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Improving the Compressive Strength of Joss by the Addition of (S.F.) and (P.V.A.).

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Abstract

In this research, an attempt has been made to improve the compressive strength of joss by using two additives , namely : (S.F.) and (P.V.A.) . For this objective four mixes were used , the first mix is the reference mix (mix of no additives) and the rest three are the mixes of using the two additives (S.F. and P.V.A.) individually (each one alone) and together (combined) respectively .

Because of the importance of "Setting Time" property from practical aspects in gypsum works , it was taken into consideration together with the "Compressive Strength" property in this study .

In the beginning , when (S.F.) alone with a content of (1.2%) was added,the compressive strength of the mix was improved by (33.56%) as compared to that of the reference mix , but the mix setting time is reduced by (22.07%) . After that , the other additive (P.V.A.) with a content of (4%) was added to the (S.F.) mix (together) , the result was a more improvement in the compressive strength has occurred (to reach (40.37%)) , while the percentage of reduction in the setting time remained unchanged (i.e. 22.07%) .

Keywords : Joss , (S.F.) , (P.V.A.) , Compressive Strength , Setting Time .

1-Introduction

In the recent years gypsum products have been exceedingly used as in-door finishing . Houses , especially in the U.S.A. and Europe , are either built from or lined with gypsum-based products favored by architects because of their superior properties , such as obtainable availability of in-expensive raw materials , volumetric stability , acoustic and thermal insulation , fire resistance , quite low toxicity and the comparatively low energy and temperatures needed in its manufacture [1] . Gypsum is also used in several applications beyond the construction field : e.g. in making molds for ceramic products [2] , in medical [3] , and dental accessories or implants [4] , furthermore , it is the major constituent in Portland cement in order to delay its setting time [5] . The numerous applications of gypsum plaster are primarily based on its specified properties [6] , [7] .

Many researchers have attempted to develop plaster characteristics and extend its range of applications throughthe addition of other materials [7] , [8] , [9] . One of these additives is "Silica gel" (a highly porous form of silica) , it is a by-product of the sodium silicate industry with fabulous heat and fire resistance , chemical-stability , along with a large specific surface area , and high water sensitivity . In addition , its erratic nature reduces density as well as thermal conductivity and promotes the high temperature durability of plaster composites with trivial loss of compressive strength [2] , [10] . The yield strength , elastic modulus , and interior bond of plasterboards have been observed to increase whennano-SiO2 is added[11] . Silica fume , in turn , is a very good pozzolanic material with a high reaction rate , although it is rarely used with gypsum [12] . Many authors have reported that the addition of ultra-fine sand (U.F.S.) or micro-silica improves the mechanical properties of Portland cement pastes [13, 14] .

The water-gypsum ratio has an influence on the basic physical characteristics of the hardened gypsum , such as its volumetric density , total open porosity, and other related characteristics such as its moisture , mechanical , thermal and acoustic insulation properties. The theoretical water-gypsum ratio necessary for the hydration of calcium sulphate hemi-hydrate CaSO4·½H2O into calcium sulphate dehydrate CaSO4·2H2O is (0.187). Additional water , in a so called over-stoicheio-metric quantity , is necessary for the process of hardening of the gypsum paste . The properties of the hardened gypsum made from a gypsum paste by casting , pressing , or vibrating , depend on the value of the water / gypsum ratio [15] .

2. Experimental Work

2.1. Materials

2.1.1. Gypsum

2.1.1.1. Gypsum products

Materials that are resulted from the calcinations of gypsum (CaSO4.2H2O) and having the chemical composition of hemihydrate (CaSO4.1/2H2O) are called "Gypsum Products". Although they are identical in compositions and x-rays diffraction peaks, they are different in their physio- mechanical properties. They consist of three main types : locals joss , plasters , and dental stone, each type has several varieties[16] . The first type is of our concern in this research.

2.1.1.2. Local Gypsum (Joss)

The word "joss" is derived from the Assyrians word "jasso". Local joss in Iraq is a materials produced from calcined gypsums by the "Koor method" Gypsums rocks pieced are placed on opening in the koor domes and the heated source is at the base of the domes . Heating continue for (24) hours . The final products the joss is a mechanical mixtures of un-hydrates , bassanite and un-burnt gypsum .

