ELSEVIER

Cement & Concrete Composites **17** (1995) 85–86

Editorial

The term 'high performance concrete' has become extremely fashionable these days. It is not clear if high performance means high quality, high durability or high strength, although the term is often used in the context of high strength with the implication that high durability is automatically obtained. High strength concretes should generally be much less permeable to aggressive agents because of the lower water–binder ratios used in their fabrication process; however, the degree of permeability achieved *in situ* is a function of the degree and extent of curing, and the opportunity that the cement matrix has to continue its hydration process and develop a closely knit and tight pore structure. The main difficulty arises of course when trying to quantify durability aspects. There is no well defined and clear relationship between strength, pore structure and permeability since all are influenced by many factors, but more importantly all vary with time. However, if one can design a highly durable concrete to develop both high early strength as well as long term strength, then perhaps all the requirements of high performance concrete would have been met.

That high strength concrete can be beneficial is now no longer a matter of debate. The Repair, Evaluation, Maintenance and Rehabilitation Programme in the US demonstrated, for example, that a 95 MPa high strength concrete can have significantly improved resistance to erosion, and therefore such a concrete can be highly cost-effective in hydraulic structures where abrasive action of water-borne debris can be very severe on concrete. In pavements subjected to studded tyres, as occurs in Norway, for example, high strength concrete can 'armor' such pavements, and experimental pavements with 160 MPa concrete have been laid to study their effectiveness. In tall buildings high strength concrete can bring substantial savings, and 130 MPa concrete has been used to reduce column sizes.

It is now fairly clear that the use of high strength concrete in highway bridges can bring substantial benefits. The experimental bridge built in Joighy, France, in 1989, used 60 MPa concrete design strength and consisted of 114 m long × 15·8 m wide three-span, continuous, externally prestressed double-T sections. The concrete was cast in place using local materials. It was found that the volume of concrete needed was 30% less compared to a 35 MPa concrete design, resulting in a 24% reduction in the dead load from the superstructure.

An engineering study carried out for the North Carolina Department of Transportation in the States investigated the benefit of increasing concrete strength from 40 to 80 MPa. Using AASHTO prestressed box beams, it was found that the increased concrete strength allowed the span lengths to be increased up to 17%; for some sections the increase was 30%. The Federal Highway Administration Study in 1987 on applications of high strength concrete for bridges evaluated the potential benefits of increased concrete strengths up to 70 MPa. The benefits included increased span lengths, wider girder spacings, and reduced section of compression members. For example, it was found that for a 45·7 m long simple span bridge 11 m wide, increasing the concrete strength from 40 to 70 MPa enabled the reduction of the number of girders from nine to four.

One of the main obstacles facing engineers wanting to use high strength concrete is the lack of adequate design criteria; the present design specifications are based on the properties of conventional strength concrete, and cannot be extended to cover high strength. Knowledge of the expected durability and reliance on effective design specifications are needed before the high strength can be fully exploited.

The key to high performance and long-term durability lies in the microstructure of the cementitious systems, and superior products can be engineered by increased packing efficiency. The need for efficient quality control and careful selection of materials cannot be overstressed. For example, not all cementitious materials and not all superplasticizers are compatible or perform well in high performance concrete. The production processes of high strength concrete need to be carefully organized. Operations such as blending water, introduction of admixtures, air-entrainment, mixing, transporting and placement methods are all critical in obtaining a uniformly consistent concrete which will be able to develop the properties needed to resist the effects of severe environments. Offshore stuctures pose major and complex challenges to concrete technology in terms of high cement contents, requirements of workability, effects of pumping on air entrainment, and placement to produce concretes which will require minimum maintenance for up to 30 years.

There is clearly more need to understand the mechanics and mechanisms of degradation processes and diffusion characteristics. We need to know more about transport mechanisms, and of the interactive interrelationship between porosity and permeability. The way forward should focus on two issues — optimize the material characteristics for a given load and climatic condition, and optimize the structural section design to maximize the benefits of the material properties. At the end of the day, however, construction technology has to be cost-effective, minimize waste, conserve resources and energy, and enhance the quality of life.