An Analytical Study on The Performance of Natural Hydraulic Lime Mortars By Using Egg Albumen As Bio-Admixture

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Abstract- *Mortar is the most common component of the construction materials used for centuries. The use of admixtures is essential in preparing mortar mix with mechanical properties suitable for the restoration of ancient structures. In the present study, Natural Hydraulic Cement Lime (NHCL) mortar was modified by adding Egg Albumen (EA) as an admixture in varying concentrations of 10%, 20%, and 30% by weight of water, and tested for their fresh-state, mechanical, physical, and durability properties The objective behind the work is that the protein-rich Egg Albumen could increase workability due to their lubricating and viscous nature, besides enhancing mechanical properties due to their adhesive nature that could effectively bond the lime and sand together. The work's main objective was to investigate the fresh and hardened state properties of EA-modified hydraulic cement lime mortar and to discuss the results Proteins form an impermeable hydrophobic layer that restricted the penetration of water. As a result, the connectivity between the EA-modified- NHCL mortar's pores was disrupted, resulting in the decreased capillary intake of water and salt solutions. Therefore, EA-modified NHCL mortars, with their upgraded workability, mechanical, and durability properties, are considered a new generation of sustainable admixtures that could preserve heritage value structures and assure potential use in modern construction The replacement of cement we can use lime and Egg Albumen as an admixture by the weight of water in the required proportions for 6 cubes.*

I. INTRODUCTION

Cement:- A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as non-hydraulic or hydraulic respectively, depending on the ability of the cement to set in the presence of water Non-hydraulic cement does not set in wet conditions or under water. Rather, it sets as it dries and reacts with carbon dioxide in the air. It is resistant to attack by chemicals after setting Hydraulic cements (e.g., Portland cement) set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet conditions or under water and further protects the hardened material from chemical attack. The chemical process for hydraulic cement was found by ancient Romans who used volcanic ash (pozzolana) with added lime (calcium oxide) Modern hydraulic development began with the start of the Industrial Revolution (around 1800), driven by three main needs: Modern cements are often Portland cement or Portland cement blends, but industry also uses other cements Portland cement, a form of hydraulic cement, is by far the most common type of cement in general use around the world. This cement is made by heating limestone (calcium carbonate) with other materials (such as clay)

Natural hydraulic lime:- Hydraulic lime (HL) is a general term for calcium oxide, a variety of lime also called quicklime, that sets by hydration. This contrasts with calcium hydroxide, also called slaked lime or air lime that is used to make lime mortar, the other common type of lime mortar, which sets by carbonation (re-absorbing carbon dioxide (CO_2) from the air). Hydraulic lime provides a faster initial set and higher compressive strength than air lime and hydraulic lime will set in more extreme conditions, including under water The terms 'hydraulic lime' and 'hydrated lime' are quite similar and may be confused but are not necessarily the same material. Hydrated lime is any lime which has been slaked whether it sets through hydration, carbonation, or both Calcium reacts in the lime kiln with the clay minerals to produce silicates that enable some of the lime to set through hydration. Any unreacted calcium is slaked to calcium hydroxide which sets through carbonation. These are sometimes called 'semi-hydraulic lime' and include the classifications feebly and moderately hydraulic lime, NHL and NHL Sand and larger sized aggregates make up the larger proportion of most mortars. Colour, texture and overall strength are all strongly affected by the choice of aggregate The aggregates most commonly used with hydraulic lime are sand and grit, although for the purpose of matching historic mortars various impurities may have to be added. A good sand should be Natural Hydraulic Cement Lime (NHCL) mortar was modified by adding Egg Albumen (EA) as an admixture tested for their fresh-state, mechanical, physical, and durability properties. The rationale behind the work is that the protein-rich Egg Albumen could increase workability due to their lubricating and viscous nature, besides enhancing mechanical properties due to their adhesive nature that could effectively bond the lime and sand together. The work's main objective was to investigate the fresh and hardened state properties of EA- modified hydraulic lime mortar and to discuss the resultsa washed sharp sand with angular grains to ensure good bonding qualities. Soft building sands should be avoided as their rounded grain shape can result in excessive shrinkage Sands used should be well graded with a range of grain sizes, which for most plaster, render and mortar work will range from 5mm down to 75 micron. Larger sized aggregates may be used in some mortar or pointing work. As a rule of thumb for pointing, the maximum size of aggregate should be no bigger than one third of the joint width. Sands, which contain a clay or silt content of more than 4% should be avoided, as these will inhibit the contact between lime binder and aggregate Sands which have a high fines content should also be avoided as the larger surface area of these will require more water in the mixing. This higher water content will induce shrinkage and can affect flexural and compressive strengths. Monogranular sands should be avoided as they will possess poor workability qualities and will inhibit good vapour exchange i.e. the ability to breathe

