IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Performance of Pervious Concrete made with Black Marble Stone Waste Aggregate

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Abstract : Normal or conventional concrete, which is a combination of cement, sand, coarse aggregate and water, forms a hard surface. The fast urbanization and infrastructure developments cause compactly constructed buildings. Depletion of ground water is a major problem today due to the lack of percolation of rain water into the soil. The impermeable nature of conventional concrete restricts the flow of rainwater into the ground. Pervious concrete is one solution to this problem. Pervious concrete is also called enhanced porosity concrete, which is used widely nowadays due to its higher infiltrating ability. Pervious concrete is made up of cement paste, coarse aggregate with little or no fine aggregate. The paste binds the aggregate particles together to develop a system of interconnected and highly permeable voids that encourage the quick drainage of water. Generally, it is used in parking areas, areas with light traffic, residential streets, pedestrian roads and drain covers. The proper utilization of pervious concrete is recognized as Best Management Practice by the U.S. Environmental Protection Agency (EPA) for providing storm water management. On the other hand, many new methods and materials are being introduced for production of concrete to meet the increasing demand. The cost of production of aggregate is increasing at a shocking rate and there is a depletion of the natural resources which give the raw material for its manufacture. The use of waste material as a replacement of coarse aggregate in concrete has become the thrust area for construction industry. It can be used as partial replacement of aggregate in concrete, without compromising on its desired strength. The present research work is focused on pervious concrete made with black marble stone waste aggregate. In the present research study, marble waste is used for the pervious concrete in the proportions of 0, 50, 100% in place of natural aggregate. To know the behavior of the above proposed Pervious concrete, an experimental investigation is done to evaluate different properties.

IndexTerms **– Pervious concrete, Black Marble Stone waste Aggregate, Compressive Strength, Bearing Strength.**

I. INTRODUCTION

INTRODUCTION

Concrete is a composite material consisting of cement, sand, coarse aggregate and water and is the most commonly used material in construction globally. It is a brittle material with higher compressive strength. There has been continuous development in the manufacturing of concrete since the time of invention. Initially, materials like gypsum or limestone were burnt and used as crude cement. Later, these cements are mixed with sand and water to form mortar, which was a binding material used to fix stones to each other.

Over the years, there was an improvement in the combination of materials which further led to present day concrete. Concrete has gained importance due to its inherent properties and wide range of applications. As there is a huge requirement for concrete production in society, the materials and process of manufacturing of concrete must be very carefully carried out to produce good quality concrete. The constituents of concrete influence the quality of concrete and the life of the structure.

To improve the strength characteristics in any type of concrete, mineral constituents play a vital role in the ingredients of concrete. Many Works has been carried out to improve the performance of the concrete. To prevent the extinction of natural resources in the environment, the usage of new materials in concrete is also increasing day by day without compromising the required properties of concrete to meet the increasing demand in the industry. Concrete is a hard, impervious material in general. There are different types of concrete developed from time to time, such as fiber reinforced concrete, self compacting concrete, light weight concrete, high density concrete etc. to meet the various applications.

II. NEED OF THE STUDY.

The Government of India is emphasizing to develop rain water harvesting arrangements for each house, very particularly in drought areas. In view of this, it is required to develop few arrangements to infiltrate the rain water or unwanted water, so as to enhance the water table or storage capacity. Many works have been carried out on pervious concrete to study the strength,

porosity, permeability characteristics by replacing coarse aggregate with alternate 3 materials. Need for reuse of alternate materials is important for construction industry due to lack of availability of materials (coarse and fine aggregate).

