Strength Characteristics of Polypropylene Fiber Reinforced Porous Concrete

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Abstract - The experimental work was carried out to know the influence of different aspect ratio (AR) of polypropylene fibers on the strength properties of fiber reinforced porous concrete. A mix proportion of 1:3, water-cement ratio 0.50, AR 400, 800 and 1600, fiber content 0.50%, and a Conplast F-297 synthetic foaming agents are used in this work. The required numbers of specimens were casted and tested for compressive strength, theoretical flexural strength and shear strength using different shear planes and also workability. Based on the obtained results it was concluded that an AR400 gives a better compressive strength and flexural strength when compared to other AR. And also a shear strength is good for the single shear plane of size 150*70 mm for an AR of 400 and it was also observed that the workability of concrete decreases with the increase of AR. Hence, the polypropylene fibers with an aspect ratio of 400 are more suitable the production of fiber reinforced porous concrete.

***Key Words*:** Porous concrete, polypropylene fiber, aspect ratio, foaming agent, compressive strength, flexural strength and shear strength.

1. Introduction

The porous (foamed) concrete is a concrete which contains cement slurry, fine aggregates, water & foaming agent [11, 15,]. The density of the porous concrete is usually lies between 600-1600kg/m^3 [1, 6]. The porous (foamed) concrete was seen used way back in 1920's, as a production of aerated concrete, which is used for insulation [3, 8]. But later in 1950's and in 1960's, the composition, properties and production of porous (foamed) concrete was carried out in a detailed study [2, 6]. Using the above researches the various admixtures were introduced in late 1970's and 1980's for the production of foamed concrete [4, 10]. Finally, the researches and the use of porous (foamed) concrete grown at a rapid in the last 20 years [9, 13]. The first ever application of the porous (foamed) concrete was in Netherland, which was mostly used for void filling and stabilization of ground [5, 14].

The introduction of any fibers into the porous concrete makes it fiber reinforced porous (foamed) concrete [7, 12]. The presence of fibers in the concrete will help in increase of overall performance of the structure; mainly the fibers will reduce the formation of micro cracks formed during the early age of the concrete [1, 9]. In the present dissertation work, manufactured sand and natural sand are used along with the polyproflene fibers of different aspect ratio [4, 8]. The use of coarse aggregates is completely avoided for making the porous (foamed) concrete, lightweight in nature [15]. The density of 1600kg/m^3 is assumed as the cast density after processing various trials using different densities [11].

The present study relates the fiber reinforced porous (foamed) concrete of different aspect ratio to the natural porous concrete containing M-sand as fine aggregates and also relates the porous concrete containing m-sand with natural sand[5,6]. In the current experimental work, the influence of different aspect ratio of the polypropylene fibers on the mechanical properties of the porous concrete are studied at 28days of curing[9,11]. After curing, the hardened concrete is testing for determining the compressive strength, theoretical flexural strength and shear strength of the fiber reinforced porous (foamed) concrete[7,15]. The main objective of the present study is know the influence of different aspect ratios of polyproflene fibers on the strength and workability properties of porous concrete are studied, they are compressive strength, theoretical flexural strength and shear strength for varied dimensions[4,10].

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2. Materials and Methodology

- Cement: The Ordinary Portland Cement of grade 53 confirming to IS: 8112-1989 was used. Test results of 53-Grade OPC are mentioned in Table.No.1
- Fine aggregates: M-sand and River sand belongs to Zone- II, confirming to IS: 383-1970 specification was used and having the fineness modulus of 3.16 and 2.71 respectively. Test results of fine aggregate are mentioned in Table.No.2
- Fibers: Polypropylene fibers of various aspect ratios such as 400 800 and 1600 were used and added 0.50% by weight of cement. Properties of Polypropylene fibers are mentioned in Table.No.3
- Foaming Agent: A synthetic foaming agent naming Conplast F-297 was used for the production of foam. Properties of Conplast F-297 are mentioned in Table.No.4**.**
  Foam was produced by adding 17ml of Conplast F-297 to 1lt of water and was mixed thoroughly with the help of mechanical stirrer until dense foam is formed.
- Water: Ordinary potable water free from organic content, turbidity and salts was used for mixing and for curing throughout the work.
- Mix proportion: A mix proportion of 1:3 one part of cement and three parts of sand were used with a water cement ratio of 0.50.

