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Evolution of generic supporting conditions for feeders of 500 MWe PHWR

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ABSTRACT : Feeder piping consists of 784 number of closely spaced, inter-connected flexible pipes catering for large thermal and creep movements besides seismic and other loadings. The analytical strategy for evolving generic supporting conditions is outlined in this paper.

1 INTRODUCTION

A typical 500 MWe Pressurised Heavy Water Reactor (PHWR) core has 392 coolant channels connected to feeder pipes (Fig.1). As the layouts of these piping on either side of reactor core are mirror images and as they are also symmetrical about the vertical centre line of reactor , only 196 different configurations exist. The sizes and lengths of these SA 333 Gr.6 Carbon steel piping vary between 40-80 mm of nominal bore and 7-20 metres respectively. This is a Class 1 piping designed as per Sec.III,Div.1,NB of ASME Code.

2 STEP-BY-STEP SIMPLIFICATION OF THE COMPLEXITIES

As there are only a few configurations with systematic variations encompassing all the feeder layouts, the lengthy task of qualifying 196 configurations was rationalised by grouping them based on their geometrical similarity and then arriving at the supporting conditions based on the analysis of a few representative feeders in each group. The mutually conflicting requirements of flexible layout for large thermal and creep movements, and stiffer layout for seismic loadings was tackled by evolving strategic supporting conditions. The problems due to close spacing were resolved by minimising the number of supports and by selecting their locations appropriately. Based on the studies performed on the simplified beam models with rigid coupling type of interlacing (Hari Prasad et al,1991) which showed that frequencies and mode shapes of individual feeders were not altered significantly when they are coupled; and based on the literature (Usmani et al, AECL) which states that the effect of spacers is predominantly that of dampening the response, higher damping values of 2% and 3% of critical damping for OBE and SSE respectively were adopted than recommended by ASME Code and feeders were analysed individually. The problem of multi-support excitation was simplified by using envelope response spectra approach. A typical response spectrum is shown in Fig.3. Also, the feeders were decoupled from the main PHT system by suitably supporting the headers, as the studies revealed that interaction effects are negligible.

3 METHOD OF QUALIFICATION

Feeders were categorised into four groups based on their geometric similarity on each side of reactor face as follows:

- Group-I :vertically directed feeders in the upper half
- Group-II :vertically directed feeders near the centre
- Group-III:horizontally directed feeders near the centre
- Group-IV :horizontally directed feeders in the lower half

The analysis was performed in two phases as follows:

Phase-I Analysis: The objectives here were to analyse a few representative feeders and then arrive at the supporting conditions for each group. Feeders K01 (Gr-I),P11,P12 (Gr-II),L09,L10 (Gr-III), W11,W12 (Gr-IV) were selected (Fig.2). A general purpose computer program SAP IV was used and piping was discretised using 3-dimensional pipe elements. The stiffness of rigid supports were modelled using spring elements. The interlacing was modelled using higher damping values. The end connections of feeders were assumed to be rigid but the thermal and creep movements of connecting equipments were accounted for. Any layout modification was avoided as it would affect entire spectrum of feeders due to their close spacing. Based on the study of feeder layouts, feasible locations for generic supporting conditions were identified and their possible combinations were formulated. Subsequently, stress analysis and qualification as per ASME Code was carried out for each of these combinations. This was required to meet the objectives of minimum number of supports and generic supporting conditions. The following observations were made from this analysis (R.S. Soni et al, 1993):

1.The outlet feeders from Group-I require no support.

2.The inlet feeders of Group-II require no supports and outlet feeders require a constant weight hanger

3.The inlet feeders from Group-III require a x- directional support on the vertical run and a y- and z- directional support on the top horizontal run to the header (Figs.4-6). It shall be noted that although it was possible to qualify without an x-directional support, this recommendation was made as the stresses due to seismic loading were reduced considerably while those in the operating condition have shown only marginal increase.

4.The outlet feeders from Groups-III and IV require a support in the vertical direction on the top horizontal run to the header (Figs.4-6). Notice that although the inlet feeders are smaller by about 2 metres than the outlet feeders, they required more number of supports in case of Group-III. This is because the significant modes of these feeders are falling in the peak zone of applicable response spectra.

The results ofsome case studies are shown in Figs.4-6.

