CHAPTER 2

REVIEW OF LITERATURE

2.1 GENERAL

Recycled material has been used for two decades in concrete manufacturing. It deserves serious attention. Disposal of wastes like fly ash, silica fume, rice husk ash, blast furnace slag, recycled concrete aggregate and foundry refuses becomes serious problems from environmental and economic considerations. Technologies, which can transform these wastes into value-added products are most welcome to make use of such materials as replacements for the conventional building materials. The transformation can achieve the twin objectives of waste disposal and natural resource conservation together. In this chapter, a review of the findings of the earlier research workers on the properties of above waste material application in concrete construction is provided. The influence of above material addition on the properties of concrete, namely workability, compressive strength, cost analysis has also been considered.

Concrete as a construction material has the largest production of all materials used in construction. Concrete required for extensive construction activity can always be made available, since the ingredients of concrete are materials of geological origin. Despite this fact, wide spectrums of waste materials are not normally accepted for production of concrete. From the viewpoint of maintaining the ecological balance, waste materials may have to be judiciously combined with other ingredients to produce concrete of
acceptable strength and durability. Such materials are broadly grouped as marginal materials. The specific reasons for this classification of wide spectrum of materials are non-compliance with standard specification, incomplete exploration, poor performance and lack of appropriate technology.

Satisfactory utilization of marginal materials depends on the following factors:

- Technical Feasibility,
- Durability of the processed concrete, and
- Economic feasibility

With the ongoing research efforts to develop appropriate technology and field trials to monitor the performance and assessment of economic feasibility, the usage of marginal materials would eventually increase. In this review, the earlier findings of marginal materials other than Ordinary Portland Cement (OPC), sand, coarse aggregate and their application are discussed.

### 2.2 APPLICATION OF QUARRY ROCK DUST IN CONCRETE CONSTRUCTION

In the production of concrete, granite stone and river sand are used as coarse and fine aggregate, respectively. Although these materials are usually available at some places, it is economical to substitute these materials by locally available ones. River sand, which is most commonly used as fine aggregate in the production of concrete and mortar, poses the problem of acute shortage in many areas. At the same time, increasing quantity of quarry rock dust as waste is available from crushers. The disposal of this dust creates
serious environmental problems. It is possible to use this quarry rock dust in making concrete by partial or full replacement based on availability of natural sand. This will not only minimize the cost of construction but will also solve the environmental problem of disposing the quarry rock dust.

Nagaraj and Zahida Banu (1996) have reported that due to its higher surface area quarry rock dust consumes more cement when it is compared with sand. Quarry rock dust and sand mixture reflect the same concrete strength in hardened state. Thus enhancing the utilization of quarry rock dust will be more effective.

Hudson (1997) has reported the acceptance of quarry rock dust with what high percentages of minus 75 micron (200 mesh) Materials (or “dust”) in quarry rock dust, along with the introduction of specifications to mix with concrete.

Babu et al (1997) have tested a series of three various fine aggregate substitutes like cherthala sand, quarry rock dust, and beach sand. From his study, the basic compressive stresses were arrived by prism tests, for a mortar proportion of 1:6. His results do not agree with code provision to some extent.

Narasimhan et al (1999) have reported that concrete mixtures could be designed by using quarry rock dust as fine aggregate, targeting the strengths above 5 MPa greater than specified characteristic strengths.

Nagaraj (2000) has stated that quarry rock dust can be advantageously used as fine aggregate in concrete mixtures with appropriate technology. There are three possibilities of ensuring the workability, namely
combination of quarry rock dust and natural sand use of different doses of superplasticizer and change in water content using Generalized Lyse’s role.

Sahu et al (2003) have found that there is a significant increase in compressive strength, modulus of rupture and split tensile strength for both the concrete mixtures when sand is partially replaced by quarry rock dust. The workability of the concrete mixtures decreased with an increase in percent of quarry rock dust as partial replacement of sand.

Nisnevich et al (2003) have reported that in lightweight concrete replacements of bottom ash with quarry rock dust close to 50 percent were achieved with increased strength and reduction in activity of concentrations of radio-nuclides.

Prakash Rao and Giridhar Kumar (2004) reviewed the concrete cubes/prisms with crusher dust concrete which indicates 17 percent higher strength in compression, 7 percent more in split tensile strength and 20 percent more flexural strength (Modules of rupture) than the concrete cubes / prisms with river sand as fine aggregates. The differences in strength are possible due to the sharp edges of stone dust providing stronger bond with cement compared to the rounded shape of river sand.

2.3 PHYSICAL CHARACTERISTICS OF QUARRY ROCK DUST

This section covers the important physical properties of quarry rock dust carried out by various researchers.
2.3.1 Absorption and Moisture State

Aggregates that are porous can absorb water. Absorption is thus governed by porosity. For the pores of an aggregate particle to fill with water, the pores must be interconnected and open the surface so that water from the exterior can penetrate the solid. Absorption is expressed as the ratio of the increase mass of an oven-dried sample after saturating the mass of the saturated-surface-dry.

Prakash Rao and Gridhar Kumar (2004) have reported that the quarry rock dust has the water absorption of 0.90 percent. Nisnevich et al (2003) have found that quarry rock dust has higher water absorption of 8.2% to 10.5%.

2.3.2 Void Content

Void content applies to an assemblage of particles, usually a collection of particle size of irregular shape. These particles do not fit together perfectly, leaving voids between them. The volume of these voids is extremely important in a concrete mixture because it has to be filled with cement paste or matrix.

Nisnevich et al (2003) have shown that quarry rock dust indicates high volume of voids: i.e., 42.4 to 50.0% (in standard natural sand it is varied in the range of 36-40%). The volume of voids is 6 to 8 % higher for quarry rock dust.
2.3.3  Particle Shape

Particle shape refers not only to the basic shape of aggregate particles, but also to other measures such as angularity, flakiness and so on. Particle shape can be classified by measuring the dimensions of particles, that is length, width and thickness.

Shetty (2002) has reported the methods of manufacturing and crushing technology of modern crushers. The modern crushers are specially designed for producing, cubical, smooth textured, well graded, good enough to replace natural sand. Nisnevich et al (2003) have stated that the shape of quarry rock dust is mainly angular or flat in shape.

2.3.4  Fineness Modulus (FM)

Grading refers to the particle size distribution and it is a characteristic of aggregate in their granular form. The grading of an aggregate is the quantitative distribution of its various particle sizes in terms of the proportions passing through sieves with square openings of different standard apertures (or sizes). Grading is determined by a sieve analysis on a sample of aggregate, in which a series of standard sieves are rested or stacked one on top of another with increasing aperture size from the bottom to top, and through which a sample of aggregate is passed from the top, usually aided by shaking or vibrating the sieves.

In their study on quarry rock dust Nagaraj and Zahida Banu (1996) have shown that Fineness Modulus (FM) has the value of 2.5. Babu et al (1997) found that the FM value of quarry rock dust has 2.08. Mattur C. Narasimhan et al (1999) found that the FM value of quarry rock dust has 2.80.
Nagaraj (2000) has reported that the FM value of quarry rock dust has 1.70. Sahu et al (2003) found that FM value of quarry rock dust is 2.70. Prakash Rao and Giridhar Kumar (2004) have found that the FM value of quarry rock dust is 2.71.

2.3.5 Specific Gravity

Specific gravity refers to the volume of the solid material. Therefore, it is defined the ratio of the mass of the solid, referred to vacuum, to the mass of an equal volume of gas-free distilled water, both taken at a stated temperature.

