# A STUDY ON SEISMIC BEHAVIOR OF REINFORCED CONCRETE BUILDINGS UNDER VARYING FREQUENCY CONTENTS

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**Abstract -** *Seismic activity such as earthquake is the result of sudden discharge of energy within the earth's outside that creates seismic waves. Ground shaking and crack are the major impacts produced by seismic tremors. It has social as well as financial results such as causing passing and harm of living things particularly human creatures and harms the built and natural environment. In arrange to require safeguard for the misfortune of life and harm of structures due to the ground movement, it is vital to get it the characteristics of the ground movement. The foremost critical energetic characteristics of seismic activity is peak ground acceleration (PGA), recurrence substance, and length. These characteristics play overwhelming run the show in considering the behavior of structures beneath seismic loads. The quality of ground movement is measured based on the PGA, recurrence substance and how long the shaking proceeds. Ground movement has diverse range of frequencies such as low, intermediate, and high. Present work manages the investigation of recurrence content of ground movement on built-up RC structures. Linear time history examination is acted in underlying investigation done using STAAD Pro. The proposed technique is to consider the reaction of low, mid, and skyscraper-built-up substantial structures under low, moderate, and high-recurrence content ground movements. Regular two, and six-story RC structures with six ground movements of low, transitional, and high-recurrence substance having equivalent span and PGA are analyzed.*

***Key Words*: *Earthquake, STAAD Pro, Reinforced Concrete, Seismic Load, Linear Time History Analysis***

## 1. INTRODUCTION

Seismic performance of reinforced concrete (RC) frame buildings is mostly assessed based on the distinct interstorey drift limits defined by many existing guidelines. In reality, damage of a structure is a continuous process under the action of the load and depends on a number of factors. A few research is carried out to study the frequency content of the ground motion. Early standards had been mainly focused on to protect buildings against collapse; the new and further improved rules are allotted to minimize the damage costs, by preserving the non- structural elements and the structures within an acceptable damage level . Thus, the fundamentals of Performance Based Seismic Design were set up.

### 1.1 Behavior of RC Buildings under Seismic Load

A seismic design method taking into account performance principles for two discrete limit states which includes analysis of a feasible partial inelastic model of the structure using time-history analysis for properly scaled input motions, and nonlinear static analysis (pushover analysis).

## 2. LITERATURE SURVEY

Narhire, et al [11] studied the frequency content of the movement of the floor in the RC buildings. The analysis of linear time history is performed in the analysis and structural design software (SAP2000). The proposed method is to study the response of low-end-high reinforced concrete buildings in low, intermediate and high frequency movements. The answers of each earth movement for each type of building in terms of moving the floor, floor speed, floor acceleration and base shear are studied and compared. The results show that high-frequency ground movements have a significant effect on RC buildings.

Kianoush and Ghaemmaghami [12] studied the effect of the frequency content of the earthquake in the seismic behavior of the fluid rectangular tanks system which is studied using four different seismic movements.

Cakir [13], experimented with a 3D phenomenon of the interaction of the land-soil-soil-soil / foundation structure, is simulated using the finished element method to analyze the dynamic behavior of the cantilevered retention wall sent to different earth movements

Xin et al [14] the particular characteristics of earthquakes in the near fault regions, mainly effects of force and deficiency, can cause significant damage to long span bridges. In this document, the research is conducted to analyze the seismic behavior of concrete steel arched bridge Long span called Zangmu bridge in fling step movement. First, a model of finietelement is built for the bridge with the adequate consideration of geometric materials and non-linearity; Secondly, three types of seismic loads, including registered land movements, idealized pulse models and residual components are illustrated. Then, a comparative analysis and parametric analysis are carried out for information on the effect of the various components in fling step movements in the seismic response; finally, the potentially dangerous positions of the CFST file are estimated when it takes the voltage rate as the performance assessment standard.

Fabozzi et al [15] showed a real case of study represented by a large open multipropy excavation and a circular segmented tunnel in a densely urbanized area from the city center of Naples was used to investigate some of the aforementioned aspects. The precise geotechnical characterization and the choice of the reference entry movements lead to a first estimate of the Free field's movement of the ground, which was subsequently used for pseudo static disconnected analyzes.
Clemente et al [16] Supervised The importance of a precise non-linear analysis of its behavior in the earthquakes of different magnitudes is indicated, to ensure that the seismic effects on the superstructure do not exceed those assumed in design. The importance of monitoring is evident. It allows a rapid control of seismic performance and so that the suitability of these structures is managed during the emergency phase. We recommend a real-time monitoring system.

