GENESYS (GENeral Engineering SYStem)

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GENESYS
(GENeral Engineering SYStem)

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1. History of GENESYS

In 1967 the Ministry of Public Building and Works, now the Department of the Environment, set up a working party to examine suitable computer programs which were available to structural engineers to see if any could be used and made more widely available in the construction industry by improvement, translation for a wider range of computers, or simply by making them better known. The working party proposed that the greatest need was to establish some order out of the chaos that at present exists. The working party found that the main obstacles preventing engineers from using computers were that

a) Current programs are not readily exchanged between computer owners.

b) There are many different methods of preparing data for the programs that do exist which increases unnecessarily the errors in data preparation.

c) There is much duplication in certain areas but notable gaps particularly for programs which do simple design operations.

The first report of the working party maintained that future wastage of programming effort could be much reduced by housing a system which could file any new program in its library for use by all. The system is now called The GENeral Engineering SYStem, or GENESYS.

Professor Peter Morice of Southampton University led a separate team of experts who evaluated the GENESYS proposal. They compared GENESYS with many other systems, including ICES and PLAN, that it was thought might be adopted to satisfy the same specification. Representatives of the construction industry, consulting engineers, contractors, central and local government bodies and also computer manufacturers and bureaux, were all approached in order to find out if there would be sufficient support for the system. The industry was strongly in favour of the proposal. They had recognised a need for such a system and GENESYS appeared to fulfill their requirements.

Clearly the order of cost put such a project outside the reach of individual engineering consultants and computer firms, who might perhaps have ventured the capital. Computer firms, however, could not have been

expected to preserve the machine independent characteristics of the project. So, towards the middle of 1969 the Ministry of Public Building and Works secured the financial authority to give Alcock, Shearing and Partners the contract to write the system and placed several other contracts elsewhere to produce the initial set of subsystems (which are the problem-solving programs). GENESYS is now in the final stages of development and will be released in the spring of 1972.

2. What is GENESYS?

The Basic System, GENESYS can be used only through the medium of the basic system which controls all the input and output operations and also the storage of programs and data. This is the computer software which will be issued to computing installations in the form of magnetic tapes or disc packs together with detailed operating instructions. As the basic system retains control of everything that goes on inside the computer the term "subsystem" is used in preference to program for the set of instructions written to solve particular problems.

GENTRAN. This is the language in which all subsystems are written. GENTRAN is an extension of FORTRAN and it follows that many existing FORTRAN programs will need only minor alterations to turn them into GENESYS subsystems.

GENESYS is machine independent. It can run on a large variety of computers.

ICL 1900 series
ICL System 4
IBM 360 series
Honeywell 200 series
CDC 6600

The minimum size of main store is 32K of 24 bit words or the equivalent. Backing store: four magnetic tapes or one disc.

The three main features of GENESYS are that :-

1. It is a library of programs which can be run on a large variety of computers,

2. the sequence of programs used in the calculation is under the control of the User,

3. the input data required by these programs falls into a standard pattern.

The library of programs will be increased by subsystems written by GENESYS users. The GENESYS Centre, of which more will be said later, will operate a brokerage service whereby authors of subsystems will be able to lease or sell them to other GENESYS users.

The information for a GENESYS subsystem consists of tables and commands. The tables contain the data and the commands instruct the system what is to be done with the data. By using commands the engineer is able to direct the sequence of calculations carried out by the computer. By this means he does not lose control of his design and consequently he has more confidence in using a computer for calculations.

It has long been a recognised fact, that, when using a computer most faults occur due to incorrectly presented data. It is also true that these data errors occur because an engineer has to learn a new set of rules for data preparation every time he operates a different program. GENESYS goes a long way towards eliminating these faults by using a standard form of data input for all subsystems. An engineer may be designing highways and then change to designing buildings or some such operation. The same rules will apply and he will not notice any difference in the manner in which he prepares his data.

The first five subsystems which will be issued by the GENESYS Centre will be :-

(i) FRAME-ANALYSIS/1. This subsystem enables an engineer to describe a loaded skeletal frame for elastic analysis. The skeletal frame may be a space frame, a grid loaded normal to its plane, or a plane frame loaded in its own plane. No limits are imposed by the subsystem on the number of joints, members, etc. The size of the problem able to be solved by FRAME-ANALYSIS/1 is only limited by the size of computer being used.

(ii) HIGHWAY/1. This subsystem has been developed from Chapter 6 of the British Integrated Program System for Highway Design. The engineer is able to obtain the following information.

  (a) Setting out schedules for alignments, paving limits and slope stakes.

  (b) Details of cross-sections including the location of substrata where they intersect the cut surface.

  (c) Tabulation of volumes of cut and fill calculated separately for each material in the geological model.

  (d) Volumes of cut and fill in regions where one road in an interchange overlaps another.

