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Study on the Compressive Strength of M20 Grade Concrete by Partial Replacement of Coarse Aggregate with Waste Rubber Tyres

Bhagyalakshmi T M, Anand C

Lecturer, Department of Civil Engineering, Government Polytechnic, Mirle, Karnataka, India

Lecturer, Department of Civil Engineering, Government Polytechnic, Mirle, Karnataka, India

ABSTRACT: The enormous development on production of vehicles resulted in growing amount of waste rubber tyre. Consequently, waste rubber is considered as one of the most waste materials that might cause environmental problems. Incorporating tyre rubbers in concrete pavement has been widely studied as one of the promising and sustainable solutions to these current environmental problems. This paper explored the effect of replacing coarse aggregate with waste tyre rubber on respective percentages. Three replacement ratios were suggested to substitute the coarse aggregate in concrete of 5%, 10% and 15% and comparing the compressive strength between Normal concrete cubes and partial replacement of waste rubber tyre cubes.

KEYWORDS: WASTE RUBBER TYRE, COMPRESSIVE STRENGTH, CEMENT CONCRETE

I. INTRODUCTION

Concrete is one of the most widely used man-made construction material. It is obtained by mixing cement, water and aggregate and sometimes admixtures in required proportion. The raw materials from which it is prepared; cement and aggregates, affect both the quality and cost of construction. Cement owes its unique position as the structural material to the fact, that it is economically highly resistant to fire, wind, water and earth quakes. In the recent times its use in construction has been increased considerably thus the cities and towns are virtually becoming cement jungles. The demand is likely to increase in the future to match the growing population, housing, transportation and other amenities. The availability and proximity of aggregate to the construction site also effect the cost of construction. Aggregate is as important as cement to form a cement mortar that is very useful in construction of buildings. The aggregate is usually derived on natural sources.

The use of recycled rubber as the partial replacement of coarse aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum. Concrete is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing cost. concrete has low tensile strength, low ductility, and low energy absorption. Concrete also tends to shrink and crack during the hardening and curing process. These limitations are constantly being tested with hopes of improvement by the introduction of new admixtures and aggregates used in the mix. One such method may be the introduction of rubber to the concrete mix. It is a perfect way to modify the properties of concrete and rubber tyres at the same time. We find the compressive strength of concrete with partial replacement with waste rubber tyre for coarse aggregate.

India has taken step to move forwards infrastructures towards the growth of globalisation. Due to manufacturing of tyres with synthetic rubber, proper disposal of this waste tyres has become difficult. Every year over 1.6 billion new tyres are generated and around 1 billion of waste tyres are generated. However, the recycling industry processed only 100 million tyres every year. The purpose of addition of the rubberised materials to concrete is to improve its properties of tensile strength, hardness, abrasion resistance, tear resistance and on workability of concrete. The construction industry is always increasing its uses and applications. Therefore, it is required to find alternative materials to reduce the cost of concrete. On the other hand, non-biodegradable waste i.e., water bottles, cool drink bottles and disposable glasses, shredded or crumbed rubber etc. is creating a lot of problems in the environment and its disposal becoming a great difficulty.

Here we study about the use of rubber pieces as coarse aggregate in the concrete. Concrete specimen of various percentages of rubber like 5%,10% and 15% as a partial replacement of coarse aggregate were tested. The compression

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test was conducted for the control specimen and specimen with rubber. Finding the compressive strength between normal concrete cubes and partial replacement of waste rubberized cubes.

II. METHODOLOGY

Raw materials required for the concreting operations of the present work are:
a) Ordinary Portland Cement 53 Grade
b) Fine aggregates conforming to any one of the four grading zones as per IS 383-1970 may be used
c) Coarse aggregates- Two sizes of course are used one 16 mm passing through 12.5 mm retained and other 25 mm passing through 20 mm retained as per IS: 2386 – 1963
d) Water to be used in the concrete work should be free from injurious amount of oil, acids, alkaline, or other organic or inorganic impurities and It should be free from iron, vegetable matter or other any type of substances, which likely to have adverse effects on concrete or reinforcement.
e) Concrete tested with varies percentages of waste rubber for 5%,10% and 15% of coarse aggregates with rubber tyre pieces. The purpose of addition of the rubberised materials to concrete is to improve of tensile strength, hardness, abrasion resistance, tear resistance and on workability of concrete of its properties and to study its effect on workability of concrete.

