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Evaluation of the Combined Effect of (T.G.P.) and (S.F.) Additives on the Properties of Local Juss

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ABSTRACT

In this research, an attempt has been made to study the effect of adding T.G.P. and S.F. additives (by weight) separately and together on local juss characteristics. The research plan consists of investigating three main gypsum properties , namely : the compressive strength , the setting time and the bulk density . According to the plan, the total number of local juss mixes used is eighteen, these mixes were divided in to two groups according to (water / juss) ratios (0.3 and 0.4). Each group (i.e. nine mixes) was arranged according to : T.G.P. and S.F. contents (by weight) , i.e. : 0.0%, 0.2% and 0.4% (for T.G.P.) , and 0.0% , 0.6% and 1.2% (for S.F.) . Each mix has three cubic (5×5×5)cm. specimens . It was found that , the addition of only S.F. to the local juss mixes , increases the compressive strength and bulk density for both (Water / Juss) ratios (0.3) and (0.4), while the setting time increases for (W / J = 0.4) but decreases for (W / J = 0.3) . And, the addition of only T.G.P. to the local juss mixes , the compressive strength and bulk density of juss increases for (W / J = 0.4) , but decreases for both (W / J) ratios (0.3) and (0.4) . It was also found that, when using both additives of S.F. and T.G.P. , the bad effect [on juss properties] of each individual additive is reduced by the presence of the other additive , while the good effect of each of them is enlarged by their combination [as compared with our no additives reference case] . Finally, it was found that for (W / J = 0.4) , the addition of both T.G.P. and S.F. at their upper content [S.F. / J = 1.2% , T.G.P. / J = 0.4%] gives the best percentage of increase for compressive strength , setting time , and bulk density of local juss.

***Keywords**: Local Juss (Gypsum), Tree Glue Powder (T.G.P.), Silica Fume (S.F.), Compressive Strength, Setting Time, Bulk Density.*

1- INTRODUCTION

Gypsum products have been exceedingly used in the recent years as in-door finishes. Houses , are either built from or lined with gypsums-based products , especially in Europeand U.S. , they are preferable by architects because of their supreme characteristics , such as obtainable availability of in-expensive raw materials , volumetric stability , thermal and vocal insulations , fire resistance , quite low toxicity and the comparatively low temperature and energy needed in its manufacture [1].Gypsum is also used in several implementations beyond the structural (building)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].

Many investigators have tried to develop gypsum characteristics as well as extend its applications domain through the addition of other materials [6],[7],[8]. One of these adding materials is Silica fume,although it is rarely used with gypsums [9] , it is a very good pozzolanic material with high reaction rateswhich reveals a very good effect in improving the compressive strength of gypsum [10].

The water/gypsum ratios have a real effect on the major mechanical characteristic of gypsum products, such as its volumetric densities, porosity, and other regardingproperties such as its humidity , mechanical, thermal and vocal isolation characteristics. The theoretical water / gypsum ratios needed for the hydrations of calcium sulfate hemi-hydrate $CaSO_4 \cdot ½H_2O$ into calcium sulfate dehydrate $CaSO_4 \cdot 2H_2O$ is(0.187) . Extrawater, in a quantity called over-stoichiometric, is needed for the hardening process of the paste of gypsum . The properties of the hardened gypsum made from the paste of gypsum by casting, compressing (or shaking) , depend on the values of the water-gypsum ratio[11].

One of the most disadvantages of gypsum mixes , precisely in the preparation of the gypsum 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 weakness point stimulated some researchers to search for additives that work as a gypsum retarders (increasing gypsum setting time) . Tree glue powder is found to be a very efficient one in this aspect [12].

2. Experimental Work

2.1. Materials

2.1.1. Gypsum

2.1.1.1. Gypsum Products

Substances that are produced from gypsum calcinations ($CaSO_4.2H_2O$) and having the chemical composition of hemihydrate ($CaSO_4.1/2H_2O$) are called "Gypsum Products". Although they are similar in composition and x-ray diffraction peaks , they are unlike in their physio- mechanical characteristics. They consist of three major kinds: local juss, plaster, and dental stones, each kind has various assortments [13]. The first type attains our concern in this research.

2.1.1.2. Local Juss (J) .

The word "juss" is derived from the Assyrian word "jasso". Local juss in Iraq is a material produced from calcined gypsum by the "Kouramethod" Gypsum rock pieces are placed on openings in the" koura" dome and the heat source is at the dome base . Heating continues for 24 hours. The final product "the juss" is a mixture of anhydrite, bassanite and unburnt gypsum.

Local juss (Gypsum) that is used as a main constituent in this project was calcium sulfate hemihydrate gypsum ($CaSO_4.½H_2O$), it was obtained from the local market of construction materials in Baghdad.

2.1.2. Silica Fume (S.F.) .

Silica fume is highly reactive pozzolanic substance and is a byproduct from the production of silicon or ferro- silicon metal. It is a very fine powder and composed from the flue gases from electric arc ovens .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".

2.1.3. Tree Glue Powder (T.G.P.).

Tree glue is taken from trees called (Arak) usually grow in Iran , it is grinded and used primarily for wooden works , but here it is used may be for the first time as an additive to local juss mixes .

2.1.4. Mixing Water

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

2.2. Gypsum Mixes

Eighteen mixes of gypsum have been studied in this research, these mixes were divided in to two groups according to (water/juss) ratios (0.3and 0.4). Each group (i.e. nine mixes) was arranged according to: T.G.P. and S.F. contents (by weight), i.e. : 0.0%,0.2% and 0.4% (for T.G.P.) , and 0.0%,0.6% and 1.2% (for S.F.) . These mixes are shown in Table (1).

