International Journal of Advanced Technology in Engineering and Science
Vol. No.4, Issue No. 12, December 2016
www.ijates.com
ijates
ISSN 2348 - 7550

COST EFFECTIVE COMPOSITE CONCRETE USING LIME SLUDGE, FLY ASH AND QUARRY SAND

H R Dhananjaya[1] and Basavaraj[2]

[1]*Dept of Civil Engineering, School of Technology,*
Pandit Deendayal Petroleum University, Gandhinagar, (India)
[2]*Dept of Civil Engineering, Nitte Meenakshi Institute of Technology, Bangalore, (India)*

ABSTRACT

This paper presents the study on effect of industrial waste materials namely lime sludge, fly ash and quarry sand on compressive strength, split tensile strength and flexural strengths of M_{30} grade concrete. Here in M_{30} grade concrete, cement is partially replaced by lime sludge 10 to 40 percent and fly ash 10 to 20 percent, and sand is partially replaced by quarry dust (sand) 20 percent in five mix proportions. The results of these five mixes are compared with controlled mix. The mix proportion with partial replacement of cement by lime sludge 10 percent, fly ash 10 percent and with partial replacement of sand by quarry dust 20 percent, in general yielded better results than remaining all mixes.

Keywords: Lime Sludge, Quarry Sand, Fly Ash, Split Tensile Strength, Compressive Strength

I INTRODUCTION

Concrete is a basic material, which is largely being used in the construction of buildings, bridges, pavements, dams, marine and sanitary structures. Due to the growing global environmental safety awareness, and stricter regulations on managing industrial wastes, the world is increasingly looking in to researching properties of industrial wastes and finding solutions on valuable component part so that can be used as secondary raw material for other industrial applications. Lime sludge is a byproduct of paper making in the paper mill industries and fly ash is by-product of coal thermal power plants. To date, these by-products used in other industrial branches and in the field of civil engineering constructions, such as in cement production along with clinker and in masonry work for civil works. Taking in to account the specificity of physical and chemical properties of fly ash and hypo-sludge and the possibilities for their use in concrete, this research work accounts the possibilities of using fly ash and hypo-sludge together as partial replacement of cement in concrete. The reduction in the sources of natural sand and requirement for reduction in the cost of concrete, has resulted in the increase need to identify substitute material to sand as fine aggregate especially in the concrete. Quarry dust is resulting as byproduct during granite quarrying activities. The present work attempted to reduce cost of concrete by using quarry dust as partial replacement of sand in concrete and partial replacement of cement by fly ash & lime sludge.

In this paper a study has been made for the development of cost effective concrete using industrial waste material like fly ash, lime sludge and quarry sand (quarry dust). This also helps in solving disposal problem of fly ash, lime sludge and quarry dust to some extent.

II LITERATURE REVIEW

Sarika G.Javiya et al [1]studied Hypo sludge utilization in mortar by replacing cement by hypo sludge towards compressive strength, water absorption and sorptivity with different time lapses. .In the reference paper[2], Aman jatale et al, carried out investigation on effect of fly ash on mechanical properties of the concrete like workability, setting time, density, air content, compressive strength by replacing the cement with 20%,40% and 60% of fly ash. M15,M20 & M25. The modulus of elasticity of concrete decreases with increase of replacement of cement by hypo sludge is reported by Solanki and Pitroda[3]. Use of hypo-sludge in pavement construction will improve transportation functionality & ecological sustainability and results in developed traffic safety and reduces life cycle cost by Pitroda et al [4].

III MATERIALS USED

The ingredients used in the composite concrete are ordinary Portland cement, coarse aggregate, fine aggregate (sand), quarry sand (quarry dust), fly ash and lime-sludge. The lime sludge is waste product from paper industry. The fly ash is the waste material from coal industry. The physical properties like specific gravity etc are obtained from the laboratory. The details of various materials used in the composite concrete are given below:
Ordinary Portland cement (OPC) of 53 grades taken in a single slot, from Ultra Tech cement company was used throughout the course of the investigation. The specific gravity of cement is 3.05. Local river sand was used, confirming to the standard specifications of IS 383-1970[5]. It falls under the category zone – III. Specific gavity of the sand is 2.6. Locally available coarse aggregates of 20 mm downsize were used. Specific gravity of the course aggregate is 2.64. The potable water is used in this investigation..

