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Physico-Mechanical Impact of Different Cem Ii 42.5 MPa Cement Brands on Hardened Concrets in Cameroon

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Abstract

Cement is defined as a hydraulic binder composed of finely ground powdered materials which, when mixed with water or a saline solution, form a plastic paste capable of binding various substances as it hardens. This study aims to highlight the impact of different class II cements (strength class 42.5 MPa) available on the Cameroonian market (ROBUST, CIMAF, DANGOTE, and MEDCEM) on the compressive strength of hardened concrete at different curing ages. To determine which cement brand provides the best compressive strength at maturity, a series of tests were carried out on samples from each brand, including consistency, setting time, density, compressive strength, and water absorption. The results support our hypothesis: cements are often used indiscriminately with identical dosages, based solely on their mass, in an attempt to achieve similar compressive strength outcomes. The study revealed that the finer the cement, the higher its compressive strength. Additionally, less dense cements produce lighter concretes but require more water for optimal workability, which affects the water-to-cement ratio. DANGOTE cement exhibited the highest compressive strength (29.09 MPa), followed by MEDCEM, and all the studied cements exceeded the target strength of 25 MPa at 28 days.

Keywords: Physico-Mechanical; strength; Concrete; Cement; Strength Class.

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1. Introduction

Mineral binders are finely ground powders that, when mixed with water, form a plastic paste that hardens into a stone-like state through physical and chemical processes. They are obtained by firing mineral materials. Mineral binders are divided into two families: hydraulic binders, which harden in contact with water and gain strength and stability in open air or even underwater. Among these are Portland cement and hydraulic lime (natural or artificial). Aerial binders harden only in contact with water and gain strength and stability in open air only [4,17]. These include plaster and aerial lime. In 1817, [3,13] discovered the chemical principles of cements and defined the manufacturing rules. He is also considered the inventor of cement. In 1824, [10,12] obtained a patent for the manufacture of Portland cement, though it still had many unresolved aspects. It was only in 1845 [10,12] clearly established the manufacturing rules for this product. The core composition of cement, expressed in percentages, refers to the sum of main and secondary components, excluding calcium sulfate and any additives. Portland cement has multiple uses. It is used for the preparation of grout (cement + water), mortars (cement + sand + water), and concretes (cement + sand + gravel + water). It is found in buildings, civil engineering works, roads, and dams. Cement specifications are defined by standard [2,18]. Thus, the strength or load-bearing capacity of concrete depends on several parameters, such as the type and size of aggregates, the water-to-cement (W/C) ratio, the cement proportion, the type of mixing water, among others. It is necessary to establish dosage correlations between different cement brands while maintaining the same strength, in order to avoid, particularly in large-scale projects, potential failures caused by uncontrolled use of multiple cement brands under the same standard.

1.1. Literature Review

1.1.1.The Influence of the W/C Ratio

The authors [1,9] experimentally showed that: the characteristic length of concrete lies between four and six times the size of the largest aggregate in its composition. However, this estimate is not valid for mortars, where the largest aggregate may not represent the greatest heterogeneity; peak stress and volumetric fracture energy density decrease as aggregate size increases; conversely, fracture energy increases with aggregate size. He also developed a hierarchical model accounting for the heterogeneous nature of the microstructure.[8,13] studied the evolution of autogenous shrinkage and thermal transfer properties of cement pastes with low W/C ratios (0.25; 0.30; 0.35; and 0.40) and subjected to different isothermal curing temperatures (10, 20, 30, 40, and 50°C). Simultaneously, the hydration kinetics and chemical shrinkage of these pastes were measured. The results show minimal variation in the thermal properties of cement pastes within the studied range of temperatures and W/C ratios.[5,14] experimentally characterized the influence of saturation level and water-to-cement ratio on concrete behavior under high confinement. This aimed to better understand concrete response under severe stresses (close-range explosions or ballistic impacts). The studies required the formulation of a reference ordinary concrete and two modified concretes with different W/C ratios. The load capacity of concrete increases with confining pressure for dry concrete, but beyond a certain pressure level, it remains limited for wet or saturated concrete.

1.1.2.Cement Concrete for Roads

Reference [6,7,11] highlighted the complexity of the cement concrete problem and the difficulty in obtaining a rigorous assessment of cement dosage in hardened concrete. The most commonly used method consists of conducting a controlled acid attack on hardened concrete to selectively dissolve both anhydrous and hydrated cement components. Since calcium silicates represent the essential phases of cement, the "soluble silica" content is often used alone to determine the cement content. He also identified the main acid-interfering factors arising from the nature of the cement, aggregates, and aging conditions of the concrete. Furthermore, [6,7,11] showed that in most cases, determining the carbonation rate of a concrete, even one made with limestone, can provide an approximate estimate of its cement composition.This literature review allows us to conclude that cement is a binding material between the aggregates that form concrete after water is added. Thus, the strength or load-bearing capacity of concrete depends on several parameters such as the type and size of aggregates, the W/C ratio, the cement proportion, the type of mixing water, among others.

2. Materials and Methods

In order to assess the influence of various locally produced CEM II cement brands of 42.5 MPa strength class available on the Cameroonian market on concrete strength, an appropriate methodology had to be applied to effectively carry out laboratory work and determine key parameters.

2.1. Field Work

This step involved acquiring the various materials based on their origin.

2.1.1.Materials Used

Several materials were used:

- Sand 0/5 mm;
- Gravel 5/15 mm;
- Cement CPJ CEM II /A 42.5R;
- Cement CPJ CEM II /B 42.5R;
- Potable water.

