"A STUDY ON BEHAVIOR OF SOFT STOREY BUILDING CONSIDERING DIFFERENT SUPPORT CONDITION"

Dhaval D. Dhingani [1], Prof. K. J. Dhandha [2]

[1] PG student, Structural Engineering, Darshan Engg. College, Rajkot , Gujarat, India
[2] Assistant Prof., Civil Department, Darshan Engg. College, Rajkot, Gujarat, India

Abstract— Open ground storey (OGS) building has taken place in the Indian urban environment because it provides the parking area. But from past earthquakes, OGS buildings have performed poorly and collapse due to soft storey effect. This soft storey effect is due to stiffness of infill wall. After Bhuj earthquake, to overcome this effect Indian standard 1893 part-I provides Multiplication Factor (MF) 2.5 to compensate the soft storey effect. This MF is multiplied to Bending moment & Shear force of bare frame analysis for ground storey element.

But this multiplication factor is on empirical basis there is no any scientific approach to define MF value. It neglects natural time period of building which is a function of flexibility of soil under the foundation and amount of opening in the infill. So aim of this project is to check applicability of Multipliication value 2.5 considering percentage of opening in infill wall and flexibility at foundation due to soil. Combine effect of soil flexibility and Infill wall gives justification about MF value. Nonlinear static Pushover analysis is carried out.

Keywords: Soft Storey building, Multiplication Factor, Soil Flexibility, Opening in Infill wall

I. INTRODUCTION

Open Ground Storey buildings(also known as Soft Storey buildings) are commonly used in the urban environment nowadays since they provide parking area. From past earthquakes, this type of building shows comparatively higher tendency to collapse during earthquake. In analysis, bare frame is assumed without infill walls for simplification This neglects stiffness of infill walls. To overcome this soft storey effect clause 7.10.3(a) in IS 1893:2002 gives multiplication factor 2.5 to shear force & bending moment calculated in bare frame for ground storey elements(Column, Beam). This multiplication value doesn't consider the effect of different stiffness of infill walls and soil flexibility. Many literatures concluded that it is vary from 1.0 to 4.8, Yet there is no proper justification about this factor.

II. LITERATURE REVIEW:

S.A.Bhat, V.K. Sehgal, Saraswati-Setia[1] performed analysis on building to check the applicability of MF 2.5 by ESA and RSA. They concluded that MF 2.5 increases dimension of column and percentage Reinforcement. MF should be 1.25 instead of 2.5 They recommended that Effect of infill wall, Different height of building, Nonlinear Analysis should be considered.

R. Davis, D. Menon, A.M. Prasad [2] concluded thath MF based on linear dynamic analysis is 1.11-2.39 for seven storey building. MF from Nonlinear Dynamic analysis 1.14-1.29 for seven storey building The Multiplication factor increases with height of building mainly due to the higher shift in the time period.

Dr.Abhay Sharma, Dr.Vivek Garg, Dharmesh Vijaywargiya [3] discussed on MF and decided that it should be less than as suggested by code. Parameters associated with infill like strong infill and weak infill, %openings affect the member forces which is not considered in IS code for MF.

J. N. Arlekar, Sudhir K. Jain, C.V.R Murthy[4] suggested that soft storey should at least 50% stiffer than above storey. The soil flexibility needs to be examined carefully before finalizing the model. This study highlights error involved in modeling such building as complete bare frame. Linear Static Analysis is performed on building. Soil is modeled by Winkler Approach.

K.Bhattacharya & S.C. Dutta[5] Aim of this paper is to study the effect of soil flexibility on the change in lateral natural periods of building frames considering various parameters such as (i) different soil condition (ii) number of stories (iii) number of bays (iv)ratio of column to beam stiffness (v) frequency of the ground excitation. In this study, Finite Element method is adopted by taking 3-d frame elements in 2,4 bays in both direction & 1,2,4 & 6 storey buildings. Effect of soil- flexibility appreciably alter the lateral natural periods of any building structure. This is primary parameter, which regulates the seismic lateral response of the building frames. Evaluation of natural time parameter without considering soil flexibility may cause serious error in seismic design. If the effect of the infill brick wall is not considered while studying the seismic behavior of building frames, the effect of soil flexibility may not be recognized. There is no appreciable change in natural period due to soil flexibility while change in beam to column stiffness ratio.

