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ORIGINAL RESEARCH ARTICLE

EVALUATION OF CONCRETE STRENGTH WITH SCARIFIED ROAD WASTE MATERIAL

K. Mohammed[1]* and Z. Mustapha[2]
[1]*Department of Civil and Water Resources Engineering, University Maiduguri, Maiduguri, Borno State, Nigeria*
[2]*Department of Civil Engineering, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria*
**Corresponding author's email address:* engrkachalla@unimaid.edu.ng

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ABSTRACT

The rising construction materials cost, dwindling materials availability and environmental challenges couple with the serious effect of construction waste have caused a serious concern in the construction industry. Most of the time, repairs of failed road pavements result in generation of Scarified Road Material Wastes (SRMW) and these are usually dumped by the roadsides thus causing environmental issues. These SRMWs could be useful if recycled in the production of concrete but their composition remains a question. Hence, this study seeks to investigate the suitability of SRMW in the production of concrete if used as fine aggregate. The fine aggregate content in nominal concrete mix was altered with SRMW that ranged between 0 – 40 % at an increment of 10%. Similarly, the SRMW was used as an additive in normal concrete mix. The casted concrete cubes of 150 x 150 x 150mm size were tested for strength on 7, 14, 21 and 28 days periods. The experimental results showed that the use of scarified road waste material in lieu of fine aggregates in concrete mixes yielded some promising characteristics. The study revealed that it can be useful in the production of light weight concrete within an optimum range of 10% replacement.

1.0 Introduction

Concrete plays a major role in any infrastructural development and aggregate is one of the basic constituents - constituting about 75% of its total volume (Eze et al., 2018). The high and increasing cost of these materials has greatly hindered the development of shelter and other infrastructural facilities in developing countries especially Nigeria. There arises the need for engineering consideration of the use of cheaper and locally available waste materials to meet desired need, thus paving way to an overall reduction in construction cost while maintaining sustainable development goals (Olutoge, 2010). Several methods were employed to minimize constructional waste to ensure maximum utilization of scarce resources and curtail the ever challenging effect of constructional waste such as the scarified wearing course layer of pavement. This scarified surface contains greater percentage of the ever dwindling aggregates. Aggregates utilization in concrete production stand at about one billion tons per year and this has led to several environmental challenges that included depleting securable sand deposits and an associated price increase in the material (Ezeagu and Agusi, 2018). The rapid extraction of sand from the river beds causes problems like erosion, lowering of the water table, sinking of bridge piers, change in river courses leading to floods, deepening of the river beds, loss of vegetation on the bank of rivers, and so on. Over the years, Scientists in the construction and building industry have been conducting research on the utilization of waste products in concrete. Some of the waste products that have been studied include fly ash, rice husk, saw dust, and discarded tires, plastic, glass rock, steel slugs, stone dust and ceramic (Shankar and Ali, 1992; Sahu et al., 2003; Rao and Andal, 2002). While it was known that each waste product has its specific effect on properties of both fresh and hard concrete, the use of such product in producing concrete not only makes it economical but also solves some of the current waste disposal problems (Reddy, 2010). Nowadays, societies are facing the challenges of how best to use the wastes emanating within the environment and that includes the constructional wastes.

Waste recycling means continual use of the resources that have already been used (De Beir et al., 2010). Primarily, the effort is aimed at the maximum possible saving of raw material resources, fuels and energy demands, reduction of waste volume and environmental sustainability (Cimpan, 2016). Additionally, material recycling contributes to environment conservation by reducing greenhouse emission (Jagannadha, 2015). Consequently, the increasing volume of road deterioration in recent years has forced society to re-use the generated deteriorated waste (Jagannadha, 2015). Due to this, there has been a natural increase in the use of recycled material in civil engineering (Leite et al., 2011). In road construction, recycled material is most often used in base construction layers and in concrete production, it can serve as a substitute for natural aggregate (Wu, 2012). Scarified Road Material Waste (SRMW) is a waste from a deteriorated pavement that is normally dumped by the road site to fallow or used as fill material in some cases. While it was known that this material can be used as constituent material in concrete production, its appropriate categorization in terms of strength class suitability still remains a challenge if used as substitute materials in concrete. Hence, this study seeks to investigate the behavioural performance of SRMW in concrete medium.

2. Materials and Method

The materials used for this study included fine aggregate (river sand), SRMW samples, coarse aggregate and ordinary Portland cement and were all obtained within Maiduguri, Borno State, Nigeria. The SRMW which was obtained at a dump site near an ongoing road construction work was further crushed manually and segregated using sieve 4.75mm aperture size. Subsequent retained particles on the sieve were re-crushed and sieved to yield finer materials for the concreting work that was used to replace some portion of the natural occurring sand under normal concrete mix. The aggregates in this concrete production were clean and well-graded according to literature requirements (BS 882, 1992).

