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Effects of Admixture Sika on the Resistance of Different Types of Cement Used for Ordinary Concrete in the North West Region of Cameroon

Penka Jules Bertrand[1], Mbuh Moses Kuma[1,2], Nsahlai Leonard Nyuykongi[1] ,Guimegueu Wamba Lafortune[2],Patrick Bame Che[2]

[1]Department of Civil Engineering and Architecture, National Higher Polytechnic Institute, University of Bamenda, P O. Box 39 Bambili Cameroon.
E-mail:penkajules@gmail.com,nsahlaileonardn@gmail.com, lepahlestephanieisha@gmail.com
[2]Department of Civil Engineering and Forestry Techniques, Higher Technical Teacher Training College, University of Bamenda, P O. Box 39 Bambili Cameroon.
Email:mbuhmoses10@gmail.com, wangiadrerna@gmail.com, patrickbameche@gmail.com
Corresponding authors' emails: mbuhmoses10@gmail.com

Abstract
When concrete fails to perform its functions with its natural four ingredients sand, cement, gravel and water, admixtures are added to improve on its performance (less than 5% of the mass of cement). These admixtures have, a general rule to modify the properties of concretes, mortars or grouts, in the fresh and hardened state (to decrease the E/C ratio, to improve the workability, to reduce the dosage of cement, to increase the mechanical strength, change the setting and hardening time, improve the permeability and modify some particular properties). Sika, being the most common admixture in our milieu, the objective of this research is to study the influence of SIKA admixture especially the super plasticizer/high water reduction on the resistance of ordinary concrete in the context of North-West region of Cameroon because most concretes do not give the intended resistance. To achieve this goal, we used the most available super plasticizer in the region SIKAVISCOCRETE – KRONO 20, with 2 different dosages (0.5% and 0.8%) within the range of the proposed dosage; and 2 different brands of cement are used with the same resistance class (DANGOTE and ROBUST). The objectives were to study the workability of fresh concrete with the incorporation of a super plasticizer, the compressive and tensile strength of hardened concrete after 3days, 7days and 28days. The results of this research showed that relative to the control concrete without admixtures, the super plasticizer improved the workability of concrete with an increase of respectively 54.4% and 138% with DANGOTE cement and 23.3% and 73.33% with ROBUST cement. The compressive strength and tensile strength of concrete, using the both types of cement also increased with the dosage of super plasticizer SIKA. With the highest dosage of SIKA (0.8%), the compressive and tensile strength of adjuvanted concrete compared to the control concrete is respectively 20.10% at 28 days in compressive strength with ROBUST and 22.87% at 28 days with DANGOTE; and 17.07% at 28 days of tensile strength with ROBUST and 10.50% at 28 days with DANGOTE. The more the dosage of the super plasticizer is high, the more the concrete is workable and resistant. The cement ROBUST is more resistant than DANGOTE when incorporating super plasticizer. And we note that the resistance of ordinary concrete with both cements increase over time.
Keywords: SIKA; cement; admixtures, concrete; super plasticizer
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1. Introduction

Concrete is the most widely used construction material. It allows the production of large spans and complex shapes. It is essentially a mixture of minerals grains of variable dimensions and water possibly incorporating admixtures and additions. Some minerals, called aggregates, are inert. Others, binders, react with water to form a paste which sets and hardens in air or underwater, giving rise to a high-performance composite material. Without concrete, in terms of housing, schools, hospitals and infrastructure, we could not achieve what we are building today. Whether it is robustness or versatility, the breadth of its mechanical and physical properties continues to grow, and until today, its expression is still based on experience and gradually becomes a reasonable method of using the tools. Engineers are built on a scientific foundation, which requires entry into all disciplines of materials sciences. Admixtures are chemical products that are increasingly common in the production of concrete. Added in low doses during the preparation of concrete (admixture represent less than 5% of the mass of the concrete); these products improve certain characteristics of this material (water tightness or setting time

for example). The different types of admixtures that exist will allow us to obtain concrete with the specific characteristic that is of interest.

