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Case Studies in Construction Materials

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ABSTRACT

The preliminary and inevitable interest in the use of partial replacements or by – products as complementary pozzolanic materials was mostly induced by enforcement of air pollution control resulted from cement production industry. Rise husk is by- product taken from rice mill process, with approximately the ratio of 200 kg per one ton of rice, even in high temperature it reduces to 40 kg. This paper presents benefits resulted from various ratios of rice husk ash(RHA) on concrete indicators through 5 mixture plans with proportions of 5, 10, 15, 20 and 25% RHA by weight of cement in addition to 10% micro- silica (MS) to be compared with a reference mixture with 100% Portland cement. Tests results indicated the positive relationship between 15% replacement of RHA with increase in compressive strengths by about 20%. The optimum level of strength and durability properties generally gain with addition up to 20%, beyond that is associated with slight decrease in strength parameters by about 4.5%. The same results obtained for water ab- sorption ratios likely to be unfavorable. Chloride ions penetration increased with increase in cement replacement by about 25% relative to the initial values (about less than one fifth).

INTRODUCTION

Over the past decades, concrete technology has entered broad-based areas of activities to enhance concrete performance by introduction of self-compacting concrete (SCC), high strength concrete (HSC) or maybe ultra-high strength concrete (UHSC). “Self- compacting concrete (SCC) was first developed in 1988 by Professor Okamura intended to improve the durability properties of concrete structures [1]”. “HSCs are known to have a higher amount of cement binder in the mix design properties with low w/b ratio”. The high mass of cement content produced substantial heat liberation in the concrete due to the reaction between cement and water, which can lead to cracking [2]. The merits of minerals compounded with HSC likely to have less amounts of cement with specific ecological and environmental benefits, optimized mechanical indicators, cost effective, energy consumption, lower levels of CO2 emission(proves one tone of greenhouse gas to be released in to atmosphere per one ton of cement manufacturing), need for fresh materials, so on.

Common mineral additions are granulated blast furnace slag, silica fume, fly ash and limestone filler [3]. it should be bore in mind that the indicators of mix design, composition and final properties of HSC in fresh and hardened states are totally different from that of in common concretes. When the amount of powder additive increase, so the workability of concrete whether mechanically or chemically in some cases drastically improve in specified ratios of replacement. “In order for the paste to flow properly and to be able to transport coarse aggregate grains, it must have a sufficient viscosity at high shear rates. This behaviour is usually insured by using modern superplasticizers, which allow for a target adjustment of the paste viscosity at low shear rates without significantly influencing the flow behaviour at high shear rates [4]”.

HSC is important in high rise buildings to reduction of columns both in number and size to provide ambient space, to be used in bridge constructions, marine foundations, and heavy industrial floors. High strength concrete achieved by incorporation of super- plasticizers embedded to prevent segregation, lower ratios of c/w and water/binder, and strength effective degrees at the hardened state. Combination of minerals leads to low permeability based on slight interface remained between paste and coarse aggregates to be filled and more dense concrete.

Regarding mineral admixtures it can be say that they come from several sources with various effects on fresh and hardened properties of concrete. The most common mineral admixtures include silica fume (sub-product of ferrous-silica alloy industry); granulate blast furnace slag (sub-product from steel fabrication), and fly ash (sub-product from coal fired power stations [5]) other ones are clay, volcanic pozzolans cause hydraulic and chemical effects on concrete. The first reactions caused by chemical reactions due to hydration. The production of calcium silicate hydrates from a pozzolanic reaction contributes to concrete microstructure densification, to decrease porosity and to increase strength [6]. It was indicated that natural pozzolans have more significant con tribution to permeability reduction when compared to strength gain. The more recent pozzolan studied in various articles from different points of view is rice husk ash with considerable contributions on durability, permeability and chloric ions penetration.

Addition of amorphous silica is accompanied by improving interface transition area leads to concrete with more packing density. A series of investigations carried to evaluate RHA concrete considering hardened properties, favourable percentage of RHA re- placement, curing time, electrical resistivity, compressive strength and influencing parameters followed by increase in the percentage of RHA replacement in the mix [2–5–7,12,13,25].

