

Oxford University Computing Laboratory

Computer Manuals

ICL 1900 Civil Engineering and Building
Structural Analysis
Continuous Beam Analysis Mk2
3rd Ed 1971

4293

CIVIL ENGINEERING & BUILDING

Structural Analysis

Continuous Beam Analysis MK2. 3rd Ed. 1971

1900

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MANUAL (NOTICE NO.)

11/10/72

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CONTINUOUS BEAM ANALYSIS MARK 2 (1)

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Amended Continuous Beam Analysis programs #X2B3/3 and #X2B4/2 will shortly be available; the errors reported in the Software Notice 1900/OTHER ENGINEERING AND MISCELLANEOUS/55 have been corrected in these versions.

This notice also contains details of input data formats for the programs, which should be read in conjunction with Chapter 2 (page 5) of the manual.

DETAILS OF INPUT DATA FORMATS

In a single run of the program, it is possible to analyse any number of beams and to impose on each beam any number of loading cases. Data for each beam must be input in the order described on page 5 of the manual.

The general form of the data input is thus as shown in the following table:

*PARAMETER DATA	Introduces parameter data for beam 1
*BEAM DATA	Introduces beam data for beam 1
*LOADING DATA	Introduces loading case 1 for beam 1
*LOADING DATA	Introduces loading case 2 for beam 1
*LOADING DATA	Introduces loading case 3 for beam 1
*LOADING DATA	Introduces loading case N (say) for beam 1
*PARAMETER DATA	Introduces parameter data for beam 2
*BEAM DATA	Introduces beam data for beam 2
*LOADING DATA	Introduces loading case 1 for beam 2
*LOADING DATA	Introduces loading case 2 for beam 2
*LOADING DATA	Introduces loading case 3 for beam 2
*LOADING DATA	Introduces loading case M (say) for beam 2
*PARAMETER DATA	Introduces parameter data for beam 3
*BEAM DATA	Introduces beam data for beam 3

The data may be repeated in the above format for

1 of 4

beams 3,4,5, and so on.

***END** Terminates the data and the run

Should the loading data for any beam be omitted, then only the beam data will be listed on the line printer; no attempt will be made to analyse the beam in question.

In the absence of errors in the data, each loading case will cause an analysis of the current beam and the results will be output to the line printer.

The data terminator (***END**) must be present only at the end of the data.

Data preparation formats

Each data record must start in column 1 of a card or directly after a new-line character on paper tape, unless otherwise stated.

Blank lines on paper tape or blank cards will be ignored by the program.

In the data sheets shown in the manual (see Appendix 1, page 35) all the data fields shown within heavy black lines must be left-justified for each card or paper tape record.

The effective FORTRAN formats for each data sheet are described below:

PARAMETER DATA (see page 36)

<i>Record (in input order)</i>	<i>Effective FORTRAN format</i>	<i>Comments</i>
*PARAMETER DATA	A4	Left justified within the field.
Job reference number	3A4	May appear anywhere within the 12 character field.
Job heading	10A4	May appear anywhere within the 40 character field.
Number of spans	I0	Free format (integer).
Unit of length	A4	Must appear within the 4 character field.

CONTINUOUS BEAM ANALYSIS MARK 2 (1)

<i>Record (in input order)</i>	<i>Effective FORTRAN format</i>	<i>Comments</i>
Unit of force	A4	Must appear within the 4 character field.
Young's Modulus	E0.0	Free format (real).
End-support type	A3	Must appear within the 3 character field.
*BEAM DATA	A4	Left justified within the field.

BEAM DATA (see page 37)

<i>Record (in input order)</i>	<i>Effective FORTRAN format</i>	<i>Comments</i>
CANTV { A B (not with SPAN)	A4,A2	The character A or B must appear in the 6th column of the card or paper tape record.
SPAN <i>span-number</i> (not with CANT)	A4,I0	The span number may appear anywhere after the directive.
Number of sections	I0	Free format (integer).
Length of span	E0.0	Free format (real).

Beam cross section details

The cross-section details for each section within a span (or cantilever) have the following general form:

$n \text{ } ch \text{ } X \text{ } Y \text{ } Z$

where n is the section number and ch is the area type.

The numbers of character positions, including space characters, shown on data sheets 2(a) and 2(b) (pages 37 and 38) are significant. The section number, area type, and X , Y and Z values may however appear anywhere within their specified fields.

If the area type specified is one of R,G,U or L, then the values X , Y and Z must be specified. If the section number is omitted, it is assumed that the area details form a continuation record for the last

specified section number, and that the moments of area specified in the continuation record are to be added to or subtracted from the calculated moments of area at that section.

If the area type specified is I, then the total second moment of area for the section, about the neutral axis, is specified in the X field.

If the area type specified is P, then the details for the section are taken from a previously defined span and section number, the span and section numbers to be referenced being specified in the X and Y fields respectively.

It is not possible to add or subtract any increment of area for a section type specified with I or P.

LOADING DATA (see page 40)

The loading data is introduced by the directive *LOADING DATA. This directive must be left-justified within the paper tape or card record.

The loading data details take the general form:-

n ch W L1 L2

where *n* is the span number and *ch* is the type of loading.

The numbers of character positions, including space characters, shown on data sheet 3 are significant. The span number, loading type, and *W*, *L1* and *L2* values may however appear anywhere within their specified fields.

The span number must be specified with each load in the loading set. The value *L2* is not specified with the point-load (P).

Further loading sets must each be preceded by the directive *LOADING DATA.

DATA TERMINATOR

The data terminator *END indicates the end of the data. The program will continue with any necessary calculations, and output the results to the line printer.

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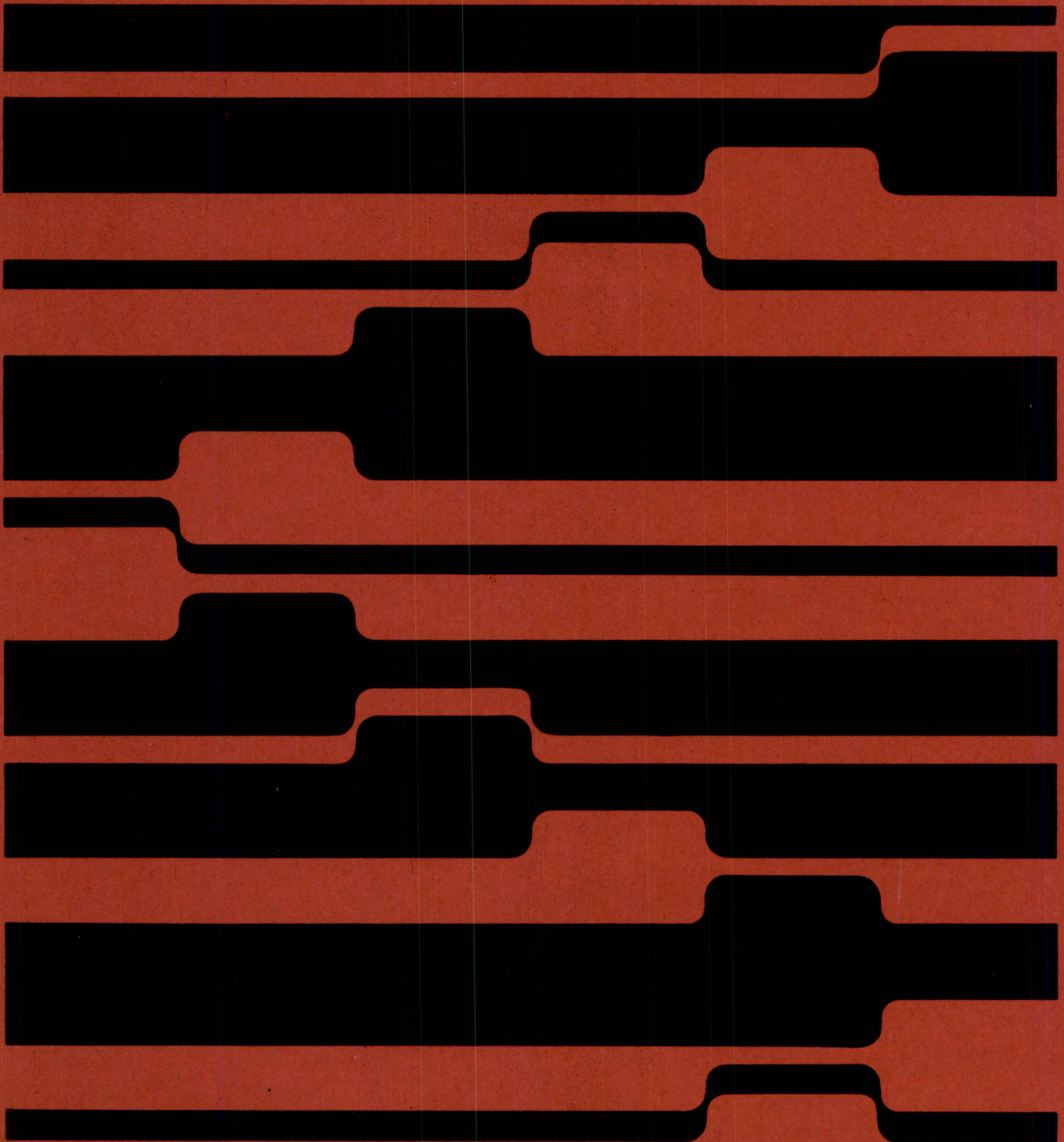
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Continuous Beam Analysis Mk 2

1900 Series

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Technical Publication 4293

© International Computers Limited 1971

First Edition (Continuous Beam Analysis) February 1967

Second Edition (Continuous Beam Analysis Mk 2) November 1970

Third Edition (Continuous Beam Analysis Mk 2) August 1971

Issued by Technical Publications Service
International Computers Limited
Head Office: ICL House, Putney, London SW15
Produced by ICL Printing Services
at Letchworth, Hertfordshire

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Preface

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The 1900 Series Continuous Beam Analysis program analyses the effect of various combinations of loads on two-dimensional continuous beams and slabs; any combination of loads and any structure of beam or slab may be specified by the user, subject to certain restrictions on problem size (see page 3). This program, which is written in FORTRAN, is based on the Mark 1 program (written in EMA) which has been available for some years. It allows the engineer to use any self-consistent combination of units that he may require.

