Incorporation of Rice Husk Ash and Metakaolin as Partial Replacement of Cement in M20 Concrete

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Abstract: ***In this developing era concrete and cement mortar are widely used by the construction industry, with this development. Large amount of industrial wastes are generated and if these wastes are not properly used it will create severe problems, keeping the environment in mind, concrete engineers are trying to find some alternative materials which will not only replaces the cement content but also improves the strength of concrete.***

As we also know that during the manufacturing of cement large amount of CO_2 is released into the environment, but if we use such material that will replace the quantity of cement content therefore indirectly we are contributing towards the prevention of our planet from global warming and other pollutions. Also in this research work the Rice Husk Ash and Metakaolin are used. The Metakaolin is obtained by calcinations of pure or refined kaolin clay at a temperature between 650°C and 850°C, followed by grinding to achieve a fineness of 700 m2/kg to 900m2/kg. The resulting material has high pozzolanity. And rice husk ash obtained from the rice processing units, by adding these two products with concrete, not only replaces the cement content but also increases the strength of concrete like compressive, flexural & split tensile strength etc. These two materials RSH & Metakaolin were incorporated with concrete with varying percentages of 2%, 4%, 8%, & 10% . The proper codal precautions were followed during the manufacturing the concrete cubes of 150 X 150 X 150mm and cylinders of size 150 mm X 300 mm casted with varying percentages of RHA & Metakaolin. The total number of specimen which were prepared 36 cubes were casted with proper curing and the series of tests were conducted on these specimens like Split tensile, Flexural, Compressive strength, Normal consistency test etc. It was concluded that the strength of concrete increased by incorporated the Rice Husk Ash & Metakaolin.

Keywords: ***Rice Husk Ash, Waste Paper Sludge Ash, Split Tensile strength test, Flexural strength Test***

I. INTRODUCTION

Concrete is one of the mostly widely used material in the world .it is the mixture of cement, fine aggregate, coarse aggregate and water. The strength of concrete depends upon the ingredients which are used in preparing this .The cost of constructional materials increases day by day due huge demand of it .so the concrete engineers look towards the alternative material that not only improves the strength of concrete but replaces the cement content which intern relate the cost of our construction work. The main advantage of incorporating the supplementary cementing material not only improves the strength but also help in preventing the pollution. It also improves the durability. Durability is linked to the physical, chemical and mineralogical properties of material and permeability.

Several studies in the developing countries including Thailand, Pakistan and Brazil worked on the materials like Rice Husk Ash and Metakoalin, these materials not only enhance the properties on concrete but also contributes towards the green environment.

Rice Husk Ash:

Rice husk ash (RHA) is a by-product from the burning of rice husk. Rice husk is extremely prevalent in East and South-East Asia because of the rice production in this area. The rich land and tropical climate make for perfect conditions to cultivate rice and is taken advantage by these Asian countries. The husk of the rice is removed in the farming process before it is sold and consumed. It has been found beneficial to burn this rice husk in kilns to make various things. The rice husk ash is then used as a substitute or admixture in cement. Therefore the entire rice product is used in an efficient and environmentally friendly approach. Rice husk ash is produced in large quantities globally every year and due to the difficulty involved in its disposal, can lead to RHA becoming an environmental hazard in rice producing countries, potentially adding to air and water pollution. Rice husk ash is a natural pozzolana, which is a material that when used in conjunction with lime, has cementitious properties. Several studies have shown that due to its high content of amorphous silica, rice husk ash can be successfully used as a supplementary cementitious material in combination with cement to make concrete products. RHA can be carbon neutral, have little or no crystalline Si02, or no toxic materials, as in the case of off-white rice husk ash. According to the Food and Agricultural Organization of the United Nations, global production of rice, the majority of which is grown in Asia, totaled 746.4 million tons in 2013. This means that the volume of unused rice husks amounted to 150 million tons. Due to their abrasive character, poor nutritive value, very low bulk density, and high ash content only a portion of the husks can be used as chicken litter, juice pressing aid, animal roughage and pesticide carrier. The remaining husks are transported back to field for disposal, usually by open field burning. RHA is obtained by burning of rice husk. When RH is properly brunt, it has high silica content and can be used as an admixture in mortar and concrete. India produces about 122 million tons of Paddy every year. About 20-22% rice husk is generated from paddy and 20-25% of the total husk becomes a Rice Husk ash after burning. The RHA is used as Pozzolanic material for making concrete.

