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Mathematical model approach for suitability of GGBS as a replacement material for cement and pond ash as a replacement material for fine aggregate in Concrete

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Abstract

The paper deals with the mathematical approach for suitability of GGBS as a replacement material for cement and pond ash material for fine aggregate in concrete. Larger source of carbon foot prints are evolved as in the form of Portland cement production. Huge amount of CO_2 are released in the atmosphere during the production of cement and after their usage on micro and mass concreting works. The modern world is moving towards green concreting and cementing works in the reduction of CO_2 emission level. Hence the cement must be effectively replaced by some other cementitious materials without compromising the desired properties of concrete. The coal based power plant generates a huge amount of fly ash as in the forms of Particulate matters which borne a huge deterioration level in the air quality standards which is collected from electrostatic precipitator and the bottom ashes are disposed in a slurry form in large ponds and dykes. Pond Ash requires huge area, water and energy to dispose off, so recycling of the pond ash is indeed required. The initial work of the study were carried out in achieving the successive results on mechanical behaviour of the replacement concrete then followed by arriving a mathematical suitability for the arrived results

The purpose of this study is to find the suitability of GGBS as a replacement material for cement and pond ash as a replacement material for fine aggregate without compromising the strength & durability of conventional concrete. Replacement of cement partially by GGBS also reduces the supply demand on cement and may also reduce the emission of CO_2 into atmosphere. The physical and chemical properties of GGBS and pond ash has been studied and both the industrial wastes are used to replace the cement and fine aggregate up to 40% and 20% respectively in concrete. The specimens were tested for its mechanical properties such as compressive strength, split tensile strength and flexural strength on 7, 28, 56 days and durability properties like water permeability and chloride permeability.

(List Of Symbols and abbreviations: CA- Coarse Aggregate, CC- Conventional Concrete, C-S-H- Calcium Silicate Hydrate, GGBS- Ground Granulated Blast furnace Slag, BFC- Blast Furnace Slag, PM-Particulate Matters)

I. INTRODUCTION

1.1 GENERAL

Concrete is considered to be very durable material that requires little maintenance. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a leading role in the development of structures of Sheltering, Housing, Infrastructuring etc., leading to utilization of large quantity of cement and fine aggregate. **Wang Ling *et al* (2004)** analysed the performance of GGBS and the effect of GGBS on fresh concrete and hardened concrete. GGBS concrete witnesses development in compressive, Chemical attack and durability behaviour of concrete. **GlicerioTriches *et al* (2006)** presented a laboratory research of RCC mixtures with addition of bottom ash for composite pavements. Results revealed that an increase in flexural strength levels at increasing levels of fine aggregate replacement by bottom ash. An important process in the concrete mixing is the formation of C-S-H gel which is primarily due to the addition of cement. The hydration of the Portland cement results from the production of Portlandite crystal [$Ca(0H)_2$] and amorphous calcium silicate hydrate gel[$C_3S_2H_3$] (C-S-H) in large amounts. Hydrated cement paste contains approximately70% C-S-H, 20% $Ca(0H)_2$; 7% sulpho-aluminates and 3% secondary phases. **GlicerioTriches *et al* (2006)** presented a laboratory research of RCC mixtures with addition of bottom ash for composite pavements. Results revealed that an increase in flexural strength levels at increasing levels of fine aggregate replacement by bottom ash. The use of Ground Granulated Blast-Furnace Slag has a positive effect on binding the $Ca(0H)_2$ compound, which decreases the quality of the concrete. At the end of the reaction of the slag and $Ca(0H)_2$, hydration products, such as C-S-H gel is formed.

1.2 GGBS

The normal ratios of aggregates and water to cementitious material in the mix remain unchanged. GGBS ican effectively replaces the role of portlant pozzolona by weight.

Replacement levels for GGBS vary from 25% to up to 80%.GGBS cement is slightly less expensive than Portland cement, concrete made with GGBS cement will be similarly priced to that made with ordinary Portland cement. **Shariq *et al* (2008)** studied the effect of curing procedure on the compressive strength phenomenon of cement mortar and concrete incorporating GGBS.

