International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

Strength Evaluation of Fire Affected Hospital Building by using Non Destructive Test

Er. Skindar Bakht Shah
Research Scholar, Dept. of Civil Engineering.
Indo-global group of Colleges.
Abhipur, Mohali, India

Er. Manjit Kaur
Assistant Prof, Dept.of Civil Engineering
Indo-global group of Colleges
Abhipur, Mohali. India

Abstract:- **Concrete is broadly utilized for the development of frameworks, for example, structures, spans, cooling towers, stacks, mechanical and other numerical structures. Fire is one of the most damaging incidental loads that a structure can be oppressed during its lifetime. The measure of harm caused will depend for the most part on the seriousness and the term. The physical properties of concrete and the reinforcement steel are altered by the temperature and range of fire. Recovery of flame harmed structures are typically favored than destroying and remaking. Assessment of fire damaged concrete usually starts with visual observation followed by Non destructive tests Rebound hammer test, ultrasonic pulse velocity test, Carbonation Test. The Rebound hammer and ultrasonic pulse velocity measurements made on a structure will provide a qualitative estimation of the damaged members with the undamaged one. This paper outlines a methodology for assessing the condition of a fire damaged concrete structure based on non-destructive; the observations of the fire affected hospital building were taken and then compare with fire un-affected portion of the hospital building.**

Key words: Fire damaged, Rebound hammer, Ultrasonic pulse velocity, Rehabilitation

I. INTRODUCTION

The purpose of using Non destructive tests is to determine the quality and integrity of materials, components or assemblies without affecting the ability to perform their intended functions. This paper deals with the change in properties of a fire affected concrete. Now days there are incidents of fires in buildings are often heard which are increasing day by day and also the repair and rehabilitation of fire damaged structures has become an area for study and research. Many efforts are been laid down to carry out research in these related fields. To build a structure usable again after fire damage is a discipline of great concern by civil engineering community. Concrete is known to exhibit a good behavior at high temperature, and the concrete is incombustible in Nature. Generally concrete having low thermal conductivity, which guarantee a slow propagation of thermal transients within the structural members. It was confirmed from the fire affected hospital building caused due to gas explosion located in Baramulla, Jammu and Kashmir that the physical and mechanical properties of concrete affected due to elevated temperature. A significant reduction in compressive strength, tensile strength has been found in the fire affected hospital building. Physical properties such as density, porosity, color and morphological properties were also remarkably affected. Hence there is a need of using Non destructive test techniques to evaluate the properties of fire affected hospital building.

Key words: Non destructive test, compressive strength, tensile strength, porosity

II. LITERATURE REVIEW

Adam Levesque et al [2019] This research focuses on the effect of fire on structures due to the Boko Haram insurgency in Maiduguri, Northern Nigeria. It is aimed at giving a further contribution to understand the effect of fire with respect to the local aggregates, quenching methods and proposing an assessment methodology based on a suitable analytical procedure applied to reinforced concrete subjected to sustained fire. . The samples were burnt in a designed fire simulation furnace using sugarcane bags' as fuel with varying air velocities for 2 hours. Cooling of samples was carried out using water splashing, CO_2 powder fire extinguisher and air cooling methods before the compressive strength tests using a Seidner Compressive Testing Machine and Non-destructive test with Rebound Hammer. **Kumavat H.R. et al. (2014)** The paper present case study include the use of various Non-Destructive Test (NDT), to evaluate the concrete quality of building age was 8 years. Initially, the structure deteriorates due to cyclic temperature variations, physical causes and aggressive chemical attack the research paper also focus on standard testing procedure of NDT and sequence of operation for obtaining accuracy as well as the problems created during the testing and the limitations of the tests are considered. **Said M. Allam, Hazem M.F and Elbakry Alaa G. Rabeai [2013]** has investigated The behavior of reinforced concrete slabs under fire loading has been studied by researchers for many decades . It is well known that when the temperature increases the slab fire resistance decreases. This is because when concrete is exposed to heat, chemical and physical reactions occur such as loss of moisture, dehydration of cement paste and decomposition of the aggregate. Such changes lead to high pore pressures caused by the water evaporation, internal micro cracks and damages appear in concrete Also, the increase in the temperature leads to a decrease in the yield strength of the steel reinforcement. Concrete spelling under high temperatures is a major factor of reducing its fire resistance. The spelling is caused by the build-up of pore pressure during heating. **F Ali, A Nadjai, A Abu-Tair [2011]** has investigated the Explosive spalling of high

