A CASE STUDY OF STRENGTHENING OF AN EXISTING RESIDENTIAL BUILDING FOR USING IT AS A GARMENTS FACTORY

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ABSTRACT
Recently, the rise of the commercial uses of building is enormously large, especially in urban areas of developing country like Bangladesh. Many of the investors are using a residential building as garments factory without any improvement of structure, which leads it to collapse such as, the tragedy of RANA PLAZA. The aim of this study is to provide a better solution of using a residential building safely and efficiently as a garments factory while it had not been predesigned for commercial use. The whole study includes analysis of structure elements with increasing loads, detect the failed members and provide them proper treatment of strengthening so that the building can sustain with moderated loading condition. There are number retrofitting methods are available in modern civil engineering works. In this study jacketing procedure is used for strengthening the existing building. The major analysis and design works, both in initial and retrofitted structural conditions are done by ETABS software. It is observed that, the correlative strengthening work can be carried out if any of structure members is damaged or cracked due to unsuspected loading or environmental disruptions.

Keywords: Strengthening method; retrofitting technique; jacketing; garments factory

INTRODUCTION
The RC buildings are designed and constructed according to which purpose it is to be used such as residential purpose, industrial or commercial purpose. The elements of the building are though so that they are carried out according to their functions. If the purpose of use of a building is changed, the whole loading patterns is replaced by moderated loading system. So the behaviours of the structural elements may be changed. In some cases, some of the members need to be improved. The whole process requires strengthening the existing elements (Handbook, 2007).

The Garments sector has emerged as one of the biggest earner of foreign currency and day by day it is extending. The investors are opting to generate the factories in urban areas where the labours are available. The problem that arises includes limited resources with lack of place. It is much efficient, in this case, to convert a residential building into an industrial building.

The present study provides a better solution of using a residential building safely and efficiently as a garments factory while it had not been predesigned for commercial use. In the study analysis work is done of structure elements with increasing loads, detect the failed members and provide them proper treatment of strengthening so that the building can sustain with moderated loading condition.

RETTROFITTING TECHNIQUE USED FOR EXISTING BUILDING

Jacketing of Columns
Jacketing of columns consists of added concrete with longitudinal and transverse reinforcement around the existing columns. This type of strengthening improves the axial and shear strength of

columns while the flexural strength of column and strength of the beam-column joints remain the same.

Fig. 1: Construction Techniques for Column Jacketing.

Jacketing of Beams

Jacketing of beams is recommended for several purposes as it gives continuity to the columns and increases the strength and stiffness of the structure (Md. Akhter et al., 2013). While jacketing a beam, its flexural resistance must be carefully computed to avoid the creation of a strong beam-weak column system.

Enlarging the Area of Footing

The loads from a building get transmitted to the soil through the foundation. A seismic retrofit of a building includes strengthening of inadequate foundations or supplementing with new foundation. This covers the important aspects of deficiencies of foundation, analysis and assessment of foundation, the types of intervention to strengthen the foundation and the methods of execution.

STRUCTURAL PLANS

A five-story residential building was designed and constructed according to the BNBC, 1993 code. The plan of typical floor is shown in Fig 2.

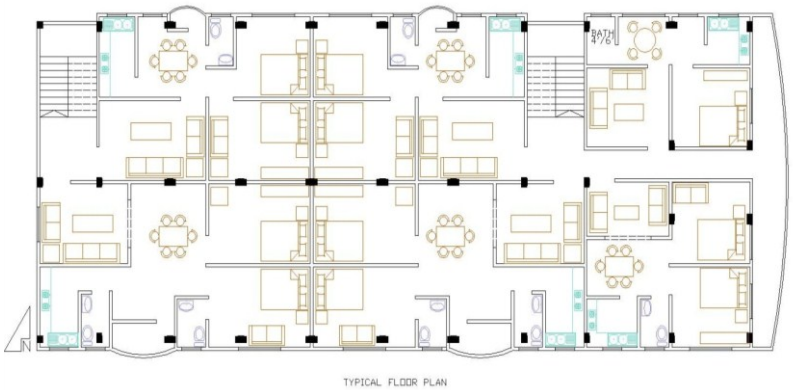


Fig. 2: Typical floor plan.

