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Mechanical Stability of Rayon Fibre Reinforced Concrete

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***Abstract:** The article analyses the mechanical stability of concrete with additions of rayon fibre by determining the fresh property like workability and strength properties like compressive strength, split tensile strength and flexural strength of concrete of grade M30.The effect of rayon fibre on reinforced concrete in variations of 0%, 0.1%, 0.15% and 0.2% was studied. This work includes the casting and testing of rayon fibre reinforced concrete. The test was conducted after 7 days and 28 days and the results were compared with conventional concrete.The mix design of strength of 30 N/mm2 was implemented using Indian Standard method.Concrete is extensively used in the construction industry. Traditional concrete is incapable of taking higher tensile stress and hence fails upon tensile stress. The Rayon fibre induced concrete is an excellent substitute for this problem. This paper reports on the results of an experimental investigation for assessing the behavior of rayon fibre in reinforced concrete and alsoto study the properties of materials and procedure of mix design of fiber reinforced concrete. The main motive is to determine the properties of concrete by adding rayon fibre to the concrete in certain percentage and comparing it with the traditional concreteand physical characteristics of rayon fibres. Rayon fibre is a manufactured fibre made out of natural sources such as wood, agricultural products that are regenerated and cellulose fibre, which can be used to enhance the bending characteristics of concrete.Micro fibres like rayon provide flexibility and also act as reinforcement. Rayon fibre reinforced concrete can be used in the construction of mega structures.*

***Keywords:** Rayon viscose fibre, Fibre reinforced concrete, Flexural behaviour, mechanical properties*

I. INTRODUCTION

Concrete is the frequently used in construction around the world. However, concrete has low tensile strength, and low energy absorption when compared to concrete's compressive strength. Concrete would lead to better performance by improving its toughness (tensile strength) and by minimizing the defects in concrete. An effective way to enhance the tensile properties of concrete is by using fibers in concrete.Based on the origins of natural fibers, they are usually classified in three groups, namely- plant, animal, and mineral [5]. It is used in concrete to control cracking due to plastic shrinkage, to reduce the permeability of concrete and thus reduce the bleeding of water. The amount of fibers added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed as "volume fraction" typically ranges from 0.1 to 0.2%. If the fibber's modulus of elasticity is higher than the matrix (concrete or mortarbinder), they help to carry the load by increasing the tensile strength of the material. Thus, concrete containing cement, water, aggregate and discontinuous, uniformly dispersed or discrete fibers is called Fibre Reinforced Concrete (FRC).Fiber Reinforced Concrete (FRC) is a composite obtained by adding a single type or a blend of fibers to the conventional mix which increases its structural integrity. Fibers are uniformly distributed and oriented in FRC. Properties of FRC vary with type of concrete used, fiber material, geometries, distribution, orientation and densities. To compensate the brittleness behavior of plain concrete, fiber reinforced concrete is often considered as an alternative. The main objective of this report is to study the bending behaviour of the bendable reinforced concrete with rayon fibres.The ordinary concrete lacks in compressive strength, flexural strength, bending and workability. This study is carried out to utilize rayon concrete to fulfil these properties.

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II. MATERIALS AND METHODS

A. Material used

The materials used in the experimental behaviour of rayon fibre in reinforced concrete are cement, coarse aggregate, fine aggregate and rayon fibre.

i. Cement

Ordinary Portland cement of grade of M30 was used with an initial setting time of 30 minutes and final setting time of 10 hours. Ordinary Portland cement is vastly used in the construction field. The ingredients of the cement are Argillaceous or silicates of alumina in clay form and also shale. Calcareous or calcium carbonate, which is in the form of limestone, chalk and marl which is a mixture of clay and calcium carbonate.

ii. Coarse Aggregates

Locally available coarse aggregates were used. The coarse aggregate used were of size 10 mm and was implemented in all tests performed on the concrete.

iii. Fine Aggregates

Locally available M-sand (Manufactured sand) was used. M-sand is an excellent substitute of river sand and is extensively used in the construction industry.

Manufactured sand is mainly produced from hard granite stone by crushing. The size of manufactured sand (M-Sand) is less than 4.75mm.

iv. Rayon Fibre

Rayon viscose fibres as shown in fig.1 having a specific gravity 1.14 and density 1.53 g/cm^3 were used. The cost of rayon was Rs.170/kg.

