CHAPTER 1

INTRODUCTION

In construction industry concrete is a material which is most widely used in the world. Concrete can also be called as man-made stone which is made after solidification of water, cement, aggregates (Badea, 2007) this solidification takes place, after mixing cement, water and aggregate and this chemical reaction is known as hydration.

Cement + Water + Aggregate = Concrete

1.1 Environmental Impact of Concrete

The main environmental concern in the production of cement and concrete is the energy consumption.The total production of cement in the world is 1.6 billion tons which produces 7% of the total carbon dioxide transferred to the atmosphere (Mehta P. , 2001).

According to (NRMCA, 2012) during the process of manufacturing cement their are two processes during which CO_2 is produced

1) Use of fossil fuel in the process of burning.

2) Calcinations in which calcium oxide is produced during the heating process of calcium carbonate which releases CO_2.

90% of concrete is composed of water, sand and gravel by weight. Small amount of CO_2 is produced during mining process of gravel, crushing stone and transportation of concrete to the construction site. The major amount of CO_2 is due to the manufacturing of cement.

According to (Obla, 2009) 9 tons of CO_2 is emitted in the production of 1 ton of cement and about 10% of cement by weight is used in 1 cubic yard of concrete (weighs around 2 tons) for reducing this CO_2 emittion many studies have been made for introducing supplementary cemtions material such as Fly Ash, Rice hush ash and Bick dust.

1.2 Fly Ash (FA)

As we know that electricity is playing a major role in the development of the country. In India coal is mainly used for the production of electricity. In the production of electricity powdered coal is burnt which results in the production of fly ash.

According to (NTPC, 2007) In India 60 % of electricity is generated by burning coal as a fuel. Huge quantity of ash is generated from Indian coal as it has low calorific value of around 3000-3500 k and high ash content of around 30-35%. So as our present scenario power sector is growing and due to this at the end of year 2012 ash generation will reach 175 million tonne per annum, which will become a huge problem to dump it.

Previous studies shows that Fly ash can be utilize in concrete which was first investigated (Raymond E. Davis, 1937) and published a paper telling that fly ash shows excellent pozolanic properties. For ordinary construction 30% fly ash and for heavy construction 50% of fly ash can be replaced by cement. (Berry, 1986) told about the research which took place between 1976 to 1984 in the advancement and practical application of the use of fly ash based concrete.

After 1980 many studies has been done on the use of fly ash in concrete as a supplementary cementations material. Major fly ash producing countries has started using more fly ash in concrete also called High volume fly ash concrete. CANMET in 1985 developed High Volume Fly Ash concrete. It was a high performance concrete which shows superior durability and excellent mechanical properties. (Malhotra) High Volume Fly Ash concrete(HVFA) helped to reduce the consumption of cement and water and increased the workability of the concrete due to the use of large proportion of Fly ash.

1.2.1 Production of Fly Ash

Fly ash is a residue which is obtained after the combustion of coal in the furnace of a thermal plant. Then this fly ash is collected by electrical or mechanical precipitations which is known as dry process or by wet process which is an old method.

1.3 Rice Husk Ash (RHA)

India is the second highest rice producing country in the world after China. Rice Husk is a by-product which comes from the rice mills. Around 120 million tons of rice paddy is produced in India in which 20 % part is rice husk (Jivani, 2007). Disposal of such a big amount is hazardous for the rice producing nations. Rice Husk Ash (RHA) is generated by burning rice husk in boilers. For every thousand kilogram of paddy around 220kg of rice husk is produced and on burning this 220kg of rice husk around 55kg of rice husk ash is generated which is 25% of rice husk (Koteswara Rao. D, 2011) .So considering India which is the major producer of rice in the world, disposing this great amount of Rice Husk Ash is a big problem.

Research shows that Rice Husk Ash can be used as a pozzolon and can be used in concrete as a cement replacement (Pitt, 1976). Further several studies has been made on Rice husk ash showing that the concrete having RHA have good Compressive strength, splitting tensile strength and modulus of elasticity at various ages and chloride diffusion is reduced (A. A. Ramezanianpour, 2009). These studies proves that if RHA is used as a substitute for a percentage of part and cement will not only become a means of disposal of this agricultural waste but also will lessen the cost of the construction.

1.3.1 Effect of Temperature on Rice Husk Ash

Rice Husk Ash shows different chemical composition at different burning temperature (Hwang, 1989). It has been also shown from several studies that rice husks when burnt in controlled conditions between temperatures of 500^{o}C to 700^{o}C and ground to particle sizes of less than 10 μm will perform acceptable pozzolanic properties to apply in cement and concrete industries (V.B.Columna, 1974). Uncontrolled combustion results in poor quality of Rice Husk Ash as at lower than 500^{o}C the ashes contain high carbon content and high amount of loss in ignition, and at temperatures greater than 700^{o}C crystalline silica ash is formed (DEEPA, 2008).

1.4 Brick Dust (BD)

One of the oldest construction materials is brick, which was first used in Southern Turkey and around Jerico dating 7000 Bc(Brick Directory 2015). According to (Kidder, 2015) their are two major ingredients from which building bricks are made, one is clay and other is sand.

Brick dust is the waste product which comes from the field where bricks are made and from the demolition waste of the building. As Brick is composed of clay which contains sufficient amount of soluble silica and alumina finely grounded brick dust when combined with lime shows pozzolanic reaction (Rogers, 2011). As earliest said that Brick is the oldest and majorly used construction material so large amount of Brick dust is generated during manufacturing of Bricks and demolition of the constructional structure so it is a major problem to dispose such a large amount of Brick Dust.

If Brick dust is used as a replacement for a percentage of cement then is will not only reduce the problem of disposing this waste, it will also reduce the environmental impact which is caused by the CO_2 emission from the manufacturing of the cement.

1.5 Potential Use of Brick Dust And Rice Husk Ash in Lucknow

Lucknow is known as city of Nawabs. According to (ICICI, 2011) present metropolitan area of Lucknow is 3091.40 sq km. Lucknow is surrounded by many district like Sitapur, Barabanki, Hardoi, Raebareli and Unnao. In past 17-18 years city has experienced lot of infrastructural development. Large number of private developers like Ansal, Sahara, Eldeco and DLF has entered in this infrastructural development. Lucknow metro Project has also started its construction in the year 2014. According to (CRISIL) Lucknow is one of the next top ten cities in India with enormous real estate potential.

1.5.1 Rice Husk Ash

In a Report (Dwivedi, 2011), Lucknow division which comprises of Lucknow, Unnao, Raebareli, Sitapur, Hardoi, Kheri, Shahu ji Maharaj Nager is major produces of rice.Total area in which rice production done is 792763000 hectare with a production of 1610409 mt of rice during the year 2010-2011 which is maximum as compared to other divisions in Uttar Pradesh. Rice mills in Lucknow division uses rice husk as a fuel to generate steam for parboiling process. In this experiment rice husk was burnt in an controlled combustion process for about 2 hrs with a burning temperature ranging between 600-800 degrees. The ash abtained was grounded for 2 hours and the colour of the ash was light grey.

1.5.2 Brick Dust

Brick Dust is a waste product obtained from different brick kilns and tile factories. Now day's construction work is on large scale so demand of brick also increases so due to this brick kiln industries all over the world also increased. There are numerous brick kiln which have grown over the decades in an unplanned way in different part of Lucknow. Tons of waste products like Brick Dust or broken pieces or flakes of bricks (brick bat) come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as waste material.

1.6 Research Objective

The objective of this research is to find the scope for the use of Brick Dust and Rice Husk Ash in Luckow division to reduce the amount of cement in concrete for the construction work in Lucknow. This is done via material testing of concretes with various percentage of replacement of cement by Fly Ash from Reliance power plant in Rosa Shahjahanpur, Uttar Pradesh and Rice Husk Ash and Brick Dust collected from Lucknow division, Uttar Pradesh.

In present time fly ash is used in concrete as replacement of cement in a percentage for construction work. Fly ash used in the experiment was bought form Reliance power plant in Rosa, Uttar Pradesh. As there is no power plant near by Lucknowwhich produces good quality Fly Ash, so construction companies use to buy fly ash which cost around Rs1 per kg. Maximum cost includes transportation cost. So it is necessary to find out other waste material which is easily available in

Lucknow division so this cost can be reduced and the problem of disposing industrial waste material is minimized.

As we know that Lucknow is the highest producer of rice in Utter Pradesh and their is a large number of brick manufacturing companies in Lucknow so Rice Husk Ash and Brick Dust is generated as a waste in a large quantity which is also a threat to environment so this research is done for finding the possibility of using Rice Husk Ash and Brick Dust as a replacement for a percentage of cement rather than Fly Ash.

1.7 Outline of Thesis

Their are six chapters in this thesis which are:-

The first chapter explains the need of using waste material in concrete for reducing the cost of concrete and scope for using Rice Husk Ash and Brick Dust in Lucknow division instead of Fly Ash so that concrete can be more cheaper by using local waste material rather than Fly Ash which is not a local material.

Chapter 2 is literature review, which summarizes those work which has already been done in the field of Fly Ash concrete, Rice Husk Ash concrete, Brick Dust concrete.

Chapter 3 deals with Materials which describes about every material used along with their properties

Chapter – 4 Methodology-which describes the whole experimental program.

Chapter – 5 Results and Discussion - which give the results of the testing of the material, compressive strengths of the of Rice husk Ash concrete, Fly Ash concrete, Brick Dust concrete and variations in the respective weights of the cubes with the changing proportions.

Chapter - 6 Conclusion and Future Scope- which evaluates the scope of use of Rice Husk Ash and Brick Dust as a replacement of a percentage of cement in concrete instead of Fly Ash which summarize the whole experiment, results and finding of this study as well as possibilities for future work.

CHAPTER 2

LITERATURE REVIEW

Many studies have been done on the use of Fly Ash since 1980 (Berry, 1986) increasing the concern about the strength and durability of the concrete structures. After that use of more fly ash in concrete which is also known as “High Volume Fly Ash Concrete” has been extensively in some countries which are major producers of Fly Ash. Many studies also have been done on Fly Ash and its effect on various systems in which it is used.

Previous work done by (Pitt.N, 1976)and (Cook, 1977) have shown that in building construction rice husk ash can be used for making alternative cements. It is well also undertood that when rice husk is burnt under controlled condition the ash produced is an amorphous ash of high lime reactivity for which number of methods are available. In India rice husk is used as a fuel for operations like parboiling of paddy, cooking etc .and the process is very rarely controlled to produce a good quality amorphous ash.

Brick is the oldest construction material composed of clay which contains good amount of silica and alumina therefore finely grounded brick dust can be used as a replacement of a percentage of cement as it shows pozzolanic reaction. (Rogers, 2011)Less number of studies has been done on the replacement of brick dust as a replacement of a percentage of cement in concrete

2.1 Studies with Fly Ash

(Alvin Harison, 2014) Investigated out to study the utilization of non-conventional building material (fly ash) for development of new materials and technologies. It is aimed at materials which can fulfil the expectations of the construction industry in different areas. In this study, cement has been replaced by fly ash accordingly in the range of 0% (without fly ash), 10%, 20%, 30%, 40%, 50% and 60% by weight of cement for M-25 mix with 0.46 water cement ratio. Concrete mixtures were produced, tested and compared in terms of compressive strength. It was observed that 20% replacement Portland Pozzolana Cement (PPC) by fly ash strength increased marginally (1.9% to 3.2%) at 28 and 56 d respectively. It was also observed that up to 30% replacement of PPC by fly ash strength is almost equal to referral concrete after 56 d. PPC gained strength after the 56 d curing because of slow hydration process.

(Dr S L Patil, 2012) Investigated out to study the utilization of fly ash in cement concrete as a partial replacement of cement as well as an additive so as to provide an environmentally consistent way of its disposal and reuse. This work is a case study for Deep Nagar thermal power plant of Jalgaon District in MS. The cement in concrete matrix is replaced from 5% to 25% by step in steps of 5%. It is observed that replacement of cement in any proportion lowers the compressive strength of concrete as well as delays its hardening. This provides an environmental friendly method of Deep Nagar fly ash disposal.

(A. Camoes, 2003) Investigated the possibility of producing low cost enhanced performance concrete or even low cost High performance concrete(HPC), with 28 day strength in the range of upto 60 MPa, using low quality as received materials like fly ash and locally available crushed aggregates. In this wa, a significant reduction in the use of Portland cement, as well as that scarce natural resources would be obtained. The effect of amount of fly ash was evaluated using0, 20%, 40% and 60% cement replacement in the mixures with different quantities of toatal binder

(400kg/m^3, 500kg/m^3 and 600kg/m^3). Workability, mechanical and durability properties of the produced concretes were studied. Findings indicate that it is possible to produce HPC with upto 60 MPa by replacing upto 40% of cement by fly ash and using local available crushed granite aggregates.

(A. Bilodeau, 2001) Investigated that supplementary cementing materials be used to replace large proportions of cement in the concrete industry, and the most available supplementary cementing material worldwide is fly ash, a by-product of thermal power stations. In order to increase considerably the utilization of fly ash that otherwise is being wasted, and to have a significant impact on the production of cement, it is necessary to advocate the use of concrete that will incorporate large amounts of fly ash as replacement for cement. However, such concrete will have to demonstrate performance comparable to that of conventional portland cement concrete, and must be cost effective. In 1985, CANMET developed a concrete incorporating large volumes of fly ash that has all the attributes of high-performance concrete i.e. excellent mechanical properties, low permeability, superior durability, and that is environmentally friendly. The Liu Centre for the Study of Global Issues was designed using sustainable principles in order to reduce its demand on the environment and existing infrastructure. His findings with those principles help to use the high-volume fly ash concrete in some elements of the building because of the beneficial impact that the use of this type of concrete has on the environment. The use of the high-volume fly ash concrete in the Liu Building will serve to demonstrate the potential of this type of concrete for other future applications, especially in the Vancouver area.

(Upadhyaya, 2014) Invetigated that the ordinary portland cement (OPC) is one of the main ingrdients used for the production of concrete. unfortunateluy production of cement involves emission of large amount of carbon dioxide gas into atmosphere, a major contributer for green house effect and the global warming , hence it is invitable either to search for another material or partially replace it by some other material. the search of any other such material which can be used as an altrernative for cement should lead to global sustenable development and lowest possible environmental impact. concrete property can be maintained with advance mineral admixtures such as flyash as partial replacement of cement 0 to 30%. compressive strength of concrete with different dosage of fly ash was studied as partial replacemnet of cement. from the experimental investigations.His findings were that, the optimum replacement of flyash to cement without changing much compressive strength is 10%.

(L.K. Crouch, 2007) Investigated the use of concrete containing high volumes of fly ash (HVFA) has recently gained popularity as a resource-efficient, durable, and sustainable option for a variety of concrete applications. In this study, two HVFA mixtures, one containing Class C fly ash the other Class F fly ash, were compared with TDOT Class A general use mixtures using the same class of fly ash at a smaller replacement percentage. The HVFA mixtures reached similar to higher long term compressive strengths, due to the pozzolanic properties of the fly ash and the lower w/cm ratios. Also, the water permeable void contents and absorptions were lower for the HVFA mixtures at all ages, indicating that the durability of the HVFA is much better than that of the TDOT mixtures. The setting times for the HVFA mixtures were approximately two hours longer than those of the TDOT Class A mixtures at laboratory conditions (72oF (22 oC)). Also, the costs of the HVFA mixtures were slightly higher. However, for field placements at warmer temperatures, the time of set and cost of the HVFA mixtures would decrease while the cost of the TDOT Class A mixtures would increase, due to the need for chemical admixtures. His findings say that the use of HVFA mixtures would be ideal for warm weather placements; when compared with the TDOT Class A mixtures, the HVFA mixtures exhibit comparable costs, increased compressive strengths, and enhanced durability properties.

(T.P.Agrawal, 2012) Investigated the utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement in the long-term durability of concrete combined with ecological benefits. Three grades of ordinary Portland cement (OPC) namely: 33, 43 and 53 as classified by Bureau of Indian Standard (BIS) are commonly used in construction industry. This paper reports a comparative study on effects of concrete properties when OPC of varying grades were partially replaced by fly ash. The main variable investigated in this study is variation of fly ash dosage of 10%, 20%, 30% and 40%. The compressive strength, durability and shrinkage of concrete were mainly studied. Findings shows that, inclusion of fly ash generally improves the concrete properties upto certain percent of replacement in all grades of OPC.

(Craig Heidrich, 2013)According to his investigation whenever coal is burnt, coal combustion products are produced by the thermal transformation of the mineral matter present into amorphous inorganic oxides. Largescale use of coal in power generation gives rise to significant quantities of coal combustion products from which important 'hard won' end use markets have been established. Existing and proposed end use markets for coal combustion products (CCPs) are not only of critical importance to the economics of power generation, but also to the established supply chain participants which have invested, researched, developed and promoted CCPs into various end use markets, for example the construction sector use large quantities. Globally, the continued growth in utilization of CCPs is dependent on many factors beyond the quality and characteristics. Appropriate legislation and regulation coupled with the development of international classification systems, standards and codes of practice are only a few of the important enablers for easing the way towards increasing utilization and securing the 'legal certainly' for continued investment. The paper provides a global perspective on the role of coal in worldwide energy production and changing paradigms in the energy mix. Current global CCP production and utilization including volume and value of international trade will be discussed. An overview of country-specific classification systems for CCPs will be discussed, moreover the important role of legislation in creating legal certainty for the ongoing investment in CCPs management and market development.

(Shaswata Mukherjee, 2012) Investigated out to study the physical and mechanical property of high volume fly ash cement paste. Ordinary portland cement was replaced by 0, 20, 30, 40, 50, 60 and 70 % class F fly ash (by weight). Water- binder ratio in all mixture was kept constant at 0.3. Cube specimens were compacted in table vibrator. As expected bulk density decreases with fly ash increment in the mixture. Apparent porosity and water absorption value increases with replacement of cement by fly ash. Results confirm the decrease in compressive strength at 3, 7 and 28 day with fly ash addition and it is more prominent in case of more than 30% fly ash content mixes. Ultrasonic pulse velocity test results indicate that the quality of the paste deteriorate with increase of fly ash content in the mixture.

2.2 Studies with Rice Husk Ash

(M.U Dabai, 2009) Investigated that compressive strength tests which were carried out on six mortar cubes with cement replaced by rice husk ash (RHA) at five levels (0, 10, 20, 30, 40 and 50%). After the curing age of 3, 7, 14 and 28 days. His findings that the compressive strengths of the cubes at 10% replacement were 12.60, 14.20, 22.10, 28.50 and 36.30 N/mm2 respectively and increased with age of curing but decreased with increase in RHA content for all mixes. The chemical analysis of rice husk ash revealed high amount of silica (68.12%), alumina (1.01%) and oxides such as calcium oxide (1.01%) and iron oxide (0.78%) responsible for strength, soundness and setting of the concrete. It also contained high amount of magnesia (1.31%) which is responsible for the unsoundness. this indicated that RHA can be used as cement substitute at 10% and 20% replacement and 14 and 28 day curing age.

(Dao Van Dong, 2008) Investigated key properties of high strength concrete using rice husk ashes (RHAs). RHAs obtained from two sources: Vietnam and India were used to partially replace as cement binder in high strength concrete. Properties of concrete, including: slump, density, compressive strength, water and chloride permeability resistances, were investigated in comparison between samples without using RHA and samples using two types of RHAs. Experimental results showed reasonable improvements in compressive strength, water and chloride permeability resistances of concrete using the RHAs. His findings presented that the samples composed the India RHA were much better than that of the Vietnam RHA. The utilisation of RHA in concrete has several benefits like reducing agricultural waste which is the main cause for environmental problems in agricultural countries.

(FENG Qing-ge, 2004) Investigated the effect of highly active rice husk ash (RHA) produced by an industrial furnace on some properties of concrete. The strength, pore volume and pore distribution of concrete and the $Ca(OH)_2$ content in concrete were investigated by JIS A 1108 (Method for test of compressive strength of concrete), a mercury instrument porosimeter, and the thermogravimetric analysis, respectively. His findings show that, with RHA replacement of cement , the compressive strength of concrete increases and the average pore radius of concrete is greatly decreased, especially the portion of the pores greater than 20mm in radius is decreased while the amount of smaller pores is increased, and the more the RHA replacement, the less the amount of $Ca(OH)_2$ in concrete.

(Ramasamy, 2011) Investigated on Rice Husk Ash (RHA) concrete to evaluate the compressive strength and to study its durability properties. In his experimental work of rice husk concrete, cement was replaced at various percentage levels such as 5%, 10%, 15%, 20% and control concrete was also prepared for comparison purpose. Two grades of concrete, namely M30 and M60, were prepared. His findings shows that strength of the concrete increased with the levels of percentage of replacement of 10% at which the increase in strength was 7.07% at 90 days compared to normal concrete. In the case of M60 grade concrete the compressive strength increases with the addition of super plasticizer. In general, Saturated Water Absorption (SWA) increased in the case of RHA Concrete up to 10% replacement level, but the same diminished with addition of super plasticizer. His findings also shows that porosity of RHA Concrete decreased from 4.70% to 3.45% when the replacement level increased from 5% to 20%. There is a further decrease with the addition of super plasticizer. The chloride ion permeability value of RHA Concrete was very low between 100-1000 coulomles, as compared to normal concrete. It was observed from tests that RHA concrete was more resistant to HCl solution than that of control concrete. The percentage of resistance against alkaline attack of M30 grade RHA concrete varied from 25 to 67 and the corresponding value for M60 grade was from 35 to 70 for replacement levels varying from 5% to 20%. There was a higher resistance against sulphate attack for both continuous soaking and cyclic at addition of 20% RHA.

(Le Anh-tuan Bui, 2012) Investigated strength and durability properties of concrete with or without three types of rice husk ash (RHA), namely, amorphous, partial crystalline, and crystalline RHA. The three types of RHA were added into concrete at a 20% replacement level. His findindings shows that the pozzolanic reactivity of amorphous RHA was higher than that of partial crystalline and crystalline RHA. Concrete added with amorphous RHA showed excellent characteristics in its mechanical and durability properties. Findings showes that higher the amount of crystalline silica in RHA, the lower the concrete resistivity value became. When compared with each other, concretes with 20% of the cement replaced with these types of RHA achieved similar ultrasonic pulse velocity values, but all were lower than that of the control concrete. The incorporation of these kinds of RHA significantly reduced chloride penetration.

(Guilherme Chagas Cordeiro, 2009) Investigated on the different grinding times in a vibratory mill, operating in dry open-circuit, on the particle size distribution, BET specific surface area and pozzolanic activity of the RHA, in order to improve RHA's performance. Four high-performance concretes were produced with 0%, 10%, 15%, and 20% of the cement (by mass) replaced by ultrafine RHA. For these mixtures, rheological, mechanical and durability tests were performed. For all levels of cement replacement, especially for the 20%, the ultra-fine RHA concretes achieved superior performance in the mechanical and durability tests compared with the reference mixture. His findings shows that workability of the concrete was reduced with the increase of cement replacement by RHA.

