INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue2)
Available online at www.ijariit.com

Remedial Measures to Seismic Effects for Architectural and Structural Design

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Abstract: ***Architectural and structural features are mutually dependent on each other in a seismic resistant design. Their interrelation should be such that it does not impede its behaviour in seismic zones. This paper follows the study of principles, methodology, measures and certain remedies to contradict effects of earthquake on structures. A proposition on step-back building form is presented, stating that how a step-back building can perform productively during ground motion. As a result eccentric values are analyzed to reduce torsion so as to attain a stable structural configuration.***

Keywords: Concentrated load; Deformation; Ductility; Flexible floors; Load distribution; Step-back building; Stiffness; Strength; Torsion.

INTRODUCTION

Architectural features and structural configurations are inter-related in a building. There interaction may be such that it can truncate the capacity to resist ground motion. Impacts of seismicity over structural and non structural elements are unalike. Therefore, it is necessary that the design is such that both the elements are consonant to each other. Otherwise, there will be chances of damage or a complete collapse.

Hence, all the structural, non-structural and other spatial elements that are associated to
a building must be in a harmony. The basis of this scheme is to ensure that these elements behave in accordance to the structural design.
Like in a building both beams and columns should perform synchronously so that it can handle earthquake effects without any chance of collapse.
This situation includes describing basic principles of earthquake resistant architecture, relationship between architectural features and structural configurations and how to harmonize them, and measures to enhance the response of building against seismicity.

PRINCIPLES

The basic principle for designing a seismo-resistant building depends upon the four aspects of buildings that are;
Seismic structural configurations
Lateral stiffness
Lateral strength
Ductility
Other than these aspects there are several more considerations that are to be kept in mind while designing like; Shape, appearance, functionality and feasibility of building.
Strength, stiffness and ductility of buildings should be achieved by referencing legitimate seismic design codes. Structural configurations that perform better during ground motion are the results of coherent architectural features that do not hinder structural features.

MEASURES TO ENHANCE THE RESPONSE OF BUILDING AGAINST SEISMICITY

- Simplicity in the building form tends to the smoother movement of forces i.e. there is no changing of path while travelling of forces.
- Reducing extra unnecessary weight like thickness of plaster, depth of roof from the building or by using the materials that are light in weight.

- Floors that are purposed with heavy concentrated loads should be located at lower levels of building rather than at higher levels.
- Shape of the building should be such that its centre of mass coincide the geometrical centre. This situation results into a balanced configuration and hence, the building will not be susceptible to torsion effects.
- Materials used for construction should be referred from the design codes.
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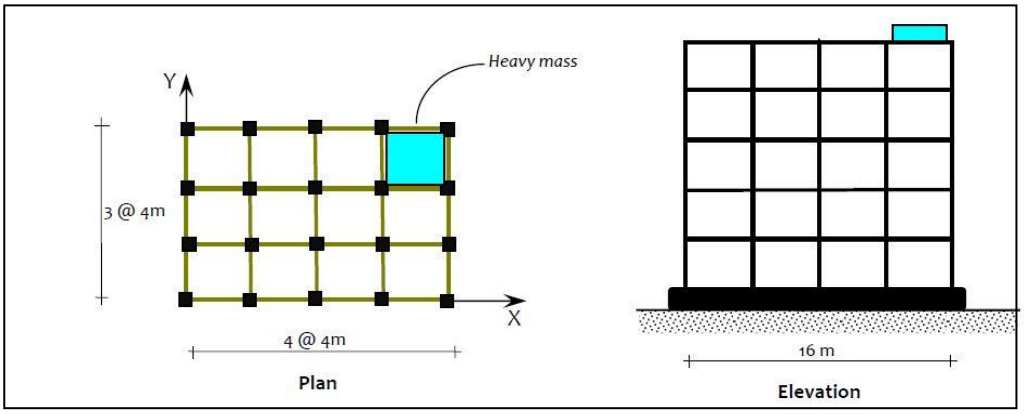
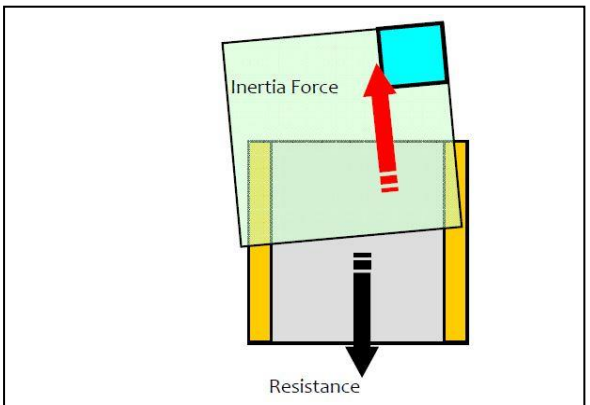
RELATIONSHIP BETWEEN ARCHITECTURAL FEATURES AND STRUCTURAL CONFIGURATIONS AND HOW TO HARMONIZE THEM

