SHEARWALL FRAME INTERACTION UNDER EARTHQUAKE MOTION

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SUMMARY

The paper presents the study of characteristics of shear wall frame interaction under the action of earthquake motion with respect to a fifteen storeyed idealised shear wall-frame building. The effects, of variation of parameters like shear wall to column stiffness ratio, column to beam stiffness ratio, shear wall to frame height ratio, axial deformations in the structure, etc. on the dynamic response are studied herein.

INTRODUCTION

Shear wall buildings are much stiffer and develop larger inertia forces than the framed buildings during an earthquake. However, because of their much larger strength, they have generally been subjected to smaller structural damage. In order to have some knowledge of its structural behaviour under the action of earthquake motions, it is aimed to study the influence of various parameters on the dynamic response of buildings with shear walls.

METHOD OF ANALYSIS

The frame-shear wall building is idealized as a two dimensional F-L-W (Frame-Link-Wall) system (5). This idealized structure and its lumped mass model for dynamic analysis are shown in Fig. 1. The method of analysis adopted in this study is based on (i) influence coefficient matrix approach (1) and (ii) stiffness matrix approach (2,4). Besides the usual assumptions of elastic analysis, the following main assumptions are made here:

i) The substitute frame and shear wall are connected at each floor level through rigid hinged links.

ii) The base of the frame and shear wall is assumed rigid, that is, the deformations of the soil and foundation are assumed zero.

iii) Bending deformations are taken into account in all members. Axial and shear deformations in beams and columns are neglected. Axial deformation in shear wall is neglected but shear deformation is considered. Axial deformations in columns and shear wall are included in one case for comparing the effects.

PARAMETERS CONSIDERED FOR STUDY

The frame shear wall building is completely described by the following parameters (See Fig. 1).

S_s/S_c = Ratio of shear wall to column stiffness in first storey

S_c/S_b = Ratio of column to beam stiffness in first storey

S_{ct}/S_c = Ratio of column stiffness in top to that in bottom storey

S_{bt}/S_b = Ratio of beam stiffness in top to that in bottom storey

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S_{st}/S_s = Ratio of wall stiffness in top to that in bottom storey

m_t/m = Ratio of lumped mass at top floor to that at bottom floor

d/h_s = Ratio of depth to height of shear wall

h_s/h = Ratio of shear-wall to frame height

Housner's average acceleration spectrum curve, as adopted by Indian Standards, for 5% of critical damping has been used to compute the response in first three modes of vibration. Three values of fundamental time period were assumed as 1.0, 1.5 and 2.5 sec and the higher mode periods were calculated. The dynamic response consists of deflection, shear force and overturning moment. The range of variation of various parameters is given in col. 1 of Table 1.

RESULTS AND DISCUSSIONS

The form of results obtained is shown by typical diagrams in Fig. 2. The distribution of dynamic forces, deflections, shears and overturning moments in frame and shear wall each were plotted along the height for various parameter combinations. One parameter was varied at a time when the other parameters were kept fixed. For this purpose the following parameter combination was considered as the basic case:

$$m_t/m = S_{bt}/S_b = h_s/h = 1.0,\ S_{ct}/S_c = 0.1,\ d/h_s = 0.2,\ S_c/S_b = 20,$$
$$S_s/S_c = 30,\ T = 1.5\ s.$$

The significant observations are summarised in Table 1. The gradual reduction of mass towards the top results in reduced forces in both frame and shear wall. A change of shear wall stiffness relative to the frame, S_s/S_c changes the distribution between them very appreciably, larger value of S_s/S_c throwing more load on the shear wall. Consideration of axial deformations has a similar effect.

Figures 3, shows typical variation of proportion of shear taken by the wall along the height. It is seen that due to the consideration of shear deformations in the wall, the proportional shear taken by the wall in its bottom portion is considerably reduced as compared with the case when the effect of shearing deformation is ignored as shown by dotted lines.

CONCLUSIONS

Dynamic response of shear wall frame system under earthquake motion is studied for a wide range of structural parameters. The reduction in the mass of upper storeys of structure is very effective in reducing dynamic forces. It will be advantageous to keep the shear wall height less than the frame by 15 to 20%. Axial deformations in columns and wall have significant effect on dynamic response in certain portions of the height of frame and wall.

