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PERFORMANCE EVALUATION FOR STRENGTH OF M30 DESIGN MIX CONCRETE WITH PARTIAL RPLACEMENT OF CONVENTIONAL INGREDIENTS IN CEMENT AND FINE AGGREGATE

KOKKILIGADDA DHANMANTRI
P.G Student, Visakha Technical Campus, Narava, Visakhapatnam.

N. CHENNA KESAVA RAO
Assistant professor, Visakha Technical Campus, Narava, Visakhapatnam.

E.V. RAGHAVA RAO
Professor, Head of the Dept, Visakha Technical Campus, Narava, Visakhapatnam.

ABSTRACT:

Concrete has been a major construction material for centuries. Yet concrete construction so far is mainly based on the use of virgin natural resources. Cement and aggregate, which are the majority significant component utilized in concrete creation, are the crucial resources desirable for construction industry. This inevitably led to a continuous and growing demand of natural resources utilized for their production. With this the concrete protection becomes an important issue; hence it has to be replaced with other materials. The present paper focuses on investigating characteristics of M30 concrete with limited substitute of cement with Municipal solid waste incineration (MSWI) ash and sand with the stone dust (crusher sand). The cubes and cylinders are tested for compression, flexure and tensile strengths. It is found that by the limited substitution of cement with MSWI ash and sand with Stone dust helped in betterment of the strength of the concrete significantly compared to ordinary mix concrete.

KEYWORDS: Municipal Solid Waste Incineration (MSWI) Ash, Stone Dust (Crusher Sand), Compressive strength, Flexure strength, Tensile strength, etc.

INTRODUCTION:

With continuous production, use of solid waste is increasing continuously. Recent studies proposed the strength improvement of the ash and hence useful in production of concrete up to 35%. A structure block consists of 35-60% combined ash, 25-50% of sand and 15% of OPC is work resembling to a hardest super plasticizer. The ecological easiness of concrete cannot be entirely esteemed without deliberation that cement and concrete trade is presented an ideal house for massive quantities of waste products from other industries. The cement and concrete trade is exceptionally sited to get rid of many wastes from the environment while receiving significant economic and technical benefits at the same time. The utilization of manufacturing byproducts in substitution of natural resources is broadly supported in structure development, while at the same time saving natural resources and energy. Brandish Aniline Soda Fabrics (BASF) India limited is a grass root chemical company producing 1700 TPD of metal dyes and 8200 TPD of polymeric dispersions situated at Bala near Surathkal. It has an effluent treatment plant which receives industrial effluent from the dyes and the dispersions manufacturing plant (pH 2-12) and domestic effluent consisting of kitchen and sanitary waste(neutral pH).After preliminary treatment of the effluents the chemical sludge and biological sludge is centrifuged and the wet cake is dried ,which is later incinerated in a fluidized bed incinerator. Generally extremely minute modification we can monitor by replacing 10% of civil solid waste incineration ash mix with cement concrete. So we can increase the percentage of ash quantities into the concrete mixes and check the strength. In our case replacement of MSW by Cement is 30, 40 and 50%. More over fine aggregate is also replaced by stone dust (crusher sand) with a replacement of 0, 25, 50, 75 and 100% in M30 grade of concrete. It is essential for ecological motive to set up a material consumption scheme for the fire waste ash residue as a substitute of disposing this ash into landfill. The intend of this manuscript is to learn the practicability of replacing MSW and stone dust raw materials in for cement and fine aggregate production. MSWI bottom ash and MSWI fly ash are the main types of ashes being evaluated.

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1.2 OBJECTIVE OF THE STUDY:

The huge MSW is formed every year. Many countries are working on waste management. Burning the waste may reduce the mass up to 70% but it creates the environment polluted. Generation of electricity from waste may generate revenue. In this process the ash is produced and the utilization of the ash is the objective of this study.