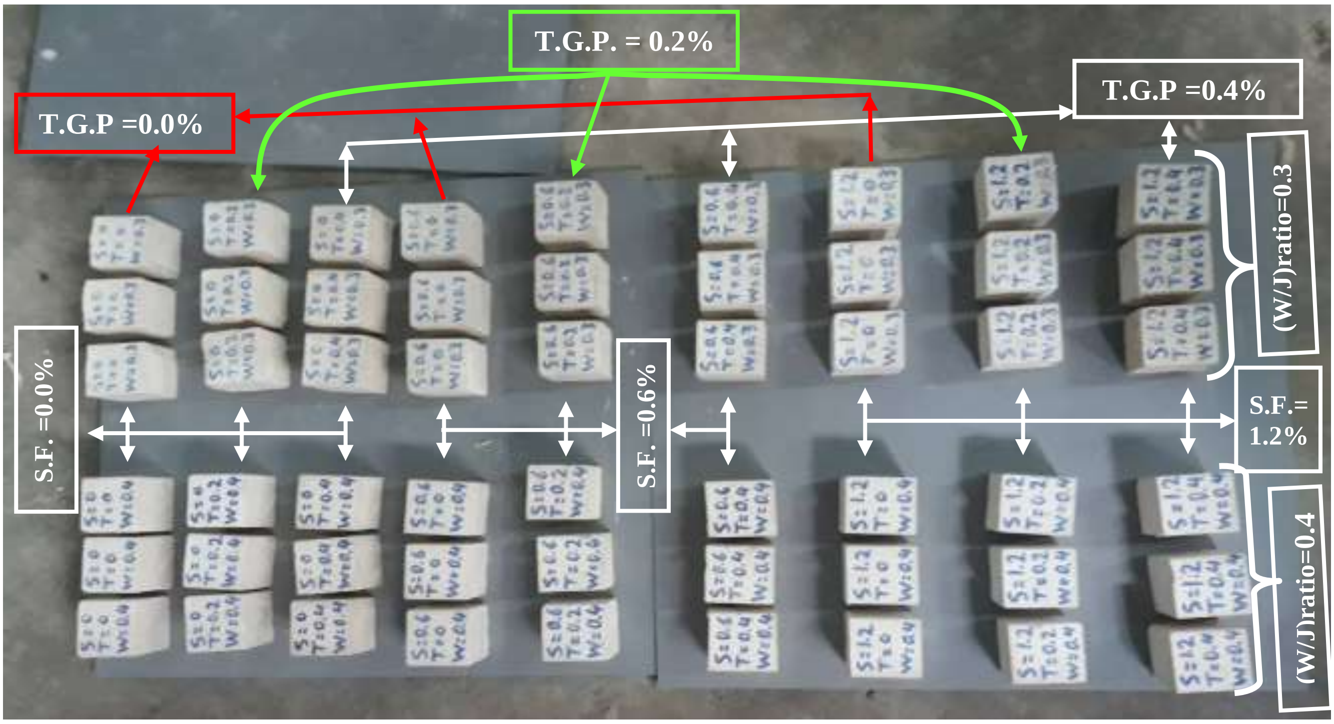

Figure 1: Groups of Tested Specimens

Table 1: Description of Mixes.

Mix No.	T.G.P. content % by weight	S.F content % by weight	(W/J) ratio	Ingredients Per (100g) Gypsum	Mix No.	T.G.P. content % by weight	S.F content % by weight	(W/J) ratio	Ingredients Per (100g) of Juss
Mix 1	0.0	0.0	0.3	(100g) of Juss + (0.0g) S.F +(0.0g)T.G.P + (30g) water	Mix 10	0.0	0.0	0.4	(100g) of Juss + (0.0g) S.F +(0.0g)T.G.P + (40g) water
Mix 2	0.2	0.0	0.3	(100g) of Juss + (0.0g) S.F+(0.2g)T.G.P + (30g) water	Mix 11	0.2	0.0	0.4	(100g) of Juss + (0.0g) S.F +(0.2g)T.G.P + (40g) water
Mix 3	0.4	0.0	0.3	(100g) of Juss +(0.0g) S.F+(0.4g)T.G.P + (30g) water	Mix 12	0.4	0.0	0.4	(100g) of Juss + (0.0g) S.F +(0.4g)T.G.P + (40g) water
Mix 4	0.0	0.6	0.3	(100g) of Juss + (0.6g) S.F+(0.0g)T.G.P + (30g) water	Mix 13	0.0	0.6	0.4	(100g) of Juss + (0.6g) S.F +(0.0g)T.G.P + (40g) water
Mix 5	0.2	0.6	0.3	(100g) of Juss + (0.6g) S.F+(0.2g)T.G.P + (30g) water	Mix 14	0.0	0.6	0.4	(100g) of Juss + (0.6g) S.F +(0.2g)T.G.P + (40g) water
Mix 6	0.4	0.6	0.3	(100g) of Juss + (0.6g) S.F+(0.4g)T.G.P + (30g) water	Mix 15	0.2	0.6	0.4	(100g) of Juss + (0.6g) S.F +(0.4g)T.G.P + (30g) water
Mix 7	0.0	1.2	0.3	(100g) of Juss + (1.2g) S.F+(0.0g)T.G.P + (30g) water	Mix 16	0.0	1.2	0.4	(100g) of Juss + (1.2g) S.F +(0.0g)T.G.P + (40g) water
Mix 8	0.2	1.2	0.3	(100g) of Juss + (1.2g) S.F+(0.2g)T.G.P + (30g) water	Mix 17	0.2	1.2	0.4	(100g) of Juss + (1.2g) S.F +(0.2g)T.G.P + (40g) water
Mix 9	0.4	1.2	0.3	(100g) of Juss + (1.2g) S.F+(0.4g)T.G.P + (30g) water	Mix 18	0.4	1.2	0.4	(100g) of Juss + (1.2g) S.F +(0.4g)T.G.P + (40g) water

2.3. Mixing Procedure

All mixes were made by weighted quantities (gypsum, T.G.P., S.F., and water). In the beginning, the required quantity of T.G.P.is added to the required quantity of water and mixed very well . On the other hand, the required quantity of S.F. is added to the required quantity of local juss and very well mixed ,then all components are re-mixedtogether manually for (approximately 40 seconds), then poured in to the mold. For mixes having (W / J =0.4) , the mold has been vibrated benefiting from the vibration of a(small generator) for about 10 second to ensure a good compaction of the mix , while mixes having (W / J =0.3) , the compaction process is achieved by pressing the mix into the mold . After about 50 minutes, the cubic (5×5×5cm) specimens were taken off from the mold. Then, the specimens were exposed to the direct sun light for about one week at approximately 38 °C heat.

2.4. Testing Program

2.4.1. Compression Strength.

In this research, the 50 mm cubic specimens were tested 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][14] **.**

2.4.2. Setting Time.

One of the most disadvantages of gypsum mixes, precisely in the preparation of the gypsum paste is that its setting time is rather small (e.g. 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 (T.G.P. and S.F.) individually and together on juss 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 semi-cone pan (60*70*40) mm dimensions**,** the apparatus is shown in Fig.(1-b) , [test is carried out according to ASTM :C472-99][14] .

Fig. (1-a) Compressive Strength Test **Fig.(1-b) Vicat Apparatus**

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2.4.3. Bulk Density.

The bulk density is equal to the weight of each sample divided by its volume [where the volumes were calculated by using the displaced mercury method] for all local juss mixes.

3. Parametric Study (Results &Discussions)

3.1. Compressive Strength:

3.1.1. Effect Of S.F. Content on Compressive Strength of Juss with Various (W/J) Ratios.

The right parts of Fig.(2) and Table (2) show that the compressive strength of juss increases with the increase of S.F. content for mixes having (W/J) = 0.3 and 0.4 . The reason for this increase might be related to the

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chemical effect of S.F. on the (water – gypsum) reaction which strengthens the interior bound between juss crystals.

3.1.2. Effect of T.G.P. Content on Compressive Strength of Juss with Various (W/J) Ratios.

The left parts of Fig.(2) and Table (2) show that : for mixes having (W / J = 0.3) , the compressive strength of juss decreases with increasing S.F. content. While for mixes having (W/J = 0.4) , the compressive strength of juss increases with increasing S.F. content . This behavior may be interpreted as follows : When T.G.P. is mixed with water , the result solution has an adhesive nature which strengthens the bond between the particles of juss for high water content mixes (of low strength) , while for low water content mixes (i.e. of high strength) there is no sufficient water for T.G.P. to attain its adhesive nature , hence the T.G.P. particles weakens the bond between the juss particles.

