

PROPOSED RETROFITTING STRATEGIES FOR EXISTING MULTISTORIED RC FRAMED HOSPITAL BUILDING

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“CERTIFICATE”

This is to declare that the major project on the topic of “Proposed Retrofitting Strategies for Existing Multistoried RC framed Hospital Building” is a bonafide record of work done by Saloni Priyadarshini for the partial fulfillment of the requirement of the degree of M.E., Civil Engg. (Structures) from Delhi College of Engineering, Delhi.

This project has been carried out under the supervision of Dr. (Mrs.) P. R. Bose, Prof. & Head and Shri Alok Vema, Lecturer, Civil Engg. Dept., Delhi College of Engineering.

I hereby state that I have not submitted the matter embodied in the report for award of any other degree.

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1. INTRODUCTION

This Report comprises of **Proposed retrofitting measures for Ward Block** of a Hospital Located in North East District of Delhi. This is a study of existing RC framed building as per latest prevailing codes, i.e. IS:456-2000, IS:1893-2002, IS:875:1987, IS:13920-1993, IS:4326-1990 etc (since it was designed on the basis of 1975 code of practices) and proposing various types of retrofitting. The purpose of this study is to have seismic evaluation of existing building and a model program for retrofit. For analysis of building response spectrum method (with 5% damping for RC framed buildings) has been adopted.

Although IS: 1893-2002 has been used to evaluate seismic forces, peak ground acceleration and spectral values, do not necessarily account for seismic sources or site conditions in rigorous way. There are significant knowledge gaps about local seismic sources and site conditions. Local seismic sources need to be defined, including location, fault mechanism, distance to sites, maximum magnitude and response spectra. A significant amount of work is needed to rigorously address ground shaking potential in India and to develop probabilistic maps or charts so that sufficient data is available at the time of design.

Liquefaction potential is one of the areas to be considered while designing (or checking in this case) of foundation. But since this study mainly reflects seismic

safety of superstructure, liquefaction potential of soil and other soil parameters have been assumed to be well within safe limit.

The **Hospital Block** is 8 - storied and it was constructed in the year 1980. The building was designed as per 1975 prevailing code of practice. Two revisions of Indian code (IS: 1893) have taken place since then in 1984 and 2002, each after some damage-causing earthquake. The building is resting on raft foundation of 750mm thickness at a depth of 2.0 m below ground level. Soil bearing capacity was reported to be 150 KN/M².

2. OBJECTIVE

To propose suitable retrofitting measure for existing Hospital building as per the latest code of practice to meet Maximum Considered Earthquake guidelines.

3. PROPOSED METHODOLOGY

- a. Analysis to be carried out for a various number of options suggested by Peer Review Panel, India & Peer Review Panel (USA) for existing building as per latest prevailing codes(IS:456-2000, IS:1893-2002, IS:13920-1993, IS:4326-1993, IS:875-1987).
- b. Results to be compared with existing structural drawings.
- c. Carry out various retrofitting analysis based on its feasibility.
- d. Select an appropriate retrofitting strategy after looking at the options available.

4. PROJECT DESCRIPTION

4.1. ARCHITECTURAL DRAWINGS - (TYPICAL FLOOR PLAN)

Floor plans & elevations of building are shown as below. The structural arrangement of building (framing plans and column locations) are based on these architectural drawings. Electrical & plumbing services are also indicated on these drawings only.

5. CONDITION ASSESSMENT

- There was no major visible deterioration found in most of the structural members such as columns, beams and slabs.
- Three-four external columns were found to have noticeable cracks. Rusting of steel is found to be approximately 10%.
- These types of columns are only three / four columns in the building.
- Machine room columns above terrace have large deterioration.

6. ASSUMPTIONS

- Building idealized as a 3-D Space Frame structure on STAADPro-2005.
- Analysis has been carried out for MCE and I=2 and R=4 since ductile detailing has not been provided. A static Coefficient method analysis as well as a Response Spectrum Analysis has been carried out
- Building has been analyzed twice –first with Bare walls as per 7.6.1 of IS 1893:2002.Next the analysis has been carried out with Infill Panels by modeling them as diagonal struts and using the time period as per 7.6.2 of IS1893.
- Two options for retrofitting have been considered, one with enlarged column sizes at periphery of building and another with introducing shear walls as book ends.

