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BEHAVIOR OF MORTAR INCORPORATE WITH FLY ASH AND STONE DUST CURING IN SALINE WATER

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ABSTRACT

Construction activities are increasing day by day in different regions and utilities are causing scarcity of natural resources which is being forced due to its over exploitation. Depletion of natural resources boosting up the threat to the environment. Since construction activities cannot be stopped, conservation of natural resources has become one of the greatest challenges for engineers. Finding alternative materials which can be fully or partially replaced by naturally available materials in construction can be effective approach in this regard. Mortar is a mixture of sand, water and cement which is used widely in construction industry due to good performance in plastering and bedding work.In one hand, stone dust is such an alternative material which can be effectively being used in construction as partial replacement of natural sand. On the other hand, use of fly ash and stone dust will decrease the land fill of waste disposal. However, a portion of the world's carbon dioxide emission is attributed to cement industry, which is the vital constituent of mortar so replacement of cement will also be beneficial for environment. Construction officials in coastal areas have long been facing the challenge of building and maintaining durable structures in a salty environment. Gradual penetration of sea salts and the subsequent formation of expansive and leachable compounds lead to disintegration of structure. The successful performance of a coastal structure depends to a great extend on its durability against the aggressive coastal environment. Disintegration of structures in saline environments is mostly caused by chemical deterioration such as sulfate attack, chloride attack and leaching. Physical deterioration from crystallization of soluble hydrated salts in pores of the surface erosion and abrasion promotes further disintegration. The overall results of these attacks on stuctures are softening, cracking and partial removal of cover mortar. This in turn exposes a fresh surface for further attack. Also in order to save fresh drinking water, saline was used for curing to obseve the applicability of salty water of coastal areas. Experimental investigation was performed in this study to describe the change in compressive strength and water absorption of mortar cubes in salty exposures. Mortar cubes were casted varying the quantity of fly ash and stone dust for the replacement of cement and sand. From this experiment optimum use of fly ash and stone dust can be suggested where fly ash is 10-20% of cement with 100% stone dust in mortar paste for saline environment. More than 30% replacement of cement with fly ash is not recommended for drastic reduction of compressive strength.

Keywords: *Fly ash, Stone dust, Saline environment, Land fill, Carbon dioxide.*

1. INTRODUCTION

Mortar can be considered as workable paste which is used to build up bonding among the bricks, stones and gaps sometimes. For creating mortar, a mixture of cement and sand has to be made and mixed thoroughly in dry condition. Shovels can be used to mix the water. Then with the hydration cement will gain the strength gradually. Until the hydration has taken place, it is necessary to see that mortar is wet. After laying mortar, the process of ensuring sufficient moisture content for hydration is known as curing. Water is sprayed for curing. Curing is normally done within 6–24 hours after mortar is used. It may be noted that initial period for water requirement is more for hydration and gradually it reduces. Hydration of cement begins with the addition of water and it binds sand particles and also the surrounding surfaces of masonry and concrete. Well-proportioned is called when mortar provides impervious surface. As leaner mix is not capable of closing the voids in sand, the plastered surface is porous. The strength of mortar is affected by the proportion of cement and sand. In construction field we use mortar in various purposes. Mortar has been using for thousand years as a means of adhering bricks or concrete blocks with one another. Again, cement mortar continues to be used in various types of constructions as to plaster slab and walls which make them impervious, to provide neat finishing to walls and concrete works, masonry joints pointing, for making building blocks, as a filler material in ferro cement works, for filling joints and cracks in walls also, as a filler material in stone masonry. In thermal power plant fly ash is the produced. For the low heat hydration and higher workability, it is used in mortar or concrete. Surprisingly, there is only 14 percent of total production of fly ash was utilized each year, other than that was disposed in landfills (Kuan & Saleh, 2016). Use of fly ash should be increased for reducing landfill. Normally, sand is used as common fine aggregate in construction work. On the other hand, Stone powder from stone crushing zones appears as a problem for effective disposal (Mahzuz, Ahmed, & Yusuf, 2011). If sand can be replaced with stone dust it can be a part of solution of this problem. Again, only 2.5% of the world's water bodies are said to be of fresh water and the remaining constitute of contaminated water with salt or other substances. According to the report of the World Meteorological Organization, more than half of the world's population would not have enough drinking water by 2025 (Pravallika & Lakshmi, 2014). The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which had been increased up to 102 million hectares in 2000 and the amount has risen to 105.6 million hectares in 2009 and continuing to increase, according to the country's Soil Resources Development Institute (SRDI). Salinity increased around 26 percent in the last 35 years, in this country, spreading into non-coastal areas as well (Haider, 2019). In coastal areas, saline water can be used for construction instead of fresh water and to do so an optimum percentage of fly ash with stone dust should be determined.