2.1.2. Nature and Origin

With the aim of promoting local materials, all the materials used in this research were locally sourced (from Cameroon).

Table1: presents the nature and origin of the various materials

Material	Nature	Origin	Specification
Sand	River/rolled sand	Sanaga River (Ebebda – Cameroon)	0/5 mm
Gravel	Crushed stone from quarry	Tchipou – Bamoungoum	5/15 mm
Cement	CPJ CEM II/A 42.5	CIMAF (Douala – Cameroon)	NC 234:3009-6
	CPJ CEM II/B 42.5	ROBUST / CIMENCAM (Figuil)	NC 234:3009-6
		DANGOTE (Douala – Cameroon)	NC 234:3009-6
		MEDCEM (Douala – Cameroon)	NC 234:3009-6
Water	Potable tap water	CDE (Cameroon Water Distribution)	—

Figure 1: Sand and Gravel

Figure 2: Cement brands analyzed

2.1.3.Laboratory Work

All experimental procedures were conducted at the Materials and Geotechnics Laboratory of the Fotso Victor University Institute of Technology in Bandjoun. Tests included the characterization of raw materials such as sand, gravel, cement, and concrete.

2.2. Experimental Methodology

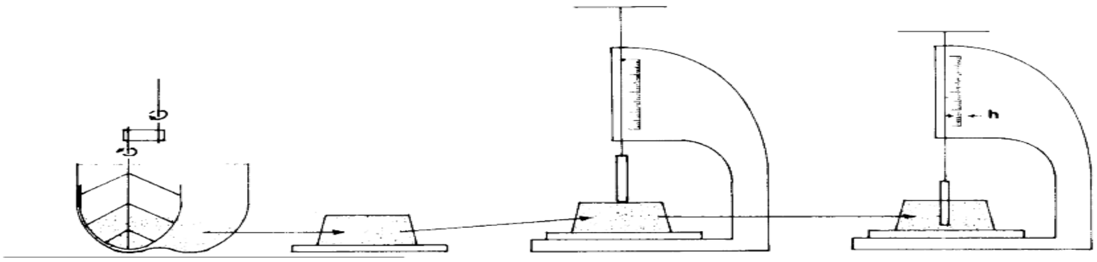
The study followed a purely experimental approach, involving the preparation of specimens and characterization of materials based on the following properties:

- Physical properties: moisture content, bulk density, specific gravity, absorption rate, sand cleanliness, and optimal compaction density.
- Geometrical properties: particle size distribution, fineness modulus, flakiness index, and slump value.
- Mechanical property: compressive strength testing.

2.2.1.Cement Testing

Consistency Test

This test determines the water-to-cement (W/C) ratio that yields a standard consistency paste, neither too stiff nor too fluid. It is conducted using a Vicat apparatus equipped with a 10 mm diameter plunger and a 300 g weight. Standard consistency is achieved when the needle penetrates to a depth of 6 ± 1 mm from the bottom of the mold within 30 seconds of release.



Mixing of the Sample Penalty of the Probe

Figure 3: Diagram of the consistency test principle

Test procedure:

- Adjust the Vicat apparatus by lowering the needle until it touches the flat base plate, then align the pointer with the zero mark on the scale.
- Raise the needle to the standby position.
- Thoroughly clean and dry all tools (mixer, bowl, etc.).
- Pour the selected amount of water (based on W/C ratio) into the mixing bowl.
- Add 500 g of cement within 5 to 10 seconds.
- Record the end of this step as zero time.
- Start the mixer at low speed for 90 seconds.
- Stop the mixer and scrape the sides of the bowl with the paddle for 15 seconds.
- Resume mixing for another 90 seconds at low speed.
- Quickly place the paste into a clean, dry, truncated cone mold placed on a flat glass plate avoid excessive

compaction.

- Position the mold under the Vicat needle, align the needle flush with the top of the mold, and lock it.
- Four minutes after zero time, release the needle into the paste and, after 30 seconds, measure the depth d between the needle tip and the base plate.
- Repeat the procedure, adjusting the W/C ratio, until a penetration of d = 6 ± 1 mm is achieved.
- Plot a curve of penetration depth (d) versus W/C ratio to determine the optimal value.

2.2.2.Concrete Testing Procedures

The hydration of cement initiates a progressive process. For a certain period, the material remains workable and plastic. After some time, however, it becomes difficult to handle, and its temperature rises; it sets and gradually hardens. This test is carried out by measuring the penetration of a needle with a diameter of 1.13 mm, fixed to the mobile part of the apparatus with a total mass of 300 g, into a cement paste placed in a truncated conical mold and prepared with the water content determined from the consistency test. The beginning of setting is defined when the needle stops at a distance of d = 4 ± 1 mm from the base of the mold, and the end of setting corresponds to the moment when the needle penetrates no more than 0.5 mm from top of the truncated conical mold.

Initial Setting Procedure

- Adjust the apparatus equipped with the needle by lowering it until it touches the flat base plate, then set the reference mark to zero

- Raise the needle to the standby position.
- Prepare the paste using the optimal water content determined from the consistency test.
- Quickly place the paste into the truncated cone mold without excessive compaction, on a flat glass plate.
- Align the mold under the Vicat needle, lower it flush with the top, and lock it.
- Drop the needle; record this as zero time. After 30 seconds, note the penetration depth.
- Clean the needle after each penetration.
- Place the mold and plate into a water bath at 20°C (or control room temperature at 20°C).
- Repeat the depth measurement every 10 minutes until it reaches 4 ± 1 mm.
- Record the initial setting time from zero.
- Track temperature changes every 10 minutes using a second sample.

