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Physical and geotechnical characterization of Bambui River sands, Northwest Region Cameroon to produce sustainable micro-concrete roofing tiles

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ABSTRACT

The importance of sustainable construction practices is notably significant in developing nations like Cameroon, where there is a strong need for cost-effective, long-lasting, and environmentally conscious building materials. In the Northwest Region of Cameroon, the Bambui River sands have attracted interest as a potential source for producing sustainable micro-concrete roofing (MCR) tiles. This study aims to conduct a thorough assessment of the physical and geotechnical properties of the Bambui River sands to determine their suitability for producing sustainable MCR tiles. Seven representative sand samples were gathered from various locations along the Bambui Riverbed and analyzed at the local materials promotion authority. The physical characterization involved particle size analysis and sand equivalent testing on the river sands. Following this, the geotechnical characterization included testing MCR tiles produced from the river sands for flexural strength, permeability, water absorption, and impact resistance. The results of the physical characterization revealed the sands contain a mixture of coarse, medium, and fine grains. The sand equivalent tests indicated that the sands were clean, with values ranging from 83.87% to 97.14%. The manufacturing of MCR tiles from the Bambui River sands adhered to recommended standard procedures. The resultant MCR tiles exhibited promising geotechnical characteristics through various tests, such as flexural strength, permeability, water absorption, and impact resistance. Specifically, the flexural strength, average water absorption, and impact resistance (measured by ball drop height) were recorded at 10.68 MPa, 10.70%, and 900 mm, respectively. These outcomes suggest that the Bambui River sands are well-suited for producing sustainable MCR tiles.

Keywords: river sands, sustainable MCR tiles, Bambui, Northwest Region, Cameroon

INTRODUCTION

The construction industry plays a crucial role in societal development, providing essential infrastructure for shelter, commerce, and industries (Mane et al., 2017). However, the traditional practices of construction have often resulted in adverse environmental impacts, depletion of natural resources, and increased carbon footprint (Angel et al., 2017; Bogas et al., 2015). In recent years, there has been a growing global emphasis on sustainable construction practices, seeking to reduce environmental degradation, optimize resource efficiency, and enhance the resilience of built structures (Oludolapo & Charles, 2017; Shen et al., 2016). One such area of focus within sustainable construction is the development and utilization of eco-friendly building materials, such as micro-concrete roofing (MCR) tiles, which offer a promising solution for sustainable and durable construction. These roofing tiles offer a durable and cost-effective alternative to traditional roofing materials, such as clay and/or metal, while also providing thermal insulation and aesthetic appeal (Agbede et al., 2016). The production of MCR tiles involves the use of locally sourced materials, which can help reduce transportation costs and support local economies (Kagonbe et al., 2020).

MCR tiles, a form of concrete tiles, comprise of cement, aggregates, water, and sometimes admixtures. Among these components, aggregates are pivotal in shaping the material's characteristics. Sand, a crucial aggregate in concrete, provides stability and volume to the mix (Chowdhury, 2022), which is more than 30.00% of the total volume of concrete (Akinboboye et al., 2015; Sabih et al., 2016). Sand is a naturally occurring granular material composed of finely divided rock and mineral particles (Magudeaswaran & Eswaramoorthi, 2016; Sabih et al., 2016). The composition of sand is highly variable, depending on the local rock sources and conditions. In composition, silica (SiO_2) is the predominant oxide. Mineralogically, they consist of quartz resulting from the disintegration of granites, sandstone, and similar rocks by natural processes of weathering and erosion (Mhedhebi et al., 2015). Generally, sand is obtained from riverbeds or from sand dunes originally formed by the action of winds. The usual particle size of sand grains is between 0.075 and 4.750 mm with further subdivision of coarse sand in range of 2.000 mm to 4.750 mm, medium sand in range of 0.42 mm to 2 mm and fine sand between 0.075 mm to 0.420 mm (Terzaghi et al., 1996). The characteristics of sand significantly affect the performance of fresh and hardened concrete and have an impact on the cost effectiveness of concrete (Tebbal & Rahmouni, 2016). Gradation or particle size distribution and cleanliness of sand affects the properties of concrete like packing density, voids content, workability, and strength (Sabih et al., 2016).

