Experimental Investigation on Concrete with Partial Replacement of Bitumen Coated Coarse Aggregate

K. ManojKumar[1], E. Ethaya Oviya[1], A. Kanimozhi[1],
[1]UG Students, Department of Civil Engineering,
M.A.M College of Engineering & Technology,
Trichy, India.

Mrs. K.Vairakannu[2]
[2]Associate. Professor, Department of Civil Engineering,
M.A.M College of Engineering & Technology,
Trichy, India.

***Abstract*— Concrete is widely used predominant material which accounts for production of 6 million metric tons. An attempt has been made to utilize the bitumen coated aggregate in concrete. In this study, M_{25} Grade of concrete is used, wherein the normal aggregate is replaced by bitumen coated aggregate in proportion of 10%, 20% and 30% respectively. A comparison has been made between the specimens of partially replaced coarse aggregate and the same set of specimens with bitumen coated coarse aggregate. The aim is to study the fresh and hardened properties such as compressive and split tensile strength and ascertain whether the feasibility of the same technically and economically. Test results indicated that the replacement of coarse aggregate by 10% has attained higher strength in this cases mentioned above.**

Keywords*—Bitumen coated aggregate, compressive strength, Split tensile strength

I. INTRODUCTION

Concrete is the most widely used material on earth after water. Many aspects of our daily life depend directly or indirectly on concrete. Concrete is prepared by mixing various constituents like cement, aggregates, water, etc., which are economically available. Concrete is unique among major construction materials because it is designed specifically for civil engineering projects. Concrete is a composite material composed of granular materials like coarse aggregates embedded in a matrix and bound together with cement or binder which fills the space between the particles and glues them together. Concrete plays a critical role in the design and construction of the nation‘s infrastructure. All along in India we have been using natural sand and gravel in concrete manufacturing. Availability of natural aggregate is getting depleted and also becoming costly. Hence, there has to be an emphasis on the use of waste and byproduct in all areas including construction industry. As 75% of concrete is composed of aggregate it is important that we look to maximize the use of waste as aggregate input in concrete making.

The general introduction of our project is to investigate the mechanical properties of the concrete mix. The paper investigates the behavior of concrete by replacing normal aggregate and bituminous coated aggregate have been mixed in different ratios. An attempt has been made to utilize the bitumen coated aggregate instent of normal aggregate. They are mixed in the proportion of 10%, 20%, 30% respectively. The coating of polymers on the surface of the aggregate has resulted in many advantages and ultimately helps to improve the quality of flexible pavement. The coating of plastics over aggregate also improves the quality of the aggregate[1]. Hot Mix Asphalt (HMA) mix design is the process of determining optimum binder content which satisfies the marshall properties. The result obtained from the experiment show that the SUPERPAVE aggregate gradation is superior than the MORTH aggregate gradation in almost all the criterions of strength and volumetric parameters[2]. The use of over burnt brick in the bituminous mixes requires higher amounts of bitumen binder compared to the conventional mix because of the high porosity and roughness of the brick aggregate. In this, they used Zycosoil as additive admixture. By using Zycosoil as a coating over aggregate the properties of aggregate improve. They have found that Zycosoil increases that the tensile strength of mix by 3 to 14% and fatigue life by 6 to 25% [3]. The strength is same with the conventional concrete only at 10% and 20% replacement of aggregate by sea shell. The strength is gradually decreasing at 30% replacement of seashells[4]. The use of modified bitumen with the addition of processed waste plastic of about 5-10% by weight of bitumen helps in substantially improving the Marshall stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage. The process is environment friendly[5].

II. EXPERIMENTAL PROGRAM

2.1 MATERIALS

2.1.1 CEMENT: The most common cement used is an Portland Pozzolana cement .The Portland pozzolana cement of 43 grade is been used. Many test were conducted on cement; some of them are specific gravity etc,.

2.1.2 AGGREGATE: The size of aggregates used is 20mm and the grain size of sand used is of zone II. The aggregate tests are performed and the result are as follows.

2.1.2.1 FINE AGGREGATE (F.A): In this study locally available river sand which is free from impurities is used. The size of it is less than 2.36mm.The specific gravity and fineness modulus of this fine aggregate where found by following tests.