7. DATA AVAILABLE OF EXISTING BUILDING

- Ward Block-A - 8 storied RCC framed structure , 28.8 m x 13.94 m in plan & 27.43m high
- Columns - 400 x 600 mm and 400 x 750 mm in size & beams as follows-
 1. 300 x 400 mm in size(outer beams)
 2. 400 x 400 mm (internal beam on grids B)
 3. 400 x 600 mm (all main beams between C and D)
 4. 300 x 600 mm (between D 17 to D 19)
 5. 400 x 500 (between grid A and C on all grids from 1 to 10)
- By soil investigation report - medium soil with a low water table & Allowable Bearing pressure of 11.5t/sq.m and a K value of 2 kg/cu.cm.
- Walls made of Burnt Clay bricks of Class 75, all outer walls 9” thick and inner walls 4.5” thick mostly.
- RCC water tank placed on terrace of 5.04m x 14.8m x 1.7m in size.

8. MATERIAL USED

- Material properties as listed in the structural drawings have been utilized for analysis while the Condition Assessment is being carried out in the meantime to confirm these values.
- For the present analysis, a concrete mix of M25 (based on 1:1:2 recorded in the structural drawings) and steel reinforcement of Fe 415 has been adopted.

9. DATA ASSUMED FOR ANALYSIS (FOR RETROFITTING STRATEGIES):

9.1. PROPOSAL-I

- Columns - 400 x 600 mm and 400 x 750 mm in size is assumed as 400 x 1600 mm at base, gradually tapered to 400 x 800mm at top.
- Internal columns as well as beams are assumed to have same properties as of the existing building.
- Infill panels are taken into account while analyzing.

9.2. PROPOSAL-II

- Shear wall are introduced in buildings at book ends.
- All columns as well as beams are assumed to have same properties as of the existing building.
- Internal Infill panels are taken into account while analyzing.

9.3. PROPOSAL-III

- Steel bracing has been introduced in end frames (extreme sides).
- Properties of all other structural members remains the same as that in existing structure.
- ISMB250 has been adopted as x-bracings in frame, assuming to take only in plane shear. Shear out of plane and all moments were released at the time of analysis.
- Effect of infill panels have not been taken into account.

9.4. PROPOSAL-IV

- RCC wall of 100mm thickness has been introduced in end frames, at the same location where bracings were considered (brick wall is removed).
- Properties of all other structural members remains the same as that in existing structure.
- Effect of infill panels have not been taken into account.

.10. ANALYSIS

The analysis for both the retrofitting options has been carried out on STAADPRO-2005 as per static coefficient method as well as response spectrum method.

Proposal – I consists of enlargement of column sizes from 400 x 600mm to 400 x 1600mm. (Only at periphery). The STAAD model consists of beams and columns (as members) and slabs (as elements or plates). However these slabs are modeled only to take into account diaphragm action and assumed to have zero density so as to avoid repetition of loading.

Proposal – II consists of book ends type of shear wall. Reinforced concrete wall has been modeled (elements or plates) as book ends with 230mm thickness. Again these walls are assumed to have zero density to avoid double loading.

Proposal – III consists of bracings in end (side) frames. ISMB250 has been modeled as x-bracings to study the behavior of building. These bracings were not taken below plinth beam level so as to avoid touching foundations while retrofitting. Although this option was applied only in side frames, we can have a no. of arrangement (locations) of these for further study.

Proposal – IV consists of RCC walls in same bay where bracings were placed (extreme side) frames. Thickness of wall is assumed as 100mm. this to be noted that

we cannot have too thick wall as it will add on to the dead weight of building since we are not taking it upto foundation level.

Building Time Period as per IS 1893-2002

(Bare frame-without Brick in fills)

- $T_a = .075 \times h^{0.75}$ seconds

$$= .075 \times 27.43^{0.75} = 0.889 \text{ seconds}$$

$$S_a/g \text{ value} = 1.5$$

$$R_F = 4, I = 2, Z = 0.24$$

- Base Shear as per IS 1893 = $0.24/2 \times 2/4 \times 1.5 = 0.09$, i.e. 9%

(Frame-With Brick infill)

- $T_a = .09 \times h/\sqrt{d}$ seconds

$$= .09 \times 27.43/\sqrt{28.8} = 0.49 \text{ seconds}$$

$$S_a/g \text{ value} = 2.5$$

$$R_F = 4, I = 2, Z = 0.24$$

- Base Shear = $0.24/2 \times 2/4 \times 2.5 = 0.15$, i.e. 15% (Ref 1893:2002)

- Time period used = 0.5 sec., & corresponding S_a/g value of 2.5 sec. thus giving a Base Shear of 15%.

