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SEISMIC EVALUATION & RETROFIT ASSESSMENT OF JLNM1 HOSPITAL, RAINAWARI SRINAGAR

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Abstract

Seismic evaluation has been a matter of concern for engineers since long. The structures constructed earlier have to be evaluated to check whether or not they meet the required seismic demands. Seismic evaluation is necessary to check any strengthening measures (retrofitting) required in the structure. The aim of this paper is to present the seismic evaluation report of a very old hospital in the Srinagar city. In addition some suitable retrofitting measures have been suggested so as to strengthen the hospital building and make it functional. There is a need to evaluate every such important structure that has got damaged overtime due to unexpected loads or natural disasters.

Keywords: Seismic retrofit, seismic evaluation, base shear, shear walls, unreinforced masonry, hazard assessment, Vulnerability

1. INTRODUCTION

Jawaharlal Nehru Memorial Hospital was initially a mission hospital and later on it was named as Jawaharlal Nehru Memorial (JLNM) hospital. The foundation stone of this hospital was laid in 1889. The superstructure work was started in October 1908 and the project was completed in 1936. The present condition of building is reflected in the photographs shown in the section to follow. This is one of the oldest hospitals in old city of Srinagar. As is mandatory, that these lifeline structures have to perform better than other structures. The initiative was taken up to carry out the seismic evaluation of important lifeline buildings in the city.

2. Structural problems in the building

The various structural problems present in the existing building are list as under:

- Sinking of floor at the entrance (Fig. 1)
- Damage of masonry wall (Fig. 2)
- Large cracks at various critical locations (Fig. 3)
- Sway of front wall (Fig. 4)

The pictures depicting these problems are shown below;

Fig. 1: Sinking of floor

(a) (b)

Fig. 2: Damage in the walls

Fig. 3: Large crack in the wall

Fig. 4: Sway of front wall

3. Probable causes of observed structural problems in the building

a) Presence of earthen caves/cavities:

Rainawari was previously known as "Kralyar" meaning "Potters Town" because the main occupation was the people there was making earthen utensils and other household things. For this purpose they used to dig caves/cavities for getting the soil. Thus various caves and cavities are still expected to be there in the ground which when subjected to the loads from above may lead to subsidence of the ground surface which eventually creates various problems in the structure. Since JLMN Hospital is located in the same region, the cause of subsidence at the entrance is probably due to the same reason.

b) Leakage from the bathrooms:

Due the inadequate maintenance and fitting of the bathrooms, there has been leakage of water which has percolated into the foundation. This in turn led to the subsequent subsidence just adjacent to the sides of the bathrooms.

c) Absence of bands:

The existing building is constructed using stone masonry. As such the building doesn't have any bands (lintel band, sill band, gable band, plinth band) which are necessary to be provided as per the guidelines of the seismic codes of design for masonry structures. This can also be attributed for the sway of the building.

4. Seismic analysis

Seismic analysis was carried out for existing two storey unreinforced masonry building is located in Rainawari, Srinagar (Seismic zone V). The structure is founded on medium soil. The building

is 7.4 m in height, 49 m in length and 26.5 m in width. The lateral load resistance to the building is provided by the perimeter load bearing URM[2] walls which have uniform thickness of 600mm in both storeys. The walls are perforated with openings for doors and windows. The building is provided with wooden joist flooring system which behaves as flexible diaphragm.

Using the available data and plan of the building the seismic performance was evaluated. Analysis was carried out as per Indian codes of practice viz. IS:1893-2002 & IS:875. The results of the analysis as worked out are given below.

4.1 Base shear calculation

Seismic weight of building = W = 29370.77 KN

Time period = T = 0.13s

Average response acceleration coefficient = S_a/g = 2.5 (for 0.1 <T<0.55)

For Seismic zone V, Zone factor = Z = 0.36

Importance factor, I = 1.5

Response reduction factor, R = 1.5

As per IS:1893-2002,

Design horizontal acceleration coefficient, $A_h = ZS_aI/2gR = 0.45$

Design Base Shear, $\mathbf{V_b = A_hW = 0.45 \times 29336.72 = 13216.85\ KN}$

4.2 Base shear distribution at the floor levels

As per IS: 1893: 2002, design base shear shall be distributed along the height of building as per the expression;

$$\mathbf{Q_i = V_b\ (W_i h_i^2 / \Sigma\ W_j h_j^2)} \qquad \{j = 1 \text{ to } n\}$$

The distribution of base shear along the height of building is shown in Table 1.

Table 1: Base shear Distribution

Level	W_i (KN)	h_i (m)	h_i^2	$W_i h_i^2$	$W_i h_i^2 / \Sigma W_i h_i^2$	Q_i (KN)
Roof	8896.11	7.4	54.76	487150.98	0.645	8524.87
1st	19583.92	3.7	13.69	268103.86	0.355	4691.98
				Σ = 755254.96	**Σ = 1**	

4.3 Evaluation for seismic retrofitting

1) Shear stress in walls

The primary load resisting elements in the URM building are the load bearing walls. If the walls are subject to larger stresses (shear stresses), then they become vulnerable to earthquakes. The in-plane shear strength of masonry walls is crucial factor for the survival and stability of the URM buildings

[2] Un - Reinforced Masonry

particularly those buildings wherein the large size openings in masonry wall make them extremely weak and vulnerable. So, if the shear stresses are beyond the permissible limits, then the walls should be strengthened to meet the existing demands.

