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Time History Analysis of Multi-Storied Building (G+9)

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ABSTRACT: Structural Analysis is the branch which involves in the determination of behaviour of structure in order to predict the responses of different structural components due to effect of loads. Time history method gives all possible forces which are generated, and there by displacement of structure. during entire duration of ground motion at equal interval, typically 0.05to 0. A1sec. STAAD. Pro is a structural analysis design program software. To get some idea about the handling of an integral building design software like staadpro and study of seismic forces responses on building life cycle and to define the analyse behaviour of building using time history analysis. This project deals with the identification of bending and shear forces due to several load conditions. i.e., Analysis and also deals with the design of sections to increase the serviceability of the G+9)storied building. This paper gives time history analysis by using time-acceleration data as input function and then performance of the structure is evaluated with various mode shapes and time-acceleration results.

This research study investigates the change in dynamic characteristics of reinforced concrete moment-resisting frame buildings without and with fully infill walls. In addition, building models with partially infill walls have also been investigated. A set of different building models have been developed to perform the analysis as (1) bare frame (without infill walls). (2) frame with fully infill walls, (3) frame models with infill panels and soft storied located at base level, 3rd storied level, 6th storied level, and 9th storied level. The two ground excitations are applied separately in two orthogonal directions. The structural software package STAAD Pro has been used in developing the building models and performing the simulation analysis. Some selected numerical simulation results in terms of storied shear forces, lateral deflections, inter story drift ratios and overturning moments at each storied level are obtained for all the considered configurations.

1. INTRODUCTION

Earthquake engineering is the scientific field concerned with protecting society, the natural and the man-made environment from earthquakes by limiting the seismic risk to socio-economically acceptable levels Traditionally, it has been narrowly defined as the study of the behavior of structures and geo-arcatures subject to seismic loading, thus considered as a subset of both structural and geotechnical engineering. However, the tremendous costs experienced in recent earthquakes have led to an expansion of its scope to encompass disciplines from the wider field of civil engineering and from the social sciences, especially sociology, political science. economics and finance.

OBJECTIVE

The objectives of this study are as the following:

- To study the behaviour of low, medium and high-rise structure through determining natural frequency
- To determine the multi-storied drift of the building on passing traditional or conventional Malaysia design.
- To redesign such structure to earthquake loading and re-evaluate the multi storied drifts.
- Foresee the potential consequences of strong earthquakes on urban areas and civil infrastructure
- Design, construct and maintain structures to perform at earthquake exposure up to the expectations and in compliance with building codes

LITERATURE REVIEW

Hamid Reza Tabatabaiefar, Ali Massumiet.al !" As the Iranian seismic code does not address the soil-structure interaction (SSI) explicitly; the effects of SSI on RC MRFs are studied using the direct method in this paper. Four types of structures on three types of soils, with and without the soil interaction, are modelled and subjected to different earthquake records. The results led to a criterion indicating that considering SSI in seismic design, for buildings higher than three and seven stories on soil with (shear wave velocity) Vs<175m/s and175<Vs<375 m/s, respectively, is essential. A simplified procedure has been presented, on the basis that lateral displacement increments could be applied to the fixed base models using simple factors.

Eduardo Kausel et.al 12 Soil-structure interaction is an interdisciplinary field of endeavour which lies at the intersection of soil and structural mechanics, soil and structural dynamics, earthquake engineering, geophysics and geo-mechanics, material science, computational and numerical methods, and diverse other technical disciplines. Its origins trace back to the late 19th century, evolved and matured gradually in the ensuing decades and during the first half of the 20th century, and progressed rapidly in the second half stimulated mainly by the needs of the nuclear tools such as finite elements, and by the needs for improvements in seismic safety. power and offshore industries, by the debut of powerful computers and simulation The pages that follow provide a concise review of some of the leading developments
that paved the way for the state of the art as it is known today. Inasmuch as static foundation stiffness is also widely used in engineering analyses and code formulas for SSI effects, this work includes a brief survey of such static solutions.