Note: For repeated tests, maintain 10 mm spacing between needle points.

➢ Final Setting Procedure

- Invert the filled mold onto the glass base plate.
- Attach the ring accessory to the needle. 4
- Center the inverted mold under the Vicat apparatus.
- Adjust the needle to just touch the paste surface.

- Release the needle.
- Observe the ring trace: final setting is reached when no visible trace remains.
- Place the mold in a water bath at 20°C.
- Clean the needle after each reading at 10–20 minute intervals.
- Record final setting time from zero.
- Empty, clean, and discard the mold.

2.2.3.Concrete Mix Design

Concrete mix design makes it possible, on the one hand, to determine, according to the workability and strength requirements defined by the specifications, the quantities of materials needed for the production of one cubic meter of concrete, depending on their nature. On the other hand, it allows the definition, based on the type of structure to be built, of the parameters necessary for the placing of the concrete and for the short and long-term stability of the structure. The main parameters to be taken into account are:

- Workability
- Target strength
- Cement type and dosage
- Aggregate type and density

The Dreux-Gorisse method was used to calculate optimal mix ratios in compliance with standards:

- Determination of water-to-cement ratio
- Cement and water dosage
- Mix with minimum void ratio
- Concrete compactness
- Specific gravity of aggregates
- Final mix proportions.

2.2.4.Fresh Concrete Testing: Slump Test

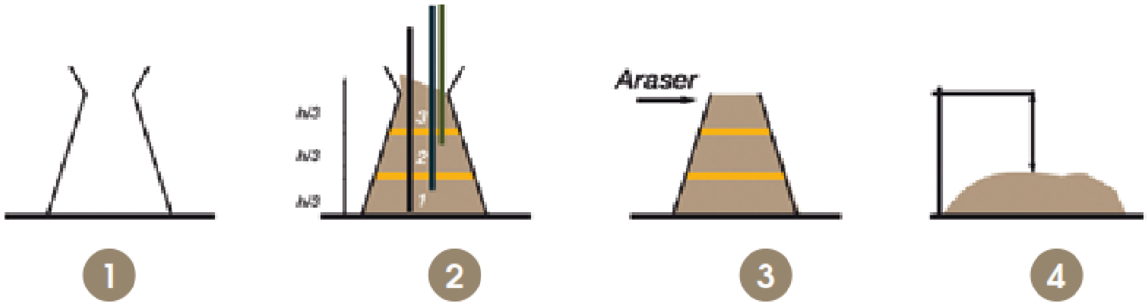
Concrete is a moldable material; therefore, in order to properly fill a formwork and ensure adequate reinforcement covering, it must exhibit a certain workability. This property is defined by measuring the consistency of the concrete, which depends on its intended use and type. Consistency is determined by the slump test. Once the concrete has been prepared, the execution process of the test is as follows:

- Place a slightly damp mold on a horizontal surface.

- Fill it in three equal layers, each tamped 25 times.

- Level the top, clean the base area, and lift the mold vertically within 5–10 seconds.

- Measure slump to the nearest 10 mm.



Clean and Oiled Cylindricol Mold

Vibration of each of three layers
25 Blows/Layers

Level the Surface

Level the Surface

Figure 4: Steps of the slump test procedure

2.2.5.Fresh Concrete Density

After achieving the desired slump:

- Clean, oil, and tighten a 16×32 cm cylindrical mold.

- Weigh the empty mold (M1).

- Fill it in three layers, vibrating each.

- Level and clean the mold.

- Weigh the filled mold (M2).

- determination of the concrete density $D = \frac{M_2 - M_1}{V}$ with V volume of mold (1)

3.2.6. Hardened Concrete Testing

The placed concrete is compacted to refusal in three layers for 160/320 cylinders, in two layers for 110/220 cylinders and 150 mm cubes, and in a single layer for 100 mm cubes. The specimens must remain in the mold and be protected against shocks and drying (wind, sun) for a minimum of 16 hours and a maximum of 2 days (extended to 3 days in case of weekends or public holidays), at a temperature of 20 °C ± 5 °C. If the ambient temperature is below 15 °C, storage can be carried out in an insulated box (capacity: 9 specimens maximum). Transportation must be done while protecting specimens from shocks and drying. Within three hours after demolding, the specimens must be stored in water at 20 °C ± 2 °C until testing, or in a chamber at 20 °C ± 2 °C with relative humidity > 95%.

2.2.6.Compression Strength Test

Specimens are tested to failure in a compression machine. Peak load determines compressive strength, accurate to 0.5 MPa.

Procedure:

- Center the surfaced specimen between the machine plates.

- If unsurfaced, use shims (wood boards, sandboxes).

- Close safety door and release valve.

- Start the machine.

- Turn load valve to maximum until contact is made.

- Reduce loading speed by ~12 turns.

- Apply load until failure. Record maximum load (Fc).

- Once fractured, reduce load rate and release pressure.

- Stop the machine.