(Ramadhansyah Putra Jaya, 2011) Studied the compressive concrete strength and the gas permeability properties over varying fineness of the rice husk ash were experimentally investigated. Their relationships among them were analyzed. In his study eight samples were made from the rice husk ashes with a different grain size were used, *i:e:* coarse original rice husk ash 17.96 μm (RHA0), 10.93 μm (RHA1) 9.74 μm (RHA2), 9.52 μm (RHA3), 9.34 μm (RHA4), 8.70 μm (RHA5), 6.85 μm (RHA6) and 6.65 μm (RHA7). The ordinary Portland cement was partially replaced with the rice husk ash (15 wt%). His findings showed that the RHA3 produced the concrete with good strength and low porosity. Additionally the strength of the concrete was improved due to the partial replacement of RHA3 material in comparison with normal coarse rice husk ash RHA0. On the other hand the influence of OPC and RHA materials on the concrete permeability was affected by the grinding time and age (*i:e:*, curing time). The permeability coefficient decreased with the increasing of curing time. The relationships between compressive strength and permeability coefficient are greatly affected by curing times and are sensitive to the grinding cementitious systems.

(Maurice E. Ephraim G. A., 2012) Investigated the effects of partially replacing Ordinary Portland cement (OPC) with our local additive Rice Husk Ash (RHA) which is known to be super pozzolanic in concrete at optimum replacement percentage which will help to reduce the cost of housing. The specific gravity of RHA was found to be 1.55, the density of RHA concrete was found to be 2.043, 1.912 and 1.932kg/m3 at 10%, 20% and 25% replacement percentages respectively. His findings shows that RHA concrete was very workable with a slump value of over 100mm. The incorporation of RHA in concrete resulted in increase water demand and enhanced strength. The compressive strength values at 28days were found to be 38.4, 36.5 and 33N/mm2 at the same replacement percentages above. These compressive strength values compared favourably with the controlled concrete strength of 37N/mm2at a mix ratio of 1:1.5:3.

(Deepa G Nair, 2013)Investigated on high strength and high performance concrete which are being widely used all over the world. Most of the applications of high strength concrete have been found in high rise buildings, long span bridges etc. The potential of rice husk ash as a cement replacement material is well established .Earlier researches showed an improvement in mechanical properties of high strength concrete with finely ground RHA as a partial cement replacement material. A review of literature urges the need for optimizing the replacement level of cement with RHA for improved mechanical properties at optimum water binder ratio. His findings discusses the mechanical properties of RHA- High strength concrete at optimized conditions.

(Makarand Suresh Kulkarni, 2014) In this investigation optimized RHA, by controlled burn and or grinding, has been used as a pozzolanic material in cement and concrete. Using it provides several advantages, such as improved strength and durability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions. Up to now, little research has been done to investigate the use of RHA as supplementary material in cement and concrete production in Vietnam.The main objective of this work is to study the suitability of the rice husk ash as a pozzolanic material for cement replacement in concrete. However it is expected that the use of rice husk ash in concrete improve the strength properties of concrete. Also it is an attempt made to develop the concrete using rice husk ash as a source material for partial replacement of cement, which satisfies the various structural properties of concrete like compressive strength.His findings from the entire experimental work & studies concluded that mix M2 (M0+20%RHA) is the best combination among all mixes, which gives max, tensile, flexure & compression strength over normal concrete.

2.3 Studies with Brick Dust

(Hemraj R. Kumavat, 2013) Investigated brick waste for its use as a replacement of cement and sand in cement mortar as it behaves as a pozzoloana. It may make an important contribution towards decreasing the adverse effect of the production, disposal and the dumping of brick waste on the environment. His findings show that richer mixes gives lower value of bulk density and higher values of compressive strength for sand replacement with brick waste up to 40%. It also presents useful data for the brick manufacturing industry, builders and mortar manufacturing companies in terms of minimizing the impact of brick waste and using eco-efficient materials.

(B.Rogers, 2011) Investigated an optimal methodology for determining whether a given brick dust will produce a pozzolanic reaction when combined with lime. This property will be referred to as pozzolanicity. The research required a review of the properties of pozzolanic materials, the nature of the pozzolanic reaction, and a review of existing methods for determining pozzolanicity. A testing program performed at the Architectural Conservation Laboratory at the University of Pennsylvania was designed and executed to evaluate methods for testing pozzolanicity of brick dust to determine their efficacy. His findings of the tests was the final result of the research, along with recommendations for ways in which this immensely valuable resource can be tested and utilized economically and sustainably for conservation work in the future.

(Sharda Sharma, 2014) Investigated on concrete block pavements (CBPs) which have appearance of solid block with interlocking properties with each others for laying on the surface of road or pedestrian. As per requirement and use there are various sizes, shapes, patterns and designs of the CBPs are available now a days. In this paper we have considered the experimental study for construction of paver blocks with partial replacement of cement with brick kiln dust at concrete mix (CM)

0 %, 5 %, 10 %, 15 %, 20 %, 25 % and 30 % with adding superplasticizer admixture is maximum 2 % of superplasticizer by weight of cement. His findings considered the compressive strength and water absorption of paver block at 7, 14 and 28 days.

(R. Walker, 2011)Investigated on pozzolanic properties including particle size, specific surface, chemical and mineral composition, amorphousness and water demand, affect their reactivity as well as the strength of lime–pozzolan pastes. Reactivity was evaluated with chemical, mechanical and mineralogical methods. A number of artificial pozzolans were investigated including Ground Granulated Blastfurnace Slag (GGBS); Leca; Pulverised Fuel Ash (PFA); Calcined Clay (Metastar); Microsilica (MS); Rice Husk Ash (RHA); Red Brick Dust (RBD); Tile and Yellow Brick Dust (YBD). His findings concludes that the pozzolan's specific surface has a much greater influence on the water demand of the paste than its particle size or the lime:pozzolan ratio. It was evidenced that each pozzolan has a particular water demand for a given workability that increased with its specific surface; and that the replacement of lime by pozzolan lowers the water demand of the paste except for Metastar, on account of its greater fineness and specific surface. There is a good correlation between the chemical and physical activity indices and the rate of portlandite consumption. These evidenced that the most amorphous pozzolans (Metastar, GGBS, RHA and MS) are the most active. Finally, it also appears from the results, that the amount of lime combined by reactive crystalline phases in the pozzolans is insignificant when compared to that bound by their amorphous fraction. He also concluded that amorphousness determines pozzolan reactivity to a much greater extent than any other pozzolan property. It also concludes that the specific surface area of the pozzolan governs the water demand of the paste, while amorphousness largely determines the strength of the paste. In contrast, the chemical composition of the pozzolan is not instrumental as a variable affecting neither pozzolan reactivity nor the strength of the paste.

(Hasanpour, 2013)Investigated the feasibility of using waste bricks powder of Gachsaran Company in concrete. Cement is replaced by waste bricks powder in different proportions until 40 percent by weight. pozzolanic properties of bricks powder and compressive strength of concrete were investigated. His findings demonstrated that the bricks powder show pozzolanic properties. Findings also show that concrete with partial cement replacement by waste bricks powder has minor strength loss. The results of the investigation confirmed the potential use of this bricks powder material to produce pozzolanic concrete.

CHAPTER-3

MATERIALS

3.1 Concrete Making Materials

There are many types of concrete available, created by varying the proportions of the main ingredients below. By varying the proportions of materials, or by substitution for the cement and aggregate phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties. The mix design depends on the type of structure being built, how the concrete will be mixed and delivered, and how it will be placed to form this structure.

3.1.1 Cement

The most common cement used is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 43 grade (Jaypee OPC) conforming to IS:8112-1989 is used. Many tests were conducted on cement; some of them are specific gravity, consistency tests, setting time tests, compressive strengths, etc. (IS8112, 2013)

Fig:3.1 JAYPEE Cement (OPC 43 grade)

3.1.2 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Water cement ratio used is 0.46 for M20, 0.42 for M25, 0.38 for M30 concretes. Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and allows it to flow more freely. Less water in the cement paste will yield a stronger, more durable concrete; more water will give a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles, and other components of the concrete, to form a solid mass.

Reaction:

Cement chemist notation: $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$

Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO).(SiO_2).(H_2O)(gel) + Ca(OH)_2$

Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO).2(SiO_2).4(H_2O)(gel) + 3Ca(OH)_2$

3.1.3 Aggregates

Fine and coarse aggregate make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are mainly used for this purpose. Recycled aggregates (from construction, demolition and excavation waste) are increasingly used as partial replacements of natural aggregate, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted.

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383(1970) are used. Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is used in combination as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screened, to eliminate deleterious materials and over size particles. fine aggregate, coarse aggregate and grit. (IS383, 1970)

Fig: 3.2 Aggregate in open field

3.1.4 Chemical Admixtures

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. In normal use, admixture dosages are less than 5% by mass of cement, and are added to the concrete at the time of batching/mixing. The common types of admixtures are as follows.

i. Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are $CaCl_2$ and NaCl. However, use of chlorides may cause corrosion in steel reinforcements and is prohibited in some countries.
ii. Retarders slow the hydration of concrete, and are used in large or difficult pours where partial setting before the pour is complete is undesirable. Typical polyol retarder is sugar, sucrose, sodium gluconate, glucose, citric acid, tartaric acid and etc.
iii. Air entrainments add and entrain tiny air bubbles in the concrete, which will reduce damage during freeze-thaw cycles thereby increasing the concrete durability. However, entrained air is a trade-off with strength, as each 1% of air may result in 5% decrease in compressive strength.
iv. Plasticizers/Super Plasticizers (water-reducing admixtures) increase the workability of plastic or “fresh” concrete, allowing it to be placed more easily, with less consolidating effort. Typical plasticizers are liginsulphate, polyol type. Alternatively, plasticizers can be used to the water content of a concrete (and have been called water reducers due to this application) while maintaining workability. This improves its strength and durability

characteristics. Super plasticizers (high-range water-reducing admixtures) are a class of plasticizers which have fewer deleterious effects when used to significantly increase workability, representative super plasticizers are sulfonated naphthalene formaldehyde condensate, sulfonated melamine formaldehyde condensate and acetone formaldehyde condensate, etc. more advanced super plasticizers is polycarboxylate type.In the experimental program Glenium Sky 8630 which is a high performance super plasticiser based on polycarboxylic ether was used.

Fig:3.3 Superplasticiser used in Experimental Work

Fig:3.4 Superplasticiser in containers

3.1.5 Fly Ash

Fly Ash used was taken from L&T plant which is bought and brought from Reliance power plant in Rosa, Uttar Pradesh with a density of 746kg/m^3

3.1.6 Brick Dust

Brick Dust was collected from the fields of Brick Kilns near Kukrail, Lucknow, Uttar Pradesh. The brick waste collected was then ball grinded. After grinding Brick Dust was sieved from 300µ sieve and the portion which passed from the sieve was used in the experiment.Density measured was 1542kg/m^3

3.1.7 Rice Husk Ash

Rice Husk taken from lucknow region was burnt in the gasifier plant in G.S.K. Bharat pvt limited under a controlled burning of 600-800 degree celcius and then the residue ash was ball grinded to a fine powder. After grinding Rice Husk Ash was sieved from 300µ sieve and the portion which passed from the sieve was used in the experiment. Density measured was 167kg/m^3

CHAPTER-4

METHODOLOGY

4.1 Mix Proportion Designation

The common method expressing the proportion of ingredients of a concrete in the terms of parts of ratios of cement, fine and coarse aggregates. For e.g. a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4. The proportions are either by volume or by mass.

4.1.1 Factors To Be Considered For Mix Design

The design of concrete mix will be based on the following factors:

Table 4.1: Grades Of Concrete ((IS456, 2000)clause 6.1)

Grade Designation	**Specified Characteristic Compressive Grade Designation Strength In N/Mm^2 At 28 Days Curing**
M 10	10
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40
M 45	45
M 50	50
M 55	55
M 60	60

In the designation of a concrete mix M refers to the mix design and the number to the specified characteristic compressive strength of 15 cm^3 cube at 28 days curing expressed in N/mm^2. M 15 and less grades of concrete may be used for lean concrete bases and simple foundation for masonry walls. Grades of concrete lower than M 20 shall not be used in reinforced concrete structure as per 456-2000. Grades of concrete lower than M 30 shall not be used in pre stressed concrete structure. (IS456, 2000)

i. **Maximum nominal size of aggregate:** It is found that larger the size of aggregate, smaller is the cement requirement for particular water cement ratio. Aggregates having a maximum nominal size of 20mm or smaller are generally considered satisfactory.
ii. **Minimum water-cement ratio:** The minimum w/c ratio for specified strength depends on the type of cement.
iii. **Workability:** The workability of concrete for satisfactory placing and compaction is related to the size and shape of the section to be concreted.

4.1.2 Target Mean Strength

Considering the inherent variability of concrete strength during production it is necessary to design the mix to have a target mean strength which is greater than characteristic strength by a suitable margin.

$$f_t = f_{ck} + 1.65 \times S$$

where,

f_t = Target mean strength

f_{ck} = Characteristic strength

S = Standard deviation of the particular mix which is available in IS 456-2000. The value of k is equal to 1.65 as per IS 456-2000 where not more than 5% of the test results are expected to fall below the characteristics strength.

Table: 4.2 Assumed Standard Deviation (S) (IS10262, Concrete mix proportioning, 2009)clauses 3.2.1.2, A-3 and B-3)

Grade Of Concrete	M10	M15	M20	M25	M30	M35	M40	M50
Standard Deviation (N/mm^2)	3.5	3.5	4.0	4.0	5.0	5.0	5.0	5.0

4.1.3 Procedure

i. Determine the mean target strength f_t from the specified characteristic compressive strength at 28-day f_{ck} and the level of quality control.

$$f_t = f_{ck} + 1.65\ S$$

where S is the standard deviation obtained from the table of approximate content given after the design mix.

ii. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water-cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in Table and adopt the lower of the two values.

iii. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.

iv. Select the water cement, for the required workability and the maximum size of aggregates (for aggregates in saturated surface dry condition) from table.

v. Determine the percentage of fine aggregates in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.

vi. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate, the values are given in table.

vii. Calculate the cement content from the water cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

viii. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps F and G above, calculate the content of coarse and fine aggregate per unit volume of concrete from the following relations:-

$$V = \left[W + \frac{C}{S_C} + \frac{1}{P}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_C} + \frac{1}{1-P}\frac{C_a}{C_{ca}}\right] \times \frac{1}{1000}$$

where V = Absolute volume of concrete

= Gross volume (1 m^3) minus the volume of entrapped air

S_c = Specific gravity of cement

W = Mass of water per metre cube of concrete, in kg

C = Mass of cement per metre cube of concrete, in kg

p = Ratio of fine aggregate to total aggregate by absolute volume

f_a, C_a = Total masses of coarse and fine aggregates, per cubic metre of concrete respectively, in kg

S_{fa}, S_{ca} = Specific gravities of saturated surface dry fine and coarse aggregates respectively.

ix. Determine the concrete mix proportions for the first trial mix.

x. Prepare the concrete using the calculated proportions and cast three cubes of 150mm size and test them wet after 28-days moist curing and check for the strength.

xi. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived. (IS10262, Concrete Mix Design, 2009)

4.2 Various Tests Carried Out For Mix Design

4.2.1 Tests on Cement

4.2.1.1 Determination of Fineness of Cement

A. Purpose

To establish the procedure for determination of fineness of cement by dry sieving.

B. Scope

The fineness of cement has an important bearing on the rate of hydration and ultimately the gain of strength.

C. Reference Document

IS:4031 (PART-1)

D. Apparatus

i. 90 micron sieve with lid and pan
ii. Balance 0.01 accuracy
iii. Brush

E. Procedure

i. Weight 100 gm. cement sieve from a standard sieve of 90 micron.
ii. Sieve continuously cement sample giving circular and vertical motion for a period of 15 minutes. Then weigh the retained mass left on sieve.
iii. After sieving the residue by weight on an IS 90 micron shall be weighed.

Acceptance Criteria = Residue on the 90 micron sieve shall not exceed 10% of the total weight of the sample. (IS4031(PART-1), 1996)

Result: 4.38 %

4.2.1.2 Determination of Normal Consistency For Cement

A. Purpose

To find out the normal consistency of cement.

B. Scope

The SOP works method of finding out normal consistency of cement as per IS:4031 Part-4.

C. Reference Document

IS:4031 (PART-4)

D. Apparatus

i. Vicat Apparatus Conforming to IS: 5513-1976.

ii. Balance

iii. Gauging Towel conforming to IS: 10086-1982.

iv. Standard Weights

v. Non-Porous Plate

E. Detailed Procedure

i. Take 500 gms. of cement.

ii. Add 24% of water into cement.

iii. The paste must be prepared in a standard manner and filled into vicat mould within 3-5 minutes.

iv. After filling the mould, shake it to expel air.

v. A standard plunger is brought down to touch the surface of the paste in the test block and quickly release allowing it to sink into the paste by its own weight.

vi. Take the reading.

vii. Conduct the 2nd trial with 25% of water and take the reading.

viii. Conduct similar trials with higher w/c ratio till plunger penetrates for a depth of 33-35 mm from the top.

ix. The percentage of water at which penetration gives 33-35 mm from the top 0r 5-7 mm from the bottom is Standard Consistency.

Acceptance Criteria : Amount of Water as a % by mass of the dry cement. (IS4031(Part-4), 1988)

Result:

Table: 4.3 Consistency for Cement

S. No.	**% of Water (P)**	**Initial Reading**	**Final Reading**	**Height not penetrated (mm)**
1.	32	6	13	07
2.	34	6	12	06

Water required for normal consistency, **P = 34%**

4.2.1.3 Determination of Setting Time of Cement

A. Purpose

Determination of Initial and Final Setting Time.

B. Scope

The time interval is retained for the cement paste/mortar/concrete for its workability while mixing ,transporting, and placing.

C. Reference Documents

IS-4031-1988 (PART-5)

D. Apparatus

i. Vicat Needle Apparatus
ii. Trowel Balance
iii. Weights
iv. Stop Watch

E. Detailed Procedure

a) Initial Setting Time

i. Take 500 gm of sample.
ii. Add 85% of consistency water to produce paste.
iii. Fill paste in vicat mould within 2.5 minutes.
iv. In the beginning needle will pierce through test block but after sometime when the paste starts losing its plasticity, the needle may penetrate only to a depth 33-35 mm from the top.
v. Interval of time at which the needle penetrates to test block to a depth equal to 33-35 mm from the top is taken as initial setting time.

b) Final Setting Time

i. Replace vicat needle by a circular attachment.
ii. The cement shall be considered as finally set when upon lowering the attachment gently cover the surface of the test block, the concrete needle makes an impression.

iii. The circular arrangement impression not seen on the mould is considered as final setting time.

Acceptance Criteria : Initial Setting Time should not be less than 30 minutes.

Final Setting Time should not be more than 600 minutes. (IS4031(Part-5), 1988)

Result:

Initial Setting Time = **165 minutes**

Final Setting Time = **270 minutes**

4.2.1.4 Determination of Compressive Strength of Cement

A. Purpose

To establish the compressive strength of cement mortar.

B. Scope

The scope is to determine compressive strength of hardened cement.

C. Reference Documents

IS-4031 (PART-6) & IS : 8112-1989

D. Apparatus

i. Compression Testing Machine
ii. Cube Moulds(7.06cm)
iii. Vibrating machine/Stapula for hand compaction
iv. Measuring Cylinder and curing tank

E. Detailed Procedure

i. Take 555grams of standard sand and 185grams of cement(ratio of cement to sand is 1:3) in a non-porous metallic tray and mix them with the help of trowel for one minute.

ii. Add water having a quantity P/4+35 percentage of combined weight of cement and sand (P is percentage of water required for normal consistency of cement.

iii. Mix the three ingredients thoroughly until the colour of mixture becomes uniform immediately after mixing, the mortar is filled in the cube mould of size 7.06cm. The area of the face will be equal to $50cm^{2.}$ Compact the mortar either by hand compaction in a standard specified manner

iv. Whole assembly is immersed in water at a temperature of $27 \pm 2^{o}C$ and kept for 24 hours.

v. Test the cube for compressive strength at the periods of 3, 7 and 28days. (IS4031(Part-6), 1988)

Result

Table: 4.4 Compressive Strength of Cement

S.No	**Type of Cement**	**Compressive strength at age of**		
		3 days	**7 days**	**28 days**
1	Ordinary Portland cement(OPC) Grade 43	$21KN/mm^2$	$32KN/mm^2$	$45KN/mm^2$

4.2.2 Tests on Aggregate

4.2.2.1 Determination of Silt Content in Fine Aggregates

A. Purpose

To find out the Silt Content in Fine Aggregates.

B. Scope

Clay or silt may be present in aggregates in the form of surface coatings which interfere with the bond between aggregates and the cement paste and increases the amount of water necessary to wet all the particles in the mix. It is therefore essential that the aggregates should not contain silt and clay.

C. Reference Documents

IS-2386 (PART-II)

D. Apparatus

200 ml glass measuring cylinder

E. Detailed Procedure

i. Place the sample of sand into the cylinder upto 100 mm mark.
ii. prepare salt water by adding teaspoonful of salt to a pint of water.
iii. Add salt water into the cylinder upto 150 ml mark.
iv. Shake the cylinder thoroughly and allow the sand to settle for 30 minutes.

Acceptance Criteria : Silt content should not exceed 5% of the fine aggregate used. (IS2386(Part-2), 1963)

Result:

Table: 4.5 Silt Content in Fine Aggregate

S. No.	**Silt Level, h_1 (ml)**	**Sand Level, h_2 (ml)**	**Silt Content $(h_1/h_2) \times 100$ (%)**
1.	04	96	4.16
2.	03	97	3.09

Silt content in the given sample of fine sand = **3.625%**

4.2.2.2 Determination of Bulking of Sand

A. Purpose

To determine the bulking of sand.

B. Scope

In concrete mix design, when the quantity of sand to be measured volumetrically, correction has to be applied for the volume increase of sand with moisture content. This can only be done if the bulking of sand is known.

C. Reference Documents

IS-2386 (PART-II)

D. Apparatus

i. Balance

ii. Measuring cylinder, 250 ml capacity

E. Detailed Procedure

i. Weigh dry sand 300 gm. and add 2% of water by weight and thoroughly mix.

ii. Pour the damp sand in a 250 ml measuring cylinder until it reaches the 200 ml mark.

iii. Consolidate the sand by shaking.

iv. Fill the cylinder with water and stir the sand, the water must be sufficient to submerge the sand completely. Now read the upper surface of sand.

v. Repeat the process for 2%, 4%, 6% and 8% moisture content by weight. (IS2386(Part-3), 1963)

Result

Table: 4.6 Bulking of Sand

	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**
% moisture content by weight	2	4	6	8
Level of sand after submerging in water	168	151	149	148
% Bulking [(200-1)/x]*100	118.45	131.78	133.55	134.45

4.2.2.3 Determination Of Particle Size Distribution Of Fine Aggregates By Sieve Analysis

A. Purpose

To study the particle size distribution of fine aggregates by sieve analysis and to find out the fineness modulus of the given sample.