There are certain criteria that are to be considered while designing structures that are vulnerable to earthquake shaking;

Load distribution
A building with multiple storeys might function differently at different storeys. In that case, it is not possible to distribute loads evenly. So, zones like swimming pools, warehouses, heavy machines should be placed at lower levels.
So, it can be stated that "higher storeys should be the lighter ones".

Concentrated loads
A symmetrical built form has the least chance of being affected by torsion. Symmetry of a building is not only stated by its plan but by the fact that every element is evenly distributed. Irrespective of non-structural elements whose mass are negligible in comparison to the mass of whole unit.

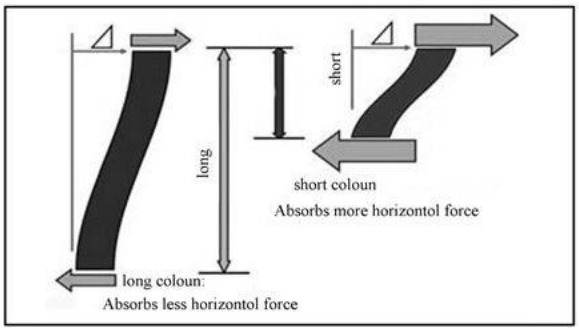




Concentrated mass at one corner of building

Flexible floors
Open floors or soft storey forms a discontinuity in the linear movement of forces to the ground.
This causes concentration of forces at the junction which can make them weak.
The presence of such large openings makes it vulnerable to damage. Therefore, it is advisable to avoid such floors. There might be some situation in which column separation at bigger spans are required, so, such floor should be kept at the top or designed as an individual unit.

Short columns
Since short columns are stiffer, therefore, the flexibility of other columns will vary with these columns but there length deformation will of same amount. So, there will be more chances of concentration of forces at these columns.
Hence, they are more receptive to rupture which may result in total collapse or twisting effect. Shape and site location of the building should be considered in this case.