Compressive strength Rc (in kN/m²) is calculated using contact area A.

$$R_c = \frac{F_C}{A} \qquad (2)$$

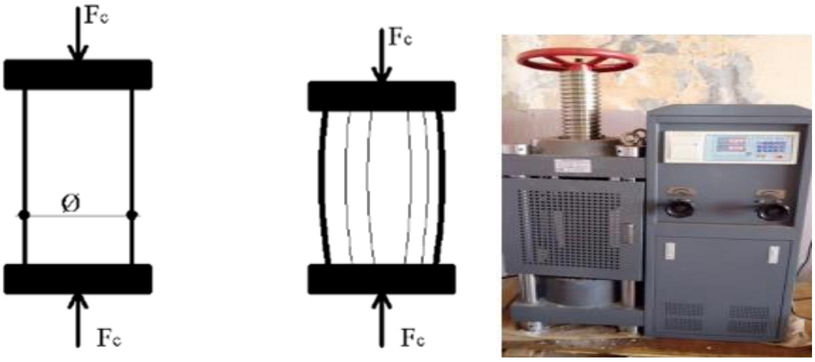


Figure 5: Compression test setup

2.2.7.Water Absorption of Specimens

This test allows us to understand the behavior of concrete when exposed to water. It therefore consists in determining the amount of water absorbed by normal concrete over time. The specimens are placed in an oven for 48 hours after demolding, then weighed to record the dry mass (M_d). They are then immersed in water for 24 hours and weighed again to obtain the wet mass (M_w).

$$A_b(\%) = \frac{M_w - M_d}{M_d} \times 100 \qquad (3)$$

3. Results and Discussion

3.1. Results

At the end of this study, densities are essential data for the characterization of a material. The most important of all is the specific gravity, which represents the actual density of the material. The values we obtained are recorded on the following table

Table 2: Density of the materials used in the concrete mix design

Materials	Specific Gravity	Temperature (°C)	Temperature Correction Coefficient	Corrected Density	Verification
Sand	2.65	25	0.008	2.67	2≤ρsol≤ 3
Gravel	2.70	25	0.008	2.72	
CIMAF Cement	2.97	25	0.008	2.99	2.9≤ρcement≤ 3.1
ROBUST Cement	2.93	25	0.008	2.95	
DANGOTE Cement	2.98	25	0.008	3.00	
MEDCEM Cement	2.89	25	0.008	2.91	

3.1.1.Cement consistency test

Thus, for our tests, we obtained the values shown in Table 3.

Table 3: Results of the consistency test of different brand of cement

CIMAF					**DANGOTE**			
Water content supplied (%)	26%	28%	30%		Water content supplied (%)	25%	30%	32%
penetration	28	10	6		Penetration	30	7	5
ROBUST					**MEDCEM**			
Water content supplied (%)	25%	30%	33%	35%	Water content supplied (%)	25%	30%	32%
penetration	35	15	10	6	Penetration	30	10	6

3.1.2.setting time test of cement

following the above consistency test, 360g or 380g of cement depending on the size of the mold, is taken again for setting time test (initial and final setting times). This quantity of cement is mixed with water according to the water-to-cement ratio determined during the previous consistency test.

Table 4: Summary of results of the setting time test of cement

SETTING TIME TEST							
MEDCEM		ROBUST		DANGOTE		CIMAF	
C	PENETRATION	TIME	PENETRATION	TIME	PENETRATION	TIME	PENETRATION
0	0	0	0	0	0	0	0
10	0	10	0	10	0	10	0
20	0	20	0	20	0	20	0
30	0	30	0	30	0	30	0
40	0	40	0	40	0	40	0
50	0	50	0	50	0	50	0.5
60	0	60	0.5	60	0	60	0.5
70	0.5	70	0.5	70	0	70	0.5
80	0.5	80	0.5	80	0.2	80	0.5
90	0.5	90	0.5	90	0.2	90	0.5
100	0.5	100	0.5	100	0.3	100	1
110	0.5	110	0.5	110	0.5	110	1
120	0.5	120	0.5	120	1	120	1
130	1	130	0.5	130	1,5	130	1
140	2	140	1	140	4	140	1.5
150	4	150	1.5	150	0	150	2.5
160		160	2	160	0	160	4
170		170	4	170		170	

3.1.3Concrete mix design

The results obtained for the different types of cement are recorded in the tables below.

Table 5: Concrete mix composition with CIMAF 42.5

MATERIAL	Corrected compaction coefficient	Absolute volume	Density	Dosage in kg/m^3
CIMAF Cement	0.805	116.81	2.99	350
Gravel		399.16	2.72	1085.71
Sand		289.05	2.67	771.75
Water		/	/	219.06
Density				2426.52

Table 6: Concrete mix composition with ROBUST 42.5

MATERIAL	Corrected compaction coefficient	Absolute volume	Density	Dosage in kg/m^3
ROBUST Cement	0.805	118.39	2.95	350
Gravel		398.24	2.72	1083.20
Sand		288.38	2.67	769.97
Water		/	/	219.06
Density				2422.23

Table 7: Concrete mix composition with DANGOTE 42.5

MATERIAL	Corrected compaction coefficient	Absolute volume	Density	Dosage in kg/m^3
DANGOTE Cement	0.805	116.71	3.00	350
Gravel		399.21	2.72	1085.85
Sand		289.08	2.67	771.85
Water		/	/	219.06
Density				2426.76

Table 8: Concrete mix composition with MEDCEM 42.5

MATERIAL	Corrected compaction coefficient	Absolute volume	Density	Dosage in kg/m^3
MEDCEM Cement	0.805	120.01	2.91	350
Gravel		397.29	2.72	1080.64
Sand		287.70	2.67	768.15
Water		/	/	219.06
Density				2417.85

