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Review on "Effect of Various Concentric Bracing in Building"

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Abstract: The most principal and productive factor in providing strength to a structure against gradual collapse is the kind of lateral load carriage system of the structure. In recent years earthquakes have made a great impact on structures specially high-rise buildings. In this review response of structures in different seismic zones done by various researchers is shown. They have compared the structures based on factors like storey displacement, base shear, storey stiffness, time factor and lateral load bearing methods effective for the structures. Different analysis have been done on practical models, stimulation analysis and software based structural analysis. Based on their studies various bracing methods for a structure to bear lateral load in multi-storey buildings have been proposed. This review is also concerned about the methodology to be used in order to get the better result of structures in terms of seismic analysis. In most of the cases X- bracing had a significant role in providing lateral strength to the structure.

Keywords: Structure, Base shear, Stadpro, Etab, Bracing, Displacement, Seismic, Earthquake.

INTRODUCTION:

The population is growing at a rapid pace, and land is becoming increasingly scarce, thus multi-story building is the only viable option.[16] A reinforced concrete structure should be built to carry combined loads (dead, live, and seismic) at a certain level of safety. [1] Because of their increased ductility and energy absorption capability, high-rise steel buildings sustain less damage during big earthquakes than concrete structures. Bracings, which resist lateral loads, are an important component of these building systems.[4]As a result, it is critical to provide enough structural solidity and soundness with the purpose of determining imperviousness to horizontal loads induced by wind or seismic forces in tall structures. Steel bracing in the R/C structures are one simple option. The combination of a reinforced concrete frame and steel bracing improves the structure's behaviour and performance while also increasing its stiffness and strength.[20]

To produce desirable seismic responses of buildings with concentric steel bracing, numerous research studies have been conducted. This paper is an overview of a number of literary works. To summarize the solutions on the complexity of buildings with steel bracing, the methodology and structural reaction are reviewed.

LITERATURE REVIEW

Hendramawat S, et.al. 2013 [1], purposes to check whether if the addition of steel bracing could improve the seismic performance of an existing reinforced concrete building (the UNS Engineering Faculty's 5th Building. The model has been analyzed using Etabs, dead load, live load, and earthquake load has taken into consideration. The study uses three seismic evaluation methods: Nonlinear Static Pushover Displacement Coefficient Method, Improvement of Nonlinear Static Pushover Displacement Coefficient Method, and dynamic time history analysis as described in SNI 03-1726-2002, FEMA 356, and FEMA 440.As per the result If steel bracings are used for seismic retrofitting, the performance of the existing building could be improved. The proposed steel bracings reduce target displacements in both directions by 16 % to 55 %. Meanwhile, the seismic performance of retrofitted buildings is unchanged by the size ofsteel bracing elements.

Can-Xing Qiu, et. al. 2016 [2] have done Pushover and incremental dynamic analyses to evaluate seismic-resistant, multi-story steel frames with self-centering braces .Comparison has been made with BRBFs. SDOF analysis, pushover analysis, and IDA are used to compare three parameterized SC-BFs and one BRBF. The model has been generated by replacing the BRBs in the six story building with various types of SCBs. The software OpenSees was used to model. A set of 20 ground motions is scaled to different seismic intensity levels so that the change from elastic to inelastic behaviour may be observed. It conclude that SC-BFs with improved post-yield stiffness and energy dissipation capability have more consistent inter-story drift ratios and less seismic performance variability .

K.M. Ward, et. al. 2012 [3] introduces A Cast Modular Ductile Bracing System (CMDB) , it includes CM bracing system at the ends & centre of the braces that provides reliable strength, stiffness, and deformation capacity. Using nonlinear static and transient dynamic analysis, a comparative study was conducted with normal SCBF. The software ANSYS has been used for analysis. Analytical study was used to develop a Cast Modular Ductile Bracing system. The Cast Modular Ductile Bracing System can be used alternative to SCBFs. To characterise the CMDB design flexural and axial over strength factor has been considered. The findings are being used to develop a physical prototype for testing in the lab.