  (e) Outcrop areas of the various geological materials on the formation surface of the road.

  (f) Soil stripping and seeding quantities.

(iii) BRIDGE. This subsystem carries out a linear elastic analysis of bridges where transverse load distribution need not be considered.

(iv) RC-BUILDING/1. This subsystem allows a user to analyse, design and detail a Reinforced Concrete building of beam and slab construction. The building may be irregular in plan or elevation and may include rectangular and skewed sections.

(v) SLAB-BRIDGE/1. This subsystem is described in the Appendix.

The GENESYS Centre

No matter how good GENESYS may be, merit along will not secure its acceptance by engineers. Only by first class presentation and adequate supporting services is it possible to overcome the initial inertia which always exists when a radical innovation of this kind is provided. The Government considered it essential that there should be a body of of engineers who, conversant with every aspect of GENESYS, would be able to

maintain improve and develop it; and that this organisation should be available to all users of GENESYS to provide any maintenance, advisory or consultancy service that they need. It was also considered equally essential that a full information service be available and that educational facilities be provided by courses, lectures and demonstrations for both the programmers who write for GENESYS and the engineers who would use the existing Subsystems. The GENESYS Centre has been established at the University of Technology, Loughborough, Leicestershire, in order to market the system and to provide the services which have been described above.

The brokerage service has been mentioned before and this will also operate from the Centre. It is a fundamental feature of the concept of a national system that a library of compatible programs will grow and be accessible to all users, but it is neither practical or desirable that the GENESYS Centre should be solely responsible for the production. It is a prime aim of GENESYS to encourage engineers to convert existing programs and to write new ones in the system format and to make these programs available to others who wish to use them. Insofar as may be practical, a library of such programs will be formed at the Centre whence they will be supplied to engineers on whatever terms may have been agreed to by their authors. Thus the Centre is the central focus of GENESYS affairs and the forum within which consultation and co-operation will develop and flourish.

4. GENESYS International

Everything that has been mentioned so far concerns the United Kingdom. What about overseas? A flood of enquiries from all over the world has proved to the GENESYS Centre that there are great possibilities for GENESYS overseas. However, the position abroad must be different from that in the United Kingdom. Links with the GENESYS Centre must be reduced to a minimum. An organisation in Loughborough cannot provide an effective back-up service to customers in foreign countries and would have to devolve this function to a suitable agency. Ideally there should be a Centre in each country similar to the Centre in the United Kingdom. This Centre will deal with all the daily support necessary and will act as a link between the overseas user and Loughborough.

It is planned to operate an international brokerage service similar in function to the service operating in the United Kingdom. This will encourage users to market their programs overseas and, what is more important, encourage international technological co-operation using a standard system, a standard language and standard documentation.

APPENDIX

SLAB-BRIDGE/1

This is based directly upon the program known as Design and Analysis Program Package BECP/1. This package, sponsored by the Department of the Environment, analyses and aids the design of reinforced concrete slab bridge structures (flat slab/grillage combinations) and is based on the Finite Element thin plate and beam bending program BAPS, developed at University College, Swansea under Professor O.C. Zienkiewicz.

To enable BAPS to be more readily used for slab bridge design problems, separate programs were developed which together with BAPS made up an integrated suite of programs in the package BECP/1. This suite of programs has now been extensively used by bridge designers but nevertheless has recently required considerable alterations to make it easier to operate. SLAB-BRIDGE/1 is a further development which utilises successfully the GENESYS system to enable the engineer to solve a complex problem simply and efficiently.

SLAB-BRIDGE/1 carries out a finite element analysis of concrete bridge slab (or slab and beam) structures. The finite element mesh and co-ordinate data can be automatically generated for most regular or semi regular plan shaped bridge structures by setting up a regular grid system over the structure. The structure can have any arbitrary support conditions including elastic bearings while settlements of these supports can also be considered. All standard bridge loadings (B.S. 153 HA and HB loadings) can be easily applied.

The results of the analysis are related to a finite element mesh and are in the form of nodal displacements, nodal reactions and the moment field Mx, My and Mxy and the principle values M_1, M_2 and θ at the centre of each plate bending triangular element or Ma, Mb and T for each beam element.

Any of these results can be printed when required and displacements and moments for only selected nodes or elements need be obtained. Additionally, for structures containing plate elements only, nodal averaged values of moments can be obtained. Results of previous load cases can be combined and factored. The plate bending moment fields for all loading cases (including ones formed by combining previous results) can be processed to obtain critical design moments of resistance of compressive reinforcement in specified directions in the top and bottom of the slab.

By using the GENESYS system SLAB-BRIDGE/1 is able to have the following features.

1. The package is not machine tied and can run on any machine with a GENTRAN compiler without any conversion being necessary.

