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Optimum Location of Lift Core Wall for Flat Slab and Conventional Beam System Using Generated Response Spectra

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ABSTRACT

The performance based seismic analysis has become widespread, growing awareness is being set to improve structural recital throughout seismic actions. Increased frequency and magnitude of seismic waves fetching a requisite of more earth quake resistant structures comprising shear wall and frames. The study considers field evidence on probable structural effects of strong ground movements. Shear wall is the best way to control deflection during earthquake, but it interferes with architecture and feasibility. To eliminate this discrepancy, lift core wall analysis is presented in this paper. Reinforced concrete coupled lift core wall with open sections structure is a resourceful seismic improved structural method. It has huge lateral stiffness and strength and can afford good control of seismic hazards of buildings under earthquake loads.

In this framework of probabilistic seismic hazard analysis, the ideal approach for obtaining the maximum ground movements is in sense of acceleration, velocity, displacement which is scaled to 15 sec. Based on extensive theoretical study on characteristics of seismic ground response, improved response spectral values are proposed in this paper for medium soil site conditions. The enlargement of acceleration based approaches for consideration and design has formed the need for reliable/ feasible acceleration response spectra for a extensive sort of response periods and damping ratio to defeat few correlations in IS 1893-2002(part I) code. The study reviews comparative evolutions of dynamic analysis of flat slab system and conventional beam system in reinforced concrete buildings of G+10 storey with most favorable locations of lift core wall by considering case study of Indian earthquakes, response spectrum is generated for the damping ratio of 5% with the period 4 sec with an increment of 0.05sec. The consequences emphasize on the structural behavior of multi storey buildings of symmetric and asymmetric configuration/ models by 3D modeling using E-Tabs Software in the terms of storey displacement, storey drift, storey stiffness, time period and frequency. Conclusions obtained will help in identifying the optimum location of lift core wall that will help in achieving the earthquake performance objective.

Key Words: *Lift Core Wall, Flat Slab, Conventional Beam System, Response Spectrum Analysis*.

1. INTRODUCTION

The movement of ground due to seismic waves takes place continuously with periods and amplitudes ranging from milliseconds to days and nanometers to meters respectively without any intimation. It affects living beings and their environment along with structural disaster had always been one of the great natural calamities expectation ahead the mankind, since past failures are immemorial and brings its waken countless miseries and hardship to the people affected and is of awareness for civil engineers by constructing earthquake resistant structures and is termed as strong ground motion. The movement of the ground can be express in terms of acceleration, velocity, or displacement. The variation of ground acceleration with time, recorded at a point on the ground throughout an earthquake is called an accelerogram simultaneously velocity and displacement is calculated by integration [3].

Earthquake response spectrum is the popular tool in the seismic analysis of multi storey structures subjected to varying ground motion. Response spectrum curves can be obtained by plotting peak values of strong ground motions along y axis and time period or frequency along x axis. For a given damping ratio response spectrum can be summarized as the locus of maximum response of the SDOF structure. To understand the capacity of structures to withstand seismic resistivity by Strong earthquake ground motions, response spectra give a handy tool to engineers. Displacement, velocity and acceleration are used to express of amplitudes of ground motion[5].

Shear wall usage is the finest way to overcome deflection during increased intensity and frequency of earthquake in fetching a requirement of more seismic resistant structures. Sometime in order to defeat architectural feasibility and providing convenience to users, lift core wall is used instead of shear wall. To survive earthquake forces in horizontal direction lift core wall gives required lateral strength and are transfer those horizontal forces to next element in the load path beneath them sufficiently. lift core wall provides stability against blast deriving, wind and seismic hazards as a structural system and also avoid pounding of adjacent buildings in urban areas and shear failure [4].

Flat slab structure consists of slab directly resting on the columns without the any beams [6]. In 1906 A.D. Tumer originated the document of flat slab construction in America [8]. Due to absence of beams, flat slab system has been generally used in India and many countries. Building height can be reduced by using flat slab and also dead load can be minimized with flexible building plan. In conventional beam system slab rests on beam and obviously dead load is more and building plan flexibility is less [6].