Super plasticizer/ high water reducers in an admixture that cause the strong increase in the workability of the mixture while maintaining mechanical performance. They also make it possible, without changing the consistency (or the workability) of the concrete, to significantly reduce the mixing water content and therefore the W/C ratio. They give concretes high short-term and very long-term mechanical resistance. Electrostatic phenomena are therefore predominant for the rheological behavior of the grout. Due to their chemical compositions; cement particles can have different charges. Opposite charge will attract each other. The cement particles will flocculate and increase the viscosity of the grout. Water plays two roles in the cimentitious materials: reactive and vehicle roles**.** To improve mechanical performance of these materials, it is necessary to reduce the water acting as vehicle because its evaporation leaves pores filled with air which will collapse when a certain pressure threshold has been exceeded (reduction in resistance to pressure). Greater porosity also increases the different transport processes (diffusion and advection) of water, gases (CO_2 and O_2) and dissolved chemical species within the concrete, which favor its carbonation and facilitate swelling reaction.

Super plasticizer increases the fluidity of cimentitious materials in the fresh state, which makes it possible to reduce the proportion of water and thus considerably improve the mechanical strength and durability of concrete. By absorbing through sorption phenomenon, on the surface of cement particles and by coating them (steric effects), super plasticizers increase the electrostatic or steric repulsion forces between them, which reduces contact between particles and promotes flow. Note that sorption is the process by which a substance is absorbed onto or into another substance. It results from the action of gas or liquid molecules brought into contact with a solid material and which adhere to its surface.

Steric affect is a set of attractions and repulsions between atoms of a molecule linked to the over lapping of the clouds of electronic orbital lobes which affects the normal shape of the molecule as well as its properties during a chemical reaction. The vast majority of super plasticizers currently used in the concrete industry are polynaphtalene sulfonates (PNS) whose mode of action is essentially electrostatic repulsion. Super plasticizers are generally anionic polyelectrolytes. This research focuses on the impact of admixture SIKA, an admixture frequently used in cement industry. This study aims to evaluate how the incorporation of SIKA influences the quality of resistance of ordinary concrete made up with 2 different brands of cement.

2. Material and methods

2.1. Materials

For the confection of our concrete, we used local materials. The materials used in our work are aggregates collected from Ndop, in the North West region of Cameroon, two different brands of cement, mixing water and admixture (superplasticizer). The materials characteristics were determine experimentally at the laboratory GEOSTRUCT in Bamenda Nkwen according to the French standards (NF EN 206+A2/CN). Table 1 brings together the results of the properties of the aggregates used.

Table 1: Properties of aggregates from North-West region

Characteristics of aggregates	**Granular classes**		
	0/5	**5/15**	**15/25**
Apparent density(Kg/m^3)	1.35	1.38	1.43
Absolute density(Kg/m^3)	2.43	2.77	2.46
Visual Equivalence of sand (%)	77.88	-	-
Sand Equivalence by Piston (%)	67.90	-	-
Fineness modulus (%)	2.76	-	-
Losses (%)	0.8	1.6	0.6

Cements used are ROBUST and DANGOTE buy in local ironmongery of Kwen.
ROBUST choose is CEM II/B-P 42.5R and DANGOTE is CEM II/B-P 42.5R. It is mostly used cement in the region. The physical and mechanical properties of cements are indicating in the Table 2.

Table 2: Physical and mechanical characteristics of cements used

Feature	**value**	
Cements	**ROBUST**	**DANGOTE**
Normal consistency (%)	-	-
Initial setting time (min)	181	151
Final setting time (min)	305	243
Resistance class at 28days(mpa)	46.16	45.9
Hot expansion (mm)	-	2
Apparent density (Kg/m3)	-	-
Absolute density (Kg/m3)	2.85-3.21	2.85-3.21

The mixing water used for hydration was tap water. The admixture used was SIKA VISCOCRETE KRONO 20 he from the SIKA company. SIKA VISCOCRETE KRONO-20 is a new generation non-chlorinated high water reduction/ super plasticizer, based on acrylic copolymer, which comes in the form of a yellow liquid. The characteristics of the superplasticizer are in table 3.