3.1.4.Slump test using the Abrams cone

for our work, we obtained the results shown in table 9 below

Table 9: Slump as a function of cement type

Types of Cement	CIMAF	ROBUST	DANGOTE	MEDCEM
Slump (cm)	8	7.5	7	7

3.1.5. Bulk density

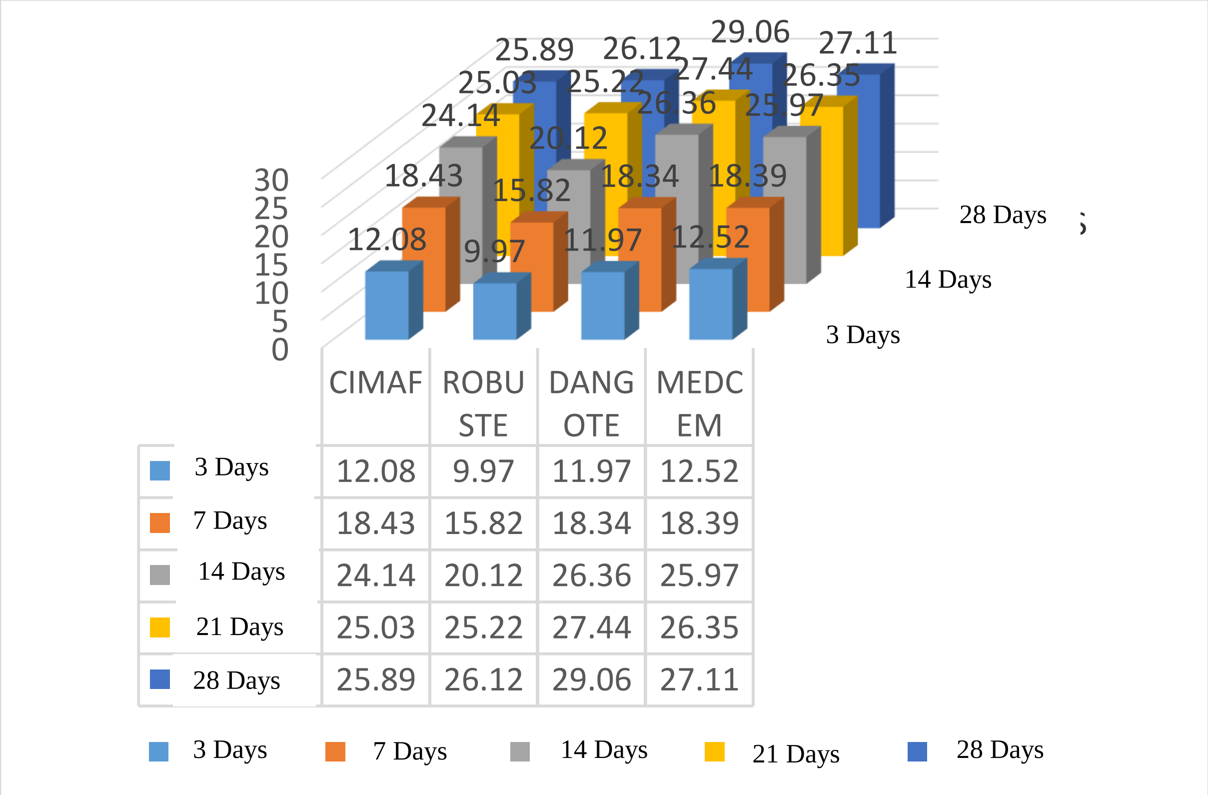
Table 10 summarizes densities of different concrete samples after demolding.

Table 10: Bulk density of concrete specimens after demolding

CIMAF				**ROBUST**			
Specimen	Mass	Volume	Density kg/m^3	Specimen	Mass	Volume	Density kg/m^3
E1	15.6	0.00643	2426.13	E1	15.6	0.00643	2426.13
E2	15.4		2395.02	E2	15.5		2410.58
E3	15.8		2457.23	E3	15.6		2426.13
Average	**15.57**		**2426.13**	**Average**			**2420.95**
DANGOTE				**MEDCEM**			
Specimen	Mass	Volume	Density kg/m^3	Specimen	Masse	Volume	Density kg/m^3
E1	15.6	0.00643	2426.13	E1	15.4	0.00643	2395.02
E2	15.7		2441.68	E2	15.55		2418.34
E3	15.7		2441.68	E3	15.5		2410.58
Average	**15.67**		**2436.50**	**Average**			**2407.98**

3.1.6. Compressive strength tests

The compression tests on different cylindrical specimens were carried out at specific ages, namely on the 3rd, 14th, 21st, and 28th day. Hence the histogram shown in figure 6.



	CIMAF	ROBUSTE	DANGOTE	MEDCEM
🟦 3 Days	12.08	9.97	11.97	12.52
🟧 7 Days	18.43	15.82	18.34	18.39
⬜ 14 Days	24.14	20.12	26.36	25.97
🟨 21 Days	25.03	25.22	27.44	26.35
🟦 28 Days	25.89	26.12	29.06	27.11

Figure 6: Histogram of the stress values at d-days as a function of the types of cement

Table 11: Absorption tests results

Specimen	**CIMAF**				**ROBUST**			
	Masse sèche	Masse humide	average		Dry Mass	Wet Mass	Average	
			Dry Mass	Wet Mass			Dry Mass	Wet Mass
E1	14.8	16	14.8	16	14.8	16.25	14.78	16.125
E2	14.8	16			14.75	16		
	Absorption %		8.11		Absorption%		9.15	
Specimen	**DANGOTE**				**MEDCEM**			
	Dry Mass	Wet Mass	Average		Dry Mass	Wet Mass	Average	
			Dry Mass	Wet Mass			Dry Mass	Wet Mass
E1	14.8	16	14.85	16	14.6	15.8	14.6	15.85
E2	14.9	16			14.6	15.9		
	Absorption %		7.74		Absorption%		8.56	

3.2. Discussion

It is observed that the materials used comply with standards for ordinary concrete. From these results, it can be seen that the lightest cement is the MEDCEM brand, while the densest is the DANGOTE brand, as illustrated by the histogram in Figure 7.