B. Scope

For the purpose of concrete mix design, the information given by sieve analysis is of prime importance.

C. Reference Documents

IS-2386 (PART-1)

D. Apparatus

i. Set of IS Sieves
ii. Balance
iii. Sieve shaker

E. Detailed Procedure

i. Weigh accurately the given air dried sample of aggregate.
ii. Place the weighted sample in the topmost sieve of the nested sieve in the sieve shaker, arranged in the order of decreasing size.
iii. Screw tightly the sieves on the sieve shaker.
iv. Operate the shaker for not less than 15 minutes for manually operated sieves.
v. Stop the shaker by switching off.

vi. Lay the material retained on each sieve on a balance and calculate the cumulative weight retained on each sieve.

vii. Obtain cumulative percentage weight retained on each sieve.

viii. Add all these percentages and divide the total by 100. The resulting figure is the fineness modulus of the given sample. (IS2386(Part-1), 1963)

Result:

Table: 4.7 Fineness Modulus Test For Fine Aggregate

S. No.	Sieve Opening Size (mm)	Weight of sand retained (gm)	Percentage weight retained (%)	Cumulative percentage of sand retained (%)	Percentage of fine aggregate passing (%)
1.	4.75	11	1.1	1.1	98.9
2.	2.36	29	2.9	4.0	96
3.	1.18	91	9.1	13.1	86.9
4.	0.6	330	33.0	46.1	53.9
5.	0.3	425	42.5	88.6	11.4
6.	0.15	94	9.4	98.0	2.0
7.	Pan	20	2.0	100	0.0

Fineness modulus = Cumulative percentage of sand retained / 100

= (1.1 + 4.0 + 13.1 + 46.1 + 88.6 + 98.0) / 100

= 250.9 /100

= **2.51**

Table:4.8 Fineness Modulus Test For Coarse Aggregate

S. No.	Sieve Opening Size (mm)	Weight retained (gm)	Percentage weight retained (%)	Cumulative percentage weight retained (%)	Percentage of aggregate passing (%)
1.	20	207	4.14	4.14	95.86
2.	16	288	5.76	9.9	90.1
3.	12.5	690	13.8	23.7	76.3
4.	10	2156	43.12	66.82	33.18
5.	4.75	1590	31.8	98.62	1.38
6.	2.36	59	1.18	99.80	0.2
7.	1.18	10	0.2	100	0
8.	0.6	0	0	100	0
9.	0.3	0	0	100	0
10.	0.15	0	0	100	0

Fineness modulus = Cumulative percentage of aggregate retained / 100

= (4.14 + 9.9 + 23.7 + 66.82 + 98.62 + 99.80 +100 +100 +100 +100) / 100

= 702.98 /100

= **7.02**

4.2.2.4 Determination of Specific Gravity Index of Aggregates

A. Purpose

To determine the Specific Gravity of Aggregate.

B. Scope

Specific Gravity of aggregate is used in the design calculation of design mix.

C. Reference Documents

IS-2386 (PART-3)

D. Apparatus

Pycnometer

E. Detailed Procedure

i. Weigh the pycnometer (W1).

ii. Fill 1/3rd of pycnometer with aggregate sample and weigh it (W2).

iii. Fill the remaining 2/3rd of pycnometer with water and weigh it (W3).

iv. Empty the contents of pycnometer, fill it entirely with water and weigh it (W4).

v. Calculate the specific gravity of aggregate by the formula:

$$\text{Specific Gravity, } G_s = (W2 - W1) / [(W4 - W1) - (W3 - W2)]$$

Result

Table:4.9 Specific Gravity Test Of Fine Aggregate

S. No.	**Observation**	**Trial**	
		1	**2**
1.	Weight of specific gravity bottle, W_1 (gm)	21	21
2.	Weight of specific gravity bottle and one-third aggregate, W_2 (gm)	48	51
3.	Weight of specific gravity bottle and one-third aggregate and water, W_3 (gm)	88	89
4.	Weight of specific gravity bottle and water, W_4 (gm)	71	71
5.	Specific Gravity of the Coarse aggregate	2.62	2.65

Specific Gravity, G_s = $(W_2 - W_1) / \{(W_4 - W_1) - (W_3 - W_2)\}$

$= (48 - 21) / \{(71 - 21) - (88 - 48)\}$

= **2.65**

Table: 4.10 Specific Gravity Test of Coarse Aggregate

S. No.	Observation	Trial	
		1	2
1.	Weight of specific gravity bottle, W_1 (gm)	491.0	491.0
2.	Weight of specific gravity bottle and one-third aggregate, W_2 (gm)	811.0	825.0
3.	Weight of specific gravity bottle and one-third aggregate and water, W_3 (gm)	1407.0	1415.0
4.	Weight of specific gravity bottle and water, W_4 (gm)	1198.0	1198.0
5.	Specific Gravity of the Coarse aggregate	2.88	2.85

Specific Gravity, G_s = $(W_2 - W_1) / \{(W_4 - W_1) - (W_3 - W_2)\}$

$= (811 - 491) / \{(1198 - 491) - (1407 - 811)\}$

= **2.88**

4.2.2.5 Determination of Water Absorption of Aggregates

A. Purpose

To determine the water absorption of aggregates.

B. Scope

Water absorption capacity of aggregate affects the water cement ratio and hence needs to derived for concrete mix design.

C. Reference Documents

IS-2386 (PART-3)

D. Apparatus

i. Oven
ii. Weighing Machine

E. Detailed Procedure

i. Dry the specimen.
ii. Weigh the dry specimen about 1 kg or so.
iii. Immerse in portable water at room temperature for 24 hours.
iv. After 24 hours, weigh the specimen in SSD (Surface Saturated Dry condition).
v. Place the specimen in oven and dry at constant rate.
vi. Calculate % absorption of aggregate by the given formula:

$$[(B-A)/B] \times 100$$

where, B = weight in SSD condition

A = weight in dry condition

Result

Table: 4.11 Water Absorptions Test of Aggregate

S. No.	Weight of Dry Aggregate (gm)	Weight of Wet Aggregate (gm)	Water Absorption Capacity (%)
1.	1000	1005	0.5
2.	1000	1006	0.6

Water Absorption Capacity = (Weight of wet aggregate - Weight of dry aggregate) / Weight of dry Aggregate

= {(1005 - 1000) / 1000} x 100

= **0.5%**

4.2.3 Workability

Workability is the ability of a fresh (plastic) concrete mix to fill the form/mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration), and can be modified by adding chemical admixtures. Raising the water content or adding chemical admixtures will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and/or segregation of aggregates (when the cement and aggregates start to separate), with the resulting concrete having reduced quality. The use of an aggregate with an undesirable gradation can result in a very harsh mix design with a very low slump, which cannot be readily made more workable by addition of reasonable amounts of water.

Workability can be measured by the Concrete Slump Test, a simplistic measure of the plasticity of a fresh batch of Concrete following the IS 4926:2003 test standards. Slump is normally measured by filling an "ABRAMS cone" with a sample from a fresh batch of concrete. The cone is placed with the wide end down onto a level, non-absorptive surface. It is then filled in three layers of equal volume, with each layer being tamped with a steel rod in order to consolidate the layer. When the cone is carefully lifted off, the enclosed material will slump a certain amount due to gravity. A relatively dry sample will slump very little, having a slump value of one or two inches (25 or 30 cm). A relatively wet concrete sample may slump as much as 8 inches.

Slump can be increased by adding chemical admixtures such as mid-range or high-range water reducing agents (super-plasticizers) without changing the water-cement ratio. It is a bad practice to add water on-site which exceeds the water-cement ratio of the mix design, however in a properly designed mixture it is important to reasonably achieve the specified slump prior to placement as design factors such as air content, internal water for hydration/strength gain, etc. are dependent on placement at design slump values.

High-flow concrete, like self-consolidating concrete, is tested by other flow-measuring methods. One of these methods include placing the cone on the narrow end and observing how the mix flows through the cone while it is gradually lifted.

After mixing, concrete is a fluid and can be pumped to where it is needed. (M.S.Shetty, 2006)

4.2.3.1 Concrete Slump Test

In construction and civil engineering, the Concrete Slump Test (or simply Slump Test) is an in-situ test or a laboratory test used to determine and measure how hard and consistent is a given sample of concrete is, before curing.

The concrete slump test is, in essence, a method of quality control. For a particular mix , the slump should be consistent. A change in slump height would demonstrate an undesired change in the ratio of the concrete ingredients, the proportions of the concrete are then adjusted to keep a concrete batch consistent. This homogeneity improves the quality and structural integrity of the cured concrete.

A. Concept

"Slump" is simply a term coined to describe how consistent a concrete sample is, rather than using obscure descriptions such as "wet" or "runny". The height of the concrete mix after being placed in the slump cone differs from one sample to another. Samples with lower heights are predominantly used in construction, with samples having high slumps commonly used to construct roadway pavements.

B. Purpose

The goal of the test is to measure the consistency of concrete. Many factors are taken into account when satisfying requirements of concrete strength, and to make sure a consistent mixture of cement is being used during the process of construction. The test also determines the "workability" of concrete, which provides a scale on how easy is it to handle, compact, and cure concrete. Engineers use the results to then alter the concrete mix by adjusting the water-cement ratio or adding plasticizers to increase the slump of the concrete mix.

C. Procedure

The slump test has witnessed many technological advances, and some countries even perform the test using automated machinery. To simplify, generally accepted method to perform the test is as follows:

D. Apparatus

i. Large Pan
ii. Trowel to mix concrete mixture
iii. Steel tamping rod
iv. Slump cone
v. Ruler
vi. Concrete (Cement, water, sand & aggregates)

E. Steps

i. Place the mixing pan on the floor and moisten it with some water. Make sure it is damp but no free water is left.
ii. Firmly hold the slump cone in place using the 2 foot holds.
iii. Fill one-third of the cone with the concrete mixture. Then tamp the layer 25 times using the steel rod in a circular motion, making sure not to stir.
iv. Add more concrete mixture to the two-thirds mark. Repeat tamping for 25 times again. Tamp just barely into the previous layer (1").

v. Fill up the whole cone up to the top with some excess concrete coming out of top, then repeat tamping 25 times (if there is not enough concrete from tamping compression, stop tamping, add more, then continue tamping).

vi. Remove excess concrete from the opening of the slump cone by using tamping rod in a rolling motion until flat.

vii. Slowly and carefully, remove the cone by lifting it vertically (5 seconds ± 2 seconds), making sure that the concrete sample does not move.

viii. Wait for the concrete mixture as it slowly slumps.

ix. After the concrete stabilizes, measure the slump height by turning the slump cone upside down next to the sample, placing the tamping rod on the slump cone and measuring the distance from the rod to the original displaced centre. (IS4926, 2003)

4.3 Design Mix

4.3.1 Design Mix for M20 Grade Concrete:

A mix M20 grade was designed as per IS 10262:2009 and the same was used to prepare the test samples. (IS10262, Concrete mix proportioning, 2009)

A. Data for Mix Proportion:

The following data are required for mix proportion of a particular grade of concrete:

i. Grade designation.

ii. Type of cement.

iii. Maximum nominal size of aggregate.

iv. Minimum cement content.

v. Maximum water cement ratio.

vi. Workability.

vii. Exposure condition as per table 4 and 5 of IS 456.

viii. Max temperature of concrete at the time of placing.

ix. Method of transporting and placing.

x. Early age strength requirements, if required.

xi. Type of aggregate.

xii. Max cement content.

B. Target strength of mix proportioning ((IS10262, Concrete Mix Design, 2009), 3.2):

Target mean compressive strength f'_{ck} is given by:

$$\mathbf{f'_{ck} = f_{ck}+1.65s}$$

where

f'_{ck} = Target mean compressive strength at 28 days in N/mm^2

f_{ck} = Characteristic compressive strength at 28 days strength in N/mm^2

s = Standard deviation N/mm^2

C. Concrete mix proportion:

$f'\ ck = f_{ck}+1.65s$

$= 20+1.65*4$ (IS10262, Concrete Mix Design, 2009) clauses 3.2.1.2

$= 26.60 N/mm^2$

D. Calculation of water content:

W/C= 0.46

Water content for 25-50 mm slump =**186 liters** (IS10262, Concrete mix proportioning, 2009)clause 4.2, A-5 and B-5)

Water content for 120 mm slump = 186+6/120*186

= 195 liters

E. Calculation of cement content:

W/C = 0.46

Cement content = 195/0.46 = 424 kg.

424>300 (ok) (from (IS456, 2000)Table 5)

F. Proportioning of coarse and fine aggregate:

From Table 3 of (IS10262, Concrete mix proportioning, 2009)volume of coarse aggregate for 0.5 W/C = 0.62

Present W/C = 0.46

Therefore volume of coarse aggregate need to increase to decrease fine aggregate by 0.08

The coarse aggregate increase by the formula:

+- 0.01 for every +- 0.05 change of W/C ratio

Coarse aggregate for 0.42 W/C ratio = 0.008+0.62 = 0.628

For pump able reduce by 10%

Volume of coarse aggregate = 0.628*0.9 = 0.565

Volume of fine aggregate = 1-0.565 = 0.435

G. Mix calculation:

a) Volume of concrete = 1 m^3

b) Volume of cement = Mass/sp.gravity*1/1000

= 424/3.15*1/1000

= 0.135 m^3

c) Volume of water = Mass/ sp. gravity* 1/1000

= 195/1000

= 0.195 m^3

d) Volume of all aggregate = 1- (0.14+0.195)

e = 0.670 m^3

e) Mass of coarse aggregate = e*volume of coarse*sp.gravity*1000

= 0.670*0.565*2.88*1000

= 1090 kg

f) Mass of fine aggregate = e*volume of fine*sp.gravity*1000

= 0.670*0.435*2.65*1000

= 773 kg

H. Mix proportion:

Cement = **424 kg**

Water = 195 **liters**

Fine aggregate = **773 kg**

Coarse aggregate = **1090 kg**

W/C ratio = **0.46**

Ratio = **<u>1:1.82:2.57</u>**

4.3.2 Design Mix for M25 Grade Concrete

A mix M25 grade was designed as per (IS10262, Concrete Mix Design, 2009) and the same was used to prepare the test samples.

A. Data for mix proportion:

The following data are required for mix proportion of a particular grade of concrete:

i. Grade designation.
ii. Type of cement.
iii. Maximum nominal size of aggregate.
iv. Minimum cement content.
v. Maximum water cement ratio.
vi. Workability.
vii. Exposure condition as per table 4 and 5 of IS 456.
viii. Max temperature of concrete at the time of placing.
ix. Method of transporting and placing.
x. Early age strength requirements, if required.
xi. Type of aggregate.
xii. Max cement content.

B. Target strength of mix proportioning:

Target mean compressive strength f'_{ck} is given by:

$\mathbf{f'_{ck} = f_{ck}+1.65s}$ (IS10262, Concrete Mix Design, 2009)**,**3.2

where

$\mathbf{f'_{ck}}$ = Target mean compressive strength at 28 days in N/mm^2

$\mathbf{f_{ck}}$ **=** Characteristic compressive strength at 28 days strength in N/mm^2

S = Standard deviation N/mm^2

C. Concrete mix proportion:

$f'ck = f_{ck}+1.65s$

$= 25+1.65*4$

(IS10262, Concrete Mix Design, 2009) clauses 3.2.1.2, A-3 and B-3)

= $31.60 N/mm^2$

D. Calculation of water content:

W/C= 0.42

Water content for 25-50 mm slump =**186 liters** (IS10262, Concrete Mix Design, 2009)clause 4.2, A-5 and B-5)

Water content for 120 mm slump = 186+6/120*186

= 195 liters

E. Calculation of cement content:

W/C = 0.42

Cement content = 195/0.42 = 465 kg.

465>300 (ok) (IS456, 2000)table 5

F. Proportioning of coarse and fine aggregate:

From table 3 of ((IS10262, Concrete Mix Design, 2009) table-5) volume of coarse aggregate for 0.5 W/C = 0.62

Present W/C = 0.42

Therefore volume of coarse aggregate need to increase to decrease fine aggregate by 0.08

The coarse aggregate increase by the formula:

+- 0.01 for every +- 0.05 change of W/C ratio

Coarse aggregate for 0.42 W/C ratio = 0.016+0.62 = 0.636

For pump able reduce by 10%

Volume of coarse aggregate = 0.636*0.9 = 0.57

Volume of fine aggregate = 1-0.57 = 0.43

G. Mix calculation:

a) Volume of concrete = 1 m^3

b) Volume of cement = Mass/sp.gravity*1/1000

= 465/3.15*1/1000

= 0.14 m^3

c) Volume of water = Mass/ sp. gravity* 1/1000

= 195/1000

= 0.195 m^3

d) Volume of all aggregate = 1- (0.14+0.195)

e = 0.665 m^3

e) Mass of coarse aggregate = e*volume of coarse*sp.gravity*1000

= 0.665*0.57*2.88*1000

= 1092 kg

f) Mass of fine aggregate = e*volume of fine*sp.gravity*1000

= 0.665*0.43*2.65*1000

= 758 kg

H. Mix proportion:

Cement = **465 kg**

Water = 195 **liters**

Fine aggregate = **758 kg**

Coarse aggregate = **1092 kg**

W/C ratio = **0.42**

Ratio = **<u>1:1.63:2.35</u>**

4.3.3 Design Mix:

A mix M30 grade was designed as per (IS10262, Concrete Mix Design, 2009) and the same was used to prepare the test samples.

A. Data for mix proportion:

The following data are required for mix proportion of a particular grade of concrete:

i. Grade designation.
ii. Type of cement.
iii. Maximum nominal size of aggregate.
iv. Minimum cement content.
v. Maximum water cement ratio.
vi. Workability.
vii. Exposure condition as per table 4 and 5 of IS 456.
viii. Max temperature of concrete at the time of placing.
ix. Method of transporting and placing.
x. Early age strength requirements, if required.
xi. Type of aggregate.
xii. Max cement content.

B. Target strength of mix proportioning:

Target mean compressive strength f'_{ck} is given by:

$$\mathbf{f'_{ck} = f_{ck} + 1.65s}$$

(IS10262, Concrete Mix Design, 2009) 3.2

where

$\mathbf{f'_{ck}}$ = Target mean compressive strength at 28 days in N/mm^2

f_{ck} = Characteristic compressive strength at 28 days strength in N/mm^2

s = Standard deviation N/mm^2

C. Concrete mix proportion:

$f'ck = f_{ck}+1.65s$

= 30+1.65*5 (IS10262, Concrete Mix Design, 2009) clause 3.2.1.2, A-3 and B-3)

= $38.25 N/mm^2$

D. Calculation of water content:

W/C= 0.38

Water content for 25-50 mm slump =**186 liters**

((IS10262, Concrete Mix Design, 2009) clause 4.2, A-5 and B-5)

Water content for 120 mm slump = 186+6/120*186

= 195 liters

E. Calculation of cement content:

W/C = 0.38

Cement content = 195/0.38 = 513 kg.

513>300 (ok) ((IS456, 2000) Table 5)

F. Proportioning of coarse and fine aggregate:

From table 3 of (IS10262, Concrete Mix Design, 2009) volume of coarse aggregate for 0.5 W/C = 0.62

Present W/C = 0.38

Therefore volume of coarse aggregate need to increase to decrease fine aggregate by 0.08

The coarse aggregate increase by the formula:

+- 0.01 for every +- 0.05 change of W/C ratio

Coarse aggregate for 0.42 W/C ratio = 0.024+0.62 = 0.644

For pump able reduce by 10%

Volume of coarse aggregate = 0.644*0.9 = 0.58

Volume of fine aggregate = 1-0.58 = 0.42

G. Mix calculation:

a) Volume of concrete = 1 m^3

b) Volume of cement = Mass/sp.gravity*1/1000

= 513/3.15*1/1000

= 0.162 m^3

c) Volume of water = Mass/ sp. gravity* 1/1000

= 195/1000

= 0.195 m^3

d) Volume of all aggregate = 1- (0.162+0.195)

e = 0.643 m^3

e) Mass of coarse aggregate = e*volume of coarse*sp.gravity*1000

= 0.643*0.58*2.88*1000

= 1074 kg

f) Mass of fine aggregate = e*volume of fine*sp.gravity*1000

= 0.643*0.42*2.65*1000

= 716 kg

H. Mix proportion:

Cement = **513 kg**

Water = 195 **liters**

Fine aggregate = **716 kg**

coarse aggregate = **1074 kg**

W/C ratio = **0.38**

Ratio = **1:1.4:2.09**

Table: 4.12 design mix proportion for M20 Grade Concrete replacing Fly Ash

Grade	W/C	% Replaced	Cement (kg)	Fly Ash(FA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M20	0.46	0%	22.988	0	42.75	16.275	37.975	10.57	120	12
		5%	21.839	1.149	42.75	16.275	37.975	10.57	120	12
		10%	20.689	2.299	42.75	16.275	37.975	10.57	120	12
		15%	19.539	3.449	42.75	16.275	37.975	10.57	115	12
		20%	18.39	4.598	42.75	16.275	37.975	10.57	110	12
		25%	17.241	5.747	42.75	16.275	37.975	10.57	100	12
		30%	16.091	6.897	42.75	16.275	37.975	10.57	95	12
		35%	14.942	8.046	42.75	16.275	37.975	10.57	90	12
		40%	13.792	9.196	42.75	16.275	37.975	10.57	90	12

Table: 4.13 design mix proportion for M20 Grade Concrete replacing Brick Dust

Grade	W/C	% Replaced	Cement (kg)	Brick Dust(BD) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M20	0.46	0%	22.988	0	42.75	16.275	37.975	10.57	120	12
		5%	21.839	1.149	42.75	16.275	37.975	10.57	120	12
		10%	20.689	2.299	42.75	16.275	37.975	10.57	120	12
		15%	19.539	3.449	42.75	16.275	37.975	10.57	110	12
		20%	18.39	4.598	42.75	16.275	37.975	10.57	105	12
		25%	17.241	5.747	42.75	16.275	37.975	10.57	100	12
		30%	16.091	6.897	42.75	16.275	37.975	10.57	95	12
		35%	14.942	8.046	42.75	16.275	37.975	10.57	90	12
		40%	13.792	9.196	42.75	16.275	37.975	10.57	80(0.5)	12

(0.5) Refers that to maintain the slump of 80-120, 0.5% suprpasticiser was used

Table: 4.14 design mix proportion for M20 Grade Concrete replacing Rice Husk Ash

Grade	W/C	% Replaced	Cement (kg)	Rice Husk Ash(RHA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M20	0.46	0%	22.988	0	42.75	16.275	37.975	10.57	120	12
		5%	21.839	1.149	42.75	16.275	37.975	10.57	120	12
		10%	20.689	2.299	42.75	16.275	37.975	10.57	120	12
		15%	19.539	3.449	42.75	16.275	37.975	10.57	115	12
		20%	18.39	4.598	42.75	16.275	37.975	10.57	110	12
		25%	17.241	5.747	42.75	16.275	37.975	10.57	100	12
		30%	16.091	6.897	42.75	16.275	37.975	10.57	90	12
		35%	14.942	8.046	42.75	16.275	37.975	10.57	80(0.5)	12
		40%	13.792	9.196	42.75	16.275	37.975	10.57	80(0.8)	12

