A Review study on Performance of O-bracing Under Dynamically Activated Conditions

Mohammad Qasimumar[#1], Durgesh Tupe[*2], G R Gandhe[#3]

[#] *Department of Civil Engineering, Deogiri Institute of Engineering and Management studies, Aurangabad, Maharashtra, India*

[1]civilerqasim@gmail.com

[2]gajendragandhe@gmail.com

[3]durgeshtupe@gmail.com

***Abstract*— In this paper different types of structural systems which are adopted for improving performance of high rise structures against static as well as dynamic loading are studied. Due to quite importance of high rise structures there members should be analyzed and designed perfectly. FEM method of analysis is the best way to analyse these tall buildings. O-bracing found to be new bracing system.**

***Keywords*— Structural system, Bracing system, O-bracing, Time history analysis, FEM**

I. Introduction

The migration from rural to urban areas to a large extent which has caused scarcity of land space for horizontal development. So it has become a need of today to have development in direction towards sky.

Maryam Boostani [9] Proposed bracing systems for earthquake resistant steel structures are introduced and studied through an experimental program and fem (finite element method) numerical analysis. These proposed bracing systems called O-grid. Linear and nonlinear behaviour of the new O-grid bracing systems are studied and compared with x-bracing system and MRF in one story base models. Response spectrum analysis and nonlinear static (pushover) analysis are used by FEM.

Giovanni Maria Montour [6] Evaluated a framework for assessing the ‘‘local’’ structural issues in the design of dia-grid tall buildings, and present a methodology for establishing the need for a specific secondary bracing system (SBS) as a function of the dia-grid geometry.

Suresh P [3] presented a case study and stated that tall structures are more flexible and susceptible to vibrations by wind induced forces. In the analysis and design of high-rise structures estimation of wind loads and the inter storey drifts are the two main criteria to be positively ascertained for the safe and comfortable living of the inhabitants.

F. Albermaniet [1] has developed efficient upgrade schemes using diaphragm bracings. Tower strength improvement was investigated by adding a series of diaphragm bracing types at mid-height of the slender diagonal members. Analytical studies showed that considerable strength improvements could be achieved using diaphragm bracings.

Md. Ashiquzzaman [2] Presented different configurations and types of bracing systems are investigated experimentally to compare their effectiveness with the current block-and-tie methodology. Finite element models (FEM) were developed using ABAQUS to replicate the experimental results followed by additional analysis using the validated Finite Element model.

Kelly Young [4] presented the results of investigation on the periods of eccentrically braced frame (EBF) structures with varying geometric irregularities. A total of 12 EBFS were designed and analyzed. Based on the results obtained from vibration theory, equations for the approximate periods are put forth for EBFS which take into account vertical and horizontal irregularities. Through statistical comparison, it was found that a 3-variable power model which is able to account for irregularities resulted in a better fit to the Rayleigh data than equations which were dependent on height only.

Wen wu Lan [5] Presented experimental and analytical investigations of steel– concrete composite structural walls with internal bracings. In the experimental study, four full-scale wall specimens were tested under cyclic load reversals. The performance of the wall specimens in terms of load–deformation response and cracking patterns were described.

R. Montouri [7] Investigated the influence of the bracing scheme on the seismic performances of moment resisting frames-eccentrically braced frames (MRF-EBF) dual systems, designed according to two design approaches: the first one is the theory of plastic mechanism control (TPMC) while the second one is based on Euro-code 8 (ec8) design provisions. Even though TPMC design approach is not introduced in modern seismic codes, it has earned the reputation of being a robust design approach because of its strong theoretical background, based on the kinematic theorem of plastic collapse extended to the collapse mechanism equilibrium curve to assure a collapse mechanism of global type.

Dia Eddin Nassania [8] presented a comparison of the seismic response of steel frames by using different types of bracing systems. The bracing systems are x-braced frames, v braced frames, inverted v braced frames, knee braced frames and zipper braced frames. The steel frames are modeled and analyzed in four different height levels. Nonlinear static and dynamic analyses were performed. The frames consist of three bays and steel braces were inserted in the middle bay of each frame. The structural responses of frames are studied in terms of capacity curve, drift ratio, global damage index, base shear, storey displacements, roof displacement time history and plastification. The results showed a good improvement in the seismic resistance of frames with the incorporation of bracing. The results revealed that the bracing elements were very effective in diminishing drifts since the reduction of inter-storey drifts with respect to unbraced frames were on the average 58%. Also steel braces considerably reduced the global damage index.

