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Improving The Load-Bearing Capacity Of Pavement Soils Of Kinshasa (D.R.Congo) Using Geogrids In Controlled Laboratory Settings

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Abstract
The use of geosynthetics is common practice in most of the engineering and environmental communities. They are used to build roads, streets, forest paths, canals, railways and dams, to delay coastal erosion or keep waste inside landfill cells. These synthetic materials, which are increasingly used in the rest of the world, allow to adequately complement natural materials (clay, sand, gravel) by providing specific properties that meet the multiple requirements of building designers. The objective of our work is to study the behavior of road materials reinforced by geosynthetic sheets of the geogrid type. It is about understanding the influence of the presence of geosynthetics on the CBR bearing characteristics of the material in the soils of Kinshasa (D.R. Congo) low lying areas where roads are designed or a 15-20 years life span, but live much lesser time frame owing to a plethora of reasons among those are of geotechnical type such as capillary water rise and poor load-bearing capacity of roads materials. We have evaluated the load-bearing capacity of road materials through various tests, and we have noticed an increase in the load-bearing capacity of reinforced road materials with geogrid Fornit 40.
Keywords: *Kinshasa, roadway, geosynthetics, geogrids, CBR, bearing capacity, road materials*

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I. Introduction

In the city province of Kinshasa, the destruction of road infrastructure is widespread. Among these causes are poor choice of materials (acceptability criterion), their poor implementation (e.g., insufficient compaction, lack of drainage) and lack of maintenance (Mutela,2016). Hence, the improvement or treatment of these pavements is necessary. Improvement techniques are multiple, but in this work, we will propose a technique for improving soil reinforcement by geogrids , which is an interesting alternative technique and has many advantages over other techniques. These reinforcement materials offer economic and future-oriented solutions. Recent research on geogrids for soil reinforcement in road design and construction has progressed considerably, addressing challenges such as poor subgrade performance, deformation control, and cost-effectiveness of pavement systems. Several studies have provided experimental and numerical information on the behavior of geogrid- reinforced soils under various loading and environmental conditions. Poursorkhabi et al. (2024) presented an innovative approach where layered soil applications were reinforced with a geogrid during trench wall construction to improve their stability. Similarly, Dulaimi et al. (2024) studied the impact of soil moisture content and compaction variations on the interface shear strength between geogrid and clayey subgrade soils. These studies collectively highlight how geogrid reinforcement significantly improves the lateral confinement, overall stiffness, and bearing capacity of road structures. Furthermore, Al- Barqawi et al. (2021) presented a comprehensive review of polymeric geogrids , highlighting that advancements in manufacturing have led to different uniaxial , biaxial , and triaxial configurations, which enhance road reinforcement applications by optimizing the interlocking mechanisms with the soil. Research has also increasingly focused on the potential for sustainable and cost-effective materials for geogrid applications . Torio-Kaimo and Romano (2022) explored recycled plastic composites impregnated with organo-clay, demonstrating that these composites are effective as reinforcing agents for asphalt concrete layers and aggregate bases, thereby improving the cost-benefit ratio over the entire life cycle of pavement construction. In a similar vein, Aga (2021) evaluated locally produced geogrids for the stabilization of expansive soils, showing that geogrids can serve as effective alternatives to traditional chemical stabilizers by controlling swelling and improving bearing capacity. These studies support the choice of geogrids as a sustainable option, combining material innovation and performance improvement in road design. In addition to experimental work, several studies have used advanced testing and numerical methodologies to better understand the interacting mechanisms between geogrids and soils. For example, Skuodis et al. (2020) used triaxial tests to evaluate the changes in soil shear strength when reinforced with a single layer of geogrid , thus replicating real road construction conditions. Furthermore, Wang et al. (2022) used the Discrete Element Method (DEM) to study the micromechanical interactions at the geogrid -soil interface, thus shedding light on factors such as interlocking and friction that govern the overall behavior of the composite. Sadiq et al. (2022) validated these results with finite element simulations, demonstrating that geogrid reinforcement can significantly reduce rutting of asphalt pavements under cyclic and dynamic loading. Other computational tools have also been used to predict the long-term behavior and optimize the design of geogrid- reinforced roads . Finite element analyses, as shown by Leonardi et al. (Leonardi et al., 2020), have evaluated the performance of geogrid -stabilized unpaved roads , highlighting improvements in durability and driver comfort due to better subgrade support. This modeling work is essential for the design of resilient pavement systems, capable of withstanding heavy traffic and environmental variations while maintaining their structural integrity. This recent research highlights that geogrids offer a versatile solution for soil stabilization in various pavement applications. Experimental studies have demonstrated improvements in lateral confinement, stiffness, and load distribution (Poursorkhabi et al., 2024; , Dulaimi et al., 2024; , Skuodis et al., 2020), while sustainable material innovations such as recycled composites and locally produced geogrids promise improved cost-effectiveness and long-term performance (Torio-Kaimo & Romano, 2022; , Aga, 2021). Advanced numerical modeling further supports these experimental findings, providing a pathway to optimize the application of geogrids in road construction and rehabilitation (Sadiq et al., 2022; , Wang et al., 2022; , Leonardi et al., 2020). Collectively, this body of work validates the effectiveness of geogrid reinforcement in improving pavement performance and guides future design strategies aimed at developing resilient infrastructure.

In this work we aim to show that this geogrid reinforcement technique improves and increases the capacity of the CBR bearing index of the materials; this is proven through laboratory tests. This work aims to: propose and demonstrate the use of geogrids to improve the different road materials used in Kinshasa; evaluate the bearing capacity of soils reinforced by geogrids.

II. Materials And Methods

For the completion of this work, we had to resort mainly to several methods in order to achieve the assigned objectives: we proceeded firstly by consulting previous documents relating to our subject of study (bibliographic and internet); then a field trip was carried out for the collection of samples and the collection of data on the ground; the experimental approach at the Safricas Laboratory (African Society of Constructions and Asphalting) in particular by tests to evaluate the CBR bearing capacity of road materials reinforced and not reinforced with geosynthetics . The technical materials required on the ground for data collection include: a GPS; bags and marker to record the sample numbers; a field notebook; a digital camera; a pickaxe; a spade; a jeep; pens and pencils and several other accessories. In the laboratory, tests were carried out with the following essential materials: proctor mold ; CBR mold; tamper; oven; bins; scales; hammer mass; a metal blade; graduated cylinder, etc.

Soil samples Collection

For the experimental approach, we used road materials from the Kinshasa region. We first proceeded to the sampling, identification and characterization of materials by a series of tests. The different materials are: Platform soils from Yolo , Mombele and Kingabwa ; Crushed aggregates (0/4 and 0/60). ; and Geogrid type FORNIT 40. In this work we used and sampled some road materials from Kinshasa coming from different municipalities which include (figure 1): LIMETE (Kingabwa and Mombele); KALAMU (Yolo-north University Avenue) and NGALIEMA (Lutendele quarry). The samples taken in Limete and Kalamu are the platform soils taken at 50 cm depth for each sample, and that of Ngaliema are taken from the Luntendele quarry. The different samples were taken using the materials mentioned above.

