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A Review on Seismic Evaluation of RC Building with Different Arrangement of Steel Bracing

Sarang H. Kshirsagar[1], Abhijeet A. Galatage[2]

[1]P.G Student, Department of civil Engineering, Flora Institute of Technology, Pune, Maharashtra
Assistant Professor,Department of civil Engineering,Flora Institute of Technology, Pune, Maharashtra

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Abstract –In General, the structure in high seismic areas may be susceptible to the severe damage. Along with gravity load structurehas to withstand to lateral load which can develop high stresses. Now a day, steel bracings in R.C. structure are most popular system to resist lateral load due to earthquake, wind, blast etc. The use of bracing will be the viable solutionfor enhancing earthquake resistance. So there is a need of precise and exact modeling and analysis using software to interpretrelation between brace frame parameters and structural behavior with respect to conventional lateral load resisting frame.There are various softwares used for analysis of different type of lateral load resisting system such as, E-TABS, SAP2000,STADPRO, etc. In this paper, a few of the past research work has been discussed for modeling and analysis of brace frameRC structure and conventional lateral load resisting frame structures, co-relation of efficiency and various parameters arecompared. It is found from the analysis in software, The type of bracing, location of bracing, bracing stiffness and bracingmaterial, etc. have significant effects to the lateral capacity of the structure. In this paper comparative study of RC braceframe structure with conventional lateral load resisting frame has been carried out with different type of bracing, variousparameters of bracing and property of bracing by different researchers discussed.

Key Words:Bracing, Response spectrum analysis, Lateral Displacement, Story Drift, Story Shear.

1. INTRODUCTION

The primary purpose of all kinds of structuralsystems used in the building type of structures is totransfer gravity loads effectively. The most commonloads resulting from the effect of gravity are deadload, live load and snow load. Besides these verticalloads, buildings are also subjected to lateral loadscaused by wind, blasting or earthquake. Lateral loadscan develop high stresses, produce sway movementor cause vibration. Therefore, it is very important forthe structure to have sufficient strength againstvertical loads together with adequate stiffness toresist lateral forces.There are two types of bracingsystems, ConcentricBracing System and Eccentric Bracing System . Thebraces are usually placed in vertically aligned spans.This system allows obtaining a great increase ofstiffness with a minimal added weight, and so it isvery effective for existing structure for which thepoor lateral stiffness is the mainproblem. Theconcentric bracings increase the lateral stiffness ofthe frame, thus increasing the natural frequency andalso usually decreasing the lateral drift. However,increase in the stiffness may attract a larger inertiaforce due toearthquake. Further, while the bracingsdecrease the bending moments and shear forces incolumns, they increase the axial compression in thecolumns to which they are connected. Sincereinforced concrete columns are strong incompression, it may not pose a problem to retrofit inRC frame using concentric bracings.

2. STEEL BRACING

Steel bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure. Different types of bracings used are diagonal, V type, inverted V type, K type, X type.

