Optimization of Lime-Fly Ash Mix

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***Abstract* -- The disadvantages of present high grade cements are more shrinkage which leads to cracks, brittle in nature which causes cracks on minor movement, leakage, porosity, less durability, looses plasticity early. This results in less durable structures. Hence, under such circumstances, the present need is to introduce such material in practice which can be a suitable combination of Old and New technologies and can give high performance results; i.e. the product which gives strength as well as durability. Portland cement is an excellent material for mass concrete and engineering structures but the last 50 years have shown that it is not the greatest for mortars, plasters and renders as it is too hard, too rigid and too permeable. High energy costs and CO_2 emissions associated with OPC production in the last few decades have prompted the use of cement replacement materials. Pozzolanic material, fly ash combined with lime can be used as partial or complete substitutes for OPC.**

Keyword--Portland cement, pozzolanic material, fly ash, lime, OPC

I INTRODUCTION

A. Fly Ash

Fly ash is a pozzolanic material containing reactive silica and/ or alumina which on their own have little or no binding property but, when mixed with lime in presence of water, will set and harden like cement. They are important ingredients in the production of an alternative cementing material to ordinary Portland cement (OPC). As per recent report total fly ash generation in the country will be around 300-400 million tons per year by 2016-17. The present utilization being only 55.69 % (2014-15) , there is huge potential for use of fly ash. Since unutilized fly ash would pose dangerous challenge to environment due to pollution of air and water. Through this research work certain amount of fly ash would get utilized in the construction sector. There are huge problems in disposal of unutilized fly ash. For disposal large area of precious land is required which in today's context is a costly affair. Due to scarcity of land, this precious land goes in vain. Therefore through this research work, an attempt has been made to utilize the fly ash rather than disposing it.

Through this research work an attempt has been made to use locally available resources. The lime is from Rajur mines Dist. Chandrapur which is a local mineral. The fly ash is from Khaperkheda Thermal Power station Dist Nagpur. This is locally available. Therefore there is saving in cost. There is a reduced material cost due to cement savings and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions.

B. Lime

There are two basic types of lime for traditional lime mortars 1). Non hydraulic lime mortars - Those that set and harden by the reaction with air. 2). Hydraulic lime mortars - Those that set and harden by the reaction with water [1]. The non-hydraulic lime mortar sets very slowly through reaction with the carbon dioxide in air. The speed of set can be increased by using impure limestone in the kiln, to form hydraulic lime that will set on contact with water. Alternatively pozzolanic material such as Fly Ash, calcined clay or brickdust may be added to the mortar mix. This will have a similar effect of making the mortar set reasonably quickly by reaction with the water in the mortar.

One of the greatest benefits of lime mortar is its recyclability. After a building has served its purpose, lime mortar can easily be removed from brickwork, unlike Portland cement which is extremely difficult to remove. After it has been removed lime is very easy to recycle because the mortar has the same chemical makeup ($CaCO_3$) as the raw materials from which it was derived. The mortar can go straight to the kiln. Lime mixed with cement is much more difficult to recycle.

Portland cement is an excellent material for mass concrete and engineering structures but the last 50 years have shown that it is not the greatest for mortars, plasters and renders as it is too hard, too rigid and too permeable. For these reasons, many people think that lime mortar will be a better fit for modern mainstream buildings and structures. The combination of lime with modern technologies and higher demand could cause the market for lime mortar to take off. The future of lime mortar is far better than Portland cements. The introduction of carbon tax, or legislation setting targets for recycling of buildings could make Portland cement impractical and therefore make lime mortar the better choice [2]. "The future is green, lime green" as Prichett would put it. Limes are produced at a temperature of around 900 to 1100 °C, Portland cement is produced at 1200 to 1500 °C. That means that more energy is required to produce a metric ton of Portland cement than a metric ton of hydraulic lime, thereby increasing CO_2 emissions. Portland cement does not just produce a little more CO_2 emissions than lime mortar, but Portland cement production is responsible for 1500 million metric tons of CO_2 each year that is approximately 10 percent of all worldwide CO_2 productions. So with the introduction of carbon tax or legislation setting targets for recycling buildings, lime mortar has a great chance to overtake the mortar market in the future if not soon.

