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Contribution to the Amelioration of Concrete Comportment with the Variation of Chemical Admixture based on local materials

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***Abstract*— Today, the construction industry's technological advancements offer a wide range of chemical additions or adjuvants, in line with the development of various concrete types. Notable among these are superplasticizer admixtures, including those of sulfonate nature, Polycarboxylate, acrylic polymer, and silicone-based. These varieties are broadly classified into two categories: the first, which enhances workability through lubrication, and the second, which modifies rheology. For our experimental program, we've chosen two types of admixtures: a Polycarboxylate admixture that enhances workability and an acrylic polymer-based admixture that alters rheology, both of which have practical applications in the construction industry.**

These admixtures are generally classified into two categories: the first is workability-modifying admixtures, which enhance workability through lubrication, and the second is rheology-modifying admixtures. In our experimental program, we have chosen to use two types of admixtures: a polycarboxylate workability-modifying admixture and an acrylic polymer-based rheology-modifying admixture. Where the behaviour of the chemical admixture varies with the concrete components used, this study aims to achieve two objectives. The first objective is to study the variation in concrete behaviour as a function of superplasticisers, and the second is the valorisation of local materials. The results of our experiment, if successful, could open up new avenues for research and development in the field of concrete technology, inspiring further exploration and innovation.

***Keywords*— concrete, chemical admixtures, acrylic polymer, polycarboxylate, workability-modifying, rheology-modifying**

I. INTRODUCTION

The most widely used material of all time, concrete, is a heterogeneous and composite material. The term "heterogeneity" refers to the significant difference between its compressive and tensile behaviour, while "composite" refers to the composition of concrete. Generally, concrete is composed of cement, the binding element, and aggregate, which represents the granular structure. Additional components are added to the concrete composition, including mineral and chemical admixtures. The principal purpose of introducing more mineral admixture is to minimize costs and produce sustainable concrete, particularly if this addition is naturally present in significant quantities and of high quality in southern Algeria.

Currently, construction technology offers a wide variety of chemical admixtures, which align with the development of various types of concrete. These admixtures are generally classified into two categories: the first is workability-modifying admixtures, which enhance workability through lubrication, and the second is rheology-modifying admixtures, which are additives that alter the flow properties of concrete. In our experimental program, we have chosen to use two types of admixtures: a polycarboxylate workability-modifying admixture and an acrylic polymer-based rheology-modifying admixture. Where the behaviour of the chemical admixture varies with the concrete components used, this study aims to achieve two objectives. The first objective is to study the variation in concrete behaviour as a function of superplasticisers.

One of the conditions for the durability of concrete is that its porosity (sum of water and residual voids per unit volume of concrete) is minimal. It is therefore necessary to introduce into the concrete the maximum possible proportion of aggregate with a minimum of mixing water, the concrete having to be sufficiently workable. It is easy to believe that the characteristics of the aggregates, particularly geometrical ones, influence how these three conditions will be satisfied. However, it is crucial to note that aggregates, even those suitable from the point of view of geometrical characteristics, can have a detrimental effect on the

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durability of the concrete. This underscores the importance of exercising caution and giving thorough consideration to the selection and use of aggregates. The second objective of this paper is the valorization of local materials, the results of our experiment could revolutionize the field of concrete technology, significantly enhancing the performance of concrete and inspiring further research and development in the field.

II. Material and Method

II.1. Cement past

The cement used in the cement paste is CEM II/A 42.5. After several attempts to fix the water dosage for a standard consistency, the water-cement ratio is approximately 26.1% at a controlled temperature and humidity.

II.2. Admixture

Admixtures are chemical additives resulting from technological developments in the construction industry. They are long-molecular products that act on a concrete composition by dispersing the granular mixture, where part of the molecule is absorbed by the cement gains and the other part acts as a brush. Currently, there are several varieties of admixtures; in our research, we used two types. The first is a superplasticiser based on polycarboxylates that acts on the concrete composition by flocculating the granular product. The second is also a superplasticiser of a different nature, based on a new-generation acrylic copolymer admixture that acts through rheological dispersion, whose main properties are listed in Table I.

TABLE I. Characteristics of Admixtures.

