International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue14
November 2017

Effects of Torsion Lateral Stability of Building Structure

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ABSTRACT: *This paper surveys the effects of torsion on the global lateral stability of a shear wall building with typical plan and elevation layouts. In order to achieve the goal of study, a parametric investigation procedure is undertaken, on a series of sample structures with a condition which can cause torsion and their lateral stability under earthquake and gravity loading is investigated and discussed. To study the effects of torsion on the lateral stability of building structures, three asymmetric models are constructed by moving the shear-wall couple in the centric model from grid lines "-X1_X1" to grid lines "X1_ X2" in one model, and to grid lines "X2_X3" and grid lines "X3_X4" in another models. In addition the effects of axial loading and increasing storey number on the lateral stability of building structures are parallely studied on one of the series models. To study the influence of storey number, three different stories are constructed on the same series model keeping their inter storey height constant. Load-displacement diagrams are constructed for the above three conditions and are shown in Figure 6-1_Figure 6-10. From the Load-displacement diagrams, global lateral stability "D" is computed. Reduction in global lateral stability due to the induced asymmetry proved to be (89%, 97% and 98%) respectively. Furthermore it is shown that the effect of axial loading is considerable in both the centric and eccentric wall configurations. And the lateral stability of a structure on the same configuration decreases while increasing storey number. Thus depending on the analysis results conclusions and recommendations are made and some further studies are forecasted*

INTRODUCCTION:

Background of Study Field inspections of earthquake performance of buildings demonstrate that the simpler the building the better the behavior, all other parameters being similar. Here are two main reasons for this: first, it is easier to understand the overall earthquake behavior of a simple building than that of a complex one; second, it is easier to understand, formulate in drawings, and construct simple structural details than complicated ones. Symmetry and regularity in plan and elevation are desirable for much the same reasons. Symmetry is important in both directions of a plan. Lack of symmetry (in mass distribution and/or in stiffness, strength and ductility) leads to torsional effects which are difficult to assess properly and which can be very destructive. A plan layout with reentrant angles should be avoided (see Figure1.1 below).

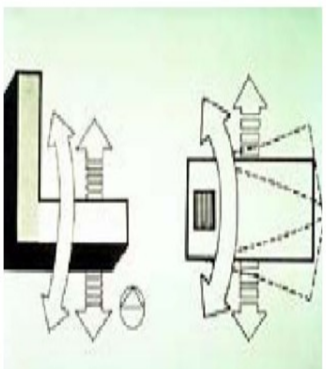

Figure 1-1: Shape of Building Plan (L Configuration) and By a Very Stiff Off-Center Core Area in a Rectangular (Regular) Plan Building.

Figure 1-1 shows torsional effects created by irregular shape of building plan (Lconfiguration) and by a very stiff off-center core area in a rectangular (regular) plan building. A structure with a complex configuration is subjected to torsion. When a building twist, its wall and frames displace at each floor about some center ofrotation creating inter storey drift. More over the building will be subjected to high acceleration with shorter period during earthquake hazards. A well planned structural configuration or form, in conformance with code requirements, is expected to achieve objectives such as ϖ Predictable behavior ϖ Simplicity of design & construction ϖ Minimized structural cost for the required function The objectives of the architectural and other design team members however, may not primarily have these goals as aesthetics and specialized function, to name a few, may have equal or greater priority. Moreover, they may be in direct conflict with the goals of structural design. Early cooperation with other design team members, who have a stake in the structural form, can be very effective in realizing the desired objectives and achieving the cost/benefit tradeoffs that are acceptable to all. The structural engineer, being aware of the implications of building configuration on the stated objectives, is obliged to inform the team of any adverse impacts preferably at the earliest opportunity in the planning process. This is because architects are responsible for the architectural configuration of buildings at first and architects may have greater priority to aesthetics, space and circulation than the structural stability of the building. If you tour around construction sites in the city, it is not uncommon to see walls located arbitrary. For instance the following buildings are typical examples of buildings

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where structural walls and lift shafts are at an extreme edge.

1.2. Objective and Scope of Study

1.2.1. General Objectives Providing conceptual design to architects and clients. Conceptual design is defined as the avoidance or minimization of problems created by torsion by applying an understanding of the effect rather than using numerical computations. ϖCreating control or decrease of demands: a decrease in demand can be achieved by a proper selection of the configuration of the building and its structural layout and by the proper proportioning and detailing of the structural and non-structural components, that is, by following the basic principles or guideline for achieving efficient lateral stability.ϖ Increase awareness to professional architects and graduate engineers.

1.2.2. Scope of Study Material linearity is considered throughout the analysis. ϖ The study is conducted on series samples regular in plan and elevation with stiff off wall location. ϖ Structural walls are considered to resist moments while contribution of frames is ignored.

