Seismic Risk Assessment of Existing Concrete Buildings

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ABSTRACT:
Recent earthquakes in India have shown the fragility of existing reinforced concrete buildings. Multi-story structures in Gujarat's metropolitan areas have been severely damaged by the 2001 Bhuj earthquake. Existing Indian RC structures, most of which were built to withstand gravity loads, were in grave danger. As a result of previous earthquakes, it became evident that old buildings needed to be reassessed for seismic safety. In a nation like India, where earthquakes are common, a streamlined assessment procedure is required to carry out a seismic evaluation. It's critical to figure out how earthquake-resistant and risk-management-friendly a structure is. The present design of a reinforced concrete bare black frame, infill frame, and infill frame and soil impact is evaluated using the Response Spectrum analysis approach. This model's performance is evaluated using response spectrum analysis (RSA), which is a seismic evaluation technique. Each format's analysis reinforcement is calculated and retrofitted appropriately. Another retrofitting approach is investigated in this paper. Additionally, in seismic evaluations of existing RC structures, infill plays an important role.
Upgrading and masonry infill wall are the main topics of discussion., reinforced cement, upgrading,

INTRODUCTION
Among the many natural disasters, earthquakes may do significant damage to man-made buildings. Engineering techniques need to be honed in order to analyse earthquake structures since their forces are random and unexpected. India has seen several of the world's largest earthquakes in the recent century. More than half of the nation is designated earthquake-vulnerable. The whole Himalayan belt, including the north-east area, is vulnerable to significant earthquakes with magnitudes of higher than 8.0.

Fig 1: Area expose to seismic risk in Indian Classification

Four big earthquakes struck the nation in the recent century: a large one in Assam in 1897, a smaller one in Kangra in 1905, a larger one in Bihar Nepal in 1934, and a smaller one in Assam in 1897. (1950). We've seen a number of recent earthquakes, including the Bihar Nepal earthquake in 1998, the Killari earthquake in 1991, the Jabalpur earthquake in 1999, and most recently the West Bengal earthquake in the last few years (2011). All of these earthquakes have resulted in a massive loss of life and extensive damage to existing reinforced concrete (RC) structures. The most recent structures in metropolitan areas are badly planned and constructed.... Older buildings may not be able to meet the more strict requirements of IS 1893(Part 1):2002, is 4326:1993 and IS 13920:1993, even if they were constructed according to the current standards. Current structures may be seismically unsound since the design code's specifications are always being refined to reflect advances in technical understanding.

When the ground shakes violently, buildings may suffer serious damage or even collapse, according to studies of earthquake damage from the past and the present. Many manmade buildings, bridges, industrial and port infrastructure and considerable economic losses may be caused by an earthquake of modest magnitude.

Many people in India were concerned about the dangers of earthquakes after the devastating Bhuj quake in 2001. The majority of India's megacities are built in seismically active regions and are only meant to be reached by foot. Seismic zoning of some places was also enhanced while increasing magnitudes of the intended seismic pressures. As a result of the aforementioned factors, seismic evaluations are required for a huge number of existing structures in India. As a result, the evaluation of existing RC structures in India is becoming more important.

1.2 NEED FOR SEISMIC EVALUATION

Aftershocks and other major earthquakes are common after major earthquakes. In the past, earthquakes have shown that a large proportion of buildings in metropolitan areas are damaged by moderate to severe earthquakes. It is also known that buildings damaged before to the earthquake may collapse in a subsequent earthquake. Many people lost their lives as a result of such tragic tragedies. Thus, these constructions put human life, financial assets, and the environment at danger.. Decisions on the post-earthquake functioning and the restoration of damaged structures are thus critical to the post-earthquake recovery process. There is also a growing danger of earthquakes due to significant earthquakes in different sections of the nation, which is not socially acceptable. As a result, action must be taken immediately to correct this condition, and seismic assessments of existing buildings are seen to be the most effective approach.

For the complete design of new engineering facilities, more dependable seismic norms and codal provisions should be developed. In order to accurately assess the impact of an earthquake on a structure's vulnerability, accurate assessments of structural performance during an earthquake are necessary. It's possible to predict which parts of the structure are most likely to be damaged in future earthquakes. Deformation of these components is therefore reduced as a result of these rapid structural actions. The structure's total stability may then be enhanced, resulting in greater overall seismic performance.