The present research work deals with producing pervious concrete. The pervious concrete is prepared with natural aggregates and marble stone waste aggregate (Coarse aggregate) and along with reduction of fine aggregates (Sand) to make concrete porous. For this concrete, the following tests are conducted to know the performance.
1) Compressive Strength
2) Bearing Strength

III. LITERATURE REVIEW

1. N. Venkata Ramana (2012) discussed replacement of stone waste (CA) with natural aggregate in different proportions of 0, 25, 50, 75 and 100%. Concrete mix designed for work as per ACI 522R-06 provisions. Cube compressive strength was decreased from 38 to55%. ACI recommends that the compressive strength of pervious concrete should be in range of 2.8 to 28Mpa and the split tensile strength is decreased from 3 to 27% respectively. The predicted values by proposed equation were about 0.9 to 1.1 and the permeability of concrete increases with replacement.

2. M. Aamer Rafique Bhutta et.al, (2012) conducted a study to estimate properties of high performance porous concrete. The results showed that, the larger the coarse aggregate, lower is the strength. Further the compressive strength of HPPC was higher compared to CPC, this is because bonding between cement paste to aggregate had enhanced by adding cohesive agent in HPPC. Effect of aggregate size on permeability of porous concrete was also studied and it showed the permeability values between 0.25 and 3.3 cm/s which were high enough to be used as a drainage layer porous concrete blocks. The aggregate gradation did show consistent influence on permeability that is smaller the aggregate size lower the permeability.

3. Carsana et al. (2013) studied the strength and durability properties of pervious concrete with embedded steel bars and found the compressive strength is in the range of 7 to 30 MPa. However, pervious concrete with reinforcing bar and no fine particles is susceptible to carbonation and corrosion.

4. Darshan S. Shah, Jayeshkumar Pitroda (2014) discussed the hardened properties of pervious concrete related to construction industry applications. To study the hardened properties of pervious concrete the pervious concrete mixture with cement, coarse aggregate/gravel and water was prepared and casted with different concrete mix proportions, with different gravel sizes and with different grades of cement (OPC Grade 53, PPC Grade 53). After the required period of curing i.e., 7, 14, 28 days the casted blocks were subjected to compressive strength test and flexural strength test.

5. Shivakumar (2014), done research on buildings demolished waste is increasing now a days, the paper discussed strength characteristics for different replacement levels and recommends aggregate ratio of 1:8 50% of BDW is recommended for low traffic volume. It is inferred that BDW porous concrete is more comparable than conventional concrete.

IV. OBJECTIVE OF THE STUDY

The present work is mainly to be focused on the development of normal strength M20 grade concrete using black marble stone waste as replacement of natural aggregate in the proportions of 0, 50 and 100%. Along with this, the fine aggregate quantity is reduced by 20, 21 60 and 100% in the required mix, which results in creation of pores in the concrete.
1.To study the hardened properties like Compressive strength, bearing strength.

V. MIX DESIGN

The proper proportioning of concrete materials is the prime factor for obtaining better fresh and hardened properties. In the present work the coarse aggregate in the concrete is replaced by BMSWA in proportions of 50 and 100%. The mix design is done as per IS 10262- 2009 for target mean strength of the 26.6 MPs, the water cement ratio obtained is 0.50. The mix proportions of 1: 1.5: 3 are obtained. The mix design procedure can be viewed in the Appendix. In this investigation, natural aggregate is replaced with black marble stone waste aggregate by 0, 50 and 100%. The weights of materials for all the mixes are shown in Table 5.1

Table 5.1 Weight of materials

Nomenclature	Cement	Fine Aggregate	Coarse Aggregate	BMSWA	Water
NA – 100	393	675	1127	0	197
NA – 50	393	675	563.5	563.5	197
BMSWA - 100	393	675	0	1127	197

5.1 MIXING

All the required quantities of cement, sand and coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water is added to the composite mixture and mix thoroughly until a uniform mixture is formed. The same procedure is repeated for different mixes which includes the reduction of fine aggregate in different percentages and replacement of coarse aggregate with black marble stone waste aggregate. The complete mixing is done by hand mixing.

