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An Experimental Investigation on Partial Replacement of Fine Aggregate by Crumb Rubber in Concrete

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Abstract: Usage of waste materials has been among the most pressing concerns in civil engineering in recent years. One of the most significant problems limiting environment to save the environment. The disposal of the different industrial waste materials becoming problems in world and that is directly and indirectly affecting environment. The use of the waste materials in construction fields is one answer to this problem. This technique has lately emerged as one of the alternatives use of waste materials incorporating with concrete. Experiment with compression and tensile behavior of crumb rubber and fly ash in construction as partial replacement of cement based on pozzolonic characteristics.By using M30grade mix concrete Basic properties of materials,compression and tensile tests were tested. Based on experimental investigation Strength properties was compared with different percentage of Crumb Rubber and fly ash compared with conventional concrete.

Keywords:*Concreteblocks, Crumb Rubber, Fly ash.*

1. INTRODUCTION

The disposed of squander material is the main issues in the world nowadays. The dumping of the squander tyres from vehicles is a important matter because this material is very hard to degrade even after a long period of time. The unused rubber is also used as natural substance for rubber goods. Concrete is made up of cement, aggregate so because of this which there is exploitation in the natural aggregates or resource. There are many ways which were used for the consumption of waste tyre, one of them is the application of crumb rubber in the concrete as full or partial replacement of coarse aggregates or fine aggregates The favorable results in this case have will have a higher benefaction towards the reducing of waste material disposed problems by used of the waste materials as a raw ingredients for other construction needed. As filling the land with tyre and combustion discarded rubber tyres is a very tough and environmental pollution producing process. Concrete mixture which consists of crumb rubber may be satisfied to use for basic and nonfunctional purpose, for example, lightweight concrete dividers, as exterior finishes, and compositional parts. The use of crumb rubber with concrete will be good performing in the structuring of the wall as it act as a shock absorber as well as sound absorber and also the heat.

Crumb rubber concrete is the concrete made out of tire chips and scrap elastic. The common use of discarded rubber specifically tire which have been grind have been used in highway for asphalt mixes as a binder. Material performance experiments have been proposed to determine the partially of using rubber in concrete. Research has shown that replacement of the sand with rubber results in a lower in compressive strength and split tensile strength and flexural.

Tyres made up of very different materials and also the chemical composition which include several rubbers, carbon black, steel cord, ash content, volatile matter, and other organic and inorganic minor components. The generation of amount of tyre rubber vanish is generating more and more ecological problems. The present rate of growth is unexpected without decreasing of fossil energy like crude oil, natural gas and coal. Proper waste management is an additional role by recycling:

• 100 million tires are produced by the recycling industry every year.

• 80 million tires are recycled into a crumb rubber, creating playground surfaces especially for children as a cushions synthetic turf for playing in pitch to overcome sudden impact and more.

• 20 million tires are used in concrete for partial replacement with the natural aggregates and light weight, filler for road embankment, rail vibration dampening and other uses in engineering uses.

• 4 million tires are recycled into a shed for animals as a mat and also growing of plants as an agricultural applications.

• 13 million tires are exported for uses in other countries like Brazil, China and USA.

Fig.1.1 Show the Waste tyre

1.2 PROBLEM IDENTIFICATION:

The development of any infrastructure has a critical effect on the surroundings through the extraction of natural materials, the utilized of energy in the creation and transport processes, the creation of masses from waste products and environmental and health damage at all stages of the life cycle of hazardous components.

• The increase of population and the increased in the vehicles industry the generation of the tire is more and the same the producer of discarded tire is increasing day by day.

• The excessive extraction of sand and gravel leads to the depletion of rivers. In riverside mines, the down part of the stream sinks, which can be caused to shoreline erosion. The excessive extraction of sand come to a threat to bridges, shorelines and buildings near to them Waste tires has highly thread to serious environmental, health and aesthetic problems as they are big and full of voids, non-biodegradable, good breeding place for insects and rodents, mosquito, snakes, mice etc.