Table 3: Characteristic of the super plasticizer admixtures

Aspect	**Color**	**Density**	**Dry extract (%)**	**pH**	**Chloride content (ci)**
liquid	yellow	1.08 ± 0.020	$41.0 \pm 1.0\%$	4.0 ± 1.0	$\leq 0.1\%$

Methods

The varied concrete is built up with quantity gather in the table 4 bellow.
The method used to get those quantities is Dreux-gorisse method.

Table 4: Composition of concrete (Kg/m^3)

Components	**Dosage (kg/m^3)**	**Dosage for 1cylindrical mold (kg)**	**Dosage for 1cubic mold (Kg)**
Gravel (15/25mm)	790.93	5.08	2.69
Gravel (5/15mm)	237.23	1.52	0.80
Sand (0/5mm)	734.83	4.72	2.48
Cement DANGOTE	380	2.44	1.28
Cement ROBUST	380	2.44	1.28
Water	213.48	1.37	0.72
Super plasticizer (0.5%)	1.9	0.012	0.0064
Super plasticizer (0.8%)	3.4	0.019	0.012
Theoretical density of concrete	3.1	3.1	3.1
Total weight with DANGOTE cement (without admixture)	2356.47	15.13	7.97

The incorporation of admixtures into concrete is done during mixing or before implementations.
The admixture will be incorporate in two doses:

- 0.5% and I will call this specimen CPS1
- 0.8% and will call this specimen CPS2

The addition of the admixture should never be done on dry concrete. I will be absorbed by the aggregates, hence its ineffectiveness.
The test tubes were divided as 6 cylindrical molds of specimen with ROBUST cement for tensile and compressive test. And the rest was the cubic specimen.

All the test pieces made are indicated in the table below:

Table 5: Distribution of prepared test pieces

Concrete		Number of test pieces											
		DANGOTE specimen						ROBUST specimen					
		For tensile strength(15x15)			For compressive strength (15x15)			For tensile strength (15x15)			For compressive strength (15x15) and (16x32)		
N° of days		3	7	28	3	7	28	3	7	28	3	7	28
CW		3	3	3	3	3	3	3	3	3	3	3	3
CSP1		3	3	3	3	3	3	3	3	3	3	3	3
CSP2		3	3	3	3	3	3	3	3	3	3	3	3
		9	9	9	9	9	9	9	9	9	9	9	9
Total	108	27			27			27			27		

CW is the control concrete, CSP1 is the concrete where 0.5% of superplasticizer SIKAVISCOCRETE KRONO 20 he was incorporated and CSP2 CSP1 is the concrete where 0.8% of superplasticizer SIKAVISCOCRETE KRONO 20 he was incorporated.
In fresh state, sagging was measured by the Abram's cone test illustrate by the Figure 1. At the hardened state, the test carried was compressive and tensile strength tests at ambient temperature.

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Figure 1: Abram's cone subsidence (Slump) tests

After opening the formwork, the cubic specimens were kept in water for 3days, 7days, and 28days (Figure 3); then were taken out of the water and dried at ambient temperature (Figure 4) before being tested for compressive strength test (Figure 5) and tensile strength test (Figure 6) .

Figure 2: preservation of test specimens in water

Figure 3: compressive strength tests on cylindrical and cubic specimens

Figure 4: tensile strength tests on cylindrical and cubic specimens

3. Results and Discussion

3.1. Abram's cone test

The Abram cone test is used to evaluate the workability of concrete.

– For the cement ROBUST, the value of the slump vary between 5.5 and 6 for CW; for CSP1 is between 9.9 and 11.3 and for CPS2 is between 17.9 and 23.5.

– For cement DANGOTE the value of the slump vary between 8.5 and 10 for CW; for CSP1 is between 12.9 and 15 and for CPS2 is between 20.2 and 23.