J. Yang, J.B. Li, G. Lin et.al D indicate that direct integration of the ground acceleration data provided for seismic soil-structure interaction analysis often causes unrealistic drifts in the derived displacement. The drifts may have a significant effect on large-scale interaction analysis in which the displacement excitation is required as an input. This paper proposes a simple approach to integration of the acceleration to acquire a realistic displacement-time series. In this approach, the acceleration data is firstly baseline corrected in the time domain using the least-square curve fitting technique, and then processed in the frequency domain using a windowed filter to further remove the components that cause long-period oscillations in the derived displacement. The feasibility of the proposed approach is assessed using several examples and comparisons are made between the results obtained using the proposed scheme and those using other complicated procedures.

H.Yoshioka; J.C. Ramallo; and B.F.Spencer Jr. et.al states in this paper that one of the most successful means of protecting structures against severe seismic events is base isolation. However, optimal design of base isolation systems depends on the magnitude of the design level earthquake that is considered. The features of isolation system designed for an El Centro-type earthquake typically will not be optimal for a Northridge-type earthquake and vice versa. To be effective during a wide range of seismic events, an isolation system must be adaptable. To demonstrate the efficacy of recently proposed ,,,smart" base isolation paradigms, this paper presents the results of an experimental study of a particular adaptable, or smart, base isolation system that employs magneto rheological -MR! Dampers. The experimental structure, constructed and tested at the Structural Dynamics and Control/Earthquake Engineering Laboratory at the Univ. of Notre Dame, is a base-isolated two-degree-of freedom building model subjected to simulated ground motion. A sponge-type MR damper is installed between the base and the ground to provide controllable damping for the system. The effectiveness of the proposed smart base isolation system is demonstrated for both far-field and near-field earthquake excitations.

A. B. M. Saiful Islam, M. Jameell, M. A. Uddin and Syed Ishtiaq Ahmad et.alobserves in this work that seismic base isolation is now a days moving towards a very efficient tool in seismic design of structure. Increasing flexibility of structure is well achieved by the insertion of these additional elements between upper structure and foundation as they absorb larger part of seismic energy. However in Bangladesh, this research is still young for building structures. Therefore, this is a burning question to design isolation device in context of Bangladesh. Effort has been made in this study to establish an innovative simplified design procedure for isolators incorporated in multi-storied building structures. Isolation systems namely lead rubber bearing (LRB) and high damping rubber bearing (HDRB) have been selected for the present schoolwork. Numerical formulation and limiting criteria for design of each element have been engendered. The suitability to incorporate isolation device for seismic control has been sight seen in details. The study reveals simplified design procedures for LRB and HDRB for multi-storied buildings in Bangladesh. The detail design progression has been proposed to be included in Bangladesh National Building Code (BNBC)

Radmila B. Salic et.al Iu In this paper the authors have demonstrated the effect of dynamic response of the seven-story residential building under the earthquake ground motions. Mode shapes, natural frequencies and damping ratios of the existing fixed base building are obtained by ARTEMIS (Ambient Response Testing and Modal Identification Software). The fixed base model represents the dynamic behavior of the structure and seismic isolated model representing the dynamic behavior of the structure isolated by lead rubber bearing seismic isolation system. Dynamic analysis of both models has been performed by ETABS (Nonlinear version 9.0.4). The finite element model was chosen to satisfy the needs of this analysis. The Dynamic responses of fixed base and seismic isolated models have been calculated for four types of real earthquake time histories of different frequency characteristics whose value is determined based on the detailed site response analysis. The authors have showed that increase of natural period of structure increases flexibility of the same structure. In seismic isolated model, base shear force is highly reduced. Increased flexibility of the system led to increase of the total displacements due to the elasticity of the existing isolation. Implementation of the isolation system resulted into thereduction of the inter story drifts. Analysis of seismic isolated model has shown significant reduction of the story accelerations.

2. METHODOLOGY

General

Analysis of any structure for resisting earthquake is the basic need of this In this project analysis of a seismic resistant structure is a need of concern, and thereby establishing a comparison between structures with fixed base and Basically many analysis and design software's can be adopted to ale and design any earthquake resistant structure. There are many methods for enosis and design such as equivalent static method, response spectrum method and time history method. Among all these methods in this study only time history method is adopted. In this study ETAB 2016 software is used for analysis.