• Dumping of discarded tires is very tough as it need larger space causing problems to the surrounding environment and neighboring place. If disposed in the environment, it will be stockpiled, causing landfilling problems with rapidly depleting the available sites for solid waste disposal.

Fig 1.2: burning tires causing toxic pollution

2. LITERATURE REVIEW

1. A study on “Wastetyre crumb rubber particle as a Partial Replacement to Fine Aggregate in Concrete” by Wakchaure M, Mr.Chavan P. A (2014), to research the reinforced concrete column with squander tire rubber tiny piece of unique dimension and percentages by taking the concrete compressive strength 24 N/mm2 and 28 N/mm2 .Therefore it is concluded that higher substance of squander tyre crumb rubber dimension in concrete increment of

workability . The use of squander tire crumb rubber dimension supplant to fine aggregate in concrete at 0.5 % and 1.0% it was observed that, there was no effect on compressive , flexural and split tensile strength of concrete when compare with similar normal concrete mix.

2. A study on "Partial Replacement of fine Aggregate in Self-Compacting Concrete using Crumb Rubber" by Aneetta. J and Fathima Saleem, (2019), this study enhances the perception of the substance properties of self-compacting concrete through research laboratory testing to propose the best dimension and extent of crumb rubber. Hence it is concluded that as the percentage of squander rubber increment, flexural strength will be higher and Compressive strength is lower as the percentage of squander rubber increases. Crumb rubber here is add up 15% and 20%.

3.A study on "Crumb Rubber in Concrete—The Barriers for Application in the Construction Industry" by Patricia Kara De Maeijeret (2021), this aim to conduct a comprehensive literature survey to summarize the experienced of crumb rubber concrete application of concrete in the last 30 days. It shows the certain gaps prevent obtaining a coherent overview of both mechanical behaviour and environmental impact of crumb rubber concrete. Hence, it is concluded that Alternative material to replace natural aggregate and Crumb rubber concrete (CRC).

2.1OBJECTIVES

The process requires a broad laboratory for studying the extent of crumb rubber in the preparation of rubberized concrete. The motive of the research is to know the strength behavior that is change in compressive strength, and Split tensile strength of concrete rubberized with variation of percentage of rubber crumb along with the utilization of coal ash as a mineral admixtures.

• To regulate the Engineering properties of Coarse aggregate, Fine aggregate and Crumb rubber.

• To evaluate the mechanical properties of Conventional concrete (CC) by using M30 grade of concrete.

• To the behavior of Modified Concrete (MC) with adding Crumb rubber of 2%, 4%, 6%, 8% and 10%.

• To evaluate Cost analysis for conventional v/s modified concrete.

• To analyze and compare the strength variation CC and MC.

3. MATERIALS AND METHODOLOGY

1. CEMENT: Cement is the commonly used construction material that has both the action and state of adhering and sticking together due to which it can make bonding and bind particles of solid matter into a compact durable solid mass. . But is used to bind sand and gravel together. Cements used in construction are usually inorganic often lime or calcium silicate. Cements manufacture cause environment impact at all stage of the process. These include emission of airborne pollution in the form of dust, gases, noise, and vibration when operating machinery and during blasting in quarries and damage to countryside. The Ordinary Portland cement of 53 grades in concrete mix is used.

Test on cement the following tests have been conducted on cement used:

1. Specific gravity
2. Normal consistency
3. Initial and Final setting time
4. Fineness test.

Table 3.1 Showing Basic properties of cement

TEST	RESULT	REFERENCE IS CODE
Specific Gravity	3.11	3.1-3.16 for OPC according to IS 4031(part 4)-1998
Normal consistency	28%	22-30% according to IS:4031(part 4)-1998
Initial setting time	30min	Should not be less than 30 min according to IS 4031(part 4)-1998
Final setting time	10 hrs.	Should not be more than 10 hrs. (600 min)
Fineness test by sieve analysis	6.14%	IS code for finance test of cement is IS: 4031 (Part 1) – 1996.

