A REVIEW ON EFFECTS OF ADDITION OF METAKAOLIN WITH VARIOUS ADDICTIVES IN PRODUCTION OF MASNORY UNITS

Devika Sudhakaran[1], Emy Poulose[2]

[1]PG student, Civil Department, Toc H Institute of Science and Technology, Kerala, India
[2]Asst. Professor, Civil Department, Toc H Institute of Science and Technology, Kerala, India

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Abstract - *The fields of construction have undergone tremendous changes through several decades. The use of renewable agricultural byproducts and other wastes as additives in construction material industry is gaining increased research attention due to their positive effects in the mechanical and physical properties of bricks, concrete and other building materials. The commonly used addictives are limestone powder, used brick powder, saw dust and some supplementary cementitious materials like ground granulated blast furnace slag, rice husk ash, metakaolin, silica fume. Metakaolin is a siliceous material which can be produced from a variety of primary and secondary sources containing kaolinite. The hydration of calcium based materials result in shrinkage cracks which can in turn reduce the strength, therefore the addition of siliceous material like metakaolin, fly ash, and used brick powder can help to increase the strength. This report is focused on the effects of addition of siliceous materials like metakaolin and waste addictives from agricultural and food processing units in the properties of bricks and concrete.*

Key Words: **Brick, Concrete, Metakaolin, Shrinkage crack, Silicious Material, Waste addictives.**

1. INTRODUCTION

From ancient period, human beings started the construction of various structures with locally available materials and with the growing experiences of them, there were changes in the material used in all the field of constructions. Changes also occurred in the method of production of brick and concrete also the combinations of materials used were changing continuously. Clay bricks were a common scenario in the construction. Along with the various circumstances, modifications of ordinary clay bricks also came into existence. The use of fertile agricultural land for making clay bricks created problems in the field of cultivation, and intern affected the brick industry. Therefore researchers focused to replace the clay bricks partially or fully with other types of soil and also with the addition of different waste materials from industries, some supplementary cementitions materials like fly ash/GGBS/used brick powder; even fibers were incorporated for the production of bricks. Calcium based materials can be effectively used as an addictive in concrete in the form of calcium hydroxide and calcium carbonates, but the hydration of calcium based materials result in shrinkage cracks which can in turn reduce the strength, therefore the addition of siliceous material like metakaolin, fly ash, and used brick powder can help to increase the strength. Also the reaction between metakaolin and lime based materials result in the formation of products that contain aluminosilicates, this resultant paste contribute long term strength. This report is mainly focused on the effects of addition of siliceous materials like metakaolin and waste addictives from agricultural and food processing units in the properties of bricks and concrete.

2. MATERIALS AND PAST WORKS

2.1 Metakaolin

It is the anhydrous calcined form of the clay mineral kaolinite. It is formed when the mineral kaolin, is heated to a temperature between 600 and 800[illegible] . From the chemical point of view, metakaolin consists of minerals that are necessary for hydraulic reactions. Siliceous content is around 60% and alumina content is 30%. The addition of metakaolin into the mix should result in an enhanced strength of lime pastes and increased durability. As kaolin contains no carbonates, no CO_2 is released during heating leading to reduced embodied CO_2 in the final materials when replacing cement or lime.

2.2 Limestone powder

It is a carbonate sedimentary rock that is often composed of the skeletal fragments of marine organisms. Its major component is calcium carbonate ($CaCO_3$). Limestone has numerous uses, as a building material, an essential component of concrete , as aggregate for the base of roads, as white pigment or filler in paints, as a soil conditioner.

2.3 Saw dust

It is a waste product of wood working operations such as sawing, milling, planing, routing, drilling and sanding. It is composed of fine particles of wood and it is also known as wood shaving. Saw dust can be used for the preparation of masonry blocks and bricks.

