International Journal of Research in Civil Engineering and Technology

E-ISSN: 2707-8272
P-ISSN: 2707-8264
IJRCET 2024; 5(1): 35-39
www.civilengineeringjournals.com/ijrcet
Received: 06-12-2023
Accepted: 14-01-2024

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A study of non-destructive assessment of fire affected RCC cold storage by rebound hammer and cost analysis for rehabilitation

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Abstract
As concrete having low thermal diffusivity property, increase in temperature slows down during fire situation. Results concrete structure performs well in such situation, but if concrete exposed to high temperature its strength and stiffness is decreases. So the knowledge of residual strength in concrete member required to decide, whether the fire affected structure should be demolished or repaired. The residual strength in concrete member is find out through NDT testing for that various instrument such as rebound hammer, ultrasonic pulse velocity, core cutter etc. are used. The aim of this study is to understand methodology, factor affecting on testing, interpretation of results, conclusion, remedial on fire affected concrete members are done through NDT testing of RCC structures. To fulfill the aim we study the report of NDT testing by rebound hammer of fire affected RCC OM cold storage, Kupwad MIDC.

Keywords: NDT Test, RCC structure, residual strength, rebound hammer

Introduction
This study deals with the change in properties of a fire affected concrete structure. A site named as OM cold storage, Kupwad, Miraj MIDC, Maharashtra, India was affected by a continuous fire for 72 hours. Ultimately, this exposer to high temp affects the strength and quality of concrete. Hence by performing the NDT tests on that structure, they determine these variations. The grade of the concrete use for RCC structure is M20. The concrete grade properties of the RCC cold storage structure are totally same before the structure was affected by fire hence practical point of view, one can study the effect of fire on a concrete structure. NDT tests on cold storage were performed with help of rebound hammer and readings were noted. Through referring readings and visual verification conclusion and remedial were stated.

Methodology
Visual survey
The structure is a R.C.C. framed structure. Each column, beam and slab within the section was observed for a range of defects such as cracks, seepage and peeling of paints.
The basis on which the observations were made is given below.
Special attention was given towards the cracking pattern, extent of burn and deflection observed on beams columns and slabs.

1. The de-lamination that had taken place in the brick and the R.C.C columns and beams.
2. The cracking pattern, was observed & its type - whether there were separation cracks between masonry walls and the columns.
3. Walls were observed for any stagnation, dampness, and color variation.
4. Special attention was given towards the cracking pattern, extent of burn and deflection observed on beams columns and slabs.

Tapping
Every column, beam and slab was subjected to tapping. This gave a clear picture about the status of the member subject to tapping. Members in sound condition gave a clear ringing sound while the member, who was in stage of deterioration, gave a hollow sound.

Instrumentation

Three tests were carried out on selected columns and beams to get a clear picture about the strength of the RCC framework of the building.

Surface Strength Profile - Rebound Hammer Method

The hammer is principally a surface hardness tester. The principle is that when a spring-loaded shaft strikes a surface its rebound is a function of the hardness of the surface. The force on the shaft and its rebound are developed and measured by the hammer. The operations are very simple. They consist of releasing the plunger from locked position by pressing gently against the hard surface and check for zero setting of rebound number indicator on the graduated scale. The hammer is then strongly pressed against the surface under investigation this releases the spring load weight, which strikes the plunger and causes the impact.

Details of RCC cold storage and Results of Rebound test

Drawing.

