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concrete using metamorphic, volcanic and sedimentary rocks (crushed gneiss, crushed basalt and alluvial sand) as fine Aggregate. Economical study is also presented.

This report describes work that is aimed at improving the understanding of the role of fine aggregates in concrete. The variables considered are aggregate type, aggregate cost, and aggregate content in normal and high-strength concretes.

The cement used is a Portland cement composed of CPJ CEM II/A class 42.5 R. This is CIMAF's cement (Cement of Africa) produced and marketed in Cameroon. Its physico-mechanical characteristics are given in Table 1.

The water used for the mixing of different concrete comes from Cameroon's water (CDE). The water is supposed to be potable and contains no harmful impurities. It is therefore very useful for making concrete.

Three types of sands with the same size range (0/5) were used in this work. Two coming from quarry sands and other from River Sanaga (alluvial sand). River Sanaga is the longest river in Cameroon, about 918 Km of length. Concerning quarry sands, one comes from an industrial quarry located in Bamougoum, western region of Cameroon, which exploits a rock mass of magmatic origin (Basalt) and the other comes from an industrial quarry located in Eloundem, a locality in the central region of Cameroon which exploits a rock mass of metamorphic origin (Gneiss). These quarry sands are respectively denoted SB for basalt and SG for gneiss. The main physical properties of these sands are shown in Table 2.

In order to make our concrete, we used coarse aggregates from gneiss with fractions (5/15) and (15/25). These crushed stones originate from an industrial quarry exploited in Eloundem. Some of their properties are summarized in Table 3.

The observations of thin section of gneiss and basalt rocks permit us to know the various minerals that these sands contain.

The methodology for the formulation of concrete is the Dreux-Gorisse method [8]. We choose to make concretes with the characteristics contained in Table 4.

The density was determined according to the standard norm (NF EN 12350-6, 1999) [9].

The workability of the concrete is evaluated by using the Abrams cone, according to the standard norm (NF EN 12350-2, 1999) [10].

Strength of concrete is commonly considered as the most valuable property in Portland cement concrete. Although in many practical cases other characteristics such as durability and permeability may in fact be more important. Nevertheless, strength usually gives an overall picture of the quality of concrete because strength is directly related to the structure of the hydrated cement paste. Moreover, the strength of concrete is almost invariably a vital element of structural design [11].

Compressive strength of concrete is commonly considered to be its most valued property, although in many practical cases, other characteristics, such as durability, impermeability and volume stability, may be more important. Moreover, compressive strength usually gives an overall picture of the quality of concrete.

The simple compressive strength of the concrete was determined on 12×16 cm cylindrical specimens. The test is carried out according to

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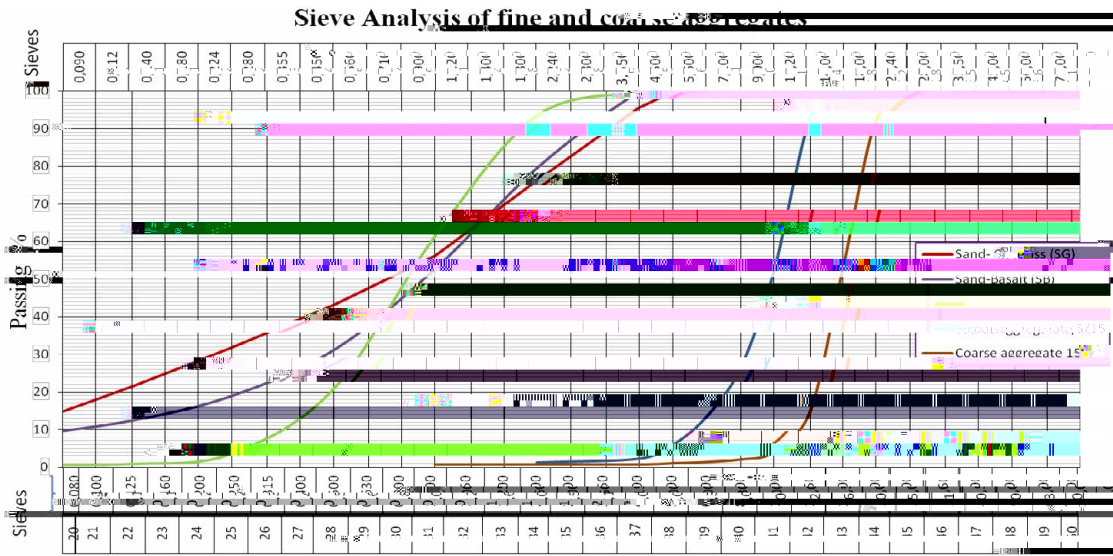


Figure 4: Sieves analysis of aggregates (fines and coarse).

