Seismic load Effect on Building Configuration

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Abstract— The behavior of building during Earthquake depends critically on its overall shape, size and geometry. The Seismic performance of building is available and new design methods should account for the building ability to dissipate energy and the effect of the lateral deformation. These aspects involve both plan and structural configuration of building. This paper presents structural and seismic behavior of buildings. The purpose is to outline the criteria loading on structure of building during strong earthquake. Building are the complex system and multiple configuration have to be considered at the moment of designing them. That's why at the planning stage of building, architects and structural Engineers must work together to ensure that the unfavorable features are avoided and good configuration is chosen.The Indian standard code IS 1893 (part I: 2002) guideline & methodology are used to analyze the problem.

Key words: Building Shapes, structural configuration, seismic effect, building response, structural irregularity, susceptible

I. INTRODUCTION

The Indian subcontinent has a history of devastating earthquake. The major reason for the high frequency and intensity of the earthquake is that the Indian plate is driving into Asia at aerate of approximately 47 mm/year. Geographical statistics of India show that almost 54 percent of the land is vulnerable to earthquakes. During the last decade, however, three strong large earthquakes (M6.0-7.9) occurred in peninsular India. The 1993 Killari earthquake in the southern block of the shield, the 1997 jabalpur earthqake in the central SONTA zone and the 2001 Bhuj earthquake in Kuch rift basin; in the western part of shied. They are majorly damaged in building failure due to poor structural configurations. (Figure.1).

Fig. 1: A Photo of Bhuj Earthquake major damages in building.

Shapes and structure has significant bearing on the performance of building during strong earthquake. Building characteristic is the fundamental period of vibration of the Building (measure in seconds). The fundamental period of a building depends in a complex way on the stiffness of the structural system; its mass, and its total height. Seismic waves with periods similar to that of the building will cause resonance, and amplify the intensity of earthquake forces that building resists. The amount of force individual structural seismic elements and their components must resist. Structural configuration is important characteristic that affects building response. Earthquake-resistant buildings, particularly their main elements, need to be built with ductility in them. Such buildings have the ability to sway back-and-forth during an earthquake, and to withstand earthquake effects with some damage but without collapse. Ductility is one of the most important factors affecting the building performance. for the earthquake prediction provide good detailing at prone location to ensure ductile behavior of building. Earthquake shaking of a simple rectangular building results in a fairly uniform distribution of forces throughout the building. In a more complex T or L shaped building, forces concentrated at the inside corners created by those shapes. Similar arise when a building has floor roof levels of adjacent portions offset vertically (split levels) or when the first storey is taller or 'softer' than the other stories. Irregularly shaped building, shown in Fig- are subjected to special design rules because otherwise they can suffer greater damage the regularly shape of building.

II. STRUCTURAL CONFIGURATIONS

Configuration plays an important role in the seismic performance of structure subjected the Earthquake actions. Concentrations of inelastic depend are likely to occur in zones of geometrical discontinuities and/or mass and stiffness irregularities if the available ductility is limited, failure is initiated, thus possibly leading to collapse. Structural configuration, in plan and elevation, on seismic performance depends upon:

(1) Size- as the absolute size of structure increceses; the range cost-efficient configurations and system is reduced. For example, while standardized simple and symmetrical shapes are generally used for high rise building, more option is available for low to medium rise structure. Size may also dictate the choice of specific material of construction. For example, high rise structures may require high-strength concrete (e.g. Laogon and Elnashai, 1999; Aoyama, 2001, among others).

(2) Proportion- Earthquake response of a structure depends on its relative proportion rather than absolute size. Low slenderness in plan and elevation is beneficial reduced elevation slenderness ratio minimize overturning effects for building, the ratio of the height(H) to the smallest depth (B) should not exceed 4-5 (Dowrick; 1987).This figure is exceeded by for in moern tall building wide, which exhibit H/B of 10-15 (CTBUH, 1995).

(3) Distribution and concentration- vertical and plan distribution of stiffness and mass is important to achieve adequate seismic performance. In tall and slender building and slender building, lateral deformability reduces the earthquake-induced forces.

