Utility of Glass Powder and Pozzocrete as Replacement of Cement in Concrete

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ABSTRACT:

Utilization of waste materials such as Pozzocrete and glass powder as constituents of concrete is gaining significance because of various ecological troubles caused by storing these wastes and environmental effects of producing and using cement. Hence, use of alternative materials in place of cement in concrete is extremely enlarged. Application of these materials as supplementary cementitious materials is now a universal development. Moreover, use of waste materials in construction industry reduces the consumption of Portland cement per unit volume of concrete. Portland cement has high energy consumption and emissions associated with its manufacture, which can be reduced by replacing cement partially with waste products.

Keywords: *cement; concrete; Pozzocrete; glass powder; fly ash*

1. INTRODUCTION

Reuse of recycled or waste materials for the construction of civil structures is a topic of great interest. Mixing of mineral admixtures in concrete and mortar improves compressive strength, pore structure and permeability. Some of this materials, known as Pozzolana, which by themselves have no cementitious properties, however, when used with Portland cement reacts to form cementitious materials.

Cement both in mortar and concrete, is the most crucial element of the infrastructure and has been known as a long-lasting construction material [1, 2]. However, the ecological aspects of cement are now gaining anxiety of researchers, as cement manufacturing is responsible for about 2.5% of total worldwide waste emissions from industrial sources [1]. Using different types of waste materials in construction industry is now a growing trend. Recycling of waste materials is a twofold purpose (a) to minimize the amount of waste to be deposited and (b) to preserve natural resources [3].

Partial replacement of Portland cement in concrete reduces the volume of Portland cement. This reduction in cement volume further reduces the construction cost, energy loss and waste emissions such as carbon dioxide (CO2) emission. This also, reduces the energy consumption and thus, reduces the rate of global warming [2, 4, and 5, 6].

With construction becoming increasingly competitive, ambitious and having to build in ever more aggressive conditions, for example in the Gulf states and the Middle/Far East countries, it is not surprising that design engineers are specifying higher performance concrete (HPC), particularly in term of workability, strength and/or durability. Indeed, the National and International Standards and Codes of Practice worldwide, reflect this, with their acceptance of a very big range of constituent materials for making structural concrete.

American Concrete Institute defines HPC as a specially engineered concrete, one or more specific characteristics of which have been enhanced through the selection of component materials and mix proportions [5]. Such materials, so called the 21st century concrete, are characterized by improved mechanical and durability properties resulting from use of chemical and mineral admixtures as well as specialized production processes [7].

HPC mixture includes recycled materials such as fly ash, blast furnace slag and silica fumes. HPC provides enhanced strength and durability properties and contributes towards long lasting structures and pavements. The constructability can also be enhanced by proper mixture proportioning and testing [4].

Pozzocrete 100 is a superfine processed fly ash designed for application in high performance concrete. The fineness specifications of Pozzocrete 100 are defined as - retention on 25 microns – 5%, max Specific Surface Area – 600 m^2/kg, min.

To evaluate the Effectiveness of glass powder and Pozzocrete 100 as alternative cementitious material, these materials are required to be mixed in concrete by replacing with 10%, 20%, 30% and 40% volume of cement. These selected materials can be compared with Portland cement concrete on the following parameters –

1. Compressive strength after 3, 7 and 28 days
2. Setting time
3. Workability

2. BRIEF LITERATURE REVIEW:

Fly ash is the largest component of the coal combustion products in thermal power plants. Using fly ash as a partial cement replacement in concrete is effective on many levels. Fly ash reduces the permeability and heat of hydration, and increases the strength of concrete [7, 2]. Replacing Portland cement with fly ash reduces green house gas emissions. For every ton of cement manufactured, 1 t of green house gases is produced.

Fly-ash mix can have the same or better early strength as regular concrete while also maintaining workability. Use of FA improve economics - it is a result of reduced raw-material costs, and reduces environmental impact – as there is a direct relationship between reduced cement usage and reduced Green house gas production[10] .

Replacement of cement with 10–20% of FA, leads to an improvement in bending strength and strain, bending toughness and water absorption [2]. In the modern construction practice 15%-20% of fly ash by mass of the cementitious material is now commonly used in North America. Higher amounts of fly ash on the order of 25%-30% are recommended when there is a concern for thermal cracking, alkali-silica expansion or sulfate attack. Such high proportions of fly ash are not readily accepted by the construction industry due to a slower rate of strength development at early age The high-volume fly ash concrete system overcomes the problems of low early strength to a great extent through a drastic reduction in the water-cementitious materials ratio by using a combination of methods, such as taking advantage of the super-plasticizing effect of fly ash when used in a large volume [5]. The results of compressive tests show that the compressive strength decreases with the increase in content of fly ash. [8].

