ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 2, March 2016

EXPERIMENTAL STUDY OF MESH CONFINED CONCRETE SUBJECTED TO HIGH TEMPERATURE

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ABSTRACT

Nowadays fire accidents are happening in most of the buildings which causes heavy damage to the buildings and result in loss of durability. In order to avoid the consequences an experimental investigation is carried out using mesh confinement concrete. Concrete is a non-combustible material and has a slow rate of heat transfer. High temperature can cause the formation of cracks. These cracks resembles like any other cracks propagation may eventually cause loss of structural collapse and shorting of span life. One mighty problem which occurs when concrete is exposed to fire is spalling. This is the phenomenon in which explosion ejection of chunks in concrete from the surface of the material, due to the breakdown in surface tensile strength. In order to reduce early cover spalling, a new idea has been investigated . This is implemented by installing relatively cheap materials such as glass mesh, nylon mesh, GI weld mesh and wire mesh in cylindrical specimens with a length of 300mm and 150mm diameter. It has been understood from the literature to reduce the spalling in concrete and strength can be improved by mesh confinement. Hence an experimental investigation will be done to study the performance of mesh confinement concrete subjected to fire. In this project work the four types of meshes such as glass, wire, nylon and GI weld type were used as confinement materials in the cylinders.

INTRODUCTION

GENERAL

Concrete is a widely used construction material in buildings and several other Structures for a quite long time. Concrete can be defined as a composite binding material having constituents as aggregate, finer sand and fine cement and water in predefined proportion so as to achieve required strength .Concrete is a composite having properties that change with time. Durability of concrete depends on many factors including its physical and chemical properties, the service environment and design life. Plain concrete is strong in compression while weak in tension. The idea of reinforcing concrete with steel bars gave rise to a new composite called Reinforced Concrete which is capable of withstanding both compression and tension simultaneously. Thus reinforced concrete has become the most commonly used construction material.

OBJECTIVE

The objective of the project work is to study the properties of ordinary conventional concrete (OCC) and mesh confinement concrete exposed to temperature and cooled the specimens by quenching method and air-drying method. The study is carried out by experimental approach.

SCOPE OF THE STUDY

The scope of this project work is to resist the spalling of concrete and to reduce the loss of strength under temperature exposure. The spalling of concrete can be reduced by using mesh confinement material in the cylindrical specimens. The mesh confinement will improve the strength and also other mechanical properties. Hence a research program is conducted to study the behavior of mesh confinement concrete under the temperature effect.

PROPERTIES OF MATERIALS USED

GENERAL

This chapter describes about the properties of materials used for the project work.

PORTLAND CEMENT

The cement used for the test specimens is Ordinary Portland Cement (OPC) -53 grade conforming to IS 12269:1987 and the specific gravity of cement is 3.15.

FINE AGGREGATE

Natural river sand is used as fine aggregate for casting the specimens. For concrete specimens, fine aggregate was passing through 4.75mm sieve and had a specific gravity of 2.68 with grading zone II as per Indian Standard Specification
(IS 383:1997) was used.

COARSE AGGREGATE

Coarse aggregate are the crushed stone, which is used for making concrete. The size of coarse aggregate used for casting the specimen is 20mm and the specific gravity of coarse aggregate is 2.72.

WATER

Portable water is used for casting and curing of the specimens as per IS 456:2000.

CONFINEMNT MATERIALS

The meshes were chosen as confinement materials for this project work. Here the four types of meshes such as glass, nylon, wire and GI weld mesh were used and they are shown.