2. RESPONSE SPECTRA

The expansion of acceleration based commences to assessment and design of structures has formed the requirement for consistent acceleration response spectra for a extensive sort of damping ratios and response periods. Current work for particular earthquake scenarios considers the simple way to construct compatible acceleration spectrum in addition of seismic design codes on the base of three ground motion criterion. The outcome reflects the impact of magnitude and site classification on shape of the spectra [1]. In this study based on sever earthquake occurred in India, response spectra is generated by considering strong ground motions[2].Selected seismic wave data in terms of peak ground acceleration(PGA)(m/s^2),peak ground velocity(PGV)(m/s) and peak ground displacement(PGD)(m) are scaled to 15sec. in order to prepare precise response spectra[3]. Response spectrum analysis provides a realistic way to relate the knowledge of dynamic nature of structures to design seismic resistant structures.

Lift Core Wall. In multistory buildings RC core walls with open sections are normally used to resist lateral load and sometimes they designed to defend against lateral seismic load. Such walls usually give accommodation to elevator shaft or staircase and also play a important role in increasing the capacity of structures to resist lateral load [7].

RC core walls usually construct to withstand lateral force primarily in tall buildings. Lift core wall along with architectural purpose provides required stiffness, strength and needed capacity for deformation to encounter the demands of strong seismic activity of ground. In tall buildings, the technique used to withstand lateral force is occasionally concentrate in fairly some walls which are scattered throughout the floor plate or core wall within center to give enough stiffness and lateral strength desired to bound the acceptable level lateral deformation[10].

Lift core wall is provided in deferent locations ie at the center corner edge for both flat slab and conventional beam system and then optimum location of lift core wall is determined to resist seismic action on buildings.

Flat Slab and Conventional beam system. The major advantages of flat slab system in multistory buildings against traditional slab beam column system structures are architectural feasibility, economical aspects, lesser construction period and flexible design space. Flat slabs system is extensively flexible under lateral load due to absence of deep beams than conventional reinforced concrete frame system which makes the structure more sensitive to strong seismic proceedings [9].

The performance of flat slabs under seismic load shows some drawbacks such as essential non dissipative characteristics during seismic response of the building and also they more susceptible under earthquake excitation to P - Δ effect of second order.[11]

Models are prepared for both Flat slab and conventional beam system with different locations of lift core wall for symmetric and asymmetric plain configuration.

3. MODELLING

ETABS software is used for the dynamic analysis of structures with specialization in dynamic and linear static analysis of structures. This software has huge range capability in designing structural systems which can hold wind and vertical loads, response spectrum analysis.

Computational Models. To establish seismic characteristics of structures, models are prepared in both flat slab and conventional beam system with optimum locations of lift core wall (LCW) according to IS 1893(I)-2002 code provision and generated response spectra. Rectangular, 'I' shaped, 'H' shaped and '+'shaped multi storey buildings are analyzed with five different locations of lift core wall in each shape using both IS 1893(I)-2002 and generated response spectra in response spectrum analysis. Lift core walls are provided in centre, Edge x and y directional, corner d1 and d2 directional position in each rectangular, 'I' shaped, 'H' shaped and '+' shaped configuration.

