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Torsion in Buildings with Setbacks a...

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ABSTRACT

Tall buildings are frequently built with setbacks and she... structural irregularity in the vertical plane or horizontal ... recognize that the equivalent static load approach may not b... the seismic load distribution in such buildings. The codified ... analysis are evaluated vis a vis dynamic methods specified in IS... codes. A 6 storey framed building with setbacks, an 8 storey buil... storey frame-shear wall buildings were selected. The Indian ... amplification factor of 1.5 but does not specify accidental eccentri... clarify how to account for the accidental eccentricity in the dyna... does. Therefore, the dynamic analysis is carried out in two manners ... is concluded that the static provisions of the Indian code are ... need to account for accidental eccentricity. NBCC static results ... dynamic results within about 20%.

INTRODUCTION

Most building codes give simplified torsional provisions for re... only. Such buildings can be analyzed statically using 2-D modelling. ... buildings, a 3-D dynamic analysis is recommended by almost all code... vertical and horizontal planes is defined in the codes. The objec... the applicability of the static torsional provisions of IS:1893-1984 a... buildings with setbacks and shear walls. The analyses were perform... static approach as well as the response spectrum approach. Recent... studied the static and dynamic provisions of the NBCC 1990 for ... setback and observed that the static base shear is within 20% of ... base shear. They concluded that the equivalent static method can b... design of such buildings. The present work is extended to shear wal...

METHOD OF ANALYSIS

The Indian code and the Canadian code require the calculatio... for the static analysis of asymmetrical buildings. The design eccentric...

$$e_a = \alpha e + \beta D_n \qquad \text{and} \qquad e_b = \gamma e - \beta D_n$$

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setback building (Fig. 4b) as well as its frame 1 and frame 2 by 10% (Fig. 6).

The total shears in each frame of the 8 storey setback building obtained by the NBCC methods are shown in Fig. 7. It can be seen that the NBCC static method underestimates the base shear in the edge frame 1 by up to 18%. It gives conservative results elsewhere in this setback building. A similar observation was made by Tso and Yao (1994) in their 8 storey setback building. They studied in detail the contribution of different modes on the dynamic response. IS:1893 static method again overestimates the shears by about 20% (not shown). The main difference between the Indian and NBCC specifications is the absence of accidental eccentricity in the former which affects the dynamic response significantly.

Twelve storey buildings

The static and dynamic frame shears in the 12 storey frame building and the shear wall building are shown in Figs. 8, 9 and 10. The dynamic base shears were magnified so that they were equal to those given by the static base shear before carrying out the torsional analysis. The 12 storey frame building was asymmetric but without any irregularity in the vertical plane as defined in the Indian or Canadian codes. In the frame building, therefore, both the codified static and dynamic methods are applicable. IS:1893 static method again overestimates the shears by about 20% (not shown). It can be seen that the NBCC static frame shear is less in frame 2 in the upper four storeys and in the entire frame 3 by about 10% than the corresponding dynamic values (Fig. 8).

The static and dynamic frame shears in the shear wall building are shown in Figs. 9 and 10 in accordance with the IS:1893 and NBCC respectively. The NBCC static provisions overestimate the total storey shears in this building by 30% (not shown). The frame shears are overestimated except in the upper storeys of the flexible edge frame 3 (Fig. 10).

UBC dynamic method vs. NEHRP dynamic method

The results of these two dynamic methods were also shown in Figs. 6 to 10. It can be easily seen that the frame shears in the building are within 10% of each other in all cases. The difference in the frame shears is generally about 25% and the trend is mixed. In terms of the efforts, there is not much difference in the two methods. Both require a set of three analyses. The UBC dynamic method requires three dynamic analyses and the envelope is obtained, while the NEHRP method requires one dynamic analysis and two static analyses and then the results are added so as to get the worst effect. The UBC dynamic approach is preferred.