Fig. 1: Glass mesh

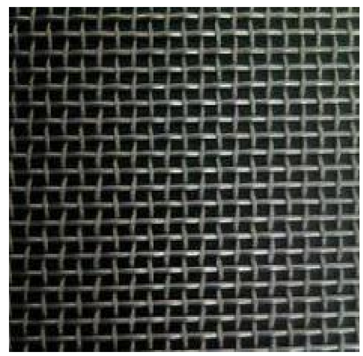

Fig. 2: Wire mesh

Fig. 3: Nylon mesh

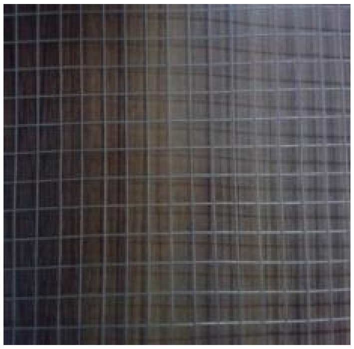

Fig. 4: GI weld mesh

PROPERTIES OF MESH

Table . 1: Properties of mesh

Parameters	**Specifications**			
Type of mesh	Glass type	GI weld type	Nylon type	Wire type
Material	Glass	Steel	Nylon	Steel
Mesh shape	Square	Square	Square	Square
Mesh opening(mm)	2.5 x 2.5	12.7 x 12.7	0.5 x 0.5	0.5 x 0.5
Width(m)	1	1	1	1
Thickness(mm)	1	1	1	1
Diameter of mesh(mm)	0.2	1	0.3	0.3
Density(kg/m^3)	0.160	7850	0.271	7850
Melting temperature	600°C	900°C	160°C	800°C

EXPERIMENTAL PROGRAM

GENERAL

In this study, a NSC of M20 grade was considered. The mix design for the above grade of concrete was done by IS 10262:2009. The mix proportion obtained was 1: 1.51: 2.68: 0.45 (cement: sand: coarse aggregate: water). A total of 45 numbers of NSC confined with mesh cylinders of length 300mm and diameter 150mm were cast. The cylinders have been exposed to a temperature of about 300°C. The loss in compressive strength and the deflection due to load when exposed to higher temperature has been studied. Besides, the loss in weight and mechanical properties of cylinders due to high temperature has also been studied.

CASTING OF SPECIMEN

Steel moulds were used for casting the cylinders. Before casting, machine oil was applied on all the surfaces of moulds. For mesh confinement concrete the meshes were installed in the mould before casting. To prevent the mesh from loosening the mesh was tied with steel wire at a spacing of 100mm through the whole length and the concrete was mixed thoroughly and was poured into the moulds in layers. Each layer of concrete was compacted using a table vibrator. After 24 hours of casting, the specimens were removed from the moulds and cured under water for 28 days. After curing, the cylinders were taken out of the curing tank and air dried for a period of 24 hours in a well-ventilated shed at ambient atmospheric conditions.

OVEN

An oven designed for a maximum temperature of 300°C was used. The oven was heated by means of exposed heating elements laid on the refractory wall of the inside chamber, which was approximately 300 x 300 x 400 mm inside dimension. The test specimens were stacked with sufficient space between two adjacent specimens to obtain a uniform heating in each specimen. The test specimens were heated in batches due to limited capacity of the furnace. Extreme care was taken when handling the heated concrete specimens.

Fig. 5: Oven

Fig. 6: Cylinders in oven @ 320°C

TESTING OF SPECIMEN

Weight Loss

The following procedure was adopted to find the weight loss of the test specimens:

1. After 28 days curing the weight of the test specimens was taken at 1day. Let it be W_1 kg.
2. The test specimens were exposed to the particular temperature. After exposed to the particular temperature, the weight of the test specimens is taken at 1 day. Let it be W_2 (kg.).
3. The weight loss of the test specimens is equal to (W_2 - W_1) kg.

COMPRESSION BEHAVIOUR

For finding the compressive strength and other mechanical properties a universal-testing machine with compressometer or dial gauge with specimen was used.

The under mentioned procedure was followed to test cylinder specimen for compressive strength and other mechanical properties

1. After fire test, the cylindrical specimens were cooled by the above two process. The specimens were allowed to dry for one day.
2. This specimen was fixed with dial-gauge and then placed in 1000kN capacity of Universal Testing Machine (UTM).
3. The load was applied to the upper most surface of the specimen. The axis of the specimen was aligned carefully with the axis of the loading device. The load was applied without shock and increased continuously at a uniform rate 5kN/min until the specimen fails.
4. The deformation is noted at each stage of loading with the help of dial gauge. The maximum load at failure and deformation was noted.

