Innovation for the Use of BUSHGRAVEL and PITSAND as Aggregates for Concrete in Construction Industry

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ABSTRACT

This paper illustrates the variation in compressive strength of washed and graded aggregate with unwashed natural aggregate in Akure, Ondo State. The aim is to know the feasibility of using Bushgravel and Pitsand as coarse and fine aggregates respectively for construction as it is generally being used in Akure, Ondo State and its environ. 2 sets of Concrete cube of mix ratio 1:2:1, 1:2:2, 1:2:3, 1:2:4, 1:2:5 and 1:2:6 were casted using washed and sorted aggregate for the first and unwashed aggregate for the second. Various laboratory tests were carried out on the aggregates to know its constituent and it was observed that the Bush gravel generally used as coarse aggregate in its unwashed and unsorted form contains just 15.6% coarse aggregate while the rest is boulders, fine aggregates and silts. It was observed that the maximum compressive strength is with a mix ratio of 1:2:6 for unwashed Bush gravel and 1:2:1 for a washed and sorted bush gravel which is 14.89 N/mm^2 and 24.44N/mm^2 respectively.

Keywords: Bush Gravel, PitSand, Cement, Concrete, Boulders.

INTRODUCTION

The deterioration of reinforced concrete is a major problem. The cost of repairing deteriorated structures has become a major liability for highway agencies, estimated to be more than $20 billion and to be increasing at $500 million per year. The primary cause of this deterioration (cracking, delamination & spalling) is the corrosion of steel reinforcing bars due to chlorides.

For most corrosion-protection measures, the basic principle is to prevent the chloride ions from reacting with the steel surface and also to increase the time needed for the chloride ions to penetrate through the concrete cover.

The chloride content of Portland cement is typically very low. However, the chloride content of ground granulated blast furnace slag is variable and depends on the water used in the quenching process.

Aggregates may contain chlorides, especially if they are obtained from sites associated with seawater or groundwater containing chlorides.

Potable water can contain small amounts of chlorides (20 to 100ppm). This amount of chlorides is generally considered to be significant. When used in concretes with typical mix proportions, the resulting concrete has a chloride concentration that is much lower than the threshold limit.

Water with a hydrogen parameter pH in the range of 4 to 12.5 is recommended for making concrete. High content of harmful compounds (chloride and sulphate, silt or suspended particles) in water retards the setting and hardening of cement. (Dvorkin L. and Dvorkin O.)
Organic substances (sugar, industrial wastes, oils, etc.) can also reduce the rate of hydration processes and concrete strength.

Admixtures based on calcium chloride ($CaCl_2$), some water reducers and setting admixtures contain chlorides. The amount is considered to be insignificant if the chloride content is less than 0.01 percent by mass of the cementitious material.

Corrosion inhibitors are used in concrete for parking structures, marine structures, and bridges where chloride salts are present.

Concrete should be workable, finishable, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

Similarly the type of coarse aggregate does not seem to have a significant effect on the corrosion resistance of concrete prepared using them. (Al-Dulaijan S.U et. al)
Water with a hydrogen parameter pH in the range of 4 to 12.5 is recommended for making concrete. High content of harmful compounds (chloride and sulphate, silt or suspended particles) in water retards the setting and hardening of cement.

The accepted practice of establishing constant mixture proportions by weight contributes to problems arising from variability in aggregates and construction needs.

The method for selecting trial proportions is of minimal importance. Arbitrary means are as efficient as complex procedures. The only meaningful factors are the characteristics of the composite.

In some parts of the world, particularly in the tropics and desert regions, local aggregate materials are affected by widely different geological and climatic conditions. They may contain impurities, such as leached and evaporite salts, which would not be expected in unacceptably large concentrations in temperate countries. The physical and chemical stability of rock materials in the ground (and in use) can vary widely: for example, joints and fractures in a source of aggregate in temperate conditions may not raise serious doubts about its potential suitability (Indeed they may assist quarrying and processing) but in tropical conditions they may greatly accelerate the effects of already rapid weathering processes and in a hot and environment may allow deleterious substances to penetrate into the rock mass. Thus, the recognition of familiar rock types or geological formations is no guarantee that usable aggregates will be obtainable from them. Ideally, only fresh or faintly weathered rock material should be used for aggregate.