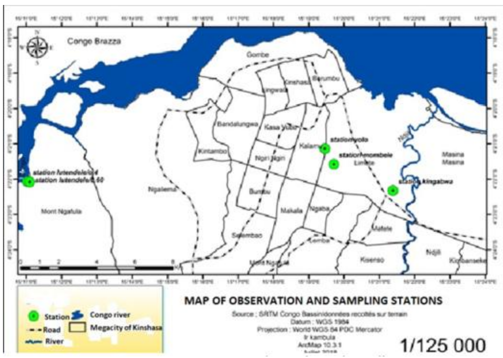

Figure 1: Observation and sampling map

Material classification tests use

There are several types of geotechnical tests and each type of test has its own scope of application and is only of value if properly performed and interpreted. The different tests carried out in this work are: Granulometric analysis; Atterberg limits ; Organic matter content; Proctor test; and CBR test (Californian Bearing Ratio)

Identification of road materials used

The purpose of soil identification is to determine a set of physical, mechanical or chemical properties that allow it to be characterized. The aim is to analyze the relative share of the two fractions to predict the behavior of the soil.

Identification of geogrids

As part of this work, we chose to use geogrid , which is one of the most widely used geosynthetics in the road sector today. It is a geogrid supplied by HUESKER. We used geogrids provided with types and characteristics that are listed in the following table 1:

Table 1: Identification of geogrids used with PP=Polypropylene

Types	40/40
Characteristic of the material	
Mass (gr/m ^{2})	330
Matter	PP
Coating	Polymer
Mesh (mm)	40x40
Mechanical characteristic	
Tensile strength (KN/m)	200

Classification tests of the materials used

There are several types of geotechnical tests, and each type of test has its own area of application and is only of value if correctly performed and interpreted.

The different tests carried out in this work are: water content; Granulometric analysis; Proctor test; and CBR test (Californian Bearing Ratio);

Grain size analysis consists of determining the dimensional distribution of the grains constituting an aggregate whose dimensions are between 0.063 and 125 mm. For our study, the laboratory provided us with the ASTM sieve series including 0.149 / 0.297 / 0.590 / 1.19 / 2.38 / 4.76 / 9.52 / 19.10 / 38.10 / 76.38

Proctor and CBR tests

For the Proctor test we had the following equipment at our disposal: A tray; A scale with a capacity greater than 6 kg; A Proctor mold with base and rise or CBR mold with base and rise; Plastic containers; A metal blade; Modified Proctor tamper or normal Proctor tamper ; Graduated cylinder and water burette to moisten the soil ; Oven , precision scale, small containers to measure water. The Proctor test according to the standard (number of layers, number of tamper strokes per layer and arrangement of these strokes) Remove the rise and level (Standard NFP11-300)

The CBR punching test is a load-bearing test (ability of materials to support loads) of embankments and compacted sub-bases of road structures.

This involves experimentally determining bearing indices (IPI, CBR) which allow:
- to establish a soil classification (GTR)
- to assess the trafficability of earthmoving machinery (IPI)
- determine the thickness of the pavements (CBR increases ⇒ thickness decreases)

This phenomenon can be reproduced by compacting the material under Proctor test conditions in a CBR mold and then measuring the forces to be applied to a cylindrical punch to make it penetrate at constant speed into a test piece of this material (NFP 11-300 Standard).

We performed the unreinforced and reinforced CBR tests with geogrid Fornit (Figure 2).

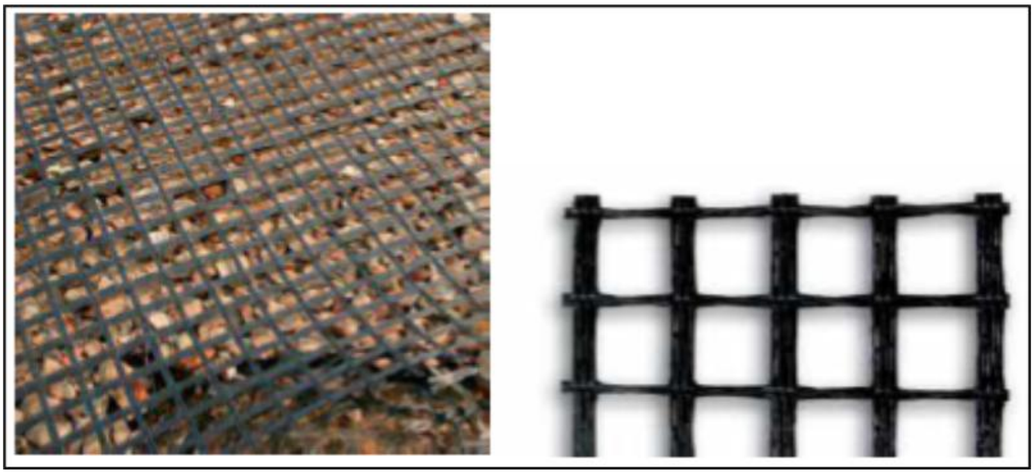

Figure 2 : View of the geogrid location provided by the proctor and CBR test Kingabwa Material

We placed the geogrid sheet after compacting the second layer during the test (Figure 3).

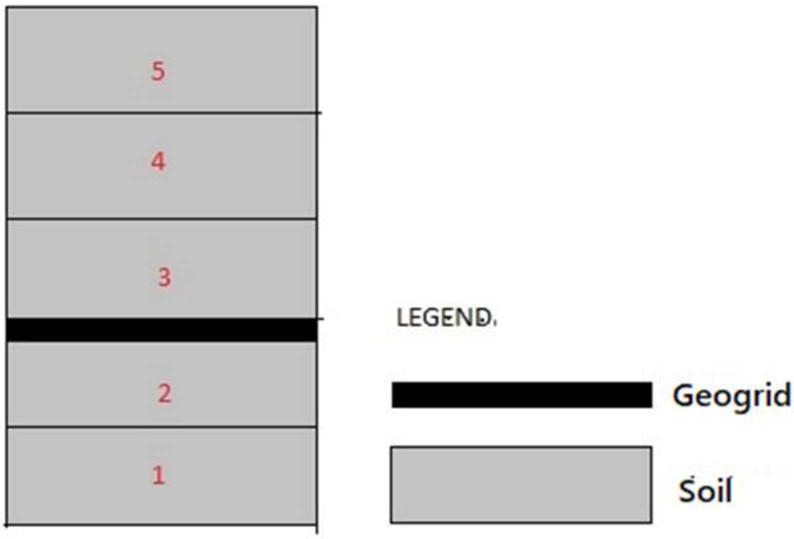

Figure 3: View of the geogrid location provided by the proctor and CBR test Kingabwa Material

III. Results And Discussion

Water content

The detailed results of the water content test are presented below. Table 2 gives the summary of these results.

Table 2: Summary of the results of the measurement of water content of the road materials used

Road materials used	Container No.	Weight of the Material wet + Container (g)	Weight of the Material dry + Container (g)	Weight of water (g)	Tare (g)	Weight of the material dry (g)	Water content (%)
Kingabwa soil	F44	1995.5	1755.0	240.5	410.8	1344.2	17.9 ≅ 18
Mombele soil	F11	1801.3	1639.3	162	364.0	1275.3	12.7 ≅ 13
Yolo Ground - North	XX	3837.2	3361.7	475.7	1195.1	2166.6	21.9 ≅ 22
0/4	F30	823.5	821.5	2	374.3	447.2	0.45
0/60	F11	886.1	865.7	20.4	363.5	502.2	4.06

Grain size analyses

The detailed results of the particle size analysis test are presented in table 3 below. In this case, we limited ourselves to particle size analysis by sieving after washing. We began by washing the samples, drying them in an oven for 3 hours at 175 °C and then proceeding to sieving. We provide a summary of these results (figure 2).