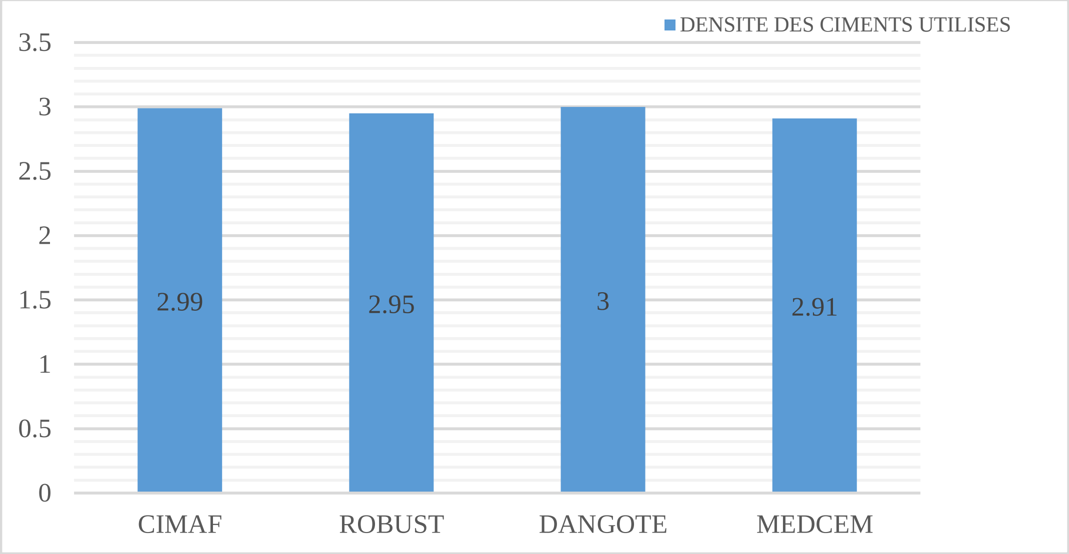


Figure 7: Histogram of the densities of different Cement brands

This study shows that cement consistency is optimal at the following ratios:

W/C = 30% for CIMAF CPJ 42.5;

W/C = 30.5% for DANGOTE 42.5;

W/C = 32% for MEDCEM 42.5;

W/C = 35% for ROBUST.

It is clear that CIMAF cement requires the smallest amount of water, whereas ROBUST cement requires the largest amount compared to the others, as shown in Figure 8.

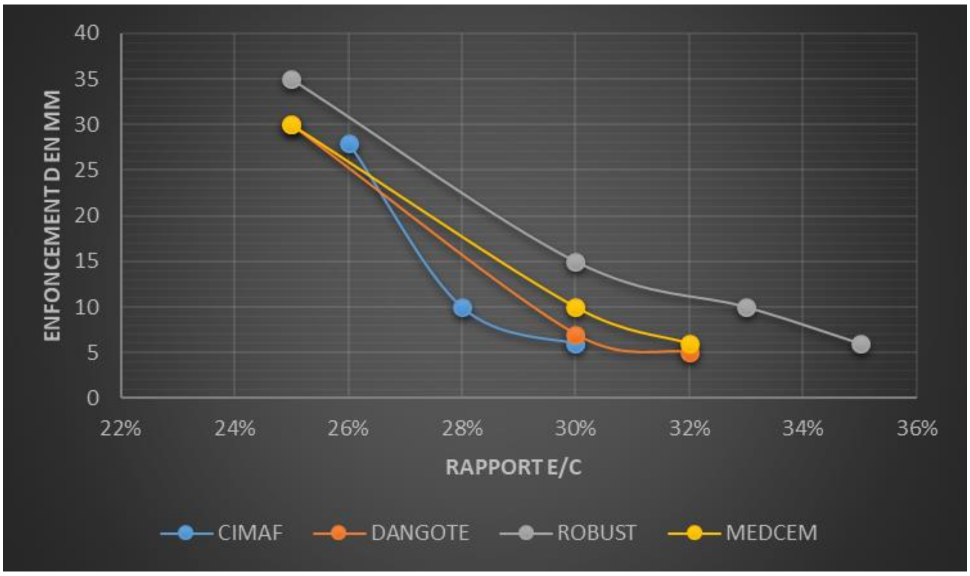


Figure 8: Penetration curves as a function of the water-to-cement ratio (W/C)

From the setting tests, it was observed that from the start of mixing, the initial setting occurred at:

- 140 minutes (2 h 20 min) for DANGOTE, ending at 2 h 40 min;
- 150 minutes (2 h 30 min) for MEDCEM, ending at 3 h 05 min;
- 160 minutes (2 h 40 min) for CIMAF, ending at 3 h 25 min;
- 170 minutes (2 h 50 min) for ROBUST, ending at 3 h 30 min.

It follows that DANGOTE cement has a slower hydration reaction but a faster setting, whereas ROBUST cement has the earliest initial set.

