The Earthquake Resistance Design of Open Ground Storey Building Using Stad-Pro Software

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Abstract- *Earthquake occurred in multistoried building shows that if the structures are not well designed and constructed with and adequate strength it leads to the complete collapse of the structures. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistance structures. In seismic analysis the response reduction was considered for two cases both Ordinary moment resisting frame and Special moment resisting frame. The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II. The total structure was analyzed by computer with using STAAD.PRO software. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. The special moment of resisting frame structured is good in resisting the seismic loads.*

Keywords- Earthquake, seismic forces, response spectrum, seismic analysis, deflection diagrams, moment.

I. INTRODUCTION

Structural design of buildings for seismic loading is primarily concerned with structural safety during major earthquakes, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural behavior under large inelastic, cyclic deformations. Behavior under this loading is fundamentally different from wind or gravity loading, requiring much more detailed analysis, and application of a number of stringent detailing requirements to assure acceptable seismic performance beyond the elastic range. Some structural damage can be expected when the building experiences design ground motions because almost all building codes allow inelastic energy dissipation in structural systems.

The seismic analysis and design of buildings has traditionally focused on reducing the risk of loss of life in the largest expected earthquake. Building codes have based their provisions on the historic performance of buildings and their deficiencies and have developed provisions around life safety concerns, i.e., to prevent collapse under the most intense earthquake expected at a site during the life of a structure. These provisions are based.

The concept that the successful performance of buildings in areasof high seismicity depends on a combination of strength, ductility manifested in the details of construction, and the presence of a fully interconnected, balanced, and complete lateral-force-resisting system. In regions of low seismicity, the need for ductility reduces substantially. In fact, in some instances, strength may even substitute for a lack of ductility. Very brittle lateral-force-resisting systems can be excellent performers as long as they are never pushed beyond their elastic strength.

At present people are facing problems of lad scarcity, cost of land. The population explosion and advent of industrial revolution led to the exodus of people from villages to urban areas i.e. construction of multi-storied buildings has become inevitable both for residential and as well as office purposes. The high raised structures are not properly designed for the resistance of lateral forces. It may cause to the complete failure of the structures. The earthquake resistance structures are designed based on some factors. The factors are natural frequency of the structure, damping factor, type of foundation, importance of the building and ductility of the structure. The structures designed for ductility need to be designed for less lateral loads as it has better moment distribution qualities. This aspect is taken care of by response reduction factor R for different type of structure. For high performance, the building is designed as an SMRF. It needs to be designed only for lesser forces than it is designed as an OMRF.

In most structures that are subjected to moderate-to-strong earthquakes, economical earthquake resistance is achieved by allowing yielding to take place in some structural members. It is generally impractical as well as uneconomical to design a structure to respond in the elastic range to maximum expected earthquake-induced inertia forces. Therefore, in seismic design, yielding is permitted in predetermined structural members or locations, with the provision that the vertical load-carrying capacity of the structure is maintained even after strong earthquakes.

II. OBJECTIVES

The particular objectives of the study are:

1) To Study the applicability of the Multiplication Factor of 2.5 as given by IS Code 1893 Part-1(2002), Medium Rise Open ground storey Building.
2) To study the effect of infill strength and stiffness in the seismic analysis of Open ground storey building.
3) To prevent collapse under the most intense earthquake expected at a site during the life of a structure.
4) Minimize the hazard to life for all structures.
5) Increase the expected performance of structures having a substantial public hazard due to occupancy or use.
6) Improve the capability of essential facilities to function after an earthquake.
7) Staad pro design of earthquake resistance structure.

III. SCOPE OF THE DESIGN/ PROJECT

In general, most earthquake code provisions implicitly require that structures be able to resist

1. Minor earthquakes without any damage.
2. Moderate earthquakes with negligible structural damage and some nonstructural damage.
3. Major earthquakes with some structural and nonstructural damage but without collapse. The structure is expected to undergo fairly large deformations by yielding in some structural members.

