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A Research on to Study the Seismic Behaviour of a Multi-Storey Building with RC Moment Resistance Frame and Shear Wall

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ABSTRACT

Seismic analysis plays a important role in the engineering structure, after the major earthquake that is Kashmir earthquake (2005) and Gujarat earthquake (2001), there is a attention about the vulnerability assessment of earthquake on the structure. Generally, after the Gujarat earthquake it was seen that the building was failed because of the soft-story behavior. When the seismic waves are produce or we can say that when the seismic waves are strikes to the any building, the reduction in lateral stiffness takes place and thus the mass in the ground floor results the higher stress in vertical member under seismic load. To overcome this effect moment resistant frame STORY used.

Moment resistant frame is a assemblage of columns and beams in the rectilinear form. In the M.R frames beams are rigidly connected by the columns. After these earthquake the Indian Standard codes was revised that is IS 1893 in IS 2002.In the present study we use the MR frames for overcome the effect of the earthquake and the building is modeled in the software named as "Resist". In this study we will also discuss about the wind load on the building.

The moment resistant frames are used commonly to resist the lateral loads (seismic load). The moment resistant frames are of two types which are:-

1. Ordinary Moment Resistant Frames.
2. Special Moment Resistant Frames.

The SMRF are used in the high vulnerable area or zone for providing the ductile behavior. The response factor for the SMRF is about 5. The aim of the study is to analysis the building with moment resistant frame for earthquake and for the wind loads and gives the results.

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INTRODUCTION

The moment resistant frame is also gives stability to the structures. The vertical members (columns) and the horizontal members (beams) provide the rigid connection to the structure which resist the deformation and also resist the movement of the elements relative to each other.

The moment resistant structure are use full because these do not requires the other structural like braced frames or structural wall. The RC frame structure also provides the large area for the window opening and any other required opening.

The Gujarat earthquake was the major earthquake that was happened recently in India. In that earthquake approx. 13800 peoples was killed and approx. 167000 peoples was injured and with that the large number of buildings were damaged or completely collapse.

After the Gujarat earthquake the codes were also revised to improve the resisting power of the building to resist the earthquake.

Because of the intentional ignorance , unawareness and less knowledge the risk due to the earthquake continue increases unnecessarily.

Over the decates many of the researchers comes on the conclusion that the earthquake does not kills the peoples but the buildings do.

Now a day the engineers believes that we can built the earthquake resistant buildings which are economical and they also prevent to the collapse and prevents the peoples life

ADVANTAGE OF THE RC FRAMED BUILDINGS

1. It provides resistance to collapse
2. It controls the deformation of the structure
3. It controls the cracking of the structure
4. It gives the large space for opening
5. It provides rigid connections to the structure

Literature

Syed et al., (2019) studied on earthquake resistant buildings due to increase in accidental and intentional explosions, high-rise buildings can be exposed to those types of blast pressures. This research is aimed at exploring the structural behavior and performance of earthquake resistant reinforced concrete (RCC) frame structures under blast loading. For this study, typical reinforced concrete frame structures designed to be earthquake resistant according to International Building Code (IBC 2009) and ACI 318-11 provisions applicable for Abu Dhabi city were studied. Vulnerability of these structures were investigated under different realistic blast scenarios obtained by varying scaled distances and explosion charge-weights to study the structural response. Investigations on variation in performance by changing material properties and structural configurations were also included in this study.

Sayed Mahmoud, (2019) studied on Responses to lateral loads induced by wind and earthquakes are among the governing factors in the structural design of these structures. In the current trend, adjacent tall buildings are being horizontally connected for different purposes. However, such horizontal linkages potentially change the behavior of the structure, which limits the applicability of design codes. This research comprehensively assesses the response of linked high-rise buildings under earthquake loads, following design-code requirements. The effect of sky-bridge location on the induced responses is examined as well. The building configurations were excited by a set of ground-motion records with different peak ground accelerations. The lateral dynamic earthquake loads were separately applied in two orthogonal directions (the sky-bridge and perpendicular directions) and the responses to each load were investigated. The connecting bridge location affected the predicted dynamic load-induced responses of the building structures slightly in some scenarios, but dramatically in one scenario.

