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Seismic Analysis of Soft Storey Reinforced Concrete Structure with Eccentric Bracing

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Abstract— *A* ***building construction in India is generally of masonry infill reinforced concrete (RC) construction. In case of multi-storey buildings, the common practice is to keep storey free from masonry infill. This is done mainly to fulfil parking requirements of occupants or commercials spaces in case of upper storey. In present study eccentric bracings are used as a means to reduce soft storey mechanism in masonry infill reinforced concrete (RC) building which provides ductility and lateral stiffness to structure with greater economy. Non-linear analysis i.e. time history analysis is used to study the seismic response. Open storey also provides free space for commuting of vehicle at soft storey level. Seismic performance of a structure located in Indian seismic zone-V as per Indian standard code 1893-2016 is investigated using nonlinear dynamic analysis. To account stiffness and structural action of masonry infill panels, the equivalent diagonal strut method has been utilized. Three ground motion records are used to perform the earthquake analysis of the considered model configurations. The finite element based software ETABS has been used in developing the building models and performing analysis. Various response parameters like base shear, storey displacements, and storey drift are calculated to understand seismic behaviour. Result of this study conducted show that by using eccentric bracing drift limitation given in IS 1893;2016 get satisfied.***

Keywords—RCC Building Frame, Soft storey, Eccentric bracing,Time history analysis, Masonry infill walls, diagonal strut

I. INTRODUCTION

Among various measures to reduce soft storey effect, provisions of steel bracing to masonry infill reinforced concrete buildings having soft storey is an appropriate method of strengthening of soft storey, which is also an economical means to measure seismic performance of structure. Provision of bracing systems give required stiffness to soft storey. Among various types of bracing such as X, V and K bracing has been investigated for strengthening soft storey building by various researchers. It is apparent that these bracing systems disturb the functional requirement of a soft storey structures if provided at first storey level. Also, in developing countries like India, due to limitation of parking space at first storey is the only alternative left in multi-storey buildings. In this context, eccentric bracing is an alternative for other types of bracing, which would allow free movement of vehicles in first storey along with lateral stiffness. The bracings system would be a better as well as suitable method for strengthening of soft storey. Eccentric bracing is used in steel structures, though only occasionally and for architectural purpose until. After that, eccentric bracings have been investigated and used as structural element in steel structures. This bracing system is preferred over other bracings in steel structures due to its high lateral stiffness with adequate ductility and damage concentration.

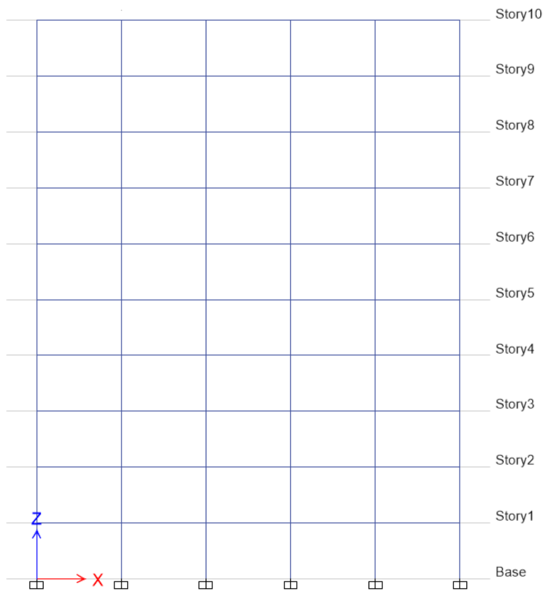
II. METHODOLOGY

In order to investigate seismic performance of RCC frame buildings with and without eccentric bracing a ten storey symmetrical reinforced concrete moment-resisting frame building is considered. The considered symmetrical building has of 25m in length, divided into 5 bays and 16m in width divided into 4 bays as shown in fig.1. The associated storey height considered is of 3.2m. In modeling of soft storey building frame other relevant data is given in table 1,

