

Optimum usage of Using Metakaolin and Quarry Dust in High Performance Concrete

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Abstract: - Today's environmental problems are more and more important. The industrial area produces lots of waste materials .One of the most useful ways to solve these problems is the consumption of these waste materials in concrete. The quarry dust is an economic and waste material of rock and alternative to the river sand. Conventional concrete is the most extensively used construction material world wide, both in moderately and strongly aggressive environments. High performance concrete (HPC) appears to be a better choice for stronger and durable structures. These needs have made the engineers look for an appropriate technology for improving the performance of concrete. In this paper describes the studies made to ascertain the properties of HPC M40 grade concrete by using Metakaolin as partial cement replacement and Quarry dust as partial fine aggregate replacement to determine the compressive and tensile strength experimentally.

Keywords: - Quarry dust, metakaolin, super plasticizers, M40 concrete, strength, results.

I. INTRODUCTION

Concrete despite its inherent deficiencies is the most extensively used material world wide for the construction of large infrastructural facilities. In the past there has been considerable attention for improving the properties of concrete with respect to strength and durability, especially in aggressive environments. In the foreseeable future, there seems to be no alternative to concrete as a construction material. There has been substantial advancement during the last 100 years in the science and practice of concrete technology, out of which the last 30 years have seen considerable progress, Although the compressive strength of concrete has been historically and steadily increasing the commercial potential of high strength concrete became evident for the columns of high rise buildings in the 1970's in the United States. There are other equally important criteria for the characterization of concrete such as durability, workability and toughness. For example in prestressed concrete bridges the concrete should have not only high strength but also reduced shrinkage and creep. For bridges, offshore structures, highway and airport pavements and machine foundations, concrete should possess high fatigue strength. For nuclear containers exposed to very high temperatures, the concrete must have a high resistance to thermal cracking. Therefore considerable attention has been paid to the research and development of high performance concrete (HPC) with a view to enhance the potential of the material to build for the service life of about 100 years instead of customary 40 to 50 years and to provide satisfactory performance under different aggressive environments.

II. MATERIALS AND METHODS

2.1 Materials Used:

The materials used include Ordinary Portland Cement (43 Grade), metakaolin, super plasticizers, quarry-dust, river sand, coarse aggregate and water. Cement, Metakaolin, super plasticizers, Quarry dust, River sand and coarse aggregate are tested for their physical characteristics as per the relevant standards. The results are presented in Table 1, 2, 3 and 4.

Table 1. Physical Characteristics of Cement

Characteristics	Cement
Specific gravity	3.15
Standard Consistency (%)	31.5
Initial Setting Time (minutes)	140
Final Setting Time (minutes)	480
Fineness (%)	4

Table 2. Physical Characteristics of Metakaolin

Test Particulars	Results obtained
Average particle size(μ m)	1.5
Contact surface area (m ² /gm)	15
Pozzolan Reactivity (mg Ca(OH) ₂ /gm)	1050
Specific Gravity	2.5
Bulk density (kg/m ³)	300 \pm 30
Brightness	80 \pm 2 Off-white
Physical Form	Powder

Table 3. Physical and Chemical Characteristics of Super Plasticizers

Particulars	Super slump-Pn
Usage	High-range water reducing type super plasticizer
Classification	Polycarbixylate based super plasticizer
Appearance	Light brown liquid
Solid Content	Min. 40%
Viscosity (25°C)	Max. 1000 cPS
Density	1.10 – 1.20 mg/l
pH	4.0 – 7.5

Table 4. Physical Characteristics of Fine Aggregate, Quarry dust and Coarse Aggregate

Characteristics	River Sand	Quarry Dust	Coarse Aggregate (20 mm)
Specific Gravity	2.09	2.36	3.06
Grading Zone	Zone II	-	Zone III

2.2 Mixture proportioning:

Trial mixtures were prepared to obtain target strength of 40 MPa at 28 days along with w/b ratio is 0.34. The detailed mixture proportions for the study are presented in Table 5.

Table 5. Concrete mixture proportions – based on IS 10262-2009 method

Cement (kg/m ³)	Metakaolin (kg/m ³) For 5%	Fine aggregate (kg/m ³)	Coarse aggregate (kg/m ³)	Quarry Dust (kg/m ³)	Water (kg/m ³)	Super Plasticizers (kg/m ³)
411.73	21.67	462.44	1226.389	174.06	157.6	8.27

2.3 Compressive strength test:

The prepared cubes are cured for 7 days, 14 days, 28 days, 56 days, 90 days and 120 days. At the end of curing period, the cube were placed in between the compression plates of the Universal Testing Machine and apply load gradually as shown in figure 3a,3b & 4a,4b The reading was noted at the time of first crack and at the time of failure.