Abdel Raheem, M. M. Ahmed, Tarek Alazrak[6] suggested that Fundamental period is not only a function of building height but also a function of soil flexibility. Storey shear ratio (MF) is nearer to 1.5 for various soil flexibilitywithout considering infill stiffness in RSA

III. MODELING OF INFILL WALL

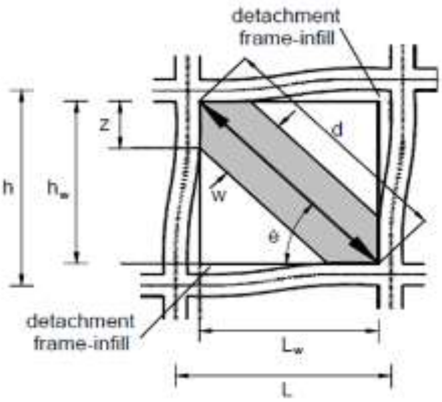


Figure: 3.1 Modeling of Infill wall

There are many formula to model the infill wall listed in table 3.1. Infill wall is modeled by single strut approach. Thickness of strut is taken thickness of wall and width of strut is taken by following . Mainstone formula is used to consider opening effect in infill wall by taking reduction factor.

Researchers	Strut width (w)	Remark
Holmes	$0.333d_m$	d_m is the lenght of diagonal
Mainstone	$0.175\,D\,(\lambda_h H)^{-0.4}$	$\lambda_h H = H\left[\frac{E_m t \sin 2\theta}{4E_c I_c h_m}\right]$
Liuw and Kwan	$\frac{0.95\,h_{m} t \cos\theta}{\sqrt{\lambda h_m}}$	$\lambda_h = \left[\frac{E_m t \sin 2\theta}{4E_c I_c h_m}\right]^{\frac{1}{4}}$
Pauly and priestley	$0.25\,d_m$	d_m is the lenght of diagonal
Hendry	$0.5[\alpha_h + \alpha_L]^{\frac{1}{2}}$	$\alpha_h = \frac{\pi}{2}\left[\frac{E_c I_c h_m}{E_m t \sin 2\theta}\right]^{\frac{1}{4}}$ $\alpha_L = \left[\frac{E_c I_c L}{2E_m t \sin 2\theta}\right]^{\frac{1}{4}}$

Table: 3.1 Formula for Modeling of Infill wall

IV. MODELING OF SOIL

Soil is modeled by spring approach which has 6 degrees of freedom.

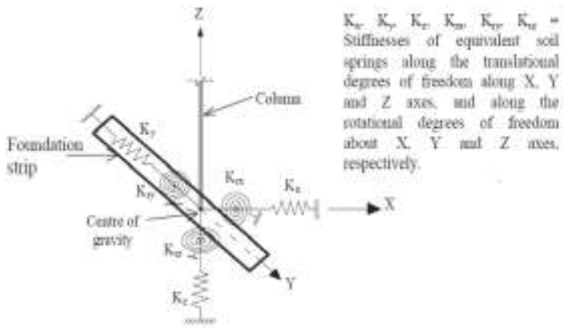


Figure: 3.2 Spring Approach for Soil Modeling

V. BUILDING ANALYSIS

Building		Seismic Parameter	
Storey	G+5	Seismic Zone	IV
storey height	3m	Importance Factor	1
Support	Varies with soil stiffness	Response Factor	3
		Type	OMRF
Floor	Rigid		
Geometrical Property			
Size of beam	300X600 mr	Column size	450X450 mm
Slab Thickness	150 mm	Wall Thickness	230mm
Material Property		Loading	
Concrete Grade	M25	Live Load	2 KN/m²
Steel Grade	Fe 415	Floor Finish	1.5 KN/m²

Table: 3.2 Data for building Analysis

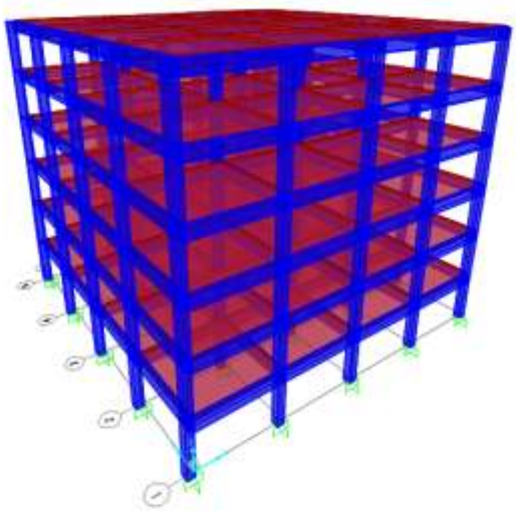
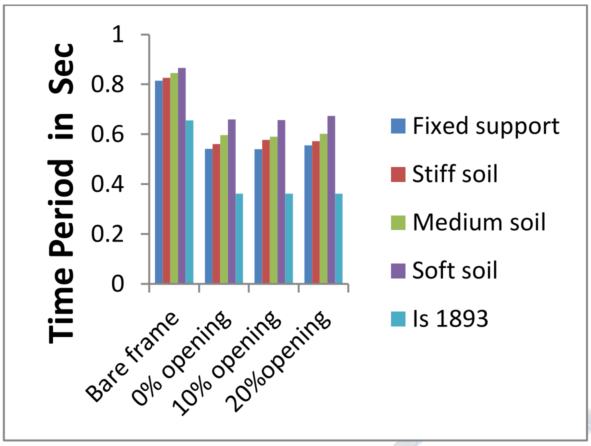


