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DURABILITY AND FIRE RESISTANCE OF CONCRETE COATED WITH INTUMESCENT PAINT

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Abstract —. The ability of structure to retain structural integrity in adverse condition of whether a fire outbreak depends upon its durability and fire resistance this research work there in tumescent fire resistant coating and fire resistant material using the same disclosed coating essentially including a) UGAMCOAT Re-retardant b) UGAMCOAT Primer C) UGAMCOAT Top coat clear to asks its usability structural concrete and fire resistance. One of the most important factors in concrete structures is the stability of the structure against external forces such as earthquakes, wind loads, fires and etc. The In tumescent paint is externally bonded to the concrete surfaces to enhance the performance of the concrete structures. Several studies were conducted to investigate the compressive strength and fire resistance of the concrete. When they are exposed to harsh environmental factors such as elevated temperature, freeze-thaw cycles, high humidity and etc. However, there are many studies which cover and study the effects of the extreme conditions at concretes coated with In tumescent paint which could help the future to avoid fatal results such as structures failures. The main goal of this paper is to collect information about durability and fire resistance of concretes coated with In tumescent paint

Keywords - UGAMCOAT Re-retardant, UGAMCOAT Primer, UGAMCOAT Top coat .

I. INTRODUCTION

Fire safety of buildings structures is becoming increasingly important in recent years throughout the world. Structural members should be signed to achieve the specific fire resistance rating according to codes or standard. Fire is one of the major hazards which may occur due to natural or man-made causes. In general, fires may be classified into five categories depending on the fuel that is burning. In recent times, there is an increase in incidences of fires in urban population due to very densely populated areas. The losses associated due to fires can be classified as loss to the life of structure, loss of human life and loss to property. It was observed that many options are available which help in early detection of fire and minimizing the losses. Smoke detectors and fire fighting equipments were studied for a public building i.e. an educational institution. Analysis of fire loads of different compartments and providing sufficient number of fire fighting equipments can help in reducing the severity of fires.

Fire proof coating including non reactive type(e.g. sprays, cement mortar) and reactive type(e.g. thin film in tumescent fire coating).The reactive fire proof coating , such as the intumescent fire coating (IFC), is composed of constituents including resin, dehydrating catalyze, carbonizing agent, vesicant fillers and additives. In tumescent coating have advantages such as light weight, high performance, simple construction, aesthetic appearance, easy to maintenance, etc. Chemical reaction occurs when IFC is heated, and large amount of heat is absorbed by the smoke and fume produced in

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the chemical reaction. Meanwhile, the in tumescent material would be charred, significantly well and gradually change to a thick fluffy foamed layer which has relatively low heat conductivity.

Durability and fire resistance are central to both short and long term structural performance of concrete. The durability of concrete a measure of its ability to weathering and deteriorating agents; maintain its original form be serviceable and environmentally compatible. The major properties of concrete affecting its dimensional stability with time include shrinkage, characterized by volume changes in concrete due to loss of moisture at different stages and for various reasons.

Fire resistance of concrete is measured by the load carrying capacity of concrete under elevated temperatures, resistance to flame penetration to heat transmission. Fire generally induces high temperature gradients on materials and, as a resultant hot surface layers tend to separate and spall from the cool interior of the body.

The use of fire retardant coating is one of the easiest, one of the oldest and one of the most efficient ways to protect materials against fire. In tumescent paints are away to achieve such protection. Fire retardant coating, acting by the phenomenon of intumescence, form on heating an expanded multi-cellular layer. It prevents heat from spreading as a consequence, this isolative barrier makes in tumescent coating particularly suitable for the protection of structural work.

Although fire safety standards are written with this express purpose, it is understandably the safety of people that assumes the greater importance. Appropriate design and choice of materials is crucial in ensuring fire safe construction. Codes and regulations on fire safety are updated continually, usually as a result of research and development.