The high demand for river sand has led to unsustainable mining practices, causing environmental degradation, and social conflicts in some areas. As a result, there has been a growing interest in using alternative sources of sand, such as recycled construction waste and manufactured sand (quarry sand), to reduce the reliance on river sand in concrete production (Liu et al., 2018). Several studies have investigated various aspects of MCR tile production, including material properties, mix design optimization, curing methods, and the incorporation of waste materials. Choi and Choi (2013) and Nkengue et al. (2019) investigated the effect of using river sand, sea sand, and quarry sand on the properties of concrete, it follows that the properties of concrete change when the origin or quality of the sand is modified (Haitham, 2018). Ogunbiyi and Olugbenga (2016) explored the mechanical properties of MCR tiles using different curing methods, highlighting the importance of proper curing techniques in ensuring the durability and performance of the tiles. Oyekan and Olubanwo (2018) evaluated the performance of MCR tiles incorporating waste materials as partial replacements for sand, demonstrating the potential for sustainable production practices. Moreover, Adekunle and Adegoke (2019) investigated the influence of curing duration on the durability properties of MCR tiles, emphasizing the need for adequate curing periods to enhance the longevity of the tiles. Ezeokonkwo and Uzoma (2017) utilized response surface methodology to optimize mix proportions for MCR tiles, aiming to achieve superior mechanical properties and cost-efficiency in production.

In Cameroon, the replacement of MCR tiles with aluminum roofing sheets (a traditional metal roofing sheet) is often due to leakages from poor aggregate materials like river sands with high organic and clay content, and sea sands with alkaline salt issues. As a solution, quarry sands are considered, being free from these impurities but costly due to energy-intensive production processes (e.g., crushing plant operations). Furthermore, the river sands used for MCR tile production must have well-graded particle sizes, including fine, medium, and coarse grains, and should be free from organic materials, silt, and clay, with a sand equivalent value exceeding 80.00% (Oyekan & Olubanwo, 2018). The significance of sustainable construction practices is particularly evident in developing countries like Cameroon, where the demand for affordable, durable, and environmentally friendly building materials is high. However, in Cameroon, the use of river sands for concrete production has been explored in the Center Region specifically at Monatele and the North Region (Kagonbe et al., 2020; Ndigui & Uphie, 1999). In the Northwest Region of Cameroon, the Bambui River sands have garnered attention as a potential resource to produce MCR tiles. The unique geological composition of these sands, combined with their local availability, presents an opportunity to explore their physical and geotechnical properties for sustainable construction applications. While the physical and geotechnical properties of the Bambui River sands have not been studied, this research seeks to address this gap by evaluating their suitability to produce sustainable MCR tiles.

The primary objective of this research is to conduct a comprehensive physical and geotechnical characterization of the Bambui River sands in the Northwest Region of Cameroon. By analyzing the physical properties (particle size distribution and sand equivalent) of these river sands, and subsequently evaluating the geotechnical properties (flexural strength, permeability, water absorption and impact resistance of MCR tiles produced from Bambui River sands). The utilization of locally available materials not only reduces the carbon footprint associated with transportation but also promotes economic development and empowers local communities through job creation and skill development in the construction sector. Furthermore, the development of sustainable building materials aligns with global initiatives to mitigate climate change, reduce energy consumption, and promote circular economy principles in the construction sector. By integrating sustainable practices into material production and construction processes, industry can effectively reduce its environmental impact, conserve natural resources, and contribute to the overall resilience of the built environment. The physical and geotechnical characterization of the Bambui River sands to produce sustainable MCR tiles represents a significant step towards advancing sustainable construction practices in the Northwest Region of Cameroon.

MATERIALS & METHOD

Physical Characterization

Particle size analysis

Particle size analysis (**Figure 1**) or sieve analysis using a column of different sieves diameter is a practice used to assess the particle size distribution of granular materials. The size distribution is often of critical importance to the way the material performs in use. This analysis was conducted following the NF EN 933-1 standard. Wet sand samples labelled SSB1, SSB2, SSB3, SSB4, SSB5, SSB6, SSB7 from Bambui River were measured each to 300 g on an electronic balance with 0.5 accuracy. The wet samples were then stored in an oven of 110 °C for 24 hours. The intention was to dry the samples before proceeding to particle size analysis. Then after which the dried samples were weighed, noticing a decrease in mass as initially was 300 g. Each sample was then vibrated

Figure 1. Particle size analysis procedure (Source: Field study)

Figure 2. Sand equivalent test procedure (Source: Field study)

through column of sieves with varying diameters ranging in descending order from; 5 mm, 4 mm, 2 mm, 1 mm, 800×10^{-6} m, 500×10^{-6} m, 250×10^{-6} m, 200×10^{-6} m, 125×10^{-6} m, and 80×10^{-6} m, with the help of an electric vibrator. Then particles captured from each of the sieves were measured as cumulative mass and registered on an excel sheet. The results were then plotted as cumulative mass percentage versus sieve size to produce a grain size distribution curve.

