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Analysis & Design Of Fire Damage Structure

Aashish Y. Soni*, R.V.R.K Prasad**,
(PG, student Department of Civil Engineering, K.D.K.C.E Nagpur)*

ABSTRACT

Fire in the structure causes higher temperature at the concrete surface, which causes reduction in compressive strength, modulus of elasticity of concrete. The architectural and structural design of a building and construction has a significant effect on its fire safety standards. In this project, the fire damaged chemical plant at Yasho Industries at Vapi is analyzed. The reason of fire was short circuit. Because of presence of highly flammable petroleum, fire bridged unable to prevent building from fire. Due to fire, serious damages in the structure were observed like cracking, spalling and deformation of concrete members etc. This building is 10yrs old. The Built-up area at each floor is 5725 sq.ft. Total number of floors was (G+5). This project presents a comprehensive design of six storey reinforced concrete fire damaged structure. The design is carried out to show the effects of fire on structural elements. The damages due fire on concrete structures at elevated temperature are determined. The present work deals with NDT on fire damaged structural elements, Determination of load & moment carrying capacity of structural elements & Methods of strengthening of fire damaged structure. The structural elements such as R.C.C. slabs, beams and columns are designed by conventional working stress method and limit state methods. From the NDT results, suitable type of jacketing is proposed for the fire damaged structure.

KEYWORDS: - *Fire damaged structure, NDT Tests, Structural Analysis, Repairing, Jacketing etc.*

1. INTRODUCTION

Fire is a catastrophic event to which any building can fall victim during its lifetime. Not only does it pose a direct threat to the occupants through the release of harmful gases and devastating heat, but the elevated temperatures themselves also have seriously adverse effects on the structural integrity of the entire building. Though undesired, fire can't be avoided altogether. Therefore fire protection efforts must be made to reduce the impact of such events. The primary goal of fire protection is to limit, to acceptable levels, the probability of death, injury and property loss in an unexpected fire. With respect to structural design, this means providing sufficient time for the occupants to exit the building and for fire fighters to extinguish the fire before any structural collapse occurs. The object is to save lives by preventing the spread of fire and to ensure that the structure does not collapse before it has been safely evacuated. A complete understanding of the structural behavior of a building in a real fire may never be achieved. It is only possible to assess the loss of strength and stiffness of a structural element exposed to a specified duration of "Standard Fire". Structures are designed for a specified fire rating and the period of endurance before collapse.

A proper assessment of the structure after a fire event involves both field and laboratory work to determine the extent of fire damage, in order to design appropriate and cost effective repairs. This article presents an overview of how to conduct a evaluation of a fire damaged structure. Two case studies are presented of fire damage evaluation and repair.

2. AIM OF PROJECT:

This project aims to determine the reduction in compressive strength of concrete & deformed yield strength of steel due to existence of fire in the structure. These work also present methods of jacketing of existing fire damaged structure.

3. OBJECTIVES OF PROJECT:

1. Condition Assessment of fire damage structure using NDT .(Rebound Hammer & Ultrasonic Pulse Velocity Test)

2. Structural Analysis of fire damage structure. (Using Software)

3. To find the Static strength of existing fire damage structural components.

4. To find the actual static strength required for existing fire damage structural components.

5. To suggest the methods of repairs & rehabilitation.

6. To find the total cost required for repairs & rehabilitation.

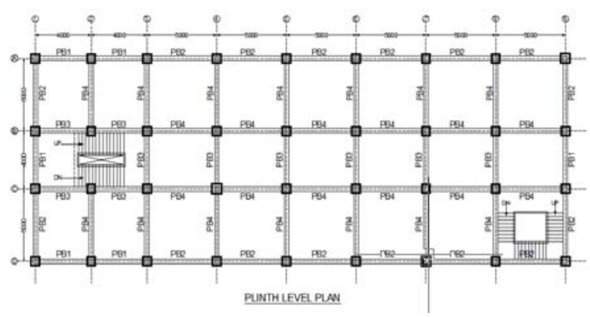
4. NDT TESTS

Concrete is susceptible to a range of environmental degradation factors and these factors limit its service life. For quality assurance and condition evaluation, tests are necessary (preferably non destructive). Non destructive tests are defined as tests that do not alter the original properties.