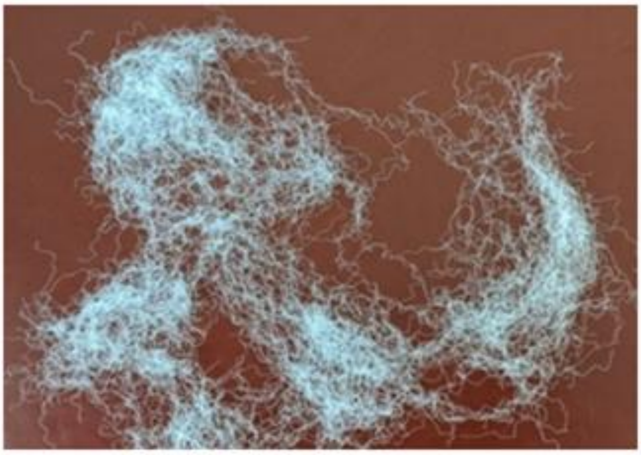

Fig. 1 Rayon Fibre

III. METHODOLOGY

The mechanical stability of rayon fibre reinforced concrete is analyzed by conducting the compression, splitting tensile strength and flexural tests on hardened concrete of grade M30. The concrete is mixed based on Indian standard method as per codal provision of IS 10262:2019. The workability of concrete to mix, transport and place it in the moulds, is to be checked by conducting slump cone test. Three cubes of size 150mm x150mm, cylinder of diameter150 mm and height 300mm and prism of size 100 mm x 100 mm x 500mm were casted foe each batch of testing. The mechanical strength of all samples were evaluated and interpreted after 7th and 28th day of curing under potable water.

A. Mix Design

The various dosages of rayon by % weight of cement adopted are 0%, 0.1%, 0.15% and 0.2%. The concrete used in this work was M30 grade and a water-cement ratio adapted was 0.45. The concrete mix was designed as per IS 10262:2019, the mix proportion is given in the table 1. [1]

Table I. Mix Design Ratio for M30 Concrete

M30 mix	Cement	Fine Aggregates	Coarse Aggregates	Water
Qty (kg/m^3)	520	692	1493	234
Ratio	1	1.33	2.87	0.45

B. Slump Test for Workability

The slump test for workability for the concrete was conducted as per IS 1199:1959. The test was carried out in the laboratory and the ideal sump value for a M_{30} mix should be 75mm ± 25mm.The slump test was conducted for 0%, 0.1%, 0.15%, 0.2% and 0.25% of rayon fibre. The obtained results were noted down in millimetres.

B. Compressive Strength Test

The compression test was conducted as per IS 516:1964 at the rate of 140 kg/cm/min and the ultimate loads were noted down. First the bearing surface of the machine was wiped off nicely and the specimen surface was cleaned. Then the specimen was placed in the testing machine and the axis of alignment was placed at the centre of the loading fame. The load was applied till the specimen failed and the maximum load attained was noted.

B. Split Tensile Strength Test

The split tensile strength for cylinders was conducted as per IS 516:1964. The cylinders were placed in the universal **testing** machine horizontally between the loading surfaces and the load was applied until the specimen failed. The failure load was recorded. The result for the Split Tensile Strength test is given in fig.6.

C. Prism Test For Flexural Strength

The prism was implemented with a 5mm diameter TMT bar while casting and the flexural strength for the concrete prism was conducted as per IS 516:1964. The concrete prisms were loaded by two-point loads placed at the third points along the span. The load is monotonically increased until flexural failure occurs. Based on the peak load, the peak flexural stress within the prism is calculated. The result for the flexural strength is shown in fig.7.