Initialy the building was constructed for residential use. After some times, it was decided that the building is to be used as garments factory. Then remodeling of plans was necessary. The revised floor plans are given below:

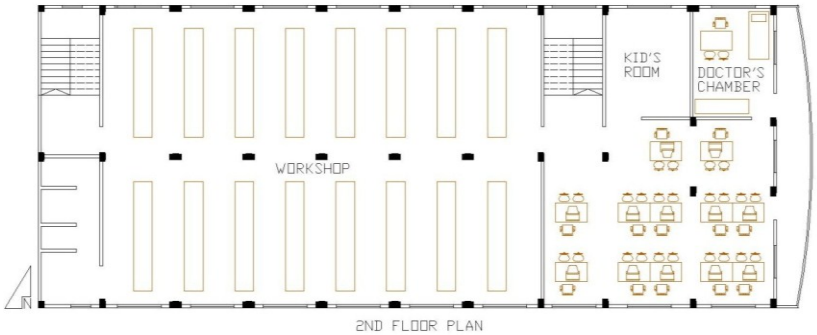


Fig. 3: Typical floor plan of Garments.

Table 1: Data of building element

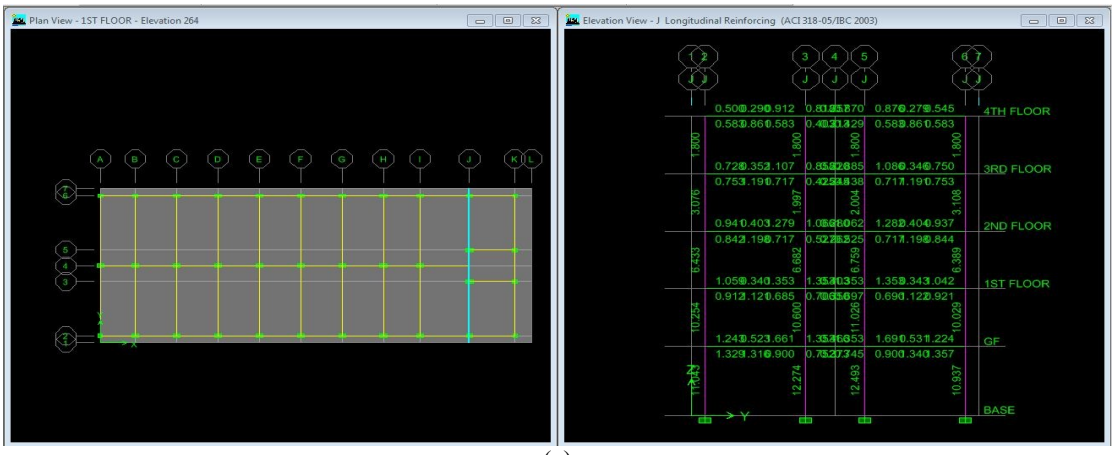
Ground floor space (sq. ft.)	Typical floor space (sq. ft.)	Columns			Beams		
		Types	Cross-Section	Number	Types	Cross-Section	Number
3925.76	4427.04	C1	10 × 20	8	B1	10 × 22	18
		C2	10 × 15	6	B2	10 × 20	1
		C3	10 × 15	18	B3	10 × 15	5
		C4	10 × 12	3	B4	10 × 15	31

DESCRIPTION OF ANALYSED MODELS

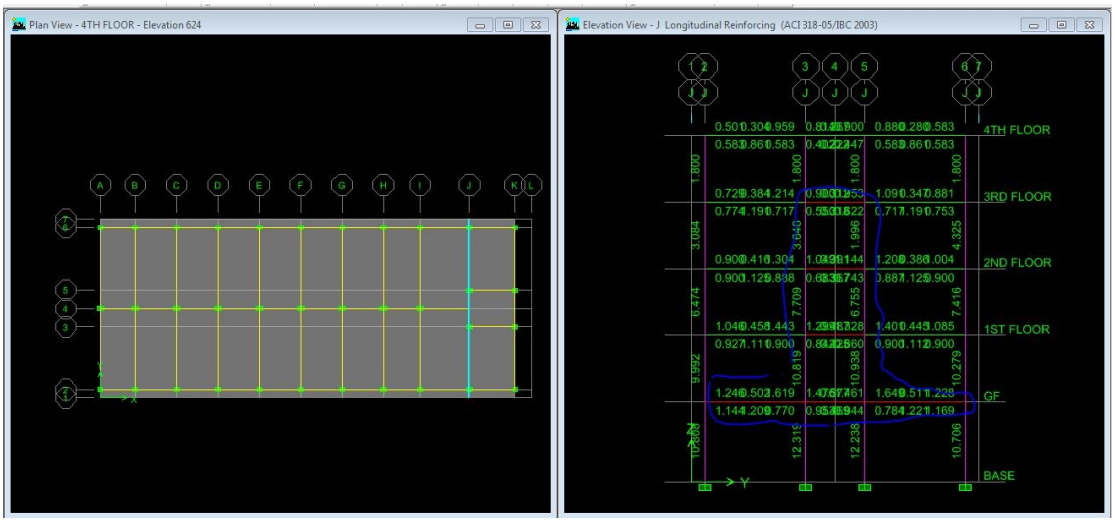
In the present study the analysis is conducted with the aid of ETABS software. Three types of analysis was done according to ACI-318-05.

