Improvement in Seismic Performance of Multistoried Building Using Metallic Bracing

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Abstract - *Seismic design relies on inelastic deformation through hysteretic behaviour. During severe earthquakes the structural system undergoes extensive damage that result in high cost of repair. Research these days has elevated and surpassed common human instinct. One such research that backed structural systems to sustain tremors of earthquake is metallic braces. These components are predominantly the lateral force resisting system in any building structure. The installation of braces within a structure system will magnetize substantial part of destruction while the parent elements persist elastically with inferior inelastic deformation. Dissipation of seismic energy occurs through inelastic yielding and buckling of bracing member in tension and compression respectively. In the present is carried out in a reinforced concrete G+7 storied moment resisting frame building which is modelled using (Software for Analysis and Design) SAP-2000. The building will be modelled in accordance with the provisions prescribed by IS:1893 2016 part I. Four patterns of bracing are fabricated on the peripheral frame of erection, where pattern being X, V, Diagonal and Inverted V. Non linear Dynamic Time history analysis (NTH) is carried out to investigate the performance of building structure due to induced dynamic forces by ground excitation. NTH is conducted using accelerogram of different earthquake. Results for NTH accessed described in the form of storey displacement, storey drift. Results show elevated performance of structure due to fabrication of bracings inside the RC frames.*

***Key Words*: Metallic Bracing, Non Linear Time History Analysis, Inelastic Yielding, Moment Resisting Frame**

1. INTRODUCTION

These multi-storeyed edifice were susceptible against natural hazards like earthquake which was life threatening for the residents. With the advancement in engineering practises, researchers developed systems which reduced the effects of seismicity on the engineered structures. One such evolution which is added to the buildings is bracing system. Bracing system is nothing but the lateral force resisting system. Earthquake induces lateral forces on to the parent elements of building. Columns are the primary lateral load resisting element of any multi-storey. These columns alone cannot counter the attack of earthquake therefore bracing members were introduced inside the frames of multi-storey to ascend the lateral stiffness of the relevant structure. The lateral force on columns are transmitted to braces through beam column joints axially. Bracing members descends the lateral deflection of the building by buckling and yielding during axial compression and tension respectively. Braces can be installed within frames in various configurations like diagonal, X, V (chevron), inverted V and K.

1.1 Modern Structural Protective System

The modern structural protective system is categorized into three major categories: Seismic Isolation System, Passive Energy Dissipation Devices and Semi Active and Active Energy Dissipation Devices. These energy dissipation devices When gets installed inside any structure curtails response due to the seismicity of earthquake ground motion. All these devices have their advantages and disadvantages but prove to be effective in improving response of structure.

Some of the seismic isolation devices proposed for dissipation of energy include Elastomeric Bearings, Lead Rubber Bearings, Combined Elastomeric and Sliding Bearings, Sliding Friction Pendulum Systems and Sliding Bearings with Restoring Forces. Semi-active systems require only nominal amounts of energy to adjust their mechanical properties, but unlike fully active systems, they cannot add energy to the structure. On the other hand active control system needs greater amount of input energy for its functional use. Considerable attention has been paid to semi-active and active structural control research in recent years, with particular emphasis on the alleviation of wind and seismic response. Some of the existing active an semi-active control devices are Active Bracing Systems, Active Mass Dampers, Variable Stiffness and Damping Systems Smart Materials. Unlike seismic isolation system, however, Passive energy Dissipation devices can be effective against wind induced motions as well as those due to earthquakes. Some of the passive energy dissipation device that is working in the present scenario is Metallic Dampers, Friction Dampers, Viscoelastic Solid Dampers, Viscoelastic or Viscous Fluid Dampers, Tuned Mass Dampers and Tuned Liquid Damper

1.2 Review of Work by Various Investigators

Rahai A.R. and Alinia M.M. [1] studied the behaviour of composite bracings. At first, a number of braced frames were selected and their behaviours under cyclic loading was studied. Then, using the data obtained from the first part, two existing concrete structures, a three story and a nine story building, were selected and strengthened against seismic loadings by both the conventional concentric steel and the latter composite bracing systems. The behaviours of these structures were then studied by the push-over method. Results revealed that With regards to the push-over diagrams, initial stiffness sand the ultimate capacities of different models, it is observed that although the X bracing systems generate laterally rigid structures; but, the encased bracing systems produce a concurrent suitable rigidity and ductility for the structures. The load–displacement curves showed that while models strengthened with the encased bracing system experienced displacements which exceeded limits targeted for life safety, their structural members behaved well within the L.S. Also, all models undertook lateral displacements greater than those expected for collapse prevention limits, and then again remained upright and did not collapse.

