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TO CHECK BEHAVIOUR OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN AND FINE AGGREGATE (NATURAL SAND) WITH STONE DUST

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Abstract - *Currently, the natural sand is exhausting at an upsetting rate, as a result of constant sand mining. Therefore, there is a requirement to discover substitute for natural sand. The object of the current line of work is to evaluate the effect of replacing cement with Metakaolin(MK) and fine aggregate with Stone dust(SD). For this study M40 grade concrete is prepared and is evaluated for fresh concrete properties and hardened concrete properties like workability, compressive, split tensile and flexural strength. Ordinary Portland cement is replaced with metakaolin by 0, 3, 6, 9, 12 and 15% while the fine aggregate is replaced with stone dust at 0, 7, 14, 21, 28 and 35% by weight. The compressive, split tensile and flexural strength properties for M40 grade concrete are compared among all the mixes at periods of 7 ,14, and 28 days. It is observe from the results that the use of metakaolin and stone dust improves the mechanical properties of concrete. The optimum results were observed at 12% and 28% replacements of metakaolin and stone dust respectively.*

***Key Words*:-** Metakaolin, Stone dust, Conplast SP430, workability, Compressive strength, Split tensile strength, Flexural strength,.

1. INTRODUCTION

The most widely used man made construction material in the world is Concrete. In the recent years, the consumption of all types of aggregate has been increasing, also artificially manufactured aggregates are considered to be more expensive to produce. The continuous extraction of natural aggregates is attracting serious environmental concerns. However, it can be cured to certain extent by the way of recycling and utilization of industrial by-products and waste materials. The application of such material in concrete not only makes it cheapest but also helps in reducing disposal concerns. Stone dust can be considered to be one such industrial waste.

The properties of natural sand and stone dust are almost identical which makes stone dust the best replacement for the natural sand. The cost of natural sand has elevated due to environmental concerns and administrative restrictions in India over the last few years. It is evident that the cost of natural sand is three to four times higher as compared to the cost of stone dust even in the places where natural sand can be easily found. Therefore, it is proposed to ascertain the possibility of replacing the sand with locally available alternatives such as stone dust, without compromising quality, strength and workability of concrete.

On the other hand Metakaolin is in widespread use all over the world in the concrete industry. Metakaolin not only contains concrete performance benefits with respect to mechanical and durability properties but is also beneficial to the environmental concerns also production of cement is associated with high carbon dioxide emissions. Metakaolin natural sources are china clay which containing Kaolinite clay mineral are high purity kaolin deposits. Metakaolin usage helps in developing high performance, high early strength and high durability in concrete.

2. OBJECTIVE OF RESEARCH

Main objectives of the experimental research are as follows:

1 To study the properties of fresh concrete this is cast by partial using metakaolin and Stone dust.

2 To study mechanical properties such as compressive strength of concrete, Tensile strength of concrete and Flexural strength of concrete at the end of 7,14 and 28 days of curing by partially replacing cement with metakaolin and Stone dust under normal curing.

3 To investigate the feasibility of the combination of metakaolin and Stone dust in concrete by determining its Workability, Compressive strength, Split strength and Flexural strength of concrete.

3. MATERIAL USED

3.1 CEMENT: OPC 43 grade cement has been used in this Study.

3.2 COURSE AGGREGATE: Course aggregate of 20mm and 10 mm were used. The specific gravity of coarse aggregate is 2.43.

3.3 FINE AGGREGATE: Locally available sand has been used in this study. It confirms to zone II with a specific gravity of 2.59.

3.4 METAKOLIN: Metakaolin is a pozzolanic probably the most effective pozzolanic material for use in concrete. It is a product that is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 900ºC.

3.5 STONE DUST: Grey color stone dust was collected from local stone crushing units of Chenab crusher, Reasi J&K. It was initially surface dry in condition and retained on IS-150 µ sieve before preparation of mix.

3.6 WATER: Water is one of the most important as it initiates the chemical reaction with cement. Potable water having pH value 7.5 is used in this is to ensure that the water is reasonable free from impurities as suspended solids and used for mixing and curing through the experiment.

3.7 SUPER PLASTICIZER: The super plasticizer used in this experimental investigation is Conplast SP430. The specific gravity is 1.20

4. METHODOLOGY

4.1 General:-

This investigation includes design of concrete mix of standard grade concrete and different test are performed. In this study design mix used is M40. The guidelines given in Indian standard codes like IS: 10262-1982 and IS: 456-2000 have been adopted for mix design of concrete. In this study cement is replaced with different percentages of Metakaolin and fine aggregate is replaced with different percentages of Stone dust compute the mechanical properties of concrete.