Indian Standard code provisions:

Indian Standard codes are the base reference by which analysis and design are carried out. Following are the various IS codes which are used for analysis and design of earthquake resistant structure with and without shear wall.

5.2.1 IS 1893 (Part-1):2016 Criteria for Earthquake Resistant Design of Structures: General provisions and Buildings:

This standard contains provisions that are general in nature and applicable to all structures. Also, it contains provisions that are specific to buildings only. It covers general principles and design criteria, combinations, design spectrum, main attributes of buildings, dynamic analysis, apart from seismic zoning map and seismic coefficients of important towns, map showing epicentres, map showing tectonic features and Letho logical map of India. The code gives overall information but only the useful information needed for analysis and design are stated here. Various Steps for analysis of earthquake resistant structure as per this code are as follows,

STEP 1 First step to calculate earthquake loads on structure is to identify the earthquake zone for which structure needs to be designed. This earthquake zones are displayed in a map in the code. Earthquake zone in India are four viz, II, III, IV and V

STEP II Calculate the load on each member and seismic weight on the members with the help of the density of particular material. Seismic weight of each floor is full dead load plus appropriate amount

1) Seismic Weight (W)- [IS 1893 (Part 1): 2016, Clause 7.4) The seismic weight of de whole building is the sum of the seismic weights of all the floors. The seismic weight of each floor is its full Dead load (DL) phase the appropriate amount of dead Load (11), the latter being that part of the ILs that may reasonably he pecked to be attached to the structure at the time of earthquake shaking. It includes the weight of permanent and movable partitions, permanent equipment, a part of the I've load, etc. While computing the seismic weight of each floor, the weight of columns and walls in any storied should be equally distributed to the floors above and below the storied Any weight supported in between storied should be distributed to the floors above and below in inverse proportion to its distance from the floors [IS 1893 (Part 1): 2016, clause 7.3]

As per IS 1893: (Part 1), the percentage of IL, as given in Table 4.1, should be used for calculating the design seismic forces of the structure, the II. of the roof need not be considered. A reduction in II. is recommended for the following reasons.

1. All the floors may not be occupied during earthquake.
2. A part of earthquake energy may get absorbed by non-rigid mountings of IL

Table percentage of imposed load to br considered in seismic weight calculation

Table 1. Seismic Load

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Imposed uniformly distributed floor load	Percentage of imposed load
Upto and including 3	25
Above 3	50

STEP III Calculate design horizontal seismic coefficient, Ah, which is given by
(cl.6.4.2)
Ah-Z/2*1/R*Sa/g
Provided that for any structure with T < 0.1s, the value of Ah will not be taken less than whatever be the value of
Where, Z is the zone factor given in Table for the maximum considered Earthquake (MCE).
The denominator is used so as to reduce the MCE zone factor to the Re Design Basis Earthquake (DBE)
I is the importance factor given in table 4.3 and depends upon the functional use of the structure, the hazardous consequences of its failure, post-earthquake functional a historical value, or economic importance.
R is the response reduction factor given in Table 9 (IS Code), and depends on the peeked seismic damage performance of the structure, characterized by ductile or bile deformations. This factor is used to decide what building materials are used, de open of construction, and the type of lateral bracing system.
-Sa is the response acceleration coefficient for 5% damping based an appropriate natural period (Ta)

3.2.2 Factors in Seismic Analysis:

The factors taken into account in accessing lateral design forces are as follows,

1) **Zone Factor (Z):-** Seismic zoning assesses the maximum severity or shaking that is anticipated in a particular region. The zone factor (Z), thus defined as a Scor to obtain the design spectrum depending on the perceived seismic hazard in the one in which the structure is located. The basic zone factors included in the code are reasonable estimate of effective peak ground acceleration. Zone factors are given in Table 2

Table.2 Zone factor

Seismic zone	II	III	IV	V
Seismic intensity	Low	Moderate	Severe	Very severe
Zone factor	0.1	0.16	0.24	0.36