1.3 POND ASH

Pond Ash, a waste product of Thermal Power Plants, is one such material, that can be adopted as a suitable material as fine aggregate in concrete, replacing natural Sand. Encouraging the usage of such a waste material is a social responsibility of researchers to promote & contribute to 3Rs – Reduce, Reuse and Recycle & there by promoting sustainable construction. **Abdulhameed *et al* (2012)** investigated the properties of concrete using tanjung bin power plant coal bottom ash and fly ash. Coal bottom ash and fly ash were utilized in partial replacement for fine aggregates and cement respectively in the range of 0, 5, 10, 15 & 20%. **Pathan *et al* (2012)** concluded in their paper that ground granulated blast furnace slag is better replacement of cement than various other alternatives.

II. METHODOLOGY

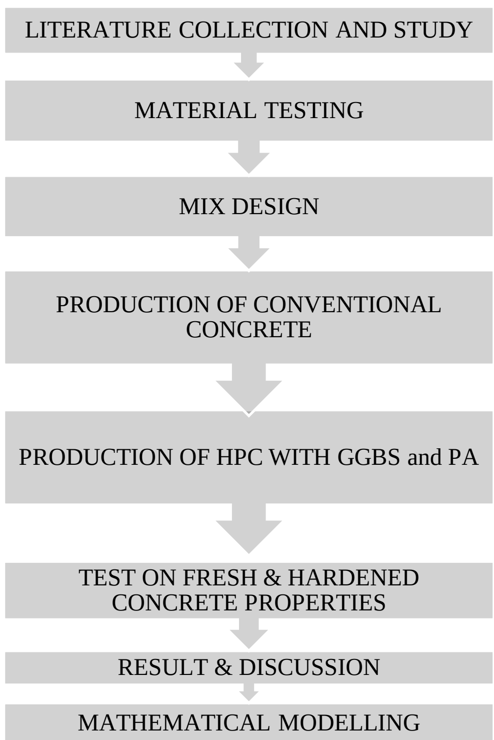

Fig. 2.1 Flow Chart of Methodology

2.1 NEED FOR THIS RESEARCH

One of the main ingredients used for the production of concrete is the Ordinary Portland Cement (OPC).Carbon-dioxide (CO_2) gas which is a major contributor in greenhouse effect and the global warming, is produced in the production of cement, hence it is needed either to search for another material or partially replacement by some other material. And also natural sand confirming to Indian Standards is becoming scarcer and costlier due to its non-availability in time, because of government laws and acts of Land, illegal dredging done by sand mafia, non-accessibility to the river source during rainy season and non-confirming with IS requirements.

GGBS is an effective alternative for cement, adopting GGBS instead of cement enhances the environmental Sustainability of cement by reducing heat of hydration of the cement which in return is one of the serious concern as in the fact of global warming.

III. MATERIAL COLLECTION AND TESTING

3.1 Cement

Ordinary Portland cement of 53 grade confirming IS 12269 was used in the experimental work and properties as mentioned in table 3.1 Chemical properties of GGBS bought from GGBS manufacturing company are given below.Table 3.1 shows the Chemical Properties of GGBS. The physical properties of cement and GGBS were found, Based on those values the mix proportions were arrived

Table 3.1 Comparison of Physical Properties of Cement and GGBS

S.NO	PROPERTY	CEMENT	GGBS
1	Specific gravity	3.134	2.98
2	Bulk unit weight	1400 kg/m^3	1454.5 kg/m^3
3	Fineness	4.2 %	2.33 %
4	Consistency	24 %	31 %
5	Initial setting time	33 mins	32 mins
6	Final setting time	600 mins	580 mins

3.2 Pond Ash

In the present investigation work, the pond ash used is obtained from **Thermal Power Station, Ennore**. Thepond Ash is available at free of cost so it results in more than 25% savings in construction if it can replace the fine aggregate. Fig. 3.2 shows the Pond Ash used in concrete.