(4) Perimeter resistance- torsion motion tends to stress lateral resisting system non-uniformly. High earthquake-induced torsion moments can be withstood by lateral resisting components located along the perimeter of the structure as displayed in fig. Perimeter column and wall create, for instance, structural configuration with high rigidity and strength (Also preferred to as torsion stiffness and resistance. The higher the radius of gyration of the plan layout of the structure, the higher the lever arm to resist overturning moments. In framed systems, the bending stiffness is significantly affected by the layout of columns in plan and elevation. Frame employing perimeter columns possess high bending stiffness and resistance; this is also true for frame wall system(Figure.2)

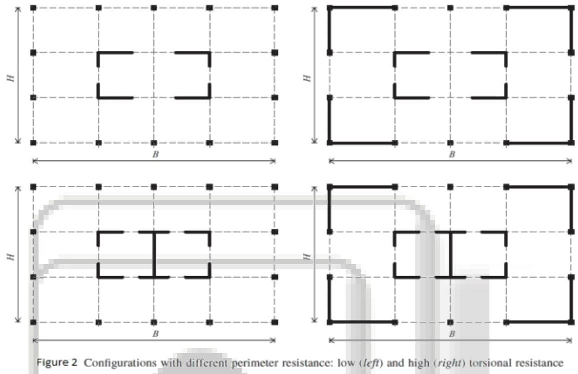

Fig. 2: Configuration with different parameter resistance

III. IDENTIFICATION OF DAMAGE IN RCC BUILDINGS

Reinforced concrete buildings have been damaged on a very large scale in Bhuj earthquake of January 26, 2001. These buildings have been damaged due to various reasons. Identification of a single cause of damage to building is not possible. The principal cause of damage to building are soft stories, floating columns, mass irregularities, poor quality of material, faulty construction practices, inconsistence seismic performance, soil and foundation effect, pounding of adjacent structures and inadequate ductile detailing in structural components, which have been described in detail subsequently.

A. Soft Storey Failure

In general, multistoried buildings in metropolitan cities require open taller first storey for parking of vehicles and/or for retail shopping, large space for meeting room or a banking hall owing to lack of horizontal space and high cost. Due to this functional requirement, the first storey has lesser strength and stiffness as compared to upper stories, which are stiffened by masonry infill walls. This characteristic of building construction creates "weak" or "soft" storey problems in multi story buildings. Increased flexibility of first story results in extreme deflections, which in turn, leads to concentration of forces at the second storey connections accompanied by large plastic deformations (Figure.3).

Fig. 3: Soft storey building failure during Bhuj Earthquake.

B. Floating Columns

Most of the buildings in Ahmedabad and Gandhidham, are covering the maximum possible area of a plot within the available bylaws. Since balconies are not counted in Floor Space Index buildings have balconies overhanging in the upper stories beyond the column footprint area at the ground storey, overhangs up to 1.2m to 1.5m in plan are usually provided on each side of the building. Lateral forces accumulated in upper floors during the earthquake have to be transmitted by the projected cantilever beams (Figure.4)

Fig. 4: Floating column building damage during Bhuj Earthquake

C. Building response characteristics

When a structure is subjected to ground motions in an earthquake, it responds by vibrating. The random motion of the ground caused by an earthquake can be resolved in any three mutually perpendicular directions: the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads — force equal to mass times gravity in the vertical direction. The building is thrown backwards and the roof experiences a force called the inertia force (Figure.5).

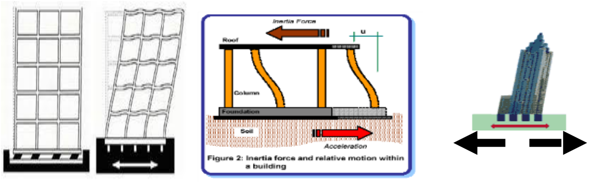

Fig. 5: Ground acceleration during Earthquake causes inertia force

For structures having lateral force-resisting elements (e.g. frames, shear walls) in both directions, the design lateral force is considered along one direction at a time, and not in both the directions simultaneously. Structural systems using concrete or masonry shear wall are stiff and result in building with short period, where as more flexible moment frame systems have longer period. Therefore a marked flexibility has to be pursued for structural internally equipped with dissipative devices (Figure.6)