M. Suneel et. al. 2019 [4] have done the pushover analysis on 6,9,12 and 15 storey special concentric X- braced frame subjected to lateral load to check the ductility and seismic performance of the structure . Sap2000 is used for modelling and analysis of the structure and has been designed according to Indian Standard Code IS: 800 and IS:

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1893(2016). The result shoes that in terms of strength and ductility, column DCRs of 0.4 & 0.5 are said to be more convenient than bracing DCRs of 0.8 & 0.9. Frames planned for 60% of total base shear below the highest considered earthquake is also set under acceptablelimits.

Temel T et al. 2011 [5] have conducted experimental and numerical analyses of brace designs on steel buildings. A three-story steel building model, built in the Civil Engineering Department of Karadeniz Technical University's laboratory at 1/2 scale of a real building, was chosen for investigation. A comparative study has been made between bare frame and braced cases , The model was braced with four different sorts of braces: cross type, Inverted V type, V type, and K type. The study found that brace components can significantly increase the stiffness of steel structures, and that the effects of bracing varies based on brace geometry.

Hongjia L et al. 2018 [6] studied that for pre-existing frame structures that are already constructed to carry gravity loads, the theoretically best arrangements of bracing elements are sought. There are three type of bracing used : Tension only bracing, bracing crossing only at the corners of the existing frame, and unrestricted ideal bracing, where bracing components can intersect at any place. Initial design solutions are identified using layout optimization techniques. The Result shows that tension-only bracing is inefficient, and the best angle of intersection is 45 degrees, which might be used as a guideline when building bracing for an existing frame.

Andrea P et al. 2018 [7] has studied the seismic analysis of seven story heavily loaded timber building superstructures moderated by CLT(Cross-Laminated-Timber) shear-walls. Strand7 Finite Element Software (2010) was used to build models. The investigation is based on numerical linear dynamic simulation and demonstrates the effects of construction differences on SFRS reactions during earthquakes. The models show that throughout design level seismic events, mid-rise buildings are vulnerable to lateral flexibility effects and transfer large uplift loads towards the foundation

Effects of eccentric steel bracing systems on seismic fragility curves of mid-rise R/C buildings: Acase study[8]

In this paper, A mid-rise R/C building of 6 floors is taken as a sample and retrofitted with eccentric steel braces and investigated through fragility analysis. The design of the mid-rise building was based on Turkish Seismic Code version of 1975. The seismic performance of the retrofitted structure was investigated by distributing the steel bracing over the height of the R/C frame. Eccentric bracings of D, K and V type were used to reinforce the original structure and each type bracing system was applied with four different spatial distribution in the structure. The study used a collection of 200 generated seismic acceleration recordings that were consistent with the elastic code design spectrum for fragility analysis. While monitoring four performance limit states namely minor, moderate, significant, and collapse, non- linear time history analysis was performed to examine the structure subjected to this set of seismic acceleration in terms of peak ground acceleration (PGA) . lognormal distribution assumption, were derived for all limit states in terms of PGA. Comparing the median values of the fragility curves of the existing building before and after retrofits, the improvement in seismic dependability achieved by the utilization of D, K, and V type eccentric bracing was evaluated. Results showed that V type braced frames gave the best seismic performance.

Seismic demand on columns in special concentrically braced frames[9]

In this study, the seismic command on the column in particular CBFs is presented to mark two problems

1) Whether columns will stay elastic during and earthquake.
2) the feasibility of adopting the first mode deformation,

as predicted by the existing design code, as the only deformation pattern for creating braced frames is investigated. Three nine-story buildings were subjected to a set of twenty ground motions employing two- story X-bracing and chevron bracing arrangements. To investigate the effect of beam strength on framed structure two unlike braced-intersecting girders was applied on two-storey X-bracing . According to the study, columns in two-story X-braced frames built according to current design code experience yielding in the course of an earthquake, and the first mode deformation is not safe to use as the only conceivable deformation pattern for creating the braced frames. Researchers observed that, the seismic command on braces in the two-story X-BFs is also rather remarkable, and are vulnerable to fracture.