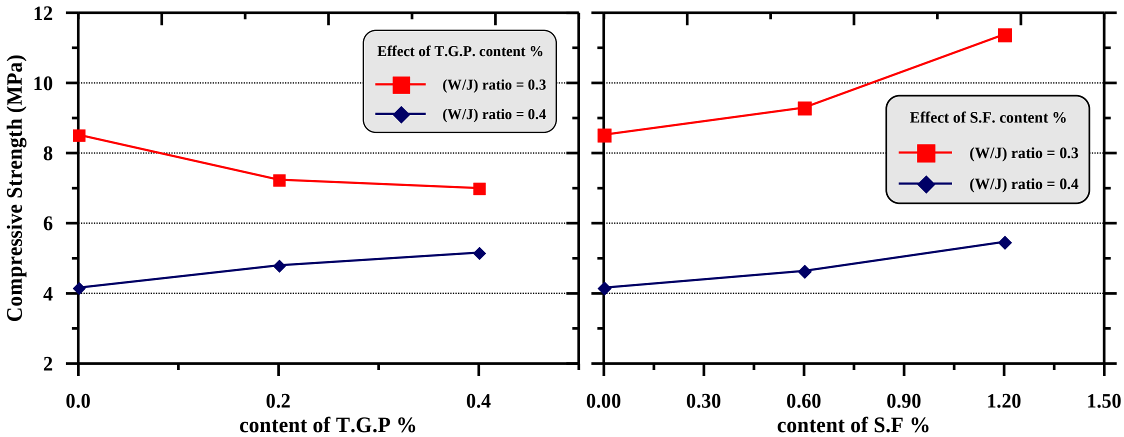


Figure (2) &Table (2): Effect of T.G.P. and S.F. Contentson Compressive Strength of Juss with Various (W/J) Ratios

Effect of T.G.P content % by weight					Effect of S.F content % by weight				
Mix No.	T.G.P content % by weight	Compressive strength MPa	Percentage of increase or decrease	(W/J) ratio	Mix No.	S.F. content % by weight	Compressive strength MPa	Percentage of increase	(W/J) ratio
Mix 1	0.0	8.52	-------	0.3	Mix 1	0.0	8.52	------	0.3
Mix 2	0.2	7.24	-15		Mix 4	0.6	9.29	9	
Mix 3	0.4	7.00	-17.8		Mix 7	1.2	11.38	33.5	
Mix 10	0.0	4.16	-------	0.4	Mix 10	0.0	4.16	------	0.4
Mix 11	0.2	4.80	+15.3		Mix 13	0.6	4.64	11.5	
Mix 12	0.4	5.16	+24		Mix 16	1.2	5.47	31.4	

3.1.3. Effect of (W/J) Ratio on Compressive Strength of Juss with Various S.F. Contents.

The right parts of Fig.(3) and Table (3) illustrate that : the compressive strength of juss decreases with increasing (W/J) ratio for all S.F. contents . And the percentage of this decrease is not obvious with the

increase of S.F. content. The reason of this result may be attributed to the fact that when (W/J) increases, the excessive water will stimulate
the gliding of particles and then decrease the cohesion between them which lead to the decrease in compressive strength [15] , another interpretation behind this result is that when the water increase, the amount of water excessive to the reaction water will produce voids after its evaporation and hence weakens the juss internal structure and as a result leads to a decrease in the material strength[16] .

3.1.4. Effect of (W/J) Ratio on Compressive Strength of Juss with Various T.G.P. Contents.

The left parts of Fig.(3) and Table (3) reveal that : The compressive strength ofjuss decreases with increasing (W/J) ratio for all T.G.P. contents . And the percentage of this decrease decreases with the increase of T.G.P. content. The reason of this behavior is exactly similar to that above-mentioned in the previous paragraph, besides, the adhesion nature of (T.G.P.– water) solution reduces the declination of this drop in compressive strength.

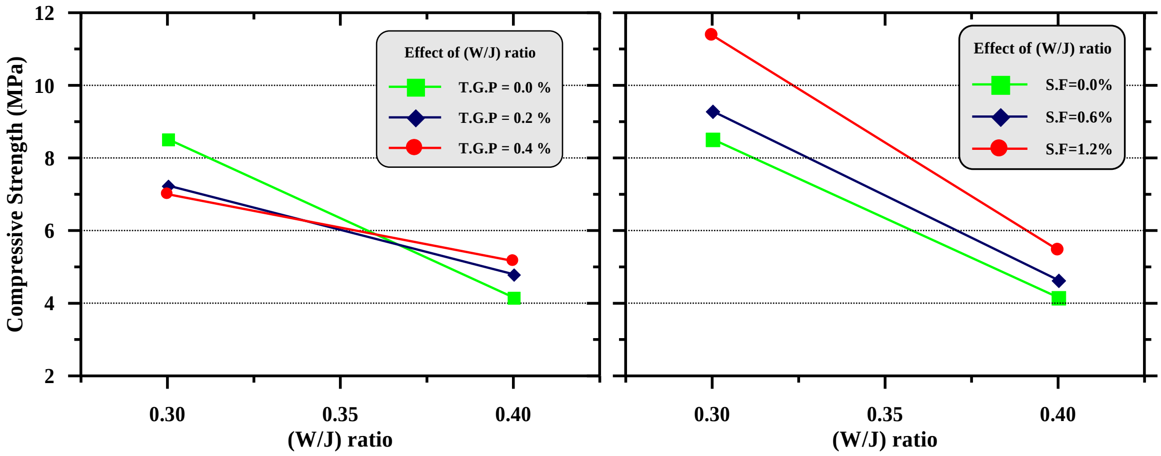


Figure (3) & Table (3): Effect of (W/J) Ratio on Compressive Strength of Juss with Various S.F. and T.G.P. Contents

Effect of (W/J) ratio with various T.G.P content					Effect of (W/J) ratio with various S.F content				
Mix No.	(W/J) ratio	Compressive strength(MPa)	Percentage of decrease	T.G.P. content % by weight	Mix No.	(W/J) ratio	Compressive strength(MPa)	Percentage of decrease	S.F. content % by weight
Mix 1	0.3	8.52	------	0.0	Mix 1	0.3	8.52	------	0.0
Mix 10	0.4	4.16	51.1		Mix 10	0.4	4.16	51.1	
Mix 2	0.3	7.24	------	0.2	Mix 4	0.3	9.29	------	0.6
Mix 11	0.4	4.80	33.7		Mix 13	0.4	4.64	50.0	
Mix 3	0.3	7.00	------	0.4	Mix 7	0.3	11.38	------	1.2
Mix 12	0.4	5.16	26.2		Mix 16	0.4	5.47	51.9	

