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Effect of viscosity modifying admixtures on the workability and mechanical resistances of self compacting mortars

Boukendakdji O.[1] ; Debieb F.[1] ; Kadri E.H.[2] ; Benramoul N.[1]
[1] Laboratoire de Matériaux et Environnement (LME) – University of Médéa (Algeria)
[2]Laboratoire Mécanique et Matériaux en Génie Civil (LMMGC) – Université de Cergy-Pontoise (France)

Corresponding:BOUKENDAKDJI Otmane, E-mail: boukendakdji_o@yahoo.fr;boukendakdji.othmane@univ-medea.dz; Tel/Fax: 00 213 (0)25 78 51 55 ;Mobile: 00 213 (0)661 483 839

Abstract
Concrete is one of the most widely manufactured materials in the world and.Today's concrete has to fulfil a wide range of requirements in both the fresh and hardened state. In most cases the properties of fresh concrete also affect the quality of the hardened concrete and ultimately its durability. This means that concrete has to be correctly proportioned and must remain homogeneous during placing and after compaction in order to avoid effects such as bleeding and segregation.Self-compacting concrete is a concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for any additional compaction.One of the latest innovations is the development of improved Viscosity Modifying Admixtures (VMA) also referred to as Stabilisers, Viscosity Enhancing Admixtures (VEA) and Water Retaining Admixtures. Water retaining admixtures are a type of VMA already defined in EN 934-2.The key function of a VMA is to modify the rheological properties of the cement paste. A suitable quantity of welan gum, a kind of natural water soluble polysaccharide, is very effective in stabilizingthe rheology of self-consolidating concrete.The objective of this article is to focus on the effect of the viscosity modifying admixtures on the workability and mechanical resistances of self compacting mortars. For this purpose two types of VMA have been used, a colloidal agent(MEDACOL BSE) and a bentonite. The experimental results have shown that mortars prepared with bentonite have given a better workability than the ones prepared with the MEDACOL BSE. On the contrary, mechanical resistances values are higher with the MEDACOL BSE.

Keywords: Self-Compacting Mortar, viscosity modifying admixtures, Workability and Mechanical Resistance.

1. Introduction
Concrete is a composite material consists of filler and binding material where the filler materials are fine or coarse aggregate and binding materials are cement paste. Today's concrete has to fulfil a wide range of requirements in both the fresh and hardened state. In most cases, the properties of fresh concrete also affect the quality of the hardened concrete and ultimately its durability. This means that concrete has to be correctly proportioned and must remain homogeneous during placing and after compaction in order to avoid effects such as bleeding and segregation. Self-compacting concrete is a concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for any additional compaction. One of the latest innovations is the development of improved Viscosity Modifying Admixtures (VMA) also referred to as Stabilisers, Viscosity Enhancing Admixtures (VEA) and Water Retaining Admixtures. Water retaining admixtures are a type of VMA already defined in EN 934-2.The key function of a VMA is to modify the rheological properties of the cement paste. A suitable quantity of welan gum, a kind of natural water soluble polysaccharide, is very effective in stabilizing the rheology of self-consolidating concrete[1].The key element inefficient workability shaping is the complex knowledge how superplasticizers influence the rheological properties of fresh concrete indifferent technological circumstances[2]. The use of viscosity modifying admixtures (VMA) has proved to be very

effective in stabilizing the rheological properties and consistency of self-compacting concrete. Viscosity modifying admixtures (VMA) are water-soluble polymers that increase the viscosity of mixing water and enhance the ability of cement paste to retain its constituents in suspension[3].According to Andreas Leemannand Frank Winnefeld, at constant water-to-binder ratio (w/b) the addition of VMA causes a decrease of mortar flow and an increase of flow time (V-funnel test) and at a constant dosage of superplasticizer (SP) mixtures with VM Arequire a higher w/b to keep the same flow properties as the reference mixtures without VMA[4].Colloidal agents improve apparent viscosity and yield stress[5].According to Ghioand Coll, the effect of the rubber of polysaccharide, in combination with a superplasticizer based on naphthalene, on the viscosity of cement pastes is greater with a lower percentage of shear.[6].Compressive and tensile strengths along with the modulus of elasticity of concretes containing a colloidal agent have higher values than without a colloidal agent [7].

