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STUDIES ON EFFECT OF FLY ASH, RICE HUSK ASH AND CRUSHER DUST ON STRENGTH OF CONCRETE

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Abstract: In this work, strength properties of concrete have been assessed by partially replacing cement with Fly ash(FA) and Rise husk ash(RHA) and complete replacement of sand with crusher dust as fine aggregate. These ingredients are already environmental pollutants, and their utilization in concrete not only save the material but also can solve the problem of their disposal and environmental pollution. Using these alternate waste materials as admixtures in concrete, cubes, cylinders and prisms were casted and tested for compressive strength, split tensile strength and flexural strength. Initially six trails were conducted by partially replacing sand with crusher dust as fine aggregate starting from 0% to 100% with the gradual increase of 20% for each trail and observed that the maximum strength was occurred at 100% replacement of fine aggregate with crusher dust. Now keeping this as constant, cement is partially replaced with FA and RHA. The proportion form for FA and RHA in cement replacement is 30% FA and 0% RHA and the last proportion taken as 0%FA and 30%RHA, with gradual increase of RHA by 5% and simultaneously gradual decrease of FA by 5%. In the above conducted trails the crusher dust has been used with and without sieving separately. About 27% increase in the compressive strength is found when the cement content is decreased to 70% and remaining 30% is replaced with fly ash. When the 30 % of the void again is divided between the fly ash and rice husk ash as 25 % and 5 % respectively, the increase in compressive strength is increased about 32%. It was observed that crusher dust when sieved has a good potential when used as fine aggregate in concrete construction
Keywords: Concrete, partial replacement, Fly ash, Rice Husk ash, Crusher dust

I. INTRODUCTION

Waste disposal is one of the major problems being faced by all the nations across the globe. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive. The increasing scarcity of raw materials leads to usage of economically alternative materials in its production. This requirement has drawn the attention of investigators to explore new replacements of ingredients of concrete with industrial wastes to protect the environment against pollution. In this study an attempt has been made to use industrial waste in a useful manner and provide safeguard to the environment by utilizing waste properly. The spiralling costs of river sand used as fine aggregate in concrete have increased the cost of construction significantly. The increase in cost of river sand is due to dwindling natural resources coupled with the restrictions imposed by government on sand quarrying. These problems have led to the search for alternative materials for fine aggregates that are eco- friendly besides being in expensive. Crusher dust available abundantly from crusher units at a low cost in many areas provides a viable alternative for conventional river sand. Use of crusher dust does not only reduce the cost of construction but also helps reduce the impact on environment by consuming the material generally considered as waste product. Concrete, typically composed of gravel, sand, water, and Portland cement, is an extremely versatile building material that is used extensively worldwide. Increase in construction activities have led to an increase in demand for the various raw materials in concrete, especially river sand which is the conventionally used fine aggregate. Due to increase in mining process, the availability of this river sand is becoming scarce. This problem has led to the search for alternative materials for fine aggregates that are eco- friendly besides being in expensive. Crusher dust available abundantly from crusher units at a low cost in many areas provides a viable alternative for conventional river sand. Use of crusher dust does not only reduce the cost of construction but also helps reduce the impact on environment by consuming the material generally considered as waste product. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. Unfortunately, significant environmental problems result from the manufacture of Portland cement due to the calcinations of limestone and combustion of fossil fuel. It releases carbon dioxide in the order of one ton for every ton of OPC produced. Attempts to reduce the use of Portland cement in concrete are receiving much attention due to environment related issues. The OPC can be replaced with industrial wastes like fly ash and RHA. Fly ash is a by product of burned coal from power station. Most fly ash is pozzolanic, which means it's a siliceous or siliceous-and-aluminous material that reacts with calcium hydroxide to form cement. When Portland cement reacts with water, it produces a hydrated calcium silicate (CSH) and lime. The hydrated silicate develops strength and the lime fills the voids. Properly selected fly ash reacts with the lime to form CSH–the same cementing product as in Portland cement. This reaction of fly ash with lime in concrete improves strength. RHA is by product of paddy industry. India is a major producer of paddy, among it Andhra Pradesh is the second largest producer of paddy. Disposal of RHA is a major problem due to its lightweight and hazardous to human life if they inhale. Considerable efforts are being taken worldwide to utilize these industrial wastes as supplementary cementing materials to improve the properties of cement concrete. The main objective of this study is to assess the characteristics strength of M25 grade concrete by partially replacing cement with fly ash and RHA and complete replacement of sand with crusher dust as fine aggregate. From the past studies the maximum strengths were in between the ranges of 25%flyash+ 5%RHA and 20%flyash+ 10%RHA in cement replacement. Considering these proportion forms in cement replacement, fine aggregate is replaced with crusher dust from 0% to 100% with gradual increase of 20% for each trail and observed that the strength is maximum for 100% replacement of fine aggregate with crusher dust. Now keeping this constant 30% cement is replaced with fly ash and RHA. The proportion form for fly ash and RHA in cement replacement is 30%flyash and 0%RHA and the last proportion taken as 0%FA and 30%RHA, with gradual increase of RHA by 5% and simultaneously gradual decrease of FA by 5%. Indian standard recommended method IS: 10262-1982 was adopted for concrete mix design of grade M25.Cubes of size 150mm× 150mm× 150mm, cylinders of size 150mmØ × 300mm and prisms of size 100mm× 100mm× 500mm were casted and tested for compressive strength, split tensile strength and flexural strength after the completion of respective curing periods.