i. Analysis as residential building
ii. Analysis as garments factory of same structure
iii. Analysis as garments factory of retrofitted structure

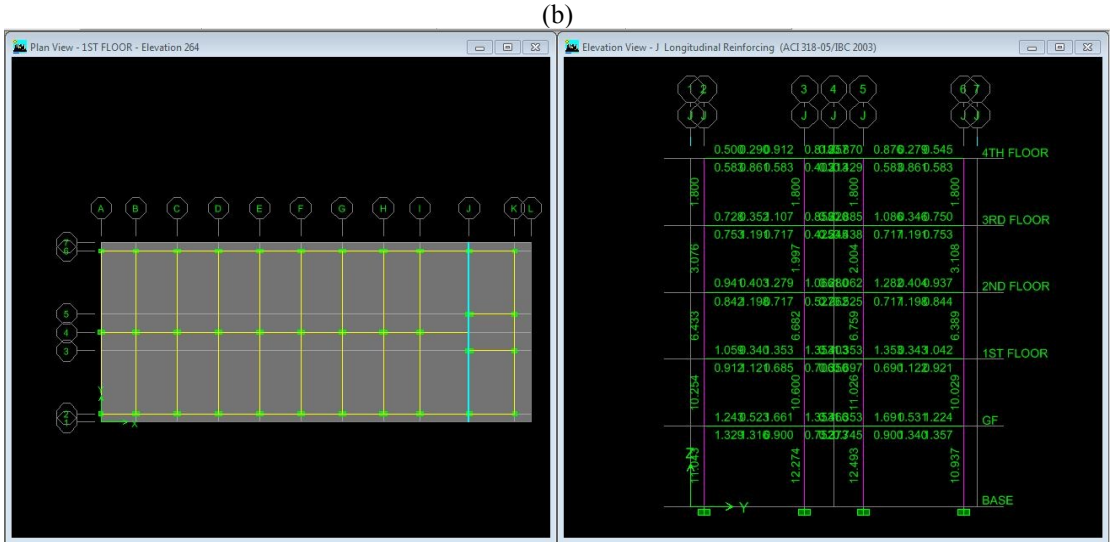
It is observed from Fig. 4 for section J, when the loading pattern was changed from residential to garments factory, some of the members are failed. It is occurred when a beam is subjected to loading, at the end of the beam, there is huge shear but the moment is comparatively small. Then due to the combination of shear stress and flexural stress, the principle stress is generated. Here, the failed beam sections are increased by beam retrofitting.



(a)



(b)



(c)

Fig. 4: Analysis data of section J for (a) Residential building, (b) Garments factory before retrofitting, (c) Garments factory after retrofitting

Similar observation can be made for section 4 and I. It is indicated that the ground floor columns requires extra reinforcement. So the short columns and ground floor columns are to be retrofitted.

RETTROFITTING DESIGN

It is seen from the previous section that when the loading cases were changed for garments factory, some members of previously designed structure were failed. Therefore the failed members needed to be retrofitted. The structure is redesigned with retrofitted members.

Retrofitting of Beams

When the manufactured load case is assigned in the structure, the result shows that B1 at grade beam (4I-6I section), the shear stress due to shear force and torsion together exceeds maximum allowed. Therefore the member is failed. Moreover, B2 beam at section 3J-5J, from ground floor to 2nd floor, is also failed due to the shear stress due to shear force and torsion together exceeds maximum allowed.

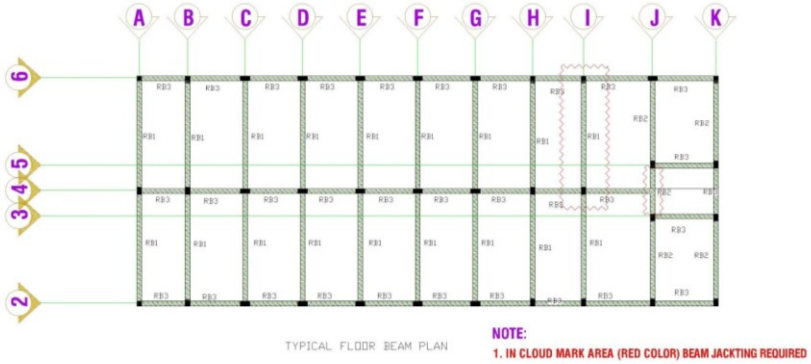


Fig. 5: Location of Beam Jacketing.