Water:- Use clean water. The addition of water should be considered carefully, as it will directly affect the ultimate strength and durability of a mortar. The more water introduced into the mortar mix, the weaker will be the final result. However too little water will prevent the chemical processes taking place and weaken the material. Generally, water should be added sparingly, until a useable consistency is achieved. Adjust quantities to give a workability suitable for the application.

Egg Albumen:- Egg Albumen is one of the oldest fining agents used for reducing the harshness of red wines. Peynaud (1984) reported that about 12.5% (w/w) protein can be found in fresh egg whites. The principal proteins in egg white are albumen (water soluble) and globular proteins (soluble in neutral dilute salt solutions). To aid solubility of egg white, addition of small amounts of sodium chloride is a common practice Natural Hydraulic Cement Lime (NHCL) mortar was modified by adding Egg Albumen (EA) as an admixture tested for their fresh-state, mechanical, physical, and durability properties. The rationale behind the work is that the protein-rich Egg Albumen could increase workability due to their lubricating and viscous nature, besides enhancing mechanical properties due to their adhesive nature that could effectively bond the lime and sand together. The work's main objective was to investigate the fresh and hardened state properties of EA- modified hydraulic lime mortar and to discuss the results Proteins form an impermeable hydrophobic layer that restricted the penetration of water. As a result, the connectivity between the EA-modified- NHCL mortar's pores was disrupted, resulting in the decreased capillary intake of water and salt solutions. Therefore, EA-modified NHCL mortars, with their upgraded workability, mechanical, and durability properties, are considered a new generation of sustainable admixtures that could preserve heritage value structures and assure potential use in modern construction

Scope:- Lime is frequently employed for restoring and conserving historic buildings and has become a cheap material due to its characteristics make it highly suitable and long lasting building materials, which is the reason for its use in mortars The addition of an Egg Albumen into the cement lime mortar to modify its properties which makes the mortar highly compressible and reduce the cost. The compressive and flexural strength of the lime mortar increases with the increasing percentage of Egg Albumen added into cement lime mortar. It is believed that the characteristics of the Egg Albumen act as a lubricant in lime mortar making the mortar easier to compact and fill the smaller void inside the mortar, thus making Egg Albumen cement lime mortar stronger than plain lime mortar

II. REVIEW OF LITERATURE

Shanmugavel, D., KumarYadav, P., Khadimallah, etal details Experimental analysis on the performance of Egg Albumen as a sustainable bio admixture in natural hydraulic lime mortars

Mortar is the most common component of the construction materials used for centuries. The use of admixtures is essential in preparing mortar mix with mechanical properties suitable for the restoration of ancient structures. In the present study, Natural Hydraulic Cement Lime (NHCL) mortar was modified by adding Egg Albumen (EA) as an admixture in varying concentrations of 10%, 20%, and 30% by weight of water, and tested for their fresh-state, mechanical, physical, and durability properties. The rationale behind the work is that the protein-rich Egg Albumen could increase workability due to their lubricating and viscous nature, besides enhancing mechanical properties due to their adhesive nature that could effectively bond the lime and sand together. The work's main objective was to investigate the fresh and hardened state properties of EA- modified hydraulic lime mortar and to discuss the results. The scope of the present study includes (i) evaluation of the effect of EA on the mechanical properties of NHCL mortars, (ii) an assessment of the influence of EA on the microstructure and porosity of the NHCL mortars, and (iii) durability assessment of the modified mortars based on the reduced capillary water uptake. Analytical techniques such as Fourier Transform were used to study the modified mortar's microstructure. Proteins form an impermeable hydrophobic layer that restricted the penetration of water. As a result, the connectivity between the EA-modified- NHCL mortar's pores was disrupted, resulting in the decreased capillary intake of water and salt solutions. Therefore, EA-modified NHCL mortars, with their upgraded workability, mechanical, and durability properties, are considered a new generation of sustainable admixtures that could preserve heritage value structures and assure potential use in modern construction