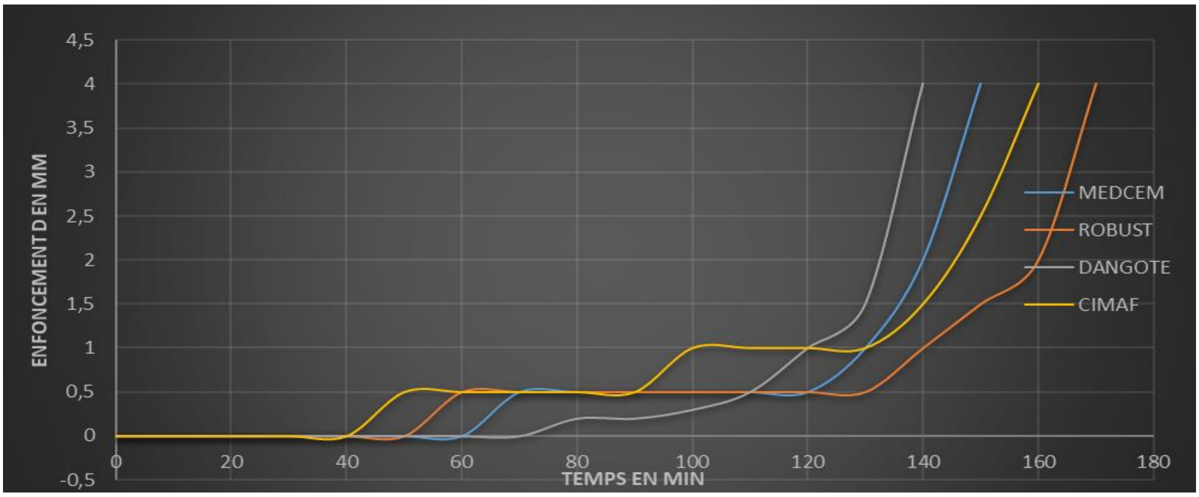


Figure 9: shows the comparative curves of the setting tests for each cement brand.

Subsequently, it was found that the lightest concrete corresponds to the lightest cement (MEDCEM) with a bulk density of 2417.85 kg/m³, while the heaviest concrete corresponds to the densest cement with a bulk density of 2426.76 kg/m³. Thus, these results confirm the production of heavy concretes.

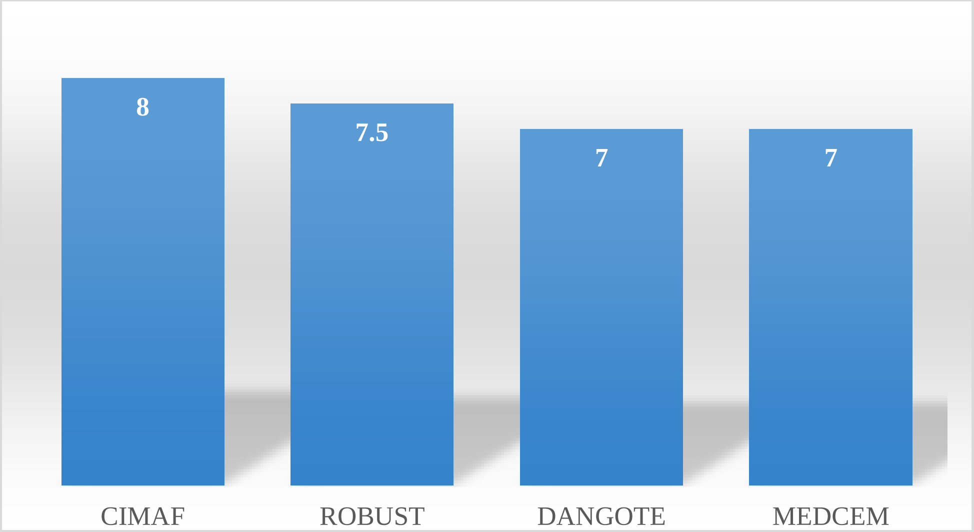


Figure 10: Slump test values diagram as a function of Cement Brand used

Figure 10 illustrates that concretes made with CIMAF 42.5 and ROBUST 42.5 cements exhibit better plasticity compared to those made with DANGOTE 42.5 and MEDCEM 42.5.

In general, all cements studied exceeded the expected 28-day design strength of 25 MPa. It can therefore be concluded that:

- MEDCEM cement provides the highest early strength (12.52 MPa), whereas ROBUST cement provides the lowest (9.97 MPa), below the expected strength. After 14 days, ROBUST-based concrete exceeds the reference curve and that of CIMAF before 21 days, but without reaching MEDCEM and DANGOTE levels at 28 days.

- MEDCEM cement, after the 7th day, provides the second-best performance up to 28 days, behind DANGOTE cement, which achieves the highest 28-day strength of 29.06 MPa.