Nevertheless, it is generally accepted that there is an approximate correlation between aggregate quality and rock porosity; it may often be taken as a very rough working rule that an otherwise suitable rock with a water absorption value of less than about 2% will usually produce a good quality aggregate and that rocks with values exceeding about 4% may not.

A study of correlations between certain physical and mechanical test data derived from the 10-14 mm fraction of borehole samples from glaciofluvial gravels in the Kelvin Valley, east of Glasgow (Gribble 1990) has shown that gravel with a water absorption value of 3% or less yielded aggregate test values that would satisfy a wide range of British Standard specifications.

The study also showed that the proportions of different rock types in the gravel influenced the water absorption value less than the degree of weathering.

It has been generally accepted that if the aggregate volumes are so chosen that the packing density of the combined aggregates is maximum then the amount of cementitious paste volume required for a given amount of workability (i.e. slump) is reduced to a minimum. The rationale typically provided is as follows: Cementitious paste should completely fill the voids between the aggregate particles and at the same time there must be a certain amount of excess left over to provide the lubrication needed for a given workability.

MATERIALS AND METHODS

The Bushgravel (Coarse Aggregate) used for this study was collected from Oda road in Akure, Ondo State, Nigeria. The sample was carefully collected in their natural undisturbed form. The Ordinary Portland cement (Dangote, Brand) used was obtained around Fiwasaye area in Akure. Pit sand was used as fine aggregates. The fine aggregate used was obtained from Igoba Town in Akure, Ondo State, Nigeria.

Specimen Preparation

The Bush gravel was divided into two sets, the first was washed and sorted to size between 10mm – 20mm nominal size. The second was unwashed and unsorted. The mix ratio used was 1:2:1, 1:2:2, 1:2:3, 1:2:4, 1:2:5 and 1:2:6. The water cement ratio between 0.4 to 0.6 was used.

Slump and compacting factor tests were carried out to check the workability of fresh concrete. The tests were carried out in accordance with the requirements of BS 1881: Part 102 (1983) for slump test and BS 1881: Part 103 (1983) for compacting factor test.

Specimen preparation for compressive strength test was performed using 150mm cube steel moulds. The specimens were cast in three layers, each layer being tamped with 35 strokes of the tamping rod spread uniformly over the cross section of the mould. The top of each mould was smoothened and leveled and the outside surfaces cleaned. The moulds and their contents were kept in the curing room at temperature of 27 $\pm$ 5^0C and relative humidity not less than 90% for 24hours. De-moulding of the cubes took place after 24hours and the specimens were transferred into water bath maintained at 27 $\pm$ 5^0C in the curing room. Compressive strength was determined at curing age 7, 14, 21 and 28 days.

RESULTS AND DISCUSSION

Physical Composition

Table 1 shows the physical composition of natural bush gravel. The result showed that bush gravel has7.4% Silt, 45.6% of fine aggregate, 14.8% of coarse aggregate and 32.2% of boulders. The silt content is between 3 to 8 % and is suitable for construction purposes. Soil samples with silt content less than 3 % have insufficient fines and will require a considerable amount of cement for a reasonable workability. If such soils are to be used for construction work they have to be blended with suitable finer aggregates from other sources. The high amount of fine aggregate in its component coupled with Silt increases the quantity of cement needed to obtain a higher strength, The lower percentage of coarse aggregate in the bush gravel is an indication of lower compressive strength since the higher the quantity of coarse aggregate, the higher the compressive strength of the concrete.

Composition	*Percentage*
Silt	7.4
Fine Aggregates	45.6
Coarse Aggregate	14.8
Boulders	32.2

Table 1: Physical Composition of Bush Gravel in Akure

The boulders present is an added advantage when used for mass concrete but where there is reinforcement, it prevents proper compaction of the mix thereby introducing air pores that reduces compressive strength of concrete. Though the specific gravity for bush gravel is 2.67.

Sieve Analysis of Aggregates

The results of the sieve analysis for fine and coarse aggregates are presented in Figures 1 and 2 respectively. It could be observed from Figure 1 that the coefficient of uniformity (C_u) and coefficient of curvature (C_c) for unwashed fine aggregates are 2.96 and 0.68 respectively while for the washed fine aggregates are 7.93 and 0.09 respectively. Thus, the sand can be said to be poorly graded for fine aggregates. (Smith and Smith, 1998).