PHASE-II Analysis: The objectives here were to confirm the supporting conditions arrived at in Phase-I analysis and to arrive at the exact demarcation between various groups. For this purpose initially a set of 9 more feeders (Fig.2) whose location is away from those included in Phase-I were selected to represent other extreme in each group. This analysis while confirmed the Phase-I results for Groups-III and IV, however,it could not confirm the results for Group-II and the boundary between Groups-I and II. Hence to confirm these findings, 9 more feeders were selected. The following observations were made based on this study (Mishra et al, 1994):

1.The supporting conditions for Group-III and IV are confirmed.

2.The inlet feeders of Group-II require a support in the y-direction on the vertical run where as the constant weight hanger on the outlet feeders can be eliminated.

3.Relocation of the boundary between Group-I and Group-II was required. Hence, the K01S feeder of Group-I earlier now belongs to Group-II.

4.The outlet feeders from Group-I require a support in the vertical direction on the top horizontal run to the header.

The finally arrived supporting conditions and group boundaries are shown in Fig.7.

5 CONCLUSIONS

In this paper, a systematic approach for the evolution of generic supporting conditions for 784 feeder pipes is presented based on the analysis of only 25 different feeder configurations.

REFERENCES

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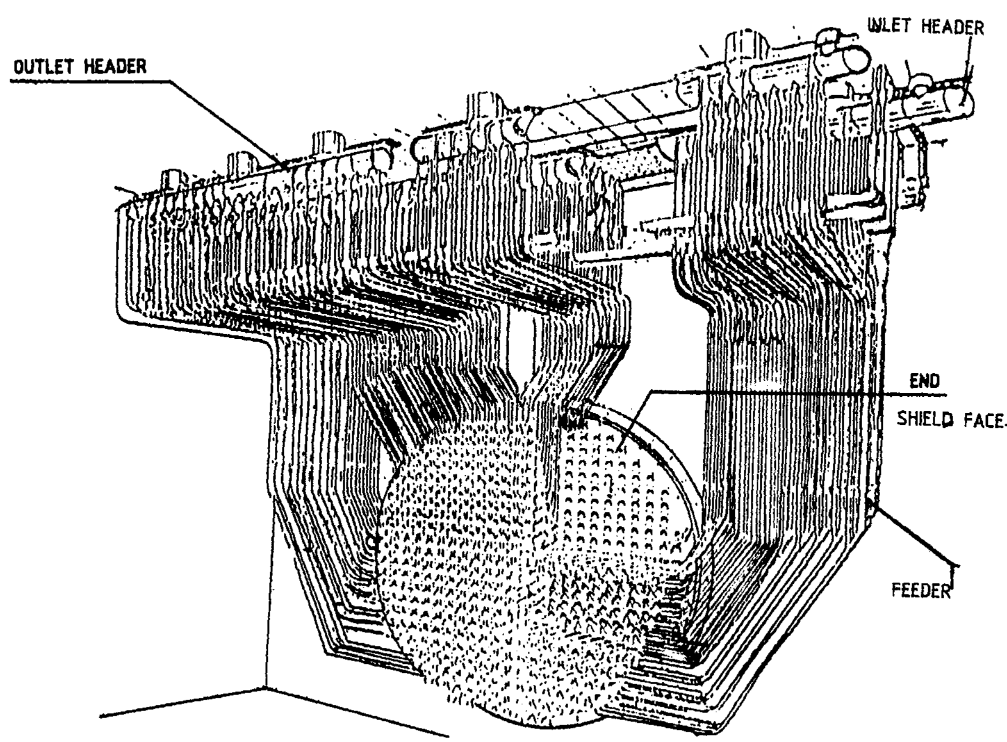