2. FINE AGGREGATE: Fine aggregate is basically any normal sand particle that comes from the land through the mining process. Fine aggregate is the fundamental fixing in concrete that composed of natural sand . The properties of fine aggregate denseness greatly influence the hardened characteristic of the concrete.

Table 3.2: Showing Properties of fine aggregate

Test	Result	REFERENCE IS Code
Specific Gravity test	2.55	As per IS:2386(part I)-1963
Bulk density	1720	1200-1750 kg/m^3 according to IS 2386(part 3)
Sieve analysis test	2.37	2.0-4.0 according to IS:2386(part I)-1963
Bulking of sand	35%	40% according IS 2386 (part-3)

Test on fine aggregate Following are the test which is conducted on fine aggregate:

1. Specific gravity test on fine aggregate
2. Bulk density on fine aggregate.
3. Sieve analysis
4. Bulking of sand.

3. COARSE AGGREGATE: Coarse aggregate is stone which are broken into small sizes and irregular in shape. In construction work the aggregate are used such as limestone and granite or river aggregate. Aggregate which has a size bigger than 4.75 mm or which retrained on 4.75 mm IS Sieve are known as Coarse aggregate. The aggregates manufactured by machine-crushed consist of stones of various sizes whereas hand-broken aggregates consist of only single size stones

Test on Coarse aggregate the following test which are conducted on coarse aggregates are:

1. Specific gravity on coarse aggregate.
2. Impact value test
3. Crushing test
4. Flakiness index value
5. Elongation index value

Table : 3.3 Showing properties of Coarse aggregate

Test	Result	As per IS code
Specific gravity test	2.72	2.5-3.0 according to IS:2386(part I)-1963
Impact value test	26.86%	20-30% according to IS: 9377:1979
Crushing strength test	10.77%	According to IS: 9377:1979
Flakiness test	11.54%	According to IS:2386(part I)-1963
Elongation test	28.9%	According to IS:2386(part I)-1963

4.CRUMB RUBBER: Crumb rubber is a polymer which is recycled from the waste tire of trucks and other vehicles. The fibre and coil is removed from the tire separately and it is grind and shredded into a required mesh and size. The crumb rubber is utilized in concrete as a partial replacement to fine aggregate to produce rubber concrete. The crumb rubber and comparison to fine aggregate it has lower specific gravity it is less attracting to moisture, strength and resists deformation. Crumb rubber is hydrophobic materials which withstand water and capture air into its surface. It also has a different gradation compared to fine aggregate which falls below the lower limit of the curve in particle size analysis. Partial replacement of fine aggregate with crumb rubber in rubber concrete is generally taken by volume of the materials due to the lower specific gravity of crumb rubber rather than fine aggregate.

Table 3. 4 showing chemical composition of crumb rubber

Major rubber component	Value %
Ash content	5.11
Polymer analysis	SBR
Volatile matter	0.56
Carbon black content	28
Acetone extract	9.6
Hydrocarbon content	56

5. FLYASH: Fly ash is described as the finely remaining part that forms from the blazing of squash coal that can be used to imply the characteristic of rubberized concrete in terms of durability and workability. Fly ash consists primarily of oxides of silicon, aluminium iron and calcium. Magnesium, potassium, sodium, titanium, and sulphur are also present to a minimum amount.

4. TEST AND TEST RESULTS

Mix proportioning of Concrete blend configuration is a method of picking reasonable part of mix and picking the relative aggregates with the opinion on passing on financially as conceivable concrete of definite base properties, noticeable accommodation, quality and quality. For this examination it is agreed to use the M30 Grade of concret. The mix calculation is done as pe the Indian standard code “IS 10262-2019”.