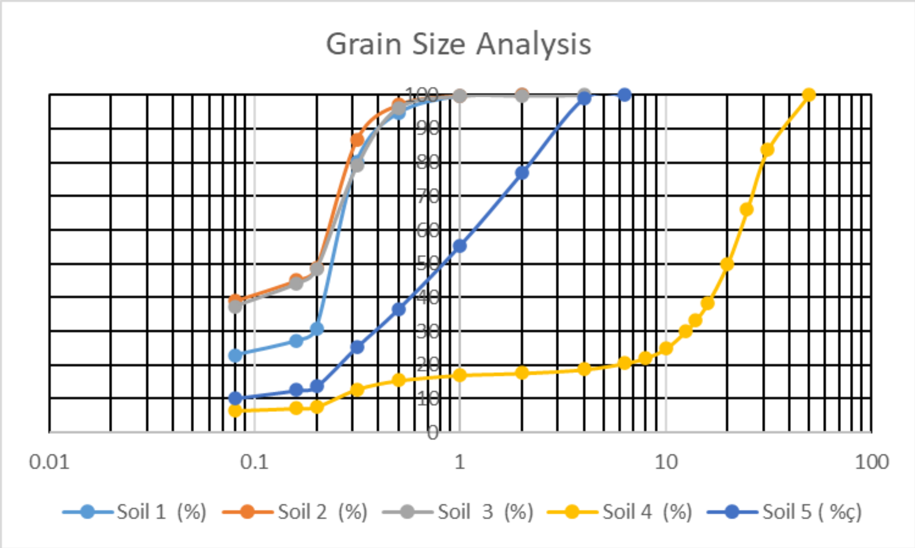

Figure 4: Grain size analyses of soil samples with soil 1 from Kingabua, Soil 2 from Yolo, Soil 3 from Yolo, Soil 4 is the crushed sand 0/4 and soil 5 is the crushed gravel 0/60

Kingabwa soil is in class 2, maximum less than 50 mm, but the sieve size of 80μ is greater than 38%. According to AFNOR, it is a low-plastic silty material or a low-polluting fine sand of class A under class A1. It can be used for subgrades or embankment if the CBR is good. According to AASHTO, the soil is in class A-4, we are in the class of relatively good materials, which can be used as a subgrade.

Yolo Soil is according to the French standard NP11-300 (AFNOR) is classified in class B and subclass B5. It is a very silty or very silty sand and is a material with low sensitivity to water. This type of sand can be used as platform material (embankments and subgrade for road infrastructure). According to AASHTO M 145-91, this type of material is in class A-2 where the 0.75 mesh size is limited to 35%. It is rated as good or excellent as platform material .

Mombele soil is a low-plastic silty material or a low-polluted fine sand of class A under class A1. It can be used for subgrades or embankment if the CBR is good. According to AASHTO, it is in class A-4, we are in the fairly good material class and can be used as a subgrade.

Soil 0/60 is according to AFNOR in class B under class B3. These are silty gravels or silt gravels that are generally insensitive to water and can be used as a subgrade or backfill, but also as a foundation material. It can be used as a base layer if the CBR is good. According to AASHTO, it is classified as Class A-1 under Class A-1-a, meaning the subgroup materials that meet the criteria such that the 2 mm sieve (i.e., elements larger than 2 mm) are less than 50% or the elements smaller than 2 mm are less than 50%. The 0.425 mm sieve must be less than 30% and the 0.075 mm sieve must be less than 15%. These are called sandy gravels or crushed gravel.

Soil 0/4 is according to AFNOR is in class B, subclass B1. It is a water-resistant silty sand that can be used as a subgrade if the CBR is greater than 30%. It is also called crushed sand or crushed gravel. According to AASHTO, 0/4 is a Class A-1 material called crushed sand. It can be described as excellent for subgrade and backfill, and even for foundation layers.

Proctor Test

Unreinforced Proctor

Geogrid sheets gave the following results: We present a summary of the results in tabular form.

Table 3: Summary of the results of Yolo sand results

Specific weight:	2.65 g/cm³
Max. density:	1.97 g/cm³
OPM:	8.8

Table 4: Summary of the results of Mombele results

Specific weight:	2.65 g/cm³
Max. density:	2.08 g/cm³
OPM:	8.9

Table 5: Summary of the results of Kingabwa results

Specific weight:	2.65 g/cm³
Max. density:	1.88 g/cm³
OPM :	13.00

Table 6: Summary of the results of Lutendele 0/60 crushed gravel

Specific weight:	2.65 g/cm³
Max. density:	2.17 g/cm³
OPM :	7.6

Table 7: Summary of the results of crushed sand from Lutendele 0/4

Specific weight	2.65 g/cm3
Max. density	1.92 g/cm3
OPM	11.5

Proctor Reinforced

Geogrid sheet gave the following results:
We present a summary of the results in tabular form.

Table 8: Summary of the results of Yolo sand results

Specific weight	2.65 g/cm³
Max. density	1.99 g/cm³
OPM	9.5

Table 9: Summary of the results of Mombele sand results

Specific weight	2.65 g/cm³
Max. density	2.09 g/cm³
OPM	10

Table 10: Summary of the results of Kingabwa sand results

Specific weight	2.65 g/cm³
Max. density	1.93 g/cm³
OPM	11.5

Table 11 : Summary of the results of crushed gravel 0/60

Specific weight	2.65 g/cm³
Max. density	2.24 g/cm³
OPM	6.1

Table 12: Summary of results for crushed sand 0/4

Specific weight	2.65 g/cm³
Max. density	2.23 g/cm³
OPM	8.1

CBR test

The CBR tests summaries are presented in Table 13.

Table 13: Summary of the results obtained from the unreinforced and geogrid -reinforced CBR tests

Materials used	Origin of materials	Material characteristics		Non-Reinforced CBR		Reinforced CBR		Comment or Observation
		AFNOR	AASHTO	Immediate	4 days of immersion	Immediate	4 days of immersion	
Sand	Kingabwa	STL	SLPP	22	19	26	21.5	Good
Sand	Mombele	SLPP	Good	14.5	6	40	14	Pretty good
Sand	Yolo	STS	SLPP	16	13	28	24	Very good
0/4	Lutendele	SLI	Exc	40	35	44	43	Excellent
0/60	Lutendele	GL	GC	65	40	70	60	Excellent

The different graphs of the CBR tests
Unreinforced CBR
Immediate CBR from Kingabwa

