A Study on Mechanical Properties and Durability Studies of Concrete using Rice Husk Ash as a Partial Replacement of Cement using Sulphuric Acid

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Abstract

Rice husk ash is a fibrous waste product of rice refining industry. This product causes severe environmental pollution, which calls for urgent ways of handling the waste. Bagasse ash mainly contains aluminum ion silica, iron &calcium oxides. The ash therefore becomes an industrial waste and poses disposal problems. So few studies have been reported that sugarcane bagasse ash as good pozzolanic material in partial replacement of cement. In this project objective is to study the influence of partial replacement of Portland cement with rice husk ash in concrete subjected to different curing environments. Experimental investigation on acid resistance of concrete inmgso4 solution. The variable factors considered in this study were concrete grade of M35 & curing periods of 7days, 28days, 60days, 90days, 180days of the concrete specimens in 1%, 2%, 3%, 4%, and 5% MgSO4 solution. Rice husk ash has been chemically & physically characterized & partially replaced in the ratio of 0%, 5%, 10%, 15%, and 20% by weight.

Keywords: Portland Cement, Concrete, Rice Hush Ash (RHA), Specimen Preparation, Testing, H2S04

I. INTRODUCTION

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and less the burden of pollutants on environment. In recent years, many researchers have established that the use of supplementary cementitious materials (SCMs) like fly ash (FA), blast furnace slag, silica fume, metakaolin (MK), and rice husk ash (RHA), hypo sludge etc. can, not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs.

Concrete is the most common construction material in the world because it combines very good mechanical and durability properties, workability and relative low cost. However, cement production emits greenhouse gases, mainly CO_2, being responsible for about 5% of global anthropogenic CO_2 emissions in the world . Since 1 kg of cement produces approximately 1 kg of CO_2, the use of low emission pozzolans as cement replacement is one of the possibilities to reduce greenhouse gases emissions.

Even though the planet warming is an issue that may be regarded from a global perspective, the use of pozzolans as cement replacement is a problem that would have local solutions since transport is one of the main cost components for cementitious materials. Rice husk is also not used for feeding animals since it is less nutritional properties and its irregular abrasive surface is not naturally degraded and can cause serious accumulation problem it consists mainly of silica (SiO_2), which indicates its potential as mineral admixture

Rice husk which is an agricultural by–product is abundantly available all over the world. Most of the rice husk, which is obtained by milling paddy, is going as waste materials even though some quantity is used as bedding material, fuel in boilers, brick kilns etc., the husk and its ash, which not only occupy large areas causing space problems, but also cause environmental pollution.

Thus the concrete industry offers an ideal method to integrate and utilize a number of waste materials, which are socially acceptable, easily available, and economically within the buying powers of an ordinary man. Presence of such materials in cement concrete not only reduces the carbon dioxide emission, but also imparts significant improvement in workability and durability. In the present investigation, a feasibility study is made to use Rice Husk Ash as an admixture to already replaced Cement with fly ash (Portland Pozzolana Cement) in Concrete

II. LITERATURE REVIEW

T. Parhizkar, M. Najimi and A.R. Pourkhorshidi (2011) [1] have presented experimental investigation on the properties of volcanic pumice lightweight aggregates concretes. To this end, two groups of lightweight concretes (lightweight coarse with natural fine aggregates concrete, and lightweight coarse and fine aggregates concrete) are built and the physical/mechanical and durability aspects of them are studied. The results of compressive strength, tensile strength and drying shrinkage show that these lightweight concretes meet the requirements of the structural lightweight concrete.

N. Sivalinga Rao, Y.Radha Ratna Kumari, V. Bhaskar Desai, B.L.P. Swami (2013) [2] have studied on Fibre Reinforced Light Weight Aggregate (Natural Pumice Stone) Concrete. In their study, the mix design was M20 and the test results are as follows: More than the target means strength of M 20 concrete is achieved with 20 percent replacement of natural coarse aggregate by pumice aggregate and with 1.5 percent of fibber. Also with 40% pumice and with 0.5% of fibbers average target mean strength of M 20 concrete is achieved. The compressive strength of pumice concrete is seen to increase with the fiber content and reaches an optimum value at 1.5% of fiber content and afterwards it gets decreased for various contents of pumice.

P.C.Taylor [3] presently a professor at Wuhan University of Technology has said that mineral admixtures affect the physical and mechanical properties of High Strength Structural Light Concrete. Addition of Fly Ash enhances the compressive strength and splitting tensile strength of HSSLC when FA was more than 20% in cementitious materials, its 28, 60 and 90 days compressive strength and splitting tensile strengths are less than those of the concrete without FA. Addition of silica fume enhances the compressive strength about 25% and splitting tensile strength also. Incorporating supplementary binders have significant influence on the modulus of elasticity of semi-light weight concrete.

Dr. Satish Chandra & Leif Berntsson [4] has reported on Light Weight aggregate concrete: Science, technology and applications, Noyes Publications; that the successful application of structural light weight aggregate demonstrated that light weight used for precast structural elements can be used in building construction to increase the speed of construction, enhance green construction environment such as reducing the wet trade on site and keep dust as reducing the wet trade on site and keep dust level at construction to the minimum.

Swamy R.H & Lambert G.H (1984) [5] studied above the light weight aggregate and proved that the thermal efficiency is very more to the light weight concrete and the load carrying capacity of the light weight concrete is same as the normal concrete by using some mineral and chemical admixtures.