2. Materials and methods

2.1 Materials

The materials used in this study were readily available on the market. In this research Ordinary Portland Cement (OPC) was used. The mortar mixtures were prepared with cement CEM II 42.5/A with fineness of 3000 cm²/g and a specific gravity of 3.15. A combination of Crushed and Dune sand on purpose of correcting dune sand to reach a fineness modulus of 2.5. Grading curves of used sands are given in Figure 1.Apolycarboxylate based Superplasticizers also was used along with two types of viscosity modifying admixtures, a colloidal agent (MEDACOL BSE) and a BENTONITE and finally water was used.

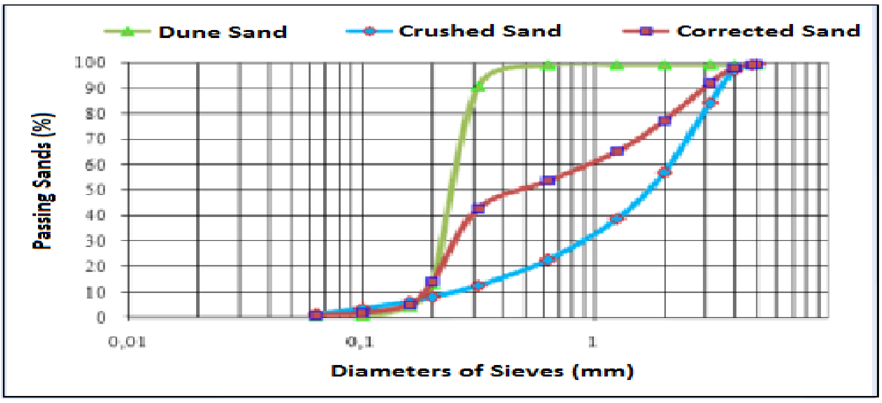


Figure 1: Grading curves of used sands

2.2 Mix proportions and preparation

In this experimental work we have found it useful to test self-compacting mortars mixes instead of self-compacting concrete mixes because of the reasons given by Domone and Jin [8]:

- SCC has a lower coarse aggregate content than that of normal concrete, and therefore the properties of the mortar are dominant.
- Assessing the properties of the mortar is an integral part of many SCC mix design processes, and therefore knowledge of the mortar properties is itself useful.
- Testing mortar is more convenient than testing concrete.

In continuation to previous work achieved by the authors [9], the mixture proportions were based on Okamura et al. method[10], with improvements made on the methods of selecting the fine aggregates content. The sand-mortar weight ratio (Vs/Vm), the water-cement weight ratio (Vw/Vc) and the superplasticizer-cement weight ratio (Sp/C) were selected by a simple evaluation test for assessing the stress transferability of fresh mortar [11].
The superplasticiser used was diluted in water before added to the mortar mixes for a better distribution of admixtures within the mass of SCM and practice in general confirms this [8].
Self-Compacting Mortars normally require a more efficient mixing, longer mixing time, to make sure that all constituents have been mixed thoroughly [12]. Hence, the following mixing procedure consisted in mixing the aggregates with cement together for half a minute before adding 70% of necessary water during one minute then

adding the remaining 30% of water containing the superplasticizer during another one minute. The mixing procedure is continued for another three minutes, immediately then we started workability tests. The first type of VMA (MEDACOL BSE), which is in powder form, is added in first stage with the cement and sand, whereas the second type of VMA, which is in liquid form, is added along with the superplasticizer.

2.3 Test Methods

2.3.1 Workability of mortar

Tests on mortar include flow spread and the V-funnel flow time. To obtain an acceptable workability of the SCM a range of acceptable values of spread between 270 and 330 cm was taken. Target values for the V-funnel test must be between 2 and 10 seconds. The polycarboxylate based superplasticizer (SP) was used in proportions of 0.8 to 2.4% of weight of cement. Water to Cement ratio was fixed at 0.45%, Sand to Mortar ratio at 0.5% and the MEDACOL BSE (VMA1) with ratios of 0.01%-0.02%-0.03% and finally the BENTONITE (VMA2) with ratios 0.5%-1%-1.5%.

2.3.2 Strength

In this study, compressive and tensile strength tests were carried out for different percentages of viscosity modifying agents used. Prismatic samples of 4x4x16 cm^3 were used for 2 different ages 7 and 28 days after curing.

3. Results and discussion

3.1 Workability

In this part results of workability tests, slump flow and v-funnel, are given for both types of VMA at a constant value of water to cement ratio of 0.45 and varying values of superplasticizer's percentage.