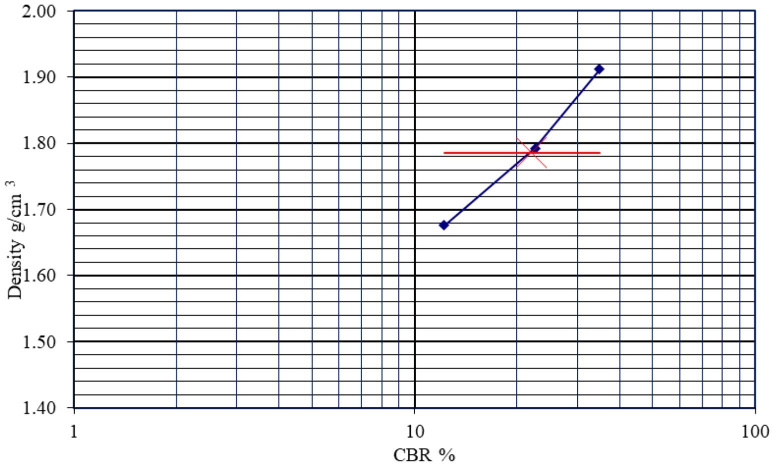

Figure 5: Graph of the immediate CBR test of Kingabwa material

CBR 4 days immersion from Kingabwa

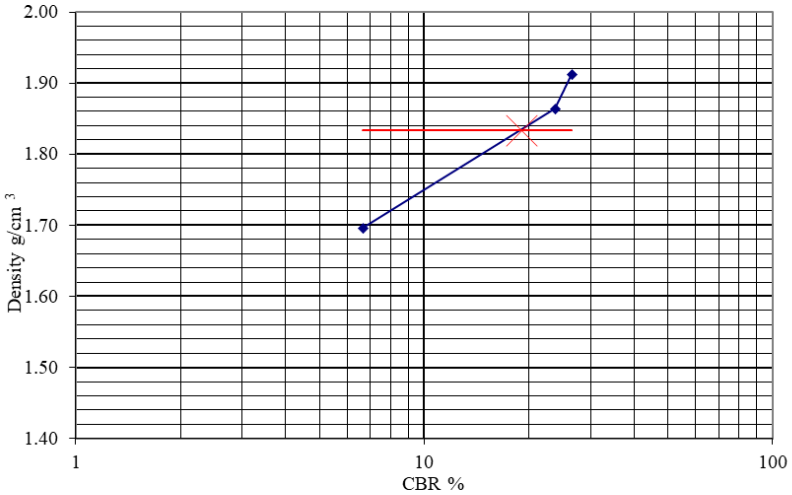

Figure 6: Graph of the CBR test at days of immersion of Kingabwa material

Immediate CBR from Mombele

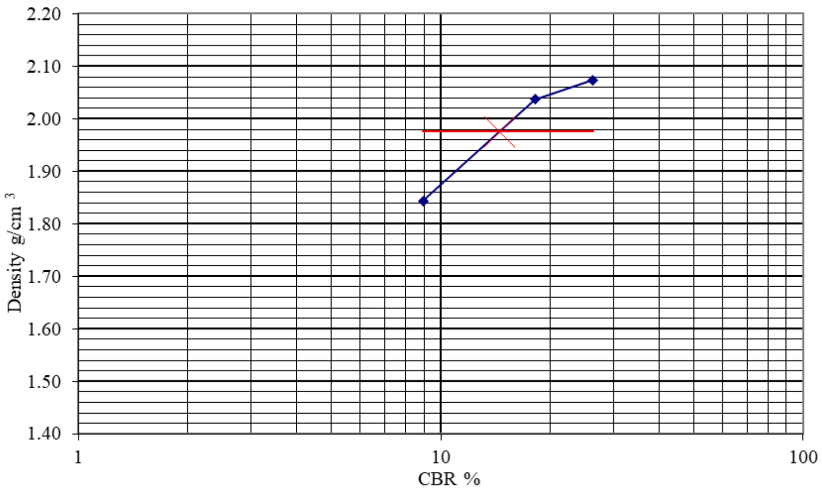

Figure 7: Graph of immediate CBR test of Mombele material

CBR 4 days immersion from Mombele

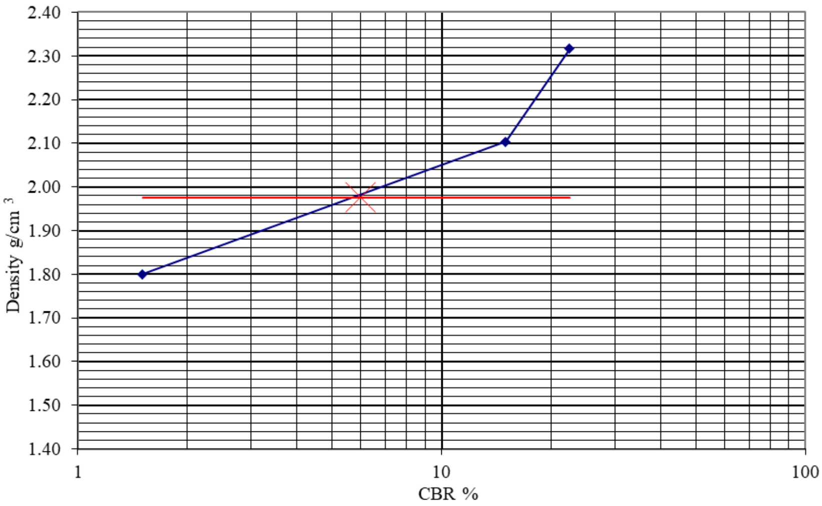

Figure 8: Graph of the CBR test at 4 days of immersion of Mombele material

Yolo 's Immediate CBR

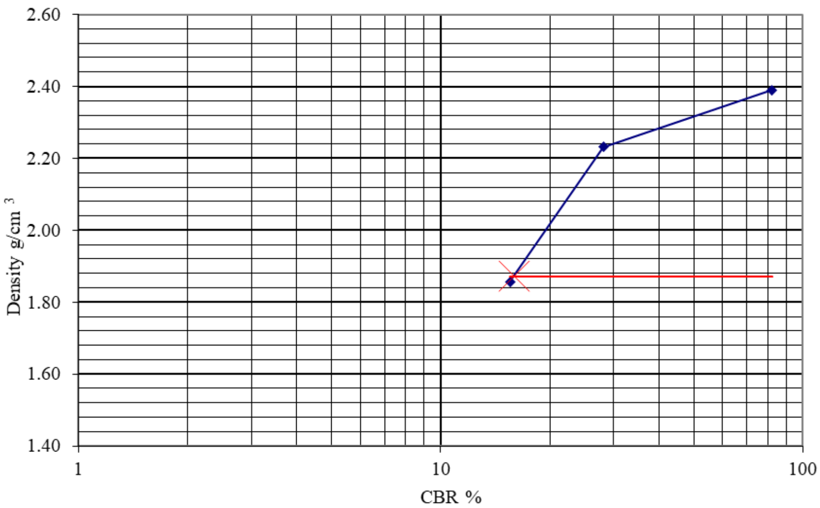

Figure 9: Graph of immediate CBR test of Yolo material

CBR 4-day immersion from Yolo

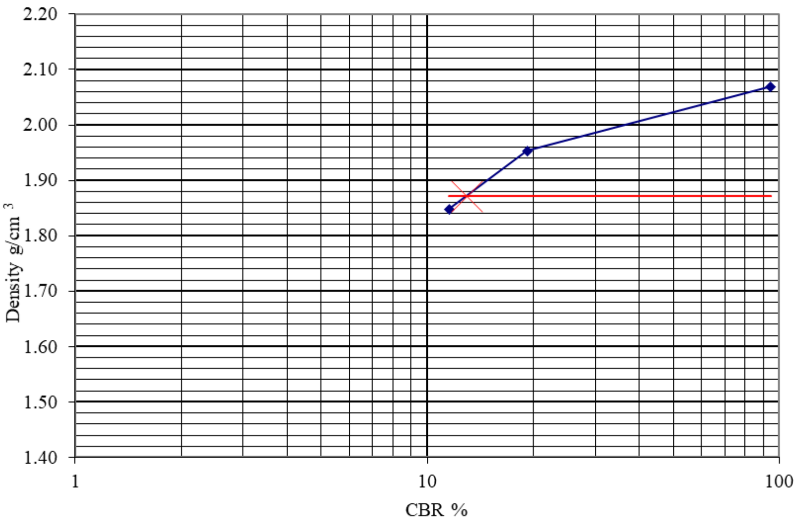

Figure 10: Graph of the CBR test at 4 days of immersion of Yolo material

