Analysis of Retrofitting Residential Building by E-Tab

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Abstract— the retrofitting of concrete structures has become increasingly important in view aging and more deterioration of infrastructure. The problem is more severe due to optimized technologies for construction. Many expansive methods are available for retrofitting structures and choice of suitable method/material is a challenge to a structural engineer. Retrofitting is the Science and Technology of strengthening the existing structures or structural elements to enhance their performance with new technology, features and components. Retrofitting of an existing reinforced concrete structure includes either repair, rehabilitation (or) strengthening terms. The term retrofit is used if the damaged structure performance was satisfying than before with some additional resistance then the term retrofit will be representative. The different retrofitting methods such as steel and concrete jacketing and application of fiber reinforced polymer (FRP) composites which were used to improve the load bearing capacity of individual structure elements are highlighted and methods such as shear walls and shear cores which can be used to improve overall stability of buildings. Most retrofitting techniques will result an increase in stiffness and slightly increase in mass. Thereby redesigning and retrofitting by column jacketing were taken to modify the structure to withstand increased load..

1. Introduction

1.1 General

Earthquakes are the most destructive of natural hazards, Earthquake occurs due to sudden transient motion of the ground as a result of release of energy in a matter of few seconds . The impact of the event is most traumatic because it affects large area, occurs all of a sudden and UN-predictable. Vibrations induced in the Earth's crust due to Internal (or) External causes that virtually shake up a part of the crust and all the structures and living and non-living things existing on it they can cause large scale loss of life, Property and disrupts essential services such of water supply, sewerage systems, communication, power and transport etc.

1.2 Factors which affect the damage of structure

- Strength of Shaking: The Strong shaking produced by a magnitude 7 earthquake becomes half as a strong at a distance of 8miles, a quarter as a strong at a distance of 17 miles, an eighth as strong at a distance of 30 miles, and a sixteenth as strong at a distance of 50 miles.
- Length of shaking: Length depends on how the fault breaks during the earthquake. The maximum shaking during the Loma Prieta earthquake lasted only 10 to 15 seconds. During other magnitude 7 earthquakes in the Bay Area, the shaking may last 30 to 40 seconds. The longer buildings shake, the greater the damage.
- Type of soil: Shaking is increased in soft, thick, wet soils. In certain soils the ground surface may settle or slide.
- Types of building: Certain types of buildings, discussed in the reducing earthquake damage section, are not resist enough to the side-to-side shaking common during earthquakes.

Earthquakes are among the most destructive natural hazards, resulting from the sudden, transient motion of the ground due to the release of energy. They are traumatic because they affect large areas, are sudden, and are unpredictable. Vibrations cause large-scale loss of life, property, and disrupt essential services.

Retrofitting existing reinforced concrete structures includes terms like repair, rehabilitation, or strengthening. The term "retrofit" is representative if the damaged structure's performance is improved with additional resistance compared to before.

Fig.1 Structure damage due to earthquake

1.3 Objective of the Study

To provide safety to the occupants by reducing the of structural collapse during severe earthquakes. This can be done by strengthening the columns and joints so that their flexural and shear capacities will be adequately stronger. Retrofit strategy refers to options of increasing the strength, stiffness and ductility of the elements or buildings as whole

Several retrofit strategies may be selected under a retrofit scheme of a building.

1. Increasing the lateral strength and stiffness of the building.
2. Eliminating sources of weakness or those that produce concentration of stresses.
3. Enhancement of redundancy in the number of

lateral load resisting elements.

4. The retrofit scheme should be cost effective.
5. Each retrofit strategy should consistently achieve the performance objective.