Fig. 5.1 Mixing of Concrete

5.2 CASTING OF CUBES

Totally 36 cubes were cast for conducting various tests. Among them 18 cubes for compressive strength test, 18 cubes for bearing strength test. For the preparation of cube specimens, the mixed concrete is poured into the cube moulds made of steel of dimensions of 150 X 150 X 150mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in layers into the moulds till the surface and leveled. The specimens are allowed to dry up for 24hrs.

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days.

5.2.1 Compressive strength test (IS 516-1989)

Compressive strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads. For this experimental study, 27 no. of cube specimens were cast in which 9specimens are of 100% Natural Aggregate, 9 specimens are of 50% Natural Aggregate + 50% MSWA and 9 specimens are of 100% MSWA. The above 6 specimens of each mix are made with reduction in fine aggregate of 20, 60,and 100% proportions. The number of specimens cast for each mix is shown in the table 5.2.

Table 5.2 No. of specimens for different mixes for Compressive strength test

Sr. No.	Replacement of Natural Aggregate with BMSWA (%)	% Of Fine aggregate reduction in mix		
		20	60	100
1.	0	3	3	3
2.	50	3	3	3
3.	100	3	3	3

This test is conducted to determine the variation of strength of the specimens with varying ratios of coarse aggregate and reduction in fine aggregate content. Compressive strength test machine (CTM) with 2000KN capacity is used to conduct the test on cubes. After placing the cube between the plates in the CTM, load is applied until the crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted. The compressive strength is calculated by Compressive Strength (s) = Failure load / Cross sectional area of specimen.

5.2.2 Bearing Strength test (IS 516-1989)

Bearing strength of concrete is important design criteria to transmit load safely to concrete supports. Structural behavior of concrete bearing is strongly related the bearing capacity of concrete block loaded through a steel bearing plate. The load transfer and failure mechanism of concrete bearing are affected by the size of concrete blocks and steel plate. The bearing strength of concrete is related to the compressive strength the ratio of the total surface area to load bearing area known as bearing ratio. For the present study bearing ratio of 10 is 38 considered. For this experimental study, 27 no. of test cube specimens were cast in

which 9 specimens are of 100% Natural Aggregate, 9 specimens are of 50% Natural Aggregate + 50% BMSWA and 9 specimens are of 100% MSWA. The above 18 specimens of each mix are made with reduction in fine aggregate of 20, 60, and 100% proportions for 28days of curing. The number of specimens cast for each mix is shown in the table 5.3.

The present study has been carried out to analyze the mechanisms of bearing failure for pervious concrete. Bearing test is conducted on the cube specimens with bearing ratio 10, to determine the variation of strength. Compression testing machine (CTM) with 2000 KN capacity is used to conduct the test on cubes. The cubes are tested with the steel plate on top of it with dimensions of 47.5 mm × 47.5 mm. Load is applied until crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted for the calculation of bearing strength.

Table 5.3 No. of specimens for different mixes for bearing strength test

Sr. No.	Replacement of Natural Aggregate with BMSWA (%)	% Of Fine aggregate reduction in mix		
		20	60	100
1.	0	3	3	3
2.	50	3	3	3
3.	100	3	3	3

VI. RESULT AND DISCUSSION

6.1 Compressive strength test

The compressive strength test of the concrete for reduction in fine aggregate at different levels of 20, 60, 100% and replacement of natural aggregate with BMSWA by 0, 50 and 100% was done. The cube compressive strengths of reduction in fine aggregate and replacement of natural aggregate with BMSWA are shown in table 6.1 and are graphically represented in the Fig. 6.1.

The cube compressive strengths of the concrete for 100% natural aggregate and reduction of the fine aggregate from 20 to 100% are 28.44Mpa to 4.69 MPa. The percentage decrease of compressive strengths for 20%, 60%, and 100% are 14.2 %, 49.85%, and 83.5% 39 respectively with respect to the 0% reduction of the fine aggregate.

