Abstract

Concrete is the most widely used construction material in the construction industry. A large volume of concrete is used for non-structural applications. These applications are mostly with low strength concrete, assumed to be unimportant and investigations on this are neglected. A comparatively large volume of concrete is consumed in these applications and its study can provide ample scope for material optimization and waste utilization in concrete. In this research, utilization of marble powder and fly ash in conventional concrete and foam concrete is presented.

For the study of non-structural concrete, effective w/c ratio of 0.5 – 1.15 is adopted. Mix design of control concrete in these higher effective w/c is difficult due to paste deficiency. Guidance is taken from Table 9 of IS 456: 2000, which is applicable to nominal mixes. A new approach is presented to design control mixes without using 20mm coarse aggregate and assuming s/a = 0.5. The obtained strength-w/c ratio relation is used for strength prediction in the entire research.

As strength decreases, higher fly ash percentage can be used to minimize cement consumption. Hence, the determination of the efficiency factor for the higher percentage of fly ash is done through experiments essential for mix design. Experiments were carried out to optimize and study the properties of concrete mixes using this derived k-factor.

Designing of concrete with marble powder ought to be carried out with proper water correction for its water absorption at surface saturated dry (SSD) condition. Determination of accurate water absorption at the SSD condition of marble powder is important and is determined experimentally. The obtained moisture content (MC) is used to design mixes for optimization of marble powder concrete, and to conduct a comparative study between marble powder with fly ash concrete. Marble powder can be utilized effectively up to total powder
content of 950 kg/m\(^3\), and with 0% or 15% fly ash. Use of 15% fly ash would provide optimum benefit in cement saving. It does not significantly affect the cost but saves a huge amount of aggregates while providing good cohesivity. Experiments were also carried out on concrete mixes for paver blocks, using fly ash and marble powder.

Strength of foam concrete is presented to be the function of density or porosity in literature. Prediction of porosity is difficult, while the dependence of strength with density is not appropriate. In this research, a novel formulation is proposed for designing and strength prediction for foam concrete. Excess of water that used for hydration of cement leads to pores. Foam that is incorporated into the mortar to also create pores. Hence, in the proposed formulation the volume of foam equivalent to water is added with water in the numerator of the effective water-cement ratio. This proposed model is validated with results presented in literature and through experiments utilizing fly ash and marble powder.

Finally, an Integrated theory was proposed for any concrete mix for designing and strength prediction. An example of 10 MPa concrete is illustrated using the proposed theory.

This thesis provides a clear view of efficient utilization of fly ash and marble powder for the production of non-structural cement and mortar based products promoting economy, sustainability and scope of entrepreneurship to youths in India and developing countries by saving of natural resources through savings in cement and aggregate consumption is important.

**Keywords:** Efficiency Factor; Fly Ash; Marble powder; Optimisation; foam concrete