2. The user no longer has to handle separate programs with the added troubles of data transfer between these programs.

3. The subsystem will be extended to analyse prestressed concrete slabs and additional post analysis processing packages and this will be readily accomplished by the inclusion of appropriate commands within

SLAB-BRIDGE/1.

4. All data is in free format with the facilities of generation of repetitive data and the inclusion of variables in data.

5. The user can easily add to the package as his requirements demand.

Apart from its obvious flexibility as a GENESYS Subsystem, SLAB-BRIDGE/1 has some attractive features not available in the earlier programs. The finite element mesh is set up by the user specifying grid lines. The mesh is generated and numbered by the computer; a regular mesh if a regular shape is specified and an arbitrary mesh if the deck is of an arbitrary shape. (See figures 1 and 2). Line loads can be easily specified and H.B. vehicle loads are generated automatically. By storing details of the finite element mesh of the deck and details of the loadings, the structure can be re-analysed with altered support conditions and using new loadings or with the original loadings. Additional load case results can be generated by combining previous load case results factored by chosen values. By processing the load case results the command REINFORCE will generate the appropriate design moments of resistance table.

The subsystem contains a series of eight separate commands. These commands must be used in a logical sequence, but all the commands need not be utilised for each problem and the sequence of using the commands is not strictly set.

The eight commands can take a number of different forms but are based on the keywords;

MAKE -	Constructs the deck of the bridge.
ASSEMBLE -	Adds supports to the deck to produce a bridge.
FORM -	Produces loading cases for the bridge deck.
APPLY -	Applies loading cases to the bridge and produces solutions.
PRINT -	Prints out selected results from the solutions.
CREATE -	Produces solutions for new loadings by factoring and combining results of existing solutions of applied loadings.
REINFORCE -	Prints the envelope of tensile steel design moments for selected load cases.

Examples of how some of the commands may appear are shown below.

```
MAKE DECK 'DECK/1' OF SHAPE 'RECTANGULAR' ...
USING MESH 'FINE' WITH SLAB PATCHES 'PATCH' ...
OF MATERIAL PROPERTIES 'ORTHO'
```

or

```
MAKE DECK 'DECK/1' OF SHAPE 'ARB' ...
USING MESH 'FINE' HAVING BEAMS 'TYPE A' OF ...
MATERIAL PROPERTIES 'BEAM-MATERIALS'
```

An example of the FORM command could be :

FORM LOAD CAGE 'LOADING-1' FROM LOAD 'DEAD'

The words between the quotes e.g. 'DECK/1' refer to the tables.

The tables follow the same rules as for all GENESYS subsystems which give the engineer the opportunity to choose his own table title and to choose the units that he wishes to work in.