Dlyet et al., (2019), this paper presents a numerical modeling of RC shear walls using ANSYS finite element program. The objective of this research is to study the effect of using FRP sheets to enhance the seismic behavior of RC shear wall buildings designed according to old code provisions. These structures exhibit a number of structural problems such as insufficient shear reinforcement and poor concrete confinement at the boundaries. The walls were subjected to monotonic and reversed cyclic loading up to failure. In this research, response of FRP-retrofitted RC shear walls subjected to lateral loads is studied using the general-purpose finite element code ANSYS. The numerical modeling is first validated against available experimental results from the literature. A total of seven wall specimens from two experimental programs were modeled and analyzed under monotonic and reversed cyclic loading. The FRP sheets are used in both the vertical and horizontal directions of the walls to enhance stiffness, flexural strength

Ramadan et al., (2017) concluded that many existing RC buildings do not meet the lateral strength requirements of current seismic codes and are vulnerable to significant damage or collapse in the event of future earthquakes. In the past few decades, buckling-restrained braces have become increasingly popular as a lateral force resisting system because of their capability of improving the strength, the stiffness and the energy absorbing capacity of structures. This study evaluates the seismic upgrading of a 6-story RC-building using single diagonal buckling restrained braces. Seismic evaluation in this study has been carried out by static pushover analysis and time history earthquake analysis. Ten ground motions with different PGA levels are used in the analysis. The mean plus one standard deviation values of the roof-drift ratio, the maximum story drift ratio, the brace ductility factors and the member strain responses are used as the basis for the seismic performance evaluations. The results obtained in this study indicate that strengthening of RC buildings with buckling restrained braces is an efficient technique as it significantly increases the PGA capacity of the RC buildings

Syedet al., (2017) conducted that due to rapid development and urbanization, coupled with relatively high average household income, cities like Abu Dhabi have transformed to a larger and advanced metropolis. Most of the medium to high-rise structures in these cities in the middle-east are designed to be earthquake resistant. Due to increase in accidental and intentional explosions, high-rise buildings can be exposed to those types of blast pressures. It is a real matter of concern for the designers to know how these earthquake resistant structures would perform when exposed to accidental blast loads. This research is aimed at exploring the structural behavior and performance of earthquake resistant reinforced concrete (RCC) frame structures under blast loading. For this study, typical reinforced concrete frame structures designed to be earthquake resistant according to International Building Code (IBC 2009) and ACI 318-11 provisions applicable for Abu Dhabi city were studied. Vulnerability of these structures were investigated under different realistic blast scenarios obtained by varying scaled distances and explosion charge-weights to study the structural response. Relative performance of RCC structures designed with and without consideration of earthquake load in load combinations is also presented.

B. Abdelwahed, (2019) studied on recent buildings failure showed that structures built according to current design codes were not robust enough under the action of unexpected loads and failed progressively. Progressive collapse is the collapse which is not proportional to the original local damage. Building progressive collapse mitigation became an urgent demand in structural engineering environment. This study aims to provide the designer engineers with wider overview on this topic to minimize the consequences of buildings progressive collapse after the event of column removal scenario

Chen et al., (2017) concluded that the pushover and nonlinear dynamic analysis method are applied to analyze the seismic performance of RC frame structure with or without slabs under the action of multiple factors in this thesis. Meanwhile, the structural response exerted by oblique seismic action is summarized from the theoretical formula derivation. By analyzing and comparing two kinds of established models, the results demonstrate that with various axial compression ratio and moment magnifying factors of columns, the seismic performance of the structure will be degraded when the influence of the floor is taken into account. And the increment of the values of axial compression ratio μ and moment magnifying factor of column ηc with the floor exceeds that without the floor.

Moreover, Earthquakes input along the principal axis can realize the "strong column weak beam" of the structure. Considering the influence of floor, when the value of axial compression ratio is higher than 0.56 or moment magnifying factors with the floor increases above 2.0, frame structure under oblique seismic action can form "strong column weak beam" yield mechanism.

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Karapetrou et al., (2017 concluded that the assessment of the seismic vulnerability of reinforced concrete (RC) buildings considering performance degradation over time due to aging effects. Chloride induced corrosion is taken into account based on probabilistic modeling of corrosion initiation time and corrosion rate. Two-dimensional incremental dynamic analysis (IDA) is performed to assess the seismic performance of the initial uncorroded (t=0 years) and corroded (t= 25, 50, 75 years) RC fixed base frame structures designed based on different seismic code levels. The time-dependent fragility functions are derived at the various time periods in terms of spectral acceleration corresponding to the fundamental mode of the structure Sa(T1,5%) for the immediate occupancy (IO) and collapse prevention (CP) limit states. Results show an overall increase in seismic vulnerability over time due to corrosion indicating the significant effect of deterioration due to aging effects on structural behavior.

Bournas,(2018) this paper explores innovative techniques by combining inorganic textile-based composites with thermal insulation for the simultaneous seismic and energy retrofitting of the existing old buildings. A brief state-of-the-art review on energy and seismic retrofitting materials and techniques is initially made, followed by the introduction of a novel concept for the simultaneous seismic and energy retrofitting of the Reinforced Concrete (RC) and masonry building envelopes, combining Textile Reinforced Mortar (TRM) jacketing and thermal insulation materials or systems. The hybrid structural-plus-energy retrofitting solutions examined are based on inorganic materials providing both cost effectiveness and fire resistance for the building envelope. The overall effectiveness of the combined energy and seismic retrofitting is demonstrated via a case study on a five stories old-type RC building. Moreover by proposing a common approach based on the expected annual loss (of consumed energy or expected seismic loss), it is possible to evaluate the financial feasibility and benefits of the proposed combined retrofitting approach.