(0.5) and (0.8) Refers that to maintain the slump of 80-120, 0.5% and 0.8% suprpasticiser was used

Table: 4.15 design mix proportion for M25 Grade Concrete replacing Fly Ash

Grade	W/C	% Replaced	Cement (kg)	Fly Ash(FA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M25	0.42	0%	24.742	0	40.82	16.33	38.102	10.39	120	12
		5%	23.505	1.237	40.82	16.33	38.102	10.39	120	12
		10%	22.268	2.474	40.82	16.33	38.102	10.39	120	12
		15%	21.03	3.711	40.82	16.33	38.102	10.39	110	12
		20%	19.794	4.948	40.82	16.33	38.102	10.39	105	12
		25%	18.556	6.186	40.82	16.33	38.102	10.39	100	12
		30%	17.319	7.423	40.82	16.33	38.102	10.39	100	12
		35%	16.082	8.660	40.82	16.33	38.102	10.39	95	12
		40%	14.845	9.897	40.82	16.33	38.102	10.39	90	12

Table: 4.16 design mix proportion for M25 Grade Concrete replacing Brick Dust

Grade	W/C	% Replaced	Cement (kg)	Brick Dust(BD) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M25	**0.42**	0%	24.742	0	40.82	16.33	38.102	10.39	120	12
		5%	23.505	1.237	40.82	16.33	38.102	10.39	120	12
		10%	22.268	2.474	40.82	16.33	38.102	10.39	120	12
		15%	21.03	3.711	40.82	16.33	38.102	10.39	110	12
		20%	19.794	4.948	40.82	16.33	38.102	10.39	105	12
		25%	18.556	6.186	40.82	16.33	38.102	10.39	100	12
		30%	17.319	7.423	40.82	16.33	38.102	10.39	95	12
		35%	16.082	8.660	40.82	16.33	38.102	10.39	90	12
		40%	14.845	9.897	40.82	16.33	38.102	10.39	80(0.6)	12

(0.6) Refers that to maintain the slump of 80-120, 0.6% suprpasticiser was used

Table: 4.17 design mix proportion for M25 Grade Concrete replacing Rice Husk Ash

Grade	W/C	% Replaced	Cement (kg)	Rice Husk Ash(RHA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M25	**0.42**	0%	24.742	0	40.82	16.33	38.102	10.39	120	12
		5%	23.505	1.237	40.82	16.33	38.102	10.39	120	12
		10%	22.268	2.474	40.82	16.33	38.102	10.39	120	12
		15%	21.03	3.711	40.82	16.33	38.102	10.39	110	12
		20%	19.794	4.948	40.82	16.33	38.102	10.39	100	12
		25%	18.556	6.186	40.82	16.33	38.102	10.39	90	12
		30%	17.319	7.423	40.82	16.33	38.102	10.39	80(0.5)	12
		35%	16.082	8.660	40.82	16.33	38.102	10.39	80(0.7)	12
		40%	14.845	9.897	40.82	16.33	38.102	10.39	80(1)	12

(0.5), (0.7), (1) Refers that to maintain the slump of 80-120, 0.5% , 0.7% and 1% suprpasticiser was used

Table: 4.18 design mix proportion for M30 Grade Concrete replacing Fly Ash

Grade	W/C	% Replaced	Cement (kg)	Fly Ash(FA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M30	0.38	0%	27.65	0	38.709	16.092	37.548	10.507	120	12
		5%	26.267	1.383	38.709	16.092	37.548	10.507	120	12
		10%	24.885	2.765	38.709	16.092	37.548	10.507	120	12
		15%	23.505	4.147	38.709	16.092	37.548	10.507	110	12
		20%	22.12	5.53	38.709	16.092	37.548	10.507	105	12
		25%	20.737	6.913	38.709	16.092	37.548	10.507	100	12
		30%	19.355	8.295	38.709	16.092	37.548	10.507	90	12
		35%	17.972	9.678	38.709	16.092	37.548	10.507	90	12
		40%	16.59	11.06	38.709	16.092	37.548	10.507	85	12

Table: 4.19 design mix proportion for M30 Grade Concrete replacing Brick Dust

Grade	W/C	% Replaced	Cement (kg)	Brick Dust(BD) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M30	**0.38**	0%	27.65	0	38.709	16.092	37.548	10.507	120	12
		5%	26.267	1.383	38.709	16.092	37.548	10.507	120	12
		10%	24.885	2.765	38.709	16.092	37.548	10.507	120	12
		15%	23.505	4.147	38.709	16.092	37.548	10.507	110	12
		20%	22.12	5.53	38.709	16.092	37.548	10.507	105	12
		25%	20.737	6.913	38.709	16.092	37.548	10.507	100	12
		30%	19.355	8.295	38.709	16.092	37.548	10.507	90	12
		35%	17.972	9.678	38.709	16.092	37.548	10.507	80(0.5)	12
		40%	16.59	11.06	38.709	16.092	37.548	10.507	80(0.8)	12

(0.5), (0.8) Refers that to maintain the slump of 80-120, 0.5% and 0.8% suprpasticiser was used

Table: 4.20 design mix proportion for M30 Grade Concrete replacing Rice Husk Ash

Grade	W/C	% Replaced	Cement (kg)	Rice Husk Ash(RHA) (kg)	FA (kg)	CA (kg)		Water (kg)	Slump (mm)	No. Of cubes
						20mm	12.5mm			
M30	0.38	0%	27.65	0	38.709	16.092	37.548	10.507	120	12
		5%	26.267	1.383	38.709	16.092	37.548	10.507	120	12
		10%	24.885	2.765	38.709	16.092	37.548	10.507	115	12
		15%	23.505	4.147	38.709	16.092	37.548	10.507	110	12
		20%	22.12	5.53	38.709	16.092	37.548	10.507	100	12
		25%	20.737	6.913	38.709	16.092	37.548	10.507	90	12
		30%	19.355	8.295	38.709	16.092	37.548	10.507	80(0.5)	12
		35%	17.972	9.678	38.709	16.092	37.548	10.507	80(0.8)	12
		40%	16.59	11.06	38.709	16.092	37.548	10.507	80(1)	12

(0.5), (0.8), (1) Refers that to maintain the slump of 80-120, 0.5% , 0.8% and 1% suprpasticiser was used

4.4 Cube Moulds: (As per IS: 516 – 1959)

The mould shall be of metal, preferably steel or cast iron, and stout enough to Prevent distortion. It shall be constructed in such a manner as to facilitate the removal of the moulded specimen without damage, and shall be so machined that, when it is assembled ready for use, the dimensions and internal faces shall be accurate within the following limits: The height of the mould and the distance between opposite faces shall be the specified size + 0.2mm. The angle between adjacent internal faces and between internal faces and top and bottom planes of the mould shall be 900+ 0.50. The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm. Each mould shall be provided with a metal base plate having a plane surface. The base plate shall be such dimensions as to support the mould during the filling without leakage and it shall be preferably attached to the mould by spring or screws. The parts of the mould when assembled shall be positively and rigidly held together, and suitable methods of ensuring this, both during the filling and on subsequent handling of the filled mould shall be provide

In assembling the mould for use, the joints between the sections of mould shall be thinly shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of the concrete.

Fig:4.1 Concrete Casted in Moulds

4.5 Casting of Test Specimens: (IS516, 1959)

4.5.1Preparation of Materials:

All materials shall be brought to room temperature, preferably 270+ 30C before commencing the results.

The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material, care is being taken to avoid the intrusion of foreign matter. The cement shall then be stored in a dry place, preferably in air-tight metal containers

Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. In general, the aggregate shall be separated into fine and coarse fraction and recombined for each concrete batch in such a manner as to produce the desired grading. IS sieve 480 shall be normally for separating the fine and coarse fractions, but where special grading are being investigated, both fine and coarse fractions shall be further separated into different sizes.

Fig:4.2 Moulds in Laboratory

4.5.2 Proportioning:

The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work. Where the proportions of the ingredients of the concrete as used on the site are to be specified by volume, they shall be calculated from the proportions by weight used in the test cubes and the unit weights of the materials.

4.5.3 Weighing:

The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

Fig:4.3 Weighing Machine in Laboratory

4.5.4 Mixing Concrete:

The concrete shall be mixed by hand or preferably in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

4.5.4.1 Machine Mixing:

The concrete batch shall be mixed on a electrically operated mixing machine or similar suitable implement, using the following procedure:

i. The cement and fine aggregate shall be mixed dry until the mixture is thoroughly blended and is uniform in color.

ii. The coarse aggregate shall then be added and mixed with the cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.

iii. The water shall then be added and the entire batch mixed until the concrete appears to be homogenous and has the desired consistency. If repeated mixing is necessary, because of the addition of water in increments while adjusting the consistency, the batch shall be discarded and a fresh batch made without interrupting the mixing to make trial consistency tests.

Fig:4.4 Mixing Machine

4.5.5 Compaction of Test Specimens: (IS516, 1959)

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete shall be filled into the mould in layers approximately 5 cm deep .In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. Each layer shall be compacted either by hand or by vibration as described below. After the top layer has been compacted, the surface of the concrete shall be finished level with the top of the mould, using a trowel, and covered with a glass or metal plate to prevent evaporation.

4.5.5.1 Compaction by Hand: (IS516, 1959)

When compacting by hand, the standard tamping bar shall be used and the strokes of the bar shall be distributed in a uniform manner over the cross section of the mould. The number of strokes per layer required to produce specified conditions will vary according to the type of concrete. For cubical specimens, in no case shall the concrete be subjected to less than 35 strokes per layer for 15 cm cubes or 25 strokes per layer for 10 cm cubes. The strokes shall penetrate into the underlying layer and the bottom layer shall be rodded throughout its depth. Where voids are left by tamping bar ,the sides of the mould shall be tapped to close the voids.

Fig:4.5 Compaction by Hand

Fig:4.6 Material Mixing in Mixing Machine

4.5.6 Curing of Test Specimens: (IS516, 1959)

The test specimens shall be stored on the site at a place free from vibration, under damp matting, sacks or other similar material for 24 hours + ½ hour from the time of adding the water to the other ingredients. The temperature of the place of storage shall be within the range of 220 to 320C. After the period of 24 hours, they shall be marked for later identification, removed from the moulds and, unless required for testing within 24hours, stored in clean water at a temperature of 240 to 300 C until they are transported to the testing laboratory. They shall be sent to the testing laboratory well packed in damp sand, damp sacks, or other suitable material so as to arrive there in a damp condition not less than 24 hours before the time of test. On arrival at the testing laboratory, the specimens shall be stored in water at a temperature of 270+ 20C until the time of test. Records of the daily maximum and minimum temperature shall be kept both during the period of the specimens remain on the site and in the laboratory.

Fig:4.7 Test specimens being cured in curing tank

4.6 Test for Compressive Strength of Concrete Specimen: (IS516, 1959)

4.6.1 Testing Machine:

The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the specified rate. The permissible error shall be not greater than + 2 percent of the maximum load. The testing machine shall be equipped with two steel bearing platens with hardened faces. One of the platens shall be fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides platen shall be plain rigid bearing block. The bearing faces of the both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied. The bearing surface of the platens, when new, shall not depart from a plane by more than 0.01 mm at any point, and they shall be maintained with a permissible variation limit of 0.02 mm.

Fig:4.8 Compression Testing Machine

Fig:4.9 Cube Testing Compression Testing Machine

Fig:4.10 Concrete Cube After Failure

4.6.2 Procedure:

Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0.2 mm and their weight shall be noted before testing.

4.6.3 Placing the Specimen in the Testing machine: (IS516, 1959)

The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel plates of the testing machine. As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Fig:4.11 Placing of Specimen in CTM

4.7 Calculation: (IS516, 1959)

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest kg per sq cm. Average of three values shall be taken as the representative of the batch provided the individual variation is not more than + 15percent of the average. Otherwise repeat tests shall be made.

CHAPTER-5

RESULTS AND DISCUSSION

5.1 Results

This thesis deals with the presentation of test results, and discussions on Compressive strength and development of Control concrete, Fly ash concrete, Rice Husk Ash concrete and Brick Dust concrete at curing period of 28 days. The present investigation is based on the IS method for Control concrete. For Fly Ash concrete , Rice Husk Ash concrete and Brick Dust concrete, replacement method is considered.Mix proportions have been obtained for M20, M25 and M30 grade concrete from the mix design. By conducting design mixes, an optimized proportion for the mix is obtained for M20, M25 and M30 grade control concrete. Compressive strength behaviour of Fly ash concrete, Rice Husk Ash concrete and Brick Dust concrete designed by the replacement method are studied, where the effect of age and percentage replacement of cement with Fly Ash, Rice Husk Ash and Brick Dust on Compressive strength is studied in comparison with that of M20, M25 and M30 grade Control concrete.

5.1.1 Mix proportioning of Control concrete:

According to IS method of mix design, the proportions of Control concrete were first obtained; trial mixes were carried out to determine the strength at 7, 28, 90 and 180 days, and the results obtained are shown in figure, where in the compressive strength obtained for M20, M25 and M30 grade design mixes are represented against age. The compressive strength at different ages of M20, M25 and M30 grade concrete under design mix are dissipated through graph. The final mix proportions arrived at is shown in tables.Comparison of compressive strength at 7,28, 90 and 180 days of design mix are shown.

5.1.2 Compressive Strength:

Most concrete structures are designed assuming that concrete processes sufficient compressive strength but not the tensile strength. The compressive strength is the main criteria for the purpose of structural design. To study the strength development of Fly Ash concrete , Rice Husk Ash concrete and Brick Dust concrete in comparison to Control concrete ,compressive strength tests were conducted at the ages of 7, 28, 90 and 180 days.

Table on next page

Table 5.1 Effect of Fly Ash on Compressive Strength of M20 Grade Concrete

Compressive strength of cubes , W/C = 0.46				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % FA	37.9	45.2	48.6	50.4
5 % FA	38.3	45.7	49.3	51.1
10 % FA	37.6	44.9	48.2	50.6
15 % FA	33.3	41.7	44.6	46.2
20 % FA	31.2	40.6	43.2	44.9
25 % FA	28.8	37.2	39.9	41.2
30 % FA	25.6	33.1	35.3	38
35 % FA	23.2	30.9	32.6	34.2
40 % FA	19.9	28.8	30.7	32.3

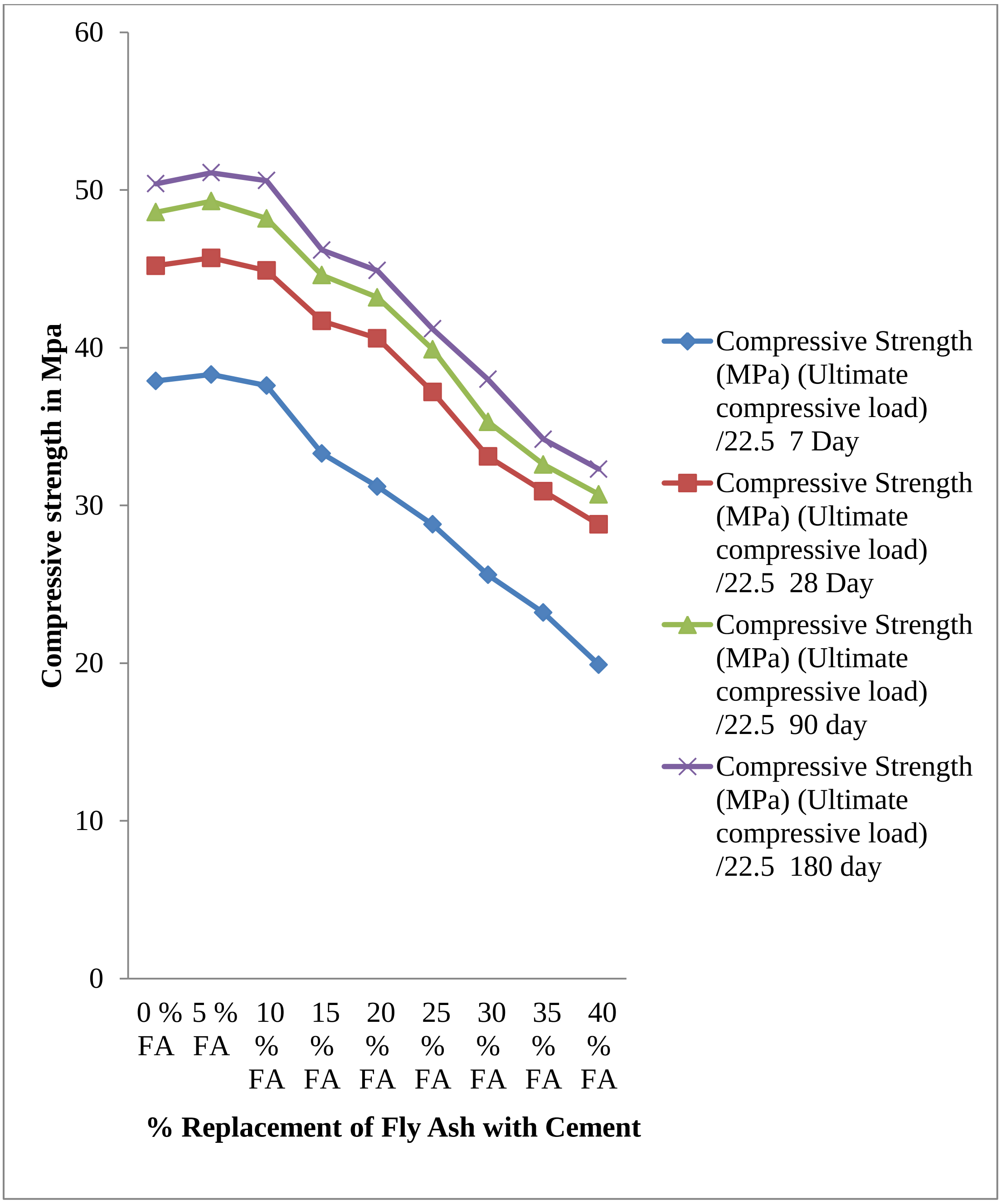

Fig-5.1 Change in compressive strength of M20 grade of concrete in different ages replacing cement with Fly Ash

Table 5.2 Effect of Brick Dust on Compressive Strength of M20 Grade Concrete

Compressive strength of cubes , W/C = 0.46				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % BD	37.9	45.2	48.6	50.4
5 % BD	38.2	45.9	48.7	50.7
10 % BD	38.8	46	49.1	51
15 % BD	33.4	42.1	45.8	48.2
20 % BD	31.2	39.9	43.6	46.4
25 % BD	28.1	36.8	40.9	43.6
30 % BD	25.2	34.1	37.6	40.3
35 % BD	22.7	31.3	33.6	36.2
40 % BD	19.2	28.2	29.6	31.2

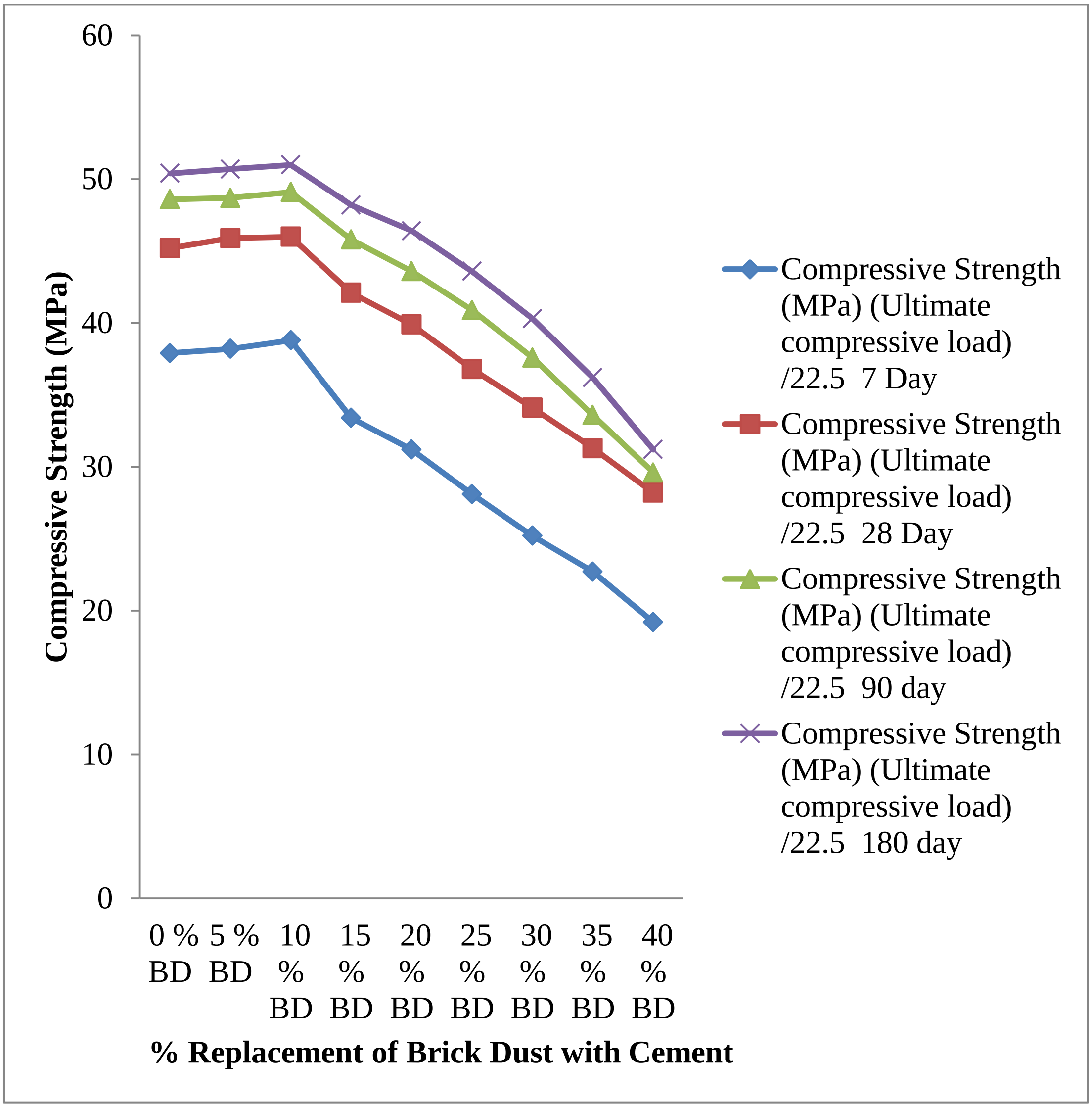

Fig -5.2 Change in compressive strength of M20 grade of concrete in different ages replacing cement with Brick Dust