2.1.2.2 COARSE AGGREGATE (C.A): The coarse aggregate used here is 20mm in size, crushed angular shape and free from dust. The specific gravity and fineness modulus was found by following tests and impact value was found to be 5.83%. The percentage of passing is within the limits as per IS: 383-1970[8].

2.1.3 BITUMEN*:*

Bitumen is a sticky black and highly viscous liquid are semi solid , some natural deposits. It is also the residue or by product of fractional distillation of crude petroleum. Bitumen composed primarily of highly condensed poly cyclic aromatic hydrocarbons, containing 95% carbon and hydrogen (± 87% carbon and ± 8% hydrogen) , up to 5% Sulphur, 1% nitrogen , 1% oxygen and 2000ppm metals. As a bitumen is mixture about 300 – 2000 chemical components with an average of around 500 – 700. It is the heaviest fraction of crude oil, the one with highest boiling point (525ºC).

2.1.3.1 DIFFERENT FORMS OF BITUMEN:

i) CUTBACK BITUMEN: A suitable solvent is mixed to reduce viscosity. Bitumen emulsion: bitumen is suspended in finely divided conditions in aqueous medium 60% bitumen and 40% water.

ii) BITUMINOUS PRIMERS: Mixing of penetrations bitumen with petroleum distillate.

iii) MODIFIED BITUMEN: Blend of bitumen with waste plastics are crumb rubber.

2.1.4 BITUMEN COATED AGGREGATE (BCA): Generally bitumen coated aggregates are used in road construction termed as asphalt concrete. The bitumen is heated up to around 150degree Celsius to decrease its viscosity and mixed with aggregates to facilitate better mixing and compaction. But here since we are doing it in small scale we have just added aggregates soaked in bitumen to test its behavior on concrete. The bitumen is mixed with coarse aggregate with 5% of its weight.

Fig 1 Bitumen Coated Aggregate

2.2 SPECIMEN DESIGNATION

i) C.C – Conventional Concrete
ii) BCA10 – Bitumen Coated aggregate of 10 % replacement
iii) BCA20 – Bitumen Coated aggregate of 20 % replacement
iv) BCA30 – Bitumen Coated aggregate of 30 % replacement

2.3 TEST ON MATERIALS

2.3.1 SIEVE ANALYSIS: The sieve analysis test is performed to obtain a distribution of grain size of the aggregate. The test was performed for 20mm aggregates, river sand.

i) SIEVE ANALYSIS FOR FINE AGGREGATE:

The sieve analysis for fine aggregate is done to find out the grain size of the sand and its zone. The analysis is done with 500grams of sand in an automatic sieve shaker for about 5 minutes with the sieve dishes are arranged from 10mm to 150 microns down the order of sieve shaker.

According to IS 2386 – 1963[9], Fineness modulus ranges are,

Fine Sand : 2.2 – 2.6
Medium Sand : 2.6 – 2.9
Coarse Sand : 2.9 – 3.2

ii) SIEVE ANALYSIS FOR COARSE AGGREGATE:

The sieve analysis for coarse aggregate is executed to find out the aggregate size and its zone. The fraction from 80mm to 4.75mm are termed as coarse aggregate. The coarse aggregate from crushed basalt rock, confirming to IS383-1970 is been used. The analysis is done with 5kg of coarse aggregate by manual sieve shaker for about 15minutes with the sieve dishes are arranged from 40mm to 150 microns down the order of sieve shaker.

TABLE 1 Technical Properties

Material	Specific Gravity	Fineness Modulus
F.A	2.61	2.87
C.A	2.71	7.03

2.3.2 WATER ABSORPTION TEST: This test is performed in order to determine the water absorption capacity of the aggregates used. Here about 300 grams of the various aggregates are taken separately and immersed in water for about 24 hours. These aggregates are then kept in oven at a temperature of 100 to 110 C° for a time period of 6 hours and then sample is weighted. The change in weight is noted. As per code the limiting value for the water absorption is 2%. The results of the aggregates tested are 1% for sand and 0.5% for 20mm aggregates.

