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Workability Studies on Fibre Reinforced Concrete Using Bethamcherla Marble Stone as a Replacement of Natural Aggregate

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Abstract -

Concrete is a tremendous material composed of cement, aggregates, sand and water in which gets hardened with time and forms into a massive structure. Concrete is the material that can be used in any type of construction works. Hence demand of concrete and concrete materials has been increased time by time due to the limited quantity of supplying of concrete materials. Because of this reason so much of research work is going on the construction materials since long time. In this process a small research work had done on the concrete by using Bethamcherla Marble Stone in place of natural aggregate in different proportions like 0%, 25%, 50%, 75% and 100%. Bethamcherla Marble Stone is basically flaggy lime stone. In that same way it is also add some quantity of Galvanized Steel Fibres to the concrete mix like 0%, 1%, and 2%, by the volume of whole concrete to improve the performance of concrete mix. The aim of the paper is to study the workability of fibre reinforced concrete by replacing natural aggregate with Bethamcherla marble stone. In this paper we know the workability of the Bethamcherla Marble Stone by experimenting the slump, compaction factor and Vee – Bee tests for each mix batch.

Key Words: Cement, Granite aggregate, River sand, Water, Bethamcherla marble stone, Galvanized steel fibres

1. INTRODUCTION

Concrete is a most prominent material in the construction industry, it is the most widely used construction material in through out the globe. It plays a very significant [4] role in the shaping our environment and sustainability of construction industry. Mainly concrete is made of sand, cement, aggregate and water. In the present years, the growth in the structural construction and the consequent increase in consumption have lead to fast decline of available natural resources on the other hand, a high volume of production has generated a considerable amount of coarse material which have adverse impact on the environment. Bethamcherla marble stone is basically flaggy [10] lime stone it is natural split. Kurnool district of Andhra Pradesh has huge amount of deposits of Bethamcherla marble stone.

Previously, concrete members reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. Furthermore, steel reinforcement used to overcome the high potentially tensile stresses and shear stresses at critical location in concrete members [3]. The additional of steel reinforcement well improve the strength of concrete, but to produce concrete with homogenous tensile properties, the progress of micro cracks is a must to decreases. It is generally accepted that the presence of fibres improves the performance of concrete. The main function of the fibres is to resist the opening of cracks due to [4] micro-cracking, increase the ability of the composite to withstand loads, and to allow larger strains in the neighbor hood of fibres. The main aim of the current paper is to investigate variability of aggregate properties and their impact on concrete production. Aggregate strength, absorption, gradation, moisture content, shape and texture, specific gravity are some of the physical and mechanical characteristics that useful to the strength and workability characteristics of concrete. Therefore, it is necessary to evaluate those properties before utilizing the aggregate.

2. BACK GROUND INFORMATION OF THE RESEARCH

The revolution in the construction industry introduces several concerns regarding accessibility of natural granite aggregate, as they are being rapidly decreased. In the

recent statistics displayed the increasing usage of construction aggregate to reach 48.3 billion metric tons by the year 2015 with the huge consumption being in Asia and Pacific [5]. Generally granite stone is used as a construction material. Though IS 383 : 1970 code tells that the use of marble stone and other stones for structural construction works, but it is very rare in reality. In this regard a ray of light was focused on the usage of Bethamcheral Marble Stone aggregate. A small area Bethamcherla in Kurnool (DIST) has huge amount of Bethacherla marble stone in the form of dumping all around the tiles factories and beside of roads due to lack of dumping area. This waste disposal is very big problem and it makes of air pollution while vehicles moving along the roads. After watching all these situations it moves to utilize the waste in construction industry.

3. SCOPE AND OBJECTIVES

The main scope of the work is to study the behavior of the Bethamcherla Marble Stone in structural construction works by conducting the some experimental works to study the variation of workability characteristics of concrete on addition of some quantity of Galvanized steel fibres. The major aim of the study is to provide some details of the use of Bethamcherla Marble Stone. And to examine the suitability of locally available Bethamcherla Marble Stone as natural granite aggregate [6].