2. BACKGROUND OF THE STUDY

Mainly, there can be two sources of producing carbon dioxide emissions one is natural and other is human. In natural sources, decomposition, ocean release and respiration may be included. Where as in Human sources can be comprised from activities like cement production at industry and in application, deforestation as well as the burning of fossil fuels like coal, oil and natural gas (Main sources of carbon dioxide emissions, 2017). From the data of World Resources Institute (WRI), it is shown that in the last 200 years, humans have added 2.3 trillion tones of CO2 to the atmosphere. Out of this 2.3trillion tone of CO2 around half of this amount was added in the last 30 years alone. The most heat-trapping gases are present in the environment; there can be some other gases which include methane (CH4), nitrous dioxide (NO2), and several artificial gases (Hydro fluorocarbons (HFCs), Per fluorocarbons (PFCs); and Sulphur hexafluoride (SF6). These are the main 6 groups which are considered for under the Kyoto Protocol. In Construction and demolition also, debris constitutes a considerable portion of solid waste. Thus, reducing the carbon dioxide emission is gaining the instantaneous importance and there by Sustainable Construction has high priority in the recent construction era. Out of several cementing materials, fly ash is the most commonly used material worldwide. According to the American Concrete Institute (ACI) Committee, fly ash is defined as "the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system.” Worldwide, the estimated annual production of coal ash in 1998 was more than 390 million tons (Rai, Kumar, & Satish, 2014). The main contributors of the coal ash were China and India. By the year 2010, about 780 million tons of fly ash produced worldwide annually. If fly ash is not utilized, may present environmental concerns, and its storage/disposal will be costly (Yerramala & Desai, 2012). The majority of fly ash is low calcium fly ash which is produced in India. The use of fly ash as admixture in cement mortar/concrete not only extends technical advantages to the properties of cement mortar/concrete but also contributes to the environmental pollution control (Rai, Kumar, & Satish, 2014). The storage of engineering materials (sand, stone) are limited so, day by day the dependency on them must be minimized. Hence, some other materials should be introduced for replacing sand. Stone dust is one of such alternatives of sand that can be used satisfactorily for the demand of fine aggregate. In Bangladesh, Jaflong is a tourist spot in the division of Sylhet. Stone collections and the location of the Khasi tribe make this place renowned which lies sixty kilometers to the northeast of sylhet. In the economy of a developing country like Bangladesh this tourism spot that can play a very significant role. Due to unplanned activities, the beauty of Jaflong is can be reduced day by day. Extraction of stone from river can affect the present condition of physical, chemical and biological process. In Jaflong there are a number of stone crushers, as a result of these huge labour oriented economic activities, a large number of low-income workers live in Jaflong and around (Haque & Ray, 2012). During the crushing of stones, a large amount of dust is created. They have been considered as a waste in the local areas. They are not given any importance and thrown here and there. While landfills are commonly used for disposal of stone dust in Bangladesh, rapid urbanization has made it increasingly difficult to find suitable landfill sites. Several attempts are seen in different researchers’ activity to find out proper utilization and disposal of waste (Mahzuz, Ahmed, & Yusuf, 2011). When structure is exposed to the coastal area, the carbondioxide present in the salt water and surrounding atmosphere permeates into the structure carbonates it and reduce the alkainity (KV, SS, & J, 2010). Salinization is a highly complex process of intrusion into surface and ground water, seepage through thin geological structures into shallow pockets of freshwater coming towards abstraction wells in Bangladesh because of the surging motion of a lava lamp and salt water intrusion after floods caused by storm. While extraction of groundwater increases, salt from the groundwater can be sucked up from depth. In the coastal zone, absorption of saline water from tidal marshes and unprotected canals can increase the problem. Local conditions may have an effect on flushing out salt, it may take several years for fresh water to 'flush' salt out of groundwater reservoirs. Sometimes, the monsoons accelerate this flushing process so long as more saline surface water does not infiltrate Incorporation of fly ash as cement replacement improve the resistance of carbonation (McIntyre, 2014). Therefore, this study was to reduce the use of fresh water in curing and analyze the property of mortar with the fly ash and stone dust replacement in the coastal area.

