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Comparative Study on Tensile Strength and Impact Load Carrying Capacity of Concrete with Rubber and Steel Fiber

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ABSTRACT

Nowadays in this modern world, accidental loads or impact loads were often prone in most structures and in which they tend to fail in a very short span. To counteract this and to increase resistance over these types of loads rubber specifically crushed rubber or crumbed rubber of size less than 5 mm can be used. The purpose of this investigation is to report on an experimental study that explores the effect of using crushed rubber in concrete mixes. Rubber is added by 14% and 18% by the weight of the cement. Physical properties such as density, compressive strength, fresh concrete properties, split-tension, and impact load capacity are examined. The results revealed a decrease in the compressive strength of concrete cylinders containing rubber. The dynamic performance of the rubber concrete is of high importance because of its highly resilient nature, as the rubber particles that are included in the concrete have a positive effect on the dynamic performance. Fibres increase their structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres. In this investigation, crank fibres were taken and added 1% by the weight of the cement. Fibres increase tensile strength and decrease cracks. This project gives a concrete mix which is a combination of cement, sand, coarse aggregate, crumbed or crushed and steel fibres for two Mix grades M20 and M40. And the cured samples after 28 days were tested for compressive strength, Split tensile test and impact tests.

Keywords: Crank Fibres, M20, M40

I. INTRODUCTION

2200 to 2600 kg/m3 is the range of the counterweight of normal cement. The heavy mass of concrete is making it an unaffordable structural material and hence this can be considered one of the major limitations of conventional cement concrete. The weight of normal cement concrete has to be reduced to improve its efficacy as concrete and several methods have been taken up to do this. If the range of the cement concrete's self-weight is 300 kg1850 kg /m3 then it is said to be lightweight concrete.

II. LITERATURE REVIEW

H.W. Reinhardt (2013) has investigated "factors affecting the tensile properties of concrete" and in this chapter reviews various influences that affect the tensile strength of concrete. These factors can include the following. They are composition, duration and curing. Also, the environmental effects such as sustained loading. The chapter also looks at what testing shows about such properties as stress-deformation behaviour.

Ncamille A.Issabsamer A. Fawaz (2018) has studied "Rubber concrete: mechanical and dynamical properties" The purpose of this paper is to report on an experimental study that explores the effect of using recycled rubber powder as an alternate fine aggregate in concrete mixes.

Natural sand in the concrete mixes was partially replaced by 5%, 10%, 15%, and 20%.partial fine aggregates replacement in the concrete mix by powdered rubber leads to a reduction in the density of the final product, because the specific gravity of rubber used was less than that of fine aggregates decreasing in the rubberized concrete strength (compressive and tensile strength) with the increasing powdered rubber content in the mixture is always detected as shown in. The strength reduction may be attributed to two reasons.

Erik Denneman, Elsabe Kearsley, Preng Alex Visser (2020) has studied on "splitting tensile test for fibre-reinforced concrete" The splitting tensile test is a much-used method to determine the tensile strength of concrete. The conventional test procedure is known to have several limitations related to size effect and boundary conditions. To elaborate, there is a report showing that it is barely possible to know the tensile strength of fibre-reinforced concrete (FRC) through the standard splitting tensile test method. The method is validated through numerical simulation of the splitting tests using a cohesive crack approach. In this paper, we show a method which is used to obtain a close estimate of the true tensile strength of FRC using the procedure developed in the paper. Keywords fibre reinforced concrete–tensile strength– fracture mechanics.

Pramod Kawde, Abhijit Warudkar (2017) has put effort into "steel fibre reinforced concrete a review" extensively used material in the construction industry is concrete this is because of its good workability and ability to be moulded to any shape. Ordinary cement in concrete possesses certain limitations like very low tensile strength, low ductility and less resistance to cracking. As compared to other fibres it is now established that one of the important properties of steel fibre-reinforced concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper past studies based on steel fibre concrete are studied in detail.