RESULTS AND DISCUSSION

GENERAL

Table. 2: Compressive strength of cylindrical specimens

Type of cylinder	Compressive strength (N/mm²)		
	At room temperature	After 300°C of heat	
		Cooling by air-drying method	Cooling by quenching method
Conventional	21.5	15.27	13.01
Glass mesh	27.45	17.54	16.97
Wire mesh	35.42	26.03	23.54
GI Weld mesh	39.05	37.34	26.04
Nylon mesh	25.47	24.62	16.41

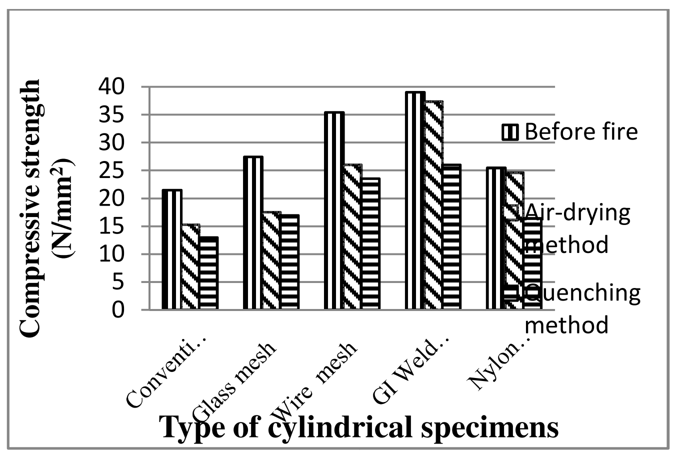

Fig. 7: Compressive strength of specimens

Table . 3: Loss in weight of cylindrical specimens

Type of cylinder	Weight loss after 300°C of heat (kg)	
	Cooling by air-drying method	Cooling by quenching method

Conventional	0.55	0.17
Glass mesh	0.615	0.17
Wire mesh	0.495	0.13
GI weld mesh	0.66	0.105
Nylon mesh	0.675	0.03

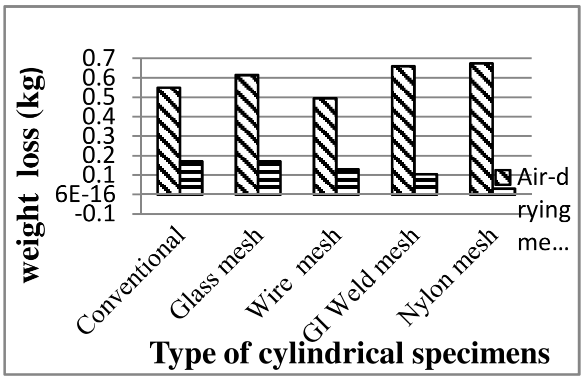

Fig. 8: Weight loss of specimens

Table . 4: Strength loss of cylindrical specimens

Type of cylinder	Strength loss after 300°C of heat (%)	
	Cooling by air-drying method	Cooling by quenching method
Conventional	28.9	39.5
Glass mesh	36.1	38.2
Wire mesh	26.5	33.5
GI weld mesh	4.4	33.3
Nylon mesh	5	2