2. METHODS OF SEISMIC ANALYSIS AND RETROFITTING

2.1 METHODS OF ANALYSIS

A structural analysis of the structural mathematical model is required to determine strength and displacement demands in various components of the structure for seismic performance analysis. Several analytical methods are available to predict the seismic performance of structures, both elastic and inelastic. Some of the seismic analysis methods used in seismic assessment are provided below;

1. Elastic analytical methods

A. Static linear analysis

B. Dynamic linear analysis

2. Inelastic analytical methods

A. Static Nonlinear Analysis

B. Dynamic nonlinear analysis.

2.1. Single diagonal strut equivalent models this method simulates the action of infill's similar to the action of diagonal struts holding the frame. The infills are replaced by an equivalent strut of length D and width W and the frame-strut system analysis is performed using the common frame analysis methods. Main stone Walls' relationships must withstand the shear forces that try to push the walls over. It is widely used in the literature to calculate the width of the diagonal strut equivalent and is given by it.

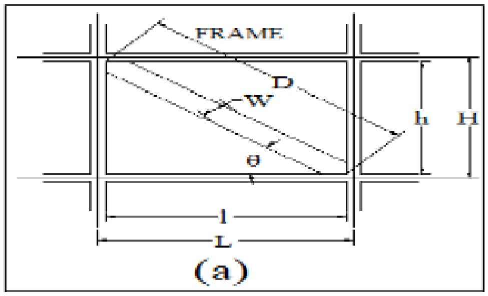


Fig 2.1 shows equivalent diagonal strut model

$$\lambda = \sqrt[4]{\frac{Ei\ t\,Sin(2\theta)}{4\,Ef\,Ic\,h}}$$

Where λ =Stiffness reduction factor

Ei = the modules of elasticity of the infill material,

N/mm2 Ef= the modules of elasticity of the frame material,

N/mm2 IC= the moment of inertia of column,

Mm4 t = the thickness of infill,

Mm H =the center line height of frames

h = the height of infill

L =the center line width of frames

l = the width of infill

D = the diagonal length of infill panel

θ = the slope of infill diagonal to the horizontal.

Width of strut without opening (W)

W= 0.175 (λ H)-0.4 D

When setting the value of the stiffness reduction factor above equation, strut width for estimation of strut width without opening has been calculated,

2.2 RETROFITION what is seismic refurbishment?

A seismic retrofit offers existing structures more resistance to earthquakes seismic activity. This process typically involves enhancing poor connections in roofs to walls, continuous ties, shear walls and the diaphragm of the roof. In the past, building codes were less stringent than today's standards and it is therefore good to inspect buildings built before 1998 as they were built before current structural codes and requirements (1997 UBC). It is the method of strengthening the damaged/undamaged old/new structures that are found to be weak with future earthquake loads. Structuring's that are vulnerable to earthquakes are generally refurbished by steel jacket, concrete jacketing, galvanized steel mesh strengthening, new supporting walls/concrete shear walls, steel straps, reinforced fiber polymer (FRP) sheets or other appropriate means. In a well-built building, renovation works may also be necessary if additional floors are added. Even old-weak buildings can be extended to cover the increased safety demand due to the extended part by properly strengthening the older part.

Selection of the correct retrofitting action

Proper study of the existing structure with various analytical tools is necessary to identify the weak areas of the structure before retrofitting work is carried out. It also helps to choose an appropriate retrofit measure to be taken in economic and security aspects. Construction structures in an acceleration sensitive region and the speed sensitive spectrum area may require various retrofitting measures. The retrofitting option suitable for one structure could prove to be ineffective for a different dynamic structure. Also, the rigidity of a building structure may increase significantly after retrofitting, thereby increasing the load consumption of the structure than before retrofitting. The increased rigidity also depends on the type of retrofitting.

In addition, a structure can increase significantly after retrofitting, increasing the demand for load on the structure than before retrofitting.