Response of a multi-storey steel composite building with concentric bracing under consecutive column removal scenarios[10]

In this article, The author's 3-D finite element modeling technique was utilised to investigate the gradual collapse of 20 story buildings made with composite steel frames. The nonlinear dynamic analysis approach was used to investigate the building's behaviour in the event of successive column removal scenarios. The building's response was thoroughly examined through ABAQUS, and strategies to prevent progressive collapse in the future designs were also suggested. The model's lateral stability to the buildingwas provided using concentric bracing.

Experimental investigation of behavior of steel frames with y-shapedconcentric bracing[11]

A study program has been established to investigate and improve the behavior of y-braced frames using gusset plate. At the BHRC1 structural engineering laboratory, tests were carried out. Four full-scale frames with y-bracings of various geometries and cross sections are included in the paper. The specimens were subjected to increasing Quasi-static cyclic loads until they yielded and failed. The findings reveal that by properly specifying cross sections and connections, out-of-plane bending with single curvature in bracing can be substituted by in-plane, double curvature buckling. For out of plane bending of bracing

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members, these sections have a higher gyration radius. Due to elasticity flexural deformation of brace members, y-bracing stress - strain energy dissipation and damping are increased. The ability of y-braced frames with new revelations to dissipate energy is comparable to that of classic X bracing. Two- different y-braced frames were designed to handle the same lateral forces as X-braced frames based on these findings. Using nonlinear static techniques, the seismic behavior of these frames was assessed and found similar.

Seismic design of columns in two-story steel concentrically braced frames with bracing members intersecting columns between floors[12]

In this article, For the columns in two-story steel concentrically braced frames with braces crossing columns between the floors, a new seismic design approach is proposed. The suggested method attempts to minimize excess inelastic deformation in braces crossing columns between the floors, which could otherwise lead to brace fracture, by taking into account the interaction between the stories. The proposed design process was first given in the context of North American steel design standards, then illustrated with a design example which is subsequently validated by dynamic analyses and analyses the seismic behavior of the frame developed with and without the method in mind. When the placement of the weakest braced panel is modified, bigger braces are employed, and column orientation is changed, the adequacy of the suggested approach is evaluated using further dynamic studies. The results show that the suggested method can accurately forecast column design forces, prevent column instability, and improve the seismic response of the braced frame by taking into account the interactions between inelastic brace responses in neighboring stories.

A Formisano et al. 2020 [13] studied to use external steel concentric brace systems to improve seismic performance of the Italian building stock, which was primarily constructed between the 1970s and 1980s,
. the seismic performance was analysed using N2 method in form of the Capacity Spectrum Method applied to three models designed , which are bare frame, full infilled frame, and pilotis frame.These models have been retrofitted using external bracing system by rational methodology . The result shows the beneficial effect of X-bracing systems has been determined to be more significant for the BF structure, which has higher safety factor increases than other structures.
Sumit G et al. 2021 [14] carried out an equivalent static analysis of G+7 RCC frame building using STAAD.PRO software. For the analysis of seismic load and earthquake load equivalent static method and dynamics analysis method has been used. The model has been designed according to Indian Standard code IS 1893(Part1):2016 in seismic zone III. From the study it has been observed that software based dynamic loading calculation gives accurate output than manually.

Ali K et al. 2018 [15] presents a strategy for enhancing concentric brace post buckling behaviour. In the centre of bracing a side mounted fuse is placed. To explore the behaviour of LF-AECB concentric braces and compare its reaction to that of ordinary concentric braces, two sets of experimental and numerical investigations were undertaken. To study the model ABACUS 6.12 software has been used . This research shows that this structural system beats typical concentric braces in respect to ductility and energydissipation capacity.

Rahul M et al. 2020 [16] has designed seven number of models with different bracing pattern in G+19 storey steel braced building. For that STAAD Pro software has been used and design parameters has been taken as per Indian standards IS 8000: 2007 and IS 1893(part1):2016. The comparative analysis has been done between these models and it has been observed that bracing can impact significantly under seismic conditions also Backward bracing design comes out to be most desirable and can reduced up to 50% of horizontal displacement at top as compared with other bracing pattern.