Ishtiaq Alam, Umer Ammar Mahmood, Umer Ammar Mahmood (2015) has studied the "Use of rubber as aggregate in concrete". rubber is produced excessively worldwide every year. It cannot be discharged easily into the environment as its decomposition takes much time and also produces environmental pollution. Reusing rubber can be a better alternative in such cases. To reuse rubber wastes, it was added to concrete as coarse aggregate and its different properties like compressive strength, tensile strength, ductility etc. rubberized concrete shows a reduction in density of concrete when compared with control concrete specimen. it is recommended to use silica fume in rubberized concrete to increase its compressive strength. It is recommended to use rubberized concrete small structures like road curbs and bearing walls etc

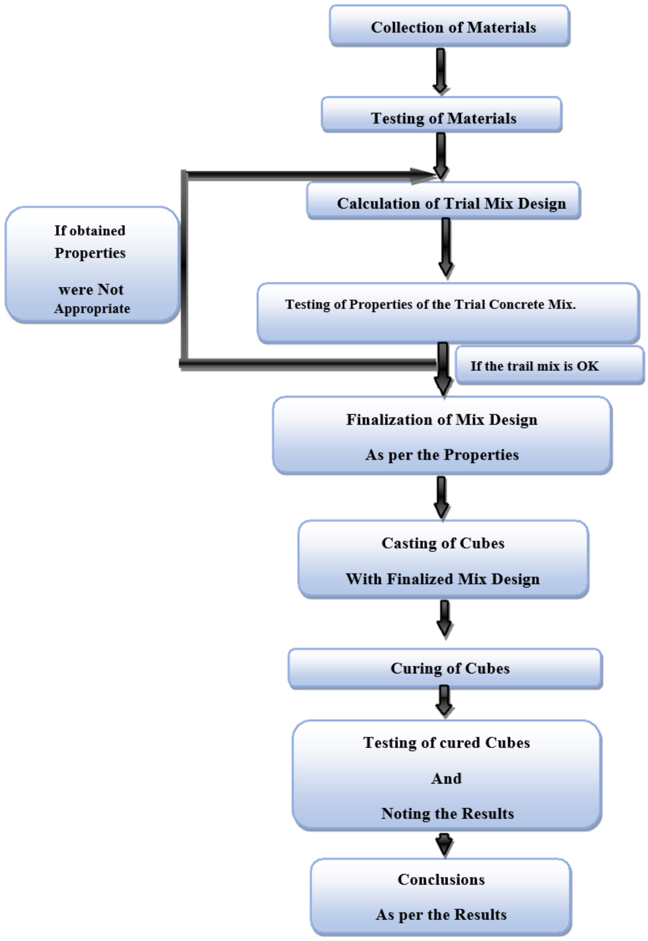
Mazen Musma (2013) has investigated studies that have shown that the addition of steel fibres in a concrete matrix improves all the mechanical properties of concrete, especially tensile strength, impact strength, and toughness. The material obtained has very high tensile strength, good response and better ductility. The predicted values of the splitting tensile strength are in good agreement with the experimental results. Thus, the validity of the suggested expression is verified against the experimental results gathered from previous research. To determine the tensile strength of fibre concrete, some parameters are taken into consideration. They include compressive strength, fibre content and the fibre aspect ratio.

In 2018, research is performed about “rubber concrete and its mechanical and dynamic properties”. the purpose of this paper is to report on an experimental study that explores the effect of using recycled rubber powder as an alternate fine aggregate in concrete mixes. Even though rubberized concrete mixture generally has a reduced compressive strength that may limit its use in certain structural applications, it has numerous useful properties, they include lower density, higher toughness and higher impact resistance compared to conventional concrete. partial fine aggregate replacement in a concrete mix by powdered rubber leads to a reduction in the density of the final product because the specific gravity of the rubber used was less than that of fine aggregates.18)

Reinhardt, H. W (1982) has put effort into "concrete under impact loading, tensile strength and bond" uniaxial impact tensile tests on plain concrete were carried out with the aid of split hook in son bar equipment with stress rates of up to 60000 n/mm2. S. Various concrete mixes were investigated. Dry and wet conditions. All the concretes showed an increase in strength with an increasing stress rate. It proved possible to formulate the tensile strength and the bond behaviour as a function of stress rate utilizing a power function. Relations between compressive strength and tensile strength are given for various stress rates.

III. METHODS AND MATERIAL

The method adopted for carrying out this experimental investigation, particularly for the methods adopted for carrying out the tests, casting, curing etc.,



Collection of materials:

The materials used in this experimental investigation are cement, Fine aggregate, Coarse Aggregate and Clinker aggregates have to be collected and ensure that the materials were free from impurities.

Testing of materials:

All the collected materials have to be tested and checked whether they are as per the concerned IS Codes. And all the tests conducted on different materials were included in this next chapter.