Table.1: Test results of 53-Grade OPC

Properties	Fineness	Normal consistency	Specific gravity	Initial setting time	Final setting time
Results	30 m^2/N	35%	3.15	130 Min	270 Min

Table.2: Test results of fine aggregates

Properties	River sand	M-sand
Specific Gravity	2.6	2.83
Fineness Modulus	2.71	3.16
Gradation	Zone II	Zone II
Water absorption	1.48%	1.20%
Bulk density	1460 Kg/m3	1597 Kg/m3

Table.3: The physical properties of Polypropylene fibers

Properties	Specific gravity	Tensile strength	Modulus of elasticity	Diameter	Melting point	Water absorption	Aspect ratio
Results	0.91	660 Mpa	4 Gpa	15 μ	165°C	Negligible	400-2000

Source: Kalyani Polymers PVT LTD supplier.

Table. 4: The physical properties of Conplast F-297

Specific gravity	Appearance	Typical dosage in litters
1.10 at 20°C	Clear liquid	0.6 -2

Source: Fosroc chemical India PVT LTD supplier.

3. Experimental procedure

In this experiment concrete was produced for the proportion 1:3 that is one part of cement and three parts of sand, for a w/c ratio of 0.50, polypropylene fibres of 0.5% by weight of cement was added along with 17ml of foaming agent was used for the mix. The required numbers of specimens were casted without (ref.mix) and with fibres for different aspect ratios of fibres such as 400, 800, 1600 using natural and manufactured sand and cured for 28 days.

3.1. Casting of Concrete Specimens

The ingredients such as cement, sand and polypropylene fibres are weighed and subjected to mix with water. Dense foam is separately produced by mechanical process with 1 litre of water and dense foam is added to the wet mix and mixing is continued till mortar attends homogeneity. Moulds are lubricated with oil before poring the mortar and three specimens of each variation are casted and after 24 hours of casting, the specimens are demoulded and kept for 28 days of curing and varies tests are carried out to know the strength and durability properties.

3.2 Testing of concrete specimens

3.2.1 Workability test

The workability test is conducted to determine the ease with which the concrete can be worked. In the present study, flow table test is conducted to know the workability of fiber reinforced porous concrete as it is self compacting and hence slump test cannot be carried out. The flow table consists of the flat metal plate or table and a cylindrical cone or mould. The flat metal plate as dimensions of 700*700 mm and mould as a 200mm bottom diameter, 130mm diameter at top and height of 200mm. Before testing, the surface of mould and table should be cleaned from foreign particles and should be placed 0n the flat surface. The c0ne should be placed at the centre of the table and the prepared concrete is poured in to it. After filling it should be allowed to settle for 2-3seconds. Then the mould is raised slowly in vertical direction till the entire concrete flows out of it and is allow to flow for 30seconds. Then the diameter of the flow along in 2 directions is measured along with the table. Finally calculate the mean of both diameters as the flow in millimeter.

3.2.2 Compressive strength test

The compressive strength test was conducted as per the IS 516:1959 code specification.

Compressive strength = f_{ck} = P/A

Where,

f_{ck} = 28days Compressive strength of concrete in MPa.

P = Load at the failure of specimen.

A = Cross sectional load applied area of the specimen.

3.2.3 Theoretical flexural strength test

The flexural strength of the porous (foamed) concrete is determined by theoretical method as mentioned in IS code 456:2000 specification. The theoretical flexural strength is calculated by using a relation as mentioned below,

Flexural strength = 0.70 * $\sqrt{f_{ck}}$ …………….. in MPa

Where f_{ck} = concrete compressive strength at 28days

3.2.4 Shear strength test

The shear strength test conducted as proposed by Bairagi and Modhera to find the shear strength of concrete. The various Shear planes are considered as proposed by M K Moroliya are used. The various shear planes used are 150*80 mm, 150*70 mm and 150*60 mm. The various shear planes considered are mentioned below in Fig.1 to 4