Kartini [2] et al. in their study indicated that higher percentages of RHA replacement lead to decrease in the compressive strength. However, 10% replacement of cement with RHA attained the targeted compressive strength addition of RHA instead of cement not only improve compressive strength, but also durability representations can be observed in normal or conventional concretes. “Bui et al. [10] in an investigation on 2005 indicated that RHA as a reactive pozzolan contributes considerably on optimization of microscopic construction of transition interface zone between paste and aggregate surface in high performance concretes”. “Investigations on binary mixes with replacement of cement by RHA first introduced by Mehta in America, focused on crucial para- meters possibly affect rice husk burning process and enhancement the final product”. Utility of ordinary Portland cement in high strength RHA concrete to have HPC varies in strength between 70 and 80 MPa.

In this document, we tried to evaluate the effects of RHA addition in cement according to some experimental background of what influence theses admixtures may have on concrete composition. We presented different levels of RHA addition from 0 to 20%, followed by some tests to examine the influence of additions on basic properties of concrete.

EXPERIMENTAL PLAN

Concrete Materials: Concrete mixtures to be examined were made in the laboratory using the following materials: cement, gravel, plasticizer, rice husk ash, sand, and MS powder.

Cement: The shahrekord type II cement was used as the main binding material in this reaserach work, which is sulphate resistance with average heat of hydration; its specifications are tabulated in Table 1 . The grading and physical properties are in conformity with the requirements necessitated by standard specifications of ASTM C 150 (Standard Specification for Portland cement).

Micro SILICA (MS): Amorphous silica is beneficial as filler to improve the interface transition zone and to produce more dense concrete [9–11]. Merits of micro-silica addition can be categorized by production of high strength concretes, exothermic rate reduction, more corrosion resistance, increase sustained strength of concrete permeated with chloride ions and sulphates in the range of 2–4 times, less per- meability, more durability, and less interaction between alkali cement with aggregates. Micro-silica tends to more strength. The amount of micro-silica offer more quality and strength by about 10–15% replacement percentage instead of cement.

Table 1
In physical properties of cement used the present study.

Accumulated mass(g/cm3)	28 days compressive strength(MPa)	Characteristic surface blain (cm2/g)	Mass(g/cm3)	property
1/16	40/9	3450	3/17	value

Table 2
Cement chemical analysis(%).

Oxide composition	Cao	AL_2o_3	Mgo	Sio_2	Fe_2o_3	So_3	$Na_2o + K_2o$	LoI
Portland cement(type II)	63/61	4.5	2/05	21/2	3/19	2/86	1/09	1.5

Rice husk ash (RHA)

RHA generally referred to an agricultural by-product of burning husk under controlled temperature of below 800 °C. The process produces about 25% ash containing 85% to 90% amorphous silica plus about 5% alumina, which makes it highly pozzolanic. "Study conducted by Mehta [14] indicated that concrete with RHA required more water for a given consistency due to its absorptive character of the cellular RHA particles. In an investigation rice husk ash obtained from Indian paddy when reburnt at 650 °Cfor a period of 1 h transformed itself into an efficient pozzolanic material rich in amorphous silica content (87%) with a relatively low loss on ignition value (2.1%) [15].

There are two ways to burn rice hush: controlled and uncontrolled methods. Initially rice husk was converted into ash by open heap village burning method at a temperature, ranging from 300 °C to 450 °C [16]. When the husk was converted to ash by uncontrolled burning below 500 °C, the ignition was not completed and considerable amount of unburnt carbon was found in the resulting ash [17]. The ash produced under controlled burning conditions between 550 °C and 700 °C by in-cinerating temperature for 1 h possibly transforms the silica of the ash into amorphous phase. Burning duration varied between 15 m to 24 h, while according to various investigation the optimum time would be 6 h with 680 °C (Table 2).

RHA possibly compensate the problem of recycling huge quantity of husk wastes to be landfilled due to lacking of knowledge about its commercial benefits. Here, RHA locally obtained from Lengan located in Isfahan. Then it was burned in laboratory mill under the temperature of 600 °C for 5 h. The results of XRF test can be seen in Table 3. Experimental results for standard chemical specifications and fluorescence ray pattern analysis are all given in Table 4.

Gravel

The coarse aggregates included local natural crushed gravel with particle sizes graded up to 4/75–9 mm and specific density of 2678 kg/m3 were used.