CONCLUSIONS

Based on the results presented in this research work, the following significant conclusions can be derived :

(1) IS:1893 static approach gives very conservative results as compared with the IS dynamic approach in all the buildings considered in this paper. This is because of the presence of a large dynamic magnification factor of 1.5 in the static design eccentricity and the absence of the accidental factor in the dynamic analysis.

(2) The NBCC static provisions underestimate the base shear and frame shears in the setback building by upto 18%, and in the 12 storey frame building by upto 10% as compared with those of the NEHRP dynamic method. In the shear wall building, the NBCC static provisions overestimate the frame shears by upto 30%.

(3) The static methods do not account for higher modes. They may be used for preliminary design of such irregular buildings. However, for the final design, dynamic analysis must

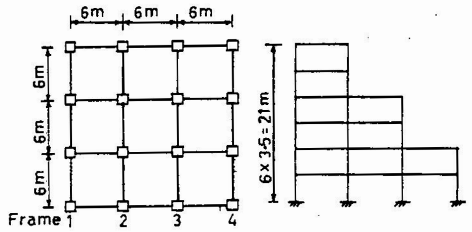


Fig.1. 6 storey frame building with setbacks

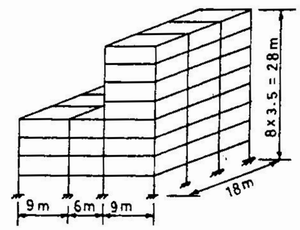


Fig.2. 8 storey frame building with setback

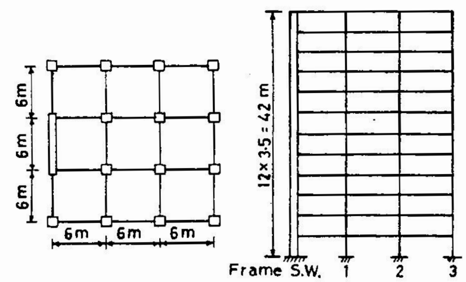
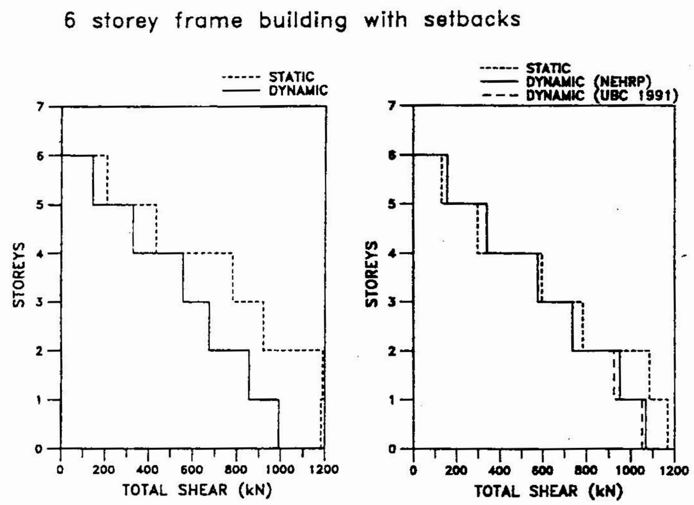


Fig.3. 12 storey frame-shear wall building



(a) (b)

Fig.4. Comparison of total storey shears in 6 storey frame building with setbacks, based on code torsional provisions (a) IS:1893 (b) NBCC 1990