Nagaraj and Zohida Banu (1996) have found that the specific gravity of rock dust is 2.48. Babu et al (1997) found that specific gravity of quarry rock dust is 2.53. C. Narasiman et al (1999) have reported that the specific gravity of quarry rock dust is 2.75. Prakash Rao and Giridhar Kumar (2004) showed that the specific gravity value of quarry rock dust is 2.60. Nisnevich et al (2003) have recorded that quarry rock dust has the specific gravity value of 2.65.

2.3.6 Summary of Physical Characteristics

The review of the literature on physical characteristics such as porosity, volume of voids, absorption, moisture state, bulk relative density, void content, particle size, grading, fineness modulus and specific gravity shows that the characteristics influence the properties of concrete.

Most researchers have agreed that Fineness Modulus (FM) varies from 2.5 to 2.80. The fact is that it also gives good indication about sand fineness medium.
The specific gravity of a quarry rock dust seems to have no difference in quality in items of natural sand.

2.4 QUARRY ROCK DUST IN PLASTIC CONCRETE

2.4.1 Workability

Workability has been defined as the amount of useful internal work required to produce full compaction (Power 1968).

Nagarajan and Zahida Banu (1996) have reported that due to its higher surface area quarry rock dust consumes more cement when it is expected to satisfy the workability.

Narashimhan et al (1999) have concluded that higher superplasticizer dosages are required for mixes using quarry rock dust as compared to control concrete to attain the same degree of workability.

Nagaraj (2000) has observed that there are three possibilities of ensuring the workability, viz. combination of quarry rock dust and sand, usage of different doses of superplasticizer and change water content using generalized lyse rule.

Sahu et al (2003) have found that the workability of the concrete mixtures increased in percentage while stone dust is used as partial replacement of sand. The workability of concrete mixes increased in percentage when superplasticizer is added.
Various researchers have studied the workability characteristics of plastic concrete. They have agreed that the workability of fresh concrete reduces due to the incorporation of quarry rock dust as fine aggregate. Adding the superplasticizer can rectify this problem. Combining of quarry rock dust and natural sand also changes the workability.

2.5 QUARRY ROCK DUST IN HARDENED CONCRETE

As strength is a vital property of concrete, among others, many investigations have reported on the development of strength of concrete with quarry rock dust in various ages. It has clearly emerged from their findings that partial replacement of natural sand with quarry rock dust results in higher strength up to 10-15% higher than control concrete.

Nagaraj and Zahida Banu (1996) have studied the compressive strength in concrete containing quarry rock dust. It reflected the same concrete strength, in the concrete containing sand. Thus the utilization of quarry rock dust is enhanced.

According to Narasimhan et al (1999), the quarry rock dust mixtures have developed the strength of 82-88% of the compressive strength of conventional concrete.

Sahu et al (2003) have examined the significant increase in compressive strength, modulus of rapture and split tensile strength for both the concrete mixes when sand is partially replaced by stone dust.

Nisnevich et al (2003) have studied the strength increased by a factor of 2 or more (when the replacement of bottom ash with quarry rock dust is close to 50 percent).
Prakash Rao and Giridhar Kumar (2004) have explored quarry rock dust which has developed 17 percent of higher strength in compression, 7 percent more split tensile strength and 20 percent more flexural strength with the concrete cubes and prisms with quarry rock dust as fine aggregate.

2.6 APPLICATION OF OTHER FINE AGGREGATE SUBSTITUTE IN CONCRETE

Isa Yuksel et al (2006) analyzed the results of some experimental studies on the use of Non-Ground-Granulated Blast-Furnace Slag (NGGBFS) as fine aggregate in concrete. Two groups of concrete samples were produced. The NGGBFS/sand ratios were 0, 25, 50, 75 and 100%. The first group (C1) contains only 0 to 7 mm (0 to 0.276in) sand as fine aggregate. The second group (C2) contains two sub-types of fine aggregates that are 0 to 3 mm (0 to 0.118 in) and 0 to 7 mm (0 to 0.276 in) sands. NGGBFS replaces 0 to 7 mm (0 to 0.276 in) sand in both groups. Strength and durability characteristics of concrete were compared with respect to control samples and vice versa.

According to the results, if the NGGBFS/sand ratio is high in the C1 type, the concrete is porous and it has relatively low compressive strength. In the C2 type, however, concrete strength and durability characteristics were better than those in C1 type. It was concluded that the non-ground-granulated blast-furnace slag could be used as fine aggregate under some conditions.

Frank P. Nichols (1982) reviewed the results of an extensive laboratory study of the effects of variations in gradation and particle shape of manufactured fine aggregates, and of variations in coarse aggregate factor and coarse aggregate maximum size on properties of freshly mixed and hardened
air-entrained Portland cement concretes. Using a range of fixed cement contents, mixing water was varied as needed to produce within a narrow range above or below a single specified target value of 3 in (76.2 mm).

The complete study included 171 experimental mixtures made from a single source of cement, a single source of crushed stone coarse aggregates and six sources of fine aggregate. One fine aggregate was commercially processed natural sand; the other five were manufactured sands with various gradation and particle shapes from five sources of crushed stone. Particle shape ranged from 47 to 55 in terms of NCSA shape Index, a measure of percentage of voids in a loose condition. Gradation variables were particularly concerned with the amount of dust of fracture or "micro-sand" included in concrete. Results show that satisfactory air-entrained Portland cement concrete which can be produced in the normal strength range with fine aggregates containing considerably more "micro sand" passing the No.100 and 200 sieves than that have been commonly allowed in typical specifications. However, a statement now appears in ASTM Specification C 33 to the effect that fine aggregate failing to meet the normal sieve analysis and fineness modulus requirements may be accepted. Thus, the results of this study confirm the validity of the permissible deviations from the gradations normally specified, as now included in ASTM C 33.

Nuno Almeida et al (2007) have attempted to solve the problem of the waste generated by the natural stone industry; several technical solutions consider the incorporation of this type of waste in other industrial activities as a by-product. This works present an overview of current solutions and the results of a research project where natural stone slurry is used to replace fine aggregate in concrete mixtures. The concrete mechanical properties are presented and the technical viability of this new construction material is illustrated.
2.7 APPLICATION OF FLY ASH, SILICA FUME AND OTHER ASH IN CONCRETE

Ambarish Ghosh and Chillara Subbarao (2001) have described physicochemical and microstructure developments of a low-lime fly ash modified with 6% and 10% of lime and 1% of gypsum. The developments were studied through X-ray diffraction, differential thermal analysis, scanning electron micrograph, and energy-dispersive X-ray microanalysis tests to gain information on the fly ash-lime and fly ash-lime-gypsum interaction. Specimens were cured up to 10 months at 30 ± 1°C, which prevailed commonly in the Tropics. X-ray diffraction test results showed the appearance of new peaks, some of which are not so prominent, indicating that the new phases formed may be in small quantity or in an amorphous state. Scanning electron micrographs of specimens modified with both lime and gypsum showed evidence of the development of a compact matrix at 3 months’ curing and a densified compact network of pozzolanic reaction products of fly ash-lime-gypsum with the increase in curing period to 10 months. Further, this development was substantiated by improvement in strength, durability and reduction in permeability of the stabilized material. The modified fly ash with improved engineering characteristics has potential for applications in civil engineering construction.