II. METHODOLOGY

2.1 OBJECTIVE OF THE PROJECT:

The Experimental investigation is planned as under.

1. To find the properties of the materials such as cement, fly ash, rice husk ash, sand, crusher stone dust, coarse aggregate, water
2. To obtain Mix proportions of OPC concrete for M25 by IS method (10262-2009).
3.To assess the concrete properties by partially replacing cement with fly ash and RHA and complete replacement of fine aggregate with crusher stone dust.
4.The concrete specimens such as cubes, cylinders, and prisms for flexural strength were casted and cured for 7days and 28days.
5.To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.
6.To evaluate and compare the results.
7. To use industrial waste in a useful manner.
8.To provide economical construction materials
9. To safeguard the environment by utilizing waste properly.

2.2 MATERIAL PROPERTIES:

The materials used in the experimental work namely cement, fly ash, RHA, fine aggregate, crushed stone dust, and coarse aggregate (passing through 20mm and retained 10mm sieve was used) have been tested in laboratory for use in mix designs. The details are presented below.

CEMENT

Ordinary Portland cement of 43 grade (Parashakthi) was used in this investigation.

The details of tests conducted on cement are described below.

Specific gravity of cement

Specific gravity of the cement is calculated by using Le-Chatlier's flask method or by density bottle method.

Cement specific gravity: 3.15

Fineness test on cement

Fineness test on cement can be calculated by sieve test or air permeability method, in commercial cement it is suggested that there should be about 25 to 30 % of particles less than 7 microns in size.

Fineness of test cement: 92%

Initial and final setting time test on cement

Initial and final setting time test on cement is obtained by vicat's apparatus, for the initial setting time of the cement vicat's needle should penetrate to a depth of 33 to 35mm from the top, for final setting time the vicat's needle should pierce through the paste more than 0.5mm. We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988.

Initial setting time of test cement: 90 mins

Final setting time of test cement: 3 hrs 30 mins (210 mins)

Standard consistency test

The Standard consistency test of a cement paste is defined as that consistency which will permit vicat's plunger having the 10mm diameter and 50mm length to penetrate to a depth of 33 to 35 from the top of the mould. The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988.

Standard consistency of test cement: 33%.

FLY ASH

The fly ash used in the test was a low calcium class F fly ash with a typical chemical composition of as given in table.1

Table 1. Chemical composition of fly ash

Component	Symbol	Percentage
Silica	SiO_2	63.00
Alumina	Al_2O_3	31.50
Ferric Oxide	Fe_2O_3	1.79
Manganese Oxide	MnO	0.004
Calcium Oxide	CaO	0.48
Magnesium Oxide	MgO	0.39
Loss on ignition	LOI	0.71

The fly ash used in the test was obtained from National Thermal Power Corporation Ltd.,(NTPC), paravada(village), Visakhapatnam(Dist.)., A.P.,

