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COMPERING THE EFECT OF USING THE COPPER BLAST FURNACE SLAG AND TAFTAN POZZOLAN ON CONCRETE PROPERTIES

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ABSTRACT
Today large number of researches are carried out on concrete properties due to it's widely use as an important construction material. The most part of concrete is cement which its cost decrease leads to producing of economical concrete. Using the industrial sweepings such as copper blast furnace slag which have pozzolan properties can make the cement economical. By using these materials not only production costs of cement will be reduced but also saving costs of sweepings will be eliminated and natural environment will be protected. In this research copper blast furnace slag milled to mesh325 which in this mesh maximum diameter of grains are 45 micron. 455 cubic specimens with size of 15×15×15 and cylindrical specimens with size of 30×15 have been made. Compressive and tensile experiments carried out and the results showed the positive effect of Taftan pozzolan and copper slag on concrete properties.

Keywords: copper blast furnace slag, compressive and tensile strength of concrete

1. INTRODUCTION
Concrete is a construction material composed of cement as well as sand and aggregate. Today the usage of pozzolans either natural or artificial has been increased. One of these artificial pozzolans is the slag of metal melt furnace such as iron, copper, etc. several researches on iron slag have been carried out in and out of Iran.
Although acceptable studies have been conducted by Prof. Barzin Mobasher at Arizona State University in America; there are no earlier ones in Iran. Slag is a byproduct of metal smelting which float to the top during the smelting process because of its low density. It includes the compounds presenting in ores as well as the materials adding for lowering down the melting point of gangue. Copper ores usually include acid gangue which mainly have silica. These are the industrial waste materials which are removed from melting tank. Up to 300 thousand tons slags are produced each year during the production of copper. Slag was prepared from two kinds of copper furnace: Reverb -from Sarcheshmeh copper Complex- and flash furnace. There is about 1% copper in the slag of converter furnace which transferred to reverb one to obtain. Then it is exposed to the weather and cooled down after exiting the furnace. But in the Flash furnace at the copper factory of

Khatun abad in Rafsanjan, the slag is cooled down by water after exiting. given such a high cooling rate makes the slag not to be crystallized and results in amorphous solid.

Therefore the substituting this kind of slag in the constituent of cement instead of reverb copper slag or pozzolan works very well. In the experiment conducted by Shargh Kan Micronize in Birjand both the slags were distinguished to be completely amorphous and enduring against the mill. Because the subject was comparing the effect of using copper slag and Taftan pozzolan on concrete properties so the grains diameter had to be similar to pozzolan in size. Therefore the slag was milled and the grains diameter decreased less than 45 micron. Because of being amorphous and high hardness (6 to 7 Mohs) this was a slow process. Unexpectedly, reverb kind was milled easier.

2. CHEMICAL ANALYSIS OF REVERB SLAG

As the slag will be a constituent of cement, its elements and components should be examined. Therefore chemical analysis was performed by Khash Cement Factory. The following table 1 demonstrates the chemical analysis of reverb slag:

SiO_2	CaO	Al_2O_3	Fe_2O_3	SO_3	MgO	Cl	K_2O	Na_2O
35.8	**6**	**8.1**	**46.84**	**0.72**	**0.3**	**0.09**	**1.44**	**0.7**

Activate module can be calculated by the following formula.

$$\frac{CaO + MgO + Al_2O_3}{SiO_2} \geq 1 \qquad (0.3+6+8.1)/35.8=0.4 \leq 1$$

Based on this formula the activation module is less than one and it is expected that it does not have appropriate properties. On the other hand according to ASTMC 618-92A the summation of this three oxides (Fe_2O_3, CaO, SiO_2) exceeds the percentile requirement of pozzolanic activity. This number compares various pozzolans for their degree of reactivity as compared to class F flyash. In this research for the study of compressive and tensile strength samples with different gravity percentages (5, 10, 15, 20, 25, 30) and ages (7, 28 days, 3 months, 6 months, and 1 year) were made and studied within 3 months. Study on 6months and 1 year samples continues.

3. INITIAL AND FINAL SETTING TIMES OF THE CEMENT PASTE

In the present study, the cement of Qaen (type two), the slag of Khatoon abad and Sarcheshmeh Copper Complex and the pozzolan of Taftan were used. The time of the cement paste experiment only carried out on 20% of the pozzolan and the copper slag replacement of cement.