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

performance concrete under fire is one of the major concerns in front of the engineering community today. It is associated with violent failure of thin layers of concrete resulting in sudden reduction of load carrying capacity which may lead to complete collapse. High pore pressures due to low permeability and stresses due to thermal gradients are considered to be the governing causes of explosive spalling. However, the failure mechanisms and all influencing parameters are not yet fully understood. The most popular method to prevent spalling is the addition of polypropylene (PP) fibers in concrete. It is generally accepted that the PP fibers leave a porous network after melting at around 160 °C, leading to an increase in permeability, thus allowing the water vapors to escape. **Mohammad Reza Hamadan et al.(2009**) In this research paper authors used Rebound hammer test and Ultrasonic pulse velocity test on specimen and existing structure and got compressive strength of concrete and comparison along with actual compressive strength which is obtain from compressive testing machine. The structural health monitoring by NDT methods comprised of UPV and RSH (Schmidt Rebound Hammer) were carried out in laboratory and site. The experimental investigation using NDT methods showed that a good correlation exists between compressive strength, SRH and UPV. **Ian A.FLETCHER, Stephen WELCH, José L. TORERO, Richard O. CARVEL, Asif USMANI [2007]** has investigated the performance of steel during a fire is understood to a higher degree than the performance of concrete, and the strength of steel at a given temperature can be predicted with reasonable confidence. It is generally held that steel reinforcement bars need to be protected from exposure to temperatures in excess of 250-300°C. This is due to the fact that steels with low C-contents are known to exhibit 'blue brittleness' between 200 and 300°C. Concrete and steel exhibit similar thermal expansion at temperatures up to 400°C; however, higher temperatures will result in significant expansion of the steel compared to the concrete and, if temperatures of the order of 700°C are attained, the load-bearing capacity of the steel reinforcement will be reduced to about 20% of its design value. **M.Z. Mohamed Firdows et al (2005)** 34-year old industrial building was investigated to assess the extent of damage and the cause(s) of deterioration. This study involved visual inspection, non-destructive testing, and laboratory analysis for materials collected from the building. Besides rebound hammer and ultrasonic pulse velocity tests, cores were also extracted from select locations and a detailed analysis of the hardened concrete was carried out. Half-cell potential and concrete resistivity measurements were also conducted. The results of the testing and analysis indicated that the structural members were affected due to chlorine gas emission and carbonation. This paper describes details of the investigations carried out, evaluation of test results and recommendations on measures for strengthening the building. **N.R. Short, J.A. Purkiss, et al [2001]** this paper deals with Assessment of fire damaged concrete structures usually starts with visual observation of color change, cracking and spalling. On heating, a change in color from normal to a pink/red is often observed and this is useful since it coincides with the onset of significant loss of concrete strength. . The full development of the pink/red color is coincident with substantial reduction in compressive strength and the method may be used to define the distance from a heated surface where strength degradation has occurred. **J.K Chege et al (2000)** this paper deals with a bomb blast affected building suffered extensive damage to structural elements and other areas of a building. Major and crucial information necessary in the evaluation included the mapping of the extent of damage which calls for both visual examination and extensive use of Non Destructive Testing Equipment and skilled personnel capable of checking for cracks, materials damage, and reinforcement bars condition including location sizing and strength measurement of critical structures elements.