Dhanaraj M. Patil [10] Presented a comparison of the seismic behavior of different bracing systems in high rise 2-d steel buildings is made. Nonlinear static pushover analyses were carried out to assess the structural performance on different bracing systems in high rise steel buildings of 15, 20, 25, 30 and 35 storeys. Five structural configurations were used: moment resisting frames (MRF's), chevron braced frames (CBF's), v-braced frames (VBF's), x-braced frames (XBF's) and zipper braced frames (ZBF's). The effects of some parameters influencing the seismic performance, including type of the bracing system, the height of the building and lateral load patterns, were investigated. The results showed that the different braced frames performed well in terms of storey displacement, inter-storey drift ratio, base shear and performance point when compared with the moment resisting frame in high rise steel buildings.

II. PRELIMINARIES

A. Structural Systems

1 *Framed system:* This is a relatively simple structural system, in which beams and columns are rigidly connected to form moment-resisting frames in two orthogonal directions resisting lateral and gravity loads. Each frame resists a proportion of the lateral load, determined on the basis of its relative stiffness compared to the sum total stiffness of the frames. For increasing structure height, there is an associated direct increase in the size of the frame elements to satisfy lateral drift and deflection limits. This structural system is applicable for buildings of up to approximately 75 m in height.

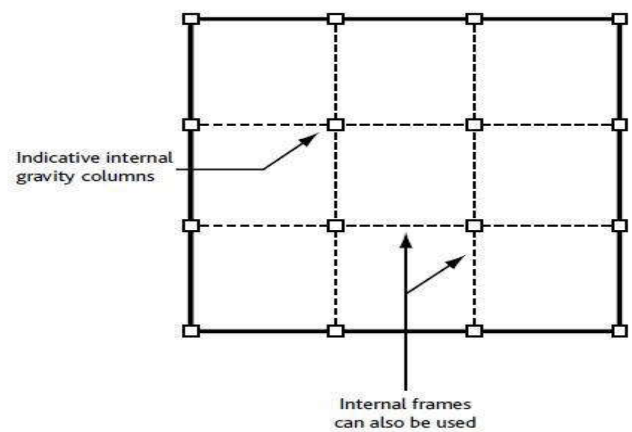

Fig. 1 Framed system [11]

2 *Shear Wall System:* This system consists of shear walls designed to resist lateral forces in two orthogonal directions. Fig 2 shows a typical arrangement, with shear walls arranged near the centre of the structure to house lifts, fire-escape stairs and other building servicing, thus providing a stiff structural spine to resist horizontal loads in two directions. This is often termed a 'core system', with the core designed to act as a single vertical cantilever with sufficient lateral, torsional and bending stiffness to resist the worst combinations of service and ultimate conditions. This system is generally sufficient for buildings up to 120 m tall.

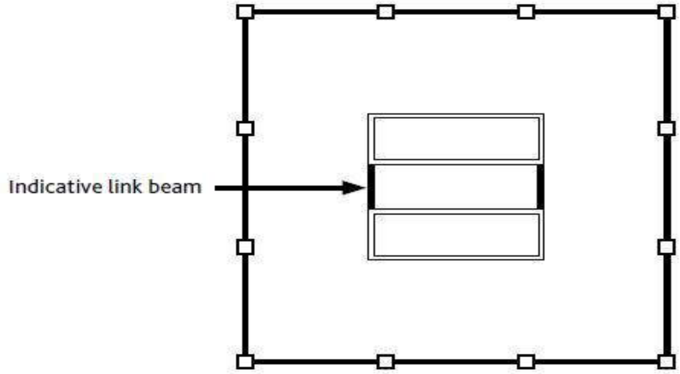

Fig 2: Shear Wall System [11]

3 *Shear Wall and Framed System:*This framing typology is essentially a combination of the two systems already outlined. The combined lateral stiffness of rigid or semi-rigid frames and core shear walls allows designers to reach heights of around 160 m cost-effectively.