Table 5.3 Effect of Rice Husk Ash on Compressive Strength of M20 Grade Concrete

Compressive strength of cubes , W/C = 0.46				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % RHA	34.9	45.2	48.6	50.4
5 % RHA	38.9	46.2	49	50.2
10 % RHA	37.6	44.1	47.6	49.1
15 % RHA	32.9	41.3	44.2	46.4
20 % RHA	30.6	37.8	41.5	43.6
25 % RHA	27.2	34.2	38	40.1
30 % RHA	22.4	31.9	34.8	36.7
35 % RHA	20.3	29.9	32.2	34.3
40 % RHA	18.1	26.8	28.6	30.1

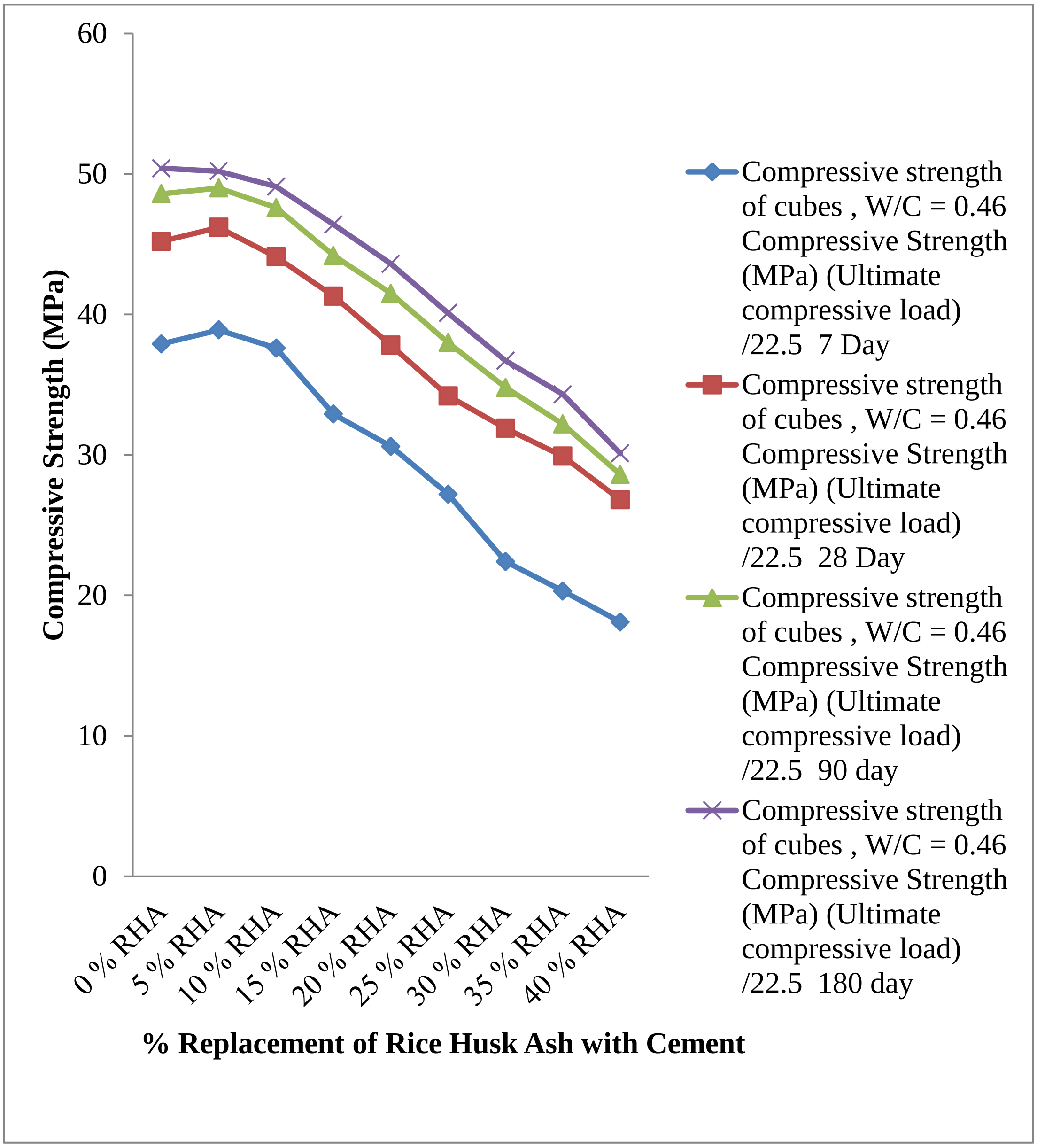

Fig -5.3 Change in compressive strength of M20 grade of concrete in different ages replacing cement with Rice Husk Ash

Table 5.4 Effect of Fly Ash on Compressive Strength of M25Grade Concrete

Compressive strength of cubes , W/C = 0.42				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % FA	41.42	51.4	53	56
5 % FA	41.78	53.8	55.6	56.4
10 % FA	41.56	54.7	56	56.9
15 % FA	40	51.1	52.4	53.8
20 % FA	39.1	49.3	52	53.6
25 % FA	37.1	48.4	49.8	51.8
30 % FA	34.5	47.1	48.9	50.9
35 % FA	31.2	44	45.6	47.6
40 % FA	27.2	38.7	40.4	43.6

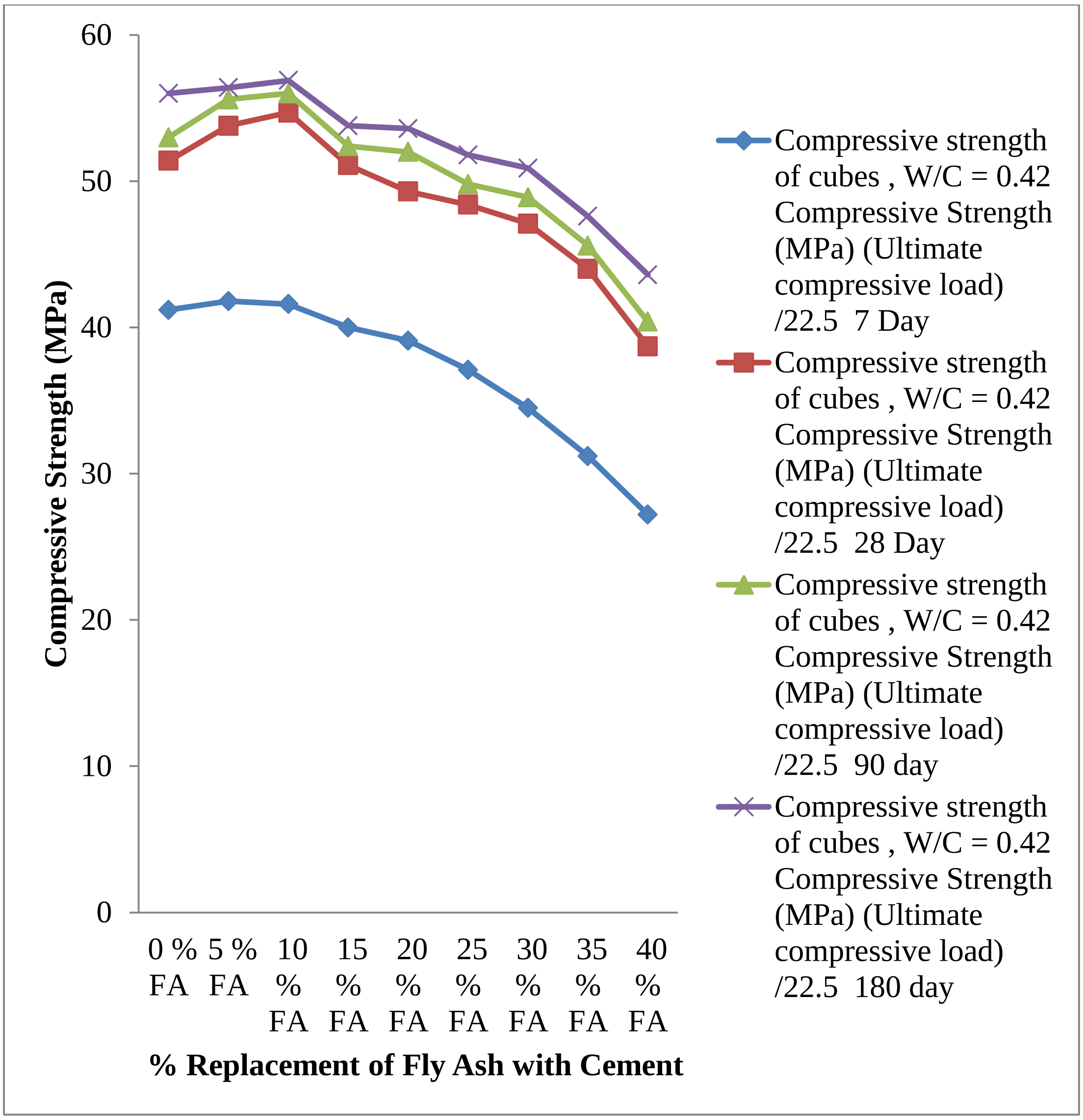

Fig -5.4 Change in compressive strength of M25 grade of concrete in different ages replacing cement with Fly Ash

Table 5.5 Effect of Brick Dust on Compressive Strength of M25Grade Concrete

Compressive strength of cubes , W/C = 0.42				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % BD	41.42	51.4	53	56
5 % BD	39.6	52	53.6	56.5
10 % BD	42.4	52.9	54.7	56.9
15 % BD	38.2	50.7	51.5	53.2
20 % BD	35.1	47.5	48.8	50.4
25 % BD	34.3	46.8	47.4	48.5
30 % BD	32.8	44.9	46.4	47.8
35 % BD	30.1	42.7	43.5	44.3
40 % BD	27.8	37.3	38.7	40.5

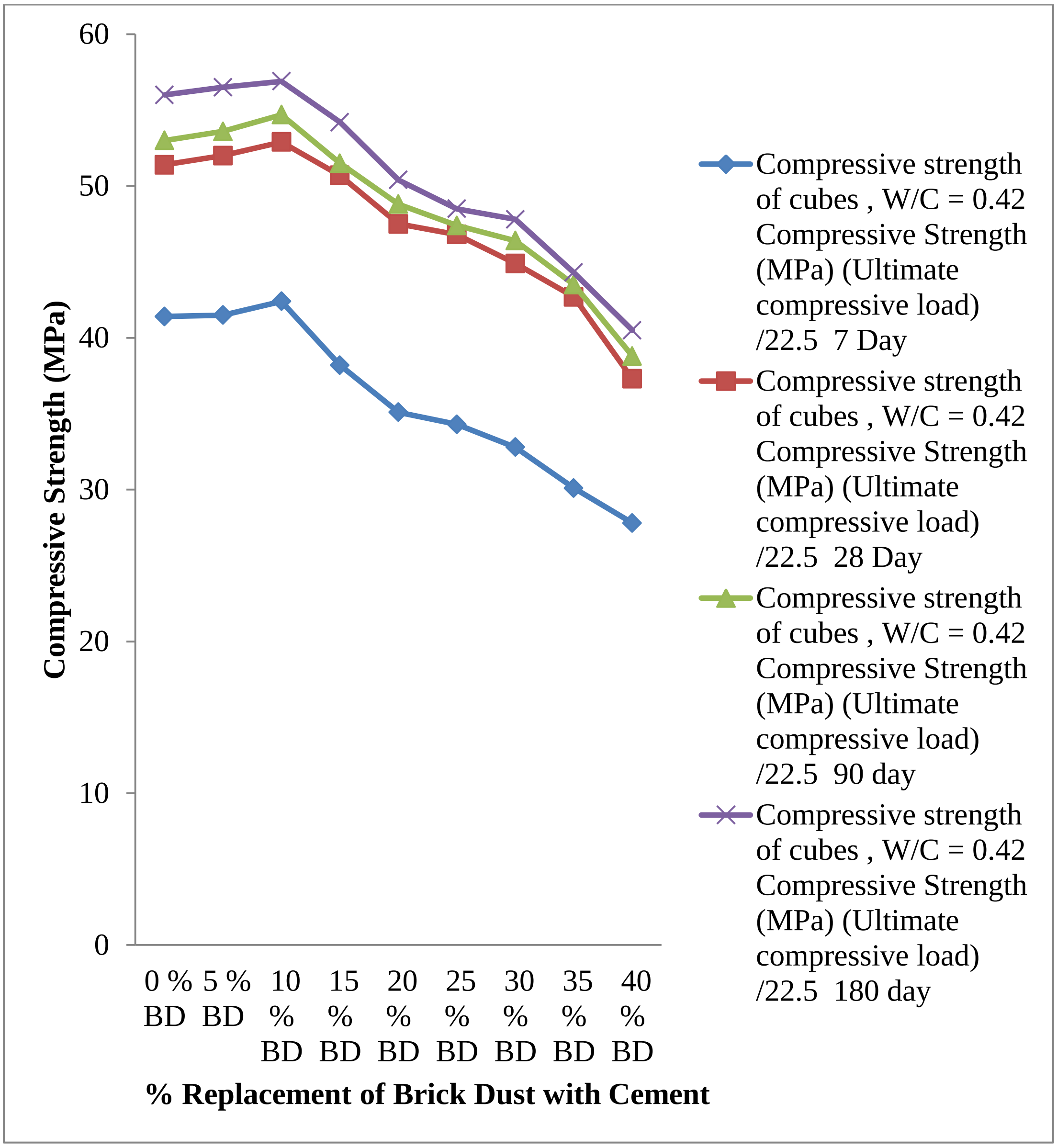

Fig -5.5 Change in compressive strength of M25 grade of concrete in different ages replacing cement with Brick Dust

Table 5.6 Effect of Rice Husk Ash on Compressive Strength of M25 Grade Concrete

Compressive strength of cubes , W/C = 0.42				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % RHA	41.4	51.4	53	56
5 % RHA	42.7	52.4	55.6	56.9
10 % RHA	40.4	50	53.8	55.6
15 % RHA	36.9	47.1	51.1	52.9
20 % RHA	34.7	44.9	48	49.8
25 % RHA	32	43.6	46.2	48.4
30 % RHA	29.8	40.9	42.7	44.9
35 % RHA	27.1	36.4	38.2	40.9
40 % RHA	24.2	34.1	36.3	38.7

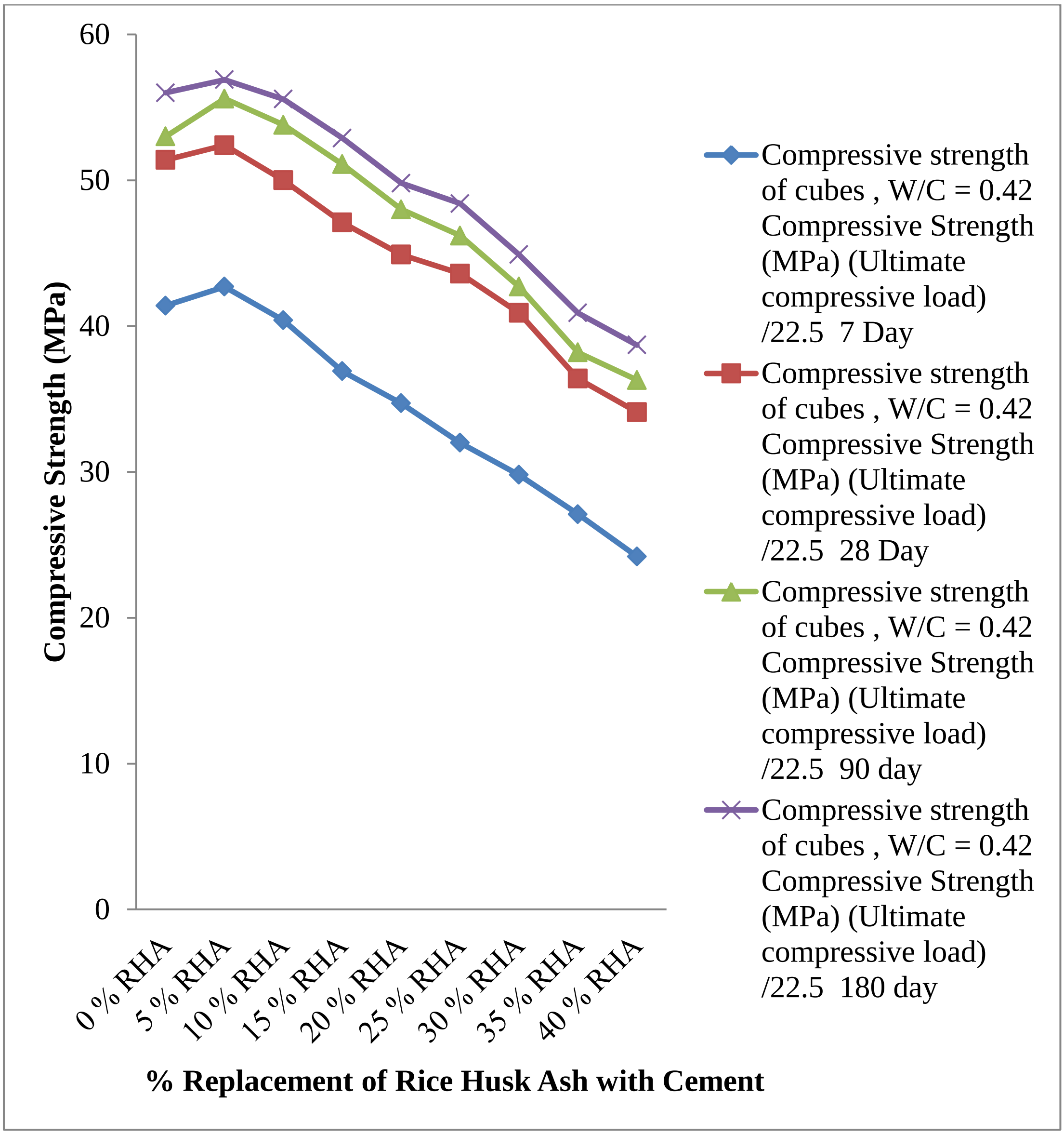

Fig -5.6 Change in compressive strength of M25 grade of concrete in different ages replacing cement with Rice Husk Ash

Table 5.7 Effect of Fly Ash on Compressive Strength of M30 Grade Concrete

Compressive strength of cubes , W/C = 0.38				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	28 Day	90 day	180 day
0 % FA	47.4	58.2	62	63.4
5 % FA	47.9	59.1	62.8	64.4
10 % FA	48.2	59.8	62.6	64.2
15 % FA	47.1	57.3	60.4	62.9
20 % FA	45.2	54.6	56.1	57.6
25 % FA	42.6	51	54.2	55.4
30 % FA	39.1	48.4	50.6	52.2
35 % FA	36.6	46.2	47.6	49.1
40 % FA	29.6	40.1	42.2	45.6

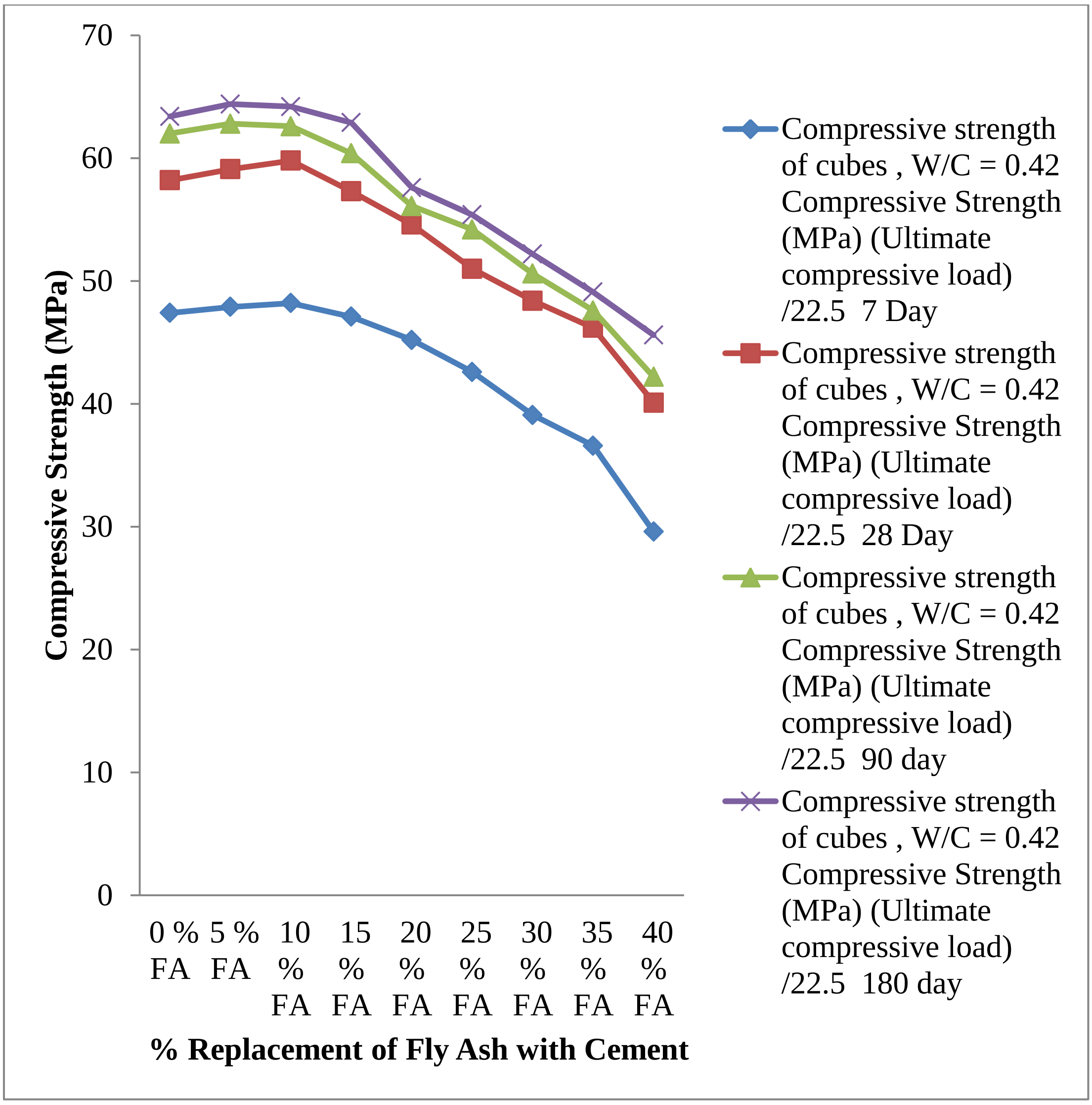

Fig -5.7 Change in compressive strength of M30 grade of concrete in different ages replacing cement with Fly Ash

Table 5.8 Effect of Brick Dust on Compressive Strength of M30 Grade Concrete

Compressive strength of cubes , W/C = 0.38				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % BD	47.4	58.2	62	63.4
5 % BD	47.5	59	62.2	64.1
10 % BD	48.6	59.6	62.6	64.7
15 % BD	44.3	56.4	59.1	61.4
20 % BD	41.2	52.3	57.7	58.1
25 % BD	38.6	49	52.9	55
30 % BD	36.6	47.3	50.2	51.2
35 % BD	35.1	45.8	46.7	47.4
40 % BD	29.4	39.9	42.9	44.1