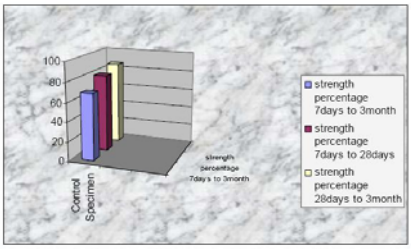

Chart 1. Ratio of Strength Relative to That Other Ages

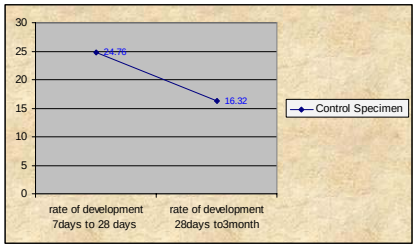

Chart 2. Compressive Strength Rate of Growth for The Witnes Specimen

In this experiment the following results using ASTM C150-200 were obtained: (here the Vicat method has been used) (a cubic specimen 5×5×5 in dimension for compressive strength and a cylindrical specimen 30×15 in dimension for tensile strength). Based on this table, the flash copper slag and the pozzolan behave the same way and have the same final and initial paste, in comparison with the other samples, the reverb copper slag has a more initial set but its final set is closer to the cement one. In higher temperature of Sistan and Baluchestan using of this cement compound is advised because it reduces the volume variety to a minimum and will prevent the likely crack due to the volume changes.

4. STUDY OF THE SAMPLES' COMPRESSIVE STRENGTH WITH THE CONTROL SPECIMEN

Analysis and study of the samples have a considerable importance and should be investigated. Samples with different gravity percentages (5 to 30%) used as cement replacement were made. Study on 6 months and 1 year ones continue. Control Specimen got 68% and 86% of the three months strength after 7 and 28 days respectively. At the end of three month rate of development became 16.32.

Analysis of the Flash Samples:

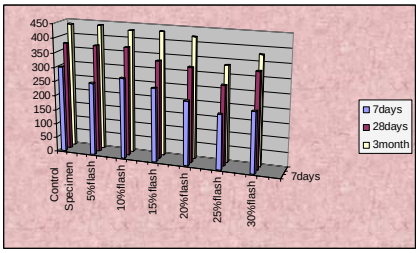

Chart 3. Compressive Strength of the Copper Slag Concrete

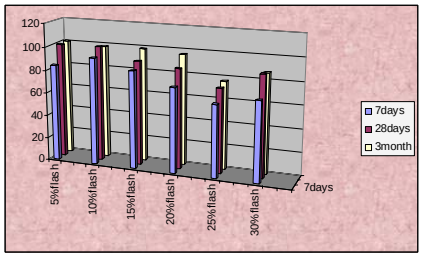

Chart 4. Compressive Strength of Flash Copper Slag concrete

The 5% flash sample considered to be the most samples because its three months strength is 58% superior to the three months sample. And 28 days sample is approximately equal to the control specimen.
The 28 days strength of the 10% flash sample is about 37% superior to the control specimen and the three months sample exceeds in early strength (400) by as much as 428 which is the appropriate percentage.

