IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 6 Ver. V (Nov- Dec. 2014), PP 26-30
www.iosrjournals.org

Strengthing of Low Ductile Reinforced Concrete Frame Using X-Bracing with Different Details

Ravi Karoda[1], Vijay Baradiya [2]
[1](*Research Scholar, Department of Civil Engineering/ I.E.S. I.P.S. Academy, Indore, MP, INDIA.)*
[2] (*Assistant Professor, Department of Civil Engineering/ I.E.S. I.P.S. Academy, Indore, MP, INDIA.)*

Abstract: *Structures in high seismic risk areas may be vulnerable to severe damage in a major earthquake. Structures designed to meet older code necessities may be at even greater risk. When these structures are evaluated with respect to current code criteria, it is observed that they lack of lateral strength or ductility. Since safety and economic considerations are major problems, these structures become viable candidates for retrofit and seismic strengthening. Diagonal bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening existing building for lateral forces. Also, another potential advantage of this system is the comparatively small increase in mass associated with the retrofitting scheme since this is a great problem for several retrofitting techniques. In this study, the use of steel bracing for the strengthening of low, intermediate, and relatively low ductile reinforced concrete frames are investigated analytically. The ultimate lateral load capacities of the strengthened frames are determined by a load controlled static analysis. The tension member design based on IS: 800:2007 code and check its strength under earthquake loading.*

Keywords: *X- bracing, Bare frame, Tension Member, Story Drift,*

I. Introduction

In the past, most of the reinforced concrete structures were designed primarily for gravity loads.Recent earthquakes have shown the importance of rehabilitating seismically deficient structures to achieve an adequate level of performance. This can be achieved by improving the strength, stiffness, and ductility of the existing structures. There are various rehabilitation techniques and to select the appropriate one, an accurate evaluation of the condition and seismic performance of an existing structure is necessary. Steel bracing systems have both practical and economical advantages. The main advantage of this method is that it is not required to rehabilitate the foundation system. since the bracing system does not introduce great additional gravity load to the existing structure and steel bracings are usually installed between existing vertical members. Steel bracing is a highly efficient and cost-effective method of resisting horizontal forces in a frame structure. Bracing has been used to stabilize laterally for the majority of the world‗s tallest building structures as well as one of the major retrofit measures. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear. A number of researchers have investigated various techniques such as infilling walls, adding walls to existing columns, encasing columns, and adding steel bracing to improve the strength or ductility of existing buildings. A bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the weak columns while increasing strength.

II. Behaviour Of Tension Members

Axially loaded tension members are subjected to consistent tensile stress, their load deformation behavior (Fig.1.1) is similar to the equivalent basic material stress strain behavior. Mild steel members exhibit an elastic range (a-b) ending at yielding (b). This is followed by yield plateau (b-c). In the Yield Plateau the load remains constant as the elongation increases to nearly ten times the yield strain. Under further stretching the material shows a smaller increase in tension with elongation (c-d), compared to the elastic range. This range is referred to as the strain hardening range. After reaching the ultimate load (d), the loading decreases as the elongation increases (d-e) until rupture (e). High strength steel tension members do not exhibit a well-defined yield point and a yield plateau (Fig.1). The 0.2% offset load, T, is usually taken as the yield point in such cases.

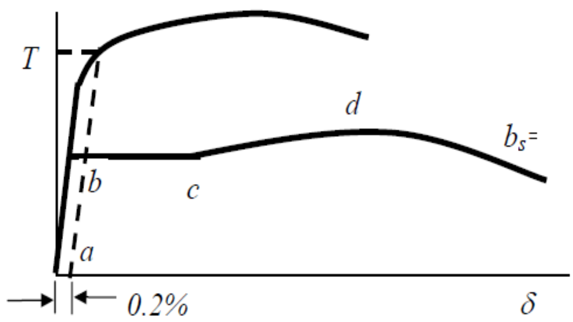

Fig. 1 Load – elongation of tension members

1. Design strength due to yielding of gross section:**-** The design of tension members, the yield load is usually taken as the limiting load. The corresponding design strength in member under axial tension is given by (C1.6.2)

$$T_d = f_y A / \gamma_{mO} \qquad (1.1)$$

Where, f_y is the yield strength of the material (in MPa), A is the gross area of cross section in mm2 and γ_{mO} is the partial safety factor for failure in tension by yielding.
The value of γ_{mO} according to IS: 800 is 1.10.