Specific gravity of the fly ash is 2.840

FINE AGGREGATE

Aggregates smaller than 4.75mm and up to 0.075mm are considered as fine aggregate

The details of test conducted on fine aggregate are described

below.
Specific gravity
The specific gravity of fine aggregates is 2.504
Fineness modulus
The standard definition of fineness modulus is as follows: "An empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100." Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963. A set of IS Sieves of sizes – 80mm, 40mm, 20mm, 16mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm. Up to 80 mm to 4.75 mm IS sieves used for coarse aggregate analysis and from 4.75 mm to 150 µm IS sieves used for analyze fine aggregates.
Sieve Analysis of Fine Aggregate
Fineness Modulus = W1/100 = 251.3/100 = 2.513
SAND BELONGS TO ZONE – III
CRUSHER DUST
Specific gravity
Specific gravity of crusher dust is 2.60
Fineness modulus of crusher dust:
Crusher dust directly from quarry was not confirmed to any zone of IS 383-1970.
Sieve analysis of crusher dust with sieving:
Fineness modulus of crusher dust: W_2/100=298/100=2.98
CRUSHER DUST BELONGS TO ZONE= II

COARSE AGGREGATE
Aggregates greater than 4.75mm are considered as coarse aggregate.
Specific Gravity
The specific gravity of coarse aggregate is 2.7
Fineness Modulus of Coarse Aggregate
Sieve Analysis of Coarse Aggregate
Fineness Modulus = W_3/100=716.65/100=7.17

2.3 IS CODE METHOD OF MIX DESIGN (IS 10262-1982)

Table 2.Design Procedure and Calculation for M25 grade concrete

(a)	Characteristic compressive strength required in the field at 28 days	25 N/ mm^2
(b)	Maximum size of Aggregate	20mm
(c)	Degree of Workability (assumed)	0.9 compaction factor
(d)	Degree of quality control(assumed)	Good
(e)	Type of exposure	Severe
(f)	Minimum cement content	250kg/m^3
(g)	Minimum water cement ratio	0.5
(h)	Maximum cement content	450kg/m^3

Table 3.Test Data for Materials:

(a)	Cement used	OPC 43 Grade
(b)	Specific Gravity of Cement	3.15
(c)	Specific Gravity of Coarse Aggregate Fine Aggregate	 2.70 2.504
(d)	Sand corresponds to Zone	III
(e)	Target mean strength of concrete	25+1.65×4.3 = 32.1N/mm^2

Selection of water cement ratio
The free water cement ratio required for the target mean strength of 32.1N/mm^2 is 0.44. This is lower than the maximum value of 0.5 prescribed for 'severe' exposure in table-5 of IS 456,
Selection of water and sand content
For 20mm nominal aggregate and sand conforming to grading Zone- II, Water content per cubic meter of concrete = 186kg
Percentage of sand = 35%
For change in values in water- cement ratio, compacting factor and sand belonging to zone – III, the following adjustment is required.
Therefore required sand content as percentage of total aggregate by absolute volume =35-4.7= 30.3%
Adjusted water content = 186+ 186× (3/100) = 191.58kg
Cement content = (191.58/ 0.44) = 435.40kg> 250(minimum cement content)
Determination of fine aggregate
$V = [W + (C/S_c) + (1/p) x (f_a/S_{fa})] x 1/1000$
$0.98 = [191.58 + (435.40/3.15) + (1/0.303) x (f_a/2.504)] x (1/1000)$
$F_{a =}$ 493.32kg
Determination of coarse aggregate
$V = [W + (C/S_c) + (1/p) x (C_a/S_a)] x 1/1000$
$0.98 = [191.58 + (435.40/3.15) + (1/0.697) x (C_a/2.7)] x (1/1000)$
C_a = 1224.48kg
Amount of water, cement, F.A and C.A as per m^3 of concrete are
Water (lts):Cement(kg):fine aggregate(kg):coarse aggregate (kg)
191.58 :435.40 : 493.32 : 1224.48
Final mix proportion by weight is:
0.44 :1 :1.13 :2.81

2.4 BATCHING, MIXING, AND CASTING OF SPECIMENS

A careful procedure was adopted in the batching, mixing and casting operations. The quantities of fine aggregate, cement and coarse aggregate were measured accurately and water was measured accurately in measuring cylinder and filled in the bucket. The fly ash, rice husk ash and cement were mixed dry to uniform colour separately. The coarse and fine aggregates were mixed thoroughly in a mixer to this mixture, the mixture of cement, fly ash and rice husk ash was added. The materials were mixed in a mixer for two minutes from the addition of water, the workability of resulting mix was found out by slump cone test. Clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in three layers.

Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould. The specimens were allowed to remain in the mould for the first 24 hours at ambient condition. After that these were demoulded with care so that no edges were broken and were placed in the curing tank.

Table 4. Proportion form of M25 grade concrete

	Water (lts/m^3)	Cement (kg/m^3)	Fly ash (kg/m^3)	RHA (kg/m^3)	Fine agg. (kg/m^3)	Crusher dust (kg /m^3)	Coarse agg. (kg/m^3)
Mix 0	191.58	435.45	-	-	493.32	-	1224.48
Mix 1	191.58	435.45	-	-	-	493.32	1224.48
Mix 2	191.58	304.82	130.63	-	-	493.32	1224.48
Mix 3	191.58	304.82	108.86	21.77	-	493.32	1224.48
Mix 4	191.58	304.82	87.5	43.13	-	493.32	1224.48
Mix 5	191.58	304.82	65.315	65.315	-	493.32	1224.48
Mix 6	191.58	304.82	43.13	87.5	-	493.32	1224.48
Mix 7	191.58	304.82	21.77	108.86	-	493.32	1224.48
Mix 8	191.58	304.82	-	130.63	-	493.32	1224.48

TESTING OF SPECIMENS FOR COMPRESSIVE STRENGTH

Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516-1959. The test results for compressive strength are presented in tables

TESTING OF SPECIMENS FOR SPLIT TENSILE STRENGTH

Concrete specimen cylinders are used to determine split tensile strength of concrete and were tested as per IS 516-1959. The test results for split tensile strength are presented in tables

TESTING OF SPECIMENS FOR FLEXURE STRENGTH

Concrete specimen beams are used to determine flexural strength of concrete and were tested by applying two point loading as per IS 516-1959. The test results for flexural strength are presented in tables

III. RESULTS AND DISCUSSION

In this section the various results obtained from the experimental investigations were presented.

3.1 EFFECT OF CRUSHER DUST PROPORTION ON COMPRESSIVE STRENGTH OF CONCRETE

The test was carried out to obtain compressive strength of M25 grade concrete. The compressive strength of concrete is tested for 7 days, 28 days, for 0%, 20%, 40% 60% ,80% and 100% replacement of crusher dust and the values are presented in tables and also graph were plotted below.

Compressive Strength of concrete for M25 with OPC + 25% FLYASH + 5% RHA

Table 5.Compressive Strength of concrete for M25 with OPC + 25% FLYASH + 5% RHA

S.NO	MIX	CRUSHER DUST %	COMPRESSIVE STRENGTH IN N/SQ MM	
			7 DAYS	28 DAYS
1	OPC + 25% FLYASH + 5% RHA	0.00	43.55	46.21
2		20.00	44.03	49.78
3		40.00	47.24	51.56
4		60.00	49.31	53.33
5		80.00	55.83	58.52
6		100.00	59.89	62.24

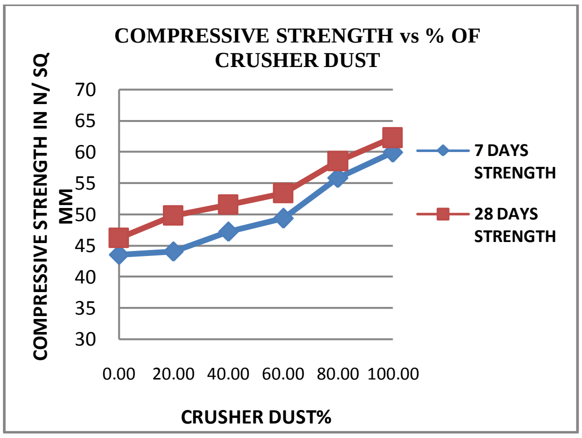

Figure 1. Graph between Compressive Strength of concrete for M25 vs % of Crusher dust