–

Table 6: Slump of different cements mix with super plasticizer

Slump (cm)		
	ROBUST	**DANGOTE**
CW	6	9
CSP1	10.4	13.9
CSP2	20	21.5

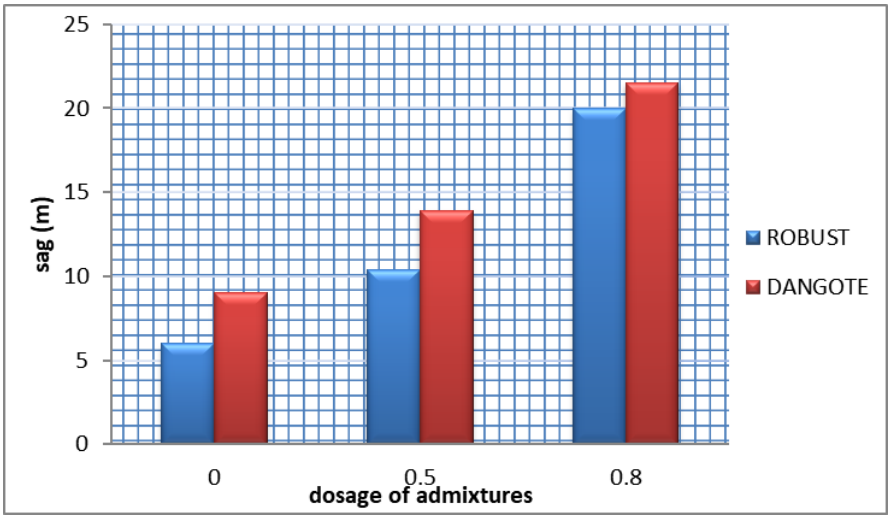

Figure 5: Slump of different concrete

Therefore, we can say that the effect of dosage on the slump is more important in CSP2 than CSP1 in the both type of cement in comparison to the control concrete with the increasing of respectively 54.4% and 138% with DANGOTE and 233.3% and 73.33% with ROBUST. But the slump is more important in DANGOTE than ROBUST with a variation of 33.65% for CPS1 and 10% for CPS2.

We note that the slump process is conform to the description did by Maanser abdelkrim (2018) who used superplasticizer to SIKA VISCOCRETE TEMPO 12 on concrete made with a 42.5 cement. He dosed the SIKA VISCOCRETE at 0.5%, 1%, 1.5% and 2%. He get a slump that values vary between 120mm and 230mm compare to the control concrete with the slump of 58 mm. in term of percentage the superplasticizer induce the maximum increase of 400% describe by the result of Maanser (7). The incorporation of super plasticizer SIKA VISCOCRETE 20 into concrete led to modifications in workability, each according to its dosage and chemical

nature. According to the results obtained for different cements and different dosage of super plasticizer, it was observed that the increase of the slump is proportional to the dosage. The super plasticizer changes the behavior of the concrete where the workability remains controlled by the dosage, giving more fluidity when dosage increases. This is due to its dispersing effect by absorbing at the surface of the cement grains, thus creating repulsive force between the particles, reducing or completely eliminating adhesion between neighboring molecules. In conclusion DANGOTE is more workable with and without super plasticizer than ROBUST.

3.2. Compressive strength test

Compressive strength of concretes increases with increasing dosage and the times. It increases in CSP1 and CSP2 compared to the strength of the CW in the both types of cements.

Table 7: Compressive strength of different concretes

Concrete	compressive strength in MPa								
	DANGOTE specimen						ROBUST specimen		
	For compressive strength						For compressive strength		
N° of days	3	7		28			3	7		28		
CW	9.00	13.50		21.82			9.99	14.97		24.22		
CPS1	10.10	15.15		24.50			11.03	16.54		26.75		
CPS2	11.06	16.58		26.81			12.00	18.00		29.09		

