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Experimental Investigation on Effect of Fly ash and Rubber in Concrete

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Abstract: This project presents the experimental investigation on the study of effect of Fly ash and rubber in concrete. Tire rubber aggregates are obtained from waste tires using two different technologies: mechanical grinding at ambient temperature or cryogenic grinding at a temperature below the glass transition temperature. Fly ash increases in strength over time, continuing to combine with free lime. Increased density and long-term pozzolanic action of fly ash, which ties up free lime, results in fewer bleed channels and decreases permeability. The rubberized concretes are affordable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. This experimental work investigates the impact of substituting part of the conventional aggregates with rubber aggregates and also by substituting part of the cement with fly ash on certain characteristics of the cement concretes.

Keywords: Fly Ash, Rubber in concrete, Compressive strength.

I. INTRODUCTION

In recent years, light weight concrete composite has become more popular constructional material owing to low density, reduction of dead load and low handling costs. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, size and proportions of mix method of compaction and curing. The adoption of light weight concrete gives an outlet for industrial waste such as scrap rubber tires, flash, clinkers etc. which otherwise creates problem for disposal of waste. Scrap tire rubber and flash are two major industrial wastes which are accumulating in huge volume every year. Disposal of these organic and inorganic wastes is a serious problem due to severe environmental problems. With the development of technology, construction industry has opened a gateway for handling these industrial wastes. Recycling of non-degradable wastes, particularly discarded rubbers tire has become a major issue since these materials have been banned from landfills and also incineration of these wastes is not environmentally friendly. Previous investigations also show that concrete composites containing tire rubber waste are known for their high toughness, meaning that they are specially recommended for concrete structures located in areas of severe earth-quake risk and also for the production of railway sleepers. Although the studies about the properties of concrete with tire rubber wastes are abundant the ones related to the durability are scarce justifying further investigations. Besides, so far investigations using rubber wastes were made using normal-strength concretes.

II. MATERIALS DESCRIPTION AND THEIR PROPERTIES

2.1 CEMENT:-

The cement used in this experimental investigation is ordinary Portland cement - Jaypee brand 43 grade. Storage of cement requires extra special care to preserve its quality and fitness for use. To prevent its deterioration, it is necessary to protect it from rain, winds and moisture.

2.2 TESTS ON CEMENT:-

Standard consistency of cement is defined as that water content at which the needle of the apparatus fails to penetrate the specimen by 5mm from bottom of the mould.

Table1. Approximate Oxide Composition Limits of Ordinary Portland Cement

OXIDE	PER CENT CONTENT
CaO	60-67
SiO_2	17-25
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-6.0
MgO	0.1-4.0
Alkalies (K_2O, Na_2O)	0.4-1.3
SO_3	1.3-3.0

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Standard Consistency of the cement paste = 30%.
Initial Setting Time of Cement = 45min.
Weight of cement taken in the mould = 400gms.

Table 2. Depth of penetration of needle with water content

A. WATER CONTENT (%)	B. DEPTH OF PENETRATION FROM BOTTOM (mm)
C. 28	D. 10
E. 30	F. 5

2.3 SPECIFIC GRAVITY

The specific gravity of cement is the ratio of the weight of a given volume of substance to the weight of an equal volume of water. It is a mere number and it denotes how many times a substance is heavy as water.
Weight of bottle (w1) = 59gm
Weight of bottle + water (w2) = 161gm
Weight of bottle+ kerosene (w3) = 132gm
Weight of bottle+ kerosene+ cement (w4) = 170gm
Weight of cement (w5) = 50gm

$$\text{Specific gravity of cement} = \frac{W_5 (W_3 - W_1)}{(W_5 + W_3 - W_4)(W_2 - W_1)}$$

Specific gravity of cement is **2.98**.

2.4 FLY ASH :-

In an industrial context, fly ash usually refers to ash produced during combustion of coal. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) and calcium oxide(CaO), both being endemic ingredients in many coal-bearing rock strata.
Weight of bottle (w1) = 60gm
Weight of bottle + water (w2) = 161gm
Weight of bottle+ kerosene (w3) = 139gm
Weight of bottle+ kerosene+ fly ash (w4) =170gm
Weight of fly ash (w5) = 50gm.
Specific gravity of fly ash is **2.1**

2.5 FINE AGGREGATES AND COARSE AGGREGATES:-

The importance of using the right type and quality of aggregates cannot be overemphasized. The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 5 mm or 4.75mm. Coarse aggregates consist of one or more combination of gravels or crushed stone with particles predominantly larger than 5 mm or 4.75mm and generally between 9.5 mm and 37.5 mm.