4. PROPERTIES OF MATERIALS USED

4.1 Cement

The cement is most widely used material in the construction industry. In this study Ordinary Portland Cement (OPC), 53 Grade was used [8]. Cement is most important ingredient in the construction works. It works as bonding material in between coarse aggregates and fine aggregate. The properties of the ordinary Portland cement of 53 Grade listed in the following table 1.

Table -1: Properties of cement

S.No	Particulars	Results
1.	Specific gravity	3.05
2.	Normal consistency	33 %
3.	Fineness of cement (m2/kg)	289
4.	Initial setting time(minutes)	80
5.	Final setting time (minutes)	185

4.2 Fine Aggregate

The locally available natural river sand which is passing through 4.75 mm I.S. Sieve was used. The properties of the fine aggregate listed in the following table 2.

Table -2: Properties of fine aggregate

S.No	Particulars	Results
1.	Specific gravity	02.68
2.	Fineness modulus	04.78
3.	Bulk density (KNm^3)	16.70
4.	Bulking of sand	21.01 %
5.	Grading of sand	Zone - Two

4.3 Natural Coarse Aggregate

Crushed granite aggregate which is available in the local resources was used. Mainly in this study it is used all-in-all aggregate size which is passing through 20 mm and retained on 10 mm IS sieve was used for the effective utilization of natural coarse aggregate [8]. The properties of the natural coarse aggregate listed in the following table 3.

Table -3: Properties of coarse aggregate

S.No	Particulars	Results
1.	Specific gravity	02.55
2.	Fineness modulus	03.70
3.	Flakiness index	18.50 %
4.	Elongation index	23.70 %
5.	Crushing value	19.42 %
6.	Impact value	17.80 %
7.	Water absorption	0.50 %

4.4 Bethamcherla Marble Stone

The Bethamcherla Marble Stone used as coarse aggregate in different proportions which is obtained from tiles industries in Bethamcherla of Kurnool (DIST). In this study Bethamcherla Marble Stone is also used all-in-all aggregate size which is passing through 20 mm and retained on 10 mm IS sieve for the effective utilization [1]. The properties of the Bethamcherla Marble Stone listed in the following table 4. The following Fig.1 shows sample of Bethamcherla marble stone.

Table -4: Properties of Bethamcherla marble stone

S.No	Particulars	Results
1.	Specific gravity	02.57
2.	Fineness modulus	05.73
3.	Flakiness index	15.64 %
4.	Elongation index	25.67 %
5.	Crushing value	22.77 %
6.	Impact value	17.48 %
7.	Water absorption	0.20 %

Fig. 1 Samples of Bethamcherla marble stone

4.5 Water

Fresh potable water which is free from concentration of organic and acidic substances has been used in this experimental investigation for mixing the concrete.

4.6 Fibres

In this study Galvanized steel fibres of aspect ratio 30 was used to improve the ductility and strength properties of concrete mix. The cross sectional dimensions of this typical Galvanized steel fibre of diameter of 0.1 cm wire was used, which are created in various form [5], [6] of geometry. The properties of the Galvanised steel fibre listed in the following table 5. The following Fig.2 shows sample Galvanized steel fibres.

Table -5: Properties of Galvanized steel fibres

S.No	Particulars	Results
1.	Diameter (mm)	01.00
2.	Modulus of elasticity (Gpa)	200.00
3.	Tensile strength (Gpa)	1.0 – 3.0
4.	Ultimate strength (Mpa)	395
5.	Failure strain (%)	3.0 – 4.0

Fig. 2 Samples of Galvanized steel fibres

5. CONCRETE MIX DESIGN

5.1 M20 Mix Concrete

Table -6: Proportions used for mix design

S.No	Particulars	Proportion
1.	Characteristic compressive strength at 28 days	20 N/mm^2
2.	Max size of aggregate	20 mm (angular)
3.	Degree of workability	25 – 50 mm (slump value)
4.	Degree of quality control	Good
5.	Type of exposure	OPC, 53 Grade
6.	Cement used	3.05
7.	Specific gravity of cement	
8.	Specific gravity a. Fine aggregate b. Coarse aggregate	 02.55 02.68
9.	Water absorption of coarse aggregate	0.5 %
10.	Grading of sand	Zone – Two
11.	Water content	186 liters

M20 grade concrete mix design carried out by using the IS 10262: 1982 and IS 10262: 2009 codes. Here it mentioned mix proportion like cement : fine aggregate : coarse aggregate of w/c ratio 0.5 in the following table 7.