The program can be run under any of the GEORGE operating systems, or in an operator's Executive environment. The minimum computer configuration required for use of this program is as follows:

- 1 1900 Series central processor with at least 16K core store
- 1 card reader or 1 paper tape reader
- 1 line printer with 120 character positions
- 1 magnetic tape deck or 1 E.D.S. transport or 1 T.E.D.S. transport

The size of the configuration available does not limit the size of the problems which can be solved by the program. All configurations having at least the minimum size given above can solve problems up to and including the maximum problem size allowed by the program. A summary of the limitations imposed on problem size by the program is given on page 3.

The program is intended to be used by structural engineers. In this manual the mathematical theory used in analysis is described in standard engineering terms. Chapter 1 introduces the theory behind the program and the terms used throughout the remainder of the manual; input and output procedures are then outlined. This chapter also summarizes the restrictions on the size of the problem, so that users may quickly assess whether the program can be of assistance for their particular problem.

Chapters 2 and 3 give detailed accounts of Input and Output respectively. Chapter 4 gives operating instructions for running under GEORGE and under Executive. Chapter 5 gives two examples of analysis performed by the program. Appendix 1 provides specimen data sheets.

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Illustrations

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Chapter 1 Introduction

SCOPE OF THE PROGRAM

The program will analyse two-dimensional continuous beams and slabs whose supports may range from a single cantilever to 12 *spans* and a cantilever at each end (a span being a length of beam between adjacent supports). The user may specify up to 19 cross-sections for each span; in the remainder of this manual these are known as *sections*. The method of calculation used by the program dictates that only an odd number of sections can be specified, and that these must be spaced evenly along the span (see *Calculations performed by the program*, below). The user also specifies the combination of loads acting on the beam; each combination is known as a *loading set*. Any number of loading sets may be specified for each beam to be analysed.

The program will calculate the effect of the loading set on each section in terms of bending moments and vertical deflections. It will also calculate the reaction, the shear force and the rotation at each support. The user thus quickly gets a full picture of the effectiveness of a given beam design under all likely conditions of static loading, and can adjust his design accordingly. The speed and ease with which the various possibilities can be analysed and assessed increase the chances of an optimum design being achieved with an economic amount of effort.

The user may specify any desired units of force and distance to be used by the program, since the method of calculation used is dimensionless. The program assumes that all data supplied to it is in consistent units; it is therefore important that all data is in the correct units before input. The specified units are used only as part of the output headings.

CALCULATIONS PERFORMED BY THE PROGRAM

The user defines the area of each section by combining standard shapes (see page 7) to form the cross-section. These standard shapes are positioned relative to a common *datum line*; this need not be the same for each section. For each section, the program calculates the total area, the depth from the centroid of the section to the datum line, and the second moment of area about the centroid. The influence coefficients and carry-over factors are calculated for each span. The program carries out all the necessary integrations by means of Simpson's Rule; hence an odd number of sections, evenly spaced along the span, must be chosen. The larger the number of sections chosen, the greater will be the accuracy of integration.

Influence coefficients and carry-over factors are determined by the standard procedure of considering each span to be simply supported, and evaluating the rotation at the ends produced by a unit moment at each end in turn.

The effect of each loading set is determined by calculating the bending moment at each section across a span and the rotations at the ends, assuming the span to be simply supported. Then the fixed-end moments at each end of the span are calculated using the influence coefficients to find the moments required to reduce the end rotations to zero.

Out-of-balance moments at the supports are eliminated by redistributing the moments along the beam, using a relaxation method, until the maximum out-of-balance moment is less than 1×10^{-8} units.

If one or more cantilever ends are present, the bending moments for these are calculated statically. The bending moment at the cantilever support is set equal to the bending moment produced by the cantilever, and the fixed end moment at the adjacent support is increased by this bending moment multiplied by the appropriate carry-over factor before commencing redistribution of moments.

Finally, the deflections and moments at each section are calculated, and the reaction, the shear force and the rotation at each support are determined.

If cantilevers are present, rotation at the end supports is taken into account when calculating deflections for the cantilever ends.

Notes: When point loads or the ends of distributed loads are placed at points other than the specified cross-sections, the resulting free bending moment diagram will not be strictly continuous, in the mathematical sense, between the sections. As continuity is a requirement of Simpson's Rule, this means that slight inaccuracies may be introduced. These may be apparent if a symmetrical loading set is applied to a symmetrical structure.

Only loads acting normal to the beam are allowed.

DATA SHEETS

The easiest way to record the data is to use a series of *data sheets* that will be self-explanatory both to the engineer who provides the data and to the operator who punches it into cards. Although it is impossible to provide standard data sheets, specimen data sheets to act as models are shown in Appendix 1 (see page 35). Each line of the data sheet is punched into a single card.

INPUT

Data is input on punched cards or paper tape, one punched card or paper tape line representing a single line on a data sheet. The data must be input in a specific order, as given below; this is also the order in which information is recorded on the Specimen Data Sheets (see Appendix 1, page 35).

Directives

Input data for each beam to be analysed in the run is divided into three groups, namely Parameter Data, Beam Data and Loading Data. Each of these is introduced to the program by a corresponding directive. These are as follows:

*PARAMETER DATA

*BEAM DATA

*LOADING DATA

For a normal run of the program, in which the effects of various loading sets on several beams are calculated, the directives followed by their data are input in the above order for each beam. The input data is terminated by the directive *END.

For example, consider a run in which two beams, A and B, are to be analysed. The data would be input in the following order:

*PARAMETER DATA
Parameter data for Beam A

*BEAM DATA
Beam data for Beam A

*LOADING DATA
Loading data for Beam A

*PARAMETER DATA
Parameter data for Beam B

*BEAM DATA
Beam data for Beam B

*LOADING DATA
Loading data for Beam B

*END

Parameter data

This defines parameters that are required for analysis of the beam such as the number of spans in the beam, the methods by which the two ends of the beam are supported and also the values of Young's Modulus for the material of the beam.

Several details used in the output headings are also defined, including the job title and the abbreviations for the units of force and length in which the input data will be provided.

Beam data

This defines beam geometry, and gives detailed information on the dimensions of sections and spans.

The shape of a section is defined in the Beam Data by defining rectangles, right-angled triangles and circles which when suitably combined make up the shape of the section.

The section details are used by the program to calculate the second moment of area of the section; alternatively the section details may be omitted and the second moment entered directly if required.

Loading data

This specifies the loading set to be analysed; any combination of point loads, uniformly-distributed loads and triangularly-distributed loads may be specified. Positive or negative loads may be specified, subject to the limitations imposed by the mathematical technique used by the program (see *Summary of restrictions*, below).

OUTPUT

For each beam of a run, the program will give a printout of both the input data and the results obtained.

The printout of input data includes the whole of the data entered on the Parameter Data Sheet (see Data Sheet 1, page 36), a list of the abbreviations for the various Area Types and Load Types to be used in the printout, an edited list of the input data on beam geometry and an edited list of the loading data for each loading set.

The results of the calculations are printed as a table giving, for each span and cantilever:

- the span number (or cantilever end)
- the section number
- the moment at each section
- the deflection at each section
- the reaction, the shear force and the rotation at each support

The program checks the format of the input data and, if an error is discovered, outputs a message on the line printer. Once an error has been discovered the program continues to check for further errors, but does not carry out any calculations. The errors in the input data are listed on the line printer as they are discovered.

SUMMARY OF RESTRICTIONS

- 1 Beams consisting of up to and including 12 spans and a cantilever at each end may be analysed.
- 2 The number of sections within a beam must be odd. Up to and including 19 sections may be specified, and must be evenly spaced along the span.
- 3 The same units of force and length must be used throughout the data. However any units required may be specified since the method of calculation used by the program is dimensionless.
- 4 The format of the data sheets must be adhered to exactly. Data may be entered anywhere within its correct field.
- 5 Some restrictions are imposed by the mathematical technique used for calculations. Limitations of the technique are that positive and negative loads must not be present on the same span, and that point loads or the ends of distributed loads placed at points other than the specified sections will cause slight inaccuracies.
- 6 Only loads acting normal to the beam are allowed.