A panel Alan M. Forster Ewan et al; Deterioration of natural hydraulic lime mortars, I: Effects of chemically accelerated leaching on physical and mechanical properties of uncarbonated materials

Received 25 March 2014, Revised 22 July 2014, Accepted 8 September 2014, Available online 28 September 2014.School of the Built Environment, Heriot-Watt University, Edinburgh EH144AS, Scotland, United Kingdom Masonry using lime binders is very common in all regions of the world. Models for the future climate in northern regions suggest more intense rainfall which will result in the materials used in mass masonry being saturated for longer periods and therefore at higher risk of binder leaching and consequent deterioration. In this first study of lime binder leaching, ammonium nitrate leachant was used to accelerate the deterioration of mortars containing natural hydraulic lime binders. Loss of binder reduced the alkalinity and strength of the mortar and increased its sorptivity. The leached depth followed diffusion- controlled kinetics with the rate constant increasing in line with the increasing free calcium hydroxide content of the binder. A predictive model was developed for uncarbonated mortars, such as those of all ages (historic or modern) found deep in mass masonry and those at early age in new construction or repairs Traditional stone masonry, consisting of units bedded in lime mortar, is common worldwide, with innumerable low rise dwellings, castles, palaces, bridges, viaducts and other infrastructural masonry (such as retaining walls) remaining in use. In Scotland alone there are an estimated 446,000 pre 1919 dwellings, totalling 20% of the building stock, and the vast majority of these are believed to be constructed of stone. Urquhart estimated that there are 24,000 traditional built stone and lime mortar facades in Glasgow, with a potential repair cost of about £0.5 billion. Anecdotal evidence from building professionals highlights situations where traditional mortars have been found to be deficient in binder and in some cases, voids have been found in walls behind an apparently sound exterior. This has been associated with progressive collapse in traditional buildings. McKibbins and Melbourne state that 'Contributory mechanisms for deterioration of masonry in all types of structures include moisture saturation and leaching of mortar.... Leaching results in physical loss of strength and adhesion. Mortar that has undergone severe leaching can become weak and friable, and is easily lost from joints by washing-out or compressive extrusion in areas of high stress, resulting in local stress concentrations and loosening of masonry units. Binder leaching is due to high moisture contents in calcium-based materials and the increased rainfall associated with climate change means that masonry will be wetter for longer. Soluble components within the mortar may dissolve and migrate through the material to be re-deposited within the pores, in construction voids, or as efflorescence on external faces of masonry . The binder components vulnerable to dissolution are portlandite (calcium hydroxide, Ca (OH2)) and calcite (calcium carbonate, CaCO3). Less hydraulic limes may have a higher proportion of Ca (OH)2 and are likely to be more reliant on carbonation for hardening as they contain a lower proportion of the hydraulic components. Whilst this does vary between different lime manufacturers, the hydraulicity of the original binder is expected to influence a mortar's long term performance. Less hydraulic lime binders should be more susceptible to dissolution, particularly in saturated, cold conditions because the solubility of both Ca (OH)2 and CaCO3 increases as water temperature decreases

Panel B.A. Silva A.P. Ferreira Pinto A .Gomes Natural hydraulic lime versus cement for blended lime mortars for restoration works