The cube compressive strengths of the concrete for 50% natural aggregate and reduction of the fine aggregate from 20 to 100% are 23.11Mpa to 2.86 MPa. The percentage decrease of compressive strengths for 20%, 60%, and 100% are 16.57%, 52.57%, and 87.62% respectively with respect to the 0% reduction of the fine aggregate.

The cube compressive strengths of the concrete for 100% BMSWA and reduction of the fine aggregate from 20 to 100% are 18.11Mpa to 0.93 MPa. The percentage decrease of compressive strengths for 20%, 60%, and 100% are 20.65%, 58.36%, and 94.86% respectively with respect to the 0% reduction of the fine aggregate.

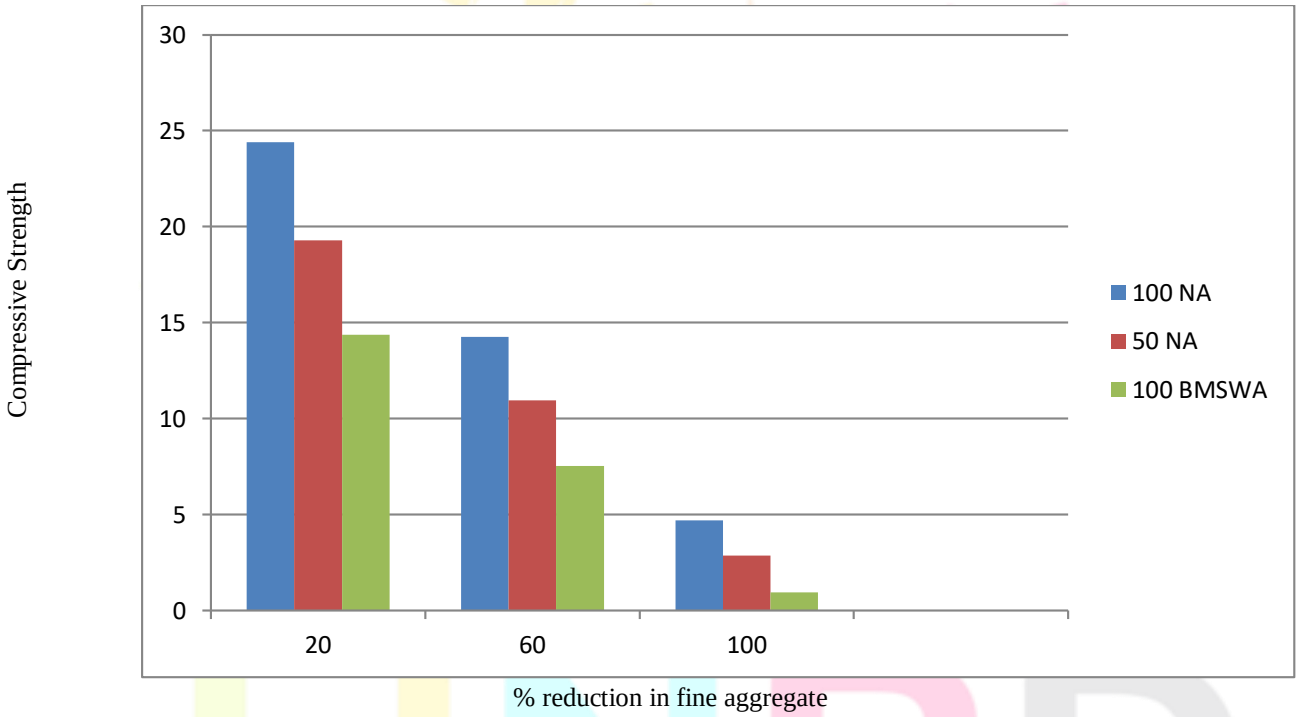
It is also observed that there is decrease in the cube compressive strength of the concrete when the natural aggregate is replaced with BMSWA. The percentage decrease of compressive strengths for 50% and 100% replacement of natural aggregate with BMSWA are 20.98% and 41.1% respectively with respect to the 20% reduction of the fine aggregate, 21.77% and 48.23% respectively with respect to the 60% reduction of the fine aggregate, 40.45% and 68.87% respectively with respect to the 100% reduction of the fine aggregate.