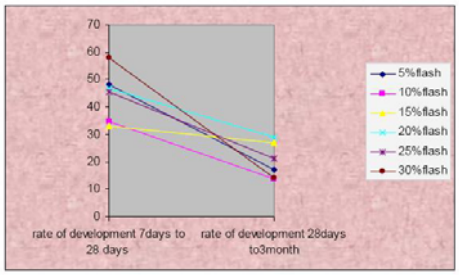

Chart 5. Compressive Strength of Growth for Flash Copper Slag

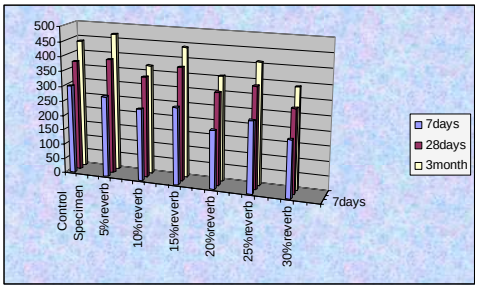

Chart 6. Compertive Results for Reverb Concrete

The strength of the 15% flash sample is about 431 which corresponds to the three months control specimen and it is superior to the specific strength. The 28days sample has the 99% of the control specimen strength. And the rate of compressive strength development during 3 months has increased in comparison to the 28 days sample. Therefore this sample has an appropriate compressive strength. The 3 months sample of the 20% flash has the 96% of the control specimen and compressive strength is superior to the specific one. Note that 28% of the control specimen strength took place during the 28 days period. The 20% flash sample is also appropriate one.
The compressive strength of the 25% flash sample is not appropriate because it has the 73% and the 76% of the control specimen strength during 28 day and 3 month period respectively. This sample has 83% of the specific strength during 3 months which is a very small amount.
The 30% flash sample has a better function than the 55% because it has 88% and 86% of the control specimen strength during 28 day and 3month period respectively. Note that 69% of the control specimen strength took place during the 7 day period. The rate of development for 3month sample is about 14%.

4.1. Analysis of Reverb Sample's Compressive Strength

In this study two dosages of 5% and 15% samples considered to be ideal. At the 28^{th} and 90^{th} day, 5% sample exceeds in strength by as much as 4% and 7% respectively over the control specimen. The strength of 15% sample during the 28 day and 3 month period is respectively 2% and 1% superior to the control sample.

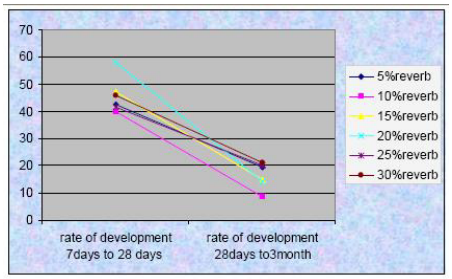

Chart 7. Compressive Strength Rate of Growth Reverb Copper Slag Concrete

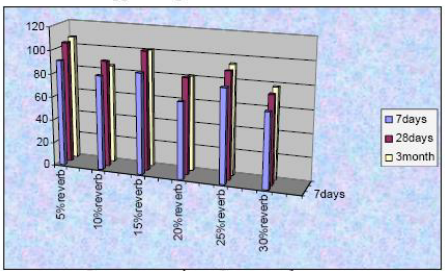

Chart 8. Compressive Strength Rate of Growth for The Witness And Reverb Copper Slag Concrete

Rate of development in 3 month period for 5% sample is about 19.36, reflecting a high rate of development in comparison to the other samples during the 3month period. The strength of the 3 months sample is superior to the control sample as much as 16%. The 20% reverb sample has 83% and 81% of the control specimen strength in 28 day and 3 month period respectively which is not an appropriate sample. But at the 3rd month, 25% reverb sample exceeds in strength by as much as 10% over the control sample and it has 94% of the control sample strength.

At the end of the 3rd month, rate of development for the 15% and 20% samples is 14% but this number for the 25% dosage is about 20%.

Because the 30% sample has 75% and 78% of the control sample strength at 28 day and 3 month period respectively, it is not considered to be an ideal sample. Its rate rate of development is 21%.

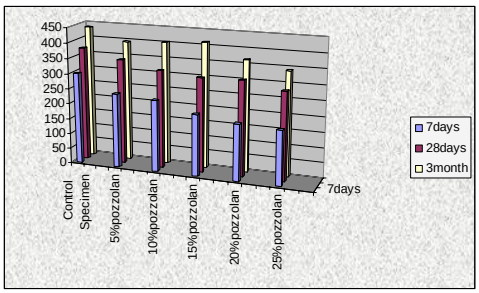

Chart 9. Compressive Strength Rate of Growth for The Witness and pozzolan concrete

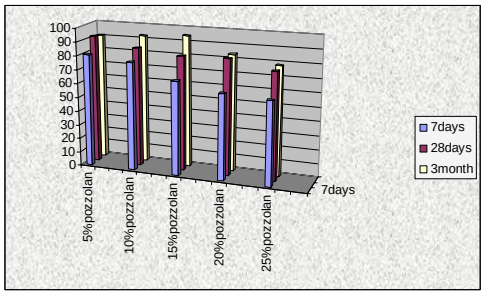

Chart 10. Compressive Strength of the Pozzolan concrete

4.2. Analysis of Pozzolan's Compressive Strength

The best sample for pozzolans was 5% one but it had 92% of strength during the 3 month period. Rate of development for this sample was 14 to 33% while the 15% sample had a high rate of development.