The utilization of rice husk for use as a cementations material in cement and concrete depends on the pozzolanic property of its ash. The pozzolanic reactivity of the ash is closely related to the form of silica present and the carbon content. Since the physical and chemical properties of silica in RHA are strongly influenced by the temperature and the duration of thermal treatment, the yield of a highly reactive ash requires a burning method that can remain a low firing temperature and a short retention period in order to give ash with low carbon content and a high surface area.

The use of RHA in concrete has been associated with the following essential assets:

- Increased compressive and flexural strengths.
- Reduced permeability
- Increased resistance to chemical attack.
- Increased durability.
- Reduced effects of alkali-silica reactivity.
- Reduced shrinkage due to particle packing, making concrete denser.
- Enhanced workability of concrete.
- Reduced heat gain through the walls of buildings.
- Reduced amount of super plasticizer.

Metakaolin:

Metakaolin is obtained by calcinations of pure or refined kaolin clay at a temperature between 650°C and 850°C, followed by grinding to achieve a fineness of 700 m2/kg to 900m2/kg. The resulting material has high pozzolanity.

Metakaolin is manufactured from pure raw material to strict quality standards. It is not aby-product. Other pozzolanic materials are currently available, but many are by products, which are available in chemical composition. They may also contain active components (such as sulphur compound, alkalis, carbon, reactive silica) which can undergo delayed reactions within the concrete and cause problems over long time periods.

Metakaolin is a high quality pozzolanic material, which is blended with Portland cement in order to improve the durability of concrete and mortars. Metakaolin removes chemically reactive calcium hydroxide from the hardened cement paste. Metakaolin reduces the porosity of hardened concrete. Metakaolin densities and reduces the thickness of the interfacial zone, this improving the adhesion between the hardened cement paste and particles of sand or aggregate.

Highly reactive metakaolin is made by water processing to remove un-reactive impurities to make 100% reactive Pozzolona. Such a product, white or cream in color, purified, thermally activated is called High Reactive Metakaolin (HRM). High reactive metakaolin shows high pozzolanic reactivity and reduction in Ca (OH)2 even as early as one day. It is also observed that the cement paste undergoes distinct densification. The improvement offered by this densification includes an increase in strength and decrease in permeability. The high reactive metakaolin is having the potential to compete with silica fume.

Importance of Metakaolin:

The quest for developing high strength and ultra high strength concretes and is special purpose concretes with certain special characteristics for use under special circumstances is increasing from time to time. The usual ultimate utility/strength/durability parameters of normal cement concrete needs certain modifications.

The special characteristics of silica fume, viz., super fineness, high silica content and etc., gave the scope for enhancing the normal cement concrete which when mixed with cement as a partial replacement. The excessive cohesiveness and excellent sulphate resistance of Metakaolin mixed concrete is of greater importance is Shotcrete applications. Metakaolin is generally more efficient in concrete having higher water-cement ratios.

Properties of Metakaolin:

Blending with Portland cement Metakaolin improves the properties of concrete and cement products considerably by:

a) Increasing compressive and flexural strength

b) Providing resistance to chemical attack

c) Reducing permeability substantially

d) Preventing Alkali-Silica Reaction

e) Reducing efflorescence & Shrinkage

f) Protecting corrosion

II. LITERATURE REVIEW

The relevant literature on lateral load resisting systems used in high rise buildings was reviewed and presented here.

Dinakar et al., (2013) studied the effect of Metakaolin Content on the Properties of High Strength Concrete. This study presents the effect of incorporating Metakaolin (MK) on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3.MK mixtures with cement replacement of 5, 10 and 15 % were designed for target strength and slump of 90 MPa and 100 ± 25 mm. From the results, it was observed that 10 % replacement level was the optimum level in terms of compressive strength. Beyond 10 % replacement levels, the strength was decreased but remained higher than the control mixture. Compressive strength of 106 MPa was achieved at 10 % replacement. Splitting tensile strength and elastic modulus values have also followed the same trend. In durability tests MK concretes have exhibited high resistance compared to control and the resistance increases as the MK percentage increases. This investigation has shown that the local MK has the potential to produce high strength and high performance concretes.

