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Buildings in Severe Earthquake Zones Made Of Structural Steel Hollow and Plate Members

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ABSTRACT
In old days wooden buildings were made in highly earthquake prone areas for its low weight. Nowadays with the advancement of steel industry if we can make these type of buildings using square hollow sections/rectangular hollow sections, steel plated/wooden floors and puffed panel walling systems then it will be more strong and low weighted also. These types of buildings are green, sustainable and eco-friendly. In this paper one model building has been analysed for seismic zone IV or wind speed 47 m/sec as per Indian Standard. Purpose of the building is residential or normal office type. It is found that wind forces developed in the structural members are greater than the seismic forces generated in the same. Because of low mass seismic forces are not generated despite of heavy ground acceleration. Proper steel bracing systems are provided vertically and horizontally for stability of the structure. The production of new structural hollow members, chequered plates, puffed/sandwiched panels have created a new era in building industry making it more sustainable in all respects.
Key words: Severe earthquake zone IV, Steel building, Hollow structural members, Steel floor, Puffed panel walls, Low weight

I. INTRODUCTION

The purpose of study is to understand the effect of earthquake on such building in highly seismic prone areas and the goal is to find ways and means to control seismic effects on those buildings. It will encourage construction of such buildings in highly seismic areas if not in large scale, at least in the construction of building marked as important building which needs to provide service to the population immediately after the event (earthquake) or building which cannot afford to be dysfunctional, such as railway stations, airports, telephone exchanges, bureaucratic offices, police stations, army headquarters etc. for any period of time. Schools and colleges should also come under this category because effect of earthquake in such buildings as would be revealed from the study is limited or even if there is limited effect, swift restoration is possible in such buildings. This is primary aspect. This should be encouraged in all parts of the country irrespective of seismic zone. The other aspect is to encourage buildings higher than 4 storeys in hilly areas of zone IV and all building in hilly areas of zone V as per Indian Standard to be steel buildings. In plain areas of zone V discretion should be used by local authorities primarily keeping in mind the height and volume of the building, the inclination should be to encourage steel buildings using low weight partition and flooring as suggested in the study. The purpose through the study is to encourage low weight construction. Heavy RCC design method is not suitable in highly earthquake prone areas.

II. BACKGROUND

The paper is built on the well known back ground of the damage that is caused by earthquake both in terms of life and property, which are visible losses. But for me more than the visible losses are the invisible traumas that people face during the earthquake and a certain period after the earthquake is more important. It is observed that people are staying nights after nights in playgrounds and open streets not knowing that open streets can be even more dangerous after earthquake. Frantic calls to experts and structural engineers are made to understand what to do and what not to do. The point that is missed is that not much can be done during those emergencies, and expert advices are not given due importance as emotions run high and hence more casualties. The point that is to be taken is that provisions should be made in advance such

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that the emergencies can be averted or at least minimized through good policy decisions. Good policy decisions can help minimize loss of life and property and more importantly the mental traumas that humanity suffers during and after the event.

One such good policy that we can propose as structural engineer is the **construction of steel buildings** (as proposed in the paper) in highly seismic prone areas in such a way that it is least affected by earthquake.

With this knowledge as back ground, our clear intent is to propose the design of a steel building with structural components (closed hollow steel sections SHS/RHS) and non-structural components (puff panels for walls and steel profiles as floor) such that seismic effect of the buildings can be eliminated or reduced to a great extent by reducing the seismic weight of the building, such that loss of life and property and more importantly mental trauma can be reduced.

The problem is that, human memory is short and we tend to forget everything over a period of time, but responsible authorities should not miss the point.

III. PROBLEMS WITH CONVENTIONAL DESIGN

Basic problems with conventional RCC design are:

- Heavy weight of building and hence high seismic effect.
- Depleting natural resources in the form of fine and coarse aggregates (which are used as raw materials) thus weakening the earth and on the other hand, additional pressure in the form of heavy buildings are put on it.
- Resulting effects are frequent earthquakes, landslides and storm floods.
- High restoration time and cost of affected buildings and hence greater effect on economy.

