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Clarification of Deterioration Mechanism of Infrastructures and Development of Technology for Efficient Maintenance and Management through COE for Infrastructure Materials Research



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R&D Objectives and Subjects

Objectives

【Social Backgrounds】

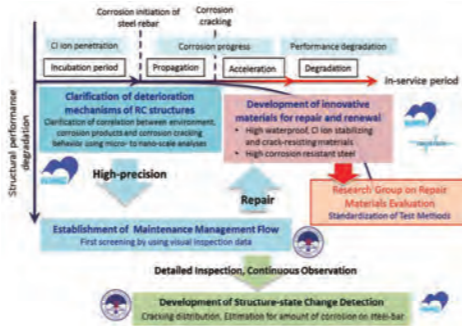
- It is necessary to develop an efficient maintenance and management flow to deal with a large stock of social infrastructures with a limited budgets and human resources in Japan.
- It is necessary to establish a feasible and highly accurate degradation diagnosis method as well as innovative repair technology.

【Purpose of Research & Development】

- Development of diagnostic technology with reduced labor, reduced cost and well-planned maintenance suitable for maintenance in local authorities.
- Fostering multi-disciplinary researchers/engineers who have a birds-eye view over materials and structures for the future.

Subjects

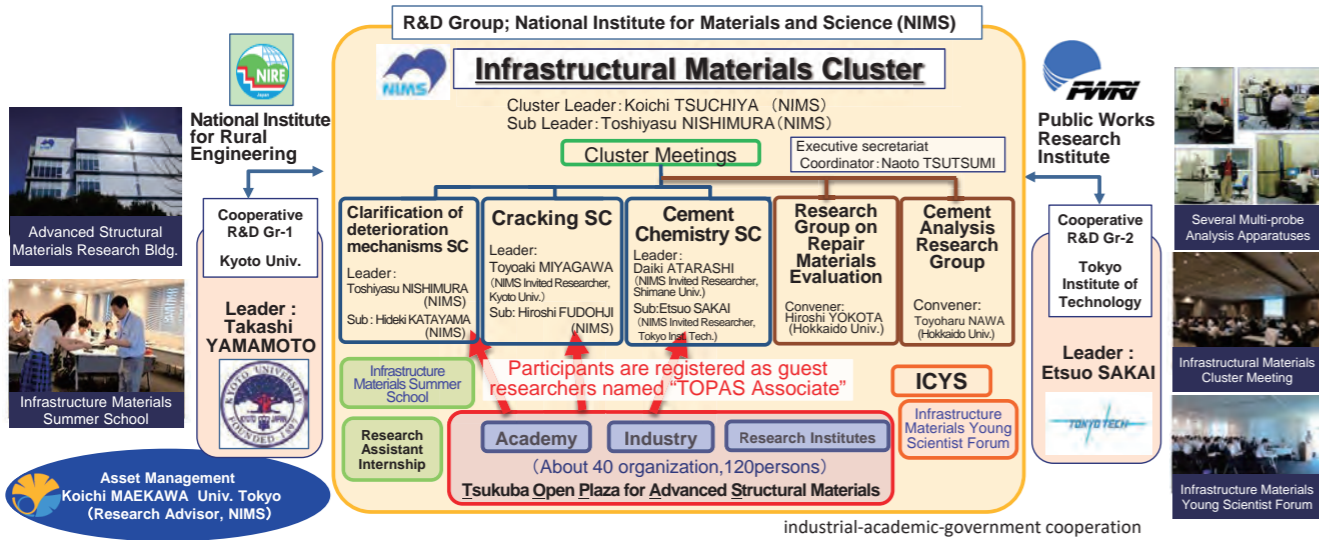
- Establishment of COE for infrastructural materials R&D to promote interdisciplinary collaboration, industrial - academic - government cooperation and human resource development.
- Clarification of deteriorating mechanisms in RC infrastructures.
- Improvement of remaining life assessment for infrastructures by clarification of the correlation between 1) environment in service, corrosion products and cracking or 2) concrete cracking and load capacity, using advanced inspection technologies, such as non-destructive evaluation and corrosion environment sensors, which have been cultivated in NIMS.
- Development of efficient repair materials and long-life materials as well as evaluation methods.



Current Accomplishments (1/4)

Consolidation to COE for infrastructural Materials R&D with industrial - academic - government cooperation

- About 30 researchers and engineers who belong to the "SIP-Social Infrastructure Materials Lab" and various analytical apparatus for infrastructural materials R&D are located in the Advanced Structural Materials Research Bldg.