Table -7: Mix proportion

W/C Ratio	Cement (Kgm^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)
0.5	372	705.7	1110.92
proportion	1	1.89	2.99

5.2 Mixing of Ingredients

The M20 grade concrete mix has been designed using IS code (IS 10262: 1982) [12] for zero percent replacement of coarse aggregate (Granite aggregate). The mix proportion attained is 1:1.89:2.99 with water cement ratio of 0.5. Keeping the mass of the fine aggregates constant, the granite aggregate has been replaced by crushed Bethamcherla marble stone aggregate in proportions like 0%, 25%, 50%, 75% and 100% by mass of coarse aggregate and also added different proportions of galvanized steel fibres like 0%, 1%, 2% by volume of whole concrete. For each percentage replacement of coarse aggregate considered, the materials are mixed in the standard way. That is, at first the fine aggregates and cement are weighed according to their proportion in the concrete mix. Then these materials are mixed carefully in dry status, then this mixture is spreads uniformly over the

weighed capacity of coarse aggregate and carefully mixed in dry status. Then the measured amount of water with water cement ratio of 0.5 is added to this dry mix and then mixed carefully. For every percentage replacement of coarse aggregate considered, to have a steady workability of the mix, a slump of 100+10 mm is managed [3].

6. WORKABILITY TESTS AND RESULTS

Workability could be denoted as the ease of placing, consolidating, and finishing fresh mixed concrete and the degree of which it prevents segregation [3]. Concrete must be workable but it should not be separable during transport and placing. The experimental tests were carried out to found the workability of concrete mix and behaviour of fibre reinforced concrete, while also related to the conventional plain concrete. The comparisons of workability of concrete includes slump, compaction factor, Vee - Bee test. With this analysis and results attained from the experimental tests, it is very clearly to know the effect of fibre reinforced concrete using Bethamcherla marble stone aggregate as a natural aggregate for structural construction works.

6.1 Slump Test

Slump test is the most commonly used method of measuring consistency of concrete. Actually the slump test "does not measure the workability of concrete", it is useful to attain the difference in the steady of fresh concrete and detecting variations in the uniformity of concrete mix from batch to batch. The water content in concrete is the most familiar reason, as other factors such as particle shape and grading of aggregate may varies the slump [3]. The following table 8 shows the slump value recorded for each mix batch.

Table -8: Slump value recorded for each mix batch

S.No	Nomenclature	Slump value with 0% fibres in mm	Slump value with 1% fibres in mm	Slump value with 2% fibres in mm
1.	NGA – 100 % BMS – 0 %	62	54	29
2.	NGA – 75 % BMS – 25 %	67	59	40
3.	NGA – 50 % BMS – 50 %	75	67	53
4.	NGA – 25 % BMS – 75 %	83	72	66
5.	NGA – 0 % BMS – 100 %	115	104	98

Note: In the above table 8 'NGA' refers to Natural Granite Aggregate and 'BMS' refers to Bethamcherla Marble Stone

6.2 Compaction Factor Test

The compaction factor test is primarily use in the laboratory conditions but now a days it is using even in the field conditions. It represents a better measurement of workability of concrete than slump test and this test best suited for controlling the production of low slump concrete mixes. The degree of compaction, called "compacting factor", is measured by the density ratio [3], [11] which can be described as the ratio of the density actually attained in the test to the density of same concrete when it is completely compacted. This method of workability test describes that the degree of fresh concrete mix will compact by itself when proceed it to fall freely by its force of gravity and without any other external forces. The following table 9 shows compaction factor value recorded for each mix batch.