Immediate CBR of crushed gravel 0/60

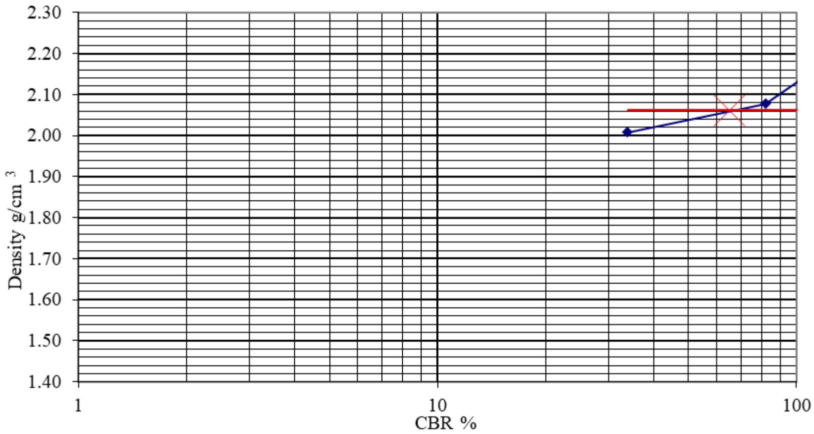

Figure 11: Graph of the immediate CBR test of crushed gravel 0/60

CBR at 4 days of immersion of crushed gravel 0/60

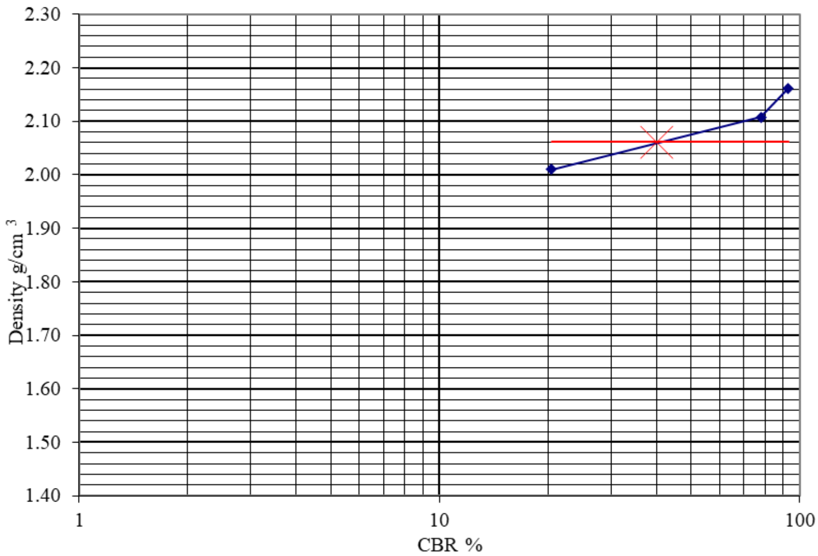

Figure 12: Graph of the CBR test at 4 days of immersion of crushed gravel 0/60

Immediate CBR of crushed sand 0/4

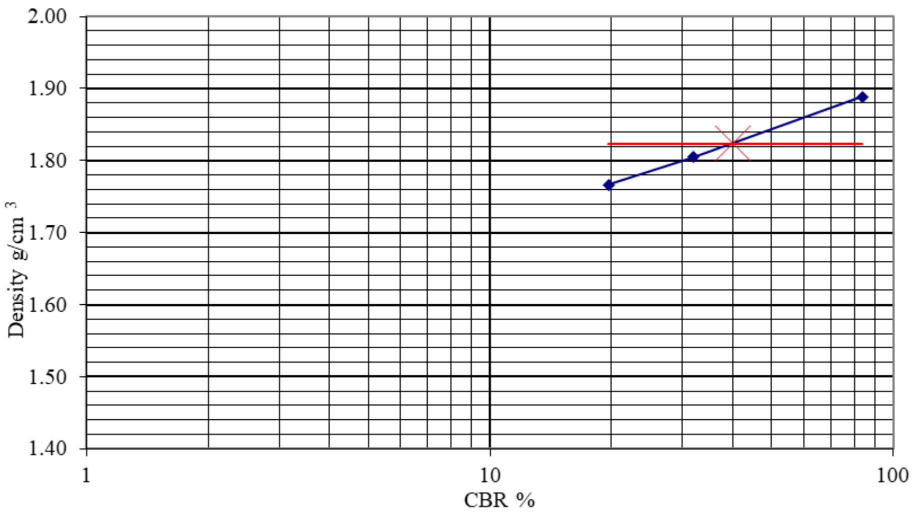

Figure 13: Graph of immediate CBR test of 0/4 crushed sand

CBR at 4 days of immersion of crushed sand 0/4

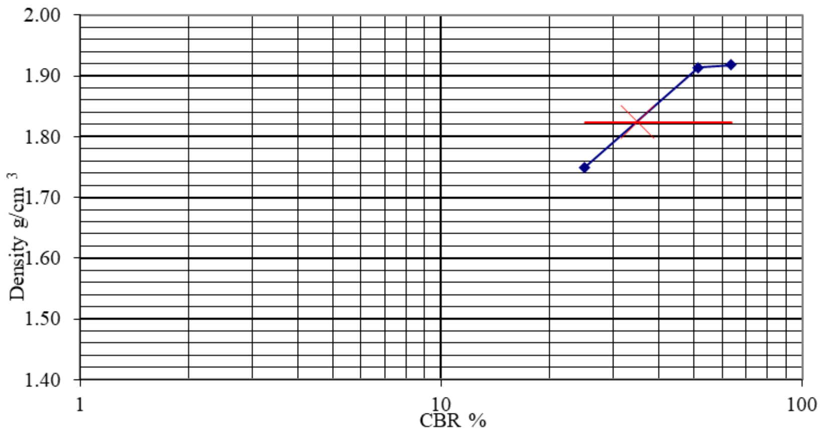

Figure 14: Graph of the CBR test at 4 days of immersion of crushed sand 0/4

Reinforced CBR
Immediate CBR from Kingabwa

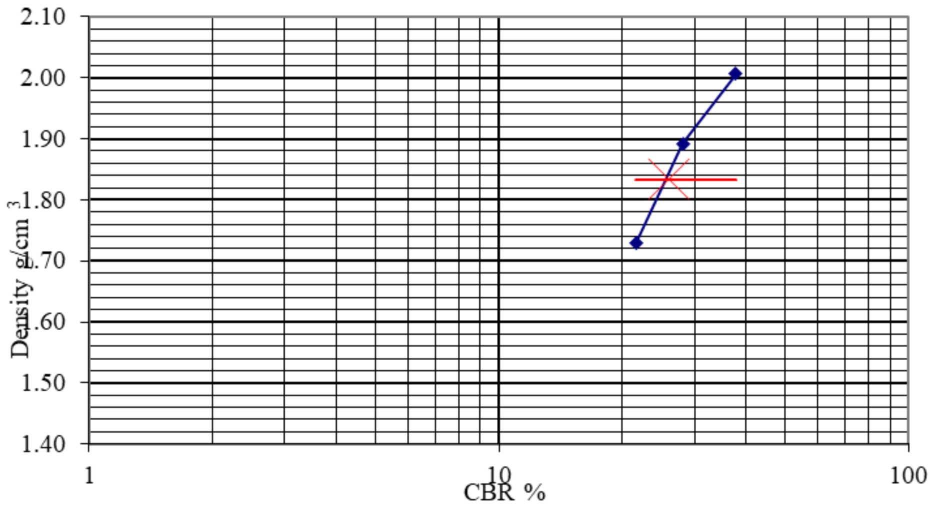

Figure 15: Graph of the immediate reinforced CBR test of Kingabwa sand

Kingabwa reinforced CBR with 4 days of immersion