II. MATERIALS USED

- Fine aggregate
- Coarse aggregate
- In tumescent coating
- Re-retardant coat
- Top coat
- Primer

FINE AGGREGATE:

Fine aggregate should consist of natural sand or crushed stone sand. It should be hard, durable and clean and be free from organic matter. Fine aggregate should not contain any appreciable amount of clay balls and harmful impurities such as alkalis, salts, coal, delayed vegetation. The silt content should not exceed 4%.

COARSE AGGREGATE:

Coarse aggregate are a broad category particulate inert materials used in construction. Hard stones are crushed to the required size and are used as coarse aggregate. The material that is retained on as IS Sieve of size 4.75 mm is called coarse aggregate. The coarse aggregates are tested before the concrete mixing. The test such as specific gravity and fineness modulus. The sizes of coarse aggregates are 7mm,14mm,20mm. The aggregates are taken as 77% of mass of concrete in the preparation of 65:35

INTUMESCENT COATING:

In tumescent paint, Fireproofing, and Fire stopping, In tumescent coatings, often referred to as In tumescent paint, are used in buildings as a passive fire resistance measure. They can be applied to structural members as an aesthetically pleasing fireproofing produc

The intumescent coating reacts under the influence of heat by swelling in a controlled manner to many times its original thickness and typically producing a layer of carbonaceous char or foam, which acts as an insulating layer for the substrate.

RE-RETARDANT COAT:

The formation of char forms the layer of carbon, thereby preventing. Further burning or forming a non-heat transferable curtain.Thisin turn also reduces chances of firedue to heat transfer or induction. Conversion of volatile matters to non ignitable gasses such as water vapor, carbon-di-oxide,etc.Thereby not allowing the combustible materials in nearby area tocatch the fire. This uniquetendency stops the fire to spread in surrounding areas of the substrate over which the paint isapplied.

Fig:1 Re-retardant coat

Properties of Re-retardant coat:

1.	Color	off white/ special shades can be manufactured.
2.	Curing	
	Surface dry	6omin
	Hard dry	8 hrs
	Free dry	48 hrs
3.	Non-volatile	min 55%
4.	Water/ acid	No effect in mild application.
5.	Fire rating	2 hrs

TOP COAT

Active type of in tumescent fire retardant topcoat. This is applied over intumescent solvent base coating and in any desiredshade. Top coat is must in humid conditions and to prevent losses of fire retardant properties of intumescent coatings.It is top coating but is also activetype fire retardant.
This comes in contact with fire first and starts releasing carbon dioxide and water molecules toblock small fires. But when temperature crosses 200degrees C, intumescent coating comes in to action andforms foam. It is halogen free too.

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Fig:2 Top coat

Properties of Top coat:

1.	Color	off white
2.	Non-volatile	min 65%
3.	Curing Surface dry Hard dry Free dry	 3 hrs 8 hrs 24 hrs
4.	Flexibility and adhesion	No visible damage or detachment of the film.
5.	Scratch hardness	No such scratch as to show as bare surface.

4.1.6 PRIMER COAT

It is specially prepared for getting the resistant properties in concrete. Generally cement concrete are not flammable but when there is fire on one side, the temperature is conducted or radiated though the concrete and when the temperature rises 200 degree C on other side, the products like paper gets self ignited. To prevent such heat transfer, these types of in tumescent coating are used.

Fig:3 primer coat

Properties of primer coat

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1.	Color	off white
2.	Curing	
	Surface dry	120min
	Hard dry	4 hrs
	Free dry	24 hrs
3.	Non-volatile	min 45%
4.	Scratch hardness	No such scratch as to show the bare surface
5.	Flexibility and adhesion	No visible damage or detachment of film.

III. Mix Design for M25 grade

Cement = 419kg/m^3
Water = 197 l/m^3
Fine aggregate = 656 kg/m^3
Coarse aggregate (20mm) = 1127kg/m^3
Density of concrete = 2400 kg/m^3
Water-cement ratio = 0.47

IV. Casting and testing of cubes

After the curing, the harden concrete is test in electrical furnace and then find compressive strength of concrete

Electrical furnace test

An electric furnace was used to heat the specimen. The maximum attained temperature in this furnace was 250°. Initially the furnace was heated to the required temperature and when the required temperature was attained the specimens were put inside with the door closing tightly so that no air could enter. Each time the cubes were kept at various temperatures and the same procedure was repeated for 1 & 2 hrs time duration. After the specified time duration, the cubes were taken out and air cooled at room temperature for 24 hours.