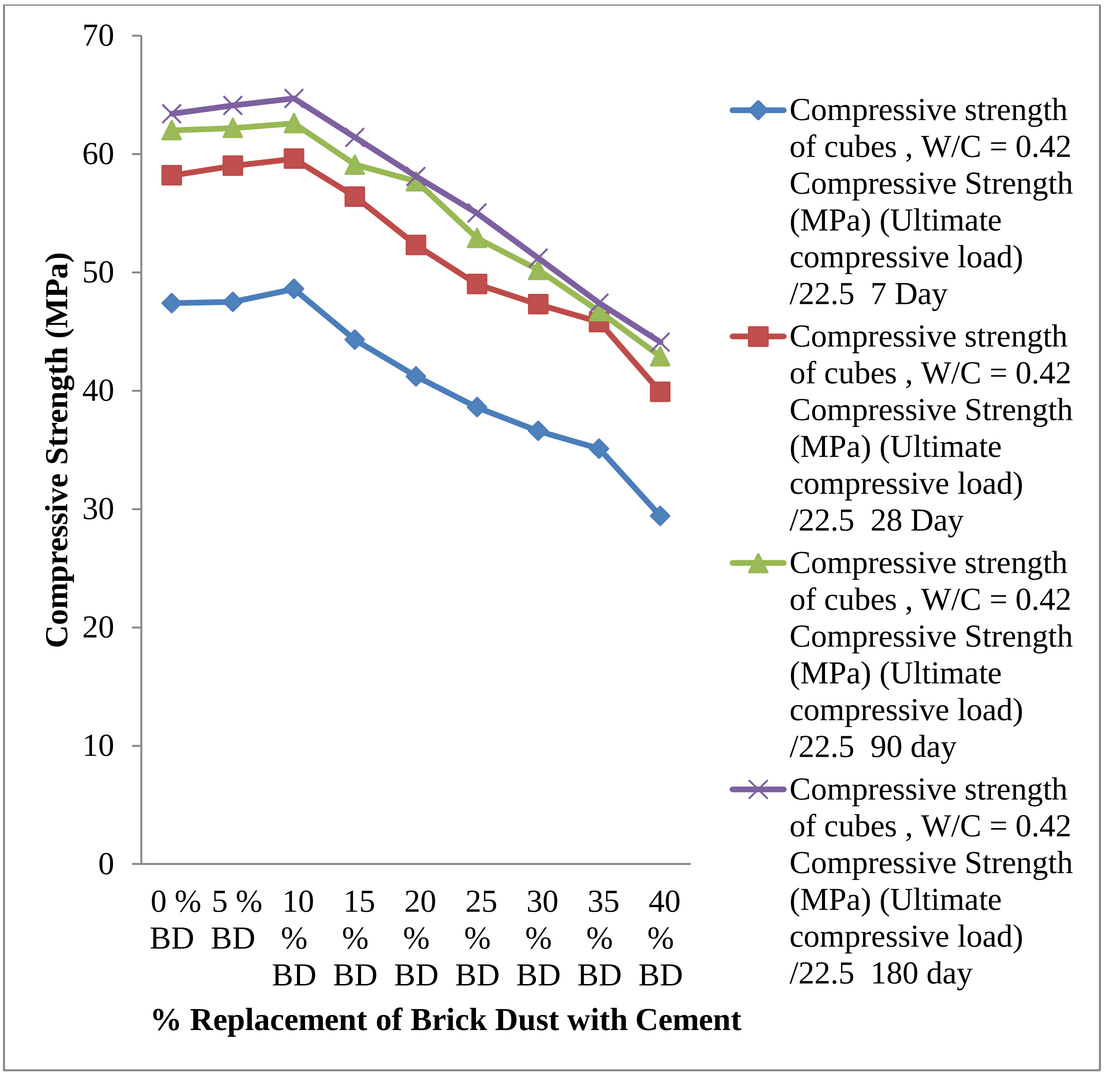

Fig -5.8 Change in compressive strength of M30 grade of concrete in different ages replacing cement with Brick Dust

Table 5.9 Effect of Rice Husk Ash on Compressive Strength of M30 Grade Concrete

Compressive strength of cubes , W/C = 0.38				
	Compressive Strength (MPa) (Ultimate compressive load) /22.5			
	7 Day	**28 Day**	**90 day**	**180 day**
0 % RHA	47.4	58.2	62	63.4
5 % RHA	48.1	58.9	62.56	64.36
10 % RHA	46.2	57.1	61.2	62.9
15 % RHA	43.9	54.4	57.6	59.1
20 % RHA	40.9	51.3	54.1	56.5
25 % RHA	35.9	46.6	49.3	51.2
30 % RHA	32.6	43.5	45.1	47.4
35 % RHA	30.2	40.1	42.8	44
40 % RHA	27.4	38.6	40.2	41.4

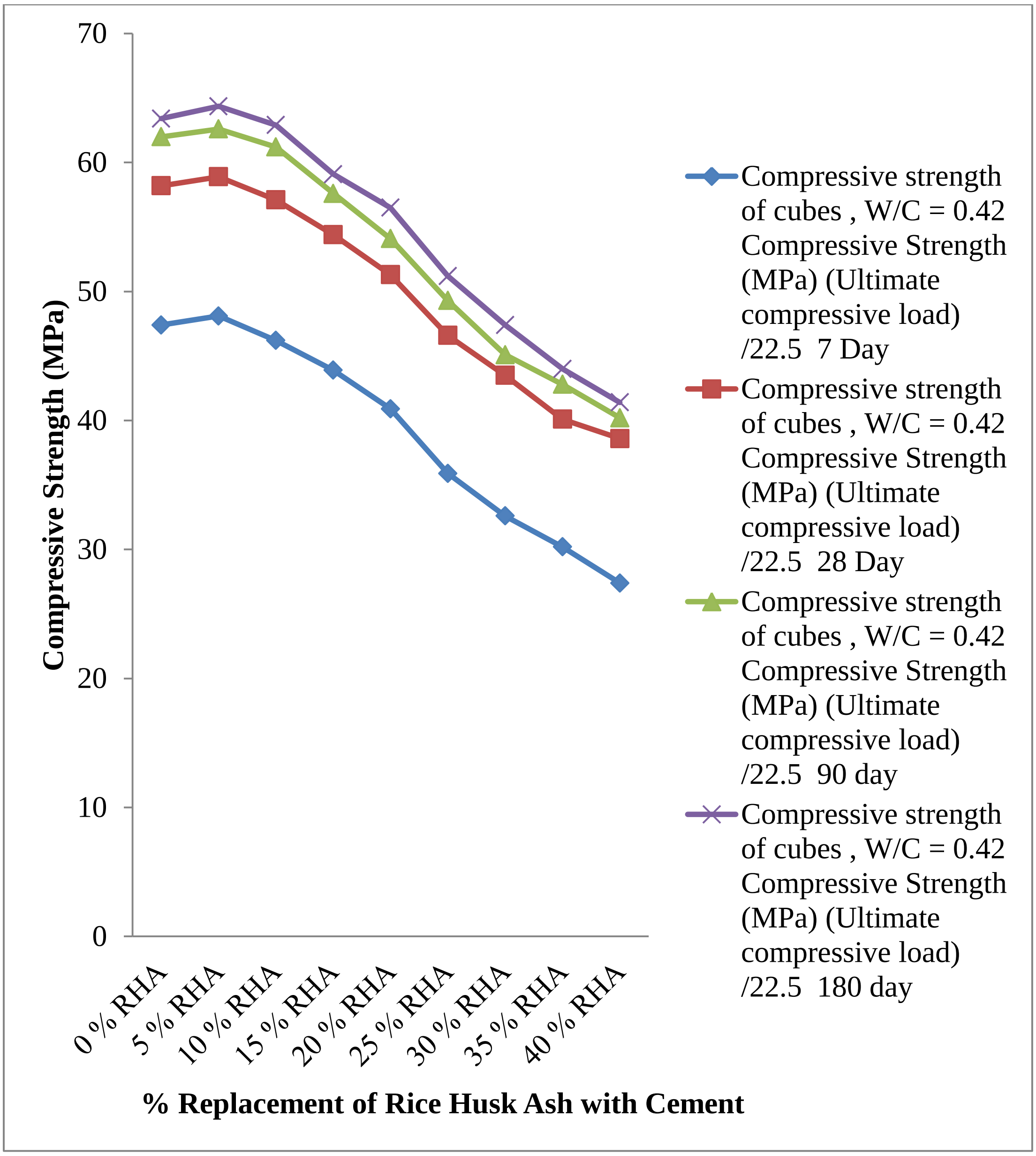

Fig -5.9 Change in compressive strength of M30 grade of concrete in different ages replacing cement with Rice Husk Ash

Table 5.10 Weight of M20 Grade Cubes Measured on 28th day

		Weight of Cubes Replaced by (In Kg)		
	% Replaced	**Brick Dust**	**Rice Husk Ash**	**Fly Ash**
M20	0	8.15	8.15	8.15
	5	8.19	8.11	8.19
	10	8.23	8.09	8.26
	15	8.34	8.04	8.31
	20	8.41	7.94	8.25
	25	8.46	7.82	8.16
	30	8.49	7.74	8.03
	35	8.50	7.67	7.97
	40	8.53	7.58	7.82

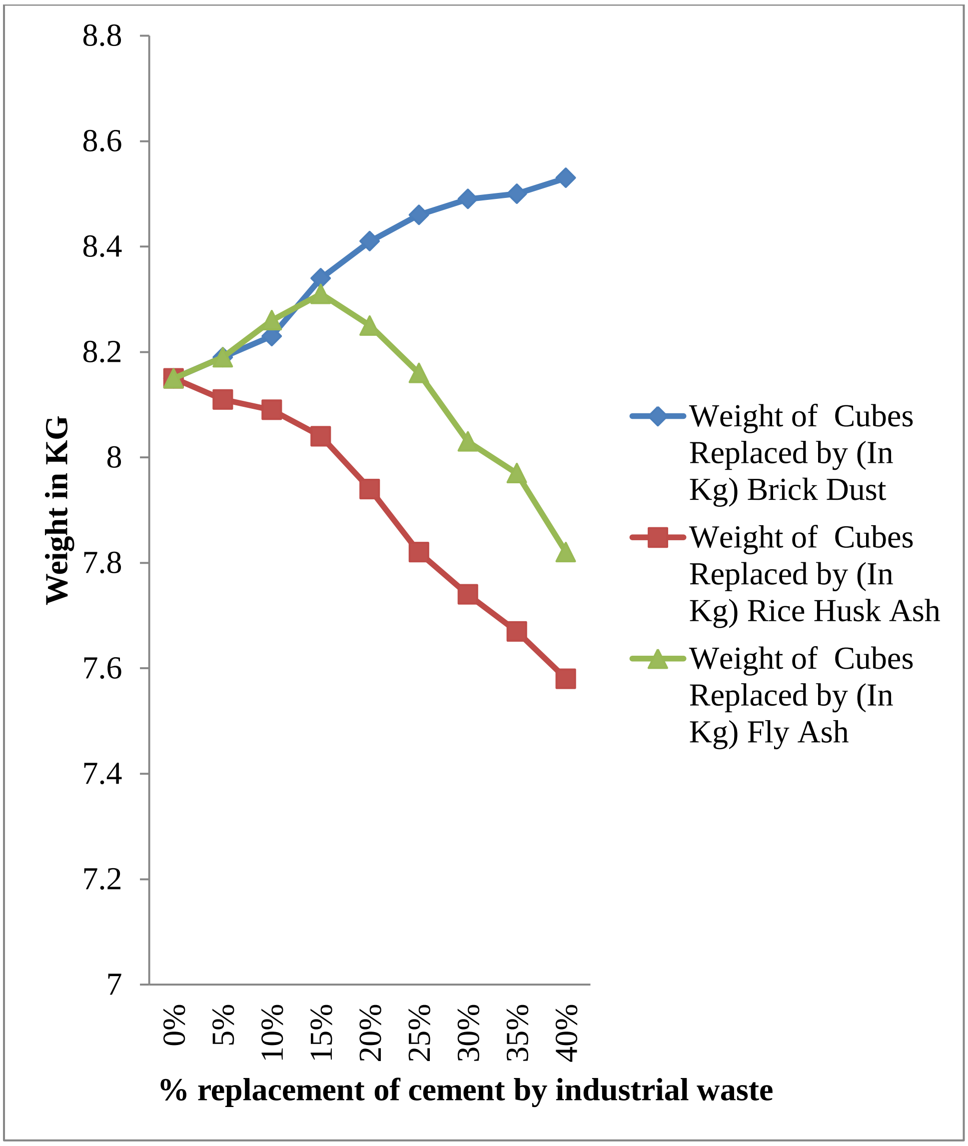

Fig -5.10 Change in Weight of M20 grade of concrete in 28days replacing cement with Fly Ash, Brick Dust and Rice Husk Ash

Table 5.11 Weight of M25 Grade Cubes Measured on 28th day

		Weight of Cubes Replaced by (In Kg)		
	% Replaced	**Brick Dust**	**Rice Husk Ash**	**Fly Ash**
M25	0	8.35	8.35	8.35
	5	8.38	8.255	8.39
	10	8.42	8.21	8.45
	15	8.43	8.16	8.47
	20	8.46	8.07	8.48
	25	8.48	7.94	8.36
	30	8.5	7.86	8.24
	35	8.52	7.79	8.18
	40	8.56	7.68	7.96

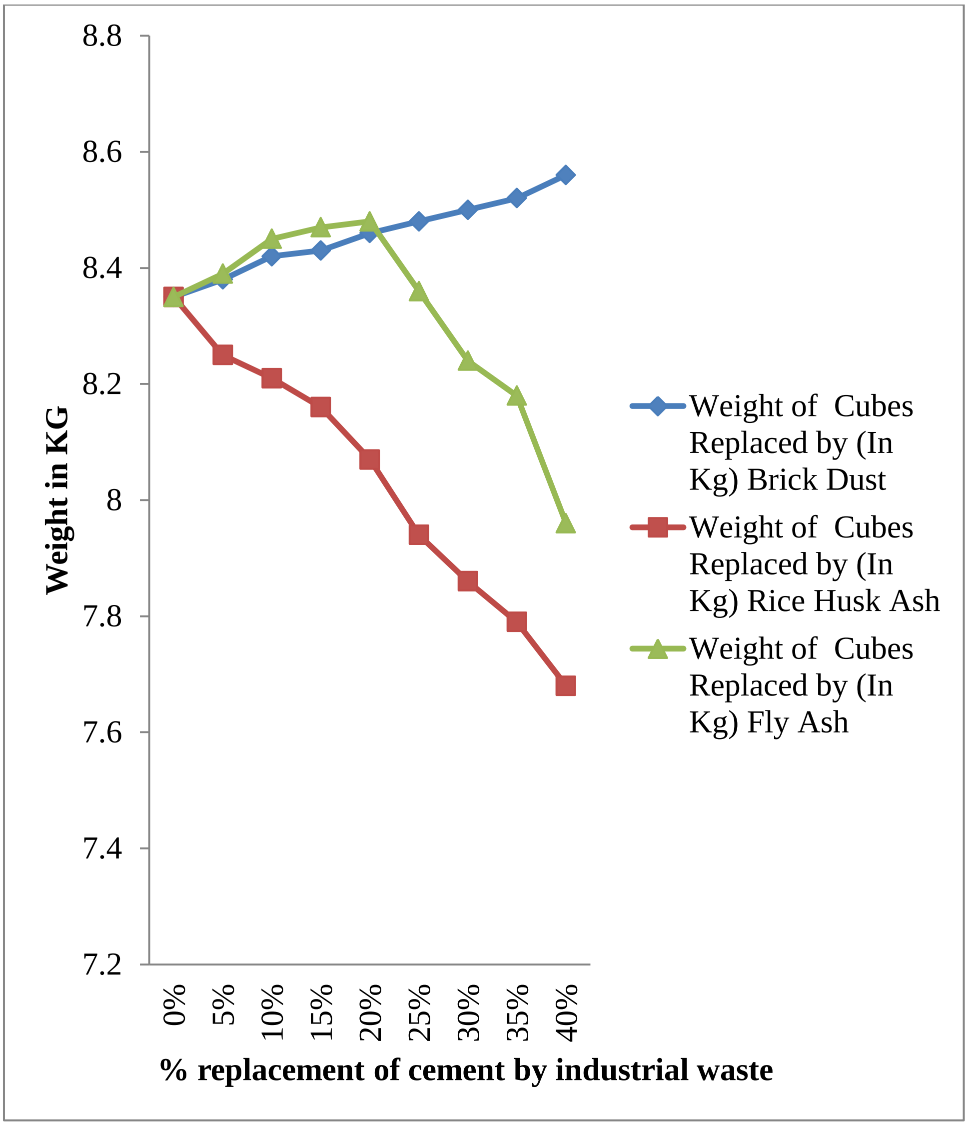

Fig -5.11 Change in Weight of M25 grade of concrete in 28days replacing cement with Fly Ash, Brick Dust and Rice Husk Ash

Table 5.12 Weight of M30 Grade Cubes Measured on 28th day

		Weight of Cubes Replaced by (In Kg)		
	% Replaced	**Brick Dust**	**Rice Husk Ash**	**Fly Ash**
M30	0	8.45	8.45	8.45
	5	8.48	8.42	8.49
	10	8.51	8.36	8.51
	15	8.53	8.26	8.47
	20	8.59	8.11	8.42
	25	8.6	7.98	8.40
	30	8.64	7.91	8.34
	35	8.70	7.84	8.25
	40	8.83	7.72	8.11

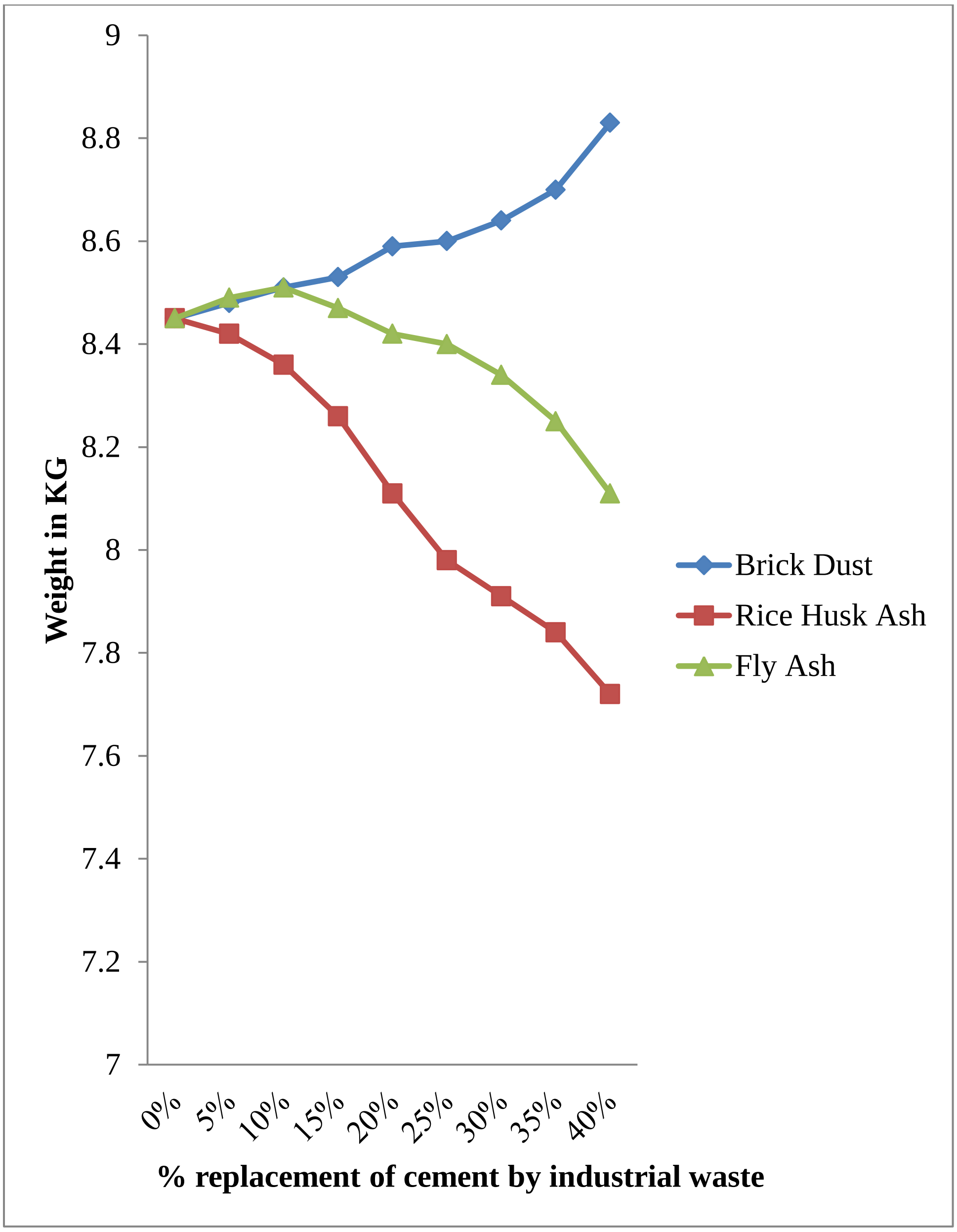

Fig -5.12 Change in Weight of M30 grade of concrete in 28days replacing cement with Fly Ash, Brick Dust and Rice Husk Ash

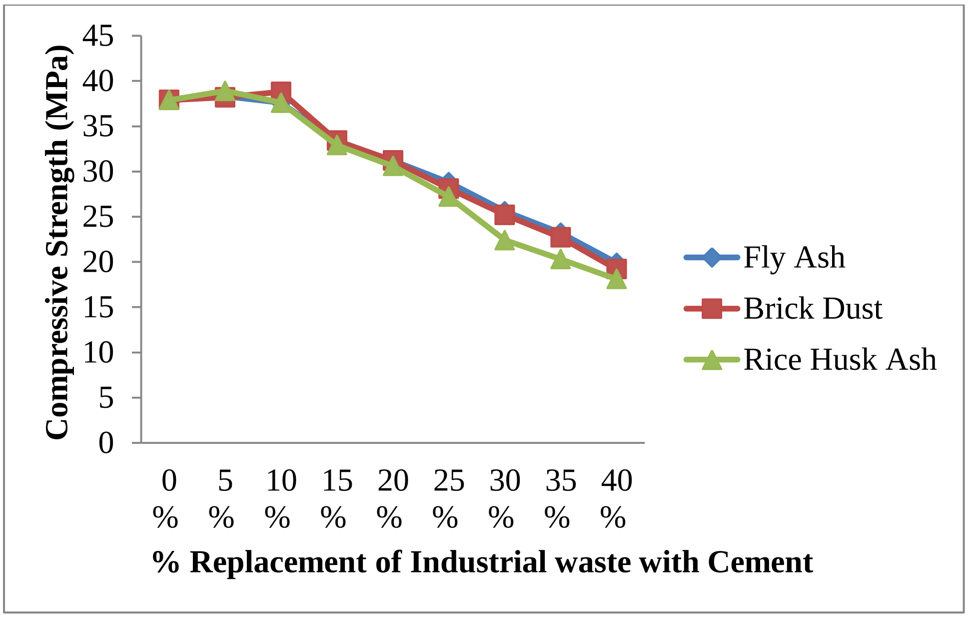

Fig -5.13 Comparison of compressive strength for M20 grade concrete at 7th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