From the results, it is observed that there is a gradual drop in compressive strength for different replacement and reduction levels. Subba reddy et.al (2017) recommended that MSWA may be used upto 50% replacement for concrete works. K. Obla (2010) conducted experiments on pervious concrete and compressive strength varies from 3 to 17 Mpa.

Table 6.1 28 Days Compressive Strength

Sr. No.	Replacement of Natural Aggregate with BMSWA (%)	Compressive Strength (Mpa)		
		% Of Fine aggregate reduction in mix		
		20	60	100
1.	0	24.4	14.26	4.69
2.	50	19.28	10.96	2.86
3.	100	14.37	7.54	0.93

Fig. 6.1 28 Days Compressive Strength



6.2 Bearing Strength test

The Bearing strength test of the concrete for reduction in fine aggregate at different levels of 20, 60, 100% and replacement of natural aggregate with BMSWA by 0, 50 and 100 % was done. The Bearing strengths of reduction in fine aggregate and replacement of natural aggregate with BMSWA are shown in table 6.2 and are graphically represented in the Fig.6.2

The bearing strengths of the concrete for 100% natural aggregate and reduction of the fine aggregate from 20 to 100% are 47.5Mpa to 7.13 MPa. The percentage decrease of bearing strengths for 20%, 60%, and 100% are 17.81 %, 52.88%, and 84.9% respectively with respect to the 0% reduction of the fine aggregate.

The bearing strengths of the concrete for 50% natural aggregate and reduction of the fine aggregate from 20 to 100% are 38.6Mpa to 4.34 MPa. The percentage decrease of bearing strengths for 20%, 60%, and 100% are 20.07 %, 55.44%, and 88.75% respectively with respect to the 0% reduction of the fine aggregate.

The bearing strengths of the concrete for 100% BMSWA and reduction of the fine aggregate from 20 to 100% are 30.24 Mpa to 1.41 MPa. The percentage decrease of bearing strengths for 20%, 60%, and 100% are 23.97 %, 60.87%, and 95.33% respectively with respect to the 0% reduction of the fine aggregate.

