post Member Analyses | (Option-2 of menu-82). |

## *18.7* EXAMINING OUTPUT OF RESULTS

The following points should be noted when examining output of results:

1- SKELETON accepts details of joints and member-end connections (hinged, pinned or cantilever-ends) in a variety of ways. The description as understood and printed by SKELETON is however unique, irrespective of how the user has described the structure. This feature stems from SKELETON's exclusive use of the asterisk * to indicate joints and member-ends which are hinged or cantilever-ends. At a later date, it makes checking and comprehending structure details easy not only to the user but also to others.

2- In addition to describing joint and member hinges, the asterisk '*' is also used for cantilever-ends. Use of '*' in the output means that member-ends at a given joint are free to rotate independently.

3- At hinged joints, the joint rotation is printed as '**'. Rotations of member ends at such joints are printed under the heading MEMBER HINGE ROTATIONS. This happens even when there is only one member at an hinged or free joint.

## *18.8* DEGREE OF INDETERMINACY

For each framework, the degree of indeterminacy is calculated from the number of members, the details of member-end connection (rigid or pinned), and the details of joint restraints. It is printed as D-OF-I towards the beginning of structure details in the output.

A negative degree of indeterminacy indicates that the frame is mathematically unstable and that the program would crash in attempting to analyse it.

A zero or greater than zero degree of indeterminacy however does not necessarily ensure a perfect/stable frame, for it is possible to have sufficient number of restraints and members but not have them at the right places.

The degree of indeterminacy can serve a useful purpose in the course of framework design. For example, a different degree of indeterminacy for apparently two similar frames (same shape and number of members and joints) indicates that the connection and or support details at their joints are different. Similarly a greater than zero degree of indeterminacy suggests that it may be possible to remove some members or restraints without making the framework unstable.

## *18.9* VOLUME OF FRAMEWORKS

Based on the sectional areas and the member lengths, the program calculates the volume of each framework. This volume is printed towards the beginning of the structure details and can be used for two purposes. Firstly to calculate the structure weight and secondly to compare the volume of two similar frameworks, a difference indicating that all member lengths and or sectional areas are not exactly the same.

## *18.10* SELF WEIGHT OF FRAMEWORKS

The structure self weight is calculated based on the length, the sectional area, and the unit-weight of its members. It is printed as a structural property towards the beginning of the framework details.

The unit-weight (i.e. weight per unit volume in the chosen units of force and length) can vary from member to member. In response to the data input question:

`Unit Weight in` *kN,m3* `(NewValue/V/Return) ?`

a *new value* typed becomes the Unit Weight constant for all sections; reply *"V"* allows the input of individual Unit Weight for each section; pressing *Return* makes the default value a Unit Weight constant for all sections **or** keeps the already defined Unit Weight values unchanged.

The self weight of frameworks can also be included automatically in their analyses. When preparing Loading Case data, a Y/N input prompt allows this weight to be included or not-included.

During data input, if default unit-weight is not correct for your existing analysis and you do not want the program to calculate the structure self-weight (e.g. the default unit-weight being 23.6 kN/m3 for concrete and you are analysing a steel structure), specify the unit-weight value as "0" zero. This will make the self weight of your structure "0" zero rather than an incorrect value.

*Section 19*

# UNACCEPTABLE DATA; RE-ENTER

During the input of data, the above statement appears when an unacceptable data is entered. Generally the reason would be obvious to the user but in case of difficulty the following list can be consulted:

**UNITS:**

- The description of force or length units cannot be a null string i.e. of less than one character.

**JOINTS:**

• No. of joints in a framework cannot be less than two.

**MEMBERS:**

• No. of members cannot be less than the number of joints minus one.

**SECTIONS:**

• No. of sections cannot be less than one.

**SECTION DETAILS:**

• Modulus, area and inertia of a section cannot be less than or equal to zero.

• To specify selected section details, the reference number of a section cannot be less than one or greater than the number of sections in the structure.

**MEMBER DETAILS:**

• Joint numbers at member ends cannot be less than one, or equal to each other, or greater than the number of joints in the structure.

• Section number of the member cannot be less than one or greater than the number of sections in the structure.

• To specify selected member details, number of members cannot be less than zero or greater than the number of members in the structure.

• When connecting member-ends to newly added joints, the joint details should be described before the member-details.

• When the member section is a newly added one, the section details should be described before the member details.

**JOINT COORDINATES:**

• To re-define coordinates of selected joints, the number of joints cannot be less than zero or greater than the number of joints in the structure.

**SPRING CONSTANTS:**

• No. of spring constants cannot be less than 1 or greater than 9.

• Magnitude of spring constants cannot be zero or negative.

**JOINT SUPPORTS:**

• Supported joints cannot be less than one or greater than the number of joints in the structure.

• Restraint code cannot be less than zero or greater than the number of spring constants (defined previously).

• Support angle cannot be negative.

• The member number, relative to which support inclination is being described, cannot be less than one or greater than the number of members in the structure.

• As discussed in Section 5.3, unstable support data is unacceptable.  If rejected, it is necessary to re-define ALL the joint restraints.

**JOINT HINGES:**

• Member hinges cannot be less than zero or greater than the number of joints in the structure.

• The number of a joint, where a hinge is being specified, cannot be less than one or greater than the number of joints in the structure.

**HINGED BAR MEMBERS:**

• No. of hinged bar members cannot be less than zero or greater than the number of members in the structure.

• No. of the member being specified as hinged bar member cannot be less than one or greater than the number of members in the structure.

**MEMBER HINGES:**

• Member hinges cannot be less than zero or greater than the number of joints in the structure.

• No. of the member and the joint where a member hinge is being specified cannot be less than one or greater than the respective number of members and joints in the structure.

• No. of the joint at which a member hinge is being specified should be one of the two joint numbers of the member ends.

**STRUCTURE DATA FILENAME:**

• No. of characters in a structure filename cannot be more than 8.

**LOADED MEMBERS:**

• Loaded members cannot be less than zero or greater than the number of members in the structure.

• No. of loads on a member span cannot be less than one.

• Load type cannot be less than one, or greater than 54, or equal to 10, 20, 30, 40 or 50.

• No. of equi-distant point loads in load type 2 (or moments in load type 52) cannot be less than one.

• Load distance 'A' cannot be greater than the distance 'B', the length of the member, or less than zero.

• Load distance 'B' cannot be less than the distance 'A' or greater than the member length.

**SAME-LOAD MEMBER-SETS:**

• No. of sets cannot be less than zero or greater than the number of members in the structure.

• No. of members in one set (other than being zero) cannot be less than two or greater than the number of members in the structure.

• A set-leader cannot be an unloaded member or a set-follower of some other SAME-LOAD MEMBER-SET; if it is a leader of a previous set, the new and the previous set members are combined together (by the program) into one set.

• Number of the member in a set cannot be less than zero or greater than the number of members in the structure. If the number specified is zero, however, then the user is asked to re-define all the SAME-LOAD MEMBER-SET details; this serves to provide an exit if input regarding the SAME-LOAD MEMBER-SETS is to be discontinued.

• A loaded member, or a set-follower of another SAME-LOAD MEMBER-SET, cannot belong to the set being described.

**LOADED/DISPLACED JOINTS:**

• Loaded/displaced joints cannot be less than zero or greater than the number of joints in the structure.

• Number of the joint being loaded/displaced cannot be less than one or greater than the number of joints in the structure.

• As a joint load, moment cannot be applied on joint hinges or cantilever ends. At joints with single members, describe the moment as a member load rather than as a joint load.

• Load cannot be applied on a restraint i.e. on supports in the horizontal, vertical and angular directions; unless it is an imposed displacement (support settlement) followed by character"D", a zero value only is acceptable as a load on these supports.

**SAME-LOAD JOINT-SETS:**

• The list of reasons is the same as that for the SAME-LOAD MEMBER-SETS described above.

**RE-NAMING OF FILES:**

• New filename cannot be the same as existing or be of more than 8 characters.

**DECIMAL PLACES**:

• No. of decimal places cannot be outside the limits being displayed.

**ANALYSIS LOCATIONS**:

• No. of analysis points cannot be less than 2 or greater than the limits being displayed.

• User defined distance to the analysis locations cannot be less than zero, or equal to zero or the member span, or greater than the member span.

• Two adjacent analysis locations (one of them being specified by the user) cannot be closer than span/2500.

**LIST OF SELECTED LOAD OR COMBINATION CASES**:

• No. of LOAD or COMBination CASES in the list cannot be less than one or greater than the limit being displayed.

• In the list of LOAD or COMBination CASE numbers N1 to N2 inclusive, N1 cannot be less than one, or N2 less than N1.

• A LOAD or COMBination CASE number in a randomly selected list cannot be less than one or specified more than once.

**LOAD COMBINATION ANALYSIS**:

• No. of combinations cannot be (other than 0 to exit) less than 1 or greater than 40 at a time in one analysis.

• COMBination CASE number cannot be (other than 0 to skip the further input of data) less than one or equal to the preceding COMBination CASE numbers in the present analysis.

• No. of load factors to be re-defined cannot be (other than 0 to exit) less than one or greater than their total number in the COMBination CASE.

• No. of load cases in one COMBination CASE cannot be less than one (other than zero to skip the further input of data), or greater than their total number in all the combinations.

• The load case number (whose load factor is being described) cannot be less than one or a number not described before in the list of load cases for all the combinations.

• A load factor cannot be zero.

**INTERACTIVE MEMBER ANALYSIS**:

• A member number (whose data is to be retrieved from the data disk for analysis along its span) cannot be less than one or greater than the total number of members in the structure.

**OUTPUT SELECTION FOR AUTO MEMBER ANALYSES**:

• No. of output types in auto member analyses, cannot be less than one or more than 9 at a time.

• Details of output type 0 cannot be displayed; this output type is assigned to members not being analysed i.e. members for which no output is is required.

• Selected number of the output type (for the display of its contents or its assignment to specify member outputs) cannot be outside the limits being displayed.

• In the list of members "1" to N1 inclusive, N1 cannot be greater than the number of members in the structure.

• In the list of members N1 to N2 inclusive, N2 cannot be less than N1, or N2 greater than the number of members in the structure.

• In a randomly selected list, number of members cannot be  more than the total number of members in the structure.

• AUTO SELECTION CASE NO (for saving details on to data disk) cannot be less than one or greater than 999.

*Section 20*

# COMPUTER LIMITATIONS AFFECTING SKELETON RESULTS

Microsoft Basic allocates 4 bytes (1 exponent, 3 mantissa) for storing values of its Real Variables. This gives approximately a 7-digit accuracy in calculations (except when 8 byte double precision numbers are used in setting up stiffness matrices and solving equations). In view of this, SKELETON results can become erroneous and absurd when analysing frameworks with disproportionate section sizes i.e. when ratio of the largest to smallest section-size is too large.

The problem generally arises when an engineer is trying to simulate the effect of a rigid member-part (e.g. a haunch) and specifies an unrealistic large value for its area/inertia. Results can also become non-sensical when analysing weird frameworks in which some member sections are either too large or too small.

It is not yet possible to establish precisely when the accuracy of the analysis results becomes un-acceptable. To avoid this pitfall of the computer limitation, users must exercise their own precautions To this end, the following comments might be found helpful:

(1) As a first check, always ensure that the sum of horizontal, vertical and angular reactions are equal to the corresponding overall forces applied on the structure.

(2) When attempting to simulate the influence of a highly rigid-member-part (e.g. a haunch or a gusset plate etc.), do not specify an unrealistically high value for the area/inertia of the section.

(3) To ascertain a manageable ratio of maximum to minimum section-size in the analysis of a framework, the following intuitively arrived limits and precautions are suggested:

> When maximum to minimum section-size ratio is less than 30, accuracy of the analysis results should generally be acceptable to the user. A normal check of the results should therefore suffice.
>
> When the maximum to minimum section-size ratio is between say 30 to 300, accuracy of the analysis results would perhaps still be acceptable to the user but he must examine SKELETON results carefully. Based on his discretion, he may regard them as acceptable if the forces are in equilibrium at each and every joint and also on the structure as a whole.

When maximum to minimum section size ratio exceeds 300, the user must check equilibrium and compatibility of forces at each and every joint very carefully; validity of results for such section size ratios should be viewed with extreme caution.

The section-size ratio referred to in the above is the ratio of sectional areas for members in pure compression (i.e. members with both ends pinned ) and of sectional inertias for members in bending. When a framework is composed of members of different materials (e.g. reinforced-concrete and steel) the ratios are to be calculated by multiplying the areas or inertias by their respective moduli of elasticity.

*Section 21*

# LOAD COMBINATION ANALYSIS

Results of Framework Analyses can be factored and added together by a Load Combination Analysis. This is useful in the limit state design where dead, live and wind loads have to be factored and applied on frameworks in a variety of ways. To this end the framework is analysed with basic loads using the FRAMEWORK ANALYSIS program, which creates the following files on to the user's data disk:

- one structure data file *(user created)*,
- one member properties file, and
- three files for each load case viz ,
  - loading data file *(user created)*,
  - analysis results file, and
  - member results file.

The LOAD-COMBINATION program is then used to factor and combine the various loads and deformations for each joint and member in the framework using information in the above created files.

To start a load combination analysis, menu-35 is obtained on the screen by taking option-3 of menu-1. The data-disk should be in drive-II and contains the structure and the load-case data (character "A" in filename) and the result (character "B" in filename) files. The files to be used may have been created *(using the FRAMEWORK ANALYSIS program)* previously either all at once or at different times. As long as they exist on the data-disk, they may be selected by options 1 to 3 of menu-37. The analysis is initiated by option-1 of menu-42.

Generally the load-factors used are all positive. The program however also permits negative factors. This has no practical design significance but for the purpose of analysis it reverses the sign/direction of loads factored negative. This feature can be used when loads are to act in a direction opposite to that originally specified in their load-case data; it should however be noted that sign/direction is reversed for ALL loads i.e. vertical as well as horizontal loads.

The information required to carry out the analysis is:

- No. of combinations

- Total number of LOAD-CASES to be combined in all the combinations, and

  - the loading case number of each LOAD-CASE
    Up to 32 LOAD-CASES can be considered for inclusion in various combinations

at one time. Before accepting further input of data, the program checks that the structure and all the load-case data and result files are present on the data disk in drive B.

- For each combination:

  - Combination Case No
    The chosen number (as in case of LOAD-CASE numbers, see Section-13) cannot be in more than two figures i.e. greater than 99. In the given range, however, any random number can be selected. Before accepting any further input, the program checks if any previous file exists using this number. If present, the user is given an option to either overwrite or choose a different number.

  - Title for the combination case
    Any description of less than 60 characters can be input. It serves as reference in the output.

  - No. of load cases to be combined

    - 1st load-case number and factor

    - 2nd load-case number and factor
      :
      :
    - nth load-case number and factor.

Following the input of above items, the program operation is similar to the FRAMEWORK ANALYSIS program. The output contents are chosen via menu-45 and the analyses are carried out one after the other. For the selection of output items, reference should be made to Section-18 of the manual.

*Section 22*

# AXIAL LOAD, SHEAR, MOMENT AND DEFORMATIONS ALONG MEMBER SPANS

The POST MEMBER ANALYSIS program is used to determine axial load, moment, shear, and deformations (deflections perpendicular and axial to member length and rotations) along member spans. Up to 46 analysis points can be chosen along the member length and, if desired, their spacing can be varied during the interactive program use.

Before members can be analysed using the POST MEMBER ANALYSIS program, the following steps should have been completed:

- Prepare structure and load case data using the DATA PREPARATION program.

- Analyse the framework using the FRAMEWORK ANALYSIS program for all LOAD-CASES

- Use the LOAD COMBINATION program to combine the LOAD-CASE results, if it is required.

- Take option-4 of menu-1 to use the POST MEMBER ANALYSIS program. This brings menu-52 on the screen.

The above steps can be carried out in one sitting or in stages at different times. The data disk is kept in its drive during each stage.

Members can be analysed either one at a time interactively or in a group automatically. When un-equal spacing of analysis points is required along the member span, only interactive analysis option can be used.

## *22.1* INTERACTIVE ANALYSIS OF MEMBERS

To start the Interactive member analysis, option-1 of menu-52 is taken. This leads to menu-57 via menus 53 to 56 inclusive. The data required while going through these menus is number of analysis points, STRUCTURE-NAME, LOAD-CASE or COMB-CASE number, and the MEMBER number; the choice between a LOAD or COMB CASE is made via option-4 of menu-57. Option-5 of menu-57 fetches data from the disk and the analysis starts automatically. When finished, menu-58 appears on the screen to display or print results or to carry out the next analysis.

## *22.2* AUTO ANALYSIS OF MEMBERS

To start the Auto member analysis, option-2 of menu-52 leads to menu-72. Here option-1 is taken to define the selection of members and their output anew, and option-2 to resume a last/unfinished auto analysis.

The selection of members and their output-contents for auto analysis is defined via menus 73 to 85 inclusive.

The information required for an auto analysis is:

- Structure name
- LOAD-CASE numbers
  Up to 9 LOAD-CASES can be included at one time. Before proceeding further, the program checks if all files relating to these LOAD-CASES (member details file, member-end-reaction and span load files) exist on the data-disk.
- COMB-CASE numbers
  As above, up to 9 COMB-CASES can be included and the program checks the presence of required files.
- No of output-types and their details
  Output-type is a selection of output contents as per menu-78. In one auto analysis, up to 9 output-types can be defined.
- Output-type for each member
  Output contents for each member analysis are defined by assigning members to each output-type via menu-79. The output-type number (to which the members are being assigned) is shown flashing in the menu and can be changed via option-4.
  If a member is not to be analysed, the output-type to which it is assigned to is 0 'zero'. The program assumes this number as the initial default value for all members.

At the end of defining the above selection, menu-82 appears on the screen and option-1 starts the auto-analysis.

Once auto analysis has begun, menu-86 shows its progress on the screen and gives options to prompt each analysis (Y/N), pause, stop & continue later, and abort/restart. In between each member analysis, a flashing display of about 6 seconds allows taking these options, if desired.

## *22.3* DECIMAL PLACES IN THE NUMERIC OUTPUT

Each time an analysis is carried out, the number of places to the right of the decimal point can be selected. The range is 1 to 7 for loads and displacements and 3 to 7 for distances to analysis locations on the member span.

In the interactive member analysis, the decimal places can be re- defined via menu-67 during the program use.

In the auto member analysis, the decimal places are chosen for each output-type via option-10 menu-78.

## *22.4* ANALYSIS LOCATIONS

The number of analysis locations along the member span can be varied to suit analysis requirements. In the auto member analyses, the spacing is always constant but in the interactive member analysis the spacing can be varied via option-2 of menu-68. This leads to the display shown in menu-70; any or all of the locations can be re-defined rapidly via this display.

During the interactive program use, the number of analysis locations are displayed at the top left corner of the screen e.g. see menu-58.

When variable spacing is described, any two adjacent locations cannot be closer than span/2500. This restriction helps avoid division by zero error when a segmental length becomes a zero or a near-zero value.

All equi-distant analysis locations are rounded up to the number of decimal places chosen by the user. The member length itself is, however, not rounded up because it affects the accuracy of the various calculated angles used in the analysis (inclination of member length and applied loads).

## *22.5* DEFLECTION, AXIAL-LOAD, SHEAR AND MOMENT DIAGRAMS

These diagrams have been referred to in the program as D-A-S-M DIAGRAMS for the sake of brevity and are plotted on four base-lines which appear vertical on the screen. These diagrams should always be examined from the right hand side of the screen. When viewed this way, their left-end (bottom of screen/diagrams) is the start-end of the member and values plotted below the base lines are positive.

The member orientation is also shown in the D-A-S-M diagrams. The start-end is shown by character "S" and the end-end by character "E". The direction for viewing the member orientation is ALWAYS upwards (from the bottom-end of screen/diagrams).

When the magnitude of axial load, shear or moment is the same to the left and right of an analysis location, the values are plotted as offsets perpendicular to the base line.

## *22.6* PRINTING RESULTS

Depending upon ones needs, a user can choose to print all, none or only a part of the output. The output elements to choose from are:

1- Heading
2- Member details

3- Member loads
4- D-A-S-M diagram
5- Maximum results
6- Results (99- displacements)
7- End-forces

One further item "DISPLACEMENTS" (oddly numbered as 99, because of being not usually required in everyday analysis) can also be printed if required.  This item prints the values of rotation, axial, perpendicular and total deflections (resultant of axial and perpendicular deflections) at all analysis points along the member length.

In the auto analysis, the above items are selected via menu-78, when describing details of output-types.  In the interactive member analysis, when an option to print (option-3, menu-58) is taken, menu-66 appears on the screen.  This permits selective printout via switches: Y=print and N=do-not-print for each item.  The switches are set by taking options 1 to 7 (99 for displacements) for individual items or option 11 and 12 for the entire group.  Option-13 of the menu concludes the existing selection and leads to printing.  As many sets of output as required can be obtained by repeatedly taking option-13 of the menu.  If two values of axial-load, shear, or moment occur at the chosen analysis points, the results are printed in two lines; the first line is for values to the LHS and the second is to the RHS of the section.

If the heading switch is on, the output is titled with the user's organisation name and details pertaining to the present analysis (JOB NO, DATE, PAGE NO, DESIGNER, and PROJECT).  The organisation name is permanently built into the program.  Heading contents regarding the analysis are defined during the program use (via option-14 of menu-66) before printing results.

## *22.7* SIGN CONVENTION FOR LOADS AND DISPLACEMENTS

### APPLIED MEMBER LOADS:

Specification of member loads and their correct signs have been described fully in Section-9.

In general the applied loads are positive when acting in the positive direction of their X or Y axes; to specify load-types 1-9, 11-19 and 21-29 the MEMBER-AXES are used; to specify load-types 31-39 and 41-49 the GLOBAL-AXES are used.

The applied moment (load-type 8,18,28,38 and 48) is positive when clockwise.

### MEMBER FORCES (INCLUDING END FORCES):

Axial force: *+ve compression & -ve tension*

Shear: *+ve tending to move the LHS of the section upwards relative to its RHS*

*Note:-*
*For framework analysis results, the sign convention is different, see Section 8.3.*

Moment: *sagging +ve and hogging -ve*

**MEMBER DEFORMATIONS:**

The axial-deflection (from the original to the new position) is calculated relative to the positive direction of the member X-axis.

The perpendicular deflection (from the original to the new position) is calculated relative to the positive direction of the member Y-axis.

The total deflection is always printed with a positive sign. The direction in which this deflection occurs can be established from the direction of its components axial and perpendicular to the member
length.

The rotation is positive when clockwise, measured from the original position.

*Section 23*

# SUGGESTIONS, CAUTIONS AND LIMITATIONS

## *23.1* APPLIED LOADS AND SUPPORT REACTIONS

To help ensure safe use of the program, always check that the sum of applied loads on the framework is equal to its support reactions.

## *23.2* E, A AND I VALUES

Unrealistic values of E,A, and I, can produce misleading analysis results (e.g. when area of columns in a framework is carelessly specified). The only safeguard to avoid this problem is to ALWAYS specify realistic values of E,A, and I.

## *23.3* KEEPING PROGRAM AND DATA DISKS IN DRIVES

At all stages of data input and analysis, the program and/or data disks are kept in their respective drives, the drive doors remaining closed. Failure to do so may cause the program to crash. The safe time to remove/replace disks is when prompted to do so or when an option menu is being displayed and the program operation is static.

## *23.4* MEMBER LOAD DISTANCES

All member load distances are ALONG the member lengths. In no case are they parallel to the global X or Y axis (unless the member itself is parallel to one of them), see Section-9.3.

## *23.5* *"PER UNIT LENGTH"* DISTANCE IN DISTRIBUTED LOADS

The distance "per unit length" in all the distributed loads (i.e. types 4, 14, 24, 34, 44, 6, 16, 26, 36 and 46) is ALWAYS along/parallel to the member length. In no case is this distance parallel to the global X or Y axis (unless the member itself is parallel to one of them), see Section-9.3.

## *23.6* SHEAR SIGN CONVENTIONS FOR FRAMEWORK AND MEMBER ANALYSIS

Sign convention for member end reactions/shears is different for the framework and the member analysis results (see Sections 8.3 and 22.7). For example, the end reactions for a simply supported beam with UDL acting downwards are both positive for the framework analysis results (acting upwards), and the LHS positive and the RHS negative for the member analysis results.

## *23.7* MAXIMUM NUMBER OF SPAN LOADS

The upper limit to the number of loads a member span can have is between 50 and 100 loads, the exact figure depends upon the number of data elements to specify them. When this limit is reached (e.g. during the load combination analysis when various LOAD CASE loads are factored and added together), program failure can occur.

## *23.8* VALUES OF MAXIMUM DEFLECTION, AXIAL-LOAD, SHEAR AND MOMENT

In the analysis along member spans, the program finds the maximum values of deflection, axial load, shear and moment at the analysis locations. They are not the maximum values anywhere in the span but the maximum at the analysis locations chosen by the user. If maximum values anywhere in the span are to be calculated, the user must know beforehand the locations where these values occur on the span and specify them as analysis points. In most practical cases, however, it would be found satisfactory to increase the number of analysis locations and obtain results very close to their maximum values.

## *23.9* IMPOSED DISPLACEMENTS AND JOINT LOADS

In a loading case data, the program stores imposed displacements and joint loads as similar values. If a joint is supported, the program considers its data values as imposed displacements.

No problem arises if structure details are described first and the loading case data later. In a usual normal data input sequence, the in-built program checks ensure that illogical data is not input. AT A LATER STAGE, HOWEVER, SERIOUSLY INVALID RESULTS CAN BE OBTAINED WHEN JOINT SUPPORTS ARE MODIFIED AND THE LOADING CASE DATA IS NOT CORRESPONDINGLY CORRECTED.

The modification of support details does not automatically checks/modifies the loading case data which has been input and stored previously. If a supported joint is modified to become a free joint, its imposed displacements (support settlements) become as joint loads. Conversely the joint loads become imposed displacements when a free joint is modified to become a supported joint. When modifying support details, it is therefore essential to ensure that all joint loads and imposed displacements have been specified correctly in each loading case.