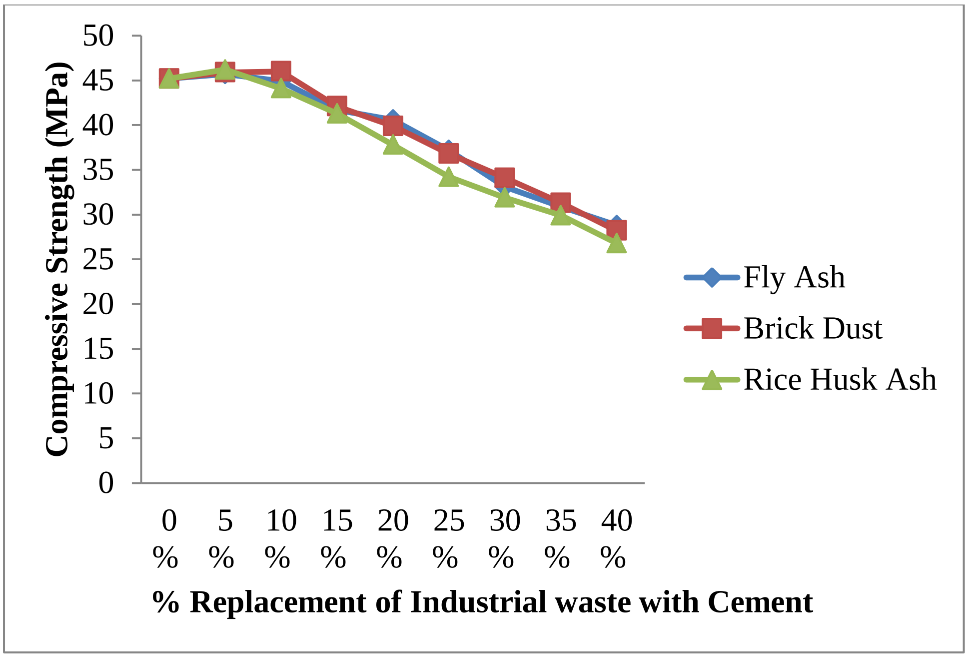

Fig -5.14 Comparison of compressive strength for M20 grade concrete at 28th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

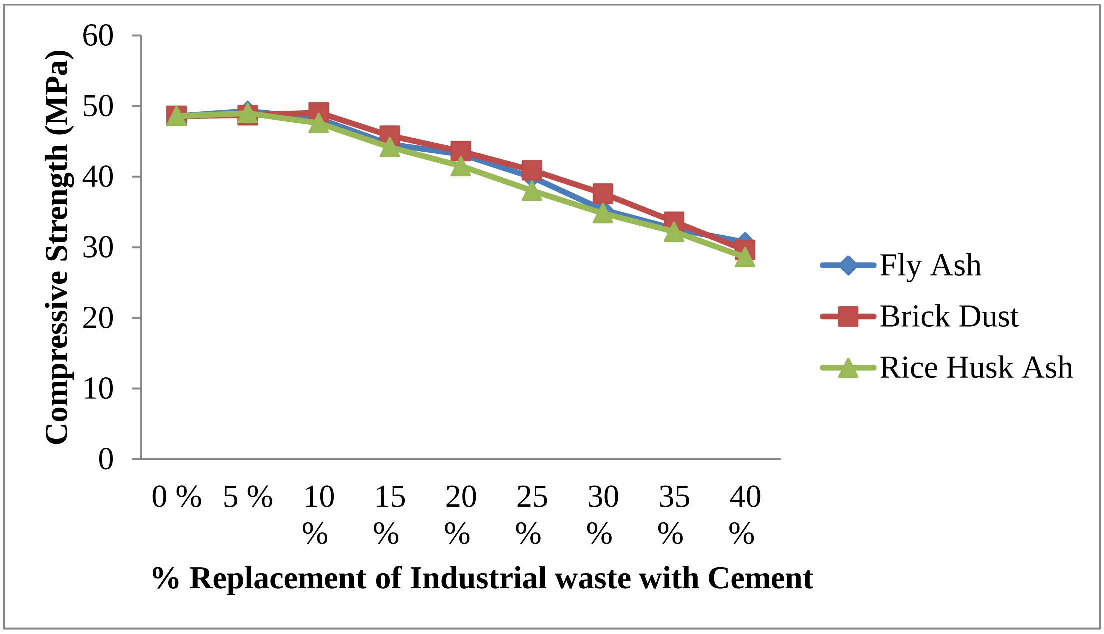

Fig -5.15 Comparison of compressive strength for M20 grade concrete at 90th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

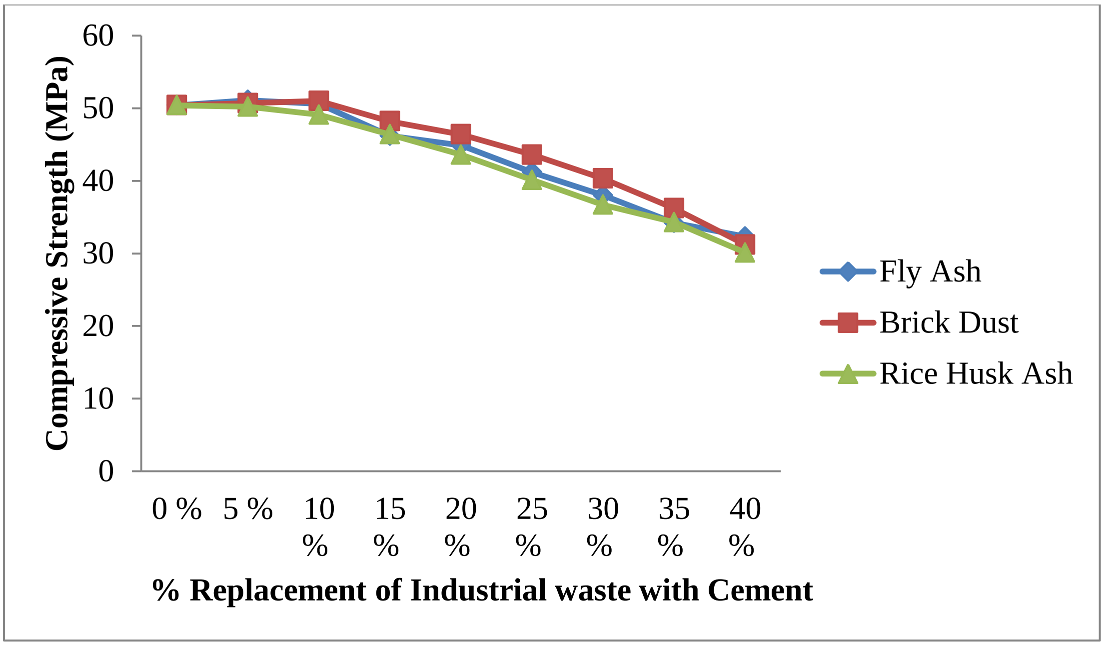

Fig -5.16 Comparison of compressive strength for M20 grade concrete at 180th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

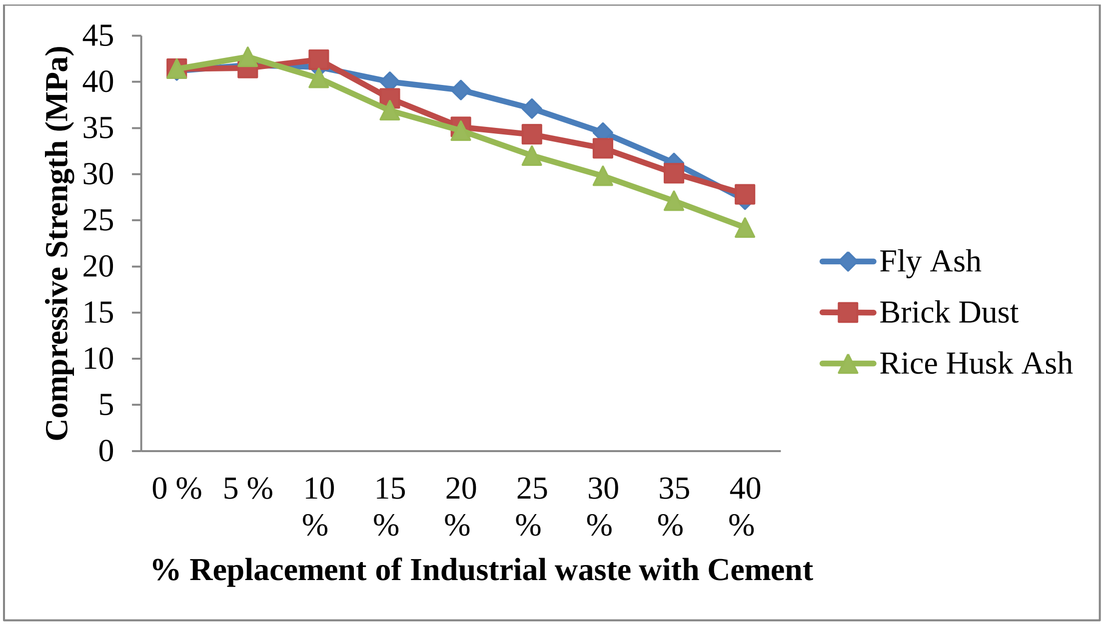

Fig -5.17 Comparison of compressive strength for M25 grade concrete at 7th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

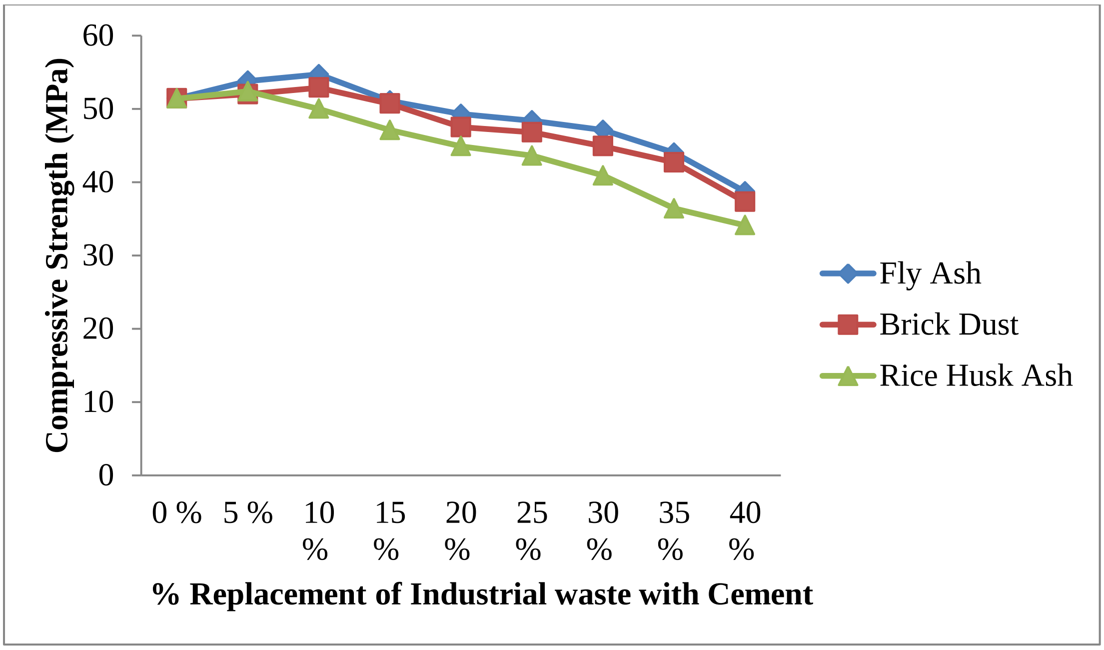

Fig -5.18 Comparison of compressive strength for M25 grade concrete at 28th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

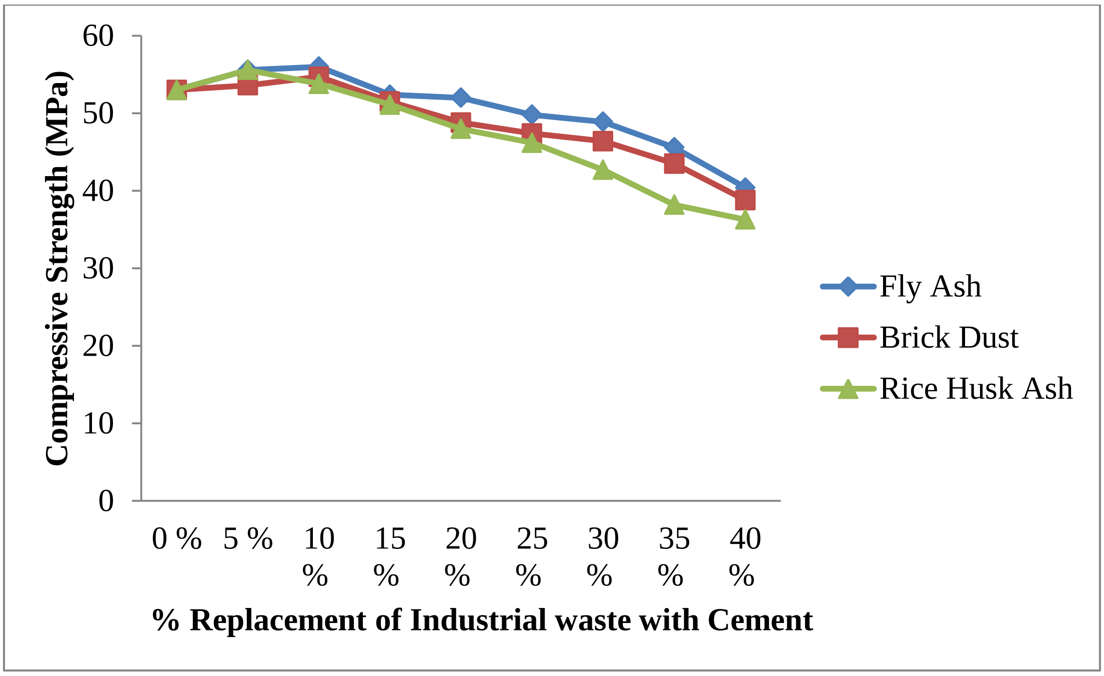

Fig -5.19 Comparison of compressive strength for M25 grade concrete at 90th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

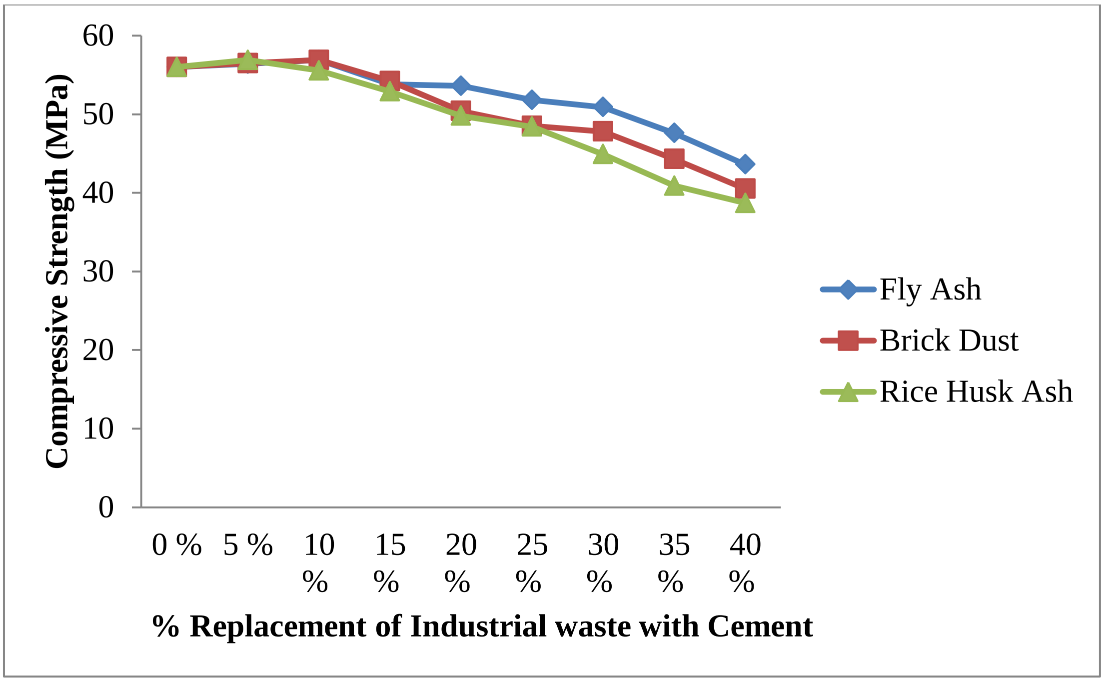

Fig -5.20 Comparison of compressive strength for M25 grade concrete at 180th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

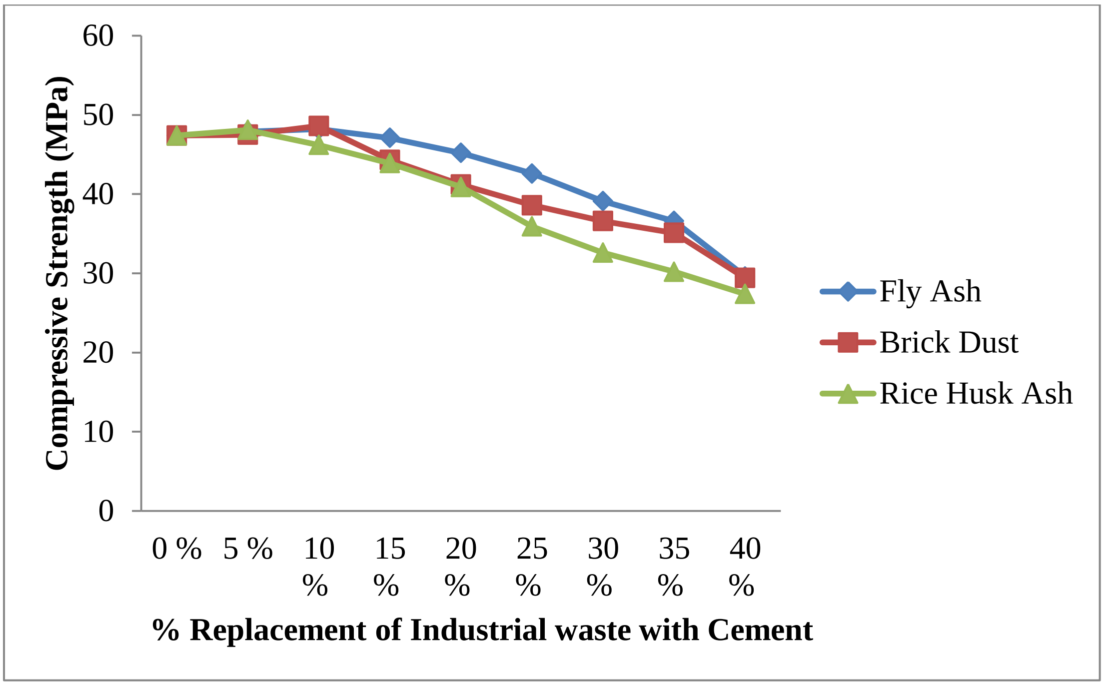

Fig -5.21 Comparison of compressive strength for M30 grade concrete at 7th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

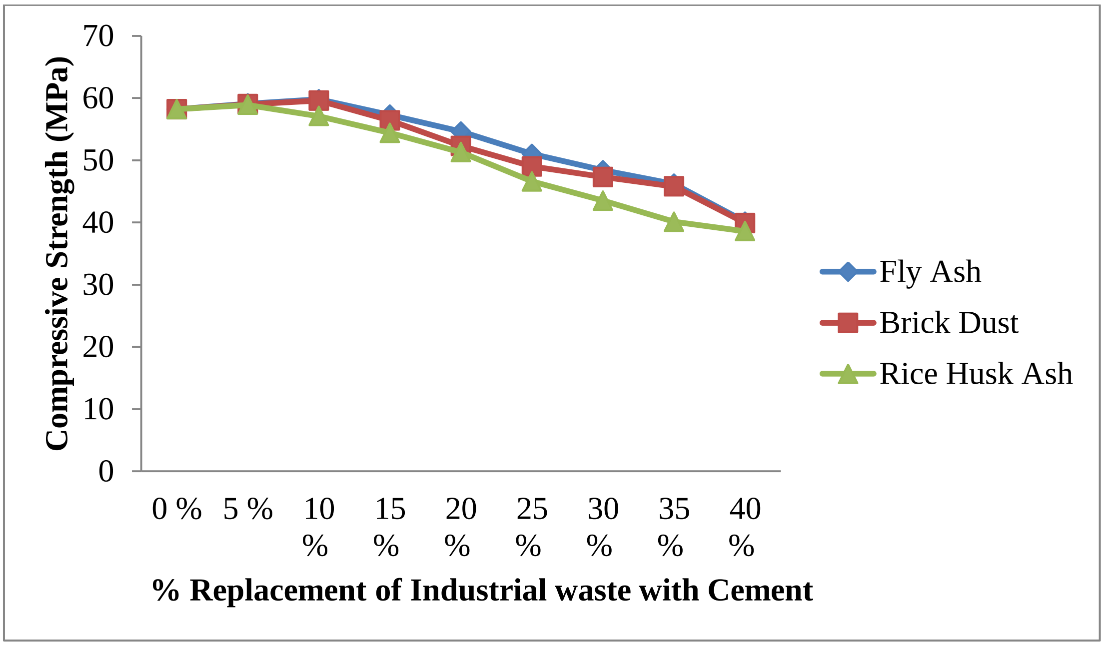

Fig -5.21 Comparison of compressive strength for M30 grade concrete at 28th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