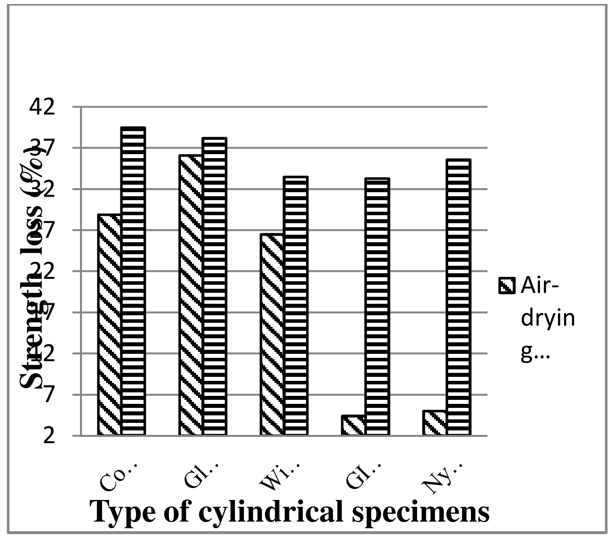

Fig. 9: Strength losses of specimens

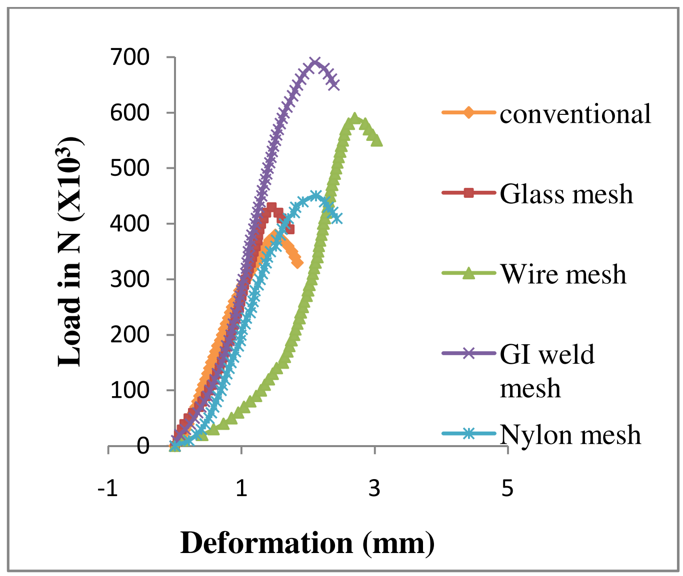

Fig. 10: Load deformation behaviour for cylindrical specimens without fire

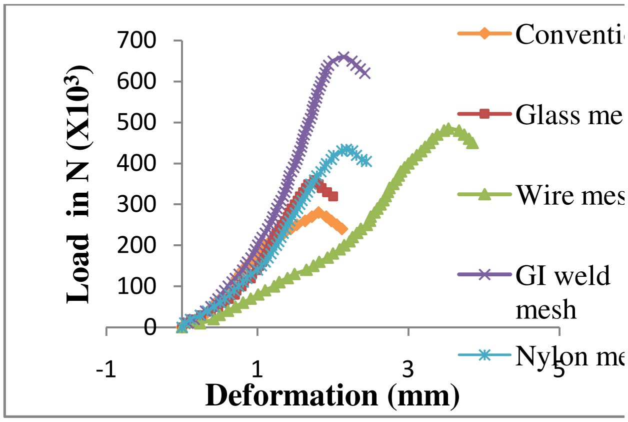

Fig. 11: Load deformaion behaviour for cylindrical specimens with fire by air-drying method

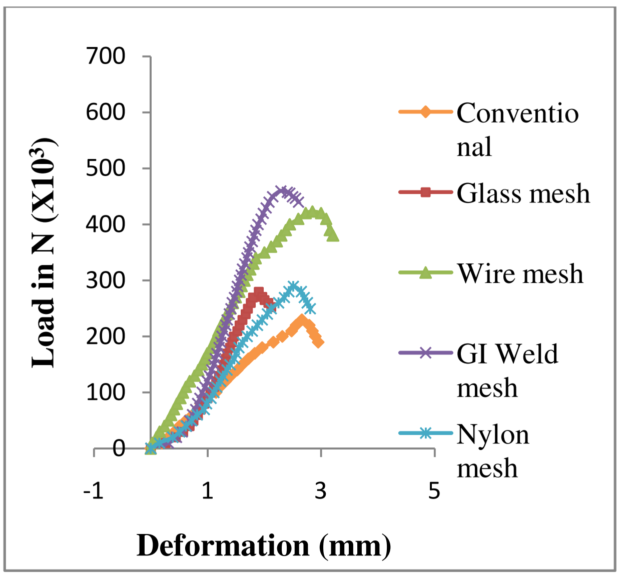

Fig. 12: Load deformation behaviour for cylindrical specimens with fire by quenching method