Plasticizer

A series of aspects generally attributed to addition of superplasticizers considering durability and resistivity in long term services. Water-reducing additives restrain concrete to be permeated with fluids and solutions. It has been stablished that providing high plasticity and initial and final strengths are advantages of plasticizers involved in prefabricated concretes. In this respect plasticizers mainly function as: 1) water reducing from 18 to 20%, even potential reduction up to 40%, 2) creation high slump, flowing and instant self-levelling.

RHA addition cause less contents of cement and exothermic rate leads to less strength at early ages. " It is well known that pozzolanic reaction occurs after the hydraulic reaction of cement because the silicate content of pozzolanic materials only react with hydroxide produced during the hydration of cement. However, the rate of pozzolanic reaction is influenced by chemical content as well as particle specific area. This is because the mechanism of pozzolanic hydration/reaction is dissolution and diffusion controlled process [18]. Because of their larger specific surface, the mixes with RHA require higher additions of superplasticizer than the other mixtures in the study, and this contributed to the higher cost in these mixtures [7].

A youngster who weds outside the jati may not just estrange his or her natal family and expanded kinfolk, yet in addition make it troublesome for his or her folks to orchestrate a licit marriage inside the gathering for other off springs. Grover takes note of how couples engaged with between station self-decision relational unions regularly confronted solid parental restriction or was some of the time compelled to isolate from one another. Now and again they additionally prevail with regards to setting up reconnections with their families subsequent to eloping. Be that as it may, there are likewise occurrences where the encounters of couples associated with between station relational unions have been set apart by extraordinary savagery on account of family and network.

Chowdhry's work on between station relational unions in Haryana demonstrates that albeit numerous positions and networks are engaged with between rank relational unions that challenge standard standards and have no social acknowledgment, it is relational unions among dalits and non-dalits that influence social fury to accept a destructive structure (2007:140). Such cases, she contends, "speak to a high point in the on-going conflictual connection among dalits and non-dalits and are seen as types of dalit statement". Be that as it may, brutality isn't constrained to relational unions where one of the gatherings is much let down in the order of standings. It is additionally apparent in situations where the rank gatherings included are proportional or higher, as Chowdhry's investigation of marriage between a Brahmin kid and Jat young lady delineates [17].

Table 3
Test result for XRF(%).

components	Ratio of the components
	86.73
Silicon dioxide(SiO2)	0.04
oxide(Al2O3)	0.61
Ferric oxide(Fe2O3)	0.39
Calcium oxide(CaO)	0.08
Magnesium oxide(MgO)	1.32
Sulphur trioxide(SO3)	9.76
Sodium oxide(Na2O3)	0.01
Potassium oxide(K2O)	0.54
Loss of Ignition(LOI)	
Tio_2	
P_2o_5	

Table 4
Chemical standards in accordance with ISIRI3433/ASTMC for each pozzolans

Chemical characteristics	Test results on RHA	Standard requirements
So_3(%)	o.35	4
Maximum humidity (%)	0.29	3
Minimum of $Sio_2 + AL_2o_3 + Fe_2o_3$ (%)	86.9	70
Total weight reduction due to burning (%)	5.4	6

SAND

The prerequisite for systematic adjustment of the fresh paste properties is that the water/binder ratio of the paste is kept at a minimum value, the so called water demand level. In order to prevent segregation of the concrete i.e. sedimentation of the coarse aggregates in the fresh concrete- the grading curve of the aggregates should adjusted to have a high fines or sand content. The sand grains hinder the coarser aggregates from sinking and thus prevent sedimentation. Natural sands, crushed sands and rounded sands, and in some cases manufactured sands are suitable for incorporating in high strength concrete. Washed river sand with size graded between 0 and 5 mm and unit weight of 2530 kg/m^3 from Sofeh mine located in Isfahan was added. Its amount is given Table 5.