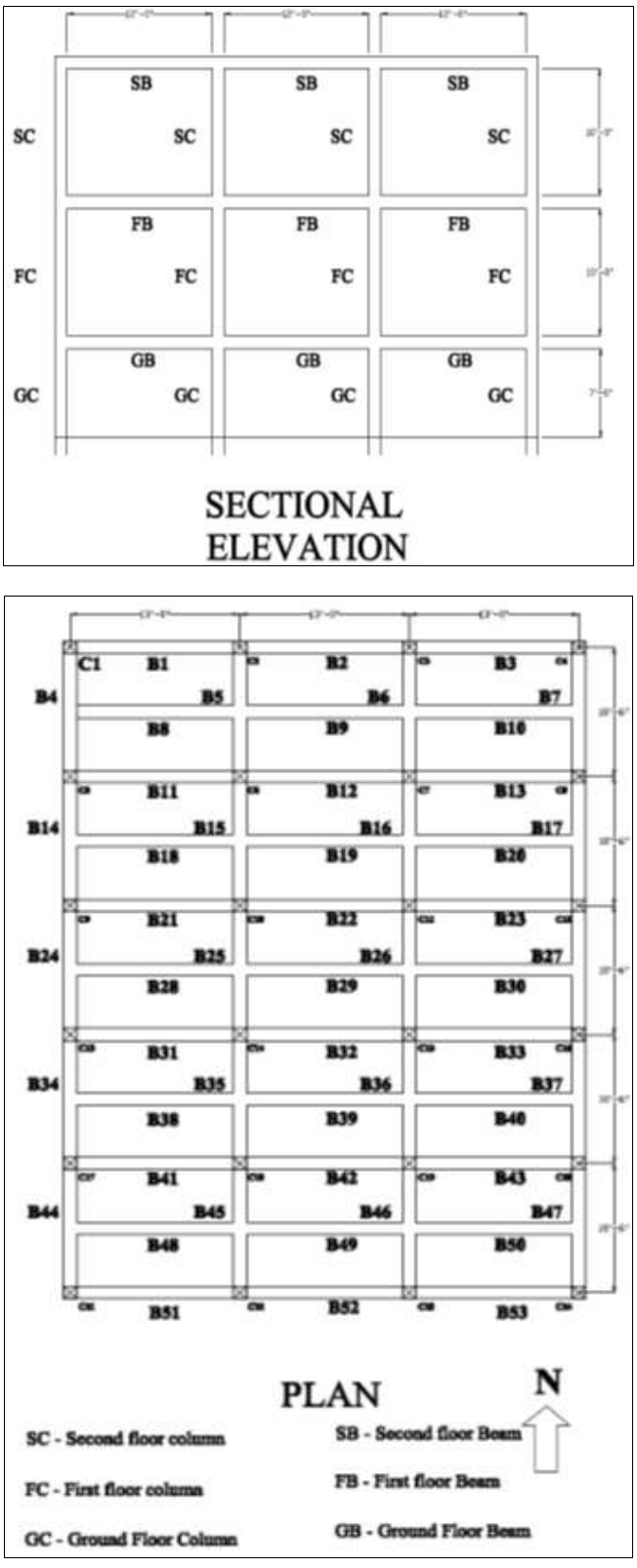

Fig 1: Details of RCC cold storage and Results of Rebound test

Table 1: Compressive Strength of Column

Sr. No.	Ground floor column (GC)	Strength (N/mm^2)	First floor column (FC)	Strength (N/mm^2)	Second floor column (SC)	Strength (N/mm^2)
1.	GC1	30	FC1	33.6	SC1	TNC
2.	GC2	26.4	FC2	19	SC2	16.8
3.	GC3	14.4	FC3	14.4	SC3	13.2
4.	GC4	19	FC4	TNC	SC4	TNC
5.	GC5	TNC	FC5	TNC	SC5	TNC
6.	GC6	-	FC6	19.8	SC6	-
7.	GC7	19	FC7	22.8	SC7	-
8.	GC8	TNC	FC8	TNC	SC8	TNC
9.	GC9	TNC	FC9	TNC	SC9	TNC
10.	GC10	15.6	FC10	19	SC10	13.2
11.	GC11	19	FC11	28.2	SC11	16.8
12.	GC12	TNC	FC12	TNC	SC12	TNC
13.	GC13	TNC	FC13	TNC	SC13	TNC
14.	GC14	-	FC14	-	SC14	30
15.	GC15	-	FC15	21.6	SC15	25.2
16.	GC16	TNC	FC16	TNC	SC16	TNC
17.	GC17	TNC	FC17	TNC	SC17	TNC
18.	GC18	25.2	FC18	-	SC18	-
19.	GC19	13.2	FC19	19	SC19	13.2
20.	GC20	TNC	FC20	TNC	SC20	TNC
21.	GC21	TNC	FC21	TNC	SC21	TNC
22.	GC22	19.8	FC22	TNC	SC22	TNC
23.	GC23	16.8	FC23	TNC	SC23	TNC
24.	GC24	21.6	FC24	TNC	SC24	TNC