Fly ash of class-C grade was procured from Bellary thermal power plant and a single lot was used through out the investigations. It was dry, free from lumps and is of Grey in colour. The specific gravity of fly ash is 2.46. The lime sludge is the waste material from the paper industry. The lime sludge used in this project work is collected from Mysore Paper Mills Bhadravathi, Shivamogga district, Karnataka. It is white in colour, resembling slaked lime. The specific gravity of lime sludge is 2.38. The quarry sand (quarry dust) used here is brought from the quarries of

North Bangalore and sieved through the IS 4.75mm sieve. The specific gravity of the quarry sand (also known as quarry dust) is 2.41

IV EXPERIMENTAL PROCEDURE

Material properties of ingredients like specific gravities of cement, fine aggregate and coarse aggregate, fly ash and copper slag were determined in concrete Lab. Moisture contents and water absorptions of fine aggregate and coarse aggregate and copper slag were also determined in the concrete Lab. Using these results the concrete mix design has been carried out for M_{30} grade concrete as per IS: 10262-2009[6].

Series of concrete cubes of standard dimensions (150 mm x 150 mm x 150 mm), concrete cylinders of standard dimension (150mm diameter and 300 mm height) and concrete prisms of standard dimensions (100mm x 100mm x 500mm) were cast with various mix proportions as specified in Table 4.1 and were cured for 28 days or 60 days. These cured concrete cubes were tested for compressive strength in compression testing machine as per IS: 516-1959[7]. Concrete cylinders were tested for tensile strength as per IS: 5816-1976[8]. Plain concrete prisms were tested for flexural strength as per IS: 516-1959.

Table 4.1 Mix proportions of ingredients for composite concrete

Grade of concrete	*Notations Mix Type*	*Ingredients in Percentage(%) by weight*					
		Cement	*Fly- ash*	*Hypo Sludge*	*Sand*	*Quarry Sand*	*Coarse Aggregates*
M_{30}	C0	100	0	0	100	0	100
	C1	80	10	10	80	20	100
	C2	70	10	20	80	20	100
	C3	60	10	30	80	20	100
	C4	50	10	40	80	20	100
	C5	70	15	15	80	20	100

V TEST RESULTS AND DISCUSSIONS

The compressive strength, flexural strength and split tensile strength of the plain concrete (without any special or industrial waste materials) have compared with that of compressive strength, flexural strength and split tensile strength of composite concrete made up with industrial waste material fly ash, lime sludge and quarry sand after 28 and 60 days curing.

5.1 Compressive strength of composite Concrete cubes

Series of concrete cubes of standard dimensions (150 mm x 150mm x 150mm) were cast as per the mix proportions given in the Table 4.1.

After 28 days and 60 days curing these cubes have been tested using compressive testing machine and results are shown in the Figures 5.1 and 5.2 respectively. These results indicate that 10 percent replacement of the cement by fly ash and another 10 percent of cement by hypo sludge after 60 days curing has yielded almost same strength of that of the controlled or plain concrete. Further increase in the content of lime sludge resulted in decrease of the compressive strength of cubes. And hence it not advisable to use lime sludge content more than ten percent of the cement content of the plain concrete wherein already cement is partially replaced by fly ash 10 percent.

5.2. Split tensile strength of composite concrete cylinders

Series of composite concrete cylinders of 150 mm diameter and 300 mm height have been cast using the mix proportions given in the Table 4.1 and tested after 28 days and 60 days curing to know their split tensile strength. These results are plotted in the Fig. 5.3 and Fig 5.4. These results indicate that 10 percent replacement of the cement by fly ash and another 10 percent of cement by hypo sludge after 28 days and 60 days curing has yielded 18.4 percent and 5 percent more split tensile strength than of that of the controlled or plain concrete cylinders respectively. Further increase in the content of lime sludge resulted in decrease of the split tensile strength.

5.3. Flexural strength of composite concrete prisms

Series of composite concrete prisms of standard dimensions 100 mm wide and 100 mm deep and 500 mm long have been cast using the mix proportions given in the Table 4.1 and tested after 28 days and 60 days curing to know their flexure strengths. These results are plotted in the Fig. 5.5 and Fig 5.6. These results indicate that 10 percent replacement of the cement by fly ash and another 10 percent of cement by hypo sludge after 28 days and 60 days curing has yielded 6.67 percent and 6.80 percent more flexural strength than of that of the controlled or plain concrete prisms respectively. Further increase in the content of lime sludge resulted in decrease of the flexural strength.

