

INFLUENCE OF SUPERPLASTICIZER ON THE RHEOLOGY OF COMPOSITE MORTARS

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Abstract- Two series of samples were prepared, a control mortar and composite mortars mixed with plastic waste. A superplasticizer powder and a superplasticizer liquid were used to define the rheological properties of each mixture. The water/cement (W/C) ratios were constant, while the percentages of plastic waste varied from 2, 5, 10 and 15%. Both fresh and mechanical properties were assessed. This research demonstrated the crucial importance of the choice of superplasticizer in the formulation of composite mortars. These factors have a direct influence on the rheological and mechanical performance of mortars, making it possible to design formulations adapted to the requirements of modern construction.

Keywords: Composite mortars, Plastic waste, Superplasticizer, Rheology.

1-Introduction

According to a World Bank report, Algeria generates around 3.7 million tonnes of plastic waste every year, a significant proportion of which ends up in landfill sites or in the natural environment [1]. Faced with this problem, researchers and engineers are increasingly turning their attention to innovative solutions for managing and recovering this waste. One promising solution is to incorporate plastic waste into construction materials such as composite mortars. This approach not only reduces the amount of waste sent to landfill, but also produces construction materials that are potentially more durable and economical [2]. Indeed, the reuse of plastics in composite mortars offers an efficient recycling solution while improving certain characteristics of the materials, such as lightness, flexibility and energy absorption capacity [3]. The main aim of this study is to assess the effectiveness of incorporating plastic waste into composite mortars in Algeria. There are several reasons for

this choice. Firstly, plastic waste management is becoming a growing concern in Algeria, where recycling infrastructures remain insufficient to deal with the volume of waste generated [4].

Secondly, Algeria's construction industry is expanding rapidly, increasing demand for innovative and sustainable building materials. By incorporating plastic waste into composite mortars, it is possible to meet this demand while reducing environmental impacts. In addition, previous studies have shown that incorporating recycled plastics into mortars can improve certain mechanical and physical properties of the materials, such as resistance to cracking and durability in aggressive environments [5]. However, these studies have often been carried out in contexts different from that of Algeria, where climatic conditions, the types of waste available and construction standards vary. Specific research is therefore essential to assess the effectiveness and suitability of these materials in the Algerian context. In summary, this innovative approach to

managing plastic waste by incorporating it into composite mortars aims to provide empirical data on the performance of these materials and to make recommendations for their use in the Algerian construction sector. The aim of this approach is to help solve the problems associated with waste management and improve the durability of construction materials in the country. This study highlighted the crucial importance of the choice of superplasticizer in the formulation of composite mortars. These choices have a direct influence on the rheological and mechanical performance of mortars, making it possible to develop formulations tailored to the requirements of modern construction.

2- Materials and test methods

2.1- Materials

- **Cement:** a CEM II / 42.5 cement from the Groupe Industriel des Ciments d'Algérie 'GICA' cement works in accordance with Algerian standard NA442-2023 [6]. This cement is suitable for the manufacture of mortars and all reinforced concrete works. The dosage of this cement is 350kg/m³. Its chemical and mineralogical composition of the clinker is given in Table 1.

- **Sand:** the sand used is quarry sand, the grain size of which was determined by sieving. The chemical and physical characteristics of this sand are given in Tables 1 and 2 respectively.

- **Plastic waste (PW):** This consists of collected plastic caps ground into powder with a diameter of less than 0.5 mm. The physical characteristics are presented in table 2. It is incorporated by mass substitution into sand with contents ranging from 2, 5, 10 and 15%.

- **Superplasticizer:** two types of superplasticizer were used.

- **A liquid superplasticizer (SPL):** this is a SIKA ViscoCrete-625 superplasticizer from the SIKA BUILDING TRUST company in Oran, which complies with standard NF EN 934-2 [7]. This additive makes it possible to produce concretes and mortars with very low W/C ratios. The physical and chemical characteristics of the superplasticizer are given in tables 1 and 2 respectively.

Table 1: Chemical and mineralogical analysis of cement, SPP, SPL and sand

Elements	Cement (%)	Superplasticizer (SPP) (%)	Superplasticizer (SPL) (%)	Sand (%)
CaO	59.93	0.88	-	-
SiO ₂	18.73	93.35	-	29.15
Al ₂ O ₃	4.38	0.29	-	-
Fe ₂ O ₃	3.31	0.34	-	0.56
SO ₃	2.63	-	≤ 4%	-
K ₂ O	0.67	-	-	-
Na ₂ O	0.23	-	-	-
MgO	1.62	-	-	-
SO ₄	-	0.97	-	-
CaCO ₃	-	3.18	-	70.45
CO ₂	-	-	-	-
CaO free	-	-	-	-
C3S	59.9	-	-	-
C2S	8.82	-	-	-
C3A	6.01	-	-	-
C4AF	10.06	-	-	-

- **A powder superplasticizer (SPP):** this is an AETERNUM 3 superplasticizer from the TEKNACHEM company in SIDI BELABES. This new-generation carbon and silicate-based powder additive, infused with active nano-micro silicates, which it combines with high pozzolanic activity, ensures rheology, fluidity without segregation and impermeability. This additive makes it possible to produce concretes and mortars with very low E/C ratios. The physical and chemical characteristics of the superplasticizer are given in Tables 1 and 2 respectively.