Gypsum (Local joss) used as a main matrix in this project was calcium sulfate hemihydrate gypsum (CaSO4.½H2O), which was obtained from local market in Baghdad.

2.1.2. Polyvinyl Acetate (P.V.A.)

Polyvinyl acetate (P.V.A.) , commonly referred to as wood glue , white glue , carpenters glue , school glue , Elmer's glue in the U.S. , or PVA glue , is an aliphatic rubbery synthetic polymer with the formula ($C_4H_6O_2$) , it is also used (unprecedentedly) here in our present work as an additive to gypsum works .

2.1.3. Silica Fume (S.F.)

Silica fumes are highly reactive pozzolanic substances and are a byproduct from the production of silicone or Ferro- silicon metals. It is a very fine powder and composed from the flue gases from electric is furnace .The silica fume that is used in this research is a product from Sica Manufacturer in Egypt and have the product name "Sika Fume-HR"

2.1.4. Mixing water

Ordinary potable water was used for mixing to all gypsum mixes in this study **.**

2.2.Gypsum Mixes

Four mixes of joss have been studied in this research according to S.F. and P.V.A. contents (by weight) : 0.0% , 1.2% (for S.F.) and 0% , 4% (for P.V.A.) . The (water/joss) ratio used for all these mixes is fixed at (0.3) . The constituent materials (Joss , S.F. , P.V.A. and water) of all mixes were weighted quantities . The mixes details are illustrated in table (1) **.**

Table 1 : Details of mixes .

Mix No.	S.F. content by weight (%)	P.V.A content by weight (%)	(W/J) ratio	Ingredients Per (100g) of Joss
Mix 1	0.0	0.0	0.3	(100g) Joss + (0.0g) S.F. + (0.0g)P.V.A + (30g) water
Mix 2	1.2	0.0	0.3	(100g) Joss + (1.2g) S.F. + (0.0g)P.V.A + (30g) water
Mix 3	0.0	4.0	0.3	(100g) Joss + (0.0g) S.F. + (4.0g)P.V.A + (30g) water
Mix 4	1.2	4.0	0.3	(100g) Joss + (1.2g) S.F. + (4.0g)P.V.A + (30g) water

2.3. Mixing procedure

In the beginning S.F. powder was added to the joss and dry mixed , then the specified quantity of the water wasadded to the mix , then re-mixed manually for (approximately 30 seconds) , and poured in to the mold . The mold has been vibrated benefiting from the vibration of a(small generator) for about 10 second . After about 30 minutes , the cubic (5×5×5)cm. specimens were taken off from the mold . Then , the specimens were exposed to the direct sun light for about two days at approximately 38 °C heat . For mixes with P.V.A. additive , the required quantity of it is added to the required quantity of waterand mixed very well , then they are added to the joss .

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2.4. Testing program

2.4.1. Compression strength .

The 50 mm cubic specimens were tested in this research at age of about one week or over to evaluate the compressive strength. Fig. (1-a) shows the testing machine used in our research [test is carried out according to ASTM: C472][17] **.**

2.4.2. Setting time .

One of the most disadvantages of gypsum plaster mixes, precisely in the preparation of the paste is that its setting time is rather small (i.e. compared with cement or concrete paste) and this disadvantage doesn't provide enough comfort for the workers to do their job freely, this promotes us to investigate the effect of our additives (P.V.A. and S.F.) individually and together on the setting time.

Setting time is usually measured by a device called (Vicat apparatus) , which consist of a 300 gm weighted rod ended with a needle (5cm. long) and (1mm. in diameter) fixed by a holder with a graduated plate and a cylindrical pan having (70*40)mm dimensions **,** the apparatus is shown in Fig.(1-b) , [test is carried out according to ASTM : C472-99][17] .