Mixture proportions

Six binder mixtures were prepared involve a control mix with 100% Portland cement and without any additive, and the others with rice husk ash in concentrations of 0,5,10,20 and 25% (labeled in the table RHA5, RHA10,…respectively), 10%micro-silica by weight of cement and w/c ratio of 40%. The substitution concentrations chosen for tests evaluated on 8 cube specimens of dimensions 100mm×100mm×100mm. Tests involved determine the compressive strength at the hardened state through a triple combination, determination of water absorption values by water curing of specimens at 1 h through triple mixtures and rapid chloride ions penetration examination on two specimens. The results are all based on average quantity obtained from the mixtures with different proportions. In addition to above mentioned, for each mix, two cube specimens of 30 × 15 lateral size prepared to evaluate tensile strength (Brazilian test) at 28 d. The compositions of mixtures are shown in Table 5.

Tests

Compressive strength test

Due to the dependence of the mechanical behaviour of concrete on its curing process, for every mechanical characterization test, the following points (proposed by RILEM) have to be stated as a minimum:

- Type and dimensions of the specimen;
- Composition of concrete;
- How to implement concrete;
- How to obtain specimens;
- Curing conditions;
- Conservation conditions;
- Number of identical tests performed or experimental scattering of the results.

According to various investigations, it is thought that the type and size of the specimens could affect considerably on compressive strength test results. Cube specimens of dimensions 100mm×100mm×100mm experienced water curing to evaluate unit weight and short term water absorption, and then placed under hydraulic jack to calculate the compressive strength at 7 and 28 d of curing. The results are all can be seen in Table 6, and following figures (Table 7).

In the case of compressive strength and chloride permeation properties, standard practice of curing for 28 days is found to be adequate. Prolonged curing up to 90 days is found to be beneficial only from the point of view of improving the resistance to water absorption [17]. The increase in strength may be due partially to the pozzolanic reaction as reported by many researchers and partially to high specific surface area and the presence of reactive silica in RHA [21].

Table 5
Mix design (Kg/m^3).

Mix plan	w/c	RHA ratio	Cement	MS/cement ratio(%)	Water	Gravel (up to 19 mm)	Sand	Plasticizer: poly carboxylic
control	0.40	0	400	10	180	840	750	15
RHA 5%	0.40	5	380	10	180	840	750	15
RHA 10%	0.40	10	360	10	180	840	750	15
RHA 15%	0.40	15	340	10	180	840	750	15
RHA 20%	0.40	20	320	10	180	840	750	15
RHA 25%	0.40	25	300	10	180	840	750	15

RHA: rice husk ash, S: washed river sand, MS: micro silica.

Table 6
Compressive strength test (Mpa) and specialized weight (gr).

Mix plan	7 days	28 days	S.S,D
Control	50.84	83.36	2530
RHA 5%	51.92	85.12	2511
RHA 10%	53	86.9	2478
RHA 15%	56.43	92.51	2463
RHA 20%	56.67	93.28	2451
RHA 25%	54.35	89.1	2437

S.S.D: saturated surface dry.

Tensile strength test (BRAZILIAN test) AND modules of ELASTICITY

Tensile strength tests originally can be evaluated based on two approaches:

Direct tension

In this test homogenous tensile stress is continuously applied on the specimen by steel or aluminium heads stuck to the ends of the specimen. A double ball jointing of the ends of the specimen is used to make sure the tensile strain is homogenous within the specimen. The test is carried out at an imposed rate. This is one of the hardest test to perform as the brittle behaviour of concrete under this type of stress only provides the first part of the curve, that is to say until the loading peak [18]".

Indirect tension

In this type of experiment, tensile fracture of the specimen loaded under compression is locally determined. The most commonly used test based on this approach is called the "Brazilian" or splitting test which is generally the diametric compression of a disk, i.e. A quasi-uniform tensile stress which developing along the diameter of the specimen and only maximal force is measured on the specimen it should be noted that tis test is not for determination of the tensile response of concrete that need structural analysis and undirected determination [8]. There are other types of approaches to determine indirect traction: three-point bending test on a concrete specimen or the four-point bending test implied the imposed moment within the beam (Fig. 1).

Tensile strength test due to lacking of homogeneity within specimen need some caution and reliable interpretation of the results, from which it is possible to evaluate the tensile response of concrete to optimize its mechanical behaviour faced with various situations and loadings. If these precautions are taken therefore we have a representative and reliable response of the material. The results of 28 day curing are given in Figs. 3 and 4.