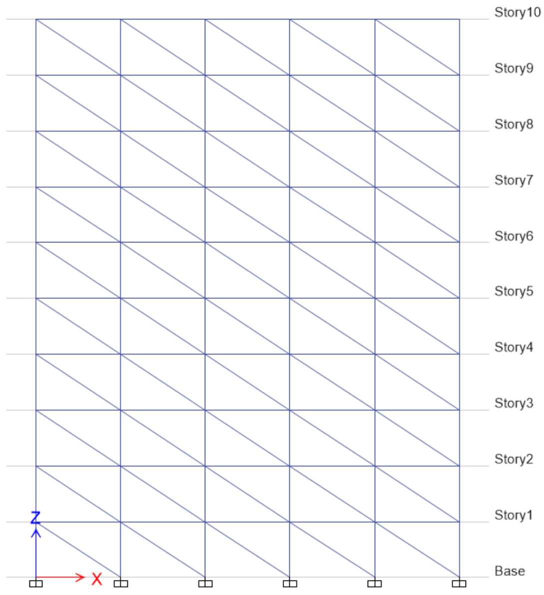
Table 1: Building Specifications

Size of building	25 m X 16 m
Grade of Concrete	M25
Grade of Steel	Fe415
Slab thickness	175mm
Wall thickness	230 mm
Size of beam	300 mm x 500 mm
Size of columns	300mm x 750 mm
Live load on floor	3kN/m^2
Floor Finish	0.75kN/m^2
Seismic zone	V
Steel Section	ISMB250

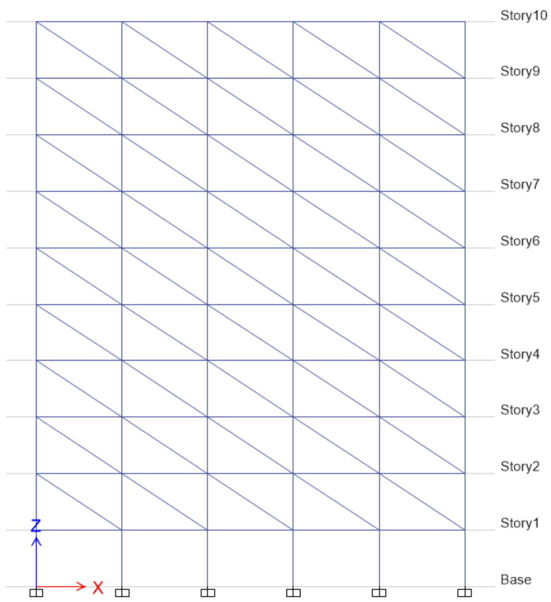
Building models such as bare frame, fully infill, Soft Storey with and without eccentric bracing models are prepared in ETAB Software package as shown in Fig.1



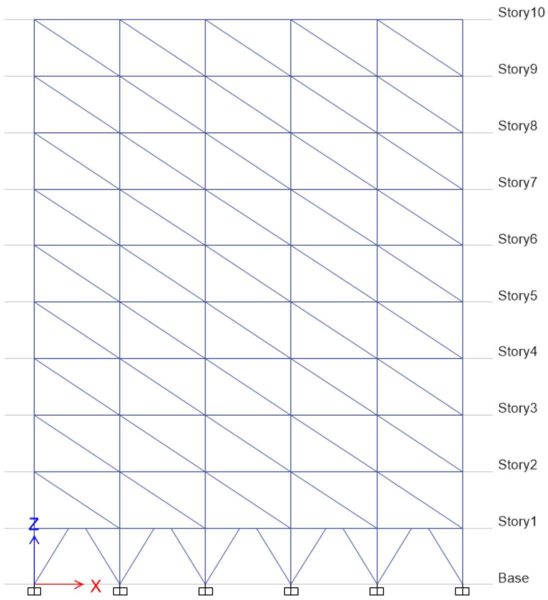
Bare frame



Infill frame



Open Ground Storey frame



Eccentrically braced frame

Fig.1 Building models

A. Modelling of Masonry Infill Walls

Brick masonry walls i.e non-structural elements are modelled using equivalent diagonal strut method given in IS1893:2016 to study various seismic parameters. In present study walls are modelled as panel elements without any opening. as per IS1893:2016 ends of diagonal struts shall be considered to be pin jointed to RC frame and for masonry Infill walls without any opening, width w_{ds} of equivalent diagonal struts is given as

$$w_{ds} = 0.175\alpha_h^{-0.4}L_{ds} \qquad \ldots\ldots\ldots\ldots(1)$$

Where

$$\alpha_h = h\left(\sqrt[4]{\frac{E_m t \sin 2\theta}{4E_f I_c h}}\right) \qquad \ldots\ldots\ldots\ldots(2)$$

Where E_m and E_f are the elasticity modulus of the materials of the masonry infill and reinforced concrete frame, I_c the moment of inertia of the adjoining column, t the thickness of the infill wall, and θ the angle made by diagonal strut with the horizontal

As per codal provisions the thickness of the equivalent diagonal strut shall be taken as thickness t of original masonry infill wall, provided h/t<12 and l/t<12, where h is clear height of masonry infill wall between the top beam and bottom floor slab , and l is clear length of infill wall between the vertical RC elements(column, walls or a combination thereof) between which it spans.

