Experimental Study on Deterioration Characteristics of Partially Repaired RC Slabs under Freezing-Thawing and Fatigue Combined Action

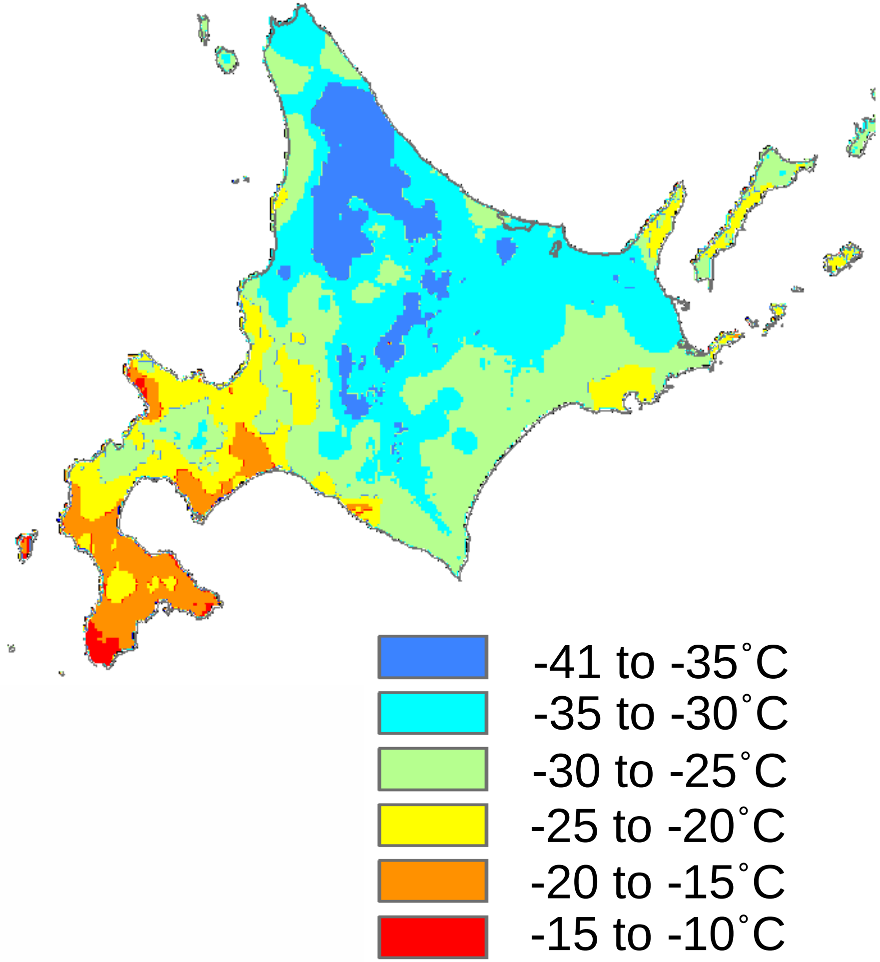
- **Ko KAKUMA**
- Researcher
- Civil Engineering Research Institute for Cold Region
- kakuma@ceri.go.jp

S. OKADA, S. OMOTE and H. NISHI
Senior Researcher, Researcher, Team Leader
Civil Engineering Research Institute for Cold Region

0. CONTENT

1. INTRODUCTION

INTRODUCTION



Severe environment brings unique damage to structures.

