Analysis And Strengthening of Distressed Structural Members of A Building– Case Study

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Abstract: For a structure to perform its optimum level or for a durable structure, the dependency lies with on the designing, proper construction practices, exposure conditions and periodical maintenance. Because of lack of proper periodical maintenance and due to inadequate quality of construction caused distress in the structural members of the building. This case study pertains to a thirty year initially constructed old building and which was developed in later stages.
As a part of study, numerical modelling is being carried out is being carried out in E-Tabs software, Non-destructive tests are carried out to find in-situ strength and retrofitting scheme by way of concrete jacketing is being proposed to cater the deficits. This study presents the verification of initial design considerations, methodology adopted for retrofitting and the sequence of retrofitting activities at site and also represents the condition of the structure after retrofitting.

Index Terms: E-Tabs, Numerical Modelling, Concrete Jacketing, Epoxy Grouting, Micro-concreting

INTRODUCTION

The project site is located near Dilsukhnagar, Hyderabad. The ground floor of the building is initially constructed in the year 1983 and later on after thirty years, First & Second floors are being constructed. During the course of years after new construction, dampness, spalling & other distresses observed in the old ground floor structural members of the building.

To check the condition of the structural members of the building, Non-Destructive tests (NDT) are carried out to find the in-situ strength of the concrete along with structural analysis is carried out using E-Tabs to verify initial design considerations and to obtain the details of the majorly loaded/affected structural member for which strengthening to be done based on test results.

Based on NDT results and the structural analysis, the failed structural members are identified. Concrete jacketing/encasement is being proposed after providing additional reinforcement to satisfy the demanded area of steel, so as to increase the load bearing capacity of the failed structural members (columns).

OBSERVATIONS

Severe cracks, spalling and dampness due to water seepages is being observed in columns & beams of the old ground floor building.

The column and beam layout of ground floor building is shown in detail in figure.1.

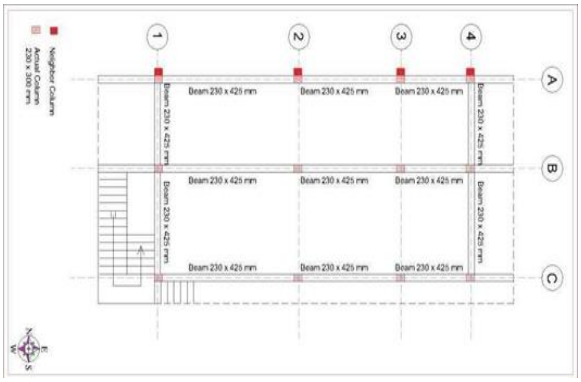

Fig.1 Layout of ground floor

Some structural members got distressed at few locations and they are shown in figure.2.

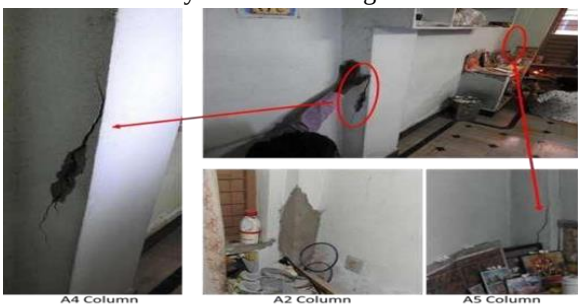

Fig.2Distressed columns

1.NON-DESTRUCTIVE TESTS (NDT):

NDT like Ultrasonic Pulse Velocity (UPV)Testing and Rebound Hammer tests were carried out to check the quality of concrete. The UPV test results vary from "Poor to Good" quality of concrete, poor indicates presence of voids/honey combing. The observed rebound values are as shown in Table-1.

