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Using of Furfural to Modify the Ordinary Portland Cement

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Abstract. This study reported the results of adding furfural on mechanical properties of Ordinary Iraqi cement. Furfural was used at four different ratios (1%, 2%, 3%, and 5 %) by weight to the mix of Iraqi Portland cement (Um- Quasar factory cement). The effect on the plasticizing and fluidity by table flow test for cement paste and slump test of fresh concrete were studied. The obtained results showed that added furfural is acting as super plasticizer. Effective relation was found between fluidity and ratio of added through effecting time of flow where the most effect additive ratio was found to be 3% .The radius of cement paste circle is linearly dependence which is a indicate of high workability. Obtained results explained in term of electrical charges on cement particles. Also found that adding furfural increasing the dispersion work between cement paste particles and preventing coarse agglomerated. The using of furfural with concrete indicates two kinds of concrete behavior. These behaviors were strongly dependence on furfural ratio .The critical value of added furfural was 1% and after which a plasticizing effect obtained.

Splitting and flexural tensile test were conducted. Three types of curing methods include dry, moisture and water curing. The obtained results showed that the moisture curing was better than other curing methods due to good results obtained with splitting tensile (6.18 N/mm^2) for 5% ratio and water curing is preferred for flexural tensile (7.05 N/mm^2 at 2% wt% of furfural).

Finally, we compared our results with AL-Abraaj Kuwait cement and we found that the Iraqi cement (Um Quasar factory cement) was better.

Introduction:

The varying in chemical additives have a significant effect on concrete workability where these additives have direct or indirect affect interfere with ordinary Portland cement which causing accelerator or retarded on cement react with water, therefore any lack of used water in concrete or cement mix causing different changes on mechanical properties. The water retarder dispersed the cement particles lead to improved the workability and increase the consistence of mixes [1, 2], ACI code (American Concrete Institute) defined or describes workability as "that property of freshly mixed concrete or mortar that determines the ease with which it can be mixed, placed, consolidated, and finished to a homogenous condition [3]. The published researches in this field that the mineral additives or Portland material have a positive effect on mechanical properties of cement or concrete mixes. Such as compressive strength, flexural strength and splitting tensile strength [4, 5], while the fly ash (which generated from crashing the cold volcanic rocks) causing increase the workability[6], while the fume silica have negative effect on workability [7,8].

The most important advantage of the used plasticizer in concrete mixes or cement mixes is keep stable of workability especially in hot and dry regions , and any changing of this property causing most popular problem in fresh mixes which decrease the slump values which effect on the mechanical properties. Research recently towards to modify a mix with zero slump loss for more

than 1 hour [9]. One of the methods using super plasticizer depends on dispersal of cement particles, which heavily clustered and thus increase the liquidity of cement or concrete mixes due to action of dispersal [10]. Polymer modified concrete has higher strength, lower water permeability, better resistance to chemicals, and greater freeze-thaw stability than conventional concrete, due to influence of polymer on the material structures, cement hydration, porosity, and unit water content, and to the chemical and physical interactions [11]. These properties make polymer modified concrete a suitable for repair of structural members, water proofing, anti corrosive and ,overlay of pavements, bridges and industrial's floors.

In recent years, using polymers in concrete was widely used due to rapidly deterioration of reinforced concrete especially in Bridge or Marine structure due to exposing to the aggressive environments. This research include the furfural mixture, which is consider an industrial waste material in this study (monomer , oligmer , polymer) to be added to the cement paste and fresh concrete mixes to know how its affecting on the flow and plasticity of Portland Iraqi cement and comparing the result with Kuwait Portland cement (type Al Abraaj).

Work Method

In this study we used the Iraqi Portland Cement product by UM QASER CEMENT FACTORY where the sand used was from the Zubair-Area in west of Basrah governorate , size of sand is passing through sieve size 2.36 mm, The mix proportion were (1:3) cement : sand ratio and mix all the materials *(cement + sand + water)* by hand to get homogenous mix. Four different ratios of furfural *(1 %, 25, 3%, and 5%)* in modifying both concrete and cement paste. Furfural brought from the Company of South Refinery (Iraqi Company) after storing for long time under high temperature where an oxidative state obtained. This oxidative state is a combination of monomer, oligmers, and polymers that makes it a waste to that company and not useful material. The water cement ratio were maintained at *(0.41)* and *(0.50)* by weight for both mortar and concrete respectively. The adding process of furfural to the cement or concrete was during the casting of mortar and concrete specimens. Pouring in steel mold with dimension *(50 x 50 x 50)* mm cubes where pouring concrete in three layers and feeding each layer by the furfural. These specimens were remove from the mold after 24 hours, and then left in air, water, and moisture for 14 days until the time of test. Three samples were tested for each test result value. The test specimens were cure in air, water and moisture cured for 14 days .At each testing curing method, at least three identical specimens were test obtained the required property of the cement and concrete. Fig.(1) and Fig. (2). show the measurement instruments , and molds *(cylindrical 50 mm dia. and 100 mm height)* and prismatic mold *(300 mm x 50 mm x50mm)* .