2) **Importance Factor: -** The importance factor is a factor used to obtain the design seismic force depending upon the functional use of the structure. It is customary to organize that certain categories of buildings should be designed for greater levels of safety than the others, and this is achieved by specifying higher lateral design forces. Such categories are (a) Buildings which are essential after an earthquake-hospitals fre stations, etc (b) Places of assembly-schools, theatres, etc. (c) Structures the collapse of which may endanger lives nuclear plants. dams. etc. the importance factor are given in table3

Table 3. Importance Factor

Structure	Importance
Important service and community buildings, such as hospitals: Schools: monumental structures; emergency buildings like telephone exchanges, television stations. radio stations, railway stations, fire station buildings; large community halls like cinemas, assembly halls and subway stations, power stations	1.5
Residential or commercial building for occupancy more than 200persons	1.2
All other buildings	1.0

3) **Response Reduction Factor:** The basic principle of designing a structure for throng ground motion is that the structure should not collapse but damage to the extural elements is permitted. Since a structure is allowed to be damaged in case of severe shaking, the structure should be designed for seismic forces much less than what is expected under strong shaking, if the structures were to remain linearly clastic. Response reduction factor (R) is the factor by which the actual base shear force should be reduced, to obtain the design lateral force. Base shear force is the force that would be generated. Table no. 9 of IS code 1893 (Part-1)- 2002 in page No. 20 shows all response reduction factors for all categories of lateral load resisting system of a building. In this project we are using Ordinary Reinforced Concrete Moment -resisting frame for response reduction factor 3.0 taken from table 9 of IS code 1893.

15 m Staging	Col – 500 x 500 – 10 #20				Col – 500 x 500 – 14 #20			
	Zone II		Zone III		Zone IV		Zone V	
	Full	Empty	Full	Empty	Full	Empty	Full	Empty
Time period	1.04	0.70	1.04	0.70	1.04	0.70	1.04	0.70
Ductility Ratio (μ)	1.57	1.52	2.62	2.21	1.57	1.53	1.53	1.53
Ductility Factor (R_μ)	2.16	4.25	3.07	8.56	2.16	4.31	3.20	3.20
Redundancy Factor (R_R)	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Over Strength Factor (R_S)	9.32	5.19	5.28	1.91	3.88	2.76	1.69	1.72
Response reduction factor	**17.3**	**18.9**	**13.94**	**14.0**	**7.20**	**10.23**	**4.65**	**4.74**
Hinges	1	2	1	2	1	2	2	2

4) Fundamental Natural Period: - The fundamental natural period Ta is the first (longest) modal time period of vibration of the structure. Because the design loading depends on the building period, and the period cannot be calculated until a design has been prepared. IS 1839 (Part 1): 2016, clause 7.6, provides formulae from which Ta can be calculated.

For a moment-resisting frame building without brick infill panels, Ta, maybe estimated by the empirical expressions [IS 1893 (Part 1): 2002, clause 7.6.11 Ta 0.075 0.75 for RC frame building

For all other buildings, including moment-resisting frame buildings with brick infill panels, Ta, may be estimated by the empirical expression. Ta= 0.09h/-vd

Where, h is height of building in meters (this excludes the basement storied where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storied when they are not so connected), and d is the base dimension of the building at the plinth level in meters, along the considered direction of the lateral force.

Model	Fundamental Natural Period (Second)
Model 1	0.94
Model 2	0.15
Model 3	0.19
Model 4	0.50
Model 5	0.19

5) Spectral Acceleration Coefficient :- Design response spectrum for rocks and soil sites are given in IS code clause 6.4.3 illustrating a figure for 5% Damping.