IV. RESULTS AND DISCUSSION

A. Slump Test For Workability

It was observed from table II and fig.2 that the slump value increased up to 0.2% of fibre content as the fibre was holding the mix intact to some extent. Slump value decreases by 15% of rayon fibre at 0.25% because the mix became heavy and formed lumps due to improper distribution and mixing. Mixing of fibre in concrete became difficult as the fibre content went more than 0.2% and workability decreased as the fibre percentage had increased. There was an increase in slump value by 7.5% for 0.1%, 12.5% for 0.15% and 18.7% for 0.2% dosages of fibre due to better disperse of fibres

Table II. Slump values

Fibre content (%)	Slump Value (mm)
0	80
0.1	86
0.15	90
0.2	95
0.25	83

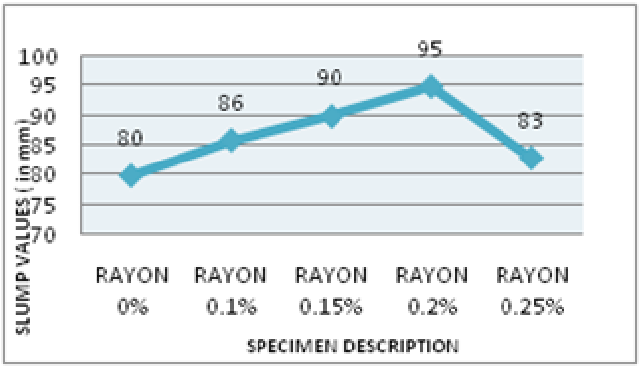

Fig.2Variation of slump values

B. Compressive Strength Test

From table III, table IV and fig.3 it was found that the cubes with rayon fibre had taken more load than conventional mix as the fibre was holding the materials steady and intact. There was an increase in the compressive strength as the percentage of fibre increased because the fibre enhanced the mix. The compressive strength had increased by 8.1% for 0.1%, 13.5% for 0.15% and 19% for 0.2% respectively compared to the ordinary cubes. It was found that there was more compression failure in the ordinary cubes compare to the cubes with rayon fibre as shown in fig.4 and fig.5.

Table III. Test results for 7 days

Fibre %	Load (kN)	Compressive Strength (KN/mm^2)
0	500	22.22
0.1	540	24
0.15	610	27.11
0.2	640	28.44

Table IV. Test results for 28 days

Fibre %	Load (kN)	Compressive Strength (KN/mm^2)
0	500	22.22
0.1	540	24
0.15	610	27.11
0.2	640	28.44

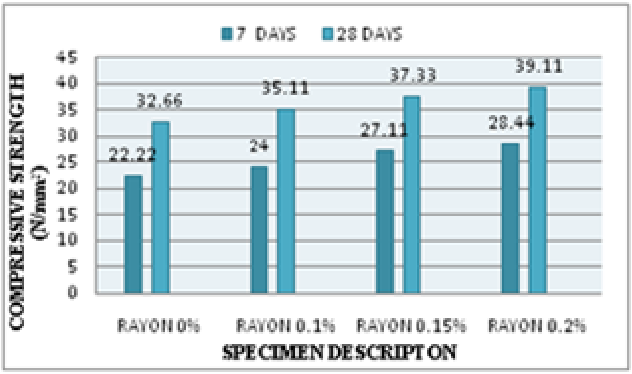

Fig.3 Variation of compressive strength of concrete

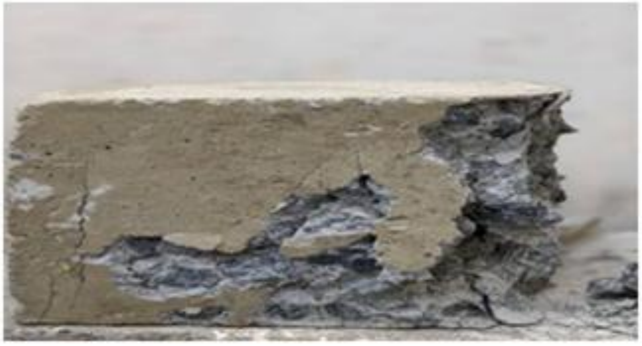

Fig.4 Failure in 0% Fibre Cube

Fig.5 Failure in 0.1% Fibre Cube

A. Split Tensile Strength Test

From table V and table VI and fig 6 it was observed that the cylinders with rayon fibre had taken more load compare to conventional mix due to the bonding provided by fibre.There was an increase in split tensile strength as the percentage of fibre increased because the rayon fibre is very good in tensile. It was also found that the split tensile strength had increased by 19% for 0.1%, 24% for 0.15% and 29% for 0.2% respectively compared to the ordinary cylinder. This is due to proper anchorage of cement concrete matrix offered by the rayon fibres.