IV. METHODOLOGY

If the structure not properly designed and constructed with required quality, they may cause large destruction of structures due to earthquakes. Response spectrum analysis is a helpful procedure for seismic examination of structure when the structure indicates linear response. Extensive literature survey by referring books, specialized papers did to comprehend essential idea of subject. Content of Reference Books-Seismic Design Concrete Buildings Selection of an appropriate plan of G+7, story building. Computation of loads and selection of preliminary cross-sections of different structural members. Geometrical modelling/demonstration and structural analysis of building for various loading conditions as per IS Codal provisions. Interpretation of results incorporate base shear, story float and story diversion. In the present work it is proposed to complete seismic investigation of multi-story RCC structures utilizing Response Spectrum Analysis method considering mass irregularity with the help of STAAD PRO software.to start the paper writing.

Seismic Design

BUILDING BEHAVIOR

The behavior of a building during an earthquake is a vibration problem. The seismic motions of the ground do not damage a building by impact, as does a wrecker’s ball, or by externally applied pressure such as wind, but by internally generated inertial forces caused by vibration of the building mass. An increase in mass has two undesirable effects on the earthquake design. First, it results in an increase in the force, and second, it can cause buckling or crushing of columns and walls when the mass pushes down on a member bent or moved out of plumb by the lateral forces. This effect is known as the $p\Delta$ effect and the greater the vertical forces, the greater the movement due to $p\Delta$. It is almost always the vertical load that causes buildings to collapse; in earthquakes, buildings very rarely fall over—they fall down. The distribution of dynamic deformations caused by the ground motions and duration of motion are of concern in seismic design. Although duration of strong motion is an important design issue, it is not presently (2004) explicitly accounted for in design.

In general, tall buildings respond to seismic motion differently than low-rise buildings. The magnitude of inertia forces induced in an earthquake depends on the building mass, ground acceleration, the nature of the foundation, and the dynamic characteristics of the structure. If a building and its foundation were infinitely rigid, it would have the same acceleration as the ground: the inertia force F for a given ground acceleration a may be calculated by Newton’s law $F=Ma$, where M is the building mass. For a structure that deforms only slightly, thereby absorbing some energy, the force F tends to be less than the product of mass and ground acceleration. Tall buildings are invariably more flexible than low-rise buildings, and in general, experience much lower accelerations than low-rise buildings. But a flexible building subjected to ground motions for a prolonged period may experience much larger forces if its natural period is near that of the ground waves. Thus, the magnitude of lateral force is not a function of the acceleration of the ground alone, but is influenced to a great extent by the type of response of the structure its self and its foundation as well.

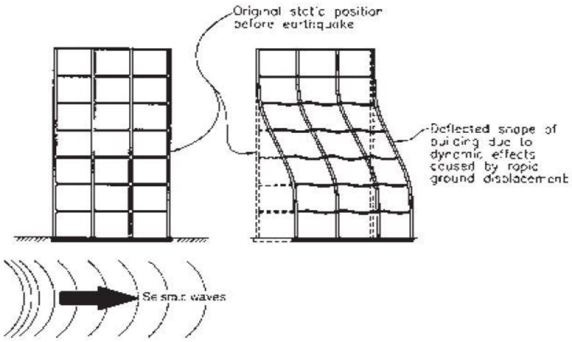


Figure 1. Behavior of a building during earthquakes

Soil Flexibility

Flexibility of soil on which buildings are founded greatly affects earthquake behavior of buildings. Besides, the choice of foundation system also contributes to overall response of buildings. For understanding effect of soil flexibility on earthquake behavior of buildings, the following are considered:

1. Three types of soil (flexible, medium and stiff): Soil is considered to behave elastically, and its flexibility is incorporated through the Modulus of Sub-Grade Reaction. And
2. Three types of foundations (isolated footings, pile and raft) Soil is modeled as elastic springs along the length of the pile and below the raft and footings.

The buildings considered, with the types of foundations supported on the above types of soils, have 10-storeys with 4 bays in X-direction and 3 in Y-direction, each of 4m span. The member sizes are those of the benchmark building. When combined footings are used, the columns are constrained to deflect vertically by themselves; in such cases, the combined footing has large area over which rests on the soil. This makes the columns that are combined to behave the way they would when they are placed on a single raft. Of course, as more columns are combined, the behavior of the building moves closer to that of a building completely rested on a raft.