	Admixture	
	Acrylic copolymer	**Polycarboxylate**
Density	1.17±0.015	1.06±0.01
pH	7.5±1.5	6±1
Chloride ion content	< 0.1%	< 0.1%
Na_2O eq. content	< 4%	< 1%
Dry extract	35±1.5%	30.2±1.3%

II.3. Sand

Béchar region is a treasure trove of construction materials, including limestone from crushed rock, located approximately 111 km northeast of the province of Béchar. Furthermore, the province of Béchar also benefits from a significant amount of natural aggregate due to the large number of valleys throughout the territory of Béchar, as well as dune sand, not to mention that of the Great Western Erg. However, what sets the region apart is its commitment to sustainable development through the recovery of local materials that do not pose future environmental hazards, a choice that is primarily based on environmental and ecological considerations (table II and Fig. 1).

TABLE II. Physical Characteristics

	Physical Characteristics					
	Bulk density	**Specific gravity**	**Fineness modulus**	**SE***	**MBt****	**Origin**
Crushed Sand	2.63	1.72	2.55	63.1	1.33	Limestone
Dune sand	1.53	1.56	1.57	97	0.1	Siliceous
* Sand equivalent test; ** the methylene bleu test.						

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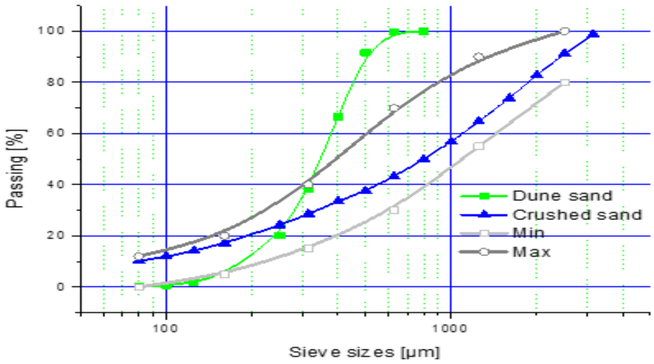

Figure. I The cumulative sieving curve.

2.4. Mixture

In this part, we launched an innovative experiment, substituting the same sand with dune sand of a different nature and shape while maintaining the workability of the mixture. This substitution, performed at a 10% step rate until a 60% substitution is reached, is a novel approach in our field. Dune sands, characterised by their dense granulometry and rounded granular shape, are formed through the process of erosion. We will now present the mixes made by adding the same additive as in the previous case (Table III). This experiment has the potential to revolutionise our understanding of dune sand substitution by utilising two different types of chemical admixtures.

TABLE III. MIXTURE WORKABILITY

	Mixture	
	W/C	**Penetration(mm)**
0% Substitution	0.5	32
10% Substitution	0.5	33
20% Substitution	0.5	35
30% Substitution	0.5	34
40% Substitution	0.5	34
50% Substitution	0.5	34
60% Substitution	0.5	32

III. RESULTS AND DISCUSSIONS

The role of a superplasticizer in construction is not limited to improving the workability of concrete. It also serves as a high-water-reducing agent, effectively reducing the water content in the concrete mixture without compromising its workability. This multifunctional nature of superplasticizers makes them a valuable asset in the construction industry.

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III.1 The effect of the kinds of superplasticizer on the workability

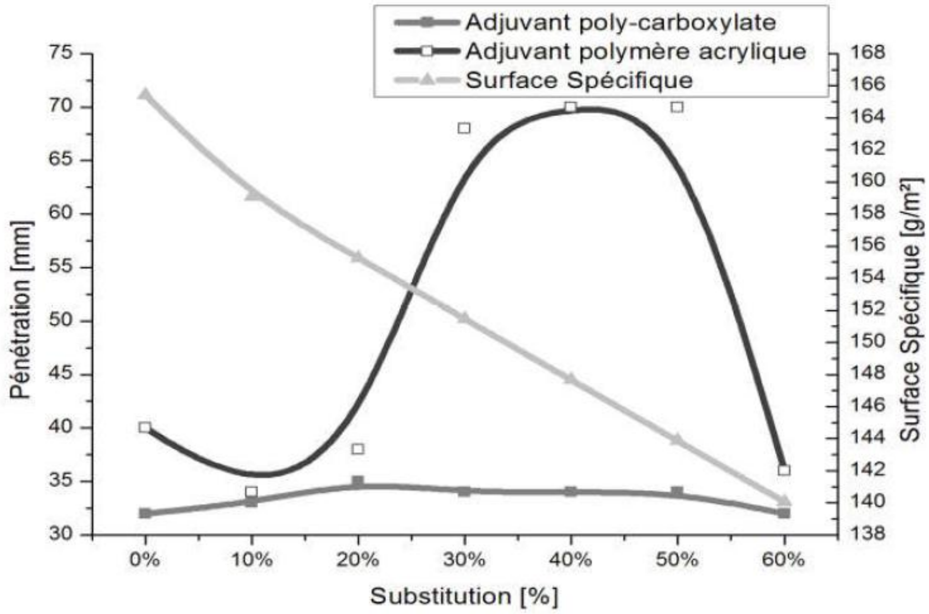

Figure. II Variation in workability as a function of the percentage of substitution and the specific surface area based on different superplasticizers.

