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Using Baggase Ash in Concrete as Pozzolan

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Abstract: The use of the industrial and agricultural wastages in concrete partly as cement replacement, reduce the cost of making concrete, also causes improvement in the properties of concrete and reduce environmental pollution. Khuzestan province is the largest part of Iran for providing sugar cane and sugar, but due to the delays in serviceability of lateral related materials, about one million tone of bagasse (waste of sugar cane) is produced, the disposal of this amount wastage need extra high cost. The aim of this research is to use bagasse ash as pozzolan. In this research the moisture percent and the method of burning bagasse, physical characteristics, chemical combination (XRF test), crystal fixtures (XRD test) and specific area of bagasse ash were investigated and compared with cement and micresilice. Replacing cement by 10% of bagasse ash by fine grade (specific area of 9000cm^2/gr), the workability and flowbility is optimized and their compressive strength at 28 days is increased by 25% in comparison with normal concrete specimens. Using bagasse ash has no effect on the setting time and absorbing water. Due to wastage nature of bagasse the producing cost is predicted to be low and can be replaced as cement.

Key words: Bagasse ash · Pozzolan · XRF test · XRD test · Compressive test

INTRODUCTION

Water and energy is used to produce the agricultural product and their wastages, the only difference between products and wastages is the way of using them. With a little investment, most of the agricultural wastages can be used. InSaroujmortar that the ancient Iranian used as sealing of the floors and viaductinfact was a pozzolan used that consist of lime slurry with some part of sand, clay and ash powder. That was the first ash of plant wastages used in building industry. The first research, with aim of the industrial use of agricultural wastages in concrete technology is referred to 1924 using of the rice dusk by Bigelreports in Germany.

Mehta in 1972 [1] was reported for the first time using rice dusk in concrete. At that time Mehta making a furnace with a conveyer belt to provide a system for use of rice dusk as fuel also production of active ash was designed that used around world in form of industrial and semi industrial products. He also used this furnace for ash production as a filling material and reinforcing elastomer and also used as a high active mineral additives for mixing with lime and replacement of Portland cement in concrete.

Bagasse (waste of cane sugar) is a lateral product of cane sugar that despite there several uses in industry due to not correct using is known as an agricultural wastage and causing thepollution the environment and consequently energy waste. The research into the use of bagasse in concrete has been undertaken many years ago and is mentioned in web site of (http://patft.uspto.gov/). Using of baggase ash as a pozzolan is resulted from the research of Keogh; Boyd T 1978 [2].

Sugar Cane and Baggase: Sugar cane is one of the most important agricultural plants that grown in hot regions. Based on the last information the area under harvesting sugar cane in Iran is about 8000Hectar that more than 99% are in Khuzestanprovince. From each 1hectar of land 90 to 100 tone of sugar cane is obtained in Khuzestan province, this is compared with just 65 tones per hectare with other sugar cane land in world. The highest level of sugar cane

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production record is belonging to Khuzestan province with 220 tones which is documented record in FAO (Food Agricultural Organization).

Baggaseis lateral production of sugarcane that after treatment of sugar cane in the form of light yellow particles is produced. The chemical composition of this product are cellulousfibers, water and some solid soluble material such as cube sugar, by passing time cube sugaris converted to alcohol also the evaporation of baggase fiber produce the metan gas which can cause fire in some circumstances. For this reason the baggase were disposed quickly from the manufactures and kept away in special storage and after a certain time they will burned under control or without any control. The burning of baggase will produce very viscous smoke that causes difficulties for producers and near residential building [3].

Despite variety use of baggase, for production of wood, MDF, papers, animal food, compose and thermal insolation the most of this are burned. The statics shows that about one million tone extra of baggase are remainedin country. The aim of this research is the evaluation use of baggase ash as pozzolan in concrete.

Cement and Pozzolans: One of the product from the cement hydration is free lime ($Ca(OH)_2$). The formation of free lime must be known because with free lime, concrete is lost strength when is exposed to harmful water. Concrete that exposedto water, due to effect of water on lime make it soluble and voids is produced and easily water penetrate. As a result of this reaction in different shape reduction in concrete strength is obtained.

ISIRI 3433 and ASTM C-618 described pozzolan as silica material or alumina-silica that has not have any cohesive characteristics them self but in form of fine powder in adjacent of moisture and normal heat reacted with calcium hydroxide and make a composition with cementious characteristics.

Using pozzolan in concrete as cement replacement will enhance the workability, followability, mechanical strength and concrete durability.

