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DETAIL ENGINEERING ANALYSIS OF ASSESSMENT OF RETROFIT MEASURES OF EXISTING STRUCTURES USING COLUMN JACKETING METHOD

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Abstract. *Retrofit measures are important considering recent events of devastating building failures, especially in the ready-made garments sector in Bangladesh. This paper will be assessing retrofit measures on existing structures with respect to realistic case studies. According to different codes and engineering practices retrofit measures may vary considerably. The paper will be introducing and evaluating different retrofit measures based on FEM modeling and in perspective to existing seismic conditions. In light of this recommendations on retrofit practice that can address seismic failure concerns will be made. To achieve this, evaluations will also be made based on Pushover analysis and Time history analysis conducted on the structure in its present state and after retrofitting. The assumptions to make the problem amenable are clearly listed and appear, in the author's viewpoint, quite reasonable. The study results are discussed in detail both in diagrams and with a simple formula. Based on the suggested procedure, Seismic retrofitting has been carried out by using explicit code of UNDP. The paper will basically focus on retrofit by column jacketing which is the most common practice in this field in Bangladesh. In light of the risk from both structural and seismic failure, the paper implies significant findings.*

Keywords: Finite element modelling, Retrofit, UNDP, Seismic Response

1 INTRODUCTION

Retrofitting is technical interventions in structural system of a building that improve the resistance to earthquake by optimizing the strength, ductility and earthquake loads. Strength of the building is generated from the structural dimensions, materials, shape and number of structural elements. Ductility of the building is generated from good detailing, materials used, degree of seismic resistance etc. Earthquake load is generated from the site seismicity, mass of the structures, important of buildings, degree of seismic resistant etc. Due to variety of structural condition of building, it is hard to develop typical rules for retrofitting. Each building has different approaches depending upon the structural deficiencies. Hence engineers are needed to prepare and design the retrofitting approaches. In the design of retrofitting approach, the engineers must comply with the building codes. The results generated by adopting retrofitting techniques must fulfill the minimum requirements on the building codes such as deformation, detailing strength etc." [1] In view of this, the paper will be assessing a case study of an existing structure located in Gazipur. It is a six storied RC structured building. The building was constructed in two phases between 2007 and 2009. A three story structure was completed in 2007 and a further three stories were constructed in 2009. This building is used mainly for light factory operations including operational offices, dining, and sewing, cutting, finishing and finished goods storage.

2 METHODOLOGIES

Several visits were made to check and collect data to assess building stability through Scanning, Rebar testing and Core cutting, on RCC column, beam and slab of different levels of the building. To assess and analyze data, followed the code of BNBC, the guide line of Accord, Alliance and National Tripartite Plan of Action (NTPA) on structural integrity, using ACI-562 code to evaluate concrete strength from core test results. The software generated program ETABS was used to analyze different types of load calculation and developed a 3D model of existing building structure and based on the evaluation a retrofit model was also developed.

2.1 Preliminary Assessment of the Structure

Based on visual inspection a preliminary assessment report was made that include

Item 1: Highly Stressed Columns

Item 2: Cracking above slabs around columns.

Item 3: Building documentation does not match as built structure and undocumented cantilever slabs.
Item 4: Localized areas of high loading in all building
Item 5: Unrestrained parapet at roof level

2.2 Geotechnical Investigation

This proposed land consisted 6 bore holes were drilled up to 15 meter depth from the existing ground level (EGL). The allowable bearing capacity of soil under the bore hole 1 to bore hole 6 considered as isolated column footing (shallow foundation) in the following way : The allowable bearing capacity of footing qa is taken for BH-1, 2 & 4 as 1.30 tsf, bh-3 & 5 as 1.40 tsf and BH-6 1.20 tsf. (F.S=2.50) at a depth 8 feet from EGL.

2.3 Strength Assessment Of Concrete

To assess the strength of the concrete, we performed core test on June 2014 and March 2015. According to the core test result of the concrete strength varies between 1580 psi and 3700 psi. Considering all these, concrete strength value of 1683 psi was found as per ACI-562 and this value was considered in the analysis.