III. OBJECTIVE OF THE STUDY

- To Investigate the Rebound hammer measurements on fire un-affected concrete and compare with the values of fire affected concrete
- To Investigate The Compressive Strength with the help of Rebound Hammer on fire un-affected concrete and compare with fire affected concrete
- To Investigate the Ultrasonic Pulse Velocity (UPV) measurements on fire un-affected concrete and compare with the values of fire affected concrete.
- To Investigate Any Discontinuity in cross section of structure like cracks, cover concrete delaminating.
- To investigate the carbonation effect on fire affected and fire UN –affected .concrete then compare with the obtained results.
- To investigate the carbonation depth of the concrete cover over the reinforcement

IV. METHODOLOGY

A precise methodology for completing a logical examination of a flame influenced in hospital building and the influenced in hospital building and the parameters that are to be assessed from these tests are displayed.

The review depends on the

1) Visual Inspection (Photographic Inspection).

- Source of fire and its location in the building
- Locations of portions with extensive, moderate and no-damage.
- Color of concrete.
- Spalling of concrete, horizontal and vertical cracks in concrete.
- Damage of structural steel sections and their locations Inspection over damaged portions

2) Conditional Survey.

The motivation behind the overview is to gather adequate information to pinpoint the reason and wellspring of the issue and to decide the degree of the harm. Contingent

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

upon the reasonable justification of the harm, the site work includes a mix of the accompanying procedures:

- Detailed visual inspection;
- Survey of cracks, spalling, concrete degradation etc.
- Drilling holes or mini-cores for carbonation test
- Coring of concrete for determination of strength and petrography examination;
- Rebound hammer test for compressive strength (comparison only);
- Ultrasonic pulse velocity test for honeycombing depth of cracks, or compressive strength (comparison only).

3) Non-Destructive Testing.

These tests are based on indirect measurement of concrete strength through measurement of surface hardness and dynamic modulus of elasticity. Calibration curves relating these properties to the strength of concrete are available. The most commonly adopted NDT methods for assessment of the strength of concrete and their principles are given in the following

Rebound Hammer: - Spring-driven mass strikes the surface of concrete and rebound distance is given in R-values. Surface hardness is measured and strength estimated from calibration curves, keeping in mind the limitations.

Ultrasonic Pulse Velocity: - It operates on the principle that stress wave propagation velocity is affected by the quality of concrete. Pulse waves are induced in materials and the time of arrival measured at the receiving surface.

Carbonation Test: - Carbonation occurs when CO2 from air finds its way into the body of concrete through its pores in presence of moisture & water forms carbonic acid which neutralizes the Ca (OH) 2 formed due to their action during setting of concrete thus reducing the alkalinity of concrete

Table 1: Relation between Rebound No and Concrete Quality

AVERAGE REBOUND	QUALITY OF CONCRETE
>40	Very Good
30-40	Good
20-30	Fair
<20	Poor and/or delaminated
0	Very Poor and/or delaminated

Table 2: Relation of Pulse velocity with Quality of concrete

PULSE VELOCITY (KM/SEC.)	QUALITY OF CONCRETE
0-2	POOR
2-2.5	DOUBTFUL
2.5-3	MEDIUM
3-4	GOOD

Picture 1 (Spalling of Concrete)

V. RESULT AND DISCUSSION

Table: 3 Specifications of the building

S.No	Specification	Data
1	Building	Hospital
2	Location	Baramulla Jammu and Kashmir
3	Fire accident	31 July 2015
4	Floors	3
5	Height of building	11 m
6	Grade of Concrete	M 25
7	Grade of steel	Fe 415

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

REBOUND HAMMER TEST

Table: 4 Ground Floor Fire Affected Portion.

C No.	Reading						R No.	Compressive Strength(N/mm^2)	Quality
	1	2	3	4	5	6			
C1	20	30	35	34	32	33	30	24	Fair
C4	29	31	27	30	28	26	29	23	Fair
C7	31	25	30	26	29	30	28	22	Fair
C13	29	28	26	25	28	27	27	20	Fair
C7	25	23	25	26	22	28	25	18	Delaminated
B1	30	32	31	25	24	29	28	23	Fair
C8	25	32	25	32	33	28	30	24	Fair

Table: 5 First and second Floor Fire Un –Affected Portion.