Snehal Kaushik (2016) studied the time history analyses, under different levels of recorded earthquake ground motion, are carried out using the computer program ABAQUS to study the seismic damage in shear wall – slab junction of an RC wall-frame building. The beams, columns, shear walls and slabs are discretized with eight-noded solid elements. The incurred cumulative damage is determined at various locations for all the three models. It is observed that the damage gets primarily concentrated at the wall – slab junction region with increasing levels of ground motion.

Ni et al., (2018) studied on Data are provided from simulation studies of post-fire earthquake (PFE) of reinforced concrete (RC) structural walls. Local response data describe material peak temperatures and residual stiffness and strength, as well as quantification of the extent of seismic damage. Global response data provide load-deformation envelopes, as well as stiffness, strength, and deformation capacity. The data can support development of simplified modeling tools for PFE analysis of buildings, as well as to support development of and interpretation of future experimental tests. For further theory behind the modeling approach and full interpretation of the data, the reader is referred to the article entitled "Post-fire seismic behavior of reinforced concrete structural walls" (Ni and Birely, 2018)

Adrian G. et al., (2019) This paper presents the results of a numerical investigation into the influence of the number of stories on the progressive collapse resistance of reinforced concrete planar frames. Starting from the specifications provided by Yi et al. (2008) in their experimental program, an initial numerical model was developed in Midas FEA software package.

Objective of the work

The specific objectives of the research are listed as follows:

- To study the behavior of the RC frame building during the seismic force.
- To study the behavior of the RC frame building during the wind force.

Scope of present work

Although all cares and due consideration on various technical issues have been given to make the technically sound and complete. However, there are certain limitations in the RESIST and so as that of present study. Floor diaphragms were not evaluated and it was assumed that the floor diaphragms have sufficient rigidity and strength to transfer loads to all the resisting elements. Connections within the resisting elements and the rest of the building were not analyzed rather it was assumed that connections have sufficient strength to ensure the expected performance of the resisting elements. Lateral structures were assumed to be uniform but in practice section sizes reduce with height. An elastic approach was used for evaluating torsion effects ignoring the inelastic deformations. Moreover, the present work provides ground for further study which can carry the outcome of the present study a way forward. Although damage index can be computed under each scenario for a given earthquake event, it is not covered here due limited time and will be considered in future work. The P-Delta effect varies with increase number of building storey and other type lateral earthquake resisting structure in a building. The effect of MR frame on the total weight of the building subsequent impact on lateral displacement, base shear and P-delta effect are subjects of future investigations.

Materials and Methodology

The study in this report is basically based on seismic evaluation of a building with moment resistant frame building. This chapter discusses the methodology adopted and project description to achieve the framed objectives in detail. It also ensures the reproducibility of the worked carried out in the thesis.

Building description

The studied building is hypothetical six storey (G+6) RCC residential building. The complete detail of the building is presented in Table 4.1 and Table 4.2

Table: Detail Building Information

Building Importance category	Normal structures	
Number of storey's	7	
Total height	24 m	
Floor plan	(-10, -10), (10, -10), (10, 10), (-10, 10)	
Floor plan properties	Area:400 m2; Perimeter length: 80 m; Centroid: (0, 0) m; Bound lengths: (20, 20) m	
Inter-storey height	3.0 m	
Floor	Weight type: Medium, Dead load: 2.90 kPa, Live load: domestic (2.00 kPa)	
Interior wall	Weight type: Light, Dead load: 0.30 kPa (over floor area)	
External wall	Weight type: Medium, Dead load: 1.26 kPa (over wall area)	
Roof	Weight type: heavy, Height: 3 m, Dead load: 4.80 kPa (over floor area), Live load: 0.25 kPa (over floor area)	
Structure in X & Y direction	Locations: (0, -9.876), (0, 9.876)	
Soil information	Parameter	Soil C (Medium)
	Description	Less than 20m soft clay or less than 60m hard clay, or less than 60m medium sand over bedrock, or less than 100m gravels., Presumptive values
	Density	1850 kg/m3
	Poisson's ratio	0.3
	Modulus of Elasticity Es	400 MPa (includes improvement factor: 2.00)
	Allowable bearing pressure(qa)	250 kPa (includes improvement factor: 1.00)

