EVALUATION OF COMPRESSIVE STRENGTH OF CONCRETE WITH BROKEN POT MATERIALS AS PARTIAL REPLACEMENT OF COARSE AGGREGATE

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ABSTRACT
Coarse aggregate is a primary ingredient for making Concrete for various construction works, including infrastructure development, low, and high-rise buildings and domestic development. It occupies about 65-80% of the concrete. Broken pot materials (B.P.M.) are waste-generated pot-making processes and day-to-day activities. The broken pot material (B.P.M.) may replace natural coarse aggregate. The broken pot (B.P.M.) was sourced from pot-selling markets/stalls at Tundun Wada and Kofar Gabas in Sokoto. Concrete of 0%, 5% and 10% replacement were produced and cured for 28 days after which the cubes were tested for strength development. It was observed that the strength of 5% replacement was lower than that of 0% while that of 10% replacement was the lowest. However, the strength developed for 5% and 10% were 27.37N/mm^2 and 22.11N/mm^2, which are acceptable for 1:2:4. It is therefore recommended that, where available in abundance, broken pot materials be incorporated in Concrete to replace coarse aggregate.

Keywords: Broken Pot, Cement, Concrete, Compressive Strength and Coarse Aggregate

INTRODUCTION

Building construction workers and civil engineers worldwide depend largely on "concrete" as a significant material in construction. It was discovered that there is a close relationship between the construction material available and the type of structure we build obviously, certain types of structures can only be built after they have developed the appropriate construction materials. Concrete in today's world is an essential construction material that is widely used because of its good properties such as sustainability, durability, adaptability and versatility (Gana Braimoh, Okwole, & Amodu, 2022). Concrete is a composite construction material of cement, aggregates (fine and coarse), and water (sometimes with admixtures) in required proportions. Concrete is the world's most important construction material. The quality and performance of concrete play a key role in most infrastructures, including commercial ones. Industrial, residential, and military structures, dams, power plants, and transportation systems. Concrete is the single largest manufactured material in the world and accounts for more than 6 billion metric tons of materials annually in the United States, federal, state, and local governments have nearly $1.5 trillion in investment in the U.S. civil infrastructure the worldwide use of concrete materials account for nearly 780 billion dollars in annual spending (Akhila, 2018 and Khadeeja, 2018).

In heterogeneous materials like Concrete, quality of the constituents, and proportions in which they are mixed determine the strength and properties of the resulting product (Agbede & Manasseh, 2009). A good knowledge of the properties of cement aggregates and water is required to understand Concrete's behavior. Aggregates are inert materials that are used as binding materials in concrete production. The aggregates occupy about 70 to 75% of the volume of the hardened mass, about three-quarters of the volume of Concrete (Neville, 1996). Aggregate is classified broadly into two categories which are fine and coarse aggregates. Fine aggregate is generally natural sand and is graded from particle 5mm in size down to the finest particle but excluding dust. Coarse aggregate is also natural gravel or crushed stone, usually larger than 5mm and usually less than 16mm in ordinary structure. As society develops challenges are posed on protecting the environment concerning the reduction of energy consumption, and natural raw materials used in construction processes. Based on this, attention has been focused on the environment, safeguarding of natural resources, and recycling of wastes in building materials.

Gunalaan Vasudevan, Seri Ganis KanapathyPillay, [2020] studied to investigate the effect of using Waste Glass Powder in Concrete. Laboratory work was conducted to determine the performance of the control sample and Concrete with used waste glass powder. They concluded that Concrete with using waste glass powder averagely had higher strength at 14 days but once the Concrete reached 28 days the control mix gave higher value compared to mix that contained waste glass powder but still give high value of the M 30 grade. Mostafa Jalal [2012] investigated the mechanical behavior of Concrete reinforced with recycled steel Fibers (R.S.F.) recovered from milling and machining process. He observed that the compressive strength of the specimens was significantly increased. By increasing the waste fibers percentage, the workability of Concrete decreased.

