■R&D Topics : Structural Materials, Degradation Mechanisms, Repairs, and Reinforcement Technologies

■R&D Theme : Clarification of Deterioration Mechanism of Infrastructures and Development of Technology for Efficient Maintenance and Management through COE for Infrastructure Materials Research

■Principal Investigator : Koichi Tsuchiya (Director of RCSM, NIMS)

■Collaborative Research Groups : Kyoto University, Tokyo Institute of Technology

R&D Objectives and Subjects

SIP Cross-ministerial Strategic Innovation Promotion Program

Objectives

【Social Backgrounds】:

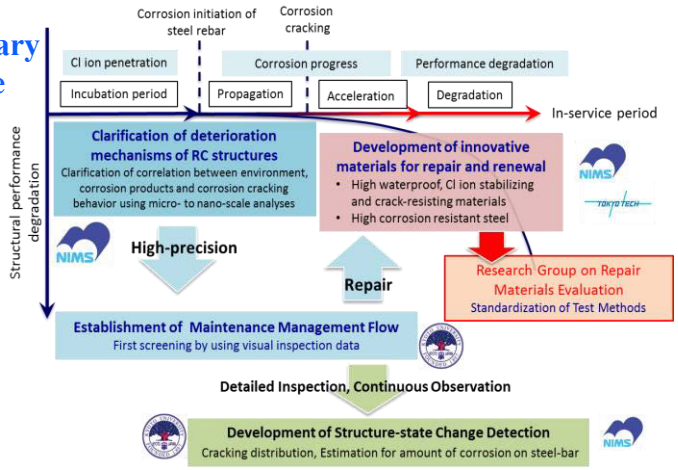
- It is necessary to develop an efficient maintenance and management flow to deal with a large stock of social infrastructures with a limited budgets and human resources in Japan .
- It is necessary to establish a feasible and highly accurate degradation diagnosis method as well as innovative repair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



Infrastructure Maintenance, Renovation, and Management

Current Accomplishments 1

SIP Cross-ministerial Strategic Innovation Promotion Program

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.

Advanced Structural Materials Research Bldg.

Infrastructure Materials Summer School

R&D Group; National Institute for Materials and Science (NIMS)

Infrastructural Materials Cluster

Cluster Leader : Koichi TSUCHIYA (NIMS)
Sub Leader : Toshiyasu NISHIMURA (NIMS)

National Institute for Rural Engineering

Public Works Research Institute

Cluster Debriefing

Cluster Meetings

Executive secretariat
Coordinator : Naoto TSUTSUMI

Cooperative R&D Gr-1
Kyoto Univ.
Leader : Toyoaki MIYAGAWA

Cooperative R&D Gr-2
Tokyo Institute of Technology
Leader : Etsuo SAKAI

Clarification of deterioration mechanisms SC
Leader: Toshiyasu NISHIMURA (NIMS)
Sub :Hideki KATAYAMA (NIMS)

Corrosion Cracking SC
Leader: Toyoaki MIYAGAWA (NIMS Invited Researcher, Kyoto Univ.)
Sub:Hiroshi FUDOHJI (NIMS)

Repairing Material SC
Leader: Etsuo SAKAI (NIMS Invited Researcher, Tokyo Inst. Tech.)
Sub:Masanobu NAITO (NIMS)

Research Group on Repair Materials Evaluation
Convener: Hiroshi YOKOTA (Hokkaido Univ.)