"Concrete can be considered as an initially isotropic material. The elastic parameters of the material are Young's modulus (E) and Poisson coefficient (ν). Regarding common concretes, those usual values of the parameters are 30,000 MPa and 0.2, respectively, and are used in numerous constitutive laws and numerical calculations for concrete structures as well as for the determination of the delayed (time dependent) deformations of concrete [22]. It was observed that decrease of tensile Young's modulus do not have any effect on the results of compressive strength.

Young's modulus is calculated by drawing a tangent to the initial linear portion of the stress strain curve, selecting any point on this tangent, and dividing the tensile stress by the corresponding strain. For purposes of this calculation, the tensile stress shall be calculated by dividing the load by the average original cross section of the test specimen. The result is expressed in gigapascals (GPa) [23].

Table 7
Concrete classification under chloride permeability based on ASTMC 1202 [24].

Chloride permeability	Charge passed in coulombs
high	> 4000
moderate	2000–4000
low	1000–2000
Very low	100–1000
negligible	< 100

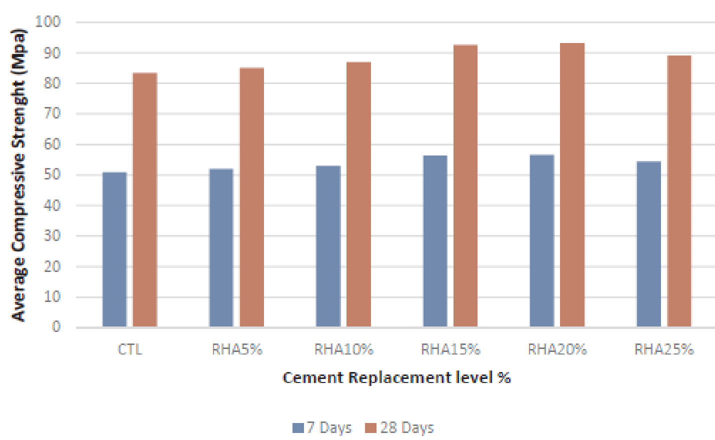

Fig. 1. Compressive strength test results (Mpa).

$$\text{Young's modululus} = \frac{\dfrac{(\text{load at point on tangent})}{(\text{original width})\,(\text{original thickness})}}{\dfrac{(\text{elongation at point on tangent})}{(\text{initial gage length}}}$$

Short term Water Absorption test

concrete can be said as a living material whose mechanical properties change in time as a function of some factors as its con- stituents, curing and conservation conditions, implementation, action of chemicals, sulphates and chlorides, delayed deformation, environmental factors and so on. Among others, maybe one the main and measurable characteristics attributed to evaporation degree at the hardened state from which the quality of concrete under various harassed conservative conditions can be determined. The percentage of water absorption defined as residual water remained in concrete interfaces which make it more vulnerable or durable. Water absorption percentage can be evaluated according to weights of specimens measured accurately after water curing for 72 h and drying phase conducted in oven dry at 105 °C. Then specimens placed for another 1 h in cold water, then weighed precisely. The combination of these two phases controlled independently leads to determine more reliably the short term water absorption degree.

Rapid chloride Permeability test

Rapid chloride permeability test (RCPT) is one of the common ways used to evaluate concrete penetration under chloride attacks corresponding to standards of ASTM C1202 [19]. It is now commonly used as one methods of concrete quality control in the country. One reason to progressive application of RCPT may be attributed to its conduction in short time. In RCPT, total charge of about 60 V passed on to a saturated specimen during 6 h period is calculated. Complete saturation of all specimens could be ensured by storing them in a vacuumed cell of mmHg1 in accordance to standard method (Fig. 2). Sousa Coutinh showed that increase in RHA would decrease capillary water absorption". In rapid chloride penetration experiment it was proved that using of RHA prevent chloride ions permeability up to four times more compared to normal concrete [26]. "Accordance to [2] increased replacement of RHA may be resulted in less charge passed values, which reduces along with increase in curing period. So, more replacement of RGA leads to less percentage of chloride ions penetration".

Presence of chloride ion is the most prominent factor of corrosion. In general, ions transfer into concrete from contaminant materials or external sources as sea water. The content of free chloride in concrete depends on its physical and chemical construction. As it can be seen in Fig. 6, total charge passed in terms of various mix plans are calculated precisely (in coulombs), in addition to penetration classification under chloride ions, are tabulated in Table 6.

