Assessment of Seismic Risk in Existing Concrete Buildings

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ABSTRACT:

Earthquakes have exposed the vulnerability of existing reinforced concrete structures in India. Multi-story buildings in Bhuj, Gujarat, were severely damaged by an earthquake that rocked the city in 2001. Because of this, many Indian RC constructions that rely on gravity loads are now in jeopardy. Seismic adequacy evaluations were required after a number of concrete structures were damaged and destroyed by earlier earthquakes. For an earthquake-prone country like India, a simplified assessment process is required. The capacity of structures to resist earthquakes is crucial for the preservation of life and the minimization of damage. Response Spectrum analysis is used to assess the current black reinforced concrete frame, infill, and soil effect. Response spectrum analysis (RSA) is used to assess this model's performance, a seismic evaluation approach. Depending on the format, it is computed and adapted accordingly. This study examines a novel way to retrofitting. In the evaluation of existing RC buildings for earthquakes, building infill plays a critical role.Upgrades and infill walls are the focus of the meeting

.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. Many of the world's largest earthquakes have occurred in India in the recent century. It is estimated that more than half of the country's land area is at risk of earthquakes. 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

Earthquakes that happened in the last century include the Assam earthquake (1897), the Kangra earthquake (1905), and the Bihar Nepal earthquake (1934). (1950). In the last several years, there have been many earthquakes in our country, including those in Bihar Nepal (in 1998), Killari (in 1991), Jabalpur (in 1999), and most recently, West Bengal (in 2013). (2011). Recent catastrophes have resulted in the deaths of a large number of people and the destruction of many existing reinforced concrete (RC) buildings. The most modern constructions in major cities are shoddy in design and execution. Even if they were built according to contemporary standards, older buildings may not be able to fulfil the more stringent criteria of IS 1893(Part 1):2002, is 4326:1993 and IS 13920:1993. The seismic safety of older buildings may be jeopardised due to the fact that engineers are constantly raising the design code's standards. According to historical and current earthquake damage assessments, moderate to major ground displacement may cause significant structural damage or collapse. Damage to man-made infrastructure, including roads and bridges, as well as large financial losses may be caused by even minor earthquakes. After the Bhuj earthquake in 2001, a lot of emphasis was paid to disaster preparation and seismic risk. There are several megacities in India that can only be accessed by foot since they are located in seismically active areas. Additionally, the magnitudes of design earthquake forces were frequently increased in several sites. As a result of the aforementioned factors, seismic assessments are required for a large number of existing buildings in India. As a consequence, the appraisal of existing RC structures in India is receiving increased attention.

1.2 NEED FOR SEISMIC EVALUATION

Aftershocks and even major earthquakes may follow a devastating earthquake. An alarmingly high number of buildings in densely populated regions have suffered only minor to severe damage in previous earthquakes. Structures that have incurred damage prior to the A series of earthquakes are also at risk of collapsing, as is well documented. People lost their lives because of these tragic situations. As a result of this, human life, financial assets, and the environment are placed at risk by these arrangements. Post-earthquake recovery requires judgments on the post-quake functioning and repair of damaged buildings. As a result of recent earthquakes, the risk of earthquakes in urban areas has increased, which has not been acknowledged by the general populace, Consequently, seismic evaluations of existing structures are considered the most effective technique to correcting this issue.

For the design of new engineering facilities, provide more reliable seismic standards and codal provisions than are now available. There are several factors to consider when assessing the potential for improvement in the seismic resistance of existing RC structures, including the performance of structures during an earthquake. Identifying the weakest points in the building's structure might help us better prepare for future earthquakes. There is less deformation as a consequence of this quick structural movement. The overall seismic performance of the structure may be improved as a consequence.

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

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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.

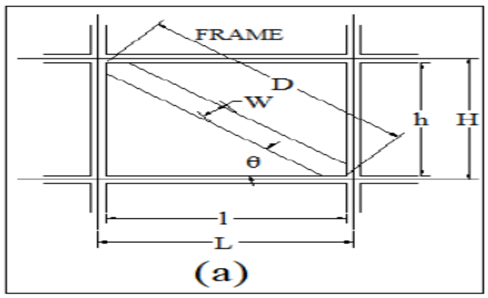


Fig 2.1 shows equivalent diagonal strut model

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

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)

$W= 0.175 (\lambda H)_{-0.4} D$

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 retrofit improves the structural integrity of existing buildings in the event of an earthquake. Enhancing weak connections between roofs and walls, such as continuous ties, shearwalls and the diaphragm's diaphragm, is the most common method used. Building norms and regulations were less strict before to 1998, which necessitates an audit of pre-1998 structures (1997 UBC). This technology may be used to strengthen buildings that will be subject to earthquake loads in the future, regardless of whether they are new or old. As a result, earthquake-prone structures are often equipped with steel jackets, reinforced concrete jackets, galvanised steel mesh strengthening and new supporting walls/concrete shear walls as well as steel straps and FRP sheets. If a well-built structure is increased in height, renovations may be required. By strengthening an older component, a new portion may be introduced to a weaker framework.