1.4 Seismic Retrofitting

Earthquake creates destruction in terms of life, property and failure of structures. In order to protect from the risk triggered by seismic disaster to the life and property, the performance of the structure must be improved and thus Seismic Retrofitting plays its role. Retrofit involves modifications to existing structures that may improve energy efficiency or decrease energy demand. Seismic retrofitting is the modification of existing structures so as to improve the seismic behavior or its components repair or strengthening up to the performance it is expected. Retrofitting also proves to be a better option catering to the economic considerations and immediate shelter problems rather than replacement of seismic deficient buildings. Two alternative approaches are conceptually adopted and implemented in practice for seismic retrofitting. The first approach focuses on upgrading the structure to resist earthquake induced forces (i.e. modifying the capacity) and is called Conventional method of retrofitting. The second approach focuses on reduction of earth- quake induced forces (i.e. modifying the demand) or Unconventional approach. Seismic retrofitting is the collection of modern techniques for earthquake resistant structure. The presence of soft and weak storey at the open ground floor, in-plane discontinuity out-of-plane offset of the ground floor columns and eccentric mass are commonly observed irregularities in the studied buildings. In absence of collector elements in the slab and proper detailing of the connections with the building frame, there is lack of integral action of the lateral load resisting elements, techniques for earthquake resistant structure. The seismic performance of beam-column joints in an RC framed structure has long been recognized as a dominant factor that affects its overall behavior when subjected to earthquake forces, as indicated in earlier version of design codes and standards. Unsafe designs and deficient detailing that does not conform to seismic codes within the joint region may result in extra inelastic story drift and excessive 1post-yield rotation, which likely cause's local failure, and may even lead to progressive collapse. The potential problems associated with the design deficiencies of the beam-column joints have been identified in many catastrophic structural failures reported in past major earthquakes. Four major objectives are identified to understand the feasibility of seismically retrofitting existing structures. The first objective is to investigate how building location affects the annual probability of attaining or exceeding specified performance levels. The second objective is to develop a framework to determine the economic feasibility of seismic retrofitting. The third objective is to study the effects that achievable loss reduction, investment return period and retrofitting. The final objective is to determine the impact of a modest retrofit strategy applied to identical example buildings.

1.5 E-Tabs Software

ETABS stands for Extended Three Dimensional Analysis of Building Systems. ETABS offers a user interface to perform Modeling, Analysis, Design and Reporting. ETABS provide sophisticated analysis and design for steel, concrete and masonry structure.

- In ETABS Beams and Columns are known as line objects. Slabs and Shear walls are known as Area objects.
- It has built in template.
- It has built in code books.
- It will calculate loads automatically on beams and columns.
- It is easy to give floor load for irregular panels.
- It performs wind load and earthquake analysis.
- Auto calculation of beam reinforcements based on moments at column face, rather than at column center line and column reinforcements based on moments at beam soffit, rather than at beam center line.
- It design shear walls
- It displays reinforcement areas or percentage on each beam and column.
- Construction sequence analysis and Pushover analysis can be done by ETABS.

1.6 Advantages

- ETABS allows users for graphic input and modification. Using these features this soft- ware ensures easy and quick model creation for any type of structure
- Creation of 3D model with the utilization of plan views and elevations. You can also create a 3D model of any kind of complex structure easily.
- Easy navigation through multiple viewing of windows. This feature allows you to create or edit your model very easily with a real-time view.
- Different view options of the 3D model including a plan view, any side elevation view, and also customization view created by the modeler
- The geometry of model copying and pasting feature from and to spreadsheets

1.7 Disadvantages

- It does not support for sloping roofs.
- It cannot generate floor loads. You have to model slabs. You have to model slabs as plate element mesh it and apply floor loads on it.

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- You cannot know what is happening inside the analysis engine of the software as like STAAD Pro.

The report documentation is not so good when compare to STAAD Pros report.

2. Structural Analysis of Existing Structure

All data related to structural analysis was taken from the field investigation and the design document from the consultant. Data taken directly is the dimension of each structural element and reinforcement bar installed. The building structure was modeled and analyzed by using ETABS program. The structure analysis results data from the ETABS program such as internal forces and displacements can be used to evaluate the structural performance due to gravity and earthquake loading.