The tests were conducted in accordance with the methods outlined in the BS codes. The stepwise procedures followed in conducting the tests are outlined below:

i. Specific gravity test was carried out in accordance with the procedure outlined in BS EN 1377-2 (1990).

ii. Particle size distribution analysis test was carried out in accordance with the procedure outlined in BS 812-103 (1985).
iii. Aggregate water moisture content test was conducted in accordance with the procedure outlined in BS 812-109 (1990).
iv. Bulk density test was carried out in accordance with the procedure outlined in BS 812-2 (1975).
v. Slump test was carried out on the fresh concrete in accordance with the procedure outlined in BS 1881-102 (1983).

Furthermore, the concreting moulds were cleaned and oiled before each casting. A total of ninety (90) concrete cubes of 150mm x150mm x 150mm were produced with a nominal mix ratio of 1:3:6 and w/c ratio of 0.55. De-moulding of the cubes was done 24 h after casting. The casted cubes were then transferred into the curing tank. The cubes were removed from the curing tank at the end of the curing periods and subsequently crushed after 5 h air-drying. Additionally, concrete cubes with SRWM were also produces in-which the fine aggregates component replacement ranges from 10% to 50% and as 10 and 20% additives (10A and 20A). The cured samples were tested at 7, 14, 21 and 28 days for compressive strength in accordance with BS 1881-116 (1983) requirements.

3. Results and Discussions

The specific gravity test result showed that the Sand, SRMW and gravel used had the value of 2.85, 2.56 and 2.66 respectively and this is in agreement with other literature findings (Neville and Brooks, 2002). Hence, this result was satisfactory; otherwise, the concrete constituent will float over the water surface in the mix (BS 812-112, 1990). Moreover, the moisture contents of sand, SRMW and gavel, were found to be 4.23%, 28.58% and 1.54% respectively as shown in Table 1. Bulk density of aggregate (sand, SRMW and gravel) for both loose and compacted samples is also shown in Table 1. This indicates that the use of SRWM in concrete production will require lesser amount of water despite the low bulk density in comparison with other aggregates.

Table 1: Physical Properties of Aggregates

Property	**Sand**		**SRMW**		**Gravel**	
Specific gravity	2.85		2.56		2.66	
Moisture content	4.23%		28.58%		1.54%	
Bulk density ρ (g/cm^3)	loose	Compacted	loose	Compacted	loose	Compacted
	0.74	0.85	0.08	0.12	0.81	0.89

Table 2 shows the slump for the various SRWM replacement from normal up to 40% replacement. The slump value increases with increasing SRWM content with about 10 mm change from 0 – 40% SWRM replacement. Interestingly, the slump values are within the workable range because the minima and maxima values were between 30mm to 50mm.

Table 2: Slump Test for the Concrete

% SRWM	W/C Ratio	Height of Concrete Before Removal of Mould (mm)	Height of Concrete After Removal of Mould (mm)	Slump (mm)
0	0.5	300	270	30
10	0.5	300	265	35
20	0.5	300	262	38
30	0.5	300	260	40
40	0.5	300	257	43
10A	0.5	300	256	44
20A	0.5	300	250	50

The result of the sieve analysis (particle size distribution curve) for of sand, SRMW and coarse aggregate respectively are presented in Figures 1, 2 and 3 respectively. The curves indicated that the SRMW sample is well-graded fine aggregate, and this is in accordance with AASHTO (1995) classification of soil system which describes fine aggregate as material that passes a 0.075 (No 200) sieve and coarse aggregate as materials pass 75mm sieve and are retained on 20mm.