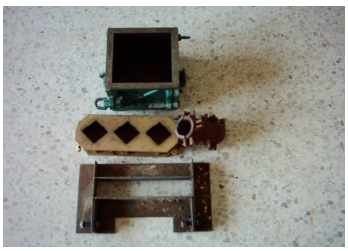

Fig.(1) Steel mold shape

Fig.(2) Machine test

The principle and equations used to calculate the tensile and flexural strength are shown below in Fig. (3) and Fig. (4):-

$F_t = 2P / \pi dL$

F_t = splitting tensile strength N/mm.

P = maximum applied load (N).

d = diameter of cylinder (mm).

L = length of cylinder (mm).

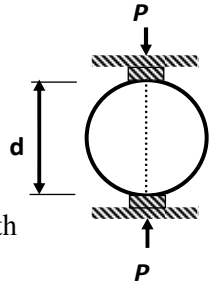

Fig. (3) Splitting Tensile Strength

$F_b = PL / bd^2$
F_b = flexural strength (N/mm^2).
P = maximum applied load (N)
L = span length (mm).
b = average width of specimen (mm).
d = average depth of specimen (mm).

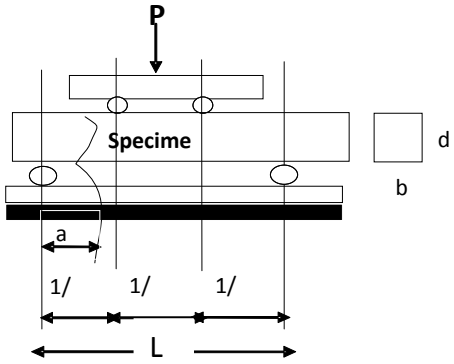

Fig. (4). Flexural strength test

The flexural strength was conducted according to the B.S.1881: part 118:1983 on testing specimens. The Flow Table test was carried out to obtain the susceptibility of plasticizing where we used the tube funnel-shaped to determine the flow of the cement paste on flat surface of fresh concrete; we use the control mix with quantities proportion *(Cement:Sand:Gravel= 1:1.5:3) and W/C=0.5.*

Mix process:

Putting the half quantity of gravel *(slightly wetting with water)* in mixing pan and then putting the sand and cement then add the other half of gravel, and mixing very well until get homogenous mixture. Adding the water gradually until obtains homogenous mixture. After that putting the slump test devise on hard flat surface after wetting the device's parts, pressing on the base with three layer of concrete and each layer compacted with standard rod (25 blow). This process should be done according to the specification, where the compacted of the first layer, the rod must not touch the base of the cone. Compacting the second and the third layer , rod must be penetrate the previous layer and note that the concrete of the third layer must be full over the top level of the cone, when finish the compacting process Remove the excess concrete from the top of the cone, using tamping rod as a screed. Clean overflow from base of cone, then immediately lift cone vertically with slow. Invert the withdrawn cone, the slumped concrete, *(perform in 5-10 seconds with no lateral or torsion)*. After that measure the amount of slump at a point over the original center of the base. The slump operation completed within period time of 2 – 3 minutes.

Result and Discussion.

The result of the flow tables even its simple technique to obtain results but it is important to know the liquidity of cement paste through free fall under gravity weight effect. On the other hand, it has a major role in determining the properties of the mixture added to the cement and its effect on the plasticity of the paste, whether if negative or positive. Fig. (5) shows the changing in spread diameter of cement paste, where the general behavior of additive effect *(furfural)* is increasing the plasticity ,which can be noted the curves of changing the spread diameter of paste its higher than the pure cement paste. Figure (6) shows the relationship between the spread diameter and the ratio of additive *(furfural),* we can note the big effect of additive to plasticizer cement paste. Return to fig. (5), this increment of liquidity after 50 minutes of adding the water to the cement for all furfural ratios is increasing. Also can see with increasing the additive ratio the cement paste does not loss the liquidity totally and the time of losing the liquidity increase with increasing the additive ratio. At ratio 1 %, the cement paste become liquid than the pure cement past and with time start with losing the liquidity due to hardening of cement. But liquidity increase with time when increasing the additive ratio (at 3%), the general varying is approximately linear which gives the importance of this ratio, which can be considered this ratio as critical point for Furfural additive to maintain the liquidity of cement paste. So we can consider it as a factor of improving the workability specially in hot weather which causing rabid evaporate the water from the mix leading to cracking and weakly physical structure for concrete at early time. These results can be explain, that the cement particles have charge constituents of cement paste, where during adding the furfural causes dispersal of cement