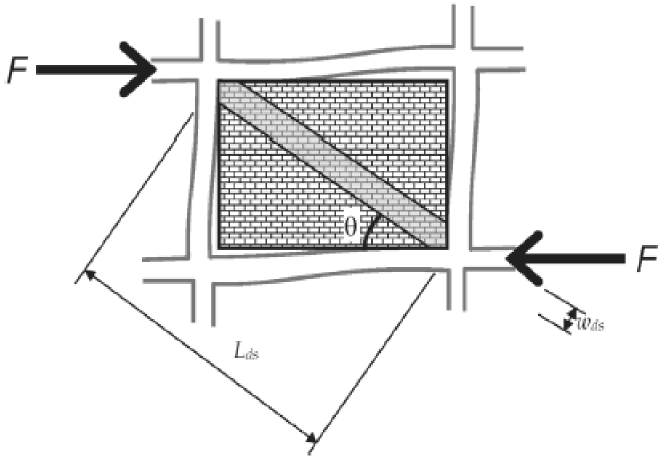


Fig.2 Equivalent diagonal strut of URM infill wall [14]

B. Time History Analysis

Time history analysis also known as nonlinear dynamic analysis, time history uses seismic data when structural behaviour is nonlinear in nature. To perform non-linear analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by-step analysis of the dynamic response of a structure to a specified loading that may vary with time. Seismic response of a structure under dynamic loading of representative earthquake is determined by using time history analysis. For analysis purpose Imperial valley(6.95), Northridge(6.69), Darfield(7.0) time histories with their Richter magnitude are selected.

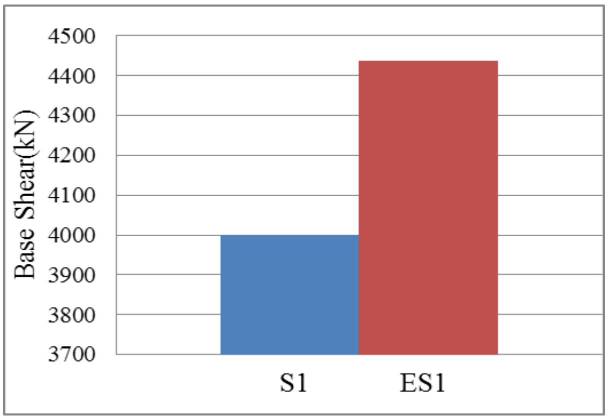
III. RESULTS AND DISCUSSIONS

In steel structures eccentric bracings are used since long time before. Eccentric bracing serves as lateral load resisting system to improve strength and stiffness of frame along with effectiveness energy dissipation in loads. In current study, eccentric bracings are used as a means to reduce soft storey effect in masonry infill reinforced concrete (RC) building. Masonry infill buildings with soft storey are usual choice for almost every general modern multi-storey construction practices in India, despite the building's vulnerability to strong ground motion earthquakes. Among other strengthening methods such as use of multiplication factor, use of extra columns, Bracing(X,V,K) eccentric bracings could be an advantageous scheme as it provides lateral stiffness and ductility to structure with greater economy and also provides free space for commuting of vehicle at soft storey level. Eccentric bracings in soft storey act as fuse during major earthquake events. The seismic performance of eccentric bracings for a seven storey building located in Indian seismic zone-V as per Indian standard code 1893-2002 are investigated using nonlinear dynamic analysis.

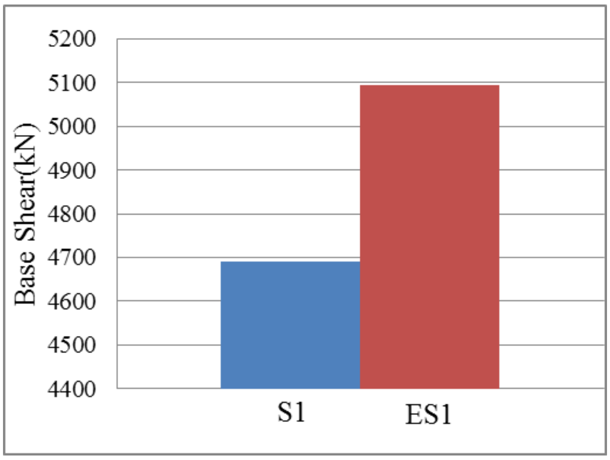
The results of analysis, reported in terms of storey shear, storey displacements, storey drift showed that buildings with eccentric bracings have lower drift demand.