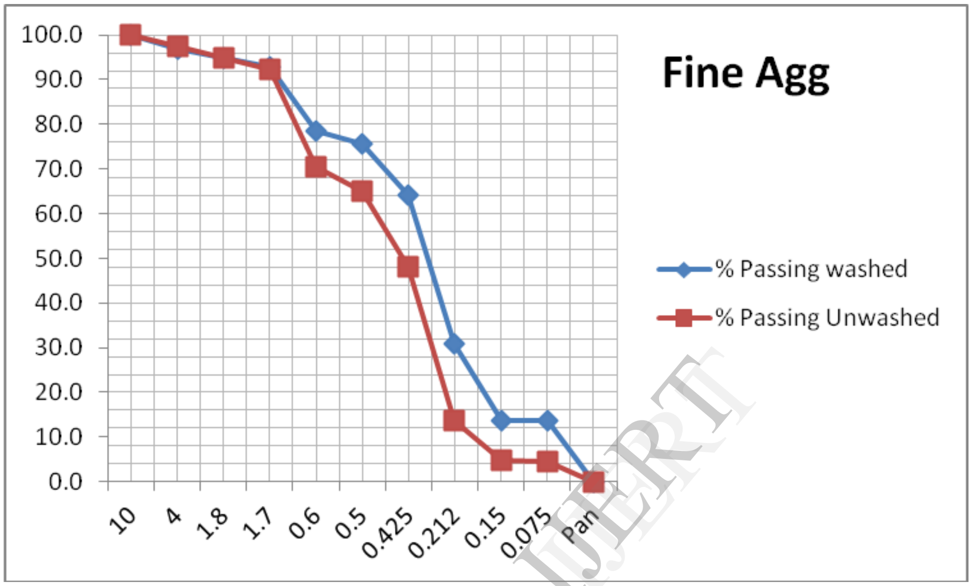

Figure 1: Particle size Distribution for washed and unwashed fine aggregate.

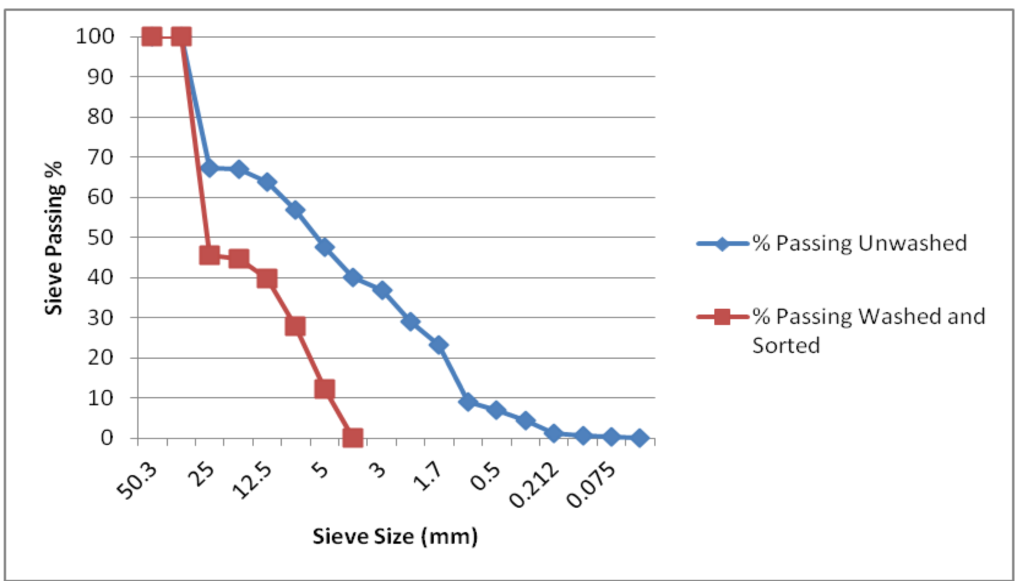

Figure 2: Particle size Distribution for washed and unwashed coarse aggregate.

Similarly, the C_u and C_c for coarse aggregates are 10.94 and 0.5 respectively for unwashed while for the washed coarse aggregate, the C_u and C_c are 5.21 and 0.58 from Figure 2. This shows that the washed gravel is poorly graded. It can be concluded that the fine and coarse aggregates are not suitable for making good concrete.