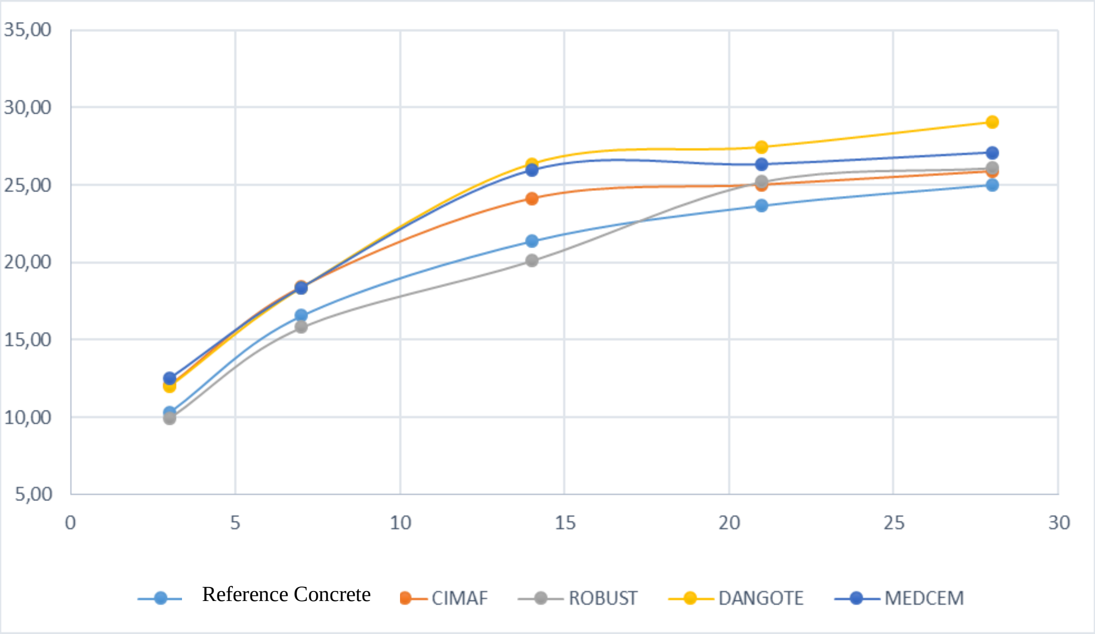


Figure 11: presents the stress–strain variation curves for the tested concrete specimens

It was also observed that ROBUST cement specimens absorb more water and are therefore more porous, whereas MEDCEM cement specimens absorb less water, making them denser and more compact.

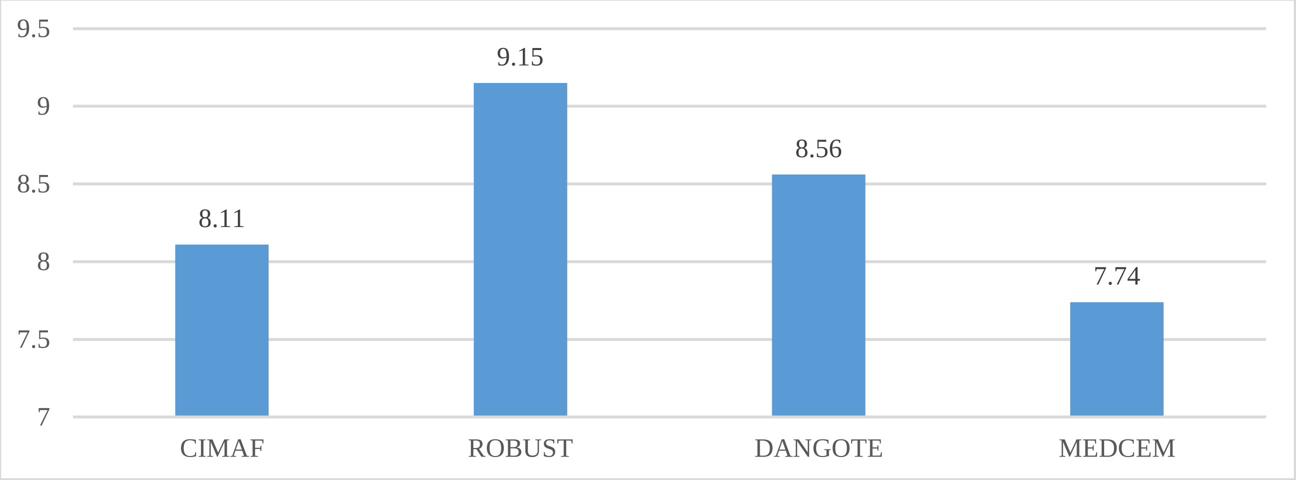


Figure 12: Histogram of absorption as a function of Cement Brands

4. Conclusion and Perspectives

4.1. Conclusion

This research was motivated by the need to demonstrate the influence of CPJ 42.5 cement types (ROBUST by

CIMENCAM, CIMAF, DANGOTE, and MEDCEM) on the compressive strength of hardened concrete. It allowed us to evaluate and understand several phenomena occurring during the mix design and curing of concrete. It can be stated that all these cements achieve the minimum design strength required in the mix design process. However, depending on the intended application and working conditions, the choice of one cement over another may be justified. Specifically:

- DANGOTE 42.5 cement provides the highest strength beyond 7 days compared to the others;
- DANGOTE cement should be used for concretes requiring rapid placement and high density;
- CIMAF-based concretes also exhibit high density and are suitable for applications requiring early strength without necessarily needing mechanical vibration, similar to ROBUST cement, which can also be used for ready-mix concrete (RMC);
- ROBUST cement has a very long setting time, making it suitable for rapid pours or projects involving less experienced workers; however, it requires mechanical vibration during placement to reduce porosity and improve mechanical performance;
- MEDCEM cement provides high early strength, good compactness, and a relatively low density, thereby reducing the dead load of structures compared to other cements of the same class.

4.2. Perspectives

After this study, several grey areas remain and would require further investigations. Thus, future work could focus on developing design charts depending on the type of cement used and the required strength and density. This would involve:

- Mineralogical and chemical studies to identify the chemical interactions taking place in these concretes;
- Determining the proportion of each cement constituent and their influence on the behavior of concrete from setting to maturity;
- Investigating admixtures that could improve the properties of one type of concrete or another depending on the cement employed.

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