2.1 Data of Existing Structure

Variable	Data
Type of structure	Residential building
Number of storeys	4
Floor height	3m
Base height	2m
Live load	2 kN/m^2
Dead load	2.25 kN/m^2
Wind load	Zone – 4 (44 m/s)
Seismic zone	Zone -2
Earthquake load	1.5 kN/m^2
Column dimensions	350 mm x 350 mm
Beam dimensions	250 mm x 250 mm
Slab thickness	150 mm x 150 mm

Table 1: Data of existing structure

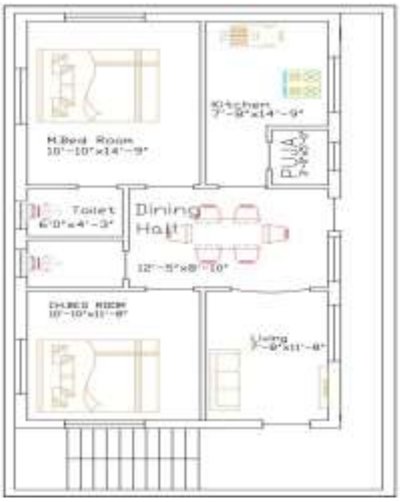

Figure 1: Plan of structure

2.2 Modeling

ETABS has a user-friendly interface and commands for easy and fast modeling, editing, rectifying the errors and warnings. Modeling begins with the setting of grid lines, defining of material properties, defining of frame and area element sectional properties, etc.

The procedure carried out for modeling and analyzing the structure involves the fol- lowing flow chart.

- Creation of Grid points Generation of structure.

  After getting opened with ETABS we select a new model and a window appears where we had entered the grid dimensions and story dimensions of our building. Here itself we had generated our 3D structure by specifying the building details.
- Defining of property.

  Here we had first defined the material property by selecting define menu to material properties. We add new material for our structural components (beams, columns, slabs) by giving the specified details in defining. After that we define section size by selecting frame sections.
- Assigning of Property.

  After defining the property we draw the structural components using command menu. Draw line for beams and create columns in region for columns by which property assigning is completed for beams and columns.
- Assigning of Supports.

  By keeping the selection at the base of the structure and selecting all the columns we assigned supports by going to assign menu to joint frame to Restraints (supports) to fix.

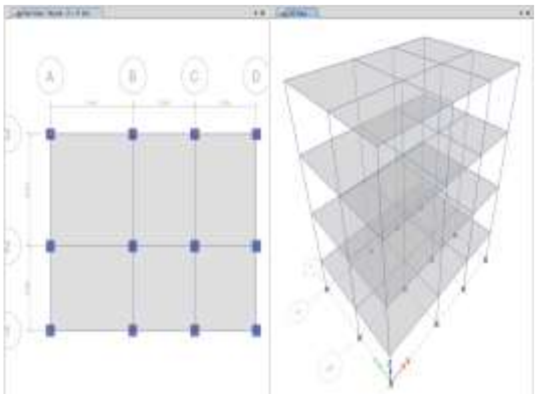

Figure 2: Plan view and 3D view of structure

- Defining of loads

  In ETABS all the load considerations are first defined and then assigned. The loads in ETABS are defined as using static load cases command in define menu.
  - Assigning of Dead loads.

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After defining all the loads dead loads are assigned for external walls , internal walls as per IS 875 1987 PART 1.

- Assigning of Live loads .
  Live loads are assigned for the entire structure including floor finishing as per IS 875 1987 PART 2.
- Assigning of wind loads.
  Wind loads are defined and assigned as per IS 875 1987 PART 3 by giving wind speed and wind angle in X,Y directions as 0 , 90 respectively.
- Assigning of seismic loads.
  Seismic loads are defined and assigned as per IS 1893 2002 PART 1 for residential building.

2.3 Analysis and Design

After the completion of all the above steps we have performed the analysis and checked for errors. Shear and bending moment diagrams are analytical tools used in conjunction with structural analysis to help perform structural design by determining the value of shear force and bending moment at a given point of a structural element such as a beam. After the completion of analysis we had performed concrete design on the structure as per IS 456:2000. For this go to Design menu to concrete design to select design combo. After this again go to design menu to concrete frame design to start design check of structure then ETABS performs the design for every structural element.

