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Strength Behaviour and Properties of Lime Based Composite Paste

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Abstract— Concrete is the most commonly used material for construction. The worldwide production of cement has greatly increased since 1990.Production of cement results in a lot of environmental pollution as it involves the emission of CO2 gas. Supplementary cementitious materials (SCM) are finely ground solid materials that are used to replace a portion of the cement in a concrete mixture. In order to understand the behaviour of lime-based mortars, and to identify the influence of pozzolonas, it is important to investigate the microstructure and properties of lime-based pastes without any aggregates. In our work nine different sets of pastes with additions of metakaolin and brick dust were studied and compressive strength were investigated . The study revealed that metakaolin exhibits much stronger pozzolonas activity than brick dust, and that the mechanical properties of pastes are not necessarily enhanced by the addition of pozzolona.

1.INTRODUCTION

The inconveniences involved in the use of lime as a binder (e.g. slow setting and carbonation, high shrinkage and low strength have been over come in the last decades by the use of Portland cement. However,the negative effects of the Portland cement in the restoration of architectural heritage, such as low plasticity, excessive brittleness and early stiffness gain together with the high content of soluble salt sleaching over time, high thermal conductivity and open porosity on grouting mortars have forced the restorers to exploit the lime-based mortars again. Moreover, many authorities have criticized the cement-based mortars for their esthetic incompatibility with the old masonry or old archeological surfaces

Today's commercial limes are very pure, even though the regulating standard is not very strict — the mass of CaO and MgO in the commonly used CL-90 lime hydrate should be higher than 90%. The presence of impurities in historic lime mortars was not usually harmful the content of silica (SiO2) and alumina (Al2O3)was mainly responsible for their hydraulic character. The reaction between lime and SiO2and Al2O3 leads to the formation of calcium silicates and aluminates

The contemporary high-purity limes without any additive slack the required durability, strength and suffer from an enormous shrinkage. Therefore, the minerals have to be added to lime in the form of

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pozzolans—in our study we used metakaolin and finely crushed bricks.Pozzolans, e.g. volcanic ash or crushed bricks, have been used since ancient times in combination with lime to improve the moisture resistance of mortars, resulting in freeze–thaw resistance and also to increase their mechanical strength and durability . Mortar with the addition of pozzolans should be able to harden in a high relative humidity (they are called hydraulic) or when the access of CO2 is limited as in the case of mortars supporting glazed tiles . Crushed ceramic material from tiles, bricks and pottery was added to lime-based mortars during the Byzantine period , and crushed bricks in the joints of load-bearing masonry were extensively used in the Roman Empire as the pozzolanic material where no volcanic material was available Such mortars were also preferred from the early Hellenistic up to the Ottoman period in water-retaining structures to protect the walls from moisture, typically in baths, canals and aqueducts . While fine brick particles were mainly used for rendering, larger crushed brick particles appeared mainly in masonry walls, arches and foundations.

2. LITERATURE SURVEY

Pacheco Torgal.F et al (2011): determined the effect of Metakaolin and Fly ash on strength and durability of concrete. The durability was found by three methods namely water absorption, oxygen permeability and concrete resistivity. They reported that partial replacement of Portland cement by 30% fly ash leads to serious decrease in early age compressive strength than the reference mix made with 100% Portland cement. The use of hybrid of them at 15% Fly ash and 15% Metakaolin based mixtures resulted in minor strength loss at early stages but showed outstanding improvement in durability.

Hemant Chauhan et al (2011) made an attempt to use industrial wastes like activated Fly ash, Iron Oxide and Metakaolin as supplementary cementitious materials in various proportions. Using these mineral admixtures with OPC cement, five different types of concrete mixtures were prepared and same were used to find compressive strength of concrete cubes at 3,7,14,28 and 56 days.