3. OBJECTIVES

- To determine the effects of saline water for curing on mortar.
- To determine the best resistive percentage of fly ash against saline environment.
- To determine the effect of stone dust on mortar.

4. METHODOLOGY

In this study 5 types of specimens were casted varying the percentage of fly ash with alternation of sand and stone dust as Table 4.1 & cured with saline water for 7, 14 & 28 days. Variation in compressive strength, water absorption, & density was recorded.

Table4.1: Trial mix detailing

Trial Mix	(Cement +Fly Ash)	Sand/Stone Dust
M1	100% Cement	100% Sand
M2	90%C+10%Fly Ash	100% Stone Dust
M3	80%C+20% Fly Ash	100% Stone Dust
M4	70%C+30% Fly Ash	100% Stone Dust
M5	60%C+40% Fly Ash	100% Stone Dust

5. MATERIALS

5.1 Cement: Ordinary Portland cement was used for this test. To have a generalized idea about the Weight ratio of the Constituents of the ordinary Portland cement a pie chart is created according to the information from a website (Ordinary Portland Cement -Constituents, Properties, Types and Uses).

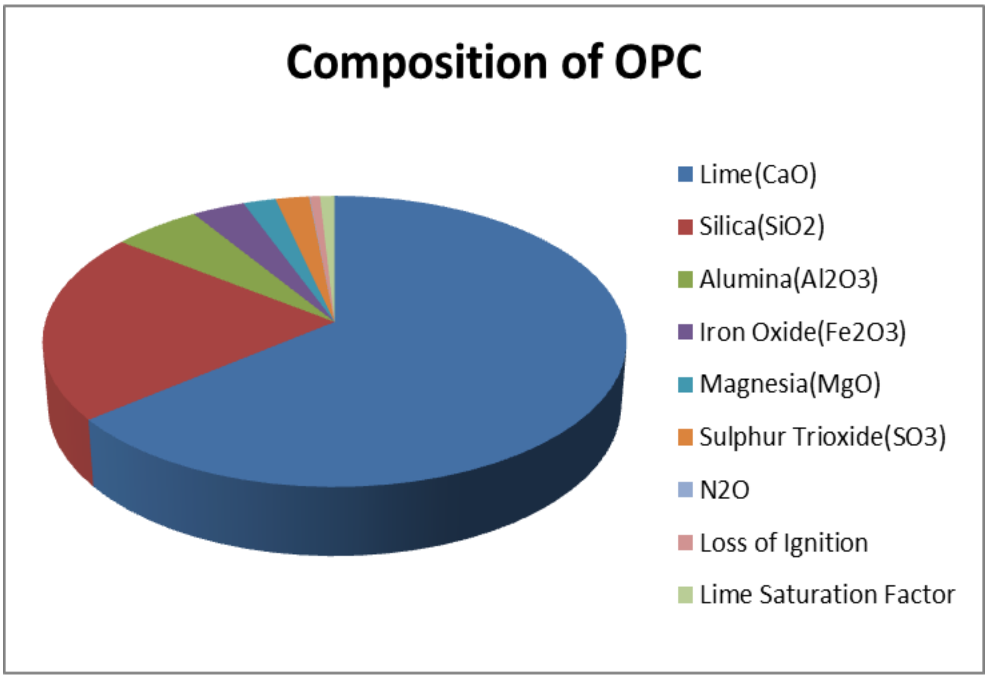

Fig. 5.1.1: Composition of OPC

5.2 Stone Dust: Stone dust was collected from Noapara, Jashore. Dust passing by No. 16 seive and retained by No.100 seive was used for casting for ensuring more uniformity among the particle and keeping the FM value (2.61) similar with the sand. Chemical composition of lime stone powder (Shuhua, Peiyu, & Jianwen) is shown below in the table5.2.1

Table 5.2.1: Chemical compositions of limestone powder/%

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	SO_3	K_2O	Na_2O	L.I
2.50	0.60	0.36	54.03	0.54	0.05	0.01	0.10	0.08	41.59

5.3 Fly Ash: **Fly ash was collected from Noapara, Jashore.**

5.4 Saline: Sea water has about 35 grams of salt per litre of water, which is almost 60 times more than the 0.6 grams of salt per litre standard for the water in coastal areas of Bangladesh (McIntyre, 2014). In this study, concentration of salt in water was 13gm/L which means 1.3% where the concentration of chloride was 12,500mmg/L