2.4 Comparison of pozzolinic activities of metakaolin and used brick powder with lime

A comprehensive study on mechanical properties of lime based pastes with the addition of metakaolin and brick dust were conducted by Nezerka et. al (2014). This work describes the behaviour of lime based mortars with the influence of pozzolan, their microstructure, and also the properties of lime based pastes without any aggregate. In this work nine different sets of pastes with addition of metakaolin and brick powder with lime were studied. The chemical compositions and microstructure were investigated by means of Thermogravimetric analysis and Scanning electron microscopy. Mechanical strength and fracture properties were determined using destructive tests. The pure lime mortar without addition of pozzolana exhibited about 10% higher porosity than those containing metakaolin (20% of binder mass). This phenomenon is explained by the formation of hydration products, such as calcium silicate hydrates. Calcium silicate hydrate (CSH) gels and calcium aluminium silicate hydrate (CASH) are among the main hydrated phases formed at the room temperature after pozzolanic reaction of metakaolin. This study revealed that metakaoline exhibits much stronger pozzolanic activity than brick dust. The mechanical properties of pastes are not necessarily enhanced by the addition of pozzolana. However, the shrinkage reduction could result in the elimination of cracking while hardening. This study was limited to the reaction of lime with metakaolin and used brick powder only, pozzolinic activity of any other addictive with lime was not mentioned.

2.5 Lime metakaolin mortar

Velosa A. et. al (2007) investigated about Lime-metakaolin mortars properties and its applications. This study described that, lime is the most sustainable binder due to lower production energy needs, lower CO_2 emission during production and CO_2 absorption by carbonation. However, in building conservation actions, the use of lime-based renders may be a necessity in order to achieve the required compatibility with ancient renders and substrates. With the purpose of developing mortars for this application, metakaolin was added to lime mortars allowing for a faster application and hardening and, possibly higher durability whilst maintaining compatibility requisites. Results of the flexural resistance test indicated an increase in strength of mortars with metakaolin and lime in relation to lime mortar with no addition. The decrease in flexural strength from the age of 28 days to the age of 90 days is a phenomenon that has been observed in other mortars, namely those containing pozzolans. Reasons for this can be linked with microcracking due to shrinkage, to which flexural strength is very sensitive. Metakaolin was an adequate pozzolanic addition for lime mortars, providing adequate mechanical and water behaviour characteristics for application in conservation mortars. Assessment of phase formation in lime-based mortars with added metakaolin, Portland cement and sepiolite, for grouting of historic masonry done by Aguilar S. et. al (2010) investigate about Lime-based mortars containing pozzolanic additions of metakaolin, sepiolite and white Portland cement are studied in order to determine their performance as historic masonry conservation mortars. Hydration products on metakaolin–lime blended mortars include stable and metastable phases. The presence of such products has been studied by means of XRD analysis, concluding that the selection between them is mainly related with the water–lime ratio. Sepiolite addition to metakaolin–lime mortars has shown to inhibit C_4AH_{13} formation. Therefore, the influence of phase distribution on the mechanical resistance was considered. Calcium silicate and calcium aluminate hydrates dehydrate in the temperature range of 120 to 250 �, Mixing water proportion is the determining factor for the selection of the hydraulic phase production in the metakaolin lime blended mortars. A slight increase in water binder ratio from 1.5 to 1.7 favours a complete substitution of silica in hydrogarnets (HG) formation. The strength decrease of about a 66% in relation to metakaolin lime mortars with no sepiolite addition cured in water at 20 �, resulting in a minimal HGs contr ibution to mechanical strengths.

2.6 Properties of brick with metakaolin and lime stone powder

Use of metakaolin with stabilised extruded earth masonry units done by Daniel et. al (2015) investigates that modern earth masonry increasingly utilized conventional methods of extruded fired brick production for the manufacture of unfired earth bricks. Unfired clay bricks can be chemically stabilized, typically by the addition of cement or lime to improve wet strength. However, the use of such binders has been shown to be ineffective for silt and clay rich soils used for extruded bricks. The research presented in this paper demonstrated the change in compressive strength that can be achieved through the addition of metakaolin to cement and lime stabilized extruded earth masonry. Commercial extruded earth brick production uses the same methods of manufacture as fired brick units without the firing. The performance of a stabiliser and the fundamental binding mechanism, may be improved by the addition of a secondary stabiliser or pozzolan. The focus of this paper is the use of metakaolin as a secondary stabiliser for modern earth masonry units. The addition of various mass fractions of metakaolin to cement and lime stabilised extruded earth masonry units are described. Metakaolin has the chemical structure of $Al_2Si_2O_7$ and exhibits pozzolanic properties that can be potentially utlised to achieve the required strength criteria of extruded unfired earth bricks. This research presents a feasible solution using 5% lime and 10% metakaolin, that would allow unfired extruded earth masonry units to be used for structural applications.