Table 1 Rebound Hammer Test results

S. No.	Column	Equivalent Compressive strength (N/mm2)
1	A2	21
2	A3	10
3	A4	21.5
4	A5	21
5	B2	15
6	B3	4
7	B4	15
8	B5	20
9	C2	16
10	C3	6
11	C4	17
12	C5	22

Based on visual observations and NDT results, following conclusion can be drawn that

(i).The structure is undergoing failure due to more loads than the anticipated at the ground floor area

(ii).The ground floor members have deteriorated almost 30 to 40%, which was obtained from NDT results.

1.STRUCTURAL ANALYSIS :

E-Tabs is being used for analysis and the parameters which were considered for analysis and design are noted in Table 2.

Numerical analysis of Existing building for gravity loads were carried out. Plan (a) shows failure of columns under assumed grade of concrete and plan (b) shows failed columns after reducing of 30% of strength in concrete and steel for same plan based on NDT results.

Table 2 specifications	
Live load	3 KN/m2
Dead load	As per geometry
Floor load	1 KN/m2
Thickness of slab	0.125 m
Height of each storey	3 m
Column	230 X 300 mm
Beam	230 X 425 mm
Grade of concrete assumed	M20
Grade of Steel assumed	HYSD 415
Wall thickness	230 mm External walls & 115 mm Internal walls
Wall load	7 KN/m
Parapet wall load	3 KN/m
Type of support	Fixedsupport (Rigid Joint)