Fig. 5.2.1: Stone Dust

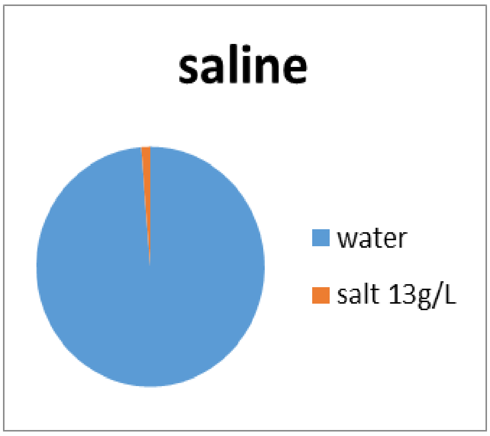

Fig. 5.4.1: Concentration of Salt

6. PROCEDURE

Compressive strength of mortar was determined by using 2 inch or 50.8mm cubes as per ASTM C109 / C109M – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars. 5.08cm cubes moulds (25.8cm^2 face area), apparatus for gauging and mixing mortar, vibrator, compression testing machine etc. were used.

- Cement and sand were mixed in dry condition with a trowel for 1 minute.
- Then water was added and mixed with the sand and cement until the mixture is of uniform colour also took the weight of the empty mould (W3).
- Immediately after mixing the mortar, mortar was placed in the cube mould and prod with the help of the rod.
- The mortar was prodded 20 times in about 8 sec to ensure elimination of entrained air and took the weight of mould full of mortar (W4).
- After 24 hours cubes were removed from the mould and their weight were measured (W1) and kept for 72 hours in oven at 105^0 C then immediately submerged in a bowl full of saline water of given concentration till testing.
- When curing age reached, specimens were taken out, cleaned with absorbent paper and again took the measurement of weight (W2) and stored in oven with 100°C for 24 hours in order to dry it for crushing.
- The whole procedure was repeated for other specimens only the sand and cement were replaced according to mix detail table.
- For determining water absorption this theory:(W2-W1)*100/W1 was used.

- For determining density, the theory used was: (W4-W3) *100/Volume of mould.

7. RESULTS AND DISCUSSIONS

Compressive strength in different time periods are shown graphically also graphical comparison of water absorption and densities of all the trial mixes are given below consequently.

Fig-7.1 shows that compressive strength decreases with the increasing percentage of fly ash. This might be for slow hydration process since fly ash is slow reactive pozzolans which slow down the process (Kuan & Saleh, 2016). In one hand, addition of stone dust ameliorates this condition by showing the optimum reaction with optimum filler capacity (Rai, Kumar, & Satish, 2014). On the other hand, curing with saline water accelerate the hydration process (Khan, Izhar, Mumtaz, & Ahad, 2016) tough it makes the compressive strength a litle bit lower by forming leachable white compounds on the surface of the mortar. For M1 compressive strength of 7, 14 & 28 days were consequently 26.30, 28.30 & 32.40 N/mm^2. For M2 these were 14.50, 20.60 & 28.80 N/mm^2, for M3 the strength was 13.60, 18.26 & 28 N/mm^2, for M4 compressive strength were 9.10, 10.10 & 11.45 N/mm^2 and finally for M5 the compressive strength was 6.30,8.00 & 8.00 N/mm^2. From the result M2 and M3 gives quiet good strength after 30 days curing as according to ASTM C109M-13 & IS 2250 21.6 N/mm^2 is considered for strong mortar. On the other hand, compressive strength of M4 is too low comparing with M2 and M3 because of the increase in fly ash percentage. For the low compressive strength M4 will not be good for structural use especially in coastal areas & M5 is too weak (as according to ASTMC109M-13 6.9 N/mm^2 for mortar is considered as weak mortar) in compressive strength to use.