2. Design strength due to rupture of critical section:- Since only a small length of the member adjacent to the smallest cross section at the holes would stretch a lot at the ultimate stress, and the overall member elongation need not be large, as long as the stresses in the gross section is below the yield stress. Hence, the design strength as governed by net cross-section at the hole, T_{dn}, is given by (C1.6.3)

$$P_{tn} = 0.9 f_u A_n / \gamma_{m1} \qquad (1.2)$$

Where, f_u is the ultimate stress of the material, An is the net area of the cross section after deductions for the hole and γ_{m1} is the partial safety factor against ultimate tension failure by rupture (γ_{m1} = 1.25). Similarly threaded rods subjected to tension could fail by rupture at the root of the threaded region and hence net area, An, is the root area of the threaded section. The net effective area of the staggered section is given by

$$An = [b - 2d + p^2 / 4g]\, t \qquad (1.3)$$

3. Design strength due to block shear:- The block shear strength T_{db}, at an end connection is taken as the smaller of (C1.6.4)

$$T_{db} = (A_{vg} f_y / (\sqrt{3}\, \gamma_{m0}) + f_u A_{tn} / \gamma_{m1}) \qquad (1.6)$$

or

$$T_{db} = (f_u A_{vn} / (\sqrt{3}\, \gamma_{m1}) + f_y A_{tg} / \gamma_{m0}) \qquad (1.7)$$

Where, A_{vg}, A_{vn} = minimum gross and net area in shear along a line of transmitted force, A_{tg}, A_{tn} = minimum gross and net area in tension from the hole to the toe of the angle or next last row of bolt in plates, perpendicular to the line of force and fu, fy = ultimate and yield stress of the material respectively

4. Angles under tension

Angles are extensively used as tension members in trusses and bracings. Angles, if axially loaded through centroid, could be designed as in the case of plates. However, usually angles are connected to gusset plates by bolting or welding only one of the two legs.
The strength of an angle connected by one leg as governed by tearing at the net section is given by (C1.6.3.3)

$$T_{tn} = (A_{nc} f_u / \gamma_{m1} + \beta_{A0} f_y / \gamma_{m0}) \qquad (1.8)$$

Where, fy and fu are the yield and ultimate stress of the material, respectively.
An_{nc} and A_o, are the net area of the connected leg and the gross area of the outstanding leg, respectively. The partial safety factors γm0 = 1.10 and γm1 = 1.25 β accounts for the end fastener restraint effect and is given by

$$\beta = 1.4 - 0.035(w / t)(f_u / f_y)(b_s / L) \qquad (1.9)$$

Where w and b_s are as shown. L = Length of the end connection, i.e., distance between the outermost bolts in the joint along the length direction, the tearing strength of net section may be taken as

$$T_{dn} = \alpha A_n f_u / \gamma_{m1} \qquad (1.10)$$

Where, α = 0.6 for one or two bolts, 0.7 for three bolts and 0.8 for four or more bolts in the end connection or equivalent weld length, An = net area of the total cross section, A_{nc}= net area of connected leg, A_{go}= gross area of outstanding leg, t = thickness of the leg.
The efficiency, of an angle tension member is calculated as given below:

$$\eta = F_d / A_{g\,*\,fy} / \gamma_{m0} \qquad (1.11)$$

Depending upon the type of end connection and the configuration of the built-up member, the efficiency may vary between 0.85 and 1.0.

Based on the above procedure tension member design according to IS: 800:2007 and the selection of angle section is based on thickness of ISA section. Following ISA section used to determine the tensile capacities of section are:-

8 mm thick	10mm thick
ISA 55 x 55 x 8	ISA 55 x 55 x 10
ISA 60 x 60 x 8	ISA 60 x 60 x 10
ISA 65 x 65 x 8	ISA 65 x 65 x 10
ISA 70 x 70 x 8	ISA 70 x 70 x 10
ISA 75 x 75 x 8	ISA 75 x 75 x 10
ISA 80 x 80 x 8	ISA 80 x 80 x 10
ISA 90 x 90 x 8	ISA 90 x 90 x 10
ISA 100 x 100 x 8	ISA 100 x 100 x 10