The paper analyses the potential of blended lime-cement mortars to substitute blended lime-natural hydraulic lime mortars as repair mortars in restoration works, since the availability of natural hydraulic lime is reduced in many countries, unlike cement. The study focuses on the pore structure of both types of blended mortars and its implications on their water transport properties, initial mechanical strength and overall incompatibility risk. The influence of binder type and composition and of binder/aggregate ratio on pore structure was discussed. Cement altered more markedly the mechanical and water transport properties of blended mortars than hydraulic lime, with consequences on compatibility. Considering the properties evaluated, blended lime-cement mortars can be used but cement content should be higher than 25% (of total binder mass), so that there is a strength increase at early age, and lower than 50%, in order to not significantly affect compatibility. Nevertheless, the blended lime mortar with 50% natural hydraulic lime presented the highest potential for restoration. The paper analyses the potential of blended lime-cement mortars to substitute blended lime-natural hydraulic lime mortars as repair mortars in restoration works, since the availability of natural hydraulic lime is reduced in many countries, unlike cement. The study focuses on the pore structure of both types of blended mortars and its implications on their water transport properties, initial mechanical strength and overall incompatibility risk. The influence of binder type and composition and of binder/aggregate ratio on pore structure was discussed. Cement altered more markedly the mechanical and water transport properties of blended mortars than hydraulic lime, with consequences on compatibility. Considering the properties evaluated, blended lime-cement mortars can be used but cement content should be higher than 25% (of total binder mass), so that there is a strength increase at early age, and lower than 50%, in order to not significantly affect compatibility. Nevertheless, the blended lime mortar with 50% natural hydraulic lime presented the highest potential for restoration

Panel Kuangliang Qiana Yufeng Songa et al Characterization of historical mortar from ancient city walls of Xin deng in Fuyang, China

The goal of this investigation is to characterize the mortar from the ancient city wall of Xindeng in Fuyang, Hangzhou (China), which reveals a history of nearly 1800 years. Several approaches were used to analyse seven specimens obtained from this ancient city wall, and physical properties, mechanical performances, binder/aggregate ratios of these specimens were then determined. However, the mixture compositions as well as the mix design vary greatly among different locations of the city wall. The results indicate that the historical wall is mainly composed of hydrated lime and sand, and parts of the specimens also contain clay. Meanwhile, calcite and quartz are the major phases present in the historical wall mortars with several impurities. Further, the specimens' great strength and large apparent density are related to the abundant aggregates used and the presence of the fragments of blue brick within the specimens

Panel J Griloa A. Santos Silvaa P. Fariab A. Gameiroa R.etal Mechanical and mineralogical properties of natural hydraulic lime-metakaolin mortars in different curing conditions

In order to increase energy and resources utilization efficiency, and to find hydraulic mortars with improved properties, in this paper we employed diatomite as partial replacement of natural hydraulic lime NHL2 (NHL) and masonry waste powder (MWP) as aggregate in the preparation of mortars. Diatomite was used at 0%, 10% and 20% replacement by weight for NHL2 and the mortars were designed with different water binder ratios (w/b). The physical, mechanical, and anti-aggressive properties such as freeze and thaw, and acid and sulfate resistance properties of mortars were tested after 14, 28 and 90 days of curing. The introduction of diatomite reduced the density of mortars, and it also reduced the total amount of raw materials, especially the amount of NHL, to prepare same volume of mortars. Diatomite replacement generally enhanced the compressive and flexural strength of hydraulic mortars. The enhancement mainly happened after 14 days of curing when pozzolanic effect was noticeable. Diatomite replacement percentage and w/b influenced porosity, compactness and strength of mortars. There existed optimal diatomite replacement percentage and w/b for mortars to attain largest strength. The introduction of diatomite improved acid and sulfate resistance of mortars greatly. All the hydraulic mortars studied in this paper can still well develop strength under freeze and thaw condition

Panel Davide Gulottaa Sara Goidanicha Cristina Tedeschib Timo G. et al Commercial NHL-containing mortars for the preservation of historical architecture. Part 1: Compositional and mechanical characterization

This paper presents the characterisation of a selection of NHL-based commercial products for the conservation of historic masonries. Two binders and four ready-mixed mortars have been analysed; both the anhydrous raw materials and the hardened mortars have been studied, focusing on those parameters which can be used as selection criteria. The influence of different curing conditions on the final microstructure has been considered as well, in order to simulate the real application. Despite the similar commercial indications provided by the manufacturers, the results show remarkable differences for what concerning both the initial composition and the final behaviour of the mortars NHL-based binders and ready mixed mortars for the conservation of historic masonries. Compositional, microstructural, mechanical features studied according to compatibility criteria. Evaluation of the influence of different substrate and curing conditions on the final microstructure. NHL class assignment data not suitable for describing the final mechanical behaviour of the mortars. Mortars intended for similar purposes show extremely heterogeneous characteristics