3.1.1 Effect of the MEDACOL BSE

MEDACOL BSE values vary from 0.01% to 0.03%. Table 1 shows values of different materials used in mortar mixes along with results of spread and V-funnel flowing time using the MEDACOL BSE as a VMA.

Table1: values of different materials used in mortar mixes along with results of spread and V-funnel flowing time
using the MEDACOL BSE as a VMA

		Sand/Mortar = 0.5 ; Water/Cement = 0.45 VMA1 = 0.01% ; 0.02% and 0.03%								
		M1	M2	M3	M4	M5	M6	M7	M8	M9
Cement (grs)		647								
Sand (grs)		1328								
Water (grs)		291.23								
SP (%)		0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4
Spread (mm)	VMA1 = 0%	247	296	300	301	312.5	311	308.5	307	306.5
	VMA1 = 0.01%				265,5	285	296	296,5	302	305
	VMA1 = 0.02%				171.5	210.5	232	270	271.5	286
	AV1 = 0.03%						100,5	164	205	254,5
V-Funnel Flowing Time (sec)	VMA1 = 0%	6,33	6,2	7	5,7	5,55	6,34	6,9	4	3,98
	VMA1 = 0.01%				9,75	6,77	5,405	5,8	4,9	4
	VMA1 = 0.02%				24	22	11.5	7	6,4	6
	VMA1 = 0.03%						29,68	23	21,2	17,62

Figure 2 shows that using a VMA workability is lost especially at lower values of superplasticizer compared to mortar without VMA. The higher the percentage used of VMA, the lower value of spread. On the other hand, figure 3 shows that the higher the percentage used of VMA, the higher values of V-Funnel flowing time.

3.1.2 Effect of the BENTONITE

BENTONITE values vary from 0.5% to 1.5%. Table 2 shows values of different materials used in mortar mixes along with results of spread and V-funnel flowing time using the BENTONITE as a VMA.