Neville and aitcin (1998) [9] suggested that high performance concrete is not fundamentally different from the traditional concrete, however, it is composed of fly ash, ground granulated blast-furnace slag and silica fume, as well as super-plasticizer.

Breitenbiicher (1997) [10] has discussed that in High Performance Concrete structures, both the increased strength as well as the improved microstructure can be utilized. Both effects are achieved using an optimized concrete technology, namely an extremely low w/c-ratio and the addition of silica fume. In the case of High Performance Concrete, reinforcement can be minimized and/or the dimensions of the structural members can be reduced.

According to Hendriks and Janssen (2003) [11] there are several options for the use of recycled materials in constructions. For every option a number of technical and environmental aspects are relevant. This paper describes several models which can be used to take the optimal decision. In general the world-wide used Life Cycle Assessment can be used as a multi-parameter model for the environmental effects.

Mazanec et al. (2010) [12] described that shortest necessary mixing time (stabilisation time) was calculated from the evolution of the power applied to the tool during mixing. It was confirmed that high w/c values resulted in short stabilisation times. In addition, the contents of silica fume and quartz flour as well as the type of cement and superplasticizer affected the stabilisation time significantly.

Yeh (2012) [13] described a method of optimizing high-performance concrete mix proportioning for a given workability and compressive strength using artificial neural networks and nonlinear programming. The basic procedure of the methodology consists of three steps: (1) Build accurate models for workability and strength using artificial neural networks and experimental data; (2) Incorporate these models in software allowing an evaluation of the specified properties for a given mix; and (3) Incorporate the software in a nonlinear programming package allowing a search of the optimum proportion mix design. For performing optimum concrete mix design based on the proposed methodology, a software package has been developed. One can conduct mix simulations covering all the important properties of the concrete at the same time. To demonstrate the utility of the proposed methodology, experimental results from several different mix proportions based on various design requirements are presented.

Very fine glass powder is considered as pozzolanic material that can replace cement in concrete and mortar. Several research works were carried out to examine the possibility of reusing waste glass in concrete and construction industry. Purpose is to reduce the generated bulk of waste glass and to minimize the production and use of cement in concrete structures. Replacement of cement with glass powder reduces the compressive strength of concrete up to 16% [14]. Researchers also investigated suitability of glass powder as sand replacement in concrete [14, 15]. No major difference was found in compressive strength. However, durability has been increased by replacing sand with glass powder in mortar.

3. PARAMETERS FOR COMPARING EFFECTIVENESS OF THESE MATERIALS

Following parameters are necessary to get evaluated for comparing the effectiveness of supplementary materials as partial replacement of cement in concrete.

3.1 Compressive Strength

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 3, 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

3.2 Initial and Final setting time

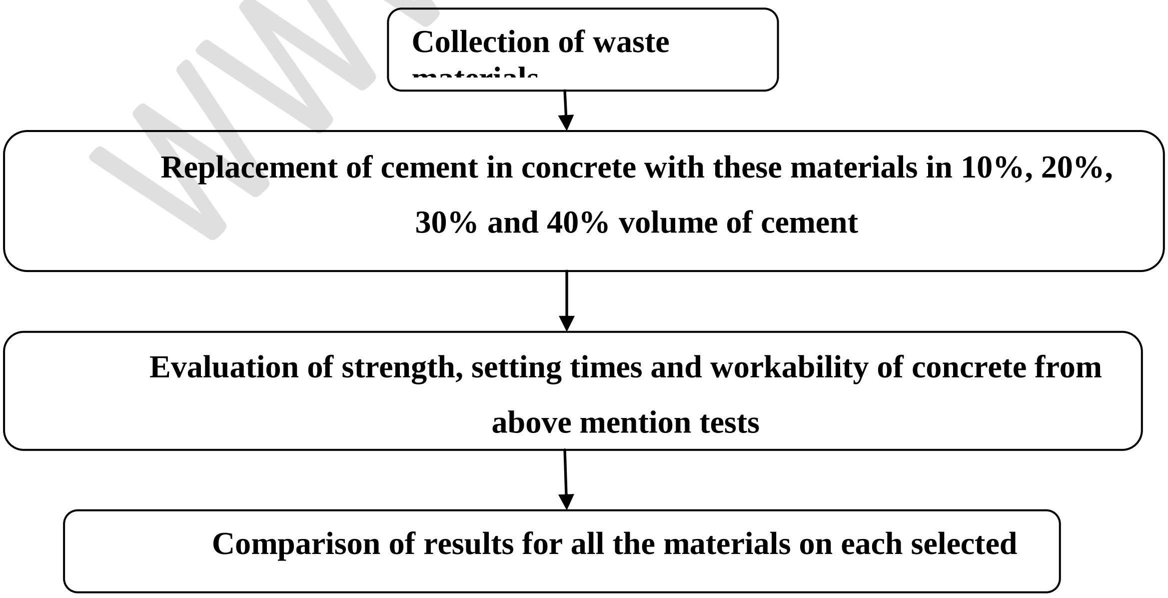
We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988. To do so we need Vicat's apparatus conforming to IS: 5513 – 1976, Balance, whose permissible variation at a load of 1000g should be +1.0g, Gauging trowel conforming to IS: 10086 – 1982.