Chapter 2 Input

DATA PREPARATION

The data is initially recorded on *data sheets*. Each data sheet is designed to be as self-contained as possible, giving all essential information required to enter the data. Data sheets should be numbered consecutively. The data should be entered only into the heavily outlined rectangles, using block capitals, with each character, digit or other symbol entered in a separate character position. Each item of data may be entered anywhere within its correct column on the data sheet. Other character positions should be left blank, or may be filled with the 1900 Series space symbol ▽.

When entering the actual values of loads, dimensions, Young's Modulus and second moment of area, the following should be noted:

- 1 Values may be entered as integer, decimal, or exponential numbers to the base 10. Integers are whole numbers with no fractional part. Decimal numbers are those with a fractional part expressed in decimal form, for example 0.00007. In exponential format the decimal number 0.00007 would be entered as 7E-5, representing 7×10^{-5} , and similarly 7×10^5 would be entered as 7E5.
- 2 All zero values must be entered as such.
- 3 When a negative value is entered, the minus sign should be placed in front of the first digit that is not zero. Only one minus sign may be entered for each negative number. For example, a negative load of 30050 pounds would be entered as -30050.
- 4 Fractions must be entered in decimal or exponential form.
- 5 No comma is allowed in a number such as 5600.

Data is input on punched cards or paper tape in the order given on the data sheets, provided that these have the same format as the specimen data sheets shown in Appendix 1 (see page 35). Each line on the data sheets is punched on a single card or between two newline characters on paper tape.

Normally, the program will be used to analyse the effects of various loading sets on one or more beams (this is not the only function of the program; it can be used to list beam properties only, see page 8). For a normal run, the data must be input in the following order:

- 1 Parameter data
- 2 Beam data
- 3 Loading data

Each group of data is introduced by a corresponding directive; the use of each directive is explained together with the format of input for each group later in this chapter, and a summary of the use of directives has already been given in Chapter 1 (see page 2).

The order of information to be given on the data sheets is set out below. This will also be the order in which the punched cards are input or in which data should be punched on paper tape.

PARAMETER DATA

Information is entered on the Parameter Data Sheet (see *Data Sheet 1*, page 36).

Parameter data is introduced to the program by the directive:

***PARAMETER DATA**

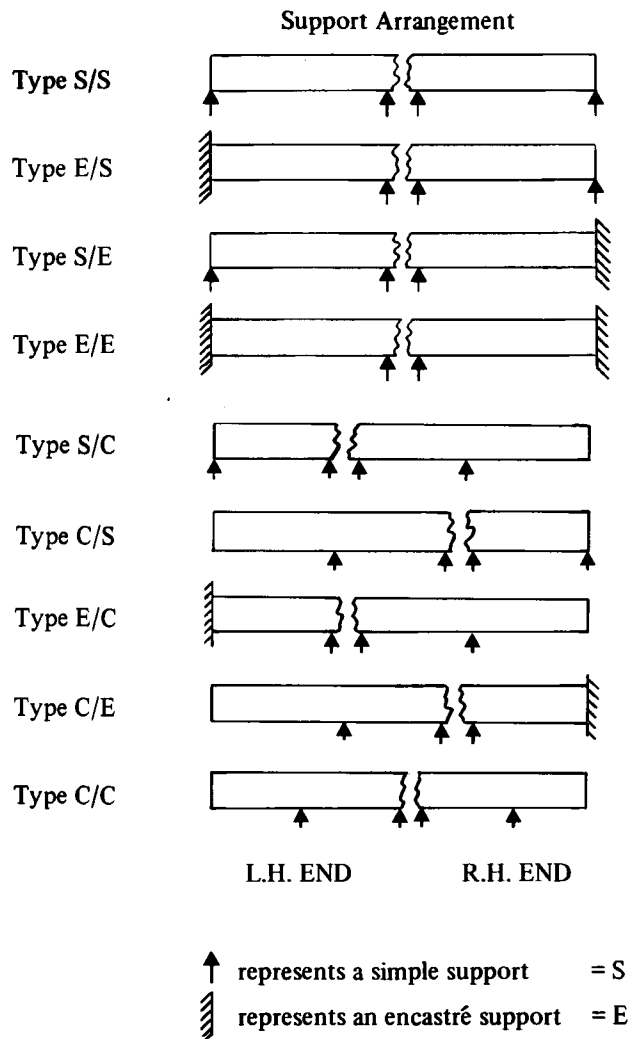
This directive is followed by:

- 1 **THE JOB REFERENCE NUMBER.** This can be up to 12 characters long
- 2 **THE JOB TITLE.** This is generally a descriptive title, and may consist of up to 40 characters

- 3 **THE NUMBER OF SPANS.** Problems with up to 12 spans and 2 cantilever ends may be handled by the program, but cantilever ends, if present, should be ignored when stating the number of spans. If the problem consists of a single cantilever only, the number of spans is entered as 0.
- 4 **THE UNIT OF LENGTH.** The unit specified must be used for all data given in length units. The parameter, however, is used only in the output headings and is entered as an abbreviation or name consisting of up to 4 characters (for example: FEET, INS., CM. etc.)
- 5 **THE UNIT OF FORCE.** The unit specified must be used for all data given in force units. The parameter, however, is used only in the output headings, and is entered as an abbreviation or name consisting of up to 4 characters (for example: TONS, LBS., KN. etc.)
- 6 **THE VALUE OF YOUNG'S MODULUS.** This value is specified by the user, and must be consistent with the units specified by parameters 4 and 5 above. The units of Young's Modulus are given by the following relation:

$$\text{units of Y. M.} = (\text{units of force}) \times (\text{units of length})^{-2}$$

- 7 **THE END-SUPPORT ARRANGEMENTS.** Nine end-support combinations may be specified and are entered as follows:



These codes refer to the type of support of the left and right end-supports of the beam.

Parameter data is ended by the following directive:

***BEAM DATA**

This directive dictates that all data following it is to be treated as Beam Data. The directive is placed at the end of the Parameter Data Sheet since a single Beam Data directive is expected by the program for each beam. This would not be the case if the directive was the first item of a Beam Data Sheet, since several Beam Data Sheets are normally required to define the Beam Data.

BEAM DATA

The spans of the beam (excluding cantilevers) are numbered from left to right, from 1 up to the maximum of 12. If there is a cantilever at the left-hand support, this is entered as CANT A before any span details are entered; a cantilever end at the right-hand support is entered as CANT B after all span details have been entered.

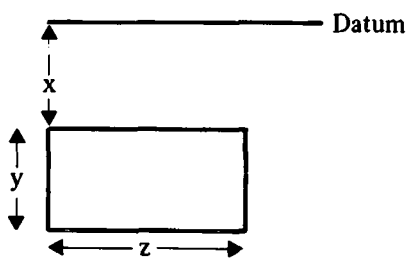
The data for each span and cantilever is entered on a separate Beam Data Sheet (see *Data Sheet 2a*, page 37); if necessary, continuation sheets (see *Data Sheet 2b*, page 39) may be used for data for each span. Data is entered in the following order:

- 1 **SPAN NUMBER.** Each span number is preceded by the letters SPAN so that it may be identified by the program. The maximum permissible span number is 12. If the data refers to a cantilever, no span number is entered.
- 2 **CANTILEVER END.** If a cantilever is present at the left-hand end of the beam, the relevant data is introduced by CANT A; if there is a cantilever at the right-hand end, then CANT B is used. If the data refers to a span, no cantilever end is entered.
- 3 **NUMBER OF SECTIONS.** This number must be odd, and no greater than 19. Sections must be equally spaced along the span, although the spacing may vary from one span to another.

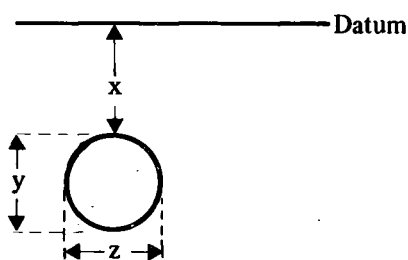
The first and last sections of a span will be at the supports, hence with the exception of the first span, the first section of a span will be the last section of the previous span.

- 4 **LENGTH OF SPAN OR CANTILEVER.** This must be in the units of length specified in the Parameter data (see page 6).
- 5 **CROSS-SECTION DATA.** Cross-sections of any shape can be defined to the program by considering them as being made up of combinations of the standard area types (see below). For each cross-section, the following data is input on a new punched card:
 - (a) The section number. As with span numbering, sections are numbered consecutively from left to right. For each span, the section details must be entered in order of section number.
 - (b) For each area within the cross-section, the following data must be given:
 - (i) **THE AREA TYPE.** This is input as the reference letter of the area type concerned and may be type R, U, L or C. These letters correspond to the following areas:

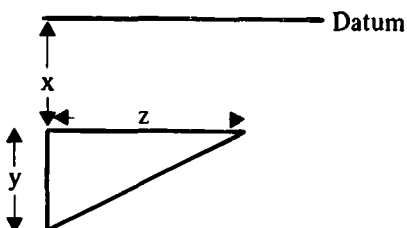
Rectangle – Type R



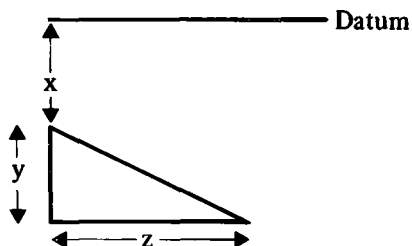
Circle – Type C



Triangle – Type U



Triangle – Type L



U – upper triangle i.e., right angle at top

L – lower triangle i.e., right angle at bottom

(right angle may be at left or right of triangle)

- (ii) The position of each area within the cross-section is defined relative to a common *datum line*, which may be placed at any convenient position and may be varied from section to section. The dimensions X, Y and Z are entered in sequence for each area, as shown above. These dimensions must be in the specified length units, and may be integer, decimal or exponential numbers.