C No.	Reading						R No.	Compressive Strength(N/mm^2)	Quality
	1	2	3	4	5	6			
C6	33	31	25	39	35	25	31	25	Good
C14	50	35	20	32	29	27	32	26	Good
C5	33	31	33	27	33	30	32	26	Good
B8	33	31	29	31	33	29	30	24	Fair
B9	30	35	29	36	30	28	31	25	Good
SECOND FLOOR									
C6	35	33	30	35	32	33	33	28	Good
C7	35	30	38	35	30	35	34	30	Good
C8	30	30	39	30	38	30	32	26	Good
C9	30	30	30	35	38	38	33	28	Good
C5	33	35	32	30	38	32	33	28	Good
C3	31	34	33	35	38	34	34	30	Good
C2	39	32	32	35	31	35	34	30	Good

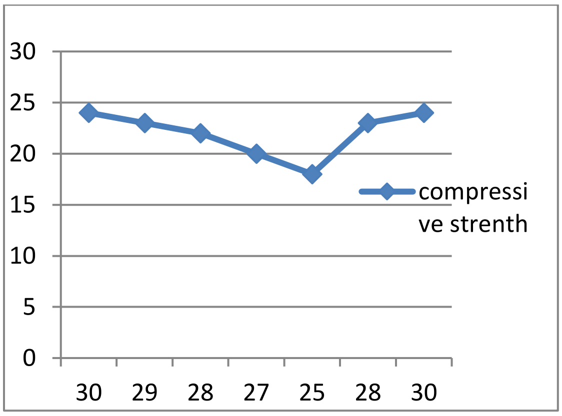

Fig: 1 Graph between compressive strength and rebound number of Fire affected portion.

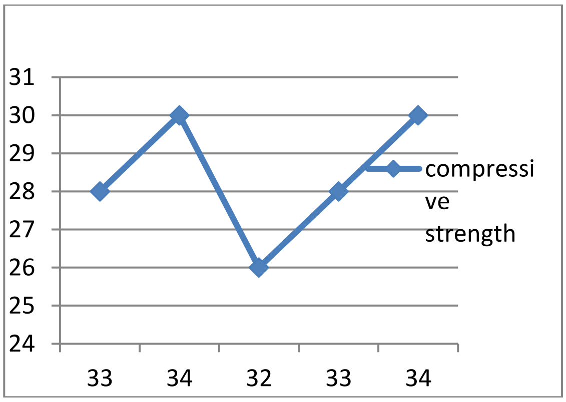

Fig: 2 Graph between compressive strength and rebound number of Fire un-affected portion

Ultrasonic pulse Velocity Test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 11, November-2019

Table: 6 Ground Floor Fire Affected Portion

C No.	Distance (Metre)	Time I	Velocity I	Time II	Velocity II	Average Velocity	Method	Quality
C4	0.381	180	2.116	170	2.241	2.178	Direct	DOUBTFUL
C10	0.381	177	2.152	180	2.116	2.134	Direct	DOUBTFUL
C11	0.381	180	2.116	175	2.177	2.146	Direct	DOUBTFUL
C12	0.381	151	2.523	160	2.381	2.452	Direct	DOUBTFUL
C13	0.381	180	2.116	171	2.228	2.172	Direct	DOUBTFUL
C14	0.381	177	2.152	185	2.059	2.105	Direct	DOUBTFUL
B1	0.381	180	2.116	172	2.215	2.165	Direct	DOUBTFUL
C6	0.178	80	2.225	76	2.342	2.283	Indirect	DOUBTFUL
C7	0.178	75	2.373	71	2.507	2.440	Indirect	DOUBTFUL
C5	0.178	75	2.373	78	2.282	2.327	Indirect	DOUBTFUL

Table: 7 First and second Floor Fire UN –Affected Portion.