Workability

The results of the slump and compacting factor, indicating the workability of the concrete are shown in Table 2. The table indicates that the slump value decreases as the aggregate content increases. The compacting factor also decreases as the aggregate content increases except for mix ratio 1:2:3.

Mix Ratio	Slump (mm)	Compacting Factors (kg)
1:2:1	108	0.94
1:2:2	77	0.96
1:2:3	82	0.99
1:2:4	38	0.97
1:2:5	63	0.98
1:2:6	25	0.98

Table 2 Slump and compacting factor values of Concrete

For the entire mix ratio, the water cement ratio of 0.4 to 0.6 was used. It was observed from figure 3 that to achieve a good workable mix, the compressive strength will be reduced.

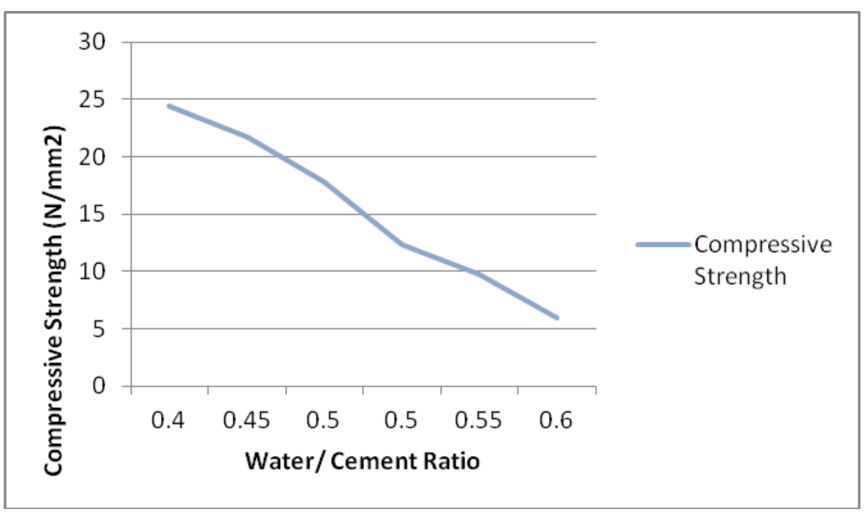

Figure 3: Effect of Water Cement Ratio on compressive strength of concrete with washed aggregate.

Increase in the compressive strength leads to decrease in the water cement ratio. This shows that little water is needed (Water for hydration) for concrete works.

Compressive Strength

The effect of unwashed and washed coarse aggregate on the compressive strength of concrete is presented in Figure 4. The figure indicates that compressive strength generally increases with higher percentage of coarse aggregate but there is higher strength when a washed and sorted coarse aggregate is used.

The result at 28 days showed a decrease in strength from 17.78N/mm^2 for washed to 11.56N/mm^2 for unwashed with mix ratio 1:2:3. Similar trend was observed for a mix ratio of 1:2:4 with strength reduction from 12.3N/mm^2 for washed to 12.0N/mm^2 for unwashed at 28 days as shown in Figure 4.