3.1.5. Combined Effect of S.F. and T.G.P. Contents on Compressive Strength of Juss.

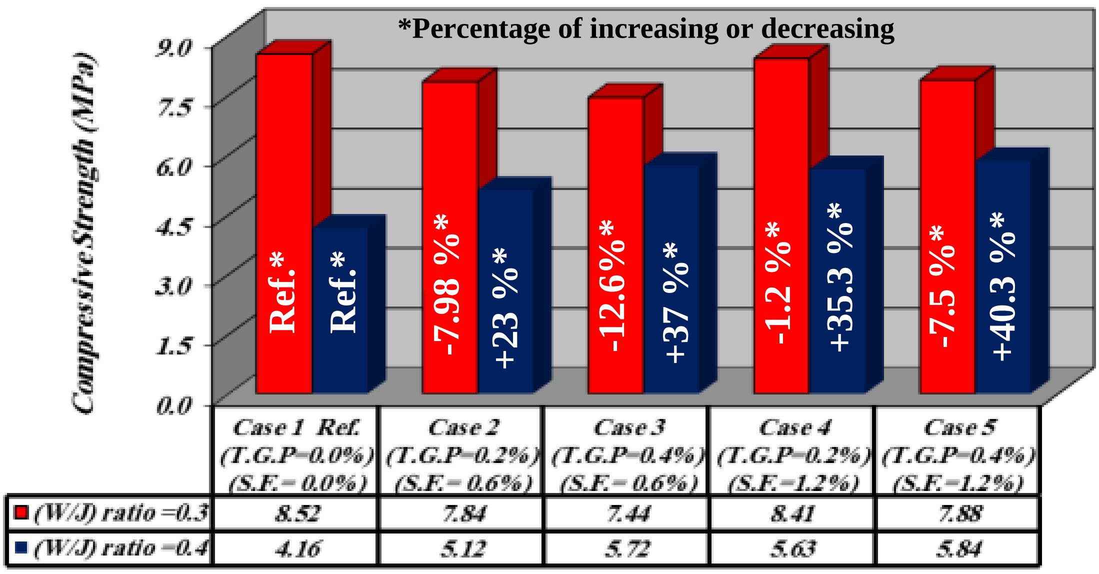
Bar Chart(1) illustrates the final results of thecombined effect of using both S.F. and T.G.P. additives on the compressive strength of juss . From this bar chart, one can state the following comparisons:

a) Comparing (case 2) with (case 3) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (=0.6%)] reveals that , for mixes having (W/J = 0.3) , the compressive strength of juss decreases , and the percentage of this decrease with respect to (case 1) [T.G.P = S.F. = 0.0%] increases with increasing T.G.P. content . While for mixes having (W/J = 0.4) , the compressive strength of juss increases , and the percentage of this increase with respect to (case 1) also increases with increasing T.G.P. content .

b) Comparing (case 4) with (case 5) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (= 1.2%)] shows the same behavior of paragraph (a) .

c) Comparing (case 2) with (case 4) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.2%)] reveals that , for mixes having (W/J = 0.3) , the compressive strength of juss increases , and the percentage of this increase with respect to (case 1) [T.G.P = S.F. = 0.0%] decreases with increasing S.F. content . The same behavior remains for mixes having (W/J = 0.4),but the percentage of this increase with respect to (case 1) increases with increasing S.F. content .

d) Comparing (case 3) with (case 5) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.4%)] reveals that , for mixes having (W/J = 0.3) , the compressive strength of juss increases , and the percentage of this increase with respect to (case 1) [T.G.P = S.F. = 0.0%] decreases with increasing S.F. content . The same behavior remains for mixes having (W/J = 0.4) , but the percentage of this increase with respect to (case 1) increases with increasing S.F. content .



Bar Chart (1): Combined Effect of T.G.P. and S.F. Contents on Compressive Strength of Juss For (W/J) Ratio = (0.3) and (0.4) .

3.1.6 Global Compressive Strength Results (G.C.S.R.).

The Table (G.C.S.R.) presents a global view over the entire results of juss compressive strength . From this table, one can notice the following behavior:

1) From the right part of the table, one can notice that, for mixes having (W/J) equals (0.3) and (0.4) , the compressive strength of juss increases with increasing S.F. content . The percentage of this increase decreases with the increase of T.G.P. content [knowing that this (%) of increase is computed according to mixes having T.G.P. contents: 0.0%, 0.2%, and 0.4%]. This means that, the effect of S.F. is reduced by the presence of T.G.P. .

2) **(A)**: From the upper left part of the table, one can see that, for mixes having (W/J = 0.3) , the compressive strength of juss decreases with increasing T.G.P. content . The percentage of this decrease increases with the increase of S.F. content [knowing that, this (%) of increase is computed according to mixes having S.F. contents: 0.0% , 0.6% , and 1.2%] . Which means that , the bad effect of T.G.P. is enlarged by the presence of S.F. .

(B) : From the lower left part of the table , one can find that , for mixes having (W/J = 0.4) , the compressive strength of juss increases with increasing T.G.P. content . The percentage of this increase decreases with the increase of S.F. content [knowing that, this (%) of increase is computed according to mixes having S.F. contents: 0.0%, 0.6%, and 1.2%]. Which means that, the effect of T.G.P. is reduced by the presence of S.F. .

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Table (G.C.S.R.): Table of (Global Compressive Strength Results).

Effect of T.G.P content % by weight							Effect of S.F content % by weight					
Mix No.	**T.G.P. content % by weight**	**Compressive strength MPa**	**Percentage of increase or decrease %**	**S.F. content % by weight**	**(W/J) ratio**		**Mix No.**	**S.F. content % by weight**	**Compressive strength MPa**	**Percentage of Increase %**	**T.G.P. content % by weight**	**(W/J) ratio**
Mix 1	0.0	8.52	-------				Mix 1	0.0	8.52	------		
Mix 2	0.2	7.24	-15	0.0	0.3		Mix 4	0.6	9.29	9	0.0	0.3
Mix 3	0.4	7.00	-17.8				Mix 7	1.2	11.38	33.5		
Mix 4	0.0	9.29	-------				Mix 2	0.0	7.24	------		
Mix 5	0.2	7.84	-15.6	0.6	0.3		Mix 5	0.6	7.84	8.2	0.2	0.3
Mix 6	0.4	7.44	-19.9				Mix 8	1.2	8.41	16.1		
Mix 7	0.0	11.38	-------				Mix 3	0.0	7.00	------		
Mix 8	0.2	8.41	-26	1.2	0.3		Mix 6	0.6	7.44	6.2	0.4	0.3
Mix 9	0.4	7.88	-30.7				Mix 9	1.2	7.88	12.5		
Mix 10	0.0	4.16	-------				Mix 10	0.0	4.16	------		
Mix 11	0.2	4.80	+15.3	0.0	0.4		Mix 13	0.6	4.64	11.5	0.0	0.4
Mix 12	0.4	5.16	+24				Mix 16	1.2	5.47	31.4		
Mix 13	0.0	4.64	-------				Mix 11	0.0	4.80	------		
Mix 14	0.2	5.12	+10.3	0.6	0.4		Mix 14	0.6	5.12	6.6	0.2	0.4
Mix 15	0.4	5.72	+23.2				Mix 17	1.2	5.63	17.2		
Mix 16	0.0	5.47	-------				Mix 12	0.0	5.16	------		
Mix 17	0.2	5.63	+2.9	1.2	0.4		Mix 15	0.6	5.72	10.8	0.4	0.4
Mix 18	0.4	5.84	+6.7				Mix 18	1.2	5.84	13.1		

3.2. Setting Time.

3.2.1. Effect Of S.F. Content on Setting Time of Juss with Various (W/J) Ratios .

The right parts of Fig.(4) and Table (4)reveals that : for mixes having (W/J = 0.3) , the setting time of juss decreases with the increase of S.F. content . The reason for this increase might be related to the chemical effect of S.F. on the (water – juss) reaction which strengthens the interior bound between local juss crystal sand accelerating the mentioned reaction. While for mixes having (W/J = 0.4) , the setting time of juss slightly increases with increasing S.F. content . It is difficult to understand the exact reason for this behavior , so we couldn't find a logical interpretation to it .