If the area is to be deducted, dimension Z is entered as negative.

If the specified datum line is below the top of any area the dimension X is entered as netative. The dimension Y must never be negative.

The user may wish to specify the value of the second moment of area for a section rather than have it calculated from section details by the program. In such a case, the letter I should be entered in the *Area Type* column and the required value in the *X dimension* column. The units must be consistent with the units of force and length given in the Parameter Data.

Where section configurations are repeated along a beam it is not necessary to repeat the area details. Any previously defined section may be used as a reference for later sections which have the same configuration. To repeat a section configuration a P is entered in the *Area Type* column, and the span number and section number of the reference section are entered in the X and Y columns respectively. If the reference section is in a cantilever end, the span number is entered as the total number of spans in the beam (excluding cantilevers) plus one for the left-hand end, or plus two for the right-hand end, as appropriate.

If several adjacent sections are the same, only details of the first need be entered. The program will encounter a gap in the sequence of section numbers, and fill the gap by repeating details of the last section read in. Hence, if all the sections of a span or cantilever are the same, only the first need be detailed: before the specified number of sections have been read in, the program will encounter the letters SPAN preceding the next span, or CANT preceding the right-hand cantilever (if one is present), and will repeat details of the first section until the gap is filled.

A listing of beam properties may be obtained without the necessity of specifying loads, if required by the user. To accomplish this the Beam Data is terminated by the directive *END. If several beams are to be listed in this way, only the data for the last is terminated by *END; data for intermediate beams is terminated by the directive *PARAMETER DATA, which prepares the program to receive data for a new beam.

LOADING DATA

Data for each loading set is preceded by the directive:

*LOADING DATA

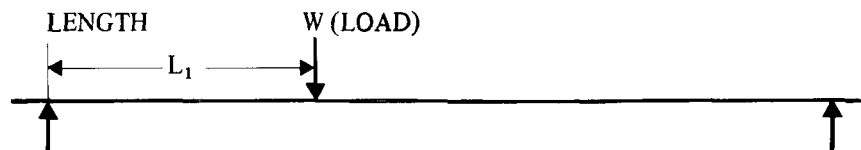
Any number of loading sets may be specified. The loads may be applied in any combination, with certain exceptions (see *Summary of restrictions*, page 3).

The data for each loading set is entered on a separate Loading Data Sheet (see *Data Sheet 3*, page 40); if necessary, data for a loading set may be continued on another Data Sheet 3 provided that the directive *LOADING DATA is deleted. This directive will thus precede each loading set.

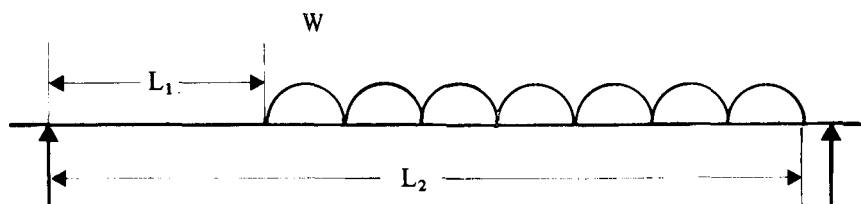
The input data required for each load within a loading set is as follows:

- 1 The span number, or cantilever end (CA for left-hand end, CB for right-hand end).
- 2 The load type. There are three load types that may be specified. These are:

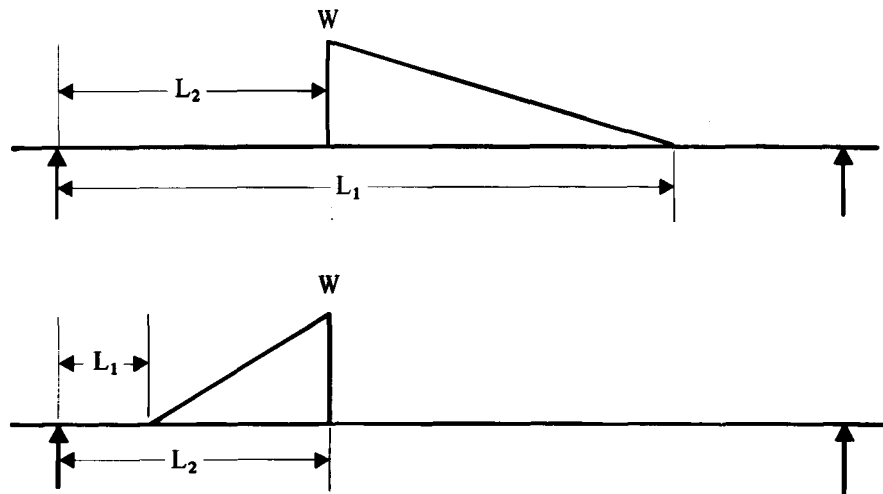
Type P, (point load)



Type U, (uniform load)



Type T, (triangular load)



- 3 The value of the load W . In the case of uniform loads, W is the load per unit length; in the case of triangular loads it is the load per unit length at the maximum point. Only loads acting normal to the beam are permitted. Loads acting downwards are entered as positive, those acting upwards as negative. Positive and negative loads may be applied to a beam provided that they are not combined in any one span. If negative and positive loads are combined in one span, the reactions and shear forces calculated will be incorrect, while if the algebraic sum of the loads on a span becomes zero, then the program will come to an error halt.
- 4 The distances L_1 and L_2 , both measured from the left-hand end of the span. In the case of a point load, Type P, the length L_2 is not entered.

If the above diagrams are to represent cantilever ends, the left-hand supports should be ignored for a cantilever at end A, while the right-hand supports should be ignored for a cantilever at end B.

If another loading set is to follow, it should be entered on a further Data Sheet 3.

If data for another beam is to follow, it should be entered on a further Data Sheet 1.

If no more input data is to follow, the loading data should be terminated by the directive:

***END**

This directive indicates to the program that all data has been read in, and calculation will proceed.

Chapter 3 Output

The output described in this chapter is repeated for each beam being analysed in a run. Sample printouts are given in Chapter 5 (see page 17).

The printout from the program lists the data which was input to the program followed by the results of calculations performed by the program.

The line printer listing of the numerical part of both the input and output data will be in 1900 Series FORTRAN G-type format. The numbers printed out will all be real numbers, that is they will have a decimal fractional part, but may be expressed either in decimal or exponential format depending on the size of the number. The value of the decimal format will be obvious but the exponential format may need to be explained.

The following is an example of a number expressed in exponential form:

0.846600E-07

The characters E-07 are the *exponent* and represent the number of powers of 10 by which the *argument*, the fraction to the left of E, must be multiplied to give the value of the number in decimal form. The example given above represents the following number:

0.846600×10^{-7}

or in decimal form:

0.00000008466

The exponent and the argument may be either positive or negative, and if either is positive it will be unsigned. Some decimal numbers may be larger than can be output in the print positions allotted to the number by the program; the exponential format is used to output such numbers accurately within the available print positions.

PRINTOUT OF INPUT DATA

The program first prints a general heading which includes the program name, its reference number and the date and time. This general heading is common to all the beams being considered in one run.

The general heading is followed by specific data for each beam being considered. The Job Reference Number and Job Title are printed, followed by the number of spans in the beam, the units of length and force, the value of Young's Modulus and the end-support type. The abbreviations representing the various Area Types and Load Types are also provided for reference.

Beginning on the next page, the program prints an edited list of the input data on beam geometry and then an edited list of input data for each loading set.

PRINTOUT OF RESULTS

For each loading set the program prints out the results in a table with the following headings:

SPAN NUMBER	SECTION NUMBER	MOMENT	DEFLECTION	SUPPORT REACTION	SHEAR FORCE	SUPPORT ROTATION
----------------	-------------------	--------	------------	---------------------	----------------	---------------------

SPAN NUMBER is replaced by CANTILEVER END when the results refer to a cantilever. Results for a cantilever at the left-hand or right-hand end of the beam will be printed out after the results for all the spans.