Table V. Test results for 7 days

Fibre %	Load (kN)	Split tensile strength (KN/mm^2)
0	150	2.12
0.1	165	2.33
0.15	175	2.47
0.2	185	2.61

TableVI. Test results for 28 days

Fibre %	Load (kN)	Split tensile strength (KN/mm^2)
0	150	2.12
0.1	165	2.33
0.15	175	2.47
0.2	185	2.61

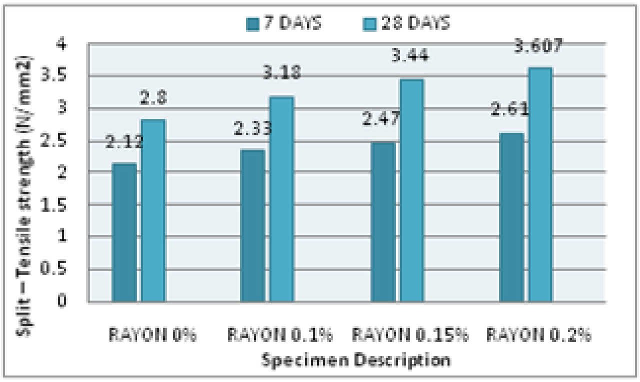

Fig.6 Variation of Split tensile strength of concrete

B. Prism Test For Flexural Strength

It was observed from table VII and fig 7that reinforced concrete with 0.2% of rayon fibre could take more loads and has shown more bending behaviour comparatively as the fibre provided good bending characteristics. Compare to conventional reinforced concrete prism, the flexural strength of the prism has increased as the percentage of fibre increased as the fibre showed good binding characteristics. The flexural strength has increased by 6% for 0.1%, 21% for 0.15% and 26.3% for 0.2% of fibre. Rayon fibre in reinforced concrete prevents the prism to fail to certain extent compared to the normal reinforced concrete as depicted in fig.8-11. This is due to significance contribution of rayon fibres to the bending tensile and compressive strength of prisms.

Table VII. Test results for 28 days

Fibre %	Load (kN)	Flexural strength (KN/mm^2)
0	28.5	14.25
0.1	30	15
0.15	34.5	17.25
0.2	36	18

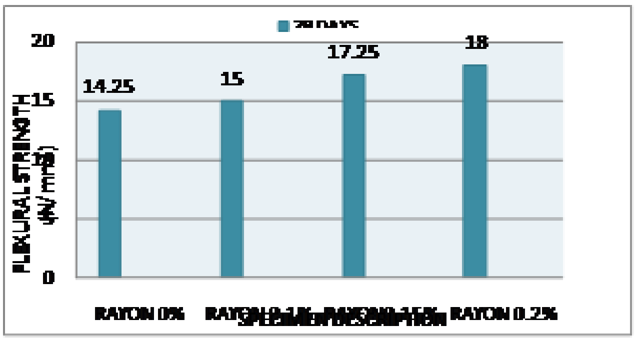

Fig.7 Variation of Flexural strength of reinforced concrete

Fig.8 Bending in 0% of Rayon Fibre

Fig.9 Bending in 0.1% of Rayon Fibre

Fig.10 Bending in 0.15% of Rayon fibre

Fig.11 Bending in 0.2% of Rayon Fibre

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V. CONCLUSION

The rayon fibre enhanced the mechanical strengths of the concrete. Addition of rayon concrete improved the workability of conventional M_{30} mix up to 0.2% of the fibre in the mix.

Optimum results were obtained in 0.2% of rayon fibre content. Adding fibres beyond 0.2% is not advisable as the mixing results in segregation and formation of lumps which further develops void in the mix as the voids result in drastic decrease in strength. The rayon fibre binds the materials firmly and showed slight increase in the compressive strength and substantial increase in the tensile strength.

The excellent tensile property of the fibre induced into the concrete. Optimum bending behaviour was achieved in samples with0.2% of rayon fibre as itcontributedsupplemental strength to the steel reinforcement in the prism as well as it has reduced widths of cracks exhibiting its flexibility. Based on the results of compression, split tensile and flexural test, the concrete with 0.2% of rayon fibre has exhibited better mechanical stability under different types of loads. Hence, it is recommended to use the Rayon Fibre concrete structure in residential and commercial buildings.

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