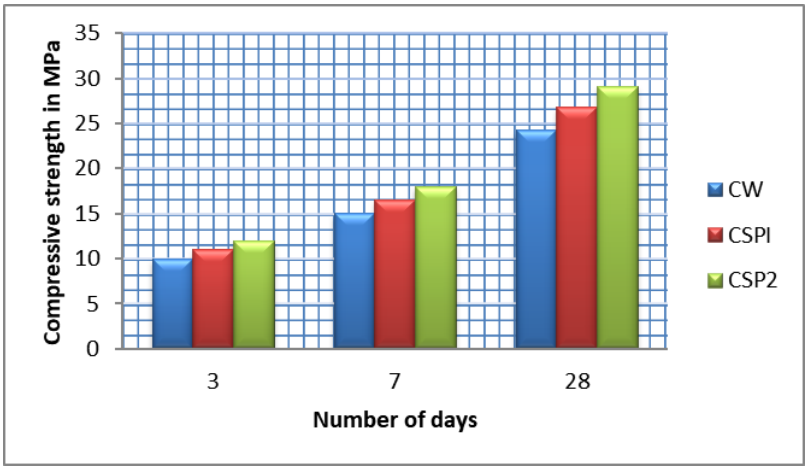

Figure 6: Evolution of compressive strength of concrete with ROBUST

According to the result in the table 4.2, the compressive strength of concrete made with ROBUST is increasing with the dosage of super plasticizer and days. I noticed for 0.5% of dosage the increase of 10.41% of the compressive strength at young age and 10.44% at 28days in comparison with the CW. The one dosed with 0.8% have an increase of 20.12% of compressive strength at young age and 20.10% at 28 days. The variation of compressive strength of concrete made with ROBUST is illustrated in Figure 4.2.

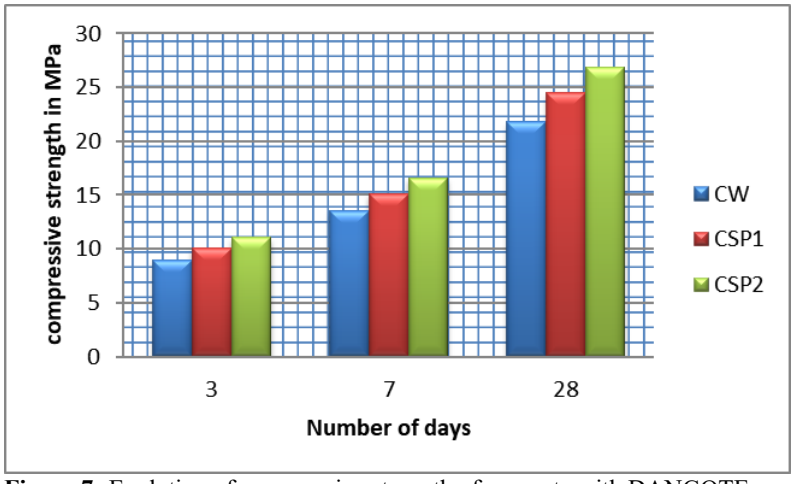

Figure 7: Evolution of compressive strength of concrete with DANGOTE

Like the result give for ROBUST, the compressive strength of concrete made with DANGOTE is increasing with the dosage of super plasticizer and duration of curing. We noticed for 0.5% of dosage the increase of 12.22% of the compressive strength at the early age and 12.28% at 28days. The one dosed with 0.8% had an increase of 22.88% of compressive strength at young age and 22.87% at 28 days. The variation of compressive strength of concrete made with DANGOTE is illustrated in Figure 4.3.

All the compressive strength results are mentioned in the table 4.2 and illustrate in Figure 4.4. We see that concrete with super plasticizer SIKA VISCOCRETE KRONO-20 gives the highest value where there is an increase of 8.5% for concrete made with ROBUST compared to the resistance of concrete made with DANGOTE for a super plasticizer dosage of 0.8% at 28days. This increase is similar to that indicated by several researchers. The role of the super plasticizer in the distribution of cement grains and improvement of the compactness is highlighted.

In conclusion with the same formulation for concrete, ROBUST is more resistant in compression than DANGOTE with and without super plasticizer.