Compressive Strength of concrete for M25 with OPC + 20% FLYASH + 10% RHA

Table 6.Compressive Strength of concrete for M25 with OPC + 20% FLYASH + 10% RHA

S.NO	MIX	CRUSHER DUST %	COMPRESSIVE STRENGTH IN N/mm^2	
			7 DAYS	28 DAYS

1	OPC + 20 % FLYASH + 10% RHA	0.00	26.66	32.24
2		20.00	27.11	34.81
3		40.00	33.77	42.86
4		60.00	38.42	47.48
5		80.00	43.55	53.12
6		100.00	48.34	56.28

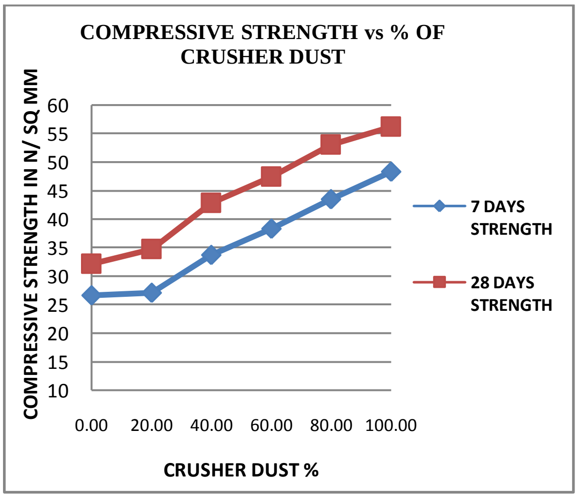

Figure 2.Graph between Compressive Strength of concrete for M25 vs % of Crusher dust

From both tables and graphs it is observed that at 100% replacement of fine aggregate with crusher dust, concrete attains its maximum compressive strength for M25 grade concrete.

However out of the two cases studied, OPC with 25% Fly ash and 5% RH A gives higher strength.

3.2 EFFECT OF VARIATION OF CEMENT ON COMPRESSIVE STRENGTH

The test was carried out to obtain the compressive strength of M25 grade concrete. The compressive strength of concrete is tested for 7 days, 28 days for different combinations. The values are presented in tables and also graphs were plotted below. The following are the different combinations used.

Table 7. Different combinations

S.NO.	MIX DESIGNATION	CONSTITUENTS
1	MIX0	100%C + 100%S+ 100%CA
2	MIX1	100%C + 100%CD+ 100%CA
3	MIX2	70%C + 30%FA + 0%RHA + 100%CD+ 100%CA
4	MIX3	70%C + 25%FA + 5% RHA + 100%CD+ 100%CA
5	MIX4	70%C + 20%FA + 10% RHA + 100%CD+ 100%CA
6	MIX5	70%C + 15%FA +15% RHA + 100%CD+ 100%CA
7	MIX6	70%C + 10%FA + 20% RHA + 100%CD+ 100%CA
8	MIX7	70%C + 5%FA + 25% RHA + 100%CD+ 100%CA
9	MIX8	70%C + 0%FA + 30% RHA + 100%CD+ 100%CA

Table 8.Compressive Strength of concrete for M25 (Crusher dust with sieving)

S. NO	MIX DESIGNATION	COMPRESSIVE STRENGTH IN N/ mm^2	
		7 days	28 days
1	MIX 0	37.55	53.8
2	MIX 1	56.44	64.89
3	MIX 2	62.9	68.32
4	MIX 3	67.81	71.24
5	MIX 4	50.22	58.66
6	MIX 5	44	51.55
7	MIX 6	49.77	52.66
8	MIX 7	37.9	45.55
9	MIX 8	35.32	38.34

Table 9.Compressive Strength of concrete for M25 (Crusher dust without sieving)

S.NO	MIX DESIGNATION	COMPRESSIVE STRENGTH IN N/ mm^2	
		7days	28days
1	MIX0	-	-
2	MIX1	46.89	63.775
3	MIX2	53.78	65.33
4	MIX3	40.88	50.22
5	MIX4	38.66	35.11
6	MIX5	35.35	44.44
7	MIX6	32.43	43.12
8	MIX7	28.44	35.12
9	MIX8	22.38	28.31