ERROR MESSAGES

If an error in the format of the input data is found by the program as the data is read in, the program will print out the following message on the line printer:

***ERROR DISCOVERED – CALCULATION STOPPED ***

The program will continue to read in the data, and to check for errors, but calculations for that beam will be stopped. All errors will be flagged on the line printer. Each error message is preceded by the following:

**** ERROR ****

This message is followed by a description of the error, which may be one of the following:

NUMBER OF SPANS IS GREATER THAN 12

END SUPPORT TYPE *xxx* NOT RECOGNISED

SPAN NUMBER IS INCORRECT

NUMBER OF SECTIONS EXCEEDS 19

NUMBER OF SECTIONS IS NOT ODD

SECTION NUMBER *xx* IS INCORRECT

AREA TYPE *x* NOT RECOGNISED

THE PROPERTIES OF THE SPAN AND SECTION SPECIFIED HAVE NOT BEEN PREVIOUSLY DEFINED

LOAD TYPE *x* NOT RECOGNISED

SOME LOADING DATA IS MISSING

SOME BEAM DATA IS MISSING

FIRST LINE OF BEAM DATA BEGINS '*xxxxx*'—IT SHOULD BEGIN 'SPAN'

NUMBER OF SPANS DOES NOT EQUAL NUMBER SPECIFIED IN PARAMETER DATA

CANTILEVER END WRONGLY SPECIFIED AS *xx*—IT SHOULD BE 'A' OR 'B'

CANTILEVER END INCLUDED IN BEAM DATA. THIS IS INCOMPATIBLE WITH THE END SUPPORT TYPE SPECIFIED

CANTILEVER END NOT INCLUDED IN BEAM DATA. THIS IS INCOMPATIBLE WITH THE END SUPPORT TYPE SPECIFIED.

UNACCEPTABLE CHARACTER *xxxx* IN NUMERIC INPUT FIELD

where *x* represents an item of input data specified in the error message.

Chapter 4 Operating

OPERATING INSTRUCTIONS

Executive priority

The program as supplied has an Executive priority of 50.

Use of peripherals

The program uses a line printer and either a card reader or a paper tape reader. These are used throughout the run.

Running under GEORGE

The peripheral unit numbers for running under GEORGE are as follows:

line printer	LPO
paper tape reader	TR0
card reader	CRO

GEORGE 1 AND 2 JOB DESCRIPTIONS

The following two examples each describe a job description suitable for running the program under GEORGE 1 or 2. The first example applies to #X2B3, the magnetic tape version of the program; the second example applies to the disc version, #X2B4.

Example 1

```
JOB RUNX2B3,658521,ENGINEER
1 DATA MT (PROGRAMVTAPE)
2 DATA CR0 (BEAMDATA)
IN 1
LOAD #X2B3
SWITCH ON 1
IN 2
ENTER 0
END
****
DOCUMENT BEAMDATA
.
.
.
****
```

Example 2

```
JOB RUNX2B4,658522,ENGINEER
1 DATA ED (PROGRAMVX2B4)
2 DATA CR0 (BEAMDATA)
IN 1
```

```

LOAD#X2B4
SWITCH ON 1
IN 2
ENTER 0
END
****
DOCUMENT BEAMDATA
.
.
.
****

```

GEORGE 3 MACRO

The following is an example of a user macro that could be written to control the running of the continuous beam analysis program under GEORGE 3. The program is assumed to be held on the file K-2DAAT8.PROGRAMVX2B3.

```

MACDEF RUNX2B3
IF PRE(ER), WE COMERR, GO TO %(ER)
IF ABS(ER), WE COMERR, GO TO 9X2B31
LO :K-2DAAT8.PROGRAMVX2B3
IF PRE(*CR) AND STR(*CR)=(),OL*CR0
IF PRE(*CR) AND NOT STR(*CR)=(),AS *CR0, %(*CR)
IF PRE(*TR) AND STR (*TR)=(),OL *TR0
IF PRE(*TR) AND NOT STR(*TR)=(),AS *TR0, %(*TR)
IF PRE(*CR) OR PRE(*TR), GO TO 9X2B32
DELETE NO INPUT SPECIFIED – MACRO ABANDONED
GO TO 9X2B33
9X2B32 IF PRE(*LP) AND NOT STR(*LP)=(),AS *LP0,%(*IP)
IF PRE(*LP) AND STR(*LP)=(),OL *LP0
IF ABS (*LP),OL *LP0
IF PRE(TIME), TIME %(TIME)
IF ABS(TIME), TIME 2 MINS
IF PRE (*CR), ON 1
EN 0
9X2B33 IF NOT DELETED (00) AND PRE(ER),GO TO %(ER)
9X2B31
ENDM

```

Calls to this macro to initiate individual runs of the program would take the form:

RUNX2B3 *input, output, time, error*

The four parameters, which take the forms described below, may occur in any order. The parameter *input* must be present; all the others are optional.

<i>Parameter</i>	<i>Possible forms</i>	<i>Effects</i>
<i>input</i>	*CR } *TR }	The input is read from the job source in the relevant mode.
	*CR <i>entrant description</i> } *TR <i>entrant description</i> }	The input is read from the entrant specified.
<i>output</i>	*LP <i>entrant description</i>	Output to the specified entrant.
	*LP } (<i>none</i>) }	Output to the monitoring file system.
<i>time</i>	TIME <i>n</i> MINS	Maximum allowable mill time <i>n</i> minutes
	TIME <i>n</i> SECS } TIME <i>n</i> }	Maximum allowable mill time <i>n</i> seconds
	(<i>none</i>)	Maximum allowable mill time 2 minutes.
<i>error</i>	ER <i>label</i>	If the run fails or an error is detected in the macro, control passes to the GEORGE command whose label is specified.
	(<i>none</i>)	If the run fails or an error is detected in the macro, control passes to GEORGE command after the macro call.

Some examples of permissible GEORGE commands to call the macro are:

RUNX2B3 *CR BEAMDATA, TIME 30 SECS

RUNX2B3 *CR, *LP RESULTS, ER 9REM

Running under Executive alone

MAGNETIC TAPE VERSION (#X2B3)

<i>Narrative</i>	<i>Console message</i>
1 Load the library magnetic tape containing the program and input	FI #X2B3 #TAPE
2 If data is on cards, input	ON #X2B3 1
3 Input	GO #X2B3 20
4 The program deletes itself with the message	DELETED:-00

DISC VERSION (#X2B4)

<i>Narrative</i>	<i>Console message</i>
1 Load the library disc containing the program and input	FI #X2B4 #X2B4
2 If data is on cards, input	ON #X2B4 1
3 Input	GO #X2B4 20
4 The program deletes itself with the message	DELETED:-00

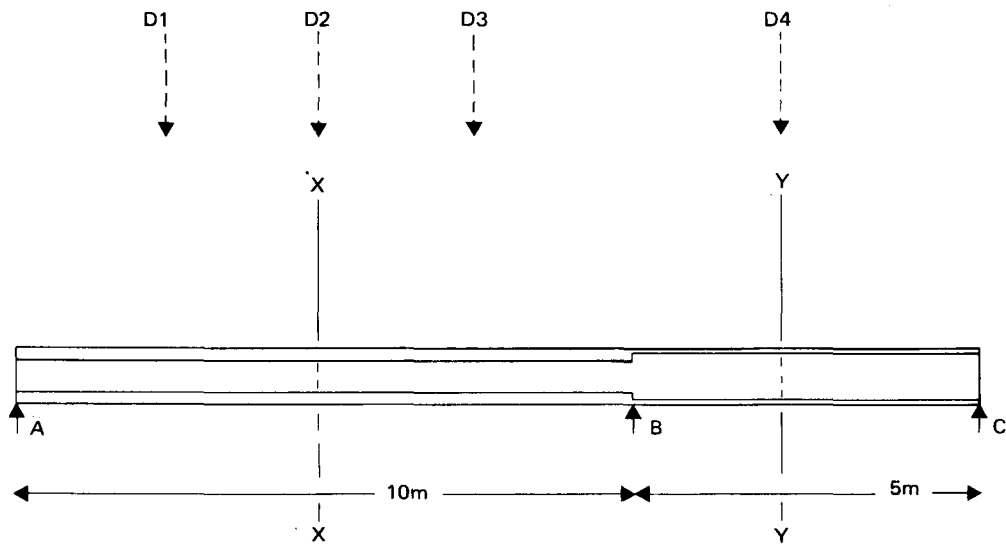
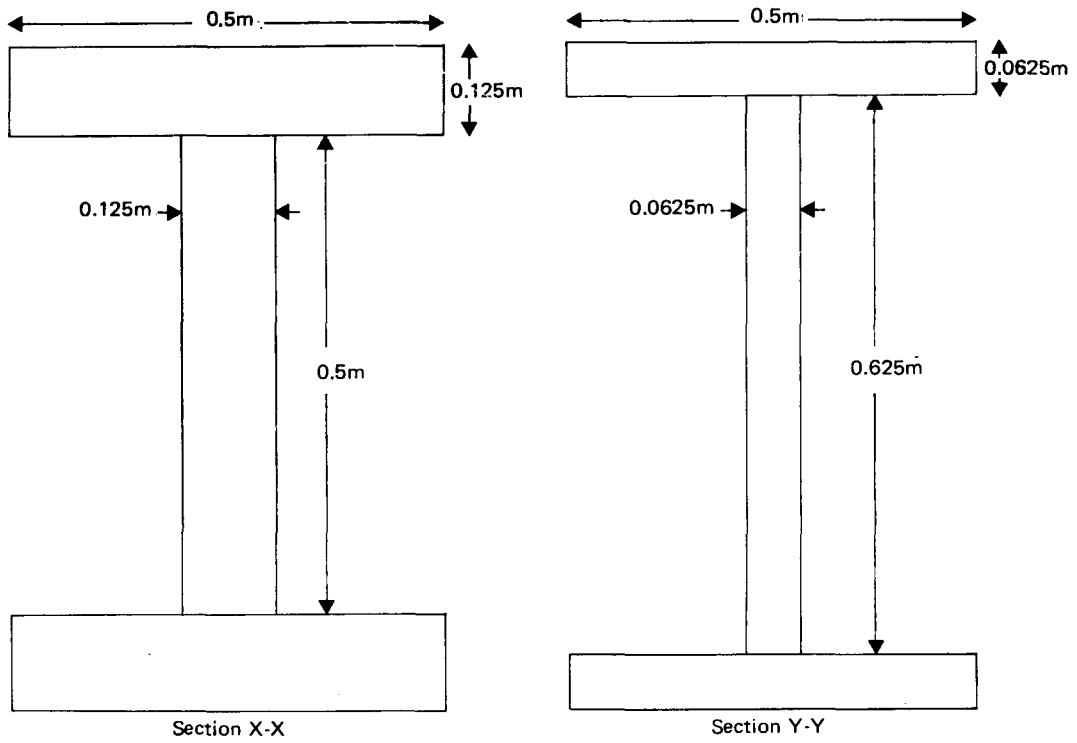