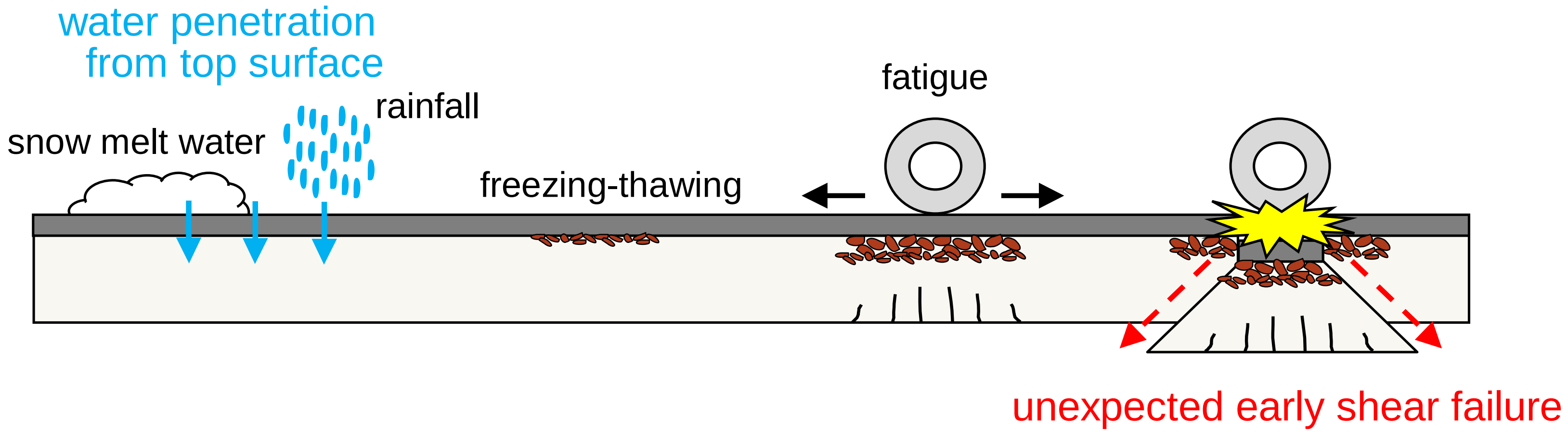
INTRODUCTION

Unpredicted failure

Upper damage

Upper damage is unique damage modes in Hokkaido.

Combination of freezing-thawing and fatigue actions



- To extend fatigue life, a systematic repair method for upper damaged RC slabs should be developed.
- This study experimentally investigates the influence of cold temperature on fatigue behavior of RC slabs with or without upper repair.

