International Journal of Civil, Structural and Earthquake Engineering
Vol. 01, No. 01, December 2015, pp. 09 – 16

Studies on Concrete Strength by Partial Replacement of Cement with Fly Ash & Rice Husk Ash and complete Replacement of Sand with Crusher Dust

D. PURNACHANDRA RAO[1], P. KARUNAKAR[2]

[1,2]*Department of Civil Engineering, Usha Rama College of Engineering and Technology, Telaprolu, Krishna District -521 109, A. P., India*

Email: *Purnadondapati.13@gmail.com,parla.karunakar@gmail.com*

Abstract : In this paper properties of concrete have been assessed by partially replacing cement with Fly ash and Rise husk ash and complete replacement of sand with crusher dust as fine aggregate.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. It was observed that crusher dust when sieved has a good potential when used as fine aggregate in concrete construction.

Introduction

Concrete, typically composed of gravel, sand, water, and Portland cement, is an extremelyversatile building material that is used extensively worldwide. Increase inconstruction activities have led to an increase in demand for the various raw materialsin concrete, especially river sand which is the conventionally used fine aggregate. Dueto 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.

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2. Literature Survey

Satish.et.al has studied the effect of partial replacement of cement with RHA and FA on concrete. In his investigation he started proportion form 30% fly ash and 0% RHA mix together in concrete by replacement of cement, last proportion taken %fly ash and 30%RHA, with gradual increase of RHA by 1% and simultaneously gradual decrease of fly ash by 1%. It is observed that though the strength of RHA concrete goes on decreasing after 15% addition of RHA, the composition of 10%RHA = 20% fly ash gives maximum strength results as well as shows the potential to be used as useful material for different building materials. The compressive strengths increases with the increase in percentage of fly ash and RHA up to replacement (21%flyash and 9%RHA) of cement in concrete for different mix proportions. The workability of RHA concrete has been found to decrease with increase in RHA replacement. The workability of RHA concrete has been found to decrease but fly ash increases the workability of concrete so RHA and fly ash mix together in concrete to improve the workability of concrete. The mechanical properties in terms of flexural and tensile strength have been significantly improved with the addition of RHA.

D. S. Rajendra Prasad et al This study focuses on utilization of waste Pozzuolana products such as fly ash and Rice Husk Ash (RHA) as an alternative to OPC to produce ternary blended cement with an objective to increase the optimum percentage of replacement of pozzuolana to OPC without affecting the concrete properties. CO2 curing is carried out to reduce the curing duration without affecting the compressive strength and trying to achieving the 28 days compressive strength in a short period of 18 hours. The study of CO2 cured specimens kept in air and water for 3 days, 7 days is also carried out along with comparison of the compressive strength of normal concrete. It is highly recommended to use fly ash and rice husk ashas partial cement replacement materials in concrete up to40% fly-ash and 10% rice husk ash respectively withoutlosing its original strength and other durabilityparameters of concrete. It was shown that the CO2 curingcan be effectively used as an alternate curing method andconcrete strength of 50% of normal water cured concreteat 28 days was achieved at 6 hrs CO2 curing and 12 hrs aircuring time.

Venumalagavellihas investigated the effect of partial replacement of cement with Ground Granulated Blast furnace Slag and sand with Robo sand(crusher dust) and found that by partial replacement of cement with GGBS and sand with Robo sand(crusher dust) helps in improving the strength of concrete substantially compared to normal mix concrete. Compressive strength of concrete can be improved by using admixtures. As a conclusion, Robosand can be used as alternative material for fine aggregate i.e. sand. Based on the results the compressive and split tensile strengths are increased as the percentage of robo sand increases. The GGBS can be an alternate material for cement, based on results 50%cement can be replaced with GGBS. The maximum compressive strength of concrete is achieved at the combination of 25% Robo sand (crusher dust) 50% ggbs.

3. CONCRETE MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

- The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.
- The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g., a concrete mix of inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

Table 4.5 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
Mix3	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

3.1 TESTS ON CONCRETE

There are many tests which are conducted to check the quality of concrete. These tests are basically divided into two categories

Various Lab Test on Fresh Concrete
Under these, we have the following tests

- Slump Test - Workability
- Compacting Factor And
- Vee- Bee Test

Figure 1: Fresh concrete after slump cone test

Figure 2: Compacting Factor apparatus

Figure 3: Vee-Bee consistometer

3.2MATERIAL PROPERTIES

Table 3.2.1 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

Table 3.2.2 Sieve Analysis of Fine Aggregate

IS SIEVE SIZE (mm)	WEIGHT RETAINED (Kgs)	CUMMULATIVE WEIGHT RETAINED (Kgs)	CUMMULATIVE % of RETAINED(W_1)	% of PASSING
10	-	-	-	-
4.75	0.095	0.095	9.5	90.5
2.36	0.043	0.138	13.8	86.2
1.18	0.111	0.249	24.9	75.1
0.6	0.129	0.378	37.8	62.2
0.3	0.308	0.686	68.6	31.4
0.15	0.281	0.967	96.7	3.3