Table 3. Properties of fine aggregate

G. SL. No.	H. CHARACTERISTICS	I. VALUE
J. 1	K. Type	L. Uncrushed
M. 2	N. Specific gravity	O. 2.74

Table 4. Properties of coarse aggregate

P. SL. NO	Q. CHARACTERISTICS	R. VALUE
S. 1	T. Type	U. Crushed
V. 2	W. Specific gravity	X. 2.74
Y. 3	Z. Crushing value	AA. 23.54%
BB. 4	CC. Impact value	DD. 29.90%

2.6 WATER :-

Water to be used in the concrete work should have following properties:-

- It should be free from injurious amount of soils.
- It should be free from injurious amount of acids, alkalis or other organic or inorganic impurities.
- It should be free from iron, vegetable matter or any other type of substances, which are likely to have adverse effect on concrete or reinforcement.
- It should be fit for drinking purposes.

2.7 WASTE TYRE RUBBER

About 30 cm long waste tyre rubber pieces are obtained from local market; the pieces were cleaned with soap water and rinse with clean water. After drying under sun at open place, both faces of the tyre pieces were rubbed with hard wire brush to make surfaces as rough as can be done by hand. The source of the rubber aggregate is recycled tyres which were collected from the local market. For uniformity of the concrete production and convenience, all the tires collected are from bike tyres. The reason for choosing these bike tyres is that they can give the required shape and size which is similar to the common natural gravel. This study has concentrated on the performance of

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a single gradation of rubber prepared by manual cutting. The maximum size of the rubber aggregate was in the range of 12mm to 20 mm as shown in Figure. The rubber aggregates used in the present investigation are made by manually cutting the tire in to the required sizes.

- Water absorption = 0.8%
- Finess modulus = 7.764
- Specific gravity = 1.187
- Flakiness index= 85%
- Elongation index = 100%

III. MIX PROPORTION

Mix design is the process of selection of suitable ingredients of concrete and to determine their properties with object of producing concrete of certain maximum strength and durability, as economical as possible. The purpose of designing is to achieve the stipulated minimum strength, durability and to make the concrete in the most economical manner.

Table 5. Mix Proportion

EE. ement	*FF. ine aggregate*	*GG. Coarse aggregate*	*HH. W/c ratio*
II. 1	*JJ. 1.86*	*KK. 2.95*	*LL.0.5*

IV. TESTS AND DISCUSSIONS

4.1 COMPRESSIVE STRENGTH:-

This test was conducted as per IS 516-1959. The cubes of standard size 150x150x150mm were used to find the compressive strength of concrete. Specimens were placed on the bearing surface of

UTM, of capacity 100tones without eccentricity and a uniform rate of loading of 550 Kg/cm2 per minute was applied till the failure of the cube. The maximum load was noted and the compressive strength was calculated.

Table 6. Estimation of quantity of materials required for the Cubes

Different proportion Replacement	No. of cubes to be prepared	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Waste tyre rubber pieces (kg)
10/5 (10% fly ash & 5% rubber)	4	1.31	0.146	2.72	4.09	0.215
20/5 (20% fly ash & 5% rubber)	4	1.168	0.292	2.72	4.09	0.215
30/5 (30% fly ash & 5% rubber)	4	1.022	0.438	2.72	4.09	0.215
10/10 (10% fly ash & 10% rubber)	4	1.31	0.146	2.72	3.88	0.431
20/10 (20% fly ash & 10% rubber)	4	1.168	0.292	2.72	3.88	0.431
30/10 (30% fly ash & 10% rubber)	4	1.022	0.438	2.72	3.88	0.431
Total		7.51	1.75	16.32	23.91	1.938

Table 7. Estimation of quantity of materials required for the Cylinders

Different proportion Replacement	No. of cubes to be prepared	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Waste tyre rubber pieces (kg)
10/5 (10% fly ash & 5% rubber)	1	2.061	0.229	4.25	6.41	0.331
20/5 (20% fly ash & 5% rubber)	1	1083	0.458	4.25	6.41	0.331
30/5 (30% fly ash & 5% rubber)	1	1.603	0.687	4.25	6.41	0.331
10/10 (10% fly ash & 10% rubber)	1	2.061	0.2529	4.25	6.07	0.675
20/10 (20% fly ash & 10% rubber)	1	1.83	0.458	4.25	6.07	0.675
30/10 (30% fly ash & 10% rubber)	1	1.603	0.687	4.25	6.07	0.675
Total		10.98	2.748	25.5	37.4	3.036