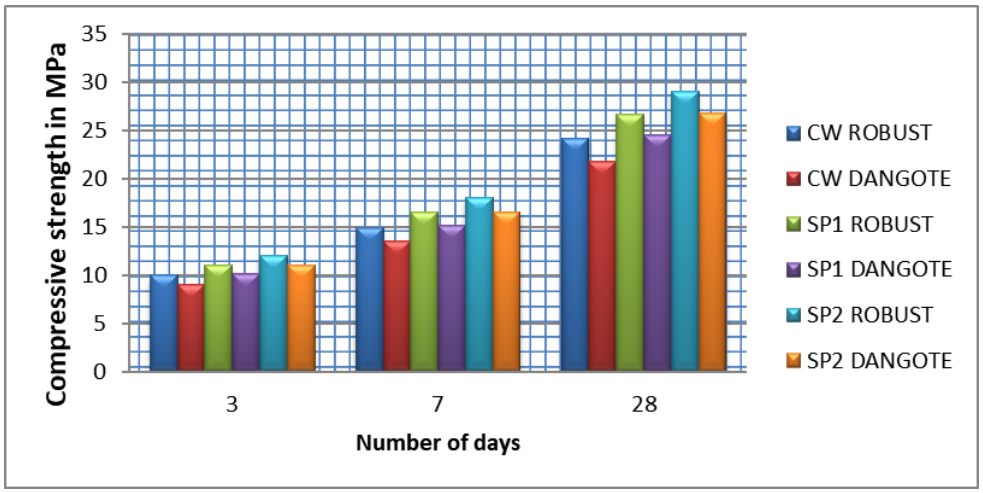

Figure 8: compressive strength of different concrete

This results is similar to what obtained Maanser (2018), OUARGLA Ichrak and AZAZI Nesrine (2023). According to Maanser results the compressive strength of concrete dosed with 0.5%, 1%, 1.5% and 2% of superplasticizer at room temperature give the highest value at the maximum dosage (2%) with the increase of 5% compare to the control concrete (7). In the same words, OUARGLA and AZAZI, (2023) obtained the maximum compressive strength with the high dosage of superplasticizer and at 28days which is equal to 49.46MPa. This is due to the fact that the super plasticizer reduce a quantity of water, the less the water is in concrete, the more resistant it is. The increase of the resistance over days shows that the superplasticizer will confer durability in term of resistance to concrete.

3.3. Tensile strength test

Figure 5 depicts the result of the tensile strengths at room temperature which are presented in table 3.3.

Table 8: Tensile strength of different concretes

concrete	tensile strength in MPa					
	DANGOTE specimen for tensile strength			ROBUST specimen for tensile strength		
N° of day	3	7	28	3	7	28
CW						
	1.14	1.40	2	1.2	1.5	2.05
CPS1						
	1.22	1.51	2.06	1.3	1.6	2.22
CPS2						
	1.26	1.60	2.21	1.32	1.67	2.4

According to the result in the table 4.3, the tensile strength of concrete made with ROBUST is increasing with the dosage of super plasticizer and days of curing. I noticed for 0.5% of dosage the increase of 8.33% of the tensile strength at young age and 8.29% at 28days compared with CW. The one dosed with 0.8% have an increase of 10% of tensile strength at early age (7 days) and 17.07% at 28 days. The variation of tensile strength of concrete made with ROBUST is illustrated in Figure 4.5.

