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BEHAVIOUR OF CONCRETE WHEN EXPOSED TO FIRE AND RETROFITTING

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ABSTRACT

Behaviour of concrete structures in fire relies upon several elements. These consist of change of material property because of fire, temperature distribution in the elements of the buildings, details of reinforcement, severity of exposure and duration. This document discusses the outcomes of increased temperatures on a some of the steel and concrete.

The goal of this is to provide a top level view of results at improved temperature of the behaviour of concrete elements and systems. The main goal of this research work is to summarize the properties of concrete at rising temperature. The properties of conventional concrete and the properties of high strength concrete subjected to elevated temperature are compared.

Fire reaction of concrete structural participants is depending on the thermal, mechanical, and deformation properties of concrete. These properties vary drastically with temperature and additionally rely on the composition and characteristics of concrete batch mix in addition to heating rate and different environmental situations. The variation of thermal, mechanical, deformation, and spalling residences with temperature are defined.

Key Words : *Concrete Behaviour, Fire, Retrofitting. Thermal Properties, Mechanical properties, Deformation.*

1. INTRODUCTION

The effects of the assorted changes happening in heated concrete area unit the alterations of its physical, thermal, and mechanical properties. Analysis has incontestable that changes within the strength of concrete as a operate of temperature area unit associated with, inter alia, concrete composition the sort of mixture used, the water/cement quantitative relation, the presence of pozzolana additives, etc. necessary factors are the speed of heating and therefore the time of concrete exposure to hot temperature.

The rise in temperature leads to water evaporation, calcium hydrate, Calcium silicate Hydrates gel dehydration, and metal aluminates decomposition, etc. beside rise in temperature, variations within the mixture occur. As a result of those changes, concrete strength and modulus of snap bit by bit lowered, and once the temperature reaches 300^{0}C, the lower in strength becomes additional fast. Once the 500^{0}C threshold exceeds, the compressive strength of concrete sometimes lowers by five hundredth to hour, and therefore the concrete is taken into account totally broken.

The microstructure of concrete is that of a material, composed of mixture, cement paste, and also the interface between them. The complexness behind this statement are often appreciated by observant the sequence of micrographs. At some level the behaviour of each material is said to its microstructure. The understanding of those relationships between structure and properties forms the premise of material science. Microstructure encompasses a large vary of structural levels, from the atomic scale there to of the engineering part, and includes all discontinuities within and between phage's, like dislocations, grain boundaries, section interfaces, pores, and cracks.

Many existing structures all round the earth, that don't fulfil the required needs because it was meant to be. These structural losses were attributable to parameters unexpected loading like collision, fatigue, earthquake and rebar damage, etc. To counteract this, differing types of repairing techniques were being applied. Failure of recent designed concrete materials in several conditions like deterioration of members,ground motions attributable to ageing are reinforced and restored using recent innovations of FRP. The strengthening and repair of Ferro concrete columns, slabs, beam and beam-column joints in construction engineering applications had been hyperbolic for twenty years. Concrete elements parts exist in bridges and buildings in several types. Differing types of repairing techniques were disbursed in previous researches. Structural failure of buildings by natural calamities is becoming a major issue hence retrofitting technique place a major role. Strengthening of reinforcement in concrete can be achieved by retrofitting technique

2.MATERIALS

1. Cement: Birla A1
2. Mineral additive: GGBS
3. Coarse aggregates: 20mm crushed aggregates
4. Fine aggregates: M sand
5. Water: Portable
6. Admixture: Super plasticizer.

3.MIX PROPORTION

Cement = 330.15 kg/m^3.
Water = 132.06 kg/m^3.
Fine aggregate = 747.916 kg/m^3.
Coarse aggregate = 1248.44 kg/m^3.
Water cement ratio = 0.4
Chemical admixture= 2.37 lt/m^3.
Proportion = 1:2.26:3.78.