1.2 SCOPE OF THE STUDY:

A bottom ash of Municipal Solid Waste incinerator (MSWI) is considered as a part of unprocessed matter for cement. With utilization of the waste the environment cleanly may also be achieved with this approach. The conventional cement properties are compared with the MSWI cement. Presence of SiO2 is found more in MSWI cement than the normal cement. The longer setting times of MSWI cement pastes than those of control cement is due to lower C3S and higher C2S levels. Compressive strength of mortar formed from MSWI cements was slightly smaller than the control cement mortar, particularly at superior MSWI percentage.

CONSITUENTS OF CONCRETE:

2.1 GGBS (GROUND GRANULATED BLAST FURNACE SLAG):

The composition of municipal solid waste varies over time and from country to country, due to the differences in lifestyle and waste recycling processes of a country; the ash content will vary too. Generally, the chemical and physical characterization of ash will depend on the compositions of the raw MSW, the operational conditions, the type of incinerator and air pollution control system design.

CHEMICAL COMPOSITION OF MSWIA:

Table 1: Chemical Composition of MSWIA

S.No	Parameter	MSWIA in Percentage
1	SiO_2 - Sicon Dioxide	38
2	CaO - Calcium Oxide	21.1
3	Al_2O_3 - Aluminum Oxide	17.5
4	Fe_2O_3 - Ferric Oxide	8
5	Na_2O - Sodium Oxide	3.5
6	ZnO - Zinc Oxide	3.5
7	Mgo - Magnesium Oxide	2.4
8	Cl - Chloride	1.8
9	K_2O - Potassium Oxide	1.8
10	TiO_2 - Titanium Oxide	1.7
11	P_2O_5 - Phosphorus Pentoxide	1.6
12	Cr_2O_3 - Cromium	0.4
13	MnO - Manganese Oxide	0.3
14	PbO - Lead Oxide	0.3
15	SO_3 - Sulfur Trioxide	0.2

2.2 STONE DUST:

The future of sand is here inspired by nature, preferred by Robo silicon- Stone Dust, is an ideal substitute to river sand. Stone Dust is formed by a rock-hit- rock crushing practice using state- of- the- art plant & machinery with world-class technology. Created from specific natural rock, it is crushed by a three-stage configuration consisting of a jaw crusher followed by a cone crusher and finally a vertical shaft impactor (VSI) to obtain sand that is consistent in its cubical particle shapes and gradation.

Stone Dust is the environmental- friendly solution that serves as a perfect substitute for the fast depleting and excessively mined river sand, which is so essential for percolating and storing rain water in deep underground pockets and protects the ground water table.

OBJECTIVE:

To determine the most optimized mix of MSWIA-based concrete. To optimize strength characteristics of concrete by partially replacement of cement by MSWIA and sand by Quarry sand (Stone Dust). To determine the variation of workability of concrete by partially replacing the cement by MSWIA sand by Quarry sand (Stone Dust). To study the fresh properties of concrete To understand the mechanical properties of concrete.

MATERIALS AND METHODS:

CEMENT:

Ordinary Portland cement of 53 grade conforming to IS 8112-1989 is used. The basic properties of cement showed in table.

FINE AGGREGATE:

Natural river sand of size below 4.75 mm conforming to zone II of IS 383-1970 is used as fine aggregate. The test results of basic properties of fine aggregates are showed in table.

COARSE AGGREGATE:

Natural crushed stone with 20 mm down size is used as coarse aggregate. The basic properties of coarse aggregates are showed in table.

MUNICIPAL SOLID WASTE INCINERATION ASH:

MSWIA was collected from Municipal Sewage yard in Madhurawada, Visakhapatnam. Below table shows the test results of basic properties of MSWIA.

STONE DUST

Stone dust is manufactured sand which is eco-friendly solution that serves as perfect substitute for the fast depleting and excessively mined river sand. Stone dust with size 0- 4.75 mm is suitable for all concrete preparations.

WATER:

Ordinary portable water is used in this investigation both for mixing and curing.

SUPERPLASTICIZERS:

In these new types of super plasticizers known as poly carboxylate super plasticizers are used. This not only increases the flow capability of the concrete but also improves the viscosity and the constituent's retention property.