*Section 24*

# TERMS DISPLAYED BY SKELETON DURING DATA INPUT

| | |
|---|---|
| A | 1st distance of load from start-end of member |
| AR | area |
| B | 2nd distance of load from start-end of member |
| COEFF | coefficient of expansion (change of length per unit length per degree rise or fall in temperature) |
| COMB-CASE | combination case for analysis using LOAD-COMBINATION program |
| E | modulus of elasticity |
| FX | force in X-axis direction |
| FY | force in Y-axis direction |
| IN | moment of inertia |
| JNT | joint |
| JNT1 | joint number at start-end of member |
| JNT2 | joint number at end-end of member |
| LOAD-CASE | loading case for analysis using FRAMEWORK ANALYSIS program |
| M | moment |
| MEM | member |
| NM | number of members in a framework |
| NO | number |
| OT | number of different output types chosen in auto member analyses |
| P | point load |
| Q | distributed (uniform or linearly varying) load per unit length |
| R-R | rotational restraint |
| SEC | section |
| STR | structure/framework |
| TEMP | temperature rise or fall in degrees (Centigrade or Fahrenheit) |
| W | distributed (uniform or linearly varying) TOTAL load |
| X-C | coordinate along X-axis |
| X-R | restraint/external-support in X-axis direction |
| Y-C | coordinate along Y-axis |
| Y-R | restraint/external-support in Y-axis direction |
| ? | prompt to input ONE data value |
| 2? | prompt to input TWO data values separated by a comma |
| 3? | prompt to input THREE data values separated by commas |
| 4? | prompt to input FOUR data values separated by commas |
| < | varying load intensity towards start-end of member |
| > | varying load intensity towards end-end of member |

## *Section 25*

# QUESTION HEADINGS DISPLAYED DURING DATA INPUT

```
Input TITLE ?

Units of Force & Length   2?  kN,m

Sections   ?

Joints     ?

Members    ?

Existing Unit Weight = 23.6 kN/m3 (Constant for all Sections)

Unit Weight in kN,m3 (NewValue/V/Return) ? V

Section          Unit Wt kN/m3
Sec-1          ? 23.1
Sec-2          ? 23.2
.
.
Sec-n          ? 23.5

Input OK (N/return)  ?

SECTION DETAILS
              E , Area , Inertia
 Sec-1    3?
 Sec-2    3?
   :
 Sec-n    3?

Input OK (N/return)  ?

JOINT COORDINATES
               X-C , Y-C
 Jnt-1    2?
 Jnt-2    2?
    :
 Jnt-n    2?

Input OK (N/return)  ?

MEMBER DETAILS
              Jnt1 , Jnt2 , Sec
 Mem-1    3?
 Mem-2    3?
    :
 Mem-n    3?

Input OK (N/return)  ?
```

```
SPRING CONSTANTS

Existing Value ; New Value
Nos = 1 ; How many (1 TO 9/return) ?
0- 0 (FREE)
1- INFINITY (FIXED)
2- 9.9E+09 ; NEW (VALUE/return) ?
:
n- 9.9E+09 ; NEW (VALUE/return) ?

SUPPORTED JOINTS ?
          Jnt , X-res , Y-res , R-res
1-    4?
      Angle (Any-in-deg/Mem) ?
2-    4?
:
n-    4?
```

*(appears if joint no is followed by letter 'A' for describing inclined supports)*

```
Input OK (N/return)  ?
Joint Hinges ?

1-Jnt No ?
2-Jnt No ?
:
n-Jnt No ?

Hinged Bar-Members ?

1-Mem No ?
2-Mem No ?
:
n-Mem No ?

Member Hinges ?

1-Mem No , Jnt No  2?
2-Mem No , Jnt No  2?
:
n-Mem No , Jnt No  2?


End of Structure Details Input
Ready to Save Data on to Disk

Input OK (N/return)  ?

To Exit: Press Return

Give New Data Filename   ?
```

```
                                      LOADING CASE n
Input TITLE ?

Input Loading Case No ?

Include Self Weight (Y/N)  ?

Input OK (N/return) ?

LOADED MEMBERS ?

1- Mem No , No of Loads  2?
   1-Load-Type ?  1 or 11 or 21 or 31 or 41
     Mem Length=
     P , A  2?
     Load Inclination: (if load type 21)
     (0 to 360 DEG) ?
   2-Load-Type ?  2 or 12 or 22 or 32 or 42
     Mem Length=
     N , P , A , B  4?
     Load Inclination: (if load type 22)
     (0 to 360 DEG) ?
   :
   n-Load-Type ?  3 or 13 or 23 or 33 or 43
     Mem Length=
     W  ?
     Load Inclination: (if load type 23)
     (0 to 360 DEG) ?
2- Mem No , No of Loads  2?
   1-Load-Type ?  4 or 14 or 24 or 34 or 44
     Mem Length=
     Q  ?
     Load Inclination: (if load type 24)
     (0 to 360 DEG) ?
   2-Load-Type ?  5 or 15 or 25 or 35 or 45
     Mem Length=
     W , A , B  3?
     Load Inclination: (if load type 25)
     (0 to 360 DEG) ?
   :
   n-Load-Type ?  6 or 16 or 26 or 36 or 46
     Mem Length=
     Q  , Q  , A , B  4?
     Load Inclination: (if load type 26)
     (0 to 360 DEG) ?
:
n- Mem No , No of Loads  2?
   1-Load-Type ?  7 or 17 or 27 or 37 or 47
     Mem Length=
     W  , A , B  3?
     Load Inclination: (if load type 27)
     (0 to 360 DEG) ?
   2-Load-Type ?  8 or 18 or 28 or 38 or 48
     Mem Length=
     M , A  2?
   3-Load-Type ?  9 or 19 or 29 or 39 or 49
     Mem Length=
     W  , A , B  3?
     Load Inclination: (if load type 29)
     (0 to 360 DEG) ?

4-Load-Type ?  51
     Mem Length=
     Temp , Coeff 2?
   5-Load-Type ?  52
     Mem Length=
     N , M , A , B   4?
   6-Load-Type ?  53
     Mem Length=
     Lack of Fit ?
     :
   n-Load-Type ?  54
```

```
     Mem Length=
     Strain ?

More Loads (Y/N) ?      (appears only if a Load-Type or MEM NO is input as 0; this
                        provides an exit when more than required LOADS/LOADED-
                        MEMBERS have been input mistakenly)
Input OK (N/return) ?

Same-Load Member-Sets  ?

NO OF MEMBERS IN SET 1 ARE ?
1- MEM NO ?
2- MEM NO ?
:
n- MEM NO ?
NO OF MEMBERS IN SET 2 ARE ?
1- MEM NO ?
-2- MEM NO ?
:
n- MEM NO ?
                     :
NO OF MEMBERS IN SET n ARE ?
1- MEM NO ?
2- MEM NO ?
:
n- MEM NO ?

Input OK (N/return) ?

HOW MANY LOADED/DISPLACED JOINTS ?

         Jnt , Fx , Fy , M

1-   4?                       Note:
2-   4?                       To specify an imposed displacement
:                             at a support, the value is followed
n-   4?                       by the character 'D'.

Input OK (N/return) ?

SAME LOAD JOINT-SETS ?

NO OF JOINTS IN SET 1 ARE ?
1- JNT NO ?
2- JNT NO ?
:
n- JNT NO ?


NO OF JOINTS IN SET 2 ARE ?
1- JNT NO ?
2- JNT NO ?
:
n- JNT NO ?

NO OF JOINTS IN SET n ARE ?
1- JNT NO ?
2- JNT NO ?
:
n- JNT NO ?

End of Input for Load Case n
Ready to Save Data on to Disk

Input OK (N/return)  ?
```

# 26- VARIOUS OPTION MENUS OF THE PROGRAM

## *Menu 1 [Master Options]*

```
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              SKELETON-9: ANALYSIS OF PLANE FRAMEWORKS
                              Copyright
                            Dr S.U.R. Khan
MASTER-OPTIONS:
 1- Data Preparation
 2- Framework Analysis
 3- Load Combination Analysis
 4- Post Member Analysis
 5- Change/Display-Filenames-in Data Drive/Dir A:
 6- Alter Default Settings
 7- Finish
Which ?
```

## *Menu 2 [Data Preparation]*

```
                   Skeleton-9: Data Preparation

Main Options:
 1- Prepare/Modify Structure Data
 2- Prepare/Modify Loading Data
 3- Print Structure &/or Load-Cases Data
 4- Change/Display-Filenames-in Data Drive/Dir C:\SK9DATA\
 5- Exit to MASTER Options
 6- Make Copy of Structure &/or Load-Case Files
 7- Finish
Which ?
```

## Menu 3 [Data Preparation]

```
        Skeleton-9: Prepare/Modify Structure Data in  &  Units
             Sections= 0        Joints= 0        Members= 0
                              Filename:

Main Options:

 1- Prepare New Data
 2- Modify/Examine Old Data
 3- Edit/Save Data in Memory

 4- Change/Display-Filenames-in Data Drive/Dir Y

 5- Prepare/Modify Loading Data

 6- Exit to MASTER Options

 7- Finish

Which ?
```

## Menu 4 [Data Preparation]

```
         Skeleton-9: Prepare/Modify Structure Data in  &  Units
              Sections= 0        Joints= 0        Members= 0
                               Filename:

To Exit: Press Return

Modify/Examine Other Structure:

Give its Filename ?
```

## Menu 5 [Data Preparation]

```
       Skeleton-9: Prepare/Modify Structure Data in  &  Units
           Sections= 0        Joints= 0        Members= 0
                          Filename: FRAME1

FILENAME: FRAME1

Insert Additional Elements (Y/Return) ? Y

SECTIONS:
How Many to be Inserted ? 1

JOINTS:
How Many to be Inserted ? 1

MEMBERS:
How Many to be Inserted ? 1
```

## Menu 6 [Data Preparation]

```
      Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
           Sections= 2        Joints= 5        Members= 4
                           Filename: FRAME1


Edit Options:

 1- Input OK; Continue                   2- To Main-Options/Re-Start

 3- Change Title/Units/Unit-Weight       4- Section Changes
 5- Joint Changes                        6- Member Changes

 7- Display/Print Structure Diagram

 8- Spring Constants & Supports          9- Joint & Member Hinges

10- Print All/Part Input Details
11- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
12- Save to Disk (Data in Memory)

NB  Structure Details Now Include All the Changes Made so far.
    If in Doubt, Take Option 7 and/or 10.

Which ?
```

## Menu 7 [Data Preparation]

```
      Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
           Sections= 2        Joints= 5        Members= 4
                          Filename: FRAME1


OPTIONS TO PRINT:

 1- Entire Details
 2- Structure Reference
 3- Section Properties
 4- Member Details
 5- Joint Coordinates
 6- Supports & Spring Constants
 7- To Main-Options/Continue

Which ?
```

## *Menu 8 [Data Preparation]*

```
      Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
           Sections= 2        Joints= 5        Members= 4
                          Filename: FRAME1

OPTIONS TO MODIFY:

 1- Exit to Main-Options
 2- Re-Define Details of SECTIONS
 3- Add Up to 1 SECTIONS
```
*(Appears if SECTIONS can be added; see notes below Menu 10)*

```
Which ?
```

## *Menu 9 [Data Preparation]*

```
     Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
          Sections= 2        Joints= 5        Members= 4
                         Filename: FRAME1

OPTIONS TO MODIFY:

 1- Exit to Main-Options
 2- Re-Define Details of JOINTS
 3- Add Up to 1 JOINTS
```
*(Appears if JOINTS can be added; see notes below Menu 10)*

```
Which ?
```

## *Menu 10 [Data Preparation]*

```
      Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
            Sections= 2        Joints= 5        Members= 4
                          Filename: FRAME1

OPTIONS TO MODIFY:

 1- Exit to Main-Options
 2- Re-Define Details of MEMBERS
 3- Add Up to 1 MEMBERS
```
*(Appears if MEMBERS can be added; see notes below )*

```
Which ?
```

Notes:

1-Addition of sections, joints and members via option-3 of menus 8,9 and 10 respectively can take place ONLY IF answer to INSERT ADDITIONAL ELEMENTS (Y/N) ? has been Yes and the numbers to be inserted has been defined beforehand via menu-5

2-All newly added sections and joints should be described/added (via option-3 of menus 8 and 9 respectively) BEFORE the member details which refer to them.

## *Menu 11 [Data Preparation]*

```
     Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
           Sections= 2        Joints= 5        Members= 4
```

```
                         Filename: FRAME1

EXISTING:

Title: EUROTRUCK DEVELOPMENT NEWBRIDGE
Units: KN     CM

OPTIONS:

 1- Change Title
 2- Change Units
 3- Unit Weight of Sections
 4- Exit

Which ?
```

## *Menu 12 [Data Preparation]*

```
     Skeleton-9: Prepare/Modify Structure Data in KN & CM Units
          Sections= 2        Joints= 5        Members= 4
                        Filename: FRAME1

Existing Unit Weight = 7.697263E-05 KN/CM3 (Constant for all Sections)


Unit Weight in KN/CM3 (New Value/V/Return) ? V

Section       Unit Wt KN/CM3
Sec- 1      ? 1
Sec- 2      ? 2
```

## *Menu 13 [Data Preparation]*

```
        Skeleton-9: Prepare/Modify Loading Data in KN & CM Units
SelfWt= 30.05199 KN   Sections= 2   Joints= 5    Members= 4    DoI= 1

Structure: FRAME1                                         Load-Case= 0
Load File:
    Title:
  Self Wt: Not-Included


Main Options:

 1- Prepare New Load Case
 2- Modify Old Load Case
 3- Edit/Save Data in Memory

 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 5- Prepare/Modify Loads for Other Structure
 6- Prepare/Modify Structure Data

 7- Exit to Master Options
 8- Finish

Which ?
```

## *Menu 14 [Data Preparation]*

```
        Skeleton-9: Prepare/Modify Loading Data in KN & CM Units
SelfWt= 30.05199 KN    Sections= 2   Joints= 5   Members= 4    DoI= 1

Structure: FRAME1                                         Load-Case= 1
Load File: A:\J2535\FRAME1  .A1
    Title: DEAD+LIVE
  Self Wt: Not-Included


Edit Options:

 1- Input OK; Continue                    2- To Main-Options/Re-Start

 3- Title/Load-Case-No/Self-Weight
 4- All Member Loads                      5- Selected Member Loads
 6- Same-Load-Member-Sets
 7- All Joint Loads                       8- Selected Joint Loads
 9- Same-Load-Joint-Sets

10- Print Options
11- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
12- Save to Disk

Which ?
```

## Menu 15 [Data Preparation]

```
        Skeleton-9: Prepare/Modify Loading Data in KN & CM Units
SelfWt= 30.05199 KN    Sections= 2   Joints= 5    Members= 4   DoI= 1

Structure: FRAME1                                          Load-Case= 1
Load File: A:\J2535\FRAME1  .A1
    Title: DEAD+LIVE
  Self Wt: Not-Included

PRINT OPTIONS:

 1- All Input
 2- Loading Reference
 3- Member Loads
 4- Same-Load Member-Sets
 5- Joint Loads
 6- Same-Load Joint-Sets
 7- Exit

Which ?
```

## Menu 16 [Data Preparation]

```
        Skeleton-9: Prepare/Modify Loading Data in KN & CM Units
SelfWt= 30.05199 KN    Sections= 2   Joints= 5    Members= 4   DoI= 1

Structure: FRAME1                                          Load-Case= 1
Load File: A:\J2535\FRAME1  .A1
    Title: DEAD+LIVE
  Self Wt: Not-Included

OPTIONS:

 1- Change Title
 2- Change Loading Case No
 3- Include/Not-Include Self Wt
 4- Exit

Which ?
```

## Menu 17 [Data Preparation]

```
        Skeleton-9: Prepare/Modify Loading Data in KN & CM Units
SelfWt= 30.05199 KN    Sections= 2   Joints= 5    Members= 4   DoI= 1

Structure: FRAME1                                          Load-Case= 1
Load File: A:\J2535\FRAME1  .A1
    Title: DEAD+LIVE
  Self Wt: Not-Included


Include Self Weight (Y/N) ? Y
```

## Menu 18 [Data Preparation]

```
                   Skeleton-9: Data Preparation


Print Structure &/or Load-Cases Data

Options to Print:

 1- Structure
 2- Structure + Load-Cases
 3- Load-Cases
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Exit to Main-Options

Which ?
```

## Menu 19 [Data Preparation]

```
                   Skeleton-9: Data Preparation



Print Structure &/or Load-Cases Data


To Exit: Press Return


Give Name of the (Previous) Structure File:

? ........
```

## Menu 20 [Data Preparation]

```
                   Skeleton-9: Data Preparation


Print Structure &/or Load-Cases Data


Load- Case Selection Options:

 1- '1' to 'N' Inclusive
 2- 'N1' to 'N2' Inclusive
 3- Random Numbers: N1,N2...NN
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Return to Main Options

Which ?
```

## *Menu 21 [Data Preparation]*

```
                SKELETON-9: CREATE NEW-NAME DATA FILES

Old-Data in Memory:                               New-Names for Saving:
Structure:                                        Structure:
Loading Case No: 0                                Loading Case No: 0
======================================================================



To Exit: Press RETURN


Give Name of the Old-Structure File ?
```

## *Menu 22 [Data Preparation]*

```
              SKELETON-9: CREATE NEW-NAME DATA FILES

Old-Data in Memory:                               New-Names for Saving:
Structure: FRAME1                                 Structure: FRAME2
Loading Case No: 1                                Loading Case No: 1
======================================================================

OPTIONS:

 1- Read: Other Old-Structure Data
 2- Read: Other Old-Loading-Case

 3- Change: New-Structure Name
 4- Change: New-Loading-Case No

 5- Save to Disc: Structure Data
 6- Save to Disc: Loading-Case Data

 7- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 8- Exit to Master-Options

 9- Finish

Which ?
```

## *Menu 23 [Framework Analysis]*

```
                   Skeleton-9: Framework Analysis

Main-Options:

 1- Begin Framework Analysis

 2- Print Last-Analysis-Copy

 3- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 4- Exit to MASTER Options

 5- Finish

Which ?
```

## *Menu 24 [Framework Analysis]*

```
                   Skeleton-9: Framework Analysis

Begin Framework Analysis

To Exit: Press Return


Give Name of the (Previous) Structure File:

? FRAME1..
```

## *Menu 25 [Framework Analysis]*

```
                  Skeleton-9: Framework Analysis

Begin Framework Analysis

Load- Case Selection Options:

 1- '1' to 'N' Inclusive
 2- 'N1' to 'N2' Inclusive
 3- Random Numbers: N1,N2...NN
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Return to Main Options

Which ?
```

## *Menu 26 [Framework Analysis]*

```
                 Skeleton-9: Framework Analysis


Select Load-Case Numbers:

Option: '1' TO 'N' Inclusive

Input 'N' (1 to  99 )  ?
```

## *Menu 27 [Framework Analysis]*

```
                 Skeleton-9: Framework Analysis

Select Load-Case Numbers:

Option: 'N1' TO 'N2' Inclusive

Input 'N1','N2' (N2-N1< 99 )  2?
```

## *Menu 28 [Framework Analysis]*

```
                   Skeleton-9: Framework Analysis

Select Load-Case Numbers:

Option: Random Numbers N1,N2....NN

How Many Load Cases (1 TO  99 )  ? n

Load-Case Number- 1  ?
Load-Case Number- 2  ?
.
.
Load-Case Number- n  ?
```

## *Menu 29 [Framework Analysis]*

```
Selection of Output-Contents:
Y  1- Heading  (20-Define its Contents)
Y  2- Structure Diagram
Y  3- Structure Reference
Y  4- Structure Details
Y  5- Loading Reference
Y  6- Member & Joint Loads
Y  7- Joint Displacements
Y  8- Member Forces
N  9- Member Deformations
Y 10- Support Reactions
  11- Decimals: Loads= 4 & Displacements= 6
  12- 1st Page No= 1       13- Lines/Page= 60    14- Lines/Gap= 6

N 15- Send Output to Data Disk File: FRAME1.STR

  16- Reset: To Print All  of 1-10
  17- Reset: To Print None of 1-10
  18- Selection OK; Proceed Further
  19- Exit to Main-Options

To Toggle the Y/N Selection: Enter the List No

Which ?
```

## *Menu 30 [Framework Analysis]*

```
                  Skeleton-9: Framework Analysis


 Select Decimal Places:

 Press Return To Exit/Main-Options

 1- Loads: n
 2- Displacements: n


Which ?
```

## *Menu 31 [Framework Analysis]*

```
                  Skeleton-9: Framework Analysis


Decimal Places for Loads:

Present Value = n


Input New Value ( Between 1 & 7 ) ?
```

## *Menu 32 [Framework Analysis]*

```
                    Skeleton-9: Framework Analysis

Decimal Places for Displacements:

Present Value = n

Input New Value ( Between 1 & 7 ) ?
```

## *Menu 33 [Framework Analysis]*

```
                 ** HEADING CONTENTS **

JOB NO

DATE

PAGE NO

DESIGNER

PROJECT


Re-Define (Y/Return) ?
```

## *Menu 34 [Framework Analysis]*

```
                     Skeleton-9: Framework Analysis


D.O.S. Error No = 53

Filename: A:\J2535\FRAME8

File Not Found

Press Space Bar to Continue
```

## *Menu 35 [Load Combination Analysis]*

```
                Skeleton-9: Load Combination Analysis

Main Options:

 1- Combine Load Cases & Analyse

 2- Print Last-Analysis Copy

 3- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 4- Exit to MASTER Options

 5- Finish

Which ?
```

## *Menu 36 [Load Combination Analysis]*

```
                   Skeleton-9: Load Combination Analysis

Combine Load Cases & Analyse

To Exit: Press Return


Give Name of the (Previous) Structure File:

? ........
```

## *Menu 37 [Load Combination Analysis]*

```
                  Skeleton-9: Load Combination Analysis

Combine Load Cases & Analyse

Load- Case Selection Options:

 1- '1' to 'N' Inclusive
 2- 'N1' to 'N2' Inclusive
 3- Random Numbers: N1,N2...NN
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Return to Main Options

Which ?
```

## *Menu 38 [Load Combination Analysis]*

```
                  Skeleton-9: Load Combination Analysis


Select Load-Case Numbers:

Option: '1' TO 'N' Inclusive

Input 'N' (1 to  32 )  ?
```

## *Menu 39 [Load Combination Analysis]*

```
                Skeleton-9: Load Combination Analysis


How Many Combinations (40 Max, 0 TO Exit) ?
```

## *Menu 40 [Load Combination Analysis]*

```
               Skeleton-9: Load Combination Analysis
Structure: ......                              No of Combinations= ..


Load-Cases Selected for 2 Combinations:
 ..     ..     ..    nn

                       Combination Analysis No n

Input Comb-Case No (1 TO 99, 0 TO Skip) ?
```

## *Menu 41 [Load Combination Analysis]*

```
               Skeleton-9: Load Combination Analysis

Combination- 1

C:\SK9DATA\SPBLM2  .D1 is an Existing File:

for Previous Comb-Case No= 1



Options:

 1- Over Write Existing File
 2- Change Comb-Case No
 3- Change/Display-Filenames-in Data Drive/Dir C:\SK9DATA\
 4- Abort Entire Analysis/Exit

Which ?
```

## *Menu 42 [Load Combination Analysis]*

```
                  Skeleton-9: Load Combination Analysis
Structure: FRAME1                              No of Combinations= 2


Load-Cases Selected for 2 Combinations:
 1    2

                       Combination Analysis No 1
Comb-Case No= 1
Title:



Input Title (60 Chrs Max)

? DEAD+LIVE+WIND
```

## *Menu 43 [Load Combination Analysis]*

```
               Skeleton-9: Load Combination Analysis
Structure: FRAME1                              No of Combinations= 2


Load-Cases Selected for 2 Combinations:
 1    2

                       Combination Analysis No 1
Comb-Case No= 1
Title: DEAD+LIVE+WIND

How Many Load-Cases to be Combined (0 TO Skip, 2 Max) ?
```

## Menu 44 [Load Combination Analysis]

```
                Skeleton-9: Load Combination Analysis
Structure: FRAME1                              No of Combinations= 2


Load-Cases Selected for 2 Combinations:
 1    2    3

                       Combination Analysis No 1
Comb-Case No= 1
Title: DEAD+LIVE+WIND
No of Load-Cases= 2

  1 - Load-Case , Factor  2? 1,1.4
  2 - Load-Case , Factor  2? 2,1.6
  3 - Load-Case , Factor  2? 3,1.2


End of Input for Analysis No 1 ;  Press RETURN to Continue
```

## Menu 45 [Load Combination Analysis]

```
Selection of Output-Contents:
Y 1- Heading  (20-Define its Contents)
Y 2- Structure Diagram
Y 3- Structure Reference
Y 4- Structure Details
Y 5- Loading Reference
Y 6- Member & Joint Loads
Y 7- Joint Displacements
Y 8- Member Forces
N 9- Member Deformations
Y10- Support Reactions
  11- Decimals: Loads= 4 & Displacements= 6
  12- 1st Page No= 1       13- Lines/Page= 60    14- Lines/Gap= 6

N 15- Send Output to Data Disk File: FRAME1.MIX

  16- Reset: To Print All  of 1-10
  17- Reset: To Print None of 1-10
  18- Selection OK; Proceed Further
  19- Exit to Main-Options

To Toggle the Y/N Selection: Enter the List No

Which ?
```

## *Menu 46 [Load Combination Analysis]*

```
               Skeleton-9: Load Combination Analysis
                        Structure: FRAME1

Load-Cases Selected for 2 Combinations:
 1    2    3

Comb-Case  Numbers  for 2 Combinations:
 1    2

Options:

 1- Input OK; Continue to Analyse
 2- Examine/Modify Combination Data
 3- Examine/Modify Output Selection
 4- Abort Analysis/To Master-Options

Which ?
```

## *Menu 47 [Load Combination Analysis]*

```
Combination Analysis No  1                           Comb-Case No= 2

Title: DEAD+LIVE+WIND

Load-Case & Combination-Factors:
 1: 1 X 1.4            2: 2 X 1.6
=====================================================================
EXAMINE/MODIFY OPTIONS: 1- Display Next Combination
                        2- Title                     3- Comb-Case No
                        4- Load Factors              5- Exit
Which ?
```

## *Menu 48 [Load Combination Analysis]*

```
                Skeleton-9: Load Combination Analysis
                         Structure: FRAME1

Load-Cases Selected for 2 Combinations:
 1    2    3

Comb-Case  Numbers  for 2 Combinations:
 1    2


Combination- 1

Existing Comb-Case No= 1

New Comb-Case No (1 TO 99) ?
```

## *Menu 49 [Load Combination Analysis]*

```
Combination Analysis No  1                            Comb-Case No= 2

Title: DEAD+LIVE+WIND

Load-Case & Combination-Factors:
 1: 1 X 1.4            2: 2 X 1.6
=====================================================================


Re-Define Load-Factors:

How Many to be Re-Defined ( 2 Max, 0 TO EXIT ) ?
```

## *Menu 50 [Load Combination Analysis]*

```
Combination Analysis No  1                           Comb-Case No= 2

Title: DEAD+LIVE+WIND

Load-Case & Combination-Factors:
 1: 1 X 1.4            2: 2 X 1.6
=====================================================================


Factors to be Re-Defined= 2

 2 - No , Load-Case , Factor 3? 2,2,1.1
```

## *Menu 51 [Load Combination Analysis]*

```
                Skeleton-9: Load Combination Analysis


Abort the Entire Analysis/Exit:

Are You Sure (Y/Return) ?
```

## *Menu 52 [Post Member Analysis]*

```
                      Skeleton-9: Post Member Analysis

Main Options:

 1- Post Member-Analysis: Interactive

 2- Post Member-Analysis: Automatic

 3- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 4- Exit to MASTER Options

 5- Finish

Which ?
```

## *Menu 53 [Post Member Analysis]*

```
Points= 0        Skeleton-9: Post Member Analysis           Loads= 0

LOAD Case: 0            Structure:                      Member No: 0

Units: ,

How Many Analysis Points ( 11 to 46 ) ? 11
```

## *Menu 54 [Post Member Analysis]*

```
Points= 11       Skeleton-9: Post Member Analysis           Loads= 0

LOAD Case: 0             Structure:                     Member No: 0

Units: ,

Structure Name ?
```

## *Menu 55 [Post Member Analysis]*

```
Points= 11       Skeleton-9: Post Member Analysis           Loads= 0

LOAD Case: 0             Structure: FRAME1              Member No: 0

Units: ,

Load/Comb Case No? 1
```

## *Menu 56 [Post Member Analysis]*

```
Points= 11          Skeleton-9: Post Member Analysis          Loads= 0

LOAD Case: 1               Structure: FRAME1              Member No: 0

Units: ,


Member No? 2
```

## *Menu 57 [Post Member Analysis]*

```
Points= 11          Skeleton-9: Post Member Analysis          Loads= 0

LOAD Case: 1              Structure: FRAME1               Member No: 2

Units: ,

New-Analysis Options:

 1- New Structure Name
 2- New LOAD/COMB Case No
 3- New Member No

 4- Change-Case: LOAD-><-COMB

 5- Fetch Data & Analyse

 6- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 7- Exit to MASTER Options

Which ?
```

## *Menu 58 [Post Member Analysis]*

```
Points= 11         Skeleton-9: Post Member Analysis          Loads= 1

LOAD Case: 1              Structure: FRAME1             Member No: 2

Units: KN, CM


Main-Options:

 1- New Analysis

 2- Display Options
 3- Print Options
 4- Change-Data Options

 5- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 6- Exit to Master-Options
 7- Finish

Which ?
```

Note:
The value displayed in the top left corner is the chosen number of analysis locations and that in the top right corner is the number of loads acting on the member span.