The increased rigidity also depends on the type of retrofitting. Conventional steel/concrete rehabilitation measures the jacketing and inclusion of new walls can significantly increase the rigidity of the structure. Thus its dynamic behavior is altered in such an analysis of the retrofitted structure Modern jacketing technology such as the wrapping of fiber-reinforced polymer (FRP) could be the best way of building capacity without altering rigidity. In addition to increasing structural stiffness, a major impact of the conventional method for retrofitting could be the development of new load paths leading to load concentration at the foundation level. This is done in the framework structures of reinforced concrete (RC) where the inclusion of concrete shear walls between the columns is done as a retrofit measures. In this way, the existing base of the adjacent columns will probably be stressed. The proper retrofitting technique shall be chosen by analyzing the existing structure in detail. Re-analysis including re-design may be necessary after retrofitting measures have been introduced. So that the goal of seismic refurbishment is achieved.

Refurbishment of design principles

The design principles must follow several factors even in the case of retrofitting, as in the case of the new construction. For example, in order to benefit fully from the potential ductility of RC members retrofitted. It is desirable to ensure that flexure is the ultimate strength rather than shear. Shear failure is catastrophic and occurs without warning of trouble. Many existing RC columns and beams were deficient in shear strength and need to be strengthened.

Shear deficiencies occur due to several reasons, such as poor shear strengthening or decreases in steel area due to corrosion, increased service load, older code design principles and building defects. Shear should be improved as far as possible in case of retrofitting. The structural members' bending, axial & ductile capacity and structure as a whole. Most current practices appear to provide greater confinement for the mostly increasing axial, shear, and ductile behavior of the structural components. Bending capacity increases can also be achieved if proper detailing and design principles are observed.

2.2.1 Beton Jacketing

Beton jackets consist of the addition of a concrete layer of longitudinal bars and closely spaced ties. The jacket strength and shear strength of the column are increased. There has been an increase in ductility (Rodriguez and Park, 1994). There is no noticeable increase in rigidity if the thickness of the jacket is small. Circular ferro-cement jackets have been found to improve ductility. The disadvantage of concrete jackets is that the column is bigger. Binding on the beam column joints is difficult, if not impossible. Drilling troughs in existing beams damages the concrete, particularly if it is of poor quality. Although there are disadvantages, it is relatively cheap to use concrete jacket. It is important to note that with the increase in bending capacity, the demand for shear is also increasing (based on bending capacity). The additional ties satisfy the shear demand.

A concrete jacket can be supplied with several schemes. A scheme is selected based on the dimensions and the strength of the existing column, available room for placing longitudinal bars, is required. The additional longitudinal bars must be anchored to the foundation and continuously through the floor slab to increase flexural strength. The required bars are usually placed at the corners to prevent the beams that are framed into the column from intercepting. Moreover, longitudinal bars on the sides of the column cannot be positioned continuously throughout the floor. These bars provide the new ties laterally. Due to the blockage in placement, a single bar cannot be made from a fie. It can be built with two bars properly attached to the new longitudinal bars. 135 hooks with adequate extension are preferred at the ends of the bars.

Fig: Concrete Jackting

a) The strengths of the new materials shall equal or exceed those of the existing column. At least 5MPa greater than the existing concrete should be the compressive strength of concrete in the jacket.

b) For columns not requiring extra longitudinal bars with an additional bending capacity of at least 12mm, bars in diameter in four corners and ties in diameter of 8mm should be provided.

c) The minimum jacket thickness should be 100 mm.

d) The minimum ties shall be 8 mm in diameter and not less than? In diameter of the longitudinal bars. The bending angle of the end of the ties is 135.

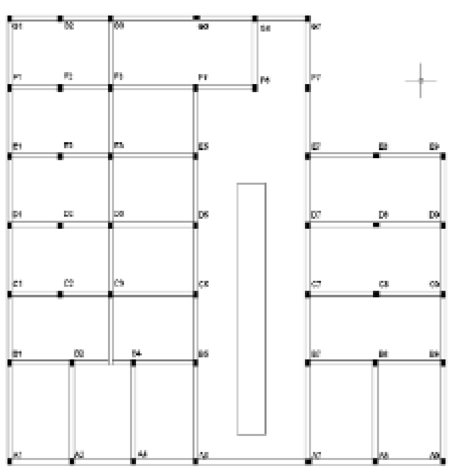
e) The center-to-center ties should not be more than 200 mm. The spacing should preferably not exceed the jacket thickness. Near the beam-column joints, for a clear column height of 1/2. The distance should not be more than 100 mm.