A) Storey Shear

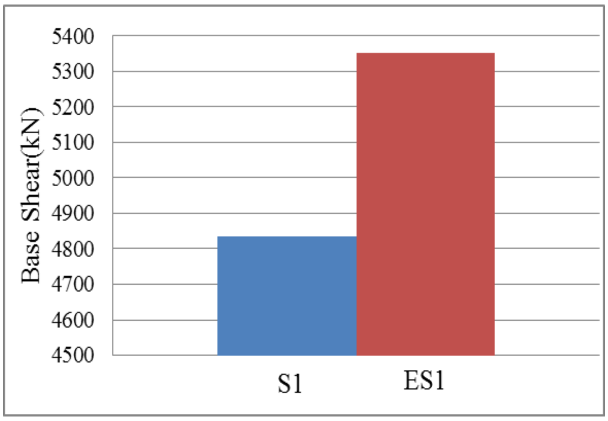
Base shear forces due to the applied lateral load in case of soft storey and eccentrically braced frame structure is presented in Fig.3 for considered building models under Imperial valley, Northridge, Darfield ground motion records applied in both x and y directions respectively. The plotted plot of base shear shows significant difference between the cases of considering frame with eccentric bracing at soft storey and Soft storey structure. It has also been noticed that with provision of eccentric bracing base shear get increased compared with open ground storey frame. This shows that inclusion of eccentric bracing increases stiffness at ground. In Fig.3 ES1 shows increase in base shear whereas S1 Shows base shear values for open ground storey frame. The percentage variation in increase of base shear is in between 6%-12%.



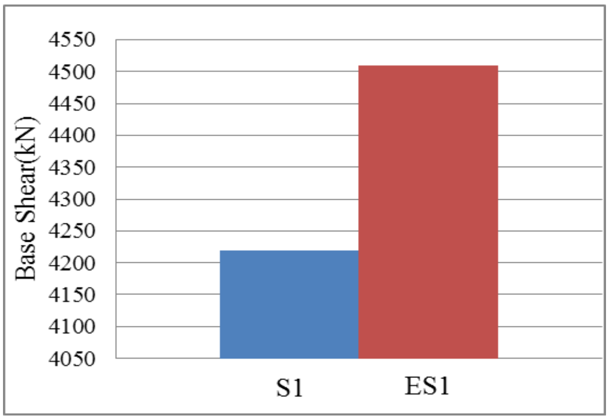
Imperial Valley(X-Direction)



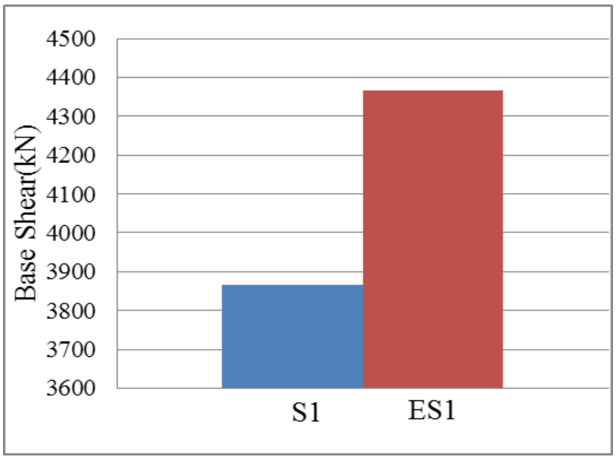
Northridge Earthquake(X-Direction)



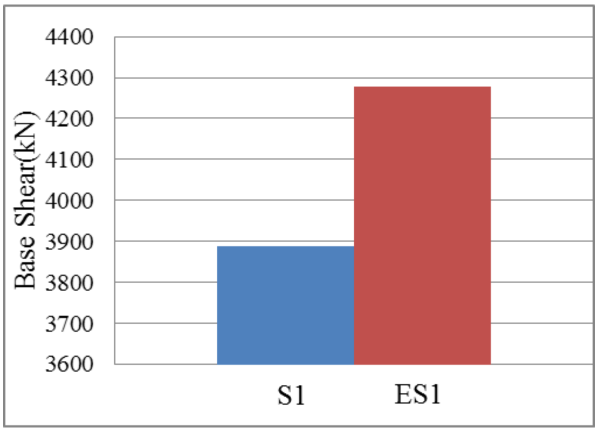
Darfield(X-Direction)