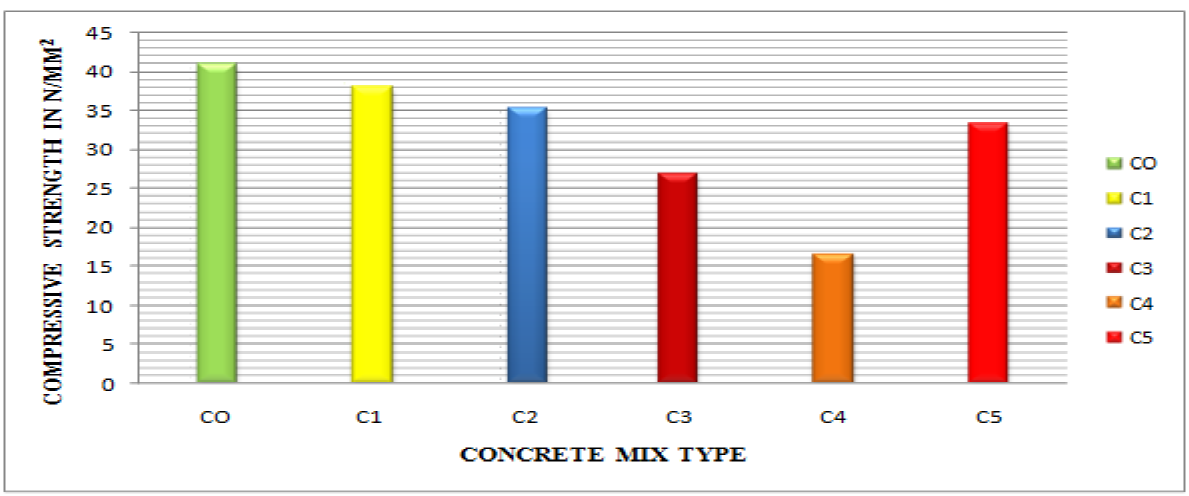

Fig 5.1: Compressive strengths of composite concrete cubes at 28 days curing

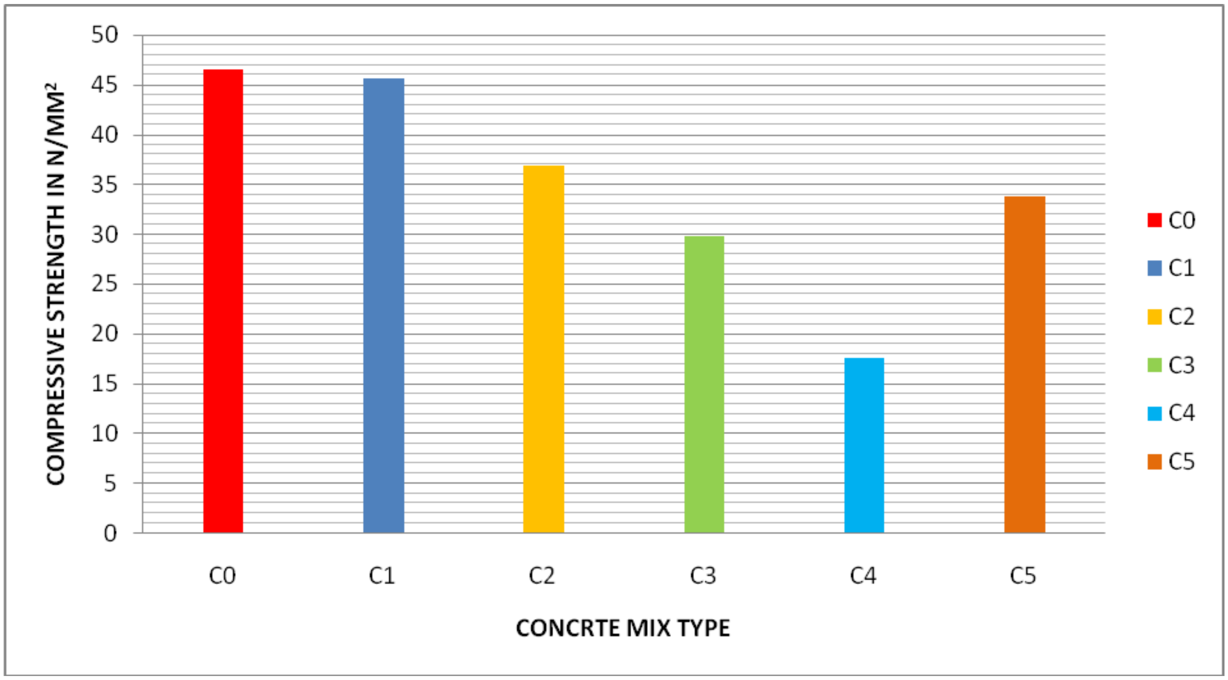

Fig 5.2: Compressive Strength of composite concrete cubes at 60 days curing

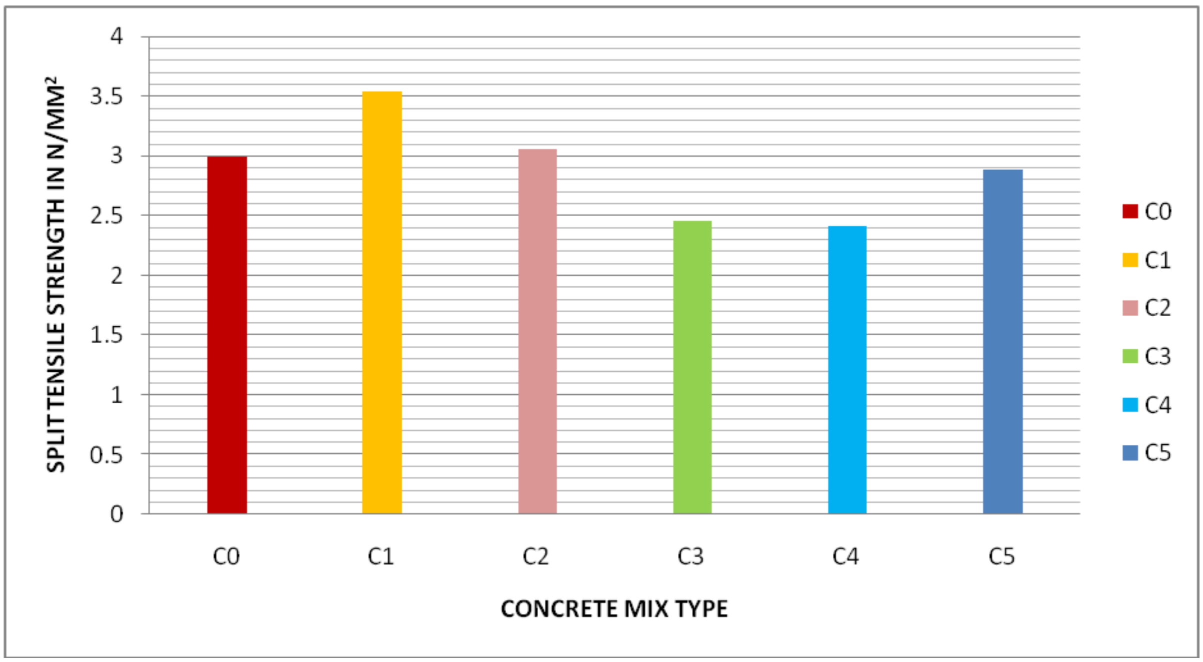

Fig. 5.3 Split tensile strength of composite concrete cylinders at 28 days curing