## *Menu 59 [Post Member Analysis]*

```
Points= 11       Skeleton-9: Post Member Analysis            Loads= 1

LOAD Case: 1             Structure: FRAME1              Member No: 2

Units: KN, CM

Display Options:

 Press Return To Exit/Main-Options

 1- Heading
 2- Member Details
 3- Member Loads
 4- D-A-S-M DIAGRAM
 5- Max/Min Results
 6- Results
 7- Displacements
 8- End Forces

Which ?
```

## *Menu 60 [Post Member Analysis]*

```
                              MEMBER ANALYSIS

FILE: FRAME1                    LOAD CASE: 1             MEMBER NO: 2
REF:                                                     UNITS: KN , CM

MEMBER DETAILS:      ANALYSIS POINTS= 11
X= 1150 CM           Y= 202.8 CM                 UNIT WT= 7.697263E-05 KN/CM3
L= 1167.745 CM       E= 21000 KN/CM2
A= 85.5 CM2          I= 24329 CM4                SELF WT= 7.685 KN

Press Space Bar to Continue
```

## *Menu 61 [Post Member Analysis]*

```
Points= 11          Skeleton-9: Post Member Analysis          Loads= 1

LOAD Case: 1             Structure: FRAME1                Member No: 2

Units: KN, CM


DETAILS OF  1  APPLIED LOADS:


  1- T43 W = 103.5 KN

  2- T1  P = 30 KN                A = 20 CM


Press Space Bar to Continue
```

## *Menu 62 [Post Member Analysis]*

```
                               MEMBER ANALYSIS

MAXIMUM/MINIMUM RESULTS FROM 11 ANALYSIS POINTS:
DISTANCE     DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   CM           CM                KN              KN          KN CM
 0           -1.3362E-06      68.674>         92.987>        -33977.94<
 116.774     -.6214<          66.877          82.794         -23714.65
 817.421      1.6342>         56.092          21.637          12870.09
 1050.97      .9503           52.497          1.252           15543>
 1167.745     1.8815E-06      50.7<          -8.941<          15094.07

Press Space Bar to Continue
```

## Menu 63 [Post Member Analysis]

MEMBER ANALYSIS

ANALYSIS RESULTS:

| DISTANCE CM | DEFLECTION CM | AXIAL-FORCE KN | SHEAR-FORCE KN | MOMENT KN CM |
|---|---|---|---|---|
| 0 | -1.3362E-06 | 68.674> | 92.987> | -33977.94< |
| 116.774 | -.6214< | 66.877 | 82.794 | -23714.65 |
| 233.549 | -.6071 | 65.079 | 72.601 | -14641.53 |
| 350.323 | -.1995 | 63.282 | 62.408 | -6758.735 |
| 467.098 | .3913 | 61.484 | 52.216 | -66.13 |
| 583.872 | .9864 | 59.687 | 42.023 | 5436.178 |
| 700.647 | 1.439 | 57.889 | 31.83 | 9748.273 |
| 817.421 | 1.6342> | 56.092 | 21.637 | 12870.09 |
| 934.196 | 1.4885 | 54.294 | 11.445 | 14801.67 |
| 1050.97 | .9503 | 52.497 | 1.252 | 15543> |
| 1167.745 | 1.8815E-06 | 50.7< | -8.941< | 15094.07 |

Press Space Bar to Continue

## Menu 64 [Post Member Analysis]

MEMBER ANALYSIS

DISPLACEMENTS:

| DISTANCE CM | ROTATION RADIANS | AXIAL-DEFL. CM | PREP.-DEFL. CM | TOTAL-DEFL. CM |
|---|---|---|---|---|
| 0 | -8.8018E-03 | 0 | -1.3362E-06 | 1.3362E-06 |
| 116.774 | -2.2313E-03 | -4.4079E-03 | -.6214 | .6214 |
| 233.549 | 2.1295E-03 | -8.699E-03 | -.6071 | .6072 |
| 350.323 | 4.5524E-03 | -1.2873E-02 | -.1995 | .1999 |
| 467.098 | 5.3097E-03 | -1.693E-02 | .3913 | .3916 |
| 583.872 | 4.6733E-03 | -2.0871E-02 | .9864 | .9866 |
| 700.647 | 2.9154E-03 | -2.4694E-02 | 1.439 | 1.4393 |
| 817.421 | 3.0786E-04 | -2.8401E-02 | 1.6342 | 1.6344 |
| 934.196 | -2.8772E-03 | -.032 | 1.4885 | 1.4888 |
| 1050.97 | -6.3677E-03 | -3.5463E-02 | .9503 | .951 |
| 1167.745 | -9.8916E-03 | -3.8819E-02 | 1.8815E-06 | 3.8819E-02 |

Press Space Bar to Continue

## Menu 65 [Post Member Analysis]

MEMBER ANALYSIS

| END-FORCES: | AXIAL KN | SHEAR KN | MOMENT KN CM |
|---|---|---|---|
| END-1 | 68.674 | 92.987 | -33977.94 |
| END-2 | 50.7 | -8.941 | 15094.07 |

Press Space Bar to Continue

## Menu 66 [Post Member Analysis]

```
OUTPUT SELECTION:

 Press Return To Exit/Main-Options

 N 1 -Heading (14-Define its Contents)
 N 2 -Member Details
 N 3 -Member Loads
 Y 4 -D-A-S-M DIAGRAM
 Y 5 -Max/Min Results
 N 6 -Results  (N 99- Displacements)
 N 7 -End-Forces

   8 -New Page No= 1
   9 -Lines/Page = 60
  10 -Lines/Gap  = 6

  11 -Reset: To Print All  of 1-7
  12 -Reset: To Print None of 1-7

  13 -Selection OK; Proceed to Print

TO CHANGE SELECTION: ENTER THE LIST NO

Which ?
```

## Menu 67 [Post Member Analysis]

```
Points= 11          Skeleton-9: Post Member Analysis          Loads= 1

LOAD Case: 1            Structure: FRAME1                 Member No: 2

Units: KN, CM


Change-Data Options:

 Press Return To Exit/Main-Options

 1- Analysis Locations

 2- Change Decimal Places

Which ?
```

## *Menu 68 [Post Member Analysis]*

```
Points= 11        Skeleton-9: Post Member Analysis           Loads= 1
LOAD Case: 1              Structure: FRAME1              Member No: 2
Units: KN, CM


No of Present ANALYSIS LOCATIONS = 11

Options:
 Press Return To Exit/Main-Options
 1- Change the No of Locations
 2- Modify/Define Locations
 3- Display Existing Locations
Which ?
```

## *Menu 69 [Post Member Analysis]*

```
Points= 11        Skeleton-9: Post Member Analysis           Loads= 1
LOAD Case: 1            Structure: FRAME1                Member No: 2
Units: KN, CM


How Many Analysis Points ( 11 to 46 ) ? 11
```

## *Menu 70 [Post Member Analysis]*

```
Points= 11        Skeleton-9: Post Member Analysis           Loads= 1

LOAD Case: 1           Structure: FRAME1                 Member No: 2

Units: KN, CM


Modify Define Analysis Locations:

Type:

 A New-Value  to Change the Existing
 Any Letter   to Exit
 (Return)     to Display/Modify the Next Location
======================================================================

Member Length = 1167.745

Location- 1 :  Existing Distance  = 116.774
               Input New Distance ?
```

## *Menu 71 [Post Member Analysis]*

```
Points= 11        Skeleton-9: Post Member Analysis           Loads= 1

LOAD Case: 1            Structure: FRAME1                Member No: 2

Units: KN, CM


ANALYSIS LOCATIONS
 1 -  0  CM
 2 -  116.774  CM
 3 -  233.549  CM
 4 -  350.323  CM
 5 -  467.098  CM
 6 -  583.872  CM
 7 -  700.647  CM
 8 -  817.421  CM
 9 -  934.196  CM
 10 - 1050.97  CM
 11 - 1167.745  CM

Press Space Bar to Continue
```

## *Menu 72 [Post Member Analysis]*

```
                    Skeleton-9: Post Member Analysis


Auto Analysis Options:

 1- Start New Analyses

 2- Resume Last/Unfinished Analyses

 3- Exit to Main-Options

Which ?
```

## *Menu 73 [Post Member Analysis]*

```
               Skeleton-9: Auto Member Analysis Output

Load-Cases= 0          Structure:                   No of Members= 0
Comb-Cases= 0                                  No of Output-Types= 1



To Exit: Press Return


Give Name of (Previous) Structure

File ?
```

## *Menu 74 [Post Member Analysis]*

```
                 Skeleton-9: Auto Member Analysis Output

Load-Cases= 0          Structure: FRAME1             No of Members= 4
Comb-Cases= 0                                   No of Output-Types= 1


Structure File: FRAME1


Option to Select Load-Cases

 1- '1' TO 'N' Inclusive
 2- 'N1' TO N2' Inclusive
 3- Random Numbers: N1,N2...NN
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Exit

Which ?
```

## *Menu 75 [Post Member Analysis]*

```
              Skeleton-9: Auto Member Analysis Output

Load-Cases= 2          Structure: FRAME1           No of Members= 4
Comb-Cases= 0                                 No of Output-Types= 1


Structure File: FRAME1


Option to Select Comb-Cases

 1- '1' TO 'N' Inclusive
 2- 'N1' TO N2' Inclusive
 3- Random Numbers: N1,N2...NN
 4- Change/Display-Filenames-in Data Drive/Dir A:\J2535\
 5- Exit

Which ?
```

## *Menu 76 [Post Member Analysis]*

```
                 Skeleton-9: Auto Member Analysis Output

Load-Cases= 2           Structure: FRAME1           No of Members= 4
Comb-Cases= 0                                  No of Output-Types= 1


Pagination Data:

 1- Ist Page No= 1

 2- Lines/Page = 60

 3- Lines/Gap  = 6

 4- Selection OK ; Exit

Which ?
```

## *Menu 77 [Post Member Analysis]*

```
               Skeleton-9: Auto Member Analysis Output

Load-Cases= 2            Structure: FRAME1          No of Members= 4
Comb-Cases= 0                                  No of Output-Types= 1


Number of Output-Types:

Existing = 1

How Many (1 to 9/Return) ?
```

## *Menu 78 [Post Member Analysis]*

```
Details of Output-Type  1

 Press Return To Exit/Main-Options

 N 1 - Begin Member Output on a New Page
 N 2 - Heading
 N 3 - Member Details
 N 4 - Member Loads
 Y 5 - D-A-S-M Diagram
 Y 6 - Max/Min Results
 N 7 - Results (N 99- Displacements)
 N 8 - End-Forces
   9 - No of Analysis Locations= 11
  10 - Decimals: Loads= 3
                 Displacements= 4
                 Analysis Locations= 3
  11 - Reset: To Print All  of 1-8
  12 - Reset: To Print None of 1-8

  13 - Display/Modify Other Output-Type

TO Change Selection: Enter the List No

Which ?
```

## *Menu 79 [Post Member Analysis]*

```
                 Skeleton-9: Auto Member Analysis Output

Load-Cases= 2           Structure: FRAME1            No of Members= 4
Comb-Cases= 0                                   No of Output-Types= 1


OUTPUT CONTENTS OF MEMBER ANALYSES:

Assign Members to: Output-Type- 1

 1- Assign Members: 1 TO N1 Inclusive
 2- Assign Members: N1 TO N2 Inclusive
 3- Assign Members: Selective N1,N2,....

 4- Change/Next Output-Type
 5- Modify/Examine Output-Type- 1
 6- Exit

Which ?
```

## *Menu 80 [Post Member Analysis]*

```
                 Skeleton-9: Auto Member Analysis Output

Load-Cases= 2           Structure: FRAME1            No of Members= 4
Comb-Cases= 0                                   No of Output-Types= 1


Assign Members to: Output-Type- 1

Members 1 TO N1 Inclusive

Input N1 ? 2
```

## *Menu 81 [Post Member Analysis]*

```
               Skeleton-9: Auto Member Analysis Output

Load-Cases= 2          Structure: FRAME1             No of Members= 4
Comb-Cases= 0                                   No of Output-Types= 1


Existing Output-Type =  1


New Output-Type ( 0  to  1 ) ?
```

Note:
Compared with menu-85, the above appears when assigning output-types to members. Here the OUTPYT-TYPE (assigned to members can be 0 (zero), meaning no output required for the member.

## Menu 82 [Post Member Analysis]

```
                Skeleton-9: Auto Member Analysis Output

Load-Cases= 2         Structure: FRAME1             No of Members= 4
Comb-Cases= 0                                  No of Output-Types= 1


MAIN-OPTIONS:

 1- Selection OK; Begin Auto Analyses

 2- Send Output to Disk File: FRAME1.MEM  [No]

 3- Display Selection

 4- Modify Selection

 5- Re-Start/Define Selection Anew

 6- Change/Display-Filenames-in Data Drive/Dir A:\J2535\

 7- Exit to Master-Options

 8- Finish

Which ?
```

## Menu 83 [Post Member Analysis]

```
               Skeleton-9: Auto Member Analysis Output

Load-Cases= 2            Structure: FRAME1             No of Members= 4
Comb-Cases= 0                                     No of Output-Types= 1


DISPLAY OPTIONS:

 1- Pagination Data

 2- Selected Load & Comb Cases

 3- Output-Type for Each Member

 4- Details of Each Output-Type

 5- Exit

Which ?
```

## *Menu 84 [Post Member Analysis]*

```
              Skeleton-9: Auto Member Analysis Output

Load-Cases= 2          Structure: FRAME1            No of Members= 4
Comb-Cases= 0                                  No of Output-Types= 1


Modify/Change Options:

 1- Pagination Data

 2- Chosen Load/Comb Cases

 3- Output-Type for Each Member

 4- No of Output-Types

 5- Contents of Output-Types

 6- Exit

Which ?
```

## *Menu 85 [Post Member Analysis]*

```
              Skeleton-9: Auto Member Analysis Output

Load-Cases= 2           Structure: FRAME1           No of Members= 4
Comb-Cases= 0                                  No of Output-Types= f



Existing Output-Type =  1


New Output-Type ( 1  to  f ) ?
```

Note:
Compared with menu-81, the above appears when contents of output types are being displayed for modification/examination. Here a 0 (zero) OUTPUT-TYPE cannot be displayed/modified.

```
                    Skeleton-9: Auto Member Analysis
                        ** Progress Report **

No of Members= 4          Structure: FRAME1          Output Types= 1
---------------------------------------------------------------------
Selected Load-Cases:
 1     2
Selected Comb-Cases:

Members-Output Types:
1-1     2-1     3-0     4-0




---------------------------------------------------------------------
              Options:  1- To Prompt Each Analysis:Y/N
                        2- To Pause
                                  3- To Stop & Continue Later
                        4- To Abort/Re-Start Afresh
                        Press Selection to Interrupt
```

*Notes:-*

1- *To select one of the above four options, a flashing display of about six seconds appears on the screen before each member analysis. To make a selection, key 1, 2, 3 or 4 is pressed while the display is flashing.*

2- *A Yes or No in option-1 is indicated by Y or N shown in inverse.*

*When auto analysis starts, the default selection is always N.*

*When option-1 is pressed (during the flashing display of about six seconds), the selection changes from N to Y or Y to N.*

*When the prompt selection is Y, the program stops after each member analysis. The next analysis starts when prompted by pressing ANY KEY. The selection can be changed to N by pressing key '1' while the display is flashing.*

*When the prompt selection is N, member analyses continue one after another. The selection can be changed to Y by pressing key '1' while the display is flashing.*

3- *The PAUSE option-2 stops the program execution. Pressing the SPACE BAR re-starts the next analysis but, before this happens, the flashing display of six seconds allows options 1 to 4 to be taken, if required.*

4- *The STOP & CONTINUE LATER option-3 ends the auto member analyses. The stage to which the analyses have been completed is stored in the data file AUTO)( so that the remaining analyses can be re-started later (by taking option-2 of menu-76). If desired, the computer can be switched off (or used for some other purpose) after this option.*

5- *The ABORT/RE-START AFRESH option-4 aborts the program execution. Details of the auto selection, however, remain intact in the data disc file AUTO)(. If required, member analyses can be re-started from the very beginning of the auto selection by taking option-2 of menu-72.*

## *Menu 87 [Default Settings]*

```
                    SKELETON DEFAULT SETTINGS:

 1- Default Output Items for Frame  Analyses

 2- Default Output Items for Member Analyses

 3- Default Unit Weight [ 23.6 ]

 4- Disk Drive/Dir for SKELETON Programs [  ]

 5- Maximum Elements in Member Loads Vector [ 2000 ]

 6- VIDEO File Items [ 2  640  200  80  0  2  1.65 ]

 7- Settings OK; Exit to Master Options

Which ?
```

## *Menu 88 [Default Settings]*

```
            Default Output Items for Frame Analyses
Y  1- Heading
Y  2- Structure Diagram
Y  3- Structure Reference
Y  4- Structure Details
Y  5- Loading Reference
Y  6- Member & Joint Loads
Y  7- Joint Displacements
Y  8- Member Forces
N  9- Member Deformations
Y 10- Support Reactions
  11- Decimals: Loads= 4 & Displacements= 6
  12- 1st Page No= 1       13- Lines/Diag= 31
  14- Lines/Page = 60      15- Lines/Gap = 6
  16- Characters/Left-Margin= 10

  17- Reset: To Print All  of 1-10
  18- Reset: To Print None of 1-10
  19- Selection OK; Save it Now
  20- Exit to Master-Options

To Toggle the Y/N Selection: Enter the List No

Which ?
```

## *Menu 89 [Default Settings]*

```
                      MASTER-OUTPUT SELECTION


1st Page No:

Existing Value = 1

Input New Value ( Between 1 to 700 ) ? 21
```

## *Menu 90 [Default Settings]*

```
                       MASTER-OUTPUT SELECTION


No of Lines/Diagram:

Existing Value = 31

Input New Value ( Between 1 to 99 ) ? 17
```

## *Menu 91 [Default Settings]*

```
                       MASTER-OUTPUT SELECTION


Characters per Left-Margin:

Existing Value = 5

Input New Value ( Between 4 to 20 ) ? 10
```

## *Menu 92 [Default Settings]*

```
         Default Output Items for Member Analyses

 N 1 - Begin Member Output on a New Page
 N 2 - Heading
 N 3 - Member Details
 N 4 - Member Loads
 Y 5 - D-A-S-M Diagram
 Y 6 - Max/Min Results
 N 7 - Results (N 99- Displacements)
 N 8 - End-Forces
   9 - No of Analysis Locations= 11
  10 - Decimals: Loads= 3 ; Displacements= 4 ; Analysis Locations= 3
  11 - 1st Page No= 1        12 - Lines/Page= 60
  13 - Lines/Gap= 6          14 - Lines/Diagram= 16
  15 - Characters/Left-Margin= 5

  16 - Reset: To Print All  of 1-8
  17 - Reset: To Print None of 1-8
  18 - Selection OK; Save it Now
  19 - Exit to Master-Options

To Toggle the Y/N Selection; Enter the List No

Which ?
```

## *Menu 93 [Default Settings]*

```
                       Post Member Analysis

                  Default Master Output Selection


Select Decimal Places:

 Press Return To Exit/Main-Options

 1- Loads ( 3 )

 2- Displacements ( 4 )

 3- Analysis Locations ( 3 )

Which ?
```

## *Menu 94 [Default Settings]*

```
                        Post Member Analysis

                  Default Master Output Selection


Decimal Places for Loads:

Present Value = 3

Input New Value ( Between  1  &  7 ) ?
```

## *Menu 95 [Default Settings]*

```
                      Post Member Analysis

                Default Master Output Selection



Decimal Places for Displacements:

Present Value = 4

Input New Value ( Between  1  &  7 ) ?
```

## *Menu 96 [Default Settings]*

```
                      Post Member Analysis

                Default Master Output Selection


Decimal Places for Analysis Locations:

Present Value = 3

Input New Value ( Between  3  &  7 ) ?
```

## *Menu 97 [Default Settings]*

```
                      Techno Consultants Ltd

             SKELETON-9: ANALYSIS OF PLANE FRAMEWORKS

                             Copyright

                           Dr S.U.R. Khan


Existing Default Unit-Weight = 23.6

Re-Define (Y/Return) ? Y

Input New Default Value ? 10.8
```

## *Menu 98 [Default Settings]*

```
                      Techno Consultants Ltd

              SKELETON-9: ANALYSIS OF PLANE FRAMEWORKS

                             Copyright

                           Dr S.U.R. Khan


Existing Program Drive/Dir is

Change (Y/Return) ? Y

Specify New Program Drive/Dir ?
```

*N.B.* *The program disk drive is nearly always the DEFAULT Drive and its description is usually a Null String. In normal use, just press RETURN to specify this drive.*

## Menu 99 [Default Settings]

```
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            SKELETON-9: ANALYSIS OF PLANE FRAMEWORKS
                          Copyright
                       Dr S.U.R. Khan


Existing Maximum Elements in Member Load Vector  2000
Re-Define (Y/Return) ? Y
Specify New Value (1000 min) ? 3000
```