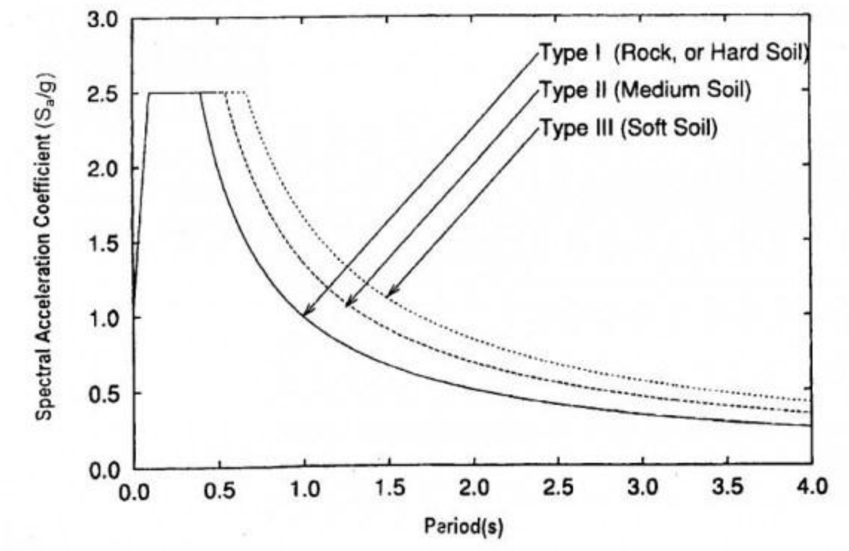

Fig. 1: Spectra for equivalent static method

The type of soil in which this response is measured are categorized under three heads, viz. Type 1= Rocky or hard strata, Type 2- Medium Soil, Type 3 = Soft soil. Medium soil is considered in this project. These spectral acceleration coefficients are based on appropriate natural periods.

STEP IV Calculate design seismic base shear for the structure (Vb). This is the total design lateral force along any principal direction. This is calculated as: Vb Ah x W

Load combinations as per IS 1893:2016 (part 1): Partial Safety factors for limit state design of reinforced concrete structures are given in Clause no. 6.3 of IS 1893 (Part 1): 2016. Following load combinations should be adopted for limit state design of reinforced concrete structures subjected to earthquake loading.

1) 1.5 (DL+IL)
2) 1.2 (DL+IL+EL)
3) 1.5 (DL+EL)
4) 0.9 DL+1.5 EL

Time History Analysis Inputs:

the basic idea of time-history analysis is to reproduce the actual behavior of a rupture under the action of ground motions. The time history analyses technique represents the most sophisticated method of dynamic analysis for structures. In this method, the mathematical model of the structure is subjected to acceleration from earthquake records that represent the expected earthquake at the base of the structure. Time history method consists of a step by step direct integration over a time interval the equation of motion are solved with the displacements, velocities and acceleration of the previous step serving as initial function. For that selected earthquake ground motions are considered as an input motion for time history analysis and applied at the base of structure.

Inputs Ground Motions and Analysis Procedure:

The horizontal component of "EL-Centro" earthquake ground motion is chosen for time history analysis. The details of the ground motion like PGA and recording station is presented in graph the ground motion are applied along the X direction. The linear Time History Analysis in STAAD Pro was performed.