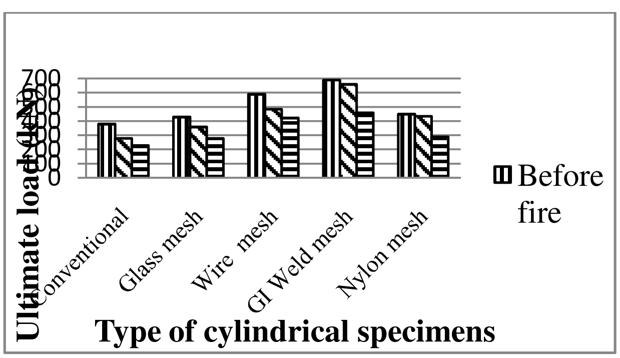

Fig. 13: Ultimate load of specimens

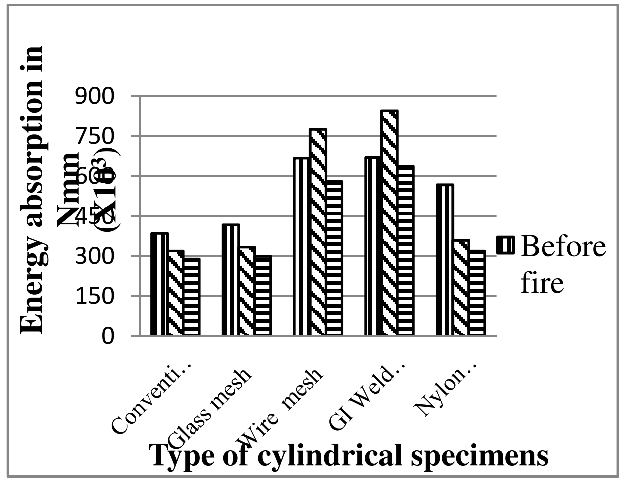

Fig. 14: Energy absorption of specimens

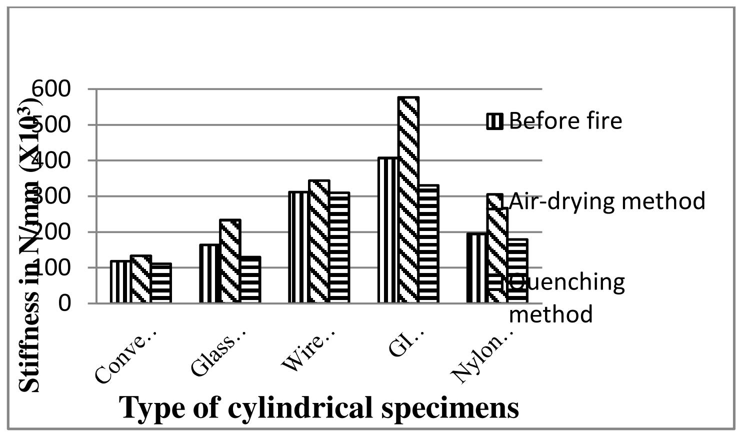

Fig. 15: Stiffness of specimens

DUCTILITY FACTOR

Ductility is the ratio between deflections at ultimate load to that at the onset of yielding. In before fire cases, the ductility factor was found to be increased by 5.83% for glass mesh specimen, 12.62% for wire mesh specimen, 21.36% for GI Weld mesh specimen, 8.74% for nylon mesh specimen as that of conventional specimen.In air-drying method the stiffness was found to be increased by 2.94% for glass mesh specimen, 8.82% for wire mesh specimen, 17.65% for GI Weld mesh specimen, 5.88% for nylon mesh specimen with reference to conventional cylinder specimen. In quenching method the stiffness was found to be increased by 4% for glass mesh specimen, 10% for wire mesh specimen, 14% for GI Weld mesh specimen, 6% for nylon mesh specimen with reference to conventional cylindrical specimen. Therfore the air-drying method has higher ductility factor compared to the quenching method and also the GI weld mesh specimen has higher ductility factor compared to the other mesh specimens. The ductility factor for all cylindrical specimens were illustrated through Figure .