## Menu 100 [Default Settings]

```
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             SKELETON-9: ANALYSIS OF PLANE FRAMEWORKS
                            Copyright
                          Dr S.U.R. Khan


                    Mode, X-res, Y-res, LMarg, TMarg, Joint, AspectR
Existing VIDEO File Items  12 , 720 , 348 , 120 , 0 ,  4 ,    1.66


Re-Define (Y/Return) ? Y
New Items  7? 12,720,348,120,0,4,1.66
```
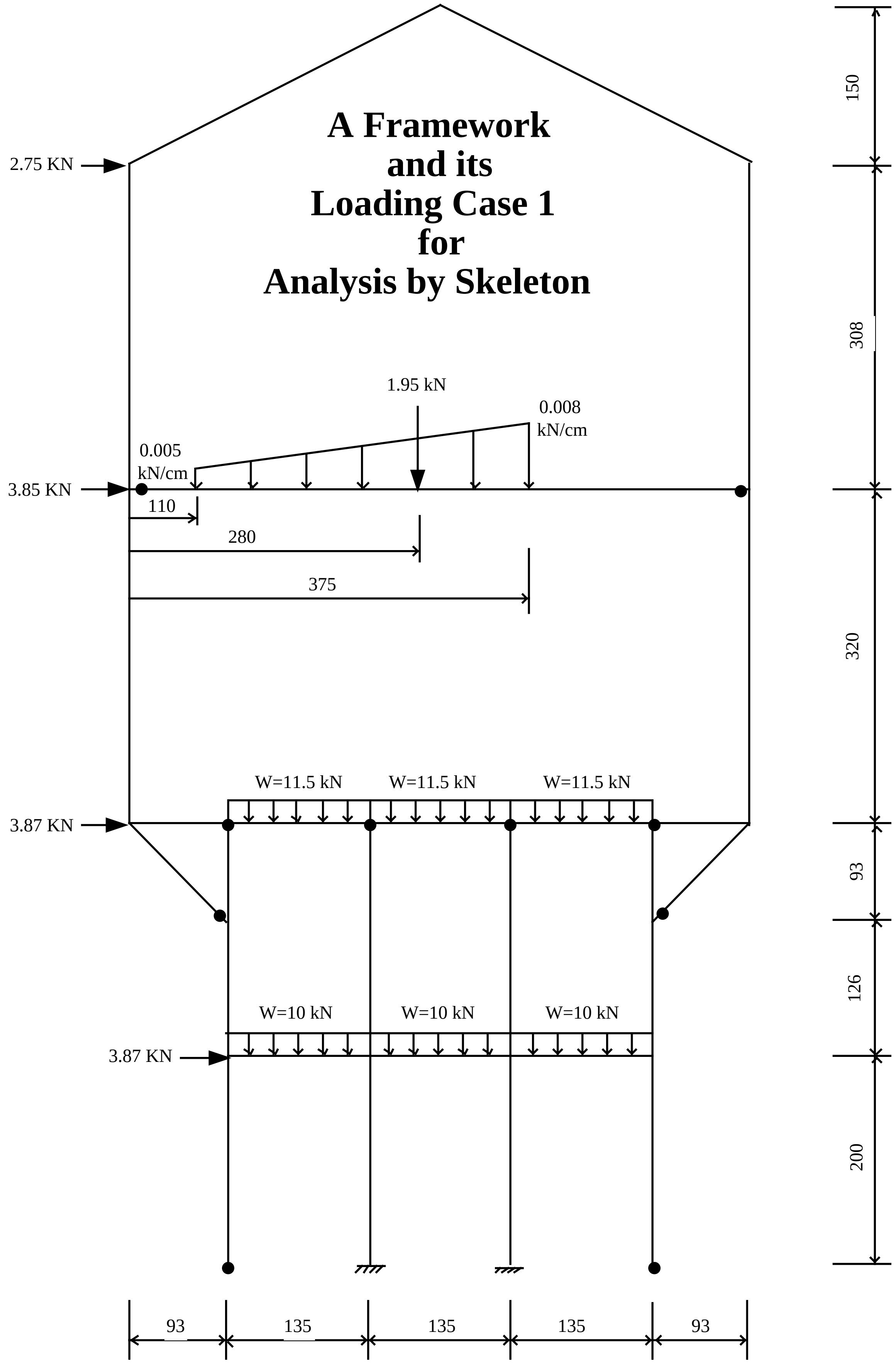
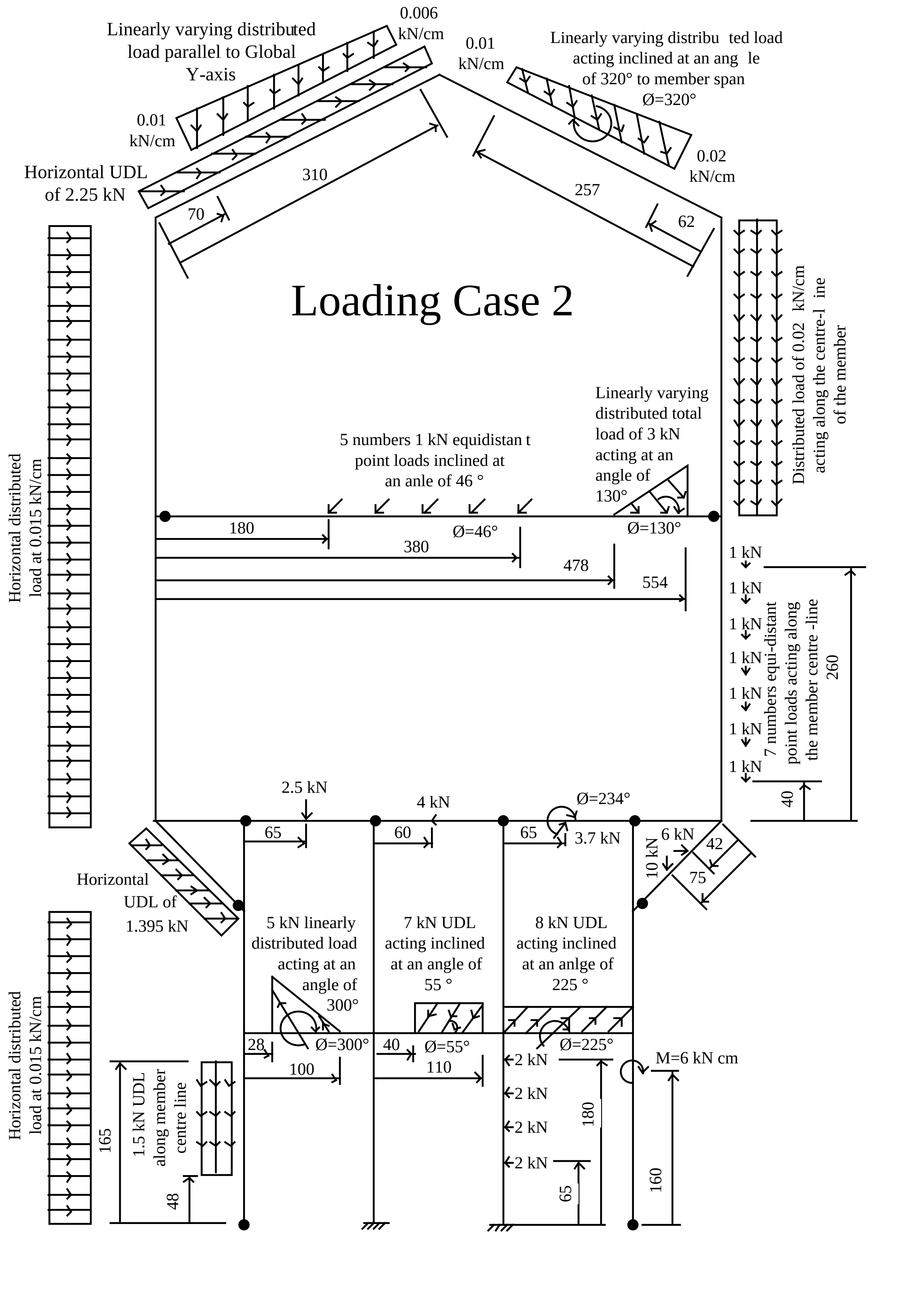
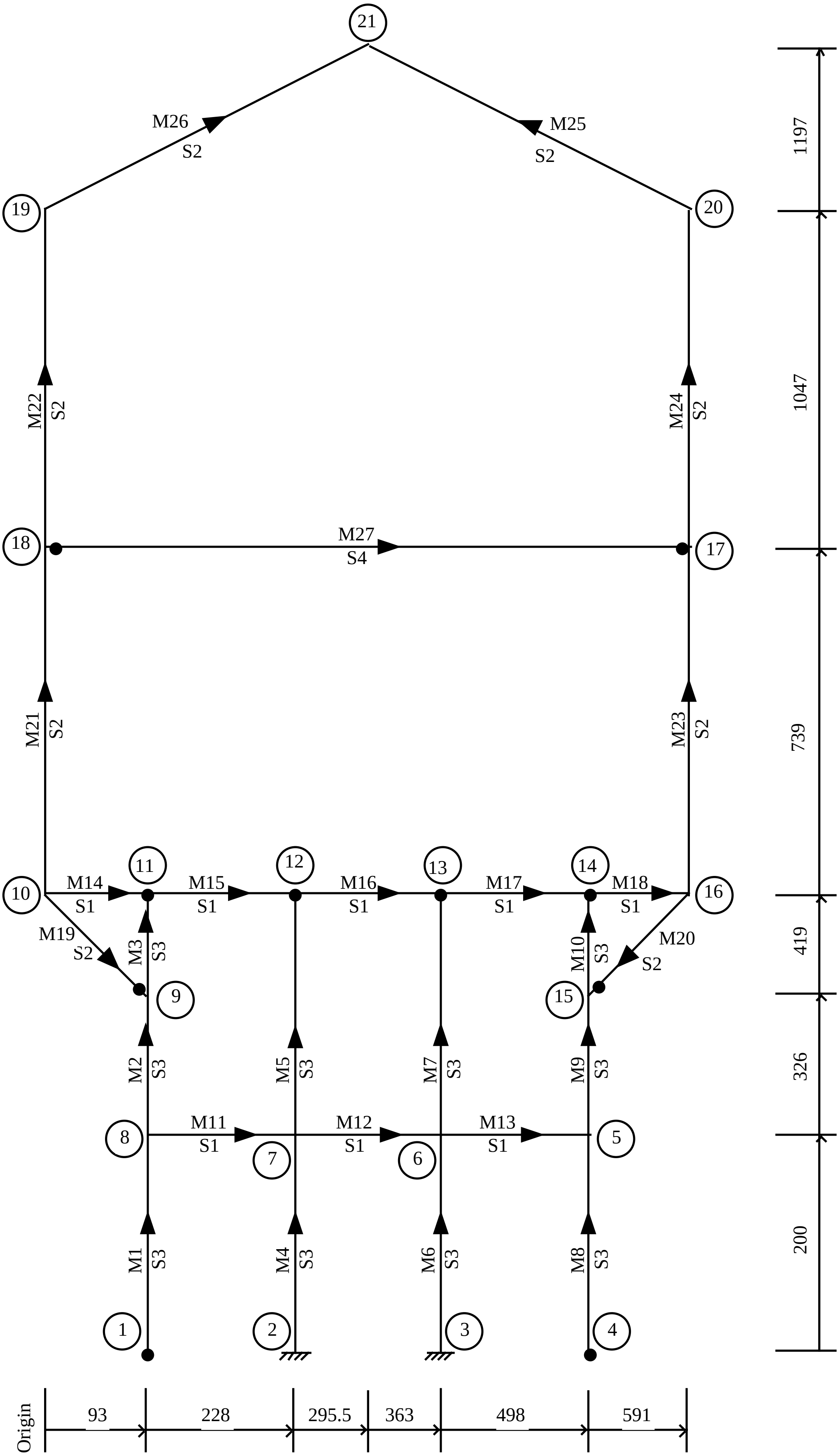

# SAMPLE PROBLEM 1




Loading Case 2
Linearly varying distributed load parallel to Global Y-axis
0.006 kN/cm
0.01 kN/cm
0.01 kN/cm
Linearly varying distribu ted load acting inclined at an ang le of 320° to member span
Ø=320°
0.02 kN/cm
Horizontal UDL of 2.25 kN
310
257
70
62
Distributed load of 0.02 kN/cm acting along the centre-l ine of the member
Horizontal distributed load at 0.015 kN/cm
Linearly varying distributed total load of 3 kN acting at an angle of 130°
5 numbers 1 kN equidistan t point loads inclined at an anle of 46 °
Ø=46°
Ø=130°
180
380
478
554
1 kN
7 numbers equi-distant point loads acting along the member centre -line
260
40
2.5 kN
4 kN
Ø=234°
3.7 kN
6 kN
10 kN
42
75
65
60
65
Horizontal UDL of 1.395 kN
5 kN linearly distributed load acting at an angle of 300°
7 kN UDL acting inclined at an angle of 55 °
8 kN UDL acting inclined at an anlge of 225 °
Ø=300°
Ø=55°
Ø=225°
28
100
40
110
2 kN
M=6 kN cm
Horizontal distributed load at 0.015 kN/cm
1.5 kN UDL along member centre line
165
48
180
65
160

# NUMBERING OF JOINTS, MEMBERS & SECTIONS FOR ANALYSIS



# SAMPLE PROBLEM 1

***AN EXAMPLE SHOWING INPUT OF***
***FRAME AND LOADING DETAILS***

**TITLE:** *SAMPELE PROBLEM 1*
**UNITS ?** *KN,CM*
**SECTIONS ?** *4*
**JOINTS ?** *21*
**MEMBERS ?** *27*

| SEC | MODULUS | AREA | INERTIA |
|---|---|---|---|
| 1 | 21000 | 28.4 | 2867 |
| 2 | 21000 | 41.8 | 6481 |
| 3 | 21000 | 32.3 | 2356 |
| 4 | 21000 | 95 | 27329 |

**MEMBER DETAILS**

| MEM | JNT1 | JNT2 | SEC |
|---|---|---|---|
| 1 | 1 | 8 | 3 |
| 2 | 8 | 9 | 3 |
| 3 | 9 | 11 | 3 |
| 4 | 2 | 7 | 3 |
| 5 | 7 | 12 | 3 |
| 6 | 3 | 6 | 3 |
| 7 | 6 | 13 | 3 |
| 8 | 4 | 5 | 3 |
| 9 | 5 | 15 | 3 |
| 10 | 15 | 14 | 3 |
| 11 | 8 | 7 | 1 |
| 12 | 7 | 6 | 1 |
| 13 | 6 | 5 | 1 |
| 14 | 10 | 11 | 1 |
| 15 | 11 | 12 | 1 |
| 16 | 12 | 13 | 1 |
| 17 | 13 | 14 | 1 |
| 18 | 14 | 16 | 1 |
| 19 | 10 | 9 | 2 |
| 20 | 16 | 15 | 2 |
| 21 | 10 | 18 | 2 |
| 22 | 18 | 19 | 2 |
| 23 | 16 | 17 | 2 |
| 24 | 17 | 20 | 2 |
| 25 | 20 | 21 | 2 |
| 26 | 19 | 21 | 2 |
| 27 | 18 | 17 | 4 |

**JOINT COORDIATES**

| JNT | X-C | Y-C |
|---|---|---|
| 1 | 93 | 0 |
| 2 | 228 | 0 |
| 3 | 363 | 0 |
| 4 | 498 | 0 |
| 5 | 498 | 200 |
| 6 | 363 | 200 |
| 7 | 228 | 200 |
| 8 | 93 | 200 |
| 9 | 93 | 326 |
| 10 | 0 | 419 |
| 11 | 93 | 419 |
| 12 | 228 | 419 |
| 14 | 363 | 419 |
| 14 | 498 | 419 |
| 15 | 498 | 326 |
| 16 | 591 | 419 |
| 17 | 591 | 739 |
| 18 | 0 | 739 |
| 19 | 0 | 1047 |
| 20 | 591 | 1047 |
| 21 | 295.5 | 1197 |

**SPRING CONSTANTS ?** *1*

**SUPPORTED JOINTS ?** 4

| JNT | X-R | Y-R | R-R |
|---|---|---|---|
| *4* | *1* | *1* | *0* |
| *3* | *1* | *1* | *1* |
| *2* | *1* | *1* | *1* |
| *1* | *1* | *1* | *0* |

**JOINT HINGES ?** *4 at 11, 12, 13 and 14*
**HINGED BAR MEMBERS ?** *1 at 27*
**MEMBER HINGES ?** *2 at 19, 9 and 20, 15*

# Input Data Loading Case 1

**TITLE ?** *CASE-1 LOADING*
**LOADED MEMBERS ?** *3*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *11, 1* | *3* | *10* |
| *15, 1* | *3* | *11.5* |
| *27, 2* | *6* | *0.005, 0.008, 110, 375* |
| | *1* | *1.95, 280* |

**SAME LOAD MEMBER-SETS ?** *2*
**1st Set:** *3 members 11, 12 and 13*
**2nd Set:** *3 members 15, 16 and 17*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *3*

| JNT | FX | FY | M |
|---|---|---|---|
| *8* | *3.87* | *0* | *0* |
| *18* | *3.85* | *0* | *0* |
| *19* | *2.75* | *0* | *0* |

**SAME-LOAD JOINT SETS ?** *1*
**1st Set:** *2 joints 8 and 10*

# Input Data Loading Case 2

**TITLE ?** *CASE-2 LOADING*

**LOADED MEMBERS ?** *17*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS | |
|---|---|---|---|
| *27, 2* | *22* | *5, 1, 180, 380* | *at 46°* |
| | *29* | *3, 478, 554* | *at 130°* |
| *26, 2* | *33* | *2.25* | |
| | *46* | *0.01, 0.006, 70, 310* | |
| *25, 1* | *26* | *0.02, 0.01, 62, 257* | *at 320°* |
| *24, 1* | *14* | *-0.02* | |
| *22, 1* | *34* | *0.015* | |
| *23, 1* | *42* | *7, 1, 40, 260* | |
| *15, 1* | *1* | *2.5, 65* | |
| *16, 1* | *11* | *-4, 60* | |
| *17, 1* | *21* | *3.7, 65* | *at 234°* |
| *20, 2* | *41* | *10, 75* | |
| | *31* | *6, 42* | |
| *11, 1* | *27* | *5, 28, 100* | *at 300°* |
| *12, 1* | *25* | *7, 40, 110* | *at 55°* |
| *13, 1* | *23* | *8* | *at 225°* |
| *1, 2* | *34* | *0.015* | |
| | *45* | *1.5, 48, 165* | |
| *6, 1* | *2* | *4, -2, 65, 180* | |
| *8, 1* | *8* | *6, 160* | |
| *19, 1* | *33* | *1.395* | |

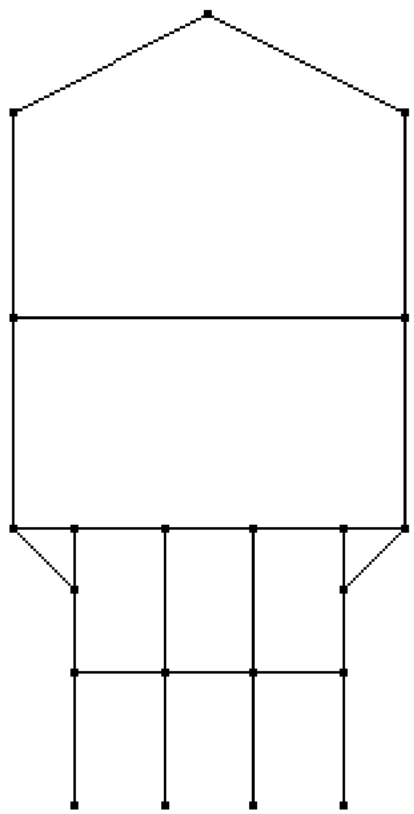
**SAME LOAD MEMBER-SETS ?** *1*

**1st Set:** *3 members 22, 21, 2*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *0*

**SAME-LOAD JOINT SETS ?** *0*

```
=====================================================================
TECHNO CONSULTANTS LTD                          PROG: SK9/IBM 880113
PORTLAND HOUSE                                  JOB NO:EXAMPLE 1
103 PORTLAND STREET                             DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                               PAGE NO:
TEL 061 236 0104                                DESIGNER:SURK
PROJECT:SAMPLE PROBLEM 1 FOR ANALYSIS BY SKELETON-9
=====================================================================
```



```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM1
TITLE: SAMPLE PROBLEM 1
UNITS: KN , CM
JOINTS= 21         MEMBERS= 27                 SECTIONS= 4
D-OF-I= 16         VOLUME = 229766.6 CM3       SELF WT = 0 KN
```

SECTION DETAILS

| SEC | MODULUS KN/CM2 | AREA CM2 | INERTIA CM4 | UNIT WT KN/CM3 |
|---|---|---|---|---|
| 1 | 21000 | 28.4 | 2867 | 0 |
| 2 | 21000 | 41.8 | 6481 | 0 |
| 3 | 21000 | 32.3 | 2356 | 0 |
| 4 | 21000 | 95 | 27329 | 0 |

MEMBER DETAILS

| MEM | JNT1 | JNT2 | SEC | X-PROJ CM | Y-PROJ CM |
|---|---|---|---|---|---|
| 1 | 1* | 8 | 3 | 0 | 200 |
| 2 | 8 | 9 | 3 | 0 | 126 |
| 3 | 9 | 11* | 3 | 0 | 93 |
| 4 | 2 | 7 | 3 | 0 | 200 |
| 5 | 7 | 12* | 3 | 0 | 219 |
| 6 | 3 | 6 | 3 | 0 | 200 |
| 7 | 6 | 13* | 3 | 0 | 219 |
| 8 | 4* | 5 | 3 | 0 | 200 |
| 9 | 5 | 15 | 3 | 0 | 126 |
| 10 | 15 | 14* | 3 | 0 | 93 |
| 11 | 8 | 7 | 1 | 135 | 0 |
| 12 | 7 | 6 | 1 | 135 | 0 |
| 13 | 6 | 5 | 1 | 135 | 0 |
| 14 | 10 | 11* | 1 | 93 | 0 |

```
 15    11*   12*   1     135              0
 16    12*   13*   1     135              0
 17    13*   14*   1     135              0
 18    14*   16    1     93               0
 19    10    9*    2     93              -93
 20    16    15*   2    -93              -93
 21    10    18    2     0                320
 22    18    19    2     0                308
 23    16    17    2     0                320
 24    17    20    2     0                308
 25    20    21    2    -295.5            150
 26    19    21    2     295.5            150
 27    18*   17*   4     591              0

JOINT COORDINATES
JNT    X-AXIS CM        Y-AXIS CM
 1*     93               0
 2      228              0
 3      363              0
 4*     498              0
 5      498              200
 6      363              200
 7      228              200
 8      93               200
 9      93               326
 10     0                419
 11*    93               419
 12*    228              419
 13*    363              419
 14*    498              419
 15     498              326
 16     591              419
 17     591              739
 18     0                739
 19     0                1047
 20     591              1047
 21     295.5            1197

JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       *       0 DEG
 2      1       1       1       0 DEG
 3      1       1       1       0 DEG
 4      1       1       *       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (KN/CM OR KN-CM/RAD)=  1
0) FREE               1) INFINITY


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM1 .A1
TITLE: CASE-1 LOADING

LOADED MEMBERS= 3
MEM  TYPE     LOAD-DETAILS
 11   T3      W = 10 KN
 15   T3      W = 11.5 KN
 27   T6      Q>= .005 KN/CM           Q<= .008 KN/CM
              A = 110 CM               B = 375 CM
      T1      P = 1.95 KN              A = 280 CM
```

SAME-LOAD MEMBER-SETS 2
AS MEMBER 11
12 13
AS MEMBER 15
16 17

JOINT LOADS

| JNT | X-AXIS KN | Y-AXIS KN | MOMENT KN-CM |
|---|---|---|---|
| 8 | 3.87 | 0 | 0 |
| 10 | 3.87 | 0 | 0 |
| 18 | 3.85 | 0 | 0 |
| 19 | 2.75 | 0 | 0 |

AS JOINT 8
10

JOINT DISPLACEMENTS

| JNT | X-AXIS CM | Y-AXIS CM | ROTATION RAD |
|---|---|---|---|
| 1 | 0 | 0 | ** |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | ** |
| 5 | .119715 | 8.350966E-03 | 3.438583E-04 |
| 6 | .120104 | 6.445508E-03 | 3.334307E-04 |
| 7 | .120715 | 6.531472E-03 | 3.32515E-04 |
| 8 | .12156 | -1.226958E-03 | 4.825122E-04 |
| 9 | .308198 | -3.510387E-04 | 2.462499E-03 |
| 10 | .583665 | -.277494 | 3.103956E-03 |
| 11 | .581313 | 7.580201E-04 | ** |
| 12 | .579742 | 1.024443E-02 | ** |
| 13 | .579406 | 1.015847E-02 | ** |
| 14 | .580306 | 1.079702E-02 | ** |
| 15 | .296047 | 1.029347E-02 | 2.496418E-03 |
| 16 | .582424 | .299244 | 3.201048E-03 |
| 17 | 1.676992 | .30096 | 3.238611E-03 |
| 18 | 1.67762 | -.277871 | 3.307033E-03 |
| 19 | 2.477048 | -.27894 | 1.690212E-03 |
| 20 | 2.462874 | .302029 | 1.738902E-03 |
| 21 | 2.617999 | -1.613246E-03 | 6.184576E-04 |

MEMBER-HINGE/CANT-END ROTATIONS 10

| MEM | JNT1 | JNT2 | ROTATION RAD |
|---|---|---|---|
| 1 | 1* | 8 | 6.704434E-04 |
| 3 | 9 | 11* | 3.173838E-03 |
| 5 | 7 | 12* | 2.977762E-03 |
| 7 | 6 | 13* | 2.979187E-03 |
| 8 | 4* | 5 | 7.259347E-04 |
| 10 | 15 | 14* | 3.33661E-03 |
| 14 | 10 | 11* | 2.935954E-03 |
| 18 | 14* | 16 | 3.05184E-03 |
| 19 | 10 | 9* | 2.904552E-03 |
| 20 | 16 | 15* | 3.039214E-03 |

MEMBER FORCES

| MEM | JNT1 | JNT2 | AXIAL KN | SHEAR KN | MOMENT KN-CM |
|---|---|---|---|---|---|
| 1 | 1* | 8 | -4.1612 | .4649 | -7.1997E-06 |
| | | | -4.1612 | -.4649 | 92.9809 |
| 2 | 8 | 9 | 4.7154 | .3271 | -798.0847 |
| | | | 4.7154 | -.3271 | -756.8646 |
| 3 | 9 | 11* | 8.089 | 8.1383 | -756.8649 |
| | | | 8.089 | -8.1383 | 1.2387E-04 |
| 4 | 2 | 7 | 22.1515 | 6.491 | -731.3599 |
| | | | 22.1515 | -6.491 | 566.8448 |
| 5 | 7 | 12* | 11.5 | 5.4576 | -1195.217 |
| | | | 11.5 | -5.4576 | -1.052E-04 |
| 6 | 3 | 6 | 21.8599 | 6.4389 | -726.3732 |
| | | | 21.8599 | -6.4389 | 561.405 |
| 7 | 6 | 13* | 11.5 | 5.4587 | -1195.447 |
| | | | 11.5 | -5.4587 | -5.2601E-05 |
| 8 | 4* | 5 | 28.3223 | .9452 | 1.4399E-05 |
| | | | 28.3223 | -.9452 | 189.0361 |
| 9 | 5 | 15 | 10.4571 | -.7734 | -796.5134 |

| | | | | | |
|---|---|---|---|---|---|
| | | | 10.4571 | .7734 | -893.9637 |
| 10 | 15 | 14* | 3.6727 | 9.6125 | -893.963 |
| | | | 3.6727 | -9.6125 | -7.432E-04 |
| 11 | 8 | 7 | 3.7323 | -8.8766 | 891.0658 |
| | | | 3.7323 | 18.8766 | -982.275 |
| 12 | 7 | 6 | 2.6988 | -8.2251 | 779.7865 |
| | | | 2.6988 | 18.2251 | -1005.603 |
| 13 | 6 | 5 | 1.7186 | -7.8652 | 751.2485 |
| | | | 1.7186 | 17.8652 | -985.5494 |
| 14 | 10 | 11* | 15.0801 | -2.339 | 217.5243 |
| | | | 15.0801 | 2.339 | 3.7683E-04 |
| 15 | 11* | 12* | 6.9419 | 5.75 | |
| | | | 6.9419 | 5.75 | |
| 16 | 12* | 13* | 1.4843 | 5.75 | |
| | | | 1.4843 | 5.75 | |
| 17 | 13* | 14* | -3.9743 | 5.75 | |
| | | | -3.9743 | 5.75 | |
| 18 | 14* | 16 | -13.5871 | -2.0773 | -4.4277E-04 |
| | | | -13.5871 | 2.0773 | -193.191 |
| 19 | 10 | 9* | -7.9089 | -3.1379 | 412.6959 |
| | | | -7.9089 | 3.1379 | -1.1746E-03 |
| 20 | 16 | 15* | 12.1413 | -2.5466 | 334.9376 |
| | | | 12.1413 | 2.5466 | -6.3246E-04 |
| 21 | 10 | 18 | -1.0346 | 3.399 | -630.2197 |
| | | | -1.0346 | -3.399 | 457.4761 |
| 22 | 18 | 19 | -3.0468 | 1.6687 | 457.4769 |
| | | | -3.0468 | -1.6687 | 971.4261 |
| 23 | 16 | 17 | 4.7071 | 3.2009 | -528.1276 |
| | | | 4.7071 | -3.2009 | 496.1759 |
| 24 | 17 | 20 | 3.0468 | 1.0813 | 496.1761 |
| | | | 3.0468 | -1.0813 | 829.2258 |
| 25 | 20 | 21 | 2.343 | -2.2274 | 829.2255 |
| | | | 2.343 | 2.2274 | 91.0975 |
| 26 | 19 | 21 | -.4149 | -3.2063 | 971.4274 |
| | | | -.4149 | 3.2063 | -91.0979 |
| 27 | 18* | 17* | 2.1199 | 2.0122 | |
| | | | 2.1199 | 1.6603 | |

