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A Review on Effect of Mass Irregularity and Floating Column on High-Rise Steel Framed Structure

Abhishek Pundir [1], Vikas Khandelwal [2]

1,2 Department of Civil Engineering, Chandigarh University, Gharuan-140413, Mohali, India,

Abstract: In modern world, new methods and techniques are being developed by conducting numerous researches every day. Enhancement in structural designing has become an impeccable part of this world. Making structure safe and cost effective is the main objectives of any structural designer. Conventionally, buildings are designed and constructed in a very simple way but now, researchers are focusing on irregular aspects of the structure so that the complex structure can be made while achieving safety and economy. Many researchers have been doing researches on floating column analysing with seismic and wind forces also as it gives a vague idea of column failure. Steel framed structure has become an important part of infrastructures as it provides umpteen benefits over RCC structures. So analysis of such structures under seismic forces and wind forces will play a significant role in advancement of infrastructure design. Therefore, in this paper, the effect of mass irregularity along with the floating column on steel framed structure has been reviewed.

Keywords:-Mass irregularity, Floating Column, Steel Framed Structure, Wind Analysis.

I. INTRODUCTION

There is no clear difference between low-rise, medium-rise and high-rise building. But still a building is said to be high-rise building when the height exceeds 45 m (approx.) and small lateral loads due to seismic or wind forces will affect the building considerably. High-rise building can be used as a commercial building, residential building or for some other type of function. Residential high-rise buildings are called as Multi-dwelling Units which is accommodated with a lift. Building having height more than 150 m are called skyscrapers which are constructed or designed with skilled professionals and machines. High strength materials are required for such constructions and each and every aspect of structure are to be considered while designing so that safety is ensured. The concept of high-rise building is more common in developed countries as they have the brains and machines to make it possible. The design of RCC high-rise building is still easier than steel framed high-rise building as RCC building entails more self-weight which gives more stability under lateral loads. In order to construct high-rise steel structures, additional members such as shear walls and struts (bracings) are used frequently.

Due to complex architectural appearances, irregularity of a structure is another aspect of structure which is now commonly considered in infrastructure designs. Regular structures simply mean having symmetrical appearance in elevation and plan in all the aspects. But irregular structure can vary in elevation or plan which means different plans at different storey or having floating columns at any level or Re-entrant corners. The level of complexity increases with the number of irregularities introduced.L-shape, Plus-shape, U-Shape, O-shape building comes underplan irregularity. And Stiffness irregularity, mass irregularity, vertical geometric irregularity etc comes under vertical irregularity of the building which is more commonly considered.

II. LITERATURE REVIEW

Dhiman, et al. (2019), compared the conventional steel sections with modern tubular steel sections for columns. For this, 12-Storey Building (total 6 models) were prepared in staad.pro by dynamic seismic analysis in zone V. Cross and V-bracing systems were considered for additional stability. The effectiveness and economy of different steel sections with respect to different parameters were recorded and conclusions were drawn. From the results of the present paper, it was concluded that the ratio of displacement (i.e. Type B to Type A) is 1.16. The ratio of displacement for the buildings having cross-bracing (i.e. Type D to Type C) is 0.98. Whereas, the ratio of displacement for the buildings having cross-bracing (i.e. Type F to Type E) is 1.05. It was also concluded that tubular sections are more economical which ultimately saves up to 20% to 30% of material cost.[1]

Zhanga, et al. (2019),studied the self-centering steel framed structure having friction dampers in intermediate columns. This was carried out in order to resolve the problem of inter-storey drift as inter-storey drift normally exceeds the limit in high-rise building. Intermediate column containing friction dampers (ICFD) and web friction devices (WFD) were used which will dissipate the large energy under earthquake forces. In present study, 8-storey model was designed and analyzed on which pseudo-dynamic tests were conducted. FEM analysis was also carried out to validate the results of present study. From the results of this research, it was found that with the introduction of ICFD, the lateral stiffness increases significantly along with the energy dissipation. Concept like self-centered structures can be applied for large span structures also.[2]

