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Proposed Simplified Method for Seismic Assessment of Existing RC Buildings

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Abstract – Further due to revision of existing codes the design seismic forces are increased and code provisions made stringent to avoid damage failures e.g., in the 2002 edition of Indian Seismic code IS: 1893, Hyderabad has been upgraded to seismic zone II from seismic zone I of the 1984 edition. Hence most of the buildings which were safe as per the previous code have become unsafe as per provisions of the new code. Hence the need to determine the seismic safety of all the existing buildings and strengthen the weaken ones to resist the seismic forces prescribed by the new code. Hence the importance of this research works. Further most of the existing buildings were not designed to resist even the earthquake forces prescribed by the old code. There is greater need to evaluate the seismic safety of all such buildings as some of them may need demolition to avoid loss of life in future earthquakes. The remaining buildings will need retrofitting and repair.

A constant study is carried out by varying the seismic areas, soil type and store number, etc., changing only one parameter at a time. A method for determine the seismic security of existing reinforced concrete structure based on the Indian seismic code is proposed. The results are validated by comparing them with methods currently in use in other countries. It is hoped that the method developed will be useful in presenting a more comprehensive seismic safety evaluation code for use by the Indian designers. The need for evaluation arises mainly due to two causes: first, most of the existing RC buildings, particularly the old ones, have not been designed to resist earthquake forces due to lack of awareness Secondly, due to the revision of the existing seismic codes, Even buildings designed by previous codes for seismic forces can become unsafe because of the increase in the seismic forces proposed. In India, because of the revision of IS: 1893-1984 in 2002, we are facing this situation. Our town in Hyderabad is now under seismic zone II, while it used to be in zone I. The main objective of the present work is to study the seismic vulnerability of existing RC buildings in Hyderabad city. Since 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.

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DURESH C. RAI (IS 15988)

The seismic performance of existing buildings in relation to the performance criteria used for new buildings is evaluated. This section defines the minimum assessment criteria for the expected life-safety performance of existing buildings with appropriate changes to IS: 1893, applicable to the earthquake design of new buildings. 1893All existing structural elements must be able to carry all other non-seismic loads in accordance with the current applicable codes for loading and material strengths. Basic inputs for seismic forces such as seismic zone, type of building, response factor should be taken directly from IS: 1893. Alternatively, a site - specific criterion for seismic design based on the principles described in IS: 1893 can be used. Changes to seismic forces as specified in IS: 1893 and to material strengths shall apply to both preliminary and detailed evaluations described in this document. The lateral force determined for strength-related checks must be modified for a reduced useful life. The life factor U, which is considered 0.67, is to be multiplied by the lateral force (base shear) for new buildings as specified in IS: 1893.

S. No.	CHECK	REMARKS
1	**Load Path**	One complete load pattern exist which transfer the internal forces from the mass to the foundation.
2	**Geometry**	Horizontal dimension equal at all stories.
3	**Weak Storey**	There are no abrupt changes in the column sizes from one storeyto another storey and no significant geometrical irregularities. Thus weak or soft storey doesn't exist.
4	**Soft Storey**	
5	**Vertical Discontinuities**	The vertical elements in the lateral force resisting system are continuous to the foundation.
6	**Mass**	The effective mass at all the floors is equal except the roof.
7	**Torsion**	The building brings symmetrical center of mass and center of rigidity coincide.
8	**Adjacent Building**	Not Applicable
9	**Short Columns**	The building has no short columns.

PRELIMINARY EVALUATION

Seismic Safety Evaluation Method

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 of building, the use of the building, 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

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).