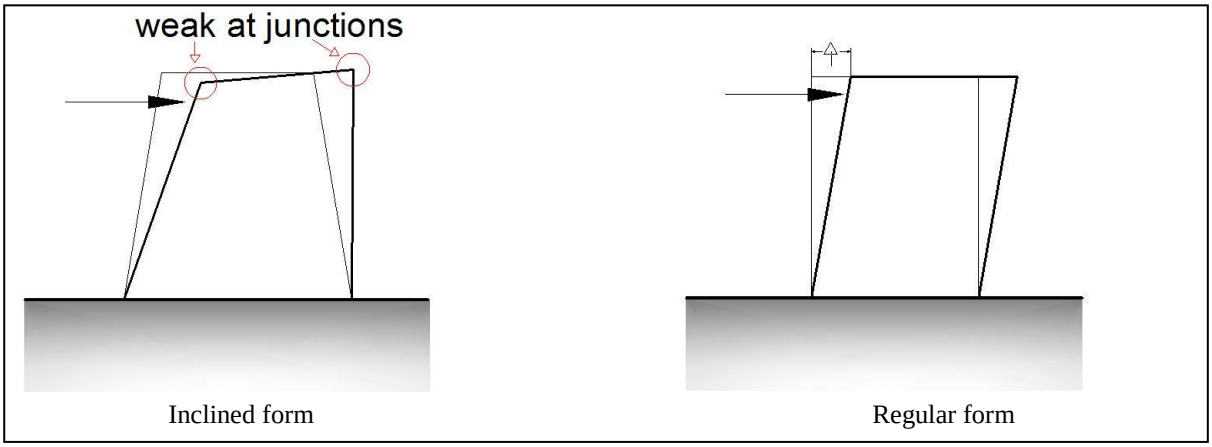
Lateral deformation in columns

HOW CAN WE REDUCE MASS OF THE BUILDING AT HIGHER LEVELS

A building tends to be more stable when it does not have any concentrated loads and heavy masses at higher levels.
We can relate it to the general concept of pyramid, where the mass is gradually reduced till the top by giving its exterior a certain amount of inclination. That inclination in seismic prone area will have a negative impact.

EXPLANATION

In a regular form of building there is a lateral displacement Δ caused by horizontal force.
But the result of deformation for an inclined wall is something different. Here, along with the horizontal displacement, roof undergoes certain amount of inclination making beam-column joint weaker.



Deformation due to horizontal forces

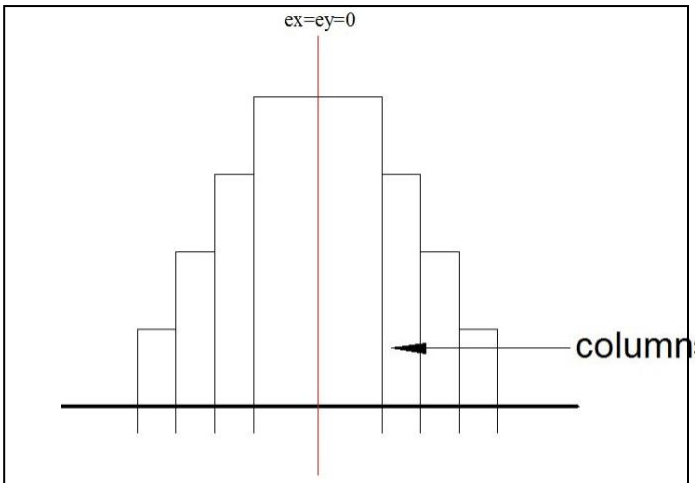
INFERENCE

- Final form of the building in every aspect (i.e. both plan and elevation) should be symmetrical so that there is no chance of concentration of mass at a point which don not lie on geometric centre.
- Mass should be reduced gradually till the top by giving a step-back in every floor respectively.
- Inclination in walls is detrimental to good resilient behaviour of buildings. Hence, it should be avoided as far as possible.

RESULT

A step-back building which is symmetrical and its centre of gravity and geometric centre coincides can be taken under consideration. This condition will help the structure to be less susceptible to torsion.

Other than geometrical regularity, type of column plays an important role in such kind of building. Floating columns are not desirable for earthquake resistant buildings. Therefore it is mandatory for columns at higher floors to be continued till footing. Continuity of columns means that forces do not have to change their path while travelling back to the ground.A step-back form is functional as well as appealing. Such type of form can be beneficial while designing a high rise structures.



ex: eccentricity in the x direction
ey: eccentricity in the y direction
Step-back building

CONCLUSION

This research concludes that after learning general principles, by laws, codes, measures and guidelines to enhance performance of a building (that confer to both architectural and structural design) in seismic zone, how can a step-back building form be stable and feasible during ground motion. By reducing the value of eccentricity, twisting effects can be reduced to a great extent.

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