2.4 Test Of Collected Steel Sample

Rebar samples collected from the building showed 53 ksi yield strength according to laboratory test results. To be in accordance with real-time scenario 40 ksi yield strength was considered for assessment.

2.5 Scanning Of Structural Member

To verify the reinforcement in the existing columns, beams and slabs, Ferro scanning was performed. Reinforcements were scanned at nineteen locations at different floor levels. Two locations at level 1 (two beams), Five locations at level 2 (four columns and one slab), seven locations at level 3 (four columns, one slab and two beams) and another five locations at level 6 (four columns one slab).

3 STRUCTURAL ANALYSIS

3.1 Structural Model

A three dimensional Finite Element (FE) analysis has been performed for this building based on as-built layout. The building has beam supported slab system (level-1, 2, 3) and edge supported slab system (level-4, 5, 6). Beams and columns were modeled with appropriate frame elements. The slab was modeled with shell elements. Fig.-1 shows the 3D model of the building and Fig.- 2 show the plan at typical floor level as modeled in the FE package ETABS 9.7.0. [2]

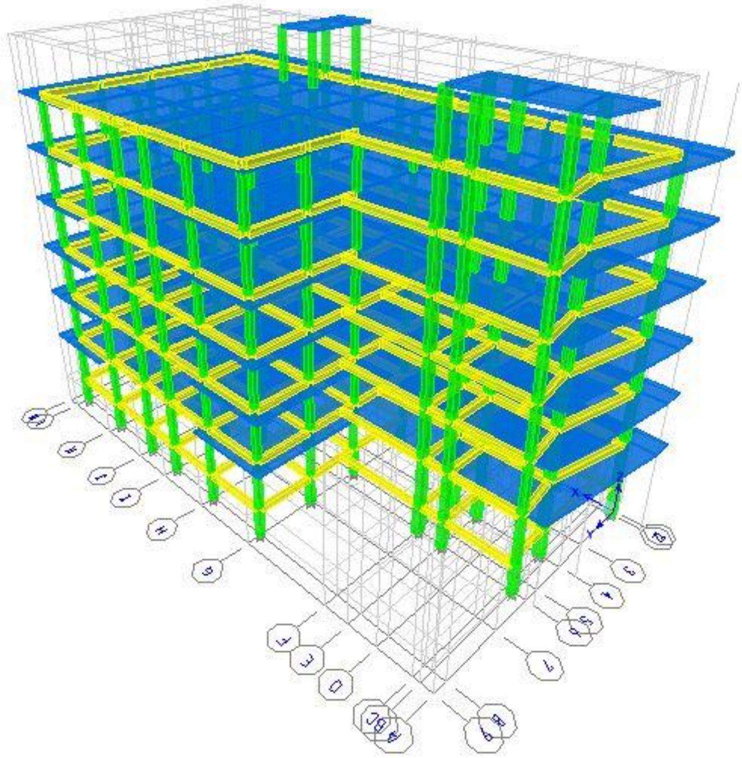

Figure 1: 3D view of the building

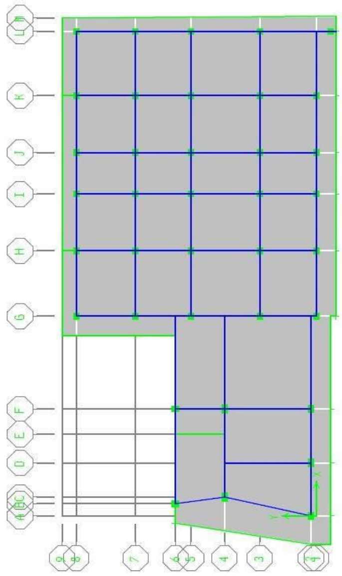

Figure 2: Plan view of the building

3.2 Boundary Condition

For a structure like this building, it is reasonable to assume that the bases of columns are fully restrained in all directions both translational and rotational. Thus all the nodes at the bottom of each column were rendered fully restrained against all sort of displacement in the node.

