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A Analytical Study on Strength Characteristics of RC Buildings Subjected to Seismic Forces

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Abstract – Most existing RC buildings, especially older ones, lack sufficient resistivity to earthquakes. When these buildings are identified, they can be upgraded to withstand future earthquakes. The estimation of the seismic safty of existing buildings is a expensive and lengthy process. Simplified techniques may be justified in most structures. The objective of this paper is to review these simplified methods for the seismic safety assessment of existing buildings. The methods available are either qualitative or analytical or they combine both. These procedures depend on conditional evaluation visual-inspection and non - destructive testing. The analytical methods include capacity / demand method, analysis push-over, inelastic time history analysis, etc. Another way of classifying the methods into three categories-Procedure level-1consisting of rapid visual screening. Level 2 procedures involving a simplified assessment of vulnerability based on information obtained from Level 1 structural drawings or site measurements. Level 3 involves detailed assessments of vulnerability using a computer. the city Hyderabad was under Seismic Zone- I up to 2002 and after that it was in Zone II as per IS:1893. All the buildings constructed before and after will be checked in accordance with latest seismic code of India and compare A Results obtained from the proposed method with the results obtained from Seismic Coefficient method as per IS-1893 using ETABS and Pushover analysis using SAP-2000 as per ATC (Applied Technology Council).

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MODELING OF THE EXISTING RC STRUCTURES

The building is eight (8) storeyed RCC frame building with brick infill walls of 115 mm thickness & without shear walls. The storey height is 3m. There are five (5) bays in X-direction & four (4) bays in Y- direction. The building is used for residential purpose only.

The concrete mix is of grade M20 & grade of steel is Fe 415. The size of column is 230x380 mm & size of beam is 230 x415mm. The c/c distance between columns is 3m. The building is located in Zone II (As per IS: 1893-2002). The building is standing over medium soil. The non-ductile detailing has been carried out for this building. The response reduction factor (R) = 3 (As per IS: 1893-2002) &Importance factor (I) = 1 (As per IS: 1893-2002).

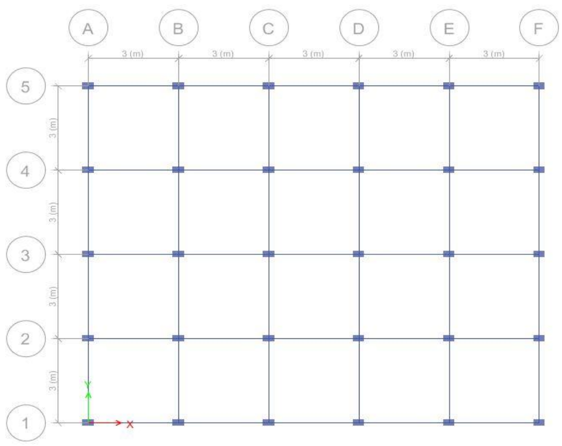

Fig – PLAN OF BUILDING

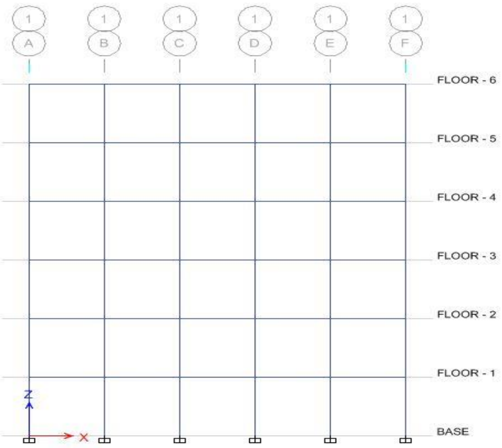

Fig – ELEVATION OF BUILDING

DATA OF BUILDING CONSIDERED FOR STUDY:-

S. No.	*DISCRIPTION*	*INFORMATION*
1	***Building Considered :-***	
	❖ Building plan ❖ Type of building ❖ Area of building ❖ No. of storeys	Symmetrical plan RCC frame building 180 m^2 Eight
2	***Cross- Section Details :-***	
	❖ Column ❖ Beam ❖ Slab Thickness	300 x 230 mm 230 x 300 mm 115 mm
3	***Loads :-***	
	❖ Dead Loads - I.S : 875 (Part – I) • Dead load of structure • Wall load - Exterior floor beams Interior floor beams Parapat ❖ Live Load - I.S : 875 (Part – I) • Live load ❖ Earthquake Load - I.S : 1893 -2002 ❖ Useable Life Factors - I.S : 15988-2013 ❖ Knowledge Factors - I.S : 15988-2013	 6.0 kN / m 6 .0 kN / m 3 .0 kN / m 2.0 kN / m^2 1.0 1.0 to 0.5
4	***Seismic Parameters :-***	
	❖ Zone Factor (Z) ❖ Importance Factor (I) ❖ Response Reduction Factor (R) Non- Ductile Frame Ductile Frame ❖ Type of soil	0.1 1 3 5 Hard Soil Medium Soil Soft Soil

G + 3 ORDINARY MOMENT RESISTING FRAME BUILDINGS RESTING ON TYPE – I SOIL (HARD SOIL)

Design Life of Building	100 Yrs
Remaining Life of Building	100 Yrs
Useable Life Factor (U)	1.0

PROCURING OF METHODS CONSIDERED

ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

Thus it is important to **analysis** a structure for **seismic** force. **Seismic coefficient method** can be used to analyze small and medium height structure up to 40m. It is a simple **method** of **analysis** and required less calculation. ... The **analysis** is done as per IS 1893:2002 (Part-1).