MEMBER DEFORMATIONS

| MEM | JNT1- | JNT2 | AXIAL CM | SWAY CM | ROTATION RAD |
|---|---|---|---|---|---|
| 1 | 1* | 8 | -1.226958E-03 | .12156 | 6.264374E-05 |
| | | | | | -1.252875E-04 |
| 2 | 8 | 9 | 8.759198E-04 | .186638 | -9.987411E-04 |
| | | | | | 9.812453E-04 |
| 3 | 9 | 11* | 1.109059E-03 | .273115 | -4.742261E-04 |
| | | | | | 2.37113E-04 |
| 4 | 2 | 7 | 6.531472E-03 | .120715 | -6.035755E-04 |
| | | | | | -2.710605E-04 |
| 5 | 7 | 12* | 3.712959E-03 | .459027 | -1.763498E-03 |
| | | | | | 8.81749E-04 |
| 6 | 3 | 6 | 6.445508E-03 | .120104 | -6.00521E-04 |
| | | | | | -2.670903E-04 |
| 7 | 6 | 13* | 3.712959E-03 | .459302 | -1.763837E-03 |
| | | | | | 8.819188E-04 |
| 8 | 4* | 5 | 8.350966E-03 | .119715 | 1.273588E-04 |
| | | | | | -2.547176E-04 |
| 9 | 5 | 15 | 1.942501E-03 | .176332 | -1.055599E-03 |
| | | | | | 1.096961E-03 |
| 10 | 15 | 14* | 5.035503E-04 | .284259 | -5.601274E-04 |
| | | | | | 2.800641E-04 |
| 11 | 8 | 7 | 8.448288E-04 | 7.758431E-03 | 4.250423E-04 |
| | | | | | 2.750452E-04 |
| 12 | 7 | 6 | 6.108955E-04 | -8.59648E-05 | 3.331518E-04 |
| | | | | | 3.340675E-04 |
| 13 | 6 | 5 | 3.890246E-04 | 1.905459E-03 | 3.193162E-04 |
| | | | | | 3.297438E-04 |
| 14 | 10 | 11* | 2.351522E-03 | .278252 | 1.120012E-04 |
| | | | | | -5.600076E-05 |
| 15 | 11* | 12* | 1.571357E-03 | 9.486411E-03 | 1.450465E-04 |
| | | | | | -1.450465E-04 |
| 16 | 12* | 13* | 3.359914E-04 | -8.59648E-05 | 1.450465E-04 |
| | | | | | -1.450465E-04 |
| 17 | 13* | 14* | -8.996129E-04 | 6.38552E-04 | 1.450465E-04 |

```
                                                             -1.450465E-04
 18  14*  16   -2.118707E-03       .288447                  -4.973631E-05
                                                              9.947228E-05
 19  10   9*   -1.185003E-03       .390754                    1.329367E-04
                                                             -6.646808E-05
 20  16   15*   1.819153E-03       .406818                    1.078894E-04
                                                             -5.394456E-05
 21  10   18   -3.771782E-04       1.093955                  -3.146539E-04
                                                             -1.115769E-04
 22  18   19   -1.069039E-03       .799428                    7.114875E-04
                                                             -9.053342E-04
 23  16   17    1.715958E-03       1.094568                  -2.194759E-04
                                                             -1.819136E-04
 24  17   20    1.069069E-03       .785882                    6.870462E-04
                                                             -8.126628E-04
 25  20   21    8.845339E-04       .340971                    7.099939E-04
                                                             -4.104502E-04
 26  19   21   -1.56638E-04        .31109                     7.514716E-04
                                                             -3.202824E-04
 27  18*  17*   6.279945E-04       .578831                    1.375077E-04
                                                             -1.300934E-04

SUPPORT REACTIONS
JNT  X-AXIS KN         Y-AXIS KN         MOMENT KN-CM     ANGLE
 1  -.4649              4.1612           -7.1997E-06        0 DEG
 2  -6.491            -22.1515           -731.3599          0 DEG
 3  -6.4389           -21.8599           -726.3732          0 DEG
 4  -.9452            -28.3223            1.4399E-05        0 DEG
===============================================================
ALL -14.34            -68.1725           -1457.733         0 DEG

                   LOAD ANALYSIS NO 2
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM1 .A2
TITLE: CASE-2 LOADING

LOADED MEMBERS= 17
MEM  TYPE     LOAD-DETAILS
 1    T34     Q = .015 KN/CM
      T45     W = 1.5 KN
              A = 48 CM                 B = 165 CM
 6    T2      N = 4                     P =-2 KN
              A = 65 CM                 B = 180 CM
 8    T8      M = 6 KN-CM               A = 160 CM
 11   T27     W>= 5 KN
              A = 28 CM                 B = 100 CM
              INCLINATION: 300 DEG
 12   T25     W = 7 KN
              A = 40 CM                 B = 110 CM
              INCLINATION: 55 DEG
 13   T23     W = 8 KN
              INCLINATION: 225 DEG
 15   T1      P = 2.5 KN                A = 65 CM
 16   T11     P =-4 KN                  A = 60 CM
 17   T21     P = 3.7 KN                A = 65 CM
              INCLINATION: 234 DEG
 19   T33     W = 1.395 KN
 20   T41     P = 10 KN                 A = 75 CM
      T31     P = 6 KN                  A = 42 CM
 22   T34     Q = .015 KN/CM
 23   T42     N = 7                     P = 1 KN
              A = 40 CM                 B = 260 CM
 24   T14     Q =-.02 KN/CM
 25   T26     Q>= .02 KN/CM             Q<= .01 KN/CM
              A = 62 CM                 B = 257 CM
              INCLINATION: 320 DEG
 26   T33     W = 2.25 KN
      T46     Q>= .01 KN/CM             Q<= .006 KN/CM
              A = 70 CM                 B = 310 CM
 27   T22     N = 5                     P = 1 KN
              A = 180 CM                B = 380 CM
              INCLINATION: 46 DEG
      T29     W<= 3 KN
```

A = 478 CM          B = 554 CM
INCLINATION: 130 DEG

SAME-LOAD MEMBER-SETS 1
AS MEMBER 22
2 21

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS

| JNT | X-AXIS CM | Y-AXIS CM | ROTATION RAD |
|---|---|---|---|
| 1 | 0 | 0 | ** |
| 2 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 |
| 4 | 0 | 0 | ** |
| 5 | .152618 | 1.513482E-02 | 6.307152E-04 |
| 6 | .153819 | 6.428857E-04 | 6.052864E-04 |
| 7 | .155121 | 8.255711E-04 | 5.778243E-04 |
| 8 | .156191 | -7.840767E-03 | 7.682716E-04 |
| 9 | .524333 | -7.913952E-03 | 4.888508E-03 |
| 10 | 1.06505 | -.551511 | 6.05118E-03 |
| 11 | 1.061577 | -7.169174E-03 | ** |
| 12 | 1.059987 | 1.214206E-03 | ** |
| 13 | 1.06139 | 1.417609E-04 | ** |
| 14 | 1.065418 | 2.130217E-02 | ** |
| 15 | .478313 | 2.143474E-02 | 4.948464E-03 |
| 16 | 1.071682 | .624118 | 6.459179E-03 |
| 17 | 3.131079 | .632006 | 6.023908E-03 |
| 18 | 3.130988 | -.552127 | 6.136546E-03 |
| 19 | 4.629582 | -.55347 | 3.317699E-03 |
| 20 | 4.630413 | .636046 | 3.325948E-03 |
| 21 | 4.933331 | 4.392319E-02 | 1.353189E-03 |

MEMBER-HINGE/CANT-END ROTATIONS 10

| MEM | JNT1 | JNT2 | ROTATION RAD |
|---|---|---|---|
| 1 | 1* | 8 | 8.378297E-04 |
| 3 | 9 | 11* | 6.22098E-03 |
| 5 | 7 | 12* | 5.908799E-03 |
| 7 | 6 | 13* | 5.913597E-03 |
| 8 | 4* | 5 | 8.275833E-04 |
| 10 | 15 | 14* | 6.995206E-03 |
| 14 | 10 | 11* | 5.754118E-03 |
| 18 | 14* | 16 | 6.493247E-03 |
| 19 | 10 | 9* | 5.721492E-03 |
| 20 | 16 | 15* | 6.456746E-03 |

MEMBER FORCES

| MEM | JNT1 | JNT2 | AXIAL KN | SHEAR KN | MOMENT KN-CM |
|---|---|---|---|---|---|
| 1 | 1* | 8 | -25.8907 | 1.1721 | -5.3998E-05 |
| | | | -27.3907 | 1.8279 | -65.5854 |
| 2 | 8 | 9 | -.394 | 4.4366 | -1857.698 |
| | | | -.394 | -2.5466 | -1417.751 |
| 3 | 9 | 11* | 5.4321 | 15.2447 | -1417.752 |
| | | | 5.4321 | -15.2447 | 1.5483E-03 |
| 4 | 2 | 7 | 2.7999 | 7.2239 | -865.3332 |
| | | | 2.7999 | -7.2239 | 579.4488 |
| 5 | 7 | 12* | 1.2037 | 10.9987 | -2408.724 |
| | | | 1.2037 | -10.9987 | -1.052E-04 |
| 6 | 3 | 6 | 2.1803 | 4.0027 | -706.8645 |
| | | | 2.1803 | -12.0027 | 713.6708 |
| 7 | 6 | 13* | -1.5521 | 10.952 | -2398.484 |
| | | | -1.5521 | -10.952 | 0 |
| 8 | 4* | 5 | 51.3297 | .475 | -3.5999E-05 |
| | | | 51.3297 | -.475 | 101.0025 |
| 9 | 5 | 15 | 33.9146 | -7.6555 | -1213.138 |
| | | | 33.9146 | 7.6555 | -2177.734 |
| 10 | 15 | 14* | -.9669 | 23.4164 | -2177.732 |
| | | | -.9669 | -23.4164 | -2.3535E-03 |
| 11 | 8 | 7 | 6.2646 | -26.9967 | 1792.113 |
| | | | 3.7646 | 22.6666 | -1493.044 |
| 12 | 7 | 6 | 7.5394 | -21.0704 | 1495.129 |

| | | | | | |
|---|---|---|---|---|---|
| | | | 3.5244 | 26.8044 | -1693.416 |
| 13 | 6 | 5 | 2.4737 | -23.072 | 1418.739 |
| | | | 8.1305 | 17.4151 | -1314.141 |
| 14 | 10 | 11* | 22.2692 | -4.1358 | 384.6274 |
| | | | 22.2692 | 4.1358 | 3.203E-04 |
| 15 | 11* | 12* | 7.0254 | 1.2963 | |
| | | | 7.0254 | 1.2037 | |
| 16 | 12* | 13* | -3.9737 | 0 | |
| | | | -7.9737 | 0 | |
| 17 | 13* | 14* | -18.9255 | -1.5521 | |
| | | | -16.7507 | -1.4412 | |
| 18 | 14* | 16 | -40.1679 | .4743 | 1.2647E-03 |
| | | | -40.1679 | -.4743 | 44.1088 |
| 19 | 10 | 9* | -14.0851 | -5.8456 | 703.9586 |
| | | | -13.0987 | 4.8592 | -3.3731E-03 |
| 20 | 16 | 15* | 43.8075 | -8.62 | 354.2338 |
| | | | 46.6359 | -2.6938 | 2.2588E-04 |
| 21 | 10 | 18 | -1.6903 | 8.1767 | -1088.583 |
| | | | -1.6903 | -3.3767 | 759.9676 |
| 22 | 18 | 19 | -3.8254 | 4.6935 | 759.968 |
| | | | -3.8254 | -.0735 | 1494.092 |
| 23 | 16 | 17 | 25.3559 | 3.0953 | -310.1224 |
| | | | 18.3559 | -3.0953 | 680.3778 |
| 24 | 17 | 20 | 14.596 | 3.3235 | 680.3785 |
| | | | 8.436 | -3.3235 | 1704.005 |
| 25 | 20 | 21 | 6.7819 | -6.0181 | 1704.005 |
| | | | 4.5412 | 4.1379 | 53.2109 |
| 26 | 19 | 21 | -1.7966 | -3.3778 | 1494.092 |
| | | | -.6594 | 6.1083 | -53.212 |
| 27 | 18* | 17* | 1.3169 | 2.1351 | |
| | | | -.228 | 3.7598 | |

MEMBER DEFORMATIONS

| MEM | JNT1 | -JNT2 | AXIAL CM | SWAY CM | ROTATION RAD |
|---|---|---|---|---|---|
| 1 | 1* | 8 | -7.840767E-03 | .156191 | 5.687238E-05 |
| | | | | | -1.268577E-05 |
| 2 | 8 | 9 | -7.318519E-05 | .368141 | -2.153486E-03 |
| | | | | | 1.966751E-03 |
| 3 | 9 | 11* | 7.447782E-04 | .537245 | -8.883152E-04 |
| | | | | | 4.441569E-04 |
| 4 | 2 | 7 | 8.255711E-04 | .155121 | -7.756067E-04 |
| | | | | | -1.977824E-04 |
| 5 | 7 | 12* | 3.886349E-04 | .904866 | -3.553983E-03 |
| | | | | | 1.776992E-03 |
| 6 | 3 | 6 | 6.428857E-04 | .153819 | -7.690933E-04 |
| | | | | | -1.63807E-04 |
| 7 | 6 | 13* | -5.011248E-04 | .907571 | -3.538874E-03 |
| | | | | | 1.769437E-03 |
| 8 | 4* | 5 | 1.513482E-02 | .152618 | 6.449083E-05 |
| | | | | | -1.323773E-04 |
| 9 | 5 | 15 | 6.299925E-03 | .325695 | -1.954164E-03 |
| | | | | | 2.363585E-03 |
| 10 | 15 | 14* | -1.325756E-04 | .587105 | -1.364494E-03 |
| | | | | | 6.822482E-04 |
| 11 | 8 | 7 | 1.070127E-03 | 8.666337E-03 | 7.040765E-04 |
| | | | | | 5.136292E-04 |
| 12 | 7 | 6 | 1.302674E-03 | -1.826853E-04 | 5.791775E-04 |
| | | | | | 6.066396E-04 |
| 13 | 6 | 5 | 1.200169E-03 | 1.449193E-02 | 4.979388E-04 |
| | | | | | 5.233675E-04 |
| 14 | 10 | 11* | 3.472567E-03 | .544342 | 1.98041E-04 |
| | | | | | -9.902062E-05 |
| 15 | 11* | 12* | 1.590252E-03 | 8.383379E-03 | 4.7816E-05 |
| | | | | | -4.664975E-05 |
| 16 | 12* | 13* | -1.402497E-03 | -1.072445E-03 | 0 |
| | | | | | 0 |
| 17 | 13* | 14* | -4.028678E-03 | 2.116041E-02 | -5.725224E-05 |
| | | | | | 5.585585E-05 |
| 18 | 14* | 16 | -6.263614E-03 | .602816 | 1.135625E-05 |
| | | | | | -2.271153E-05 |
| 19 | 10 | 9* | -2.03649E-03 | .766726 | 2.215337E-04 |
| | | | | | -1.081541E-04 |
| 20 | 16 | 15* | 6.58636E-03 | .845736 | 2.879227E-05 |

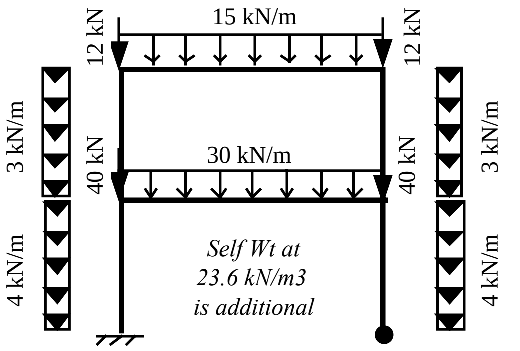
| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2.635918E-05 |
| 21 | 10 | 18 | -6.161928E-04 | 2.065938 | -4.048748E-04 |
| | | | | | -3.195088E-04 |
| 22 | 18 | 19 | -1.342237E-03 | 1.498595 | 1.270978E-03 |
| | | | | | -1.547869E-03 |
| 23 | 16 | 17 | 7.887781E-03 | 2.059397 | 2.356404E-05 |
| | | | | | -4.117073E-04 |
| 24 | 17 | 20 | 4.040718E-03 | 1.499334 | 1.155939E-03 |
| | | | | | -1.542021E-03 |
| 25 | 20 | 21 | 2.09391E-03 | .665105 | 1.318939E-03 |
| | | | | | -6.538199E-04 |
| 26 | 19 | 21 | -4.494469E-04 | .67018 | 1.295377E-03 |
| | | | | | -6.691333E-04 |
| 27 | 18* | 17* | -9.10759E-05 | 1.184133 | 1.548149E-04 |
| | | | | | -1.677199E-04 |

SUPPORT REACTIONS

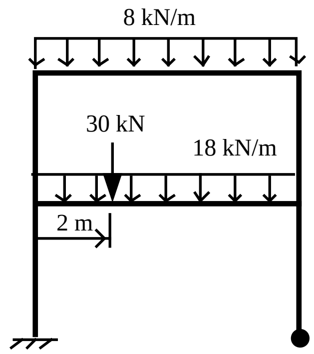
| JNT | X-AXIS KN | Y-AXIS KN | MOMENT KN-CM | ANGLE |
|---|---|---|---|---|
| 1 | -1.1721 | 25.8907 | -5.3998E-05 | 0 DEG |
| 2 | -7.2239 | -2.7999 | -865.3332 | 0 DEG |
| 3 | -4.0027 | -2.1803 | -706.8645 | 0 DEG |
| 4 | -.475 | -51.3297 | -3.5999E-05 | 0 DEG |
| ALL | -12.8737 | -30.4193 | -1572.198 | 0 DEG |

# SAMPLE PROBLEM 2

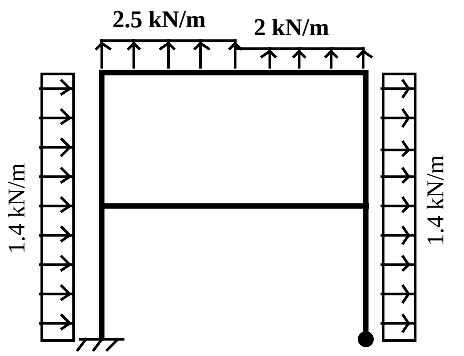
## Dead, Live & Wind Load
## Combination Analyses



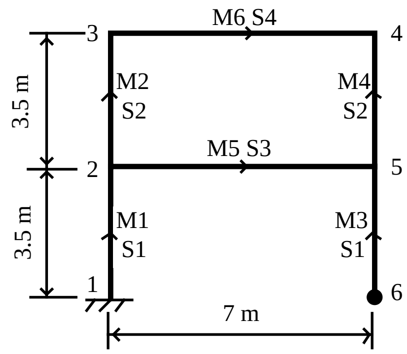

**Dead Loads**




**Live Loads**




**Wind Loads**




**Joint, Member & Section Numbering**

## Analyses Under Basic Loads

Load Case-1: Dead Loads *(Self Wt to be included by SKELETON at 23.6 kN/m3)*
Load Case-2: Live Loads
Load Case-3: Wind Loads

## Analyses Using Load Combination Facility:

Comb-Case-1: 1.4 Dead + 1.6 Live
Comb-Case-2: 0.9 Dead + 1.4 Live
Comb-Case-3: 1.2 (Dead+Live+Wind)

## Post Member Analyses (Interactive) along Member Spans:

Member-5 Load Case 2

Print *Heading, Member-Details, Member Loads, D-A-S-M Diagram, Max/Min Results and End Forces* from Analysis Results at 11 Span Points

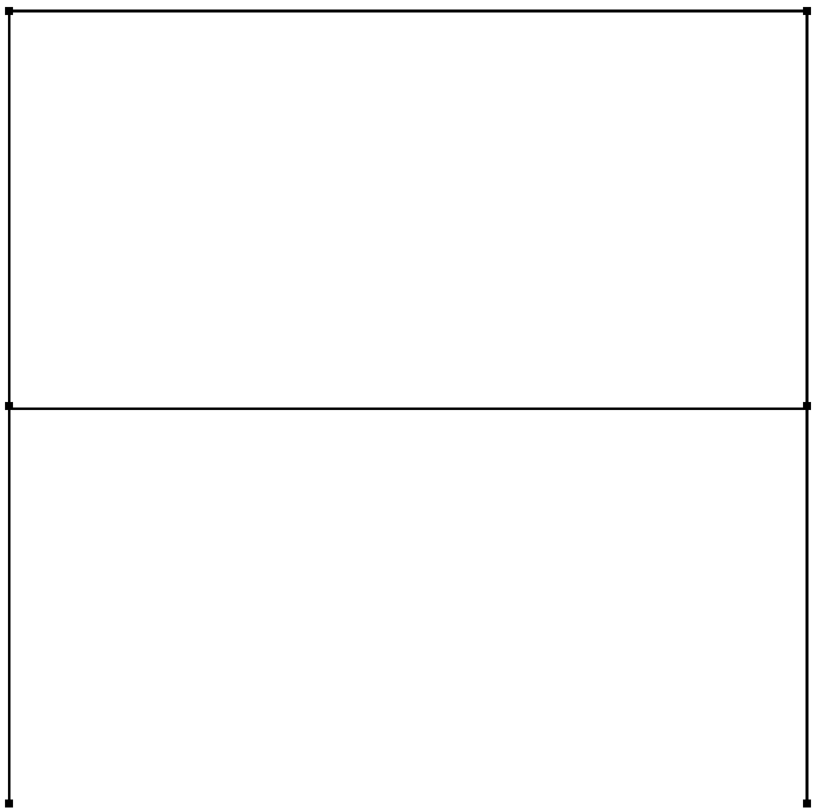
Member-5 Comb Case 1

Print Full Analysis Results viz *Heading, Member-Details, Member Loads, D-A-S-M Diagram, Max/Min Results, Results, Displacements and End Forces* from Analysis at 21 Span Points