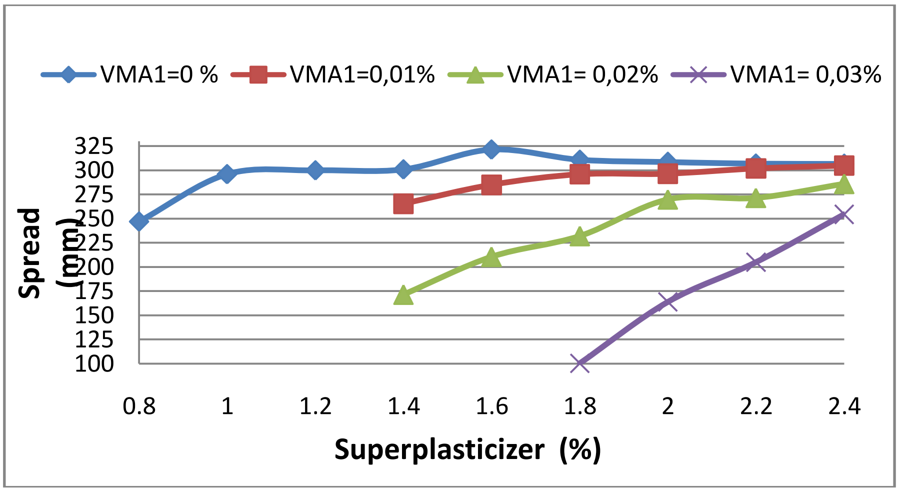


Figure 2 : Spread using MEDACOL BSE

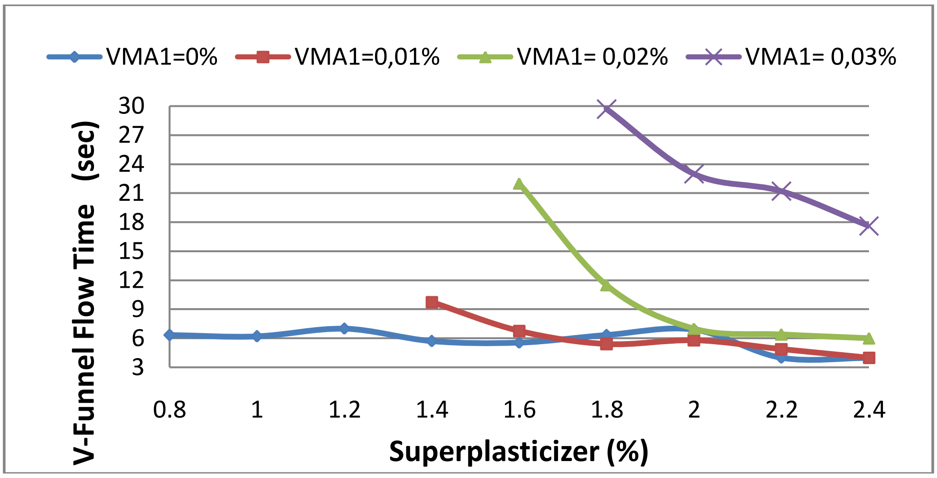


Figure 3:V-Funnel Flow Time using MEDACOL BSE

Table 2: Values of different materials used in mortar mixes along with results of spread and V-funnel flowing time using the BENTONITE as a VMA

		Sand/Mortar = 0.5 ; Water/Cement = 0.45 VMA2 = 0.5% ; 1% and 1.5%								
		M1	M2	M3	M4	M5	M6	M7	M8	M9
Cement (grs)		647								
Sand (grs)		1328								
Water (grs)		291.23								
SP (%)		0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4
Spread (mm)	VMA2 = 0%	247	296	300	301	312.5	311	308.5	307	306.5
	VMA2 = 0.5%			260	266,5	290	296	299,5	301	299
	VMA2 = 1%		237	250	257	263,2	276,3	290	296	304
	AV2 = 1.5%			264,2	268	295,5	300	302	304	296
V-Funnel Time (sec)	VMA2 = 0%	6,33	6,2	7	5,7	5,55	6,34	6,9	4	3,98
	VMA2 = 0.5%			12,98	11,92	9,25	6,93	6,66	5,94	6
	VMA2 = 1%		14	13,5	12	11	9,4	7,33	7	6,42
	VMA2 = 1.5%			10,4	9,4	5,4	5,35	5,26	5,11	6,61