Imperial Valley(X-Direction)



Northridge Earthquake(X-Direction)

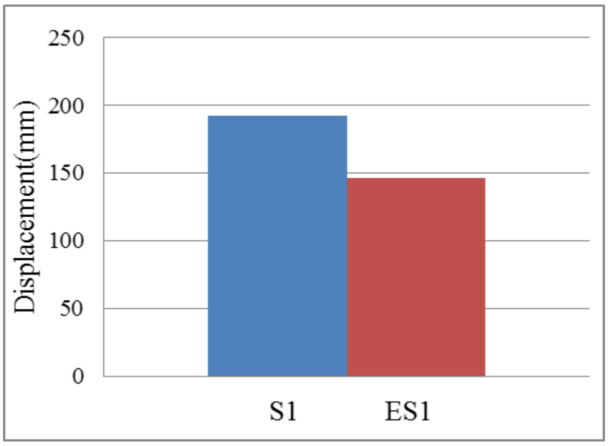


Darfield(Y-Direction)

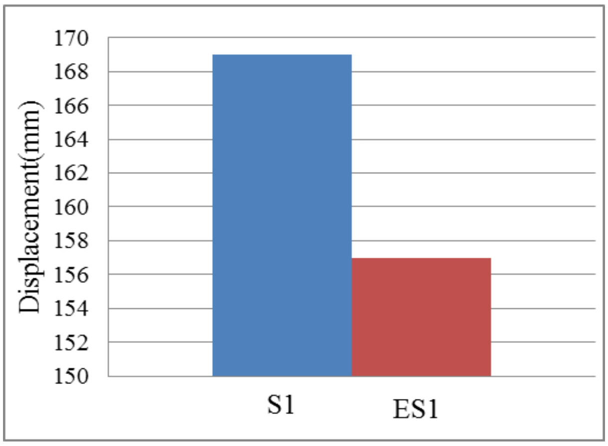
Fig.3 Base Shear

B) Storey Displacement

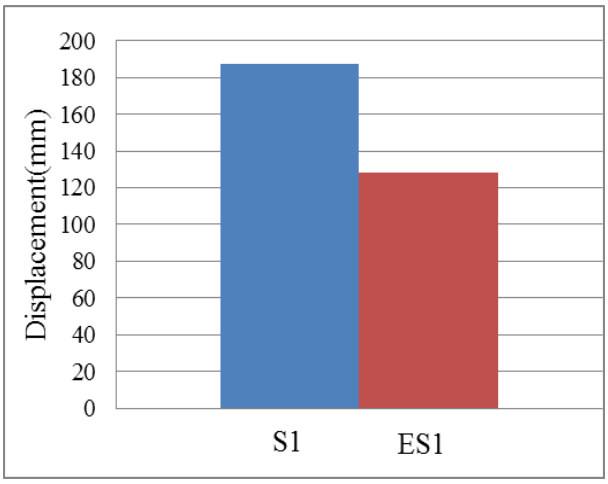
Peak displacement patterns of the 10-storey soft storey frame and eccentrically braced frame under three different time history earthquake records are presented in this section. The eccentrically braced frame model has reduced displacement in the range of 8%-31% compared with open ground storey this is due to increased stiffness at ground storey because of eccentric bracing. Eccentrically braced frame reduces increased displacement due to soft storey i.e. eccentric bracing is effective in reducing an increase in storey displacement which has occurred just after passing the soft storey level. Fig.4 shows displacement values of open ground storey frame S1 and eccentrically braced frame ES1 for three ground motions.