MSWIA

STONE DUST

COARSE AGGREGATE

FINE AGGREGATE

Table 2: Test Results for Materials of Concrete

S.No	TESTS	MATERIALS				
		Cement	GGBS	F.A	Robo sand	C.A
1.	Fineness	4 %	3 %	----	----	----
2.	Initial Setting Time	115 minutes	210 minutes	----	----	----
3.	Final Setting Time	270	----	----	----	----
4.	Specific Gravity	3.15	2.83	2.64	2.68	2.65
5.	Crushing Strength	----	----	----	----	11.9
6.	Water Absorption	0.12 %	0.14 %	1.45 %	1.40 %	0.75 %
7.	Bulk Density	1400 kg/m^3	1280 kg/m^3	1680 kg/m^3	1688 kg/m^3	1625 kg/m3

Table 3: Various Combinations of Mixes

S.No	CATEGORY	C	MSWIA	F.A	S.D	C.A	W/C	
		In Percentage						
1	MIX - 1	100	0	100	0	66	34	
2	MIX - 2	70	30	100	0	66	34	
3	MIX - 3	60	40	100	0	66	34	
4	MIX - 4	50	50	100	0	66	34	
5	MIX - 5	70	30	75	25	66	34	
6	MIX - 6	60	40	75	25	66	34	
7	MIX - 7	50	50	75	25	66	34	0.45
8	MIX - 8	70	30	50	50	66	34	
9	MIX - 9	60	40	50	50	66	34	
10	MIX - 10	50	50	50	50	66	34	
11	MIX - 11	70	30	25	75	66	34	
12	MIX - 12	60	40	25	75	66	34	
13	MIX - 13	50	50	25	75	66	34	

QUANTITIES:

Mix Proportions for M 35 Grade Concrete The Quantities of Mix design Proportions is Cement: Fine Aggregate: Coarse Aggregate: Water is **1: 1.99: 3.48: 0.4**.

5.2.1. For cube size of 150mm X 150 mm X 150 mm is

Volume of cube 0.15 X 0.15 X 0.15 = 0.003375

Cement = 334 X 0.15^3 = 1.127 Kg = 1.13 Kg.

F.A = 702 X 0.15^3 = 2.369 Kg = 2. 37Kg.

C.A = 1252 X 0.15^3 = 4.225 Kg = 4.23 Kg.

Water = 140 X 0.15^3 = 0.47 lt

5.2.2. For cylinder size of 150mm X 300 mm is

Volume of cylinder $\pi R^2 H$

Cement = 334 X π $(0.15/2)^2$ X 0.3 = 1.77 Kg.

F.A = 702 X π $(0.15/2)^2$ X 0.3 = 3.72 Kg

C.A = 1252 X π $(0.15/2)^2$ X 0.3 = 6.637 Kg = 6.64 Kg.

Water = 140 X π $(0.15/2)^2$ X 0.3 = 0.742 Kg = 0.75 kg.

5.2.3. For cube size of 500 mm X 150 mm X 150 mm is

Volume of cube 0.5 X 0.15 X 0.15 = 0.01125 m^3

Cement = 334 X 0.01125 = 3.757 Kg = 3.76 Kg.

F.A = 702 X 0.01125 = 7.897 Kg = 7.90Kg.

C.A = 1252 X 0.01125 = 14.085Kg = 14.10 Kg.

Water = 140 X 0.01125 = 1.575 lt = 1.58 lt.

TEST RESULTS:

6.1 WORKABILITY:

This section describes the results of the tests carried out to investigate the various properties of the different concrete mixes prepared in contrast with the control mixes. In the succeeding parts, the results for workability, unit weight, compressive strength test, Split tensile strength test, and flexural strength test are presented. Analysis and discussions are also made on the findings.