Sand equivalent test

Sand equivalence test (**Figure 2**) quantifies the relative abundance of sand versus clay, organic materials, and silt in a sample. The test is used to qualify aggregates for applications, where sand is desirable with little or no fines and dust. The higher the sand equivalence value indicates that there is less clay-like material in a sample. This test was conducted following the NF EN 933-8 standard. The sand samples were placed in measuring cylinders to the mark of 300 ml; water was then added to the mark of 1000 ml; calcium chloride, formaldehyde and glycerin were then introduced into the mixed solution; then the content was left for sedimentation. Since sand is denser than clay and fine materials, it would sink to the bottom of the cylinder; a ruler was used to measure the height of sand plus clay/fines in centimeter (cm) known as height 1 (h1); the same ruler was used to measure the height of the sand alone in centimeter (cm) known as height 2 (h2); then the sand equivalence value was calculated, which is the percentage of sand in a given sample using the formula: $\left(\frac{h2}{h1}\times 100\right)\%$.

Micro-Concrete Roofing Tile Production

Portland cement (CPJ CEM II 42.5R) from the Cameroon Cement Corporation (CIMENCAM) was used in this study as the binding material, fulfilling the European cement standard (BS EN 197–1/2011, 2011). A study carried out by Biyindi et al. (2019) reveals CEM II 42.5R cements can be used for reinforced and stressed concrete standard structures requiring high resistance.

Figure 3. 8 mm MCR tile production procedure: (A) tile vibrator; (B) hydraulic compressor; & (C) MCR tile on a mold (Source: Field study)

The river sands from Bambui were mixed with Portland cement in the ratio 2:1 (i.e., 6.5 liters of river sands and 3.25 liters of Portland cement) as prescribed by Ramakrishna et al. (2011) and Swiss Center for Appropriate Technology (SKAT, 1992) forming one composition. Water was added to the composition formed, mixed thoroughly with a trowel to form a viscous slurry paste otherwise known as concrete. The concrete was placed on a tile vibrator for vibration (see part a in **Figure 3**), this was to reduce the pore spaces in the concrete. After vibration, it was placed in a mold, covered with a cloth, and placed on a hydraulic compressor machine, where it was compressed to take the shape of the mold (see part b in **Figure 3**).

Three 8 mm thick MCR tiles were produced from the one composition formed. MCR tiles were covered for about 48 hours, then removed from the mold and wet cure for seven days. After curing for seven days, they were later cured (dry curing) for 14 days before sent to the quality control laboratory in the local materials promotion authority. The purpose for curing was to ensure hardening of the concrete (Adekunle & Adegoke, 2019).

In the quality control laboratory, the following geotechnical tests were carried out on MCR tiles, flexural test, permeability test, water absorption test, and impact test.

Geotechnical Characterization

Flexural strength

Flexural strength indicates the load that a material can withstand without breaking or rupturing. This test was conducted in accordance with ASTM standard method (ASTM C 67-13, 2013; ASTM C 1492-03, 2009; WSDOT Test Method T 802, 2009). One MCR tile 21 days old, was selected for testing. The tile was immersed in water for 24 hours and tested soon after removal from water. The tile to be tested was supported on two bearings or supports. The distance between the supports was two thirds of the length of the tile. The load was applied centrally through a third bearer using a rod of 38 mm diameter attached with a bucket of water whose mass (kg) can be measured and converted to Newton (N) to get the maximum bending load capacity for the tile under testing. The flexural stress was calculated using the following formula:

Flexural strength (MPa)=$(3\times P\times L)/(2\times W\times d^2)$, where P is the loading force in Newton (N), L is span length of the tile in millimeters (mm), W is width of the tile in millimeters (mm), and d is thickness of the tile in millimeters (mm).