- New industrial - academic - government cooperative group named "TOPAS" has been established to promote Infrastructural Materials R&D.
- "Infrastructural Material Cluster" (31 industries, 8 academic institutes or public labs, and 120 persons) plays an important role in the project, such as 1) information exchange, 2) several educational programs [young scientist forum, summer school, cluster seminars] and 3) discussion and investigation of cooperative R&D for social infrastructural implementation.

Current Accomplishments (2/4)

Clarification mechanisms & Application of NIMS seeds for Infrastructure Maintenance

Clarification of deterioration mechanisms in RC structures

Research seeds for fundamental research to clarify degradation mechanism and advanced technology for establishment of maintenance flow.

- A1-1 Advanced nano-scale analysis for corrosion product**
Orthogonal FIB/SEM: Suitable for 3D observation of corrosion morphology. Environmental SEM: Suitable for repairing materials for cement.
- A1-2 Accelerated corrosion test**
(Device development for accelerated supply of corrosion enhancing factors)
Rebar corrosion in concrete will be accelerated by more than 5 times by enhanced supply of a rate determining factor.
- A1-3 Monitoring of inner environment in concrete (pH and Cl)**
Development of new reference electrodes and data collection system. The corrosion starts after the environmental factors exceed threshold.

Development of efficient maintenance and renovation

Research seeds in validation or implementation phase by intense cooperation with universities, institutes and private companies through SIP.

- A1-5 High corrosion resistant steel**
Production of steel rebars which have mechanical property satisfying JIS standard. Evaluation in concrete structures. (Collaboration with Tokyo Univ.)
- A1-8 Water curing repair agent for concrete**
Start practical tests and mass production study with companies. Evaluation on concrete structures. (In collaboration with Kyoto Univ.)
- A3 scale coating**
Development of the corrosion environment monitoring system by cooperation with company (patent pending). Difference in corrosion environment is currently under investigation by corrosion monitoring of concrete model specimen in laboratory. Exposure tests have been conducted at more than 10 sites ranging from snowy cold region to tropical region. The databases for corrosion environment is currently enhanced by referring to literatures and various survey reports.
- A1-6 Strain imaging sheet to detect cracks in concrete**
Resistance test in environment (Collaboration with Public works research institute). Demonstration and performance evaluation (Collaboration with Nagasaki Univ.). Adhesion test for concrete (Collaboration with TOPAS member company).

Current Accomplishments (3/4)

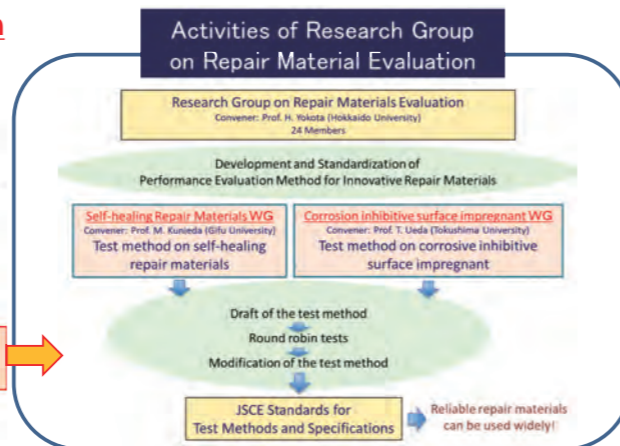
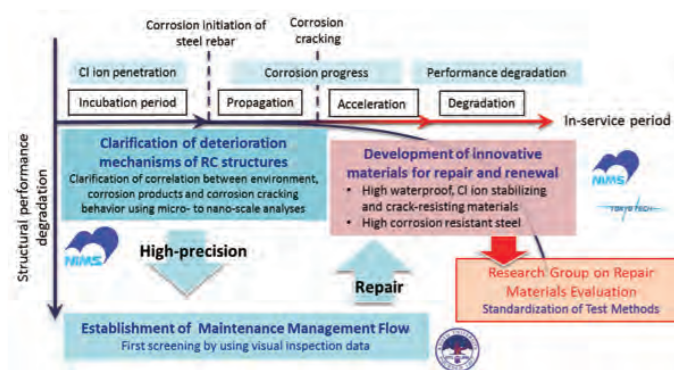
Establishment of new maintenance management flow (Kyoto University) & Development of repair materials and highly durable cement (Tokyo Institute of Technology)

The diagrams show the 'Establishment of Maintenance Management Flow' (first screening by visual inspection) and 'Development of innovative materials for repair and renewal' (high waterproof, Cl ion stabilizing, and crack-resisting materials). Specific accomplishments include:

- A2-2 Non-Destructive Testing (Kyoto University, NIMS)**: Identification of horizontal cracks of RC decks by means of AE tomography.
- A2-3 Preliminary assessment of structural capacity (Kyoto University)**: Framework for estimation of loading capacity using corrosive crack on concrete.
- A3-1 Cementitious materials having crack resistance and immobilization of Cl ion**: Selection of expansive additive (F-CaO, Ye'limite, C₂F, CaSO₄) and analysis of C₂F hydration.
- A3-2 Repair materials having the functionality of multibarrier**: LHC-CA₂-expansive additive (Exp) and EPMA analysis of immersed samples in artificial sea water.

Current Accomplishments (4/4)

Research Group on Repair Materials Evaluation



Self-healing Repair Materials WG

Development of a test method to evaluate water permeability

Substrate	Specimen thickness	Crack type	Crack width	Curing period	Head
Concrete	25 mm	Rough surface	0.2 mm	28 days	0.5 m
Mortar	50 mm	Smooth surface			1.0 m
	100 mm				

Examples of the crack type of substrate: (Rough surfaces), (Smooth surfaces)

Drafting a test method on water permeability of self-healing repair materials (2016 FY)

Water permeability test with a constant head

Corrosion Inhibitive Surface Impregnant WG

Preparation of RC specimens

Membrane curing

Treating with several kinds of surface impregnant

Electrochemical monitoring of steel corrosion in concrete

Initial content of Cl⁻ (kg/m³)

Half-cell potential (V vs. Ag/AgCl)

Corrosion rate (μA/cm²)

Corrosion rate (μA/cm²)

Elapsed time (days)

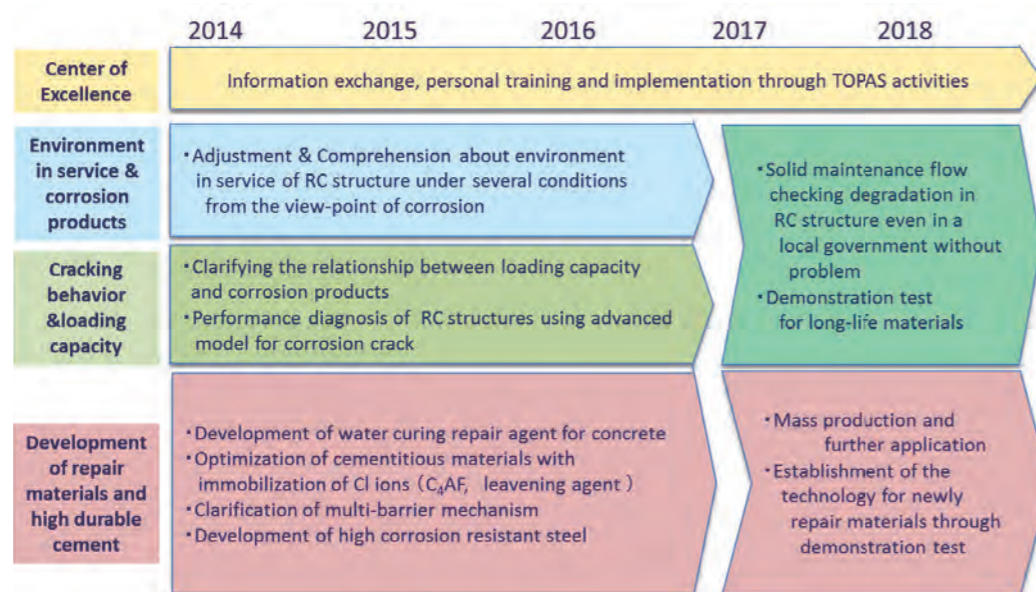
Evaluation on corrosion inhibitive effects

The test method will be prepared by analyzing data

Goals

Actual Reflection of R&D Results to the Society

Strong promotion at "Infrastructural Materials Cluster" to establish the high-efficient Maintenance Flow



- Establishment of a Core of Excellence for infrastructural materials in the SIP Project
 - Introduction of research facilities for R&D of infrastructural materials
- Sustainable network formation with industrial - academic - government cooperation
 - Co-production with infrastructural companies registered in TOPAS
- "Intellectual accumulation" concerning infrastructural materials
 - Cooperative R&D with Kyoto University, Tokyo Institute of Technology, University of Tokyo and other institutions
- Fostering great young talents to be future multi-disciplinary researcher/engineer