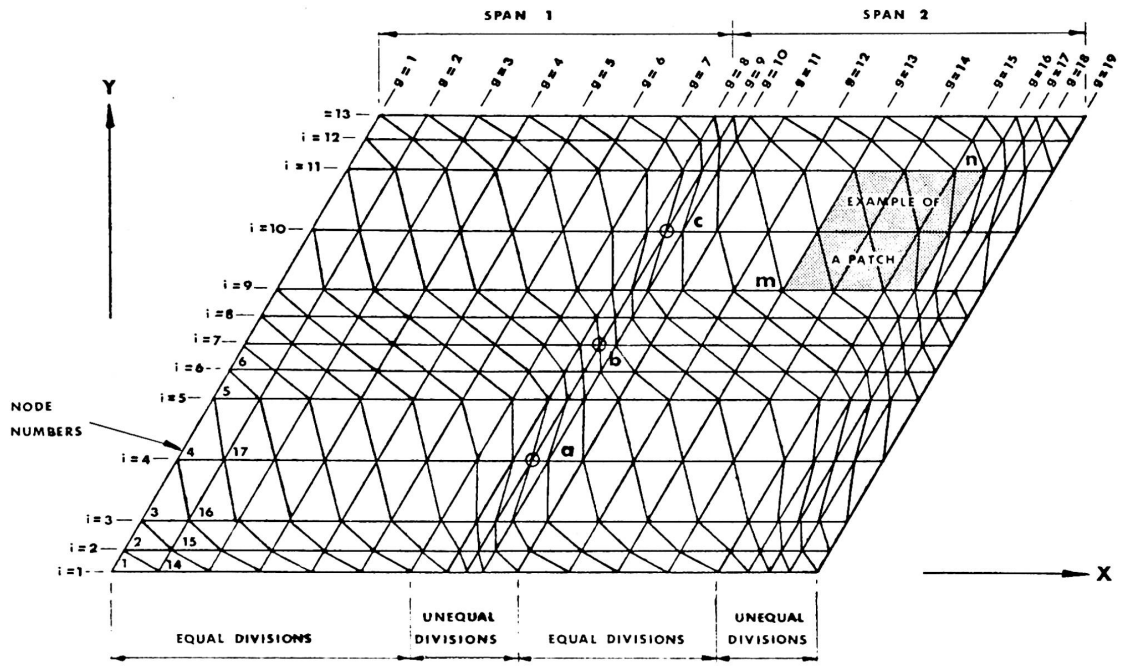

FIG 1 EXAMPLE OF DECK SPECIFICATION

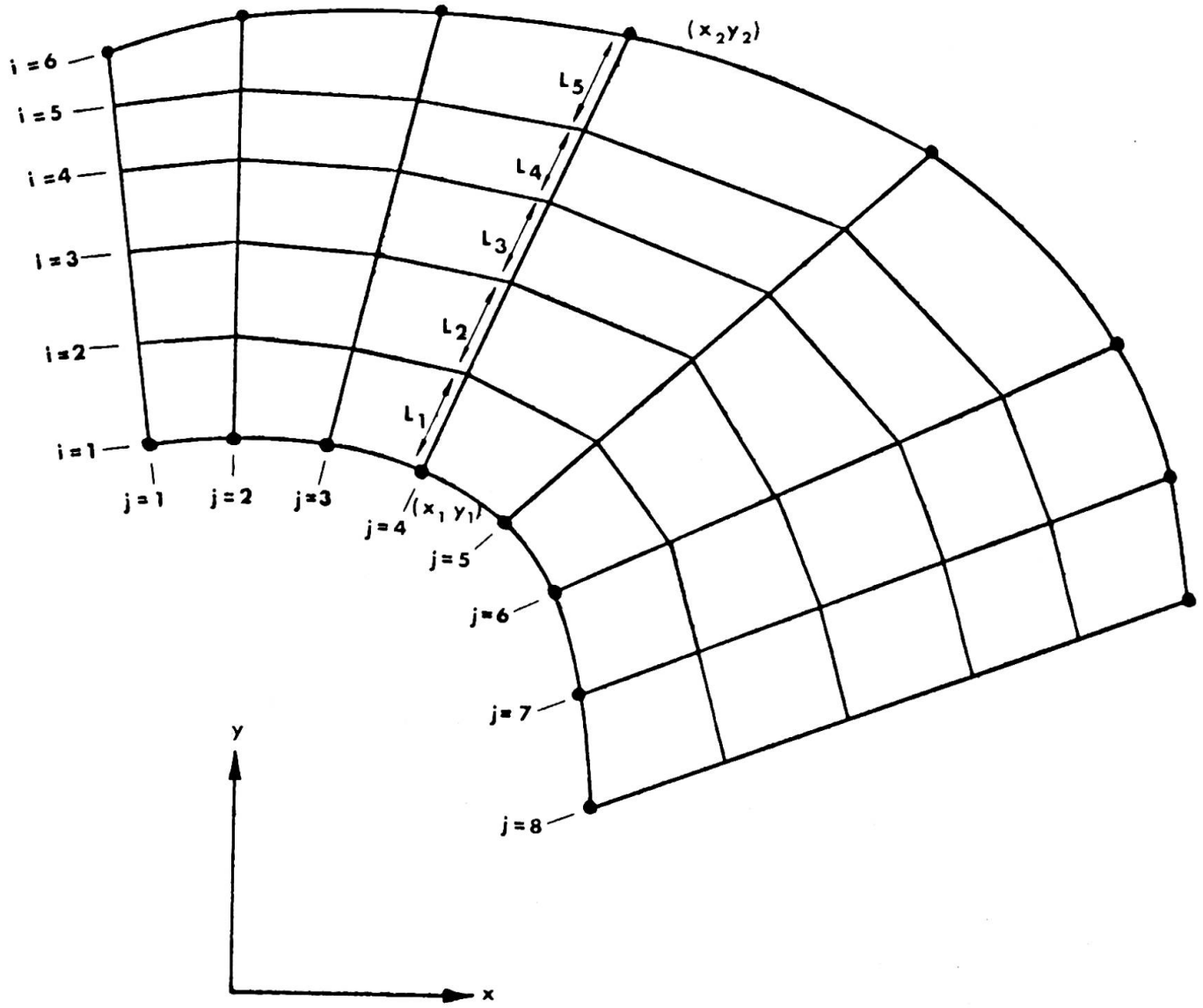

FIG 2 ABITRARY MESH GENERATOR

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Summary

In 1967 the Ministry of Public Building and Works set up a working party to study the ways of making computer programs more readily available to engineers. The working party reported that much wastage of programming effort could be reduced by a system which would file any new program in its library for use by all. This system is now called the GENeral Engineering SYStem, or GENESYS.

The main featuresof GENESYS are that it is machine independent, it has a large library of programs, by using commands the sequence of programs used in the calculations is under the control of the user and input data falls under a standard pattern. GENESYS will operate on the ICL 1900 series, IBM 360 series, ICL System 4, Honeywell 200 and CDC 6600.