4.1 STIPULATIONS FOR PROPORTIONING

a)Grade designation: M30
b) Type of cement: OPC 53 grade as per IS 8112
c) Maximum nominal size of aggregate: 20mm
d) Minimum cement content: 320 kg/m3
e) Maximum water-cement ratio: 0.45
f) Workability: 100mm slump
g) Exposure condition: mild
h) Degree of supervision: good
i) Maximum cement content: 450 kg/m3
j) Type of aggregate: Crushed angular aggregate

5. EXPERIMENTAL ANALYSIS: This study focuses on understanding the effectiveness of curing and drying method and investigates variety of mix proportions in order to achieve the ultimate strength of crumb rubber concrete with low density. Hence it is planned to test on crumb rubber concrete with varying quantity of crumb rubber adding to aggregates with variation of compressive strength and split tensile test.

- For each mix mentioned above, 3 cubes each were casted for 3, 7, 14 and 28days curing.
- Cylinders be casted for every mix for 28 days.
- Curing was done at normal room temperature.
- Cube testing was done by using Compression Testing Machine (CTM).

5.1 PREPARATION OF SPECIMENS

1. The mix proportions of M30 have been used and the same has been adopted in our study.

2. Normal concrete mix proportion of M30 was made provision with water cement ratio of 0.45.These cubes and cylinders were checked and tested after curing of 3 days, 7 days , 14 days and 28 days.

3. The results were used for comparing the results of different mixes with replacement of cement, fly ash, fine aggregate and crumb rubber.

4. Crumb rubber concrete mixes were prepared with a water cement ratio of 0.45 with crumb rubber, fly ash cement and aggregates for mix proportions.

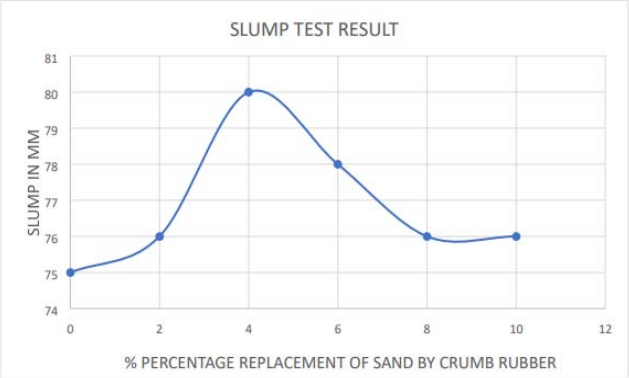
5. The fresh mixes are used for casting cubes. The cubes or cylinders were tested after curing of 3, 7, 14, and 28 days. The obtained results are compared with results of conventional concrete.

5.2 Test done on Crumb rubber concrete:

1. Workability Test: Slump cone test is done for checking the workability of M30 grade concrete.

Showing Workability test results

Crumb rubber %	Fly ash %	Height of mould H1 (mm)	Height of subsided concrete H2 (mm)	Slump = H1-H2 (mm)
0%	0%	300	225	75
2%	5%	300	224	76
4%	5%	300	220	80
6%	10%	300	222	78
8%	10%	300	224	76
10%	10%	300	224	76