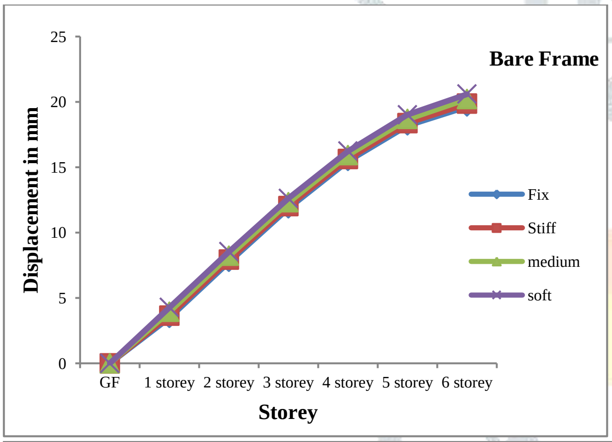
Figure: 3.3 3-D view of building

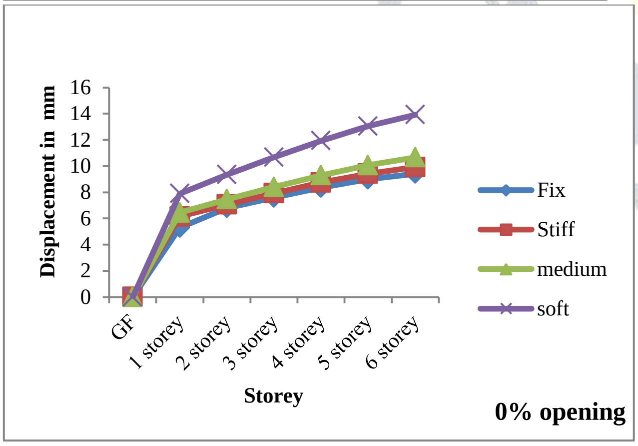
VI. Results

(1) Natural Time Period

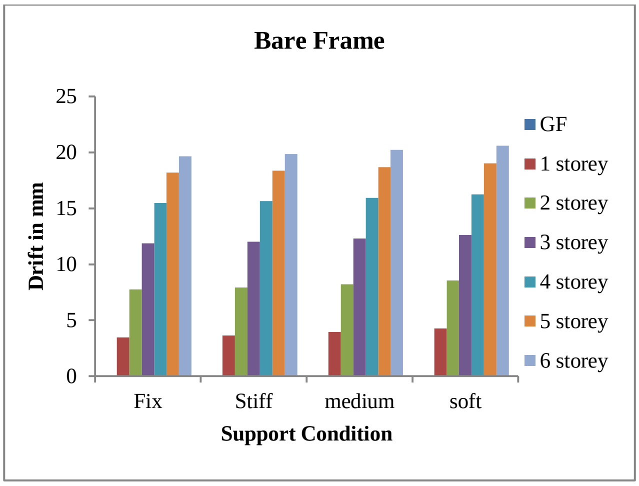


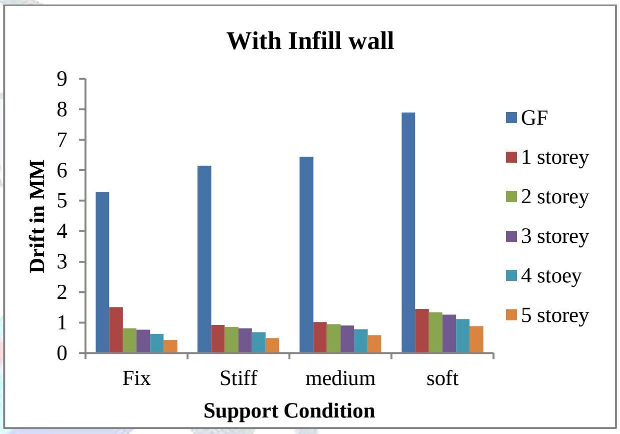
(2) Storey Displacement



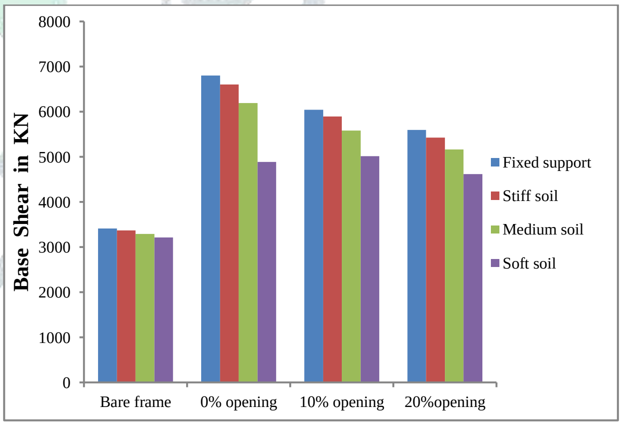


(3) Storey Drift