TNC - Test is not conducted

Table 2: Compressive Strength of Beam

Sr. No.	First floor beam (FC)	Strength (N/mm^2)	Second floor beam (SC)	Strength (N/mm^2)
1.	FB1	16.8	SB1	15.6
2.	FB2	-	SB2	-
3.	FB3		SB3	
4.	FB4	TNC	SB4	TNC
5.	FB5	-	SB5	-
6.	FB6	16.8	SB6	19.0
7.	FB7	TNC	SB7	TNC
8.	FB8	26.4	SB8	25.2
9.	FB9	13.2	SB9	14.4
10.	FB10	-	SB10	-
11.	FB11	30	SB11	28.6
12.	FB12	26.4	SB12	25.2
13.	FB13	26.4	SB13	28.6
14.	FB14	TNC	SB14	TNC
15.	FB15	22.8	SB15	21.6
16.	FB16	21.6	SB16	19.8
17.	FB17	TNC	SB17	TNC
18.	FB18	15.6	SB18	14.4
19.	FB19	13.2	SB19	-
20.	FB20	19.8	SB20	19.0
21.	FB21	28.6	SB21	26.4
22.	FB22	30	SB22	31.2
23.	FB23	19.8	SB23	21.6
24.	FB24	TNC	SB24	TNC
25.	FB25	15.6	SB25	16.8
26.	FB26	30	SB26	28.6
27.	FB27	TNC	SB27	TNC
28.	FB28	26.4	SB28	25.2
29.	FB29	19	SB29	16.8
30.	FB30	15.6	SB30	14.4
31.	FB31	21.6	SB31	22.8
32.	FB32	16.8	SB32	15.6
33.	FB33	-	SB33	-
34.	FB34	TNC	SB34	TNC
35.	FB35	16.8	SB35	19.0
36.	FB36	-	SB36	-

37.	FB37	TNC	SB37	TNC
38.	FB38	28.6	SB38	30.0
39.	FB39	26.4	SB39	25.2
40.	FB40	19	SB40	19.8
41.	FB41	28.6	SB41	26.4
42.	FB42	19	SB42	16.8
43.	FB43	19.8	SB43	19.0
44.	FB44	TNC	SB44	TNC
45.	FB45	15.6	SB45	16.8
46.	FB46	15.6	SB46	14.4
47.	FB47	TNC	SB47	TNC
48.	FB48	25.2	SB48	22.8
49.	FB49	13.2	SB49	14.4
50.	FB50	30	SB50	31.2
51.	FB51	TNC	SB51	TNC
52.	FB52	TNC	SB52	TNC
53.	FB53	TNC	SB53	TNC

TNC - Test is not conducted

Analysis of N.D.T. Results

The overall observations in the field and the results presented indicate that the quality & the workmanship in the building are satisfactory. But due to aging or may be due to high temperature majority of the members showed strength lesser than the specified strength of 20 N/mm^2. The deterioration level of the building is in progress. The strength of concrete is dropped and would deteriorate with passage of time. To enhance the life of the building and stop further deterioration, it is advised to carry out repair and strengthening works.

As per the Indian code of practice (IS: 456 1978) the strength required is minimum 20 N/mm^2.