Infrastructure Materials Summer School

Participants are registered as guest researchers named "TOPAS Associate"

ICYS

Infrastructure Materials Young Scientist Forum

Research Assistant Internship

Academy | Industry | Research Institutes

(About 40 organization,120persons)

Tsukuba Open Plaza for Advanced Structural Materials

Asset Management
Koichi MAEKAWA Tokyo Univ.
(Research Advisor, NIMS)

構造材料つくばオープンプラザ
Tsukuba Open Plaza for Advanced Structural Materials

Several Multi-probe Analysis Apparatuses

Infrastructural Materials Cluster Meeting

Infrastructure Materials Young Scientist Forum

- New industrial - academic - government cooperative group named "TOPAS" has been established to promote Infrastructural Materials R&D.
- "Infrastructural Material Cluster" (40 industries, 6 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

SIP Cross-ministerial Strategic Innovation Promotion Program

Clarification mechanisms & Application of NIMS seeds for Infrastructure Maintenance

Clarification of deterioration mechanisms in RC structures

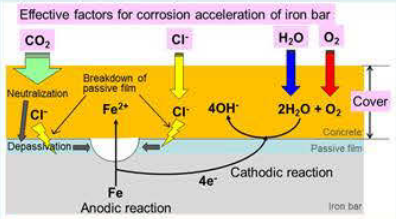
Research seeds for fundamental research to clarify degradation mechanism and advanced technology for establishment of maintenance flow .

Development of efficient maintenance and renovation

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

A1-1 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.

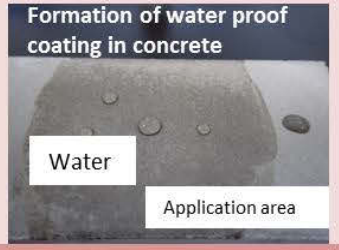


A1-2 Accelerated corrosion test (Device development for accelerated supply of corrosion enhancing factors)

Rebar corrosion in concrete will be accelerated by more than 5 times by enhanced supply of a rate determining factor.

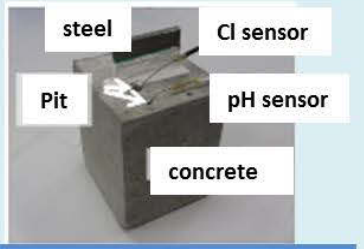
A1-5 High corrosion resistant steel

Production of steel rebars which have mechanical property satisfying JIS standard. Evaluation in concrete structures.
(**Collaboration with Tokyo Univ.**)



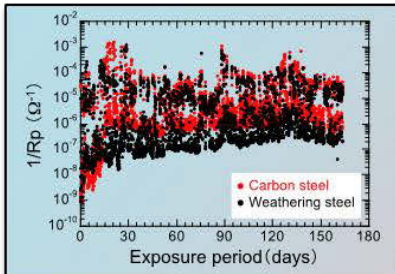
A1-8 Water curing repair agent for concrete

- Start practical tests and mass production study with companies
- Evaluation on concrete structures
(**In collaboration with Kyoto Univ.**)



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.



A1-4 Corrosion environment monitoring・corrosion environment map

- 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.

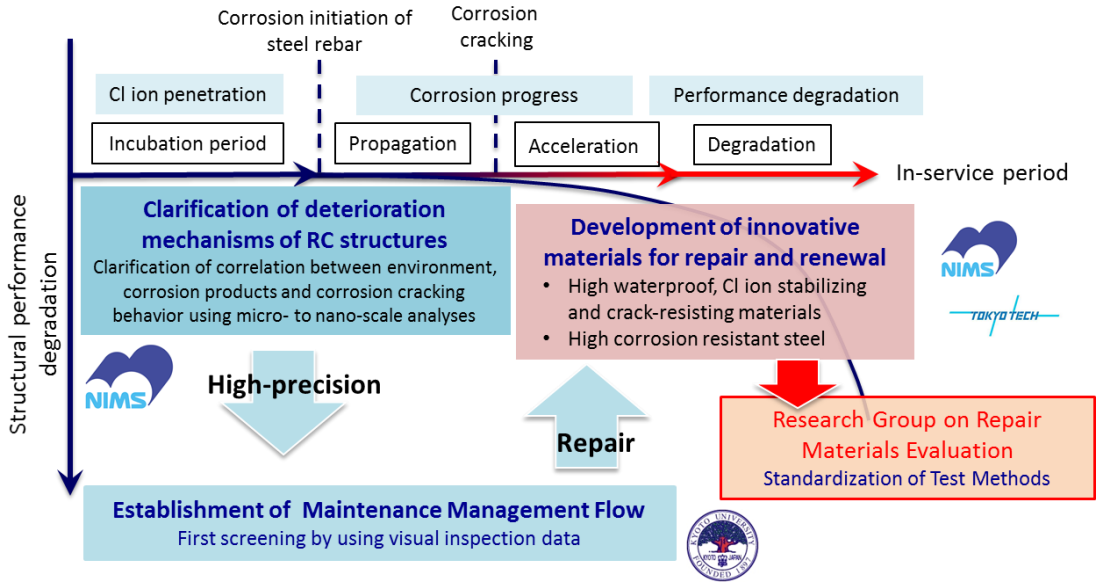
A1-6 Strain imaging sheet to detect cracks in concrete