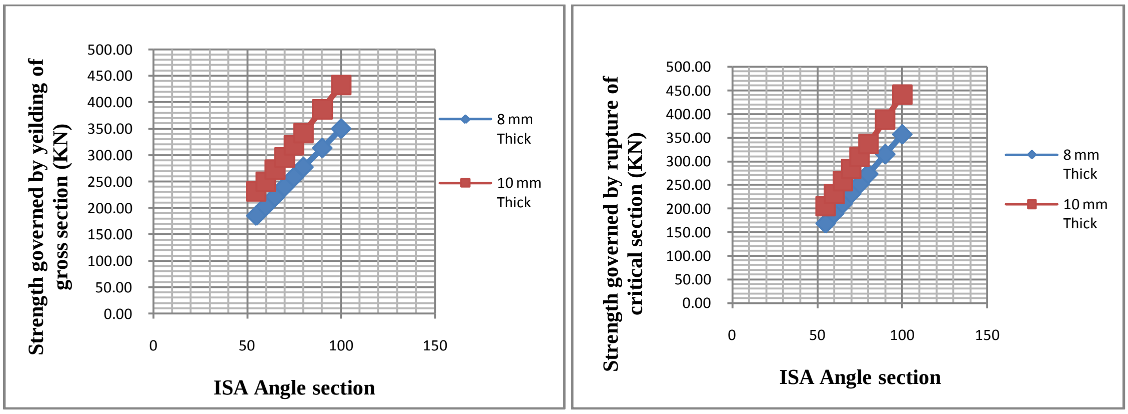

Fig. 2 Strength governed by **yielding of gross section** and **rupture of critical section** vs. ISA section

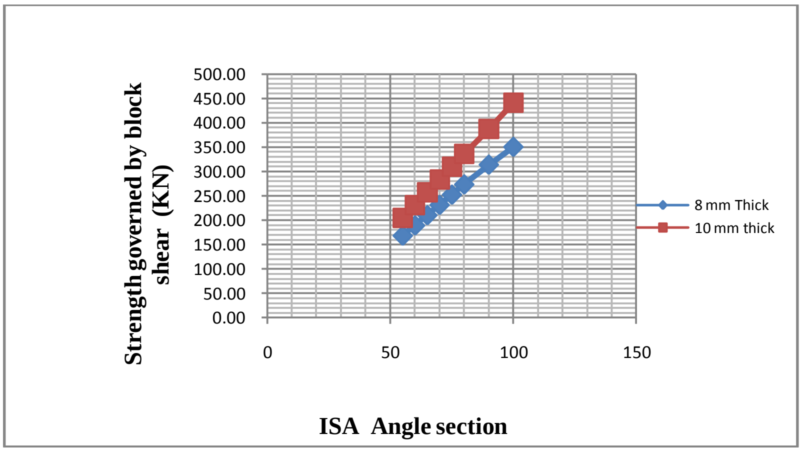

Fig. 4 Strength governed by **block shear** vs. ISA section

All three figures show the strength of braced tension member capacity in Strength governed by yielding of gross section, Strength governed by rupture of critical section and Strength governed by block shear of all Indian Standard Angle Section.

III. Analysis And Design

In order to establish the reference values, the lateral load capacity of each R/C bare frame was determined first. The ultimate lateral load capacities of Bare Frame (BF) models are shown in Fig. 5.

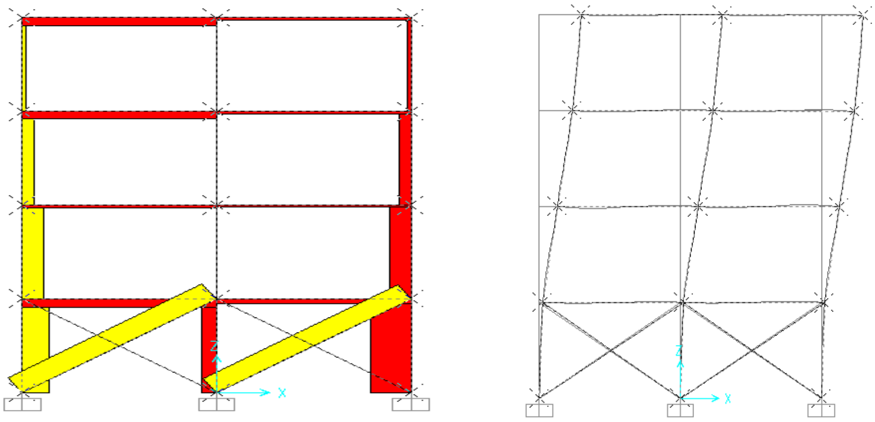

Fig.5 Compression condition total tension in bracing and the lateral behavior of steel braced RCC frame.