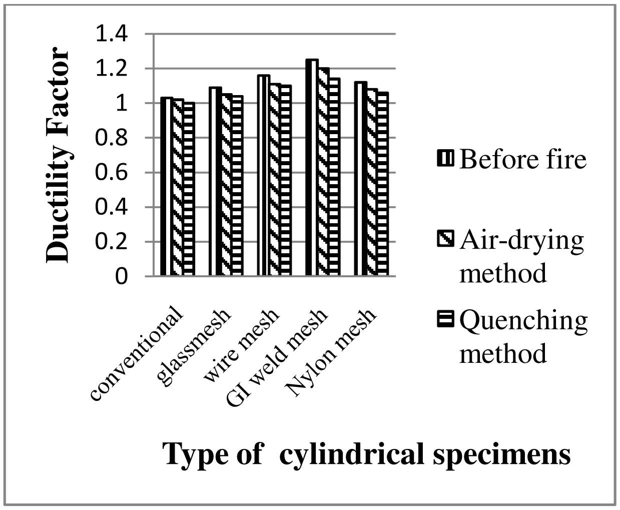

Fig. 16: Ductility factor of specimens

Table . 5: Experimental results of all cylindrical specimens in before fire

Name of the Specimen	**Load carrying capacity (kN)**	**Energy absorption capacity in Nmm ($X10^3$)**	**Stiffness in N/mm ($X10^3$)**	**Ductilty factor**
Conventional	380	383	116.18	1.01
Glass mesh	430	420	162	1.05
Wire mesh	590	665	314	1.13
GI Weld mesh	690	672	404.89	1.3
ylon mesh	450	566	197	1.06

Table . 6: Experimental results of all cylindrical specimens in air-drying method

Name of the Specimen	**Load carrying capacity (kN)**	**Energy absorption capacity in Nmm ($X10^3$)**	**Stiffness in N/mm ($X10^3$)**	**Ductility factor**
Conventional	275	325	135.33	1.05
Glass mesh	354	344	223.33	1.08
Wire mesh	476	756	333.75	1.12
GI Weld mesh	650	836	556.92	1.28
Nylon mesh	435	360	266.67	1.12

Table . 7: Experimental results of all cylindrical specimens in quenching method

Name of the Specimen	**Load carrying capacity (kN)**	**Energy absorption capacity in Nmm ($X10^3$)**	**Stiffness in N/mm ($X10^3$)**	**Ductility factor**
Conventional	230	287	110.54	1.03
Glass mesh	280	304	131	1.07
Wire mesh	423	581	312	1.12
GI Weld mesh	460	635	328.07	1.17
Nylon mesh	290	322	180.26	1.08

BEHAVIOUR OF SPECIMENS

The behavior of cylindrical specimen to temperature exposure was observed for all the specimens tested in this study. It was found that specimens exposed to 300°C temperature developed cracks in nylon mesh specimen and the color of the specimens became light yellow.

TESTED SPECIMENS

General

The tested specimens are illustrated through the Figures. Here the GI Weld mesh specimen gives better results compared to the other specimens.

Glass mesh specimen

Fig. 17: Failure of glass mesh specimen

Wire mesh specimen

Fig. 18: Failure of Wire mesh specimen

GI Weld mesh specimen

Fig. 19: Failure of GI weld mesh specimen

Nylon mesh specimen

Fig. 20: Failure of Nylon mesh specimen

CONCLUSIONS

SALIENT CONCLUSIONS

Based on the investigations, the following conclusions were drawn:

- The compressive strength of GI weld mesh specimen is higher compared to conventional specimen in before and after fire at a temperature of about 320°C.
- The specimens under air drying cooling method has higher load carrying capacity, energy absorption, compressive strength, ductility factor and stiffness compared to quenching cooling method.
- The GI weld mesh specimen has less deformation compared to conventional specimen.
- In air-drying cooling method, the load carrying capacity of GI weld mesh specimen is higher compared to the conventional specimen by the amount of 1.42 times respectively.

SUGGESTIONS FOR FUTURE WORK

This study provided a thorough understanding of the compression behavior of cylindrical specimens. However, it is useful to extend the work for further study to investigate the following points;

- It is recommended that the mesh confinement could be used in structural elements like beam and column.
- Increase the temperature on mesh confinement concrete specimens more than 300°C could be investigated.
- Durability studies could be carried out for mesh confinement concrete specimens.

- Corrosion studies could be carried out for the mesh confinement concrete.

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