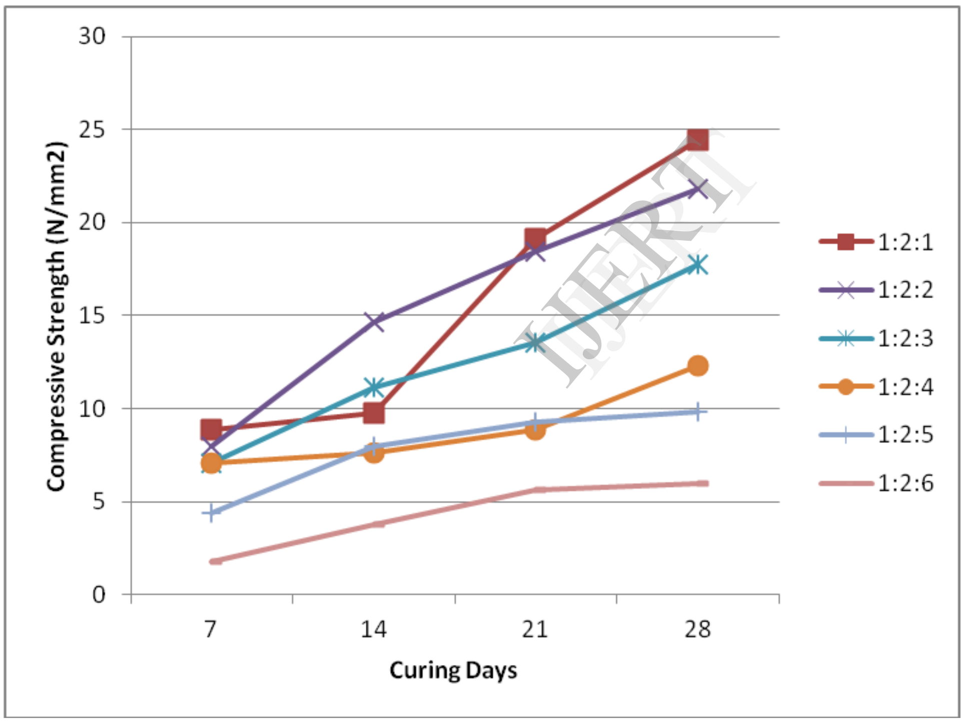

Figure 4a: Compressive Strength of washed Bush gravel and Pitsand from Akure.

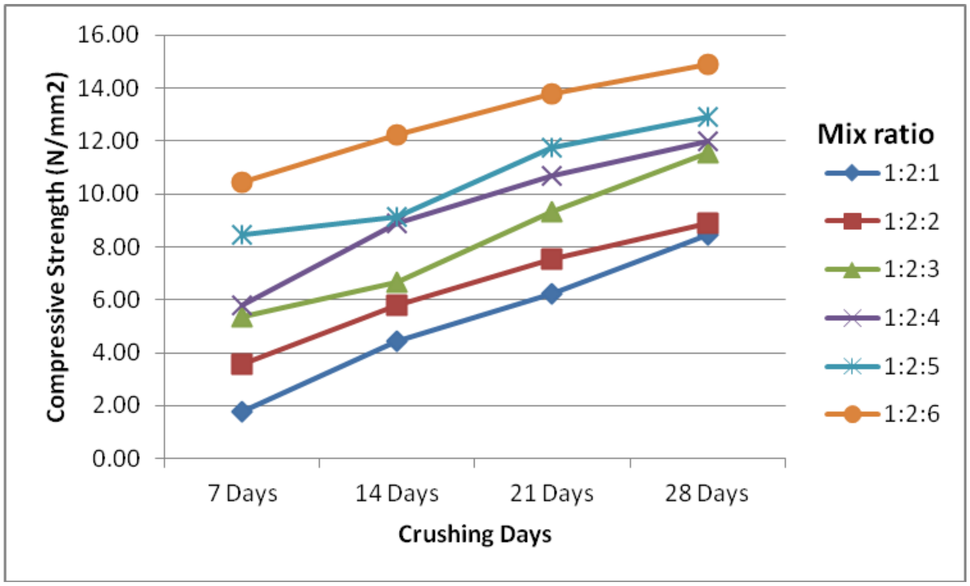

Figure 4b: Compressive Strength of unwashed Bushgravel and Pitsand from Akure.

Even though the strength variation is not high for mix ratio 1:2:4 – 1:2:6 but there is pronounced difference with mix ratio 1:2:1 where the compressive strength is 24.44N/mm^2 for washed aggregate and 8.44N/mm^2 for unwashed aggregate. These results indicate that concrete containing unwashed coarse aggregate has lesser strength with higher coarse aggregate while the reverse is the case for a washed and sorted aggregate.

Conclusion

From the results of the various tests performed, the following conclusions can be drawn:

i. Bush gravel is not suitable material for heavyweight concrete in its natural unsorted state. However when it is the only available material, there is need for washing and sorting in order to increase its strength when used for concrete.

ii. The compressive strength generally increases with lesser coarse aggregate for unwashed Bushgravel while the reverse is the case for a washed and sorted coarse aggregate.

iii. Unwashed Bush Gravel is not recommended for heavy load bearing structure but lightweight structure. When washed and sorted Bush gravel is to be used for heavyweight structure, there is need for extra caution because the maximum compressive strength is mix ratio 1:2:1 of 24.22N/mm^2. So we recommend the use with adequate admixture for heavyweight structure.

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