Fig. (1-a) : Compressive Strength Test

Fig.(1-b) :Vicat Apparatus

3. Results & Discussions.

3.1. Compressive Strength:

3.1.1. Effect of (S.F.) on Compressive Strength of Joss with Various (P.V.A.) Contents .

Figure and Table (2) presents the effect of (S.F.) on the compressive strength of the joss with two (P.V.A.) contents (0% and 4%) . They reveal that with the addition of (S.F.) alone the compressive strength is extremely increased , and the percentage of this increase in increased with the presence of (P.V.A.) .

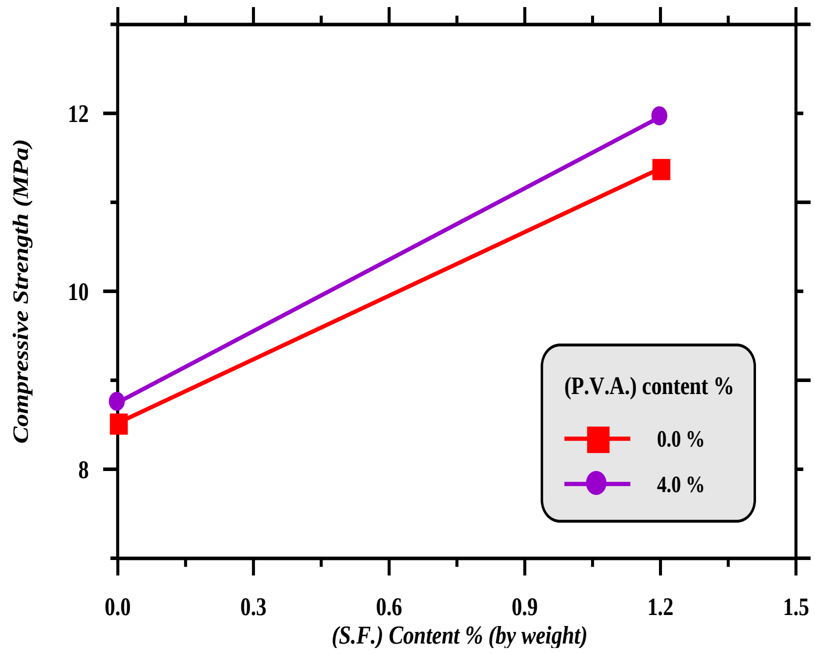

Figure (2) and Table (2) : Effect of (S.F.) on Compressive Strength of Joss with Various (P.V.A.) Contents .

Mix No.	(P.V.A.) content by weight (%)	(S.F.) content by weight (%)	(W/J) ratio	Compressive Strength (MPa)	Percentage of Increase (%)
Mix 1	0.0	0.0	0.3	8.52	----
Mix 2	0.0	1.2	0.3	11.38	33.56
Mix 3	4.0	0.0	0.3	8.75	----
Mix 4	4.0	1.2	0.3	11.96	36.68

3.1.2. Effect of (P.V.A.) on Compressive Strength of Joss with Various S.F. Contents .

Figure and Table (3) displays the effect of (P.V.A.) on the compressive strength of the joss with two (S.F.) contents (0% and 1.2%) . They illustrate that with the addition of (P.V.A.) alone the compressive strength is slightlyincreased , and the percentage of this increase is higher with the presence of (S.F.) .

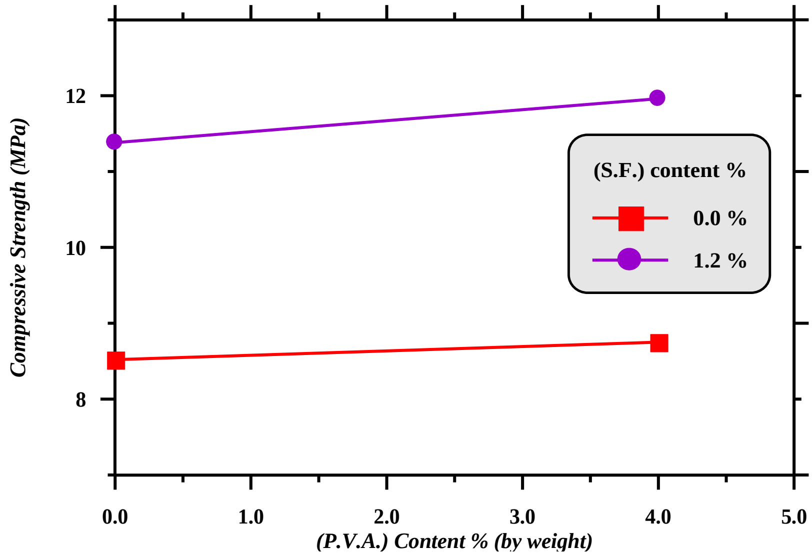

Figure (3) and Table (3) : Effect of (P.V.A.) on Compressive Strength of Joss with Various (S.F.) Contents .