Average shear stress in concrete and masonry shear walls, τ_{wall}, shall be calculated as per the following equation;

$$\tau_{wall} = V_j / A_w$$

Where,

V_j = Storey shear at level *j* and

A_w = Total area of shear walls in the direction of the loading.

- For concrete shear walls, τ_{wall} shall be less than 0.4 MPa.
- For unreinforced masonry load bearing wall buildings, the average shear stress, τ_{wall} shall be less than 0.10 MPa.

In the building under study, shear stress in the walls is,

$$\tau_{wall} = V_j / A_w \quad \text{(roof level)}$$

Force along shorter direction; $\tau_{wall} = 8524.87 / 96.102 = 88.706 KN/m^2$

$\tau_{wall} = 0.0887 N/mm^2$ (<0.1MPa, safe)

Force along longer direction; $\tau_{wall} = 8524.87 / 75 = 113.66 KN/m^2$

$\tau_{wall} = 0.1137 N/mm^2$ (>0.1MPa, unsafe)

This analysis result requires that the structure should be retrofitted.

2) h/t Ratios for walls

The walls are judged for out of plane stability based on their height/thickness (h/t) ratios. The permissible h/t ratios for unreinforced masonry walls are;

Wall Type	Zone II & III	Zone IV	Zone V
Top storey of multistory building	14	14	**9**
First storey of multistory building	18	16	**15**
All other conditions	16	16	**13**

(Ref. IITK-GSDMA Guidelines)

Walls satisfying the above h/t ratios are dynamically stable. The permissible h/t ratio results in high reliability of assessing the wall stability after cracking.

For the hospital under study, h/t ratios are;

Top storey: 3.7/0.6 = 6.16 (<9, satisfy)

1st storey: 3.7/0.6 = 6.16 (<15, satisfy)

3) Strength check of diaphragms

The ability of floor and roof diaphragms to transfer lateral forces from the vertical resisting elements above the diaphragm to other vertical resisting elements below the diaphragm needs to be checked.

Floor and roof diaphragms should be able to resist diaphragm forces F_{px} as given below;

$$F_{px} = [\sum Q_i / \sum W_i] w_{px} \qquad \{i = x \text{ to } n\}$$

Where,

w_{px} = weight of floor or roof diaphragm at level x (= dead load + finish)

Q_i = lateral loads at the ith floor

W_i = seismic weight at ith floor

Limits :

$$\mathbf{F_{px} > 0.35ZI\ w_{px}}$$

The calculations are tabulated as below;

Level	**Q_i, KN**	**$\sum Q_i$, KN**	**W_i, KN**	**$\sum W_i$, KN**	**w_{px}, KN**	**0.35ZI w_{px}, KN**	**F_{px}, KN**
Roof	8524.87	8524.87	8896.11	8896.11	930.72	175.91	**891.88**
1st	4691.98	13216.85	19583.92	28480.03	2407.76	455.07	**1117.38**

5. Possible remedial measures (As per IS:13935-1993)

I. **Seismic belts:** Provide seismic belts at lintel roof level to provide stability to the building against the lateral forces.

II. **Grouting:** Fill the cracks with cement grout or epoxy resin (as applicable) to close the prevailing crack therein. **[Clause 7.3.1; 5.3; 6.3]**

III. **Concrete Jacketing:** Apply the concrete jacket to the wall in **Fig. 3** after filling the crack with cement grout. **[Clause 7.8]**

IV. **Foundation Strengthening:**

Underpinning: It involves the removal of unsuitable soil underneath, coupled with replacement using concrete, soil cement, suitable soil, or other material. Underpinning has to be staged in small increments to prevent endangering the stability of the structure. This technique will enlarge the existing footing or extend it to a more competent soil stratum.

6. Conclusion

A simple procedure structural evaluation has been presented above. With the aim to check the adequacy of existing structural system to withstand the anticipated earthquake loads. Based on several checks, it was observed that initial structural design of building was not poor rather the damage due to soil strata below or the damage in the sanitation system with time coupled with some of disastrous earthquakes like that of Oct'2005 led to the existing severe damage. One of the major errors committed at the time of design and construction was the absence of any investigation on the nature of soil upon which the building was finally constructed. So, we learn that although we may have a sound structural design but there are a number of factors that should be taken into consideration at the stage of the planning and construction, e.g. we may construct a structure on a soil

susceptible to liquefaction or soil with a labyrinth of cavities below, without being aware of these problems. We need to integrate our strategy for the design of any structure so that our is safe enough for its occupants.

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