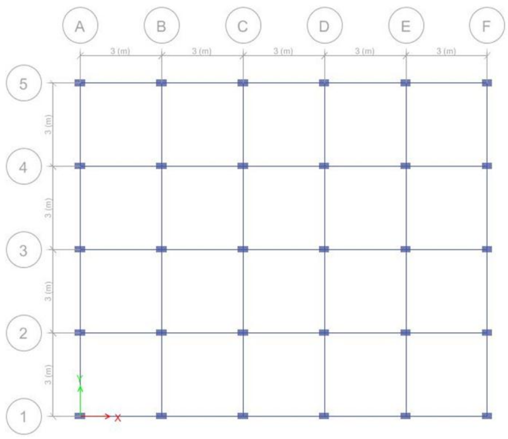

Fig – PLAN OF BUILDING

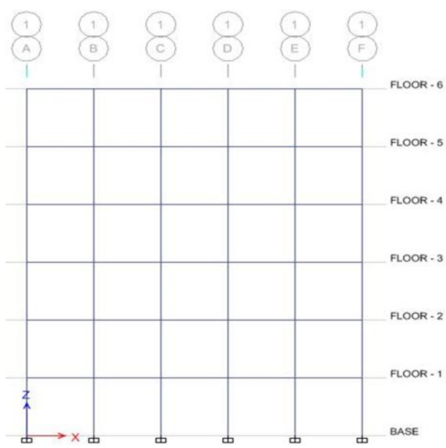

Fig – ELEVATION OF BUILDING

DATA OF BUILDING CONSIDERED FOR STUDY:-

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

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

Soil	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
HARD	GOOD	K= 1.0	SAFE	UNSAFE	UNSAFE
		K= 0.9	SAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	SAFE	UNSAFE	UNSAFE
		K= 0.7	SAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	SAFE	UNSAFE	UNSAFE
		K= 0.5	SAFE	UNSAFE	UNSAFE
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
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 - II with plan & vertical irregularity R = 3 U=1

Soil	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
HARD	GOOD	K= 1.0	SAFE	SAFE	UNSAFE
		K= 0.9	SAFE	SAFE	UNSAFE
	MODERATE	K= 0.8	SAFE	UNSAFE	UNSAFE
		K= 0.7	SAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	SAFE	UNSAFE	UNSAFE
		K= 0.5	SAFE	UNSAFE	UNSAFE
MEDIUM	GOOD	K= 1.0	SAFE	UNSAFE	UNSAFE
		K= 0.9	SAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	SAFE	UNSAFE	UNSAFE
		K= 0.7	SAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	SAFE	UNSAFE	UNSAFE
		K= 0.5	SAFE	UNSAFE	UNSAFE
SOFT	GOOD	K= 1.0	SAFE	UNSAFE	UNSAFE
		K= 0.9	SAFE	UNSAFE	UNSAFE
	MODERATE	K= 0.8	SAFE	UNSAFE	UNSAFE
		K= 0.7	SAFE	UNSAFE	UNSAFE
	POOR	K= 0.6	SAFE	UNSAFE	UNSAFE
		K= 0.5	SAFE	UNSAFE	UNSAFE

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

Soil	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
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
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
SOFT	GOOD	K= 1.0	UNSAFE	UN SAFE	UNSAFE
		K= 0.9	UNSAFE	UN SAFE	UNSAFE
	MODERATE	K= 0.8	UNSAFE	UN SAFE	UNSAFE
		K= 0.7	UNSAFE	UN SAFE	UNSAFE
	POOR	K= 0.6	UNSAFE	UN SAFE	UNSAFE
		K= 0.5	UNSAFE	UN SAFE	UNSAFE

BUILDING = G+7 ZONE - V with plan & vertical irregularity R = 3 U=1					
	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
HARD	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
HARD	GOOD	K= 0.9	UNSAFE	UNSAFE	UNSAFE
HARD	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
HARD	MODERATE	K= 0.7	UNSAFE	UNSAFE	UNSAFE
HARD	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
HARD	POOR	K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
MEDIUM	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
MEDIUM	GOOD	K= 0.9	UNSAFE	UNSAFE	UNSAFE
MEDIUM	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
MEDIUM	MODERATE	K= 0.7	UNSAFE	UNSAFE	UNSAFE
MEDIUM	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
MEDIUM	POOR	K= 0.5	UNSAFE	UNSAFE	UNSAFE
	APPARENT QUALITY	K	IS:15988 DCR	IS:15988 DE	SSEM
SOFT	GOOD	K= 1.0	UNSAFE	UNSAFE	UNSAFE
SOFT	GOOD	K= 0.9	UNSAFE	UNSAFE	UNSAFE
SOFT	MODERATE	K= 0.8	UNSAFE	UNSAFE	UNSAFE
SOFT	MODERATE	K= 0.7	UNSAFE	UNSAFE	UNSAFE
SOFT	POOR	K= 0.6	UNSAFE	UNSAFE	UNSAFE
SOFT	POOR	K= 0.5	UNSAFE	UNSAFE	UNSAFE

CONCLUSIONS:

1. There was a difference of values in Zone factor of Zone I and Zone II, that was checked. It was found that in most of the most of the buildings which were designed for seism forces, were safe as per the earlier code. However after up gradation from Zone I to Zone II most of these buildings were found to be unsafe and required retrofitting in some of the members. Hence a detailed study was carried out on a number of existing buildings.

2. The buildings which were constructed after 2002 (U=1) it was observed that results obtained for G+7 storied buildings without Ductile detailing & as per IS 15988 method.

   (i) In Zone II Hard soil the buildings were found to be safe upto good and moderate apparent quality (K=0.8 & K=0.7).

   (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.

3. More Comprehensive SEISMIC SAFETY EVALUATION METHOD has been developed which takes into consideration, some extra parameters which were not considered in some earlier methods. By using these method the results can be obtained without any Detailed Analytical Method.

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