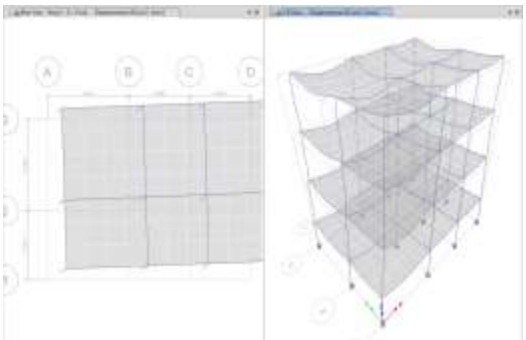

Figure 3 Displacements

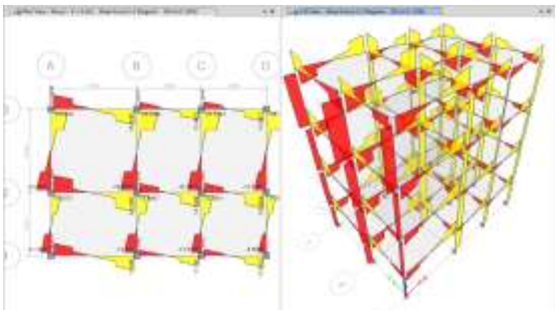

Figure 4 Shear Force Diagram

3. Classification of Retrofitting Techniques

There are different types of retrofitting techniques; they are global and local techniques. Some of the global techniques are addition of shear wall, addition of infill wall etc and local techniques are jacketing of beams, jacketing of columns and jacketing of column-beam joint.

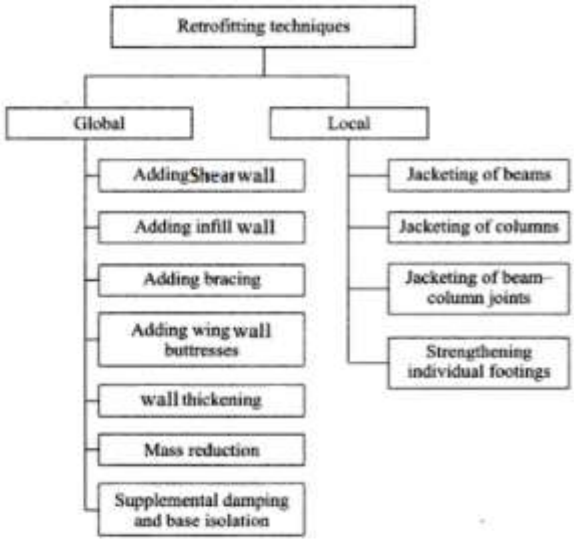

Figure 5 Retrofitting Techniques

3.1 Strengthening by Concrete Jacketing

Concrete jacketing is one of retrofitting structures used to the columns and beams of the building. The demand for using concrete jackets to strengthen or repair reinforced concrete has been increasing in the past few decades. Reinforced concrete jacketing is a common method for retrofitting existing columns with poor structural performance. Jacketing implemented by enlarging the column and beam section by increase the amount of reinforcement. Concrete jacketing is a popular method of retrofit as it follows the same design and con- traction procedures of RC columns. The jacket can provide protection from both environ- mental effects and fire. The jacket can increase the axial and flexural strength by increasing confinement and providing additional steel reinforcement. Modeling columns and beams that jacketed on ETABS is done by enlarging the cross-sectional dimensions and adding reinforcement according to the amount planned for columns and reinforcing beams.

Figure 6 Jacketing of Beam

4. Conclusions

1 Strength of the structure is increased by increase in reinforcement.

2 Retrofitting by concrete jacketing is effective in building structures that are unable to withstand working loads.

3 Displacement of the structure is reduced which attains the stability of the structure.

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