Calculation of Trail mix and Testing of properties of trail mix:

After obtaining the properties of all the materials a mix design has to be done as per the BIS method and a trail mix has to be performed to confirm the different flow properties, curing and strength have to be analyzed.

If the obtained results were not satisfying and don't meet the standard value of the IS codes again trail mix has to be calculated and the Finalization of Mix design & Casting of cubes:

If the trial mix was confined, all the other required tests have to be done. The other specimens have to be cast concerning the finalized mix design which is included in Annexure – I.

The casting of cubes with finalized mix design:

With the fixed mixed design, cast the specimens with normal convection concrete and Clinker concrete.

Curing of concrete specimens:

After the casting of specimens, the specimens have to be demoulded after 24 hours. In this experimental investigation, the following three methods were adopted

1. Normal conventional Curing.

Normal Conventional Curing:

Immerse the casted specimens into the water and cure them for 7 days and 28 days.

Testing of cured cubes:

The cured cubes from the three methods were tested using UTM (universal testing machine) to determine the compressive strength and readings have to be noted.

Conclusions:

After obtaining the results, conclusions have to be written based on the experimental investigations, few comparative graphs have to be drawn.

IV. EXPERIMENTAL RESULTS

The results obtained from the present experimental investigation that is performed to find out the properties of different properties of materials used. i.e.., Cement, Fine Aggregate, Coarse Aggregate, Rubber, Steel fibres and superplasticizers properties of Normal conventional concrete and Concrete with SCM are shown in this chapter. The mix design of concrete and the test results are given in detail.

Table 2: Physical properties of Ordinary Portland Cement of 53 Grade

S. No	Tests conducted	Test Results	IS Standard	Test Method
01.	Specific gravity	3.1	3.15	Specific bottle (IS:4031 Part – 4)
02.	Standard Consistency	30%	26%-33%	Vicat Apparatus (IS:4031 Part – 4)
03.	Initial Setting time	29.5 min	30 min	Vicat Apparatus (IS:4031 Part – 4)
04.	Fineness of cement	4%	<10%	Sieve test on Sieve no. 9 (IS:4031 Part – 4)
05.	The soundness of the Cement	3mm	<10 mm	Le Chartier Apparatus (IS:4031 Part – 4)

AGGREGATES

FINE AGGREGATES

Table 3: physical properties of Fine Aggregates

S. No	Tests conducted	Results	Method
01.	Fineness Modulus	4.32	Sieve Analysis (IS:2386 Part 2-1963)
02.	Specific gravity	2.66	Pycnometer (IS:2386 Part 2-1963)
03.	Bulk density	1501 kg/m^3	(IS:2386 Part 2-1963)
04.	Water absorption	1%	(IS:2386 Part 2-1963)

Table 4: Fineness Modulus of fine Aggregates

COARSE AGGREGATE

Gravel

Table 5: Physical properties of Coarse Aggregate (Gravel)

S. No	Tests Conducted	Results	Method
01.	Fineness modulus	6.075	Sieve Analysis method (IS:2386 Part 2 – 1963)
02.	Specific gravity	2.55	Pycnometer (IS:2386 Part 3- 1986)
03.	Bulk density	1462.2 kg/m^3	IS:2386 Part 3- 1986
04.	Water absorption	0.2%	IS:2386 Part 3- 1986

Table 6: Fineness modulus of Coarse Aggregate (Gravel)

Sieve No	Weight retained (grams)	Cumulative weight retained (grams)	% Cumulative weight retained	% Passing
40mm	0	0	0	100
20mm	2140	2140	42.8	57.2
10mm	2830	4970	99.40	0.6
4.75mm	22	4992	99.84	0.16
2.36mm	2	4994	99.88	0.12
1.18mm	0	4994	99.88	0.12
600µ	0	4994	99.88	0.12
300µ	0	4994	99.88	0.12
TOTAL	5000		607.56	

Fineness modulus of coarse aggregate (gravel) = = 6.07

Rubber

Table 7: Physical properties of Crum Rubber

Slump cone

S. No	Test Conducted	Results
01.	Specific gravity	0.63
02.	Bulk density	784 kg/m^3
03.	Viscosity index	173

Table 8: Slump values for NWC, rubber concrete and fibre-reinforced rubber concrete for

Type of concrete	Grade of concrete	Slump Value
Normal Convectional concrete	M20	46
Normal concrete + Rubber (14%)	M20	52
Normal concrete + Rubber (18%)	M20	53
Normal Concrete + Rubber (14%) + Steel fibers	M20	54
Normal concrete + Rubber (18%) + Steel fibers	M20	55