S. Lenka (2017) studied effect of Metakaolin on the properties of conventional and self-compacting concrete. They concluded following statements; The increase in MK replacement increases workability of CC and SCC in a constant w/b ratio, Increase in MK, decreases the T500 flow time and V-funnel time in addition of 0.35% of SP which belongs to VS2 and VF2 classes and satisfy EFNARC (2005) guidelines. The decrease in flow time indicates good flowability of SCC, Increase in MK increase filling height of U-funnel and L-box it comes under PA2 classes with 3 rebars in constant SP (0.35%) which satisfies the EFNARC guidelines, Compressive, split tensile and flexural strengths of CC and SCC higher as compared to control specimen at all age of curing, Replacement of MK up to 10% in cement increases compressive and split tensile and flexural strengths of CC, But after that increase in replacement results in a decrease in strength. This might be because of filler weight, hastening of PC hydration and also pozzolanic reaction of MK. Compressive strength of SCC is improved up to 10% of MK replacement compared to CC and thereafter the strength decreases whereas at 15% and 20% compressive strength of CC is greater than SCC. The maximum split tensile and flexural strength of SCC observed at 20% replacement but in CC, it improved up to 10% of replacement of MK and thereafter the strength decreases. In CC and SCC, 10% replacement of MK with OPC gives higher density value than 5%, 15% and 20%. The replacement of MK with OPC increased the density value up to 10% after that it decreased. As the MK replacement increases, the total water absorption decreases w.r.t w/b ratio in both CC and SCC. In SCC, valuable consequence of MK on water absorption lessening was further substantial because of inferior porosity and advanced pore size dissemination of MK blended matrix, as compared to normal concrete, so SCC absorbed less water than CC. The test results showed that CC has more carbonation depth than that of SCC. It indicates the durability of CC is lower than that of SCC.

Ong et al., (2006) focused on the compressive strength performance of the blended concrete containing different percentage of Metakaolin. They concluded that the cement is replaced accordingly with the percentage of 5 %, 10%, 15%, 20%, and 30% by weight. Concrete cubes are tested at the age of 1, 3, 7, and 28 days. In addition, the effect of calcination temperature to the strength performance is included in the study. Finally, the strength performance of Metakaolin-concrete is compared with the performance of concrete blended with silica fume and slag. The results show that the strength development of concrete blended with Metakaolin is enhanced. It was found that 10% replacement appears to be the optimum replacement where concrete exhibits enhanced compressive strength at all ages comparable to the performance of SF and GGBS.

Md Akhtar Hossain 2011 studied M Alamgir, QH Bari, IM Rafizul, SMT Islam, G Sarkar & MK Howlader (Eds.) ISBN: 978-984-33-2705-5, pp. 173 (1-8) Proceedings of the WasteSafe 2011 – 2nd International Conference on Solid Waste Management in the Developing Countries 13-15 February 2011, Khulna, Bangladesh Effect of Rice Husk Ash on Concrete,

The concrete made with RHA had higher compressive strength at 90 days in compression with that of concrete no RHA. However at 14 and 28 days the strength is different. The compressive strength of concrete increased by 15.6% for 10% replacement level of cement by RHA and for 20% replacement, the result was not significant. In this investigation it was observed that more time was required for increasing the pH value in the core of concrete for using RHA than OPC samples. It indicates that the concrete made with RHA was more compacted than the controlled one. The increase in compressive strength value of pH changes in concrete with RHA is due to the filler effect (physical) rather than the pozzolanic (chemical/physical).

Kumar et al., (2012) carried out an experimental study to find the suitability of the alternate construction materials such as, Rice Husk Ash, sawdust, recycled aggregate and brickbats as a partial replacement for cement and conventional aggregates. For this concrete cubes of six 150mm x150mm were casted with various alternate construction materials in different mix proportion and with different water cement ratios. Their density, workability and compressive strengths were determined and a comparative analysis was done in terms of their physical properties and also cost savings. Test results indicated that the compressive strength of the OPC/RHA concrete cube blocks increases with age of curing and decreases as the percentage of RHA content increases. It was also found that the other alternate construction materials like saw dust, recycled aggregates and brick bats can be effectively used as a partial replacement for cement and conventional aggregates.