Permeability test

Permeability test was carried out according to ASTM standard method (ASTM C 67-13, 2013; ASTM C 1167-03, 2012; ASTM C 1492-03, 2009). The selected sample was placed on a stand in such a way that its undersides were visible. Water up to approximately 10 mm height was allowed to sit on the top of the sample for 24 hours. The area between the sample and setup was properly sealed with a sealant to prevent leakage. Water drops were inspected after 24 hours and if more than two of them were found on the underside of the sample, then the sample would be considered as significantly permeable. A tile is considered to have failed the test if after 24 hours, it was found that water was dripping from, or there was free water on the underside.

Water absorption

The water absorption test was carried out according to ASTM standard method (ASTM C 67-13, 2013; ASTM C 1492-03, 2009). Four pieces from one MCR tile were dried in an oven at 110 °C for 24 hours, weighed (dry mass) and then immersed in a 500 ml test tube containing 200 ml of water for 24 hours. The volume of water displaced by each sample was observed. Then the samples were carefully wiped with a cloth and weighed again (wet mass). Water absorption value for each sample was calculated using the following formula:

$WA=[(M2-M1)/(M1)]\times 100$, where WA is water absorption (%), M1 is dry mass (g), and M2 is wet mass (g).

Impact test

This test makes it possible to predict whether MCR tiles will be able to withstand the shock of a fruit falling from a fruit tree, hailstorms, etc., once placed on the roof. The method adopted for this study was a drop-ball test drawn from Johansson (1995).

One MCR tile was placed horizontally on a 100 mm thick layer of sand. The tile was pressed to the heel in the sand to take a flat orientation. A steel ball weighing 225g was dropped from a height of 500 mm onto the center of MCR tile. The position of the ball with respect to the tile was carefully determined by a plumb line. After each drop, the height was raised by 100 mm and the procedure repeated. After each drop, MCR tile was observed for any cracks. A minimum requirement should be that MCR tile withstands the first drop without any visible crack.

RESULTS AND DISCUSSION

Physical Characterization

Particle size analysis

The particle size distribution curves of the studied sands have an “S” shape (see **Figure 4**), characteristic of the common curves obtained in sands showing a good mix of coarse, medium, and fine grains based on particle size analysis (Kagonbe et al., 2020). Various studies have shown that the particle size distribution of sands plays a very important role in the workability of concrete (Abdelgani et al., 2014). According to Makhloufi et al. (2014), sands showing a mix of coarse, medium, and fine grains produce better workability than uniformly graded sands.

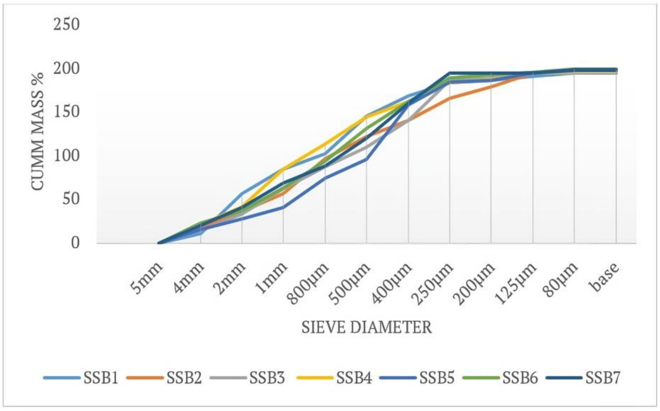

Figure 4. Grain size distribution curve for Bambui River sands (Source: Authors’ own elaboration)

Table 1. Grain size distribution for seven sand samples from Bambui River

Sample	% of coarse grain sand	% of medium grain Sand	% of fine grain sand
SSB1	29.23	57.44	13.33
SSB2	18.18	52.78	29.04
SSB3	16.92	55.39	27.69
SSB4	21.37	61.07	23.41
SSB5	13.96	66.24	19.80
SSB6	18.59	62.82	18.59
SSB7	20.65	59.95	19.40

The grain size distribution curve aided us in extrapolating the percentage of the different grain sizes for each of the sand samples using Terzhaghi et al. (1996) grain size classification scheme as seen in **Table 1**. Indeed, the particle size distribution of the studied sand showed that the samples constituted varied proportions of coarse, medium, and fine grains.