Ozel A.E. and Guneyisi E.M. [2] investigated the seismic reliability of a mid-rise reinforced concrete (R/C) building retrofitted using eccentric steel braces 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 1975 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 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 code design spectrum. Nonlinear time history analysis was used to analyze the structures subjected to this set of earthquake accelerations generated in terms of peak ground accelerations (PGA), whilst monitoring four performance limit states. The fragility curves were developed in terms of PGA for these limit states; namely: slight, moderate, major, and collapse with lognormal 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 this study, the improvement in 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.

2. MODELLING AND ANALYSIS OF FRAME

Model I - G7RCFWIFS : G+7 storey Reinforced Concrete Frame Infill Wall System which is depicted in Figure 1. Model II - G7RCFWIVBS : G+ 7 storey Reinforced Concrete Frame with IV Bracing System shown in Figure 2. Model III - G7RCFWXBS : G+ 7 storey Reinforced Concrete Frame with X Bracing System that pictures in Figure 3. Model IV - G7RCFWVBS : G+ 7 storey Reinforced Concrete Frame with V Bracing System portrayed in Figure 4. Model V- G7RCFWEBS : G+ 7 storey Reinforced Concrete Frame with Eccentric Bracing System is displayed in Figure 5.

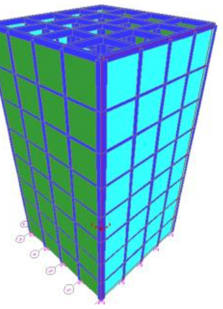


Fig -1: 3-D View of Infill Frame Structure

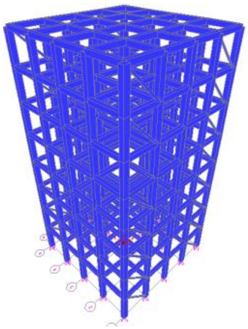


Fig -2: 3-D View of Eccentric braced Frame Structure

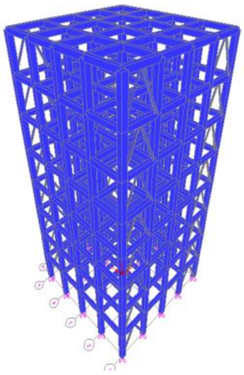


Fig -3: 3-D View of Inverted V Braced Frame Structure

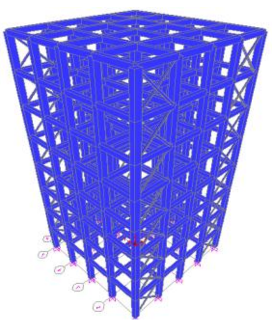


Fig -4: 3-D View of X Braced Frame Structure

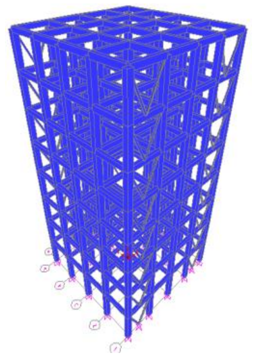


Fig -5: 3-D View of V Braced Frame Structure

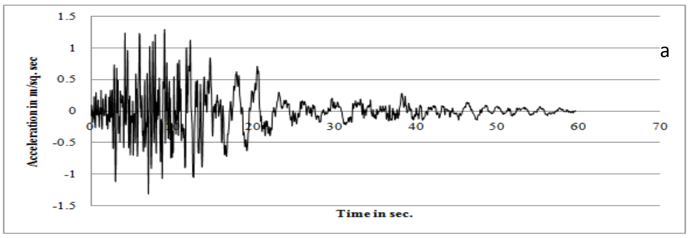
Table -1: Column and Beam Sizes for Modelling of Building