Mix No.	(S.F.) content by weight (%)	(P.V.A.) content by weight (%)	(W/J) ratio	Compressive Strength (MPa)	Percentage of Decrease (%)
Mix 1	0.0	0.0	0.3	8.52	----
Mix 3	0.0	4.0	0.3	8.75	2.69
Mix 2	1.2	0.0	0.3	11.38	----
Mix 4	1.2	4.0	0.3	11.96	5.09

3.2. Setting Time:

3.2.1. Effect of (S.F.) on Setting Time of Joss with Various (P.V.A.) Contents.

Figure and Table (4) presents the effect of (S.F.) on the setting time of the joss with two (P.V.A.) contents (0% and 4%) . They reveal that with the addition of (S.F.) alone the setting time is decreased, and the percentage of this decrease is slightly lesser with the presence of (P.V.A.).

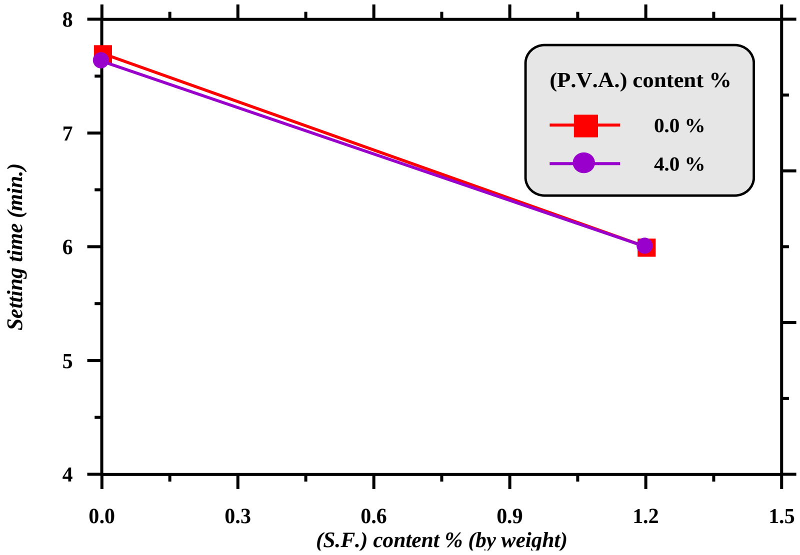

Figure (4) and Table (4) : Effect of (S.F.) on Setting Time of Joss with Various P.V.A. Contents .

Mix No.	(P.V.A.) content by weight (%)	(S.F.) content by weight (%)	(W/J) ratio	Setting Time (min.)	Percentage of Decrease (%)
Mix 1	0.0	0.0	0.3	7.7	----
Mix 2	0.0	1.2	0.3	6.0	22.07
Mix 3	4.0	0.0	0.3	7.63	----
Mix 4	4.0	1.2	0.3	6.0	21.36

3.2.2. Effect of (P.V.A.) on Setting Time of Joss with Various (S.F.) Contents .

Figure and Table (5) displays the effect of (P.V.A.) on the setting of the joss with two (S.F.) contents (0% and 1.2%) . They illustrate that with the addition of (P.V.A.) alone the compressive strength is very littledecreased , but it remains unchanged with the presence of (S.F.) .