Dass et. al (1990) investigated about lime-stabilized red mud bricks. This study incorporated a small percentage of lime in the red mud and compressed the mix at optimum moisture content in the form of bricks with a purpose of examining their strength and stability to the erosive action of water. The brick samples were studied for accelerated weathering and found suitable for use as a walling material for low-cost shelters. Modifications in the red mud mix, especially from the viewpoint of particle size distribution, have also been examined. Red mud containing 5% hydrated lime by weight can be utilized for making bricks or blocks to construct the walls of low-cost shelters.

2.7 limestone dust and wood sawdust as brick material

Suitability of using Limestone dust and wood sawdust as brick material was studied by Turgut et. al (2017). They described that the majority of abandoned limestone powder wastes (LPW) and wood sawdust wastes (WSW) were accumulated can cause certain serious environmental problems and health hazards. The paper presented a parametric experimental study which investigated the potential use of WSW–LPW combination for producing a low-cost and lightweight composite as a building material. Some of the physical and mechanical properties of concrete mixes having high level of WSW and LPW were investigated. Using WSW–LPW combination as a fine aggregate in its natural form has allowed economical, lighter and environmental-friendly new composite material. In this paper, the research work undertaken to study the properties of this new composite material which contains the various levels of WSW, LPW, small amount of cement as binder and water. The replacement of these wastes as aggregate in the tested samples dramatically reduces the unit weight. A better and smother surface is obtained. This combination provides a unique kind of building material which exhibits concrete-like appearance. Effect of high-level replacement of WSW with LPW does not exhibit a sudden brittle fracture even beyond the failure load. The reduction in the strength values causes the UPV to be decreased. The results suggest that the WSW content, the compressive and flexural strength values may approximately be determined without a destructive testing by using the non-destructive UPV measurements. Concrete with 30% replacement level of WSW which attained 7.2 MPa, satisfies the requirements in BS6073 for a building material to be used in the structural applications. However, the complete investigation of brick samples with LPW and LPW–WSW combination should include further durability tests.

3. CONCLUSIONS

Various studies were reported about the effects of addition of different materials on properties of laterite brick that were generated from industrial and agricultural activities. These can be used as substitutes for conventional materials by recycling them into new building materials. Due to the gradual depletion of naturally occurring minerals like kaolin, quartz and feldspar in the production of traditional porcelain, addition of supplementary cementitious materials (SCMs) into the clay before firing looks recent and promising. The trend is to substitute these minerals by using an alternative source of raw materials, which are abundantly available as over-burdened wastes. The main benefits come from saving natural resources and energy as well as protecting the environment (Elinwa et al. 2005). In this way, better mechanical properties, reduced porosity, limited dimensional changes and enhanced resistance to normal and severe exposure conditions can be achieved.

The microstructure and chemical composition of lime based metakaolin paste was studied by Nezrka et. al. Various studies were conducted to determine the suitability of lime stone powder with metakaolin. Lime which contains calcium reacts with matakaolin give effective pozzolanic reaction which in turn improves strength characteristics also10% of Metakaolin along with 5% lime gives an optimum mix for lime based mortar in the aspect of compressive strength and tensile strength [3],[7]. Suitability of lime stone for the stabilization of clay in brick along with some suppilmentary cementitious material and cement was also investigated. The use of waste addictives can also reduce the cost and eliminate problems caused due to its disposal. Mechanical properties and physical properties were measured in most of the studies. Main advantage of using lime-pozzolana mortar or mix is that it have lower environmental impact as compared to cement mortar. The chemical reaction of alumina and silica present in metakaolin with calcite would lead to the formation of calcium aluminate and silicate hydrates. This will fill the voids and finally a bulk paste could be formed. This could improve the mechanical property and reduce water filled porosity, and increases in compressive strength. Addition of saw dust also contribute to increase in porosity and decrease thermal conductivity [7] most of these addictives contain finely grind particles of very small diameter, therefore the available surface area for chemical reactions was more.

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