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3.2.2. Effect of T.G.P. Content on Setting Time of Juss with Various (W/J) Ratios .

The left parts of Fig.(4) and Table (4) show that the setting time of juss increases with the increase of S.F. content for mixes having (W/J) = 0.3 and 0.4 . The reason for this increase perhaps because of the adhesive and viscous nature of the (T.G.P. – water) solution that tends to slow down the (gypsum – water) chemical reaction process as any other retarder agent do .

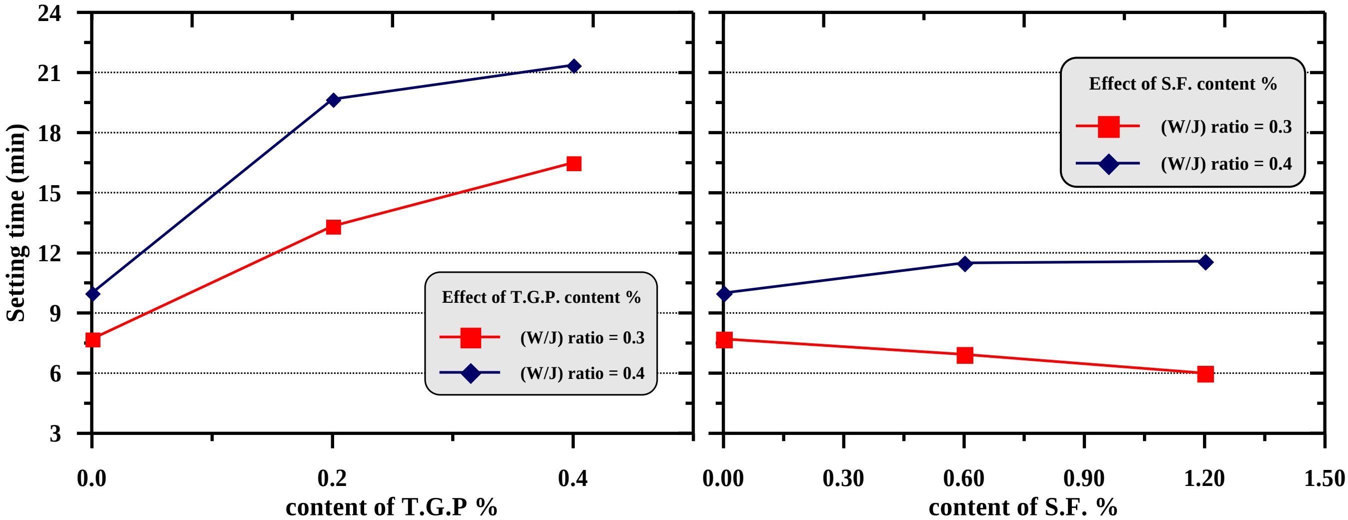

Figure (4) &Table (4): Effect of T.G.P. and S.F. Contentson Setting Time of Juss with Various (W/J) Ratios

Effect of T.G.P content % by weight						Effect of S.F content % by weight				
Mix No.	**T.G.P content % by weight**	**Setting time (min)**	**Percentage of decrease**	**(W/J) ratio**		**Mix No.**	**S.F. content % by weight**	**Setting time (min)**	**Percentage of increase OR decrease**	**(W/J) ratio**
Mix 1	0.0	7.70	-------	0.3		Mix 1	0.0	7.70	-------	0.3
Mix 2	0.2	13.33	-73.1			Mix 4	0.6	6.93	-10	
Mix 3	0.4	16.50	-114			Mix 7	1.2	6.00	-22	
Mix 10	0.0	10.00	-------	0.4		Mix 10	0.0	10.00	-------	0.4
Mix 11	0.2	19.67	-96.7			Mix 13	0.6	11.50	+15	
Mix 12	0.4	21.37	-113.7			Mix 16	1.2	11.58	+15.8	

3.2.3. Effect of (W/J) Ratio on Setting Time of Juss with Various S.F. Contents.

The right parts of Fig.(5) and Table (5) illustrate that : the setting time of juss increases with the increase of (W/J) ratio for all S.F. contents . And the percentage of this increase increases with the increase of S.F. content .The result indicates that S.F. has a very slight contribution to work as a retarding agent.

3.2.4. Effect of (W/J) Ratio on Setting Time of Juss with Various T.G.P. Contents.

The left parts of Fig.(5) and Table (5) show that : the setting time of juss increases with the increase of (W/J) ratio for all T.G.P. contents . And the percentage of this increase is not obvious with the increase of T.G.P. content .The results don't need any interpretation because the T.G.P. is the major retarder in this research and it is working so.

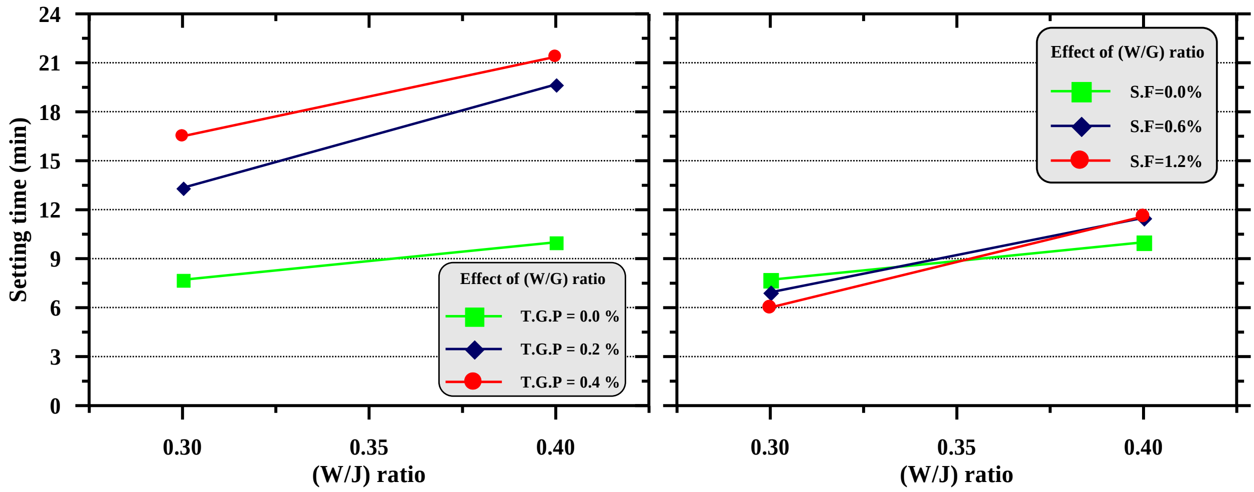

Figure (5) &Table (5): Effect of (W/J) Ratio on Setting Time of Juss with Various S.F. and T.G.P. Contents