Test Procedures for materials
a. **Specific Gravity of Cement:** Pour some of the kerosene upto the mark in the specific gravity bottle and introduce a weighed quantity of cement (about 64 gm) into the bottle. Roll the bottle gently in the inclined position until no further air bubbles rise to the surface. Fill the bottle with the total amount of cement taken and note down the volume of kerosene raised. The final reading is noted, from which the specific gravity of the cement is calculated using below equation. Specific gravity of cement = Mass of cement/ Displaced volume

LE CHATELIER FLASK

b. Fineness test on Cement Fineness of cement is measured by sieving it on standard sieve. The proportion of cement of which the grain sizes are larger than the specified mesh size is thus determined. Procedure:
1. Agitate the sample of cement to be tested by shaking for 2 minutes in a stoppered jar to disperse agglomerates. Stir the resulting powder gently using a clean dry rod in order to distribute the fines throughout the cement.
2. Attach a pan under the sieve to collect the cement passing the sieve.
3. Weigh approximately 100 g of cement to the nearest 0.01 g and place it on 90 microns sieve. Fit the lid over the sieve.
4. Agitate the sieve by swirling, planetary and linear movement until no more fine material passes through it.
5. Remove and weigh the residue. Express its mass as a percentage (W1) of the quantity first placed in the sieve.
6. Repeat the steps 3 to 5 with a fresh sample to obtain(W2). As per IS code the percentage residue should not exceed 10%. Percentage of weight residue = W2/W1x100

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c. Standard consistency of cement The principle of standard consistency of cement is that the consistency at which the vicat plunger penetrates to a point 5-7 mm from the bottom of Vicat mould. Apparatus used are vicat's apparatus using 10 mm diameter plunger fitted into the needle-holder, vicat mould, gauging trowel, measuring jar, balance, glass plates, stop watch, mixing tray, and sample of cement.

Procedure: 1. Take 400 gms of cement and prepare a paste of weighed quantity of water taking care that time of mixing [gauging] is between 3 to 5 minutes and shall be completed before any signs of setting become visible. The time of gauging shall be counted from the time of adding water to the dry cement until the commencement of filling mould.

2. Fill the vicat mould with the paste of the mould resting on a non-porous plate and then smooth off the surface of the paste making it level with the top of the mould.

3. Plan the test block in the mould together with the non-porous resting place under the rod bearing the plunger lower the plunger gently to touch the surface of the test block and quickly release allowing it to sink into the paste. The operation shall be carried out immediately after filling the mould and at room temperature. Prepare trial paste with varying percentages of water and test as described above and measure the penetration of the needle. This test is be carried cut until the specified penetrations is obtained.

4. Repeat till a paste which allows the plunger to settle to a point with in 5 mm to 7 mm from bottom of vicat mould is got.

VICAT APPARATUS

S.No	Tests	Test results	codal values
1	Standard Consistency	31%	25%-35%
2	Specific Gravity	3.13	range(3-3.15)
3	Fineness of cement	8%	(not less than 10%)

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d. Specific Gravity of Fine Aggregate Specific gravity of fine aggregate is determined by using pycnometer. The weight of the pycnometer is taken as W1. The weight of pycnometer and sand is taken as W2. The weight of pycnometer, sand and water is taken as W3. The weight of pycnometer and water is taken as W4. Now the specific gravity is determined by using the equation below. Specific gravity of sand =(W2-W1)/([(W2-W1)-(W3-W4)])

e. Particle Size distribution of fine aggregate Apparatus 10mm, 4.75mm, 2.36mm, 1.18mm, 600 microns, 300 microns, 150 microns.
Procedure: 1. Take a 0.5kg sample of fine aggregate.
2. Take set of IS Sieves.
3. Grading pattern of a sample F.A is passed by sieving a sample successively through all the sieves mounted one over the other in order of size, with larger sieve on the top.
4. The material retained on each sieve after shaking, sieve can be done either manually or mechanically.
5. Operation should be continued such time that almost no particle is passing through. For assessing the gradation by sieve analysis in the quantity of materials to be taken on the sieve is given in the table.
6. From the sieve analysis the particle size distribution in a sample aggregate in found out.
7. All the retained material should weight individually.
8. By adding the cumulative percentage of aggregate retained on the each of the standard sieve and dividing sum by an arbitrary NO.:100 like this fineness modulus is calculated.

S.No	Tests	Test results	codal values
1	Specific Gravity	2.67	range (2.6-2.9)
2	Fineness Modulus	3.05	range (2.9-3.2)

f. Specific gravity of coarse aggregate
Procedure:1. Weigh the empty pycnometer = W1gms.
2. Weigh the pycnometer with 1/3 of coarse aggregate = W2 gms.
3. Weight of pycnometer + 1/3 of aggregate + water = W3 gms.
4. Weight of full of water with pycnometer = W4 gms.
Specific gravity of sand =(W2-W1)/([(W2-W1)-(W3-W4)])

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S.No	Tests	Test results	codal values
1	Specific Gravity	2.87	range (2.6-2.9)
2	Fineness Modulus	7.61	range (5.5-8.0) (coarse sand)

g. Specific gravity of waste rubber tyre pieces

S.No	Tests	Test results	codal values
1	Specific Gravity	1.07	range (1-1.5)