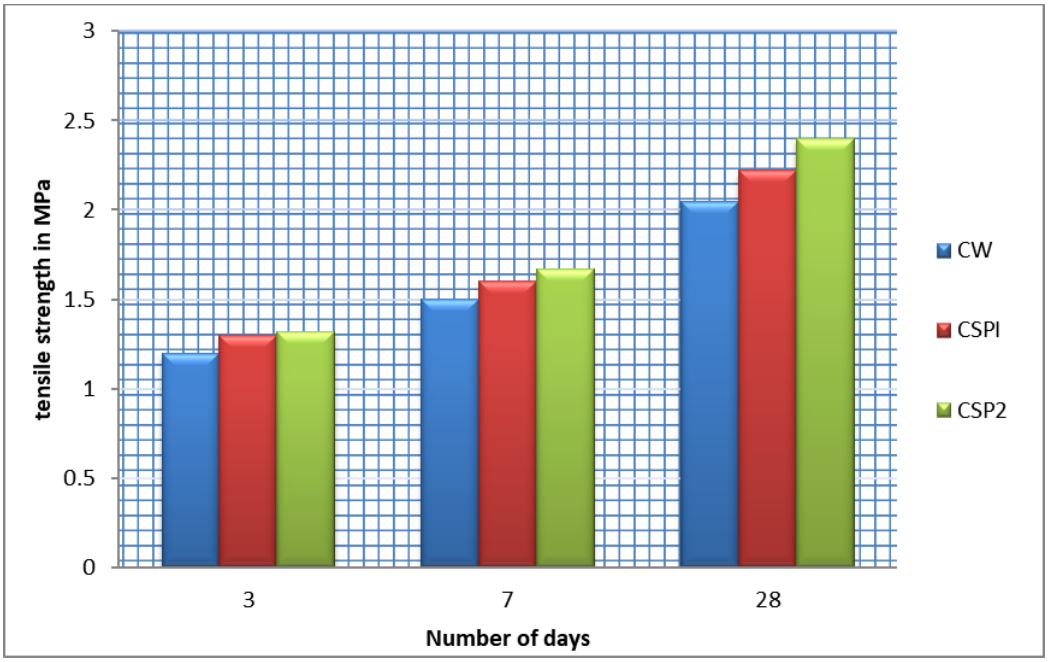

Figure 9: Evolution of tensile strength of concrete with ROBUST

Like the result for ROBUST, the tensile strength of concrete made with DANGOTE is increasing with the dosage of super plasticizer and days. We noticed that for 0.5% of dosage the increase of 7.01% of the tensile strength at the early age and 3% at 28days. The one dosed with 0.8% have an increase of 10.52% of tensile strength at young age and 10.50% at 28 days. The variation of tensile strength of concrete made with DANGOTE is illustrated in Figure 6.

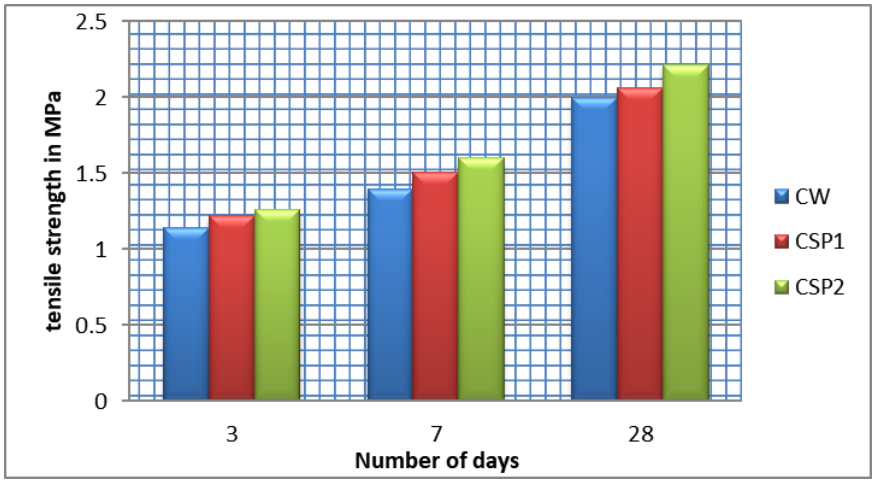

Figure 10: Evolution of tensile strength of concrete with DANGOTE

We first observe that the evolution of compressive strengths correlates perfectly with the evolution of tensile strength, depending on the dosage of admixtures. In all case the resistances are always higher than that the control concrete. This confirms the known results for the higher resistance.
All the tensile strength results are mentioned in the table 3.3 and illustrate in Figure 7. We see that concrete with super plasticizer SIKA VISCOCRETE KRONO-20 gives the highest value of tensile strength where there is an increase of 8.60% for concrete made with ROBUST compared to the resistance of concrete made with DANGOTE for a super plasticizer dosage of 0.8% at 28days. This increase is similar to that indicated by several researchers.
In conclusion with the same formulation for concrete, ROBUST is more resistant in tension than DANGOTE with and without super plasticizer.