Table 5: Results of Workability by SLUMP

S.No	MIX IDENTITY (MSWIA-Stone Dust Replacement)	SLUMP (mm)
1	MIX – 1 (0-0)	132
2	MIX – 2 (50-0)	128
3	MIX – 3 (60-0)	126
4	MIX – 4 (70-0)	124
5	MIX – 5 (50-25)	122
6	MIX – 6 (60-25)	118
7	MIX – 7 (70-25)	113
8	MIX – 8 (50-50)	115
9	MIX – 9 (60-50)	107
10	MIX – 10 (70-50)	102
11	MIX – 11 (50-75)	100
12	MIX – 12 (60-75)	94
13	MIX – 13 (70-75)	88

6.2 COMPRESSIVE STRENGTH:

Compression test was carried out on 150 x 150 x 150 mm size cubes. The specimens were loaded at a constant strain rate until failure. The compressive strength is decreased with an increase in the percentage of MSWIA and Stone dust in Cement and Fine aggregate. Results for compressive strength of cubes for 3 days, 7 days and 28 days N/mm^2.

6.3 SPLIT TENSILE STRENGTH:

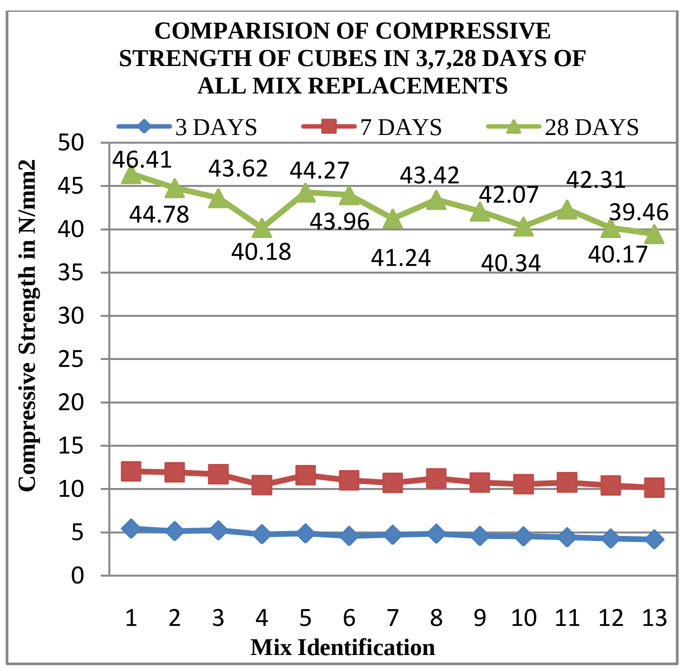
The test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders of size 150 mm diameter and 300 mm height. This test method consists of applying a diametric compressive force along the length of a cylindrical concrete specimen at a rate that is within a prescribed range until failure occurs. This loading induces tensile stresses on the compressive stresses in the area immediately around the applied load.

6.4 FLEXURAL STRENGTH:

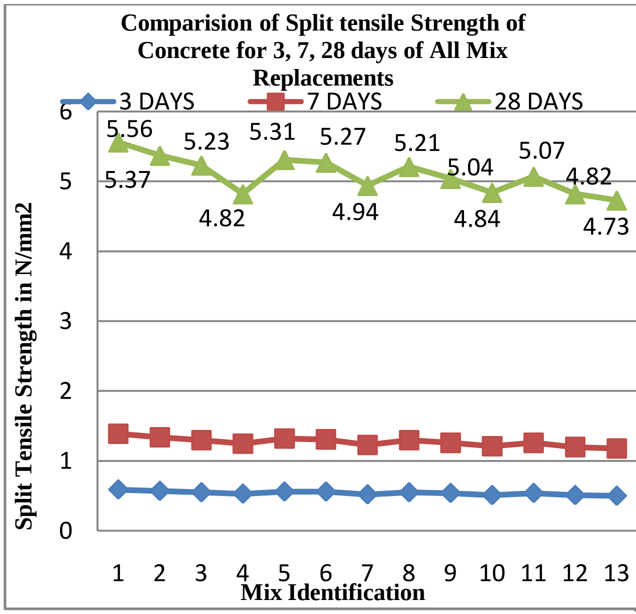
Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading (150 x 150 – mm) concrete beams with a span length at least three times the depth. The flexural strength is expressed as modulus of rupture in MPa and is determined by standard test method third-point loading or center point loading.