Effect of (W/J) ratio with various T.G.P content					Effect of (W/J) ratio with various S.F content				
Mix No.	**(W/J) ratio**	**Setting time (min)**	**Percentage of increase**	**T.G.P content % by weight**	**Mix No.**	**(W/J) ratio**	**Setting time (min)**	**Percentage of increase**	**S.F content % by weight**
Mix 1	0.3	7.70	-------	0.0	Mix 1	0.3	7.70	-------	0.0
Mix 10	0.4	10.00	+29.8		Mix 10	0.4	10.00	+29.8	
Mix 2	0.3	13.33	-------	0.2	Mix 4	0.3	6.93	-------	0.6
Mix 11	0.4	19.67	+47.5		Mix 13	0.4	11.50	+65.9	
Mix 3	0.3	16.50	-------	0.4	Mix 7	0.3	6.00	-------	1.2
Mix 12	0.4	21.37	+29.5		Mix 16	0.4	11.58	+88	

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3.2.5. Combined Effect of S.F. and T.G.P. Contents on Setting Time of Juss.

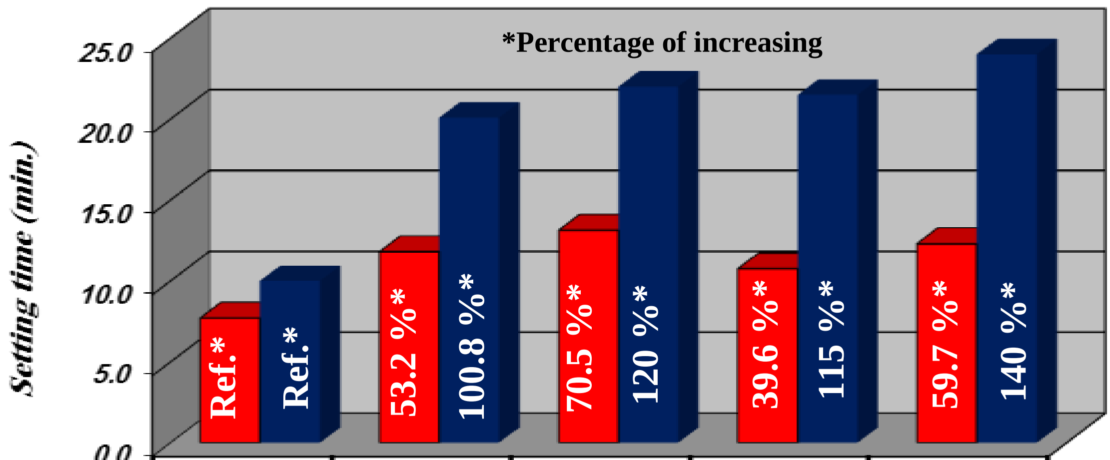
Bar Chart (2) illustrates the final results of the combined effect of using both S.F. and T.G.P. additives on the setting time of juss . From this bar chart, one can state the following comparisons:

a) : Comparing (case 2) with (case 3) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (= 0.6%)] reveals that , for mixes having (W/J) = (0.3) and (0.4) , the setting time of juss increases , and the percentage of this increase with respect to (case 1) [T.G.P = S.F. = 0.0%] increases with increasing T.G.P. content .

b) : Comparing (case 4) with (case 5) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (= 1.2%)] shows the same behavior of paragraph (a) .

c) : Comparing (case 2) with (case 4) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.2%)] reveals that , for mixes having (W/J = 0.3) , the setting time of juss decreases , and the percentage of this increase with respect to (case 1) [T.G.P = S.F. = 0.0%] also decreases with increasing S.F. content . While for mixes having (W/J = 0.4) the setting time increases , and the percentage of this increase with respect to (case 1) also increases with increasing S.F. content .

d) : Comparing (case 3) with (case 5) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.4%)] shows the same behavior of paragraph (c) .



	Case 1 Ref. (T.G.P=0.0%) (S.F.= 0.0%)	Case 2 (T.G.P=0.2%) (S.F.= 0.6%)	Case 3 (T.G.P=0.4%) (S.F.= 0.6%)	Case 4 (T.G.P=0.2%) (S.F.=1.2%)	Case 5 (T.G.P=0.4%) (S.F.=1.2%)
(W/J) ratio =0.3	7.70	11.80	13.13	10.75	12.30
(W/J) ratio =0.4	10.00	20.08	22.00	21.50	24.00

Bar Chart (2): Combined Effect of T.G.P. and S.F. Contents on Setting Time of Juss For (W/J) Ratio = (0.3) And (0.4) .

3.3. Bulk Density.

3.3.1. Effect of S.F. Content on Bulk Density of Juss with Various (W/J) Ratios.

The right parts of Fig.(6) and Table (6) show that the bulk density of juss increases with the increase of S.F. content for mixes having (W/J) = 0.3 and 0.4 . The percentage of this increase increases with the increase of

(W/J). The interpretation of this increase may bebecause the S.F. particlestend to fill the interstitial spaces between the local juss grains causing the increase in the weight without increasing the volume, and as a result increasing the bulk density, in addition to thechemical effect of S.F. on eliminating the voids in the mix .

3.3.2. Effect of T.G.P. Content on Bulk Density of Juss with Various (W/J) Ratios.

The left parts of Fig.(6) and Table (6)reveals that : for mixes having (W/J = 0.3) , the bulk density of juss decreases with the increase of T.G.P. content . It is difficult to understand the exact reason for this behavior , so we couldn't find a logical interpretation to it . While for mixes having (W/J = 0.4) , the bulk density of juss increases with the increase of T.G.P. content . The reason for this increase perhaps because of the adhesive and viscous nature of the (T.G.P. – water) solution which improves the compaction process and lead to this increase in bulk density .

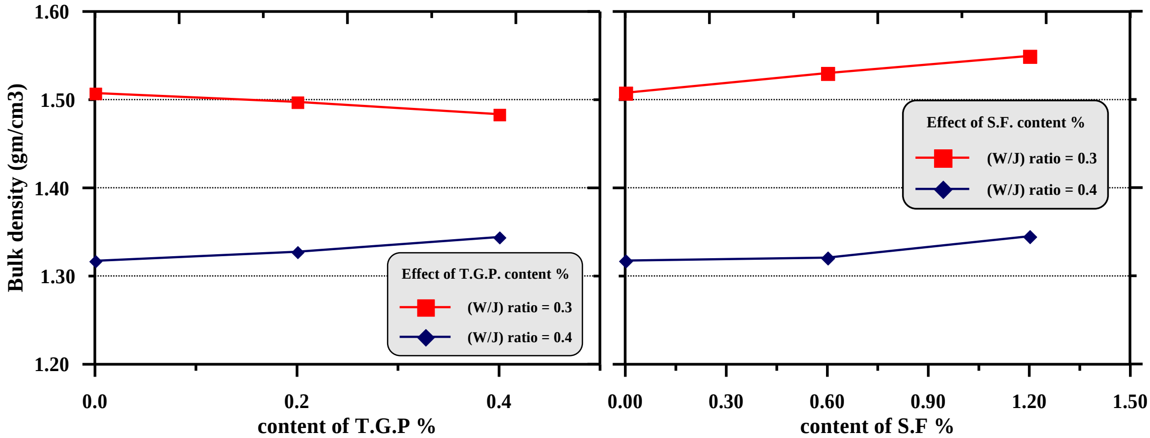


Figure (6) & Table (6): Effect of T.G.P. and S.F. Contents on Setting Time of Juss with Various (W/J) Ratios

