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CONCRETE MIX DESIGN PHILOSOPHY TO ACHIEVE THE REQUIRED STRENGTH BY USING WASHED CRUSHED STONE SAND

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Abstract
The present study is focused on the use of Manufactured sand (MS) as an alternative option to Natural Sand (NS) due to its less availability in the local markets. Under the suggested procedure M40 grade concrete mix was designed as per IS 10262:2009 with Natural sand and Manufactured sand. The MS is completely washed before the use in the laboratory for the preparation of the required samples and zone II grading is achieved for MS as per IS 383:2016. All the specimens of M-40 grade concrete are tested under strict laboratory control. The result indicates that the compressive strength with MS on 7 days and 28 days for M-40 grade concrete is found to be 4.45% higher as compared to design mix used with NS respectively. The flexural strength with MS on 7 days and 28 days for M40 grade concrete is found to be 4.78% higher as compared to design mix used with NS respectively. The rate analysis for both grade of concrete with MS and NS shows that the concrete prepared with MS is cost effective by 20% and highly economical as compared to NS.

Keywords: Compressive Strength, Flexural Strength, Manufactured sand (MS), Natural sand (NS).

I. Introduction

Sand is one of main constituents of concrete and is about 35 % of volume of concrete used for construction purpose. Natural sand is mainly excavated from river beds and always contains high percentages of inorganic materials such as chlorides, sulphates, silt and clay. Where silt and clay adversely affect the strength, durability of concrete & reinforced steel there by reducing the life of structure. Engineered sand or M-sand is a cost-effective substitute to river sand. Crushing hard granite is utilized to make manufactured sand. The M-sand is < 4.75mm in diameter. Since the construction industry is rapidly expanding, the demand of sand increased dramatically, resulting in a global lack of appropriate river sand. The use of this M-sand has risen severely as a better effect of reduction in the consumption of rich quality river sand in the building. M-Sand is often used because it is easily available also having low transportation cost [1].

II. Literature Review

Martins Pilegis et al. (2016) –This study mainly focused at the physical characteristics and also mineralogical characteristics of M-sand produced in an industry. They looked into the impact of those properties on concrete workability and strength when M-sand fully substituted by natural sand, and then used artificial neural networks to model the results (ANN).Because of the higher angularity of M-sand particles, it is thought that the M-sand concrete made in this study needs a higher water/cement (w/c) ratio for workability comparable to natural sand concrete. Water-reducing admixtures may be used to compensate if manufactured sand does not contains clay particles. Concrete with Manufactured sand concrete is having higher compressive and flexural strength results than the natural sand concrete having similar w/c ratio. The study shows that using an artificial neural network (ANN) analysis to investigate concrete strength parameters and workability behaviour depending on nature of fine aggregate (FA) and concrete-mix composition is a valuable and reliable tool [4].

Shreyas. K (2017) –M-sand is combined with concrete materials in various proportions ranging from 0% to the 40% by weight to partly replace fine aggregates, and also its different physical and

engineering characteristics are analyzed. According to this study, adding processed sand in the correct proportions would increase the compression of the concrete cubes by 15 to 20%.Mechanical performance of the concrete cubes prepared without chemical admixtures was considered for compressive strength test, which gives the characteristic increase in its strength behavior, according to various experimental analyses conducted following IS provisions. It is noticeable that replacing 10% of cement with manufactured sand in mild conditions increases the compression for 28-days and by replacing up to the 40% of cement having M-sand in mild conditions shows variation in compression. It has been discovered that using manufactured sand as an admixture will help provide greater cohesiveness in the mortar and also the concrete. Based on the findings, it is concluded that M-sand is appropriate for using as a filler material substitute and that up to the 40% replacement with manufactured sand would produce excellent results for strength and the consistency. In comparison to a original mix, the concrete mix prepared with M-sand as 20 % substitution of the fine aggregate reduces cost and provides high compressive strength [6].

V. Gokulnath et al. (2018) – This study demonstrates how M sand can be used to replace river sand and also steel-fiber in self-compacting concrete. This paper provides information about strength gained by using river sand and also the replacement of the river sand with M sand in self-compacting concrete, as well as the adding steel-fibers. They cast the concrete cube for this reason; fresh concrete test was performed. The compressive strength test was conducted in 7 days and 28 days to investigate the strength of concrete. According to the findings, applying steel fibers to fresh concrete improves compressive strength by resisting cracks and thus increases longevity. It has been discovered that M-sand can be considered as an acceptable substitute for river sand. Because of it having suitable workability, self-compacting concrete is simple to treat, and the use of M-sand reduces waste, making it an environmentally friendly material [8].