MATERIALS AND METHODS

Samples used in this research were taken from a site near to Ahwaz. The moisture content of baggase, weight and the amount of ash were measured first. The chemical composition of baggase ash by XRF method were investigated and compared with type II Portland cement and microsilice based on limitation given by ASTM C618-99 [4]. Silica existed in baggase ash if is amorphous (non-crystalline), is reacted with lime from cement hydration. Temperature and time of burning baggase are the main factors in amorphous or crystalline shape of ash. The other method is long time ash grinding. The amount of crystaland kind of silica-crystal is distinguished by XRD test. In this research many methods were used to find pozzlan activities of ash. Between them, the electrical conductivity of water-lime and pozzlan were quicker and more precise method.

After the initial tests, for testing concrete, a furnace for burning ash and grinding mill with steel balls were made. Before using ash in concrete, the specific surfaces that directly affect the grain particles size of ash, by using air-permeability device (Blaine test apparatus) were tested. The setting time of type II Portland cement and baggase ash with cement mixture by proportion (1 to 9) were compared. In the recent research, the optimize use ash or rice dusk for compressive test was 10% as cement replacement. The concrete mixes are given in Table 1.

After preparing the mixes the slump test were carried out. For each mix the 200x100mm cylinder were taken and cured in saturated lime. The compressive test was done in 7 and 28 days.

Experiments and Analyzing the Results

Physical Characteristics: he moisture content of baggase used for test was 53.28% the amount of ash obtained from burning baggase was 6.17%. The mass- volume of baggase ash was 2.52 gr/cm^3 that it was between 3.33gr/cm^3 for cement and 1.47gr/cm^3 for microsilice.

Chemical Component: For determining the chemical composition, baggase ash was tested by XRF test. In Table 2 the chemical composition of baggase ash were compared with type II portland cement, micro- silica, baggase ash from Brazil given in Ref. 2 and class C fly ash by XRF test.

According to ASTM C618-99 [4] permissible limitations with chemical analyzing of the test results, the composition was close to class C of fly ash [5]. Percentage of silica oxide (SiO_2), aluminum oxide (Al_2O_3)and iron oxide (Fe_2O_3) existed in baggase ash be able to react with lime by 50% which is within standard limit. The amount of moisture in sulfur oxide (SO_3) and also the maximum percent of alkali in ash ($N_2O+0.65K_2O$) areabove permissible limit. The main difference of the result with standard is come from the amount of the lost of redness, that majority part was remained as un-burned carbon and by changing the conditions of ash burning the amount of not burning carbon will changed.

Table 1: Two types of mixes for compressive test

Type	Cement (kg)	Baggase ash (kg)	Water (lit)	Water/cement ratio	Super plasticizer (kg)	Sand (kg)	Aggregate (kg)
A (C)	300	0	120	0.4	3.150	977.25	977.25
B (C + BA)	270	30	120	0.4	3.150	977.25	977.25

Table 2percentage of chemical composition existed in cement, microsilice, baggase ash and fly ash

Row	Material	SiO_2	Al_2O_3	Na_2O_3	MgO	K_2O	TiO_2	MnO	CaO	P_2O_5	Fe_2O_3	SO_3	LOI
1	Cement type II	22.4	3.3	0.4	2.3	1	0.3	0.1	52.2	0.1	2.9	13.5	1.3
2	Micro-silice	87.6	0.6	0.6	1.6	1.5	0	0.1	0.8	0.13	1.6	0.6	4.6
3	Baggase ash	44.7	2.4	1.5	3.5	4.4	0.3	0.1	14.9	1	2.9	6.1	16.7
4	Baggase ash (Brazil)	78.3	8.6	0.1		3.5			2.15	1.1	3.6		0.4
5	Fly ash C class	48-68	18-34		3-6				15-39		2-8	1-5	0.1-12

Table 3: Result of setting time

Sample	Cement (gr)	Baggase ash (gr)	Water (cc)	Initial setting time (min)	Final setting time (min)
1 (C)	650	0	151.5	165	225
2 (C+BA)	585	65	161.5	182	240
			Difference:	17	15