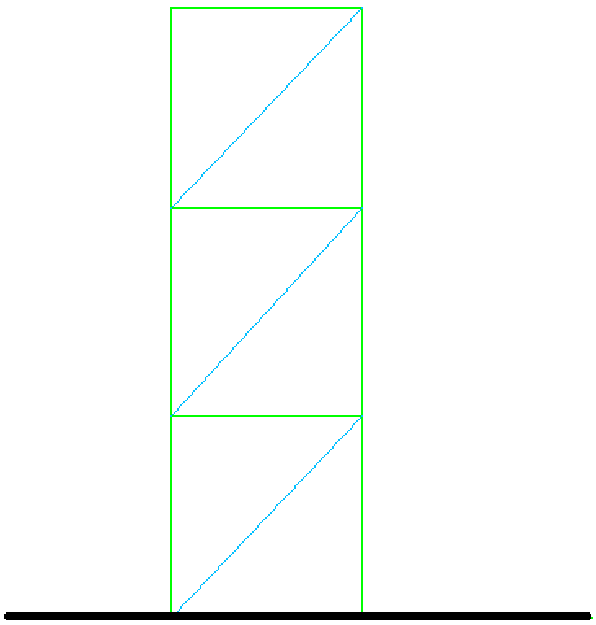

Fig.1 : Single diagonals

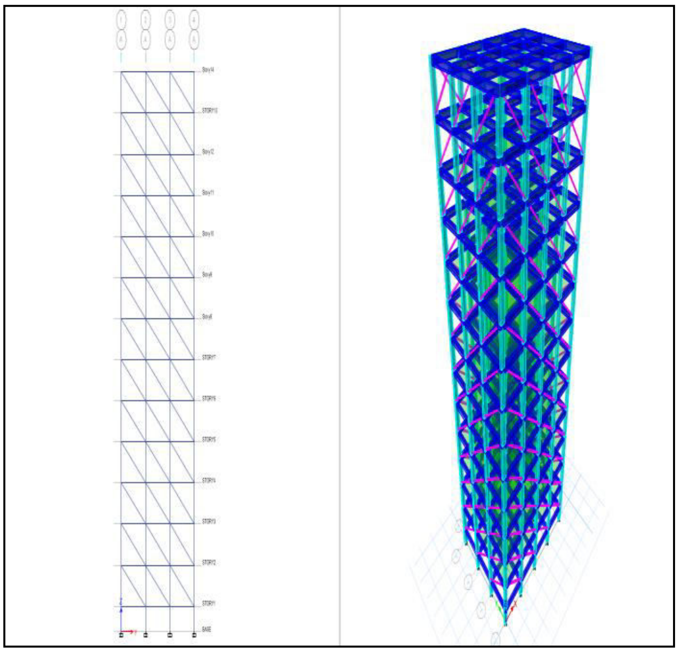

Fig-3: Elevation and 3D view of RC frame structure with diagonal bracing

3. LITERATURE REVIEW

Various research effort devoted over seismic behavior of various types of braced and non-braced frames.Following review of literature give brief summary of bracing system in RC buildings and another important things that the performance and behaviour of this system against the lateral loads.

Viswanath and Prakash reported steel bracedframe as one of the structure reinforced concretebuilding which need retrofit to overcomedeficiencies to resist seismic loads.. In the study the seismic performance of reinforced concrete (RC) building rehabilitated using concentric steel bracing was investigated. The bracing was provided for peripheral columns. A four-storey building was analyzed for seismic zone IV as per IS 1893; 2002 using STAAD Pro software. The effect of the rehabilitated building was studied. The study was extended to eight storied, twelve storied building. The percentage reduction in lateral displacement was found out. It stiffness and reduces the maximum interstory drift of the frames.

Baikerikar and kanagali studied seismic analysis of reinforced concrete frame with steel bracings, model used was square grid of 20m in each direction of 5m bay in each direction, software used was ETABS 9.7.0, and has compared the results of bare frame and braced frame and found the result that braced frame significantly lower the lateral displacements and drifts compared to bare frame and thus resisting earthquake forces efficiently. The study had been carried out for the Zone V and soft soil as specified in IS 1893-2002.

Parasiya and Nimodiyadescribed the structure in high seismic areas that may be susceptible to the severe damage. In this paper comparative study of RC brace frame structure with conventional lateral load resisting frame has been carried out with different type of bracing, various parameters of bracing and property of bracing by different researchers discussed.

Adithya andSwathiraniinvestigated the efficiency of using different types of bracings and with different steel profiles for bracing members for multi-storey steel frames. A three dimensional structure was taken with 4 horizontal bays of width 4 meters, and 20 stories was taken with storey height of 3m. The beams and columns are designed to withstand dead and live load only. Wind load and Earthquake loads were takenby bracings. The bracings are provided only on the peripheral columns. Maximum of 4 bracings are used in a storey for economic purposes. In this study, an attempt has been made to study the effects of various types of bracing systems, its position in the building and cost of the bracing system with respect to minimum drift index and inter storey drift.