4.2 Casting of Specimens:-

The test program considered the cast and testing of concrete specimens of cube (150mm x 150 mm x 150 mm) and cylinder (150mm x 300mm) and prism of (700 mm x 150 mm x 150 mm). The specimen was cast M40 grade concrete using OPC 43 grade, Natural sand and crushed stone (20mm - 4.75mm) with Metakaolin and Stone Dust. Three cubes in numbers of specimens made to take the average value. The Specimens demoulded after 24hrs. The specimens were allowed to the curing periods under normal conditions.

Mix notations

- 0MK0SD- 10% metakaolin and 0% waste foundry sand
- 3MK7SD - 10% metakaolin and 10% waste foundry sand
- 6MK14SD - 10% metakaolin and 20% waste foundry sand
- 9MK21SD - 10% metakaolin and 30% waste foundry sand
- 12MK28SD - 10% metakaolin and 40% waste foundry sand
- 15MK35SD - 10% metakaolin and 40% waste foundry sand

4.3 Testing of Specimen:-

Testing of specimen was shown in Fig 1, 2, 3, 4. Workability, Compressive Strength, Split Tensile Strength and Flexure Strength of test values were presented in table 3, 4, and 5.

4.3.1 Workability of concrete:-

Workability of concrete is the ease with which concrete can be mixed, compacted and finished with minimum loss of homogeneity. The workability of fresh concrete was measured by the slump test as per Indian standard given in BIS 1199:1959. Our target is to achieve slump value of 50 - 75 mm for different combinations.

Fig - 1: Slump test

Table 1:- Values for slump for different mixes

MIX DESIGNATION	SLUMP(mm)
0MK0SD	(74mm)
3MK7SD	(71 mm)
6MK14SD	(69 mm)
9MK21SD	(65 mm)
12MK28SD	(62 mm)
15MK35SD	(61 mm)

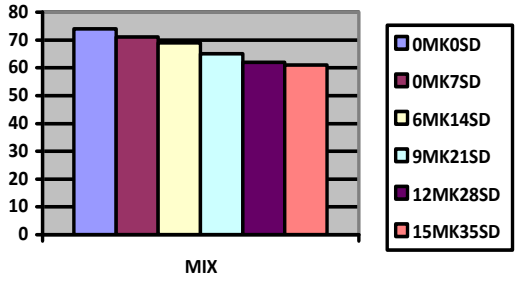

Chart - 1: Slump vs. Mix

Result- Workability is checked by slump test for different combinations 0MK0SD, 3MK7SD, 6MK14SD, 9MK21SD, 12MK28SD, 15MK35SD which show that as we increase percentage of metakaolin and stone dust slump value is decrease.

4.3.2 Compressive Strength of concrete:-

For each mix three cubes were casted (i.e. 3days, 7days and 28days) and tested using Compression Testing Machine (CTM). The each specimen is placed on the platform of the CTM. The load of 14N/mm^2/minute applied gradually until the failure stage. The ultimate load noted and average of calculated each combination and the compressive strength of corresponding specimen is calculated.

Fig – 2: Compression test

Table 2:- Average Compressive Strength of concrete in Mpa

MIX DESIGNATION	7 days (N/mm2)	14 days (N/mm2)	28 days (N/mm2)
0MK0SD	26.3	36.6	40
3MK7SD	28.5	38.2	43.3
6MK14SD	30.2	41.9	46.4
9MK21SD	32.4	44.7	48.7
12MK28SD	35.9	47.4	53.3
15MK25SD	33.3	45.1	50.1

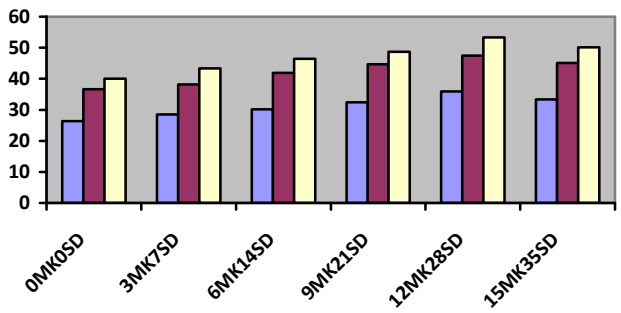

Chart - 2: Compressive strength vs. Mix

Result- Compressive strength is checked by CTM for different combinations 0MK0SD, 3MK7SD, 6MK14SD, 9MK21SD, 12MK28SD, 15MK35SD which show that for 12MK28SD we obtain maximum value but as we increase percentage of metakaolin and stone dust value is decrease.