Subramaniam et al (2005) have investigated the influence of ultrafine fly ash on the early age property development, shrinkage and shrinkage cracking of concrete. In addition, the performance of ultrafine fly ash replacing cement is compared with that of silica fume. The mechanisms responsible for an increase of the early age stress due to restrained shrinkage were assessed; free shrinkage and elastic modulus were measured from an early age. In addition, the material’s resistance to tensile fracture and increase in strength were also determined as a function of age. Results of the
experimental study indicate that the increase in elastic modulus and fracture resistance with age are comparable for the control, ultrafine fly ash, and silica fume concretes. Autogenous shrinkage is shown to play a significant role in determining the age of cracking in restrained shrinkage tests. A significant reduction in the autogenous shrinkage and increase in the age of restrained shrinkage cracking were observed in the ultrafine fly ash concrete when compared to the control and the silica fume concrete. Increasing the volume of ultrafine fly ash and decreasing the ratio of water-to-cementations materials resulted in further increase in the age of restrained shrinkage cracking and a significant increase in the compressive strength.

Cengiz Duran Atis (2003) described a laboratory investigation carried out to evaluate the strength and particularly the shrinkage properties of concrete containing high volumes of fly ash. The concrete mixtures made with 50 and 70% replacement (by mass) of Ordinary Portland Cement (OPC) with fly ash were prepared. Water-cementations material ratios were ranged from 0.28 to 0.34. Some concrete mixtures also made with super plasticizer. The strength and shrinkage properties of the concrete mixtures cured at 20°C temperature with 65% relative humidity are reported. The laboratory test results show that High-Volume Fly Ash (HVFA) concrete attained satisfactory compressive and tensile strength at 1 day of age. It also showed that 50% replacement HVFA concrete developed higher strength than OPC concrete at 28 days and beyond. The inclusion of high volumes of fly ash in concrete with a low water-cementitious material ratio resulted in a reduction in the shrinkage values of up to 30% when compared to OPC concrete. The concrete mixtures made with super plasticizer showed higher shrinkage values of up to 50% when compared to the concrete made with no super plasticizer.
Rebeiz et al (2005) have studied the use of fly ash as a replacement for sand in Polymer Concrete (PC). It is shown that a replacement of 15% by weight of sand with fly ash improves the compressive strength of unreinforced PC cylinders by about 30% and the flexural strength of steel-reinforced PC beams by about 15%. Other improvements in properties are relatively minor and include the tensile bond strength of PC under thermal cycling and the creep compliance of the PC under sustained loading. The replacement of sand with fly ash, however, does not seem to have an impact on the shear strength of PC. Potential applications of PC using fly ash are numerous, including thin overlays on bridges and floors, repairing concrete bridges and pavements, the production of precast components such as wall panels, floor blocks and underground vaults.

Potha Raju et al (2004) have described concrete elements exposed to fire, which undergo temperature gradients. As a result, the surface layers spall, exposing steel reinforcement. Relatively a some studies have been undertaken on heat-induced changes in fly ash concrete. The structural property of concrete has been studied most widely as a function of heat exposure of compressive strength. Less attention has been given to flexural strength as influenced by heat exposure. Therefore, to investigate the effect of temperature on the flexural strength of fly ash concrete this research was carried out with M28, M33 and M35 grades of concrete. Concrete specimens 100 mm x 100 mm x 500 mm with partial replacement of cement by fly ash (10%, 20% and 30% replacement levels) were heated to 100\(^\circ\)C, 200\(^\circ\)C and 250\(^\circ\)C for 1 h, 2 h and 3 h duration in an electric oven. The specimens were tested for flexural strength in the hot condition immediately after removing from the oven. The fly ash concrete showed consistently the same pattern of behavior as that of concrete without fly ash under elevated temperatures during flexure. The fly ash concrete with fly ash content up to 20% showed
improved performance compared with the specimens without fly ash by retaining a greater amount of its strength.

Barger et al (2001) have described the goal of producing concrete that provides long-term durability with regard to properties such as improved sulphate resistance and reduced susceptibility to Alkali-Silica Reactions (ASR). The reactions have led to the development of several high-performance materials. While the use of fly ashes and Ground Granulated Blast-Furnace Slag (GGBFS) in concrete is gaining acceptance in various applications, the mineralogical composition of such by-product materials cannot be as easily controlled as a manufacturing pozzolan. Since 1993 Ash Grove has developed and directed the manufacture of pozzolans to improve concrete durability, while avoiding the potential problems of byproduct pozzolan availability and uniformity. Thermally treating and converting crystalline clay materials to amorphous alumino silicates accomplish processing of these performance-enhancing pozzolans. These pozzolans can be inter locked with Portland cement clinker and gypsum to produce a Type IP blended cement or they can be ground separately as mineral admixtures for concrete. These two products are produced under the specification requirements of ASTM C 1157 or ASTM C 595 for hydraulic cements and ASTM C 618, for mineral admixtures, respectively. In ASTM C 618, the classification in their works describes some of the choices that are available to manufacturers of blended hydraulic cements to "engineer" into the cementations system. The desired properties for concrete such as improved sulphate resistance, reduced permeability and the ability to strongly mitigate ASR are attained.

Raw materials for pozzolan manufacture are chosen using criteria such as alkali content, silica-to-alumina ratio and the presence of minor constituents. Development of the required thermal treatment profile is
conducted in the laboratory prior to full-scale kiln processing of the clay. Laboratory grinds of the kiln-processed pozzolan are conducted to balance and optimize surface area, as relates to water demand characteristics. Short- and long-term paste, mortar, and concrete testing are conducted on samples form full-scale production mill test grinds.

The shales that are calcined for use as pozzolans (while not containing significant amounts of kaolinite) are converted to amorphous phase materials during the thermal treatment processing. Most of the clays that have been used for pozzolan production contain significant amounts of kaolinite ($\text{Al}_2\text{O}_3.2\text{SiO}_2.2\text{H}_2\text{O}$), when it is thermally treated; it is converted to an amorphous phase called metakaolin. Pozzolans containing metakaolin are manufactured at several sites across the United States.

Karthik et al (2003) have described fly ash and silica fume with two pozzolans that have been widely used for improved concrete strength and durability. Silica fume displays a greater pozzolanic reactivity than fly ash primarily due to its finer particle size. The reactivity of fly ash can be improved by reducing its particle size distribution. This work discusses the fresh and hardened properties of concrete made with an Ultra-Fine Fly Ash (UFFA) produced by air classification. Durability testing for chloride diffusivity, rapid chloride permeability, Alkali-Silica Reaction (ASR) and sulphate attack was also conducted. It was found that at a given workability and water content, concrete containing UFFA could be produced with only 50% of the high-range water-reducer dosage required for comparable silica fume concrete. Similarly, early strengths and durability measures as silica fume concrete were observed when a slightly higher dosage of UFFA was used with a small reduction (10%) in water content.
Peter et al (2003) have described combinations of cement kiln dust and fly ash, which were used to develop cementitious material through mechano-chemical activation. Mix combinations, made with two different proportions were subjected to various grinding regimes to activate the material. Properties, including particle size distribution, initial time set, heat of hydration, and compressive strength of the new material, were determined.

Mechanical grinding resulted in mechano-chemical activation of the material with vibratory grinding more effective than ball mill grinding. Activation was confirmed through X-ray diffraction analysis and no correlation was found between activation and the mean particle size of the material. Although not all the properties of the material tested were comparable to those of Portland cement, the results indicate the potential for significant improvement.