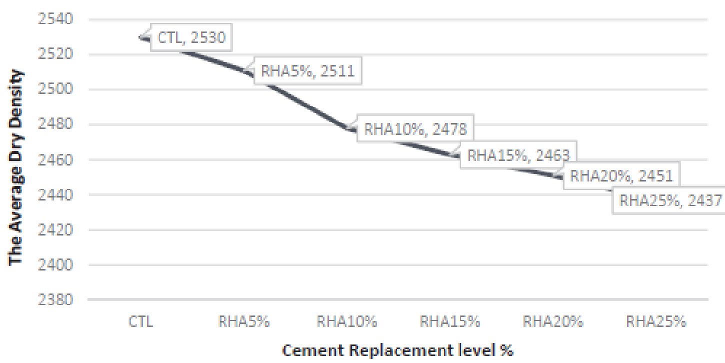

Fig. 2. comparison of specialized weight (gr).

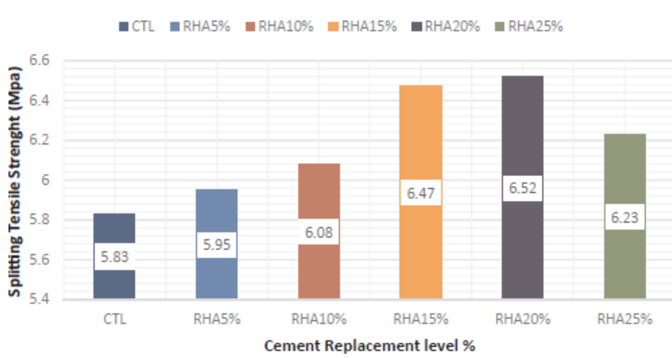

Fig. 3. Indirect tensile strength test results (MPa).

CONCLUSION

Over the past years, performance-based investigations on concretes by different additives entered extensive areas of test methods. It is generally thought that utility of additives to cement can serve to create mechanical and pro- mechanical aspects of that can be a source of economical and biological benefits, higher levels of slump flow, cohesion of fresh mixture, and strength during hardened state. Theses aspects leads to more potential opportunities can be understood in its entirely and exploited to improve concrete properties. Here, 6 mix plans varies in RHA proportions by about 0–25% also a control mix prepared to. Although there is a significant number of a study focused on application and workability of partial replacement of mineral additions in concrete, the present study aimed to present an analysis based on benefits resulting from different contents of RHA.

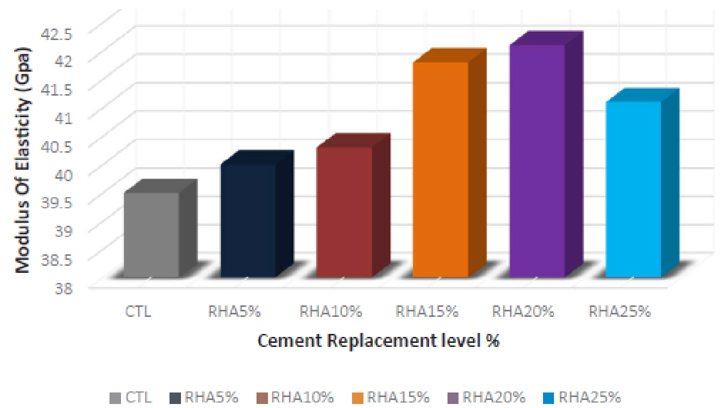

Fig. 4. Calculation of elasticity modules (GPa).

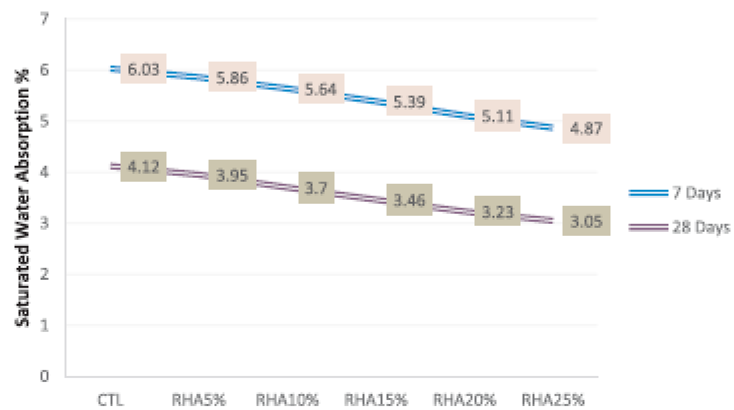

Fig. 5. water absorption test results (%).