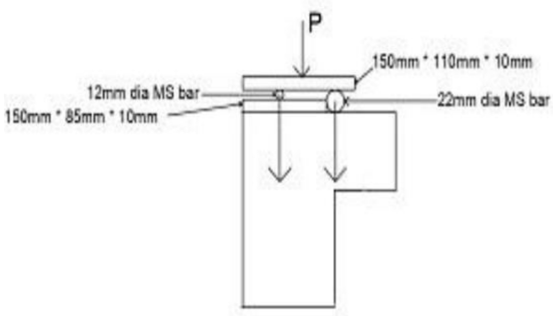

Figure.1: Shear strength test setup

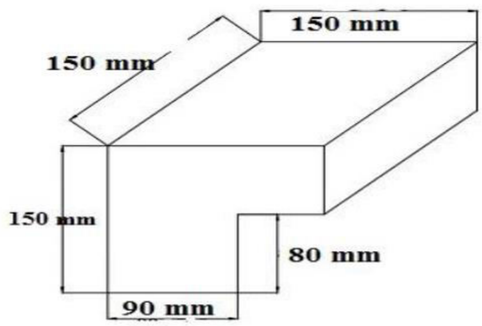

Figure.2: Shear plane 150*70 mm

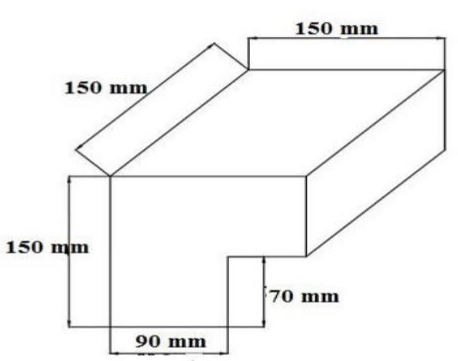

Figure.3: Shear plane 150*80 mm

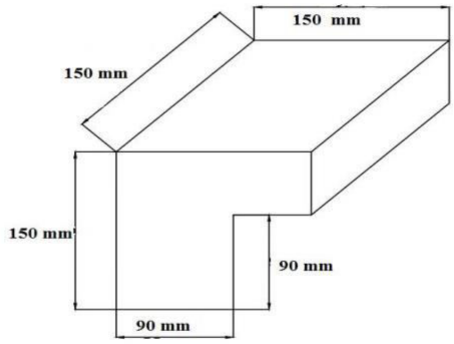

Figure.4: Shear plane 150*60 mm

4. Experimental results:

The experimental results are depicted in the form of graph shown in Fig.4 to.10

Fig.5 and Fig.6 shows the effect of addition of different aspect ratio of polypropylene fibre on compressive strength and theoretical flexural strength of PFRPC