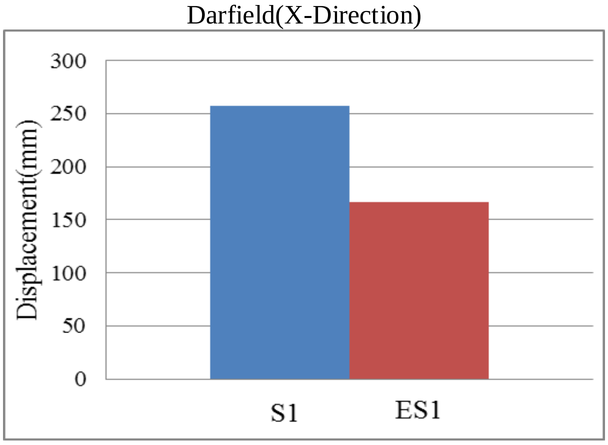
Imperial Valley(X-Direction)



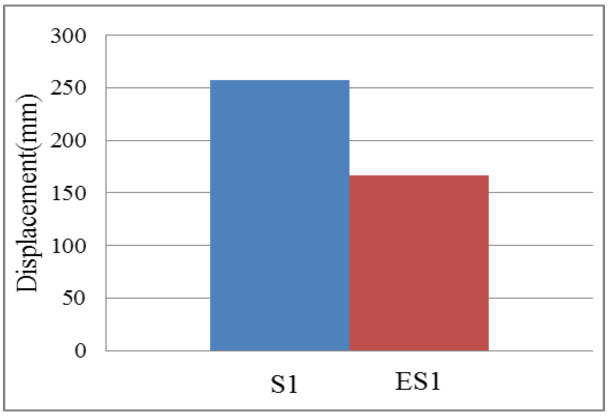
Northridge(X-direction)



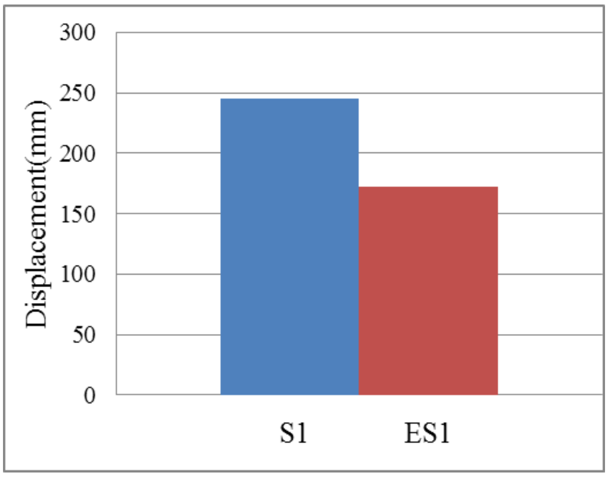
Darfield(X-Direction)



Imperial Valley(Y-Direction)



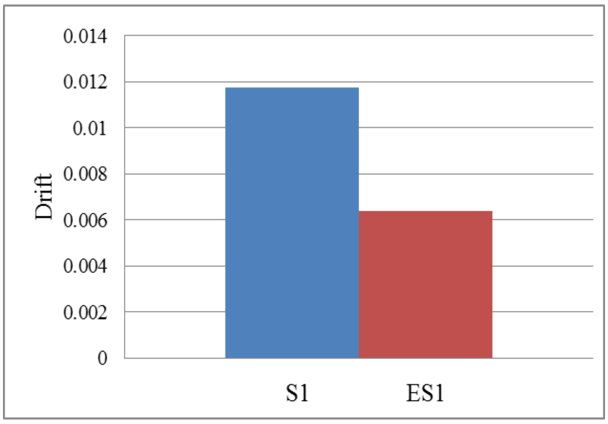
Northridge(Y-direction)