Fig. 1 GENERAL LAYOUT OF FEEDER OF 500MWe PHWR

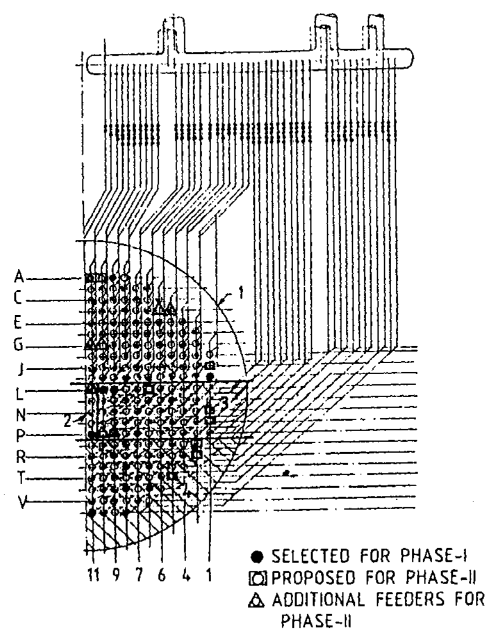


Fig. 2 SKETCH SHOWING THE GROUPING OF THE FEEDERS FOR PHASE - I & FEEDERS SELECTED FOR THE ANALYSIS

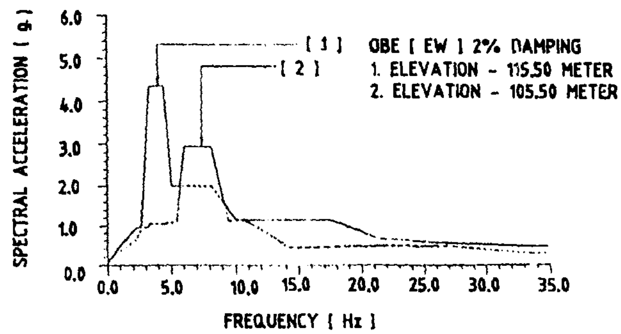


FIG. 3 : OBE RESPONSE SPECTRUM IN EAST-WEST DIRECTION

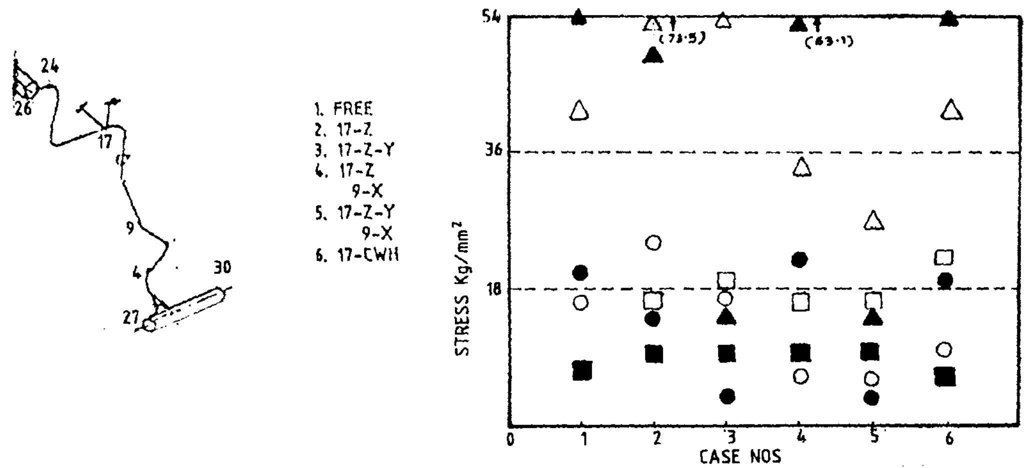


FIG:4 RESULTS OF CASE STUDIES FOR FEEDER L09S

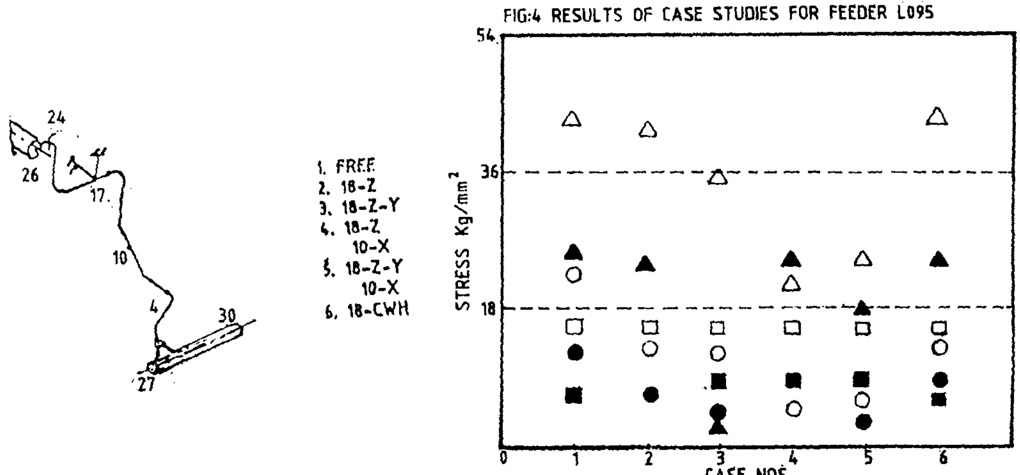


FIG.5 RESULTS OF CASE STUDIES FOR FEEDER L10S