Those sections are needed to be increased by retrofitting. After retrofitting by concrete jacketing method, those sections are adequate. According to the code, the minimum thickness of jacketing i.e. 4 inch at each face is provided. Minimum reinforcement is also provided. The detailed analysis data of retrofitted beam is given at Table 2.

Table 2: Analysis data of retrofitted beams.

Beam NO	Size (in x in)	MAX +Mu(kip-in)	MAX -Mu(kip-in)	Req. Rebar Area (in^2)		Provided Rebar (in^2)		Shear Vu	Shear Rebar Req. (in^2)
B1-R	18×32	1380	3137.9	Top	3.0	Top	5.72	63.31	.041
				Bottom	2.98	Bottom	4.84		
B2-R	18×30	868.66	1737.34	Top	2.5	Top	4.84	39.41	.005
				Bottom	2.5	Bottom	4.4		

Retrofitting of Columns

After assigning the manufactured load case in the structure, the result shows that C1 (4B-4I section) at ground floor, reinforcing required exceeds maximum allowed. Therefore the member is failed. Those sections are needed to be increased by retrofitting. After retrofitting by concrete jacketing method, those sections are adequate. According to the code, the minimum thickness of jacketing i.e. 4 inch at each face is provided. Minimum reinforcement is also provided. Shear connector are used @ 12inch c/c in each face of column.

Fig. 6: Location of Column Jacketing

Table 2: Analysis data of retrofitted beams.

Column No.	Size (in x in)	MAX Mu(kip-in)	Req. Rebar Area (in^2)	Provided Rebar (in^2)
C1-R	18×28	-964.33	4.82	7.04

Retrofitting of Foundation

When the load cases are changed for garments factory, the retrofitted columns required improved foundations. From manual calculation, the improved foundation area is 8'-6" × 8'-6" whereas the previous footing was 7'-6" × 7'-6". So the foundation has to be increased. As one layer of steel is provided in square footing, the outer faces of existing footing has to be roughly disrupted so that the internal rebar is freed at least 3inch. For new foundation, rebars are welded with the existing bars up to 1 ft. The retrofitted column rebars have to be inserted 10inch with epoxy. Then the concrete is casted at sufficient depth. The details of retrofitted foundation is shown in Fig. 7.

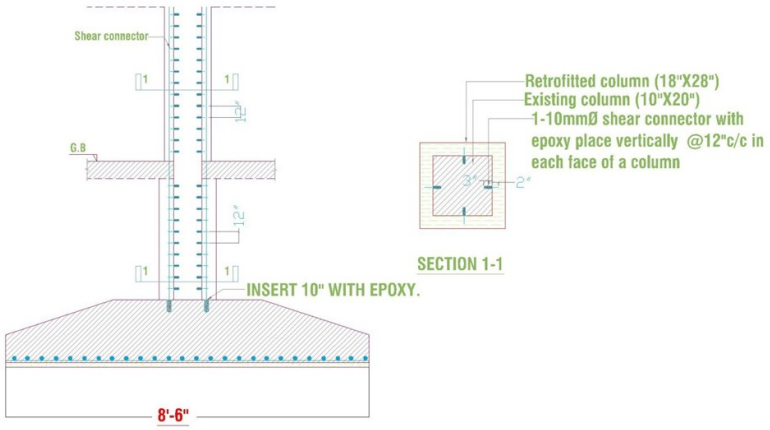


Fig. 7: Retrofitted foundation details.

CONCLUSIONS

The structural failure occurs due to change in live load from residential building to garments factory. It includes failure of columns, beams and foundation. In this paper, a retrofit of beam, column and foundation is introduced. After considering several causes, it is concluded that,

- With respect to our country, concrete jacketing is the most economic and efficient process of retrofitting of beam, column and foundation.
- As a member section has to be increased at least 4inch in each face, the rebar requirement is decreased in some cases. In such a situation, minimum reinforcement must be provided.
- In jacketing, a new layer of concrete is applied on the surface. The bond between new and old concrete does not act monolithically. But they are considered monolithic in the analysis.
- As the building structure is symmetrical by loading pattern, torsion effect is ignored.

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