- Resistance test in enviroment (Collaboration with Public works research institute)
- Demonstration and performance evaluation (Collaboration with Nagasaki Univ.)
- Adhision test for concrete (Collaboration with TOPAS member company)

Current Accomplishments 3

SIP Cross-ministerial Strategic Innovation Promotion Program

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



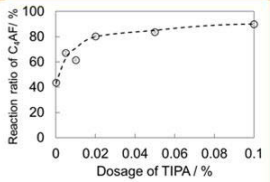
A3-1 Cementitious materials having crack resistance and immobilization of Cl ion

Selection of expansive additive

F-CaO	Ye'limite	C_4AF	$CaSO_4$
50	0	40	10

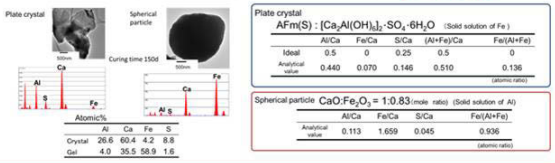
∗ Formation of AFm (Immobilization of Cl^-)

Acceleration of C_4AF hydration



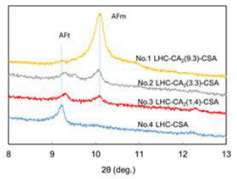
Analysis of C_4AF hydration

$C_4AF + CaSO_4 \cdot 2H_2O + nH_2O = C_3(AxFy)CaSO_4 \cdot 12H_2O + C(FxAy) \cdot nH_2O$



A3-2 Repair materials having the functionality of multibarrier

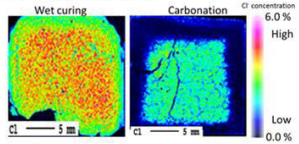
LHC-CA_2-expansive additive (Exp)

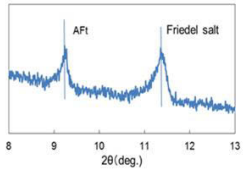


Hydrated products of LHC-CA_2-Exp

∗ Formation of AFm
∗ Protection of Cl^- penetration by carbonated layer
∗ Immobilization of Cl^- as Friedel's salt

EPMA analysis of immersed samples in artificial sea water



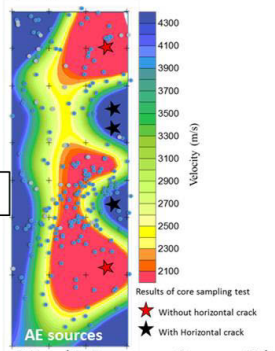


XRD pattern of inside sample

A2-2 Non-Destructive Testing (Kyoto University, NIMS)

Identification of horizontal cracks of RC decks by means of AE tomography

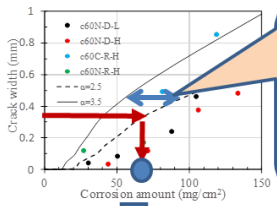
AE measurements → AE Tomography → AE source, Velocity → Identification of internal cracks



@ Hanshin Expressway Company Ltd.

