SUMMARY REPORT OF TASK GROUP A: STANDARDS FOR MATERIALS AND TESTING

Hirozo MIHASHI
Dept. of Architecture and Building Science, Tohoku University, Sendai, Japan

Summary:

Task Group A (i.e. TGA) was planned to cover the following 5 topics based on potentially relevant sections of the Building Code Requirements for Structural Concrete: 1) HPFRCC constituent materials, admixtures, additives; 2) mix proportions; 3) mechanical properties; 4) testing methods and round robin tests; and 5) quality control.

In TGA session, totally 12 papers were presented including one keynote lecture given by H. Stang with the title of "Observations from Testing HPFRCC Materials." Among 12 papers, 9 papers were related to testing methods, mechanical properties, and methods for determination of tensile material law. Other 3 papers were related to material design based on micromechanics.

Regarding the strain rate dependency of HPFRCC, the remarkable differences were shown between tensile capacity under monotonic loading and that under cyclic loading, and also between the ductility under tension-compression loading such as seismic action and that under tension-zero loading. About the tension tests, not only the shape and size of specimens but also the casting direction remarkably influences the results. From the view point of testing, bending tests are most easily managed but the method for determination of tensile material law based on the results of bending tests needs to be standardized, too. Finally it was concluded that three types of testing are necessary for: 1) Quality control; 2) Basis for design; and 3) Specialized application. Regarding material laws, two levels of models were suggested: one (Level-1) is for regular design purpose in which simple elastic-plastic models both for tension and compression are adopted; the other (Level-2) is for detailed design purpose in which 4 parameters are necessarily given to determine the bilinear stress-strain relation. Level-1 model may be used for structural analysis to understand the influence of the tensile capacity of HPFRCC on the mechanical behavior of structures. Level-2 model is rather comprehensive and it may be used for detailed design including durability design. For that purpose, crack properties such as the width needs to be further studied in connection with the material laws, too.

Discussed Items:

During the TGA discussion, the following items were clarified.

1) Why are standards for testing necessary?
    1. Testing for performance design of structures
    2. Understanding of mechanisms for developing new HPFRCC

Material properties necessary for design:

- General
    1. Compressive Strength
    2. Tensile Yield Strength
    3. Tensile Strength
    4. Compressive Stress-Strain Curve
    5. Ultimate tensile strain (strain just before localization of cracking)
    6. Tensile Stress-strain curve
    7. Young's modulus
    8. Poisson's Ratio

    (7. and 8. → Shear Modulus)

- Specific
    1. Thermal Characteristics
    2. Shrinkage
    3. Creep
    4. S-N Curve for fatigue design
    5. Cyclic behavior for seismic design
    6. Maximum crack width
    7. Shear

2) How to determine:
Test results should be applicable directly for structural design?
1. Uniaxial tension test and uniaxial compression test
2. Bending test and inverse analysis
3. Shear test

3) Influencing Factors of Testing
1. Specimen Geometry (plate, prism, cylinder, others)
2. Specimen Size (ratio to fiber length)
3. Age and curing condition (sealed, unsealed, or water)
4. Boundary Conditions (fixed, hinged, etc.)
5. Strain rate
6. Casting direction & number of casting layers
7. Static or cyclic (including tension-compression or tension-zero)
8. Notch (with or without)
9. Deformation control or load control

4) Influencing Factors of Material
1. Mix Proportion (including fiber volume fraction)
2. Type of Fiber (including diameter, length, shape, etc.)
3. Admixture and Additives
4. Type and Maximum size of aggregates
5. Mixing condition and fiber dispersion
6. Air content

5) Bending Test and Inverse Analysis
1. Inverse Analysis by FEM
2. Moment vs. Curvature Curve Model
3. Nonlinear Hinge Model

Future Tasks:
1) Roundrobine Tests
The testing conditions and schedule will be drafted by V. Mechtcherine and they will be distributed to the members.

2) State-of-the-art Report
As the activities of RILEM TC, state-of-the-art report will be published. The topics and authors of chapters connected to the work of TGA were decided.