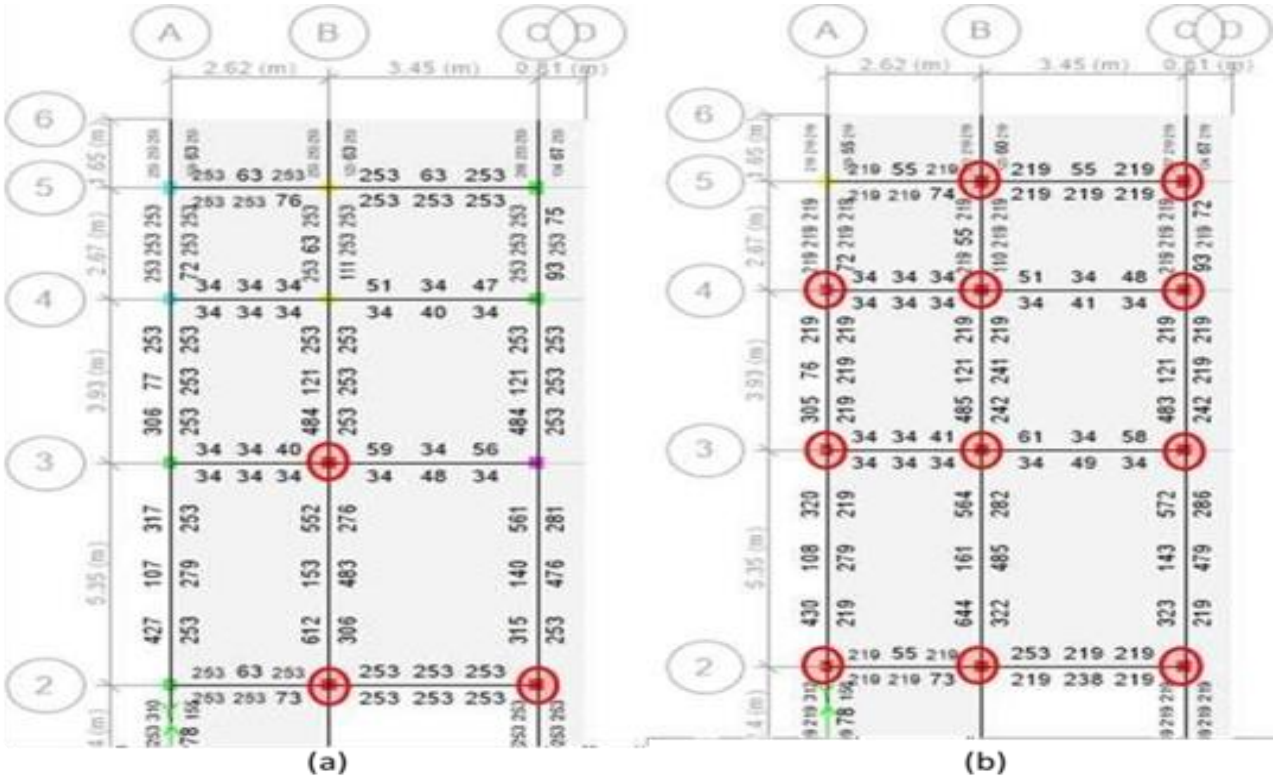

Fig.3 Comparative analysis

1. CALCULATIONS:

1.1 Determination of Area of steel (A_{st}) existing in the column: The area of steel existing in the column is found out from the designs or it can also be determined by profometer study or identifying the reinforcement bars after chipping the concrete up to cover at the top end of the column reinforcement as per site condition.

1.2 Determination of A_{st} demand in the column:
To determine the A_{st} demand, the design strength of the column is to be determined.
As per IS:456-2000 (1), Ultimate load
$Pu = 0.4 \times f_{ck} \times A_c + 0.67 \times f_y \times A_{sc}$
As all columns are of M20;
Hence f_{ck}=24N/ mm^2 and f_y=415N/ mm^2,
Ac=230*300 mm^2
Pu=0.4x24x230x300+0.67x0.8x415x678.58=760 KN
So, the

Design strength of the column is 760KN
For eg: A3 column, the compressive strength value obtained from rebound values F_{ck}=10N/ mm^2,
760000=0.4x10x230x300+0.67x415xAsc
A_{sc} will be obtained from the above equation.
A_{sc}=1035 mm^2

2. RECOMMENDED STRENGTHENING SCHEME:

Based on the NDT test results and the requirements from of the load calculations, the existing columns are proposed to strengthen by way of concrete encasement/jacketing after providing additional reinforcement. Shown in figure.4

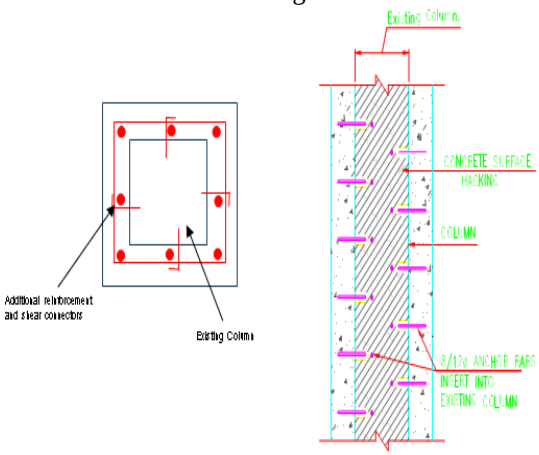

Figure-4 : Cross sectional and elevation view of proposed column encasement

3. EXECUTION:

- All the loose, spalled concrete of the existing column is chipped off as shown in figure.5.
- The exposed corroded reinforcement was cleaned using wire brush to remove the rusted portion and then treated using zinc-rich anti-corrosive paint.
- Additional vertical reinforcement anchored and stirrups were fixed at regular spacings and binded to the shear connectors shown in Figure.6.

Figure-5 : Chipping of concrete

- After fixing additional reinforcement & shuttering is done as shown in figure.7, concreting using high grade, non-shrink, free-flow micro concrete added with 12mm down aggregate at the specified ratio as per manufacture specification of micro concrete material was carried out to encase the existing distressed column.

Figure-6 : Fixing of additional reinforcement

Figure-7: Shuttering

- At the areas of the honey combing and at the areas of leakages, epoxy injection grouting was being carried out to the structural members (Columns & Beams).

4. CONCLUSION

The distressed columns were strengthened and thus increased the load carrying capacity of the columns.
No distress observed in the structural members after strengthening.
Thus the load carrying capacity and durability of the structure increased.

5. ACKNOWLEDGEMENTS:

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