The reverb and flash copper slags behave well than the pozzolans. The 5% flash samples at ages of 7, 28, and 30 days were superior to the 5% pozzolan sample as much as 3-10%. In comparison to the pozzolan sample the compressive strength of

the 10% flash sample was superior as much as 11-19%.

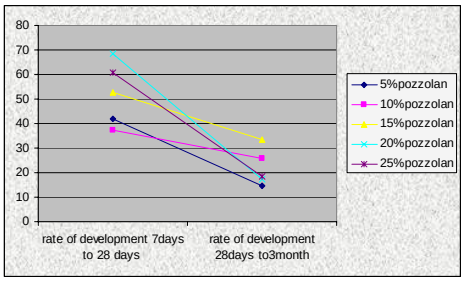

Chart 11. Compressive Strength Rate of Growth for Pozzolan concrete

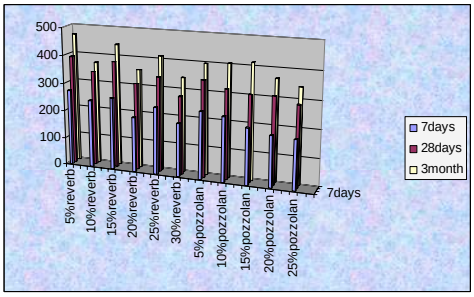

Chart 12. Compertive Results for The Pozzolan and The Flash Slag Concrete

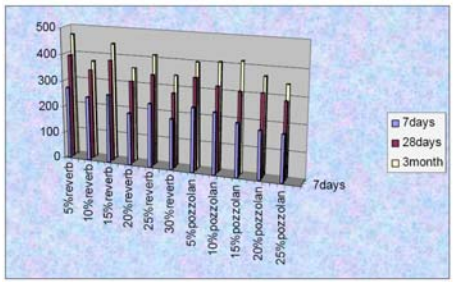

Chart 13. Compertive Results for The Pozzolan and The Reverb Slag Concrete

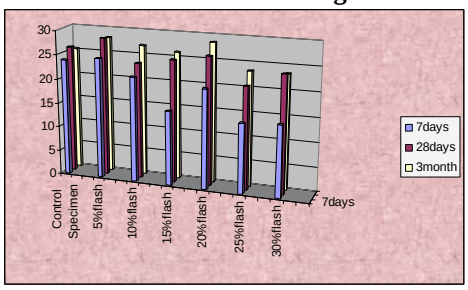

Chart 14. Tensile Strength of The Flash slag Concrete Speciems

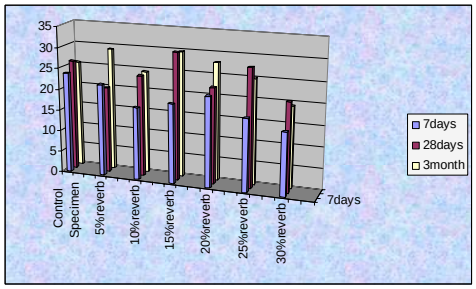

Chart 15. Tensile Strength of The Reverb slag Concrete Speciems

The 15% flash sample exceeds in strength as much as 4.5-26% over the 15% pozzolan sample.

The strength of the 20% flash sample is superior to the pozzolan sample as much as 20%.

The 25% flash sample at age of 7 days was superior to the pozzolan one at age of 7 days over 5% but at the ages of 28, 30 days it was lower than the similar pozzolan sample as much as 3-5%.

The 5-25% reverb samples at the ages of 7,28,and 30 days were superior to the 5-25% pozzolan samples as much as 4-34%.

4.3. The study of tensile VS. Bending Strength

For calculating tensile and flexural strength, cylindrical specimens (15×30 in dimension) were made and the Brazilian method was adopted for calculating the tensile strength but the coefficient made in this method was different from the experimental coefficient.