Fineness Modulus=W_1/100= 251.3/100=2.513

Table 3.2.3sieve analysis of crusher dust (passing 4.75 mm and retained 0.15mm sieve)

IS SIEVE SIZE (mm)	WEIGHT RETAINED (Kgs)	CUMMULATIVE WEIGHT RETAINED (Kgs)	CUMMULATIVE % RETAINED (w_2)	CUMMULATIVE % PASSING
10	0	0	0	100
4.75	0	0	0	100
2.36	0.25	0.25	25	75
1.18	0.215	0.465	46.5	53.5
0.6	0.095	0.56	56	44
0.3	0.175	0.735	73.5	26.5
0.15	0.235	0.97	97	3

Fineness modulus of crusher dust= W_2/100=298/100=2.98

Crusher Dust Belongs To**ZONE= II**

4.RESULTS AND DISCUSSION

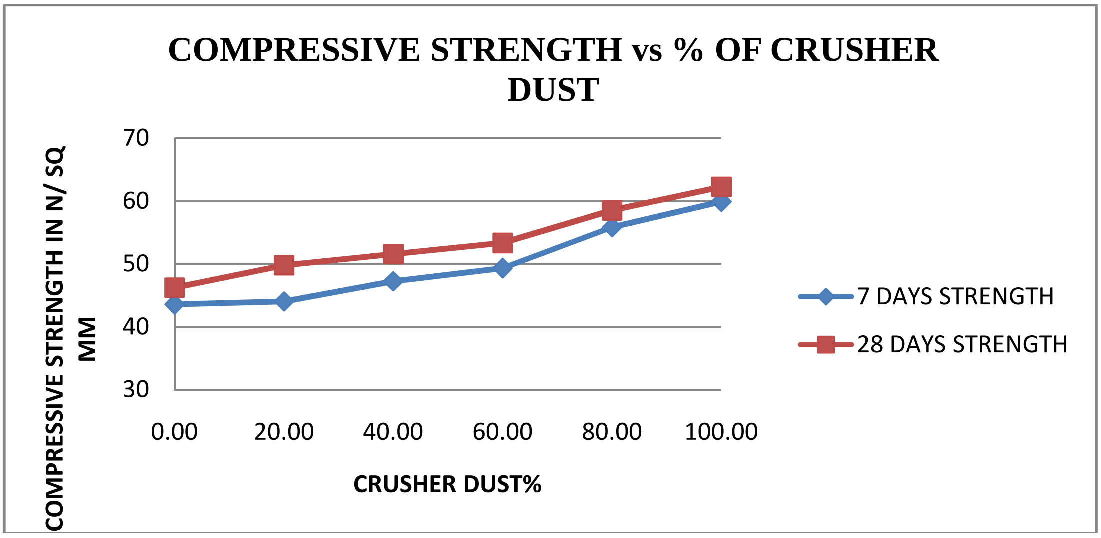
4.1 EFFECT OF CRUSHER DUST PROPORTION ON COMPRESSIVE STRENGTH OF CONCRETE

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 table no 5.1.1 and 5.1.2 and also graph were plotted below.

4.1.1 Compressive Strength of concrete for M25

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

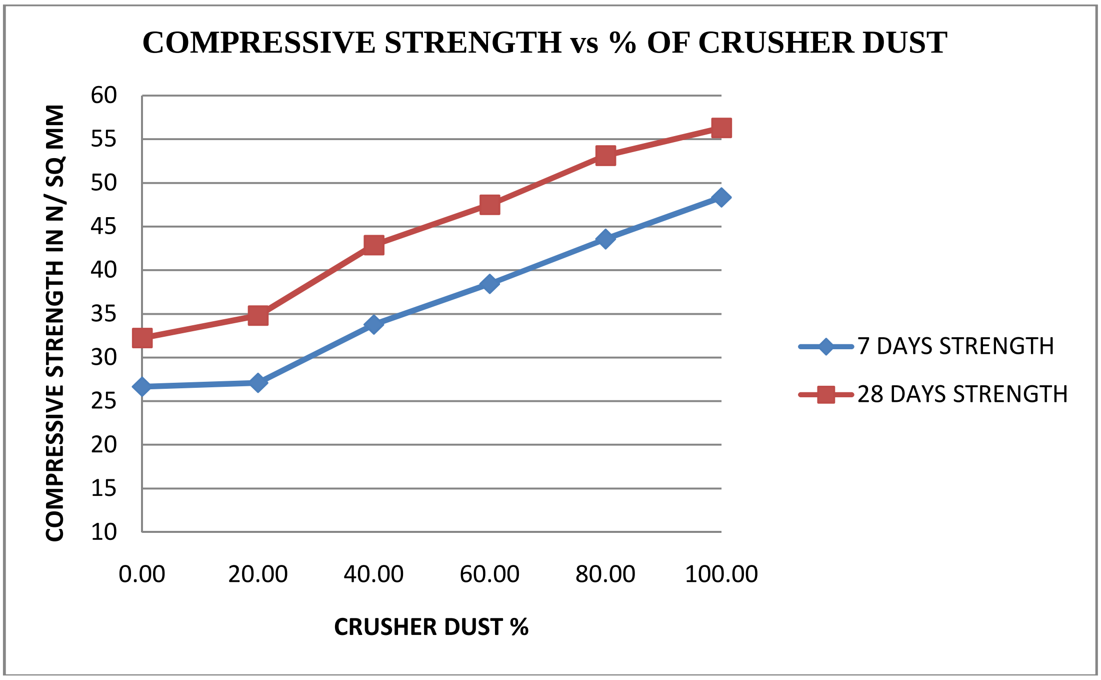
4.1.1 Graph between Compressive Strength of concrete for M25 vs % of Crusher dust