Table 6: Results of All Strengths of Specimens for 28 Days for Different Mix Identities

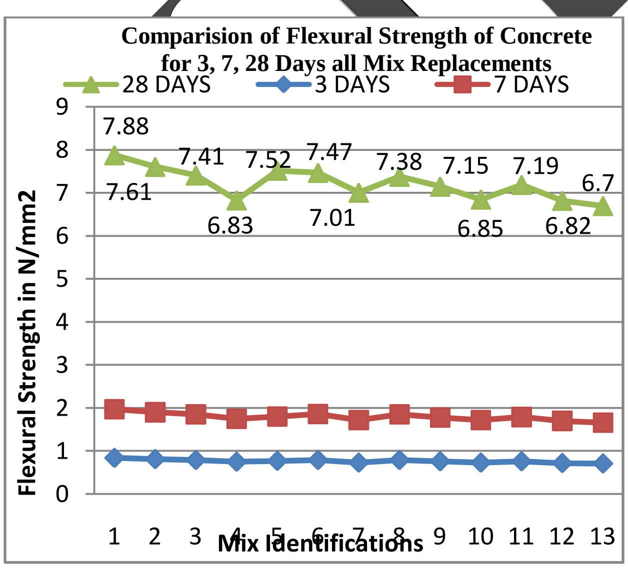
S.No	Category	Strengths for All Tests for 28 Days		
		Compressive	Split Tensile	Flexural
1	Mix 1	46.41	5.56	7.88
2	Mix 2	44.78	5.37	7.61
3	Mix 3	43.62	5.23	7.41
4	Mix 4	40.18	4.82	6.83
5	Mix 5	44.27	5.31	7.52
6	Mix 6	43.96	5.27	7.47
7	Mix 7	41.24	4.94	7.01
8	Mix 8	43.42	5.21	7.38
9	Mix 9	42.07	5.04	7.15
10	Mix 10	40.34	4.84	6.85
11	Mix 11	42.31	5.07	7.19
12	Mix 12	40.17	4.82	6.82
13	Mix 13	39.46	4.73	6.7



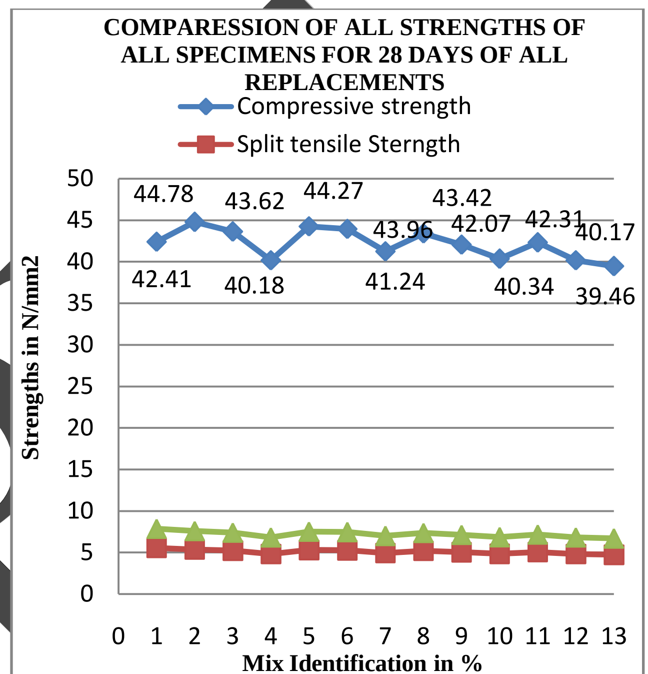
From the above **Graph** we observe that compressive strength is Satisfied by comparing with target men strength but when replacement of materials are increased then strength will suddenly decreased. So we adopt the replacement of MSWIA & STONE DUST in cement and fine aggregate of sufficient quantity for maintain the strength of the concrete.