Prof.M.S.Shetty [6] Founder Chairman of Indian Concrete Institute (Pune) has reported that the light weight concrete has tremendous advantages over the conventional concrete and said that modern technology and better understanding of the concrete has helped in promotion and use the light weight concrete.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

A. *Compressive Strength of Concrete*

Table – 1
Compressive Strength results for cubes cured in water

Sample Designation	*% of RHA*	*compressive strength at 7 days f^1_{cu}(N/mm²)*	*compressive strength at 28 days f^1_{cu}(N/mm²)*	*compressive strength at 60days f^1_{cu}(N/mm²)*
W-0	*0*	*36.89*	*45.83*	*55.69*
W-05	*5*	*37.72*	*46.75*	*56.16*
W-10	*10*	*38.79*	*47.69*	*58.63*
W-15	*15*	*35.86*	*44.78*	*56.43*
W-20	*20*	*35.78*	*43.79*	*55.57*

B. *Durability Studies*

Table – 2
Compressive Strength results for cubes cured in 1% sulphuric acid solution

Sample Designation	*% of RHA*	*Compressive Strength at 7 days f_{cu} (N/mm²)*	*Compressive Strength at 28 days f_{cu} (N/mm²)*	*Compressive Strength at 60days f_{cu} (N/mm²)*
M-11	*0*	*35.00*	*43.59*	*53.02*
M-12	*5*	*36.03*	*44.57*	*53.57*
M-13	*10*	*37.12*	*45.67*	*56.10*
M-14	*15*	*34.29*	*42.61*	*53.74*
M-15	*20*	*34.10*	*41.72*	*52.96*

Table – 3
Compressive Strength results for cubes cured in 3% sulphuric acid solution

Sample Designation	% of RHA	compressive strength at 7 days f_{cu} (N/mm^2)	compressive strength at 28 days f_{cu} (N/mm^2)	compressive strength at 60days f_{cu} (N/mm^2)
M-31	0	35.17	44.60	54.28
M-32	5	36.54	45.67	54.93
M-33	10	37.98	46.86	57.89
M-34	15	34.88	43.58	55.34
M-35	20	33.68	42.68	54.47

Table – 4
Compressive Strength results for cubes cured in 5% sulphuric acid solution

Sample Designation	% of RHA	compressive strength at 7 days f_{cu} (N/mm^2)	compressive strength at 28 days f_{cu} (N/mm^2)	compressive strength at 60days f_{cu} (N/mm^2)
M-51	0	35.09	43.62	53.39
M-52	5	36.21	44.81	53.90
M-53	10	37.17	45.87	57.22
M-54	15	34.32	42.72	54.68
M-55	20	33.26	41.89	53.78

C. *Split Strength Results for Cured in Water and Sulphuric Acid Solution*

Table – 5
Split Strength results cured in water

Sample Designation	% of RHA	Split strength at 28 days f_{cu} (N/mm^2)	Split strength at 60days f_{cu} (N/mm^2)
W-0	0	5.20	5.59
W-05	5	6.25	5.16
W-10	10	7.25	7.63
W-15	15	3.80	6.43
W-20	20	3.79	5.57

Table - 6
Split Strength results for cured in 1% sulphuric acid solution

Sample Designation	% of RHA	split strength at 28 days f_{cu} (N/mm^2)	split strength at 60days f_{cu} (N/mm^2)
M-11	0	3.59	5.02
M-12	5	4.57	5.57
M-13	10	5.67	6.10
M-14	15	2.61	3.74
M-15	20	1.72	2.96

Table – 7
Split Strength results for cured in 3% sulphuric acid solution

Sample Designation	% of RHA	split strength at 28 days f_{cu} (N/mm^2)	Split strength at 60days f_{cu} (N/mm^2)
M-31	0	4.60	4.28
M-32	5	5.67	4.93
M-33	10	6.86	7.89
M-34	15	3.58	5.34
M-35	20	2.68	4.47

Table - 8
Split Strength results for cured in 5% sulphuric acid solution

Sample Designation	% of RHA	Split strength at 28 days f_{cu} (N/mm^2)	split strength at 60days f_{cu} (N/mm^2)
M-51	0	3.62	3.39
M-52	5	4.81	3.90
M-53	10	5.87	7.22
M-54	15	2.72	4.68
M-55	20	1.89	3.78

IV. CONCLUSIONS

1) The specific surface area of RHA is 420 m^2/kg greater than 330 m^2/kg of cement. The workability of RHA concretes have decreased in compared with ordinary concrete. It is inferred that reduction in workability is due to large surface area of RHA.
2) The compressive strengths of concrete (with 0%, 5%, 10%, 15% and 20%, weight replacement of cement with RHA) cured in Normal water for 7, 28, 60, 90 days have reached the target mean strength.
3) The compressive strengths of concrete (with 0%, 5%,10%,15% and 20%, weight replacement of cement with RHA) cured in different concentrations of (1%,3%,5%) Sulphuric acid solution for 7, 28, 60,90 days (Table 4.13 to Table 4.15),

indicate that at 5% replacement there is increase in strength and it extended in 10% replacement also and then decrease in strength is noticed at 15% and 20% replacements.

4) The split strengths of concrete (with 0%, 5%,10%,15% and 20%, weight replacement of cement with RHA) cured in different concentrations of (1%,3%,5%) sulphuric acid solution for 28, 60 ,90 days (Table 4.26 to Table 4.28), indicate that at 5% replacement there is increase in strength and it extended in 10% replacement also and then decrease in strength is noticed at 15% and 20% replacements .
5) Due to slow pozzolanic reaction the Rice Husk Ash(RHA) concrete achieves significant improvement in its mechanical properties at later ages.
6) In concretes cement can be replaced with 20% RHA without sacrificing strength.

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