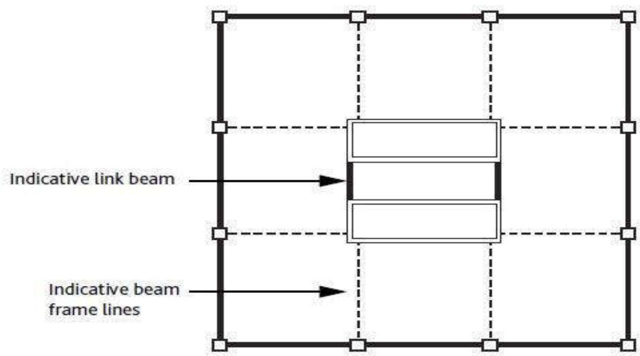

Fig 3: Shear wall-Framed system [11]

4 *Framed Tube System: T*his system is based on a hollow tube, with the large distance between the tension and compression elements in both directions serving to resist lateral forces. The structural principle is based on the flange of the tube frame being perpendicular to lateral wind forces, tied at each end by the webs of the framed tube which are oriented parallel to the wind. In order to form an adequately stiff hollow tube, studies must be undertaken to determine the appropriate size and spacing of the perimeter members. The framed tube system is suitable for buildings up to approximately 150-170 m in height.

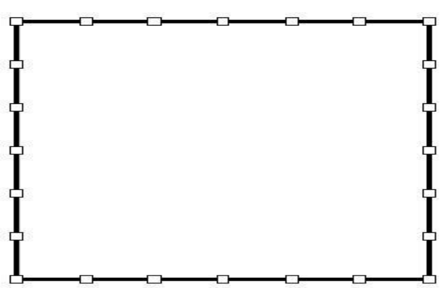

Fig 4: Framed tube system [11]

5 *Tube in Tube System:* This system combines the stiffness of the perimeter-framed tube with a set of stiff internal reinforced concrete core walls. Structurally, this arrangement will act in a similar manner to the shear-wall and-frame system but will be considerably more robust due to the strong lateral strength of the outer tube. The application of this system allows for the design of buildings up to approximately 180-200 m in height.

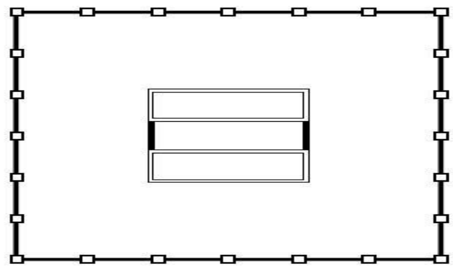

Fig 5: Tube in tube System [11]

6 *Bundled-tube system:* This System is also called as modular tube system. This system is best suited to building heights greater than 70 storeys, or super-tall structures. While this system performs in the same manner as the tube system, the number of flange' frames is increased by introducing inner 'web' wall or frame elements splitting the plan area into a series of modules. The term 'bundled' describes the adjacent nature of the modules, all of which should be apportioned to share lateral loads across the width of the building in both directions. This system is also stated as 'rigid tube' or a 'true cantilever', as the significantly increased stiffness will allow the efficient design of 225 m-tall buildings.

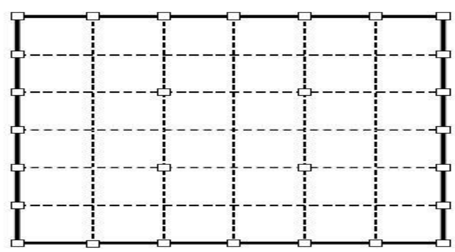

Fig 6: Bundled tube system [11]

7 *Braced-tube system:* Similarly to the bundled tube, this system uses diagonal bracing added to the perimeter tube frames to increase the tube system's lateral stiffness and accommodate increased building height. This allows for greater column space and thus more free area for glazing within the facade. With this structure, the aesthetic form of the building is largely dictated by the diagonal bracing lines. The external tube elements act as bracing frames by transferring lateral loads to the foundations along the diagonal tension and compression lines, and also redistribute the gravity loads from the highly stressed to less stressed columns, ensuring a high degree of structural redundancy and many load paths. This system is most suited to buildings up to 300 m, or super-tall.