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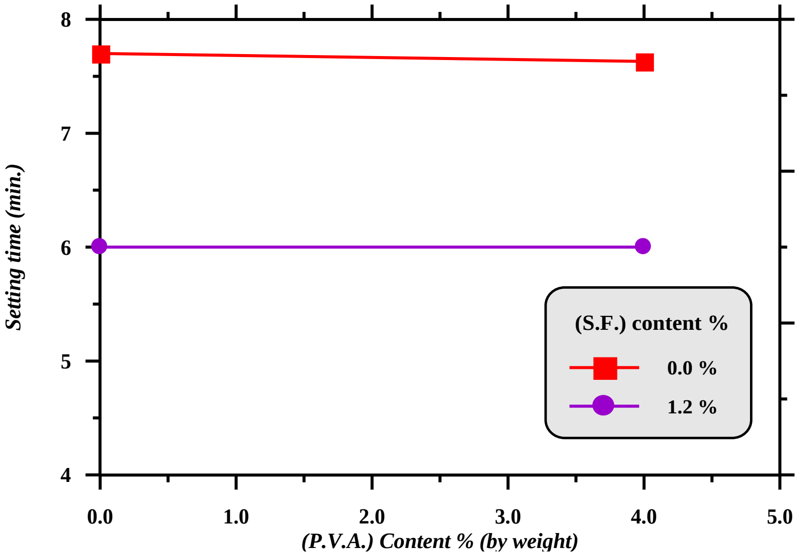

Figure (5) and Table (5) : Effect of (P.V.A.) on Setting Time of Joss with Various (S.F.) Contents .

Mix No.	(S.F.) content by weight (%)	(P.V.A.) content by weight (%)	(W/J) ratio	Setting Time (min.)	Percentage of Decrease (%)
Mix 1	0.0	0.0	0.5	7.7	----
Mix 3	0.0	4.0	0.5	7.63	0.909
Mix 2	1.2	0.0	0.5	6.0	----
Mix 4	1.2	4.0	0.5	6.0	0.0

3.3. Privilege of the Combined Addition of (S.F.) and (P.V.A.):

3.3.1. On Compressive Strength.

Bar chart (1) shows the combined effect of (S.F.) and (P.V.A.) on the compressive strength of joss . It displays that if taking the case of Mix 1 (i.e. : zero S.F. and zero P.V.A.) as a reference case , then when adding S.F. alone (Mix 2) , the compressive strength is increased by (33.56%) , while when using P.V.A. alone (Mix 3) , the compressive strength is increased by (2.69%) , but when using both S.F. and P.V.A. (Mix 4) , the compressive strength is increased by (40.37%) , which means that when using both (S.F.) and (P.V.A.) the percentage of increasing in the compressive strength is higher than the algebraic sum of that results from using each additive individually .

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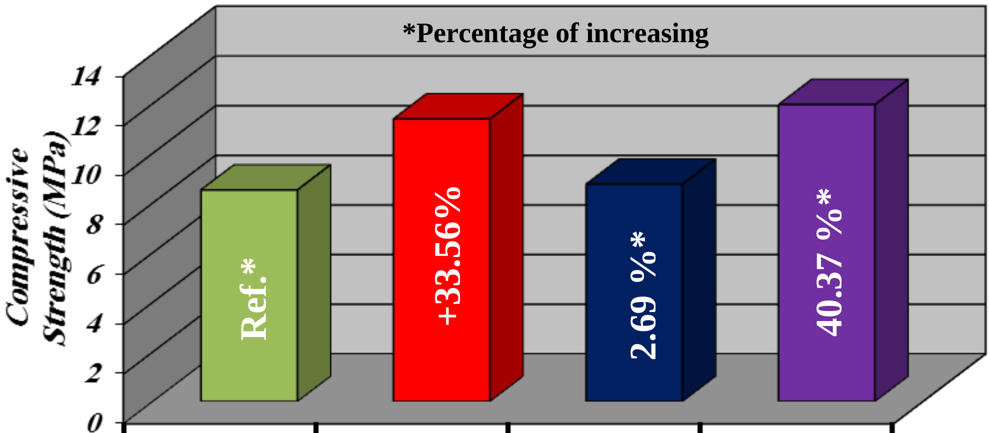
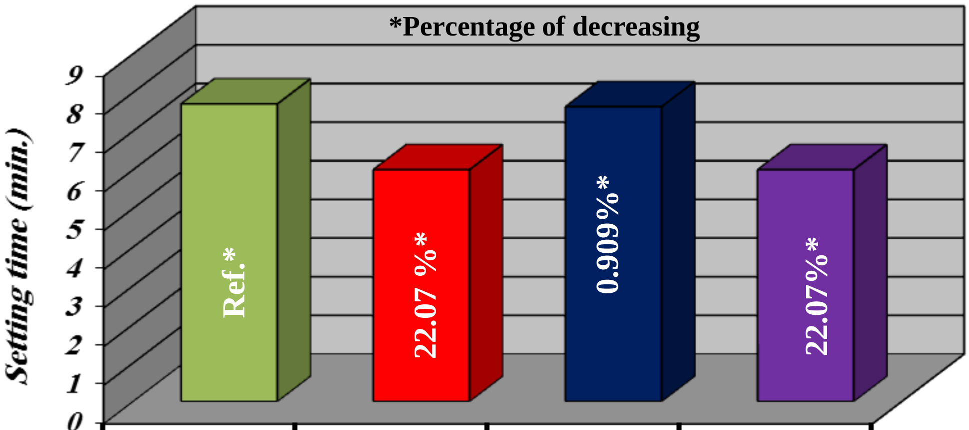