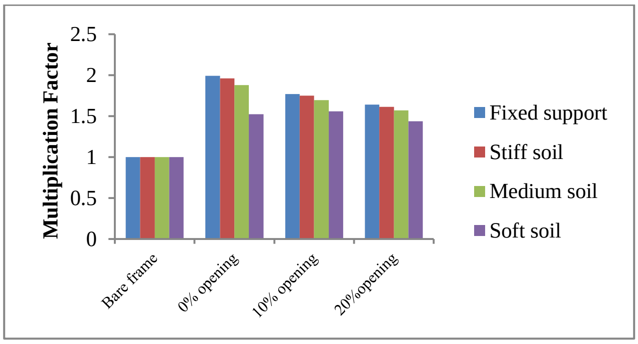




(4) Base Shear

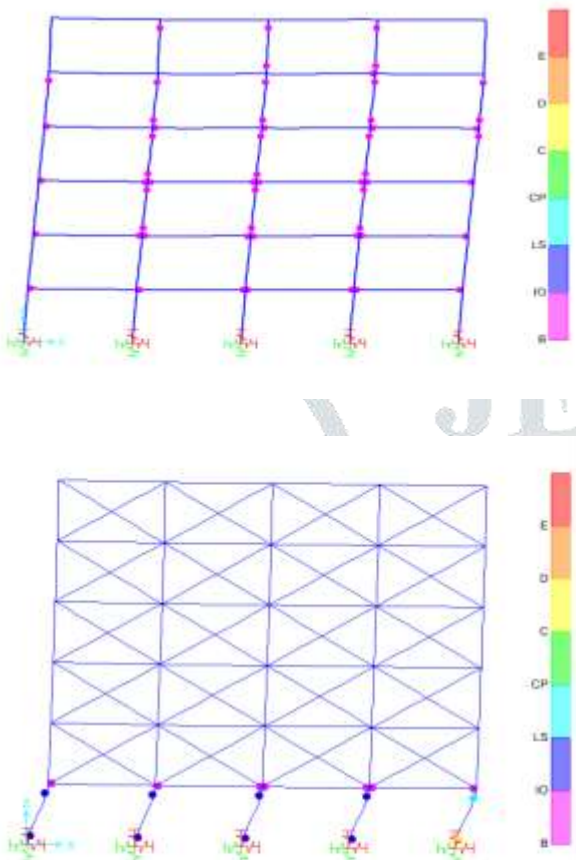


(4) Multiplication Factor

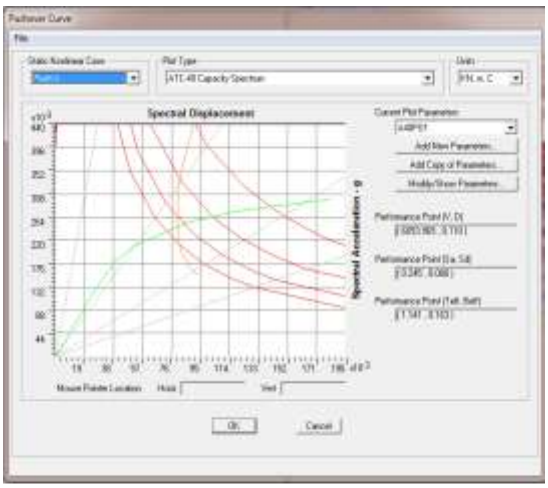


	Bare frame	0% opening	10% opening	20%opening
Fixed support	1	1.99	1.77	1.64
Stiff soil	1	1.96	1.75	1.61
Medium soil	1	1.88	1.70	1.57
Soft soil	1	1.52	1.56	1.44

