ABSTRACT

Concrete is the most widely used building material in the world due to its versatility, low cost and durability. The most commonly used fine aggregate is natural river sand. The demand for natural sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price. The Government has already banned sand mining due to environmental problems in some identified areas of major rivers. Thus, an investigation is needed to identify a suitable substitute that is eco-friendly and inexpensive and in this connection the use of quarry dust as fine aggregate has occupied a promising factor in the preparation of concrete.

Quarry dust can be defined as residue, tailing material after the extraction and processing of rocks to form fine particles less than 4.75mm. Quarry dust being, by and large, a waste product, will also reduce environmental impact, if consumed by construction industry in large quantities. Hence, the use of quarry dust as fine aggregate in concrete will reduce not only the demand for natural sand but also reduces the environmental problems. Moreover, the replacement of sand by quarry dust will offset the production cost of concrete, and hence the successful utilization of quarry dust as fine aggregate will turn this waste material into valuable resource.

Corrosion of steel in concrete is one of the major causes of premature deterioration of reinforced concrete structures, leading to structural failure. A number of remedies such as use of mineral admixtures, addition of inhibitors and rebar coating have been suggested to prevent corrosion of steel
in concrete structures. Mineral admixtures are finely divided siliceous materials which are added to concrete in relatively large amounts, generally in the range of 20 to 50% by weight of Portland cement. The use of mineral admixtures like fly ash and ground granulated blast furnace slag (GGBFS) in quarry dust concrete as partial replacement of cement, improves ease of pumping of the concrete, strength, durability and reduction of cement consumption. In addition to the cost saving, it also reduces CO₂ emission during the manufacture of Portland cement. Corrosion inhibitors are widely used to delay or retard corrosion of reinforcing steel in concrete. In this study, the multi-functional benefits of organic and inorganic corrosion inhibitors are discussed with regard to the strength, corrosion protection of embedded steel and resistance to chemical attack.

In order to enhance the strength and durability characteristics of the quarry dust concrete the cement was partially replaced (10-50%) with fly ash and ground granulated blast furnace slag and their influence was studied. Efforts were also taken to determine the optimum replacement level of these mineral admixtures in quarry dust concrete. Concrete construction along the coastal areas is frequently reported to be unsatisfactory as the concrete in these areas are found to be deteriorating rapidly due to the effect of chloride. The use of corrosion inhibitors is found to be one of the effective methods to control rebar corrosion. Therefore, an attempt has been made to study the performance of the organic and inorganic inhibitors at the dosage of 1%, 2%, 3% and 4% by weight of cement in quarry dust concrete to control rebar corrosion. The organic inhibitors used were triethanolamine, diethanolamine and diethylamine and the inorganic inhibitors were calcium nitrite, calcium nitrate and sodium nitrate. The optimum percentage addition of various
inhibitors for maximum strength and corrosion resistance was also determined individually.

The elements present in the quarry dust was evaluated by Energy Dispersive X-ray (EDAX) technique. The various strength properties that were determined are compressive strength, flexural strength, split tensile strength and bond strength in addition to water absorption test. The resistance to corrosion is evaluated by means of impressed voltage technique in saline medium and weight loss method. The results have been confirmed with AC impedance method. The surface analysis of embedded steel was done by scanning electron microscope (SEM).

Concrete cubes of size 150 x 150 x 150mm, beams of size 500 x 100 x 100 mm, cylinders of size 150mm diameter and 300 mm long were cast for compressive, flexural and split tensile strength tests. After 3, 7, 28, 56, 90 and 180 days curing the specimens have been tested as per IS: 516 – 1964. Cylinders of size150mm diameter and 300 mm long with rods of 70cm length and 16mm diameter kept at the centre have been used for determination of bond strength. Water absorption of hardened concrete specimens has been calculated based on ASTM C642-81. Concrete cylinders of size 75 mm diameter and 150 mm length have been cast with a high yield strength deformed (HYSD) steel bar of 16mm diameter embedded centrally into it to assess the corrosion protection efficiency under impressed voltage method, weight loss method and AC impedance method. From the embedded portion of the rebar, 2cm length has been cut and examined using scanning electron microscope for interpreting microstructures of materials on the surface of the specimen.

Results indicate that, When compared with conventional concrete quarry dust concrete shows 10.6% improvement in strength and corrosion
EDAX analysis shows that the chief element present in the quarry dust is silica (Si) along with aluminium, calcium and iron in lesser quantities. The addition of fly ash replacing cement partially up to 30% in quarry dust concrete produces increase in strength and corrosion resistance properties but further addition of fly ash of 40% and 50% results in decrease of strength and durability properties. The maximum strength values are obtained for 30% replacement of fly ash in quarry dust concrete. Among all the percentages of GGBFS added starting from 10% to 50%, the replacement level of 40% of GGBFS is considered to be the optimum level of cement replacement in quarry dust concrete for getting maximum strength and corrosion resistance. The specimens cast with 2% addition of triethanolamine, diethanolamine and diethylamine show maximum improvement in mechanical strength properties, corrosion resistance and lesser water absorption and permeability. In the case of inorganic inhibitors, the specimens cast with 2% addition of calcium nitrite and 3% addition of calcium nitrate and sodium nitrate show maximum improvement in mechanical strengths, corrosion resistance and lesser water absorption and permeability. SEM images confirm that the inhibitor has been migrated and formed a protective film on the surface of the steel embedded in quarry dust concrete.

From the above conclusions and comparison of the costs of the materials it has been arrived that 30% fly ash blended cement concrete containing quarry dust as fine aggregate can be effectively and economically utilized in the construction industry. For the construction works in chloride laden coastal areas requiring strength and corrosion resistance, quarry dust concrete with 3% calcium nitrate as inhibitor can be effectively and economically utilized.