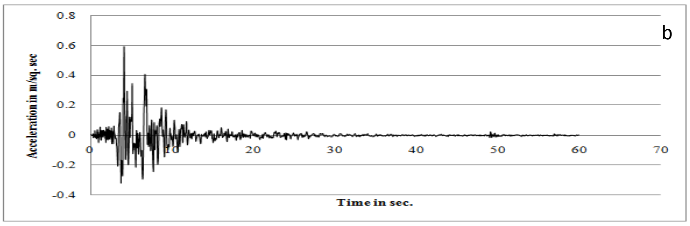
Sr.No.	Element	Notation	Size (mm)
1	Column	C1	400 X 500
2	Beam	B1	300 X 400

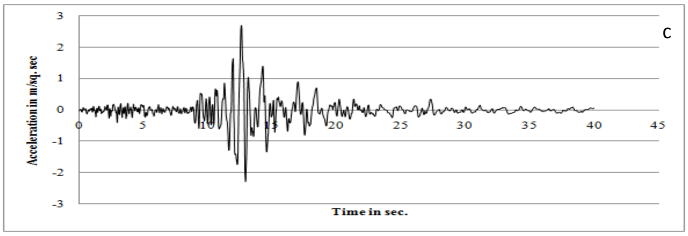
Table -2: Assumed Data for Models

Building	G + 7 Storey
Slab Thickness	150 mm
Live Load	3 kN/m^2
Floor Finish	1 kN/m^2
Concrete Grade	M20
Concrete Density	25 kN/m^3
Steel Grade	Fe415
Steel Density	7850 kN/m^3
Earthquake Used	North Ridge, Imperial Valley, Kern & North Ridge

In non linear dynamic time history analysis, the earthquake motion is directly applied to the base of a given structure with the help of the computer program. Instantaneous stresses throughout the structure are calculated at small intervals of time for the full duration of the earthquake or the significant portion of it. The maximum stresses in any member that occurs during the earthquake can then be found by scanning the output record and the design reviewed. The actual plot of four ground motion record considered for study is shown in Figure. 6







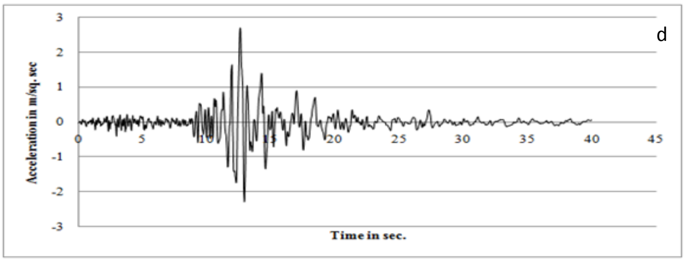


Fig -5: Input Acceleration Time History (a) Imperial Valley (b) North ridge (c) Loma Prieta (d) Kern Earthquake

The main purpose of applying nonlinear dynamic time history analysis is to examine the response of modelled building structure under real earthquake ground motions. The analysis exhibits actual behaviour caused due to seismic disturbances. The resulting response found from such an evaluation is very realistic in nature. Therefore the consequences of installing PED's in structure could be investigated on a factual basis. NTH is carried out by imposing three time histories on to the modelled structure which are applied in the horizontal direction and their outcomes are discussed in terms of storey drift and displacement.

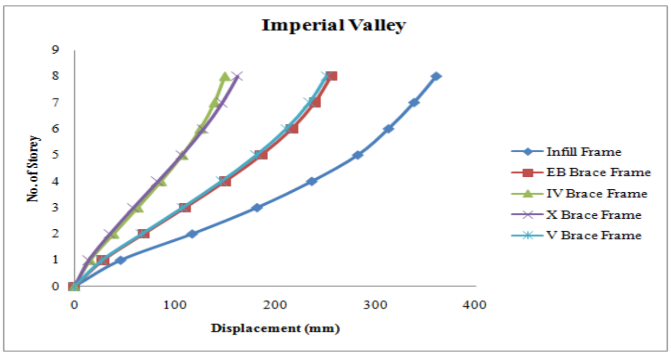


Chart -1: Displacement comparison for bare frame and braced frame model for Imperial Valley earthquake