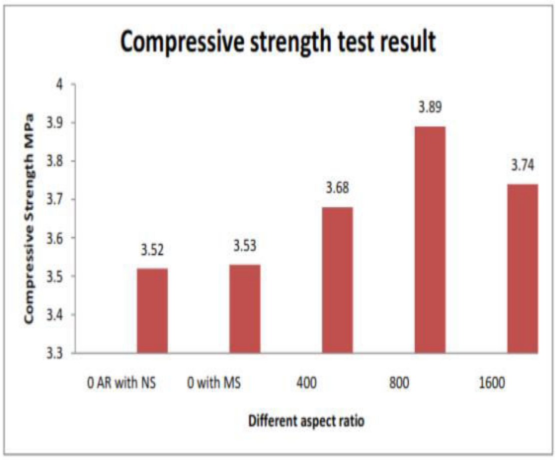

Figure.5: The variation of 28days compressive strength test results

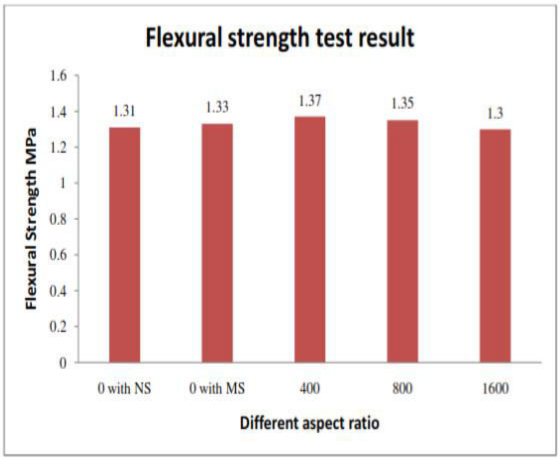

Figure.6: The variation of 28days theoretical Flexural strength test results

Fig.7 and Fig.8 shows the effect of addition of different aspect ratio of polypropylene fibre on Shear strength of shear planes 150*80 mm and 150*70 mm of PFRPC

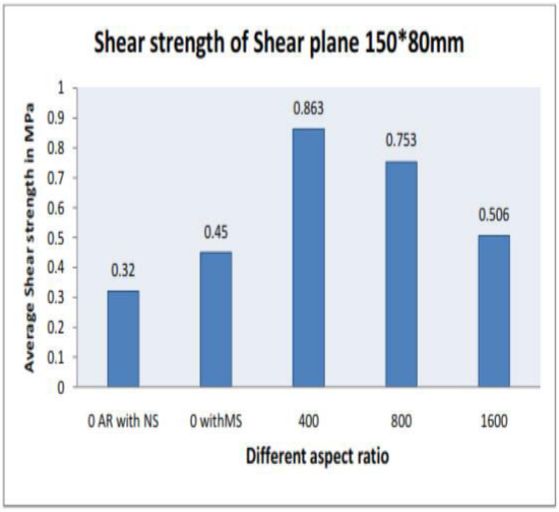

Figure.7: The variation of shear strength test results (shear plane 150*80)

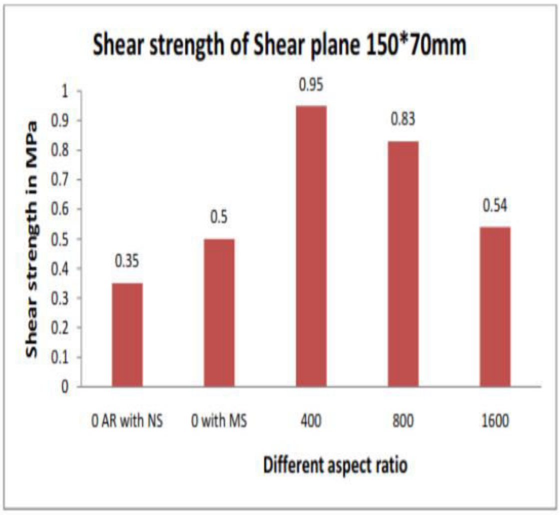

Figure.8: The variation of Shear strength test results (shear plane 150*70)

Fig.9 and Fig.10 shows the effect of addition of different aspect ratio of polypropylene fibre on Shear strength of shear planes 150*60 mm and comparison between various shear planes of PFRPC

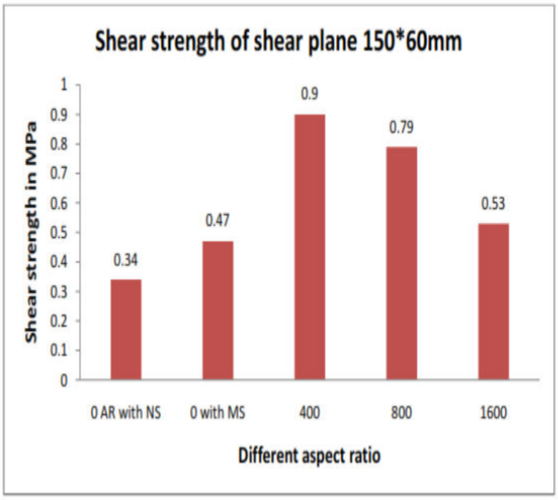

Figure.9: The variation of shear strength test results (shear plane 150*60)