Fig:4 Electric furnace

Compression strength test

Compression strength test is the most test conducted on hardened concrete, because it is easy to test and desirable characteristic properties of concrete are measured.

The cube specimen is of the size (150mmx150mmx150mm) isused for testing. The compressive strength test of concrete is done by using compressive testing machine. The specimen is placed in compression testing machine in such a way that load applied gradually in cast surface. The load at failure has been noted.

Compressive strength=(Failure load/Cross sectional area (N/mm^2)

Fig.5 Compressive testing machine

V. RESULT AND DISCUSSION

5.1 RESULTS OF ELETRIC FURNACE AND COMPRESSIVE STRENGTH

The test specimen of electric furnace and compressive strength of concrete with various mix combination is determined at 28 days for M 25 grade. The results of compressive strength are given below in table:

5.1.1 Compressive strength for conventional mix (M 25):

For 7, 14 and 28 days, three cubes is tested for conventional mix and compressive strength of conventional mix are given below in the table:5

Table 5 Average compressive strength for conventional mix

S.No	Mix	Average compressive strength(N/mm^2)	
		14 days	28 days
1.	M25	16.25	26.02

5.1.2 Compressive strength test for Re-retardant coat:

For 28 days, three cubes is tested in electric furnace for Re-retardant coat and compressive strength of grade M 25 mix are give below in the table 5.1&5.2.

Table 5.1 Average compressive strength for single coat

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	fck (N/mm^2)	AVERAGE
1.	250	2	650000.00	23.33	27.33
2.	250	2	870000.00	28.67	
3.	250	2	900000.00	30	

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Table 5.2 Average compressive strength for Double coat:

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	fck (N/mm^2)	AVERAGE
1.	250	2	690000.00	25.43	30.15
2.	250	2	770000.00	29.73	
3.	250	2	800000.00	33.21	

5.1.3 Compressive strength test for Top coat:

For 28 days three cubes is tested in electric furnace for Top coat and compressive strength of grade M 25 mix are given below in the table 5.3&5.4

Table 6.3 Average compressive strength for single coat

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	fck (N/mm^2)	AVERAGE
1.	250	2	780000.00	29.11	28.47
2.	250	2	680000.00	24.67	
3.	250	2	770000.00	28.63	

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Table 5.4 Average compressive strength for double coat:

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	fck (N/mm^2)	AVERAGE
1.	250	2	820000.00	28.95	29.02
2.	250	2	750000.00	23.78	
3.	250	2	790000.00	27.55	

5.1.4 Compressive strength test for Primer coat:

For 28 days three cubes is tested in electric furnace for primer coat and compressive strength of grade M 25 mix are given below in the table 6.4& 6.4.1

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Table 5.5Average compressive strength for single coat

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	f_{ck} (N/mm^2)	AVERAGE
1.	250	2	660000.00	25.78	26.44
2.	250	2	870000.00	28.76	
3.	250	2	830000.00	26.89	

Table 5.6 Average compressive strength for double coat

S.NO	TEMERATURE (°C)	HEATING TIME (Hrs)	FAILURE LOAD (N)	f_{ck} (N/mm^2)	AVERAGE
1.	250	2	630000.00	26.32	27.64
2.	250	2	720000.00	27.01	
3.	250	2	780000.00	28.62	