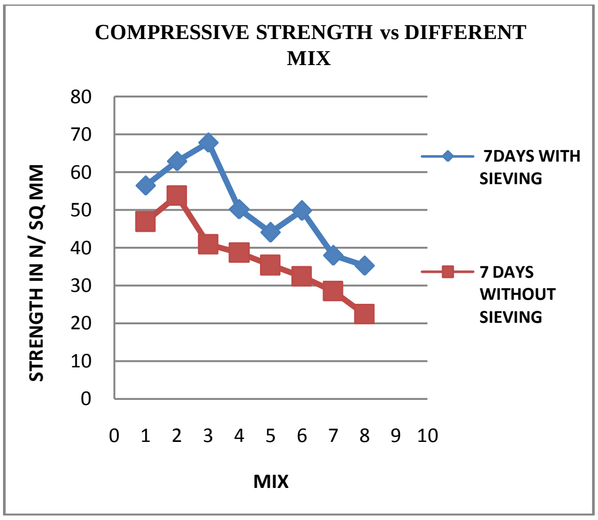

Figure 3.Graph between Compressive Strength of concrete for M25 vs different mix proportions at the age of 7days

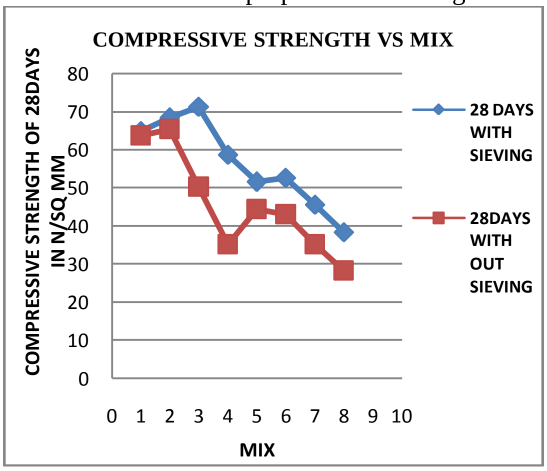

Figure 4.Graph between Compressive Strength of concrete for M25 vs different mix proportions at the age of 28days

From the above graph it is evident that the compressive strength of the Concrete both with sieving and without sieving following almost the same pattern though there is a constant offset between both. Concrete mix with sieving showed better strength than that of the one without sieving. From the Graph it is understood that the same pattern is shown for all mixes of the Concrete both sieving and without sieving. How ever, as the age increased (from 7 to 28 days), the offset between the mix with sieving and without sieving is minimized. Overall from the above tables and graphs it is observed that all the different concrete mix is achieving the target mean strength at the age of 28days. But the compressive strengths of crusher dust which is passing 4.75mm sieve and retained on 0.015mm sieve are slightly higher when compared with crusher dust used directly from quarry.

3.3 EFFECT OF VARIATION OF CEMENT ON FLEXURAL STRENGTH OF M25 GRADE CONCRETE

The test was carried out to obtain the flexural strength of M25 grade concrete. The flexural strength of concrete is tested for 28 days for different combinations. The values are presented in table and the graph was plotted below.

Table 10. Flexural Strength of concrete for M25

S. NO	MIX DESIGNATION	FLEXTURAL STRENGTH IN N/ mm^2	
		28 DAYS	28 DAYS (WOS)
1	MIX0	6.48	-
2	MIX1	7.09	6.7
3	MIX2	6.83	6.67
4	MIX3	5.85	5.83
5	MIX4	5	5.18
6	MIX5	5.46	4
7	MIX6	6.04	5.55
8	MIX7	5.7	4.63
9	MIX8	5.3	4.18

(WOS: without sieving)

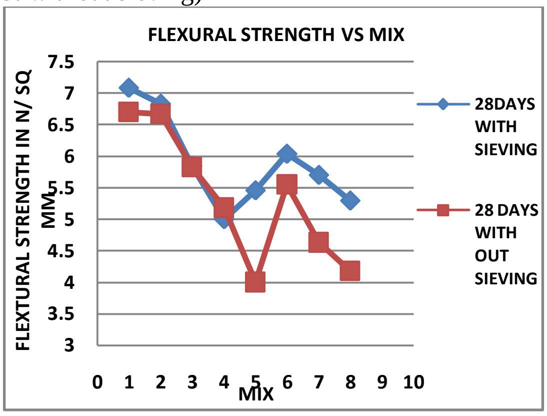

Figure 5.Graph between flexural strength of M25 grade concrete vs different mix proportions

From the graph it was clearly observed that different mix showed different strength in decreasing pattern. Mix1 and Mix2 don't have much difference in the flexural strength though the cement content is reduced by 30%. But when fly ash was replaced with the Rice husk ash the Strength started decreasing.