The first observation to be made is the profitability of the acrylic polymer-based superplasticizer, which exhibits a workability variation interval of 70 to 34 mm, even at a constant water/cement ratio. In contrast, the workability variation interval for the carboxylate copolymer-based superplasticizer is between 34 and 32 mm (Figure 3.24). At 40% substitution, the new generation of superplasticizers becomes more profitable in terms of workability due to the lubrication mode of this type of additive. Where at this percentage of substitution, an optimum suspension is achieved by producing an optimal inter-granular rearrangement, where it has been noted that the quantity of the mixture remaining after filling and surfacing the moulds decreases from 40% substitution, even at 50% substitution where it is noted that the entire quantity of the mixture is contained in the mould. The use of the new generation of superplasticizers has led to the appearance of a layer of bleed water, which becomes more significant as the substitution progresses. By their nature, acrylic superplasticizers promote the appearance of a layer of bleed water, which acts as a protective layer through a molecular film against water evaporation, thereby ensuring the quality of the concrete. This is noticeable in the laboratory by a yellowish colour on the upper surface of the mould.

III.2 The influence of the nature of the dispersing element on the fresh density

Changing the medium of action, i.e., the granular mixture, which changes the behaviour of the mixtures. In the case of using an acrylic polymer-based superplasticizer in the presence of a spherical element and according to the figure below (Figure 3.26), we note that the suspension optimum has changed, where there is also an increase in the fresh density at 10% substitution. In comparison, this reaches a maximum value at 30% substitution, noting that, despite the progression in substitution, the fresh density maintains a non-decreasing trend and does not fall below 2.3 (t/m3). In this respect, it is essential to note that the use of acrylic superplasticizer allows the appearance of a layer of bleed water, which becomes increasingly significant as the percentage of substitution increases. The latter is a protective layer formed by a molecular film against water evaporation.

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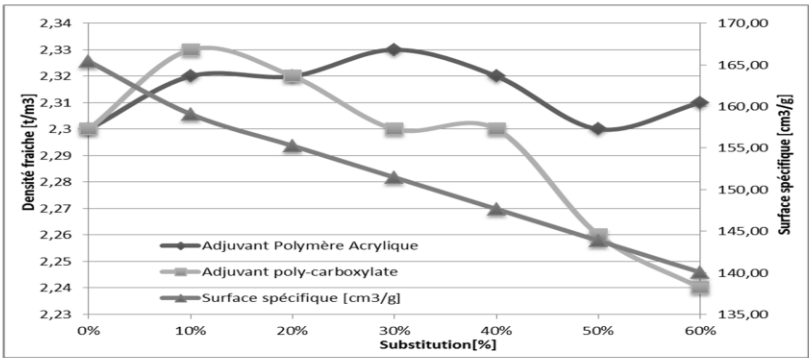
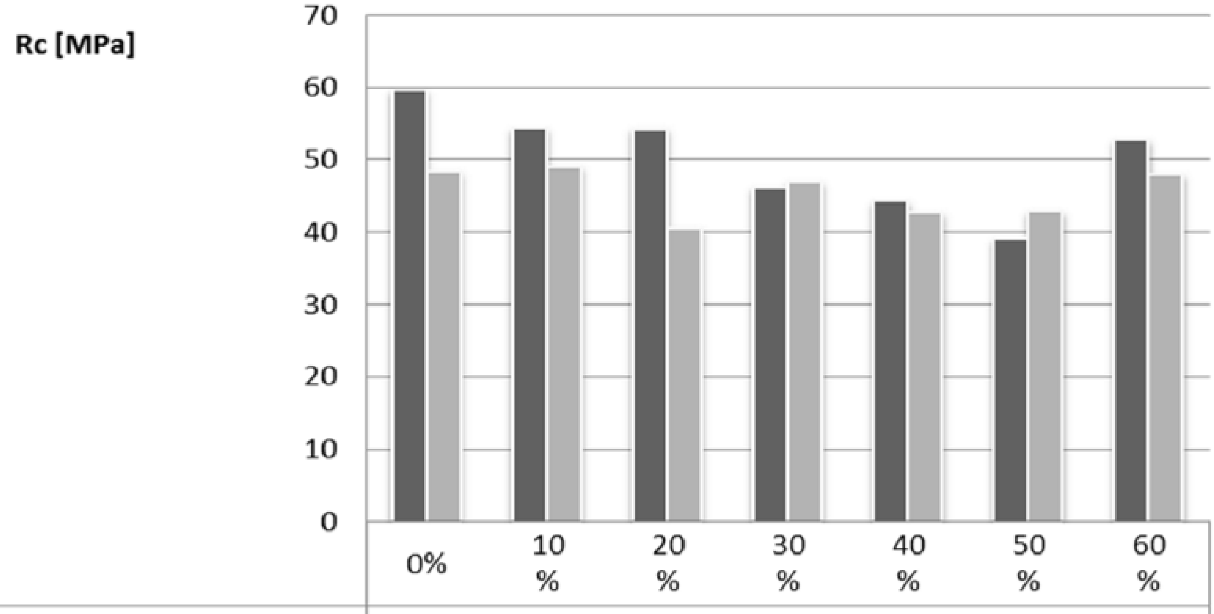