## 3. STRUCTURAL MODELING

Concrete is the most commonly utilized building material. It is strong in compression but weak in tension, thus steel, which is strong in both tension and compression, is utilized to strengthen the tensile capacity of concrete, resulting in reinforced cement concrete

### 3.1 Regular RC Buildings

Two, and six-story regular reinforced concrete buildings, which are low, mid, and high- rise, are considered. The beam length in (x) transverse direction is 4m and in (z) longitudinal direction 5m. Figure 1 shows the plan of the three buildings having three bays in x-direction and five bays in z-direction. Story height of each building is assumed 3.5m. Figure 1 and 2 shows the frame (A-A) and (01-01) of the six and two-story RC building respectively. For simplicity, both the beam and column cross sections are assumed 300 mm x 400 mm. Plan of two, and six-story regular RC buildings (all dimensions are in mm) .

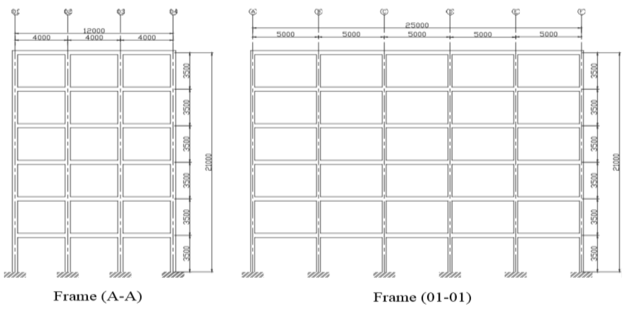


**Figure 1**: Frame (A-A) and (01-01) of six-story regular RC building (all dimension are in mm)

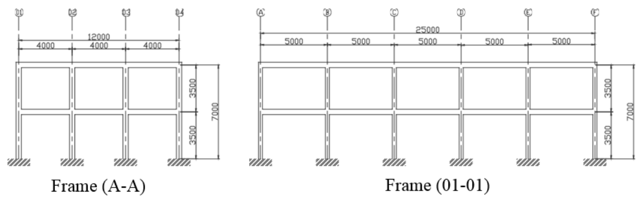


**Figure 2**: Frame (A-A) and (01-01) of two-story regular RC building (all dimension are in mm)

### 3.2 Gravity Loads

Slab load of 3 kN/m$^2$ is considered for the analysis and wall load of 17.5 kN/m is applied both on exterior and interior beams of the RC buildings as per IS 875 (Part1). Live load of 3.5 kN/m$^2$ is provided in accordance to IS 875 (Part2). Table 1 shows the gravity loads.

For seismic weight, total dead load and 50 percent of live load is considered as per Table 8 of IS 1893 (Part1): 2002. For calculation of seismic weight, no roof live load is taken.

**Table -1:** Gravity loads which are assigned to the RC buildings

| Gravity Load | Value |
|---|---|
| Slab load (dead load) | 3 (kN/m$^2$) |
| Wall load (dead load) | 17.5 (kN/m) |
| Live load | 3.5 (kN/m$^2$) |

### 3.3 Material Properties

Table 2 shows the concrete and steel bar properties, which are used for modeling of the reinforced concrete buildings in STAAD Pro

**Table -2:** shows the concrete and steel bar properties

| Concrete Properties | | Steel Bar Properties | |
|---|---|---|---|
| Unit weight ($\gamma c$) | 25 (kN/m$^3$) | Unit weight ($\gamma s$) | 76.974 (kN/m$^3$) |
| Modulus of elasticity ($Ec$) | 22360.68 (MPa) | Modulus of elasticity ($Es$) | 2x105 (MPa) |
| Poisson ratio ($\nu c$) | 0.2 | Poisson ratio ($\nu s$) | 0.3 |
| Thermal coefficient ($\alpha c$) | 5.5x10-6 | Thermal coefficient ($\alpha s$) | 1.170x10-6 |
| Shear modulus ($Gc$) | 9314.95 (MPa) | Shear modulus ($Gs$) | 76913.07 (MPa) |
| Damping ratio ($\varsigma c$) | 5 (%) | Yield strength ($Fy$) | 415 (MPa) |
| Compressive strength ($Fc$) | 30 (MPa) | Tensile strength ($Fu$) | 485 (MPa) |

## 4. RESULT AND DISCUSSIONS

Ground movement is the development of the world's surface from impacts or tremors. It is created by waves that are delivered by unexpected pressing factor at the dangerous source or sudden slip on a deficiency and go through the earth and along its surface. In this part, the attributes of the six ground movements, which are utilized for the time-history investigation of the RC structures, are clarified. Then, at that point, a concise portrayal is given for direct time-history examination.