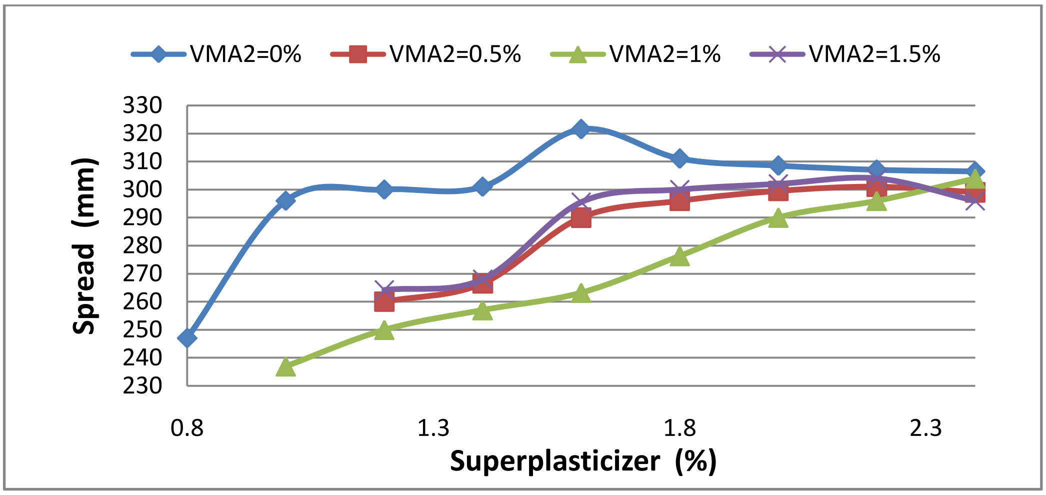


Figure 4: Spread using BENTONITE

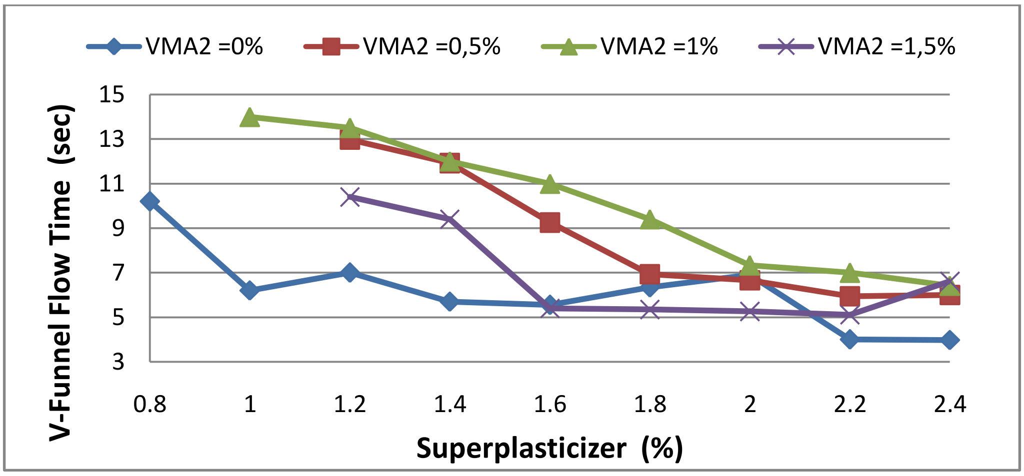


Figure 5: V-Funnel Flow Time using BENTONITE

Figure 4 gives a different behavior of mortars with BENTONITE than those with MEDACOL BSE. The loss of workability is less, and using a value of 1.5% of VMA2 gives higher value of workability than with 0.5% or 1% of VMA2. Figure 5 gives similar results.

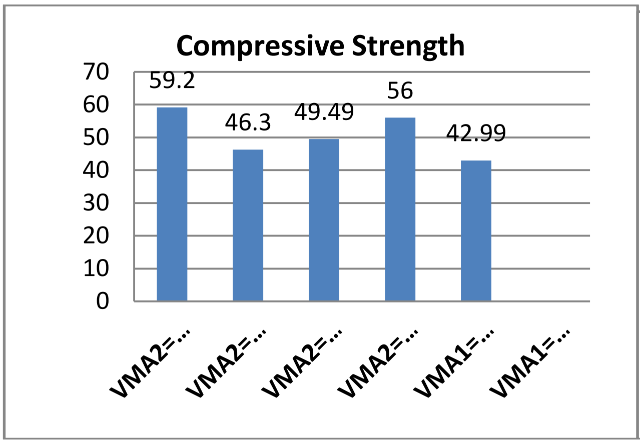
As a conclusion of this part of workability analysis, we can say that the use of the BENTONITE as a viscosity modifying agent is more benefic than MEDACOL BSE.

3.2. Strength

Using viscosity modifying agents, we noticed a loss in workability. All strength values started from an SP% of 1.6 and above. We found it better to give strength results (compressive and tensile strengths) for each value of SP separately. In the following sections, we give the best results for both VMA's, MEDACOL BSE and BENTONITE.

3.2.1. for SP = 1.6%

With both figures 6 and 7, we can notice an increase in strength with increase of values of VMA2 (BENTONITE), whereas result of VMA1 (MEDACOL BSE) in much lower.



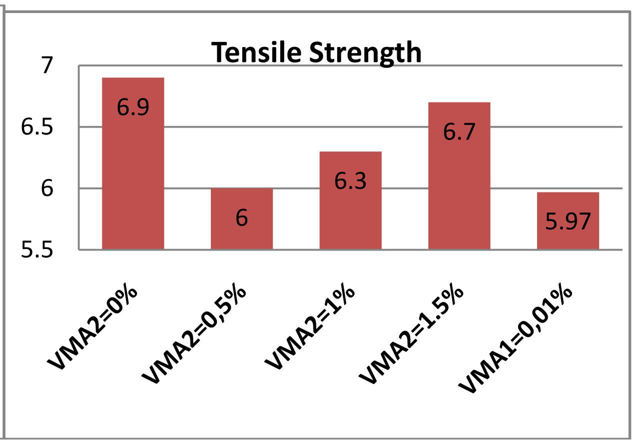
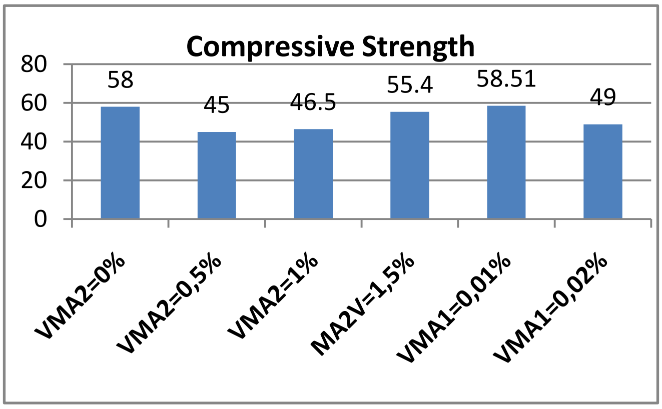


Figure 6: Compressive Strength for SP=1.6%

Figure 7: Tensile Strength for SP=1.6%

3.2.2 for SP = 1.8%

Similarly to previous results, figures 8 and 9, show that there is an increase in strength with increase of values of VMA2, on the contrary there is a loss in strength with increase of values of VMA1. Mortar with 0.01% of VMA1 gives the best value of strength.



