ABSTRACT

Experience gained from the use of conventional concrete led to the development of new materials. The combined use of silica fume as supplementary cementing material and superplasticizer in concrete, leads to the development of high-performance concrete with enhanced durability. Addition of fibers to high-performance concrete / high-strength concrete transforms the material from a brittle to a comparatively ductile one, thereby enhancing the engineering properties of concrete. Steel fibers have distinct advantages over other types of fibers due to their high-elastic modulus and a strong bond with the surrounding cementitious matrix. In view of the above, steel fiber reinforced concrete (SFRC) is increasingly used day by day as a structural material and has gained acceptance in several infrastructural and industrial applications. A critical review of literature has revealed that studies on high-performance concrete incorporating steel fibers are rather scarce.

An attempt has been made in this study to investigate the role and contribution of steel fibers on the various static and dynamic (impact) mechanical properties, and durability properties of high-performance concrete. Further, the behaviour of high-performance steel fiber reinforced concrete (HPSFRC) plates under in-plane and transverse loads has also been studied.

Silica fume, crimped steel fibers and a commercial superplasticizer of sulphonated naphthalene formaldehyde condensate were used in this
experimental investigation. Water-cementitious materials (w/cm) ratios ranging from 0.25 to 0.4, silica fume replacements ranging from 5 to 15%, and fiber volume fractions of 0%, 0.5%, 1% and 1.5% were used in the concrete mixes. Mixtures were proportioned using the guidelines and specifications given in ACI 211.4R-1993 and BIS 10262-1982, and guidelines of ACI 544.3R-1993.

The experimental programme was divided into three phases. In the first phase, the various static mechanical properties of HPSFRC were studied. Experiments were conducted to assess the compressive strength, flexural strength, splitting tensile strength, elastic modulus and compressive toughness of the high-performance concrete reinforced with crimped steel fibers. Mathematical models have been developed using statistical methods to quantify the effect of fiber content on compressive strength and tensile strengths of HPSFRC in terms of fiber reinforcing index (RI). In the second phase, impact performance of HPSFRC was studied. Empirical expression for predicting the ultimate failure strength was developed. Durability properties such as water absorption, air content, co-efficient of absorption, sorptivity, and resistance to the attack of acid and sea water were studied. In the third phase of the work, plate elements of size 600 x 600 x 30 mm were prepared using the HPSFRC mixes of w/cm = 0.4 and 0.3. Behavior of plates under combined in-plane and transverse loads was investigated and an analytical model was developed to determine the central deflection of the plate elements.

It was found that the static and dynamic (impact) mechanical properties of high-performance concrete were improved significantly by the
addition of crimped steel fibers, except, that of the compressive strength which has shown only a moderate improvement. Statistical models developed for predicting the 28-day compressive and tensile strengths were found to give good correlation with the reported results of earlier researchers. Impact performance of HPSFRC was markedly improved. Durability test results show that the quality of HPSFRC is superior. It was observed from the plate behaviour study that SFRC plates restrain the cracks and have enhanced ductility.