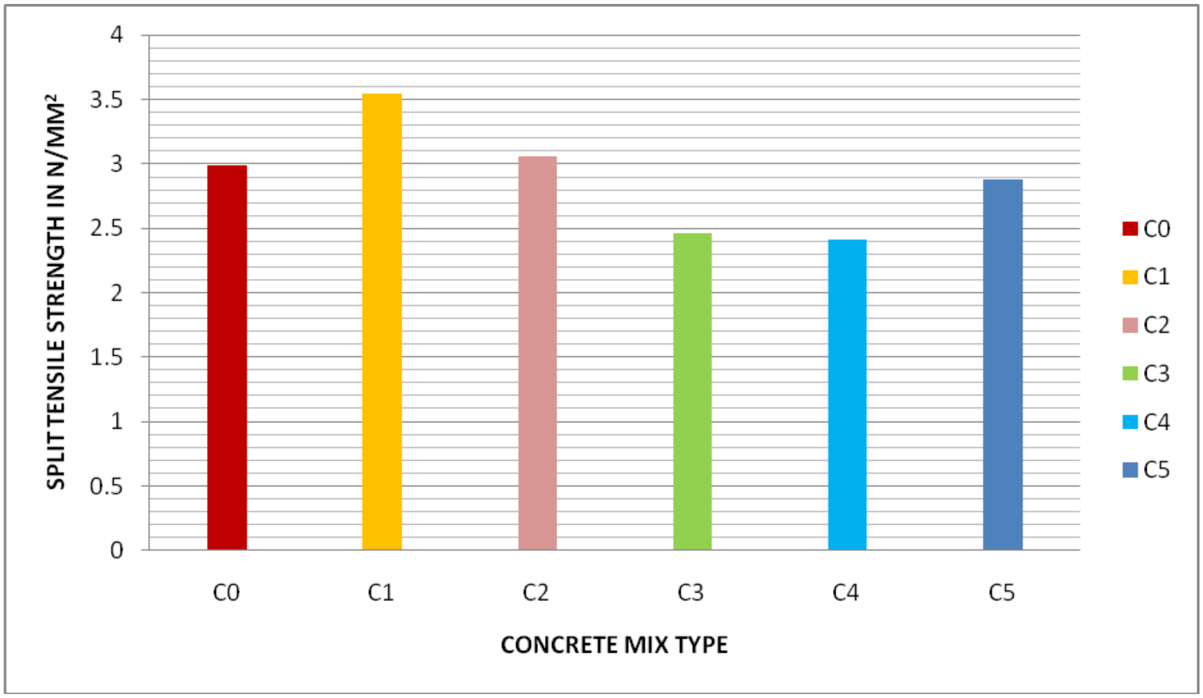

Fig. 5.4 Split tensile strength of composite concrete cylinders at 60 days curing