C No.	Distance (Metre)	Time I	Velocity I	Time II	Velocity II	Average Velocity	Method	Quality
C8	0.381	175	2.177	182	2.093	2.135	Direct	DOUBTFUL
C7	0.381	182	2.093	170	2.241	2.167	Direct	DOUBTFUL
C6	0.381	170	2.241	177	2.152	2.196	Direct	DOUBTFUL
C3	0.381	174	2.196	171	2.228	2.212	Direct	DOUBTFUL
C5	0.178	71	2.570	80	2.225	2.397	Indirect	DOUBTFUL
C13	0.178	73	2.488	75	2.373	2.410	Indirect	DOUBTFUL
C12	0.178	75	2.373	75	2.373	2.373	Indirect	DOUBTFUL
C11	0.178	77	2.351	71	2.570	2.460	Indirect	DOUBTFUL
C10	0.178	80	2.225	71	2.570	2.397	Indirect	DOUBTFUL
C9	0.178	75	2.373	77	2.351	2.362	Indirect	DOUBTFUL
SECOND FLOOR								
C7	0.381	120	3.175	113	3.371	3.273	Direct	Good
C12	0.178	65	2.740	61	2.940	2.840	Indirect	MEDIUM
C11	0.178	60	2.960	65	2.740	2.850	Indirect	MEDIUM
C10	0.178	61	2.940	62	2.870	2.905	Indirect	MEDIUM
C9	0.178	74	2.450	69	2.580	2.515	Indirect	MEDIUM
C8	0.381	120	3.175	113	3.392	3.30	Direct	GOOD
C6	0.178	72	2.455	65	2.740	2.597	Indirect	MEDIUM
C4	0.178	65	2.740	61	2.940	2.840	Indirect	MEDIUM
B8	0.178	60	2.960	62	2.870	2.915	Indirect	MEDIUM

The building is essentially a three storied framed structure having columns and beams running in perpendicular directions and is covered by R.C.C. slab. The fire has occurred mainly in the Ground floor of the building , so readings obtained from the rebound hammer test in fire affected portion of the building are not satisfactory as compared with Readings obtained from the rebound hammer test on second floor of the building are satisfactory as the concrete used in building is of M25 grade.

Based on the UPV values, the members may be classified as:

a) Unaffected - members with hair cracks and UPV values greater than 3.5 km/sec
b) Moderately affected- members with wide cracks and UPV values between 2.5 and 3.5km/s
c) Fairly affected - members with major cracks, spalling of concrete, and UPV values
Below 2.5 km/sec
d) Severely affected - major cracks, spalling of concrete, exposure and de-bonding of Reinforcement and finally the load carrying capacity can be calculated based on the Parameters evaluated using the various test results.

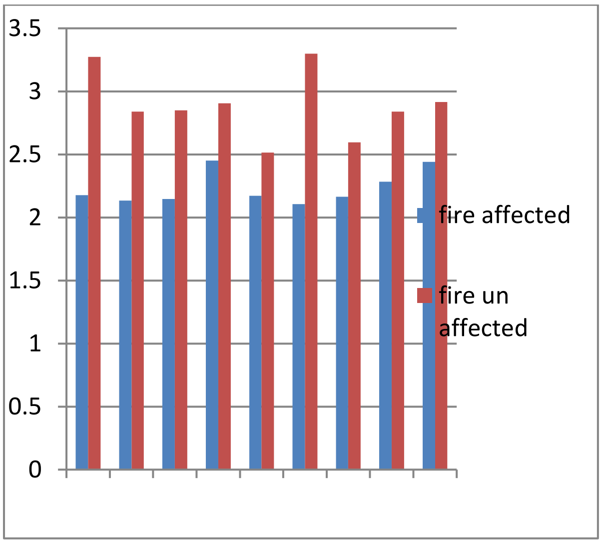

Fig: 3 Graph between pulse velocity (km/s) and Quality of concrete for fire affected and un-affected.