2. LITERATURE REVIEW

2.1. Torsion An eccentric system is defined as a system with non-coincident center of mass and center of stiffness where center of mass is the point at which all the mass of a body may be considered to be concentrated in analyzing its motion. Non uniform distributions of mass, stiffness and strength in an asymmetric building cause the building to experience torsional moments and rotational deformations around vertical axises. Rotational deformation cause non uniform distribution demand in lateral force resisting elements and increased damage in an asymmetric buildings[Error! Reference source not found.]. The vulnerability of asymmetric buildings has been addressed by building seismic design codes in the form of special torsion provisions. In these provisions the design eccentricity is defined as a combination of the stiffness eccentricity and accidental eccentricity. The plane in which any transverse force applied through causes no torsion is called Shear Center.

2.2. LATERAL STABILITY, Drift and P-Delta Design for drift and lateral stability is an issue which should be addressed in the early stages of design development. In many cases, especially in tall buildings or in cases where torsion is a major contributor to structural response, the drift criteria can become a governing factor in selection of the proper structural system. The relative lateral

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p-ISSN: 2348-795X
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displacement of buildings is sometimes measured by an overall drift ratio or index, which is the ratio of maximum lateral displacement to the height of the building. More commonly, however, an inter story drift ratio, angle, or index is used, which is defined as the ratio of the relative displacement of a particular floor to the story height at that level. The term drift means the relative lateral displacement between two adjacent floors, and the term drift index, is defined as the drift divided by the story height

2.2.1. Concept of Lateral Stability To illustrate the concept of lateral stability, consider an ideal column without geometrical or material imperfections. Furthermore, assume that there are no lateral loads, and that the column remains elastic regardless of the force magnitude. If the axial force is slowly increased, the column will undergo axial deformation, and no lateral displacements will occur. However, when the applied forces reach a certain magnitude called the critical load (Pcr), significant lateral displacements may be observed.It is important to notice that when the magnitude of axial force exceeds Pcr, there are two possible paths of equilibrium: one along the original path, with no lateral displacements, and one with lateral displacements. However, equilibrium along the original path is not stable, and any slight disturbance can cause a change in the equilibrium position and significant lateral displacements. The force Pcr is called the bifurcation load or first critical load of the system. For this ideal column reaching the bifurcation point does not imply failure simply because it was assumed that it will remain elastic regardless of the deflection magnitude. However, in a real column, such large deformations can cause yielding, stiffness reduction, and failure. In a structural system, buckling of critical members and the corresponding large lateral displacements can cause a major redistribution of forces and overall collapse of the system. It is important to note that the bifurcation point exists only for perfectly symmetric members under pure axial forces. If the same ideal column is simultaneously subjected to lateral loads, or if asymmetry of material or geometric imperfections are present, as they are in any real system, lateral displacements would be observed from very early stages of loading. When a frame under constant gravity load is subjected to slowly increasing lateral loads, the lateral displacement of the system slowly increases, until it reaches a stage that in order to maintain static equilibrium a reduction in the gravity or lateral loads is necessary This corresponds to the region with negative slope

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on the forcedisplacement diagram. If the loads are not reduced, the system will fail. When the same frame is subjected to earthquake ground motion, reaching the negative slope region of the load-displacement diagram does not necessarily imply failure of the system In fact, it has been shown that in the case of repeated loads with direction reversals, such as those caused by earthquake ground motion, the load capacity of the system will be significantly larger than the stability load for the same system subjected to uni-directional monotonic loads. Perhaps this is one reason for scarcity of stability-caused building failures during earthquakes. Exact computation of critical loads, for real buildings, is a formidable task. This is true even in a static environment, let alone the added complexities of dynamicloading and inelastic response. Exact buckling analysis is beyond the capacity and resources of a typical design office, and beyond the usual budget and timeframe allocated for structural analysis of buildings. In everyday structural analysis, the stability effects are accounted for either by addressing the problem at the element level (via effective length factors), or by application of one of the various P-Delta analysis methods.

CONCLUSION:

Torsion has an adverse effect on lateral stability of buildings.

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ith the same magnitude of lateral and axial load, the lateral stability of a building decreases with increase in the eccentricity between center of mass and center of rotation. Thus, the current construction practices with buildings having large eccentricities between center of mass and center of rotation should be avoided.

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n highly seismic areas, excessive lateral drift should be minimized by selecting the most centric configuration compatible with architectural requirements. However if architectural considerations like space and circulation require eccentric placement of the lift shafts, torsion must be minimized by providing balancing structural elements. ϖ For the same location of walls, lateral stability of a building decreases as its storey number increases. Thus high rise buildings should be designed to have good lateral stiffness to maintain their stability during high seismic hazards.

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ateral stability of a building is affected by axial loading. Hence superstructure axial loads should be considered while designing buildings.

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