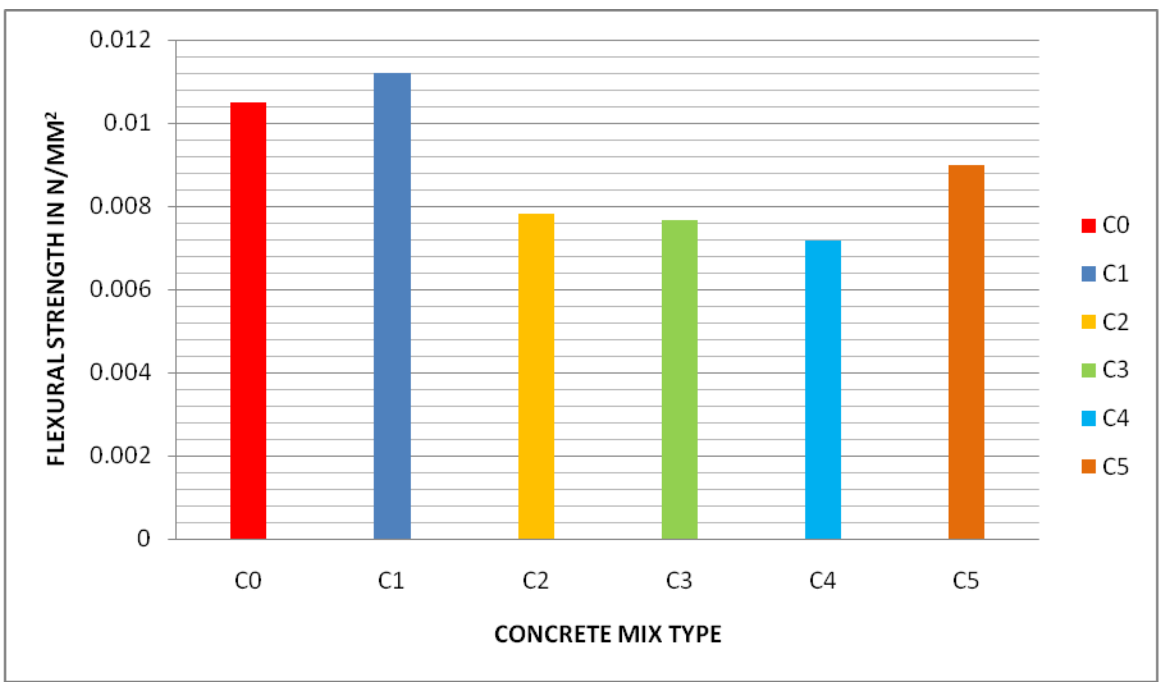

Fig. 5.5 Flexural strength of composite concrete prisms at 28 days curing

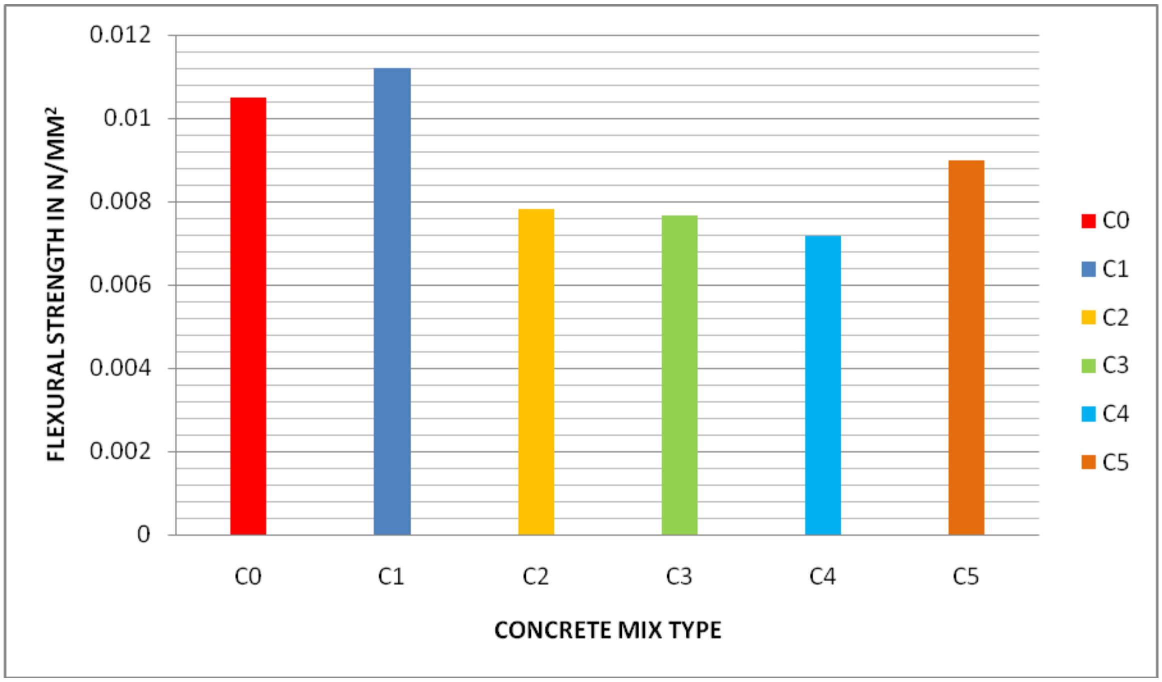

Fig 5.6 Flexural strength of composite concrete prisms at 60 days curing

VI CONCLUSIONS

In the present investigation, a study has been made for the development of cost effective concrete using industrial waste material like fly ash, lime sludge and quarry sand. From the present investigation following conclusions are drawn:

1. Composite concrete with 10 percent replacement of cement (weight) by fly ash and 10 percent replacement of cement by lime sludge (weight) yielded compressive strength of concrete cubes slightly lesser at 28 days curing and almost same compressive strength at 60 days curing, in general, compared to compressive strength of conventional (plain) concrete. Further replacement of cement by lime sludge (more than 10 percent) will reduce the compressive strength of concrete below strength of conventional (plain) concrete.
2. Above composite mix i.e. 10 percent replacement of cement (weight) by fly ash and 10 percent replacement of cement by lime sludge (weight) yielded more split tensile strength by 18.4 percent and 5 percent compared to split tensile strength of conventional (plain) concrete after 28 days and 60 days curing respectively. Further replacement of cement by lime sludge (more than 10 percent) will reduce the split tensile strength of concrete below strength of conventional (plain) concrete.