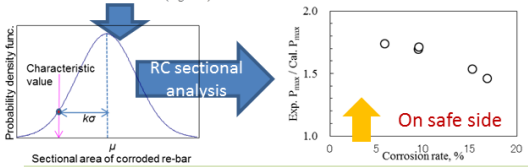
Evaluation of internal damages of RC
Evaluation of corrosion of steel bars or ASR in RC

A2-3 Preliminary assessment of structural capacity (Kyoto University)



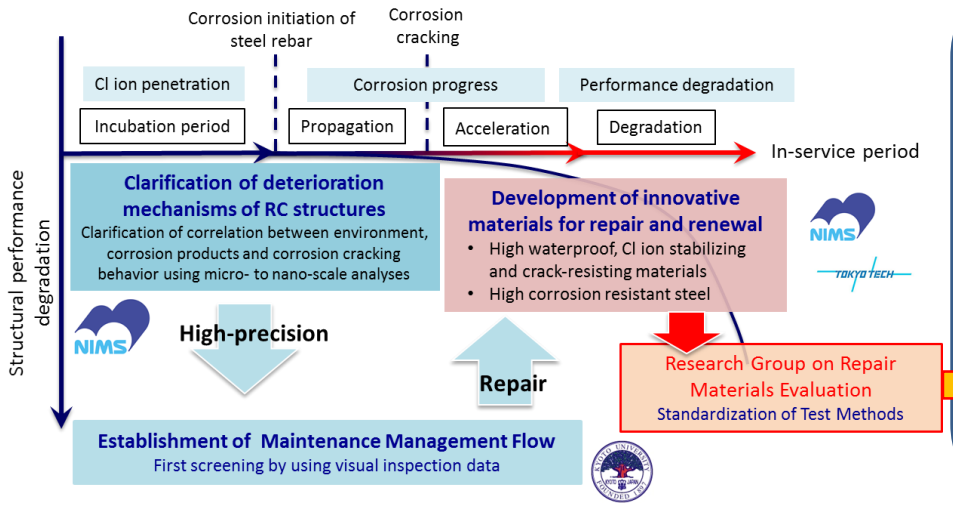
Considering generation condition of corrosion product

e.g. condition	Generation condition	Volumetric expansion ratio
	Relatively dry environment	Around 3.1 (g-FeOOH)



Framework for estimation of loading capacity using corrosive crack on concrete

Research Group on Repair Materials Evaluation



Activities of Research Group on Repair Material Evaluation

Research Group on Repair Materials Evaluation
Convener: Prof. H. Yokota (Hokkaido University)
24 Members

Development and Standardization of Performance Evaluation Method for Innovative Repair Materials

Self-healing Repair Materials WG	Corrosion inhibitive surface impregnant WG
Convener: Prof. M. Kunieda (Gifu University)	Convener: Prof. T. Ueda (Tokushima University)
Test method on self-healing repair materials	Test method on corrosive inhibitive surface impregnant

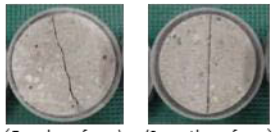
Draft of the test method
Round robin tests
Modification of the test method

JSCE Standards for Test Methods and Specifications → Reliable repair materials can be used widely!

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 Mortar	25 mm 50 mm 100 mm	Rough surface Smooth surface	0.2 mm	28 days	0.5 m 1.0 m



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

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

Water permeability test with a constant head

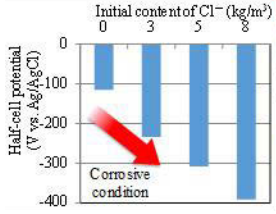
Corrosion Inhibitive Surface Impregnant WG

