Applications and Recommendations of High Performance Fiber Reinforced Cement Composites with Multiple Fine Cracks (HPFRCC) in Japan

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1. INTRODUCTION

High performance fiber reinforced cement composites with multiple fine cracks (HPFRCC) show remarkably high ductility under uniaxial tensile stress and excellent performance distinguished from conventional cement-based materials by multiple cracking and strain hardening behaviors. Characteristics of HPFRCC include crack width controlling capability keeping crack width in a permissible range. Appropriate use of the tensile performance can work out a structural component excellent in both durability and mechanical performance. The Japan Society of Civil Engineers (JSCE) has published the world's first design recommendations for HPFRCC [1]. English version of the recommendations is going to be published soon. In this seminar, applications of HPFRCC in Japan and the JSCE recommendations are introduced.

2. JSCE RECOMMENDATIONS FOR HPFRCC

Contents of the recommendations are shown in Table 1. The recommendations specify that structural performance, serviceability and resistance to the environmental actions have to be verified on the basis of performance verification concept. Test methods for measuring tensile strength, tensile strain capacity, and crack width are also specified because tensile performance is one of the most important material properties in the design of HPFRCC. The test methods enable us to define material properties regarding tensile yield strength, ultimate tensile strain capacity, and maximum crack width for given HPFRCC, which are subjected to the design verification. The recommendations allow cracks not only in ultimate limit state but also in service condition of members. The serviceability limit state design is required to verify the resistance to the environmental actions throughout the design life on the basis of the calculated tensile strain or crack width nucleated in members subjected to service conditions.

The recommendations are provided for synthetic short fiber reinforced cement composites that exhibit a pseudo strain-hardening behavior and form multiple fine cracks under uniaxial tensile loading. More specifically, the targeted materials are those exhibit mean ultimate tensile strain capacity of more than 0.5 percent and mean crack width of less than 0.2 mm as determined with test methods specified in the recommendations. Applicable range of the recommendations

Table 1 – Contents of JSCE Recommendations for HPFRCC

1 General
2 Design basis
3 Material properties for design
4 Load
5 Structural analysis
6 Safety verification of structures
7 Serviceability verification of structures
8 General structural details
9 Verification for resistance to environmental actions
10 Concrete work
11 Shotcrete
Testing and evaluation methods
Appendix

Irrigation channel

Tunnel

Figure 1 – Applications of HPFRCC.

includes steel reinforced HPFRCC members and existing reinforced concrete structures covered with HPFRCC layer, but excludes monolithic use of HPFRCC in members.

3. APPLICATIONS OF HPFRCC IN JAPAN

The following applications of HPFRCC in Japan take advantage of the superior mechanical properties and fine cracking mode of such composites.

- Bridge decks to improve fatigue resistance through the tensile force bearing capacity
- Dampers in reinforced concrete buildings to increase energy absorption and suppress vibration during earthquakes
- Surface repair of dams and irrigation channels (Figure 1) to improve shielding properties
- Surface repair of retaining walls deteriorated due to alkali silica reaction to improve aesthetic appearance
- Surface coating of railway viaducts for carbonation retardation
- Surface coating of tunnel lining made with SFR shotcrete (Figure 1)

4. CONCLUDING REMARKES

Applications of HPFRCC are still in incunabula and associated with problems to be solved, while HPFRCC possess a unique feature that has never been presented by the existing cement-based materials. A worldwide active research and development of HPFRCC imply a possibility to realize concrete structures with excellent safety, serviceability and durability performance.

REFERENCE

1. 'Recommendations for Design and Construction of High Performance Fiber Reinforced Cement Composite with Multiple Fine Cracks (Draft)', *Concrete Library 127*, Japan Society of Civil Engineers, 2007.3.