2.3 MIX PROPORTIONS

The concrete mix is designed as per IS 10262-2009, IS456 -2000 for the normal concrete. The grade of concrete which we adopted is M_{25} with the water cement ratio of 0.4. Maximum size of aggregate is 20mm. Degree of workability is 0.92 from the compaction factor test.

TABLE 2 Mix Ratio

	W/C Ratio	CEMENT	F.A	C.A
RATIO	0.4	1	1.12	2.49

TABLE 3 Replacement Ratio

Specimen Designation	Cement	F.A	C.A	B.C.A	W/C ratio
C.C	1	1.12	2.49	0	0.4
BCA10	1	1.12	2.24	0.25	0.4
BCA20	1	1.12	1.99	0.5	0.4
BCA30	1	1.12	1.74	0.75	0.4

2.3.1 FRESH CONCRETE PROPERTY

SLUMP CONE TEST: The aim of this test is to determine the workability of the cement concrete to be used. The mix is prepared and placed in a clean slump cone mould and tamped by three layers of about 25 stokes each layer and the top of the cone is levelled off. Then the mould is lifted up vertically and the nature of slump is analysed to get the workability of the given cement concrete. For the water cement ratio of 0.4 the slump obtained for each bitumen coated aggregate concrete design mix and conventional design mix are given below (in mm):

Fig 2 Slump Cone Test

TABLE 4 Slump Value

Concrete Mix	Slump (mm)
C.C	40
BCA10	40
BCA20	45
BCA30	50

The above slump value are within the permissible limit as per IS code 456[6] and suitable for construction purpose and also has a good workability.

2.4 CASTING AND CURING

Two different sets of specimens are used prepared using design mix. In the first set, the specimen are casted by varying the percentage of replacement of corase aggregate by bitumen coated coarse aggregate starting from 0 to 30% with an increment of 10% by weight of coarse aggregate and the are represented as 10,20,30 respectively as shown in table. In the second set, the former procedure is followed. Cube with size 150mmX150mmX150mm, cylinders with 150mm diameter X 300mm height are prepared. The samples are demoulded after 24hrs from casting and kept in a water tank for 7 days and 28 days curing

TABLE 5 Details of Specimen

S.NO	Specimen description	Cubes (Nos)	Cylinder (No s)
1	C.C	6	3
2	BCA10	6	3
3	BCA20	6	3
4	BCA30	6	3

Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. The result of this process is increased strength and decreased permeability. 7 days and 28 days Curing is done for every concrete blocks

Fig 3 Cylinder Casting

Fig 4 Cube Casting

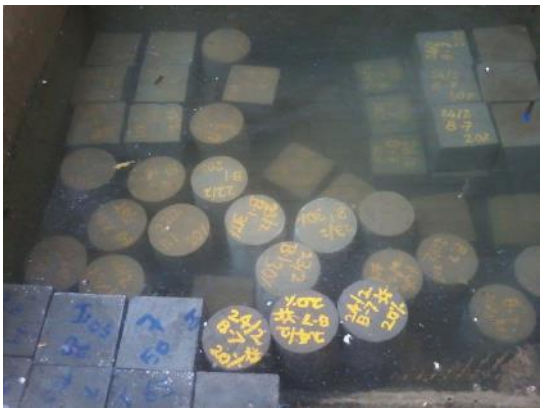

Fig 5 Curing of specimens

Fig 6 Compression Test Machine (CTM)

III.RESULT AND DISCUSSIONS

After a detailed study we have obtained the following results for compression strength as shown is table 6 & 7.

3.1 CONCRETE

The 7days strength was found for compressive strength test and 28 days strength for other tests. The results are given in the following Table. It was found that there was a certain percentage increase in strength in specimens with BCA as a coarse aggregate replacement material when compared with normal concrete specimens.

3.2 COMPRESSIVE STRENGTH TEST

The compressive strength was tested for concrete cubes of dimension 150 x 150 x 150 mm. The test was carried on the Compressive Test Machine of capacity 2000KN. In compressive strength test the loading rate was 5.25KN/s. The compressive test was conducted on 150mm³ specimens at 7th days.