The compressive strength of Rice Husk Ash concrete was found to be in the range of 70-80% of conventional concrete for a replacement of cement up to 20%. The Rice Husk Ash concrete occupies more volume than cement for the same weight. So the total volume of the Rice Husk Ash concrete increases for a particular weight as compared to conventional concrete which results in economy. Due to the lower density of RHA concrete the self-weight of structure gets reduced which results in overall savings. The compressive strength of recycled aggregate concrete was found to be in the range of 70 to 80 % of conventional concrete. The compressive strength of brick bat concrete was found to be nearly 35 % of conventional concrete. The compressive strength of saw dust concrete was found to be nearly 10 to 15% of conventional concrete. So the concrete made with alternate construction materials like brick bats and saw dust can be used for partition & filling purposes & nailing purposes where the strength is not the criteria. Wherever compressive strength is not a criteria, the concrete made with alternate construction materials can always be preferred.

Jayanti Rajput et al (2013) have studied on the effect of RHA used as supplementing cementing material on the strength of mortar by partial replacement of OPC. Cement mortar paste were proportioned with varying dosages of RHA as partial replacement of OPC in the range of 5% to 30% by weight of cement.

From the test results they concluded that: This paper concluded that if approximately 10% of cement is replaced by equal amount of RHA, there is not any significant depreciation in the compressive strength.

Moser et al., (2015) The potential for binary and ternary blends of Metakaolin with 2 differing particle size distributions, and Class C fly ash to mitigate alkali-silica reactions (ASR) with a highly reactive fine aggregate, were evaluated using accelerated mortar bar test (AMBT) and concrete prism test (CPT) methods. Binary blends of Metakaolin or Class C fly ash reduced expansion by 55-90% and 25-37% compared to the control, respectively. When incorporating Metakaolin with a lower mean particle size, binary blends showed a greater reduction in expansion compared with Class C fly ash. Ternary blends of Metakaolin and Class C fly ash resulted in a marginally higher expansion than binary blends incorporating the same amount of Metakaolin. Correlation between AMBT and CPT results was good at high levels of expansion but poor for those compositions producing expansions near the acceptable limits corresponding to increased addition rates of Metakaolin and/or Class C fly ash.

Bai et al., (2014) Development of a multivariate statistical model for consistency parameter prediction including slump, compacting factor and vibe time for concrete incorporating FA and MK is described. The models constructed provide an efficient, quantitative, and rapid means for obtaining optimal solutions to consistency prediction for concrete mixes using PC-FA-MK blends as binder. Based on the experimental data, comprehensive regression analysis and significance tests were performed and the best-fit models for predicting consistency parameters were found. Values of consistency were calculated by the proposed models and gave a good agreement with observed experimental data. It indicates that the models are reliable, accurate and can be used in practice to predict the consistency of PC-FA-MK blends.

Elahi et al., (2009) Conducted an experimental investigation was carried out to evaluate the mechanical and durability properties of high performance concretes containing supplementary cementations materials in both binary and ternary systems. The mechanical properties were assessed from the compressive strength, whilst the durability characteristics were investigated in terms of chloride diffusion, electrical resistivity, air permeability, and water absorption. The test variables included the type and the amount of supplementary cementitious materials (silica fume, fly ash, and ground granulated blast-furnace slag). All the ternary combinations can be considered to have resulted in high performance concretes with excellent durability properties.

Hossain et al., performed a study at the concrete made with RHA had higher compressive strength at 90 days in compression with that of concrete no RHA. However at 14 and 28 days the strength is different. The compressive strength of concrete increased by 15.6% for 10% replacement level of cement by RHA and for 20% replacement, the result was not significant. In this investigation it was observed that more time was required for increasing the pH value in the core of concrete for using RHA than OPC samples. It indicates that the concrete made with RHA was more compacted than the controlled one. The increase in compressive strength value of pH changes in concrete with RHA is due to the filler effect (physical) rather than the pozzolanic (chemical/physical).

III. OBJECTIVE OF STUDY

- To study the behaviour of concrete for various proportions of Rice Husk Ash, Metakaolin and combination of both (Rice Husk Ash + Metakaolin) with the strength parameters and workability parameters.
- To examine the feasibility of using unprocessed Rice Husk Ash and Metakaolin to reduce the amount of cement.
- To evaluate the strength parameters for individual replacement and various combinations of Rice Husk Ash and Metakaolin.
- To compare the results of different proportions and combinations of incorporated Rice Husk Ash and Metakoalin.
- To figure out the most durable, economical and high performance proportions of Rice Husk Ash and Metakaolin.
- The seismic performance of high rise commercial building is determined on the basis of following parameters:

IV. MATERILAS AND METHODOLOGY

1. CEMENT

Cement is a material, generally in powder from, that can be made into a paste usually by addition of water and, when poured, will set into a solid mass. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days, and in this study OPC 43 is used.