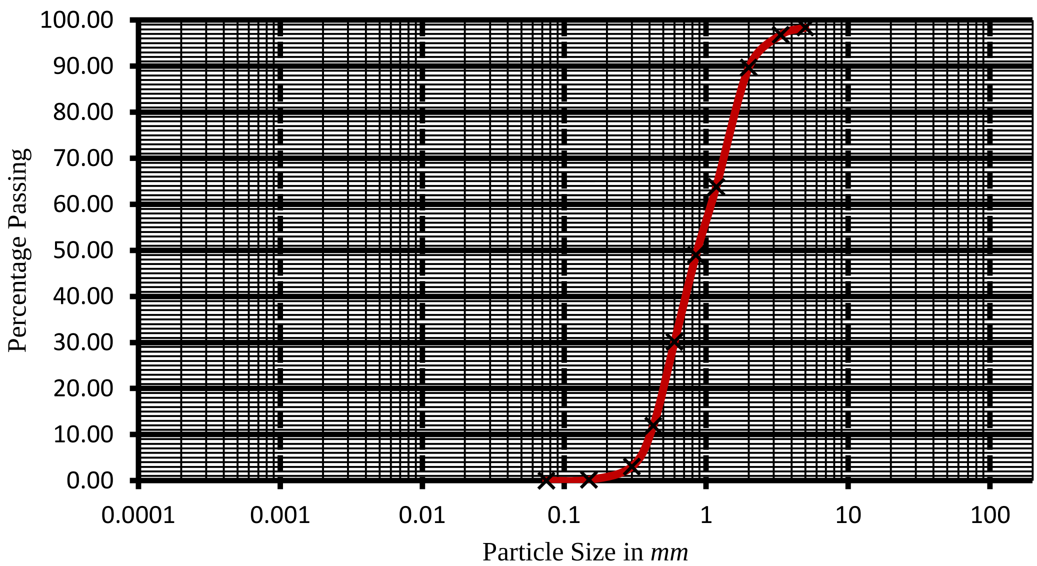

Figure 1: Particle- Size Distribution Curve for the Sand

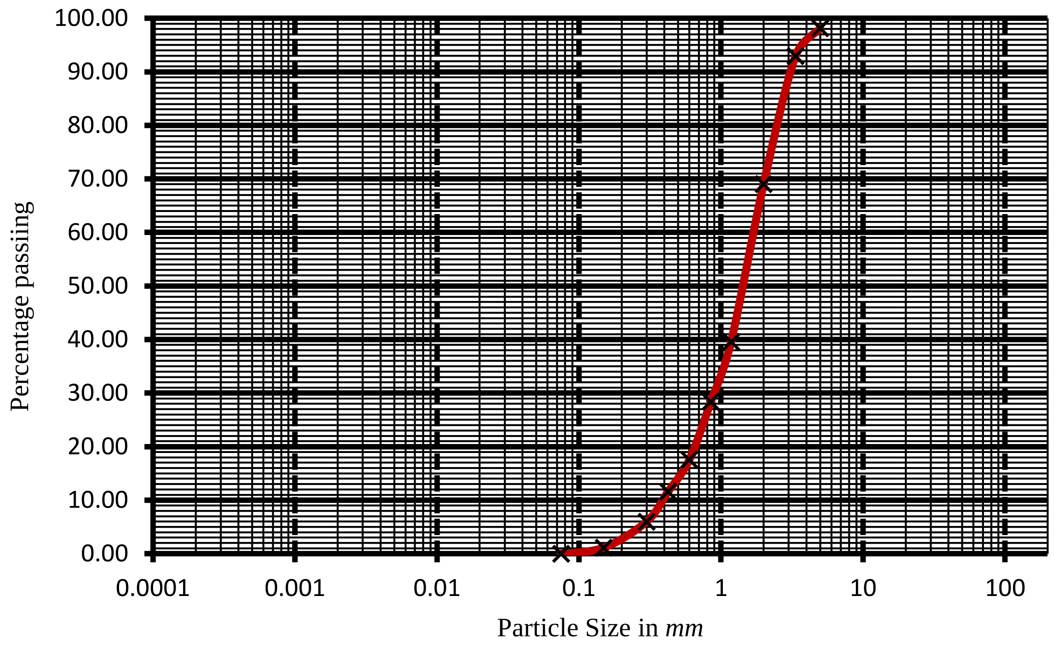

Figure 2: Particle-Size Distribution Curve of the SRMW

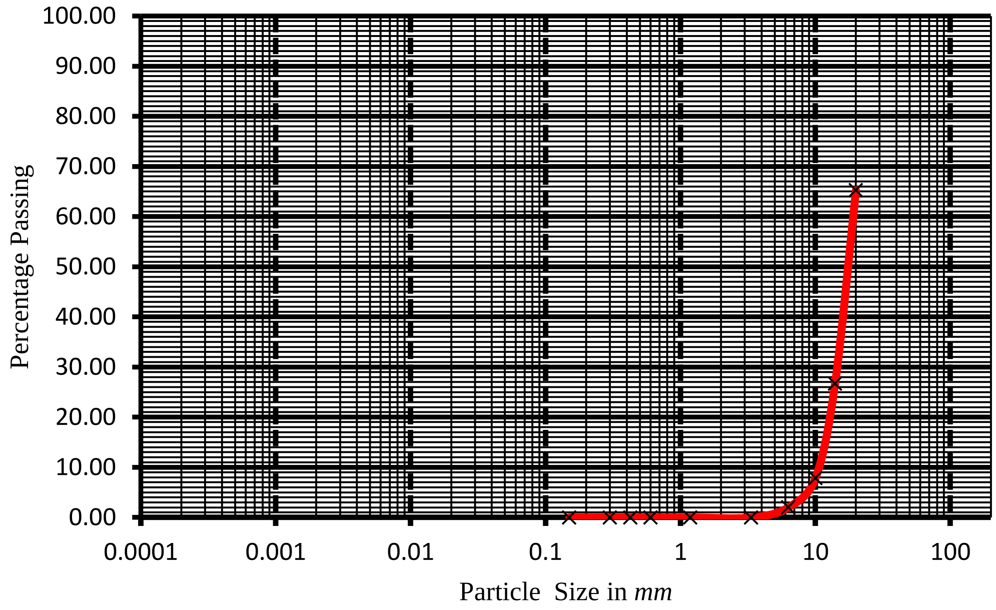

Figure 3: Particle-Size Distribution Curve of the Coarse Aggregate

Table 3 presents the concrete compressive strength for the respective range between 7 – 28 days period. The effect of replacement of fine aggregate with SRMW on concrete compressive strengths is shown with Figure 4. It can be observed that the compressive strength of the concrete decreased with increasing SRMW content because the maximum target mean strength at 28 days was 24.17 MPa and the minimum value of 6.6 MPa at 40% SWRM. However, despite the decreasing strength, addition of 10% (10A) admixture had the potential to increase the concrete strength even at the 10% SWRM. The investigation revealed that replacing fine aggregates beyond 10% is not advisable because of the decreasing strength behaviour with further addition of SWRM. On the alternative, the use of SWRM will be effective under low strength concrete, 10.4 MPa which can further be increased to 11.4 MPa with additional additives at 28 days. This type of concrete is equivalent to grade 7 concrete that has a value of 7N/mm^2 specified for plain concrete as recommended in BS-8110-1 (1997).