Table 3.2 Comparison of Physical Properties of Fine aggregate and Pond Ash

S NO	PROPERTY	FINE AGGREGATE	POND ASH
1	Specific gravity	2.64	1.972
2	Bulk unit weight	1800 kg/m^3	879 kg/m^3
3	Fineness modulus	2.278	2.39

IV. MIX DESIGN

Mix design were developed for M 35 grade as per the Indian Standard, IS 10262: 2009

I) Mix Proportions:

Water : Cement : Fine aggregate : Coarse aggregate

0.40 : 1 :1.910 : 3.89

Correction for Water Absorption

Therefore, Design mix ratio after correction

Water : Cement : Fine aggregate : Coarse aggregate

0.45 : 1:1.89 : 3.86

Table 4.1 Mix proportions for various Mixes

MIX NAME	GGBS (%)	CEMENT (%)	POND ASH (%)	F.A (%)
Conv.mix	0	100	0	100
Mix 1	10	90	10	90
Mix 2	20	80	10	90
Mix 3	30	70	10	90
Mix 4	40	60	10	90
Mix 5	10	90	20	80
Mix 6	20	80	20	80
Mix 7	30	70	20	80
Mix 8	40	60	20	80

V. RESULTS AND DISCUSSIONS

5.1 .Slump Test

For the different mi proportions of GGBS and pond ash mixture the slump values are studied. Ratios of replacement level as (10:10).(20:10),(30:10),(40:10) has been carried out for the various mix proportions are carried out in a controlled manner. The Slump value obtained for the replacement of mi proportions has the range of High workability medium of slump value from 105 mm for the nominal mix and for the controlled design mix the proportions got the values from 97mm to 20 mm for the various replacement level as in the ratio of GGBS and pond ash. The lower workability range is obtained for the mix proportion value of (40:20).

Table 5.1 Slump values of Fresh Concrete

Mix Name	GGBS (%)	Pond Ash (%)	Slump Value	Degree of workability
C.C	0	0	105 mm	High
M-1	10	10	97 mm	Medium
M-2	20	10	94 mm	Medium
M-3	30	10	87 mm	Medium
M-4	40	10	82 mm	Medium
M-5	10	20	81 mm	Medium
M-6	20	20	78 mm	Medium
M-7	30	20	75 mm	Low
M-8	40	20	69 mm	Low

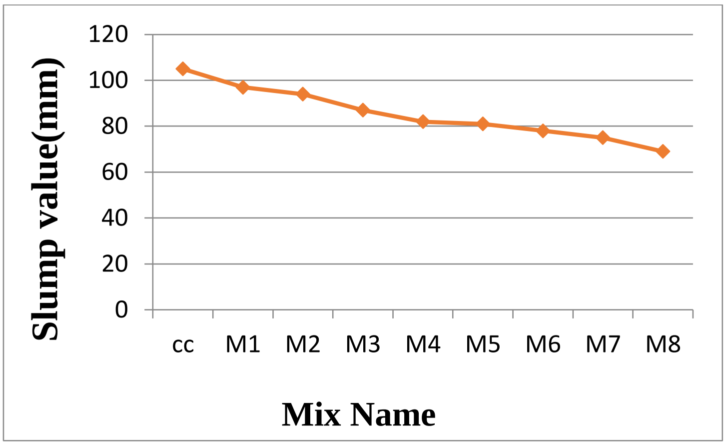

Fig.5.1 Slump values for various mix

5.2 Compressive Strength Test

The test specimens are casted in steel cube moulds of size 150mm, cylinder mould of size 150x300mm. The test cube specimens are made as soon as practicable after mixing and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete is filled into the mould in layers approximately 5 cm deep. Each layer is compacted either by hand or by vibration. After the top layer has been compacted the surface of the concrete is brought to the finished level with the top of the mould, using a trowel. After proper curing concrete cubes are tested in compression testing machine