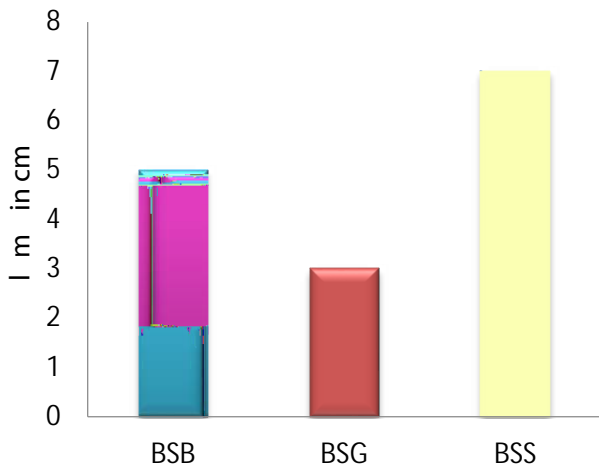


Figure 5: Workability of fresh concrete.

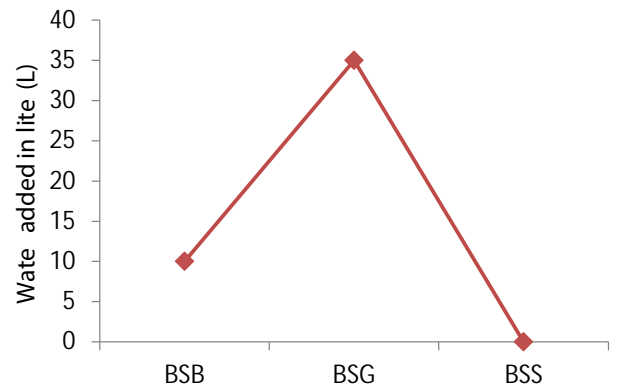


Figure 7: Water dosage for each type of fresh concrete for a cubic meter.

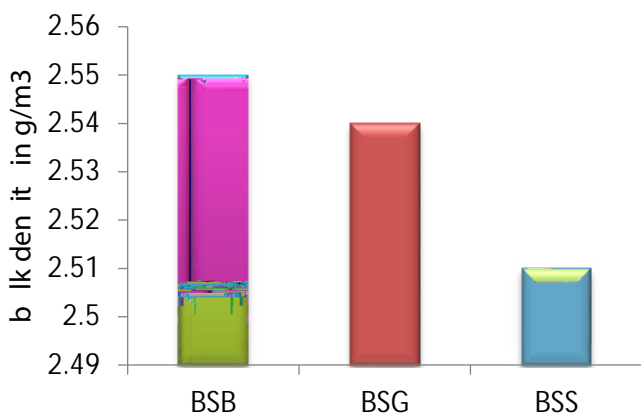


Figure 6: Density of different fresh concrete type.

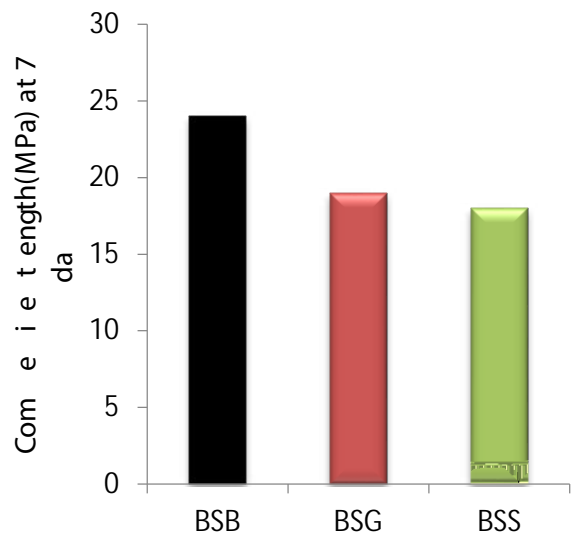


Figure 8: Compressive Strength at 7 days.

and opaque minerals (7 to 10%). On the other hand, a macroscopic observation of SS sand reveals that it is of terrigenous sedimentary origin and contains quartz (more than 90%) and micas (Figures 2 and 3).