According to the specifications proposed by SKAT (1992), it is recommended that the percentages of the different classes of particles in the aggregate for eight mm MCR tiles be, as follows: coarse particles 5.00% to 30.00%, medium 50.00% to 80.00%, and fine 10.00% to 50.00%. Based on these recommendations, the sands from the Bambui River are considered well graded, having a good representation of coarse, medium, and fine grains.

Sand equivalent test

Sand equivalent test was carried out to quantify the number of organic materials, silt and clay associated with the sand samples. Organic materials, silt and clay affect the workability and structural integrity of the concrete, as they turn to inhibit reaction with the cement binder. For sand to be used for production of high standard MCR tiles, it must be clean with less than 20.00% composition of organic material,

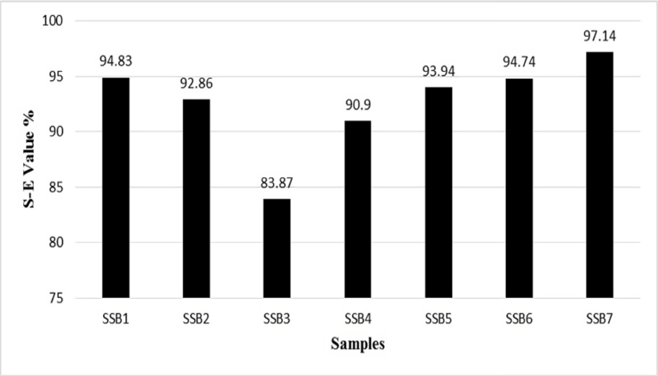

Figure 5. Sand equivalent results for seven sand samples from Bambui River (Source: Authors' own elaboration)

Table 2. Flexural strength of MCR tile produced from Bambui River sands cured for 21 days (span length=420 mm, width of tiles=330 mm, & thickness of tiles=8 mm)

Loading force: N	Flexural strength: MPa
358	**10.68**

silt, and clay. **Figure 5** shows the sand equivalent value for the seven sand samples from Bambui River.

The values range from 83.87% to 97.14%. According to the NF EN 933-8 standard, the studied sands are classified as very clean sands. Teshager (2019), study the effects of excessive silt and clay as well as organic impurities composition in river sand used in concrete production as these impurities affect the overall performance of concrete product.

The results obtained showed that the higher the percentage of silt/clay/organic impurities content in the sand samples, the higher the reduction effect on the strength and workability of the concrete. Kagonbe et al. (2020), studied the physical characterization and the optimization of fineness moduli of some natural river sand samples for their appropriate valorization on construction. The sand equivalent results vary between 91.10% and 96.80%, characteristic of very clean sand. The sand equivalent results for the Bambui River sands had a minimum value of 83.87% implying the sands are clean, since their sand equivalent values are greater than 80.00%.

Geotechnical Characterization

Flexural strength test

The flexural strength test was conducted after eight mm MCR tiles were cured for a period of 21 days. The flexural stress for MCR tile produced was calculated according to standard method and the results shown in **Table 2**.

From **Table 2**, the tile produced had a value of 10.68 MPa. It can be seen from **Figure 6** that the flexural strength for MCR tile was approximately twice in contrast to the minimum standard requirements of six MPa (CIP-16, 2000).

Nonetheless, the values of flexural strength obtained were much higher as compared to BS 6073 (1981), this is due to an excellent binding ability between the Portland cement and the river sands. This results are similarly to the findings of Nadeem et al. (2017), where the flexural stress values for the roofing tiles were reported to be in a range of 11.4 MPa to 12.2 MPa far above the minimum standards, the results obtained was due to the fact that the sands were clean constituting less than 20.00% of silt and organic materials that could potentially hinder the reaction between sand and the binder.

The flexural strength results for Bambui River sands can be attributed to the cleanliness of the sands, as seen from the sand equivalent test, with less than 20.00% organic materials, clay, and silt content. This cleanliness factor plays a significant role in ensuring the structural integrity of the concrete, thus leading to the satisfactory flexural strength value observed in the produced MCR tile.