2. AGGREGATES

Generally, aggregates occupy 70% to 80% of the volume of concrete and have an important influence on its properties. They are granular materials, derived for the most part from natural rock (crushed stone, or natural gravels) and sands.

3. WATER

Drinking water is good for making concrete. Water serves following purposes Water is used to prepare a plastic mixture of the various ingredients and to impart workability to concrete. Water is also needed for the hydration of the cementing materials to set and harden during the period of curing.

4. RICE HUSK ASH (RHA)

Rice milling generates a by-product known as husk. Rice husk ash is an attractive pozzolana. Due to its low cost and high activity it has a promising perspective in sustainable construction. The main component of the rice husk ash is silica, which is the element that governs the reactivity of the ash. The Rice Husk Ash is obtained by burning the Rice Husk, obtained from local mills, in heaps of 50 to 60kg in open air.

5 METAKAOLIN

The Metakaolin is obtained From the 20 MICRONS LIMITED Company at Balanagar in Hyderabad. The specific gravity of Metakaolin is 2.4. The metakaolin is in conformity with the general requirement of Pozzolona.

TESTS PERFORMED:

- **TESTS ON CEMENT:**

  Normal Consistency

  Initial and Final Setting Time

  Fineness Test of Cement

- **TESTS ON AGGREGATES**

  Sieve Analysis of Fine Aggregates

  Sieve Analysis of Coarse Aggregates

  Impact Test

  Specific Gravity

- **TESTS ON RHA & METAKAOLIN**

  Mixed variety of paddy husk will be used. Heaps of 25-30 Kg will be burnt in open yard for over 24 hours at a time and the ash obtained was collected in clean bags. Do the same procedure for METAKAOLIN.

i. **Tests on Fresh Concrete**
   A. Slump Test
   B. Compaction Factor Test

ii. **Hardened Concrete Tests**
   A. Compressive Strength: This test is performed on cube specimens to determine compressive strength at various ages.
   B. Splitting Tensile Strength: This test is performed on cylinder specimen to evaluate its tensile strength at various different ages.

MIX DESIGN:

Table 1. Design stipulations for proportioning

• Grade designation	M20
• Type of cement grade	OPC 53 grade confirming to IS12269:1987
• Maximum nominal size of aggregates	20 mm
• Minimum cement content kg/m^3	320 kg/m^3
• Maximum water cement ratio	0.55
• Workability	75 mm (slump)
• Exposure condition	Mild
• Degree of supervision	Good
• Type of aggregate	Crushed angular aggregate
• Maximum cement content	450 kg/m^3
• Chemical admixture	Not

Table 2. Test Data for Materials

• Cement used	OPC 53 grade confirming to IS 12269:1987
• Specific gravity of cement	3.10
• Specific gravity of	
• Coarse aggregate	2.88

• Fine aggregate	2.63
• Sieve analysis • Coarse aggregate • Fine aggregate	Coarse aggregate : Conforming to Table 2 of IS: 383 Fine aggregate : Conforming to Zone III of IS: 383

Table 3. The mixture proportions used in laboratory for Experimentation are shown in table

Mix	%	**w/c ratio**	**Water (Kg/m^3)**	**Cement (Kg/m^3)**	**Fine Aggregate (kg/m^3)**	**Coarse Aggregate (Kg/m^3)**	**RHA (Kg/m^3)**	**Metakaolin (Kg/m^3)**
Control	-	0.50	186	372	562	1217	-	-
Rice Husk Ash	2	0.50	186	353.4	562	1217	18.6	-
	4	0.50	186	334.8	562	1217	37.2	-
	6	0.50	186	316.2	562	1217	55.8	-
	8	0.50	186	297.6	562	1217	74.4	-
Metakaolin	2	0.50	186	353.4	562	1217	-	18.6
	4	0.50	186	334.8	562	1217	-	37.2
	6	0.50	186	316.2	562	1217	-	55.8
	8	0.50	186	297.6	562	1217	-	74.4
Mixture of RHA and Metakaolin	2	0.50	186	353.4	562	1217	9.3	9.3
	4	0.50	186	334.8	562	1217	18.6	18.6
	6	0.50	186	316.2	562	1217	27.9	27.9
	8	0.50	186	297.6	562	1217	37.2	37.2

V. RESULTS AND DISCUSSIONS

FRESH CONCRETE:

1 Slump Test:

Table 4. Slump Tests Results

Mix	**Percentage**	**Slump Value**
Control	0%	90mm
RHA	2%	65mm
	6%	55mm
	8%	25mm
	10%	20mm
METAKAOLIN	2%	60mm
	4%	55mm
	6%	50mm
	8%	20mm
Mix (RHA+ METAKAOLIN)	2%	30mm
	4%	20mm
	6%	15mm
	8%	7mm

2 Compaction Factor Test:

Table 5. Compaction Factor Results

Mix	Percentage	Compaction Factor
CONTROL	0%	0.93
RHA	2%	0.90
	4%	0.87
	6%	0.83
	8%	0.82
METAKAOLIN	2%	0.92
	4%	0.90
	6%	0.85
	8%	0.81
MIX (RHA+METAKAOLIN)	2%	0.84
	4%	0.83
	6%	0.80
	8%	0.78

HARDENED CONCRETE:

1: Effect of Age on Compressive Strength

The 28 days strength obtained for M20 Grade Control concrete is 30.93 N/mm2.The strength results reported and presented in the form of graphical variations, where the compressive strength is plotted against the age of curing in fig. 1.

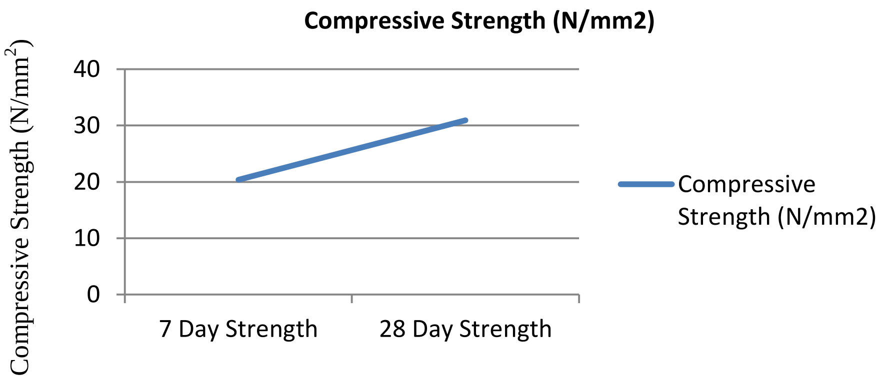

Fig.1: Compressive Strength of Control Concrete

2: Effect of Age on Split Tensile Strength of Control Concrete

The 28 days tensile strength obtained for M20 Grade Control concrete is 2.71 N/mm2.The strength results reported and presented in the form of graphical variations, where the compressive strength is plotted against the age of curing in fig. 2.

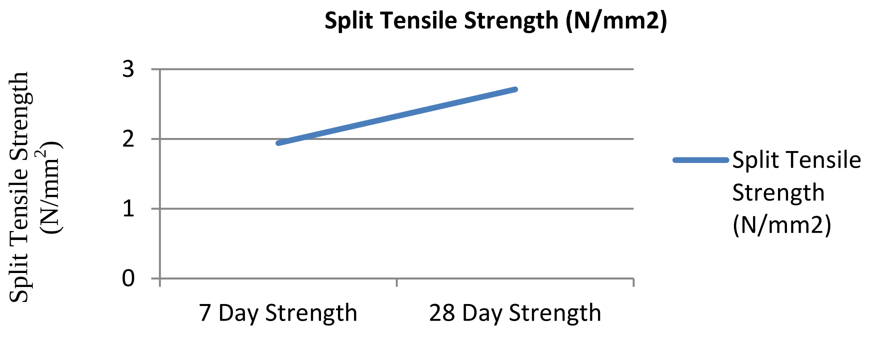

Fig 2: Split Tensile Strength of Control Concrete

3: Effect of Compressive Strength of Concrete Containing various percentages of Mix(RHA+ Metakaolin)