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TABLE - 1

EFFECTS OF VARIOUS PARAMETERS ON DYNAMIC RESPONSE OF SHEAR WALL

Parameter	Variation in Value	Variation in Dynamic Shear in		Variation in Dynamic Moment in	
		Frame	Shear Wall	Frame	Shear Wall
S_s/S_c	10 to 50	(-) 60%	(+) 90%	(-) 30%	(+) 150%
S_c/S_b	10 to 30	(-) 35%	(+) 15%	(-) 24%	(+) 60%
S_{ct}/S_c	.1 to .2	(+) in top, 10%	(+) in top, 10%	(+) in top, 10%	(-) in top (+) in bot. 10%
S_{bt}/S_b	.5 to 1	(-) in top only	(+) in top only	(+) in bot 8%	(-) 8%
S_{st}/S_s	.5 to 1	Slight (+)	(+) 20%	(-) in bot. 5%	(+) 5%
m_t/m	.5 to 1	Signif. (+) 80%	Signif. (+) 60%	Signif.(+) 150%	Signif.(+) 80%
d/h_s	.1 to .2	(+) in bot. (-) in top, 60%	(-) 15%	(+) in bot. (-) in top	Slight (-)
h_s/h	.7 to 1	(-)	(+) in top, (-) in bot.	Slight (-) in middle	Slight (-) in middle
Axial def. in col. and walls incld.		(-) 30%	Slight (+) in top	Slight (-)	Slight (+)

Notes: 1. '+' indicates increase and '-' decrease in value as the parameter increases.

2. Percentage shown is maximum at any point along the height.

3. Where portion 'top' or 'bottom' is not stated, the variation is similar along full height.

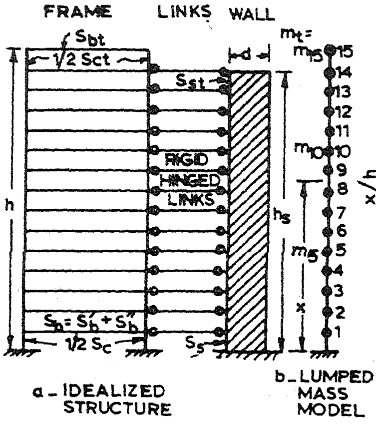

Fig. 1_ Frame shear wall building

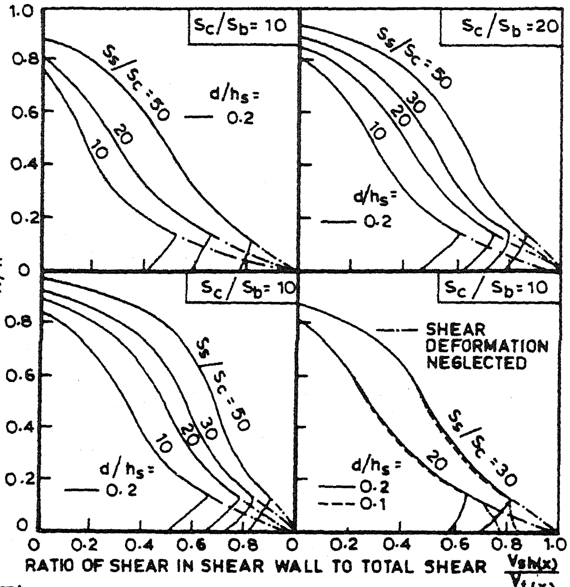

Fig. 3_ Shear ratio vs height of structure in first mode

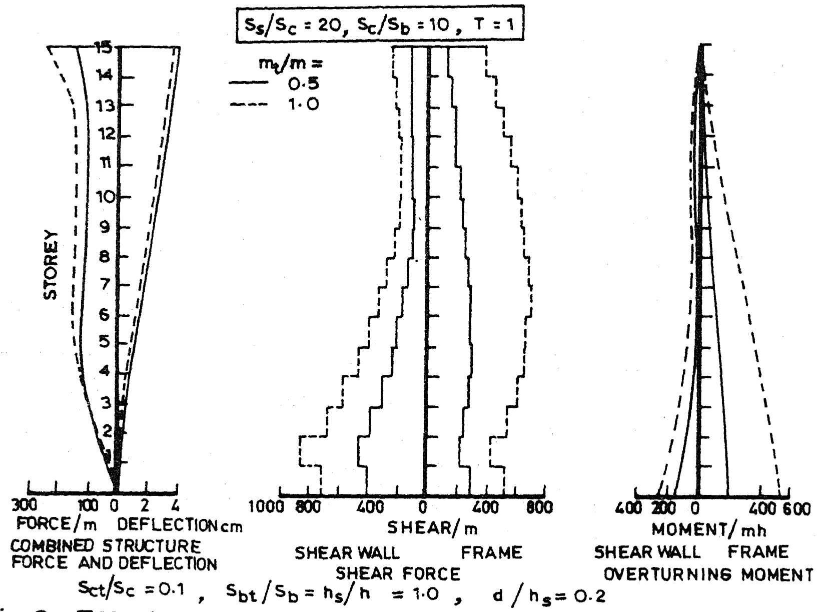

Fig. 2_ Effect of mass variation of structure along height on dynamic response