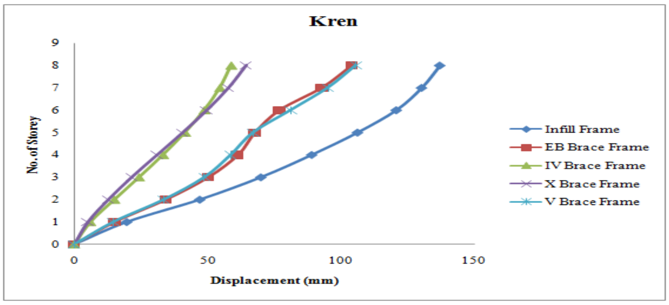


Chart -2: Displacement comparison for bare frame and braced frame model for Kern earthquake

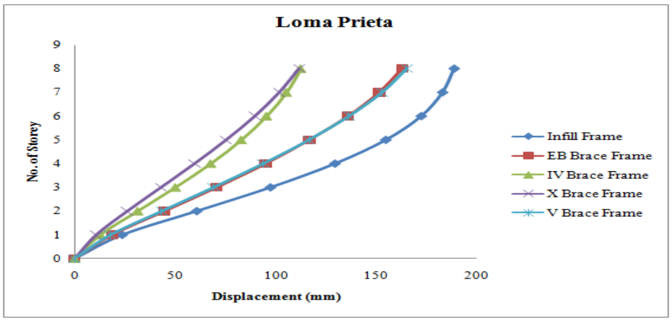


Chart -3: Displacement comparison for bare frame and braced frame model for Loma Prieta earthquake

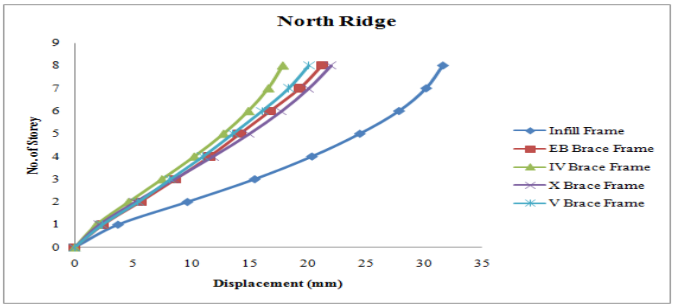


Chart -4: Displacement comparison for bare frame and braced frame model for North Ridge earthquake

The effect of bracings could be studied form tables and figures of storey displacement. It is observed that imparting different bracing patterns to the bare frame structure reduces the displacements at each storey level thereby reducing the top storey displacement substantially. It followed from the table that modelling Eccentrically brace frame reduces displacement of top storey by 36.43%, 44.49%, 17.26% and 36.09% for Imperial Valley, Kern, Loma Prieta and North Ridge earthquake respectively. Similarly for Chevron braced frame top storey displacement lowers by 62.48%, 67.46%, 42.45% and 45.03% for the same series of earthquake as above respectively. X braces curtails the top storey displacement to 60.89%, 65.49% , 44.42%, 33.44% and V brace lowers it to 37.66%, 43.18%, 16.48% and 39.07% for same series of earthquake respectively. Results also show that IV brace and X brace are the most effective in curtailing the top storey displacement than V and eccentric braces. Imparting braces to the bare frame structure adds on to the lateral stiffness of structure thereby reducing the displacement at each storey.

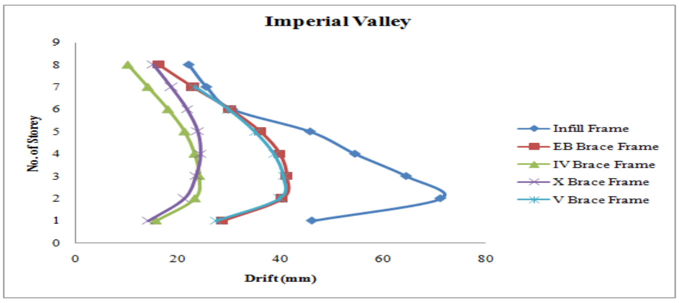


Chart -5 Storey Drift comparison for bare frame and braced frame model for Imperial Valley earthquake.