3 ANALYSIS PROBLEM

3.1 STRUCTURAL DETAILS:

RC Frame Details	
1] Grade of concrete	20 N/mm²
2] Grade of steel	415 N/mm²
3] modulus of elasticity of concrete	22.36 kN/m²
4] modulus of elasticity of steel	2x10⁵ kN/m²
5] unit weight of concrete	25 kN/m³
6] Poisson's ratio	0.2
7] Sizes of beams	230x300mm,230x380mm, 230 x 450mm
8] Sizes of columns	230x300mm,230x380mm, 230 x 450mm

Brick masonry Infill Details	
1] strength of brick masonry	4 N/mm²
2] unit weight of masonry	20 kN/m³
3] modulus of elasticity of brick masonry(550f_m)	2035 N/mm²
4] Thickness of peripheral wall	230mm
5] Poisson's ratio	0.15
6] Single strut model width a) along X-direction b) along Y-direction	 380,390,420,440,370,350mm 480,450,400,380,530mm
Soil Properties	
Type	Gravel
E (Modulus of Elasticity)	120 N/mm²
Poisson's Ratio	0.15



View of building.

3.2 Models of Analytics

For the purpose of analysis and design four models were considered as 1. Bare frame (S.M.R.F infill frame with masonary effect not considered)

2. Completely in filled frame (S.M.R.F infill frame with masonary effect considered)

3. In filledcenter opening frame (15 percent)

4. In filled corner opening frame (15 percent)

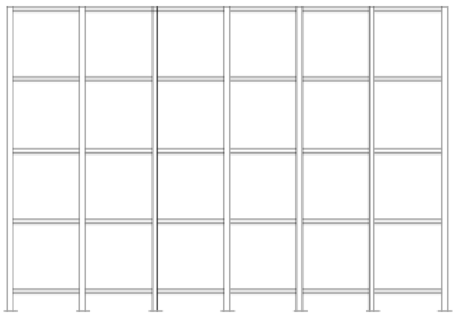


Fig 3.2: bare frame model

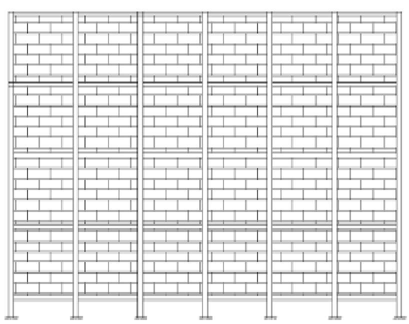


Fig 3.3: Fullyin filled frame model

All frames above were designed with the help of STAAD-Pro software. Some columns were chosen to get results and they are as column no.C1, C2, C3& C5. The results found are shown using the parameter graph.

4. RESULT COMPARISON 1.

The actual construction is reinforced and compared to the required reinforcement in the Brick Infill Model and Brick Infill + Soil Interaction Model under seismic design. If compression is more than the reinforcement required in the brick infill and the soil interaction effect than it is necessary to retrofit the actual section, the seismic forces will be sufficient to carry. But if the actual strengthening is less than the strengthening required.

In the brick infill or soil interaction model effect, the particular member needs to be retrofitted. The main parameter in the study is strengthening of members and maximum building displacement.

Table: - 4.1. Reinforcement Comparison of building.