Lee et al (2003) have described the use of fly ash as a cement replacement material increasing the long-term strength and durability of concrete. Despite the great benefits, the use of fly ash is limited due to the low early strength of fly ash concrete. To eliminate this problem, many studies have been conducted on accelerating the pozzolanic properties of fly ash. The research investigated the strength and micro structural characteristics of fly ash-cement systems containing three kinds of activators Na₂SO₄, K₂SO₄, and triethanolamine to accelerate the early strength of fly ash mortars. Through the use of thermal gravity analysis, it was demonstrated that the activators not only decreased or maintained the amount of Ca (OH)₂ products, but also increased the production of ettringite at early ages. X-ray diffraction, scanning electron microscopy, and mercury intrusion porosimetry also confirmed that in the early curing stages of fly ash-cement pastes containing activators, large amounts of ettringite were formed, resulting in a reduction in the pore size ranging from 0.01 to 5 μm. The research results support the supposition that
the addition of small amounts of activators is a viable solution for increasing the early-age compressive strength of fly ash concrete.

Gengying Li and Xiaohua Zhao (2003) described a laboratory study on the influence of combination of Fly Ash (FA) and Ground Granulated Blast-Furnace Slag (GGBFS) on the properties of high-strength concrete. A contrast study was carried out for the concrete incorporating FA and GGBFS, control Portland cement concrete and high-volume FA High-Strength Concrete (HSC). Assessments of the concrete mixes were based on short-and long-term performance of concrete. These included compressive strength and resistance to H₂SO₄ attack. The microstructure of the concretes at the age of 7 days and 360 days was also studied by using scanning electron microscope. The results show that the combination of FA and GGBFS can improve both short-and long-term properties of concrete, while HSC requires a relatively longer time to get its beneficial effect.

Ana et al (2006) have reported the results of experimental research on certain engineering properties of a new (Portland cement-free) concrete made with alkali-activated fly ash. Laboratory tests were conducted to determine its mechanical strength, modulus of elasticity, bond strength, and shrinkage. The results show that mortar and concrete made with Portland cement-free activated fly ash levels a high mechanical strength in short periods of time. Concrete has a moderate modulus of elasticity and bond better to reinforced steel and shrink less than ordinary Portland cement (OPC) concrete.

Santanu Bhanja and Bratish Sengupta (2003) have obtained a better understanding of the isolated contribution of silica fume on concrete and determining its optimum content. Extensive experimentation was carried out over water-binder ratios from 0.0 to 0.3. The results indicate that the optimum
replacement percentage for 28-days strength is not a constant but depends on the water-cementitious material ratio (w/cm) of the mixture and has been found to range from 15 to 25%. On quantifying the pozzolanic and physical effects of silica fume, it is observed that both the mechanisms significantly contribute to the concrete strength.

Sulapha (2003) and associates studied the carbonation of concrete incorporating Ground Granulated Blast-Furnace Slag (GGBFS) and Silica Fume (SF). It is observed that a decreased water-to-binder ratio and replacement level of GGBFS, SF, or and GGBFS fineness and curing age in water leads to better carbonation resistance. However, compared to a plain concrete, incorporating mineral admixtures (except GGBFS with higher fineness and SF) generally shows lower resistance to carbonation due to the dominating effect of the reduction in calcium hydroxide over pore refinement. Hence, adequate curing is recommended enhancing the resistance of concrete containing GGBFS and SF to carbonation. It is also found that both the carbonation and compressive strength serve as good indicators for the carbonation rate of concrete with and without mineral admixtures.

Sarkar (2006) has investigated considerable efforts are being taken worldwide to utilize local natural waste and by-product materials in making concrete such as Silica Fume (SF) or Rice Husk Ash (RHA) as supplementary cementing materials to improve concrete properties like durability and strength. The effect of using SF or RHA as a partial replacement for cement has been investigated. Ilmenite and Baryte used to study the heavy weight concrete. The durability of the studied concrete was investigated. The study was extended to investigate the microstructure, the infrared and thermal analysis, and the effect of absorbed gamma radiation of the studied concrete types. Results showed that ilmenite concrete mixed with 15% SF has the highest density; compressive, tensile, flexural, and bond strengths; modulus of
elasticity; and attenuation coefficient values. Concrete mixed with RHA has good resistance to sulphate attack, while concrete mixed with SF had better resistance to sulphate attack. There was no significant effect for either SF or RHA on the concrete gamma attenuation coefficient. Results showed that concrete mixed with RHA has higher mechanical and physical properties than that of mixed without any additives by lower properties than that of mixed with SF.

Robert C. Lewis and Hasbi (2001) have described that Silica Fume (SF) is not only used as a part replacement or addition to cement in a concrete mix but also to enhance the performance characteristics of concrete. This work outlines a number of the diverse projects from around the world and then looks at the use of silica fume in the Indian context.

Silica Fume (SF) has been used for closely 35 years now. At first its use was purely as a cement replacement due to the proximity of plants to concrete producers. As the testing developed, it soon became apparent that the effect of the silica fume was much greater than merely providing extra strength. Over the last three decades the use has transferred from replacement to addition and Silica Fume (SF) is now used to enhance the performance characteristics of concrete. In this way, the high performance concretes produced can be used in many situations where the use of an ordinary mix cannot be considered.

Robert C. Lewis (2001) has studied about the use of micro-silica concrete during the last decades. The concrete has grown at a fast pace. The author presents a broad overview, covering briefly topics such as the production of micro silica, efforts of standardization, comparison of current standards and properties of micro silica concrete, both in the fresh and hardened states.
Micro silica (also known as condensed silica fume or silica fume) was first tested in Norway in 1947, revealing a variety of potential application benefits. The development of large-scale production equipment in the 1970s allowed increased use of micro silica in concrete. This led to the introduction of national and international standards for the use of the material as an additive to improve the quality of concrete. There has been a rapid growth in the usage of micro silica concrete to the present level of over 5 million m³/year.

Bui et al (2005) have described Rise Husk Ash (RHA), which has been used as a highly reactive pozzolanic material to improve the microstructure of the Interfacial transition Zone between the cement paste and the aggregate in high-performance concrete. Mechanical experiments of RHA blended Portland cement concretes revealed that in addition to the pozzolanic reactivity of RHA (chemical aspect), the study grading (physical aspect) of cement and RHA mixtures also exerted significant influences on the blending efficiency. The relative strength increase (relative to the concrete made with plain cement, expressed in %) is higher for coarser cement. The gap-grading phenomenon is expected to be the underlying mechanism. This issue is also approached by computer simulation. A stereological spacing parameter (i.e., mean free spacing between mixture particles) is associated with the global strength of the blended model cement concretes. This work presents the results of a combined mechanical and computer simulation study on the effects of particle size ranges involved in RHA-blended Portland cement on compressive strength of gap-graded concrete in the high strength/high performance range. The gap-graded binder reflects improved particle packing structure accompanied by a decrease in porosity and particularly in particle spacing.
Bapat et al (2006) have described a high volume of lagoon (pond) ash produced as a waste from the thermal power station in North India. The lagoon ash is used as a replacement of cement (55%-65%) in concrete. The test specimens were prepared with and without super plasticizer. No air-entraining agent was used. At constant slump, the required amount of water reduced with the addition of lagoon ash. The slump retention property of the concrete with super plasticizer and lagoon ash was studied. A substantial increase in the setting time (initial and final) was observed. The development of early strength (1, 3 days) was low. The 28 days strength for concrete with lagoon ash, without the addition of super plasticizer, was in the range of 16.4-24.3 MPa for 65 and 55% cement replacement, respectively. The change in strength of concrete was observed over a period of 365 days in the present study. The investigation indicates possibilities of utilizing lagoon ash in concrete. An attempt was made to use lagoon ash in the concrete mix, referred to as dry lean concrete, used as base course for concrete pavements.