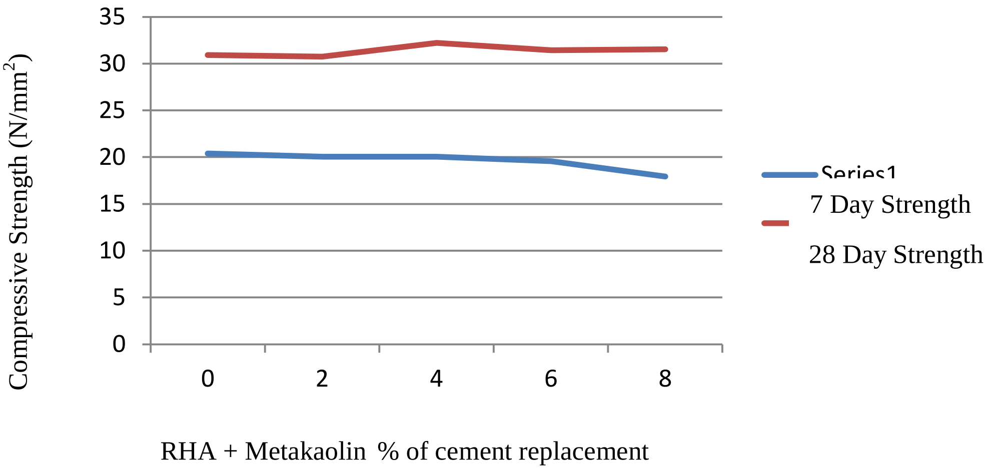

Fig. 3: Compressive Strength of Mix (RHA+ Metakaolin) Concrete

4: Effect of Split Tensile Strength of Concrete Containing various percentages of Mix (RHA+ Metakaolin)

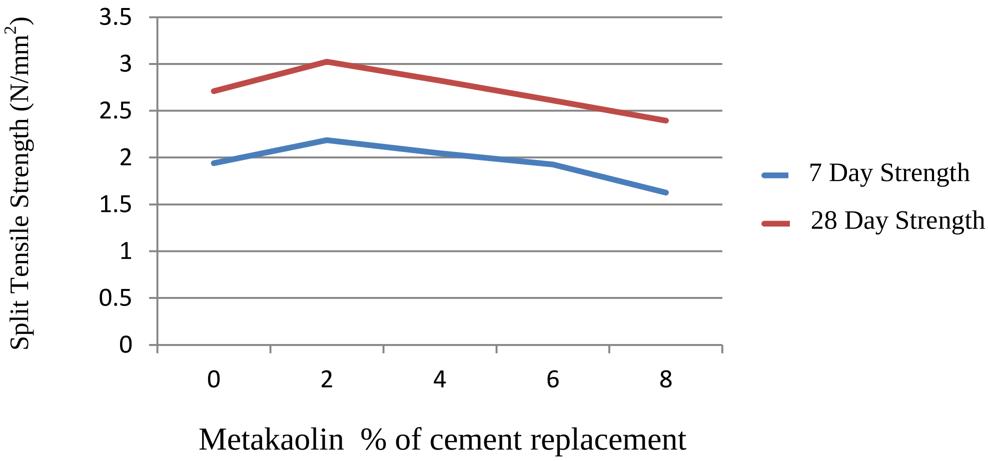

Fig. 4: Split Tensile Strength of Mix (RHA+ Metakaolin) Concrete

VI. CONCLUSIONS

The objective of this experimentation has been to evaluate the possibility of successful replacement of cement with RHA, Metakaolin and MIX (RHA+Metakaolin) in concrete.

The conclusion drawn during the experimentations are as follows:

- The compressive strength increases up to 25% with 8% replacement of cement by Metakaolin. So, up to 8% replacement it can be used as a supplementary material in M20 grade of Concrete.
- The split tensile strength increases up to 15% with 2% replacement of cement by Metakaolin.
- The above result shows that there is 8% increase in split tensile strength with 2 % RHA replacement. So, it is possible to design M20 grade of concrete incorporating with RHA content up to 2%.
- As test results shows, the Mix (RHA + Metakaolin) can also be used as a replacement of cement.
- Control mix with 4% RHA and Metakaolin shows 5% increase in compressive strength of M20 conrete.
- Control mix with 2% RHA and Metakaolin shows 30% increase in split tensile strength of M20 conrete.
- The study showed that the early strength of RHA, Metakaolin and Mix (RHA+Metakaolin) concrete was found to be less and the strength increased with age.
- The workability of RHA, Metakaolin and Mix (RHA+Metakaolin) concrete has been found to decrease with the increase in replacements.
- Based on the results of Split Tensile Strength test, it is convenient to state that there is substantial increase in Tensile Strength due to the addition of RHA, Metakaolin and Mix (RHA+ Metakaolin).
- Use of Metakaolin, Rice Husk Ash and Mix (RHA+ Metakaolin) in concrete can prove to be economical as it is non useful waste and free of cost.

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