Murali.G and Sruthee P(2012) experimentally studied the use of Metakaolin as a partial replacement substance for cement in concrete. The use of Metakaolin in concrete effectively enhanced the strength properties. The optimum level of replacement was reported as 7.5%. The result showed that 7.5% of Metakaolin increased the compressive strength of concrete by 14.2%, the split tensile strength by 7.9% and flexural strength by 9.3%

Paiva.H et al (2012) determined the effect of Metakaolin on strength and workability of concrete. The experimental results showed that the use of Metakaolin decreased the workability and to get the required slump, High range water reducing admixtures (HRWRA) were essential.

Erhan Guneyisi et al (2012) made an investigation to determine the effectiveness of metakaolin (MK) and silica fume (SF) on the mechanical properties, shrinkage, and permeability related durability of high performance concrete. Mechanical properties were evaluated by means of compressive and splitting tensile strength. Water absorption and gas permeability tests were carried out to find out the permeation characteristics of the concrete with Metakaolin and Silica fume. The experimental results showed a considerable increase in the compressive strength properties of blended concrete than the control mix for different water cement ratios.

3. Benefits

- It minimizes binder production, significantly reducing the associated co2 emissions and energy consumption;
- It reduces the extraction of raw materials for binder and aggregates production, and lessens the environmental impact associated with the disruption of the landscape and riverbeds by mine workings.
- It encourages the avoidance of using paints and other coating products when plasters with red coloured ceramics are applied. As a product for incorporation in lime mortars aimed to repair or replace the mortar in old buildings, they might have technical advantages:
- Mortars made with suitable amounts of ceramic waste may show a high degree of compatibility with old buildings masonry systems, particularly when compared to mortars with hydraulic binders;
- The mortars may exhibit superior performance when compared to pure air lime mortars, because of the hydraulic behaviour due to the potential for pozzolanic reaction of ceramic dust waste;
- Ceramic waste introduced as aggregate may induce better binder/aggregate cohesion, because of the shape and composition of the fragments;

4. Workability of Concrete Mixes

BINDER COMBINATION	WORKABILITY (SLUMP)		
	w/c = 0.55	w/c = 0.6	w/c = 0.65
A	Shear slump/ 115mm	Shear almost collapse slump/ 128mm	Collapse slump/ 145mm
B	True slump/ 49mm	Shear slump/65mm	Collapse slump/ 115mm
C	True slump/40mm	Shear slump/52mm	Shear slump/92mm
D	True slump/ 30mm	True slump/43mm	Shear slump/ 75mm
E	True slump/ 20mm	True slump/30mm	Shear slump/62mm
F	True slump /25mm	True slump/35mm	True slump/43mm

5. Results and Discussion

Effect of mechanical properties of lime and metakaolin mortar paste Figure 1 shows the compressive strength of lime and metakaolin mortar paste for various mass ratios of 9:1, 8:2, 7:3, and 6:4 ratios respectively. Similarly Figure 2 shows the tensile strength of the above said mortar paste ratios. The compressive strength result shows that there is an increase in the compressive strength with the increase in the age of concrete. When lime and metakaolin mortar paste results compared with 100 % lime mortar paste there is an increase in the compressive strength. The percentage of increase varies by 13% for M1 mix, 25% for M2 mix, 29% for M3 mix and 43% for M4 mix for the age of 7 days. Similarly 10% for M1 mix, 14% for M2 mix, 39% for M3 mix, and 65% for M4 mix for the age of 14 days. Similarly 13% for M1 mix, 24% for