4.3.3 Split tensile Strength of concrete:-

For each mix the cylinders were casted of size 150mm x 300mm and tested in CTM. The specimen placed perpendicular to normal axis on the CTM. The load applied gradually until the failure occurs in specimen.

Fig – 3: Split tensile test

Table 3:- Average Split Tensile Strength of concrete in Mpa

MIX DESIGNATION	7 days (N/mm2)	14 days (N/mm2)	28 days (N/mm2)
0MK0SD	2.96	3.97	4.42
3MK7SD	3.08	4.14	4.61
6MK14SD	3.18	4.28	4.76
9MK21SD	3.26	4.39	4.88
12MK28SD	3.42	4.59	5.11
15MK25SD	3.31	4.45	4.95

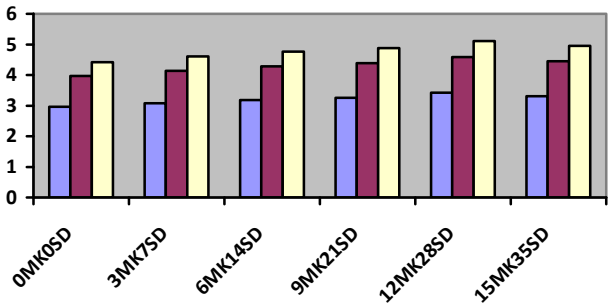

Chart - 3: Split tensile strength vs. Mix

Result- Split tensile strength is checked by CTM for different combinations 0MK0SD, 3MK7SD, 6MK14SD, 9MK21SD, 12MK28SD, 15MK35SD which show that for 12MK28SD we obtain maximum value but as we increase percentage of metakaolin and stone dust value is decrease.

4.3.4 Flexural Strength of concrete:-

For each combination 3 the prisms were casted and tested in Flexural Testing Machine (FTM). The specimen of prism of size 700 mm x 150 mm x 150 mm placed horizontally on the platform of the FTM load 0.3 N/mm^2/minute is applied gradually. The ultimate load noted and average is calculated and the flexural strength of corresponding specimen is calculated.

Fig – 4: Flexural strength test

Table 4:- Average Flexural Strength of concrete in Mpa

MIX DESIGNATION	7 days (N/mm2)	14 days (N/mm2)	28 days (N/mm2)
0MK0SD	3.86	4.87	5.32
3MK7SD	4.06	5.24	5.51
6MK14SD	4.12	5.35	5.68
9MK21SD	4.16	5.46	5.75
12MK28SD	4.92	5.67	6.14
15MK25SD	4.51	5.52	5.89

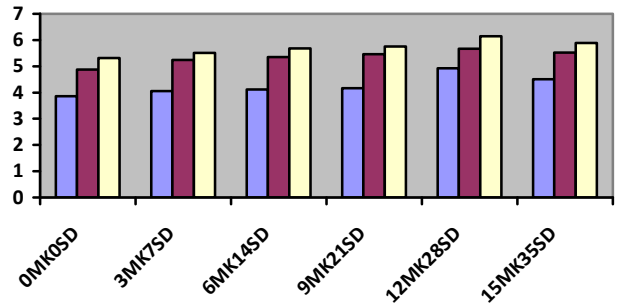

Chart - 4: Flexural strength vs. Mix

Result- Flexural strength is checked by CTM for different combinations 0MK0SD, 3MK7SD, 6MK14SD, 9MK21SD, 12MK28SD, 15MK35SD which show that for 12MK28SD we obtain maximum value but as we increase percentage of metakaolin and stone dust value is decrease.

5. CONCLUSIONS

The following conclusions of investigation can be derived based on the results and discussions above:

- The compressive strength of concrete with partial replacement of cement with metakaolin and stone dust as fine aggregate is increase (up to 33.25%) in combination 12MK28SD as compare to 0MK0SD (i.e. without any replacement).
- Stone dust can be used in place of natural sand (Fine aggregates) in concrete without much affecting compressive strength of concrete.
- Maximum compressive strength , workability and split tensile strength is attains at 12MK28SD i.e. 12% replacement of cement with metakaolin and 28% replacement of natural fine aggregate with stone dust.
- The workability of concrete was decreased at increment level of metakaolin and stone dust it may be due to rough surface and angular shape of stone dust particles in comparison of smooth sand.
- The Split tensile strength of concrete with partial replacement of cement with metakaolin and stone dust as fine aggregate is increase (up to 15.61%) in combination 12MK28SD as compare to 0MK0SD (i.e. without any replacement).
- The Flexural strength of concrete with partial replacement of cement with metakaolin and stone dust as fine aggregate is increase (up to 15.41%) in combination 12MK28SD as compare to 0MK0SD (i.e. without any replacement).

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BIOGRAPHIES

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