Member-6 Comb Case 3

Print Full Analysis Results as above from Analysis at 17 Span Points

```
==========================================================================
TECHNO CONSULTANTS LTD                               PROG: SK9/IBM 880113
PORTLAND HOUSE                                       JOB NO:EXAMPLE 2
103 PORTLAND STREET                                  DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                                    PAGE NO:
TEL 061 236 0104                                     DESIGNER:SURK
PROJECT:DEAD LIVE & WIND LOAD COMBINATIONS SAMPLE PROBLEM 3 SKELETON9
==========================================================================
```



```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM2
TITLE: SAMPLE PROBLEM 2
UNITS: KN , M
JOINTS= 6          MEMBERS= 6                  SECTIONS= 4
D-OF-I= 5          VOLUME = 6.44 M3            SELF WT = 151.984 KN

SECTION DETAILS
SEC  MODULUS KN/M2   AREA M2          INERTIA M4       UNIT WT KN/M3
 1     2.5E+07         .15              .0014            23.6
 2     2.5E+07         .12              .001             23.6
 3     2.5E+07         .4               .0058            23.6
 4     2.5E+07         .25              .0032            23.6

MEMBER DETAILS
MEM  JNT1  JNT2  SEC    X-PROJ M         Y-PROJ M
 1     1     2     1     0                 3.5
 2     2     3     2     0                 3.5
 3     6*    5     1     0                 3.5
 4     5     4     2     0                 3.5
 5     2     5     3     7                 0
 6     3     4     4     7                 0
```

```
JOINT COORDINATES
JNT    X-AXIS M         Y-AXIS M
 1      0                0
 2      0                3.5
 3      0                7
 4      7                7
 5      7                3.5
 6*     7                0

JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       1       0 DEG
 6      1       1       *       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (KN/M OR KN-M/RAD)=  1
0) FREE              1) INFINITY


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM2 .A1       SELF WT= 151.984 KN
TITLE: DEAD LOADS

LOADED MEMBERS= 6
MEM  TYPE     LOAD-DETAILS
 1    T0      SW= 12.39 KN
      T14     Q =-4 KN/M
 2    T0      SW= 9.912 KN
      T14     Q =-3 KN/M
 3    T0      SW= 12.39 KN
      T44     Q = 4 KN/M
 4    T0      SW= 9.912 KN
      T44     Q = 3 KN/M
 5    T0      SW= 66.08 KN
      T4      Q = 30 KN/M
 6    T0      SW= 41.3 KN
      T44     Q = 15 KN/M

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS KN           Y-AXIS KN           MOMENT KN-M
 2        0                   40                  0
 3        0                   12                  0
 4        0                   12                  0
 5        0                   40                  0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS M            Y-AXIS M            ROTATION RAD
 1       0                   0                   0
 2       1.066528E-03        2.755944E-04        1.445231E-03
 3       1.170453E-03        3.867555E-04        1.279499E-03
 4       .001134             3.897629E-04       -1.270981E-03
 5       1.079344E-03        2.784267E-04       -1.363188E-03
 6       0                   0                   **

MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*   5     1.14417E-03
```

```
MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN            SHEAR KN           MOMENT KN-M
 1   1     2     308.4747           -14.3278            10.6213
                 282.0847            14.3278           -39.5259
 2   2     3     105.487            -32.6369            58.2983
                 85.075              32.6369           -55.9307
 3   6*    5     311.5093            14.3278           -2.3283E-06
                 285.1194           -14.3278            50.1472
 4   5     4     105.637             32.6369           -57.7732
                 85.225             -32.6369            56.4559
 5   2     5    -18.309              136.5977          -97.8242
                -18.309              139.4823          -107.9203
 6   3     4     32.6369             73.075            -55.9307
                 32.6369             73.225            -56.4559

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL M             SWAY M             ROTATION RAD
 1   1     2     2.755944E-04       1.066528E-03      -3.047223E-04
                                                       1.140509E-03
 2   2     3     1.111611E-04       1.039251E-04       1.415538E-03
                                                       1.249806E-03
 3   6*    5     2.784267E-04       1.079344E-03       8.357862E-04
                                                      -1.671573E-03
 4   5     4     1.113362E-04       5.455548E-05      -1.378776E-03
                                                      -1.286569E-03
 5   2     5    -1.281628E-05       2.832356E-06       1.444826E-03
                                                      -1.363593E-03
 6   3     4     3.655336E-05       3.007386E-06       1.27907E-03
                                                      -1.271411E-03

SUPPORT REACTIONS
JNT  X-AXIS KN          Y-AXIS KN         MOMENT KN-M      ANGLE
 1   14.3278           -308.4747          10.6213           0 DEG
 6  -14.3278           -311.5093         -2.3283E-06        0 DEG
================================================================
ALL  0                 -619.984           10.6213          0 DEG


                   LOAD ANALYSIS NO 2
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM2 .A2
TITLE: LIVE LOADS

LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 5    T44     Q = 18 KN/M
      T1      P = 30 KN               A = 2 M
 6    T4      Q = 8 KN/M

SAME-LOAD MEMBER-SETS 0

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS M            Y-AXIS M            ROTATION RAD
 1       0                   0                   0
 2       8.046392E-04        1.041847E-04        9.704207E-04
 3       9.861646E-04        1.366537E-04        4.005168E-04
 4       9.687857E-04        1.265462E-04       -3.861117E-04
 5       8.093735E-04        9.368195E-05       -7.900042E-04
 6       0                   0                   **

MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*    5     7.418764E-04
```

```
MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN           SHEAR KN           MOMENT KN-M
 1   1    2      111.6265          -8.7536             5.6146
                 111.6265           8.7536            -25.023
 2   2    3      27.8306           -15.5168            31.2252
                 27.8306            15.5168           -23.0837
 3   6*   5      100.3735           8.7536             0
                 100.3735          -8.7536             30.6376
 4   5    4      28.1694            15.5168           -30.0394
                 28.1694           -15.5168            24.2695
 5   2    5     -6.7632             83.7959           -56.2482
                -6.7632             72.2041           -60.677
 6   3    4      15.5168            27.8306           -23.0837
                 15.5168            28.1694           -24.2695

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL M            SWAY M             ROTATION RAD
 1   1    2      1.041847E-04       8.046392E-04      -2.298969E-04
                                                       7.405237E-04
 2   2    3      3.246903E-05       1.815254E-04       9.185563E-04
                                                       3.486524E-04
 3   6*   5      9.368195E-05       8.093735E-04       5.106269E-04
                                                      -1.021254E-03
 4   5    4      3.28643E-05        1.594123E-04      -8.355506E-04
                                                      -4.316581E-04
 5   2    5     -4.734262E-06      -1.050277E-05       9.719211E-04
                                                      -7.885038E-04
 6   3    4      1.737883E-05      -1.01075E-05        4.019607E-04
                                                      -3.846678E-04

SUPPORT REACTIONS
JNT  X-AXIS KN         Y-AXIS KN         MOMENT KN-M      ANGLE
 1   8.7536           -111.6265          5.6146             0 DEG
 6  -8.7536           -100.3735          0                  0 DEG
================================================================
ALL -9.5367E-07       -212               5.6146             0 DEG


                   LOAD ANALYSIS NO 3
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM2 .A3
TITLE: WIND LOADS

LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 1    T34     Q = 1.4 KN/M
 6    T6      Q>=-2.5 KN/M              Q<=-2.5 KN/M
              A = 0 M                   B = 3.5 M
      T6      Q>=-2 KN/M                Q<=-2 KN/M
              A = 3.5 M                 B = 7 M

SAME-LOAD MEMBER-SETS 1
AS MEMBER  1
 2    3    4

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS M            Y-AXIS M            ROTATION RAD
 1       0                   0                   0
 2       1.628843E-03       -1.363303E-05        2.406207E-04
 3       2.327831E-03       -2.45249E-05        -1.547472E-04
 4       2.329387E-03       -8.5501E-06          2.526171E-04
 5       1.631008E-03       -1.066971E-06        5.98379E-05
 6       0                   0                   **
```

```
MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*   5     7.048136E-04

MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN             SHEAR KN            MOMENT KN-M
 1   1    2    -14.6068              14.2811            -24.5398
               -14.6068             -9.3811              16.869
 2   2    3    -9.3359               6.2894             -5.324
               -9.3359              -1.3894              8.1138
 3   6*   5    -1.1432               5.3189              2.3283E-06
               -1.1432              -.4189               10.0412
 4   5    4    -6.4141               3.5106             -4.6623
               -6.4141               1.3894             -.95
 5   2    5    -3.0917              -5.2709              22.193
               -3.0917               5.2709             -14.7035
 6   3    4    -1.3895              -9.3359              8.1138
               -1.3895              -6.4141              .95

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL M              SWAY M              ROTATION RAD
 1   1    2    -1.363303E-05         1.628843E-03       -4.653838E-04
                                                        -2.247632E-04
 2   2    3    -1.089187E-05         6.989873E-04        4.091004E-05
                                                        -3.544579E-04
 3   6*   5    -1.066971E-06         1.631008E-03        2.388114E-04
                                                        -4.061643E-04
 4   5    4    -7.483129E-06         6.983794E-04       -1.396991E-04
                                                         5.308016E-05
 5   2    5    -2.164161E-06         1.256606E-05        2.388255E-04
                                                         5.804275E-05
 6   3    4    -1.55624E-06          1.59748E-05        -1.570293E-04
                                                         2.50335E-04

SUPPORT REACTIONS
JNT  X-AXIS KN           Y-AXIS KN          MOMENT KN-M      ANGLE
 1  -14.2811             14.6068           -24.5398           0 DEG
 6  -5.3189              1.1432             2.3283E-06        0 DEG
===============================================================
ALL -19.6                15.75             -24.5398          0 DEG
```

```
=====================================================================
TECHNO CONSULTANTS LTD                          PROG: SK9/IBM 880113
PORTLAND HOUSE                                  JOB NO:EXAMPLE 2
103 PORTLAND STREET                             DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                               PAGE NO:
TEL 061 236 0104                                DESIGNER:SURK
PROJECT:DEAD LIVE & WIND LOAD COMBINATIONS SAMPLE PROBLEM 2 SKELETON9
=====================================================================


                   COMB ANALYSIS NO  1
                   ==================
COMB-FILE: C:\MANUAL\SAPBLM2 .D1
TITLE: 1.4 DEAD + 1.6 LIVE
COMBINATION DETAILS:
LOAD-CASE        FACTOR
 1                1.4
 2                1.6

** SELF WT = 212.7776 KN ( 151.984KN FACTORED AT 1.4

** LOAD-CASE  1 FACTORED AT  1.4
LOADED MEMBERS= 6
MEM  TYPE     LOAD-DETAILS
 1    T0      SW= 17.346 KN
      T14     Q =-5.6 KN/M
 2    T0      SW= 13.8768 KN
      T14     Q =-4.2 KN/M
 3    T0      SW= 17.346 KN
      T44     Q = 5.6 KN/M
 4    T0      SW= 13.8768 KN
      T44     Q = 4.2 KN/M
 5    T0      SW= 92.512 KN
      T4      Q = 42 KN/M
 6    T0      SW= 57.82 KN
      T44     Q = 21 KN/M

SAME-LOAD MEMBER-SETS 0

** LOAD-CASE  2 FACTORED AT  1.6
LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 5    T44     Q = 28.8 KN/M
      T1      P = 48 KN                 A = 2 M
 6    T4      Q = 12.8 KN/M

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS KN            Y-AXIS KN            MOMENT KN-M
 2        0                    56                   0
 3        0                    16.8                 0
 4        0                    16.8                 0
 5        0                    56                   0

JOINT DISPLACEMENTS
JNT      X-AXIS M             Y-AXIS M             ROTATION RAD
 1       0                    0                    0
 2       2.780562E-03         5.525277E-04         3.575996E-03
 3       3.216498E-03         7.601037E-04         2.432126E-03
 4       3.137517E-03         7.481421E-04        -2.397153E-03
 5       2.806079E-03         5.396885E-04        -3.172471E-03
 6       0                    0                    **

MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*   5     2.788841E-03

MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN            SHEAR KN           MOMENT KN-M
 1   1    2     610.467            -34.0646            23.8531
                573.5209            34.0646           -95.3731
```

```
 2   2    3     192.2107          -70.5186           131.578
                163.6339           70.5186          -115.237
 3   6*   5     596.7107           34.0646           0
                559.7647          -34.0646           119.2262
 4   5    4     192.9629           70.5186          -128.9455
                164.3861          -70.5186           117.8695
 5   2    5    -36.4536            325.3102         -226.9511
               -36.4536            310.8018         -248.1717
 6   3    4     70.5188            146.8339         -115.237
                70.5188            147.5861         -117.8695


MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL M            SWAY M            ROTATION RAD
 1   1    2     5.525277E-04       2.780562E-03     -7.944462E-04
                                                     2.78155E-03
 2   2    3     2.07576E-04        4.359358E-04      3.451443E-03
                                                     2.307573E-03
 3   6*   5     5.396885E-04       2.806079E-03      1.987104E-03
                                                    -3.974208E-03
 4   5    4     2.084536E-04       3.314372E-04     -3.267167E-03
                                                    -2.491849E-03
 5   2    5    -2.551754E-05      -1.283915E-05      3.57783E-03
                                                    -3.170636E-03
 6   3    4     7.898104E-05      -1.196162E-05      2.433835E-03
                                                    -2.395444E-03

SUPPORT REACTIONS
JNT  X-AXIS KN          Y-AXIS KN          MOMENT KN-M       ANGLE
 1   34.0646           -610.467            23.8531             0 DEG
 6  -34.0646           -596.7107           0                   0 DEG
==================================================================
ALL -3.8147E-06       -1207.178            23.8531           0 DEG


                   COMB ANALYSIS NO  2
                   ==================
COMB-FILE: C:\MANUAL\SAPBLM2 .D2
TITLE: 0.9 DEAD + 1.4 LIVE
COMBINATION DETAILS:
LOAD-CASE        FACTOR
 1                .9
 2                1.4

** SELF WT = 136.7856 KN ( 151.984KN FACTORED AT .9

** LOAD-CASE  1 FACTORED AT  .9
LOADED MEMBERS= 6
MEM  TYPE     LOAD-DETAILS
 1    T0      SW= 11.151 KN
      T14     Q =-3.6 KN/M
 2    T0      SW= 8.9208 KN
      T14     Q =-2.7 KN/M
 3    T0      SW= 11.151 KN
      T44     Q = 3.6 KN/M
 4    T0      SW= 8.9208 KN
      T44     Q = 2.7 KN/M
 5    T0      SW= 59.472 KN
      T4      Q = 27 KN/M
 6    T0      SW= 37.17 KN
      T44     Q = 13.5 KN/M

SAME-LOAD MEMBER-SETS 0

** LOAD-CASE  2 FACTORED AT  1.4
LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 5    T44     Q = 25.2 KN/M
      T1      P = 42 KN                 A = 2 M
 6    T4      Q = 11.2 KN/M

SAME-LOAD MEMBER-SETS 0
```

```
JOINT LOADS
JNT      X-AXIS KN            Y-AXIS KN           MOMENT KN-M
 2        0                    36                  0
 3        0                    10.8                0
 4        0                    10.8                0
 5        0                    36                  0

JOINT DISPLACEMENTS
JNT      X-AXIS M             Y-AXIS M            ROTATION RAD
 1       0                    0                   0
 2       2.08637E-03          3.938935E-04        2.659297E-03
 3       2.434038E-03         5.393952E-04        1.712273E-03
 4       2.37681E-03          5.279513E-04       -1.68444E-03
 5       2.104532E-03         3.817388E-04       -2.332876E-03
 6       0                    0                   **

MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*   5     2.06838E-03

MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN          SHEAR KN          MOMENT KN-M
 1   1    2     433.9043         -25.15              17.4196
                410.1533          25.15             -70.6055
 2   2    3     133.9011         -51.0968            96.1838
                115.5303          51.0968           -82.6549
 3   6*   5     420.8813          25.15             -4.6566E-06
                397.1303         -25.15              88.0251
 4   5    4     134.5105          51.0968           -94.051
                116.1397         -51.0968            84.7877
 5   2    5    -25.9463           240.2522          -166.7893
               -25.9463           226.6198          -182.0761
 6   3    4     51.0968           104.7303          -82.6549
                51.0968           105.3397          -84.7877


MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL M           SWAY M            ROTATION RAD
 1   1    2     3.938935E-04      2.08637E-03      -5.961057E-04
                                                    2.063191E-03
 2   2    3     1.455017E-04      3.476681E-04      2.559963E-03
                                                    1.612939E-03
 3   6*   5     3.817388E-04      2.104532E-03      1.467085E-03
                                                   -2.93417E-03
 4   5    4     1.462126E-04      2.722773E-04     -2.410669E-03
                                                   -1.762233E-03
 5   2    5    -1.816242E-05     -1.215478E-05      2.661033E-03
                                                   -2.331139E-03
 6   3    4     5.722838E-05     -1.144386E-05      1.713908E-03
                                                   -1.682805E-03

SUPPORT REACTIONS
JNT  X-AXIS KN         Y-AXIS KN         MOMENT KN-M      ANGLE
 1   25.15            -433.9043          17.4196           0 DEG
 6  -25.15            -420.8813         -4.6566E-06        0 DEG
=================================================================
ALL -3.8147E-06       -854.7856          17.4196          0 DEG


                   COMB ANALYSIS NO  3
                   ==================
COMB-FILE: C:\MANUAL\SAPBLM2 .D3
TITLE: 1.2 ( DEAD + LIVE + WIND )
COMBINATION DETAILS:
LOAD-CASE        FACTOR
 1                1.2
 2                1.2
 3                1.2

** SELF WT = 182.3808 KN ( 151.984KN FACTORED AT 1.2

** LOAD-CASE  1 FACTORED AT  1.2
LOADED MEMBERS= 6
```

```
MEM  TYPE     LOAD-DETAILS
 1    T0      SW= 14.868 KN
      T14     Q =-4.8 KN/M
 2    T0      SW= 11.8944 KN
      T14     Q =-3.6 KN/M
 3    T0      SW= 14.868 KN
      T44     Q = 4.8 KN/M
 4    T0      SW= 11.8944 KN
      T44     Q = 3.6 KN/M
 5    T0      SW= 79.296 KN
      T4      Q = 36 KN/M
 6    T0      SW= 49.56 KN
      T44     Q = 18 KN/M

SAME-LOAD MEMBER-SETS 0

** LOAD-CASE  2 FACTORED AT  1.2
LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 5    T44     Q = 21.6 KN/M
      T1      P = 36 KN                 A = 2 M
 6    T4      Q = 9.6 KN/M

SAME-LOAD MEMBER-SETS 0

** LOAD-CASE  3 FACTORED AT  1.2
LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 1    T34     Q = 1.68 KN/M
 6    T6      Q>=-3 KN/M                Q<=-3 KN/M
              A = 0 M                   B = 3.5 M
      T6      Q>=-2.4 KN/M              Q<=-2.4 KN/M
              A = 3.5 M                 B = 7 M

SAME-LOAD MEMBER-SETS 1
AS MEMBER  1
 2    3    4

JOINT LOADS
JNT      X-AXIS KN            Y-AXIS KN           MOMENT KN-M
 2        0                    48                  0
 3        0                    14.4                0
 4        0                    14.4                0
 5        0                    48                  0

JOINT DISPLACEMENTS
JNT      X-AXIS M             Y-AXIS M            ROTATION RAD
 1       0                    0                   0
 2       4.200013E-03         4.393753E-04        3.187527E-03
 3       5.381338E-03         5.986613E-04        1.830323E-03
 4       5.318487E-03         6.093109E-04       -1.685371E-03
 5       4.22367E-03          4.4525E-04         -2.512026E-03
 6       0                    0                   **

MEMBER-HINGE/CANT-END ROTATIONS  1
MEM JNT1-JNT2   ROTATION RAD
 3   6*   5     3.109033E-03

MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN            SHEAR KN           MOMENT KN-M
 1   1    2     486.5932           -10.5603           -9.9647
                454.9252            16.4403           -57.2158
 2   2    3     148.778            -50.2372            101.0395
                124.2836            56.1172           -85.0808
 3   6*   5     492.8876            34.0803            4.6566E-06
                461.2196           -28.2003            108.9912
 4   5    4     152.8708            61.9972           -110.9698
                128.3764           -56.1172            95.7305
 5   2    5    -33.7964             258.1472          -158.2553
               -33.7964             260.3488          -219.961
 6   3    4     56.1172             109.8836          -85.0808
                56.1172             113.9764          -95.7305
```

MEMBER DEFORMATIONS

| MEM | JNT1 | JNT2 | AXIAL M | SWAY M | ROTATION RAD |
|---|---|---|---|---|---|
| 1 | 1 | 2 | 4.393753E-04 | 4.200013E-03 | -1.200004E-03 |
| | | | | | 1.987523E-03 |
| 2 | 2 | 3 | 1.59286E-04 | 1.181325E-03 | 2.850005E-03 |
| | | | | | 1.492801E-03 |
| 3 | 6* | 5 | 4.4525E-04 | 4.22367E-03 | 1.902269E-03 |
| | | | | | -3.718789E-03 |
| 4 | 5 | 4 | 1.640608E-04 | 1.094817E-03 | -2.824831E-03 |
| | | | | | -1.998176E-03 |
| 5 | 2 | 5 | -2.365746E-05 | 5.874783E-06 | 3.186687E-03 |
| | | | | | -2.512865E-03 |
| 6 | 3 | 4 | 6.285124E-05 | 1.064962E-05 | 1.828802E-03 |
| | | | | | -1.686892E-03 |

SUPPORT REACTIONS

| JNT | X-AXIS KN | Y-AXIS KN | MOMENT KN-M | ANGLE |
|---|---|---|---|---|
| 1 | 10.5603 | -486.5932 | -9.9647 | 0 DEG |
| 6 | -34.0803 | -492.8876 | 4.6566E-06 | 0 DEG |
| ALL | -23.52 | -979.4808 | -9.9647 | 0 DEG |

```
=====================================================================
TECHNO CONSULTANTS LTD                         PROG: SK9/IBM 880113
PORTLAND HOUSE                                 JOB NO:
103 PORTLAND STREET                            DATE:
MANCHESTER M1 6DF                              PAGE NO:
TEL 061 236 0104                               DESIGNER:
PROJECT:
=====================================================================

FILE: SAPBLM2                     LOAD CASE: 2            MEMBER NO: 5
REF:                                                      UNITS: KN , M

MEMBER DETAILS:     ANALYSIS POINTS= 11
X= 7 M              Y= 0 M                  UNIT WT= 23.6 KN/M3
L= 7 M              E= 2.5E+07 KN/M2
A= .4 M2            I= .0058 M4             SELF WT= 66.08 KN

APPLIED LOADS= 2
       1- T44 Q = 18 KN/M
       2- T1  P = 30 KN                A = 2 M

DEFORMED         AXIAL                 SHEAR                   BENDING
 SHAPE           FORCE                 FORCE                   MOMENT

E          ----------------E     -------E                -------E
9          ----------------9      ------9                     --9
8+++       ----------------8       -----8                       8+++
7++++      ----------------7        ----7                       7++++++
6+++++     ----------------6          --6                       6++++++++
5+++++     ----------------5            5                       5+++++++++
4+++++     ----------------4            4                       4+++++++++
3++++      ----------------3            3++                     3+++++++++
2+++       ----------------2            2++++++                 2+++++
1          ----------------1            1+++++++                1
S          ----------------S            S+++++++++       ------S
        S                                            E

MAXIMUM/MINIMUM RESULTS FROM 11 ANALYSIS POINTS:
DISTANCE    DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   M           M                KN               KN          KN M
 0           0              -6.763<          83.796>        -56.248
 2.8         2.4632E-03     -6.763           3.396           83.82>
 3.5         2.5407E-03>    -6.763          -9.204           81.787
 7          -1.0743E-10<    -6.763          -72.204<        -60.677<

END-FORCES:         AXIAL             SHEAR             MOMENT
                     KN                KN                KN M
END-1              -6.763             83.796           -56.248
END-2              -6.763            -72.204           -60.677
=====C:\MANUAL\SAPBLM2=====LOAD-CASE 2=====MEM 5=======================
```

```
=====================================================================
TECHNO CONSULTANTS LTD                         PROG: SK9/IBM 880113
PORTLAND HOUSE                                 JOB NO:
103 PORTLAND STREET                            DATE:
MANCHESTER M1 6DF                              PAGE NO:
TEL 061 236 0104                               DESIGNER:
PROJECT:
=====================================================================

FILE: SAPBLM2                    COMB CASE: 1            MEMBER NO: 5
REF:                                                     UNITS: KN , M

MEMBER DETAILS:     ANALYSIS POINTS= 21
X= 7 M              Y= 0 M                   UNIT WT= 23.6 KN/M3
L= 7 M              E= 2.5E+07 KN/M2
A= .4 M2            I= .0058 M4              SELF WT= 66.08 KN

SELF WT= 92.512 KN  FACTORED AT 1.4
APPLIED LOADS= 3
       1- T4  Q = 42 KN/M
       2- T44 Q = 28.8 KN/M
       3- T1  P = 48 KN                 A = 2 M

DEFORMED         AXIAL                SHEAR                    BENDING
 SHAPE           FORCE                FORCE                    MOMENT

E          ----------------E     --------E              -------E
9          ----------------9       ------9                     9
8+++       ----------------8        -----8                     8+++
7++++      ----------------7          ---7                     7++++++
6+++++     ----------------6           --6                     6++++++++
5+++++     ----------------5             5                     5+++++++++
4+++++     ----------------4             4                     4+++++++++
3++++      ----------------3             3+++                  3+++++++
2+++       ----------------2             2+++++                2++++
1          ----------------1             1+++++++              1
S          ----------------S             S++++++++       ------S
        S                                           E

MAXIMUM/MINIMUM RESULTS FROM 21 ANALYSIS POINTS:
DISTANCE    DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   M           M                KN               KN          KN M
 0           2.1485E-10     -36.454<         325.31>        -226.951
 3.15        9.8091E-03     -36.454          12.66           325.752>
 3.5         9.8864E-03>    -36.454         -16.746          325.037
 7          -2.1485E-10<    -36.454         -310.802<       -248.172<

ANALYSIS RESULTS:
DISTANCE    DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   M           M                KN               KN          KN M
 0           2.1485E-10     -36.454<         325.31>        -226.951
 .35         1.3324E-03     -36.454          295.905        -118.238
 .7          2.7655E-03     -36.454          266.499        -19.818
 1.05        4.216E-03      -36.454          237.093         68.311
 1.4         5.6095E-03     -36.454          207.688         146.148
 1.75        6.8803E-03     -36.454          178.282         213.692
 2.1         7.9714E-03     -36.454          100.877         266.145
 2.45        8.8392E-03     -36.454          71.471          296.306
 2.8         9.4573E-03     -36.454          42.065          316.175
```

| | | | | |
|---|---|---|---|---|
| 3.15 | 9.8091E-03 | -36.454 | 12.66 | 325.752> |
| 3.5 | 9.8864E-03> | -36.454 | -16.746 | 325.037 |
| 3.85 | 9.6898E-03 | -36.454 | -46.151 | 314.03 |
| 4.2 | 9.2287E-03 | -36.454 | -75.557 | 292.731 |
| 4.55 | 8.521E-03 | -36.454 | -104.963 | 261.14 |
| 4.9 | 7.5934E-03 | -36.454 | -134.368 | 219.257 |
| 5.25 | 6.4812E-03 | -36.454 | -163.774 | 167.082 |
| 5.6 | 5.2287E-03 | -36.454 | -193.179 | 104.615 |
| 5.95 | 3.8884E-03 | -36.454 | -222.585 | 31.856 |
| 6.3 | 2.522E-03 | -36.454 | -251.991 | -51.194 |
| 6.65 | .0012 | -36.454 | -281.396 | -144.537 |
| 7 | -2.1485E-10< | -36.454 | -310.802< | -248.172< |

DISPLACEMENTS:

| DISTANCE<br>M | ROTATION<br>RADIANS | AXIAL-DEFL.<br>M | PREP.-DEFL.<br>M | TOTAL-DEFL.<br>M |
|---|---|---|---|---|
| 0 | 3.5778E-03 | 0 | 2.1485E-10 | 2.1485E-10 |
| .35 | 3.9924E-03 | 1.2759E-06 | 1.3324E-03 | 1.3324E-03 |
| .7 | 4.1569E-03 | 2.5518E-06 | 2.7655E-03 | 2.7655E-03 |
| 1.05 | 4.0963E-03 | 3.8276E-06 | 4.216E-03 | 4.216E-03 |
| 1.4 | 3.8354E-03 | 5.1035E-06 | 5.6095E-03 | 5.6096E-03 |
| 1.75 | 3.3991E-03 | 6.3794E-06 | 6.8803E-03 | 6.8803E-03 |
| 2.1 | 2.8137E-03 | 7.6553E-06 | 7.9714E-03 | 7.9714E-03 |
| 2.45 | 2.1328E-03 | 8.9311E-06 | 8.8392E-03 | 8.8392E-03 |
| 2.8 | 1.3916E-03 | 1.0207E-05 | 9.4573E-03 | 9.4573E-03 |
| 3.15 | 6.1477E-04 | 1.1483E-05 | 9.8091E-03 | 9.8091E-03 |
| 3.5 | -1.7273E-04 | 1.2759E-05 | 9.8864E-03 | 9.8864E-03 |
| 3.85 | -9.4609E-04 | 1.4035E-05 | 9.6898E-03 | 9.6899E-03 |
| 4.2 | -1.6805E-03 | 1.5311E-05 | 9.2287E-03 | 9.2287E-03 |
| 4.55 | -2.351E-03 | 1.6586E-05 | 8.521E-03 | 8.521E-03 |
| 4.9 | -2.9329E-03 | 1.7862E-05 | 7.5934E-03 | 7.5934E-03 |
| 5.25 | -3.4012E-03 | 1.9138E-05 | 6.4812E-03 | 6.4812E-03 |
| 5.6 | -3.7312E-03 | 2.0414E-05 | 5.2287E-03 | .0052 |
| 5.95 | -3.8979E-03 | 2.169E-05 | 3.8884E-03 | 3.8885E-03 |
| 6.3 | -3.8767E-03 | 2.2966E-05 | 2.522E-03 | 2.5221E-03 |
| 6.65 | -3.6425E-03 | 2.4242E-05 | .0012 | 1.1998E-03 |
| 7 | -3.1706E-03 | 2.5518E-05 | -2.1485E-10 | 2.5518E-05 |

| END-FORCES: | AXIAL<br>KN | SHEAR<br>KN | MOMENT<br>KN M |
|---|---|---|---|
| END-1 | -36.454 | 325.31 | -226.951 |
| END-2 | -36.454 | -310.802 | -248.172 |

=====C:\MANUAL\SAPBLM2=====COMB-CASE 1=====MEM 5======================

```
=====================================================================
TECHNO CONSULTANTS LTD                         PROG: SK9/IBM 880113
PORTLAND HOUSE                                 JOB NO:
103 PORTLAND STREET                            DATE:
MANCHESTER M1 6DF                              PAGE NO:
TEL 061 236 0104                               DESIGNER:
PROJECT:
=====================================================================

FILE: SAPBLM2                     COMB CASE: 3            MEMBER NO: 6
REF:                                                      UNITS: KN , M

MEMBER DETAILS:     ANALYSIS POINTS= 17
X= 7 M              Y= 0 M                   UNIT WT= 23.6 KN/M3
L= 7 M              E= 2.5E+07 KN/M2
A= .25 M2           I= .0032 M4              SELF WT= 41.3 KN

SELF WT= 49.56 KN  FACTORED AT 1.2
APPLIED LOADS= 4
       1- T44 Q = 18 KN/M
       2- T4  Q = 9.6 KN/M
       3- T6  Q>=-3 KN/M                Q<=-3 KN/M
              A = 0 M                   B = 3.5 M
       4- T6  Q>=-2.4 KN/M              Q<=-2.4 KN/M
              A = 3.5 M                 B = 7 M

DEFORMED         AXIAL                SHEAR                   BENDING
 SHAPE           FORCE                FORCE                   MOMENT

E          E++++++++++++++++     --------E              --------E
9++        9++++++++++++++++       ------9                      9
8++        8++++++++++++++++        -----8                      8++
7++++      7++++++++++++++++          ---7                      7++++++
6+++++     6++++++++++++++++           --6                      6+++++++
5+++++     5++++++++++++++++             5                      5++++++++
4+++++     4++++++++++++++++             4++                    4+++++++
3++++      3++++++++++++++++             3+++                   3++++++
2+++       2++++++++++++++++             2+++++                 2+++
1++        1++++++++++++++++             1++++++                1
S          S++++++++++++++++             S++++++++       -------S
        S                                           E

MAXIMUM/MINIMUM RESULTS FROM 17 ANALYSIS POINTS:
DISTANCE    DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   M           M                KN              KN           KN M
 0            1.9471E-10     56.117<         109.884>       -85.081
 3.5          5.5757E-03>    56.117         -.996            105.472>
 7            0<             56.117         -113.976<       -95.73<

ANALYSIS RESULTS:
DISTANCE    DEFLECTION      AXIAL-FORCE     SHEAR-FORCE      MOMENT
   M           M                KN              KN           KN M
 0            1.9471E-10     56.117<         109.884>       -85.081
 .438         8.844E-04      56.117          96.008         -39.991
 .875         1.8636E-03     56.117          82.164         -1.06
 1.313        .0028          56.117          68.288          31.889
 1.75         3.7568E-03     56.117          54.444          58.706
 2.188        4.5274E-03     56.117          40.568          79.513
 2.625        5.1074E-03     56.117          26.724          94.216
```

| | | | | |
|---|---|---|---|---|
| 3.063 | 5.4643E-03 | 56.117 | 12.848 | 102.882 |
| 3.5 | 5.5757E-03> | 56.117 | -.996 | 105.472> |
| 3.938 | 5.436E-03 | 56.117 | -15.135 | 101.939 |
| 4.375 | 5.0541E-03 | 56.117 | -29.241 | 92.243 |
| 4.813 | 4.4518E-03 | 56.117 | -43.38 | 76.339 |
| 5.25 | .0037 | 56.117 | -57.486 | 54.299 |
| 5.688 | 2.7567E-03 | 56.117 | -71.625 | 26.024 |
| 6.125 | 1.7849E-03 | 56.117 | -85.731 | -8.358 |
| 6.563 | 8.3223E-04 | 56.117 | -99.87 | -49.005 |
| 7 | 0< | 56.117 | -113.976< | -95.73< |