Figure 1 Dimensions of the beam used in Example 1

Chapter 5 Examples

EXAMPLE 1

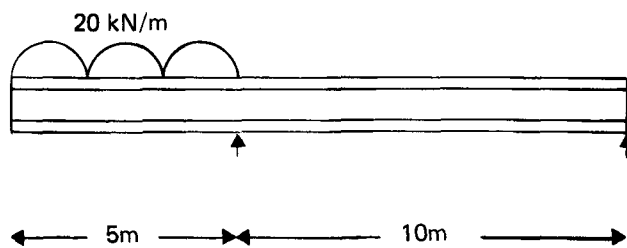
This example demonstrates how the program can be used to obtain influence lines of bending moments and deflection at certain sections of a continuous beam.

Details of the beam considered in the example are given in Figure 1 (page 16). The example considers the effect of a point load of 100 kiloNewtons moving along the beam. The load is successively placed at positions D_1 , D_2 , D_3 and D_4 , and the effects of the load in terms of bending moments and deflection at section X-X are calculated; these four loading cases have been chosen for simplicity and economy of space, but for greater accuracy the number of loading cases should be increased as required.

The data required by the program is given as completed data sheets (see pages 18 to 24). The line printer output from the program is given on pages 25 to 27. It should be noted that the format in which data is input, as illustrated by the data sheets, differs from both the edited list of input data and the results, which appear on the line printer output. Output is in FORTRAN G-type format (see page 11).

The results of the calculation are summarised as influence lines of the bending moments and deflection at section X-X (see Figure 2, page 28).

EXAMPLE 2



This example illustrates the case of a beam with a cantilever end. The section for the beam is the same throughout as that for the span AB in Example 1. The cantilever end (end A) is uniformly loaded with a load of 20 kN/m. The data required by the program is given on pages 29 to 32; the line printer output from the program is given on pages 33 and 34.

ICL

Data Processing

1900 Series Continuous beam analysis program

Notes to punch operator

Punch data enclosed by heavy lines only
 Each line must be punched on a new card or a new line of paper tape
 Spaces only where indicated by:
 (a) ▽ characters
 (b) Blank character positions thus:

Parameter data

Data sheet 1
 Reference: K/REM/3
 Page number: 1

***PARAMETER DATA**

K/REM/3

Job reference number

C▽B▽A - DATA▽3

Job heading

2

Number of spans
 [Ignore cantilevers. Enter 0 if problem consists of cantilevers only]

M

Unit of length to be used throughout the data

KN

Unit of force to be used throughout the data

2.07E6

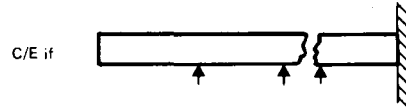
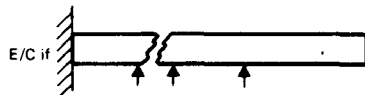
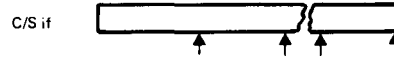
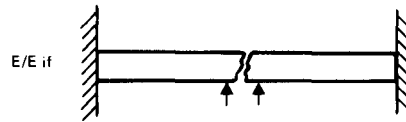
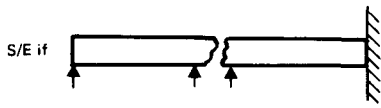
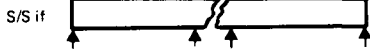
Value of Young's Modulus
 [in (force units) X (length units)²]

S/S

End-support type

***BEAM DATA**

For End-Support Type, enter



Continue on Data Sheet 2(a) (Beam data)

ICL 1900 SERIES CONTINUOUS BEAM ANALYSIS (M283/2)
 DATE: 26/03/71 TIME: 20/35/27

JOB REFERENCE NUMBER: K/REM/3

JOB TITLE: C B A DATA - 3

NUMBER OF SPANS: 2

UNIT OF LENGTH: M

UNIT OF FORCE: KN

YOUNG'S MODULUS: 20700000, KN PER SQ. M

END SUPPORT TYPE: S/S END A SIMPLY SUPPORTED END B SIMPLY SUPPORTED

AREA TYPES ARE ABBREVIATED AS FOLLOWS:-

RECT - RECTANGLE
 CIRC - CIRCLE
 TRI1 - TRIANGLE: RT, ANGLE AT TOP
 TRI2 - TRIANGLE: RT, ANGLE AT BOTTOM

LOAD TYPES ARE ABBREVIATED AS FOLLOWS:-

PL - POINT LOAD
 UDL - UNIFORM LOAD
 TDL - TRIANGULAR LOAD

A AND B REFER TO THE LEFT-HAND AND RIGHT-HAND ENDS OF THE SPAN RESPECTIVELY
 SS - SIMPLY SUPPORTED
 EN - ENCASTRE

* * * * *

BEAM GEOMETRY
 SPAN NUMBER 1

LENGTH OF SPAN = 19.0000 M

9 EQUALLY SPACED SECTIONS

SECTION NUMBER	AREA TYPE	DIMENSION X M	DIMENSION Y M	DIMENSION Z M	SECTION NUMBER	X=SECTION AREA SQ.M	DEPTH TO CENTROID M	2ND MOMENT OF AREA TO 47M CM
1	RECT	U.000000E 00	0.125000	0.500000	1	0.187500	0.375000	0.130719E-01
	RECT	U.125000	0.500000	0.125000	2			0.130719E-01
	RECT	U.625000	0.125000	0.500000	3			0.130719E-01
2					4			0.130719E-01
3					5			0.130719E-01
4					6			0.130719E-01
5					7			0.130719E-01
6					8			0.130719E-01
7					9			0.130719E-01
8								
9								

SPAN PROPERTIES

INFLUENCE COEFFICIENTS

END A	END B	1 KN MOMENT AT	ROTATION AT (RADIANS)
SS	SS	A	A = 0.117622E-05
SS	SS	B	B = 0.117622E-05
SS	SS	A/B	B/A = 0.508912E-06
SS	SS	A	A = 0.883568E-06
SS	SS	B	B = 0.883568E-06

CARRY-OVER FACTORS

FROM A TO B = -0.50000
 FROM B TO A = -0.50000

Example 1

SPAN NUMBER 2
 5 EQUALLY SPACED SECTIONS
 LENGTH OF SPAN = 5.00000 M

SECTION NUMBER	AREA TYPE	DIMENSION X M	DIMENSION Y M	DIMENSION Z M	SECTION NUMBER	X-SECTION AREA SQ.M	DEPTH TO CENTROID M	2ND MOMENT UP AREA (M TO 4TH)
1	RECT	0.000000E+00	0.625000E-01	0.500000	1	0.101563	0.375000	0.867716E-02
	RECT	0.625000E-01	0.625000	0.625000E-01	2			0.867716E-02
	RECT	0.687500	0.625000E-01	0.500000	3			0.867716E-02
2					4			0.867716E-02
3					5			0.867716E-02
4								
5								

SPAN PROPERTIES

END A		END B		1 KN M MOMENT AT		ROTATION AT (RADIANS)		CARRY-OVER FACTORS	
SS	SS	SS	SS	A	B	A	B	FROM A TO B	FROM B TO A
SS	SS	SS	SS	A/B	A/B	A	B	=0.50000	=0.50000
SS	EN	SS	EN	A	B	A	B		
EN	SS	EN	SS	B	A	B	A		

LOADING CASE 1

INPUT DATA

SPAN NUMBER	LOAD TYPE	W KN	L1 M	L2 M
1	PL	100.000	2.50000	

RESULTS

SPAN NUMBER	SECTION NUMBER	MOMENT KN -M	DEFLECTION M	SUPPORT REACTION KN	SHEAR FORCE KN	SUPPORT ROTATION RADIANS
1	1	0.00000E+00	0.00000E+00	68.445	68.445	0.154635E-03
	2	85.356	0.18542E+03			
	3	171.11	0.32361E+03			
	4	131.67	0.37882E+03			
	5	92.226	0.36134E+03			
	6	52.782	0.29294E+03			
	7	13.339	0.19540E+03			
	8	-26.103	0.90493E+04			
	9	-65.548	0.00000E+00			
2	1	-65.548	0.00000E+00	44.664	13.110	-6.00220E-04
	2	-49.161	-0.49893E+04			
	3	-32.774	-0.57021E+04			
	4	-16.387	-0.35638E+04			
	5	0.00000E+00	0.00000E+00			
				-13.110	13.110	0.30411E-04