Cube compressive strength (fck) in MPa = P/A

Where,

P= cube compression load

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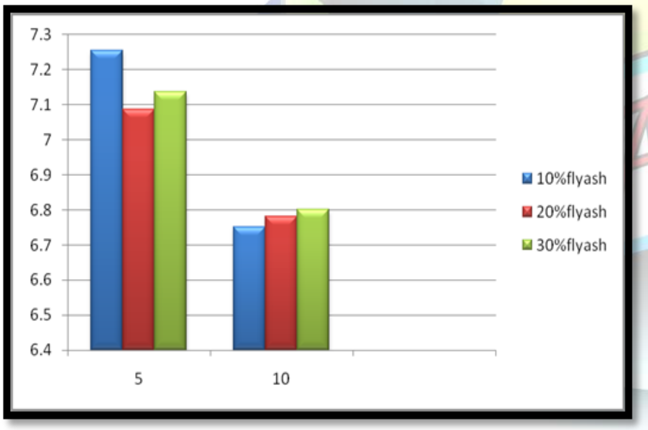
MM. Sample description	NN. Ave. Weight of cube (kg)
OO. 10/5	PP. 7.256
QQ. 20/5	RR. 7.875
SS. 30/5	TT. 7.138
UU. 10/10	VV. 6.75
WW. 20/10	XX. 6.78
YY. 30/10	ZZ. 6.8

A= area of the cube on which load is applied (= 150 x 150= 22500 mm^2)

4.2 SPLIT TENSILE TEST:-

Cylinders of size 15cm (dia) x 30cm (height) are casted. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied until the failure of the cylinder, along the vertical diameter. When the load is applied along the generatrix, an element on the vertical diameter of the cylinder is subjected to a horizontal stress of 2P/πld.



Splitting strength gives about 5 to 10% higher value than the direct tensile strength.

V. Results And Discussion

5.1 Workability:

Workability is the ability of the concrete to be easily moulded. Slump test was performed to evaluate the workability of selected mix proportion. It was observed that increasing percentage of rubber aggregates and fly ash leads to an increase in the workability. This was due to the round and uniform shape of the aggregates used in this study.

Workability was mainly affected by the shape and size of rubber, aggregates size, bonding between rubber and cement mortar and water cement ratio.

5.2 Density

Table below shows the obtained values of weight for different cube moulds which directly represents the denity of concrete specimen. Results showed that increase in rubber contents decreases the density of concrete composite. The control mix had the highest density. Effect of crumb rubber was highly noticeable on density which was due to low specific gravity of the crumb rubber as compared to fine and coarse aggregate.

Table 8. Obtained slump values

Hence it is economical to add flyash upto 30%with 10%rubber to obtain a good combination of strength and weight.

X-axis - represent rubber content in %.

Y-axis- represents density in kg/m^3

5.3 Compressive strength

Table below shows the values compressive strength values obtained which represents the influence of rubber contents and fly ash on compressive strength of mix concrete composite. Compressive strength of mix concrete composite reduced significantly with increase in rubber content and fly ash. Concrete strength mainly depends on the bonding between cement and aggregates, size and hardness of aggregates.

Table 9. Compressive strength of mix concrete composite

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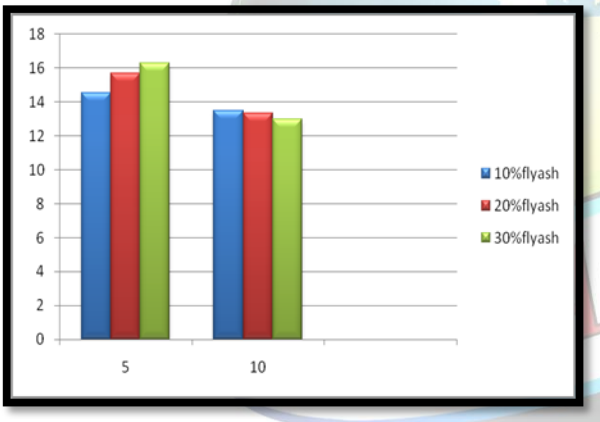
Sl no	Sample description	Load (KN)	7 days Compressive strength (N/mm²)	Load (KN)	28 days Compressive strength (N/mm²)
1	10/5	216.2	9.609	327.6	14.56
2	20/5	232.65	10.34	352.575	15.67
3	30/5	241.605	10.74	366.075	16.27
4	10/10	200.475	8.91	303.75	13.5
5	20/10	197.75	8.79	299.925	13.33
6	30/10	193.05	8.58	292.5	13