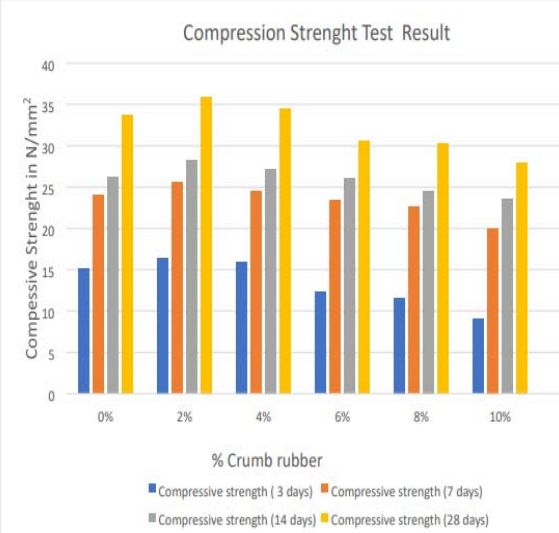


2. Compression Test:

Compressive test on cubes

Showing Compressive Strength test results

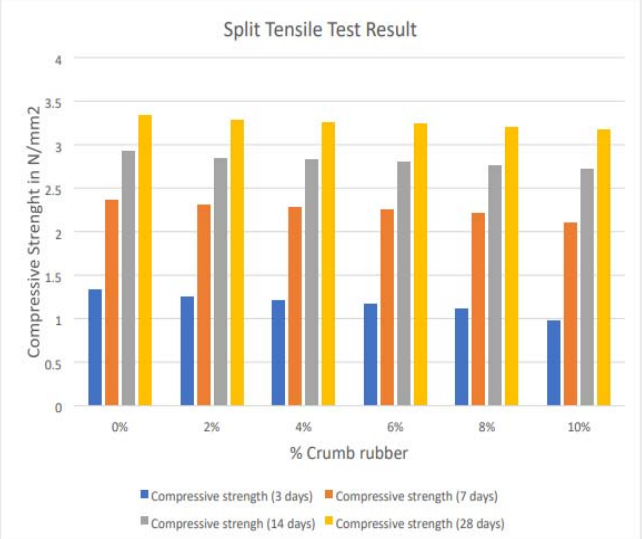
Crumb rubber %	Fly ash %	Compressive strength for 3 days N/mm²	Compressive strength for 7days N/mm²	Compressive strength for 14days N/mm²	Compressive strength for 28days N/mm²
0%	0%	15.43	24.01	26.21	33.72
2%	5%	16.44	25.59	28.25	35.97
4%	5%	15.91	24. 45	27.16	34.49
6%	10%	12.26	23.34	26.0	31.55
8%	10%	11.55	22.56	24.56	30.53
10%	10%	11.21	21.23	24.01	30.11



3. SpiltTensile Strength

Showing Split tensile strength test result

Crumb rubber %	Fly ash %	Split tensile strength for 3days N/mm²	Split tensile strength for 7days N/mm²	Split tensile strength for 14days N/mm²	Split tensile strength for 28days N/mm²
0%	0%	1.33	2.36	2.93	3.34
2%	5%	1.25	2.31	2.85	3.28
4%	5%	1.21	2.28	2.83	3.26
6%	10%	1.17	2.25	2.81	3.25
8%	10%	1.12	2.22	2.76	3.21
10%	10%	1.09	2.10	2.72	3.18



6. CONCLUSION

• The purpose of this experimental study is to identify the performance of a crumb rubber concrete in terms of compressive strength and split tensile strength.

• The greatest demand in this century is pollution free environment for which crumb rubber concrete is the solution in terms of construction industry.

• The rubberized concrete is relatively less consumption of the raw materials, durability, high resistance to freezing and thawing, hydrophobic materials, innovative technology and relative cost effectiveness, so crumb rubber concrete is a sustainable concrete.

• Based on the results it is seen that the compressive strength for rubber crumb concrete is increase for 2% of CR and 4% of Flyash for 28 days of curing.

• The compressive strength test of modified concrete of 6%, 8% and 10% is loss up to 10%.

• From the investigation it is observed that the split tensile test for hardened modified concrete was decrease about 4.7% when sand is substitute by crumb rubber of 2%, 4%, 6%, 8% and 10%.

• The concrete mixed with higher percentage of rubber crumb possess low workability that is with the higher in percentage of rubber the concrete workability decrease. It was seen that the slump value decrease about 2%.

• Based from the investigation the crumb rubber is relatively low effective cost when compared to the natural fine aggregate and it is more beneficial.

• The used of rubber crumb concrete can impart the performance of concrete, decreasing the dead weight and highly durable.

• Rubberized concrete can be utilized in roads as a binder as it highly absorbs vibration and also in non- load bearing structure where load is minimum.

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