Jones and Magee (2002) have reported a laboratory experimental programme that investigated the performance of concrete made with ternary combinations of Portland Cement (PC) and with pulverized Fuel Ash (PFA), Ground Granulated Blast Furnace Slag (GGBFS) and Silica Fume (SF), with a view to developing a simple concrete mix constituent proportioning method. The test mixes used combinations of these cements that conformed to ENV 197-1. All mixes used gravel aggregated mixes and a superplasticizer to achieve slump class S2 (60-90 mm) to provide characteristic cube strengths from 20 to 60 N/mm². Standard cube strengths were measured up to 180 days. Recommendations are made for the optimum PC replacement level to achieve the highest cube strength at 28 and 180 days for mixes both with and without silica fume. The data has been generalized and fitted to the familiar format of the BRE Design of Normal Mixes to allow the proportioning of the concrete mix constituents. A visual from the mix design method has been adopted such
that the combinations of cements that can be used to achieve particular characteristics cube strengths are simple to identify.

Chai Jaturapitakkul and Raungrut Cheerarat (2003) have summarized the potential of using bottom ash from the Mae Moh power plant in Thailand as a pozzolanic material. Bottom ash, which was rarely used in concrete due to its inactive pozzolanic reaction, improved its quality by grinding until the particle size retained on Sieve 325 and it was less than 5% by weight. Bottom ashes before and after being ground were investigated and compared for their physical and chemical properties. The bottom ashes were used to replace Portland cement type I in mortar and concrete mixtures. The results indicated that the particle of bottom ash was large, porous, and irregular in shape. The grinding process reduced the particle size as well as porosity of the bottom ash. Compressive strengths of mortar containing 20%-30% of bottom ash as cement replacement were less than that of cement mortar at all ages, but the use of ground bottom ash produced higher compressive strength than the cement mortar after 60 days. When ground bottom ash was used at a 20% replacement of cement to make concrete, the concrete with higher cement content produced higher percentage compressive strength as well as a higher development rate than those of the low cement content concretes. With the cement content in ground bottom ash concrete of 440 and 260 kg/m$^3$, the concrete needed 14 and 60 days, respectively, to develop higher compressive strength than that of the concrete without bottom ash. As a result of the compressive strengths, it was concluded that ground bottom ash could be used as a good pozzolanic material.

Mohammad et al (2003) have studied the potential use of Jordanian oil shale ash as a raw material or an additive to Portland cement mortar and concrete. Different series of mortar and concrete mixtures were prepared at different water to binder ratios and different oil shale ash replacements of
cement and/or sand. The compressive strength of mortar and concrete specimens cured in water at 23°C was determined over different curing periods, which ranged from 3 to 90 days. The results of these tests were subjected to a statistical analysis. Equations were developed by regression analytical techniques to relate the effect of batch constituents on the strength developments of oil shale ash mortars and concretes. The models were checked for accuracy by comparing their predictions with actual test results.

The obtained results indicated that OSA replacement of cement; sand or both by about 10% (by wt) would yield the optimum compressive strength. The replacement of cement by 0% to 30% would not reduce its compressive strength significantly. It was found that oil shale ash on its own possesses a limited cementitious value and its contribution to mortar or concrete comes through its involvement in the pozzolanic reactions. The statistical model developed showed an excellent predictability of the compressive strength for mortar and concrete mixes.

Gemma Rodriguez de Sensale (2006) has explained the development of compressive strength up to 91 days of concretes with rice-husk ash (RHA), from a rice paddy milling industry in Uruguay. RHA produced by controlled incineration from the USA was used for comparison. Two different replacement percentages of cement by RHA, i.e., 10% and 20% and three different water / cementitious material ratios (0.50, 0.40 and 0.32) were used. The results are compared with those of the concrete without RHA, with splitting tensile strength and air permeability. It is concluded that residual RHA provides a positive effect on the compressive strength at early ages, but the long term behaviour of the concretes with RHA produced by controlled incineration was more significant. Results of splitting tensile and air permeability reveal the significance of the filler and pozzolanic effect for
the concretes with residual RHA and RHA produced by controlled incineration.

Khandaker et al (2006) have assessed the suitability of using Volcanic Ash (VA) as cement replacement materials in concrete production. Tests were conducted on 36 concrete mixtures replacing 0 to 75% by mass of normal Portland cement by VA. The performance of Volcanic Ash Concrete (VAC) mixtures was evaluated by conducting comprehensive series of tests on fresh and hardened properties as well as durability. The fresh and hardened properties of the concrete were assessed by slump, air content and compressive strength, while durability characteristics were investigated by Rapid Chloride Permeability (RCP), Drying Shrinkage (DS), water permeability, Mercury Intrusion Porosimetry (MIP) and Differential Scanning Calorimetry (DSC) tests. VACs showed better durability properties compared to control concrete with 0% VA. The improved performance of VACs was attributed to the refinement of pore structure, lowering the presence of free chloride due to Friedel's salt formation and pozzolanic action due to the presence of VA. VAC having a minimum strength of 15 MPa (a requirement for some structural concrete applications) can be obtained by replacing up to 40% (by mass) of cement with VA. The development of inexpensive and environmentally friendly VAC with acceptable strength and durability characteristics (as illustrated in this study) is helpful for the sustainable development and rehabilitation of volcanic disaster areas around the world.

Felix et al (2002) have reported some properties of concrete with Saw Dust Ash (SDA) as a replacement for Ordinary Portland Cement (OPC). The compressive strength of specimens with replacement levels ranging from 10% to 30% cured for periods of 3-90 days showed a decreasing strength with higher ash content. The 28-day split tensile strength of SDA concrete specimens showed a similar trend. The SDA concrete was observed to gain
rapid strength at later ages indicating a pozzolanic activity of the ash. Although only concrete with a 10% replacement level attained the 20 N/mm² designed strength at 28 days. Test results indicate that SDA concrete can attain the same order of strength as conventional concrete at longer curing periods.

2.8 APPLICATION OF WASTE GLASS AND RECYCLED CONCRETE

Ilker Bekir Topcu and Mehmet Canbaz (2004) have experimented with waste glass (WG), as coarse aggregate in the concrete. As a result of the study conducted, WG was determined not to have a significant effect upon the workability of the concrete and only slightly in the reduction of its strength. Waste glass cannot be used as aggregate without considering its Alkali-silica-Reaction (ASR) properties. As for cost analysis, it was determined to be lower than the cost of concrete productions. WG could be used in the concrete as coarse aggregates without high cost.

Ahmad Shayan and Aimin Xu (2004) have described a large proportion of the post consumer glass which is recycled into the packaging stream again. Some smaller proportions are used for a variety of purposes, including concrete aggregate. However, a significant proportion, which does not meet the strict criteria for packaging glass, is sent to landfill taking the space that could be allocated to more urgent uses. Glass is unstable in the alkaline environment of concrete and could cause deleterious ASR problems. This property has been used for an advantage by grinding it into a fine glass powder (GLP) for incorporating it into concrete as a pozzolanic material. In laboratory experiments, it can suppress the alkali reactivity of coarser glass particles as well as that of natural reactive aggregates. It undergoes beneficial pozzolanic reactions in the concrete and could replace up to 30% of cement in
some concrete mixes with satisfactory strength development. The drying shrinkage of the concrete containing GLP was acceptable.