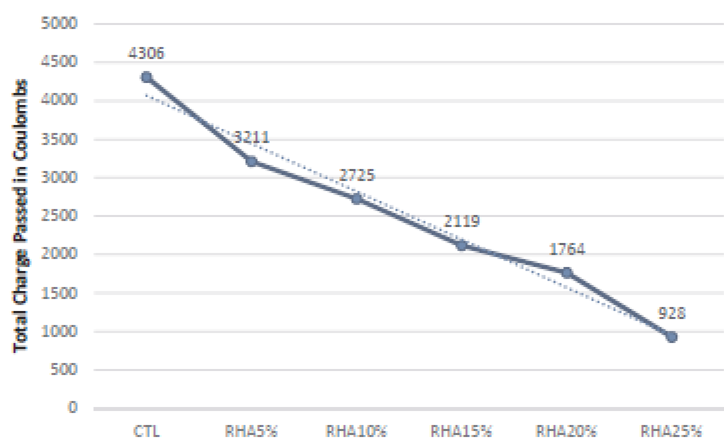

Fig. 6. Permeability test results (in coulombs).

From the study conducted, the following results obtained:

- to more comprehensive framework to environmental- based issues.
- Incorporating of RHA to cement contributes to low ratios of chloride ion penetrations up to 928 Coulombs by 25% RHA re- placement.
- The mixtures with 25% RHA showed the lowest ratios of water absorption by about 4.8% at 7 days and 3% at 28 d of cuing respectively.

- The performance of rice husk ash in concrete is of factors influencing the amount of silica added. This is because rice husk ash contains 85% to 95% weight percent of amorphous silica. Rice husk ash as a pozzolanic reactive material can be used to improve surface area of transition zone between the microscopic structure of cement paste and aggregate in the high-performance concrete.

- Increase of 6.9% compressive strength at 7 days, and 6.8% at 28 days were obtained with increase in containment of RHA up to 25%, but the results are likely to be contrasted by more ratios of replacements. The same trend was observed for the tensile strength most increased up to 6.8% RHA, and then it tends to be decreased. In the case of compressive strength and chloride permeation properties, standard practice of curing for 28 days is found to be adequate. Prolonged curing upto 90 days is found to be beneficial only from the point of view of improving the resistance to water absorption.

- Replacement with 25% rice hush ash result in drastic enhancement of the permeability properties of blended concrete compared to that of in ordinary concrete, such that cause

  - Leads to 26% reduction in water permeability.
  - Leads to 78% reduction in chloride permeation.

These results drastically benefits durability and resistance of concrete constructions and their service life.

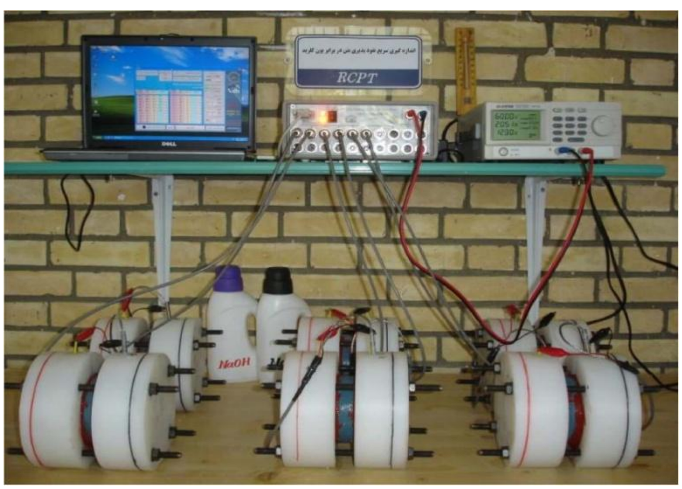

Figure 7

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