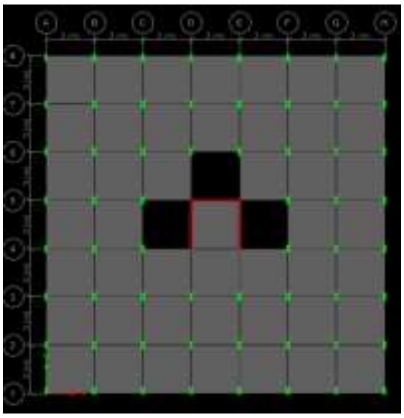

Fig. 1 Model with Centre LCW position

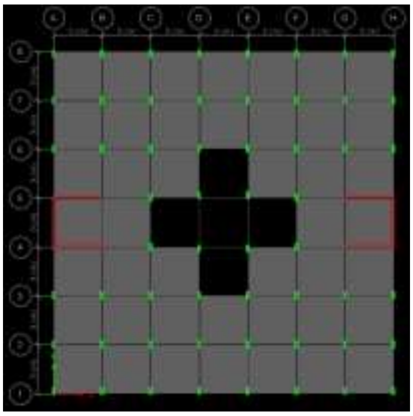

Fig. 2 Model with X directional Edge LCWposition

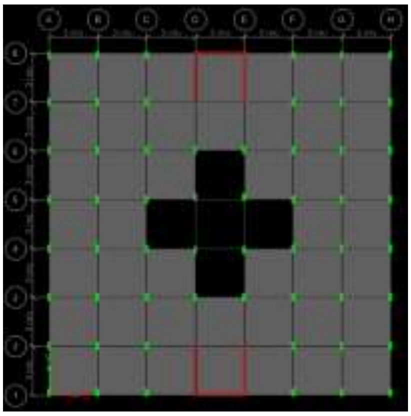

Fig. 3 Model with Y directional Edge LCWposition

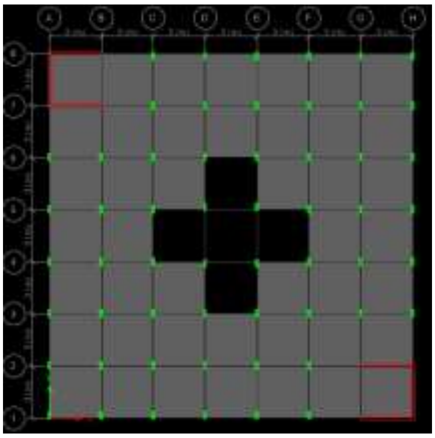

Fig. 4 Model with corner d1 LCW position

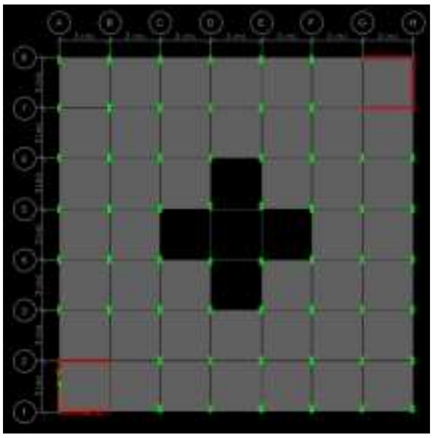

Fig. 5 Model with corner d2 LCW position

LCW positions as in fig. 1,2,3,4,5 are provided in other 3 different patterns as shown in next fig. Later models are prepared for conventional beam system in the same manner.

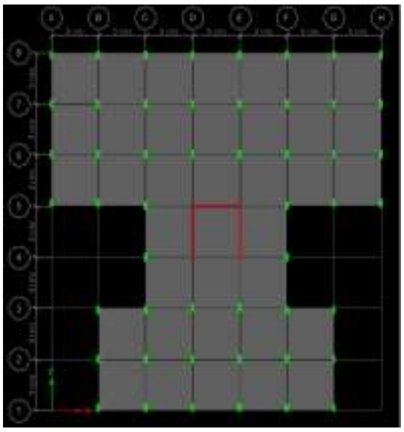
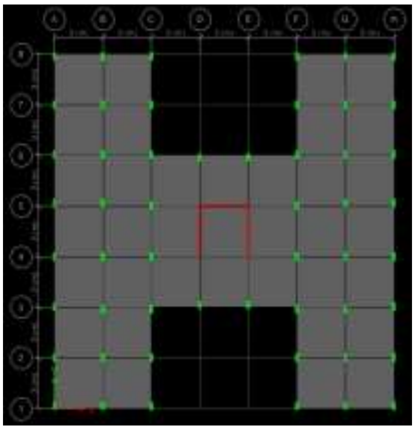
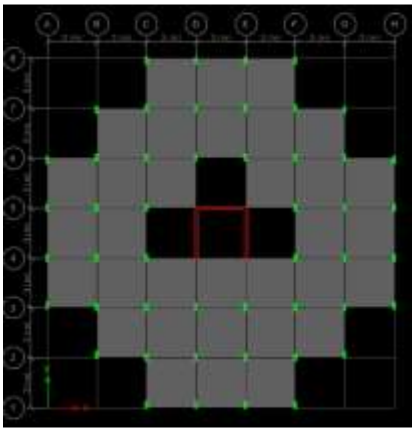

Fig. 6 'I' shaped model with Centre LCW position **Fig. 7 'H' shaped model with Centre LCW position** **Fig. 8 '+' shaped model with Center LCW position**