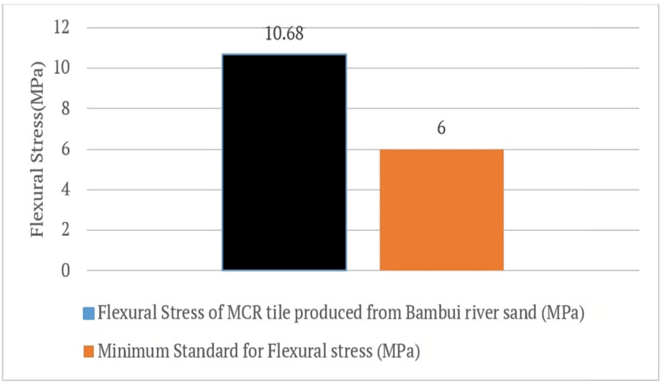

Figure 6. Flexural stress value for MCR tile produced from Bambui River sands with minimum standard of 6 MPa (Source: Authors' own elaboration)

Table 3. Permeability test results for MCR tile produced from Bambui River sand

Sample	Permeability test
MCR tile made from Bambui River sands	PASS

Permeability test

The permeability test conducted on MCR tile produced from Bambui River sands revealed positive results, indicating that no water droplets were found on the opposite side of the tile after the 24 hours testing period. This absence of water droplets indicates that the tiles did not allow water to pass through, signifying a successful test outcome, as shown in **Table 3**.

The permeability test is essential for assessing the presence of micro voids within MCR tiles, which might result from factors such as insufficiently graded sands or inadequate vibration of the mortar during production, leading to increased pore spaces. The positive results in this test suggest the absence of micro voids within the tile. This outcome can be attributed to the well-graded nature of the sands used in the production process, including a mix of coarse, medium, and fine grains as identified during particle size analysis. Similar findings were reported by Ndigui and Uphie (1999) in their research on natural river sands from Monatele, where positive results in the permeability test indicated the absence of micro voids. The reason for this absence of micro voids was attributed to the well-graded nature of the sands from Monatele, underscoring the importance of proper grading in preventing the formation of micro voids within MCR tiles.

The comparison between the current study and the work of Ndigui and Uphie (1999) suggests that the positive results

Table 4. Water absorption test result

Sample	M1 (dry mass in g)	M2 (wet mass in g)	Water absorption value (%)
1	221.5	244.0	10.16
2	226.0	249.0	10.18
3	227.0	252.0	11.01
4	222.5	248.0	11.46
Average			10.70

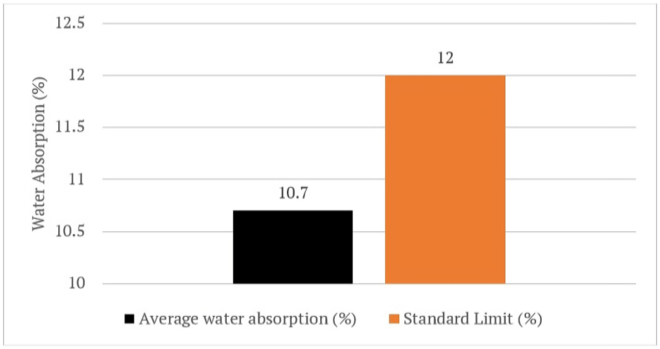

Figure 7. Average water absorption for with reference to standard limit of 12.00% (Source: Authors' own elaboration)

obtained in the permeability test for MCR tiles Bambui River sands can be attributed to the well graded composition of the sands used in the production process.

Water absorption test

Water absorption test is crucial for determining the moisture content that roofing tiles can absorb, as excessive absorption can lead to undesirable cracking and structural integrity issues in MCR tiles. The more pores are contained in a material, water absorption is greater and so the resistance of the material reduces. Cavities (pores) contained in a material happened because of poor quality and the composition of the constituent materials (Martínez-Lage et al., 2016). In this study, the water absorption test was conducted to quantify the moisture uptake of MCR tiles.

The percentage of water absorption for the samples were calculated according to standard method and the results are shown in **Table 4**. The results in **Table 4** and **Figure 7** indicate that the water absorption water absorption range from 10.16% to 11.46% with an average value of 10.70%. The water absorption values attained were below the standard limit of 12.00% (ASTM C 1492-03, 2009). The low percentage of water absorption was thought to be due to low porosity of MCR tiles (Hung et al., 2015; Zhang & Zong, 2014).