From the above **Graph** we observe that Split Tensile strength is Satisfied by comparing with target men strength but when replacement of materials are increased then strength will suddenly decreased. So we adopt the replacement of MSWIA & STONE DUST in cement and fine aggregate of sufficient quantity for maintain the strength of the concrete. And by comparing Compressive strength and Split tensile strength it is 5 % to the compressive strength values.



From the above **Graph** we observe that Flexural Strength is Satisfied by comparing with target men strength but when replacement of materials are increased then strength will suddenly decreased. So we adopt the replacement of GGBS & ROBO SAND in cement and fine aggregate of sufficient quantity for maintain the strength of the concrete. And by comparing Compressive strength and Flexural strength it is average to the 10 % of the compressive strength values.



From the above **Graph,** we observed that the Strengths of concrete are decreased due to increase in percentage of replacement MSWIA and STONE DUST in concrete. So we adopt the replacement of sufficient quantity for maintain the strength of the concrete.

RESULTS & CONCLUSIONS:

Based on this experimental study, it can be concluded that

- As percentage of MSWIA replacing in cement is increased the workability of mix decreases. Irrespective of percentage of stone dust is replaced in river sand (F.A).
- At constant percentage replacement of river sand with stone dust the workability of concrete does not get affected as percentage MSWIA replacing the cement is varied.
- The admixture concrete has shown improvement in workability with MSWIA. Hence observed that a mineral admixture varies the workability and strength upto obtained limit. Addition of stone dust shows improvement in workability and strength.

- River sand is replaced by Stone dust with a maximum of 100% and cement is replaced MSWIA with a variation of replacement of 30, 40 and 50 %.
- The conventional mix of concrete attains strengths of 46.41 N/mm^2 of compressive strength, 5.56 N/mm2 of split tensile strength and 7.88 N/mm^2 of flexural strength.
- More overly the strengths of concrete is changed when the cement and sand are partially replaced.
- The Maximum increase in compressive, tension and flexure strength is higher than compared to target mean strengths for 28 Days. But more overly strength of conventional mix is huge.

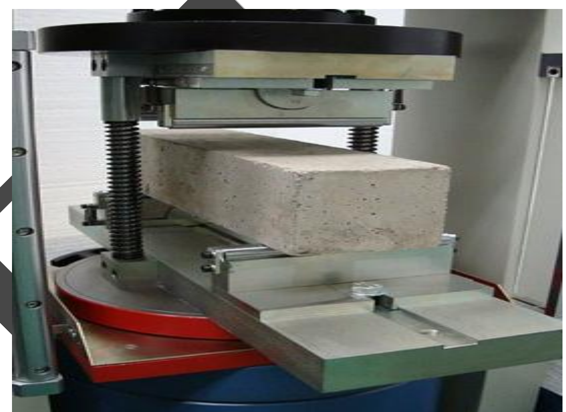
DISCUSSIONS:

By comparing all the Test values of different strength mainly for 28 Days is

- While we discuss the nature of concrete it is good in compression and week in tension. From the above results we observed that for mostly in all the mix identities M1 to M13 is higher, than the target mean strength i.e., replacing 50-50 % of Cement by MSWIA and simultaneously Fine aggregate and Stone dust of 25-75 %.
- The Ratio between the strength variations of concrete has 5% of tension and 10 % of Flexure. These are observed from strength a characteristic of all specimens i.e., cube, Cylinders and rectangular concrete specimens.
- Therefore from the above strength values we observed that River sand with Stone dust are fully replaced, but the random strength variations that are observed when MSWIA and cement are partially replacement.
- Therefore from the above strength values we adopt the percentage of MSWIA and Stone dust are replaced in cement and fine aggregate is upto 50 % of MSWIA in cement and 75 % of Stone dust in fine aggregate is more advisable to use in the construction.

(a)

(b)



(c)

Figure a, b, c : Tests for all type of Concrete Moulds

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