Models analyzed with other considered LCW position for the pattern as in fig. 6,7,8. Total models are considered to analyze for both flat slab and conventional beam system are,

1. Rectangular shaped models with specified LCW locations with IS 1893(I)-2002 RS
2. 'I' shaped models with specified LCW locations with IS 1893(I)-2002 RS
3. 'H' shaped models with specified LCW locations with IS 1893(I)-2002 RS
4. '+' shaped models with specified LCW locations with IS 1893(I)-2002 RS
5. Rectangular shaped models with specified LCW locations with generated RS
6. 'I' shaped models with specified LCW location with generated RS
7. 'H' shaped models with specified LCW location with generated RS
8. '+' shaped models with specified LCW location with generated RS

Material properties: 3D RC frames of seven bays with 3m distance in each direction having G+10storey have been taken in to consideration. The RC frames are designed as per Bureau of Indian Standards codes, IS 456-2000, "Plain and Reinforced Concrete-code of practice",

IS 1893(I) - 2002, "Criteria for Earthquake Resistance Design of Structures". The M25 and HYSD 500 steel bars are used for reinforcement

Size of The Structural Elements: For 3m storey height of the multi storey buildings 230*500mm size is considered for column and beam with 125mm slab thickness and 230mm lift core wall thickness is considered for conventional beam sytsem. Similar size of slab column and LCW used for flat slab system. The sizes of elements are considered according to IS 456-2000 code.

Loads and load combinations:3kN/m^2 live load considered with 25% mass source and by deducting 30% of wall load for openings 8.904kN/m^2 is considered and load combinations is taken according to IS 1893(I)-2002(6.3.1.2) code.

Response Spectra(RS) Generation: For severe earthquake data RS is generated with the medium soil condition. In this study 1986 NE Saitsama,India[2]. earth quake data is considered by scaling the data to 15sec. to make easy is generating RS[3]. Considered strong ground motions are peak ground acceleration(PGA) 0.139g, peak ground velocity(PGA) 0.0587m/s and peak ground

displacement(PGD) 90cm[2]-[3] for the zone V scaling of peak ground motions spectral acceleration(SA) is calculated for 4sec period with increment of 0.05sec and 5% damping using the equations as shown $T_C=5(PGV/PGA)$ $T_B=T_C/4$ $T_{D=}8(PGD/PGV)$ $\eta=\sqrt{10/(5+\xi)}$ due to 5% damping η is become constant.

For $0 \leq T \leq T_B$ $SA(T)=PGA[1+(T/T_B)(2.5\eta-1)]$. (1)

$T_B \leq T \leq T_C$ $SA(T)=PGA(2.5\eta)$. (2)

$T_C \le T \le T_D$ SA(T)=PGA(2.5η)(T_C/T). (3)

The generated RS is done by plotting spectral acceleration along Y axis and time period along X axis as shown[1].

Fig. 9 Generated Response Spectra (RS)

4. RESULTS AND DISCUSSIONS

Response spectrum analysis is carried out for models mentioned for both flat slab and conventional beam system. By considering suitable position of LCW, comparisons done between shapes in terms of Storey drift and stiffness, '+' shaped pattern shows better results apart from other pattern, '+' shaped pattern is mainly considered for the study of slab system and response spectra

Slab system Comparison. For this study StoreyDrift andStorey Stiffness parameters are considered. The graphs shown below are for '+' shaped models of flat slab system and conventional beam system as per IS response spectra and generated RS.