3.3 Retrofit Assessment

After software based analysis a great number of columns in the building were found to be inadequate. Design Load to Structural Element Capacity of Column (D/C Ratio) for columns in Level-1 are shown in Table-1. Inadequate columns are to be considered as those with D/C ratio greater than 1 and marked in red in the table.

Table 1: D/C ratio for columns in level-1.

Grid Line	A	B	C	D	E	F	G	H	I	J	K	L
1							2.18	1.91	2.37	2.34	2.33	
1C												O/S

2	1.61			1.75		1.66						
3							2.66	1.98	2.06	2.01	2.42	2.24
4			1.71			1.67						
5							2.95	2.01	1.99	1.97	2.02	2.11
6		1.36				1.64						
7							1.88	1.95	1.96	1.97	1.95	1.95
8							2.55	2.02	1.90	1.92	2.01	1.89
	N	O	P	Q	R	S	T	U	V	W	X	Y
1A							2.51	2.58				
1B	1.65			2.23		1.87						

After retrofitting the design load to structural element capacity are as follows in Table 2.

Table 2: D/C ratio for columns after retrofit in level-1.

Grid Line	A	B	C	D	E	F	G	H	I	J	K	L
1							0.44	0.38	0.39	0.36	0.33	
1C												0.32
2	0.42			0.21		0.41						
3							0.42	0.35	0.34	0.33	0.34	0.33
4			0.48			0.47						
5							0.44	0.35	0.24	0.24	0.27	0.31
6		0.43				0.43						
7							0.39	0.27	0.23	0.23	0.24	0.24
8							0.37	0.25	0.19	0.19	0.24	0.25
	N	O	P	Q	R	S	T	U	V	W	X	Y
1A							0.89	0.91				
1B	0.81			0.96		0.82						

Column jacketing method was incorporated in the structural retrofit model using SD section design process in the ETABS 9.7.0 software. The column sections were increased by 5 inches on each side by reinforced concrete jacketing method. [3]

3.4 Time History Analysis

In this study, nonlinear time history analysis was performed using SAP2000 [4] in basic frame and retrofitted frame. It has seen that, in retrofitted frame story drift was decreased in a significant manner with respect to the as built structure. Story drift data has shown in fig 3.

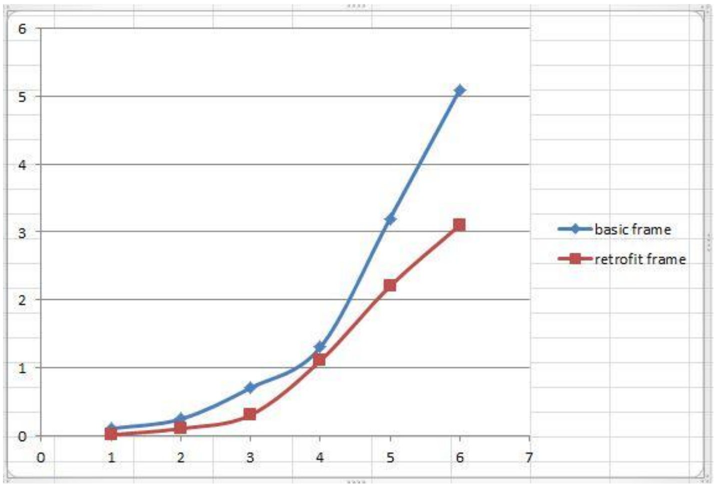

Figure 3: Story Drift in Basic Frame and Retrofit Frame

4 ACKNOWLEDGEMENTS

The author would like to thank the management of Elite Garments Ltd for their advice and help in data collection for this study.

5 CONCLUSIONS

Based on the present study, the following conclusions can be drawn:

- Concrete jacketing of columns and encasing the joint region in a reinforced fillet is an effective but the most labor-intensive strengthening method due to difficulties in placing additional joint transverse reinforcement.

- Retrofitting by column jacketing decrease storey drift in a large extent.
- It is important to obtain accurate as-built information and analytical data to perform a seismic evaluation of the existing structure and to select the appropriate retrofitting strategy
- Further research should be conducted to improve the selection of appropriate retrofit techniques using criteria based on performance, economy and constructability

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