Landolfo, et al. (2019), analyzed the lightweight steel framed systems (LWS). Main constituents of LWS entail gypsum, wood and cement-based panels which can be utilized for structural and non-structural infrastructures. The present paper evaluates its performance under seismic forces. The previously work along with the ongoing research work on LWS are reviewed and comparison was made available for different seismic coded of North America, Oceania and Europe. Other works such as the results of shake table which was carried out on LWS structural and non-structural architectural systems were also briefly reviewed. [3]

Papagiannopoulos, et al. (2018), compared the obtained results from 3-D non-linear seismic analysis (time-history) of concentrically braced steel model. It was ensured that only tension was sustained in the bracing of these steel structures without any compression. Cheap and easy fabricate brace was used in the present study as forces are released in compression and restrained in tension. Further comparison was carried out between the steel structures entailing braces having tension only and braces which restraint the buckling under the seismic responses. After analyzing the structures, it was concluded that both the braces show similar behavior when subjected to seismic forces. But the overstressing in the column of tension only braced structures was huge.[5]

Jing, et al. (2018), studied the computational modeling methodology which will help in determining the realistic load paths and load sharing when light-frame low-rise structure was analyzed under wind forces with the linear and nonlinear range. In order to achieve former, 3-D finite element modeling was done in order to evaluate the behavior of structure when subjected to wind forces, and tested at the Wall of Wind (WOW) Experimental Facility (EF) at Florida International University which ultimately provides investigational results in order to validate the FE modeling. Different materials along with the structural connections such as sheathing nails and framing-to-framing connections were accommodating by the numerical model which will help in predicting the performance of various structural members and connections. [6]

Tailor, et al. (2017), attempted to check the feasibility of Concrete-Filled Steel Tube which was used as a column in steel structure and evaluation was done with respect to performance and cost. An actually constructed structure was selected for the present study and it was designed as per the guidelines of IS800:2007. All the Columns of steel structure model were then replaced by equivalent square and circular Concrete-Filled Steel Tube columns. Seismic analysis was then carried out on both the models and comparison was done after evaluating the building's various members. Concrete-Filled Steel Tube (CFST) showed far better results than normal steel framed building when subject to static and dynamic loading. It was also found to be more economical than conventional steel frame.[7]

Bhosale, et al. (2017), investigated the seismic performance of structures with mass irregularity, stiffness irregularity and strength irregularity which may behave differently from that of regular structures. Different criteria were introduced for the design of irregular structures under natural hazards. Previous research work was carried on different methodologies which quantifies the elevation irregularities of the structures while evaluating the fundamental mode properties. In present paper, the accuracy of fundamental mode properties was checked in order to quantify the elevation irregularities. A correlation was created between the existing vertical irregularities with the seismic risk with respect to fragility curve, annual probability of collapse, and drift hazard curve. But no correlation was found between them. Structures having open-ground story and floating columns are more vulnerable to seismic risk when compared with regular building as per the results. But, stepped and setback structures performed better when compared with normal framed building. Therefore, detailed investigational research work needs to be carried on stepped and setback structures.[8]

Nassania, et al. (2017), had a scrutinized study of earthquake engineering and seismology field. Accurate type of member which resists lateral force has a significant impact on the performance and behavior of the building. Therefore, present paper presents the research work showing the comparison of behavior of steel framed structures by utilizing different bracing systems such as X type, V type, Inverted V type, Knee type and zipper type system under seismic forces. Different storey building models (total 4) were analyzed and designed under non-linear static and dynamic analysis. The model has 3 bays and bracing systems were introduced at the middle bay. The behavior of steel frame was evaluated in terms of drift ratio, capacity curve, global damage index, base shear, storey displacements, etc. the results reflected that steel framed structures behaved better when bracing systems were introduced. Almost 58% of drifts were reduced after adding bracing system to the structure along with the global damage index. [9]

Ali, et al. (2015), discusses the performance of frame-wall irregularities on existing reinforced concrete buildings which were hit by the 1999 Kocaeli Earthquake in Turkey. In particular, reference is created for the non-linear static analysis along with the non-linear dynamic analysis RC buildings entailing shear walls. While considering the merits of layered shell model it was selected for the present study. 3D model was also used to capture the damaged occurred after reconnaissance studies.[12]