The model structures are design for relatively large seismic loads and the beam column connections are assume to be pinned so that the seismic load was resisted mainly by the braces. The results of this study can be review as follows:

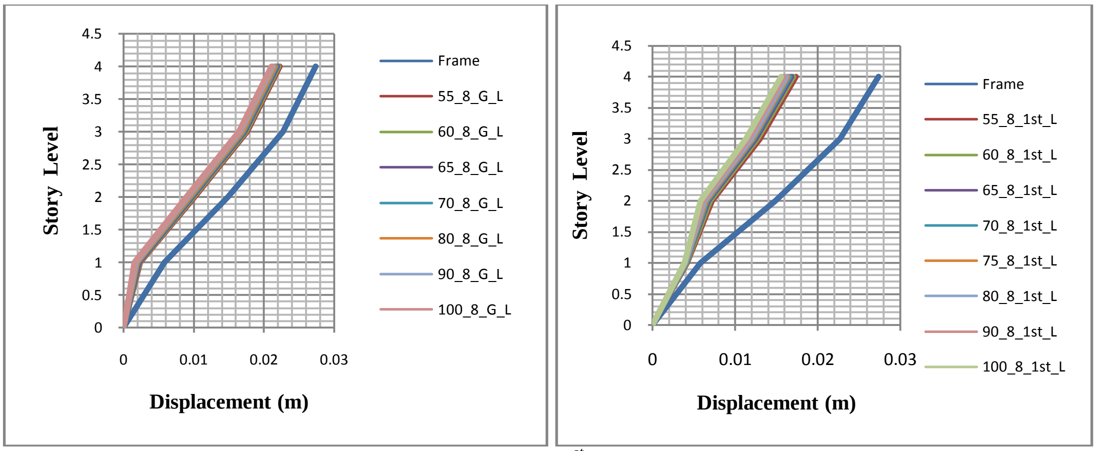

Fig. 6 X–Bracing apply in Ground and 1st floor with 8mm thick steel bracing

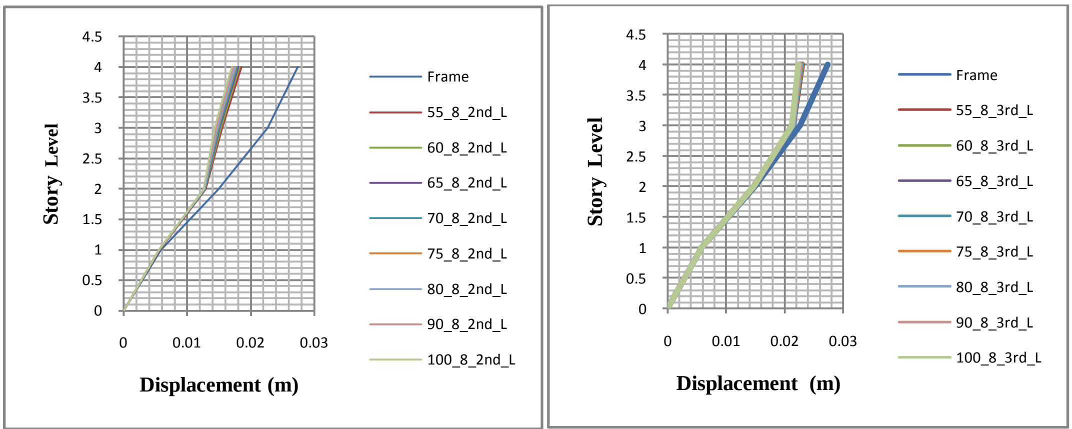

Fig. 7 X–Bracing apply in 2nd and 3rd floor with 8mm thick steel bracing

IV. Result

The following conclusions are drawn based on the parametric work conducted in this study regarding the rehabilitation of existing R/C frame structures for increasing their lateral load resisting capacities for seismic effects.