R. Padmanaban et al. (2020) – They presented the use of M-Sand in concrete manufacturing, Mix design and quality expectations from the user industry. From the complete survey and study about the M-Sand they concluded that the acute shortage Of river sand, huge short coming on quality of river sand, high cost, and environmental effects, the construction industry shall start using the manufactured sand to full extent as alternative. Hence M-Sand is eco friendly. M-Sand is more economical and cost effective in construction industry as it gives more workability, high strength and durability to the concrete with less pre and post concrete defects.

III. Objectives and Methodology

3.1 Objectives

The main objective of the study are summarized as below.

1. To analyze and compare the compressive and flexural strength of M-40 grade concrete by using Manufactured and Natural Sand.
2. To study the economic viability of manufactured sand as an alternative option to Natural sand.

3.2 Methodology

For the preparation of the required grade of concrete the cement (OPC 43 Grade),coarse aggregate (black basalt rock), fine aggregate (river sand and manufactured sand) and other admixture were used as per the design mix. Cement used for the Mix Design is **Ultra-tech cement (OPC 43 Grade)** conforming to I.S 8112. Black Basalt coarse aggregate obtained from, Agarwal crusher pithampur, Indore is used as per IS 383:216. Narmada river Natural sand conforms to zone II as per the specifications of IS 383:2016 is used for the Mix design. The Manufactured sand conforms to zone II as per the specifications of IS 383:2016 is used for the Mix design was collected from pithampur, Indore.

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Fig. 1 M-sand and Natural sand

The M-40 grade concrete is designed as per IS 10262:2009 and total 60 cubes and beams are casted 30 each with manufactured sand and natural sand and are tested for compressive strength and flexural strength after 7 days and 28 days under strict laboratory conditions. As per specification of IS 9103:1999, admixture used is SMS 910 water reducing. When used in large dosage, it can have a negative effect on setting times.

Fig. 2 Casting and curing of specimens

IV. Results and Discussion

4.1 Compressive Strength Test

The compressive strength of concrete M40 cubes is analyzed. The cross section of mould used is the 150mm X 150mm X 150mm and it is decided according to the size and grade of the aggregate. The concrete cubes are placed in water After 24 hours of casting. Compressive strength is find out by the load per unit area that means load taken by the cube is divided by the area of the cross section cube mould.

Fig. 3 Testing of cubes

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Table 1 Compressive Strength of M-40 Grade concrete

Age in days	7 days	14 days	28 days	IS code used
Manufactured sand	38.47 N/mm^2	42.66 N/mm^2	47.86 N/mm^2	IS 456:2000
Natural sand	36.68 N/mm^2	41.98 N/mm^2	46.92 N/mm^2	IS 456:2000

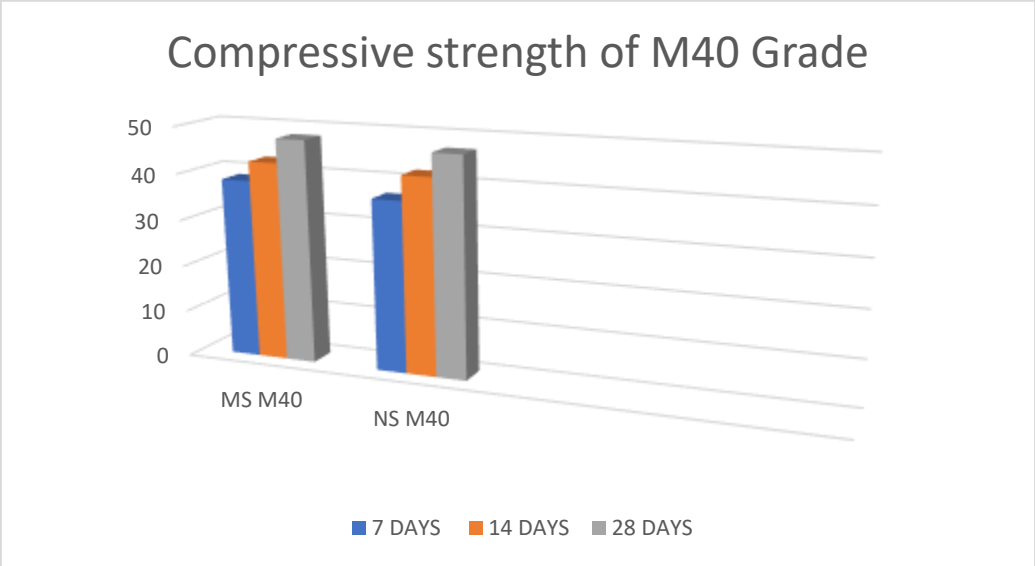

Fig. 4 Compressive Strength of M-40 Grade concrete

4.2 Flexural Strength Test

According to IS: 516-1959, standard size of test specimen 150mmX150mmX700mm are used for determining flexural strength of beams. If minimum size of aggregate 20mm are used, a beam of size 10cm*10cm*50cm may be used. The proportioning and preparation of mould is done as per clause 7 on page no 15 in IS: 516-1959.