IV. MIX DESIGN FOR M20 GRADE OF CONCRETE (IS-10262-2019)

A concrete mix proportions of 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

Step-1: Stipulations for Proportioning
a. Grade Designation:M20
b. Type of cement: OPC 53 grade
c. Max. nominal size of coarse aggregate:20mm
d. Min. Cement content:345kg/m3 (From IS: 456-2000 (for severe condition)
e. Max. Water - Cement ratio: 0.5 (From IS: 456-2000 Table5)
f. Workability:75mm Slump
g. Exposure condition: Severe
h. Method of concrete placing: Manual
Step-2: Tests data for Materials a) Cement used: OPC 53 grade b) Specific gravity of cement: 3.13 C)
Specific gravity of I) Coarse aggregate: 2.87 II) Fine aggregate: 2.67 18
Step 3 — Determination of Target Strength standard deviation for M20 IS 4.0 taken from IS-10262-2019 If target = f ck + 1.65 x S = 20 + 1.65 ×4.0 = 26.6N/mm2
Step 4 — Selection of water / cement ratio: - From Table 5 of IS 456 Maximum water-cement ratio for Mild exposure condition = 0.55 but we take and design of water cement ratio is 0.5
STEP 5 –Selection of water content For 20mm aggregate and 50mm slump: -186 L Water-content for 75mm Slump = 186+(0.03Ö186) = 191.58L Adopted Water Content = 190 L
STEP 6 –Selection of cement content From Table 5 of IS 456 Minimum cement Content for mild exposure condition = 300 kg/m3 w/c=0.5 190/c=0.5 c=345 kg/m3 345 kg/m3 > 300kg/m3 , hence, OK
Step-7: Proportion of volume of Coarse aggregate and Fine aggregate From IS 10262:2009 Table no.3 Volume of Coarse aggregate corresponding 20mm size and Fine aggregate zone - II for Water - Cement ratio 0.5 is 0.62. In the present case Water - Cement ratio is 0.5 Therefore volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the Water - Cement ratio is lower by 0.05% the proportion of volume of coarse aggregate is increased by 0.01% Therefore the corrected portion of volume of coarse aggregate for W/C ratio 0.5 is for every 0.05 change is 0.01. The corrected portion of coarse aggregate for W/C ratio 0.5 is 0.62. For manual placing of concrete there is no change in proportion
Volume of course aggregate content= 0.62 - 0.01 = 0.61 Volume of fine aggregate content = 1 -0.61 = 0.39
STEP-8: Mix calculation: 1.Volume of concrete = 1m3 2.Volume of cement = MASS OF CEMENT/SPECIFIC GRAVITY Ö1000 = 345/3.13Ö1000 19 = 0.110 m3 3.Volume of water = MASS OF WATER/SPECIFIC GRAVITY ×1000 = 190/1 × 1000 = 0.19m3 4.Volume of aggregate added = 1-(0.110+0.19) = 0.7 m3 5.Coarse aggregate = 0.7 ×0.61 × 2.87 × 1000 = 1225kg/m3 6.Fine aggregate = 0.7 ×0.39 × 2.87 × 1000 = 728.9kg/m3
STEP-9: MIX PROPORTIONS FOR 1m3 OF CONCRETE Cement = 345kg/m3 Fine aggregate = 730kg/m3 Coarse aggregate = 1225kg/m3 Volume of water = 190 L RATIO=1.16:2.66:4.13
FOR 1 CUBE (150Ö150Ö150mm) Cement = 1.16kg Fine aggregate = 2.66kg Coarse aggregate = 4.13kg
FOR 9 CUBES Cement = 10.45 kg Fine Aggregate = 24 kg Coarse Aggregate = 37.2 kg

Mixing
The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the all ingredients of concrete into a uniform mass. Thorough mixing of materials is essential for the production of uniform concrete. The mixing ensure that the mass becomes homogeneous, uniform in colour and consistency. Two methods are adopted for mixing concrete, Hand mixing and Machine mixing.

Casting of Concrete Cubes

The test moulds are kept ready before preparing the mix. Moulds are cleaned and oiled on all contact surfaces. The concrete is filled into the moulds in layers and then vibrated. The top surface of concrete is struck off level with a trowel. The number and date of casting are put on the top surface of the cubes.