Example 1

LOADING CASE 2				INPUT DATA			
SPAN NUMBER	SECTION NUMBER	LOAD TYPE	PL	M KN	L1 M	L2 M	
1	1			100.000	5.00000		
1	1	0.00000E 00		0.00000E 00	39.512	39.512	0.139079E+03
2	2	49.390		0.19430E+03			
3	3	98.781		0.36134E+03			
4	4	148.17		0.47584E+03			
5	5	197.56		0.50433E+03			
6	6	121.95		0.43795E+03			
7	7	46.342		0.30344E+03			
8	8	-29.267		0.14504E+03			
9	9	-104.88		0.00000E 00			
2	1	-104.88		0.00000E 00	81.463	20.975	-9.97433E-06
2	2	-78.658		-0.79829E-04			
3	3	-32.439		-0.91233E-04			
4	4	-26.219		-0.57031E-04			
5	5	0.00000E 00		0.00000E 00	-20.975	20.975	0.48538E-06

LOADING CASE 3				INPUT DATA			
SPAN NUMBER	SECTION NUMBER	LOAD TYPE	PL	M KN	L1 M	L2 M	
1	1			100.000	7.50000		
1	1	0.00000E 00		0.00000E 00	15.823	15.823	0.039833E+04
2	2	19.779		0.10316E+03			
3	3	39.558		0.19540E+03			
4	4	59.337		0.26580E+03			
5	5	79.116		0.30344E+03			
6	6	98.895		0.39739E+03			
7	7	118.67		0.23475E+03			
8	8	13.454		0.12209E+03			
9	9	-91.767		0.00000E 00			
2	1	-91.767		0.00000E 00	102.53	19.333	-8.89177
2	2	-68.826		-0.69830E-04			
3	3	-43.884		-0.79829E-04			
4	4	-22.942		-0.49835E-04			
5	5	0.00000E 00		0.00000E 00	-19.333	19.333	0.44575E-06

LOADING CASE 4				INPUT DATA			
SPAN NUMBER	SECTION NUMBER	LOAD TYPE	PL	M KN	L1 M	L2 M	
1	1			100.000	2.50000		
1	1	0.00000E 00		0.00000E 00	-4.1311	-4.1311	-2.43288E-06
2	2	-5.1639		-0.39936E-04			
3	3	-1.328		-0.87031E-04			
4	4	-13.92		-0.78403E-04			
5	5	-20.456		-0.61233E-04			
6	6	-23.820		-0.22439E-04			
7	7	-30.984		-0.99839E-04			
8	8	-36.148		-0.49835E-04			
9	9	-41.311		0.00000E 00			
2	1	-41.311		0.00000E 00	62.393	58.282	0.488376E-04
2	2	31.316		0.8822E-04			
3	3	10.478		0.10932E-03			
4	4	52.172		0.7716E-04			
5	5	0.00000E 00		0.00000E 00	41.738	-41.738	-0.67824E-06

END OF JOB REF. K/REV/3

Example 1

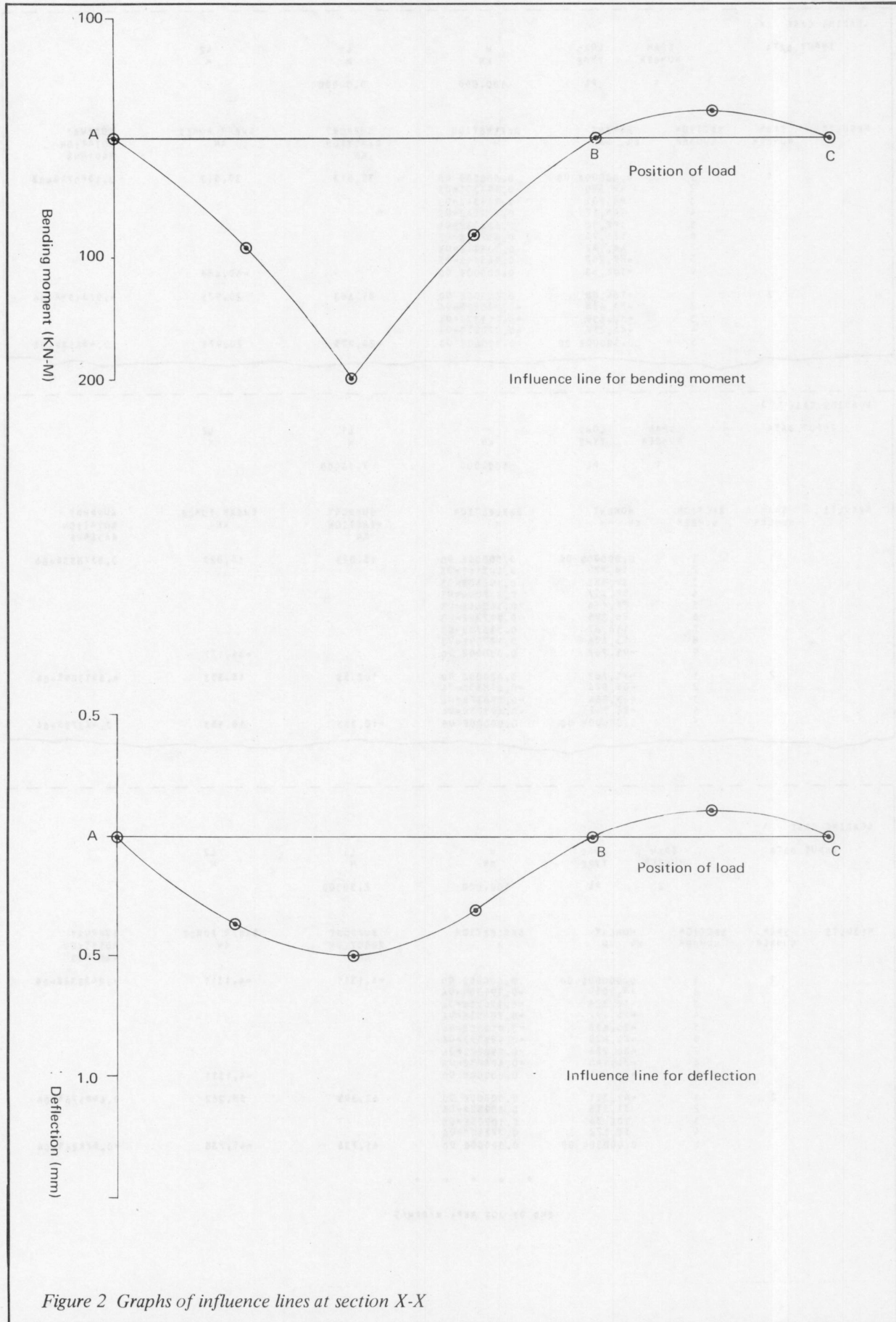


Figure 2 Graphs of influence lines at section X-X

ICL

Data Processing

1900 Series Continuous beam analysis program

Notes to punch operator

Punch data enclosed by heavy lines only
 Each line must be punched on a new card or a new line of paper tape
 Spaces only where indicated by:
 (a) ▽ characters
 (b) Blank character positions thus: |_|_|_|_|

Parameter data

Data sheet 1
 Reference: K/BS/1
 Page number: 1

* P A R A M E T E R D A T A

K/BS/1

Job reference number

C B A - DATA 4

Job heading

1

Number of spans
 [Ignore cantilevers. Enter 0 if problem consists of cantilevers only]
 Unit of length to be used throughout the data

M

K,N

Unit of force to be used throughout the data

2,0,7,E,6

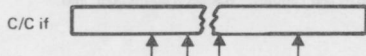
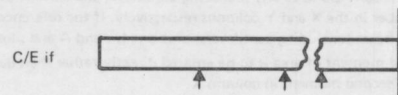
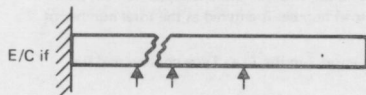
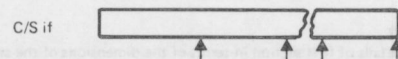
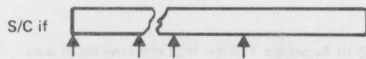
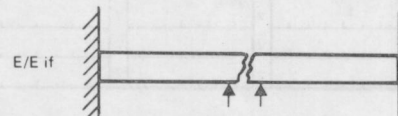
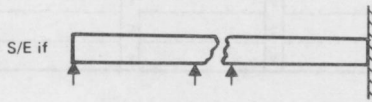
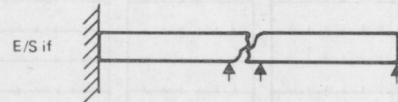
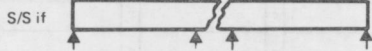
Value of Young's Modulus
 [in (force units) X (length units)²]

C/S

End-support type

* B E A M D A T A

For End-Support Type, enter



Continue on Data Sheet 2(a) (Beam data)