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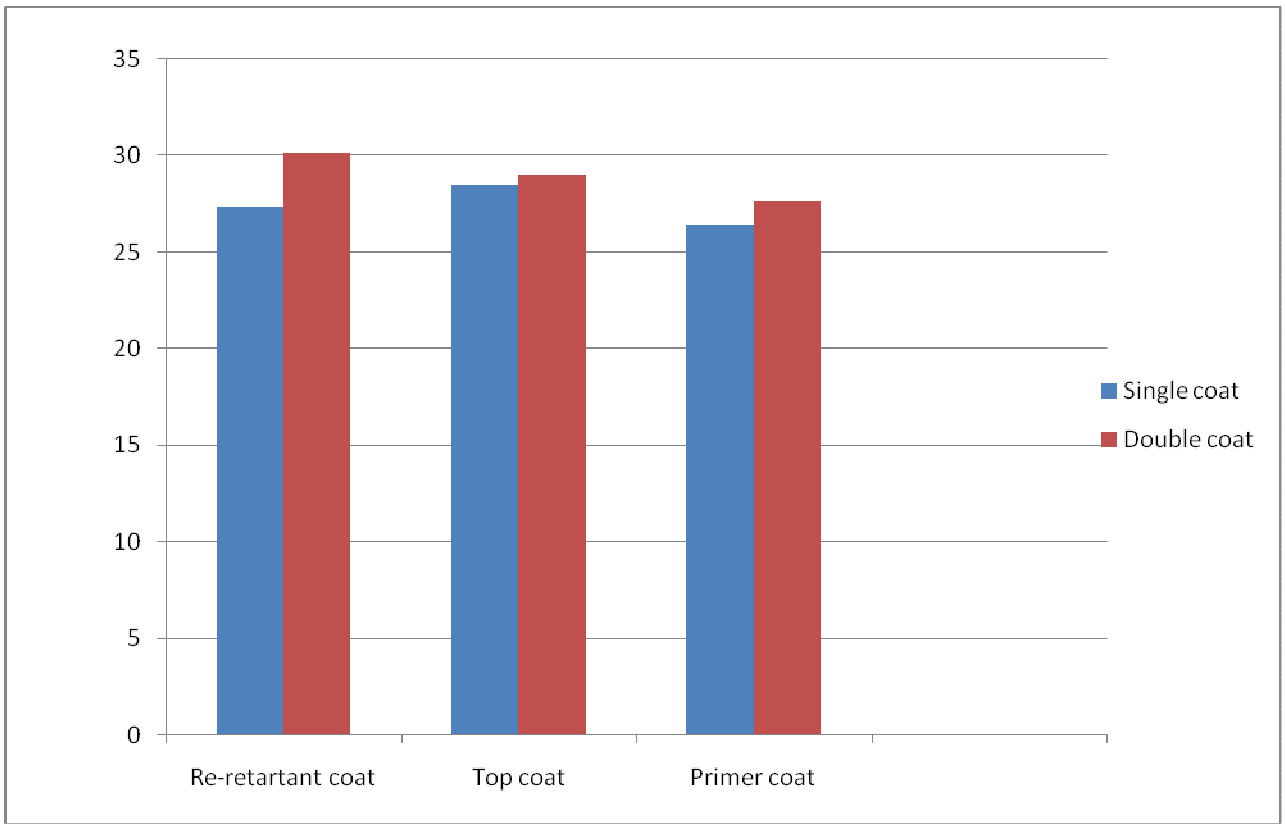

Fig: 6 Bar chart

VI. CONCLUSION

Based on the results & their scrutiny, the following conclusions could be drawn:

1. Concrete is subjected to fire resistance should be experience for different coating and then heating, and maintain cooling. From the view point of the different coat heating rate and high temperature level are the two factors which influence the concrete properties more significantly than other factors.

2. Up to250°C, concrete remains should not affect and appearance the strength.

3. The quality of concrete suffers slightly & strength too comes down. Structure/ structural members remain serviceable although the factor of safety comes down. Affected structure/ structural members will require minor repairs & patchwork to recuperate.

4. Most of the above researches are on the behavior of concrete under high temperature condition rather than fire condition. Since the literature on the behavior of concrete under fire conditions is very limited, the literature even under elevated temperature has to be used as a part of the base of further research. The further research needs urgently to be carried out under the standard fire condition.

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