3.3 Workability:

The behavior of green or fresh concrete from mixing up to compaction depends mainly on the property called "workability of concrete". Workability of concrete is a term which consists of the following four partial properties of concrete namely, Mix ability, Transportability, Mould ability and Compact ability. The slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. Slump cone apparatus is required to evaluate workability of concrete.

4. METHODOLOGY FOR PERFORMING ABOVE STUDY

Following is the methodology to be adopted for performing this study



CONCLUSION:

Utilization of waste materials such as blast furnace slag, fly ash, medical waste ash and silica fume, waste glass powder etc. in the construction field, has gained importance because of the shortage of natural resources and various environmental problems caused by storing wastes. In the present study methods for evaluating utility of glass powder and Pozzocrete 100 as partial replacement of cement in concrete have been discussed.

REFERENCES:

i. Amin N. "Use of Bagasse Ash in Concrete and Its Impact on the Strength and Chloride Resistivity "Journal of Material in Civil Engineering , May 2011, P. 717-720

ii. Sujivorakul C., Jaturapitakkul C.and Taotip A." Utilization of Fly Ash, Rice Husk Ash, and Palm Oil Fuel Ash in Glass Fiber–Reinforced Concrete" Journal of Material in Civil Engineering , Sep. 2011, P. 1281 -1288

iii. Zega C. J. and Di Maio A.A." Recycled Concretes Made with Waste Ready-Mix Concrete as Coarse Aggregate "Journal of Material in Civil Engineering , Mar. 2011, P. 281 -286

iv. Vanikar S.N. "The Advances and Barriers in Application of New Concrete Technology", International Workshop on Sustainable Development and Concrete Technology, Beijing 2004, P. 25-33

v. Mehta P.K. "High-Performance, High-Volume Flyash Concrete for Sustainable Development", International Workshop on Sustainable Development and Concrete Technology, Beijing 2004, P. 3-14

vi. Shah S.P. and Wang K. "Development of "Green" Cement For Sustainable Concrete Using Cement Kiln Dust And Fly Ash" International Workshop on Sustainable Development and Concrete Technology, Beijing 2004, P. 15-23

vii. Zachar J. "Sustainable and Economical Precast and Prestressed Concrete Using Fly Ash as a Cement Replacement" Journal of Material in Civil Engineering , Jun 2011, P. 789-792

viii. Ren Z and Wang L." Research Of High Fly Ash Content In Concrete With Dipy Construction Formwork ", International Workshop on Sustainable Development and Concrete Technology, P. 347-359

ix. Bai Y.,Ibrahim R. and Basheer P.A.M. "Journal of Material in Civil Engineering**",** International Workshop on Sustainable Development and Concrete Technology, Beijing 2004, P. 77-88

x. Adam Neville and Pierre-Claude A tcin "High performance concrete- An overview" Materials and Structures/Mat~riaux et Constructions, Vol. 31, Mars 1998, pp 111-117

xi. Dr.-Ing. R. Breitenbiicher "Developments and applications of high-performance Concrete" Materials and Structures/Materiaux et Constructions, Vol. 31, April 1998, pp 209-215

xii. Ch. F. Hendriks and G. M. T. Janssen "Use of recycled materials in constructions" Materials and Structures" / Matdriaux et Constructions, Vol. 36, November 2003, pp 604-608

xiii. O. Mazanec Æ D. Lowke Æ P. Schießl "Mixing of high performance concrete: effect of concrete composition and mixing intensity on mixing time. Materials and Structures (2010) 43:357–365

xiv. I-Cheng Yeh, "Design Of High-Performance Concrete Mixture Using Neural Networks And Nonlinear Programming. Journal Of Computing In Civil Engineering / January 1999

xv. Taha B., Nounu G. "Utilizing waste recycled glass as sand/cement replacement in concrete" Journal of Material in Civil Engineering, 21(12), 709-721.

xvi. Tan K.W., Du H. "Use of waste glass as sand in mortar: part I- fresh, mechanical and durability properties", Cement and Concrete Composites, 35, 109-117.