11. DISCUSSION OF RESULTS

➤ Deflection in structure as per the latest prevailing codes such as

1. Max. Deflection in “without infill analysis” = 79.5mm
2. Max. Deflection in “with infill analysis” = 57.5mm
3. Max. Deflection in “Retrofit Proposal - I” = 50.8mm
4. Max. Deflection in “Retrofit Proposal - II” = 44.4mm
5. Max. Deflection in “Retrofit Proposal - III” = 84.88mm
6. Max. Deflection in “Retrofit Proposal - IV” = 84.33mm

Permissible deflection = 57.8mm (Ht. of building = 28.93m above ground)

Hence, Proposals-I, II & IV are well within safer limit.

Proposal-III is not helping to control deflection. However another set of combinations of bracings may give desired results.

➤ Number of columns failing in all analysis are as follows:

1. “without infill ” = 247 (72.22%)
2. “with infill ” = 89 (26.02%)
3. “Retrofit Proposal - I” = 16 (4.67%)
4. “Retrofit Proposal - II” = 82 (23.98%)
5. “Retrofit Proposal - III” = 257 (75.15%)
6. “Retrofit Proposal - II” = 261 (76.3%)

Total no. of columns = 342 (no. of STAAD members)

Although no. of column failures in Proposal – II seems higher than that of “with infill analysis”, this may be attributed to the fact that plate connectivity with members in STAAD can not give desired results (since deflection in this case is even lower than Proposal-I). This option will have to be analyzed with different approach to have desired results.

➤ Proposal – III & IV have not been taken upto foundation, which may be the reason for undesired deflections in column as well as high requirement in reinforcement.

➤ Max. reactions on foundations due to superstructure :

1. Existing Structure = 2835 KN, 21.5KNM (DL+LL),
= 3400 KN, 730. KNM (0.9DL+1.5EQ)
2. “Proposal-I” = 3190 KN, 539KNM(DL + LL)
= 3916 KN, 1831KNM (for 0.9DL+1.5EQ)
3. “Proposal-II” = 2975 KN, 620.12KNM (for DL + LL)
= 7876 KN, 1885KNM(for 0.9DL+1.5EQ)

There is an increase in vertical load (since we are giving additional members/ elements) of @ 12.5 % and 5% in proposal I & II respectively as compared to that of existing building. However there is significant increase in moments at base in both options(15% in proposal – I & 131.6% in proposal – II)

➤ Max story drift:

1. Existing Structure = 9.9 MM
2. “Proposal-I” = 3.5 MM
2. “Proposal-II” = 1.4 MM

Story drift has decreased upto 65% in proposal-I & 85 % in proposal-II.

12. CONCLUSION

- The building needs retrofitting as per latest prevailing codes (IS456-2000, IS 1893-2002, IS 875:1987, IS13920-1993).
- The columns are failing in deflection check (for existing structural arrangement) criteria and the value is as high as 1.4 times the permissible limit. Hence existing building is not safe in serviceability criteria. As per Story drift criteria proposal – I & II both gives very low values.
- Based on support reactions criteria Proposal-II will need foundation retrofitting to counter for increased moments.
- Deflections in both retrofit proposals, viz. I & II are well within permissible limit and either can be adopted depending on the feasibility on the basis of cost as well as construction.
- Proposal-III & IV needs to be further explored to come to any particular conclusion.

13. SCOPE OF FUTURE STUDY

Post Latur earthquake in 1993 and Bhuj earthquake in 2001, the need for amendments in IS codes were imperative. These amendments are being carried out quite successfully. However buildings of pre- Latur or Bhuj or any other earthquake needs to be restored as per now prevailing codes, especially historical monuments and structures of high importance (such as bridges, hospitals, stadiums etc.). As much the behavior of building with two retrofit options have been studied, still the following may be considered in the ways of improvements/options:

- Location of shear walls may be rearranged so as to get still lesser deflections and shear. e.g. Instead of book ends shear walls may be assumed at different column locations.
- Also number of shear wall may be increased or decreased to study different structural behavior.
- External columns (buttresses) may be enlarged in both directions to reduce deflections and requirement of steel in columns.
- Retrofitting with staggered shear wall panel needs to explored.
- The effect of adopted retrofit strategy on foundations needs to be studied and if possible suitable alternative for its retrofitting can be explored.

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