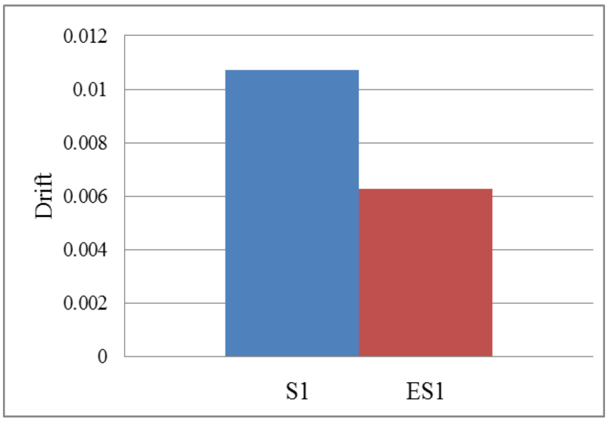
Darfield(y-Direction)
Fig.4

C) Storey Drift

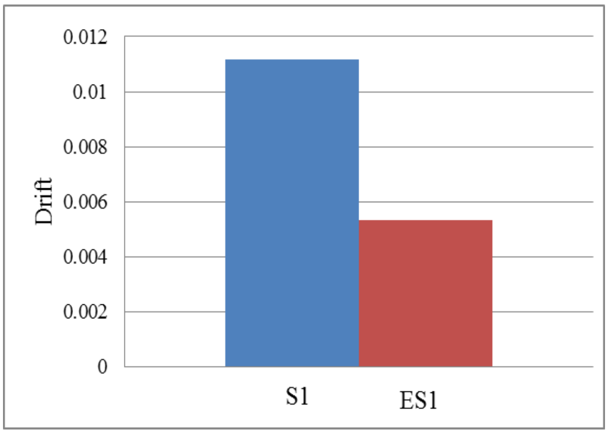
Inter-storey drift of open ground storey along with strengthened eccentric braced frame is shown in this section. Building frames strengthened with eccentric bracings show phenomenal decrease in storey drift. The maximum storey drift ratios of 10-storey structure for both the frame under Imperial valley, Northridge, Darfield ground motion records are shown in fig.5. These obtained results demonstrate the differences among the drift profiles of the building structure modelled as open ground storey frame and eccentrically braced frame.. It has also observed that presence of soft storey increases drift at that particular storey which drastically get reduced with provisions of eccentric bracing fulfilling maximum drift limit given in IS1893:2016 (storey drift in any storey shall not exceed .004 times the storey height). It can be seen from the figures, the captured values of the drift ratios at the specified soft storeys of the infill frame building models which was exceeding in case of soft storey get reduced with provision of eccentric bracing. the percentage reduction is in the range of 41%-67%.



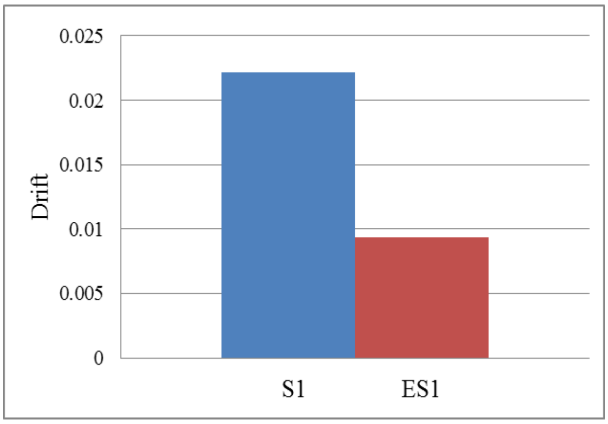
Imperial Valley(X-Direction)



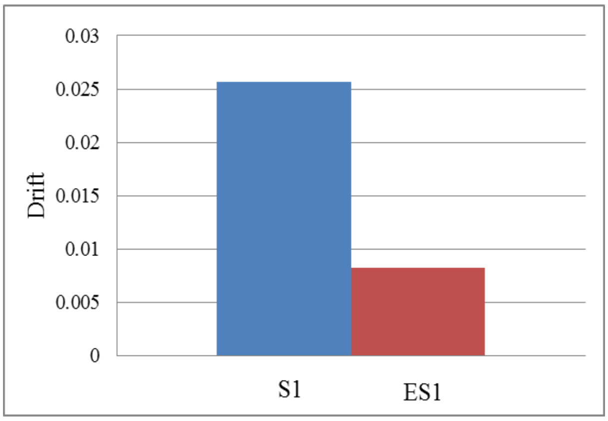
Northridge(X-Direction)



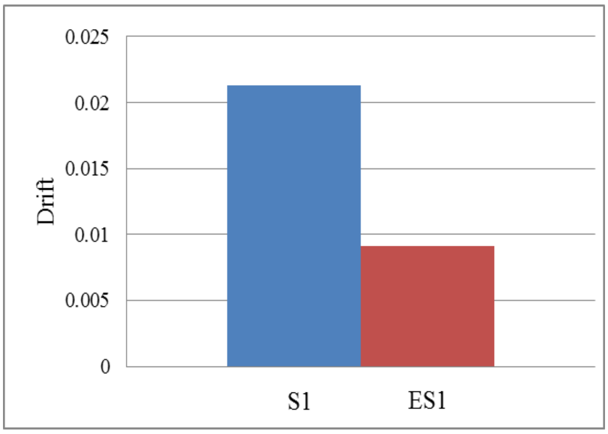
Darfield(X-Direction)