In experimental method, strength can be calculated from the following formula: (N/mm^2)

(cf= compressive strength of cylindrical specimen)

Experiment on the cylindrical specimens for calculating tensile strength showed this results:

The coefficient for samples at ages of 7, 28 and 90 days became 1057, 1.5 and 1.375 respectively (Kg/Cm^2).

For calculating flexural strength the following experimental formula is used:

Which in comparison to the tensile strength formula is 18% superior. According to the calculated coefficient, the flexural strength is higher than the tensile one.

The tensile strength showed increase with the addition of copper slag. The positive rate of development for three dosages of 5,10 and 20% of reverb samples stand in contrast with the 15, 25 and 30% samples i.e. the increase in ages of samples will decrease the tensile strength.

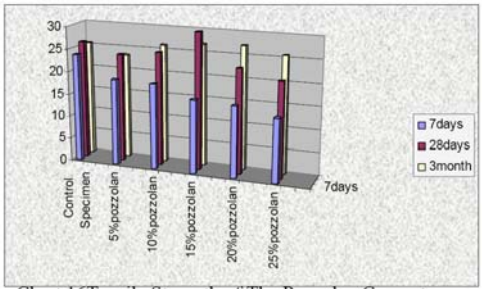

Chart 16. Tensile Strength of The Pozzolan Concrete Speciems

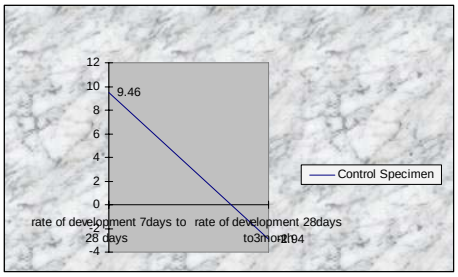

Chart 17. Tensile Strength Rate of Growth for The Witnes Specimen

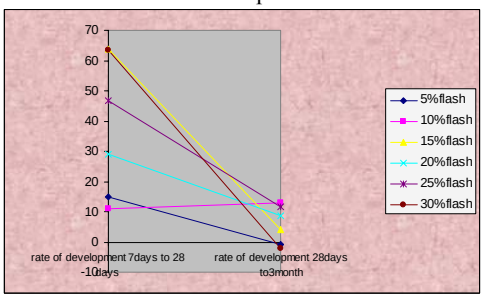

Chart 18. Tensile Strength Rate of Growth Flash Copper Slag Concrete

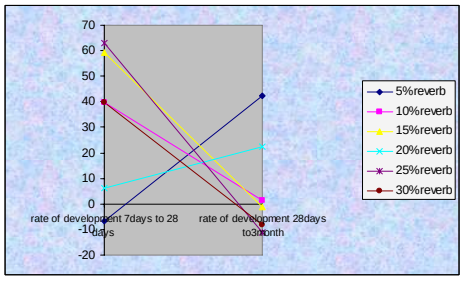

Chart 19. Tensile Strength Rate of Growth Reverb Copper Slag Concrete

For the 10-25% flash samples, the tensile strength is positive as compared to the 5 and 30% samples reflecting negative one.

The increase in percentage and ages of pozzolan translates into an increase in the rate of development. Forexample three dosages of 10,15,and 15% pozzolan samples have a rate of development between 4-22% but 5 and 15% sample have a negative rate of development.

5. CONCLUSION

The studies carried out on the copper slag resulted in an improvement in the concrete properties such as tensile strength as well as compressive one.
The flash samples had a high tensile and compressive strength than the reverb ones. However the reverb samples were better than pozzolan ones. Therefore the flash samples (for 5%slag) considered to be optimum and ideal.
The 10 -20% flash copper slag had a compressive strength as much as the specific one; so the following benefits can be derived from the usage of them in concrete:

1. Using the potential of the artificial pozzolans in development projects
2. Lowering the cost of the concrete production
3. Optimizing the concrete's quality
4. Increasing the concrete efficiency and the quality of concrete productions
5. Increasing the age of concrete constructions against erosion factors
6. Eliminating the materials added in the concrete compound resulted in lowering the cost of the concrete
7. Making a change in development
8. Eliminating slag in copper smelting operation
9. Lowering the use of energy in the concrete production
10. Protecting the environment from the copper wastes
11. Using in the concrete constructions such as damming, silos, water reservoirs, etc.

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