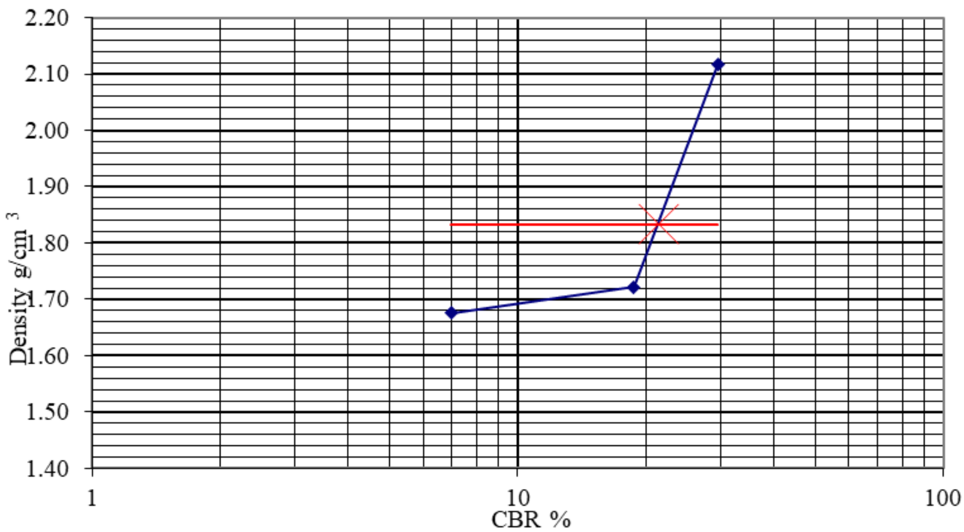

Figure 16: Graph of the reinforced CBR test of Kingabwa at 4 days of immersion

Immediate CBR from Mombele

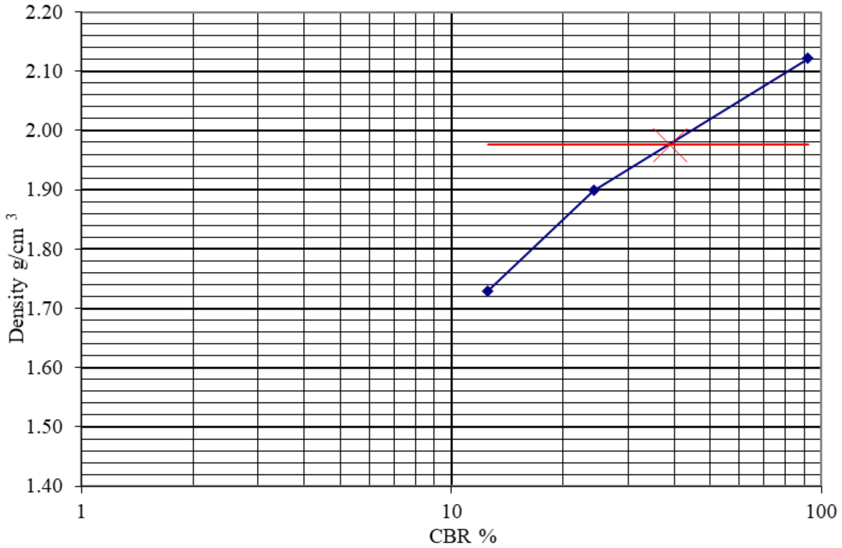

Figure 17 : Mombele reinforced CBR test

Kingabwa reinforced CBR with 4 days of immersion

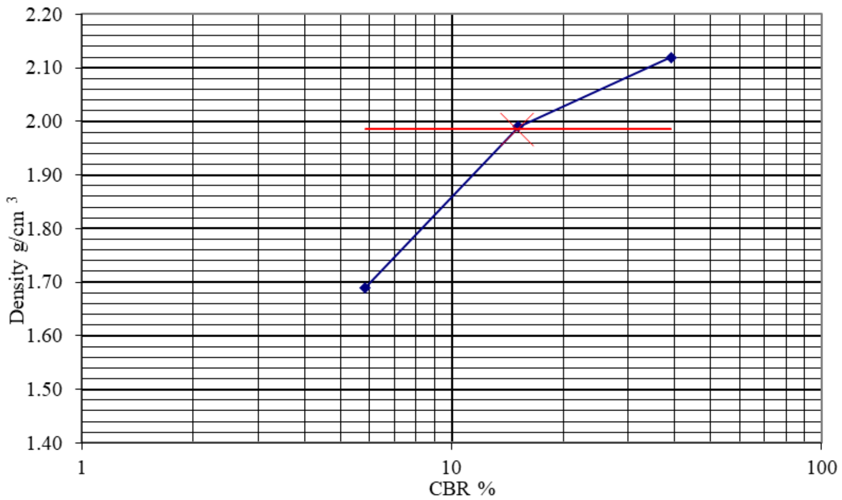

Figure 18: Graph of the reinforced CBR test of Mombele at 4 days of immersion

Yolo 's Immediate CBR

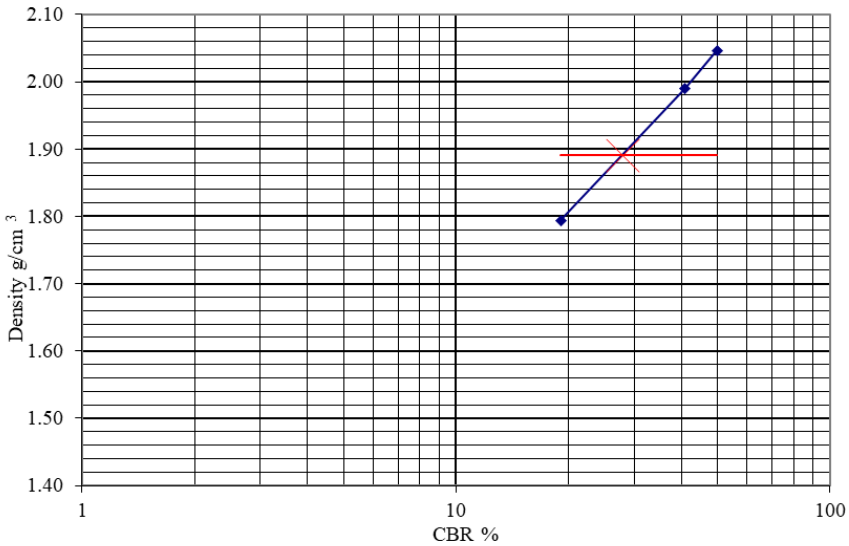

Figure 19: Yolo 's reinforced CBR test

Yolo 's reinforced CBR with 4 days of immersion

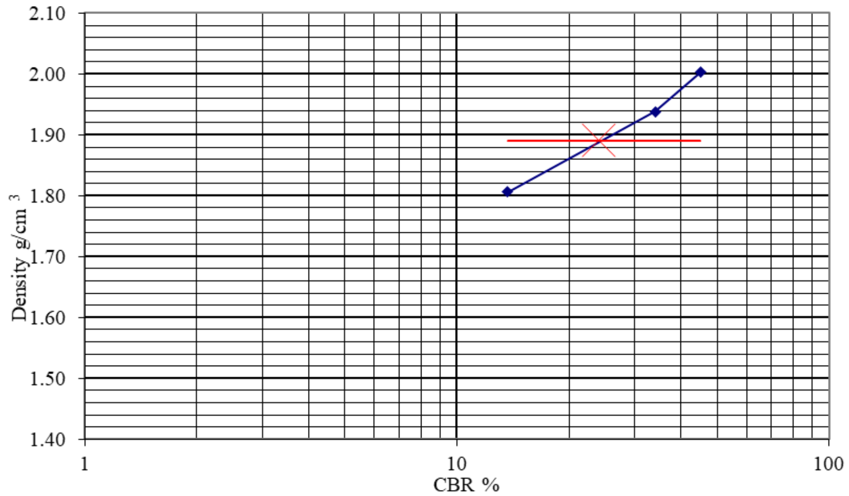

Figure 20: Yolo 's reinforced CBR test at 4 days of immersion

CBR reinforced with crushed gravel 0/60

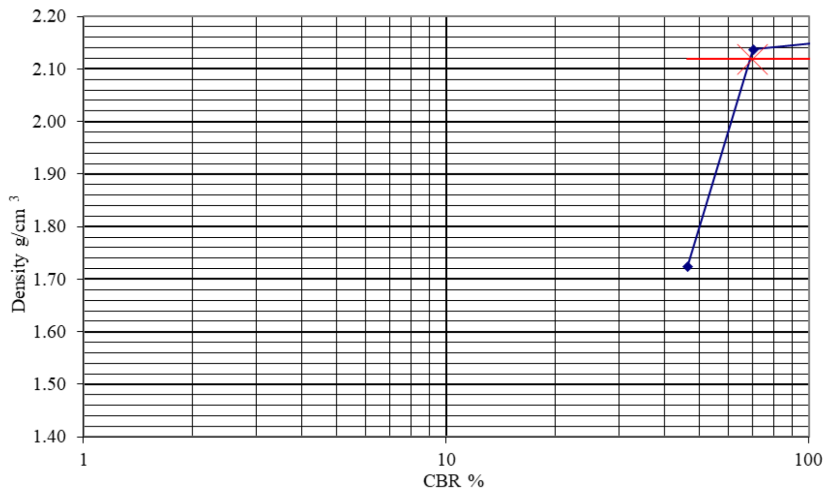

Figure 21: Graph of the immediate reinforced CBR test on crushed gravel 0/60