Panel Frowin Ruegenberg Martin Schidlowski Tobias Bader Anja Diekamp Assessing the influence of the mixing

method on porosity and durability of NHL-based renders based on key parameters

Natural hydraulic lime (NHL) is a common binder material in historic mortars and becomes increasingly used in recent restoration works for the preservation of cultural heritage. These plasters, renders and masonry mortars are suitable for applications, where elevated water permeable characteristics are required. At the building site different workmanship methods may be used, which can be simulated by e.g. different mixing times. Hence, within the present study two NHL-based recipes using hydrated lime of different origin (dry powder and lime putty suspension) were evaluated with regard to the effect of different mixing methods and water content on fresh and hardened mortar characteristics based on a comprehensive experimental program. Additionally, the porosity was evaluated by direct and indirect methods for assessing the water transport behaviour. Although durability and the underlying water transport properties are strongly related to porosity, this study focused primarily on this essential interrelation described by key parameters found in literature and evolved within this study. The results revealed that the mixing method and its associated water content as well as the type of hydrated lime affect strongly the fresh and hardened mortar properties. The pore structure characteristics that resulted from different fresh mortar treatment are crucial for the developing of durability

III. METHODOLOGY

3.1 Materials Used And Their Properties;-

CEMENT: 53 grade ordinary Portland cement was used for this experimental investigation. It was ensured that the cement was taken from the same brand and a single batch. To prevent the cement from humidity, moisture it was stored in airtight containers. The cement was tested in accordance to IS 4031-1988 standards

FINEAGGREGATE: In this current investigation, locally available clean river sand was used in form of fine aggregate and various properties of sand were tested as per IS 2386-1963. It was also ensured that the sand used was free from salt, organic impurities and clayey matter. The fine aggregate was confirming to grading zone – II of IS 383-1970. The sand retained on 0.075 mm IS sieve and was passing through 4.75mm IS sieve. The results of properties tested for sand are given in the table 3.2.

COARSE AGGREGATE: Construction aggregate, or simply "aggregate", is a wide group of coarse particulate material used in construction, as well as sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. Aggregates are the majority mined materials in the world. Aggregates are a constituent of composite materials such as concrete and asphalt concrete; the aggregate serve as reinforcement to insert strength to the overall composite material

Natural hydraulic lime-Natural hydraulic lime is produced by heating limestone that naturally contains clay and other impurities. Calcium reacts in the lime kiln with the clay minerals to produce silicates that enable some of the lime to set through hydration. Any unreacted is slaked to calicium hydroxide which sets through carbonation Fineness of Lime [IS 4031: 1996 Part I]

1. Sample of lime was taken and air lumps found in the cement were removed with fingers.
2. Weighed approximately 100 g of the lime and placed it on the 90 micron IS sieve. The sieve was closed with a lid on its top to avoid wastage of lime while sieving.
3. The lime was continuously sieved for 15 minutes.
4. The residue was weighed after 15 minutes of sieving. Its mass is termed as a percentage (R_1) of the quantity first placed in the sieve.
5. The whole procedure was repeated using a fresh 10 g sample to obtain

MIX DESIGN PROCEDURE The main object of cement lime mortar mix design is to select the optimum proportions of the various ingredients cement lime mortar of which will yield fresh cement lime mortar of desirable properties like workability and hardened Mortar possessing specific characteristic compressive strength and durability The following basic data is required to be specified for the design of a cement lime mortar mix:

Grade of cement mortar : M20 Grade
Type of exposure : Severe
Type of cement used : OPC 53 Grade
Specific gravity of cement : 3.14
Zone of sand : Zone II
Specific gravity of sand : 2.46
Type of water : Potable

PREPARATION OF TESTING SPECIMENS

Mixing :-Mixing of ingredients is done in pan mixer of capacity 50L. The cementitious materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water, Egg Albumen and mixing. Wet mixing is done until a mixture of uniform colour and consistency are achieved

