THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

SURVEY OF SOFTWARE ON MICRO COMPUTERS FOR FINITE ELEMENT ANALYSIS OF FLAT SPRINGS

Report No 389

by

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SEPTEMBER 1986

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SUMMARY

Computer programs have been developed by SRAMA and based upon standard formulae, for the checking and designing of round and rectangular wire helical springs. These programs have proved over the years to be accurate and of great benefit to spring designers. There are however many complex spring designs manufactured from flat material which can be extremely difficult to analyse with any great degree of accuracy due to the formulae involved and the geometry of the spring.

There is a technique called Finite Elements, used for the analysis of deflection and stresses in a component, which has been in existence and employed outside the spring industry for many years. Although it could be employed for spring analysis, computer software has only been available on mainframe computers until recently. This report surveys computer programs based upon this technique which are presently available for micro computers and discusses the possible limitations regarding their application to the analysis of spring designs. This has initiated considerable concern regarding the accuracy of the finite element techniques when applied to components subjected to large deflections, as is the case with springs. Consequently, it has been recommended that

evaluation trials be performed on the most suitable software packages to cover the analysis of actual spring designs and compare the results with practical test data.

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1. INTRODUCTION

Over the years SRAMA has developed a suite of computer programs to cover the checking and design of helical coil springs both from round and rectangular section material. These programs are based upon traditional formula and have proved satisfactory. There are, however, no programs presently available dedicated to the checking of spring presswork designs manufactured from flat material. Since the form of such springs can be very complex and thus difficult to analyse many inaccuracies may occur with traditional methods due to the complex calculations and the assumptions made in order to simplify a spring's geometry.

One technique for the analysis of stress and deflection in a component, which has been employed outside the spring industry for many years, is that of finite elements. Initially this form of solution has required the use of mainframe computers to solve the complex numerical equations set up by the analysis. However, as finite element programs have been developed and improved they have also become available on mini computers. More recently, with the increase in computing power of microcomputers, finite element software has now been developed for these machines. This software is not as versatile as the versions on mainframe computers and so is more restrictive on the type of problem that can be analysed, but is now more within the purchasing power of the spring manufacturer.

The aim of this survey was to find finite element software compatible with the IBM range of micro computer and which will be of use in the analysis of spring designs produced from flat material. This software will then be evaluated on sample designs and the results compared with the practical tests in order to determine the most suitable package.

2. FINITE ELEMENT TECHNIQUES

The theory of finite element analysis is to section a component into many elements and a typical mesh has been constructed for half of a spring clip which is detailed in Figure 1. These elements may take many shapes and for accurate results, need to be small, especially in the highly stressed regions. Each element has a number of nodes associated with it, distributed around its circumference; it is then necessary to define which nodes are constrained and in which directions, and at what points forces are acting on the component and in which direction. Finite element techniques calculate the deflection of each node and the stress at that position and hence the overall deflection of the component and the stress distribution inside it. The number of nodes and types of elements have a dramatic effect upon the accuracy of calculation and thus affect the presentation and accuracy of results. Consequently, the facilities in the computer software, with respect to the generation of the element mesh and its alteration in critical areas, are important.

Most finite element software is capable of analysing two dimensional components (ie constant width). However, many spring presswork components are not constant width and therefore the ability to analyse 3D shapes would be an important advantage in a package for use in analysing spring forms.

3. CONSTRUCTION OF A MODEL

For any problem to be analysed by computer the specification of the component has to be input into the computer's memory. This consists of the material properties, loading and fixing characteristics of the component and finally the dimension and shape of that component. The latter data can be input to the computer for analysis by a finite element package, in one of two ways. Some packages (Table 1) are compatible with a draughting package so that the actual component can be constructed on the screen under software control. This is by far the simplest method of entering the details into the computer and of enabling alterations to the component's design to be performed simply and quickly. The software will then perform all the necessary calculations and convert the design into the necessary data format for the finite element software to understand.

The alternative method for the input of the component's design is for the co-ordinates at each change in the component's shape to be calculated. Then, whenever the design of the component is changed the co-ordinates have to be recalculated thus making design changes very time-consuming. For a two dimensional model only the x and y co-ordinates need to be calculated, but for a three dimensional component the z co-ordinate must also be calculated. Once the co-ordinates have been determined they are input into the computer with various codes and in a set sequence.

The draughting packages are by far the easiest method for inputting the information, in addition to which they eliminate the possibility of errors in the calculation of co-ordinates. Also, designs can easily be modified and the effect of such changes then determined. However the draughting packages can be very expensive.