3. Above composite mix i.e. 10 percent replacement of cement (weight) by fly ash and 10 percent replacement of cement by lime sludge (weight) also yielded more flexural strength by 6.67 percent and 6.8 percent compared to flexural strength of conventional (plain) concrete after 28 days and 60 days curing respectively. Further

replacement of cement by lime sludge (more than 10 percent) will reduce the flexural strength of concrete below strength of conventional (plain) concrete.

4. Therefore composite mix with 10 percent replacement of cement (weight) by fly ash and 10 percent replacement of cement by lime sludge (weight) yielded, in general, almost same compressive strength, better split tensile and flexural strengths compared to that of plain concrete. There is 20 percent (10 percent by fly ash and 10 percent by lime sludge) saving in the cost of cement and 20 percent saving cost of sand as it is replaced by quarry sand ,can be achieved with this mix.
5. Further this composite mix solves the disposal problem of fly ash, lime sludge and quarry sand to some extent.

6.1 Scope for future work:

1. Permeability tests on the present composite concrete mix are to be carried out to assess the degree of impervious of the concrete which largely helps in identifying the amount of corrosion in steel of reinforced concrete structures.
2. Durability of concrete of present mix has to be ascertained by carrying out tests at or more than 60 days for compressive strength, split tensile and flexural strength of the concrete.

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