C. Lime-Fly Ash mix

Lime-pozzolana mixture which essentially, a mixture of lime and pozzolana could be used as an alternative cementing material to ordinary Portland cement for certain categories of work like masonry mortar and plaster, foundation concrete, leveling course under floors, road and airfield bases, pre-cast

building blocks (including light weight blocks), paving blocks, soil stabilization and filler in water bound macadam in road construction. Hence the production and marketing of properly mixed, ready to use and properly packaged dry mixtures of lime-pozzolana of specified strength would go long way in making available a standardized product that could be safely used in construction as a substitute for Portland cement in places mentioned above.

For Lime-Pozzolana mix, of this area, as a mortar for construction neither the standard test results and references have been produced nor it is available with the Engineers for ready reference. Whereas such material needs actual data of performance, durability and strength of the product as per the requirement of BIS when it is used in construction work. Hence lime-pozzolana mix could not get popularized and could not be accepted by technical persons and mass consumers for the use in construction activity.

The evolved knowledge of this research work will be utilized for the creation of awareness amongst consumers and to rely on the test results.

D. Lime pozzolana mix

The pozzolana or mineral admixture plays a double role in these cases. The pozzolanic particles fill the empty spaces between cement grains and between other pozzolanic particles and improve packing. Only a small part of the added pozzolana, less than 30%, reacts. The compressive strength, however, does not correspond to the low level of hydration achieved. Some have attributed the strength increase to the contribution of electrical interaction between the smallest fly ash particles [3].

II METHODOLOGY

For optimization of mix fly ash proportion was varied from 0.75, 1.00, 1.25 and 1.50 and sand proportion was varied from 2.0, 2.5 and 3.0. Lime proportion was taken constant at 1.0.

Thus following combinations of mix proportions of Lime: Fly Ash: Sand were decided as

A_{11} (1:1.5:2), B_{12}(1:1.5:2.5), C_{13}(1:1.5:3),
D_{21}(1:1.25:2), E_{22} (1:1.25:2.5), F_{23} (1:1.25:3),
G_{31}(1:1:2), H_{32} (1:1:2.5), I_{33} (1:1:3),
J_{41} (1:0.75:2), K_{42} (1:0.75:2.5), L_{43}(1:0.75:3),

The combinations are chosen with a view to get optimum proportion of Lime and Fly Ash, as a full replacement of cement in mortar. Water required based on consistency test was worked out. The samples were casted for all above combinations and tested at 7 and 28 days of age.

Procedure as detailed in IS 2250-1981 [4], IS 4098 – 1983 [5] was followed while casting the cubes. Various specimens were tested for different mix proportions is presented in tabular form in Table-1

TABLE 1: OPTIMIZATION OF LIME - FLY ASH MIX.

Code	Mix Proportion Lime : Fly- ash : sand	Compressive Strength N/mm² 7 days	28 days
A_{11}	1:1.5:2	0.250	0.380
B_{12}	1:1.5:2.5	0.492	0.746
C_{13}	1:1.5:3	0.637	0.966
D_{21}	1:1.25:2	0.914	1.380
E_{22}	1:1.25:2.5	0.607	0.920
F_{23}	1:1.25:3	0.488	0.740
G_{31}	1:1:2	0.351	0.532
H_{32}	1:1:2.5	0.639	0.969
I_{33}	**1:1:3**	**1.036**	**1.571**
J_{41}	1:0.75:2	0.840	1.273
K_{42}	1:0.75:2.5	0.403	0.612
L_{43}	1:0.75:3	0.786	1.192

III CONCLUSION

From Table -1, optimum strength has been observed for the mix of lime and fly ash proportion of 1:1. Maximum strength has been observed for the mix proportion of lime: flyash: sand ratio as 1:1:3.From the observations the suitable proportion of cementing material (i.e. lime : fly ash) for mortar would be equal i.e. 1:1.

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