	GRAYLOC ELBOW	HEADER BENDS
DESIGN CONDITION	○	●
LEVEL A	□	■
LEVEL B	△	▲

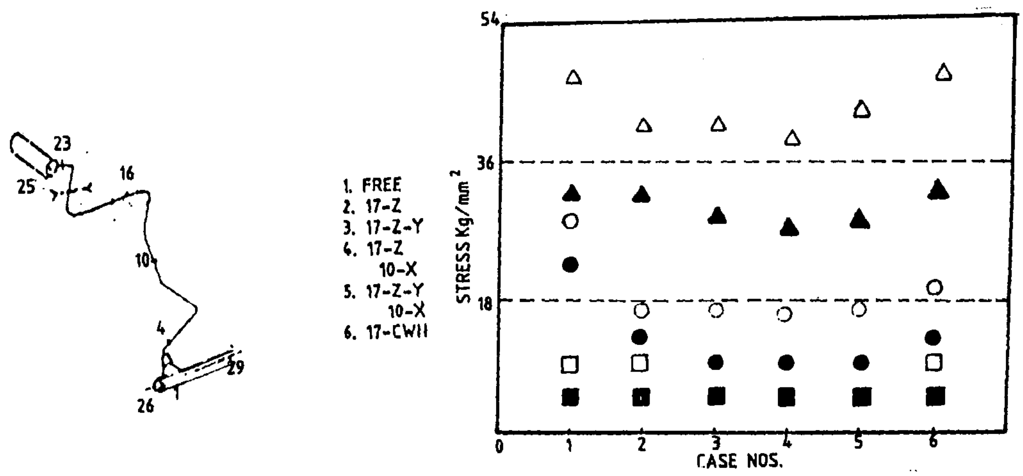
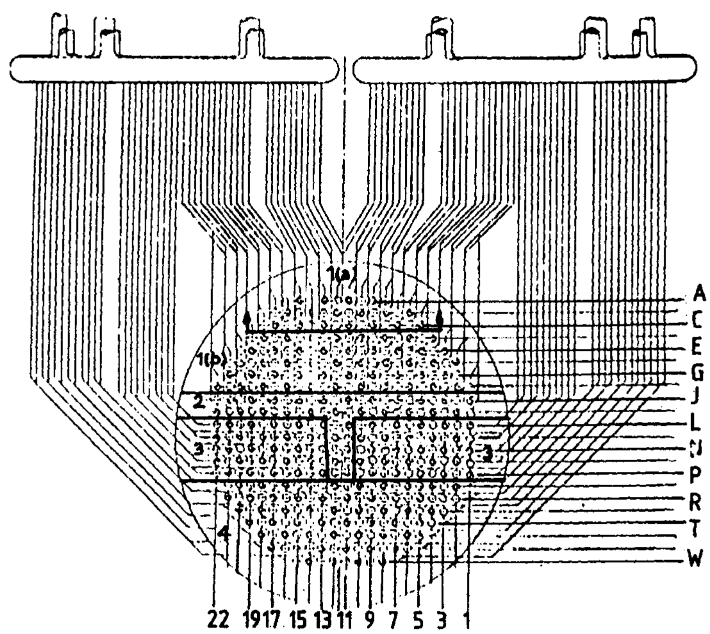


FIG.6 RESULTS OF CASE STUDIES FOR FEEDER WIIS

	GRAYLOC ELBOW	HEADER BENDS
DESIGN CONDITION	○	●
LEVEL A	□	■
LEVEL B	△	▲



GROUP	INLET SUPPORT	OUTLET SUPPORT
I(a)	FREE	VERTICAL
1(b)	FREE	FREE
2	E-W	FREE
3	VERTICAL & N-S & E-W	VERTICAL
4	VERTICAL	VERTICAL

FIG.7 : FINAL SUGGESTED FEEDER GROUPING