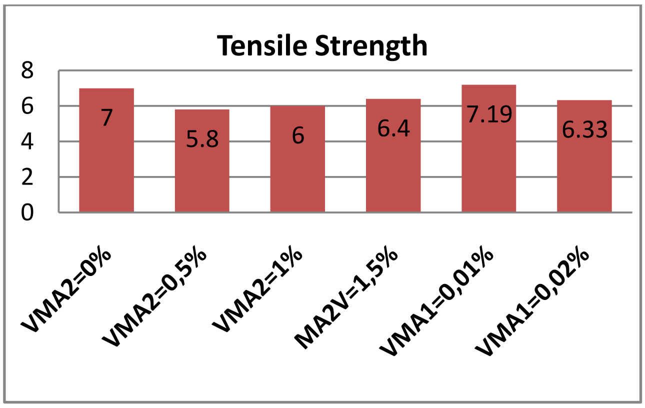
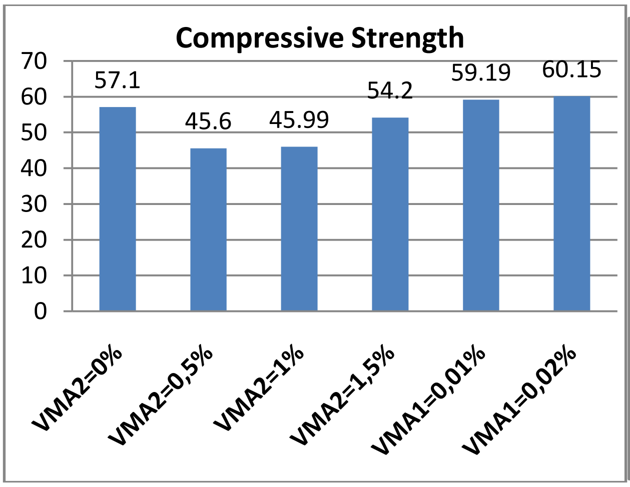


Figure 8: Compressive Strength for SP=1.8%

Figure 9: Tensile Strength for SP=1.8%

3.2.3. for SP = 2%

Starting with SP=2%, we can notice clearly from figures 10 and 11, that VMA1 is giving better results as far as strength is concerned.



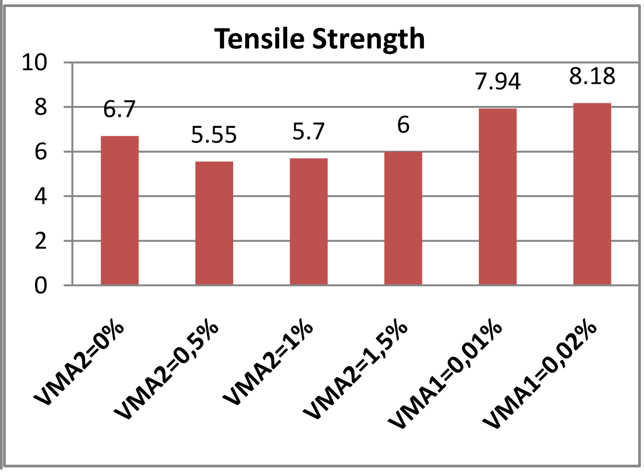
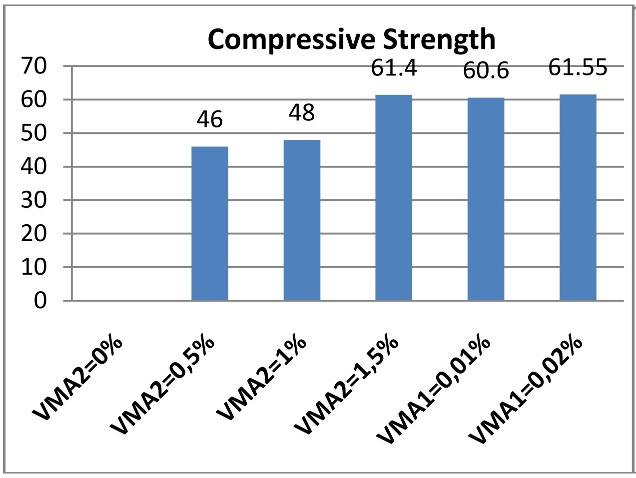