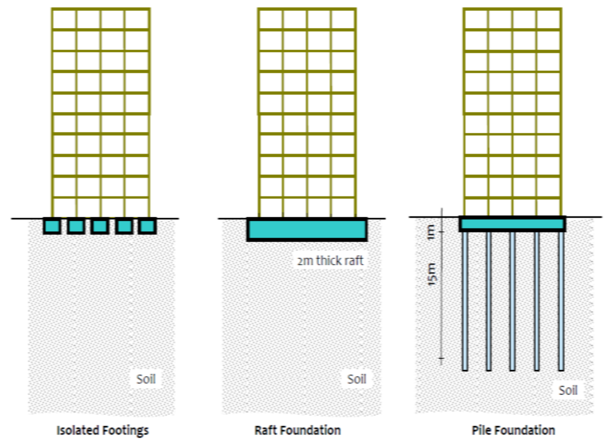


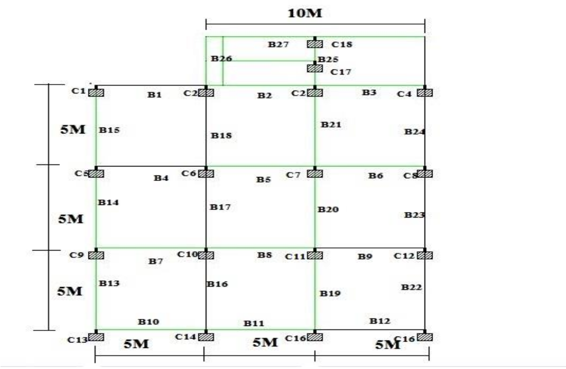
Figure7.3. Foundation systems of buildings: Three basic types of foundations commonly used.

SEISMIC DESIGN CONCEPT

An effective seismic design generally includes

1. Selecting an overall structural concept including layout of a lateral-force resisting system that is appropriate to the anticipated level of ground shaking. This includes providing a redundant and continuous load path to ensure that a building responds as a unit when subjected to ground motion.
2. Determining code-prescribed forces and deformations generated by the ground motion, and distributing the forces vertically to the lateral-force-resisting system. The structural system, configuration, and site characteristics are all considered when determining these forces.
3. Analysis of the building for the combined effects of gravity and seismic loads to verify that adequate vertical and lateral strength and stiffness are achieved to satisfy the structural performance and acceptable deformation levels prescribed in the governing building code.
4. Providing details to assure that the structure has sufficient inelastic deformability to undergo fairly large deformations when subjected to a major earthquake. Appropriately detailed members possess the necessary characteristics to dissipate energy by inelastic deformations.

V. CONCRETE BUILDINGSPLAN



Data of the Example

The design data shall be as follows:

Live load typical floor	: 4.0 kN/m2 at
terrace	: 1.5 kN/m2 on
Floor finish	: 1.0 kN/m2
Water proofing	: 1.5 kN/m2
Terrace finish	: 1.0 kN/m2
Location	: Mumbai city
Wind load 875-Not designed for wind	: As per IS:
earthquake loads exceed the	load, since
	wind loads.
Earthquake load (Part 1) - 2002	: As per IS-1893
Depth of foundation	: 2.5 m
below ground	
Type of soil Medium as per IS:1893	: Type II,
Allowable bearing pressure	: 200 kN/m2
Average thickness of footing isolated footings	: 1.0 m, assume
Storey height 3.45m	: Typical floor:
Floors floors.	: G.F. + 7 upper
Ground beams at 100 mm below G.L.	: To be provided
Plinth level	: 0.6 m
Walls brick masonry walls	: 150mm thick
periphery.	only at

Seismic Weight Calculations

The seismic weights are calculated in a manner similar to gravity loads. The weight of columns and walls in any storey shall be equally distributed to the floors above and below the storey. Following reduced live loads are used for analysis: Zero on terrace, and 50% on other floors [IS: 1893 (Part 1): 2002, Clause 7.4)

Storey 8 Terrace)

		DL + LL
From slab	15 x 15 (5.625+0)	1265.625 + 0
Parapet	4 x 15 (3.33 + 0)	199.8 + 0
Walls	0.5 x 4 x 15 x (11.5 + 0)	345 + 0
Secondary beams	18 x 5 x (3.25 + 0)	292.5+ 0
Main beams	8 x 15 x (4.025 + 0)	483 + 0
Columns	0.5 x 5 x 16 x (6.9 + 0)	276 + 0
Total		2861.925
		= 2862 kN

Storey 7, 6, 5, 4, 3:

		DL + LL
From slab	15 x 15 x(4.125 + 0.5 x 4)	928.125 + 450
Walls	4 x 15 x (11.5 + 0)	690 + 0
Secondary beams	18 x 5 x (3.25 + 0)	292.5 + 0
Main beams	8 x 15 x (4.025 + 0)	483 + 0
Columns	16 x 5 x (6.9 + 0)	552+0
Total		2945.625+450
		=3396kN

(3) Storey 2:

		DL + LL
From slab	15 x 15 x (4.125 + 0.5 x 4)	928.125 + 450
Walls	0.5 x 4 x 15 x (11.5 + 0)	345 + 0
Walls	0.5 x 4 x 15 x (11.5 + 0))	345 + 0
Secondary beams	18 x 5 x (3.25 + 0)	292.5 + 0
Main beams	8 x 15 x (4.025 + 0)	483 + 0
Columns	16 x 0.5 x (3.45+ 3.55) x (6.9 + 0)	386.4 + 0
Total		2780 +450
		= 3230kN

(4) Storey 1 (plinth):

		DL + LL
Walls	0.5 x 4 x 15 (11.5+ 0)	345 + 0
Walls	0.5 x 4 x 15 x (11.5 + 0)	345 + 0
Main beams	8 x 15 x (4.025 + 0)	483+ 0
Column	16 x 0.5 x 3.55 x (6.9 + 0) 16 x 0.5 x 1.1 x (6.9 + 0)	196 +0 61+ 0
Total		1430 + 0
		= 1430 kN

Seismic weight of the entire building = 2862 + (5 x 3396) + 3230 + 1430

= 24502 KN.

The seismic weight of the floor is the lumped weight, which acts at the respective floor level at the center of mass of the floor.

Design Seismic Load

The infill walls in upper floors may contain large openings, although the solid walls are considere d in load calculations. Therefore, fundamental time period T is obtained by using the following formula:

Ta = 0.075 h $^{0.75}$ [IS 1893 (Part 1):2002, Clause 7.6.1]
= 0.075 x $(27.7)^{0.75}$
= 0.9055 sec.

Zone factor, Z = 0.16 for Zone III, IS: 1893 (Part 1):2002,Table2

Table 3 Seismic Zone Factor *Z*
(*Clause* 6.4.2)

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

Importance factor, I = 1.5 (public building)
Medium soil site and 5% damping
Sa/g=1.36/0.97=1.402
IS: 1893 (Part 1): 2002, Figure

2.Ductile detailing is assumed for the structure. Hence, Response Reduction Factor, R, is taken equal to 5.0. It may be noted however, that ductile detailing is mandatory in Zones III, IV and V.
Hence,

VB = Ah W
= (ZI/ 2R) X {Sa/g} X W
=(0.16/2) X (1.5/5) X1.5
=0.036

Base shear,

VB = Ah W
= 0.036 x 24502= 882 kN.

The total horizontal load of **882 kN** is now distributed along the height of the building as per clause 7.7.1 of IS1893 (Part 1): 2002.

VI. STAAD PRO DESIGN

Introduction to STAAD-Pro

Our paper involves analysis and design of multistoried (8-story) using a worldwide most common used designing software STAAD-Pro.

Advantages of STAAD-Pro:

- Confirmation with Indian Standard Codes,
- Versatile nature of solving any type of problem,
- Easy to use interface,
- Accuracy of the solution.

STAAD-Pro SEISMIC ANALYSIS

Ta = 0.90312 sec.,
Sa/g = 1.506.
Load Factor =1,
Ah =0.0241,
Total Weight=16436.42kN,
VB = 396.03Kn

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*
* TIME PERIOD FOR Z 1893 LOADING =     0.90312 SEC
* SA/G PER 1893=     1.506, LOAD FACTOR= 1.000
* VB PER 1893=     0.0241 X     16436.42=     396.03 KN
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VII. CONCLUSION

- The G+7 residential building has been analyzed and deigned using STADD. Pro.
- Seismic forces have been considered and the structure is designed as an earthquake resistant structure.
- To conclude, STADD. Pro is versatile software having the ability to determine the reinforcement required for any concrete section based on its loading and determine the nodal deflection against lateral forces.
- It experiences static as well as dynamic analysis of the structure and gives accurate results whichare required. The following points have been obtained at the end of the design.

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