Sung T-Yueh Tu et al (2006) have studied the utilization of recycled aggregates, which can minimize environmental impact, and slow down the huge consumption of natural resources used for concrete applications. However, recycled aggregates are not suitable for usage in the production of High Performance Concrete (HPC) due to their relatively high absorption capacity, unstable properties and recycled aggregates' weaker strength. Such inadequacies can be overcome by carefully examining the characteristics of recycled aggregates and then adopting proper mixture proportions. In this study, recycled aggregates generated from demolished-construction wastes were examined and the Densified Mixture Design Algorithm (DMDA) was applied in the design of HPC. Results showed that HPC specimens containing recycled aggregates can be designed to have a slump of more than 180 mm and a slump-flow larger than 550mm. However, HPC specimens with high amounts of recycled aggregates and cement added lost their high-flowing and self-consolidating characteristics after 1 hour due to their greater water absorption. Local standards of durability were satisfied at the age of 91 days both by concrete resistivity and chloride ion penetration.

Ahmad Shayan and Aimin Xu (2003) have described the previous investigation on Recycled Concrete Aggregate (RCA), which has been limited largely to the manufacturing of non structural grade concrete up to 32 MPa strength grade due to undesirable physical properties of RCA. For example, high water absorption leads to high water demand of concrete. The restriction seriously limits its market value and consequently diminishes the use of RCA as a construction material. The use of RCA in higher-strength (50 MPa) structural concrete has beneficial environmental consequences by
further conserving rock resources currently used to produce concrete aggregate. This study attempted to improve the surface properties of RCA and report on the influence of the improved RCA on the strength development and durability properties of 50MPa-strength grade concrete.

In addition to strength development, drying shrinkage, Alkali-Aggregate Reaction (AAR), sulphate resistance, and chloride permeability were also investigated. The results show that RCA can be used to produce 50 MPa structural concrete made with virgin aggregate.

How-Ji Chen et al (2003) have explained application of building rubble collected from damaged and demolished structures, which is an important issue in every country. After crushing and screening, this material could serve as recycled aggregate in concrete. A series of experiments using recycled aggregate of various compositions from building rubble was conducted. The test results show that the building rubble could be transformed into useful recycled aggregate through proper processing. Using unwashed recycled aggregate in concrete will affect its strength. Their effect will be more obvious at lower water/cement ratios. When the recycled aggregate was washed, these negative effects were greatly improved. This is especially true for the flexural strength of recycled concrete. The recycled coarse aggregate is the weakest phase at a low water/cement ratio. This effect will dominate the strength of recycled concrete. This mechanism does not occur in recycled mortar. The quantity of recycled fine aggregate will govern the mortar strength.

Schuur (2000) has examined the suitability of crushed building and demolition waste as a raw material for the production of calcium silicate products. Replacing the natural sand with crushed building and demolition waste of different sources has produced calcium silicate bricks. The
mechanical properties of the bricks made with these wastes are comparable or, in some cases, even better than those of bricks with natural sand. The green shear strength of the bricks is higher. The amount of quartz and reactive SiO$_2$ in the waste materials is high enough for the formation of tobermorite as a cementations material between the grains. A negative aspect is the appearance of brown stains on the surface of the bricks when the waste materials are slightly contaminated with organic substances. This risk can be reduced when, besides the crushing the waste, a washing process is included.

Mandal et al (2002) have considered recycling concrete waste as coarse aggregates for new concrete construction, which is gaining importance on the international scale. Although the mechanical properties of Recycled Aggregate Concrete (RAC) are well known, the study on durability performances of RAC appears to be very limited. This study was an attempt to investigate and compare the durability performance of the RAC and Natural Aggregate Concrete (NAC). The effect of addition of fly ash replacing cement partially on the overall performances of RAC and NAC was also incorporated. The test results reveal that the durability of RAC is comparatively less than that of NAC. However, the addition of fly ash replacing cement partially in RAC seems to enhance durability.

Baoshan Huang et al (2004) have explained the usage of tyre rubbers in construction. Over the years, there has been mounting interest in the use of recycled tyre rubbers in highway construction. Tyre rubber-filled concrete, a rubberized Portland cement concrete with a portion of aggregates replaced by tyre rubber particles, represents an alternative usage of recycled tyre rubbers. It is found that rubberized concrete has higher toughness. However, its strength decreases significantly as the rubber content increases. This limits its application to secondary structural components only. Very little progress has been made in increasing the strength of rubberized concrete due
to the lack of understanding of the toughening mechanism. In this study, rubberized concrete was treated as a multiphase particulate-filled composite material. A modified three-layers-built-in composite model was proposed based on a previous study of ordinary concrete samples, which were prepared and tested to provide basic physical/mechanical properties in analysis. The effect of various design parameters on the composite strength was evaluated. The finite element analysis validated the test results.

Senthamarai and Devadas Manoharan (2005) have studied the usage of hazardous industrial wastes in concrete making, which will lead to greener environment. In ceramic industry about 30% production is wasted. The wastes are not recycled at present. In this study an attempt was made to find out the suitability of the ceramic industrial wastes as a possible substitute for conventional crushed stone coarse aggregate. Experiments were carried out to determine and to compare them with those of conventional concrete made with crushed stone coarse aggregate. The properties of the aggregates were also compared. Test results indicate that the workability of ceramic waste coarse aggregate concrete is good and the strength characteristics are comparable to those of the conventional concrete.

Nik D. Oikonomou (2005) has studied the subject of concrete recycling, which is regarded as very important in the general attempt for sustainable development today. In a parallel manner, it is directly connected with (a) increase of demolished structures; (b) demand for new structures and (c) results—especially by natural phenomena (earthquakes, etc.). The present work refers to the concrete recycling subject and, more specifically, to a proposal for Greek specifications of Recycled Concrete Aggregates (RCA) with reference to international experience and practice. The existence of Greek specifications of RCA—the European ones would come much later—would help Olympic Games 2004 to be as "green" as possible.
2.9 SPECIAL CONCRETE