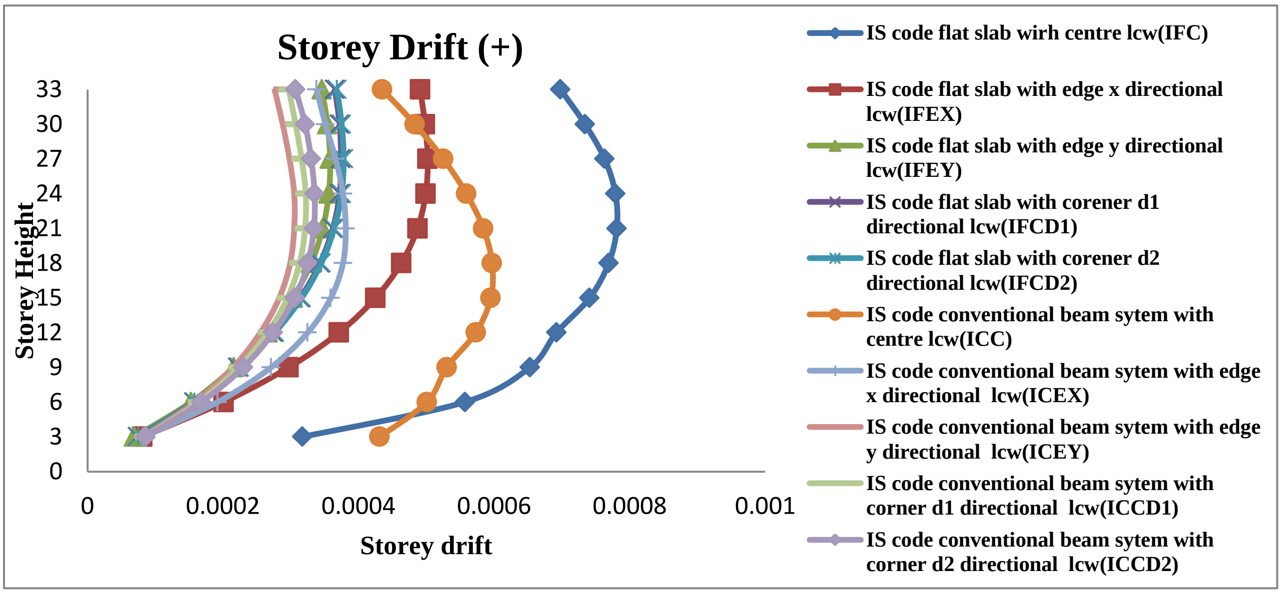

Fig. 10 Storey Drift as per IS 1893(I)-2002 RS

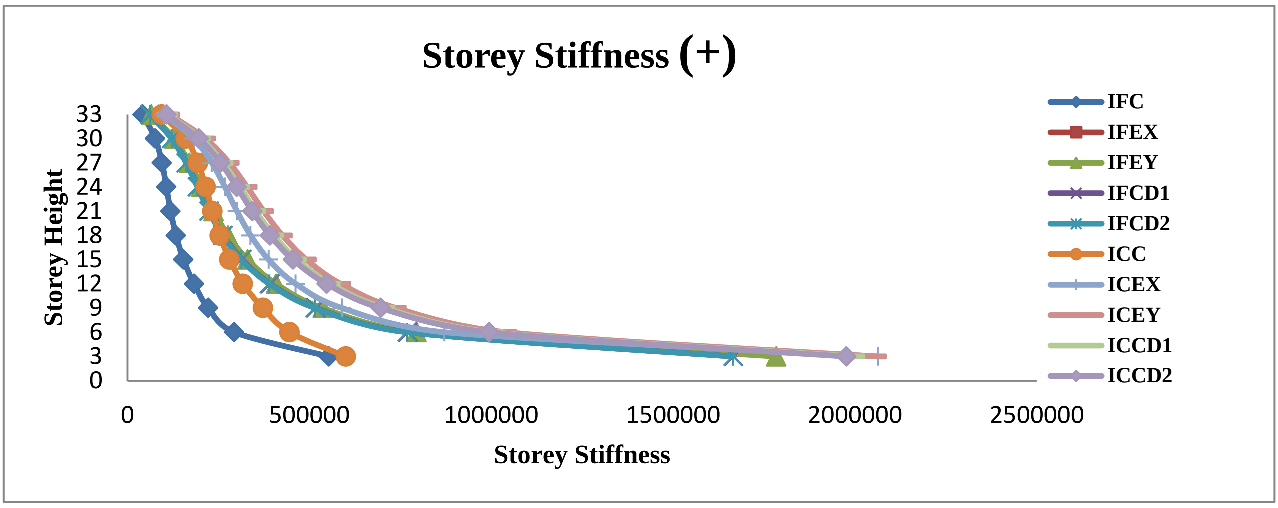

Fig. 11Storey Stiffness as per IS 1893(I)-2002 RS

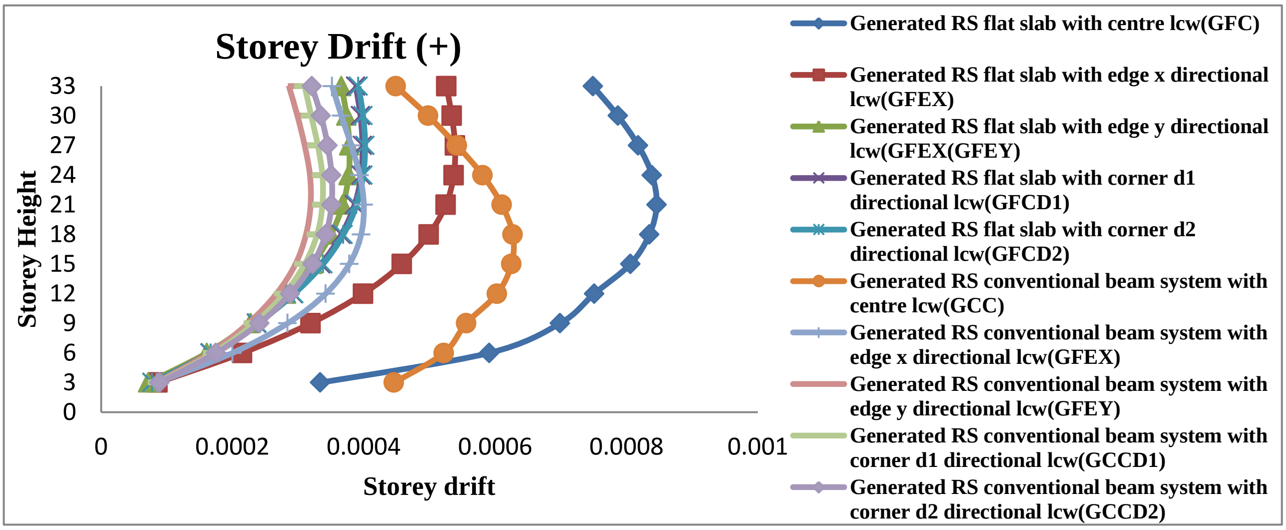

Fig. 12 Storey Drift as per generated RS