Effect of T.G.P content % by weight						Effect of S.F content % by weight				
Mix No.	T.G.P content % by weight	Bulk density (gm/cm3)	Percentage of increaseor decrease	(W/J) ratio		Mix No.	S.F. content % by weight	Bulk density (gm/cm3)	Percentage of increase	(W/J) ratio
Mix 1	0.0	1.507	-------	0.3		Mix 1	0.0	1.507	------	0.3
Mix 2	0.2	1.497	-0.66			Mix 4	0.6	1.530	+1.52	
Mix 3	0.4	1.484	-1.52			Mix 7	1.2	1.549	+2.78	
Mix 10	0.0	1.317	-------	0.4		Mix 10	0.0	1.317	------	0.4
Mix 11	0.2	1.328	+0.83			Mix 13	0.6	1.321	+0.3	
Mix 12	0.4	1.344	+2.05			Mix 16	1.2	1.345	+2.1	

3.3.3. Effect of (W/J) Ratio on Bulk Density of Juss with Various S.F. Contents .

The right parts of Fig.(7) and Table (7) illustrate that : the bulk density of juss decreases with the increase of (W/J) ratio for all S.F. contents . And the percentage of this decrease is not obvious for S.F.content .The reason of this decreasing may be because of the generations of airs bubble tripped during the mixing process and the evaporation of the excessive waters which is needs for workability purpose.

3.3.4. Effect of (W/J) Ratio on Bulk Density of Juss with Various T.G.P. Contents.

The left parts of Fig.(7) and Table (7) show that : the bulk density of juss decreases with the increase of (W/J) ratio for all T.G.P. contents . And the percentage of this decrease also decreases with the increase of T.G.P. content .The reason for this decrease perhaps because of the adhesive and viscous nature of the (T.G.P. – water) solution which improves the compaction process and lead to this increase in bulk density .

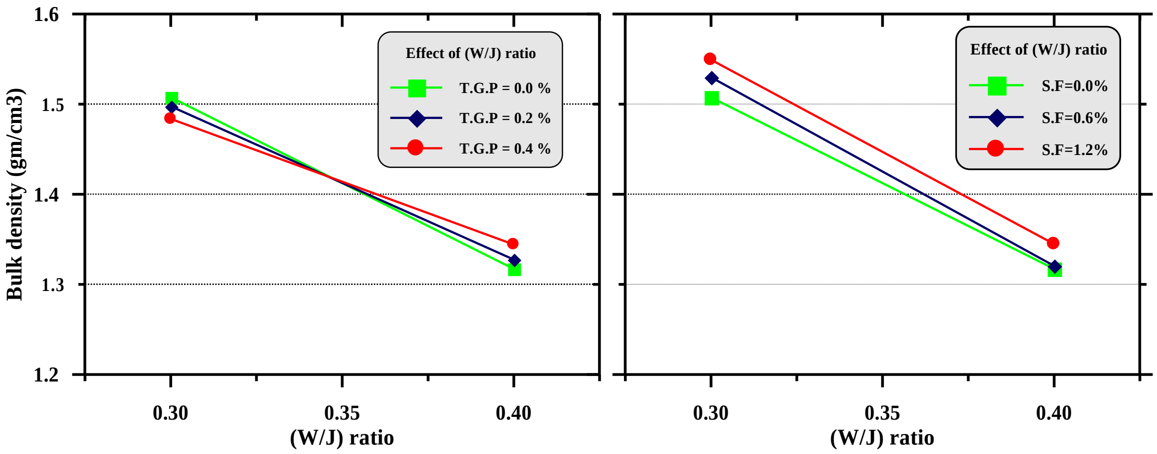


Figure (7) &Table (7): Effect of (W/J) Ratio on Bulk Density of Juss with Various S.F. and T.G.P. Contents

Effect of (W/J) ratio with various T.G.P content					Effect of (W/J) ratio with various S.F content				
Mix No.	(W/J) ratio	Bulk density (gm/cm3)	Percentage of decrease	T.G.P. content %by weight	Mix No.	(W/J) ratio	Bulk density (gm/cm3)	Percentage of decrease	S.F. content %by weight
Mix 1	0.3	1.507	------	0.0	Mix 1	0.3	1.507	------	0.0
Mix 10	0.4	1.317	-12.6		Mix 10	0.4	1.317	-12.6	
Mix 2	0.3	1.497	------	0.2	Mix 4	0.3	1.530	------	0.6
Mix 11	0.4	1.328	-11.2		Mix 13	0.4	1.321	-13.6	
Mix 3	0.3	1.484	------	0.4	Mix 7	0.3	1.549	------	1.2
Mix 12	0.4	1.344	-9.4		Mix 16	0.4	1.345	-13.1	

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3.3.5. Combined Effect Of S.F. and T.G.P. Contents on Bulk Density of Juss.

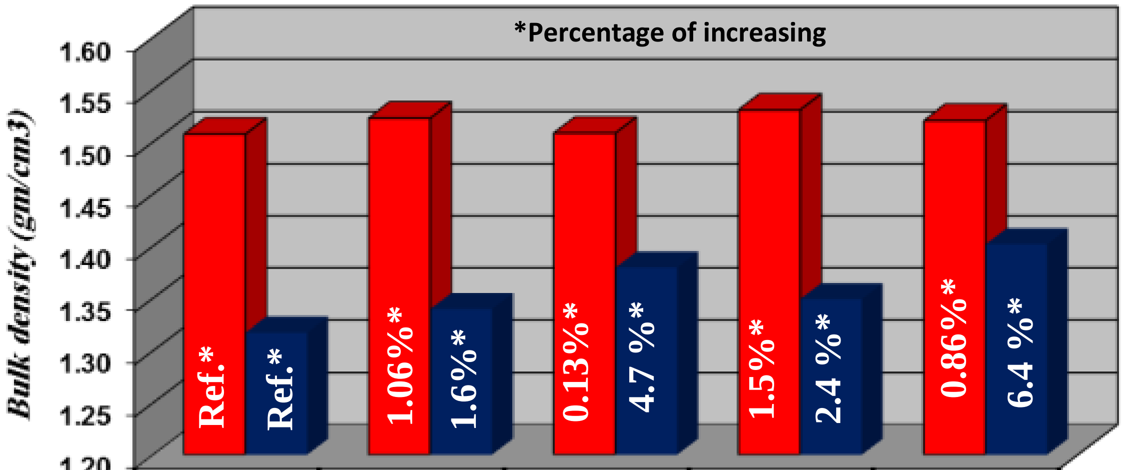
Bar Chart (3) illustrates the final results of the combined effect of using both S.F. and T.G.P. additives on the bulk density of juss . From this bar chart, one can state the following comparisons:

a) Comparing (case 2) with (case 3) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (= 0.6%)] reveals that , for mixes having (W/J = 0.3) , the bulk density of juss decreases , and the percentage of this decrease with respect to (case 1) [T.G.P = S.F. = 0.0%] also decreases with increasing T.G.P. content . While for mixes having (W/J = 0.4) the bulk density increases , and the percentage of this increase with respect to (case 1) also increases with increasing T.G.P. content .