Mohamed Lachemi et al (2003) have investigated Self-Consolidating Concrete (SCC) in the fresh state. This concrete is known for its excellent deformability, high resistance to segregation, and use, without applying vibration and congested reinforced concrete structures characterized by difficult casting conditions. Such a concrete can be obtained by incorporating either mineral admixtures such as Fly Ash (FA) and slag cement or Viscosity-Modifying Admixtures (VMAs). The use of VMAs is very effective in stabilizing the rheology of SCC. Commercial VMA currently available in the market is costly and increases the price of such a concrete. Research to produce an economical SCC with desired properties has been conducted over the last few years with the use of mineral admixtures for use and development of a cost-effective VMA. This study presents the comparative performance of SCC manufactured with FA, slag cement, and various VMA based on fresh and mechanical properties and also on cost. Twenty-one concrete mixtures were investigated. FA SCC mixtures had cement replacement of 40%, 50%, and 60%, while slag cement SCC mixtures had the replacement of 50%, 60%, and 70%. The water-cementitious material ratios (w/cm) ranged from 0.35 to 0.45. Three different VMA, including Welan gum (WM), a commercial one, named COM, and a new saccharide-based VMA, named A, were used in VMAs, SCC mixtures with W/cm of 0.45. Tests were carried out on all mixtures to obtain fresh properties such as viscosity and stability. Tests were also carried out to obtain mechanical properties such as compressive strength. The influence of percentages of FA or slag cement, w/cm, dosage of high-range water-reducing admixture, dosages of air-entraining agent and types of VMA on the properties of SCC were critically reviewed. The results showed that incorporating FA, slag cement or VMA, could successfully develop an economical SCC with desired properties. Three different economical mixtures were identified from FA, slag...
cement, and VMA-based SCC satisfying the targeted strength of 35 MPa. These mixtures included FA with 50% replacement, slag cement with 60% replacement and a mixture with new VMA A with a w/cm of 0.45. It was found that these SCC could replace the control concrete and could be more economical (30 to 40% in case of FA and slag cement). The new VMA A was found to develop a SCC with better fresh and hardened properties and at significantly lower cost compared with its commercial counter parts - COM and WM. Although the VMA SCC with new A-VMA was slightly costlier than those with FA and slag cement, it was more resistant to segregation and had higher early strength development.

Kallol Sett and Vipulanandan (2004) have described the effect of adding glass and carbon fibers on the compressive and tensile behaviour of Polyester Polymer Concrete (PPC). The compressive and tensile strengths of the optimum PC were 55 and 7 MPa, respectively. PC systems with fibers were optimized based on the workability and mechanical properties. Fibers improved the properties of the PC system to varying degrees, which depended on the type and amount of fibers. The tensile-to- compressive modular ratio for the PC was 0.75. Strength, stiffness and stress-strain models were used to predict the observed behaviour of PC. The pulse velocity method and the impact resonance method were sensitive to determine the changes in non-destructive properties of PC systems with the addition of fibers. The pulse velocity method predicted the static moduli more closely than the impact resonance method. The damping properties of polymer concrete systems have been quantified.

Papayianni et al (2005) have studied the use of superplasticizer in concrete manufacturing and this played a central role in the development of high strength and performance concrete. Superplasticizers are admixtures, which are added to concrete mixture in very small dosages. Their addition
results in significant increase of the workability of the mixture in reduction of water/cement ratio or even of cement quantity. Their performance depends on the type of the superplasticizer, the composition of the concrete mixture, the time of addition and the temperature conditions during mixing and concreting.

Measurements of workability, slump loss, air content, as well as of strength development have been made to reach a conclusion about superplasticizer performance with the use of two kinds of aggregate: one natural (river) and another crushed limestone. Apart from this, it seems that the quantity of fines in a mixture influences the performance of superplasticizer.

Nader Ghafoori and Shivaji Dutta (1995) have investigated the physical and engineering characteristics of various no-fines concrete mixtures. No-fines concrete mixtures subjected to impact compaction are studied under unconfined compression, indirect tension and static modulus of elasticity. The results are interpreted as functions of mixture proportions. The effect of impact-compaction energies, consolidation techniques, and mixture proportions, curing types and testing conditions on physical and engineering properties are presented. The abrasion characteristics and resistance to freezing and thawing of no-fines concrete are also discussed. It was found that the strength of no-fines concrete is strongly related to its mixture proportion and compaction energy. A sealed compressive strength of 20.7 MPa (3,000 psi) can readily be achieved with an aggregate cement ratio of 4.5:1 or less and minimum compaction energy of 165 J/m³ (4,303 ft - lb/cu ft). The splitting tensile-compressive relationship followed a pattern similar to that of conventional concrete. No-fines concrete had a lower modulus of elasticity than conventional concrete. The ultimate drying shrinkage of compacted no-fines concrete was found to be approximately 280 x 10⁻⁶ about half that typically expected in conventional concrete. Air-entrained no-fines concrete
exhibited a higher resistance to freezing and thawing than non-air-entrained mixtures.

Jin and Liz (2000) have described the young concrete which usually refers to the concrete with an age less than 7 days. Due to the progress of hydration, the mechanical properties of young concrete are quite different from those of mature concrete. This investigation is aimed at understanding the mechanical properties of young concrete under both uniaxial compression and tension. The uniaxial compression and uniaxial tension tests have been conducted on the concrete specimens at ages of 12 hours, 18 hours, 24 hours, 48 hours, 72 hours and 168 hours. By utilizing the circumferential control and adaptive control, the complete stress-strain (deformation) curves have been obtained for young concrete under either uniaxial compression or uniaxial tension. The experimental results show that the behavior of young concrete is quite ductile until about 3 days. The effect of incorporating metakaolin into concrete mix has also been studied in this research. It is found that the metakaolin can significantly enhance the mechanical properties of young concrete.

Jin et al (2005) have studied the results of experimental investigations on the behavior of both high (HSC) and normal strength (NSC) concrete at early ages. The mechanical experiments included compression test, splitting tension, and fracture test. The tests were conducted at ages of 12 h, 1, 2, 3, 7 and 28 days. In addition to various strengths, the complete stress-strain curves of concretes under uniaxial compression at different ages were obtained by utilizing the circumferential control method. It was found that the strength development rate of HSC was sharper than that of NSC at early ages. To investigate the microstructure developmental of concrete at early ages, Mercury Intrusion Porosimetry (MIP) was used to examine the pore size and accumulated pore volume for both HSC and NSC. The results
showed that the porosity decreased with the progress of hydration. Accordingly, the strengths of both HSC and NSC increased as the result of progress of microstructure development.

Leemann and Hoffmann (2005) have explained the Self-Compacting Concrete (SCC) used in Switzerland. Usually the concrete has a relatively low binder content and a low viscosity and a high yield stress which characterize its rheological properties. Until now SCC has been mainly used for walls. An important condition for its application is knowledge of the resulting properties and how they compare with Conventionally Vibrated Concrete (CVC). In this study nine different SCC mixtures having the volume of paste and the ratio between sand and gravel as variables were compared with four different mixtures of CVC. Compressive strength, flexural strength, E-modulus, as permeability, shrinkage and creep were measured. The relative amount of paste caused differences in the properties of the two types of concrete. SCC displayed a lower E-Modulus, a higher shrinkage and higher creep rate at an identical compressive strength. Properties that are mainly controlled by the water- blinder ratio such as compressive strength, flexural strength and oxygen permeability -were similar for SCC and CVC.

Chi et al (2003) have examined the compressive strengths and elastic moduli of cold-bonded palletized lightweight aggregate concretes. Three types of aggregates were made with different fly ash contents. Experimental data were analyzed statistically. Test results of Multivariate Analysis of Variance (MAV) with 95% confidence level (\(x=0.05\)) show that the properties of lightweight aggregates and the water/binder ratio are two significant factors affecting the compressive strength and elastic modulus of concrete.
Kayali et al (2003) have studied and investigated effect of polypropylene and steel fibers on high strength lightweight aggregate concrete. Sintered fly ash aggregates were used in the lightweight concrete; the fines were partially replaced by fly ash. The effects on compressive strength, indirect tensile strength, and modulus of rupture, modulus of elasticity, stress-strain relationship and compression toughness are reported. Compared to plain sintered fly ash lightweight aggregate concrete, polypropylene fiber addition at 0.56% by volume of the concrete caused 90% increase in the indirect tensile strength and 20% increase in the modulus of rupture. Polypropylene fiber addition did not significantly affect the other mechanical properties that were investigated. Steel fibers at 1.7% by volume of the concrete caused an increase in the indirect tensile strength by about 118% and an increase in the modulus of rupture by about 80%. Steel fiber reinforcement also caused a small decrease in the modulus of elasticity and changed the shape of the stress-strain relationship to become more curvilinear. A large increase in the compression toughness was recorded. This indicated a significant gain in ductility when steel fiber reinforcement is used.