Imperial Valley(Y-Direction)



Northridge(Y-Direction)



Darfield(Y-Direction)

Fig.5

IV. CONCLUSIONS

The following results summarize the main findings of the eccentrically braced storey structural models

1. The results clearly show that large displacements occur at storey level in soft storey building get reduced with provision of eccentric bracing
2. A strengthening scheme which consists of steel eccentric bracings placed at particular storey which results in increased stiffness of that storey with reduced drift and displacement of a structure.
3. The results of dynamic analysis show that frames with eccentric bracings have lesser storey drift than that of soft storey frame satisfying drift limit given in IS1893:2016
4. It can be concluded that steel eccentric bracings could be an effective strengthening scheme for masonry infill reinforced concrete soft storey buildings as it keeps functional requirement of structure compared with other bracing systems.

V. REFERENCES

[1] Jaswant N. Arlekar, Sudhir K. Jain and C.V.R. Murty(2015), "Seismic Response of RC Frame Buildings with Soft First Storeys", *Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat*,pp.45-49.

[2] Sayed Mahmoud, Magdy Genidy, Hesham Tahoon(2016), "Time-History Analysis of Reinforced Concrete Frame Buildings with Soft Storeys", *science direct*, vol.3, pp.214-226.

[3] G. V. Mulgund, D. M. Patil, P. B. Murnal, A. B. Kulkarni(2010), "Seismic Assessment of Masonry Infill RC Framed Building with Soft Ground Floor", *International Conference on Sustainable Built Environment*, pp.169-175.

[4] Arshad K. Hashmi and Alok Madan(2008),"Damage forecast for masonry in-filled reinforced concrete framed buildings subjected to earthquakes in India", *science direct*, Vol. 94, No. 1,pp.61-73

[5] Haran Pragalath D.C, Avadhoot Bhosale, Robin Davis P and Pradip Sarkar(2016), "Multiplication factor for open ground story buildings – a reliability based evaluation". *Earthquake Engineering and Engineering Vibration*, Vol.15, No.2, pp. 283-295.

[6] Hemant B. Kaushik, Durgesh C. Rai, Sudhir K. Jain(2009), "Effectiveness of Some Strengthening Options for Masonry In-filled RC Frames with Open First Story". *Journal of Structural Engineering*, Vol. 135, No. 8,pp. 925-937.

[7] L. Teresa Guevara-Perez(2012), "Soft Story and Weak Story in Earthquake Resistant Design: A Multidisciplinary Approach"*15 WCEE.*

[8] Fadi oudah, Raafat el-hacha(2014), "Seismic evaluation of RC moment resisting frames with masonry infill walls'',*8th AMCM international conference,* wrocaw, Poland.

[9] Davis Robin, Menon Devdas, Meher Prasad, "Earthquake-Resistant Design Of Open Ground Storey RC Framed Buildings", Journal of Structural Engineering, Vol. 37, No. 2, pp 117-124, June-July 2010.

[10] Danish Khan, Aruna Rawat(2016), "Nonlinear Seismic Analysis of Masonry Infill RC Buildings with Eccentric Bracings at Soft Story Level". *World Multidisciplinary Civil Engineering-Architecture-Urban Planning Symposium*, pp. 9 – 17.

[11] Rozaina Ismail, Khalid Ismail , Izzul Syazwan Ishak(2018), "Retrofitting of soft storey building by using different bracing system due to earthquake load", *14th International Conference on Concrete Engineering and Technology*.

[12] Aniendhita Rizki Amalia and Data Iranata(2017), "Comparative study on diagonal equivalent methods of masonry infill panel", *Green Process, Material, and Energy: A Sustainable Solution for Climate Change*, pp. 030011-11.

[13] IS 456 (2000), "Indian Standard for Plain and Reinforced Concrete" Code of Practice, Bureau of Indian Standards, New Delhi. 2000.

[14] IS 1893 Part 1 (2016),"Indian Standard Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi.

[15] ETABS 2016, Integrated Finite Element Analysis and Design of Structures Basic Analysis Reference Manual, Computers and Structures Inc. Berkeley.

[16] Snehash Patel, *Earthquake resistant design of low-rise open ground storey framed building*, Department of civil engineering, National institute of technology, Rourkela, May 2012.

[17] ETABS 2016, "Integrated Finite Elements Analysis and Design of Structures analysis Manual", Computers and Structures, Inc. (CSI), Berkeley, California, USA.