	Mix1 Ref. (P.V.A.=0.0%) (S.F. =0.0%)	Mix 2 (P.V.A.=0.0%) (S.F.=1.2%)	Mix 3 (P.V.A=4.0%) (S.F.= 0.0%)	Mix 4 (P.V.A.=4.0%) (S.F.=1.2%)
Compressive Strength (MPa)	8.52	11.38	8.75	11.96

Bar Chart (1) : Combined Effect of (S.F.) and (P.V.A.) on Compressive Strength.

3.3.2. On Setting Time.

Bar chart (2) presents the combined effect of (S.F.) and (P.V.A.) on the setting time of joss . It illustrates that if taking the case of Mix 1 (i.e. : zero S.F. and zero P.V.A.) as a reference case , then when adding S.F. alone (Mix 2) , the setting time is decreased by (22.07%) , while when using P.V.A. alone (Mix 3) , the setting time is decreased by (0.909%) , but when using both S.F. and P.V.A. (Mix 4) , the setting time is decreased by (22.07%) , which means that (P.V.A.) has no effect to setting time when used together with (S.F.) .



	Mix1 Ref. (P.V.A.=0.0%) (S.F. =0.0%)	Mix 2 (P.V.A.=0.0%) (S.F.=1.2%)	Mix 3 (P.V.A=4.0%) (S.F.= 0.0%)	Mix 4 (P.V.A.=4.0%) (S.F.=1.2%)
Setting time (min.)	7.7	6	7.63	6

Bar Chart (2) : Combined Effect of (S.F.) and (P.V.A.) on Setting Time .

5. Conclusions

1) When adding (S.F.) alone , the compressive strength is extremely increased by (33.56%) , and this percentage of increase increases with the presence of (P.V.A.) (to become 36.68%) .

2) When adding (S.F.) alone , the setting time is decreased by (22.07%) , and this percentage of decrease slightly decreases with the presence of (P.V.A.) (to become 21.36%) .

3) When adding (P.V.A.) alone , the compressive strength is slightly increased by (2.69%) , and this percentage of increase increases with the presence of (P.V.A.) (to become 5.09%) .

4) When adding (P.V.A.) alone , the setting time is very little decreased by (0.909%) , while the setting time remains unchanged with the presence of (S.F.) .

5) When using both S.F. and P.V.A. (Mix 4) , the compressive strength is increased by (40.37%) as compared with the reference caseMix 1 (i.e. : zero S.F. and zero P.V.A.), which means that when using both (S.F.) and (P.V.A.) the percentage of increasing in the compressive strength is higher than the algebraic sum of that results from using each additive individually .

6) When using both S.F. and P.V.A. (Mix 4) , the setting time is decreased by (22.07%) as compared with the reference case Mix 1 (i.e. : zero S.F. and zero P.V.A.), which equals the percentage resulted from the case of Mix (2) ,which means that (P.V.A.) has no effect to setting time when used together with (S.F.) .

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