Casting The cast iron moulds of size 150×150 mm is cleaned of dust particles and applied with mineral oil on all sides before cement lime mortar is poured in to the moulds. The moulds are placed on a level platform. The well mixed cement lime mortar is filled in to the moulds and kept on vibration table. Excess cement lime mortar was removed with trowel and top surface is finished level and smooth

Curing The specimens were removed from the moulds after 24hr from the time of adding the water to the ingredients. The specimens then marked for identification. These specimens were then stored in clean water for the required period of curing

COMPRESSIVE STRENGTH TEST PROCEDURE :-

Compressive strength of a material is defined as the value of uni-axial compressive stress reached when the material fails completely. In this investigation, the cube specimens of size 150 mm x 150 mm x 150 mm of all the multi blended mix cement lime mortar are tested. The testing was done on an automatic compression testing machine of 200 KN capacities. The machine has a facility to control the rate of loading with a control valve. The plates are cleaned and oil level is checked, and kept ready in all respects for testing

After the required period of curing, the cube specimens are removed from the curing tanks and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally. The smooth surfaces of the specimen are placed on the bearing surfaces. The top plate is bought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched on In each case the cube was positioned in such a way that the load was applied perpendicularly to the direction of casting with a loading rate of 140 $kg/cm^2/min$ was maintained and it was continued till the specimen fails, i.e., with further increment of load, no resistance was offered by the specimen, that maximum load was recorded. The test was repeated for the three specimens and the average value was taken as the mean strength

IV. RESULTS OF THE EXPERIMENTAL INVESTIGATIONS

COMPRESSIVE STRENGTH TEST

Mortar cubes of size 70.6mm×70.6mm×70.6mm were cast with and without Egg Albumen. During casting, the cubes were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demolded and subjected to curing for 7 days in portable water. After curing, thespecimens were tested for compressive strength using compression-testing machine of 2000KN capacity. The maximum load at failure was taken. The average compressive strength of Mortar and mortar specimens was calculated.

Split Tensile Strength Test :- Mortar cylinders of size 150 mm diameter and 300mm length were cast with incorporating Egg Albumen as partial replacement of sand and cement. During casting, the cylinders were mechanically vibrated using a table vibrator. After 24 hours, the specimens were demolded and subjected to curing for 28 days in portable water. After curing, the cylindrical specimens were tested for split tensile strength using compression-testing machine of 2000kN capacity. The ultimate load was taken and the average split tensile strength was calculated

Flexural Strength Test Procedure: The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from centre to centre is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm centre to centre. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsional stresses or restraints

ACID AND SULPHATE ATTACK A durable Mortar is one which resist chemical attack, weathering action and abrasion while maintaining its anticipated engineering properties. Inadequate durable Mortar exhibits deterioration which can be because of external or internal causes within the Mortar itself. The several actions can be chemical, physical or mechanical. Alkali- silica and alkali-carbonate reactions are generally the chemical causes of deterioration. External chemical attack happens mainly by the action of aggressive ions, such as sulphates, chlorides, carbon dioxide, industrial or natural liquids and gases. Impact, erosion, abrasion or cavitations attributes to the mechanical damage. There are various physical causes which origins deterioration in Mortar. Those include the effects of high temperature, alternating freezing and thawing of Mortar and the associated action of de-icing salts Considering local conditions, in this investigation the impact of external chemical attack on Mortar because of exposure to 5% HCl, 5% H_2SO_4, 5%MGSO4 and 5% Na_2SO_4 wasstudied by submerging Mortar cubes of size 70.6 mm x 70.6 mm x 70.6 mm in above mentioned acid and sulphate solution for a period of 7 and 28 days, beyond 28 days of water curing. The cubes were immersed in acid and sulphate solutions contained in a tub. A minimum distance of 40 mm was maintained between the cubes placed in tubs containing acid and sulphate solutions. The compressive strength and weight of the cubes were measured at 7 and 28 days of exposure in the above solutions. Each test result was averaged out from of six test result