particles and did not conglomerate (a part of used water in mix proportion and not using it in the initial cement chemical reaction). That's mean The process of dispersal increases effectiveness when increasing ratio of furfural added to the cement paste so the amount of water involved in the initial cement hydration process will improve the workability.

In addition, we study the effect of the adding the furfural on the fresh concrete mixes like conducting the slump test. In Fig. (7) can see the changing in slump of concrete versus the ratio of additives *(Furfural)*. We can notice that the ordinary concrete (pure concrete) shows increasing in slump values, but does not continue, while the results have positively effect of adding the additives, lead to increasing the slump values during period from 10 to 30 minutes which shows the increasing the liquidity and make the Furfural as a plasticizer. However, we cannot consider it a super plasticizer. This happen due to the dispersal the cement particles through increased adsorption Furfural added to the cement surfaces particles and thus the efficiency improved for the release the water trapped and that lead to improve the workability of concrete. In Figure (8) can notice the varying of concrete slump as a function of additive ratio. We can see at the ratio *(1%)* additive work as a factor increase the liquidity while at other ratios working to accelerate the hardening of concrete.

This study extend to measuring the flexural and splitting tensile strength for modified concrete mixes with Furfural , figure (9) varying the flexural strength with two other variables , adding of Furfural ratio by weight and the method of curing (*water, moist and dry curing*). From the result, we can notice that the wet curing is the best method especially for the splitting tensile strength. Well we obtain *(6.18 N/mm2)* at *(5%)* ratio of Furfural while the value of splitting strength is very low for the dry treatment. In addition, the results were compared with those how have water curing but when we reach at the ratio 5% decrease clearly to reach 2.354 N/mm2 ,this occur due to evaporate the extra water causing void working as internal pipes up to the concrete surface which lead to enter the salts inside the concrete. Figure (10) shows relationship between splitting tensile strength and additive ratio for different curing method. Here the water curing is the best method, which gives us the high value *(7.05 N/ mm^2)* at ratio 2% of Furfural, these results was compared with Ordinary Kuwait Cement *(Type Abraaj)* where the splitting Tensile Strength was 3 N/mm^2 and the flexural strength was 6.05 N/mm2, that mean this additive give us an improving at this property.

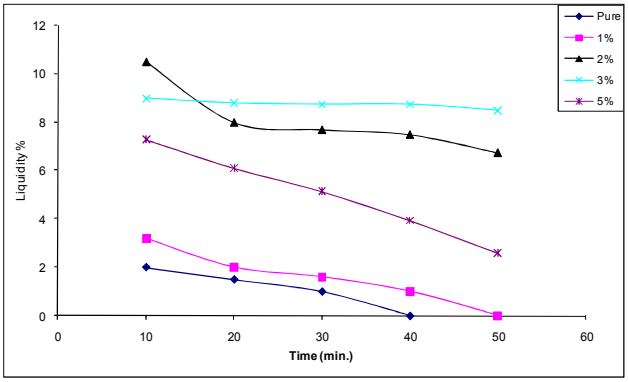

Fig. (5) The relation between the Liquidity and Time for different additive ratio

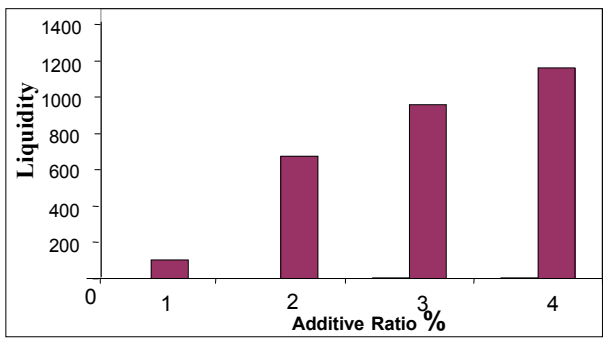

Fig. (6) The Percentage of changing the diameter of Liquidity with different Additive Ratio