Fig. 5 Flexural testing

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Table 2 Flexural Strength of M-40 Grade concrete

Age in days	7 days	28 days	IS Code Used
Manufactured sand	4.09 Mpa	5.76 Mpa	IS 516-1959
Natural sand	4.02Mpa	5.26 Mpa	IS 516-1959

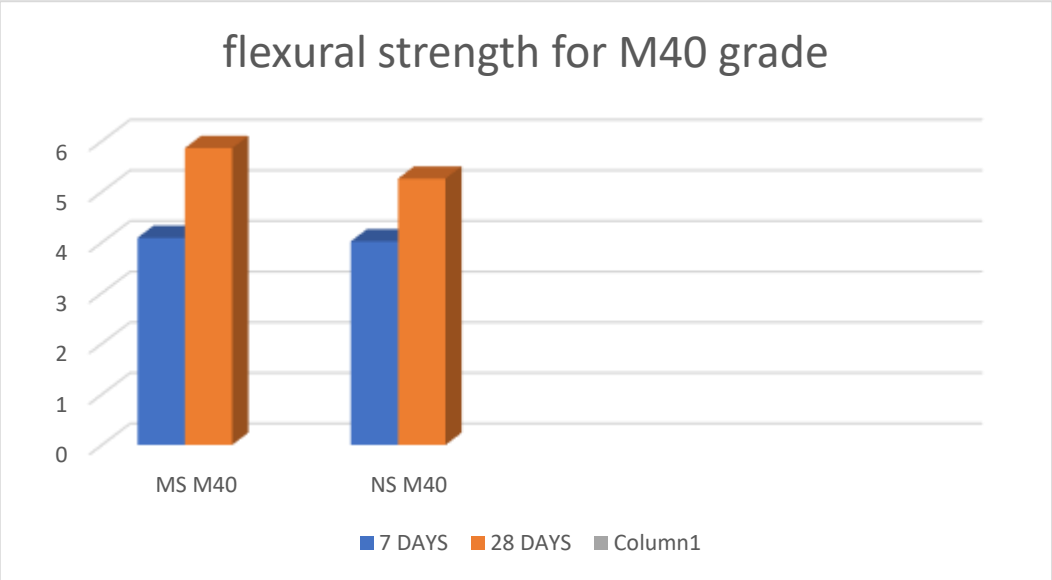

Fig. 6 Flexural Strength of M-40 Grade concrete

4.3 Economic analysis of rates of manufactured sand and natural sand

The Manufactured sand is artificially made sand available in every weather condition whereas Natural sand is naturally accruing sand at the river basin and not easily available at every weather conditions.

Table 3 Market rate of M-40 Grade concrete using Natural sand

Material	Weight	Market Rate
Cement	**407 Kg**	**Rs.2800**
Coarse Aggregate (20 mm)	**652 Kg**	**Rs.450**
Coarse Aggregate (10 mm)	**575 Kg**	**Rs.402**
Fine Aggregate (Natural Sand)	**749 Kg**	**Rs.1572**
Water	**137**	**-**
Total	**2520 kg**	**Rs.5225**

Table 4 Market rate of M-40 Grade concrete using Manufactured sand

Material	Weight	Market Rate
Cement	**407 Kg**	**Rs2800**
Coarse Aggregate (20 mm)	**652 Kg**	**Rs450**
Coarse Aggregate (10 mm)	**575 Kg**	**Rs402**
Fine Aggregate (M-Sand)	**749 Kg**	**Rs861**
Water	**137**	**-**
Total	**2520 kg**	**Rs4513**

Table-5: The rate difference between the concrete made by M-sand and natural sand

Cement	Sand	Aggregate	Concrete Grade	Rate m^2
OPC	Natural sand	Black Basalt CA	M-40	Rs5225 m^2
OPC	Manufactured Sand	Black Basalt CA	M-40	Rs4513 m^2

The table shows that concrete produced by Manufactured sand is cost effective by 15%.

V. Conclusion

The test like compressive strength and flexural strength Are conducted on concrete with manufactured sand as replacement of natural sand. The data assembled during the course of investigation lead to the following conclusions.

1. The compressive and flexural strength of concrete M-40 grade is increased by 4.45% and 4.78% respectively after replacement of natural sand with manufactured sand.
2. The market rate for M-40 grade of concrete with MS and NS shows that the concrete prepared with MS is cost effective by 15% and highly economical as compared to NS.

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