4. FINITE ELEMENT LIMITATIONS AS APPLIED TO SPRINGS

The finite element technique is based around the calculation of very small deflections and inaccuracies occur in calculation when the overall deflection of a component is large. This is a major limitation since in the majority of spring designs, large deflections are encountered. Certain packages on mainframe computers can now handle components with large deflections but this has not yet been applied to micro computers.

Despite extensive discussions with the software suppliers it has proven impossible to obtain an opinion on the levels of inaccuracy that might occur. Consequently it is not yet possible to state how great a problem these inaccuracies may be in the analysis of spring designs. A full evaluation trial of micro computer software packages will therefore be necessary to compare the results with those obtained by software on a mainframe computer and with physical testing of sample components. From this type of evaluation it will be possible to determine if the level of inaccuracy, or the level of work required to keep errors to a minimum, is acceptable. Also the limitation of the software upon a components deflection for accurate analysis may be quantified.

5. OUTPUT OF INFORMATION

The basic results obtained from a finite element analysis may be presented in two forms, both of which can appear on the screen or on the printer. Firstly, the results can be displayed in tabular form detailing the deflection of each node and the stresses at that position. Secondly, the model can be displayed detailing its loaded and free positions and the stress levels in that model.

The quality of the model's presentation is dependent upon both software and hardware, with the latter relating to the resolution of the monitor and the computer's colour capacity. With respect to software, the quality of presentation is dependent upon the modes of display available and facilities which are detailed below and in Table 1.

a) Zoom and Panning

This option enables sections of a design to be enlarged on the screen to enable a study in greater detail. However it is essential that the area to be enlarged is easily specified by the operator which is not the case for all software.

b) Stress Contours

These are lines drawn on the model by the computer to join all points of equal stress. Each line then represents a different stress value and so the stress at any point can easily be seen and stress concentrations highlighted by the reduced spacing between the lines. An alternative to contour lines offered by some packages is the use of colours. The principle is the same where different shades of colour between red and blue represent a stress value. Then stress concentrations are depicted by the red areas and the stress at any point can be determined from the colour chart.

An additional feature to some programs is that of Dynamic Considerations. This enables the deflection of a spring to be seen at various points through its loading cycle. The computer will display each frame in turn at a specified time interval to enable each frame either to be studied in detail or simply to show the change in component shape as an animation. This is of considerable advantage when the stress contours are shown on the model at the same time, as the operator is then able to view easily the change in the stress levels in the component during deflection and note any changes in the position of any stress concentrations.

A feature on one software package that employed colours for stress contours in addition to considering three dimensional objects was to view the building of the model. This consisted of each three dimensional element representing a stress level by colour and the computer building the model element by element. This then enabled the stress levels in the component to be viewed as well as those on the surface of the component.

6. DISCUSSION

Details on a considerable number of finite element software packages were obtained, many of which have been tailored for various areas of the construction industry and are not applicable for the analysis of springs. Consequently only those packages from which the literature indicated their suitability for the analysis of spring designs have been included in this report and, where possible, a demonstration was obtained of the most interesting of these packages. Although the demonstrations followed a standard format and were based upon standard problems unrelated to springs, it was possible to ascertain whether or not the packages were capable of handling spring forms. Where it was found that some software advertised under different titles was in fact the same package but available from different sources, only one of these has been quoted in the report.

All the software packages listed in this report appear capable of analysing simple two dimensional problems whilst some are capable of analysis on three dimensional components. However there is concern about the accuracy of results with all packages when encountering large deflections of a component. The inaccuracies could not be quantified by any of the software suppliers as they had no experience of applying the software to components similar to springs. Consequently it is proposed that the most applicable software packages should be obtained on loan or lease for a short period of time in order to evaluate them using spring designs. At the same time, sample designs should be supplied to companies offering a finite element bureau service so that these designs may be analysed using software on a mainframe computer. In addition, physical testing of sample springs should be performed to enable these results to be compared with those from both methods of finite element analysis. This will then enable any inaccuracy in calculation using the micro computer software to be highlighted against the results from the mainframe computer. Finally an overall indication as to the relationship between finite element analysis and practical results will be obtained. The evaluation of the software will also incorporate considerations regarding ease of operation and presentation of results, enabling the most suitable suitable package for the analysis of spring components to be identified. Once the most suitable package has been identified the limitations as to the type of design that can be analysed will be determined.