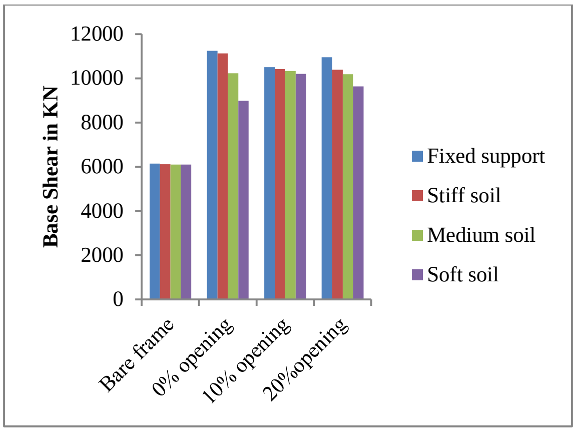
(5) Hinge Formation



(6) Pushover Curve



(7) Base Shear at Performance Point



VI. Conclusion

[1] Soil flexibility increases the time period of building. Time period increment is more in infill wall frame with different opening than bare frame. Also dynamic time period of building is more than static time period as specified in IS code 1893:20002.

[2] There is no significant increase in displacement and drift in bare frame but comparable increase in displacement and drift of infill wall frame while increasing the soil flexibility, so **effect of soil flexibility and infill wall should be considered simultaneously.**

[3] Base shear force decreases with increase in soil flexibility and percentage opening.

[4] Displacement at performance point increases with increase in soil flexibility while shear force at performance point decreases with increases in soil flexibility

[5] Multiplication factor decrease with increase in soil flexibility and percentage opening. Multiplication factor remains between 1.44 to 1.99 for G+5 storey building which is smaller than as mentioned 2.5 in IS code.

.

IV. References

[1] S. A. Bhat, Saraswati Setia and V.K. Sehgal (2015) "Seismic Response of MRF with OGS Designed as per Code Provisions" Advances in Structural Engineering(Springer), DOI 10.1007/978-81-322-2193-7_68

[2] R. Davis, D.Menon, A.M. Prasad (2008) "Evaluation of MF for OGS buildings using Nonlinear Analyses" The 14th World Conference on Earthquake Engineering

[3] J.N.Arlekar, Sudhir Jain and C.V.R Murty (1997) "Seismic Response of RC frame Buildings with soft first storeys"Golden Jubilee Conference New Delhi

[4] Dr. A. Sharma and Dr. Vivek Garg(2014) "Seismic Response of a mid rise RCC Building with soft storey at Ground Floor" IJSET Vol. 02 ISSN:2348-4098

[5] Koushik Bhattacharya and S.C Dutta (2003) "Assesing lateral period of building frames incorporating soil-flexibility" Jounal of sound and vibration (Elsevier) DOI:10.1016/S0022-460X(03)00136-6

[6] S.E.A Raheem, M.M.Ahmed, T.M.A.Alarzak “Evaluation of soil-foundation-structure interaction effects on seismic response demands of multi-storey MRF buildings on raft foundation” Int J Adv Struct Eng(2015) DOI 10.1007/s40091-014-0078-x

[7] Subramanian, N. (2004) Discussion on seismic performance of conventional multi-storey building with open ground floors for vehicular parking by Kanitkar and Kanitkar. The Indian Concrete Journal. 78. 11-13

[8] IS 1893 Part 1 (2002) Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.

[9] H.B.Kaushik, Durgesh Rai and Sudhir Jain(2009) “Effectiveness of some strengthening options for Masonry-Infilled RC Frames with Open Fisrt Storey” Journal of Structural Engineering(ASCE)

[10] SAP 2000 (2015) Integrated Software for Structural Analysis and Design. Computers & Structures, Inc., Berkeley, California

[11] P.G. Asteris, "Lateral stiffness of brick masonry infilled plane frames", J. Struct. Eng. ASCE, vol. 129, no. 8, pp. 1071-1079, 2003.

[12] ATC-40, Applied Technology Council, Seismic Evaluation and Retrofit of Concrete Buildings, Volume 1, 1996.