2.3.1 Compressive strength test for cubes:



Figure 3a Testing of concrete cube specimen for compressive strength



Figure 3b Failure mode of cube specimen in compressive strength

2.3.2 Compressive strength test for cylinders:



Figure 4a Testing of concrete cylinder specimen for compressive strength



Figure 4b Failure mode of cylinder specimen in compressive strength

2.4 Split tensile strength test:

The prepared cylinders with the help of moulds and cured 28 days and 56 days. At the end of curing period, the cylinders were placed in between the compression plates of the Universal Testing Machine and loaded gradually as shown in figure 5 The reading was noted at the time of first crack and at the time of failure.



Figure 5 Failure mode of specimen in split tensile strength

III. RESULTS AND DISCUSSION

The development of strength (compressive and split tensile strength) with age for different replacement levels of metakaolin and 40% of quarry dust as a partial replacement of river sand with constant dosage of super plasticizers are as follows.

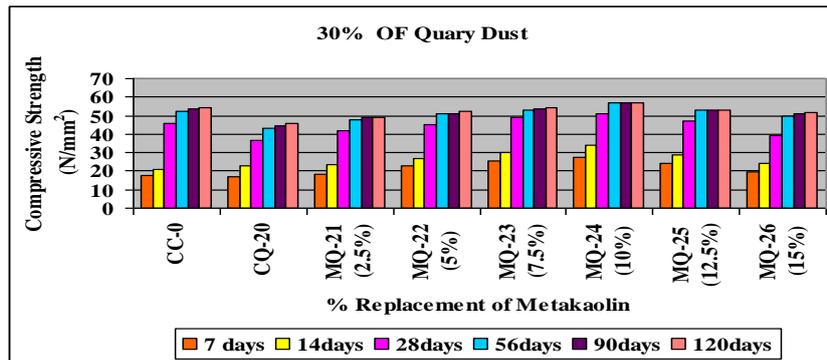


Fig- 6 7,14, 28,56,90 and 120 Days cube strength

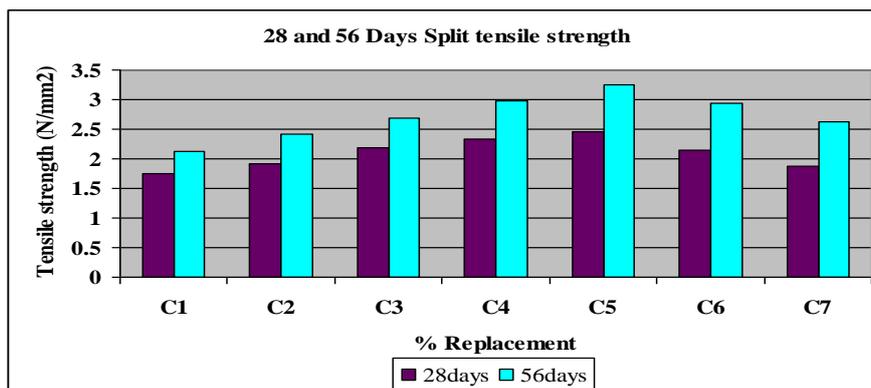


Fig-7- 28 and 56 Days Split tensile strength

IV. CONCLUSIONS

The present investigation shows that by the optimum percentage (0, 2.5, 5, 7.5, 10, 12.5 & 15 %) of Metakaolin as a partial replacement for cement together with partial replacement of natural river sand with quarry dust at (0, 10, 20, 30, & 40 %), results in the production M40 grade mixes. The following conclusions can be derived based on the results and discussions above:

1. From the above experimental results it is proved that, Quarry Dust can be used as alternative material for the fine aggregate (sand). And Metakaolin can be used as one of the alternative material for the cement used for producing HPC. Based on the results the compressive and split tensile strengths are increased by mixing of Metakaolin with Quarry Dust.
2. The compressive strengths are 16%, 16%, 10%, 10%, 10% and 10% at the period of 7, 14, 28, 56, 90 and 120 days and the increase in the split tensile strength is 16% and 12% at the period of 28 & 56 days, by replacing 10% of cement with Metakaolin and 30% of sand with Quarry Dust with 3% Super Plasticizers

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