CBR reinforced with crushed gravel after 4 days of immersion

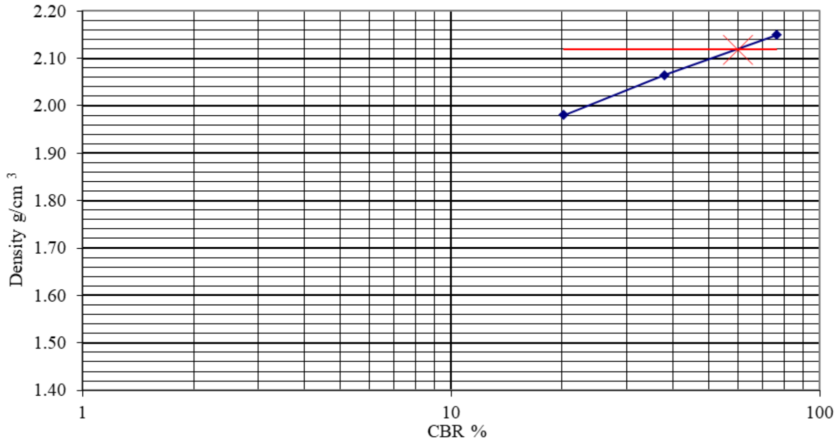

Figure 22: Graph of the immediate reinforced CBR test on crushed gravel 0/60 at 4 days of immersion

- CBR reinforced with crushed sand 0/4

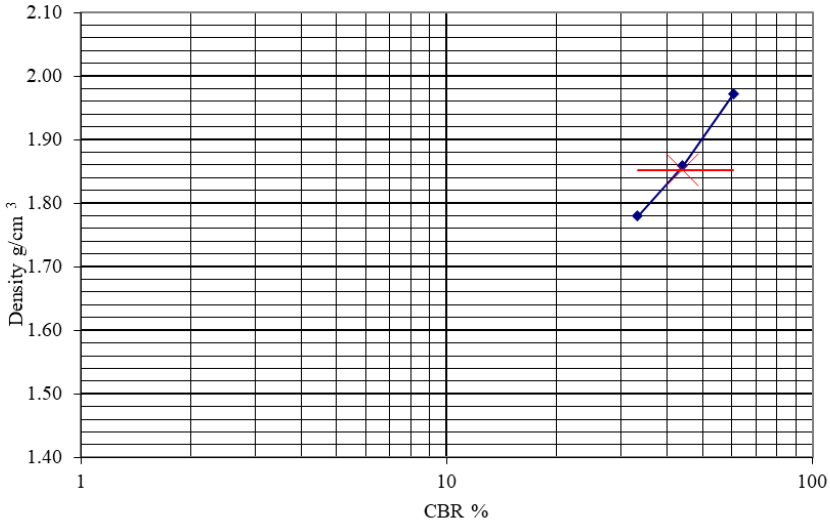

Figure 23: Graph of the immediate reinforced CBR test on 0/4 crushed sand

CBR reinforced with crushed sand after 4 days of immersion

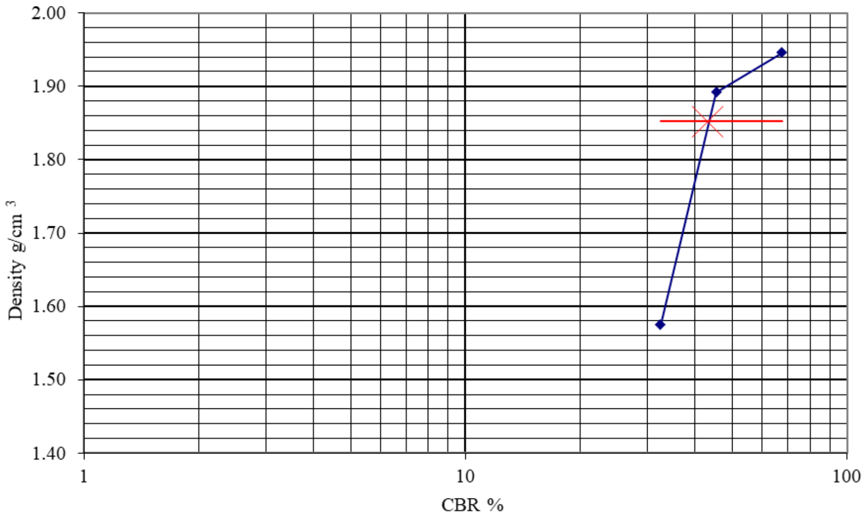

Figure 24 : Graph of the immediate reinforced CBR test on crushed sand 0/4 at 4 days of immersion

Interpretation of CBR results

According to the acceptability criteria, the material taken from 17th Street Limete / Kingabwa Avenue corresponds to low-plastic silty sand according to the AASHTO classification or to low-polluted fine sand according to the AFNOR classification.