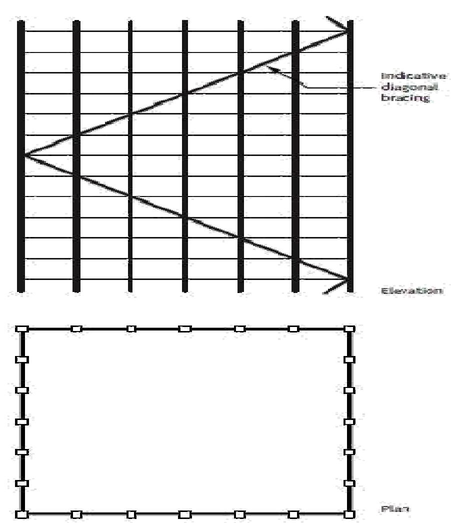

Fig 7: Braced tube systems [11]

B. Bracing systems

1 *External and Internal bracing:* As the name itself suggest, external bracing is bracing which are provided at the exterior frames to retrofit the frame. On the other hand the internal bracing is when a structure is integrated with a bracing system inside the structure with the internal units or the internal panels of the frames. The decision for the type of bracing to be used depends upon the magnitude of the lateral load, the magnitude of the ductility desired and the aesthetic requirement of the structure. The bracings may be directly or indirectly attached to the frames. The connection of braces to beams and columns may be a simple connection. In seismic regions the braced connections may be constructed as rigid so as to reduce the lateral drift and to improve the reserved strength in the frame after an earthquake.

2 *Concentric and eccentric bracing:* The concentric bracing system improves the lateral stiffness of the frame and decreases the lateral drift of the structure whereas the eccentric bracing system reduces the lateral stiffness of the structure and also improves the damping i.e. the energy dissipation capacities of the structure. In case of eccentric bracing system the beam to bracing connection is eccentric and the lateral stiffness of the structure depends upon the flexural stiffness of the beams and columns, hence the lateral stiffness of the frame is reduced. If the lateral stiffness is increased the structure may attract larger inertia forces due to earthquake.

3 *X- Bracing or Cross bracing:* Cross-bracing (or X-bracing) uses two diagonal members crossing each other. These only need to be resistant to tension, one brace at a time acting to resist sideways forces, depending on the direction of loading. As a result, steel cables can also be used for cross-bracing. However, cross bracing on the outside face of a building can interfere with the positioning and functioning of window openings. It also results in greater bending in floor beams.

Fig. 8 X- bracing system [8]

4 *O-Grid Bracing System:* This system is firstly introduced by M. Boostani [9]. As the name suggested in this system O-grids or circular shaped bracing system are used so as to resist various lateral forces, reduce torsional effects and make the structure more flexible. This complete study is based on this concept. Fig.16 indicates a typical layout of O-grid bracing system.

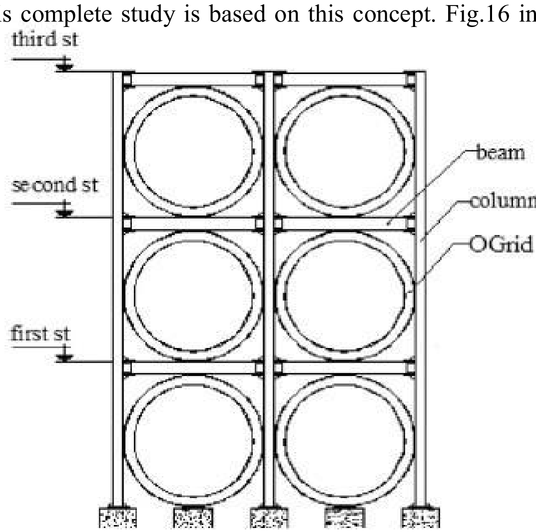

Fig. 9 Typical O-grid bracings [9]

III. Conclusions

In above discussion, most of authors studied the effect of different bracing systems in improving the performance of high rise structure against seismic and dynamically activated condition. Only one author [9] introduced the concept of O-bracing. We conclude that further work should be done for O-bracing implementation in high rise structure.

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