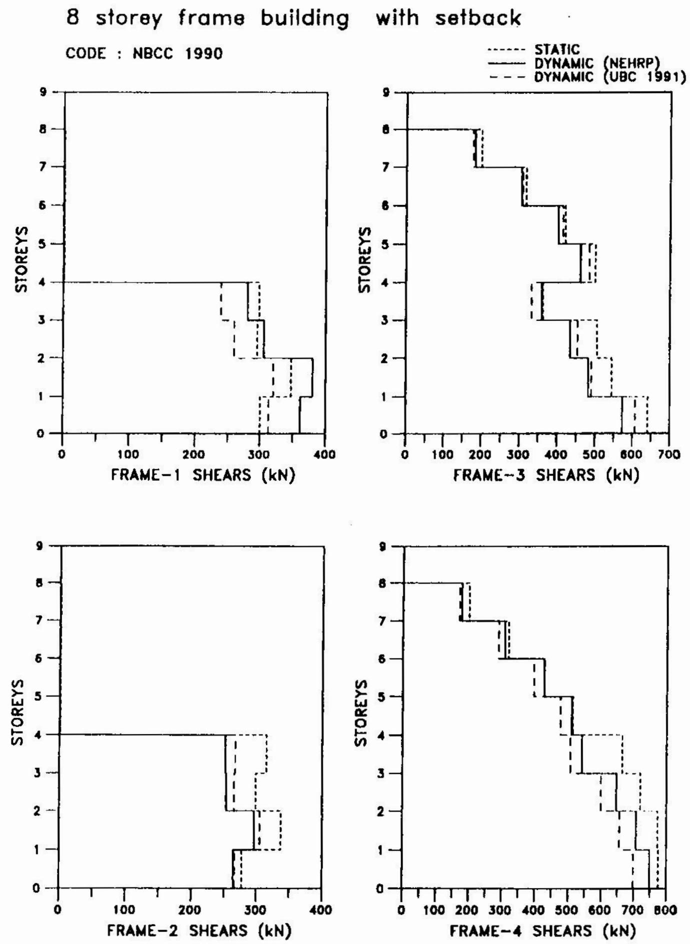


Fig.7. Comparison of frame shears based on NBCC 1990 torsional provisions

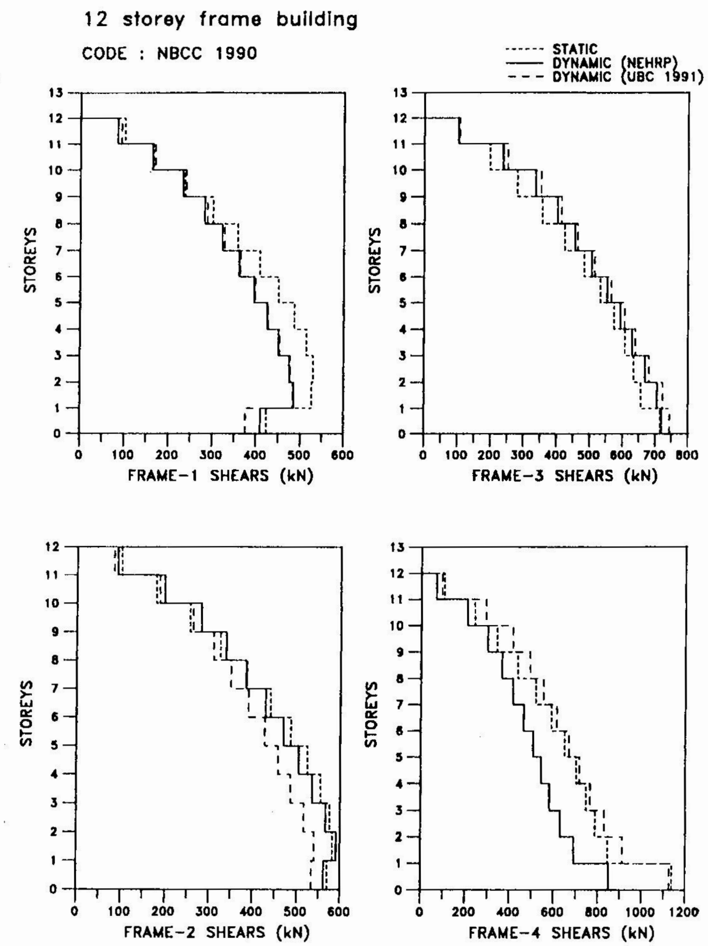


Fig.8. Comparison of frame shears based on NBCC 1990 torsional provisions