Gowardhan andDhawaleinvestigated a few of the past research work for modeling and seismic analysis of high rise steel frame building without bracing & same building with different types of bracings, co-relation of efficiency and various parameters were compared. It was found from the analysis in software, The type of bracing, location of bracing, bracing stiffness and bracing material, etc. have significant effects to the lateral load resisting capacity of the structure. In this paper comparative study of high rise steel frame building without bracings & same building with different types of bracings like Diagonal, X, K & inverted V and performance of each frame has been carried out, various parameters of bracing and property of bracing by different researchers discussed.

Bhosale and Shaikhreported the seismic analysis of reinforced concrete (RC) buildings with different types of bracing (Diagonal, V type, Inverted V type, Combine V type, K type, X type). The bracing was provided for peripheral columns and any two parallel sides of building model. A thirteen-storey building was analyzed for seismic zone III as per IS 1893: 2002 using ETAB software. The percentage reduction in storey displacement was found out. It was found that the X type of concrete bracing significantly contributes to the structural stiffness and reduces the maximum storey drift of the frames. The bracing system improves not only the stiffness and strength capacity but also the displacement capacity of the structure.

Takey and Vidhaledescribed the analysis of high-rise steel building frame with different bracing section. Equivalent static analysis was carried out for steel moment resisting building frame having (G+9) storey situated in zone III. Modelling was done by using Response spectrum method. The steel moment resisting building frame was analyze by with and without steel bracing system. The analysis of steel bracing and the building were carried out using Software. The main parameters considered in this study to compare the seismic performance of buildings are bending moment, shear force, story drift and axial force. The models were analyze by equivalent static analysis as per IS 1893:2002.

Kevadkar and Kodag investigated that the structure in high seismic areas may be susceptible to the severe damage. In this study R.C.C. building was modeled and analyzed in three Parts, Model with Different bracing and shear wall, Model with different shear wall system, Model with Different bracing system The computer aided analysis was done by using ETABS to find out the effective lateral load system during earthquake in high seismic areas. The performance of the building is evaluated in terms of Lateral Displacement, Storey Shear and Storey Drifts, Base shear and Demand Capacity (Performance point). It was found that the X Type of steel bracing system significantly contributes to the structural stiffness and reduces the maximum inter story drift, lateral displacement and demand capacity (Performance Point) of R.C.C building than the shear wall system

Paul and Agarwal reported that an experimentally obtained pushover curves of a size RC frame models with and without infill wall and steel bracing have been used to calibrate the non-linear analytical model of the frame. The pushover testing has been carried out on three non-ductile frame models namely bare frame (BF), infilled frame (INF) and a steel braced (SBF) frame under quasi-static condition. The non-linear analytical model was further extending for the seismic evaluation and retrofitting of a 4-storied 2D frame using infill wall and analyzed and designed using different versions of IS: 456 and IS: 1893. Re-evaluation of these frames has been carried out to with masonry infill and steel bracing as retrofitting scheme using pushover analysis. The different pushover parameters of the frames of the frames before and after retrofitting have been compared.

Ozel and Guneyisi investigated the seismic reliability of a mid-rise reinforced concrete (RC) building retrofitted using eccentric steel braces was investigated through fragility analysis. As a case study, a six storey mid-rise R/C building was selected. The design of selected sample building was made with reference to 1973 version of the Turkish Seismic Code. The effectiveness of using different types of eccentric steel braces in retrofitting the building was examined. The effect of distributing the steel bracing over the height of the R/C frame on the seismic performance of the retrofitted building was studied. For the to strengthening of the original structure, D, K, and V type eccentric bracing systems were utilized and each of these bracing systems was applied with four different spatial distributions in the structure. For fragility analysis, the study employed a set of 200 generated earthquake acceleration records compatible with the elastic structures mal subjected to this of earthquake accelerations generated in terms. The fragility curves were developed in terms of PGA for these limit states namely slight, moderate, major and collapse with long normal distribution assumption. The improvement of seismic reliability achieved through the use of D,K, and V type eccentric braces was evaluated by comparing the median values of the fragility curves of the existing building before and after retrofits. As a result of study, the improvement seismic performance of this type of mid-rise R/C building resulting from retrofits by different types of eccentric steel braces was obtained by formulation of the fragility reduction.