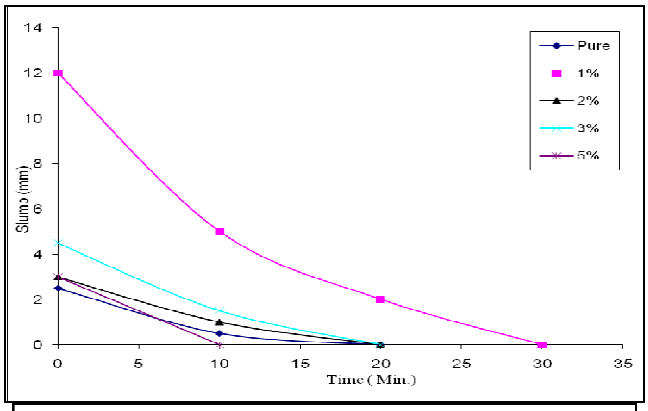

Fig. (7). Concrete Slump for different Additive Ratio

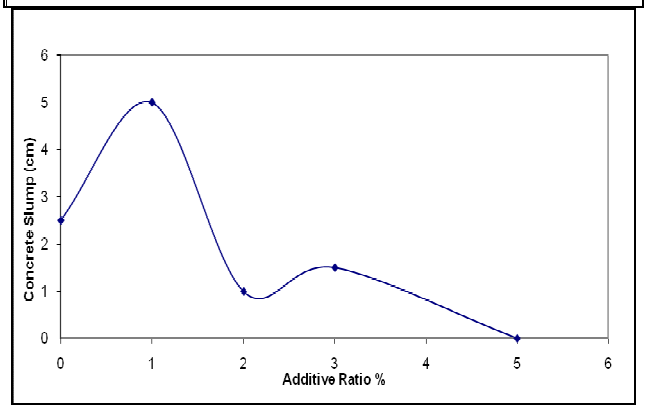

Fig. (8) Slump of Fresh Concrete Versus the Additive Ratio

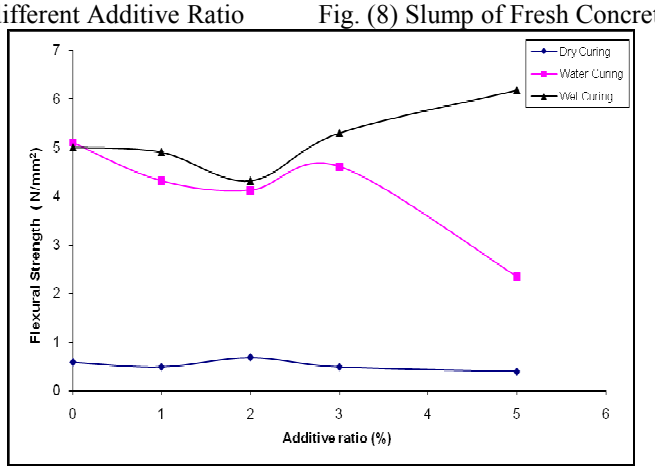

Fig.(9) Flexural Strength – Additive Ratio with Different Curing Method

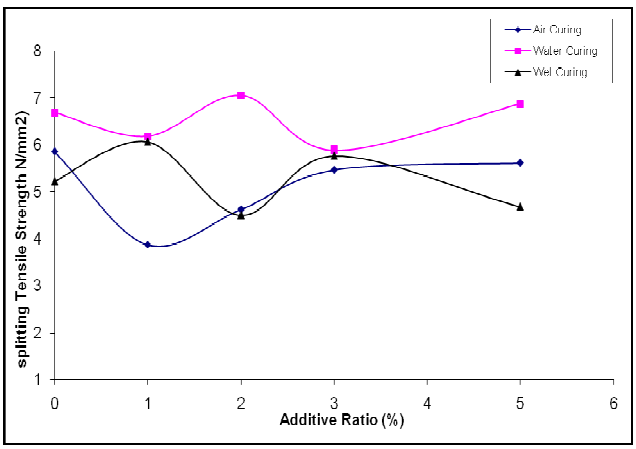

Fig.(10) Splitting Tensile Strength-Additives ratio relation with Different Curing Method

5. Conclusion:

The obtained results show the ability of using the Furfural as a good material to modified the Iraqi Ordinary Cement (*Um-Qaser Factory*) and improving both the Splitting and Flexural Strength of the used cement. The increment of the used additive had a significant effect on the liquidity and flow of the cement paste through its influence on the agglomerated cement particles. The modified cement and concrete are suitable for using in hot or cold regions depending on the added furfural ratio. Finally, the switching between plasticizing and hardening behavior mode is strongly depend on workability due to the amount of coarse agglomerated

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