The index carrying CBR at 95% of the OPM after 4 days of immersion is equivalent to 19. This type of soil can therefore be suitable for use as a base material for various road structures, i.e. as a platform soil. It can also be used as substitute material given that its CBR at 95% of the OPM is greater than 10 in accordance with the requirements laid down by the CEBTP Tropical Pavement Design Guides. It should also be noted that the CBR value of this material exposed to the open air (in relatively favorable conditions) is equivalent to 22.

After carrying out simple reinforcement using geogrid , the CBR at 95% of the OPM after 4 days of immersion increases from 19 to 21.5, an increase of 13.16% and the immediate CBR at 95% of the OPM increases from 22, an increase of 26%.

Mombele material also corresponds to low-plastic silty sand or low-polluted fine sand. The index carrying CBR at 95% of the OPM after 4 days of immersion is equivalent to 6, a value slightly higher than the threshold required for road base, which is normally 5. This type of material can also be used as base material. In the open air, we observe a relatively significant increase in CBR which goes from 6 to 14.5. The soil therefore presents a significant sensitivity to water.

After simple reinforcement, the immediate CBR at 95% OPM increases from 40 and 15 respectively after 4 days of immersion. This result demonstrates that the sensitivity to water is still high, however, this type of soil can be suitable, when simply reinforced, for use as a filler material.

It is far from reaching the threshold required for the foundation soil, which is 30. The use of this soil as a foundation layer is therefore to be avoided regardless of the reinforcement used.

The material collected from University Avenue is yellow silty sand. This is a low-plastic silty sand and is considered a good bedding or subgrade material according to AASHTO.

This type of material is the best material in place from a geotechnical point of view given the low variation in its CBR bearing index when exposed to the open air and when immersed for 4 days in water. The CBR bearing index at 4 days of immersion at 95% OPM gives 13 while the CBR at 95% OPM of material exposed to the open air gives 16. We therefore note a low loss of bearing capacity when it is facing the water.

It is also noted that the measured values can allow this material to be used as a base material but also as a sub-base material.

After a single reinforcement, we find a CBR at 95% OPM after 4 days of immersion which increases from 14 to 24, and from 16 to 28 for exposure to the open air. In view of this increase, we believe that a double reinforcement will facilitate the use of this material for the foundation layer.

The crushed sand O/4 according to AFNOR, can be designated as water-resistant silty sand. This type of material is an excellent material for a foundation layer. Its CBR bearing index at 95% OPM after 4 days of immersion corresponds to the measured value of 35 while the CBR bearing index at 95% OPM in the open air corresponds to 40, which attests, in view of these values, that this soil has a low sensitivity to water. The measured values therefore present this material as an excellent material for the foundation layer given that its CBR is greater than 30% in accordance with the acceptability criteria defined in the practical guides for the design of tropical pavements.

After a simple reinforcement, we note an increase in the index bringing CBR to 95% OPM after 4 days of immersion and exposure to the open air respectively of 43 and 44. For the case of low traffic, we estimate that double reinforcement may lead us to use this type of soil as a base layer material. We also note that increasing the compaction to 98% of the OPM brings the result from 43 to 51%.

The crushed material 0/60 are silty gravels or silt gravels insensitive to water (See AFNOR) or sandy gravels or crushed gravels (AASHTO). However, it should be noted that the 0/60 collected are only 0/50 according to the granulometry presented. Crushed gravel 0/50 is one of the most used materials in the Democratic Republic of Congo in the construction of foundation layers for road infrastructure given that the CBR at 95% OPM after 4 days of immersion is well above 30. The CBR measured at 95% OPM of crushed gravel taken from the SAFRICAS LUTENDELE quarry corresponds after 4 days of immersion and exposure to the open air to 40 and 65 respectively. After a simple reinforcement, the CBR index at 95% OPM was reduced to 60 after 4 days of immersion and to 70 after 4 days of exposure to the open air. It is noted that this material can be used as a base course material for low traffic pavements when it undergoes simple reinforcement and can allow the Projector to make savings, that is to say instead of using the 0/31.5 crushed stones which cost more, we can use, for low traffic pavements, 0/60 crushed stones, which cost less.

Based on the results obtained after single reinforcement, we believe that this material can be used equally well for high-traffic roads when double reinforced. It is therefore likely to achieve CBRs close to or exceeding 80, which is the required threshold.

In this section, we have presented the different geotechnical tests carried out in the work, their principles and their operating methods. We have presented the results of the unreinforced and reinforced CBR tests carried out on some road material taken from the field. We have evaluated the load-bearing capacity of road materials through various tests, and we have noticed an increase in the load-bearing capacity of reinforced road materials, hence its importance as found elsewhere by Poursorkhabi et al.,2024; Skuodis et al., 2020 and Leonardi et al., 2020.

IV. Conclusion

This present final study had as main objectives to evaluate the capacity of the CBR bearing index and its improvement with geosynthetics . This work showed that the bearing capacity of the pavement is very significantly improved by the inclusion of geogrids . This can result either in a significant reduction in the thickness of the layers to be implemented, or in the possibility of building soil in place with poor or even zero bearing capacity, such as soft clays and muds. Complementing the experimental work of certain researchers cited in our bibliography testifying to a certain improvement brought by the reinforcement geosynthetic ; our work has indeed affirmed by the results obtained during our laboratory tests. We note a significant average improvement in the CBR capacity of our materials, ranging from orders of more than 40% of the initial unreinforced value. From an economic point of view, increasing the CBR by reinforcing geosynthetics , especially geogrids , allows for the implementation of relatively thinner base layers (in aggregates), while providing the same capacity and functionality as a thicker unreinforced layer. Typically, the reduction in the number of aggregates is in the order of 40% to 60%.

Since the support largely determines the lifespan of the roadway, for various reasons, including economic ones, the current trend is to adapt the road technique to the use of local materials, including soils with evolving characteristics, sands and low-bearing materials, and geogrids seem to give us very good results in this area, since just through our tests we noticed the increase in the CBR bearing index thanks to reinforcement with a geogrid sheet , these results allow us first to recover an unusable local material due to its poor geotechnical characteristics and then its reuse after reinforcement in all efficiency. To future generations we recommend continuing research by studying the cases of reinforcement with two geogrid sheets and also to evaluate the impact of the variation of the mechanical characteristics of the geogrids on the CBR bearing capacity to use geogrids type 60/60, 80/80, 120/120 etc. and to evaluate the bearing capacity. Finally, in the case of our country, the DRC, we recommend that policy makers, drafters of tender documents and companies integrate the use of geosynthetics into our road infrastructure because they offer profitability and stability at a lower cost and a much longer lifespan than unpaved and unreinforced roads.

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