In some cases, water must be added so that the workability increases and as a result, the compressive strength decreases a little. By using waste fibers, cracks distribution got much more uniform during failure. The desired quantity of fibers from the compressive strength point of view was between 2-3 percent. Mohd Monish et. Al. [2013] They investigated that huge quantities of construction and demolition waste are generated annually in developing countries like India. Disposing this waste is a very serious problem because it requires huge space for its disposal, and very little demolished waste is recycled or reused. The paper deals with the effect of partial replacement of coarse aggregate by demolished waste on workability and compressive strength of 7 and 28 days. The concrete mix design was done by IS:10262 (1982).

The cement content in the mix design was taken as 380 kg/m3 which satisfies minimum requirement of 300 kg/m^3. Three specimens each having 0%, 10%, 20%, and 30% demolished waste as coarse aggregate replacement for mix of 1:1.67:3.33were cast and tested after 7 and 28 days to have a comparative study. They concluded that up to 30% replacement of coarse aggregate with recycled aggregate Concrete was comparable to conventional Concrete Up to 30% of coarse aggregate replaced by demolished waste gave strength closer to the strength of plain concrete cubes and strength retention is in the range of86.84-94.74% as compared to conventional Concrete. Javed Ahmad Bhat et. al [2012] They carried out An exploratory study on the suitability of Machine Crushed Animal Bones (C.A.B.) as partial or full replacement for normal coarse aggregates in concrete works. The physical and mechanical properties of machine-crushed animal bones and locally available normal aggregate have been determined and compared. Many concrete cubes of size 150×150×150 mm with different percentages by weight of normal aggregate to crushed animal bones as coarse aggregate were cast, tested and their physical and mechanical properties were determined. They concluded that lightweight Concrete using C.A.B. aggregate can be achieved by replacing normal aggregate by C.A.B. aggregate approximately 50% or more. The average unit weights corresponding to 50%, 75%, and 100% of C.A.B. aggregate inclusion in concrete are19.60 K.N./m^3, 17.65 KN/m^3, and 16.55 KN/m^3 respectively, for nominal concrete mix 1:1.5:3. Compressive strength of C.A.B. concrete (lightweight)is low as compared to normal Concrete.

The use of broken pot materials to replace coarse aggregate in Concrete is an innovation which will promote finding alternative to use of natural resources directly and promote the use of waste materials in our community.

MATERIALS AND METHOD

Materials

Most materials used for the experimental work were obtained within Sokoto metropolis. And they are: Broken pot materials got from Pot market at kofar Gabas and Tudun Wada, Sokoto. The broken pot materials were taken to the Umaru Ali Shinkafi Polytechnic Concrete Laboratory, Sokoto for further processes.

Cement used was obtained from Gidan Man'ada cement stalk. Its Ordinary Portland Cement produced by Bua Cement Company Sokoto. For the experimental work, coarse and fine aggregates were obtained at the tipper garage behind the Umaru Ali Shinkafi Polytechnic, Sokoto.

Water was obtained from the tap water supply to the Concrete lab., UASPOLY Sokoto.

Fig. 1. Broken Pot Material (B.P.M.)

Fig. 2. Natural Coarse Aggregate

METHOD

Mixing of the Concrete was performed in the concrete lab. After weighting out the various quantities of materials, the cement and fine aggregate were first mixed under dry condition until the mixture became thoroughly blended, then the coarse aggregate was introduced, mixed with the already mixed cement and sand until the mix becomes uniformly distributed throughout the batch. Water was added to the mix and continued until a homogeneous concrete mix appeared and the desired consistency emerged. BS Standard used 150mm×150mm×150mm mould. Moulds were oiled with engine oil (as releasing agent) to ensure easy demoulding operation. The Concrete in the mould were filled in three layers approximately 50mm thick with the Concrete (that is about 50mm depth). Adequate compaction by hand was done using a standard steel tamping rod. Each layer was compacted with at least 25 strokes per layer using the tamping rod before the cube is filled up with Concrete and then compacted complete the trowel was used to give smooth finish on the surface after casting.

After the casting, proper identification marks showing the time interval and the type of coarse aggregates used were given. Then, the concrete moulds were left in the laboratory for 24 hours. After 24 hours, the cubes were demoulded and transferred into the curing tank. The compressive strength test was carried out on all the specimens using the compressive strength test machine, as found in the test method B.S. 1881, part 116, 1983.

