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ORNL - TM - 225

COPY NO. - 4

DATE - May 4, 1962

COMPARISON OF PIPE STRESS COMPUTER PROGRAMS

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ABSTRACT

The capabilities and results of several pipe stress analysis computer programs are compared. The results of the programs are consistent with each other, the average percentage differences in most cases being less than 1.6%. The Revised SHARE Program No. GS3812 is recommended for general use.

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Introduction

Because of the extensive piping associated with the experimental loops of the EGCR it was decided to investigate several of the pipe stress programs available and select one for use in the EGCR loop design studies. The programs investigated were:

IBM 650 . . . . . .Pipe Stress - Kellogg Method

ORACLE . . . . . .ORACLE Program No. 831

IBM 704 . . . . . .SHARE No. GS3812

IBM 704 . . . . . .SHARE No. GS3805

Description of Programs

The program for the IBM 650 computer[1], as all of the other programs investigated, was based on the Kellogg Method of pipe stress analysis.[2] This program is limited to relatively small systems of 2 or 3 anchors with no intermediate restraints. The output consists of: (1) the bending moment, torsional moment, bending stress, torsional stress and the expansion stress at both ends and the mid-point of each curved member and at each anchor, and (2) the moments and forces at the anchors for both hot and cold conditions. Because of the limited size, the required input of initial and final coordinates of each member, and the lack of rotation and deflection information this program was not considered further for general use.

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[1] W. S. Pickrell, J. H. Rogers, L. S. Woo, Pipe Stress Analysis on the IBM 650 Computer.

[2] M. W. Kellogg Co., Design of Piping Systems, John Wiley and Sons, Inc., 1956.

The program for the ORACLE[3] was originally written to compute the moments and forces at the origin and the stresses at the origin and end of each member for a multi-branched system. The expansion stress and the combined stress by the principal and shear stress theories is calculated. The program has been expanded to also compute the rotations and deflections at the end of each member. This program cannot handle intermediate restraints, does not apply the stress intensification factor automatically, requires a separate calculation for each branch of a multi-branched system and requires additional debugging for rotations and deflections in multi-branched systems. For these reasons this program was not considered applicable for general use.

The SHARE No. GS3812 Piping Flexibility Analysis program[4] is a large capacity, (maximum of about 60 segments) easily used, general piping analysis program. It can handle three different types of intermediate restraints and calculates the stress intensification factor for each curved member and applies it to the bending stresses automatically. The output consists of the total moments and forces acting on all anchors and restraints, the expansion stress, deflection and rotation at the end of each member and a variety of optional information for checking purposes. On analyzing results of the program, discrepancies were observed for the computed stress at the end of certain curved members. An error in the programming affecting certain curved members was found and corrected. Since the stress in the beginning of a curved member is

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[3] P. S. Lindsey, F. Gunness Pipe Stress Calculations by UCNC-ORNL ORACLE Code No. 261, Catalytic Construction Company, Oct. 5, 1956.

[4] Lela M. Keough, Piping Flexibility Analysis L03812, General Electric Co., Schenectady, June, 1959, SHARE Distribution No. 713

always equal to or greater than the stress in end of the preceeding straight member, the program was revised to include the stress at beginning and end of each member rather than just at the end. This program is compatible with the new IBM 7090 computer which is coming into wide use. Because this revised program can handle large systems with intermediate restraints it appears to be the most useful program.

SHARE Program No. GS3805[5] is quite similar to GS3812 except in size. It can handle only 2 or 3 anchor systems without intermediate restraints and because of these limitations it was not considered further.

Comparison of Results

To determine the accuracy and reliability of the SHARE Program No. GS3812 several problems were run which had been calculated by other programs and the results were compared. The comparisons are summarized in Table I.

One of the example problems in the writeup of the IBM 650 program was run on the 704. The moments and forces on the anchors were compared and the average percentage difference was found to be 4.6% of the 704 results. Because of different methods of computing and combining stresses and the differences in form of output a comparison of the stress was not possible.

Three piping systems which had been run previously on the ORACLE were run on the IBM 704 using Program No. GS3812 and the results of the

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[5] Lela M. Keough, Pipe Stress and Deflections, L03805, General Electric Co., Schenectady, July 1958, SHARE Distribution No. 532.

two programs compared. The average difference was 1.6% for the forces and moments on the anchors and 1.6% for the stress at the end of each straight member. The rotations and deflections for single branch systems given by the two programs agree quite closely, in most cases exactly within the significant digits in the output.

Because the ORACLE program does not apply the stress intensification factor, it was not possible to compare results for curved members. Using the moments and forces from the 704 program the stresses at the end of five curved members were calculated by hand. These differed from the 704 computed values by an average of only 0.3%.

The results of the revised 704 program was also compared with the results of a problem run by the M. W. Kellogg Company. The forces and moments at the anchors agreed within an average of 1.0% and the stresses at the beginning and end of each curved member agreed within about 0.6%.

Table I

Average Percentage Differences Between Results From the Revised SHARE Program No. GS3812 and Other Calculations

	Moments and Forces	Combined Stresses
IBM 650 Program	4.6%	*
ORACLE Program	1.6%	1.6%
Kellogg Program	1.0%	0.6%
Hand Calculations	*	0.3%

*Not compared

Conclusions and Recommendations

The revised SHARE Program No. GS3812 has the following advantages over other means of pipe stress analysis for general use:

1. Considerable time is saved over hand calculations.
2. Large, complex problems can be handled easily.
3. The input is relatively easy to prepare.
4. The basic program is widely used by other firms.
5. The reliability of the results is high.
6. The cost of running a problem is small compared with having it done by an outside firm.

It is recommended that this program be used in the analysis of piping systems.

Distribution

1-3. DTIE, ORO
4. M. J. Skinner
5-6. Central Research Library
7. Document Reference Section
8. C. L. Allen, K-25