VI. CONCLUSION AND FUTURE SCOPE

1. The duration of fire in the room is of one hour and the estimated temperature is of the order of 300-500ºC.
2. The Ground Floor of the building is majorly affected by the fire and heat. Because of high temperature, the concrete cover is spalling out of the main members.
3. Rebound hammer shows higher compressive strength in fire un –affected portions than of fire affected portions.
4. The effect of fire is clearly observed in UPV values i.e., the UPV readings of Un – affected portion is higher than the affected portion.
5. The Core was also extracted from one of the front columns up to 250mm depth, which shows the concrete is affected up to the cover level.
6. The pH of concrete is decreased to 9 at Ground floor.

VII. RECOMMENDATIONS

1. By using these results we can modify the properties of hospital buildings.
2. To increase the compressive strength of fire affected buildings Concrete Jacketing has been used to increase the capacity of existing structures by placing cage around the beams and columns
3. Grouting technique can be used on inclined and vertical cracks on walls, columns and beams.
4. Epoxies and Epoxy Systems including Epoxy Concretes are used as repairing materials.
5. Keim mineral paints preferred to protect from carbonation.

VIII. REFERENCES

[1] Adam Levesque et al [2019] "effect of fire on structures due to the Boko Haram insurgency in Maiduguri, Northern Nigeria" American journal of civil Engineering and Architecture .2019,Vol 7 10.12691/ajcea-7-1-1.

[2] Kumavat H.R. et al. [2014] "The concrete evaluation is necessary for the proper diagnosis of successful rehabilitation work" International Journal of Research in Engineering and Technology EISSN: 2319-1163.

[3] Said M. Allam, Hazem M.F and Elbakry Alaa G. Rabeai [2013] "behavior of reinforced concrete slabs under fire loading has been studied by researchers for many decades" International Journal for Innovative Research in Science & Technology| ISSN (online): 2349-6010.

[4] F Ali, A Nadjai, A Abu-Tair [2011] "explosive spalling of normal strength reinforced concrete slabs subjected to conventional fire" F Ali, A Nadjai, A Abu-Tair - Materials and structures.

[5] Mohammad Reza Hamadan et al.(2009) "Rebound hammer test and UPV on specimen and existing structure and got compressive strength of concrete and comparison along with actual compressive strength which is obtain from compressive testing machine." " International Journal of Research in Engineering and Technology.

[6] Ian A.FLETCHER, Stephen WELCH, José L. TORERO, Richard O. CARVEL, Asif USMANI [2007] "steel during a fire is understood to a higher degree than the performance of concrete, and the strength of steel at a given temperature can be predicted with reasonable confidence" Directory of Open Access Journals , pp. 37-52(16).

[7] M.Z. Mohamed Firdows, A. Chellapan, J. Prabhakar and P. Srinivasan[2005],"assessing the quality of in-situ concrete in the turbo generator foundation using UPV measurements", The Indian concrete journal, Feb 2005.

[8] N.R. Short U, J.A. Purkiss, et al [2001] "Assessment of fire damaged concrete structures usually starts with visual observation of color change, cracking and spalling." Magazine of Concrete Research, Volume 54

[9] J.K Chege, "NDT Application in Structural Integrity Evaluation of Bomb Blast Affected Buildings", 15th WCNDT-Roma, Apr 2000.

[10] IS 13311: 1992 (Part 1), "Indian Standard Non-Destructive testing of Concrete-Methods of Test", Part 1-Ultrasonic Pulse Velocity.

[11] IS 13311: 1992 (Part 2), "Indian Standard Non-Destructive testing of Concrete-Methods of Test", Part 2-Rebound Hammer

[12] BS 6089: 1981, Guide to Assessment of concrete strength in existing structures.

[13] BS 1881 Part 201:1986, British Standard Testing Concrete, Part 201-Guide to the use of Non-Destructive Methods of Test for Hardened Concrete.

[14] BS 1881 Part 202:1986, British Standard Testing Concrete, Part 202 Recommendations for Surface Hardness Testing by Rebound Hammer.