RESULTS, ANALYSIS AND DISCUSSION

The cast cubes were kept in the curing tanks for further testing to determine their strength. However, during concrete mixing, the workability of the resulting concrete cubes was tested, and the results are presented in Table 3.1.

Table 3.1. Results of slump test on concrete types

Type	Slump Value
0% coarse aggregate	70mm
5% broken pots materials (B.P.M.)	65mm
10% broken pots materials (B.P.M.)	62mm

Source: (Lab., Result, 2024)

The results of the 28 days strength of concrete cubes i.e 0%, 5% and 10% are presented in the tables that follows:

Table 3.2: Results of 28 days compressive strength test for 0% replacement of coarse Agg.

Cubes No	Weight (g)	Density (g/m^3)	Load at failure (kN)	Strength (N/mm^2)
1	8634	2.5	745.76	33.14
2	8698	2.5	696.40	30.95
3	8538	2.5	680.34	30.24

Source: (Lab., test, 2024)

Average strength obtained for 0% replacement = 31.44N/mm^2

Table 3.2 Compressive strength test result for cubes made with 5% replacement broken pots materials (B.P.M.)

Cubes No	Weight (g)	Density (g/m^3)	Load @ failure (K/N)	Strength (N/mm^2)
1	7808	2.3	644.27	28.6
2	7818	2.3	588.35	26.1
3	8092	2.4	615.97	27.4

Source: (Laboratory test, 2024)

Average strength for 5% replacement was obtained to be 27.73N/ mm^2

Table 3.3. Compressive strength test for cubes made with 10% of broken pot materials (B.P.M.)

Cubes No	Weight (g)	Density (g/m^3)	Load (a) failure (K/N)	Strength (N/mm^2)
1	7703	2.3	503.36	22.37
2	7809	2.3	501.28	22.27
3	8013	2.3	487.77	21.68

Source: (Laboratory test, 2024).

Average strength for 10% replacement was obtained to be 22.13N/ mm^2.

CONCLUSION AND RECOMMENDATION

Conclusions

Based on the experimental work on evaluating the strength of Concrete made with Broken pot materials B.P.M. as partial replacement of coarse aggregate. The following conclusions have been drawn:

1. The B.P.M. has performed excellently as a good replacement for coarse aggregate in Concrete.
2. 0% replacement has the highest strength of 31.44N/mm^{2,} followed by 5% and 10 %, with 28-day strengths of 27 and 22 N/mm^{2,} respectively.
3. Workability of the Concrete was affected by the percentages of replacement.

Recommendations

It can therefore be recommended that,

1. Where available in large / appreciable quantities, broken pot materials should be used up to 10% to replace coarse aggregate in Concrete for building work.
2. More work should be done on strength development and optimization of the materials and cost in the future.

REFERENCES

BIS 383: 1970 coarse aggregate and fine aggregate from natural sources for concrete 9th Revision, BIS, New Delhi, 1970.

Gunalaan Vasudevan, Seri Ganis Kanapathy pillay, (2020) "Performance of Using Waste Glass Powder in Concrete as Replacement of Cement" American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-02, Issue-12, pp-175-181.

IS:10262-1982, Recommended Guidelines for Concrete Mix Design Bureau of India Standards, New Delhi.

IS:456-2000, Plain and Reinforced Concrete Code of Practice Bureau of India Standards, New Delhi.

Javed Ahmad Bhat, Reyaz Ahmad Qasab and A. R. Dar, (2012) "Machine Crushed Animal Bones as Partial Replacement of Coarse Aggregates in Lightweight Concrete", ARPN Journal of Engineering and Applied Sciences, VOL. 7, NO. 9,

Mohd Monish, Vikas Srivastava, V.C. Agarwal, P.K. Mehta and Rakesh Kumar, (2013), "Demolished waste as coarse aggregate in concrete", J. Acad. Indus. Res. Vol. 1(9),

Mostafa Jalal, "Compressive Strength Enhancement of Concrete Reinforced by Waste Steel Fibers Utilizing Nano SiO2",(1990) Middle-East Journal of Scientific Research 12 (3): 382-391, 2012ISSN 1990-9