Godilnez and Tena investigated the result of a study devoted to evaluate, using nonlinear analyses the behavior of ductile moment-resisting reinforced concrete braced frames structure (RC-MRCBFs) using steel bracing. RC-MRCBFs were designed for lakebed region of Mexico City. It was possible to conclude from the result obtained in this study the need to improve current guidelines in the Mexican building code in warrant a ductile behavior for this structural system and to achieve the expected collapse mechanism.

Vijaykumar andManivelreported that structural engineering plays a vital role in providing a solution that safe guards the structure as such. Bracings were used to provide stability and resists lateral loads were the base isolation technology provided passive structural vibration control. X, V and Chevron bracings provided in different sides of building and the effect of base shear in building columns was absorbed for steel bracing with and without using lead rubber bearing as base isolator. The force impact on the structure with X, V and Chevron Bracings is measured for the simulated model for different cases using SAP2000 v18 software.

Rahai and Lashgariinvestigated that steel bracing members are widely used in steel structures to reduce lateral displacement and dissipate energy during earthquake motions In this study the use of steel bracing and buckling-restrained bracing (BRB) for retrofitting an inadequate reinforced concrete building were investigated. The effectiveness of these two systems in rehabilitating a mid-storey reinforced concrete (RC) building were examined using performance-based design and nonlinear static analysis according to FEMA-356 seismic rehabilitation guidelines. Result show that both systems improve the strength and stiffness of the original structure but due to excellent behavior of BRB in nonlinear phase and under compressive forces this system shows much better performance than the rehabilitation system of concentric bracing.

Massumi and Absalan investigated experimentally that the most suitable choices in design and improvement of reinforced concrete frames is using steel bracing. In this study the result of two experimental models of reinforced concrete frames were investigated. Both frames were designed based on old traditional codes, but one of them was strengthened with steel X-bracing. With respect to experimental result and using ANSYS software, the finite element model related to these frames is mode and calibrated, and then nonlinear analyses under additive cyclic static interaction between two braced-and bare-frame systems, a new numerical model is developed. The result show considerable interaction between two systems in increasing of energy damping.

Dubey and Kute investigated, planned and conducted to study the effect of braced and partially concrete-infilled, reinforced concrete (RC) frames in comparison to the bare frames. All these frames were tested up to collapse and subjected to only horizontal loads to obtain an effective and possible solution for soft storey. In comparison to bare RC frames, partially infilled frames have more lateral load capacity. Central bracing was more effective than that of corner bracing. For the same load, braced and partially infilled frames deflected significantly less than that of the bare frames. Based on the experimental observations, a mathematical model has been proposed to calculate theoretical ultimate load for braced and partial infilled RC frames.

4. SUMMARY AND CONCLUSION

The above literature study shows that steel bracing is effective RC buildings.In many researches building with steel bracing is compared with conventional building and result are compared in terms of storey displacement, story drift, story shear, time period and material consumption. Modeling and analysis have been done in ETABS, STAAD PRO and SAP 2000. Both static and dynamic analysis have been performed. From above study it is concluded that,

- Story displacement and story driftin building with steel bracing as compare to conventional building.
- Steel bracings can be used as an alternatives to other strengthening techniques available as the total weight of structure changes significantly.
- Steel bracing reduces flexure and shear demand on beam and column and transfers the lateral load through axial load mechanism.
- Stiffness is increased by steel bracing.

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