Curing

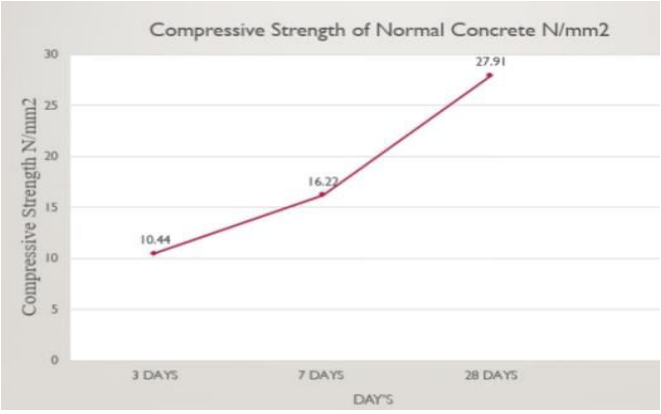
The test specimens were stored in a place free from vibration and covered with wet gunny bags for 24 hours from the time of addition of water to the dry ingredients. After this period, specimens are removed from the moulds and immediately submerged in curing tank and kept there until taken out just period to rest. The water of curing tank was renewed or every seven days and maintained at a temperature of 27 plus or minus 2 □. Figure 6.2: CURING

Compressive Strength of Cubes

In this study, the compression testing machine CTM having capacity of 3000 KN are used for compressive strength of the concrete cubes. Compressive test was carried out on cubes of dimensions 150x150x150 mm after 3 days,7 days and 28 days for each test and for each mix three specimens were tested

IV. EXPERIMENTAL RESULTS

1. Compressive Strength of Normal Concrete Cubes: The cube specimen is of the size 150mmx150mmx150mm



Test results on compressive strength of Normal concrete cubes

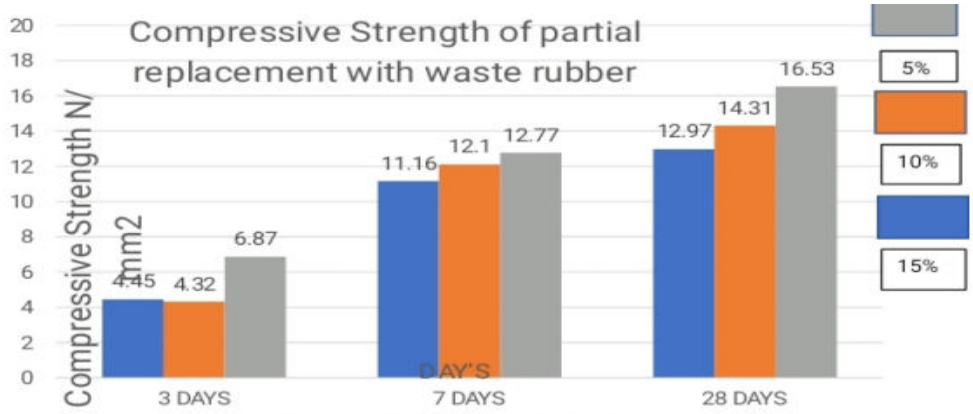
S.No	DETAILS	3 DAYS	7 DAYS	28 DAYS
1	ULTIMATE LOAD ON SPECIMEN(KN)	235 KN	365 KN	628 KN
2	COMPRESSIVE STRENGTH IN N/mm^2	10.44	16.22	27.91

2. Compressive Strength of Partial replacement with waste rubber tyre pieces

M1 = 5% REPLACEMENT OF RUBBER IN CONCRETE
M2 = 10% REPLACEMENT OF RUBBER IN CONCRETE
M3 = 15% REPLACEMENT OF RUBBER IN CONCRETE
The weights of cement and Fine aggregate is same for three replacements. cement for 3 cubes is 3.48kg Fine aggregate for 3 cubes is 7.98 kg.

Test results on partial replacement of waste rubber tyre pieces

S.No	SPECIMEN	COARSE AG-GREGATE(Kg)	RUBBER (Kg)	3 DAYS	7 DAYS	28 DAYS	% decrease
1.	M1	11.77	0.62	6.87	12.77	16.53	40
2.	M2	11.15	1.23	4.32	12.10	14.31	48.72
3.	M3	10.53	1.85	4.45	11.16	12.97	53.529



V. CONCLUSION

1) Compressive strength of the specimen of grade M20 cured for 28 days is decreased at partial replacement of 5%,10% 15% with rubber in coarse aggregate.
a) For 5% of rubber, the compression strength is 16.53 N/m2 which is around 40% reduction of strength when compared to conventional concrete.
b) For 10% of rubber, the compression strength is 14.31 N/m2 which is around 48.72% reduction of strength when compared to conventional concrete.
c) For 15% of rubber, the compression strength is 12.97 N/m2 which is around 53.53% reduction of strength when compared to conventional concrete.
2) These findings indicates that it is not advisable to use rubber aggregates in concrete mixes for high strength and load bearing applications.
3) Finally, we can use this type of concrete in PCC bed in foundation and also we can provide this concrete below flooring.
4) By using this concrete the DL of the structure will get reduced and we can use this in partition walls.

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