The interpretation of the NDT results and the correlation of the results with the strength of the concrete are as per the extensive research carried out by us.

Conclusion

The following columns and beams are identified having strength less than 20 N/mm^2.

G.F. Columns.

Column Numbers- GC3 to GC17, GC19 to GC23. (20 Nos)

F.F. Columns

Column Numbers- FC2 to FC6, FC8, 9, 10,12,13,14, FC16 to FC24, (20 Nos).

S.F. Columns

Column Numbers- SC1,2,3 to 13, 16 to 24, (20 Nos).

F, F. Beams

FB7,9,10,14,17 to 20, 23 to 25, 29,30,32 to 37, 40, 42 to 47, 49,51,52,53. (29 Nos).

S, F. Beams

SB1 to 7, 9.10.14, 16 to 20, 24,25,27,29,30,32 to 37,40, 42 to 47,49,51,52,53, (31 Nos).

Remedial Measures / Recommendations

The identified beams and columns have strength less than 20 N/mm^2. In some cases it is found considerably less than this minimum value of strength of concrete specified by I.S. Code. To ensure safety and serviceability of the structure and to enhance durability of the structure, it is recommended to strengthen the identified columns and beams.

Strengthening of columns and beams shall be carried out by reinforced concrete jacketing, thus increasing reinforcement and sectional dimensions of the member.

The surface of the member to be strengthened is made clean and dry, all loose particles are removed by wire brush. Reinforcement cage is prepared for columns and beams and the formwork is kept ready. For better adhesion of new concrete on old concrete surface epoxy adhesive is applied on the surface with paint brush. Thickness of this additional concrete is maintained 3" all over the length. This micro concrete mixed with HBR latex is placed and compacted within half an hour after application of epoxy adhesive. The concrete is cured for 21 days.

Estimate for Repair & Strengthening Work

Columns

- Average height of columns - 9'.
- Average sectional dimensions - 9" X 18".
- Thickness of new concrete - 3".
- Reinforcement - 12 mm dia. - 8 Nos. ----- 21 Kg.
- Stirrups - 6 mm dia. - 6" c/c.----- 8.50 Kg.
- Total ------ 29.50 Kg / column.
- 29.50 Kg X Rs. 45.00 = Rs. 1327.00
- Micro concrete+ HBR latex + Epoxy adhesive---- 12.375 Cuft.
- Material ------- Rs. 6000.00
- Labour -------- Rs. 1500.00
- Total ---------- Rs. 8827.00 Per column of height 9'.
- No. of columns - 60.
- Total for all columns --- 60 X 8827 = Rs. 529620.00

BEAMS

- Average length of beams - 12'.
- Average sectional dimensions - 9" X 18".
- Thickness of new concrete - 3".
- Reinforcement - 12 mm dia. - 8 Nos.-- 26 Kg.
- Stirrups - 6 mm dia. - 6" c/c. -------- 10 Kg.
- Total ------ 36 Kg / column.
- 36 Kg X Rs. 45.00 = Rs. 1620.00
- Micro concrete+ HBR latex + Epoxy adhesive Material ------- Rs. 6000.00
- Labour -------- Rs. 2000.00
- Total ---------- Rs. 9620.00 Per beam of length 12'.
- No. of beams - 60.

- Total for all columns --- 60 X 9620 = Rs. 577200.00

SLAB
- Two slab panels - 10’ X 8’ X 2 = 160 Sq. Ft.
- Rs. 16000.00

Brick wall
13’ X 7’ X 5 Nos. = 455 Sq. Ft.
Rs. 27300.00
Total = 529620.00 + 577200.00 + 16000.00+27300.00 = Rs.1150120.00.
Add Contractors profit - 15% - Rs.172518.00

Grand Total = Rs.1322638.00

Rs. Thirteen Lakh Twenty Two Thousand Six Hundred Thirty Eight Only.

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