RESULTS AND DISCUSSIONS Several researchers have investigated the possible use of Egg Albumen as a bio-admixture in Mortar and its effects on the different mechanical and long-term properties of mortar and Mortar (Tan et al 2000, Taeb et al 2002, Tang et al 2000, Zong et al 2003). While most of the reports point to benefits of using Egg Albumen as bio-admixture, in some stray cases some negative effects such as delaying of the setting time have also been reported (Ueno et al 2005, Premchand et al 2000). Although there are many studies that have been reported by investigators from other countries on the use of Egg Albumen in cement lime Mortar, not much research has been carried out in India concerning the incorporation of Egg Albumen bio admixture by the weight of its water. Even though there are various research studies have been reported by investigators about Egg Albumen, its physical properties and chemical composition varies country wide and hence its mechanical performance also varies according to that. Therefore, this research was performed to generate specific experimental data on potential use of Egg Albumen replacement as a bio admixture by the weight of its water M20 Mortar was used to perform this investigation. This chapter has been divided into four main parts. Mechanical performance of Mortar incorporating Egg Albumen as bio admixture by the weight of its water (0 to 30% replacement). Mechanical performance of Mortar and Lime members incorporating ground Egg Albumen as bio admixture by the weight of its water. (0 to 30% replacement). Durability effects of Mortar and reinforced Mortar members incorporating Egg Albumen as bio admixture by the weight of its water
Compressive Strength Test

Table 5.1 Compression Strength Values for 7 Days & 28 Days

S.No	Mix Identity	Ultimate load kN		Comp. strength N/mm^2	
		7 Days	28 Days	7 Days	28 Days
1	C100 L0 EA0	60	80	12.03	16.05
2	C100 L0 EA10	30	100	6.02	20.06
3	C100 L0 EA20	32	85	6.42	17.05
4	C100 L0 EA30	50	80	10.03	16.05
5	C75 L25EA0	70	113.79	14.04	22.82
6	C75 L25 EA10	32	90.90	6.42	18.23
7	C75 L25 EA20	35	85.77	7.02	17.20
8	C75 L25 EA30	40	52	8.02	10.43

Compressive strength test on Mortar cubes. The effect of Egg Albumen substitution shows the effect on the strength of Mortar is given in Table 5.1, which presents the average 7 and 28 days cube compressive strength of Mortar. A total number of 48 mortar specimens were cast and tested shown in Figure 5.1. The compressive strength values of Mortar mixtures with different proportions of Egg Albumen tested at 7 and 28 days are also plotted in Figure 5.1

SPLIT TENSILE STRENGTH TEST ON MORTAR CYLINDERS

Split tensile strength is defined as a method of determining the tensile strength of Mortar using a cylinder, which splits across the vertical diameter. The effect of Egg Albumen substitution as a fine aggregate on split tensile strength of Mortar is given in Table 5.2

Table 5.2 Split tensile strength test on cylinders

S.No	Mix Identity	Ultimate load kN		Tensile. strength N/mm^2	
		7 Days	28 Days	7 Days	28 Days
1	C100 L0 EA0	80.55	93.02	2.56	2.96
2	C100 L0 EA10	56.96	104	1.81	3.31
3	C100 L0 EA20	58.83	95.88	1.87	3.05
4	C100 L0 EA30	73.53	93.02	2.34	2.96
5	C75 L25EA0	87.01	110.93	2.77	3.53
6	C75 L25 EA10	58.83	99.15	1.87	3.15
7	C75 L25 EA20	61.52	96.31	1.95	3.06
8	C75 L25 EA30	65.77	74.99	2.09	2.38

Table 5.3 Flexural strength test results on Mortar beams

S.No	Mix Identity	Flexural. strengthN/mm^2	
		7 Days	28 Days
1	C100 L0 EA0	2.42	2.80
2	C100 L0 EA10	1.71	3.13
3	C100 L0 EA20	1.77	2.89
4	C100 L0 EA30	2.21	2.80
5	C75 L25EA0	2.62	3.34
6	C75 L25 EA10	1.77	2.98
7	C75 L25 EA20	1.85	2.90
8	C75 L25 EA30	1.98	2.26

ACID AND SULPHATE RESISTANCE TEST: Eight Mortar mixtures of 48 specimens were prepared and tested for acid and sulphate resistance. Each mixture consists of 12 cubes of various proportions of Egg Albumen in Mortar. Out of twelve Mortar, cubes six cubes were tested for acid and sulphate resistance (4 cubes tested for acid resistance and 4 cubes for sulphate resistance) at 7 days and 28 days