Fig. 6: Dynamic motion of building due to flexibility

To perform well in an earthquake, a building should possess four main attributes, namely simple and regular configuration, and adequate lateral strength, stiffness and ductility. In minor but frequent shaking, the main members of the building that carry vertical and horizontal forces should not be damaged; however building parts that do not carry load may sustain reparable damage but moderate condition building may be damaged such that they may even have to be replaced after the earthquake but, after strong earthquake, the building may become dysfunctional for further use, but will stand so that people can be evacuated and property recovered. The storey lateral strength is the total strength of all seismic force resisting elements sharing the storey shear in the considered direction. Different types of damage (mainly visualized though cracks; especially so in the concrete and masonry building) occur in building during earthquake. Some of these cracks are acceptable (in terms of both their size and location), while others are not. For instance, in a reinforced concrete frame building with masonry filler walls between columns, the cracks between vertical columns and masonry filler walls are acceptable, but diagonal cracks running through the column are not (figure.7) .

Fig.7: the cracks between vertical columns and masonry filler walls.

D. Irregularity in structural configuration of buildings

Seismic causes impulsive ground motions; which are complex and irregular in character, changing in period and amplitude each lasting for short time. Therefore, resonance of type as visualized under steady-state sinusoidal excitations; will not occur as it would need time to build up such amplitudes. Some irregularity type in structural configuration description below:

1) Torsion irregularity:

Tensional irregularity to be considered to exist when the maximum storey drift, calculated with design of eccentricity, at one end of structures transverse to an axis is more than 1.2 times the average of the storey drifts at the two ends of the structures. Re-entrant corner are greater than 15 percent of its plan dimension in the given direction. In general, building with simple geometry in plan has performed well during strong earthquake (Figure.8).

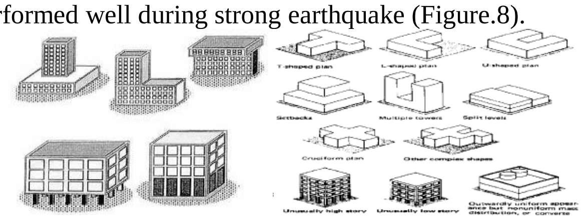

Fig. 8: Shape irregularity with causes earthquake.

2) Stiffness irregularity (soft storey & Extreme storey):

A soft storey is one in which the lateral stiffness is less than 70 percent of that storey above or less than 80 percent of the average lateral stiffness of the three storey above in the case of extreme soft storey is one in which lateral stiffness is less than 60 percent of that in storey above or less than 70 percent of average stiffness of the three storey above.

3) Mass irregularity-

mass irregularity when the seismic weight of any storey is more than 200 percent of that of its adjacent storey's.

4) Discontinuity in load carrying capacity (weak storey):

A weak storey is one in which the storey lateral strength is less than 80 percent of that in the storey above. Ideal configurations for earthquake - resistant design should possess the attributes listed in Table.1 Major Benefits that can be achieved are also given in the table. Features in Table.1 can be utilized to classify configurations as 'regular' or 'irregular' Regular structures are those employing the attributes in Table.1. These systems generally show adequate. Seismic performance; regularity is thus necessary but not sufficient under earthquake loading. Detailing is as important as regularity. Although expressed in a qualitative rather than quantitative manner, Table.1 provides simple guidelines that can be used in conceptual structural seismic design.

Attributes Benefits	**Low width - to - depth ratio Low tensional effects**
Low height - to - base ratio Low overturning effects	Similar storey heights Elimination of weak/soft storeys
Short spans Low unit stress and deformation	Symmetrical plan shape Elimination/reduction of torsion
Uniform plan/elevation stiffness Elimination of stress concentrations	Uniform plan/elevation resistance Elimination of stress concentrations
Uniform plan/elevation ductility High energy dissipation	Perimeter lateral resisting systems High tensional resistance potential
Redundancy High plastic redistribution	
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Table 1: Attributes and benefits of optimal structural configurations.

IV. CONCLUSIONS

Building having simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than building with irregular configuration. The least base shear is obtained in the case where the building is symmetrical in horizontal & vertical plan. There is substantial change in the lateral forces when any type of unsymmetrical like soft or weak storey, Infill wall etc. is incorporated in the building. Base shear is more or less of the same magnitude irrespective of change in configuration of the building. The most severe case is observed when the Ground floor is devoid of infill walls.

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