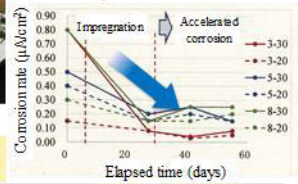
Preparation of RC specimens

Membrane curing

Treating with several kinds of surface impregnant

Electrochemical monitoring of steel corrosion in concrete

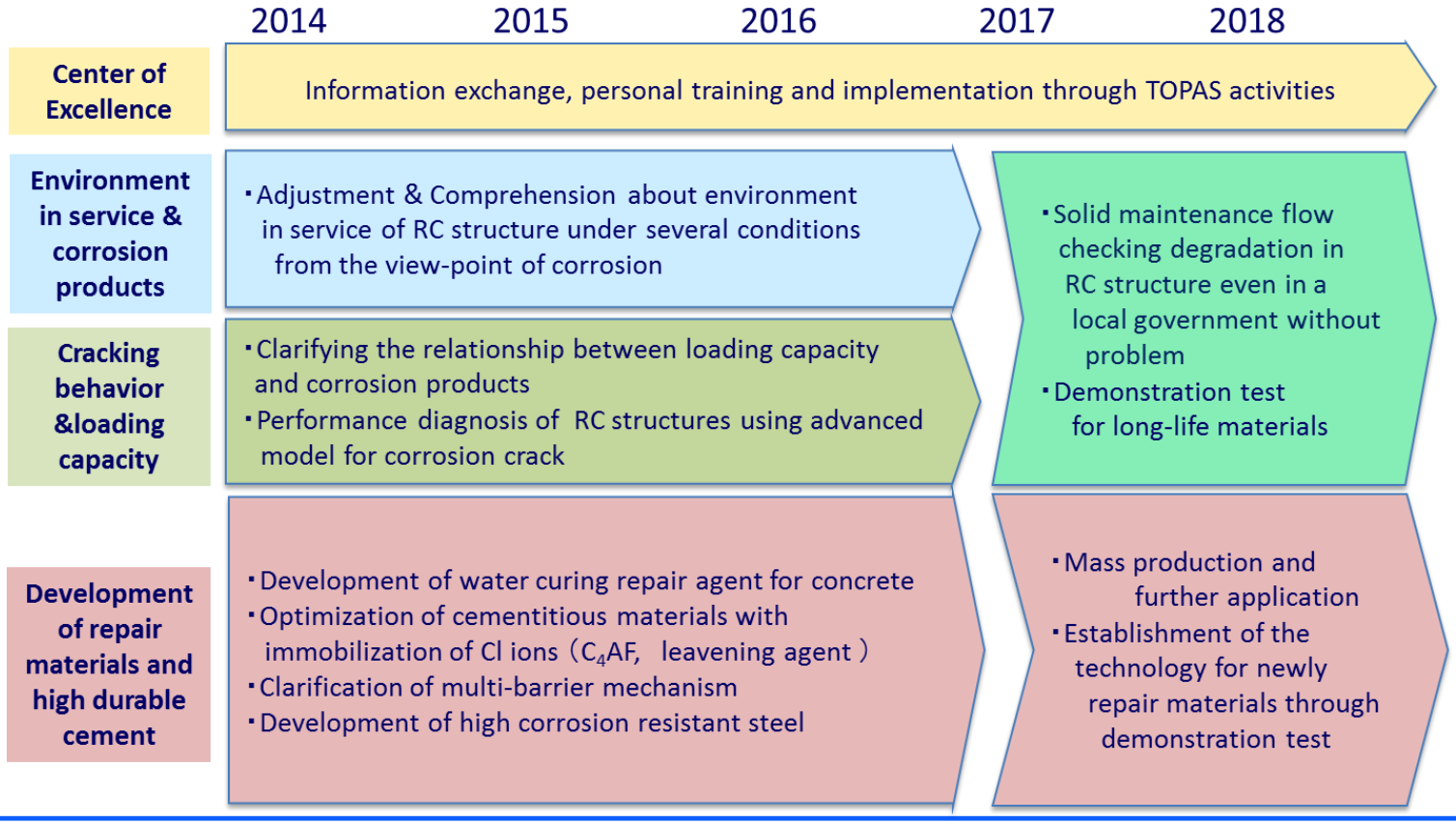




Evaluation on corrosion inhibitive effects

The test method will be prepared by analyzing data

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



- **Establishment of a Core of Excellence for infrastructure 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**