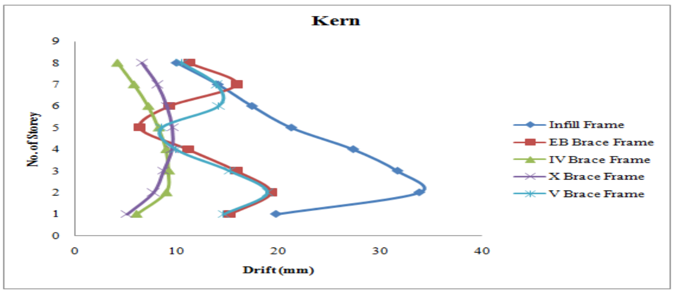


Chart -6 Storey Drift comparison for bare frame and braced frame model for Kern earthquake.

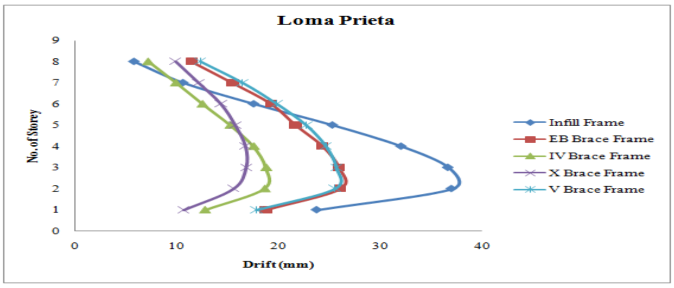


Chart -7 Storey Drift comparison for bare frame and braced frame model for Loma Prieta earthquake.

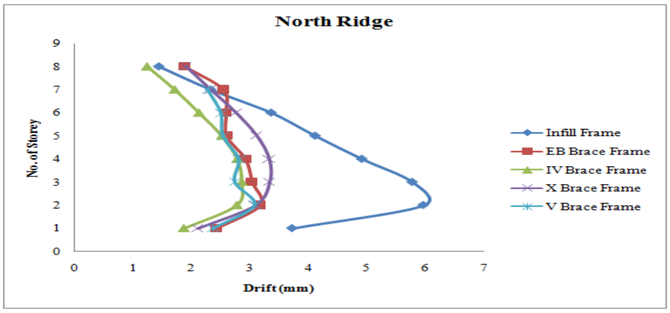


Figure 4.8: Storey Drift comparison for bare frame and braced frame model for North Ridge earthquake

Results and graphs of storey drift reveal reduced values of drift and increased performance of building structure. A drastic reduction in storey drift was observed at each storey for all earthquake time histories. 28.43% of reduction of drift was found in eccentric brace frame structure and increases again for chevron braced and X braced structure to 55.93% and 41.67% respectively for imperial valley time history. Kern earthquake outcome percentage reduction is 12.85%, 58.57%, 42.14% and 1% for eccentric brace frame, chevron brace frame, x brace and v brace frame. Though for Loma Prieta and North Ridge time histories top storey drift is greater than bare frame but for rest of the stories it is lesser. The increased lateral stiffness of the bare frame structure due bracings reduces the storey displacements thereby reducing drifts at each storey.

3. CONCLUSIONS

Through the Non Linear Dynamic Time History Analysis of bare frame and braced frames led to the following conclusions

1. An improvement in performance of structure was seen through the fabrication of metallic bracings inside the bare frame.
2. Metallic braces helped reducing the displacement at each storey to about 40% averagely.
3. X and chevron braces were more effective as compared to V and diagonal brace in controlling the storey displacement.
4. The maximum storey drift was observed at second and third storey and was found to be minimum in case of braced frames than bare frame.
5. X brace and Chevron brace effectively controlled the drift at each storey the V and diagonal bracing
6. A reduced amount of storey drift and displacement indicated towards the reduced demands on columns.
7. The maximum amount of shear force was found in bottom storey column and reduced for higher storey column.

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