The compacting factor was determined from the following equation:

$$\text{Compaction factor} = (W_1/W_2)$$

W1 = Mass of partially compacted concrete
W2 = Mass of fully compacted concrete

Table -9: Compaction factor value recorded for each mix batch

S.No	Nomenclature	Compaction factor value with 0% fibres	Compaction factor value with 1% fibres	Compaction factor value with 2% fibres
1.	NGA – 100 % BMS – 0 %	0.880	0.852	0.806
2.	NGA – 75 % BMS – 25 %	0.895	0.867	0.837
3.	NGA – 50 % BMS – 50 %	0.927	0.891	0.854
4.	NGA – 25 % BMS – 75 %	0.950	0.920	0.905
5.	NGA – 0 % BMS – 100 %	0.976	0.957	0.943

Note: In the above table 9 'NGA' refers to Natural Granite Aggregate and 'BMS' refers to Bethamcherla Marble Stone

6.3 Vee – Bee Test

This is very common laboratory test to measure indirectly the workability of fresh concrete at even very low workability. Vee-Bee consistometer test gave much more detailed indication of the workability of the fibre reinforced concrete than the common slump and compaction factor tests. The vibration of the Vee-Bee consistometer apparatus overcomes the stiffening effects of the fibres. This means that the description of the true workability of fibre reinforced concrete can be attained accurately. The following table 10 shows the Vee – Bee recorded for each mix batch.

Table -10: Vee – Bee time (sec) recorded for each mix batch

S.No	Nomenclature	Vee – Bee time with 0% fibres	Vee – Bee time with 1% fibres	Vee – Bee time with 2% fibres
1.	NGA – 100 % BMS – 0 %	5.3	5.5	10
2.	NGA – 75 % BMS – 25 %	5.0	5.1	7.0
3.	NGA – 50 % BMS – 50 %	4.4	4.9	5.7
4.	NGA – 25 % BMS – 75 %	4.1	4.2	4.9
5.	NGA – 0 % BMS – 100 %	3.7	3.9	4.3

Note: In the above table 10 'NGA' refers to Natural Granite Aggregate and 'BMS' refers to Bethamcherla Marble Stone

7. GRAPHICAL STUDY

Behaviour of Bethamcherla Marble Stone on Fibre Reinforced Fresh Concrete Mix

7.1 Slump Values

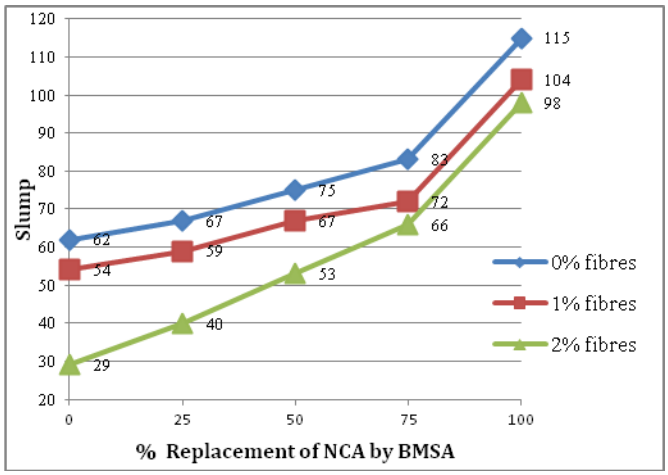

Fig. 3 % Replacement vs Slump value

This slump test value shows that increasing trend when percentage replacement of Natural aggregate with Bethamcherla marble stone increases. Fig. 3 above shows a graphical representation of % Replacement of NCA by BMS vs slump of concrete with different quantities of Galvanized steel fibres. The experimental results showed that the slump value of the fibre reinforced concrete has a decreasing trend when fibres volume dosage rate increases. The above Fig. 3 indicates that workability of concrete mix decreases as the dosage of fibres rate increases.