Seismic performance assessment of Eurocode 8-compliant concentric braced frame buildings using FEMA P-58, Giuseppe Marcantonio Del Gobbo, Martin S. Williams, Anthony Blakeborough[17]

Destruction has been seen due to earthquake in recent years resulted in costly repair and extended building downtime .As a result we need more stable structure, in this paper Eurocode 8 has been takenen in consideration but it needs better result . The aim of the project is to achieve great performance in terms of seismic analysis. To repair cost FEMA P-58 procedure can be used. Results indicated that due to high repair cost modern designed structure can be demolished during a ULS earthquake. Inspite of satisfying Eurocode drift limit structure experiences both drift and acceleration sensitive non-structural damage. So the author got the result as modern building models do not give accurate earthquakeresilience.

Seismic Analysis of RCC Multi-Storey Building with Effect of Bracing Resting on Sloped Ground[18]

In this paper, analysis is done on a multistory building building build on hilly areas that come under seismic zone cause they are highly vulnerable to earthquakes. The response spectrum approach is used to do dynamic analysis on the step-back and step-back-set back construction frames. The dynamic response has been investigated in terms of fundamental storey displacement, time period, and base shear. Results showed that step back-set back frames outperform step-back building frames in terms of performance. However, when cross bracing (X) is applied to the outside periphery of all designs at the corner ends, the performance of all models improves when compared to the building without bracing. These analysis werecarried out on E-tabs2018 Software.

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Effect of Bracing Pattern on the Most Structurally Stable Rectangular Shape of Building[19]
In this article, the effect of wind load on R.C.C. tall buildings of Rectangular shape as per IS: 875-1987 (part- 3) norms of practise is investigated, as well as the effect of bracing pattern on Rectangular shape buildings. According to IS 875(Part3):1987 standards, wind load analysis using force coefficient method is utilised to analyse a 40-story RCC high rise building. STAAD.ProV8i software was used to create a 3D model of the structure. The geometrical design of a high-rise building is an important factor that influences the structure's wind response. STAAD.ProV8i was used to simulate Rectangular form geometrical configurations with 40 storeys and a total height of 120m constructed with RCC & bracing pattern. According to IS: 875, all designs are loaded with a dead load, a live load, and a wind load (part I to III). Three types X, V, and inverted V bracing patterns were used and each patterns were compared along with the building model without braces. It was concluded that X and V type bracing made the structure most stable and OMRF regular building and inverted V models were the least stable.

EFFECT OF BRACING AND UNBRACING IN STEEL STUCTURES BY USING ETABS[20]
In this study, the steel frame is modelled using E-TABS software, and the results are compared for several bracing systems (X, Diagonal, V) on the basis of the tables and graphs obtained for lateral displacement, base shear, time period, storey displacement, and story drift. In comparison to frames with diagonal or V- bracing, it was discovered that a steel frame with X-bracing is the most ideal configuration, since it showsmaximum stiffness and lower drift.

Birendra B et al. 2021 [21] has done Response spectrum analysis in total no of 24 models where 12 models is unbraced frames and remaining 12 models is steel braced RC frame of 4,8,12 and 16 stories The seismic parameters of the structures have been researched, including the fundamental time period (FTP), inter-story drift, base shear, top storey displacements and storey stiffness. The result reveals that when the base shear contribute in the columns grows, the story's drift and displacement increase, while base shear decreases.

Shital B et al. 2021 [22] investigated the seismic behaviour of various slab structures, such as flat slab structures, conventional slab structures, and flat slab structures with drops, in various earthquake zones. These structures are multi-story structures. We used a G+5 storey building for our investigation. ETAB software was used for the analysis. We also compared the behaviour of flat bit of material construction to the old common 2 way bit of material system for various bands, parts, and zones, such as band, part zone-II,III,IV, and V ,in terms of largest point making bent moment.