Figure 10: Compressive Strength for SP=2%

Figure 11: Tensile Strength for SP=2%

3.2.4. for SP = 2.2%

Figures 12 and 13 shows that previous results are confirmed and mortars with VMA1 have better values of compressive and tensile strengths than mortars with VMA2.



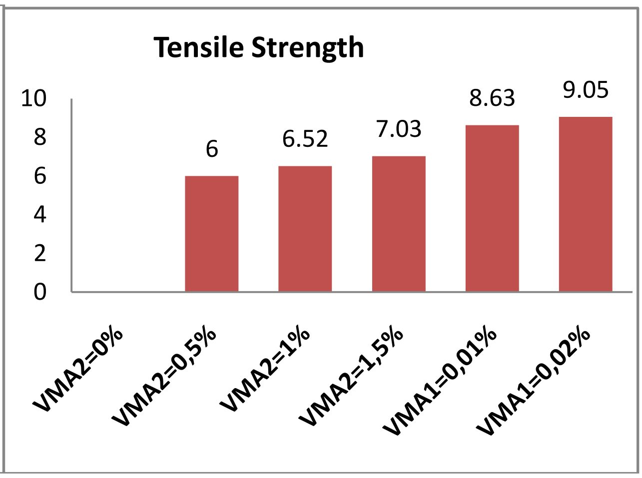
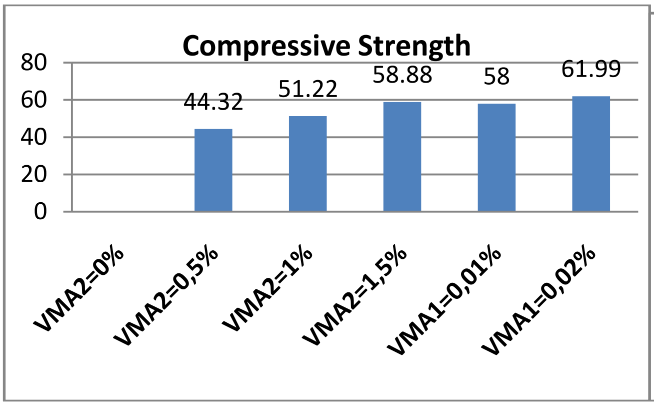


Figure 12: Compressive Strength for SP=2.2%

Figure 13: Tensile Strength for SP=2.2%

3.2.5. for SP = 2.4%

Figures 14 and 15 confirm previous results and we notice clearly that strength increase with increase of SP percentage value especially for mortars with VMA1.



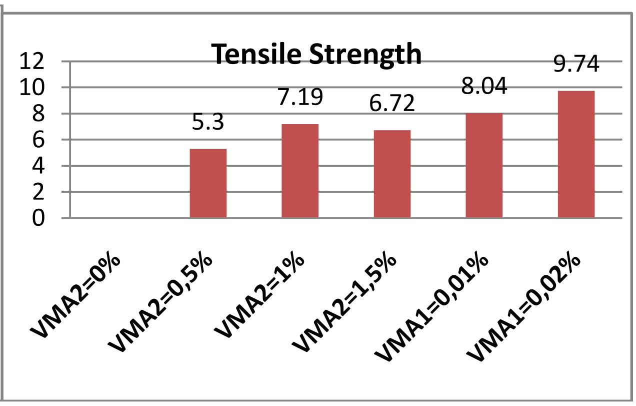


Figure 14: Compressive Strength for SP=2.4%

Figure 15: Tensile Strength for SP=2.4%

As a conclusion of this part of strength analysis, we can say that the use of the MEDACOL BSE as a viscosity modifying agent is more benefic than BENTONITE.

Conclusion

The experimental results have shown that mortars prepared with bentonite have given a better workability than the ones prepared with the MEDACOL BSE. On the contrary, mechanical resistances values are higher with the MEDACOL BSE.

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