M20-grade Concrete

Table 9: Slump values for NWC, rubber concrete and fibre-reinforced rubber concrete for M40-grade Concrete

Type of concrete	Grade of concrete	Slump Value
Normal Convectional concrete	M40	48
Normal concrete + Rubber (14%)	M40	50
Normal concrete + Rubber (18%)	M40	52
Normal Concrete + Rubber (14%) + Steel fibers	M40	54
Normal concrete + Rubber (18%)+ Steel fibers	M40	56

NORMAL WATER CURING

Normal concrete, Rubber concrete and Fibre reinforced concrete.

Table no. 10: Compressive strength for NWC, Rubber concrete and Fibre reinforced concrete for M20 grade concrete

S. No	Concrete Grade	7 days	28 days
01.	Normal Convectional concrete	13.85	19.35
02.	Normal concrete + Rubber (14%)	14.65	23.73
03.	Normal concrete + Rubber (18%)	14.33	22.60
4.	Normal Concrete + Rubber (14%) + Steel fibers	17.26	21.88
05.	Normal concrete + Rubber (18%) + Steel fibers	16.90	21.32

Table no. 11: Compressive strength for NWC, Rubber concrete and Fiber reinforced concrete for M40 grade concrete

Split tensile strength:

S. No	Concrete Grade	7 days	28 days
01.	Normal Convectional concrete	19.49	34.67
02.	Normal concrete + Rubber (14%)	20.16	35.667
03.	Normal concrete + Rubber (18%)	20.64	34.85
4.	Normal Concrete + Rubber (14%) + Steel fibres	22.32	38.52
05.	Normal concrete + Rubber (18%) + Steel fibres	21.41	37.51

Table no. 12: Split Tensile strength for NWC, Rubber concrete and Fibre reinforced concrete for M20 grade concrete

S. No	Concrete Grade	7 days	28 days
01.	Normal Convectional concrete	2.14	2.36
02.	Normal concrete + Rubber (14%)	2.23	2.58
03.	Normal concrete + Rubber (18%)	2.18	2.42
4.	Normal Concrete + Rubber (14%) + Steel fibres	2.56	2.98
05.	Normal concrete + Rubber (18%) + Steel fibres	2.43	2.76

Table no. 13: Split tensile strength for NWC, Rubber concrete and Fibre reinforced concrete for M40 grade concrete

S. No	Concrete Grade	7 days	28 days
01.	Normal Convectional concrete	3.06	3.21
02.	Normal concrete + Rubber (14%)	3.42	3.68
03.	Normal concrete + Rubber (18%)	3.15	3.55
4.	Normal Concrete + Rubber (14%) + Steel fibres	3.96	4.27
05.	Normal concrete + Rubber (18%) + Steel fibres	3.10	3.56

V. EXPERIMENTAL RESULTS AND DISCUSSION

The test results obtained from the experimental investigation on Normal Conventional concrete, Rubber Concrete and fibre
reinforced concrete in fresh and hardened states is discussed in the following states:

1. Fresh properties of Normal conventional concrete, Rubber Concrete and fibre-reinforced concrete for 0.6 water binder ratio.
2. Fresh properties of Normal conventional concrete and Concrete with SCM for 0.45 water cement ratio.
3. Hardened properties of Normal conventional concrete both water-cement ratios with conventional curing.
4. Hardened properties of Rubber Concrete for both the water-cement ratios with conventional curing.
5. Hardened properties of fibre-reinforced rubber Concrete for both the water-cement ratios with conventional curing.

Fresh properties of Normal conventional concrete, Rubber Concrete and fibre-reinforced concrete for 0.6 water binder ratio.

Tables 5.7 and 5.8, give the details about the fresh properties of the concrete, without any admixture for normal concrete and Rubber Concrete and Fiber reinforced Rubber concrete, 1% of Superplasticizer is added.

We observe the following,

From table 5.7, for M20 grade concrete with water-cement ratios of 0.6, we observe that the slump of the concrete is increasing with the increase in the rubber to the concrete.

From table 5.8, for M40 grade concrete with water-cement ratios of 0.45, we observe that the slump of the concrete is increasing with the increase in the rubber to the concrete.