For the above tabulated values,
The graph chart below is plotted to show the behavior of sample in compressive strength with different proportion of rubber and fly ash.

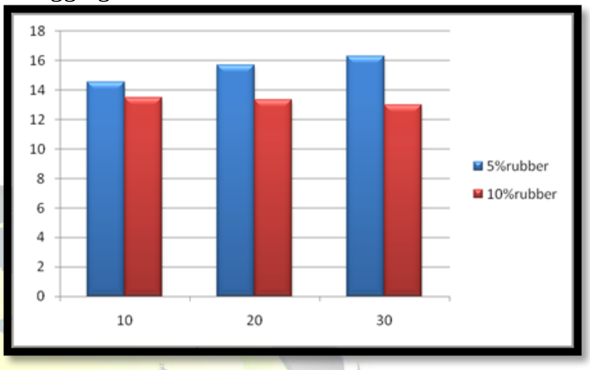
a) Behavior of compressive strength due to variation in rubber content when flyash content is kept constant.
b) Behavior of compressive strength due to variation in flyash content when rubber content is kept constant.

From the above behavior in compressive strength, it can be concluded that:

- When rubber content is kept constant and flyash is varied, it can be observed that decrease in strength is lesser.
- In the way, for vice a versa case, reduction in strength is more.

In the present experiment conducted, the sample with 30% flyash and 5 % rubber shows the greater strength when compared to the other samples. This is because lower content of rubber and higher of flyash.

5.4 Split tensile strength
Table below shows the obtained values of split tensile strength of sample. Which is of lower when compared to conventional concrete. Due to the lower bonding between the aggregates and rubber.



X-axis represents sample cube with different proportion of flyash and rubber in %
Y- axis represents the compressive strength values in N/mm^2.

Table 10. split tensile strength of sample

Sl no	Sample Description	Load (KN)	Split tensile strength (N/mm2)
1	10/5	198.7	1.405
2	20/5	217.6	1.53
3	30/5	186.1	1.316
4	10/10	198.1	1.40
5	20/10	205	1.449
6	30/10	191.7	1.35

The split tensile strength of conventional concrete varies approximately from 1.4 - 2.1 N/mm^2.

1. At 7 days:-

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Different proportion	Expected Conventional concrete strength (N/mm^2)	Partially replaced Fly ash and rubber concrete strength (N/mm^2)	Percentage of expected conventional concrete strength (%)	Partially replaced Fly ash and rubber concrete strength (%)	Difference in percentage reduction (%)
10/5	13.33	9.61	66.67	48.1	18.57%
20/5	13.33	10.34	66.67	51.7	14.97%
30/5	13.33	10.74	66.67	53.7	12.97%
10/10	13.33	8.91	66.67	44.5	22.17%
20/10	13.33	8.79	66.67	43.9	22.77%
30/10	13.33	8.58	66.67	42.9	23.77%

2. At 28 days:-

Different proportion	Expected Conventional concrete strength (N/mm^2)	Partially replaced Fly ash and rubber concrete strength (N/mm^2)	Percentage of expected conventional concrete strength (%)	Partially replaced Fly ash and rubber concrete strength (%)	Difference in percentage reduction (%)
10/5	20	14.56	100%	72.8%	27.2%
20/5	20	15.67	100%	78.35%	21.65%
30/5	20	16.27	100%	81.35%	18.65%
10/10	20	13.5	100%	67.5%	32.5%
20/10	20	13.33	100%	66.65%	33.35%
30/10	20	13	100%	65%	35%

VI. CONCLUSION

From the above graph, it can be seen that the sample (20/5) with 20% of fly ash and 5% of rubber shows the greater value. hence it can be concluded that for lower rubber content and medium fly ash content gives the higher split tensile strength.