Table 5.2 Compressive Strength

Mix Name	GGBS (%)	Pond Ash (%)	14days Compressive Strength N/mm^2	28 days Compressive Strength N/mm^2	56 days Compressive Strength N/mm^2
Conventional Mix	0	0	33.96	44.04	47.16
M 1	10	10	26.54	39.20	43.45
M 2	20	10	26.30	38.84	42.29
M 3	30	10	29.65	42.35	46.41
M 4	40	10	25.28	36.12	41.56
M 5	10	20	22.38	32.93	44.78
M 6	20	20	24.38	32.92	39.80
M 7	30	20	30.72	43.18	48.91
M 8	40	20	22.79	34.02	38.10

5.3 Artificial Neural Network Modelling:

Neural networks are trained using combination of different sets of combination series of arithmetic values. Where it assigns and reassigns and back propagates the values of network values to detect weights and biases. Usual modelling structure comprises of three layers generally Input layer, hidden layer and then a output layer.

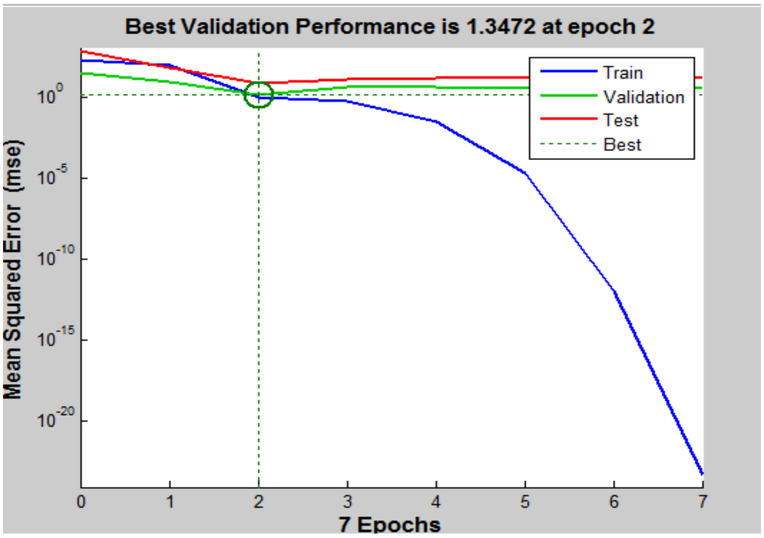

Fig 5.1: Best validation performance for trained value

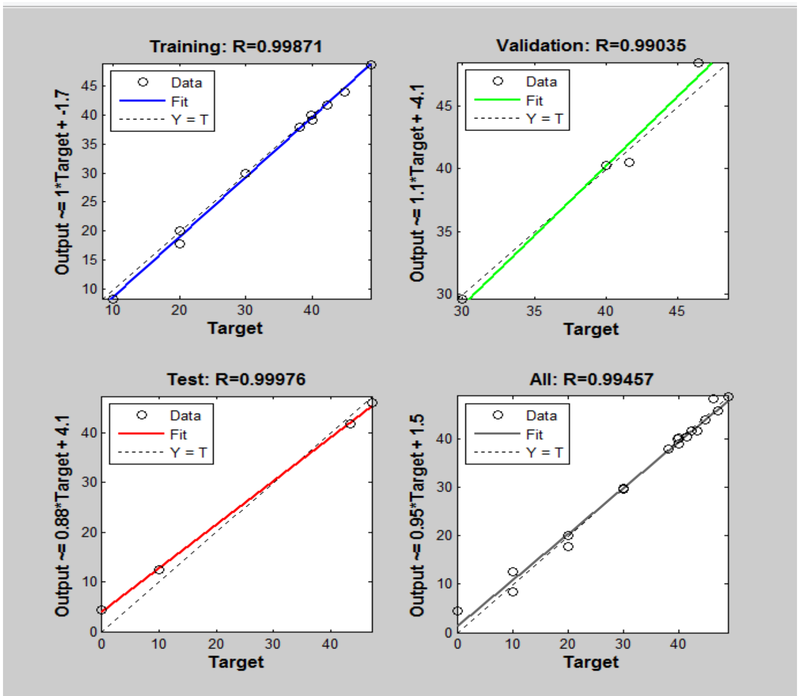

Fig 5.3: Regression value for trained model

VI. RESULTS AND DISCUSSION

The number of layers in ANN may vary from numerous to single. Here in the replacement experimentation, percentage replacement of GGBS and Percentage removal of coarse aggregate by pond ash as a input layer and the targeted output is the mean compressive strength obtained at the end of the experimentation works. The best regression model works under the value of 0.99457.The experimental work on the compressive strength and durability study of concrete in the replacement of GGBS and pond ash were studied.