4.CASTING OF CUBES

Cubes were casted with M40 grade concrete as per above mentioned mix design.
These cubes were casted with various percentages of cement and GGBS in 150mm X 150mm X 150 mm mould size and cured for 7 days, 14 days & 28 days and tested accordingly and values are noted down.
Cubes Samples:
Concrete mix 1 – 100% Cement
Concrete mix 2 - 80% Cement & 20% GGBS
Concrete mix 3 – 65% Cement & 35% GGBS
Concrete mix 4 – 50% Cement & 50% GGBS
Casted beams are tested in “Compressive test machine” at 3 days, 7 days & 28 days are reported accordingly.

5.CASTING OF BEAMS

Initially three beams of M40 grade were casted with different percentages of cement and GGBS with a beam size of 1500mm X 200mm X 300mm.
wooden shuttering is used to cast the beams of required size of 1500mm X 200mm X 300mm with 25mm clear cover box used for clear cover.
Beam sample:
Concrete mix 1 – 100% Cement
Concrete mix 2 – 80% Cement & 20% GGBS
Concrete mix 3 – 65% Cement & 35% GGBS

6.CASTING OF SLABS:

Slab of a M40 grade concrete casted at a slab size of 1300mm X 900mm X 150mm. 8mm distribution bar and 8mm main bars are used at 150mm spacing for reinforcement of slabs. 30mm clear cover are provided.

7.SPALLING OF CONCRETE

A high pore pressure would possibly result in failure as a result of explosive spalling. This air mass typically builds up in concrete mixes with low porosity, since the discharge of vapour is tiny.
The scope of application of the hydrothermal model is thus restricted to terribly “dense” concrete mixes with low porosity like high (HPC) and ultra-high performance concrete (UHPC) mixes. Normal performance concrete (OPC) typically resists fast heating

rates with solely minor spalling or perhaps while not spalling. For these styles of concrete pore pressure are smaller amount necessary and alternative mechanisms resulting in spalling become additional relevant.

This ends up in a second limitation of the analytical model on spalling. The given hydrothermal model solely covers failure as a result of high pore pressure. further stresses caused by warmth gradients or external masses don't seem to be nevertheless enclosed within the model, although these stresses square measure familiar to extend the chance of explosive spalling .

In addition to neglecting thermal and load-induced stresses, the overall application of the model is more restricted to the primary incidence of spalling. Explosive spalling typically causes severe cracking inside the concrete's structure. Cracks have a big influence on consecutive spalling of the structure since they may unleash high pore pressure. Additionally, deeper concrete sections square measure directly exposed to the warmth once spalling.

8.RETROFITTING

Retrofitting is the technique used to re-strengthen the concrete members which are damaged or failed.

There are many methods of retrofitting among them which we used for this process are as follows,

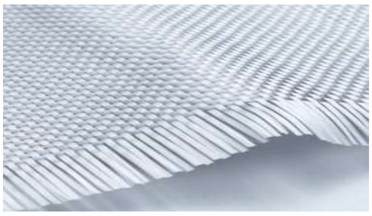
1.CFRP (Carbon fibre reinforced polymer),

2. GFRP (Glass fibre reinforced polymer) and

3.BFRP (Basalt fibre reinforced polymer).

Material 1: CFRP (Carbon fibre reinforced polymer):

Material 2: GFRP (Glass fibre reinforced polymer)



Materials 3: BFRP (Basalt fibre reinforced polymer).

9.RESIN& HARDENER

The process and technique of strengthening of concrete structures using fibre reinforced polymer mainly depends upon two materials i.e. Resin and Hardener. There are numerous types of resin and hardener available in market wide range of mechanical properties. The materials which we used are mentioned below:

a) Resin: Araldite LY 556 and

b) Hardener: HY 951.

10.METHODOLOGY OF RETROFITTING

Three types of retrofitting materials namely Carbon fibre reinforced polymer, Glass fibre reinforced polymer and Basalt fibre reinforced polymer are used. Jacketing method of retrofitting is adopted in this technique. Each retrofitting material is wrapped to each beams in order restrengthing concrete structures.

Resin and hardener plays very major role in strengthening of concrete structures and there is a need of proper mixing of resin and hardener in a proper ratio in order to firmly attachment of retrofitting materials to concrete structures.

Resin and Hardener are blended in the ratio of 1:10 and little amount of cement as added as accelerator to make a paste. This prepared paste is incorporated into the crack developed in concrete structures and then with a help of paint brush prepared paste is applied to concrete structures and immediately retrofitting material is wrapped around the paste applied concrete structures before it get dry.