Some of the software packages included in this report have been specially written for micro computers, whilst one (ANSYS) is a conversion of software developed on a mainframe computer and modified to operate on a micro computer. Thus there are various options for selection of software and hardware such that a mainframe computer can still be used for analysis of a component at a low cost if necessary. Firstly use of a bureau service may be made to perform all aspects of the design analysis where no knowledge of finite element software or computers is necessary. Secondly hardware and model building software can be purchased whereby only the model is constructed on the micro computer. The data is then sent along a telephone line for analysis by a bureau using a mainframe computer. Finally, where software has been converted from a mainframe package then that package and software may be purchased. This will enable all designs to be analysed in-house and whenever necessary the data files for the model constructed can be sent along telephone lines or by floppy disc for analysis on a mainframe computer. This latter option will eliminate any extra costs for the rebuilding of the model on a mainframe computer.

7. CONCLUSIONS

1. There are many finite element software packages available for use on micro computers though the majority of these are not applicable to the analysis of spring designs.

2. The packages suitable for analysing spring designs vary considerably in their range of capabilities from static two dimensional components to dynamic three dimensional components. However the latter option for analysis of three dimensional components is more applicable to the solution of spring designs.

3. There is an area of concern regarding the analysis of a spring design by any finite element package on a micro computer and this is the inaccuracies in calculation brought about by the large deflection of a component. The inaccuracies cannot be quantified by software suppliers due to insufficient experience on analysis of spring type components. This is an area in which further investigation must be performed before a suitable package for a spring designer can be ascertained.

8. RECOMMENDATIONS

A selection of designs should be processed by both micro computers and mainframe software packages, and the results then compared in order to quantify any inaccuracies brought about by a component's large deflection. Sample springs should also be subjected to static testing in order to compare practical and theoretical results. Where possible software packages should be obtained on loan or lease to enable the operation of those packages to be evaluated.

TABLE I POSSIBLE SOFTWARE FOR ANALYSIS OF FLAT MATERIAL SPRING DESIGN

	ANSYS	PERFINE	IMAGE 3D	IMAGE 2D	STRESS 2D	SWIFT
Source Code	1	2	3	3	4	5
Hardware Requirements	IBM AT + Hard Disk	IBM AT Apricot Sirius	IBM XT	IBM PC Apricot	IBM PC	IBM AT + Hard Disk
Analysis of 2 or 3 Dimensional Components	3D	2D	3D	2D	2D	2D
Method of Input	Keyboard	Keyboard or from a Draughting Package	Keyboard	Keyboard	Keyboard	Full CAD Package Included
Type of Stress Level Presentation	Levels of Colour	Contour Lines	Contour Lines	Contour Lines	Contour Lines	Contour Lines
Static or Dynamic Considerations	Dynamic	Static	Dynamic	Static	Static	Static
Price (£)	4571 or Rental	3750	4750	950	550	23,400

TABLE II SOURCE OF SOFTWARE PACKAGES

Source Code	Company
1	Structures & Computers Limited 1258 London Road LONDON SW16 4EJ
2	Davenport Computer Systems Aston Science Park Love Lane BIRMINGHAM B7 4BJ
3	Computer & Design Services Limited Arrowsmith Court 10 Station Approach Broadstone DORSET BH18 8AY
4	Comline Engineering Software 1 Wallace Way HITCHIN Hertfordshire SG4 OSE
5	Tangram Greyfriars Business Centre 2 Eaton Road COVENTRY CV1 2SB

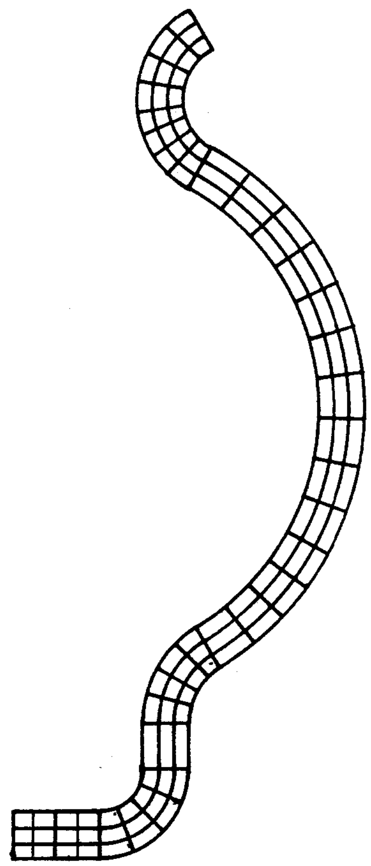

FIG 1 : TYPICAL FINITE ELEMENT MESH