Hardened properties of Normal conventional concrete, Rubber concrete and Fibre reinforced concrete for M20 grade concrete for the w/c ratio 0.6 with conventional curing

From table 5.9 which gives the details about the hardened properties of the concrete for conventional curing, we observe the following,

Table 5.9 the compressive strength values for normal concrete, Rubber concrete and Fiber reinforced rubber concrete for 0.60 w/c ratios for M20 grade the strength of the concrete at the age of 7 days and 28 days

VI. CONCLUSION

The following Conclusions were drawn from the Experimental investigation in this Present thesis

The Compressive strength of Normal weight concrete in conventional curing after 7 days and 28 days for M20 was observed as 13.85 MPa and 19.35 MPa respectively.
The Compressive strength of Normal weight concrete added with 14% of Rubber in conventional curing after 7 days and 28 days for M20 were observed as 14.33 MPa and 22.73 MPa
The Compressive strength of Normal weight concrete added 18% Rubber for M20 grade in conventional curing after 7 days and 28 days was observed as 14.65 MPa and 23.60 MPa respectively.
The Compressive strength of Normal weight concrete added with 14% Rubber and Steel fibres for M20 in conventional curing after 7 days and 28 days were observed as 17.26 MPa and 21.88 MPa respectively.
The Compressive strength of Normal weight concrete added with 18% Rubber and Steel fibres conventional curing after 7 days and 28 days for M20 were observed as 15.90 MPa and 24.32 MPa
The Compressive strength of Normal weight concrete in conventional curing after 7 days and 28 days for M40 was observed as 19.49 MPa and 34.67 MPa respectively.
The Compressive strength of Normal weight concrete added with 14% Rubber in conventional curing after 7 days and 28 days for M40 were observed as 20.16 MPa and 35.667 MPa
The Compressive strength of Normal weight concrete added with 18% Rubber for M40 grade in conventional curing after 7 days and 28 days were observed as 20.64 MPa and 34.85 MPa respectively.
The Compressive strength of Normal weight concrete added with 14% Rubber and Steel fibres for M40 in conventional curing after 7 days and 28 days were observed as 22.32 MPa and 38.52 MPa respectively.
The Compressive strength of Normal weight concrete added with 18% Rubber and Steel fibres in conventional curing after 7 days and 28 days for M40 were observed as 21.41 MPa and 37.51 MPa
The Split tensile strength of Normal weight concrete in conventional curing after 7 days and 28 days for M20 were observed as 2.14 MPa and 2.36 MPa
The Split tensile strength of Normal weight concrete added with 14% of Rubber in conventional curing after 7 days and 28 days for M20 were observed as 2.23 MPa and 2.58 MPa
The Split tensile strength of Normal weight concrete added with 18% of Rubber in conventional curing after 7 days and 28 days for M20 were observed as 2.18 MPa and 2.42 MPa
The Split tensile strength of Normal weight concrete added with 14% Rubber and Steel fibres in conventional curing after 7 days and 28 days for M20 were observed as 2.56 MPa and 2.98 MPa
The Split tensile strength of Normal weight concrete added with 18% of Rubber and Steel fibres in conventional curing after 7 days and 28 days for M20 were observed as 2.43 MPa and 2.76 MPa

The Split tensile strength of Normal weight concrete in conventional curing after 7 days and 28 days for M40 were observed as 3.06 MPa and 3.21 MPa

The Split tensile strength of Normal weight concrete added with 14% of Rubber in conventional curing after 7 days and 28 days for M40 were observed as 3.42 MPa and 3.68 MPa

The Split tensile strength of Normal weight concrete added with 18% of Rubber in conventional curing after 7 days and 28 days for M40 were observed as 3.15 MPa and 3.55 MPa

The Split tensile strength of Normal weight concrete added with 14% Rubber and Steel fibres in conventional curing after 7 days and 28 days for M40 were observed as 2.56 MPa and 2.98 MPa

The Split tensile strength of Normal weight concrete added with 18% of Rubber and Steel fibres in conventional curing after 7 days and 28 days for M20 were observed as 2.43 MPa and 2.76 MPa

From the above observations, it is clear that the specimens casted with 14% Rubber were more effective than the 18% Rubber

Similarly, the specimens with 14% Rubber with steel fibres give more strength than the other specimens after 7 days and 28 days of strength

The absorption of loads is more in the Rubber concrete specimens compared to the normal conventional concrete specimens

The presence of steel fibres in the specimens containing rubber will leads to less crack width and durability and very less wear and tear.

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