In a study conducted by Ndigui and Uphie (1999) on natural river sands from Monatele, the water absorption test yielded an average value of 7.03%, indicating high-quality roofing tiles with regards to water absorption. Similarly, Jayasinghe et al. (2006) examined the engineering properties of MCR tiles from Sri Lanka, with the water absorption test revealing an average water absorption of 8.63%. A low water absorption is an indication that MCR tiles are less absorptive and more durable, while MCR tiles with high water absorption are susceptible to damage (Abdullah et al., 2015). Furthermore, MCR tiles tested for permeability passed the test. Less porous materials are denser and denser materials have fewer chances to leak and vice versa. The higher the density, thus the lower will be the porosity and permeability (Zhang & Zong, 2014). Low porosity, low percentage of water absorption and impermeability increases the durability of concrete tiles (Farhana et al., 2015)

Table 5. Impact test (drop-ball) result

Drop height (mm)	Weight of ball (g)	Tile after impact
500	225	Ok
600	225	Ok
700	225	Ok
800	225	Ok
900	225	**Crack**
1,000	225	------
1,100	225	------

Comparing the results of this study to those of other researchers, it can be noted that the river sands from Bambui utilized in the production of MCR tiles demonstrated water absorption values well within the acceptable range for good performance tiles. These findings suggest that the river sands are suitable for producing high-quality and sustainable MCR tiles that can be effectively used in regions prone to frequent rainfall, ensuring durability and structural integrity in varying environmental conditions.

Impact test

The impact test is vital as it helps in assessing whether the roofing tiles can withstand various impacts such as fruits falling from trees or hailstorms, simulating real-life scenarios once the tiles are installed on a roof.

Drop-ball impact test results presented in **Table 5** showed that MCR tile produced exhibited no cracks from 500 mm to 800 mm ball drop height. The first visible crack for the tested MCR tiles was observed at the 900 mm drop ball height. This test was drawn from Johansson (1995), who highlighted that the minimum requirement for impact resistance should be that MCR tiles withstand the first drop height of 500 mm without any visible crack. From the impact resistance results presented in **Figure 8**, the first visible cracks were observed far above the minimum requirement, which is an indication that MCR tile has a satisfactory impact resistance.

CONCLUSIONS

Physical characterization of Bambui River sands were carried out with the aim to evaluate the suitability for it's used in the production of sustainable MCR tiles in Northwest Cameroon. According to the seven samples studied, the sands are classified as well graded showing a mix of coarse, medium, and fine grains. The sand equivalent results indicated that the sands are clean with values ranging from 83.87% to 97.14%, reducing the risk of plasticity defects when used as aggregate in concrete. The production of MCR tiles using river sands from Bambui followed the recommended standard procedures. The resulting MCR tiles produced displayed favorable geotechnical properties across various tests such as flexural strength, permeability, water absorption, and impact resistance. It was observed that the flexural strength, average water absorption, impact resistance (ball drop height) values were measured at 10.68 MPa, 10.70%, and 900 mm, respectively. The findings suggest that the Bambui River sands

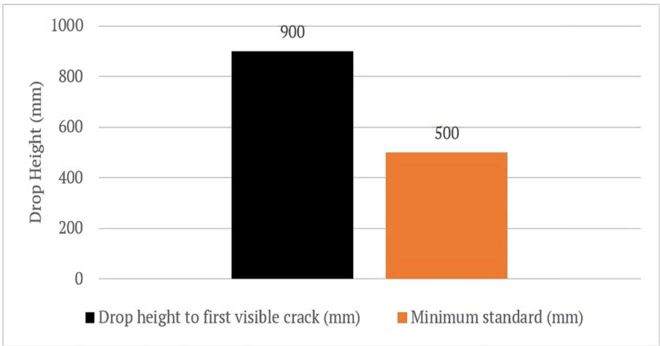

Figure 8. Drop height to first visible crack (Source: Authors' own elaboration)

are suitable to produce sustainable MCR tiles, as they offer enhanced structural integrity and durability, especially in scenarios, where resistance to bending forces is crucial for long-term performance and reliability of the roofing tiles.

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Ethical statement: The authors stated that ethics committee approval was not required for the work. The study involves data collection using online resources involving information freely available in the public domain that does not collect or store identifiable data. All related laws, rules, and regulations required for the study's implementation have been followed.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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