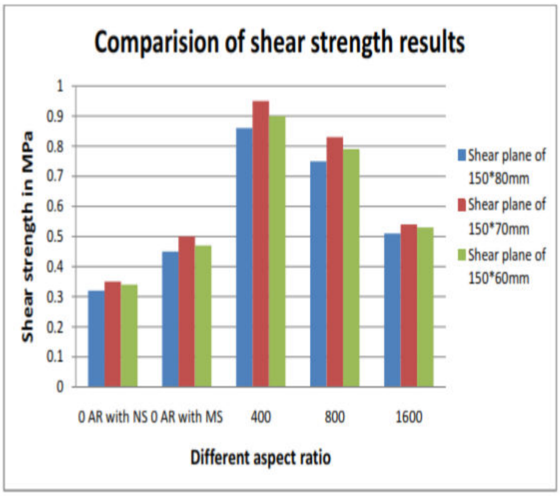

Figure.10: The variation of shear strength test results

Fig.11 shows the effect of addition of different aspect ratio of polypropylene fibre on workability characteristics of PFRPC

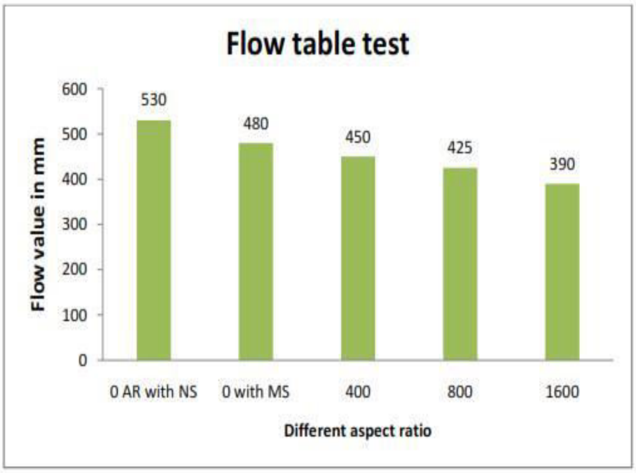

Figure.11: The variation of flow table test results

5. Observation and Discussions

Based on the obtained experimental results the following discussions were made

1. It has been observed that the polypropylene fiber reinforced porous concrete (PFRPC), shows an increasing trend in compressive strength from 0 aspect ratio to 400 aspect ratio for 0.5% addition of fibers. After an aspect ratio of 400, the compressive strength starts to decreasing, therefore high compressive strength can be achieved for an aspect ratio of 400 and the percentage increase in compressive strength is 5.7%.

2. It has been observed that PFRPC gives the maximum flexural strength for an aspect ratio of 400 for 0.5% addition of fibers, compared to other aspect ratio of 800 and 1600 this has been identified theoretically using the relation Flexural strength = 0.7 $\sqrt{f_{ck}}$

3. It has been observed that from the experimental results shows that the ultimate shear strength increases with the addition 0.5% of fibers, considerable over its plain fiber reinforced porous concrete, the specimens don’t fail suddenly; the failure load is more than 1st crack load.

4. It has been observed that from the percentage of fibers used in plain fiber reinforced porous concrete don't significantly affect the 1st cracking load but as an effect on the rate of cracking propagation failure load i.e. more in aspect ratio 400, because of availability of fibers are more than that in other aspect ratios.
5. It has been observed that from the PFRPC results increased trend in the shear strength from 0 aspect ratio to 400 aspect ratio but after an aspect ratio of 400, the shear strength goes on decreasing. Therefore the higher shear strength can be achieved for an aspect ratio of 400 with a percentage increase in shear strength of 90%.
6. It has been observed that from the PFRPC, L shaped shear specimens; the maximum shear strength can be obtained for a shear plane of 70mm thick was more, when compared to other shear planes.

6. Conclusion

Based on the observations and obtained results, the following conclusions were drawn

1. It can be concluded that the maximum compressive, theoretical flexural strength and shear strength can be achieved for an aspect ratio of 400 with the addition of 0.5% fibers.
2. It can be concluded that to achieve the maximum shear strength in shear plane the flange thickness 60-70 mm can be adopted.
3. It can be concluded that the polypropylene fiber reinforced porous concrete can be used as a building material.

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