3.4 EFFECT OF VARIATION OF CEMENT ON SPLIT TENSILE STRENGTH OF M25 GRADE CONCRETE

The test was carried out to obtain the split tensile strength of M25 grade concrete. The split tensile strength of concrete is tested for 28 days for different combinations. The values are presented in table and graph was plotted below.

Split tensile strength of concrete for M25

From the graph shown in Figure below it was observed that not much different is showed by different mix. Just small variation is observed. Tensile strength increased when mix containing cement is replaced with fly ash. Then again when fly ash percentage is decreasing, tensile strength also decreased

Table 11. Split tensile strength of concrete for M25

S NO	MIX DESIGNATION	SPLIT TENSILE STRENGTH IN N/ SQ MM	
		28 DAYS	28 DAYS

			(WOS)
1	MIX0	3.55	-
2	MIX1	3.124	2.84
3	MIX2	4.473	3.976
4	MIX3	3.976	3.55
5	MIX4	2.911	2.84
6	MIX5	3.692	3.124
7	MIX6	3.266	3.266
8	MIX7	3.266	2.84
9	MIX8	2.84	2.26

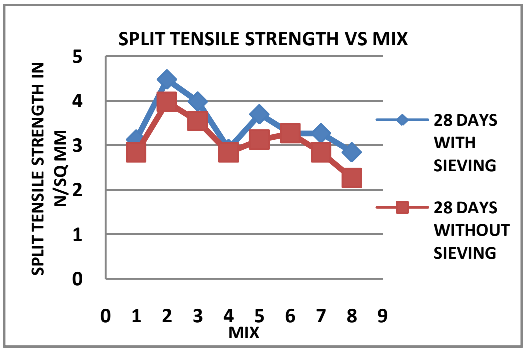

Figure 6.Graph between split tensile strength of M25 grade concrete vs different mix proportions

IV. CONCLUSIONS

From this study of comparing the properties of the concrete by varying the cement content and replacing the same with rice husk ash and fly ash, there are vital arguments to be discernible.

- Replacement of the fly ash and rice husk ash not only minuses the construction cost but also will reduce the environmental pollution as the both replacements were industrial wastes available for very low cost.
- Natural sand replacement also minimizes the construction cost and the strength of the concrete increased considerably when replace with the crusher dust.
- Concrete mix of normal composition i.e., Cement, fine aggregate and coarse aggregate is found to show inferior properties when the cement content is decreased to replace the same with fly ash. About 27% increase in the compressive strength is found when the cement content is decreased to 70% and remaining 30% is replaced with fly ash.
- When the 30 % of the void again is divided between the fly ash and rice husk ash as 25 % and 5 % respectively, the increase in compressive strength is increased about 32%.
- Sieving had a protuberant role in the compressive strength when the mix is more replaced with rice husk ash.
- Flexural strength of the concrete is found decreasing as the cement content is decreased.
- Split tensile strength showed a different reaction when the cement is replaced with fly ash and rice husk ash. When the cement is completely replaced with fly ash, tensile strength of concrete increased but the rice husk ash in the mix decreased the tensile strength.
- The rate of gaining of the strength from 7 days to 28 days also showed remarkable trend. The mix containing higher rice husk ash percent shows poor rate of increase in the attaining the 28 days strength. In contrast the mix containing high fly ash content showed similar rate of strength gaining property as that of the normal mix.

SCOPE FOR FURTHER STUDY

- Some tests related to durability and fire resistance aspect need investigations.
- Studies on replacements levels of high grade concrete can be carried out.
- The same work can be carried out by increasing the proportion form of fly ash and RHA.
- Combinations of fly ash and rice husk ash with different admixtures can be carried out.

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