### 4.1 Ground Motion Records

Structures are exposed to ground movements. The ground movement has dynamic qualities, which are peak ground acceleration increase (PGA), Peak ground velocity (PGV), top ground uprooting (PGD), recurrence content, and span. These powerful attributes assume a transcendent part in considering the conduct of RC structures under seismic burdens. The construction security relies upon the design slimness, just as the ground movement abundancy, recurrence, and span. Based on the recurrence content, which is the proportion of PGA/PGV the ground movement records are characterized into three classifications

The ratio of peak ground acceleration in terms of acceleration of gravity (g) to peak ground velocity in unit of (m/s) is defined as the frequency content of the ground motion.

### 4.2 Linear Time History Analysis

Time history examination is the investigation of the unique reaction of the design at each expansion of time when its base is presented to a specific ground movement. Static methods are pertinent when higher mode impacts are not significant. This is generally legitimate for short, customary constructions. In this manner, for tall constructions, structures with torsional deviations, or no symmetrical systems, a unique technique is required.

Two, and six -story regular RC buildings are modeled as three- dimension. Material properties, beam and column sections, gravity loads, and the six ground motions is calculated as per the IS codes. Table 3 are allotted to the consistent RC buildings and then linear time history analysis is performed. The linear time-history analysis results for regular RC buildings are shown in table 4 and 5 correspondingly.

**Table 3:** Ground motion characteristics and classification of its frequency-content for 40 s duration

| Records (Station) | Component | Magnitude | Epicentral Distance (km) | Duration (s) | Time step for response computation (s) | PGA (g) | PGV (m/s) | PGA/PGV | Frequency Content Classification |
|---|---|---|---|---|---|---|---|---|---|
| 1979 Imperial Valley-06 (Holtville Post Office) | H-HVP225 | 6.53 | 19.81 | 40 | 0.005 | 0.2526 | 0.4875 | 0.5182 | Low |
| IS 1893 (Part1) : 2002 | - | - | - | 40 | 0.01 | 1 | 1.0407 | 0.9609 | Intermediate |
| 1957 San Francisco (Golden Gate Park) | GGP010 | 5.28 | 11.13 | 40 | 0.005 | 0.0953 | 0.0391 | 2.4405 | High |
| 1940 Imperial Valley (El Centro) | elcentro_EW | 7.1 | - | 40 | 0.02 | 0.2141 | 0.4879 | 0.4389 | Low |
| 1992 Landers (Fort Irwin) | FTI000 | 7.28 | 120.99 | 40 | 0.02 | 0.1136 | 0.0957 | 1.1868 | Intermediate |
| 1983 Coalinga-06 (CDMG46617) | E-CHP000 | 4.89 | 9.27 | 40 | 0.005 | 0.1479 | 0.0573 | 2.5810 | High |

**Table 4:** Dynamic characteristics of the two-story regular RC building

| Mode | Natural Frequency (rad/s) | Period (s) | Mass Participation X (%) | Mass Participation Sum X (%) | Mass Participation Z (%) | Mass Participation Sum Z (%) |
|---|---|---|---|---|---|---|
| 1 | 12.81 | 0.49 | 0 | 0 | 95.993 | 95.993 |
| 2 | 15.76 | 0.39 | 94.563 | 94.563 | 0 | 95.983 |

**Table 5:** Dynamic characteristics of the six-story regular RC building

| Mode | Natural Frequency (rad/s) | Period (s) | Mass Participation X (%) | Mass Participation Sum X (%) | Mass Participation Z (%) | Mass Participation Sum Z (%) |
|---|---|---|---|---|---|---|
| 1 | 3.516 | 1.793 | 0 | 0 | 84.625 | 84.625 |
| 2 | 4.127 | 1.524 | 83.437 | 83.437 | 0 | 84.625 |
| 3 | 4.422 | 1.411 | 0 | 83.437 | 0 | 84.625 |
| 4 | 10.67 | 0.548 | 0 | 83.437 | 9.783 | 94.415 |
| 5 | 12.788 | 0.431 | 10.273 | 93.73 | 0 | 94.415 |
| 6 | 13.64 | 0.422 | 0 | 93.73 | 0 | 94.415 |

## 5. CONCLUSIONS

Following conclusions can be drawn for the two, and six-story regular RC buildings from the results obtained
Two-story regular RC building experiences maximum story displacement due to low-frequency content ground motion in x and z-direction. Two-story regular RC building experiences minimum story displacement due to high-frequency content ground motion in x and z-direction. Two-story regular RC building experiences maximum story velocity due to intermediate-frequency content ground motion in x-direction and low-frequency content ground motion in z-direction.
Six-story regular RC building undergoes maximum story displacement due to low-frequency content ground motion in x and z-direction. Six-story regular RC building undergoes minimum story displacement due to high-frequency content ground motion in x and z-direction. Six-story regular RC

building undergoes maximum story velocity due to low-frequency content ground motion in x and z-direction. Six-story regular RC building undergoes minimum story velocity due to high-frequency content ground motion in x and z-direction.

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