- Depending on the original design and its height to width ratio, it is possible to increase the lateral load capacities of existing R/C frame structures by up to 22% to 27 % when the bracing apply in ground floor in and as compared to 10mm thick angle section the strength increase 25% to 30% in same configuration.
- It is possible to further increase the lateral load capacities of existing R/C frame structures rehabilitated by changing the position of X-bracing. The capacity of frame increase when X-bracing apply at 1^{st}, 2^{nd} and 3^{rd} level of building. For 8mm thick in 1^{st} story bracing system the capacity increase 57 % to 74% , 2^{nd} story bracing system 47% to 59% and 3^{nd} story bracing system 18% to 20%. Its show the location of the bracing change the lateral stiffens of the structure in midrise building.
- Similarly for 10mm thick angle section in 1^{st} story bracing system the capacity increase 64% to 79% , 2^{nd} story bracing system 52% to 63% and 3^{rd} story bracing system 20% to 22%.
- The change of the thickness of angle section show only 7- 8% variation in graph. It mean for economic point of view its give clear relation between thickness of section and its strength witch one stronger and economical.

References

[1]. Agar, M., (2008). "Strengthening of reinforced concrete frames by using steel bracings." M.S.Thesis. The graduate school of natural and applied sciences of the Middle East technical university.

[2]. Antonopoulos,T., A., and Anagnostopoulos, S., A., (2013)." Improving the seismic performance of existing old pilotis type buildings by strengthening only the ground story." COMPDYN 2013, 4th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Kos Island, Greece.

[3]. Alam, M., S., Nehdi, M., and Youssef, M., A., (2009). "Seismic performance of concrete frame structures reinforced with superelastic shape memory alloys." Smart Structures and Systems, Vol. 5, No. 5, pp., 565-585.

[4]. Ghaffarzadeh, H. and Maheri, MR. (2006). Mechanical compression release device in steel bracing system for retrofitting RC frames. Earthquake Engineering and Engineering Vibration 5:1.

[5]. IS:800:2007 , General Construction in Steel - Code of Practice.

[6]. IS:465:2000. Plain and Reinforcement Concrete - Code of Practice.

[7]. IS:1893:2002, Criteria for Earthquake Resistant Design of Structures, Part 1 general Provisions and Building.

[8]. Khaloo, A., R., and Mohseni, M.,M., (2008) "Nonlinear seismic behavior of rc frames with rc braces." Asian journal of civil engineering (building and housing) vol. 9, no. 6, pp. 577-592.

[9]. Kutuk M., A., and Gov, I., (2013)," Novel bracing type against seismic loading: KX type," Mathematical and Computational Applications, Vol. 18, No. 3, pp. 438-447.

[10]. Kangavar, M., E., (2012). "Seismic Propensity of Knee Braced Frame (KBF) As Weighed Against Concentric Braced Frame (CBF) Utilizing ETABS and OPENSEES." International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Vol. 5, pp. 141-152.

[11]. Kulkarni, R., B., and Jirage, R., S., (2011). "Comparative Study of Steel Angles as Tension Members Designed by Working Stress Method and Limit State Method." International Journal of Scientific & Engineering Research Volume 2, Issue 11, ISSN 2229-5518.

[12]. Kevadkar, M., D., and Kodag, P., B., (2013). "Lateral load analysis of R.C.C. building." International journal of modern engineering research, vol.3, issue.3, pp-1428-1434.

[13]. Masri, A., C., and Goel, S., C., (1996). Seismic design and testing of an RC slab-column frame strengthened by steel bracing. Earthq. Spectra, vol., 12, No., 4, pp. 645-666.

[14]. Maheri, M., R., and Sahebi, A., (1997). Use of steel bracing in reinforced concrete frames. Journal of Engineering Structures 19:12, 1018-1024.

[15]. Maheri, M., R., Kousari, R., and Razazan, M., (2003). Pushover tests on steel X-braced and knee-braced RC frames. Journal of Engineering Structures 25, 1697-1705.

[16]. Santha Kumar A., R., (2010),"Tension Member Design." Design notes of Steel Structures, Indian Institute of Technology Madras.

[17]. Sap2000 vol 14 (2009). "CSI Anal y sis Reference Manual." Berkeley, California, USA .

[18]. Takey, M., S., and Vidhale, S., S., (2011). "Seismic response of steel building with linear bracing system (a software approach)." International Journal of Electronics, Communication & Soft Computing Science and Engineering ISSN: 2277-9477, Volume 2, Issue 1.

[19]. Viswanath, K., G., Prakash K., B., and Desai, A., (2010). "Seismic analysis of steel braced reinforced concrete frames." International journal of civil and structural engineering volume 1, no , pp.114-122.