Pushover Analysis

Pushover is astatic- nonlinear analyticalmethod in which astructure is intended to gravity loading and a monotonous, displacement- controlled lateral load behavior which increases continuously throughelastic and inelastic action until theultimate condition is achieved. Send in anything youwant, and it will turn it into something else while keeping its meaning. The output provides a static pushover curve thatplotsaparameterdependsonthe deflection. For sample, performance can relatethe strength level attain in some members to the lateral displacement atthe top of the structure, or the bendingmoment against plastic rotation can be plotted. The results show the ductile capability of the structural systemand the mechanism,the load level and thedeflection at which the failure takes place.When the frame objects are analyzed, material nonlinearity is allocated to discrete locations where plastic occurs FEMA-356 or any other user-defined or code-based criteria. Powerdrop, displacementcontrol and all other non-linear software featuresincluding link assignment, P-Deltaeffect and stage construction, are availableduring static-pushoveranalysis.

Seismic Safety Evaluation Method (SSEM)

The proposed method of evaluation of seismic safety (SSEM) iscarried out in two stages, the primaryand secondary stages.

Primary Stage :-

The primary stage is the collection of relevant data on the building under consideration, such as the building's address, the seismic zone in which the building is located, the construction year, the total area of the building, the type ofbuilding, the use of thebuilding, the year of construction, presence of soft storage plan and vertical irregularities, apparent building quality, architectural and structural drawing availability, geo-tech report and any appropriate data.

Secondary Stage:-

The second step is taken to obtain the final capacity of the building. The building's final capacity score (FCS) is obtained by taking the sum of the modified initial capacity score (AICS) and the modified seismic susceptibility score (ASSS) .Depending on the final capability score (FCS), the building safety is assessed If the final capacity score (FCS) is less than " 2, " the building is considered unsafe and a detailed assessment of the building is advised. If the final capacity score (FCS) exceeds " 2, " the building shall be considered safe. The secondary stage is performed in the following steps:

Step–1:-The building's initial capacity score (ICS) is selected according to the building being evaluated.

Step–2: Modified Initial Capacity Score (AICS) is achieved by multiplying the basic score with the M1, M2 & M3 AICS= (ICS) (M1) (M2) (M3) Modifiers

Step–3:- Seismic susceptibility score (SSS) values are selected based on the number of building floors to be evaluated.

Step – 4:- The values of the Seismic Susceptibility Score (SSS) are multiplied by the Seismic Susceptibility Score Moderator (SSSM) for all items. The final Seismic Susceptibility Score (ASSS) is obtained for the whole building by adding all values.

ASSS = Σ {(SSS). (SSSM)}

Step – 5:- The final building capacity score (FCS) is achieved by adding ASSS to AICS:

FCS = AICS + ASSS

EXPERIMENTAL RESULTS

BUILDING = G + 7 ZONE - II with plan & vertical irregularity R = 3 U=1

	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
HARD	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
MEDIUM	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
SOFT	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE

BUILDING = G + 7 ZONE - III with plan & vertical irregularity R = 3 U=1

	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
HARD	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
MEDIUM	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
SOFT	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE

BUILDING = G+7 ZONE - V with plan & vertical irregularity R =3 U=1

	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
HARD	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
MEDIUM	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
SOFT	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE

BUILDING = G+7 ZONE - IV with plan & vertical irregularity R =3 U=1

	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
HARD	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
MEDIUM	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	SSEM	ETABS	PUSHOVER ANALYSIS
SOFT	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
		K= 0.9	UNSAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
		K= 0.7	UNSAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
		K= 0.5	UNSAFE	UNSAFE	UNSAFE

CONCLUSIONS:

(c) Seismic Coefficient Method as per IS-1893 using ETABS.

(i) In Zone II & Zone III the building were found to be safe except Zone III soft soil poor apparent quality (K=0.6 & K=0.5)

(ii) In Zone IV the buildings were found to be safe in Hard & Medium soil except poor apparent qualities (K=0.5) and the buildings were found to be unsafe for soft soil all apparent qualities.

(iii) In Zone IV the buildings were found to be unsafe for all types of soils and apparent qualities.

(d) Pushover analysis by SAP-2000

- For the 7-storey building, in case of hard soil zone 2 the pushover curves and tables it can be noticed that the base shear is decreasing by decreasing the concrete strength from 1576 kN to 1347 kN but the displacement at point “D” is increasing whenever the concrete strength is decreasing for all different concrete strength from 557 mm to 727 mm.

- For the 7-storey building, in case of medium soil zone 2 the pushover curves and tables it can be noticed that the base shear is decreasingby decreasing the concrete strength from1816 kN to 1622 kN But the displacement at point “D” is increasing whenever the concrete strength is decreasing for all different concrete strength from 520 mm to727 mm.

- For the 7-storey building, in case of softsoil zone 2 the pushover curves and tables it can be noticed that the base shear is decreasing by decreasing the concrete strength from2207 kN to 1673 kN but the displacement at point “D” is increasing whenever the concrete strength is decreasing for all different concrete strength from 557 mm to 808 mm.

- The results obtained in terms of demand, capacity and plastic hinges gave an insight into the real behaviour of structures.

(i) In ZoneI I Hard soil the buildings were found to be safe upto good apparent quality (K=1 & K=0.9).

(ii) In Zone II Medium soil & soft soil the buildings were found to be unsafe for all apparent qualities.

(iii) In Zone III Zone IV & Zone V the buildings were found to be unsafe for all types of Soil and apparent qualities.

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