Example 2

SPAN NUMBER 1
9 EQUALLY SPACED SECTIONS
LENGTH OF SPAN = 10.0000 M

SECTION NUMBER	AREA TYPE	DIMENSION X M	DIMENSION Y M	DIMENSION Z M	SECTION NUMBER	X-SECTION AREA SQ.M	DEPTH TO CENTROID M	2ND MOMENT UP AREA (M TO 4TH)
1	RECT	0.000000E 00	0.125000	0.500000	1	0.187500	0.375000	0.130719E-01
	RECT	0.125000	0.500000	0.125000	2			0.130719E-01
	RECT	0.625000	0.125000	0.500000	3			0.130719E-01
2					4			0.130719E-01
3					5			0.130719E-01
4					6			0.130719E-01
5					7			0.130719E-01
6					8			0.130719E-01
7					9			0.130719E-01
8								
9								

SPAN PROPERTIES

INFLUENCE COEFFICIENTS				CARRY-OVER FACTORS	
END A	END B	1 KN M MOMENT AT	ROTATION AT (RADIANS)	FROM A TO B	FROM B TO A
SS	SS	A	A = 0.117782E-05	=0.50000	
SS	SS	B	B = 0.117782E-05		=0.50000
SS	SS	A/B	B/A = 0.584912E-04		
SS	EN	A	A = 0.883366E-04		
EN	SS	B	B = 0.883366E-04		

LOADING CASE 1

INPUT DATA	CANTILEVER END	LOAD TYPE	W KN	L1 M	L2 M
	A	UDL	20.0000	0.00000E 00	5.00000

RESULTS	SPAN NUMBER	SECTION NUMBER	MOMENT KN =M	DEFLECTION M	SUPPORT REACTION KN	SHEAR FORCE KN	SUPPORT ROTATION RADIANS
	1	1	-250.00	0.00000E 00	125.00	125.00	-0.29456E-03
		2	-218.75	-0.30193E-03			
		3	-187.50	-0.48309E-03			
		4	-156.25	-0.56073E-03			
		5	-125.00	-0.55210E-03			
		6	-93.750	-0.47447E-03			
		7	-62.500	-0.34807E-03			
		8	-31.250	-0.18116E-03			
		9	0.00000E 00	0.00000E 00	-25.000	25.000	0.14723E-03

RESULTS	CANTILEVER END	SEC NO.	MOMENT KN =M	DEFLECTION M
	A	1	0.00000E 00	0.20264E-02
		2	-3.9063	0.17484E-02
		3	-15.625	0.14730E-02
		4	-35.156	0.11999E-02
		5	-62.500	0.93168E-03
		6	-97.656	0.67220E-03
		7	-140.63	0.42630E-03
		8	-191.41	0.19990E-03
		9	-250.00	0.00000E 00

* * * * *

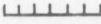
END OF JOB REP. K/BS/1

Appendix 1 Specimen data sheets

The specimen data sheets are given on the following pages. Note that the only data to be punched is that enclosed by heavy lines.

	<i>Page</i>
Data Sheet 1: Parameter Data	36
Data Sheet 2a: Beam Data	37
Area Types	38
Data Sheet 2b: Beam Data (continuation sheet)	39
Data Sheet 3: Loading Data	40

Notes to punch operator

Punch data enclosed by heavy lines only
 Each line must be punched on a new card or a new line of paper tape
 Spaces only where indicated by:
 (a) ▽ characters
 (b) Blank character positions thus: 

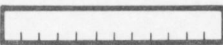
Parameter data

Data sheet 1

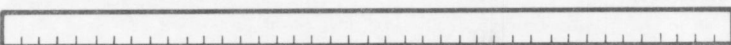
Reference:

Page number:

* P A R A M E T E R D A T A



Job reference number



Job heading



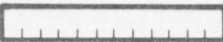
Number of spans
 [Ignore cantilevers. Enter 0 if problem consists of cantilevers only]



Unit of length to be used throughout the data



Unit of force to be used throughout the data



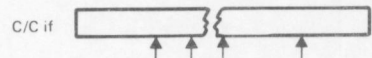
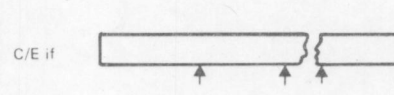
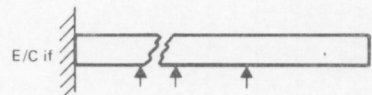
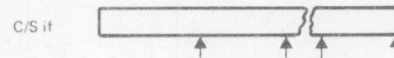
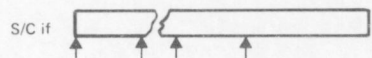
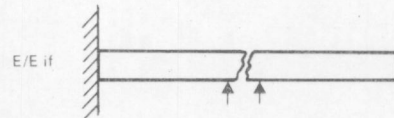
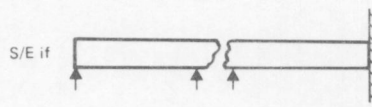
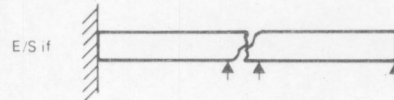
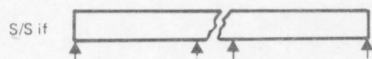
Value of Young's Modulus
 [in (force units) X (length units)²]



End-support type

* B E A M D A T A

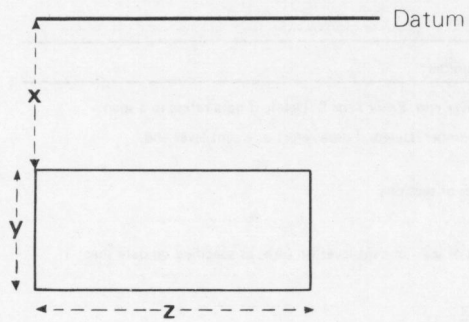
For End-Support Type, enter



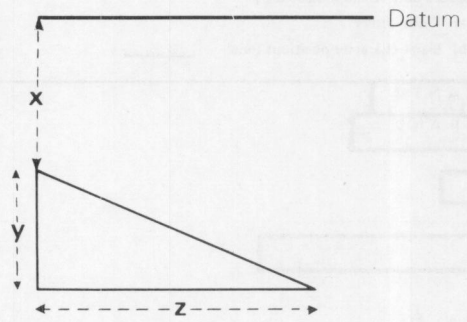
Continue on Data Sheet 2(a) (Beam data)

Area Types

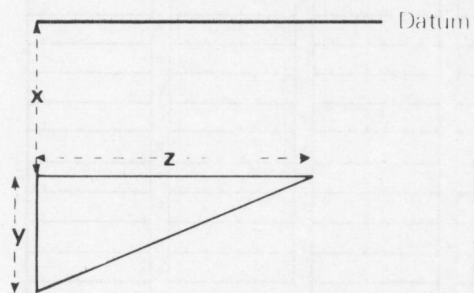
Type R



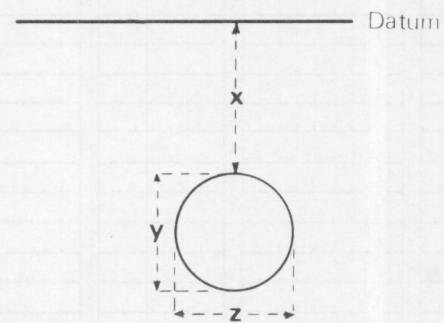
Type L



Type U



Type C



If the area is to be deducted, Z is entered as negative.

If the datum is below the top fibres of the area, X is entered as negative.

Y must never be negative.

Notes to punch operator

- Punch data enclosed by heavy lines only
- Each line must be punched on a new card or a new line of paper tape
- Spaces only where indicated by:
 - (a) ▽ characters
 - (b) Blanks in character positions thus:

Beam data (continued)

Data sheet 2(b)

Reference:

Page number:

Section number	Area type	X	Y	Z
1	▽			
2	▽			
3	▽			
4	▽			
5	▽			
6	▽			
7	▽			
8	▽			
9	▽			
10	▽			
11	▽			
12	▽			
13	▽			
14	▽			
15	▽			
16	▽			
17	▽			
18	▽			
19	▽			
20	▽			
21	▽			
22	▽			
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32	▽			
33	▽			
34	▽			
35	▽			
36	▽			
37	▽			
38	▽			
39	▽			
40	▽			
41	▽			
42	▽			
43	▽			
44	▽			
45	▽			
46	▽			
47	▽			
48	▽			
49	▽			
50	▽			

Continue in next box

Section number	Area type	X	Y	Z
1	▽			
2	▽			
3	▽			
4	▽			
5	▽			
6	▽			
7	▽			
8	▽			
9	▽			
10	▽			
11	▽			
12	▽			
13	▽			
14	▽			
15	▽			
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43	▽			
44	▽			
45	▽			
46	▽			
47	▽			
48	▽			
49	▽			
50	▽			

END

Delete unless end of run has been reached

If there are more sections in this span (cantilever), continue on a further data sheet 2(b). If this is not the last span, or else if there is a right hand cantilever to follow, enter appropriate details on a further data sheet 2(a). If beam data for every span and cantilever has been completed and there is loading data for this run, continue on a data sheet 3.

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