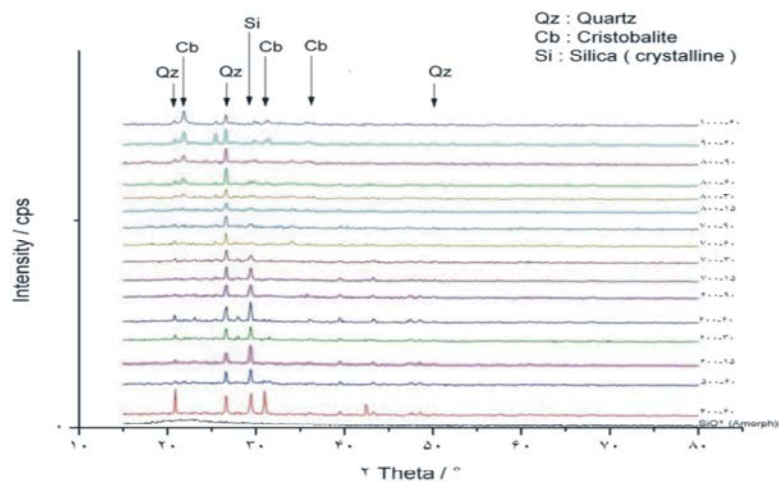

Fig. 1: The diagram obtained from XRD test of baggase ash burned in different temperature and time duration

The chemical compositions of baggase ash used for test in comparison with composition of baggase of Brazil have lower silica and higher lime (about 15%) that shows cementitious property of baggase ash in Iran.

Crystal Structures of Baggase Ash: The main composition of baggase ash is siliceous oxide SiO_2 that react with free lime from cement hydration and made aconsistent composition. But only un-crystal silica oxide has reactive properties. Heat and burning duration, are the main factors on crystal structure of ash. Therefore for determining the amorphous (non-crystal shape), the specimens were burned at different temperature and duration. By using XRD the crystal amount were investigated (Figure 1).

To confirm the results obtained from XRD test, the activity index of non-crystal pozollanic modes by using electric conductivity of saturated lime test, was determined and the test results show thatash were obtained from baggase burning in 700°C and 90 minutes and also 800°C and time of 15 minutes.

Grinding Offine Particles of Baggase Ash: The other method to make the amorphous (non-crystal) shape is grinding for long time method. Because there is no proper control on burning temperature in this work, grinding was under taken using a mill with steel balls shown in Figure 2.

Grinding time of 120 minutes were chosen and the speed of revolution were chosen so can acting as impact force that can break silica crystal existed in ash. After grinding the specific surface is related directly to grain size of particles this was measured. The results shows the specific surface were 2.5 times bigger than Type II cement. (The specific surface of grinding ash was 9031cm^2/grand specific surface of cement typeII was 3558 cm^2/gr).

Fig. 2: Grinding mill for grinding baggase ash

Fig. 3: Baggase on right and baggase ash products on left after grinding

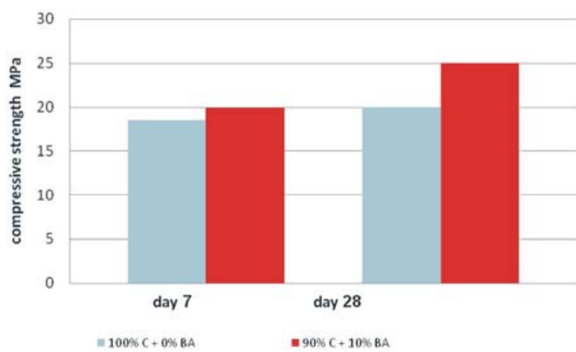

Fig. 4: Results of compression test

Setting Time of Material: For determining effect of using baggase ash as cement replacement on speed of cement hydration, by using Vicat needle, initial and final setting time of Type II Portland cement, cement mix and baggase ash (ratio of 9 to 1) were measured and the results are given in Table 3. The tests results shown that using baggase ash in concrete causes 17 minutes delay in initial and 15 minutes in final setting.

Slump and Compression Tests: Concrete mixes were made based on the proportion given in Table 1 and slump were measured that slump of control concrete specimens was 4.5 cm and concrete with 10% baggase was 6cm. The results show that in addition of increasing slump, the workability was also increased.

The results of compressive tests on control concrete and concrete with baggase in 7 and 28 days is presented in Figure 4, which shows of increasing of about 10% in compressive strength of mix with 10% baggase ash in 7 days test and 25% increase in 28 days tests, in comparison with control specimens.

CONCLUSION

The chemical composition of the baggase ash, used in this work, has nearly similar composition as Class C fly ash. By burning baggase in 700ºC and 90 minutes also temperature of 800ºC and time of 15minutes the more non-crystal ash is obtained. Use of baggase ash in concrete as 10% cement replacement causes slump increase and compressive strength and delayed in initial and final setting time.

It can be suggested that manufacture for sugar cane, providing a suitable furnace near the factory for burningtheirbaggase disposal. By this way, using baggase ash in concrete, as a pozzolan, adding to have a good quality concrete, reduce heat of cement hydration, are also cost reduction in concrete production.

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