DISPLACEMENTS:

| DISTANCE<br>M | ROTATION<br>RADIANS | AXIAL-DEFL.<br>M | PREP.-DEFL.<br>M | TOTAL-DEFL.<br>M |
|---|---|---|---|---|
| 0 | 1.8288E-03 | 0 | 1.9471E-10 | 1.9471E-10 |
| .438 | 2.1684E-03 | -3.9327E-06 | 8.844E-04 | 8.8441E-04 |
| .875 | 2.2778E-03 | -7.8564E-06 | 1.8636E-03 | 1.8637E-03 |
| 1.313 | 2.1906E-03 | -1.1789E-05 | .0028 | 2.8488E-03 |
| 1.75 | 1.9404E-03 | -1.5713E-05 | 3.7568E-03 | 3.7568E-03 |
| 2.188 | 1.5593E-03 | -1.9646E-05 | 4.5274E-03 | .0045 |
| 2.625 | 1.082E-03 | -2.3569E-05 | 5.1074E-03 | 5.1075E-03 |
| 3.063 | 5.3969E-04 | -2.7502E-05 | 5.4643E-03 | 5.4644E-03 |
| 3.5 | -3.2128E-05 | -3.1426E-05 | 5.5757E-03 | 5.5758E-03 |
| 3.938 | -6.0274E-04 | -3.5358E-05 | 5.436E-03 | 5.4361E-03 |
| 4.375 | -1.1359E-03 | -3.9282E-05 | 5.0541E-03 | 5.0543E-03 |
| 4.813 | -1.6002E-03 | -4.3215E-05 | 4.4518E-03 | 4.452E-03 |
| 5.25 | -1.9598E-03 | -4.7138E-05 | .0037 | 3.6698E-03 |
| 5.688 | -2.1825E-03 | -5.1071E-05 | 2.7567E-03 | 2.7571E-03 |
| 6.125 | -2.2336E-03 | -5.4995E-05 | 1.7849E-03 | 1.7857E-03 |
| 6.563 | -2.0794E-03 | -5.8928E-05 | 8.3223E-04 | 8.3431E-04 |
| 7 | -1.6869E-03 | -6.2851E-05 | 0 | 6.2851E-05 |

| END-FORCES: | AXIAL<br>KN | SHEAR<br>KN | MOMENT<br>KN M |
|---|---|---|---|
| END-1 | 56.117 | 109.884 | -85.081 |
| END-2 | 56.117 | -113.976 | -95.73 |

=====C:\MANUAL\SAPBLM2=====COMB-CASE 3=====MEM 6=======================

# SAMPLE PROBLEM 3

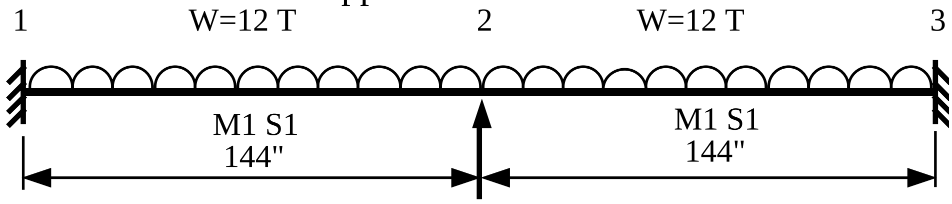
**Settlement and Rotation of Supports**

## Loading Case-1

Applied Loads are as shown in the figure below.
Support-2 Settles 0.5 inches, and
Support-3 Settles 1.5 inch.

## Loading Case-2

Applied Loads are as shown in the figure below.
Support-1 Rotates 1/250 Radians Clockwise, and
Support-2 Settles 1 inch.




## Input Data Loading Case 1

**TITLE ?** *SUPPORTS SETTLE 2 BY 0.5 & 3 BY 1.5 INCH*
**LOADED MEMBERS ?** *2*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *1, 1* | *3* | *12* |
| *2, 1* | *3* | *12* |

**SAME LOAD MEMBER-SETS ?** *0*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *2*

| JNT | FX | FY | M |
|---|---|---|---|
| *2* | *0* | *0.5D* | *0* |
| *3* | *0* | *1.5D* | *0* |

**SAME-LOAD JOINT SETS ?** *0*

## Input Data Loading Case 2

**TITLE ?** *SUPPORT-1 ROTATES 1/250 SUPPORT-2 SETTLES 1 INCH*
**LOADED MEMBERS ?** *2*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *1, 1* | *3* | *12* |
| *2, 1* | *3* | *12* |

**SAME LOAD MEMBER-SETS ?** *0*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *2*

| JNT | FX | FY | M |
|---|---|---|---|
| *1* | *0* | *0* | *0.004D* |
| *2* | *0* | *1D* | *0* |

**SAME-LOAD JOINT SETS ?** *0*

```
=====================================================================
TECHNO CONSULTANTS LTD                        PROG: SK9/IBM 880113
PORTLAND HOUSE                                JOB NO:EXAMPLE 3
103 PORTLAND STREET                           DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                             PAGE NO:
TEL 061 236 0104                              DESIGNER:SURK
PROJECT:SAMPLE PROBLEM 3 SUPPORT SETTLEMENTS USING SKELETON 9
=====================================================================
```



```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM3
TITLE: FISHER CASIES EX 5.2 SETTLEMENT OF BEAM
UNITS: T , IN
JOINTS= 3          MEMBERS= 2                 SECTIONS= 1
D-OF-I= 4          VOLUME = 288 IN3           SELF WT = 0 T

SECTION DETAILS
SEC  MODULUS T/IN2   AREA IN2        INERTIA IN4      UNIT WT T/IN3
 1    13000           1               122              0

MEMBER DETAILS
MEM  JNT1  JNT2  SEC    X-PROJ IN        Y-PROJ IN
 1     1     2     1     144              0
 2     2     3     1     144              0

JOINT COORDINATES
JNT    X-AXIS IN        Y-AXIS IN
 1      0                0
 2      144              0
 3      288              0

JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       1       0 DEG
 2      0       1       0       0 DEG
 3      1       1       1       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (T/IN OR T-IN/RAD)=  1
0) FREE              1) INFINITY
```

```
                    LOAD ANALYSIS NO 1
                    ==================
LOAD-FILE: C:\MANUAL\SAPBLM3 .A1
TITLE: SUPPORTS SETTLE 2 BY 0.5 & 3 BY 1.5 INCH

LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 1    T3      W = 12 T
 2    T3      W = 12 T

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS T            Y-AXIS T            MOMENT T-IN
 2        0                  IMP-DISP             0
 3        0                  IMP-DISP             0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS IN           Y-AXIS IN           ROTATION RAD
 1       0                   0                   0
 2       0                   .5 IMP              .007813
 3       0                   1.5 IMP             0

MEMBER-HINGE/CANT-END ROTATIONS  0

MEMBER FORCES
MEM JNT1-JNT2   AXIAL T            SHEAR T           MOMENT T-IN
 1   1    2     0                  5.6016           -201.364
                0                  6.3984           -258.728
 2   2    3     0                  8.7885           -258.728
                0                  3.2115            142.82

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL IN           SWAY IN           ROTATION RAD
 1   1    2     0                  .5               -3.472222E-03
                                                     4.340278E-03
 2   2    3     0                  1                 8.680556E-04
                                                    -6.944444E-03

SUPPORT REACTIONS
JNT  X-AXIS T          Y-AXIS T          MOMENT T-IN      ANGLE
 1   0               -5.6016           -201.364           0 DEG
 2   0               -15.1869           3.0518E-05        0 DEG
 3   0               -3.2115           -142.82            0 DEG
================================================================
ALL  0               -24               -344.184          0 DEG
```

```
                    LOAD ANALYSIS NO 2
                    ==================
LOAD-FILE: C:\MANUAL\SAPBLM3 .A2
TITLE: SUPPORT-1 ROTATES 1/25 SUPPORT-2 SETTLES 1 INCH

LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 1    T3      W = 12 T
 2    T3      W = 12 T

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS T              Y-AXIS T            MOMENT T-IN
 1        0                     0                  IMP-DISP
 2        0                    IMP-DISP             0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS IN             Y-AXIS IN           ROTATION RAD
 1       0                     0                   .004 IMP
 2       0                     1 IMP              -.001
 3       0                     0                   0

MEMBER-HINGE/CANT-END ROTATIONS  0

MEMBER FORCES
MEM JNT1-JNT2   AXIAL T              SHEAR T          MOMENT T-IN
 1   1    2     0                    10.997          -448.7176
                0                    1.003            270.8564
 2   2    3     0                    8.5134E-02       270.8565
                0                    11.9149         -580.8843

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL IN             SWAY IN          ROTATION RAD
 1   1    2     0                    1               -2.944444E-03
                                                     -7.944444E-03
 2   2    3     0                  -1                 5.944444E-03
                                                      6.944444E-03

SUPPORT REACTIONS
JNT  X-AXIS T           Y-AXIS T          MOMENT T-IN      ANGLE
 1   0                 -10.997           -448.7176          0 DEG
 2   0                 -1.0881            3.0518E-05        0 DEG
 3   0                 -11.9149           580.8843          0 DEG
================================================================
ALL  0                 -24                132.1667         0 DEG
```

# SAMPLE PROBLEM 4

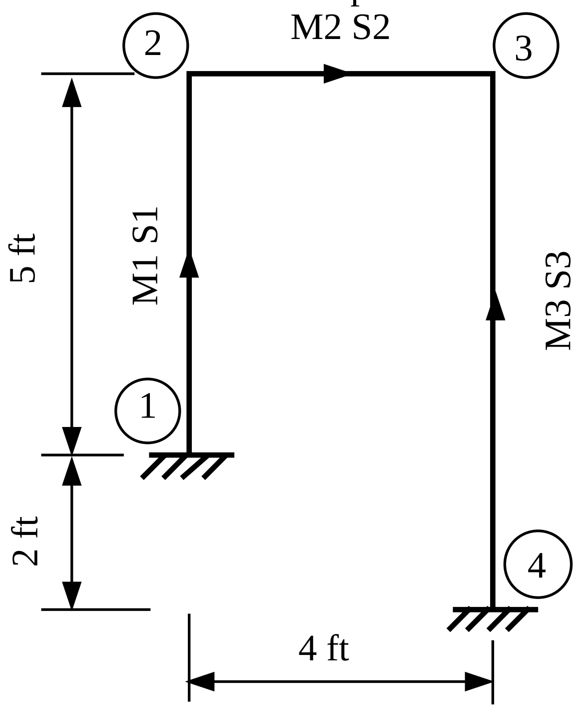
**Support Movements and Member Temperature Change**

## Loading Case-1

Support-1 Rotates 0.15 Radians Clockwise.
Support-4 Moves Laterally to the Right 0.25 ft.

## Loading Case-2

Member-2 undergoes a Temperature Rise of 97 Degrees,
and its Coefficient of Expansion is 0.00000067.




## Input Data Loading Case 1

**TITLE ?**
**LOADED MEMBERS ?** *0*
**SAME LOAD MEMBER-SETS ?** *0*
**HOW MANY LOADED/DISPLAYED JOINTS ?** *2*

| JNT | FX | FY | M |
|---|---|---|---|
| *1* | *0* | *0* | *0.15D* |
| *4* | *0.25D* | *0* | *0* |

**SAME-LOAD JOINT SETS ?** *0*

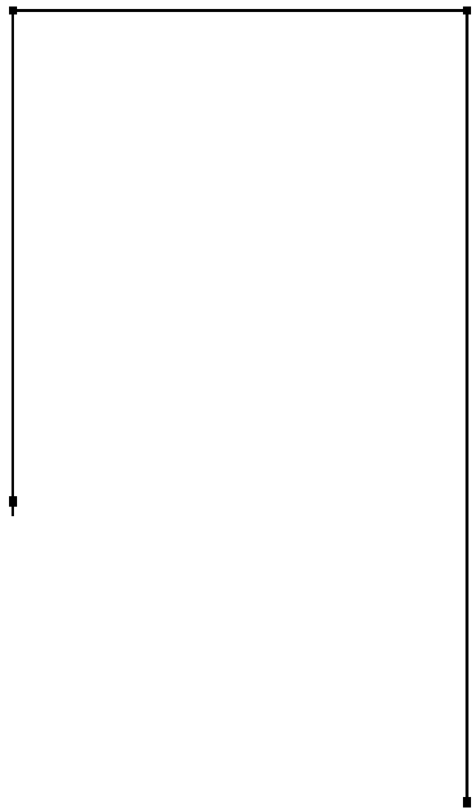
## Input Data Loading Case 2

**TITLE ?** *TEMP RISE OF 97 DEGREES IN MEMBER-2*
**LOADED MEMBERS ?** *1*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *2, 1* | *51* | *97, 0.000 000 67* |

**SAME LOAD MEMBER-SETS ?** *0*
**HOW MANY LOADED/DISPLAYED JOINTS ?** *0*
**SAME-LOAD JOINT SETS ?** *0*

```
===================================================================
TECHNO CONSULTANTS LTD                         PROG: SK9/IBM 880113
PORTLAND HOUSE                                 JOB NO:EXAMPLE 4
103 PORTLAND STREET                            DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                              PAGE NO:
TEL 061 236 0104                               DESIGNER:SURK
PROJECT:MEMBER TEMPRATURE CHANGE & SUPPORT SETTLEMENTS BY SKELETON 9
===================================================================
```



```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM4
TITLE: SETTLEMENT EXAMPLE FISHER 5.12
UNITS: T , FT
JOINTS= 4          MEMBERS= 3                 SECTIONS= 3
D-OF-I= 3          VOLUME = 135 FT3           SELF WT = 0 T
```

SECTION DETAILS

| SEC | MODULUS T/FT2 | AREA FT2 | INERTIA FT4 | UNIT WT T/FT3 |
|---|---|---|---|---|
| 1 | 2000000 | 7.5 | 5 | 0 |
| 2 | 2000000 | 6 | 4 | 0 |
| 3 | 2000000 | 10.5 | 7 | 0 |

MEMBER DETAILS

| MEM | JNT1 | JNT2 | SEC | X-PROJ FT | Y-PROJ FT |
|---|---|---|---|---|---|
| 1 | 1 | 2 | 1 | 0 | 5 |
| 2 | 2 | 3 | 2 | 4 | 0 |
| 3 | 4 | 3 | 3 | 0 | 7 |

JOINT COORDINATES

| JNT | X-AXIS FT | Y-AXIS FT |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 0 | 5 |
| 3 | 4 | 5 |
| 4 | 4 | -2 |

```
JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       1       0 DEG
 4      1       1       1       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (T/FT OR T-FT/RAD)=  1
0) FREE              1) INFINITY


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM4 .A1
TITLE:

LOADED MEMBERS= 0

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS T            Y-AXIS T            MOMENT T-FT
 1        0                   0                  IMP-DISP
 4       IMP-DISP             0                   0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS FT           Y-AXIS FT           ROTATION RAD
 1       0                   0                   .15 IMP
 2       .39992             -2.122186E-02        2.644695E-02
 3       .386736             2.122186E-02        1.599678E-02
 4       .25 IMP             0                   0

MEMBER-HINGE/CANT-END ROTATIONS  0

MEMBER FORCES
MEM JNT1-JNT2   AXIAL T            SHEAR T            MOMENT T-FT
 1   1    2    -63665.59          -39549.87           345980.8
               -63665.59           39549.87           148231.5
 2   2    3     39549.8           -63665.59           148231.5
                39549.8            63665.59          -106430.9
 3   4    3     63665.59           39549.84          -170418
                63665.59          -39549.84           106430.9

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL FT           SWAY FT            ROTATION RAD
 1   1    2    -2.122186E-02       .39992             7.001609E-02
                                                     -5.353697E-02
 2   2    3     1.318327E-02       4.244373E-02       1.583601E-02
                                                      5.385851E-03
 3   4    3     2.122186E-02       .136736           -1.953376E-02
                                                     -3.536978E-03

SUPPORT REACTIONS
JNT  X-AXIS T          Y-AXIS T          MOMENT T-FT      ANGLE
 1   39549.87          63665.59          345980.8          0 DEG
 4  -39549.84         -63665.59         -170418            0 DEG
=============================================================
ALL  .0313             0                 175562.8         0 DEG
```

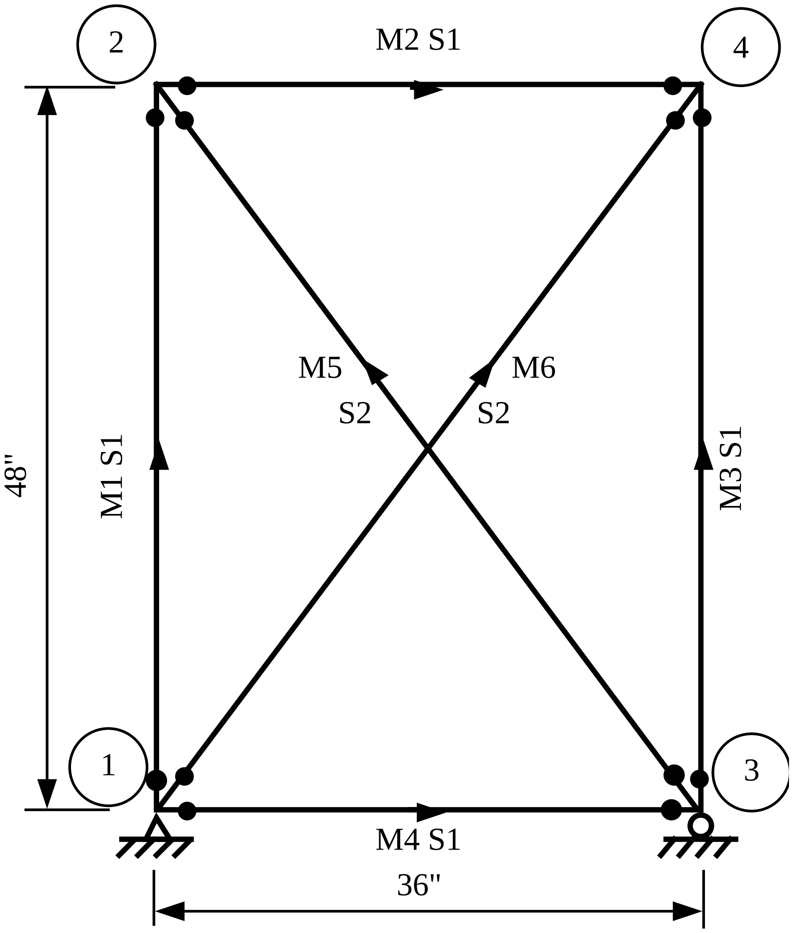
```
                   LOAD ANALYSIS NO 2
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM4 .A2
TITLE: TEMP RISE OF 97 DEGREES IN MEMBER-2

LOADED MEMBERS= 1
MEM  TYPE     LOAD-DETAILS
 2    T51     TEMP = 97 DEG            COEFF = 6.7E-07

SAME-LOAD MEMBER-SETS 0

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS FT            Y-AXIS FT           ROTATION RAD
 1       0                    0                   0
 2      -8.567813E-05        -2.507653E-06       -1.755357E-05
 3       1.609077E-04         2.507653E-06        2.256887E-05
 4       0                    0                   0

MEMBER-HINGE/CANT-END ROTATIONS  0

MEMBER FORCES
MEM JNT1-JNT2   AXIAL T            SHEAR T           MOMENT T-FT
 1   1    2    -7.523             -40.1224            135.4132
               -7.523              40.1224           -65.199
 2   2    3     40.1225           -7.523             -65.199
                40.1225            7.523             -95.2908
 3   4    3     7.523              40.1224           -185.5663
                7.523             -40.1224            95.2908

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL FT           SWAY FT           ROTATION RAD
 1   1    2    -2.507653E-06      -8.567813E-05       1.713563E-05
                                                     -4.17943E-07
 2   2    3    -2.465858E-04       5.015305E-06      -1.88074E-05
                                                      2.131505E-05
 3   4    3     2.507653E-06       1.609077E-04      -2.298682E-05
                                                     -4.179419E-07

SUPPORT REACTIONS
JNT  X-AXIS T           Y-AXIS T          MOMENT T-FT      ANGLE
 1   40.1224            7.523             135.4132          0 DEG
 4  -40.1224           -7.523            -185.5663          0 DEG
================================================================
ALL -3.8147E-06        0                 -50.1531          0 DEG
```

# SAMPLE PROBLEM 5

**Lack of Fit**

## Loading Case-1

Member-2 is 0.05 inches too long before
being forced into its position.




## Input Data Loading Case 1

**TITLE ?** *MEMBER-2 IS 0.05 INCHES TOO LONG*

**LOADED MEMBERS ?** *1*

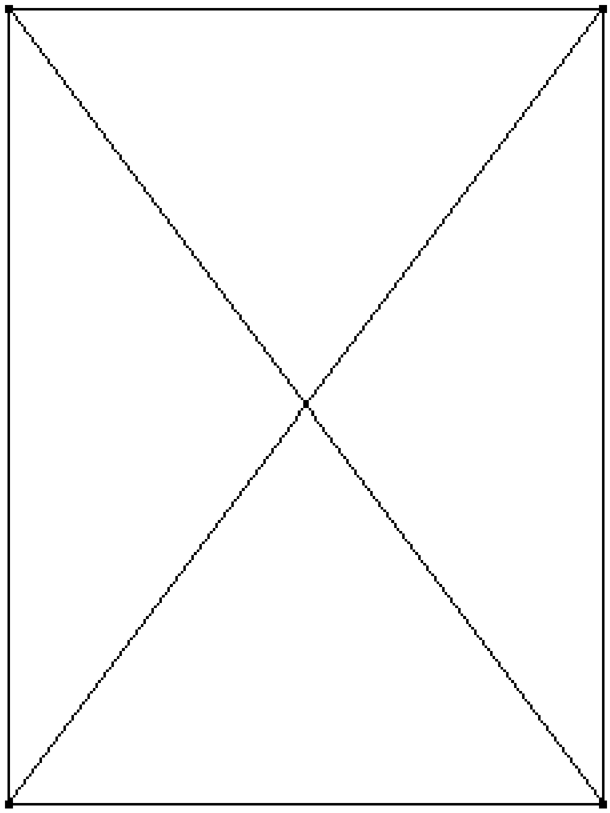
| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *2, 1* | *53* | *0.05* |

**SAME LOAD MEMBER-SETS ?** *0*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *0*

**SAME-LOAD JOINT SETS ?** *0*

```
=====================================================================
TECHNO CONSULTANTS LTD                          PROG: SK9/IBM 880113
PORTLAND HOUSE                                  JOB NO:EXAMPLE 5
103 PORTLAND STREET                             DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                               PAGE NO:
TEL 061 236 0104                                DESIGNER:SURK
PROJECT:SAMPLE PROBLEM 5 LACK OF FIT ANALYSIS BY SKELETON 9
=====================================================================
```



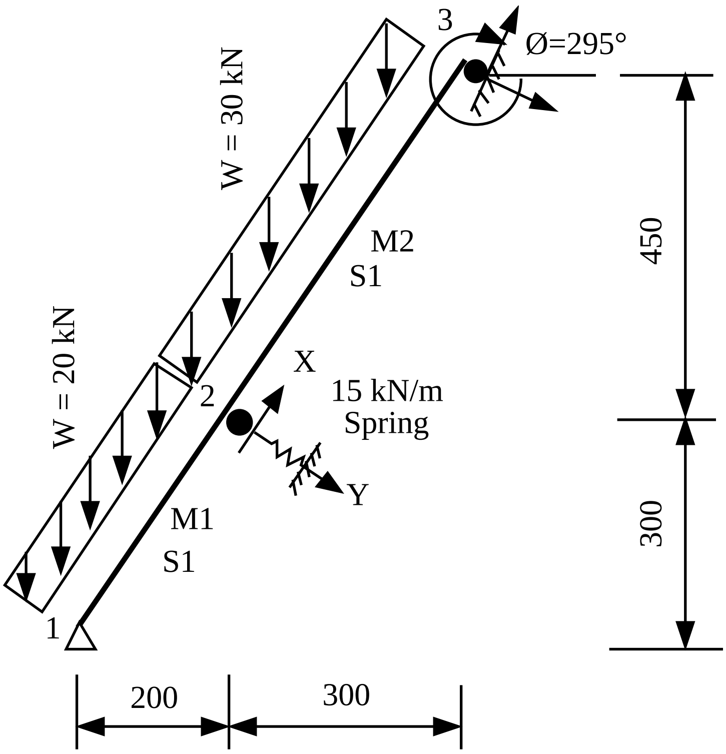
```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM5
TITLE: FISHER CASSIE LACK OF FIT
UNITS: T , IN
JOINTS= 4          MEMBERS= 6                  SECTIONS= 2
D-OF-I= 1          VOLUME = 456 IN3            SELF WT = 0 T

SECTION DETAILS
SEC  MODULUS T/IN2   AREA IN2        INERTIA IN4      UNIT WT T/IN3
 1    13000           2               1                0
 2    13000           1               1                0

MEMBER DETAILS
MEM  JNT1  JNT2  SEC    X-PROJ IN        Y-PROJ IN
 1     1*    2*    1     0                48
 2     2*    4*    1     36               0
 3     3*    4*    1     0                48
 4     1*    3*    1     36               0
 5     3*    2*    2    -36               48
 6     1*    4*    2     36               48
```

```
JOINT COORDINATES
JNT    X-AXIS IN        Y-AXIS IN
 1*     0                0
 2*     0                48
 3*     36               0
 4*     36               48

JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       *       0 DEG
 3      0       1       *       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (T/IN OR T-IN/RAD)=  1
0) FREE             1) INFINITY


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM5 .A1
TITLE: MEMBER-2 IS 0.05 INCHES TOO LONG

LOADED MEMBERS= 1
MEM  TYPE     LOAD-DETAILS
 2    T53     LACK OF FIT = .05 IN

SAME-LOAD MEMBER-SETS 0

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS IN          Y-AXIS IN          ROTATION RAD
 1        0                 0                  **
 2       -.025              3.519061E-03       **
 3       -1.979472E-03      0                  **
 4        2.302053E-02      3.519061E-03       **

MEMBER-HINGE/CANT-END ROTATIONS  0

MEMBER FORCES
MEM JNT1-JNT2   AXIAL T            SHEAR T            MOMENT T-IN
 1   1*   2*    1.9062
 2   2*   4*    1.4296             0
                1.4296             0
 3   3*   4*    1.9062
 4   1*   3*    1.4296
 5   3*   2*   -2.3827
 6   1*   4*   -2.3827

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL IN           SWAY IN            ROTATION RAD
 1   1*   2*    3.519061E-03      -.025
 2   2*   4*   -4.802053E-02       0                  0
                                                      0
 3   3*   4*    3.519061E-03       .025
 4   1*   3*    1.979472E-03       0
 5   3*   2*   -1.099707E-02      -2.052786E-02
 6   1*   4*   -1.099707E-02       2.052786E-02

SUPPORT REACTIONS
JNT  X-AXIS T          Y-AXIS T          MOMENT T-IN      ANGLE
 1  -1.7602E-07        1.4761E-07        0                 0 DEG
 3   1.7602E-07        1.4761E-07        0                 0 DEG
===============================================================
ALL  0                 2.9523E-07        0                0 DEG
```

# SAMPLE PROBLEM 6

**Elastic Spring and Inclined Supports**

Support 2 is an inclined X-roller and a Y-spring of Stiffness 15 kN/cm.
The support axes are parallel to the axes of member-1.
Support 3 is an inclined X-roller.
The support axes are inclined at an angle of 295 degrees clockwise.
Vertical Loads of 20 kN and 30 kN are applied on members 1 and 2 respectively,
as shown below.