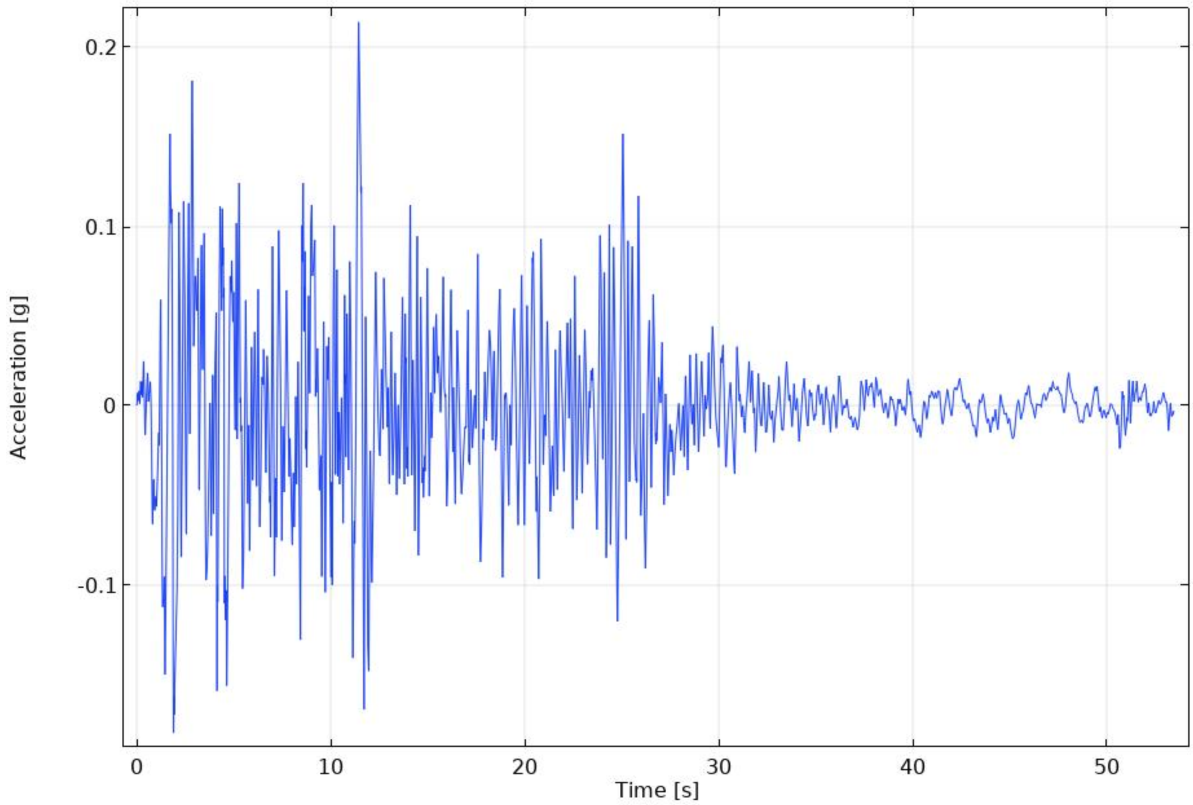

Fig.2 Graph showing EL-CENTRO ground motion data

Design of Building model:

The calculation carried out as follows:

1. The first step is to decide the minimum bearing diameter depending on vertical reaction.
2. Second step is to set the target period (2 seconds appears to be the desired one) and the effective damping B is assumed to be 5% for reinforced concrete structure according to IS 1893:200211 §7.8.2.1.
3. In third step, the spectral acceleration in relation with the desired period is to be find.
4. In next step design displacement is calculated:
5. The required stiffness to provide a period is the effective stiffness:
6. Calculate ED- design displacement
7. Calculate Fo= Force at zero displacement under loading
8. Calculate KPb- Stiffness of bearing
9. Calculate Kr= Stiffness o
10. Calculate tr= Total thickness
11. Calculate D bearing = Diameter
12. Calculate Total loaded area (AL) calculation
13. Calculate Circumference of force free section
14. Calculate Shape factor

15. H = Total height
16. Calculate bearing horizontal stiffness
17. Calculate Total bearing vertical stiffness

3. CONCLUSION

On the basis on present dissertation work, following are the conclusions.

The time period increases due to presence of mass irregularity in a structure and varies with the position of mass irregularity.

The mass participations ratio varies with the location of mass irregularities in the building. The mass participation ratio is less when the mass irregularity present in the bottom stories and no mass irregularity.

The Max. Storied displacement is maximum when the building is without mass irregularity and it decrease with the presence of mass irregularity at the lower floors and increases in the upper stories.

The Max. Storied displacement in case of earthquake in both X and Y directions is minimum when mass irregularity is not present and it varies with the presence of mass irregularity and the displacement is more in case of bottom and top stories and less when mass irregularity present in the central stories.

A parametric study was conducted to illustrate how the response modification factor would be affected in case of existence of multi-story basements, number of stories underground and taking in account the pressure effect from soil besides the retaining walls. The first main objective was to determine the R-value. While the second main objective was to compare the calculated response modification factor (R) values for reinforced concrete (RC) shear walls with those specified in IS and international codes.

Based on analysis, conclusions are made with respect to objectives of study as follow;

1) Deflection due to wind loading is dependent on the ratio of exposed surface area to the number of columns.

2) Deflection due to seismic loading is dependent on the total mass of each storied

3) However, these analyses are depending on building initial design. If the reserved strength is very high, the existing building might survive from seismic loading.

4) Static analysis is not sufficient for high rise building and it is necessary to provide dynamic analysis.

5) The difference of displacement values between static and dynamic analysis lower stories are insignificant but it increase in higher number of storied.

6) The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis.

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