b) Comparing (case 4) with (case 5) [i.e. increasing T.G.P. content from (0.2%) to (0.4%) with keeping S.F. content as constant (= 1.2%)] shows the same behavior of paragraph (a) .

c) Comparing (case 2) with (case 4) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.2%)] reveals that , for mixes having (W/J) = (0.3) and (0.4) , the bulk density of juss increases , and the percentage of this increase with respect to (case 1) [T.G.P = S.F. = 0.0%] increases with increasing S.F. content .

d) Comparing (case 3) with (case 5) [i.e. increasing S.F. content from (0.6%) to (1.2%) with keeping T.G.P. content as constant (= 0.4%)] shows the same behavior of paragraph (c) .



	Case 1 Ref. (T.G.P=0.0%) (S.F.= 0.0%)	Case 2 (T.G.P=0.2%)(S.F.= 0.6%)	Case 3 (T.G.P=0.4%)(S.F.= 0.6%)	Case 4 (T.G.P=0.2%)(S.F.=1.2%)	Case 5 (T.G.P=0.4%)(S.F.=1.2%)
(W/J) ratio =0.3	1.507	1.523	1.509	1.530	1.520
(W/J) ratio =0.4	1.317	1.339	1.379	1.349	1.402

Bar Chart (3): Combined Effect of T.G.P. and S.F. Contents on Bulk Density of Juss For (W/J) Ratio = (0.3) and (0.4).

As we reach to the end of our research , we present Table (8) , which displays the best (%) of additive combinations i.e. gives the best (%) of changing of the three local juss properties (the compressive strength , the setting time , and the bulk density) as follows :-

The Table (8) shows that , for (W/J = 0.3) , there are two (%) ratios which gave the best results , namely :

(1): Mix.9 [case 5] : gave (-7.5% , +59.7% , and +0.68%) for Compressive Strength , Setting Time , and Bulk Density , respectively , as compared with no additives mix. (Mix.1 [case 1]).

(2): Mix.8 [case 4] : gave (-1.2% , +39.6% , and +1.5%) for Compressive Strength , Setting Time , and Bulk Density , respectively , as compared with no additives mix. (Mix.1 [case 1]).

Table (8) also shows that, for (W/J = 0.4) , there is only one (%) ratio which gave the best results, namely :

(1): Mix.18 [case 5] : gave (+40.3% , +140% , and +6.4%) for Compressive Strength , Setting Time , and Bulk Density , respectively , as compared with no additives mix. (Mix. 10 [case 1]) .

Table (8) : Results of the Best Additive Combinations Effect on Properties of Juss .

Mix No.	(W/J) ratio	T.G.P. content % by weight	S.F. content % by weight	Type of addition	Percentage of changing in Compressive strength %	Percentage of changing in Setting time%	Percentage of changing in Bulk density%
Mix 1	0.3	0.0	0.0	Ref.	Ref.	Ref.	Ref.
Mix7	0.3	0.0	1.2	Individual	+33.5	-22	+2.78
Mix 3	0.3	0.4	0.0	Individual	-17.8	+114	-1.52
Mix 2	0.3	0.2	0.0	Individual	-15	+73	-0.66
Mix 9	0.3	0.4	1.2	Combined (case 5)	-7.5	+59.7	+0.68
Mix 8	0.3	0.2	1.2	Combined (case 4)	-1.2	39.6	+1.5
Mix10	0.4	0.0	0.0	Ref.	Ref.	Ref.	Ref.
Mix 12	0.4	0.0	1.2	Individual	+31.4	+15	+2.1
Mix 16	0.4	0.4	0.0	Individual	+24	+113.7	+2.05
Mix 18	0.4	0.4	1.2	Combined (case 5)	+40.3	+140	+6.4

4. Conclusions

(1): Addition of (S.F.)alone to mixes of local juss , increases the compressive strength and bulk density for both (W/J) ratios(0.3) and (0.4) .

(2): Addition of (T.G.P.) alone to mixes of local juss , decreases the compressive strength and bulk density for mixes having (W/J = 0.3) , and increases the compressive strength for mixes having (W/J = 0.4) .

(3): Increasing (W/J) ratio from (0.3) to (0.4) decreases the compressive strength and bulk density of juss . The percentage of this decrease "decreases" with the increase of (T.G.P.) alone , but the behavior of this percentage of decrease is not obvious for (S.F.) alone .

(4) : Addition of (S.F.) alone to mixes of local juss , decreases the setting time for mixes having (W/J = 0.3) , and increases the setting time for mixes having (W/J = 0.4) .

(5) : Addition of (T.G.P.) alone to mixes of local juss , increases the setting time for both (W/J) ratios (0.3)and (0.4) .

(6) : Increasing (W/J) ratio from (0.3) to (0.4) increases the setting time of local juss . The percentage of this increase "increases" with the increase of (S.F.) alone , but the behavior of the percentage of increase is not obvious in (T.G.P.) alone .

(7) : For juss mixes having (W/J = 0.3) , when both additives are used with their upper content [i.e. S.F./J = 1.2% and T.G.P./J = 0.4%] , the percentage of change of the three local juss properties with respect to mix with no additives at all , are : (-7.5%) for compressive strength, (+ 59.7 %) for setting time , and (+ 0.68 %) for bulk density .

(8) : For juss mixes having (W/J = 0.4) , when both additives are used with their upper content [i.e. S.F./J = 1.2% and T.G.P./J = 0.4%] , the percentage of change of the three local juss properties with respect to mix with no additives at all , are : (+ 40.3%) for compressive strength, (+ 140 %) for setting time , and (+ 6.4 %) for bulk density .

(9): For mixes having (W/J) equals (0.3) and (0.4), the compressive strength of juss increases with the increase of S.F. content. The percentage of this increase decreases with the increase of T.G.P. content [knowing that this (%) of increase is computed according to mixes having T.G.P. contents: 0.0%, 0.2%, and 0.4%]. This means that, the effect of S.F. is reduced by the presence of T.G.P. .

(10): For mixes having (W/J = 0.3) , the compressive strength of juss decreases with increasing T.G.P. content . The percentage of this decrease increases with the increase of S.F. content[knowing that this (%) of increase is computed according to mixes having S.F. contents : 0.0% , 0.6% , and 1.2%] . Which means that , the effect of T.G.P. is enlarged by the presence of S.F. .

(11): For mixes having (W/J = 0.4) , the compressive strength of juss increases with increasing T.G.P. content . The percentage of this increase decreases with the increase of S.F. content [knowing that this (%) of increase is computed according to mixes having S.F. contents: 0.0%, 0.6% , and 1.2%]. Which means that, the effect of T.G.P. is reduced by the presence of S.F. .

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