Minimum 24 hours left after retrofitting material is applied to concrete structure before testing it. We need to make sure that concrete structure with retrofitting material should not come in contact with water so proper covering is done to protect it from rain or water.

After 24 hours concrete structures are tested in three point loading frame and test results are compared with normal concrete structures tested results.

XI.TEST AND RESULTS

Table No 1: Cube test results

M40 Grade of compressive strength in KN/m2					
SL.NO	Age	100%	80%+20%	65%+35%	65%+35%
1	3days	35	32.13	31.02	27.24
2		33.91	31.91	30.75	26.31
3		31.95	33.06	29.82	27.02
AVG		33.62	32.36	30.53	26.85
M40 Grade of compressive strength in KN/m2					
1	7days	39.2	40.88	38.8	36.53
2		37.11	41.2	42	35.46
3		38.48	40.44	41.2	34.84
AVG		38.26	40.84	40.66	35.61
M40 Grade of compressive strength in KN/m2					
1	28days	53.42	53.11	49.77	49.28
2		55.82	52.75	50.08	48.08
3		50	53.55	49.33	46.93
AVG		53.08	53.16	49.72	48.09

Table No 2:Beam test results before exposed to fire:

Flexural strength results				
Sl.no	Grade	Properties	Load in T	Load in kn/m2
1	M40	100%	27	22.41
2		80%+20%	30	24.91
3		65%+35%	26	21.58

Table No 3: Beam test results after exposed to fire:

Flexural strength results				
Sl.no	Grade	Properties	Load in T	Load in kn/m2
1	M40	100%	18	14.94
2		80%+20%	22	18.26
3		65%+35%	16	13.28

Table No 4: Beam test results after retrofitting:

Flexural strength results				
Sl.no	Grade	Properties	Load in T	Load in kn/m2
1	M40	100%	21	17.43
2		80%+20%	24	19.92
3		65%+35%	18	14.94

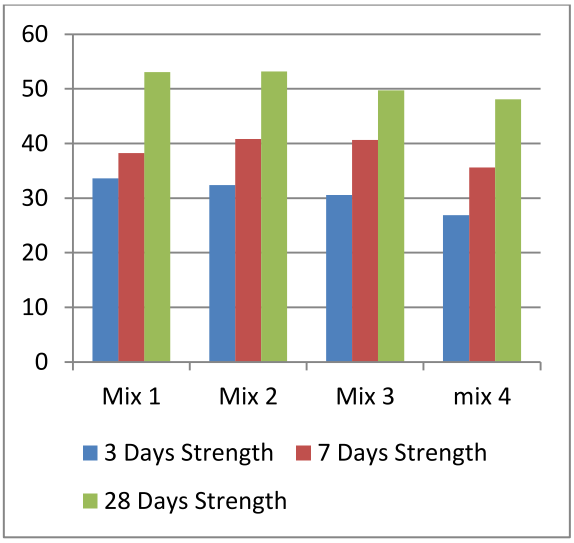
Table No 5: Slab strength results before exposed to fire:

Flexural strength result				
Sl.no	Grade	Properties	Load in T	Load in kn/m2
1	M40	65%+35%	25	20.75

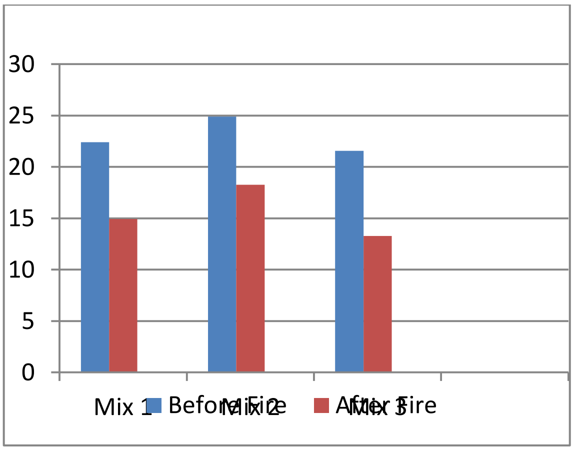
Table No 6: Slab strength results after exposed to fire:

Flexural strength result				
Sl.no	Grade	Properties	Load in T	Load in kn/m2
1	M40	65%+35%	22.5	18.68

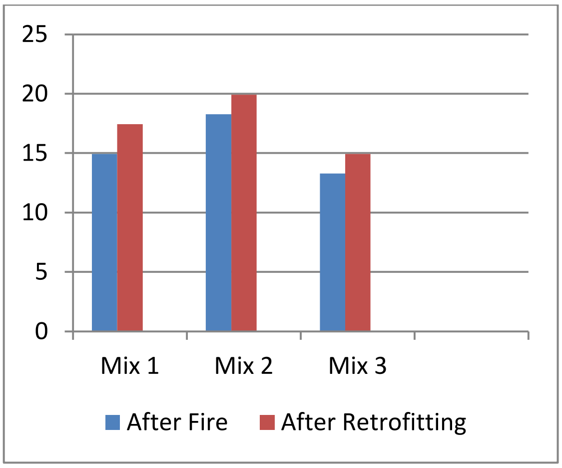
12. .GRAPHICAL REPRESENTATION



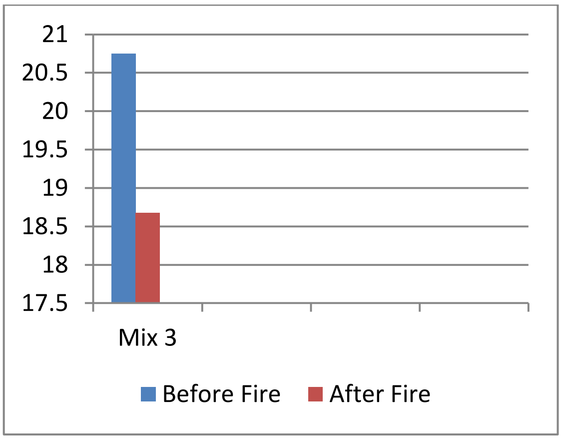
Graph No 1: Comparison of compressive strength cured for 3days, 7 days & 28 days:



Graph No 2: Comparison of flexural strength of beams before and after exposing to fire.



Graph No 3: Comparison of flexural strength of beam after exposed to fire & retrofitting:



Graph No 4: Comparison of flexural strength of slab before & after exposed to fire.

13. .CONCLUSION

Following conclusion can be made based on this project.

- Mixes considered in the current project work satisfied IS 10262:2009.
- It was achieved greater strength in cubes and beams then target strength.
- CUBES:
- Concrete mix 1 achieved maximum strength compared to other all three mixes at the curing period of 3 days, 7 days and 28 days.
- Comparing to mix 2, mix 3 and mix 4, concrete of mix 2 has achieved maximum strength near to mix 1. Hence cement can be replaced by 20% GGBS is economical and durable.
- Curing period of 28 days has achieved more strength in all the four mixes hence curing period of 28 days has to be considered for concrete structures in order to gain maximum strength.
- Concrete structures exposed to fire lose its strength as temperature rises by evaporation of internal water bound with concrete ingredients and by process of spalling.
- BEAMS:
- 3 mixes of concrete is prepared for casting of beams among which mix 2 of 80% cement & 20% GGBS achieved more strength compared to others.
- 33% strength was decreased in mix 1 after exposed to fire.
- 26% strength was decreased in mix 2 after exposed to fire.
    - 38% strength was decreased in mix 3 after exposed to fire.
- Hence concrete structures exposing to fire should be avoided in order to retain the original strength.
- SLABS:
- Mix of 65% cement & 35% GGBS was used to cast for slab.
- 10% strength was decreased in slab after exposed to fire.

- Retrofitting technique is used to re strengthening the damaged or failed concrete structures.
- 16% strength was increased in mix 1 of beam after retrofitting to concrete structures which are exposed to fire.
- 9.09% strength was increased in mix 2 of beam after retrofitting to concrete structures exposed to fire.
- 9.09% strength was increased in mix 3 of beam after retrofitting to concrete structures exposed to fire.

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