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 understood 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 In this study, cement has been replaced by fly ash accordingly in the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 way, 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 using 0, 20%, 40% and 60% cement replacement in the mixtures with different quantities of total 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) Investigated that the ordinary portland cement (OPC) is one of the main ingredients used for the production of concrete. Unfortunately, production of cement involves emission of large amount of carbon dioxide gas into atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable 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 alternative for cement should lead to global sustainable development and lowest possible environmental impact. Concrete property can be maintained with advance mineral admixtures such as fly ash as partial replacement of cement 0 to 30%. Compressive strength of concrete with different dosage of fly ash was studied as partial replacement of cement. From the experimental investigations, his findings were that, the optimum replacement of fly ash 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 (72°F (22 °C)). 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. Large scale 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 findings 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/mm2 at 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.