Inactivation of Escherichia Coli in Water Using UV Light in continuous Flow Reactor[23] Biological contamination is one of the most common and serious forms of water pollution. In this study, an attempt was made to disinfect water in a continuous flow reactor using UV radiation. Before and after disinfection, physico-chemical parameters such as salinity, pH, temp, total hardness, and bacteriological factor E.coli were investigated, all of which were within permissible limits according to IS:10500 (2012)standards. Bacteria were subjected to 240nm - 280nm uv radiation while the water flowed
through continuous flow reactor, which damages genetic molecules. First, the water was disinfected using an uncovered experimental set-up with a pair of 6 watt UV lights for microbial inactivation (E. coli), then it was modified by covering it with reflecting mirrors, then the same was altered by increasing the length & decreasing the height of the set-up, and finally it was modified by increasing the ion concentration.
This study demonstrated that UV disinfection by UV light could be used to disinfect water.

Review on "Effect of Floating Columns on Building subjected to seismic Forces"[24]
This review summarises the findings of several studies conducted by researchers. The results are compared using various parameters such as bending moment, displacement storey shear, time period, and so on. The authors modelled a variety of structures, including a standard building, a structure with floating columns, and a building with diverse solutions, and compared the results. This study also looks at the methods that should be used to improve the seismic response of buildings using floating columns. From the study it was observed that structure designing softwares were the most effective method for performing difficult analysis on structures. The review also gives solutions in order to improve seismic response in floating columns.

METHODOLOGY
From the above study it has been observed that various methodologies has been used to check the effect of steel bracing when it comes under seismic conditions. Various researchers have designed the model for the testing purpose and has taken symmetrical and non-symmetrical shaped frame where in some cases steel bracing has been applied to the pre-existing structure which are designed for gravity load conditions only ,retrofitting has been done on that structure to provide additional stiffness and strength to the structure for resisting lateral loads caused by earthquake and wind[1][6]. There is a wide range of structural softwares which has been used in different study for analysis purpose such as Staad.Pro , Etabs, ABACUS, SAP etc. These software design the structure as per the required loading condition and design codes (IS code, Euro code,AISC etc.) [1]-[24]

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According to several studies, there are a variety of strategies to model the structure in order to overcomepoor bracing response, including:

1. Self-centring bracing [2]
2. Cast modular bracing system [3][9]
3. Special concentric steel braced frames [4]
4. CLT core braced frame and perimeter shear- wall [7]
5. Eccentric steel bracing [8]
6. Y-shaped [11]
7. Bracing members intersecting columns between floors [12]
8. Side-mounted fuse [15]

Temel T. [5] has designed a three storey steel frame having 2-bay by 2-bay symmetrical design where the model is scaled ½ of the real structure having a dimension of 2.5m*2.8m*4.5m , in this structure four type of concentric bracing has been used. The experimental investigation has been compared with numerical dynamic analysis. Where as Feng Fu. [10] in is paper has discussed about the concentric bracings that he applied on a 20 storey building. He prepared a 3-D model of the structure in the ABACUS software. The lateral stability to the building was provided using X-bracings. The structure was then analysed under sudden loss of columns. The vertical displace and moment of the building were observed using graphs. A. Formisano. [13] in his paper has provided external steel bracing to an existing structure which has been erected earlier, the design has been taken into consideration according to the code and has been analysed in CSI SAP 2000.

CONCLUSION

From the Survey, it was observed that different authors have used different analysis methods on different types of structures. Some authors have done practical analysis by making 3-D models, some have applied bracings on already built structures and some have performed analysis on different software's like, ABACUS, Staad Pro Vi8, ETABs etc and applied steel bracings on the structures. Analysis with the help of software are most convenient and gives accurate result .

From the above review most of the researchers had done numerical study, experimental study ,static analysis, dynamic analysis, nonlinear static analysis and in some paper pushover analysis has been done and it has been observed with the factors such as bending moment, shear force, time period, storey stiffness, storey shear, storey displacement, base shear, seismic response along with others factors .While taking these factors into consideration it has been found that the conventional steel bracing perform well under seismic conditions but have some flaws in it. Where SCBFs, CLT core frames gives satisfactory output , with the help of some modification like installing side-mounted fuse in bracing can be helpful.
Whereas among all the conventional concentric steel bracing x-braced frame perform better than all other type of bracing, also in some cases V-type bracing can give sufficient result under some particular seismic conditions.

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