Table 2 : Physical characteristics of cement, sand, SPP, SPL and PW

Physical properties	Cement	Sand	SPP	SPL	PW
Blaine specific surface area (cm ² /g)	3308	-	1000 - 2000	-	-
pH	-	-	10	5	-
Consistency	-	-	powder	fluid	-
Sand equivalent under piston	-	85.12	-	-	-
Absolute density (g/cm ³)	3.16	2.72	0.4-0.6	1.08 ± 0.015	-
Apparent density (g/cm ³)	-	1.41	-	-	0.95
Absorption coefficient(%)	-	18	-	-	Ins.

2.2- Test method

In order to determine the consistency of each composition, it was decided to keep the same spread (60%) and therefore the same W/C ratio. Only the percentage of superplasticizer varied. Mechanical strength was assessed by measuring compressive strengths. For each mortar composition, three samples were subjected to a compression test 28 days after casting. The composition of the mortars is given in Table 3.

Table 3 : Composition of different composite mortars

Mix mortars	Cement (g)	Sand (g)	SPP (%)	SPL (%)	PW (g)	E/C
MRSPL	650	1300	-	0.5	-	0.5
MCSP2	650	1274	-	1	26	0.5
MCSP5	650	1235	-	1.35	65	0.5
MCSP10	650	1170	-	1.65	130	0.5
MCSP15	650	1105	-	1.95	195	0.5
MRSPP	650	1300	1.95	-	-	0.5
MCSP2	650	1274	2	-	26	0.5
MCSP5	650	1235	2.3	-	65	0.5
MCSP10	650	1170	2.6	-	130	0.5
MCSP15	650	1105	3	-	195	0.5

3- Result and discussion

Figure 1 illustrates the effect of superplasticizer in the fresh state of the various composites. It can be seen that to achieve the same W/C ratio with constant workability, the addition of the superplasticizer powder SPP must be increased by around 3% for the MR reference mortar and around 2% for the other composite mortars compared with the liquid superplasticizer SPL. In order to achieve a W/C ratio of 0.5, SPP requires a high silica content due to its fineness, which is comparable to that of cement. Also, the amount of silica is high, which favours an increased content of superplasticizer (silicate and carbon). The higher the PW content, the greater the demand for superplasticizer. Despite being insoluble and inert, PW encourages greater use of superplasticizer [8].

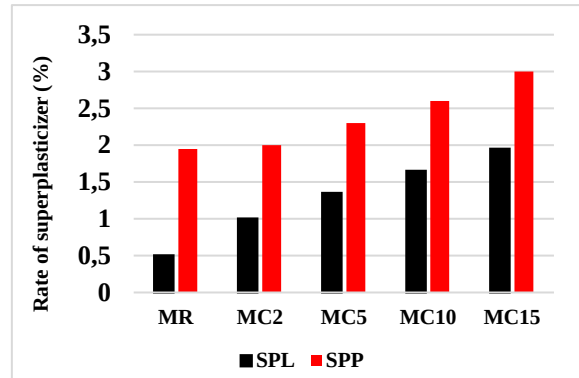


Figure 1: Effect of superplasticizers on fresh composite mortars

Figure 2 shows the mechanical strength as a function of the level of plastic waste and the nature of the superplasticizer. It can be clearly seen that the incorporation of SPP increases the compressive strength compared with the introduction of SPL. The high silica content in SPP generates a pozzolanic reaction in mortars, which increases compressive strength. Researchers have shown that powdered superplasticizers with a high silica content can increase strength [9-10], and as the PW content increases, strength tends to decrease regardless of the addition of the superplasticizer. A number of studies show that PW influences the porosity of mortars and that an optimum level should be specified for each type of formulation [11].

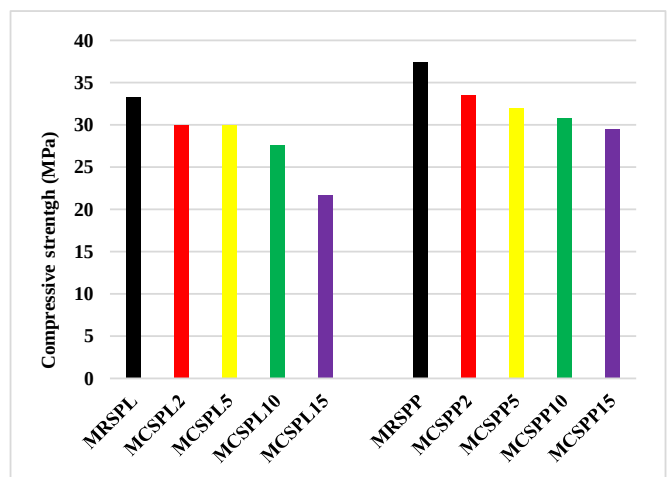


Figure 2: Compressive strength of composite mortars as a function of superplasticizer

4 - Conclusion

After simple and rapid testing, it was found that superplasticizer powder (SPP) would increase the mechanical strength of composite mortars. The level of PW in composite mortars has a direct influence on the porosity of the mortar. With a PW content of 15%, the mortar reaches 29 MPa, which is very favourable for construction mortars.

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