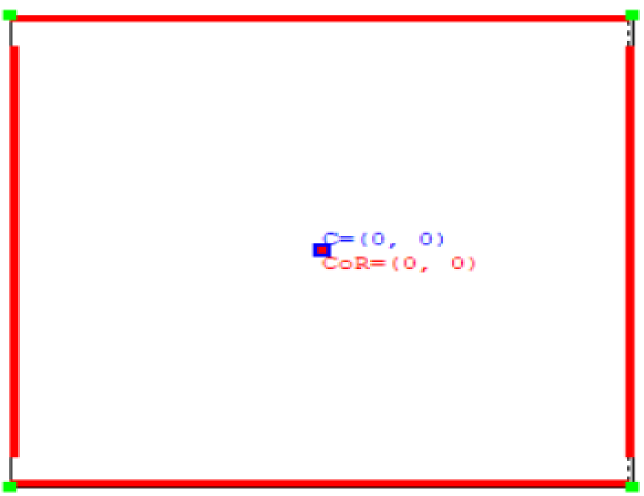
*In scenario C1-C2, C stand for medium soil, there are two scenarios for frame structure and for shear wall.

Table Torsion information

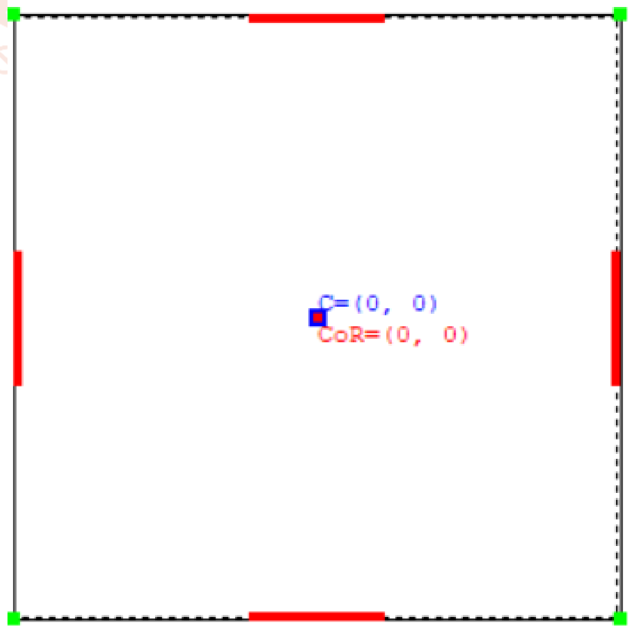
Parameter	Moment resistance frame	Shear/structural wall
Polar moment of inertia, J	3.292e+09 Nm	J=1.242 e+09 Nm
Rigidity (X & Y)	8.47e+06 N/m	3.18e+06 N/m
torsion factor (X & Y dir)	1.101	1.101

Building layout

The floor/ layout plan of the structure with moment resistance frame structure and for the structural wall is shown in the below Figure 4.1 and Figure 4.2.The centre of mass of the building ad centroid of the building coincide to each other so the building is symmetrical thus the characteristics of the building is same in Y-direction and X-direction.



Floor plan of moment resistance frame building



Floor plan of building with structural wall

Seismic information

The seismic information considered for the present work is zone IV (Hazard factor – 0.24) and soil type is medium soil

(C) as per IS code 1893:2002. For Ultimate Limit State or ULS (500 years of Recurrence interval) and Serviceability Limit State or SLS (25 years of Recurrence interval), the value of Return Period factor are considered as 1.0 and 0.25 respectively.

Load calculation

Gravity Load: According to IS code the loads which are considered for the following study are:-

- Dead load: It is the self-weight of the structure and it will be calculated acc. to the IS code.
- Live load on floor: according to the IS code 875:1987 live load on the floor is taken 2kpa.

Wind Load:

The calculations of Wind load as per Indian code: IS 875:1987 is:-

The value of Vz (Design wind speed) is expressed as follows

Vz = Vb×K1×K2×K3 -----------Eq 4.1

Where, Vb = basic design wind speed

K1, K2, K3 can be taken from the IS: 875 (part3)

Pz = Design wind pressure

Pz = 0.6 Vz2 ----------------Eq 4.2

Earthquake Load

Seismic analysis of the structure is analyzed by using IS 1893-2002. The design horizontal seismic coefficient, Ah for the structure has been computed using the following:

Ah = ZI/2R, --------------Eq 4.3

Where, Z =seismic zone factor, I =Importance factor , R= Response reduction factor

Conclusion

- The fundamental periods for MR frame and Structural wall observed in the order of MR frame > Structural wall.
- The base moment, base shears with p-delta and without p-delta are observed to be highest for the MR frame and minimum in Structural wall.
- The seismic drift determined using both ULS and SLS methods are found to have increased from ground to top storey and also observed in the order of MR frame Structural wall.
- The value of stability coefficients (θ) were found in the order of MR frame > Structural wall.
- Moreover, for a given storey inter storey drift increases with increase with θ. However, for given brace framing, a lower value of θ does not ensure less drift indicating that the stability coefficient has little to decipher dynamic behavior of building during earthquake.