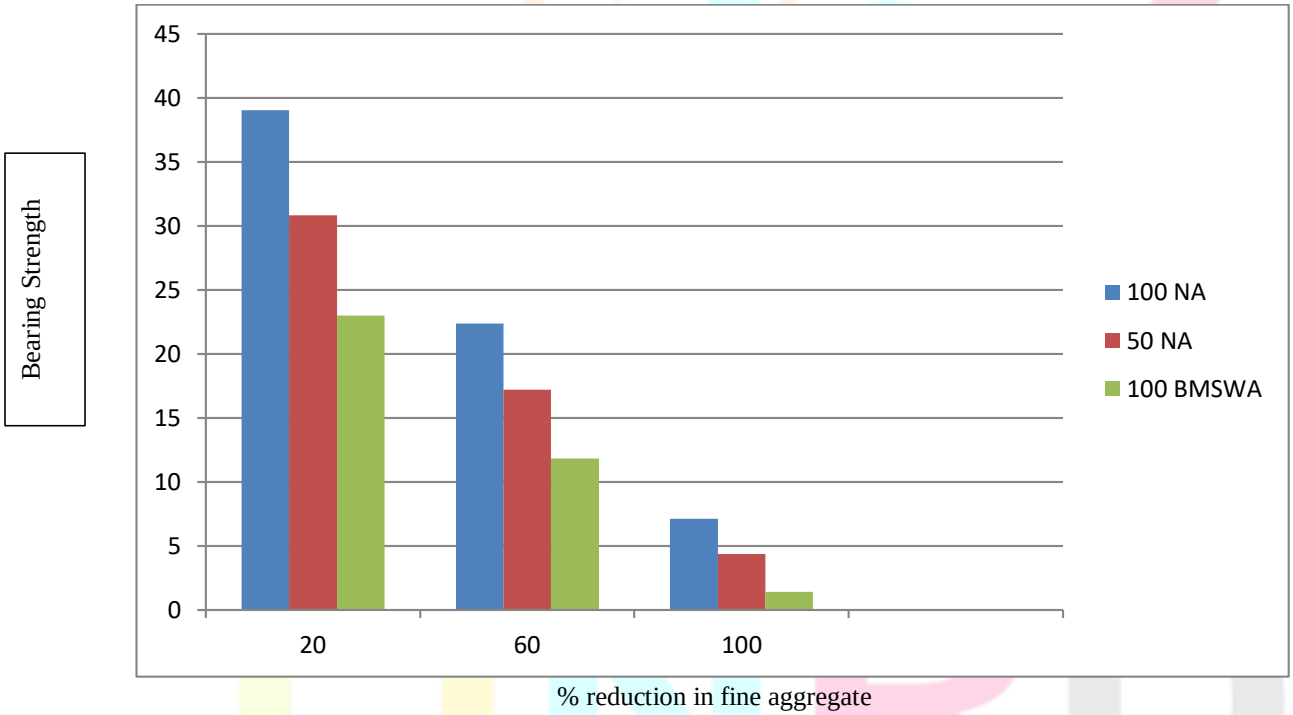
It is also observed that there is decrease in the bearing strengths of the concrete when the natural aggregate is replaced with BMSWA. The percentage decrease of bearing strengths for 50% and 100% replacement of natural aggregate with BMSWA are 20.9% and 41.11% respectively with respect to the 20% reduction of the fine aggregate,23.14% and 47.14% respectively with respect to the 60% reduction of the fine aggregate, 39.13% and 80.22% respectively with respect to the 100% reduction of the

fine aggregate. Guru prasad et.al (2012) conducted experiments on bearing Strength of pervious concrete and concluded that bearing strength decreases with replacement of recycled aggregate. Similar trend is observed in the present work.

Table 6.2 28 days Bearing Strength

Sr. No.	Replacement of Natural Aggregate with BMSWA (%)	Bearing strength		
		% of fine aggregate reduction in mix		
		20	60	100
1.	0	39.04	22.38	7.13
2.	50	30.85	17.2	4.34
3.	100	22.99	11.83	1.41

Fig. 6.2 28 days Bearing Strength



VII. CONCLUSION

The main objective of this investigation is to study the performance of the Pervious concrete made with reduction of fine aggregates (Sand) and replacement of the natural aggregate with BMSWA at 0, 50 and 100%. The performance is studied with respect to the mechanical properties namely compression, bearing.

The following conclusions were drawn based on the experimental investigations and statistical analysis on mechanical properties of pervious concrete :

1. The compressive strengths were decreased with increase of percentage replacement of BMSWA in the concrete mix. This decrease in strength may be due to less aggregate crushing strength as well as less aggregate impact value.

2. The compressive strengths of the concrete for 100% natural aggregate and reduction of the fine aggregate from 0 to 100% varies from 28.44MPa to4.69 MPa. For 50% natural aggregate the strengths are 23.11MPa to 2.86MPa and for 100% BMSWA the strengths are 18.11MPa to 0.93 MPa. It is observed that the compressive strengths are decreased due to the formation of voids with the percentage reduction of the fine aggregate. It is also observed that there is decrease in compressive strength of the concrete when the natural aggregate is replaced with BMSWA.

3. The bearing strengths of the concrete for 100% natural aggregate and reduction of the fine aggregate from 0 to 100% are 47.5MPa to 7.13 MPa .For 50% natural aggregate the strengths are 38.6MPa to 4.34 MPa and for 100% BMSWA the strengths

are 30.24 MPa to 1.41 MPa. The bearing strength of concrete showed decreasing trend with different replacement levels of MSWA.

VIII. REFERENCE

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