The geotechnical results carried out at the National Laboratory of

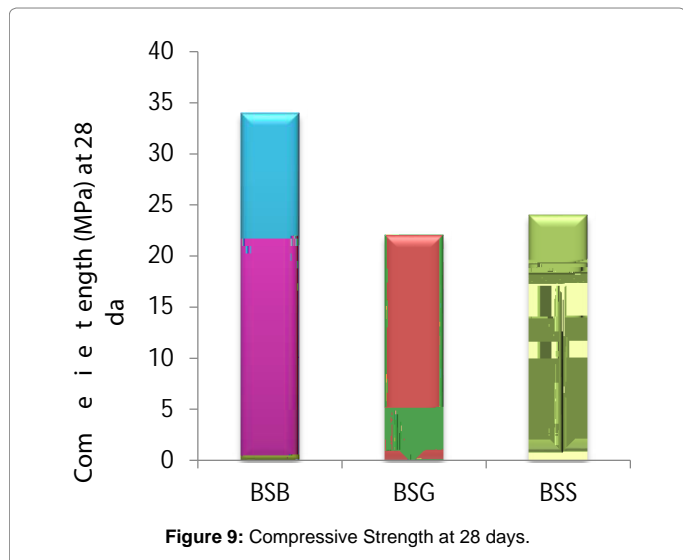
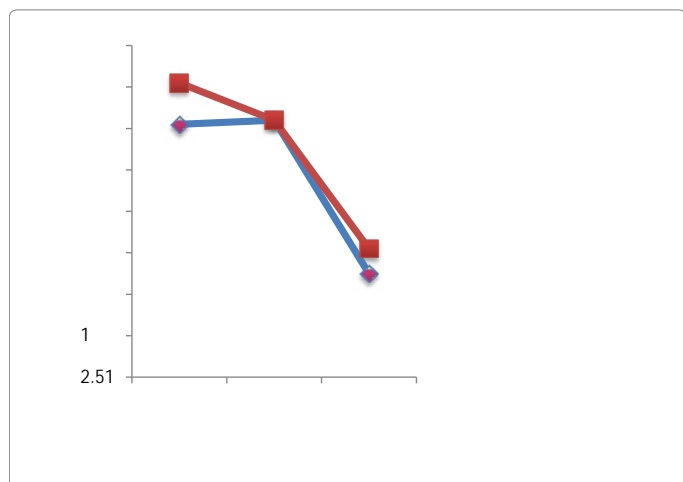


Figure 9: Compressive Strength at 28 days.



Civil Engineering (LABOGENIE) on these different sands showed that: the crushed sands SB and SG are slightly clean sands (ES=65,15 for SB and ES=75,30 for SG); they have respectively a percentage of fines of 7.9% (maximum content for concretes of current grade according to the standard relating to this grade) and 10.5%; the alluvial sand SS is a very clean sand (ES=96.98) having almost no fines (0.3%) (Tables 2, 5 and Figure 5). These results show that quarry sands have very high fines and are less clean than alluvial sands (Table 5).

Using the DREUX GORISSE formulation method, we made six concrete test pieces for each sand. Following these formulations, we subjected these specimens to the uniaxial mechanical compression test at 7 and 28 days (Tables 4 and 6).

The results of the study of the properties of fresh concrete revealed that the alluvial sands of the Sanaga are very malleable compared to SG and SB sands. Nevertheless SG sand is more malleable than crushed SB sand, because of its very angular shape. In addition to malleability, concretes made with quarry sands SB and SG have higher densities (fresh and hardened) than that of SS alluvial sand. This is explained on one hand by the shape of the grains and on the other by the intrinsic characteristic of each sand (Figures 5 and 6). Indeed, the crushed SB sand is formed from very angular sand grains, which allows a very good bonding granulate-binder. Moreover, these sand quarries contain enough fines to fill almost all the inter-granular voids and thus make the concrete more compact. In contrast, the alluvial sand has a blunted shape and has very few fines; which limits a good bonding-aggregate bond and makes the concrete not very compact. In addition these sand quarries are constituted of very dense minerals and having high densities compared to the alluvial sand (Figure 6).