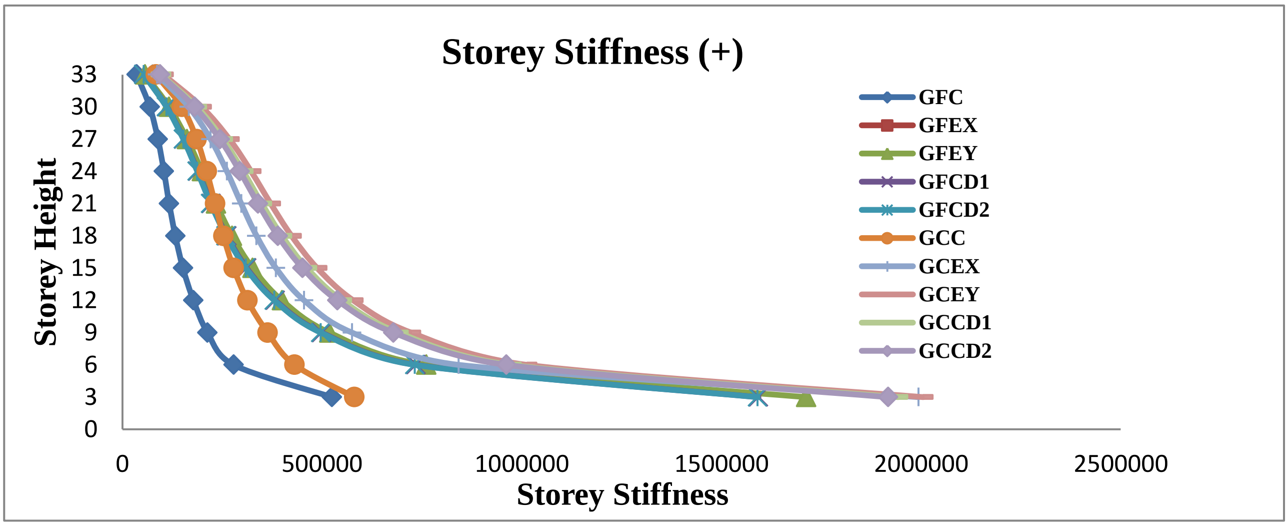

Fig. 13Storey Stiffness as per generated RS

Response Spectra Comparison, For this study storey drift and storey stiffness parameters are considered. Comparisons carried between IS 1893(I)-2002 RS and generated RS for flat slab and conventional beam system.