4.1.2 Compressive Strength of concrete for M25

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

4.1.2 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.

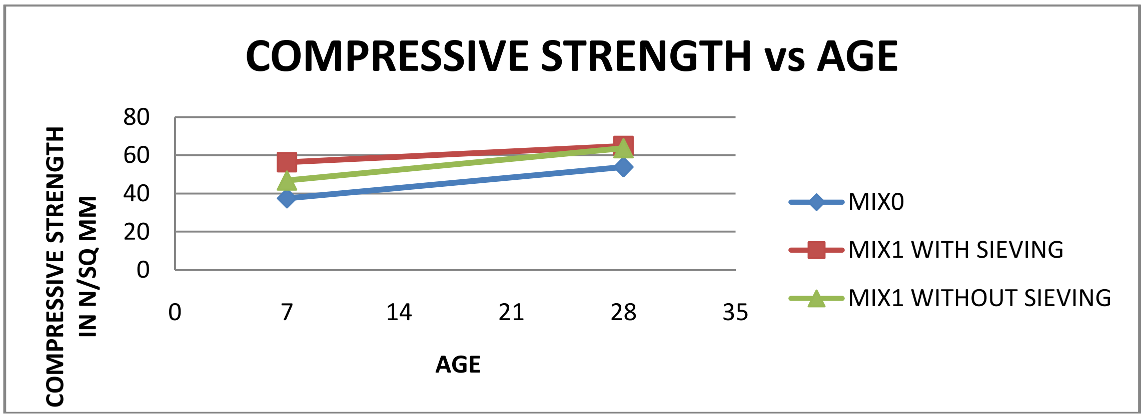
4.1.3Effect of Variation Of Cement On Compressive Strength

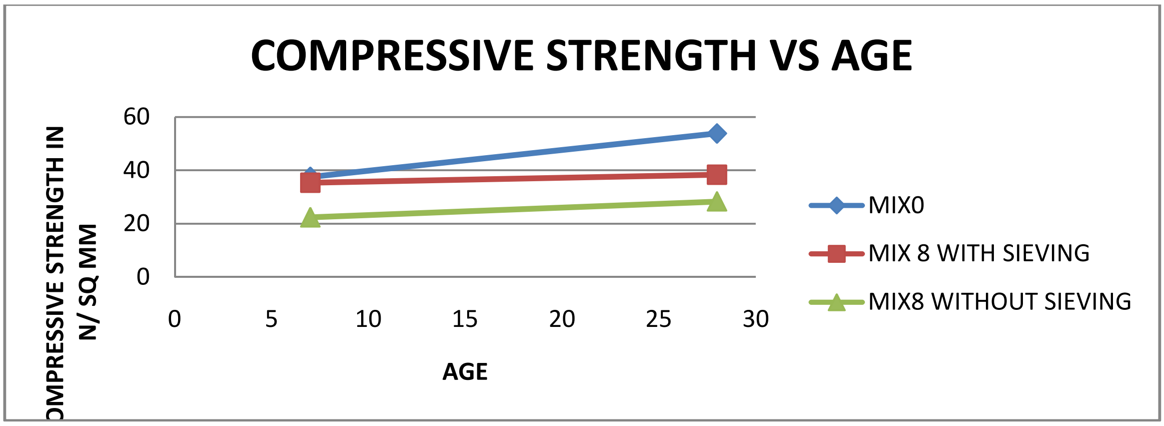
S.NO.	MIX DESIGNATION	CONSTITUENTS
1	MIX0	100%C + 100%S+ 100%CA
2	MIX1	100%C + 100%CD+ 100%CA
3	MIX2	70%C + 30%FA + 0%RHA + 100%CD+ 100%CA
4	MIX3	70%C + 25%FA + 5% RHA + 100%CD+ 100%CA
5	MIX4	70%C + 20%FA + 10% RHA + 100%CD+ 100%CA
6	MIX5	70%C + 15%FA +15% RHA + 100%CD+ 100%CA
7	MIX6	70%C + 10%FA + 20%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

4.1.3 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

4.1.4Comparing Compressive Strength Of Each Mix With The Standard Mix





5. Conclusion

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.

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