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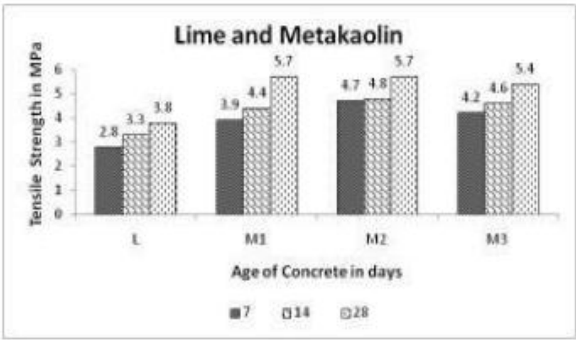
M2 mix, 51% for M3 mix, and 84% for M4 mix for the age of 28 days. The important thing to be noted in that was increase in strength is found out in later ages of lime and metakaolin mortar paste when compare with 100% lime mortar paste also the mass ratio of 6:4 has greater increase in compressive strength for all ages of mortar paste and therefore the optimum ratio among all will be 60% lime and 40% metakaolin. The tensile strength result shows there is an increase in the strength with increase in age of concrete. When lime and metakaolin mortar paste results compared with 100% lime mortar paste there is an increase in the tensile strength. The percentage increase varies by 39% for M1 mix, 67% for M2 mix, 50% for M3 mix and 42% for M4 mix for the age of 7 days. Similarly 33% for M1 mix, 45% for M2 mix, 39% for M3 mix, and 36% for M4 mix for the age of 14 days. Similarly 50% for M1 mix, 50% for M2 mix, 42% for M3 mix, and 36% for M4 mix for the age of 28 days. The important point to be observed is that increase in tensile strength for the mass ratio of 6:4 and hence 60% lime and 40% metakaolin is the optimum replacement. The failure of the specimen is brittle in nature due to the absence of reinforcing aggregates.



6. Materials used

Lime Hydrated lime is white in colour. It is a fine powder with free flowing, free from all grits and impurities with a CaO content of about > 92%. It is supplied by Sigma minerals Ltd., having a size of

Methodology

- The pastes are mixed as per specifications
- Water is added, based on the ratios in each mix
- The paste are casted in to cubes
- The size of cube is 150 cum.mm
- Three cubes are casted for each mix
- The cubes are casted for 7days,14days,28days.
- The cubes are cured for 7days,14days,28days.
- Finally compression test is done

Mix proportions Nine different mix proportions are adopted by using Lime, Metakaolin and brick dust. The water to mortar paste ratio varies from 0.30 to 0.5. The compressive strength and tensile strength results were compared with 100% lime mortar paste.

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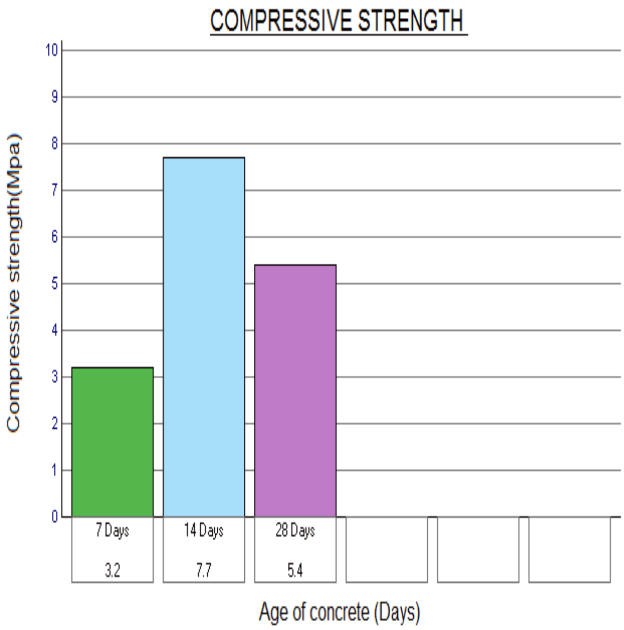
MIXING

CB-4 (LIME60%-CRUSHED BRICKS40%)



8. Conclusion and Future Work

Based on the results of experimental work, the following conclusions are drawn:

1) Metakaolin improves the compressive strength at higher cement content, enhances sulfate attack resistance but increases shrinkage.

2) Silica fume improves compressive strength at all cement contents. It also improves resistance to sulfate attack but shows highest shrinkage among all mineral admixtures used in this study.

3) Brick powder only improves shrinkage but is more susceptible to sulfate attack and higher replacement leads to decrease in compressive strength.

4) The increase in concentration of sulfate solution increases the expansion in cement mortars.

5) Increase in percentage replacement level of metakaolin and silica fume reduces expansion in mortar but opposite trend is observed in brick powder.

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