7.2 Compaction Factor Values

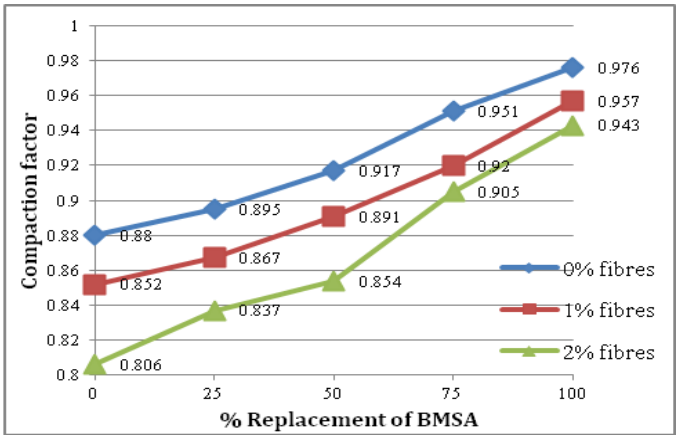

Fig. 4 % Replacement vs Compaction factor value

Similar to the slump test, the compaction factor test expresses improving trend when percentage replacement of Natural aggregate with Bethamcherla marble stone increases. The table 9 above shows the compaction factor values recorded at the time of test for all mix batches. Fig. 4 above shows a graphical representation of % Replacement of NCA by BMS vs compaction factor of concrete with different quantities of Galvanized steel fibres.

The empirical results showed that the compaction factor value of the fibre reinforced concrete has a declining trend when fibres volume percentage rate increases. The above Fig. 4 expresses that workability of concrete mix improves as the percentage of fibres rate increases.

7.3 Vee – Bee Values

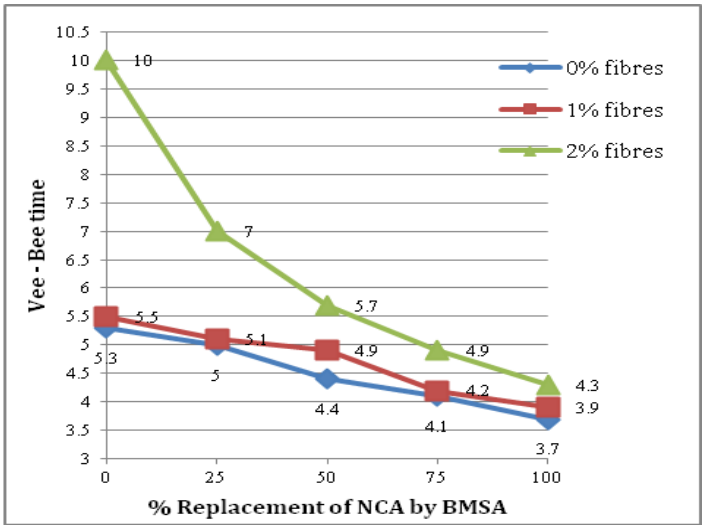

Fig. 5 % Replacement vs Vee – Bee time

Vee - Bee consistometer test gave much more accurate indication of the workability of the fibre reinforced concrete than standard slump and compaction factor test.

The vibration of the Vee - Bee consistometer apparatus overcomes the stiffening effects of the fibres. Fig. 5 above shows a graphical representation of % Replacement of NCA by BMS vs Vee - Bee time of concrete with different quantities of Galvanized steel fibres. The experimental results showed that the Vee - Bee test value of the fibre reinforced concrete has decreasing trend when fibres volume dosage rate increases. But the replacement of Natural aggregate with Bethamcherla marble stone aggregate increases Vee - Bee test value decreased. There is not much variation in the Vee - Bee value of concrete mix when we add 0% and 1% fibres but there is huge variation when we add 2% fibres. So the above Fig. 5 shows that the more addition of fibre to the concrete will lead to the decrease of workability of a concrete mix.

8. CONCLUSIONS

Workability of concrete mix decreased with replacement of natural aggregate with BETHAMCHERLA MARBLE STONE AGGREGATE. But up to some extent even replaced concrete mixes got optimum results. Addition of fibres improved the workability properties of concrete mix even it replaced with BMS. So the following conclusions are found from this experimental study.

- In this experimental work the workability of concrete gradually decreases. But up to some extent even aggregate replaced concrete mix got some good acceptable workability results.
- Addition of Galvanised fibre improves the workability of concrete mix.
- It is recommended that the replacement level of granite aggregate with Bethamcherla marble stone (BMS) limited up to 50 % only for good fresh concrete properties (workability properties).
- The present experimental study advises that to use Bethamcherla marble stone as a natural aggregate up to 50% for concrete based construction works (for minor works only in the initial stage).

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