It is to be noted that due to ease and low cost of construction, RCC building will continue to be used, but at least for selected purposes, buildings as proposed in the paper should be used. This will have desirable effect on economy of the country in longer term.

IV. EARTHQUAKE – WEIGHT OF BUILDING – DUCTILITY

It is a well known fact that seismic forces are reduced with reduction of weight of building. That ductile behavior of steel is effective in dissipating seismic forces during the period of motion and comes back to the original position most of the time without much damage. Even if there are damages, it is very limited and easily repairable. The paper uses these well known facts and advantages to design a building with steel hollow sections in earthquake zone IV which is least affected by earthquake forces.

V. BRACINGS – TIME PERIOD – DISPLACEMENT

The building proposed in this paper has been designed with all shear connections. Hence vertical bracings have been used. It has been observed during analysis that placing and quantum of bracings plays a key role in controlling the overall stiffness and hence the time period of the building. Higher quantum of bracings will increase the stiffness and also the earthquake forces which are not desirable. On the other hand inadequate bracings will increase displacement/drift of the building which a steel building will be efficient to resist because of ductility but will cause discomfort to inhabitants. Hence proper judgment is to be used to place bracings. It can vary with configuration of building. Proper review of analysis results will be required before proceeding with design. In the case of low weight building bracing system should not cause any adverse effect. Moreover, it will establish structural stability in the building skeleton frames.

VI. DESIGN OF SIX STOREY STEEL BUILDING IN EARTHQUAKE ZONE-IV WITH IMPORTANCE FACTOR 1.5, AS PER IS-1893 CODE:

- Materials used for columns, beams and bracings would be closed steel square/rectangular hollow sections of yield strength fy = 315 N / mm^2.
- Partition walls would be of low weight puff panels or glass as per architectural requirements.
- Flooring would be of stiffened steel plate of 6mm thickness/wooden with horizontal bracings.
- Response spectrum analysis has been done. Cross checked by p-delta analysis.
- Wind analysis has been performed. Basic wind speed assumed as 47m/sec.
- Following drawings are furnished to show the structural arrangement and achieved sections.
- Connections to be provided as per analysis assumptions.
- Ductile property of steel an advantage for earthquake resistant design has been acknowledged.

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- Importance has been given to reduction of weight of building by using low weight structural and non structural materials.

Intent is to design a building in earthquake zone IV in such a way that it is least affected by earthquake.

VII. RESULTS

Results achieved justify the intent to a great extent and are summarized below:

- Design results reveal that more than 90% of the members are critical in Dead load, Live load and Wind Load combinations.
- Even the balance 5-10% of the members which show criticality to earth quake forces are very marginal.
- Only those members (mainly columns) which are in proximity to the vertical bracings show criticality to earthquake forces which need slightly heavier sections.

VIII. CONCLUSIONS

- Findings encourage the initial assumption of encouraging steel buildings in highly seismic prone areas.
- Initial cost can be an issue compared to RCC building.
- Government initiative needs to be taken such that all important buildings such as railway stations, airports, bureaucratic offices, municipal offices, hospitals, telephone exchanges which are run by govt. Should be steel buildings.
- Then it should be extended to all schools, colleges and other buildings which are marked important as per IS-1893.
- Regulations should be in place to encourage such building in **zone V** and **hilly areas in zone IV**.
- Should be made mandatory **beyond a certain height** in zone IV and hilly areas in any zone.

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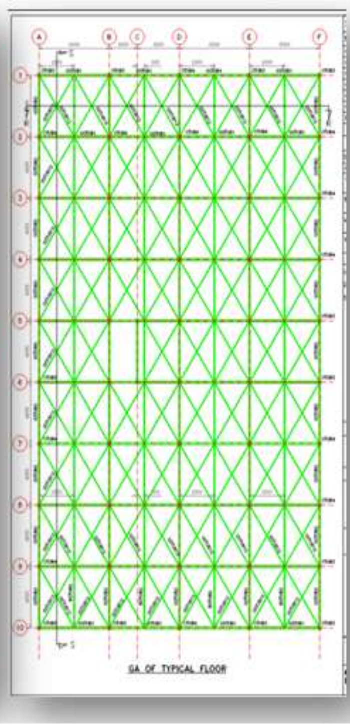