## Input Data Spring Constants & Inclined Supports

**SPRING CONSTANTS ?** *2 Nos K1 = ∞ (default auto input value), K2 = 15*

**SUPPORTED JOINTS ?** 3

| JNT | X-R | Y-R | R-R | ANGLE |
|---|---|---|---|---|
| *1* | *1* | *1* | *0* | |
| *2A* | *0* | *2* | *0* | *1M* |
| *3A* | *0* | *1* | *0* | *295* |

## Input Data Loading Case 1

**TITLE ?** *VERTICAL TYPE 43 LOADS*

**LOADED MEMBERS ?** *2*

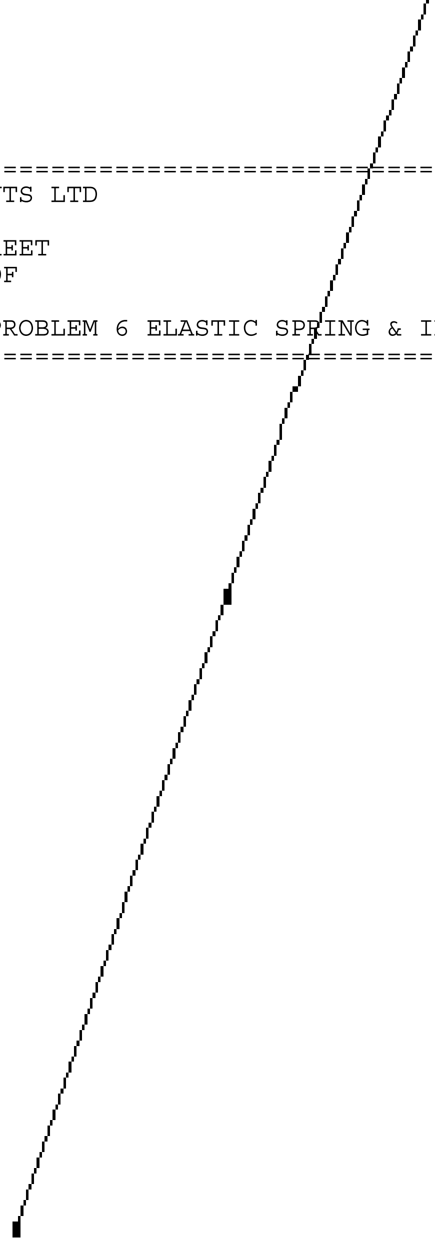
| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS |
|---|---|---|
| *1, 1* | *43* | *20* |
| *2, 1* | *43* | *30* |

**SAME LOAD MEMBER-SETS ?** *0*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *0*

**SAME-LOAD JOINT SETS ?** *0*

```
=====================================================================
TECHNO CONSULTANTS LTD                          PROG: SK9/IBM 880113
PORTLAND HOUSE                                  JOB NO:EXAMPLE 6
103 PORTLAND STREET                             DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                               PAGE NO:
TEL 061 236 0104                                DESIGNER:SURK
PROJECT:SAMPLE PROBLEM 6 ELASTIC SPRING & INCLINED SUPPORTS SKELETON9
=====================================================================
```

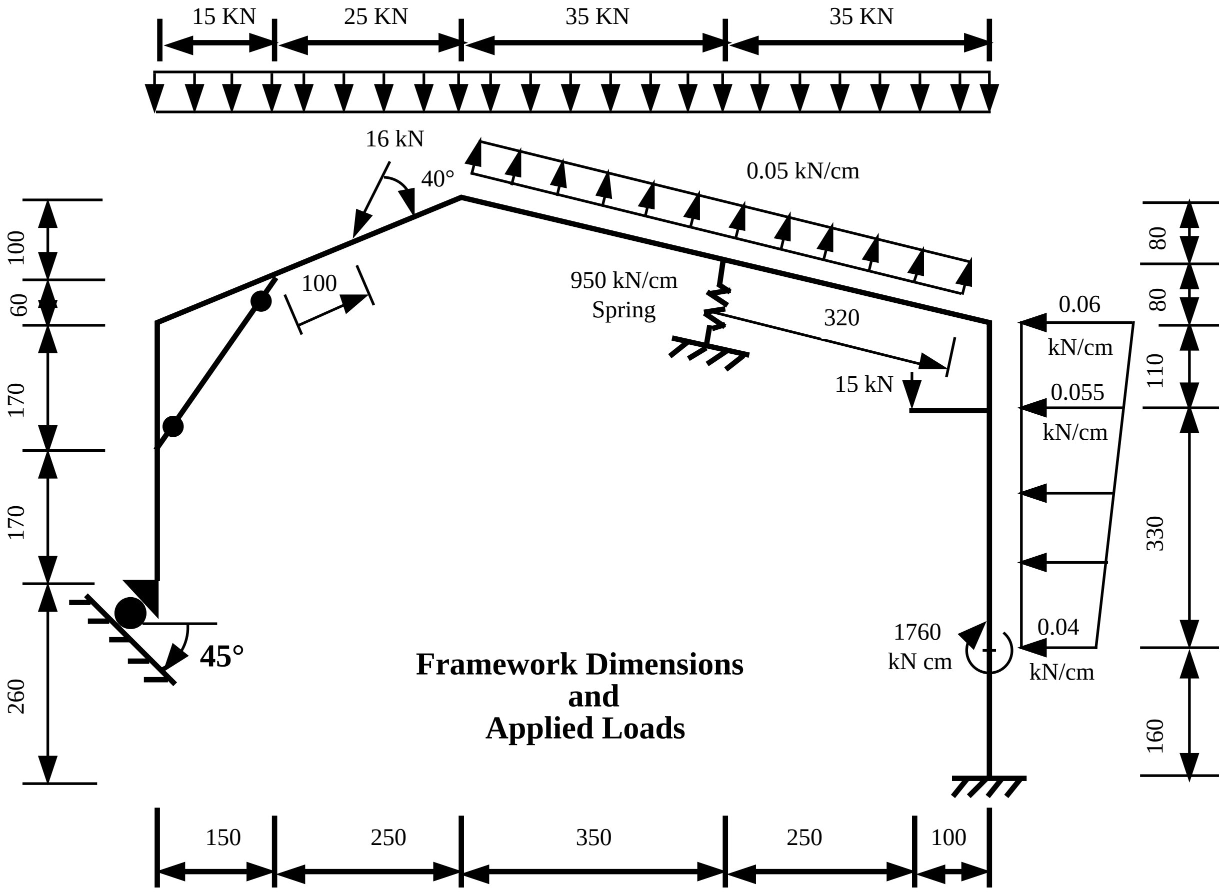


```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM6
TITLE: ELASTIC SPRING AND INCLINED SUPPORTS
UNITS: KN , CM
JOINTS= 3          MEMBERS= 2                  SECTIONS= 1
D-OF-I= 1          VOLUME = 31548.57 CM3       SELF WT = 0 KN

SECTION DETAILS
SEC  MODULUS KN/CM2  AREA CM2        INERTIA CM4      UNIT WT KN/CM3
 1    21000           35              2500             0

MEMBER DETAILS
MEM  JNT1  JNT2  SEC    X-PROJ CM        Y-PROJ CM
 1     1*    2     1     200              300
 2     2     3*    1     300              450

JOINT COORDINATES
JNT    X-AXIS CM        Y-AXIS CM
 1*     0                0
 2      200              300
 3*     500              750
```

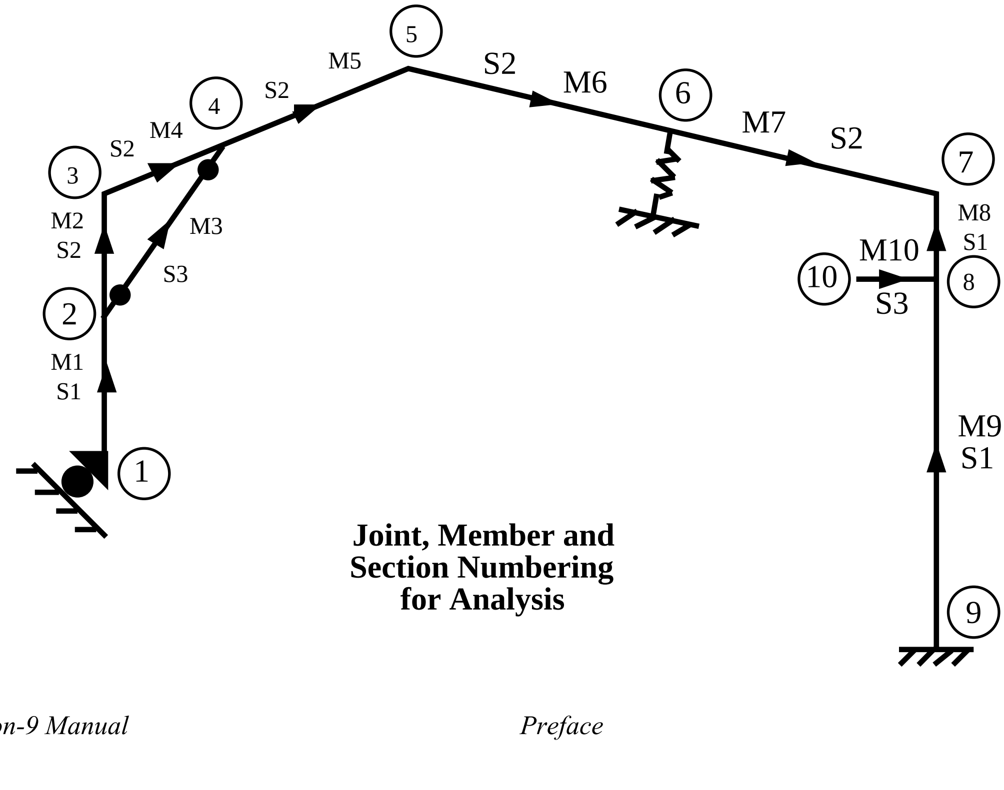
```
JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1      1       1       *       0 DEG
 2/     0       2 @     0      AXES OF MEM-1
 3/     0       1       *       295 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (KN/CM OR KN-CM/RAD)=  2
0) FREE              1) INFINITY           2)  15


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM6 .A1
TITLE: VERTICAL TYPE 43 LOADS

LOADED MEMBERS= 2
MEM  TYPE     LOAD-DETAILS
 1    T43     W = 20 KN
 2    T43     W = 30 KN

SAME-LOAD MEMBER-SETS 0

JOINT LOADS= 0

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS CM          Y-AXIS CM           ROTATION RAD
 1        0                 0                   **
 2/     -1.693599E-02       .956485 @           1.745791E-03
 3/     -2.734781E-02       0                   **

MEMBER-HINGE/CANT-END ROTATIONS  2
MEM JNT1-JNT2   ROTATION RAD
 1   1*   2     3.678631E-03
 2   2    3*   -5.445792E-03

MEMBER FORCES
MEM JNT1-JNT2   AXIAL KN           SHEAR KN          MOMENT KN-CM
 1   1*   2     42.8449            5.2591           -1.1866E-04
                26.2039            5.8349           -103.7894
 2   2    3*    26.2039            8.5124           -103.7896
                1.2424             8.1286            0

MEMBER DEFORMATIONS
MEM JNT1-JNT2   AXIAL CM           SWAY CM           ROTATION RAD
 1   1*   2     1.693599E-02       .956485           1.02582E-03
                                                    -9.070205E-04
 2   2    3*    1.009788E-02     -.952353            3.506692E-03
                                                    -3.684891E-03

SUPPORT REACTIONS
JNT  X-AXIS KN         Y-AXIS KN         MOMENT KN-CM     ANGLE
 1   19.3902          -38.5664          -1.1866E-04        0 DEG
 2/  1.7307E-05       -14.3473 @        -1.9073E-04       AXES MEM-1
 3/ -1.6244E-05       -8.223             0                 295 DEG
=================================================================
ALL  1.2824E-06       -50               -3.0939E-04       0 DEG
```

# SAMPLE PROBLM 7

## A Portal Frame with an In clined Roller and an Elastic Spring Sup port




**Framework Dimensions and Applied Loads**




**Joint, Member and Section Numbering for Analysis**

# SAMPLE PROBLEM 7

**TITLE:** *PROGRAM HANDOUT EXAMPLE*
**UNITS ?** *KN,CM*
**SECTIONS ?** *3*
**JOINTS ?** *10*
**MEMBERS ?** *10*

| SEC | MODULUS | AREA | INERTIA |
|---|---|---|---|
| **1** | *21000* | *129.2* | *75720* |
| **2** | *21000* | *85.4* | *29401* |
| **3** | *21000* | *58.9* | *9948* |

**MEMBER DETAILS**

| MEM | JNT1 | JNT2 | SEC |
|---|---|---|---|
| **1** | *1* | *2* | *1* |
| **2** | *2* | *3* | *1* |
| **3** | *2* | *4* | *3* |
| **4** | *3* | *4* | *2* |
| **5** | *4* | *5* | *2* |
| **6** | *5* | *6* | *2* |
| **7** | *6* | *7* | *2* |
| **8** | *8* | *7* | *1* |
| **9** | *9* | *8* | *1* |
| **10** | *10* | *8* | *3* |

**JOINT COORDIATES**

| JNT | X-C | Y-C |
|---|---|---|
| **1** | *0* | *260* |
| **2** | *0* | *430* |
| **3** | *0* | *600* |
| **4** | *150* | *660* |
| **5** | *400* | *760* |
| **6** | *750* | *680* |
| **7** | *1100* | *600* |
| **8** | *1100* | *490* |
| **9** | *1100* | *0* |
| **10** | *1000* | *490* |

**SPRING CONSTANTS ?** *2 Nos K1 = ∞ (default auto input value), K2 = 945*

**SUPPORTED JOINTS ?** 3

| JNT | X-R | Y-R | R-R | ANGLE |
|---|---|---|---|---|
| *1A* | *0* | *1* | *0* | *45°* |
| *6A* | *0* | *2* | *0* | *7M* |
| *9* | *1* | *1* | *1* | |

**JOINT HINGES ?** *0*

**HINGED BAR MEMBERS ?** *1 at 3*
**MEMBER HINGES ?** *0*

# Input Data Loading Case 1

**TITLE ?** *SAMPLE LOADS*

**LOADED MEMBERS ?** *6*

| MEM NO , NO OF LOADS | TYPE | LOAD DETAILS | |
|---|---|---|---|
| *4, 1* | *43* | *15* | |
| *5, 2* | *43* | *25* | |
| | *21* | *16, 100* | *at 40°* |
| *6, 2* | *43* | *35* | |
| | *4* | *-0.05* | |
| *7, 2* | *43* | *35* | |
| | *6* | *-0.05, -0.05, 0, 320* | |
| *8, 1* | *6* | *-0.055, -0.06, 0, 110* | |
| *9, 2* | *6* | *-0.04, -0.055, 160, 490* | |
| | *8* | *1760, 160* | |

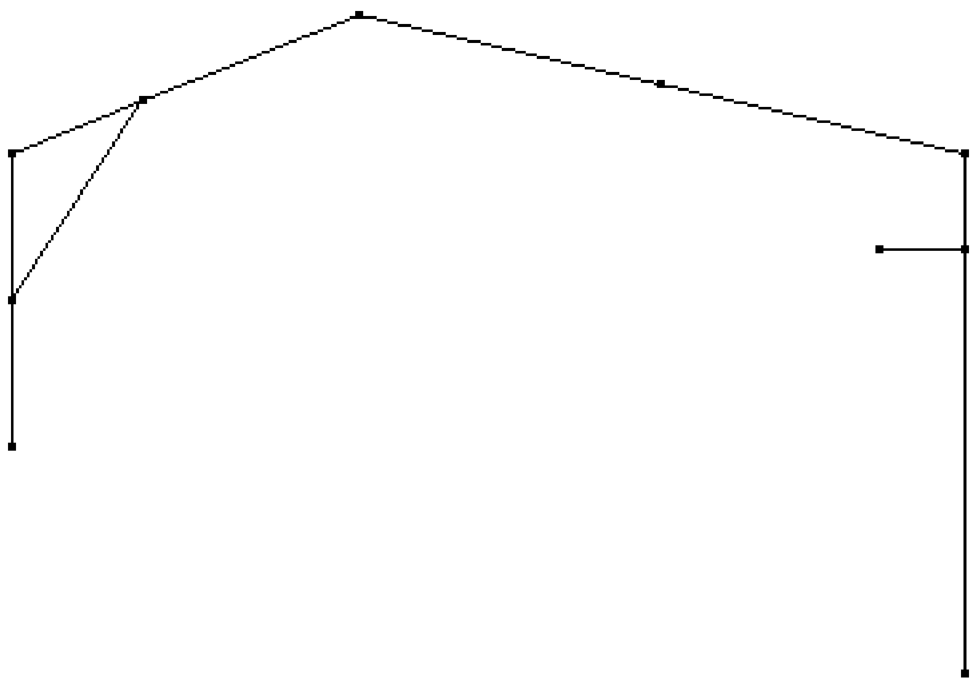
**SAME LOAD MEMBER-SETS ?** *0*

**HOW MANY LOADED/DISPLAYED JOINTS ?** *1*

| JNT | FX | FY | M |
|---|---|---|---|
| *10* | *0* | *15* | *0* |

**SAME-LOAD JOINT SETS ?** *0*

```
==============================================================================
TECHNO CONSULTANTS LTD                               PROG: SK9/IBM 880113
PORTLAND HOUSE                                       JOB NO:EXAMPLE 7
103 PORTLAND STREET                                  DATE:30 SEPTEMBER 1988
MANCHESTER M1 6DF                                    PAGE NO:
TEL 061 236 0104                                     DESIGNER:SURK
PROJECT:SAMPLE PROBLEM 7 PROGRAM HANDOUT EXAMPLE FOR SKELETON 9
==============================================================================
```



```
                   STRUCTURE DETAILS
                   =================
FILE: C:\MANUAL\SAPBLM7
TITLE: PROGRAM HANDOUT EXAMPLE
UNITS: KN , CM
JOINTS= 10         MEMBERS= 10                SECTIONS= 3
D-OF-I= 3          VOLUME = 241624.6 CM3      SELF WT = 0 KN

SECTION DETAILS
SEC  MODULUS KN/CM2  AREA CM2        INERTIA CM4      UNIT WT KN/CM3
 1    21000           129.2           75720            0
 2    21000           85.4            29401            0
 3    21000           58.9            9948             0

MEMBER DETAILS
MEM  JNT1  JNT2  SEC    X-PROJ CM        Y-PROJ CM
 1     1*    2     1      0                170
 2     2     3     1      0                170
 3     2*    4*    3      150              230
 4     3     4     2      150              60
 5     4     5     2      250              100
 6     5     6     2      350             -80
 7     6     7     2      350             -80
 8     8     7     1      0                110
 9     9     8     1      0                490
 10    10*   8     3      100              0
```

```
JOINT COORDINATES
JNT    X-AXIS CM        Y-AXIS CM
 1*     0                260
 2      0                430
 3      0                600
 4      150              660
 5      400              760
 6      750              680
 7      1100             600
 8      1100             490
 9      1100             0
 10*    1000             490

JOINT SUPPORT SPRINGS
JNT  X-AXIS  Y-AXIS  ANGULAR   ANGLE
 1/     0       1       *       45 DEG
 6/     0       2 @     0      AXES OF MEM-7
 9      1       1       1       0 DEG

NOTE:-  @ = SPRING;   / = INCLINED;   * = HINGE/CANT-END

SPRING CONSTANTS (KN/CM OR KN-CM/RAD)=  2
0) FREE              1) INFINITY           2)  945


                   LOAD ANALYSIS NO 1
                   ==================
LOAD-FILE: C:\MANUAL\SAPBLM7 .A1
TITLE: SAMPLE LOADS

LOADED MEMBERS= 6
MEM  TYPE     LOAD-DETAILS
 4    T43     W = 15 KN
 5    T43     W = 25 KN
      T21     P = 16 KN                A = 100 CM
              INCLINATION: 40 DEG
 6    T43     W = 35 KN
      T4      Q =-.05 KN/CM
 7    T43     W = 35 KN
      T6      Q>=-.05 KN/CM            Q<=-.05 KN/CM
              A = 0 CM                 B = 320 CM
 8    T6      Q>=-.055 KN/CM           Q<=-.06 KN/CM
              A = 0 CM                 B = 110 CM
 9    T6      Q>=-.04 KN/CM            Q<=-.055 KN/CM
              A = 160 CM               B = 490 CM
      T8      M = 1760 KN-CM           A = 160 CM

SAME-LOAD MEMBER-SETS 0

JOINT LOADS
JNT      X-AXIS KN           Y-AXIS KN           MOMENT KN-CM
 10       0                   15                 **

SAME-LOAD JOINT-SETS 0

JOINT DISPLACEMENTS
JNT      X-AXIS CM           Y-AXIS CM           ROTATION RAD
 1/      14.57296            0                   **
 2       6.701363            10.30786           -2.088431E-02
 3       3.200969            10.30064           -2.047018E-02
 4       2.010923            7.301588           -1.882045E-02
 5       .414382             3.330004           -1.289617E-02
 6/      1.136514            3.855898E-02 @     -4.425662E-03
 7       1.153696            3.610436E-03        2.126715E-03
 8       .896183             3.445169E-03        2.483925E-03
 9       0                   0                   0
 10      .896183            -.221013             **

MEMBER-HINGE/CANT-END ROTATIONS  2
MEM JNT1-JNT2   ROTATION RAD
 1   1*   2    -2.135145E-02
 10  10*  8     2.124916E-03
```

MEMBER FORCES

| MEM | JNT1 | JNT2 | AXIAL KN | SHEAR KN | MOMENT KN-CM |
|---|---|---|---|---|---|
| 1 | 1* | 2 | 51.4044 | -51.4066 | .1503 |
| | | | 51.4044 | 51.4066 | -8738.976 |
| 2 | 2 | 3 | -115.1746 | 57.2376 | -8738.848 |
| | | | -115.1746 | -57.2376 | 991.5391 |
| 3 | 2* | 4* | 198.8788 | | |
| 4 | 3 | 4 | -95.9214 | -85.6848 | 991.5509 |
| | | | -101.4923 | 99.612 | -13976.26 |
| 5 | 4 | 5 | 61.2491 | 14.7097 | -13976.19 |
| | | | 39.7076 | 18.7868 | -14881.24 |
| 6 | 5 | 6 | 43.3426 | 7.1412 | -14881.24 |
| | | | 51.1414 | 9.0276 | -15219.87 |
| 7 | 6 | 7 | 51.1419 | 27.4107 | -15219.88 |
| | | | 58.9408 | -9.2906 | -8319.304 |
| 8 | 8 | 7 | 4.0764 | 53.2031 | 2124.091 |
| | | | 4.0764 | -59.5281 | 8319.261 |
| 9 | 9 | 8 | 19.0764 | 37.5289 | -18975.35 |
| | | | 19.0764 | -53.2039 | 3624.045 |
| 10 | 10* | 8 | 0 | -15 | 6.08E-04 |
| | | | 0 | 15 | -1500.001 |

MEMBER DEFORMATIONS

| MEM | JNT1 | JNT2 | AXIAL CM | SWAY CM | ROTATION RAD |
|---|---|---|---|---|---|
| 1 | 1* | 2 | 3.22083E-03 | -3.603276 | -1.557089E-04 |
| | | | | | 3.114258E-04 |
| 2 | 2 | 3 | -7.216454E-03 | -3.500395 | -2.937563E-04 |
| | | | | | 1.203768E-04 |
| 3 | 2* | 4* | .044151 | -5.570992 | |
| 4 | 3 | 4 | -8.891815E-03 | -3.226525 | -4.984926E-04 |
| | | | | | 1.151241E-03 |
| 5 | 4 | 5 | 7.342078E-03 | -4.280463 | -2.923205E-03 |
| | | | | | 3.001073E-03 |
| 6 | 5 | 6 | 9.457524E-03 | -3.115389 | -4.218843E-03 |
| | | | | | 4.251663E-03 |
| 7 | 6 | 7 | .011019 | -.292111 | -3.612041E-03 |
| | | | | | 2.940336E-03 |
| 8 | 8 | 7 | 1.652671E-04 | .257513 | 1.428971E-04 |
| | | | | | -2.143129E-04 |
| 9 | 9 | 8 | 3.445169E-03 | .896183 | -1.828945E-03 |
| | | | | | 6.549805E-04 |
| 10 | 10* | 8 | 0 | .224459 | -1.196699E-04 |
| | | | | | 2.393399E-04 |

SUPPORT REACTIONS

| JNT | X-AXIS KN | Y-AXIS KN | MOMENT KN-CM | ANGLE |
|---|---|---|---|---|
| 1/ | 1.5375E-03 | -72.6984 | .1503 | 45 DEG |
| 6/ | 4.7302E-04 | -36.4382 @ | -3.9062E-03 | AXES MEM-7 |
| 9 | -37.5289 | -19.0764 | -18975.35 | 0 DEG |
| ALL | 21.9976 | -106.0029 | -18975.2 | 0 DEG |