Performing car retrofits the right way

Before any retrofitting work can begin, the current building must be thoroughly analysed using a variety of analytical methods. In addition, this helps select the most cost-effective and safest option for a refurbishment Retrofitting methods may be required for structures that are sensitive to acceleration and speed. Depending on the architecture of the structure, a retrofitting method that works in one building may not work in another. It is possible that the stiffness of a building may rise dramatically after a refit, resulting in an increase in the structure's weight. It's possible that the stiffening effect will be more evident depending on the kind of retrofit used.

When retrofitting, for example, the structure's load demand may rise significantly.It's possible that the stiffening effect will be more evident depending on the kind of retrofit used. Structural rigidity may be considerably improved by the installation of additional walls and a jacketing system. As a result, such an examination alters the retrofitted structure's dynamic behaviour. If you're looking to enhance capacity without losing rigidity, FRP jacketing may be your best option. As a consequence, the foundation may be subjected to more stress than previously thought, which might have a substantial impact on the structure's rigidity. Concrete shear walls are constructed between RC frame construction columns as a retrofit alternative. That might lead to a weakened foundation for some of the neighbouring columns. Retrofitting a building can only be done after a complete assessment of the present structure has been completed. In certain cases, it may be necessary to redesign retrofitting methods. Aiming to help in earthquake recovery.

Refurbishment of design principles

Even in the event of retrofitting, the design principles must follow certain variables, as in the case of new building. For example, in order to take use of the retrofitted RC members' potential ductility. Rather from relying just on shear, it is preferable to rely on flexure for strength. This kind of catastrophic collapse happens without notice, and there is no way to prevent it. The shear strength of many current RC columns and beams needs to be improved.

Poor shear strengthening or corrosion-induced reductions in steel area, higher service loads, outdated code design concepts, and structural flaws may all contribute to shear inadequacies. In the event of a refit, the shear should be enhanced to the greatest extent practicable. Structural members' ability to bend and to be both axially and ductilely ductile. The structural components' growing axial, shear, and ductile behaviour seems to be better controlled in most contemporary procedures. It is possible to enhance the bending capacity of a product by adhering to suitable design and details guidelines.

2.2.1 Beton Jacketing

Reinforcement is achieved by the insertion of longitudinal bars and close-spaced links to the existing concrete. There is a rise in the column's jacket and shear strength. The ductility has increased (Rodriguez and Park, 1994). Nothing stands out about it. Reduced thickness will cause the jacket to become more rigid. Circular ferro-cement jackets have been demonstrated to be ductile. There is a downside to using concrete jackets, which is that they increase the diameter of a column. At the beam-column joints, it's almost impossible to bind. When holes are drilled into concrete, particularly low-quality concrete, the material is harmed. Despite their limitations, concrete jackets are a low-cost option. Keep in mind that increasing bending strength necessitates more shear (based on bending capacity). More ties are required due to the increased demand for the product at this time.

A concrete jacket may be provided in a variety of methods. Existing column size and strength as well as any available space for placing longitudinal bars are taken into account when choosing a design. Extending the length of a floor slab is necessary to increase its flexural strength. The bars are usually placed at the corners of the column to prevent the beams that are framed into the column from interfering. It is also not possible to move the column's side longitudinal bars and place them in a straight line across the floor simultaneously. These bars supply the new lateral connections. The position of the fie makes it hard to form a single bar. The construction may be finished by connecting the two new longitudinal bars to the two existing transverse bars. At the ends of the bars, 135 hooks with sufficient extension are preferred..

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.

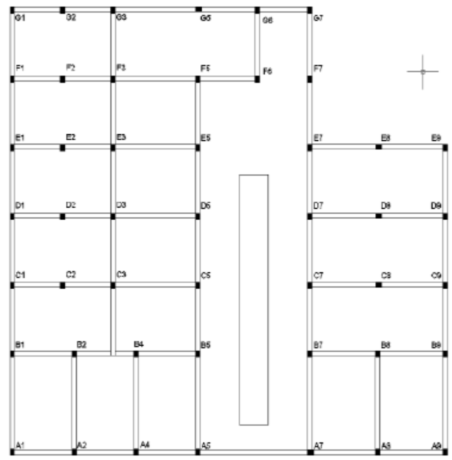
e) The center-to-center ties should not be more than 200 mm. The spacing should preferably not exceed the jacket thickness. Near the beam-column joints, for a clear column height of 1/2. The distance should not be more than 100 mm.