1) Rebound Hammer: In 1948 Ernst Schmidt a Swiss Engineer developed a device for testing concrete, based upon rebound principle when a hammer strikes concrete. The degree of rebound is an indication of hardness of concrete. Schmidt Standardized a hammer blow by developing a spring loaded hammer and devised a method to measure the rebound of the hammer.

2) Ultra Sonic Pulse Velocity: The U.P.V. method is a stress wave propagation method that involves measurement of travel time over a known path length of Pulse of Ultra Sonic compression waves (These are the waves associated with normal stress). The pulses are introduced into concrete by a Piezoelectric Transducer and similar transducer acts as receiver to monitor the surface vibration caused by the arrival of the pulse. A timing circuit is used to measure the time it takes for the pulse to travel from the transmitting to receiving transducers Figure 3.3 is a schematic of U.P.V. technique. The speed of compression wave in a solid is related to elastic constants (Modules of Elasticity and Poisson's ratio) and density. Lower quality concrete is by lower velocity.

5. STRUCTURAL ANALYSIS



Dead Load Calculations:

1) Self Weight of slab = 25x0.125
= 3.125kN/m^2
2) Floor Finish at floor level = 1.5 kN/m^2
3) Water Proofing at Terrace =2.5 kN/m^2
4) Total Slab Weight at floor level= 4.625 kN/m^2
5) Total Slab Weight at terrace = 5.625 kN/m^2
6) Wall Weight = 0.23 x (5.2-0.6) x 20
= 21.16 kN/m

7) Weight of parapet wall = 0.23 x 1.2 x 20 = 5.52kN/m

Live Load:

1) Live Load Intensity specified = 8 kN/m^2

2) Live Load at roof level =1.5 kN/m^2

PRIMARY LOAD & COMBINATION:

Type	L/C	Name
Primary	1	DL
Primary	2	LL
Primary	3	EQX+
Primary	4	EQX-
Primary	5	EQZ+
Primary	6	EQZ-
Combination	7	1.5(DL+LL)
Combination	8	1.5(DL+EQX+)
Combination	9	1.5(DL+EQX-)
Combination	10	1.5(DL+EQZ+)
Combination	11	1.5(DL+EQZ-)
Combination	12	1.2(DL+LL+EQX+)
Combination	13	1.2(DL+LL+EQX-)
Combination	14	1.2(DL+LL+EQZ+)
Combination	15	1.2(DL+LL+EQZ-)
Combination	16	0.9DL+1.5EQX+
Combination	17	0.9DL+1.5EQX-
Combination	18	0.9DL+1.5EQZ+
Combination	19	0.9DL+1.5EQZ-

6. DESIGN RESULTS

DESIGN RESULTS OF BEAM

Floor Level	Beam No.	Existing Beam Details	M.R. of Existing Beam (Factored) kN-m	Actual Bending Moment (Factored) kN-m	New Beam Details	M.R. of New Beam	Remark
Plinth Beam	PB1	300 X 450	99.36	49.06	300 X 450	99.36	Not Strengthen
	PB2	300 X 450	99.36	75.45	300 X 450	99.36	Not Strengthen
	PB3	300 X 450	99.36	49.79	300 X 450	99.36	Not Strengthen
	PB4	300 X 450	99.36	72.98	300 X 450	99.36	Not Strengthen
First Floor	SB1	300 X 500	125.25	144.88	300 X 500+ISMB150	125.25	Strengthen
	SB2	300 X 600	187.85	207.81	300 X 600+ISMB150	187.85	Strengthen
	SB3	300 X 500	125.25	260.25	300 X 500+ISMB300	125.25	Strengthen
	SB4	230 X 600	144.02	196.93	230 X 600+ISMB 150	144.02	Strengthen
	SB5	230 X 450	76.17	85.26	230 X 450 +ISA75X75X8	76.17	Strengthen
Second Floor	SB1	300 X 500	125.25	146.45	300 X 500+ISMB150	125.25	Strengthen
	SB2	300 X 600	187.85	211.85	300 X 600+ISMB150	187.85	Strengthen
	SB3	300 X 500	125.25	268.19	300 X 500+ISMB300	125.25	Strengthen
	SB4	230 X 600	144.02	198.06	230 X 600+ISMB 150	144.02	Strengthen
	SB5	230 X 450	76.17	87.26	230 X 450+ISA75X75X 8	76.17	Strengthen