REFERENCES

[1] Abdulhameed U.A, K.A.Baharudin (2012)"*Properties of Concrete using Tanjung Bin Power Plant coal bottom ash and Fly ash*" International Journal of sustainable construction Engineering and Technology(ISSN:2180-3242)Vol 3,Issue 2.

[2] Aggarwal Y, Siddique R (2014) "*Strength, Durability and Micro structural properties of concrete made with used foundry sand"* ConstructionBuild Master,25,pp 1916-1925.

[3] Aggarwal Y, Siddique R (2014)*"Microstructure and properties of Concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates"* Construction and Building Materials, volume 54,Page 210-223.

[4] Chandak.R, AtulDubey and R.K.Yadav (2012) "*Effect of blast furnace slag powder on compressive strength of concrete* ".International Journal of Innovative Technology and Exploring Engineering (IJITEE)ISSN: 2278-3075, Volume-2, Issue-4.

[5] Glicerio Triches, A.J. Silva, R. A. C Pinto (2006), "*Incorporating bottom ash in roller compacted concrete for composite pavements*", Universidade Federal de Santa Catarina.

[6] Mahesh Patel, P.S.Rao, T.N.Patel (2013)"*Experimental Investigation on Strength of High Performance Concrete with GGBS and Crusher Sand*", Indian Journal of Research, Volume 3, Issue 4.

[7] Latha K.S, Rao M.V.S, and Reddy V. S.(2012) "*Estimation of GGBS and HVFA strength efficiencies in concrete with age*", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Vol. 2, Issue 2.

[8] M.S.shetty '*Concrete Technology theory and practice*' S.Chand publication, edition 2012,ISBN:81-219-0003-4,code :10308

[9] Pathan V.G, Chute V.S, and Pathak G. (2012) "*Evaluation of concrete properties using ground granulated blast furnace slag*", International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 1.

[10] Shariq, M., Prasad, J., and Ahuja, A.K. (2008). "*Strength Development of Cement Mortar and Concrete Incorporating GGBFS*". Asian Journal of Civil Engineering (Building and Housing), 9 (1), 61-74.

[11] Sonali K.G , R. S.Deotale ,A.R. Narde (2014) "*To study the partial replacement of cement by GGBS & RHA and Natural sand by Quarry sand in concrete*" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)volume 11,Issue 2 ver.II.

[12] Wang Ling, Tian Pei, and Yao Yan. (2004)."*Application of Ground Granulated Blast Furnace Slag in HighPerformance Concrete in China*". International Workshop on Sustainable Development and Concrete Technology, Organized by China Building Materials Academy, PRC, 309-317.

[13] IS 383-1970 "*Specification for Coarse and Fine aggregate from natural sources for concrete*" Bureau of Indian Standards ,New Delhi ,India.

[14] IS 456-2000"*Code practice for Plain and cement concrete*" Bureau of Indian Standards ,New Delhi ,India.

[15] IS 516-1959"*Methods of test for strength of concrete"* "Bureau of Indian Standards , New Delhi ,India.

[16] IS2386-1963(part-III)"*Determination of Specific gravity, voids, Absorption*" Bureau of Indian Standards ,New Delhi ,India.

[17] IS 4031-1988((part II) "*Methods of Physical Test for Hydraulic Cement"*

[18] Bureau of Indian Standards ,New Delhi ,India.

[19] IS 10262-2009"*Guidelines for Concrete Mix Design*" Bureau of Indian Standards, New Delhi.