Figure. III The variation in fresh density depends on the substitution based on elements of different natures and different types of superplasticizers.

However, the behaviour of the polycarboxylate superplasticizer improves with the sequence of decreasing the specific surface area. At 10% substitution, a suspension optimum is reached, comparable to that of 30% in the case of an acrylic polymer-based superplasticizer. Note that between the 0% and 40% substitution range, the fresh density does not fall below 2.3 (t/m3). These key points reinforce our findings and provide reassurance in the results.

III.3. The influence of the nature of the dispersing element on compressive strength

As has just been presented in the following figure (figure 3.28), and as already indicated but not widely discussed, the accompaniment of the dispersing element of chemical nature with a dispersant of physical aspect, this one in the case of a superplasticizer based on acrylic polymer, comes together to play the role of a lubricant to improve the resistance to compression of the different compositions based on the aforementioned superplasticizer. This brings us back to the point that the dispersion by rheology will not decrease in the presence of aggregates of round morphology (particles that are spherical or near-spherical in shape), which can themselves be accompanied by superplasticiser to improve the mixture's behaviour, regardless of whether the mode of rheological dispersion is of a chemical or physical nature.



	0%	10 %	20 %	30 %	40 %	50 %	60 %
Adjuvant Polymère Acrylique	59,59	54,25	54,22	46,09	44,22	38,96	52,71
Adjuvant poly-carboxylate	48,25	48,96	40,47	46,88	42,66	42,81	47,92

Figure. IV. The variation of compressive strength depends on the substitution based on the elements of different natures and different types of superplasticizers.

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For the second type of superplasticizer based on carboxylate copolymer (Figure 3.28), we observe an overlap between dispersion by chemical lubrication and by physical dispersion. However, it's crucial to understand that the reduction in specific surface area remains the appropriate medium for this type of admixture. This key property significantly influences the material's behaviour, even though the compressive strength is limited to 48 (MPa).

IV. CONCLUSION

In conclusion, this study presents a set of experimental results regarding the behavior of granular components and their impact on the physical and mechanical properties of the mixture in both fresh and hardened states. The findings emphasize the heterogeneity of the granular mixture and the interrelationship between the physical and mechanical parameters. A summary of the key results is as follows:

- The substitution of materials with the addition of dune sand led to the emergence of an intergranular sliding phenomenon of a physical nature, which improved the physical and mechanical behavior of the granular mixture in both fresh and hardened states.
- Intergranular sliding can also occur due to chemical causes, such as the addition of a superplasticizer. This alters the lubrication characteristics of the superplasticizer, positively affecting the physical and mechanical properties of the mixtures; in general, the presence of the colloidal element is beneficial.
- The use of an acrylic copolymer admixture significantly enhances workability in the fresh state and continues to affect the mixture in the hardened state.

These results underscore the importance of utilizing laboratory experimentation for the practical formulation of concrete. This approach not only improves material performance but can also be economically advantageous by utilizing local materials available in varying quantities.

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