Bharatkumar et al (2001) have described high performance concrete (HPC). The concrete meets special performance and uniformity requirements that cannot always be achieved by conventional materials, normal mixing, placing and curing practices. Special performance requirements using conventional materials can be achieved only by adopting low w/c, which necessitates the use of the high cement content. But judicious choice of chemical and mineral admixtures can reduce the cement content resulting in economical HPC. However, the effect of a mineral admixture on the strength of concrete varies significantly with its properties and replacement levels. Mix proportioning methods of normal concrete cannot adequately account for the large variations in the properties of ingredients. This study presents a modified mix design procedure, which utilizes optimum
water content and the efficiency factor of mineral admixture. Results of the experimental investigation on mixes using the modified mix design are presented.

Samir Surlaker (2002) has studied the properties and composition of high performance concrete with special reference to self-compacting concrete. An outline of the new generation superplasticizer for such concrete is given. The compatibility of the different ingredients used in HPC is briefly discussed.

Alves et al (2004) have described the use of high-strength concrete (HSC). The usage has been increased all over the world. The production of this material results in large consumption of natural sources and energy. Generally it is characterized by larger consumption of cement, when compared to the conventional concretes (compressive strength < 50 MPa). In Brazil, little emphasis has been given to the HSC mix proportioning methods. The usage is not common practice in the construction industry yet; the production of HSCs is achieved through proportioning methods used for conventional strength concretes. The use of these methods, besides presenting technical difficulties, also generates high cement consumption, large consumption of energy and high consumption of raw materials in general. For the present study, four proportioning methods were selected, one for conventional concrete and three specifically for high strength. The resulting concretes are compared for compressive strength, cement consumption and economic viability. The results indicate the advantage of using specific proportionate methods for HSC, as for the same compressive strength for 28 days, saving up to 50% with the consumption of cement which represents a significant reduction of energy, raw material consumption and costs.
Bigas and Gallias (2002) have analyzed the influence of the physical characteristics of 18 fine mineral additions on water requirement, agglomeration and packing density of pastes. The main objective is to determine the principal parameters controlling their use in concrete mixtures. A standard Vicat test and a new and simple test based on agglomeration of fine particles by capillary forces of a water drop are used to determine the water requirement and the packing density. The influence of high-range of a water-reducing admixture is also studied. Results show that fine mineral additions unfavorably influence the water requirement and the packing density of cement mixtures in two cases. The first case concerns additions with regular shaped particles, which lead to loose granular structures and very high water requirement. Both Vical and 'single drop' tests could determine a critical threshold for water requirement. The second case concerns additions with mix water requirement in relation to other proportions. A high amount of high-range water-reducing admixtures could reduce this interaction phenomenon only in water-saturated mixtures.

Shridhar (2002) has reported that high strength concrete alone cannot guarantee long-term performance. This has led to the development of High Performance Concrete (HPC). Materials used in the production of HPC are the same as used in normal concrete. In addition to cement, fine aggregate, coarse aggregate water and chemical admixtures are the fifty types of ingredients used in HPC. This work deals with the role of chemical admixtures in the production of HPC for durable structures.

Jolicoeur et al (2002) have reported modern-day concrete, which frequently incorporates one or more chemical admixtures to achieve specified properties. Now binder systems have become increasingly complex, either due to addition of pozzolans (for example, silica fume) or partial cement replacement by supplementary cementitious materials or addition of fillers.
Concrete performance requirements are also increasingly demanding. Hence, chemical admixtures are rapidly gaining importance and diversity. For concrete practitioner, the variety of concrete admixture types, and the diversity of admixtures within each type creates a rather complex environment. This work attempts to present an overview of the field of chemical admixtures and provide some perspective on the need for these admixtures, their function and benefits in application. A particular emphasis is given to those admixtures - water - reducing and colloidal - which influence the rheological properties of fresh concrete.

Mailvaganam (2002) has reported the use of chemical admixtures across the world. However, it should be known whether the usage of the admixtures is essential. Guidance provided by the manufactures as well as specifications and standards of different countries are quite useful in this regard. The work presents broad guidelines, which need to be followed when using chemical admixtures.

Rajamane et al (2002) have studied the effect of indigenous Air-Entrainment Agent (AEA) on concrete. Partial replacements of cement by Fly Ash (FA), Ground Granulated Blast Furnace Slag (GGBFS) and Silica Fume (SF) were mixed with mixes and its performance was studied. The test results showed that quantity of air entrained increased with reduction in cement content and an average of about 4 percent reduction in compressive strength occurred for very 1 percent entrained air content. It was also noticed that the addition of superplasticizer in concrete diminished the air entraining effect of AEA. The addition of more filler materials in the form of aggregates (fine as well as coarse) increased the air entraining action of AEA. An increase in ambient temperature was found to cause decrease in the air entraining effect of AEA.
Narayanan and Ramamurthy (2000) have examined aerated concrete. It is relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase, yet shows vast variation in its properties. The properties of aerated concrete depend on its microstructure (void-paste system) and composition, which are influenced by the type of binder used, methods of pore-formation and curing. Although aerated concrete was initially envisaged as a good insulation material, there has been renewed interest in its structural characteristics in view of its light weight, savings in material and potential for large scale utilisation of wastes like pulverized fuel ash. The focus of this work is to classify the investigations on the properties of aerated concrete in terms of physical (microstructure, density), chemical, mechanical (compressive and tensile strengths, modulus of elasticity, drying shrinkage) and functional (thermal insulation, moisture transport, durability, fire resistance and acoustic insulation) characteristics.

Subramanian and Chattopadhyay (2002) have studied self-compacting concrete. It is a fluid mixture, which is suitable for placing in difficult conditions and in structures with congested reinforcement without vibration. It is characterized by high powder content. The resulting concrete has an excellent surface finish. This research describes the development of the mix proportions for self-compacting concrete and also the procedure used for selecting the combination of viscosity modifying agent, super plasticizer and ultrafine powders. The results of the preliminary trials with the mixture developed are described.

2.10 NEED FOR THE PRESENT STUDY

A careful review of literature reveals that several investigators have studied the utilization of quarry rock dust and other marginal material
application in concrete extensively. However the physical properties and chemical analysis of quarry rock dust have not been reported so far.

There is no standard method available for designing concrete mixtures with quarry rock dust as fine aggregate. Durability studies shrinkage, permeability studies and water absorption studies of quarry rock dust concrete have not been carried out. The effect of aggregate size in quarry rock dust concrete has not been studied and reported so far.

Hence, the present work has been carried out to investigate the physical and chemical analysis of quarry rock dust samples. The aim of this thesis is to investigate the ultimate compressive strength, flexural strength, splitting tensile strength with grade of concrete M20, M30, and M40 with various compacting factors such as 0.85, 0.92 and 0.95 with three different sizes (10 mm, 20 mm, 40 mm) of coarse aggregates and study the effect of aggregate size of compressive strength, flexural strength, durability and shrinkage of concrete elements made by quarry rock dust.