Sulphuric acid attack Table 5.4 Weight Reduction and compression strength values for cement mortar cubes effected with H_2SO_4

S.No	Mix identity	Weight of cubes before after immersion			Compression strength before H_2SO_4 attack (N/mm2)		Compression strength after H_2SO_4 attack (N/mm2)	
		Before	7Days	28Days	7 Days	28 Days	7 Days	28 Days
1	C100 L0 EA0	0.705 0.751	0.627 0.630	0.620 0.615	12.03	16.05	8.18	10.91
2	C100 L0 EA10	0.745 0.737	0.700 0.663	0.670 0.633	6.01	20.06	3.84	16.77
3	C100 L0 EA20	0.787 0.750	0.708 0.637	0.661 0.592	6.42	17.05	4.23	15.68
4	C100 L0 EA30	0.788 0.794	0.685 0.638	0.638 0.611	10.03	16.05	6.51	14.12
5	C75 L25EA0	0.786 0.787	0.738 0.708	0.691 0.637	14.04	22.82	10.38	22.79
6	C75 L25 EA10	0.712 0.759	0.676 0.698	0.626 0.622	6.42	18.23	12.63	13.49
7	C75 L25 EA20	0.794 0.786	0.754 0.762	0.682 0.715	7.02	17.20	4.49	11.69
8	C75 L25 EA20	0.712	0.690	0.662	8.02	10.43	5.21	9.65

Hydrochloric acid attack Table 5.5 Weight Reduction and compression strength values for cement mortar cubes effected with HCl

Sodium sulphate attack

Table 5.7 Weight Reduction and compression strength values for cement mortar cubes effected with Na_2So_4

Magnesium sulphate attack Table 5.6 Weight Reduction and compression strength values for cement mortar cubes effected with $MgSo_4$

V. CONCLUSIONS

From the present study the following conclusions can be drawn

1. The utilization of Egg Albumen in Mortar provides additional environmental as well as technical benefits. Partial replacement of Egg Albumen in waterv increases the workability of mortar
2. The initial and final setting time of Egg Albumen admixed Mortar is higher than control Mortar
3. The compression strength values obtained have been keenly observed and can be concluded that the values are varying according to the change in the percentage of egg albumen
4. It can be conclude that the maximum compression strength is observed for the mix C100 L0 EA0 (C – Cement, L – Lime, EA – Egg Albumen) where as the minimum compression strength is observed for C100 L0 EA10
5. From the above point it can be concluded that the maximum compression strength is obtained when the egg albumen is 0% as the egg albumen is increases the compression strength gets reduced
6. It can be conclude that the maximum tensile strength is observed for the mix C100 L0 EA0 (C – Cement, L – Lime, EA – Egg Albumen) where as the minimum tensile strength is observed for C100 L0 EA10
7. From the above point it can be concluded that the maximum tensile strength is obtained when the egg albumen is 0% as the egg albumen is increases the tensile strength gets reduced
8. The compression strength, tensile strength and flexural strength increases when the lime content is 25%.
9. During the acid and sulphate attacks it has been observed that the mortar cubes has shown major deformation for acid attack when compared to sulphate attack
10. During the acid attack the cubes has shown major deformations for the mortar cubes which are treated with H_2SO_4. It can be concluded that 50% to 60% of Calcium (Ca) has been removed when the mortar cubes are treated with Sulphuric acid
11. It has been observed that when the mortar cubes are treated with hydrochloric acid (HCl) a dark reddish color has been observed on the surface of the mortar cubes but the deformation and loss of strength is less for the cubes which are treated with HCl when compared with H_2SO_4

12. At last it can be concluded that the utilization of egg albumen will be effective if it is utilized in fraction percentages as 0.5% to 0.8%.
13. It can be also concluded that the egg albumen can be also utilized as a viscosity modifying agent (VMA)
14. For the observations it can be concluded that the utilization of natural hydraulic lime as a replacement for cement is effective which is responsible for increasing the strength
15. The major drawback because of the utilization of the natural hydraulic lime the water– cement ratio gets increased as the hydraulic lime is having high amount of water absorption property

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