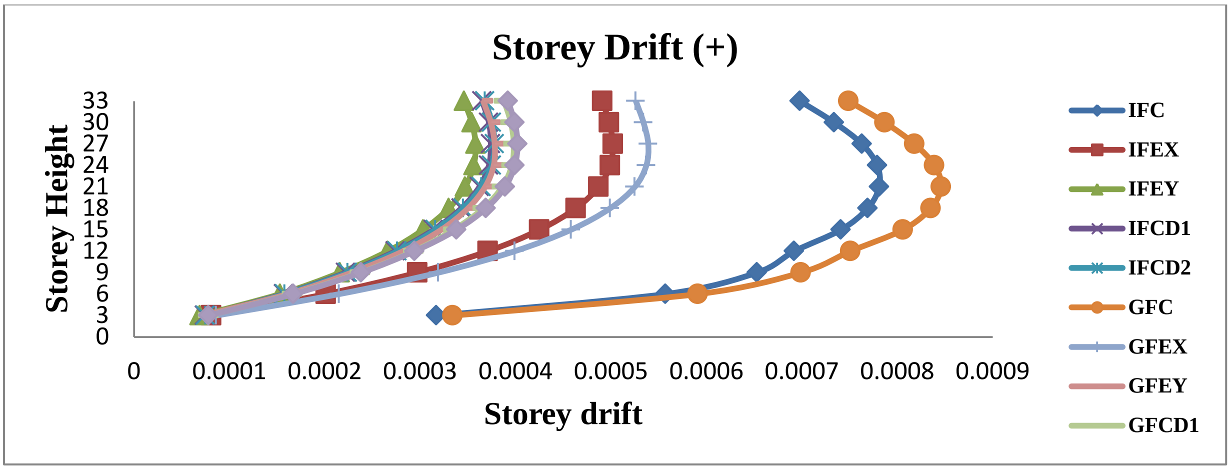

Fig. 14Storey Drift for flat slab system

Fig. 15Storey Stiffness for flat slab system

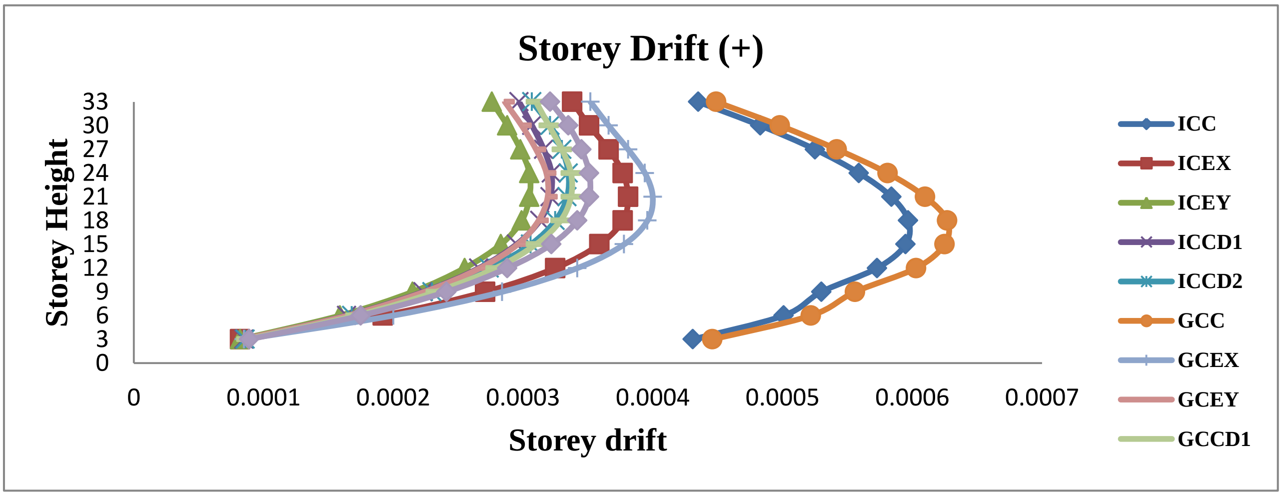

Fig. 16StoreyDrift for conventional beam system

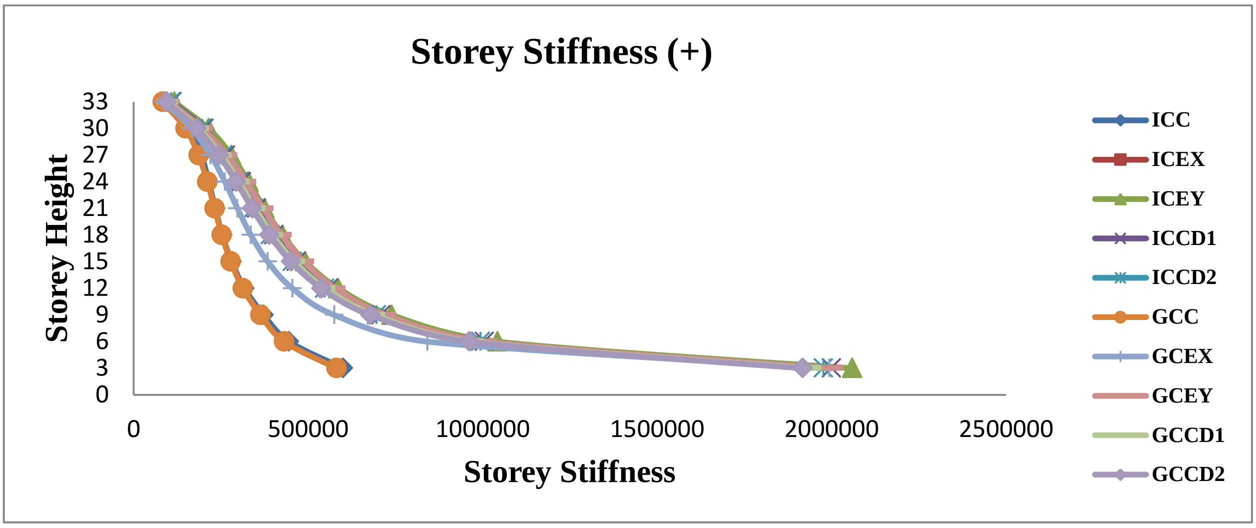

Fig. 17StoreyStiffness for conventional beam system

5. CONCLUSIONS

From the study the following conclusions are mentioned for optimum location of LCW in flat slab system and in conventional beam system by considering IS and generated RS in the first part. Second part consists slab system comparisons in both IS and generated RS and the last part consists of response spectra study.

Optimum Location of LCW: Linear dynamic analysis of flat slab system using IS 1893(I)-2002 response spectra by considering parameters like time period, storey drift, storey displacement, storey stiffness and base shear edge lift core walls in 'y' direction shows seismic resistant capability. It shows locations of LCW also improve seismic resistivity by their behavior in global flexure. Response spectral analysis of flat slab system using generated RS, conventional beam system using IS and generated RS also shows same characteristics with same parameters as mentioned earlier. After comparing locations of lift core wall suitable location of lift core with rectangular, 'I' shaped, 'H' shaped and '+' shaped models comparison is carried and reflecting results in terms of the parameters as mentioned earlier '+' shaped model shows better seismic performance because of symmetric configuration which exhibits less deformation and also suitable shape and load characteristics.

Slab System: Comparisons is done between flat slab and conventional beam system using IS 1893(I)-2002 response spectra and the flat slab and conventional beam system using generated response spectra. In both comparisons in terms of storey drift and storey stiffness conventional beam system shows much superior seismic performance than flat slab system, because flat system slab is more susceptible under earthquake excitation to P - Δ effect of second order and minimum rigidity, less vertical load which also contributes seismic resistivity.

Response Spectra: To overcome some correlations of response spectra in IS 1893(I)-2002 code response spectra generated and compared with IS response spectra. Comparisons are done in the sense of storey drift and storey stiffness for flat slab and conventional beam system. In both slab system reflecting results are more or less similar which shows response spectra can be generated for particular earthquake data and zone without go through code provisions.

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