Sharma, et al. (2015), studied the composite structure and compared it with the normal RCC and steel buildings. Numerous advantages are present for composite buildings over steel and RCC structures in different terms such as Strength, Costs, and construction time Period etc. Requirement of formwork is also eliminated because concrete will be filled inside of steel members. Therefore, in order to evaluate the performance of composite building, B+G+20 storey were modeled and comparison was carried out after analyzing them with seismic forces in zone 4 as per IS:1893(Part1)-2002. For modeling various structures, E-tabs software was used. The results were taken with respect to time period, base shear, total dead load along with the cost and time of construction. It can be concluded that, composite structures are found cost effective, more stable and requires less time for construction and are best solution to the modern infrastructure problems.[14]

Mahesh, et al. (2014), investigated the behavior of 12 storied regular and irregular residential structures while analyzing it with earthquake forces and wind forces in staad.pro and e-tabs analyzing and designing tool. Both type of analysis i.e. static and dynamic analysis were carried out on the obtained models. Different zones and locations were considered and assessment of the building's behaviors in such zones was done. The structures were evaluated in terms of story drift, displacements of column, base shear of building and the results are represented for different zones and different types of soils in order to compare.[16]

Nautiyal, et al. (2014),studied the scenario of various buildings with floating column in the different storey building in urban construction. As the presence of floating column is critical to the structure, therefore, from the design point of view, it is not preferred in earthquake active zones. Therefore, the exploration of the behavior of floating column was assessed in present paper under seismic excitation for different seismic conditions. There are no specified clauses in Indian standards related to floating column, therefore, the assessment of such structural members needs to be done.[17]

Patel, et al. (2013), had a research work on composite columns (i.e. Steel–concrete column) which are used commonly in buildings now days. Previously, many researchers carried their extensive research on such topic which entails steel hollow sections filled with concrete mass. Therefore, in present paper, a comparative investigation was carried out on 10storey, 20 storey and 30 storey entailing CFT, R.C.C. and Steel structures. Various structural parameters were recorded such as time period, displacement, base shear etc for comparison purpose. Result revealed that building entailing CFT has better load carrying capacity than RCC and Steel sectional buildings. [18]

Nanduri, et al. (2013),studied the behavior of outrigger in the structure. For this purpose, various 30‒storey structures were modeled entailing various configurations of outrigger and belt truss and analyzed under seismic and wind forces. In final conclusion, the results of lateral displacement of the building were compared. Almost 23% of the lateral displacement was restricted and reduced with first outrigger at the topand second outrigger in the structure height. The evaluation of the second outrigger was also studied thoroughly and results were drawn in various forms.[19]

Safarizkia, et al. (2013), aims to evaluate the performance of improved existing reinforced concrete building by the use of steel bracing under seismic analysis. Nonlinear Static Pushover Displacement Coefficient Method, Improvement of Nonlinear Static Pushover Displacement Coefficient Method, dynamic time history analysis were the methods used to analyze the structures. The utilization of steel bracing was done in order to improve the existing stability of the structure. The results reflect that the displacement was reduced up to 16%-55% if steel braces are used. And storey drifts after retrofitting comes within the limits.[20]

III. CONCLUSION

The present review involved various methods of related to steel structures and irregular structures. Several techniques were tried in order to resist lateral forces such as wind and earthquake forces such as introduction of bracing system and shear wall in steel structure so that additional stability is provided. Different methods have different advantages and different behavior of structural members. Following are some findings from the reviewed literature related to steel structures and irregular structures.

- Maximum and minimum ratio of displacement of column (having tubular sections and conventional sections) in 12 storey steel building comes out to be 1.16 (with no bracing) and 0.98 (with cross-type bracing).

- Almost 20% cost is reduced when tubular sections are used in 12 storey steel structures with or without bracing systems.
- The seismic resistance of steel frame was drastically enhanced after introducing the bracing systems. The inter-storey drifts were reduced effectively by different bracing elements up to 58%. Along with drifts, the global damage index was also decreased considerably.
- The time history analysis results were found almost same to that of pushover analysis. The frames with bracing system reflect lesser displacement values and damage index when compared to frames without bracing system.
- The values of base shear were calculated with extended N2 method and the nonlinear time history method are 1537 kN and 1929.46 kN respectively which reflects better correlation.
- Further the result of analysis shows that the capacity of irregularities decreases due to basement shear wall.

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