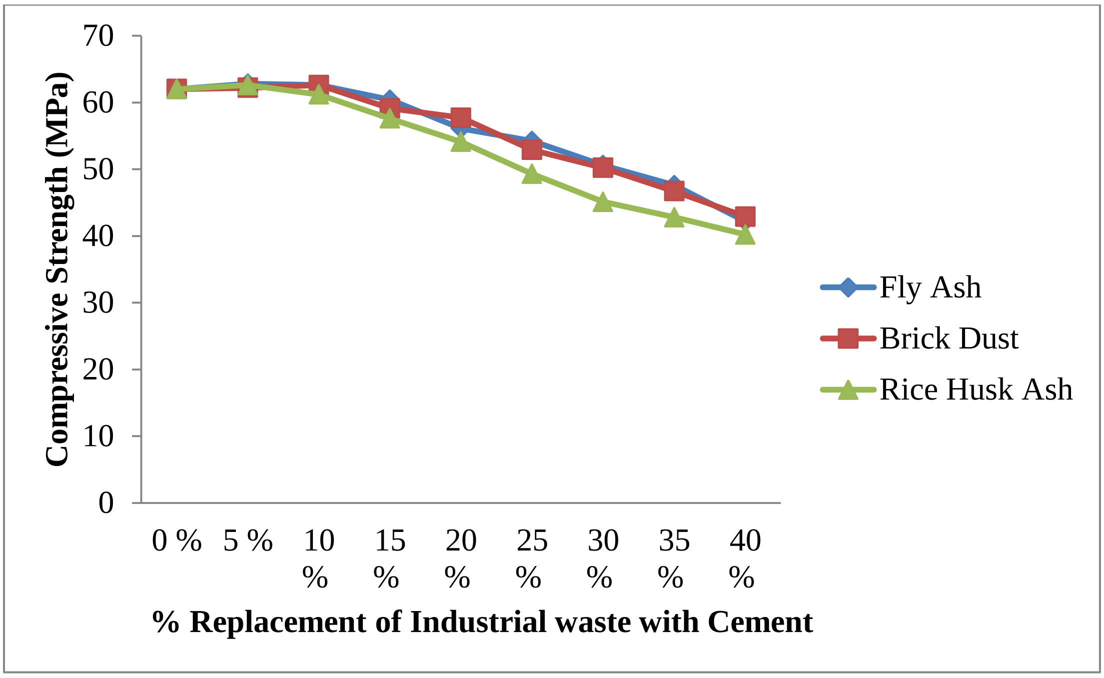

Fig -5.22 Comparison of compressive strength for M30 grade concrete at 90th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

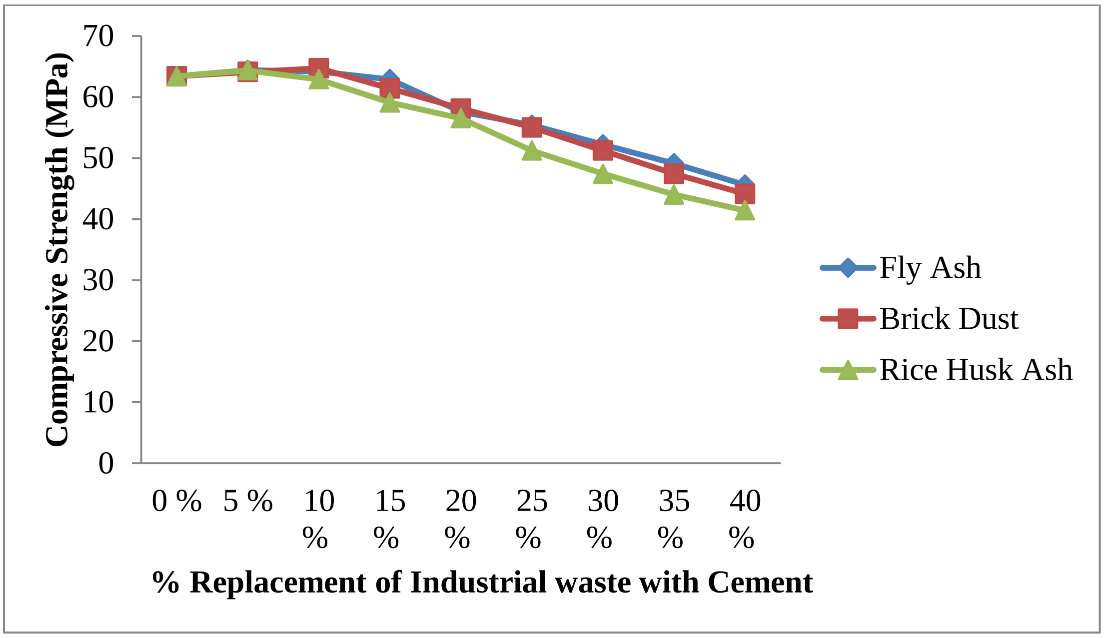

Fig -5.23 Comparison of compressive strength for M30 grade concrete at 180th day by replacing cement by Fly Ash, Brick Dust and Rice Husk Ash

5.2 Discussion

Field and laboratory test were conducted on concrete cubes replacing ordinary Portland cement of grade 43 in mix design of M20, M25 and M30 with varying amounts of Fly Ash, Brick Dust and Rice Husk Ash to determine the strength charecteristics of these cementious materials. The concrete cubes were made in L&T laboratory following the Indian standard specifications and were tested in compression testing machine and weighting scale. The following conclusion are reached:

5.2.1 Viability of using Fly Ash Concrete, Brick Dust Concrete and Rice Husk Ash concrete as a structural material

According to previous studies conducted in the replacement of cement with Fly Ash, Brick Dust and Rice Husk Ash the following conclusion was investigated:-

In case of Fly Ash concrete work done by Shantmuti Upadhyaya(2014) investigated that it is possible to replace Fly Ash upto 30% where 10% is the optimum replacement.Agarwal(2012) investigated the impact on the strength of concrete using different grades of cement and replacing cement by Fly Ash upto 40%. In this experimental programme different grades of concrete were taken and cement was replaced by Fly Ash upto 40% and the strength was measured upto 180 days

In case of Brick dust concrete very less has been done till now, Kumavat and Sona wane(2013) investigated brick waste for the its use as a replacement of cement and sand mortar upto 40%. Heidari and Hasanpour(2013) used brick powder of Gachsaran company in concrete and investigated in different proportions upto 40%

replacement with cement, his findings confirmed use of brick powder to produce Pozzolanic concrete. In this experimental programme Brick Dust was taken from Lucknow and replaced with Cement upto 40% for different grades of concrete and the strength was measured upto 180 days.

In case of Rice Husk Ash Concrete work done by Kulkarni(2014) shows that Rice Husk Ash has Pozzolanic properties and was replaced upto 20% of cement.Ramasamy(2011) investigated the use of Rice Husk Ash upto 20% replacement of cement in two grades of concrete(M30 and M60) and strength was measured upto 90days. In this experimental Rice Husk Ash was taken from Lucknow Division and was replaced by cement upto 40% for different grades of concrete and the strength was measured upto 180days.

5.2.2 Replacement of cement with Fly Ash, Brick Dust and Rice Husk Ash:

1. **Fly Ash**

   The field test on fly ash showed that it is possible to use Fly Ash as a partial replacement upto 40% of cement to produce concrete that achieves desired strength for different grades of concrete(M20, M25, M30). Although compressive strength increased upto 5% replacement, then starts decresing after replacing cement more than 5% as compared to conventional concrete. The following trends were identified by replacing cement by Fly Ash.

i. **For M20** grade of concrete it was found that around 45-50% increase in strength from 7 days to 28 days, 7-8% increase in strength from 28 days to 90 days and around 6-7% increase in strength from 90days to 180 days.

ii. **For M25** grade of concrete it was found that around 40-45% increase in strength from 7 days to 28 days, 5-6% increase in strength from 28 days to 90 days and around 7-8% increase in strength from 90days to 180 days.

iii. **For M30** grade of concrete it was found that around 35-40% increase in strength from 7 days to 28 days, 5-6% increase in strength from 28 days to 90 days and around 7-8% increase in strength from 90days to 180 days.

2. Brick Dust

The field test on Brick Dust showed that it is possible to use Brick Dust as a partial replacement upto 40% of cement to produce concrete that achieves desired strength for different grades of concrete(M20, M25, M30). Although compressive strength increased upto 10% replacement, then starts decresing gradually after replacing cement more than 10% as compared to conventional concrete. The following trends were identified by replacing cement by Brick Dust.

i. **For M20** grade of concrete it was found that around 45-50% increase in strength from 7 days to 28 days, 5-6% increase in strength from 28 days to 90 days and around 4-6% increase in strength from 90days to 180 days

ii. **For M25** grade of concrete it was found that around 35-40% increase in strength from 7 days to 28 days, 4-5% increase in strength from 28 days to 90 days and around 4-5% increase in strength from 90days to 180 days

iii. **For M30** grade of concrete it was found that around 35-40% increase in strength from 7 days to 28 days, 6-8% increase in strength from 28 days to 90 days and around 3-5% increase in strength from 90days to 180 days.

3. **Rice Husk Ash**

The field test on Rice Husk Ash showed that it is possible to use Rice Husk Ash as a partial replacement upto 40% of cement to produce concrete that achieves desired strength for different grades of concrete(M20, M25, M30). Although compressive strength increased upto 5% replacement, then starts decreasing gradually after replacing cement more than 10% as compared to conventional concrete. The following trends were identified by replacing cement by Rice Husk Ash.

i. **For M20** grade of concrete it was found that around 45-50% increase in strength from 7 days to 28 days, 6-8% increase in strength from 28 days to 90 days and around 5-7% increase in strength from 90days to 180 days

ii. **For M25** grade of concrete it was found that around 40-45% increase in strength from 7 days to 28 days, 6-7% increase in strength from 28 days to 90 days and around 6-7% increase in strength from 90days to 180 days

iii. **For M30** grade of concrete it was found that around 40-45% increase in strength from 7 days to 28 days, 4-6% increase in strength from 28 days to 90 days and around 3-4% increase in strength from 90days to 180 days.

5.2.3 Effect of Industrial Wastes on The Weight of Concrete

i. **Fly Ash:** In Fly Ash concrete their was increase in the weight of the concrete upto 15% replacement of cement with Fly Ash, then their was a gradual reduction in the mass of the Fly Ash concrete after 15% replacement of cement. At 40% replacement of cement with Fly Ash mass reduced upto 4%.

ii. **Brick Dust :** In Brick Dust concrete their was increase in the weight of the concrete continuously and at 40 % replacement of cement with Brick Dust mass increased upto 4.6%.

iii. **Rice Husk Ash:** In Rice Husk Ash concrete their was decrease in the weight of the concrete continuously and at 40 % replacement of cement with Rice Husk Ash mass decreased upto 7%.

5.2.4 Economic Analysis

i. The cost of Ordinary Portland Cement in Lucknow is about Rs320/50kg bag. The cost of cement per meter cube is around Rs 2700 for M20 grade, Rs 3000 for M25 grade and Rs3300 for M30 grade of concrete.

ii. The cost of Fly Ash is Rs 1/ kg in Lucknow, Rice Husk Ash and Brick Dust will be around 30paisa/ kg as Rice Husk Ash and Brick Dust is locally available material the transportation cost wil reduce.

iii. Based on the result of the present study a 40% replacement of Fly Ash, Rice Husk Ash and Brick Dust is possible in concrete to achieve desired strength.With this level of substitution the price of Fly Ash concrete wil reduce upto 33% and upto 40% in case of Brick Dust concrete and Rice Husk concrete.

CHAPTER-6

CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The results shows that it is possible to achieve desired strength in concrete by replacing cement upto 40% by Fly Ash, Brick Dust and Rice Husk Ash. The conclusion is as follows:

i. Fly Ash and Brick Dust concrete shows more strength as compare to Rice Husk Ash concrete.

ii. Rice Husk Ash makes concrete light in weight as compared to Fly Ash and Brick Dust concrete.So it will be helpful in reducing dead load of the construction.

iii. Brick Dust makes concrete heavier so it will be helpful in using it in foundation work and making earthen dams etc where heavy weight is essential for the structure.

iv. There is 33-40% reduction in cost of concrete by using these industrial wastes(FA, RHA and BD).

v. There is 7% reduction in the cost of concrete when using Rice Husk Ash and Brick Dust in Lucknow Region as compared to Fly Ash concrete.

6.2 Future Scope

i. More field test can be conducted od using appropriate technology to grind Rice Husk Ash and Brick Dust to make concrete.

ii. The variation in Rice Husk Ash combustion process currently employed can be investigated to determine the best source of Rice Husk Ash for the use in concrete.

iii. Effect on different curing periods on concrete.

iv. Effect on the strength of concrete by using different water cement ratio for the design mix concrete.

v. For use of Brick Dust Concrete and Rice Husk Ash Concrete as a structural material, it is necessary to investigate the behavior of reinforced Brick Dust Concrete and Rice Husk Ash concrete under flexure , shear, torsion and compression.

vi. The logistics of implementing the use of Fly Ash, Rice Husk Ash and Brick Dust concrete in developing country construction should also be investigated to ensure that this low cost construction material is helping the people who need it most.

CHAPTER 7

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CHAPTER 8

APPENDICES

Appendix –I Photographs and Calibration Certificates

Fig: I.1 Work in Progress

Fig: I.2 Cubes after 28 days of curing

Fig: I.3 Curing of cubes in progress

Fig: I.4 Work in Progress(Lubrication of cube moulds)

Fig: I.5 Ready Mix Plant in L&T Site

Fig: I.6 Lab Setup in L&T Site

Fig:I.7 Work in Progress in Concrete Lab

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CALIBRATION CERTIFICATE

Format No.5.10F-01, Issue No. 3 Dated : 01.01.2006

Certificate No. : JTH/ME/06/2013/188517

Customer's Name Address :

L & T Constrction ,Sargam Housing Project
Jankipuram,Kursi Road,Near Jenisis Club
Lucknow (U P)

me of Machine : COMPRESSION TESTING MACHINE

Date of calibration:- 17/06/2013
Calibration Due on:- 16/06/2014
Seriel No : 3385
Mark No. CTM - 01
Lab Code : ---
Make ASEW
Modal no : 09-10
Range : 2000KN/10KN
Temp. 30°c

Scale Range 0 TO 2000KN Res. In Kn 10

Details of Force Measuring Instrument used :

Capicity	Sr. No.	Cert. No	Cal. Valid upto:-
1000kN	07166.1000kN.	12070559/D5.05/C-393	25/11/2014
2000kN	PR.2000kN.0193	C-11377	05/05/2014

Indicated Force F_N kN	Std. reading At 23°C Fi	Standard reading At 30°C Fi	Position 0°	Obs. Reading of Force Prooving Ins. After Converting in kN: Position 0° (kN) F1	Position 120°	Position 120° (kN) F2	Position 240°	Position 240°(kN) F3	Mean $\bar{F}$ (kN)	Relative Acc. Error (%) (Fi - F)/F*100	Relative Rep. (%) $(F_{max} - F_{min})*100 / F$	Relative resolution	uncertainty (±)% at k=2
200	217.2	217.6	220	202	217	199	215	198	200	0.13	2.30	5.0	3.2
400	433.2	434.0	434	400	432	398	435	401	400	0.08	0.69	2.5	1.5
600	651.2	652.4	652	600	654	601	656	603	606	-0.99	0.61	1.7	1.2
800	871.5	873.1	872	799	874	801	879	805	802	-0.21	0.80	1.3	0.9
1000	1092.3	1094.4	1095	1001	1098	1003	1098	1003	1002	-0.20	0.27	1.0	0.6
1200	496.2	497.1	500	1207	498	1202	499	1204	1204	-0.37	0.40	0.8	0.6
1400	577.2	578.3	581	1407	580	1404	581	1407	1404	-0.28	0.17	0.7	0.5
600	659.8	661.0	662	1602	664	1607	664	1607	1606	-0.34	0.30	0.6	0.4
1800	743.8	745.2	747	1804	748	1807	748	1807	1812	-0.66	0.13	0.6	0.5
2000	827.2	828.8	831	2005	832	2008	832	2008	1996	0.20	0.12	0.5	0.3
observed Reading on Removal of F.(f			0.0	0.0	0.0	0.0	0.0	0.0					
Relative Zero Error%(fo) = fio/F_N *100				0.00									

Class of Machine 1

Expanded Uncertainty including relative accuracy error (±) % = 3.4

(Value of effective degree of freedom which is ∞ at confidence level 95%, So the value of Coverage factor is 1.96, i.e. 2),

Note:

1. This machine has been verified and the results have been found within permissible limits as per Indian Standard IS-1828(Part-I) :2005, Identical with ISO 7500-1: 1999
2. Results relate only to the items calibrated.
3. Certificates shall not be Reproduced Except in full, without the written approval of M/s JYOTI TEST HOUSE
4. Results Reported are Valid at the time of and under the stated conditions of measurement.

Calibrated By:

T. R. NAGAR
Chief Executive Officer
Issued by :

Page 1 of 1

Fig: I.8 Calibration Certificate of CTM for year 2013-2014

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Mob.: 09314501796, 9414011796
E-mail : brijesh_singh16@yahoo.com, visit us : www.excellentservices.co.in

Cert. No. C-0577
C-0703, C-0803

CALIBRATION CERTIFICATE

Date Of Request; **15/06/2014** Calibration Date; **17/06/2014** Certificate No. ; **1406F378**

Room Temp. ;**29.1-29.5 °C** Recommended Due Date; **16/06/2015** Page **1 OF 2**

Name And Address Of Customer:	Instrument Details
L&T CONSTRUCTION (SARGAM HOUSING PROJECT) JANKIPURAM, KURSHI ROAD, NEAR JENISIS CLUB, LUCKNOW- 226021 (U.P.)	Instrument : **Dig. Compression Testing M/c** Machine Model : 09-10 Machine Sr. No. /ID No. : 3385 Make : Associated Scientific (ASEW) Calibration Parameter : **Compression**

Details of Standard Equipment Used

Nomenclature	Sr. No.	Capacity	Certificate No	Valid Upto	Traceability
ThermoHygro Meter	61093241	-10 to 60 °C	5013833	03/10/2014	Belz Calibration Lab
Proving Ring	10288.2000kN	2000.00 kN	12090800/D5.05/C-513	22/01/2015	N.P.L. New Delhi

Scale / Range: 0-2000kN

Load in kN	Observation (Division/counts) Position 0 F1	Position 120 F2	Position 240 F3	Mean $\bar{F}$	%Relative Uncertainty (±)	%Relative Error (a)	%Relative Repeatability (b)
200	72.2	72.1	72.5	72.3	0.56	0.22	0.55
400	146.0	145.3	146.0	145.8	0.55	0.26	0.48
600	222.8	222.0	222.5	222.4	0.55	0.34	0.36
800	294.7	294.9	295.6	295.1	0.61	0.42	0.31
1000	368.5	367.5	367.9	368.0	0.65	0.48	0.27
1200	440.1	439.8	440.6	440.2	0.62	0.50	0.18
1400	512.7	512.5	512.5	512.6	0.64	0.57	0.04
1600	584.8	585.3	585.8	585.3	0.77	0.65	0.17
1800	658.5	658.8	658.3	658.5	0.86	0.77	0.08
2000	72.2	72.1	72.5	72.3	0.56	0.22	0.55

This Machine Has Been Classified As Class: I Expanded Uncertainty=±0.86%

Format No. ; SE/5.10/F 3 Rev. 00

Engineer- Calibration
Abhishek Singh

EXCELLENT SERVICES JAIPUR

Authorized Signature
Brijesh Kumar Singh
(Technical Manager)

Fig: I.9 Calibration Certificate of CTM for year 2013-2014(Part 1)

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Mob.: 09314501796, 9414011796
E-mail : brijesh_singh16@yahoo.com, visit us : www.excellentservices.co.in

Cert. No. C-0577
C-0703, C-0803

CALIBRATION CERTIFICATE

Date Of Request; **15/06/2014** Calibration Date; **17/06/2014** Certificate No. ; **1406F378**

Page **2 OF 2**

Scale / Range:

Load in kN	Observation (Divisions / Counts)			Mean $\bar{F}$	%Relative Uncertainty (±)	%Relative Error (a)	%Relative Repeatability (b)
	Position 0 F 1	Position120 F 2	Position 240 F 3				

This Machine Has Been Classified As Class: Expanded Uncertainty=±

Scale / Range:

Load in kN	Observation (Divisions / Counts)			Mean $\bar{F}$	%Relative Uncertainty (±)	%Relative Error (a)	%Relative Repeatability (b)
	Position 0 F 1	Position120 F 2	Position 240 F 3				

This Machine Has Been Classified As Class: Expanded Uncertainty=±

Format No. ; SE/5.10/F 3 Rev. 00

REMARKS:

1- The reported uncertainty is at coverage factor k=2 which corresponds to a coverage probability of approximately 95% for a normal distribution , considering the relative error of different components such as zero , resolution, Repeatability , Relative accuracy, Reference standard.

2- This machine has been verified and the result have been found within the permissible limits as per IS-1828 (part-I) 2005

3- Result relate only to the items calibrated.

4- Methodology of Calibration: Calibration procedure No. SE/SOP/ 01 based IS 1828 (part –I) -2005.

5- Certificates shall not be reproduced except in full, without the written approval of M/s EXCELLENT SERVICES.

Format No. : SE/5.10/F3 Rev. 00

Engineer- Calibration

Abhishek Singh

EXCELLENT SERVICES JAIPUR

Authorized Signature

Brijesh Kumar Singh
(Technical Manager)

Fig: I.10 Calibration Certificate of CTM for year 2013-2014(Part 2)

JYOTI TEST HOUSE

NABL Accredited Lab.

Specialist in : Calibration, Repairing of Temp., Pressure, Electricals, Electronics, Mechanical Instruments & Ferrous / Non Ferrous Testing

OFFICE & LABORATORY : B-1/111, Sector-11, Faridabad- 121006

Ph. : 0129-4008795, 4172205-06, Telefax : 0129-4008795 Mob. : 9810260558

E-mail : jyotitest98@yahoo.com, jyotitest_house9810@yahoo.com, Website : www.jyotitesthouse.com

CALIBRATION CERTIFICATE

Format No.5.10F-01, Issue No. 3 Dated : 01.01.2006

Party Name :	L &T Constrction ,Sargam Housing	Certificate No. :	JTH/ME/06/2013/188512
Address :	Projects ,Jankipuram,Kursi Road,	Date of Calibration :	17/06/2013
	Near Jenisis Club Lucknow (U P)	Sugg. due Date for Calibration :	'16/06/2014
Name of Instrument :	WEIGHING BALANCE	Make :	CAS
Range :	0-20 Kg	Mark No.:	DWB-01
Least Count :	0.02 gm	Serial No:	070745320
Location :	---	Model No.:	SW-LR
Reference Standard :	---	Environmental Conditions :	
Equip.Used for Calibration :	Std. Weights	Temp. 20 ± 2°C & R. H. 50 ± 10%	

S.N.	Standard Value in Kg	Measured Value in Kg
1	0.100	0.100
2	0.200	0.200
3	0.500	0.500
4	1.000	1.000
5	2.000	2.000
6	5.000	5.000
7	10.000	10.000
8	20.000	20.000

CALIBRATING INSTRUMENT :

Std. Weights calibrated by **Weightronics Mass Calibration Lab., Bahadurgarh** through their Certificate No. **WMCL/M/2011-C/481** Dated 07.**09.2011**

Note:

1. The Calibration results relates only to the item Calibrated/Tested.
2. The report shall not be reproduced, except in full without the written approval of the laboratory.
3. The results reported in this certificate are valid at the time of and under the stated conditions of measurement for sample identified above.

JYOTI TEST HOUSE CALIBRATED Faridabad

Calibrated By:

T. R. NAGAR
Chief Executive Officer

Issued By:

page 1 of 1

Fig: I.11 Calibration Certificate of Weighing Balance for year 2013-2014