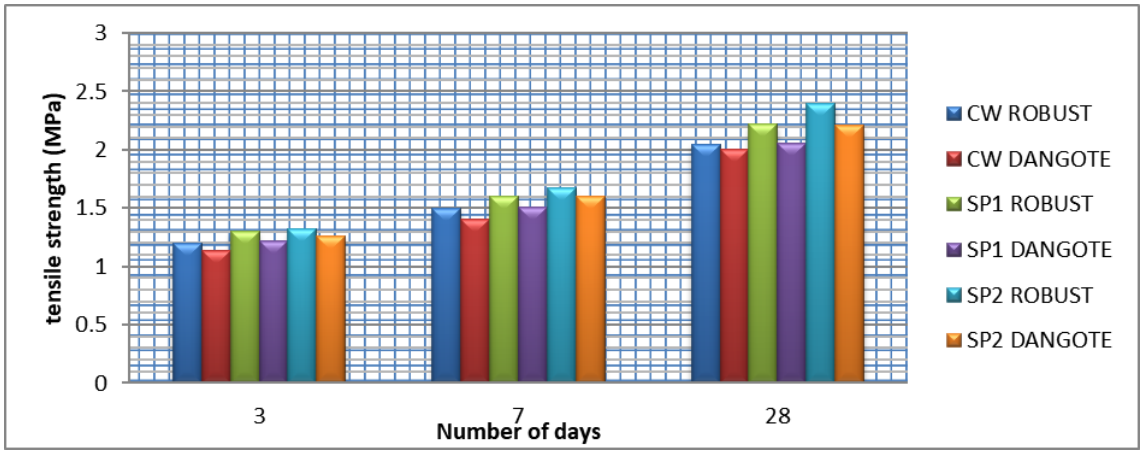

Figure 11: Tensile strength of different concrete

This trend is in conformity with results reported by Maanser, et al., (2012) In the International Journal on "Technical and Physical Problems of Engineering" (IJTPE) (8) . They show that at 20°C the greatest values of tensile strength is given by the mortar dose with the highest dosage of superplasticizer SIKAVISCOCRETE 2100 (2%) with a gain of 73% compared to the reference mortar.

4. Conclusion

In this experimental study, we were able to quantify the effect of admixture especially the super plasticizer/ high reduction of water SIKA on different brands of cements usually used in the North-West region for ordinary concrete at the fresh state and at the hardened state. At the fresh state, we studied the workability of concrete made with 2 different brands of cement with the same class of resistance (DANGOTE 42.5R and ROBUST 42.5R) while incorporating different dosage of super plasticizer (0.5% and 0.8%); at the hardened state we studied the durability aspect through the evolution of the compressive and tensile strength of the concrete with

the same characteristics of the one at fresh state at 3days, 7days and 28days. Following these experimental results, the following conclusions can be drawn:

– The maximum slumps are obtained by maximum dosage of the super plasticizer. The workability with super plasticizer is higher than the control concrete. These values vary from 104 to 215 mm corresponding to the dosage of 0.5% and 0.8%.
– The slump is higher with the cement DANGOTE than ROBUST in both control concrete and that with the super plasticizer.
– The highest compressive strength is obtained with the highest dosage of super plasticizer. The gain varies from 9.18% (0.5% of dosage) to 8.5% (0.8% of dosage). The increase of the resistance becomes more pronounced with increasing dosage and the duration of curing.
– The highest compressive strength after incorporating the super plasticizer is obtained with ROBUST cement.
– The highest tensile strength is obtained with the highest dosage of super plasticizer as at the compressive strength test. And as in the compressive strength test, the resistance to the tension increases with dosage and duration.
– The highest tensile strength is obtained with ROBUST.

Acronyms

CW : Control concrete
CSP1: Concrete with 0.5% dosage of super plasticizer
CSP2: Concrete with 0.8% dosage of super plasticizer

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7. Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the findings reported in this paper.

8. Availability of data and materials

The data that support the findings of this study are available with the corresponding author, [Mbuh Moses Kuma], upon reasonable request.

9. Authors' contributions

Penka Jules Bertrand , Mbuh Moses Kuma, Nsahlai Leonard Nyuykongi, Guimegueu Wamba Lafortune were the investigators and drafted the manuscript. Mbuh Moses Kuma designed the study, Mbuh Moses Kuma read and approved the final manuscript.

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