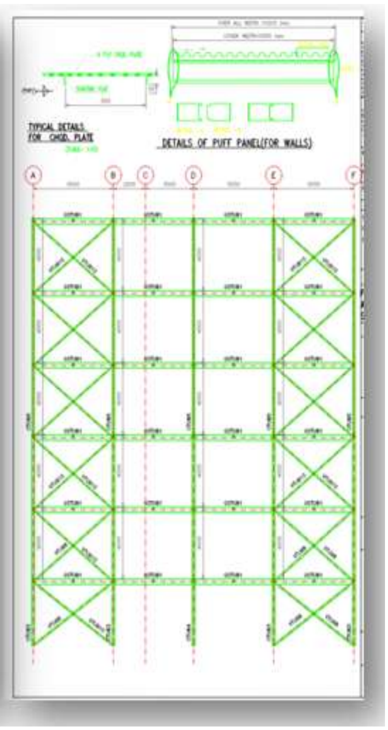

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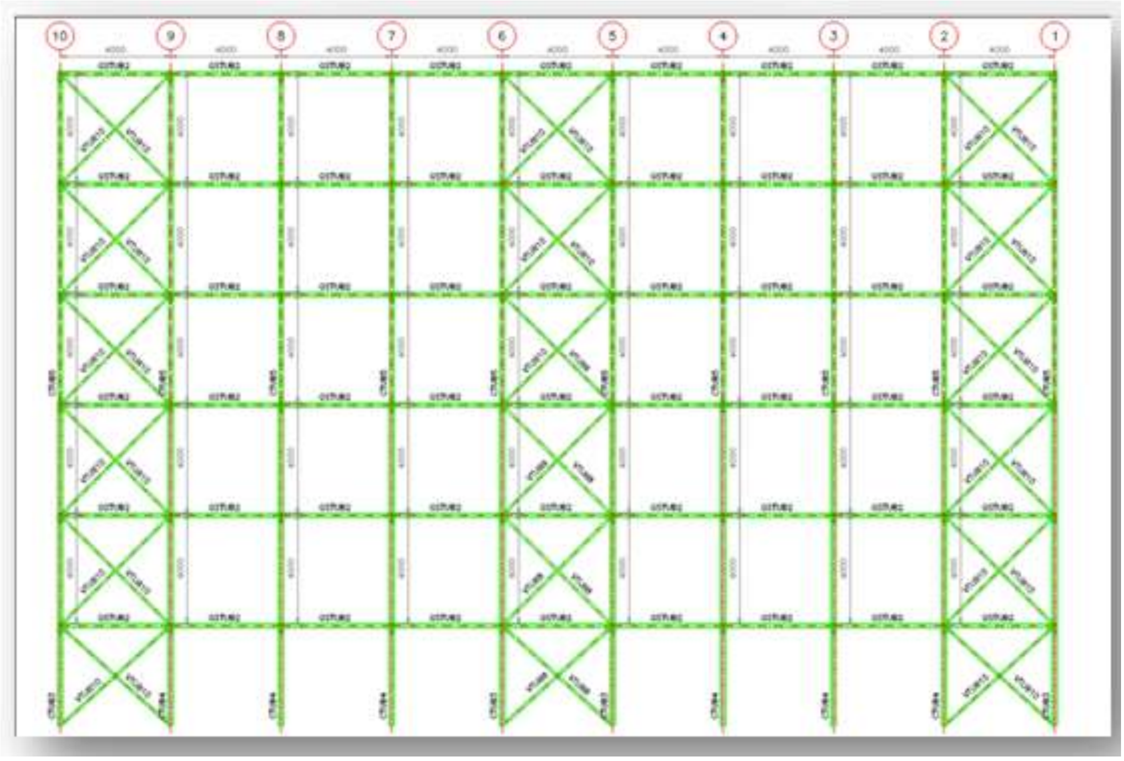

Figure 1: Building Plans and Elevations