Table 3: Compressive Strength (MPa) of concrete at varying percentages of SRMW in concrete

S/no.	SRWM content (%)	Concrete Strength (N/mm^2)			
		7 days	14 days	21 days	28 days
1.	0	14.5	18.2	22.48	24.17
2.	10	6.2	6.7	8.9	10.4
3.	20	6.4	7.0	7.2	8.5
4.	30	5.0	6.5	6.7	6.8
5.	40	5.5	5.7	6.2	6.6
6.	10 admixture	7.1	8.2	10.2	11.4
7.	20 admixture	6.8	8.3	9.0	9.6

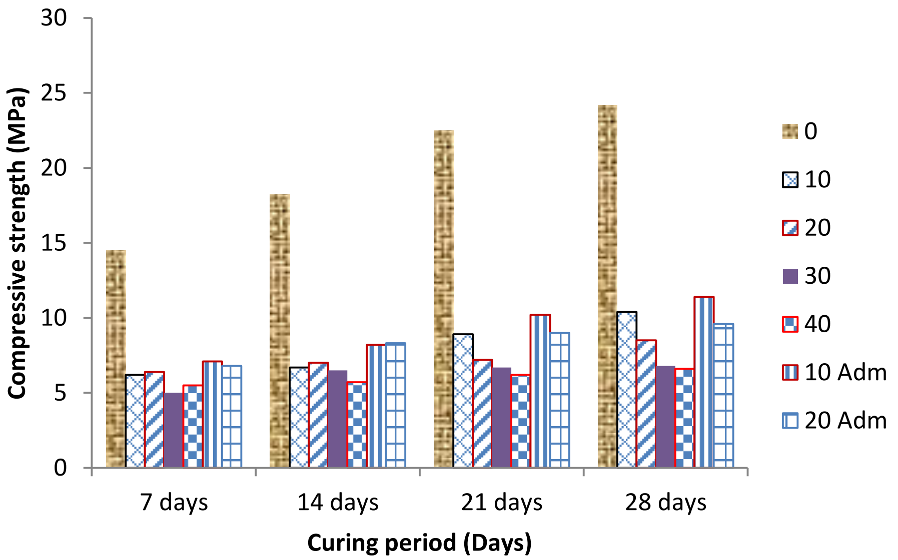

Figure 4: Characteristics strengths behaviour

4. Conclusions

To address problem of constructional waste and optimum utilization of the scarce resources especially fine aggregates in the production of concrete, this study found that the use of scarified road waste material in lieu of fine aggregate yielded some prominent results that included the addition of 10% (10A) admixture had the potential to increase the concrete strength at the maximum 10% SWRM value. This waste material use can be in an optimum value of 10% and is generally suitable for light weight concrete.

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