3 ANALYSIS PROBLEM

3.1 STRUCTURAL DETAILS:

RC Frame Details	
1] Grade of concrete	20 N/mm^2
2] Grade of steel	415 N/mm^2
3] modulus of elasticity of concrete	22.36 kN/m^2
4] modulus of elasticity of steel	2x10^5 kN/m^2
5] unit weight of concrete	25 kN/m^3
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/mm^2
2] unit weight of masonry	20 kN/m^3
3] modulus of elasticity of brick masonry(550f_m)	2035 N/mm^2
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/mm^2
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)

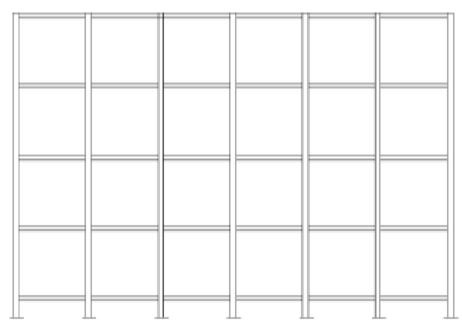


Fig 3.2: bare frame model

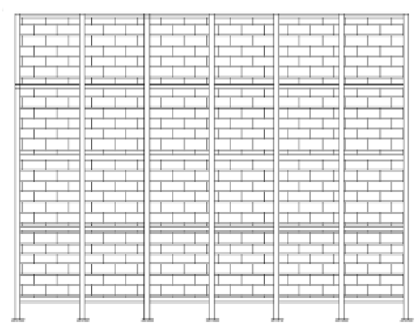


Fig 3.3: Fullyin filled frame model

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.

Using the Brick Infill Model and the Brick Infill + Soil Interaction Model, the actual building is strengthened and compared to the needed reinforcement. Compression will be adequate to carry out retrofitting if there is more reinforcement in brick infill and soil interaction effect than is needed for retrofitting. This may be an issue if the actual strengthening falls short of what's needed.

Members of the brick infill or soil interaction model must be updated. Building displacement and member strengthening are the primary considerations in this research.

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	674	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	440	440	NO
T.F.C5	230 x 300	678	453	179	179	NO

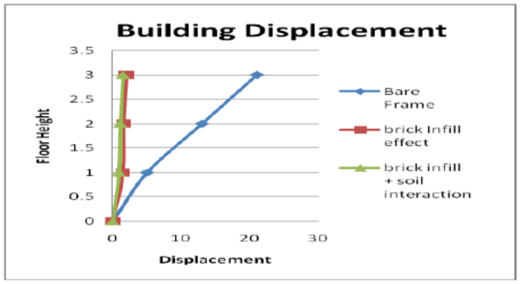


Figure No.4.1. - Displacement comparison of building

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.

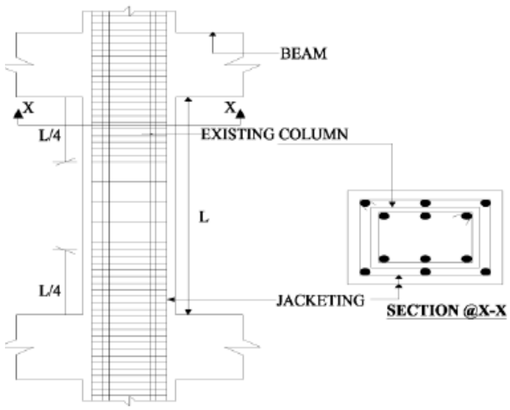


Figure e No.4.2. Column Jacketing

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 ensuring the safety and functionality of existing RC structures in this area. There is a seismic analysis on all reinforced concrete constructions The connection between brick infill modelling and soil impact modelling is likened to that of reinforcing structures. It's time to summarise the findings of the previous research.

According to the findings of this research, increasing the power of the existing entails strengthening it. It is possible to make improvements to the structure. Earthquake-resistant buildings may be found in zones III and IV. The concrete jacketing process has been chosen as the best option since it is fast, simple, and cost-effective. The structural damage earthquakes may do to buildings is enormous if infill panels are not used. Structural stiffness is increased by using infill panels. Less reinforcement is required since the infilling action enhances the frame's rigidity. The forward deflection in a bare frame is much greater than in a fully assembled frame. The brick infill + soil interaction effect structure uses 30-40% less reinforcing material than the imbalanced floor. It's also less visible at larger degrees of reinforcement variance.

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

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