ABSTRACT

Construction Industry is a fast growing sector to meet the current trends of industrialisations and infrastructure development and concrete forms a non detachable module of construction. The principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Fly ash is an industrial by-product, generated from combustion of coal in the thermal power plants and its disposal is a major problem faced by all the nations across the globe. High-volume fly ash concrete (HVFAC) will be the solution for the above mentioned problems and its adoption will enable the construction industry to become more sustainable in the resource depleting environment. There are no IS codes which specify guidelines on the mixing and production of HVFAC. Hence it requires a detailed investigation.

The total production of fly ash in the world is estimated currently to be 600 million tons. Over 75% of power generation plants in India are coal based, 230-250 MT coal is being used every year which results in the generation of 110 MT of fly ash every year. The estimated amount is about 170 million MT by the year 2010. Presently 30% of ash is being used in fillings, embankments, construction activities, fly ash hollow block and tiles. The fly ash produced from thermal plants in Tamil Nadu is about 2.7 MT. Presently majority of the coal ash generated is being handled in wet form and
disposed off in ash ponds which are harmful for the environment and moreover ash remains unused for gainful applications. Fly ash has a vast potential for use in high volume fly ash concrete especially due its physico-chemical properties.

Detailed studies on the properties of Indian fly ash mix concrete with available local ingredients to use the full potential of this concrete is needed. Experimental investigation was carried on low volume and high volume fly ash concrete (LVFAC and HVFAC) to know the effect of fly ash characteristic performance of the concrete in three Phases. In the first phase of investigation, one hundred and five specimens (105 Nos) cubical specimens of size 150×150×150 mm were cast for compressive strength test at the ages of 3, 7, 28, 56 and 90 days on HVFAC and LVFAC mixes. Split Tensile strength studies were conducted on 105 nos cylindrical specimens of size 150 mm dia × 300mm height at the ages of 3, 7, 28, 56 and 90 days. Sixty three (63 Nos) beam specimen of size (100mm × 100mm × 500 mm) were tested under two point loading at the age of 28 ,56 and 90 days for flexural strength test. Modulus of Elasticity studies were also conducted at the ages of 28, 56 and 90 days on fly ash mixes. Totally three hundred and thirty six specimens (336 Nos) of fly ash mix specimens were tested under first phase of investigations. Compressive strength on the fly ash mixes at the initial ages of 3 days were in the range of 18-34MPa while at the age of the 90 days the average compressive strength of the fly ash mix is 61 MPa. Due to pozzolanic property the high volume fly ash mixes were able to achieve compressive strength on par with control mixes at higher ages. Split tensile and Flexural
strength also showed similar type of behaviour like compressive strength. Modulus elasticity in terms of compressive strength is also found. Compressive strength being a basic strength parameter affects all other strength characteristics, relations between other strength and strength affecting parameters have been established in terms of compressive strength.

In the second phase of investigation, fracture studies were carried on 84 notched beams of length 500mm of 100 mm depth and 100 mm width with initial notch depth of 5mm, 10mm, 15mm, 20mm, 25mm, and 30mm were cast at the age of 28 days. Critical stress intensity factor (k_{ic}) plays a dominant role in fracture mechanics. Fracture studies were conducted on 84 slab specimen of size 550 × 300 ×50mm with notch depth 2.5, 5, 7.5,10 mm at the age of 28 days. Fracture energy, Fracture energy efficiency and Critical intensity factor were found for the fly ash mix, these parameters were affected to major extent by the quantity of fly ash. Impact strength studies were conducted on one hundred and five (105 Nos.) slab specimen of size 300×300×50mm at the age of 3, 7, 28, 56 and 90 days. Impact energy, Impact energy efficiency were calculated based on the experimental investigation. Compressive strength of the mix affects the impact energy. Empirical relations between impact energy and compressive strength at various ages have been derived. Totally two hundred and seventy three fly ash mix specimens (273 Nos.) were cast for the second phase investigation.

In third phase of investigation, for chemical exposure studies a total of 315 cube specimens using 6 different mixes were cast for. The fly ash concrete cube specimens are cured in potable water, 1% diluted sulphuric
acid, 1% diluted hydrochloric acid and sea water. The attack of chemicals such as sulphuric acid, hydrochloric acid and sea water were studied on various mixes (FA 0, FA 10, FA 20, FA 30, FA 40, FA 50 and FA 60) on cube specimens of size 150 × 150 × 150 mm. The physical properties of the cube specimens under various aggressive environments were observed. Empirical relations in terms of loss of compressive strength due to chemical exposure for fly ash mixes were also derived. Abrasion studies were conducted on 84 concrete tile specimen of size 70 × 70 × 25 mm on various fly ash mixes. The depth of wear increased with increased quantity of fly ash replacement at earlier ages. Permeability and water absorption studies were conducted on cubical specimens of size 150mm and 100mm respectively. At the age of 90 days due to the pozzolanic activity both permeability and water absorption have reduced a lot compared to initial ages. Totally five hundred and twenty five specimens (525 Nos.) were cast for the third phase of investigation.

Based on the detailed experimental investigation conducted on the various structural elements, it is concluded that high volume fly ash concrete achieves the required strengths at higher ages and improved performance characteristics were observed from strength and durability studies. Statistical modeling of the various parameters affecting the strength characteristics of fly ash mixes have also derived and verified with the existing results given by other researchers. Judicious selection of materials, appropriate mixing methods, proper curing, and appropriate dosage of superplasticizer will enable the production of high performing high volume fly ash concrete.