TABLE 6 Compression Test Result for 7th Day

S. No	Specimen Designation	Compressive strength N/mm^2 (7 days)
1	C.C	19.42
2	BCA10	20.17
3	BCA20	20.83
4	BCA30	19.21

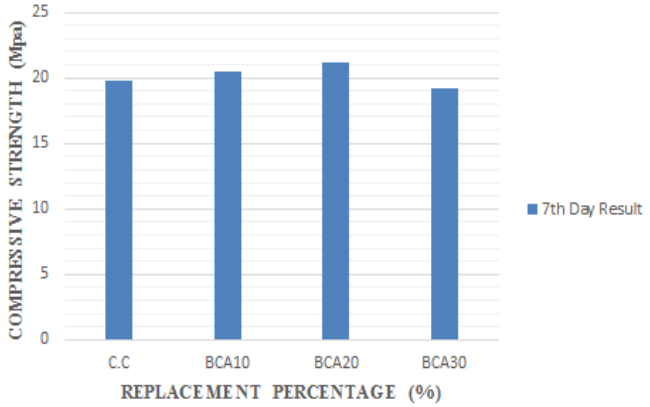

Fig 7 Compressive Strength of Concrete After 7 Days

TABLE 7 Compression Test Result for 28th Day

S. No	Specimen Designation	Compressive strength N/mm^2 (28 days)
1	C.C	26.34
2	BCA10	26.63
3	BCA20	27.25
4	BCA30	24.45

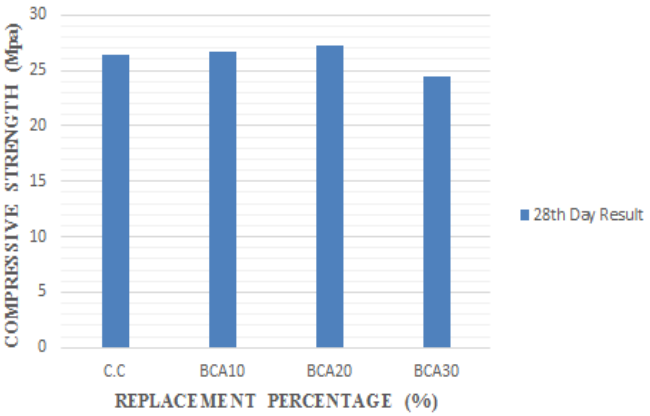

Fig 8 Compressive Strength of Concrete After 28 Days

Fig 9 Testing of Specimen in UTM

Fig 10 Failure of Specimen

Fig 11 BCA in Concrete After Failure

IV.CONCLUSION

Based on the results obtained from the experiment the following conclusions are drawn. The maximum Compressive strength of concrete without chemical admixture can be achieved by 20% replacement of BCA was found to be 7% higher than the conventional concrete. The strength had decreased when the 30% of coarse aggregate was replaced. Hence replacement of coarse aggregate with 20% BCA was achieved good strength.

REFERENCES

[1] Rajasekaran (2013) "Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite For Road Application – Green Method" American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-11, pp-01-13

[2] Sarika. P, A. k. Sandra (2015) "Comparing Properties Of Bituminous Concrete Mixes Prepared Using Morth And Superpave Gradations" University Of Texas, Hyderabad.

[3] Sarkar. D, Pal. M, Sarkar. A. K- "Laboratory Evaluation of Asphalt Concrete Prepared with Over Burnt Brick Aggregate Treated by Zycosoil," International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol:8, No:12, 2014

[4] Vignesh. S, (2015), "A Partial Replacement for Coarse Aggregate by Seashell and Cement By Fly ash In Concrete" National Conference on Research Advances in Communication, Computation, Electrical Science and Structures.

[5] Zamer.G. S, (2012), "Utilization Of Waste Plastic In Asphalting Of Roads" Scientific Reviews and Chemical Communication. 2(2), 2012, 147-157

[6] IS 456-2000 Specifications for plain and reinforced concrete.

[7] IS 10262-2009 Recommended guidelines for concrete mix Design, BIS. New Delhi, India, 2009.

[8] IS 383-1970, Specification for Coarse and Fine Aggregates from natural sources for concrete (Second revision).

[9] IS 2386-1963, Methods of Test for Aggregates for Concrete Part I Particle Size and Shape.