Column ID	Size (mm x mm)	Ast Pro. (mm²)	Ast Required(mm²)			Retrofitting Required Yes/No
			Bare Frame	Infill Wall	Soil Effect	
G.F C1	230 x 300	678	847	783	730	NO
F.F.C1	230 x 300	678	374	530	530	NO
S.F.C1	230 x 300	678	121	616	616	NO
T.F.C1	230 x 300	678	412	676	673	NO
G.F C2	230 x 380	904	No Design	903	869	NO
F.F.C2	230 x 380	904	No Design	704	704	NO
S.F.C2	230 x 380	904	No Design	477	477	NO
T.F.C2	230 x 380	904	No Design	182	182	NO
G.F C3	230 x 300	678	1145	1029	970	Yes
F.F.C3	230 x 300	678	No Design	No Design	No Design	Yes
S.F.C3	230 x 300	678	No Design	No Design	No Design	Yes
T.F.C3	230 x 300	678	No Design	No Design	No Design	Yes
G.F C5	230 x 300	678	No Design	678	660	NO
F.F.C5	230 x 300	678	No Design	670	670	NO
S.F.C5	230 x 300	678	679	640	640	NO
T.F.C5	230 x 300	678	453	179	179	NO

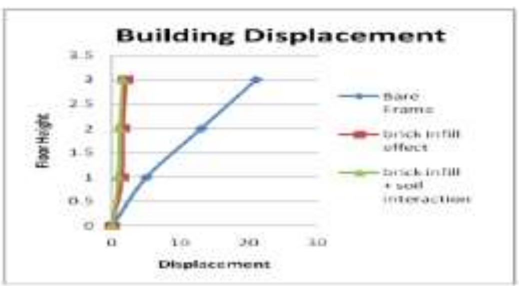


Figure No.4.1. - Displacement comparison of building

From the above figure it is found that, compared to the naked frame model, Brick infill + soil interaction effect model deflection was reduced by 90% - 92%.

Retrofitting:
Building No 1 column C3 in case of study retrofitting.

The concrete jacketing method is therefore for retrofitting Recommended for additional concrete layer from all sides, longitudinal bars and about 75 mm.The ties are closely spaced. The analysis and design is retrofitted the reinforcement done again and required is calculated. Below The table shows the necessary reinforcement afterretrofitting.

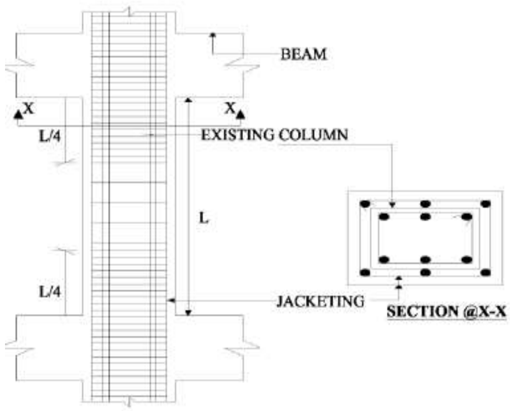


Figure e No.4.2. Column Jacketing

Table: - 4.2. Reinforcement Comparison of building After Retrofitting.

Element ID	Size (mm x mm)	Ast Provided (mm^2)	Ast Required (mm^2)		
			Bare Frame	Infill Wall	Soil Effect
G.F.C3	450 x 380	904+452	1041	930	870
F.F.C3	450 x 380	904+452	886	861	861
S.F.C3	450 x 380	904+452	545	345	345
T.F.C3	450 x 380	904+452	779	223	223

CONCLUSIONS:-

It's all about the examination and restoration of existing RC structures in this research. Existing reinforced concrete buildings have seismic studies done on them. Modeling and infilling of brick infill with soil impact model interaction are compared to the Building reinforcement. Following the completion of the research, the following conclusions may be reached.

The conclusion of this thesis is that strengthening has been done in a way that suggests the strength of the existing To the extent possible, the structure may be enhanced Building capacity needed for zone III will be enhanced thanks to the seismic resilience. Since the last time we used this technique, we've finished Effortless and cost-effective way § In the case of an earthquake, the results show that infill panels have a major influence on the behaviour of frames. Structural stiffness is generally improved with the use of infill panels. With the added rigidity from the infilling effect, there is less need for further reinforcing than would be necessary in the case of a bare metal frame.

In compared to the filled frame, deflection in the bare frame is much greater.

Compared to the imbalanced frame in the floor, the construction with brick infill + soil interaction effect is shown to need roughly 30% to 40% less reinforcement. Other higher levels, on the other hand, have a far lower level of reinforcement.

The most cost-effective structural member sizes for earthquake resistance will be utilised if the approach (analysis of infill wall + soil impacts for new buildings) is applied.

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