DESIGN RESULTS OF COLUMN

Floor Level	Column No.	Existing Col. Details	Pu (kN)	Mux (kN-m)	Muy (kN-m)	Remark	New Col. Details	Remark
Ground Floor	C1	600 X 600 16 X 20T T8@100-150	4267	2.74	0.78	Reqd Strenthening (Unsafe)	750 X 750 16 X 20T + 12 x 16T T8@100-150 +T8@100-150	Safe
	C2	600 X 600 12 X 20T T8@100-150	3633	1.06	0.58	Reqd Strenthening (Unsafe)	700 x 700 12 X 20T + 12 x 12T T8@100-150+T8@100-150	Safe
	C3	600 X 600 16X 20T T8@100-150	4290	6.17	16.82	Reqd Strenthening (Unsafe)	750 X 750 16 X 20T + 12 x 16T T8@100-150+T8@100-150	Safe
	C4	600 X 600 12 X 20T T8@100-150	4051	15.68	15.18	Reqd Strenthening (Unsafe)	700 X 700 12 X 20T + 12 x 12T T8@100-150+T8@100-150	Safe
First Floor	C1	600 X 600 16 X 20T T8@100-150	3552	2.59	1.02	Reqd Strenthening (Unsafe)	600 X 600 16 X 20T + 4 ISA 75x75x10 580x200x10 THK. Battens	Safe
	C2	600 X 600 12 X 20T T8@100-150	2998	1.10	0.80	Reqd Strenthening (Unsafe)	600 X 600 12 X 20T + 4 ISA 75x75x8 580x200x8 THK. Battens	Safe
	C3	600 X 600 16X 20T T8@100-150	3270	7.17	15.32	Reqd Strenthening (Unsafe)	600 X 600 16 X 20T + 4 ISA 75x75x8 580x200x8 THK. Battens	Safe
	C4	600 X 600 12 X 20T T8@100-150	3156	14.98	15.90	Reqd Strenthening (Unsafe)	600 X 600 12 X 20T + 4 ISA 75x75x8 580x200x8 THK. Battens	Safe

7. Conclusions

1) The original grade of concrete was $25 N/mm^2$. Due to fire, the strength of concrete is reduced to $15 N/mm^2$.
2) Deformation, cracking & spalling are observed in fire damaged structure. They are repaired by using epoxy bonding agents, Polymer concrete & cement grouting.
3) Deflection of R.C.C. beam is observed 25-40 mm in ground & first floor beams having span 4 to 5m.
4) Deflection of R.C.C. slabs is observed 10-20 mm in ground & first floor beams having span 2.5 to 3m.
5) Load carrying capacity of columns is reduced due to fire. They have strengthened by using R.C.C. & Steel Jacketing as discussed in chapter 6 by table 6.6.
6) Moment of resistance of beam is reduced due to fire. Hence Beams are strengthened by providing additional steel beam below concrete beam to increase the moment of resistance & control the deflection as discussed in chapter 6 by table 6.4.
7) Selection of type of jacketing is based on the cost of repaired material. For this fire damaged structure, R.C.C. jacketing is suitable & economical for columns.
8) For slab, additional R.C.C. flooring is provided at the top of the slab with shear connectors to increase the stiffness of slab as discussed in chapter 6 by table 6.5.
9) Rebound Hammer, Ultrasonic Pulse velocity test, PH test & carbonation test are carried out for the testing of fire damaged structure.
10) The strength of steel is reduced by 20-25% because of fire.
11) The total cost of repairing and jacketing is ` 60, 00,000/- for repaired area 17175 sq.ft. (The total cost of repair includes jacketing of columns, strengthening of beams, slabs, tri-mix flooring repair etc.)

8. References

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