The compressive strength at 28 days of the concretes formulated with the SS sand and the quarry SB, SG sands are respectively 24 MPa, 34 MPa and 22 MPa. The crushed SG sand has a low resistance due to the high fines content on the one hand. The higher the fines content, the more water will be needed; and at the same cement dosage, the resistance decreases.

On the other hand, this is related to the mineralogical properties of this sand. The SG sand is mainly composed of a very soft and alterable mineral (biotite) but also moderately hard and alterable minerals. The latter will give clays under the effect of meteoric alteration (alkaline feldspar) and thus contribute to a decrease in resistance.

In addition, this sand contains biotite which disturbing by their

| Sand Type | Grain shape | d/D(mm) | Fineness | Structure | Origin | |
|-----------|--------------|---------|----------|----------------|-------------------------------|-----------------|
| SB | Very angular | 0/5 | Fine | Rough surface | Crushed basaltic origin stone | More (7.9%) |
| SG | Few angular | 0/5 | Fine | Rough surface | Crushed gneissic stone | High (10.5%) |
| SS | rounded | 0/5 | coarse | Smooth surface | Alluvial sand | Very low (0.3%) |

Table 5: Macroscopic analysis of different sands.

| | | Types of Concrete | | |
|---|---------|-------------------|-------|-------|
| | | BSB | BSS | BSG |
| Compressive strength (Mpa)Wishes at 28 days | | 30 | 30 | 30 |
| Compressive strength (Mpa) | 7 days | 24 | 18 | 19 |
| | 28 days | 34 | 24 | 22 |
| Density (g/cm ³) | 7 days | 2.571 | 2.535 | 2.572 |
| | 28 days | 2.581 | 2.541 | 2.572 |

Table 6: Hardened concrete properties.

| Components of concrete | Cement | Water | Sand 0/5 | Gravel 5/15 | Gravel 5/25 | Total cost | Realized savings |
|------------------------|--------|-------|----------|-------------|-------------|------------|------------------|
| For CSB | 32000 | 75 | 3945 | 3914 | 6930 | 46854 | 3090 |
| For CSS | 32000 | 72 | 6282 | 4209 | 7330 | 49893 | 0 |
| For CSG | 32000 | 84 | 3945 | 3914 | 7110 | 47053 | 2840 |

Table 7: Cost in FCFA of the components for the formulation of 1 m³ of concrete.

shape and their weak inter-foliar cohesion not favorable to the adhesion of the binders (Figures 7-9).

The crushed SB sand has very angular grains. This promotes a good binder-aggregate bond and therefore makes it possible to obtain compact and resistant concretes. Moreover, this sand is made up of very hard and resistant minerals.

In view of all these results, it can be concluded that SB sand resulting from the crushing of olivine basalts offers a more resistant concrete. However, the alluvial SS sand and the SG sand have similar resistances.

This study was conducted to assess the effect of the type of sand on the mechanical properties of hydraulic concrete. This study led to the following conclusions:

- The mechanical properties of concrete are influenced by the nature and physical properties of sand;
- Concrete with crushed Sands (SB and SG) produced Small slump when compared to the river sand.
- Concrete with crushed sands need much water to obtain the same workability than the concrete with the natural sand. This is improved workability for the crushed sand due to the presence of high quantity of fine particles.

A compressive strength of concrete with natural sand (SS) increased by 33.33% after a fully replacement by basaltic crushed sand (SB) and 5.5% with gneiss crushed sand at 7 days.

The same results were observed at 28 days. Concrete with natural sand increases by 41, 67% after a full replacement by basaltic crushed sand (SB) and 8.33% with gneiss crushed sand at 7 days (SG).

The presence of mineral like biotite in the sand can reduce the strength of the concrete.

The effect on compressive strength of concrete by replacement of natural sand with artificial sand is more prominent at 7 days than that at 28 days.

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