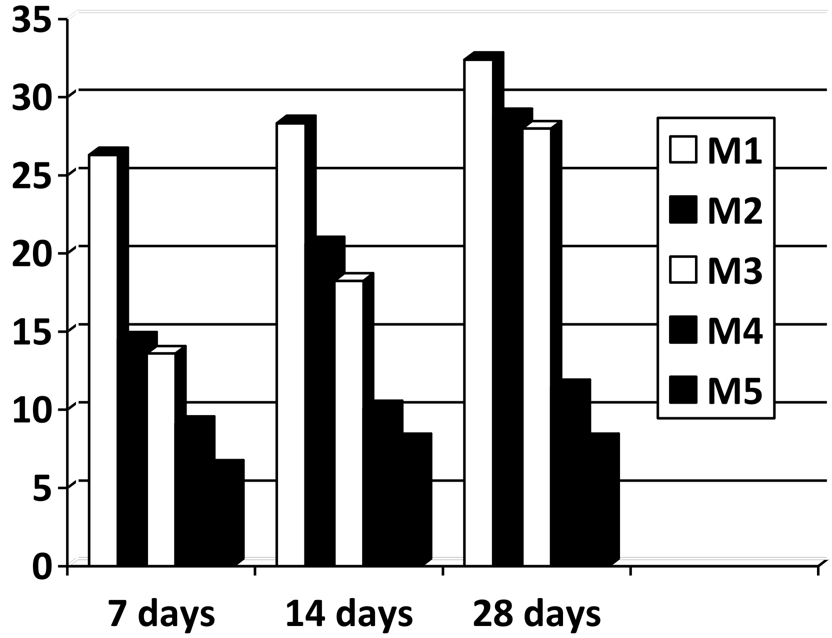

Fig. 7.1: Compressive strength in N/mm^2 over the time period.

Water absorption decreases with the increasing rate of fly ash showed in fig-7.2. Which means durability of mortar increases with the percentage of fly ash replacement.M1 has the highest water absorption rate where M5 shows the lowest. It can be explained as fly ash react with calcium hydroxide in cement to form calcium silicate hydrate (C-S-H). With increase of C-S-H, the interconnected pore structures of mortar are filled of it. Fly ash reduces the permeability (Kuan & Saleh, 2016).

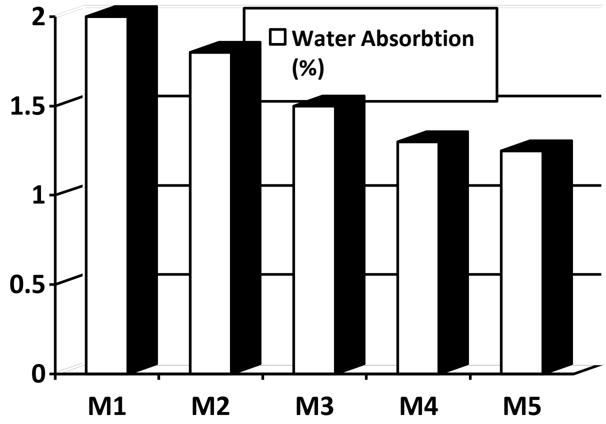

Fig. 7.2: Water absorption rate of trial mixes.

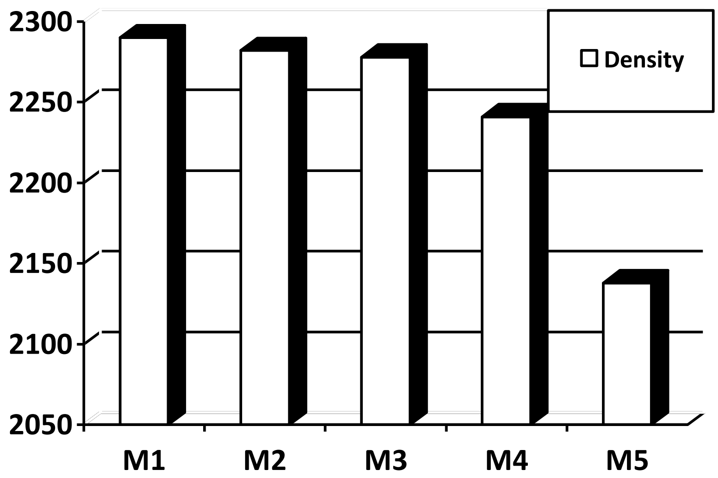

Fig. 7.3: variation densities of trial mixes.

As shown in fig-7.3 density is decreasing with the addition of fly ash which is very little for M1, M2 & M3 but M5 shows the lowest density. This may occur when the stone dust used is not pure or mixed with other substances and causes less cohesion among the particles sometimes can entrap air which create gap.

CONCLUSIONS

Effect of saline water on the specimens was noticeable. The grey colour was turning whitish grey because of salt composition on the surface of the specimen. This study indicates that among the all replaced specimens M2 shows the best performance with the compressive strength of 28.80 N/mm^2 and M5 shows the lowest compressive strength which is 8.00 N/mm^2 also M5 gives the lowest density. That means more than 30% of replacement of cement with fly ash will not be suitable to use. On the other hand, use of stone dust shows excellent performance by ameliorating the drastic reduction of compressive strength for fly ash. For coastal areas 10-20% replacement by fly ash is recommended with the use of stone dust.

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