2. TEST PROCEDURE

FATIGUE TEST

Wheel load running test

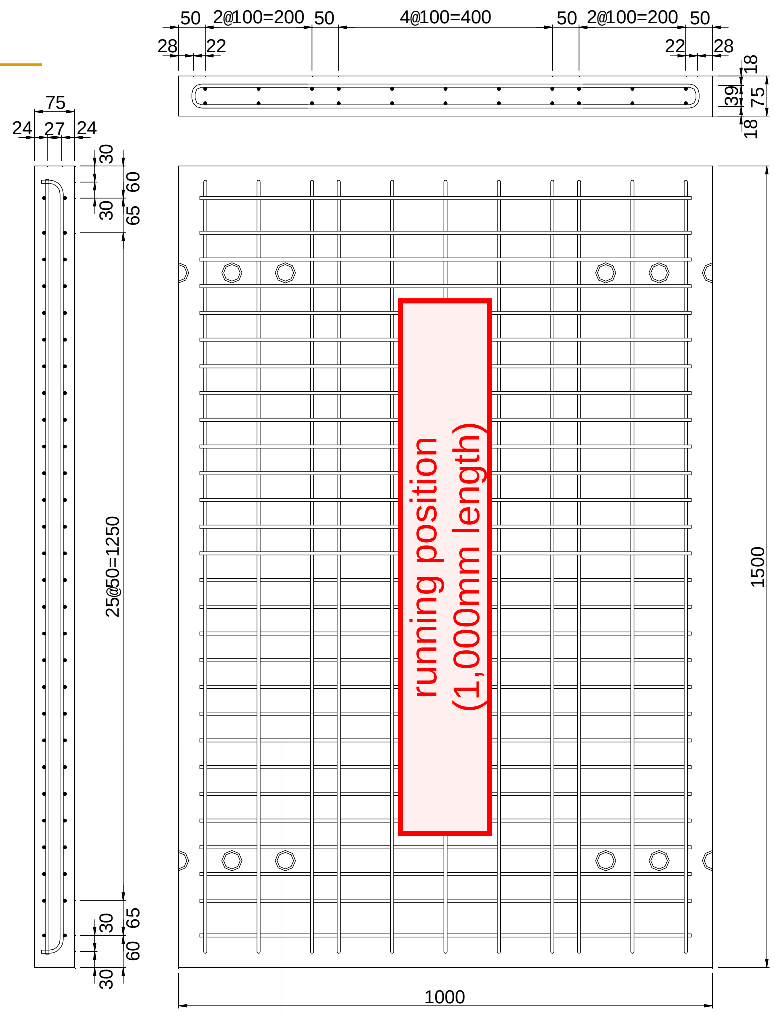
TEST SPECIMEN

List of specimens

Specimen	Repair	Environment
1	No	Dry
2	No	Frozen
3	Yes	Frozen

Geometric properties of specimens

List	Properties	
Shape	1,500 x 1,000 x 75mm	
Reinforcement	SR235	
Arrangement	main	Φ6@50 mm
	distribution	Φ6@100 mm



Reinforcement arrangement

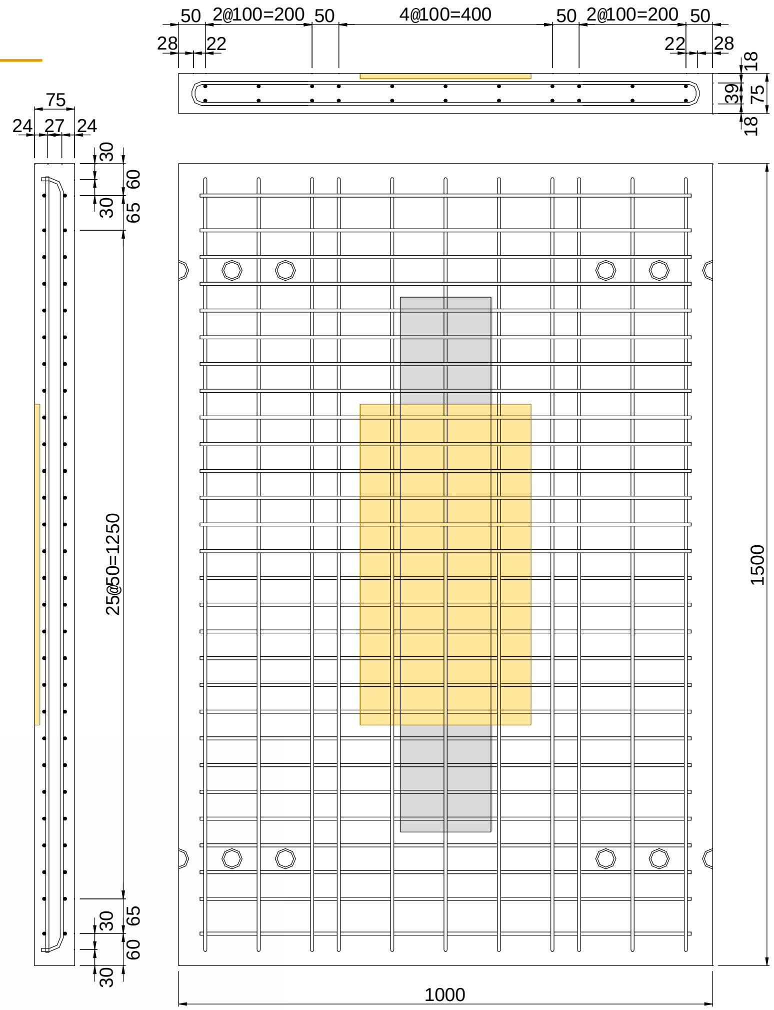
REPAIR METHOD

Specifications of repair part

List	Properties
Shape	600 x 320 x 10 mm
Material	Ultra rapid hardening concrete

1. manufacturing sound RC slab specimen without repair part
2. making a depression by water jet chipping
3. backfilling the depression by repair material

Repair flow



Position of repair part

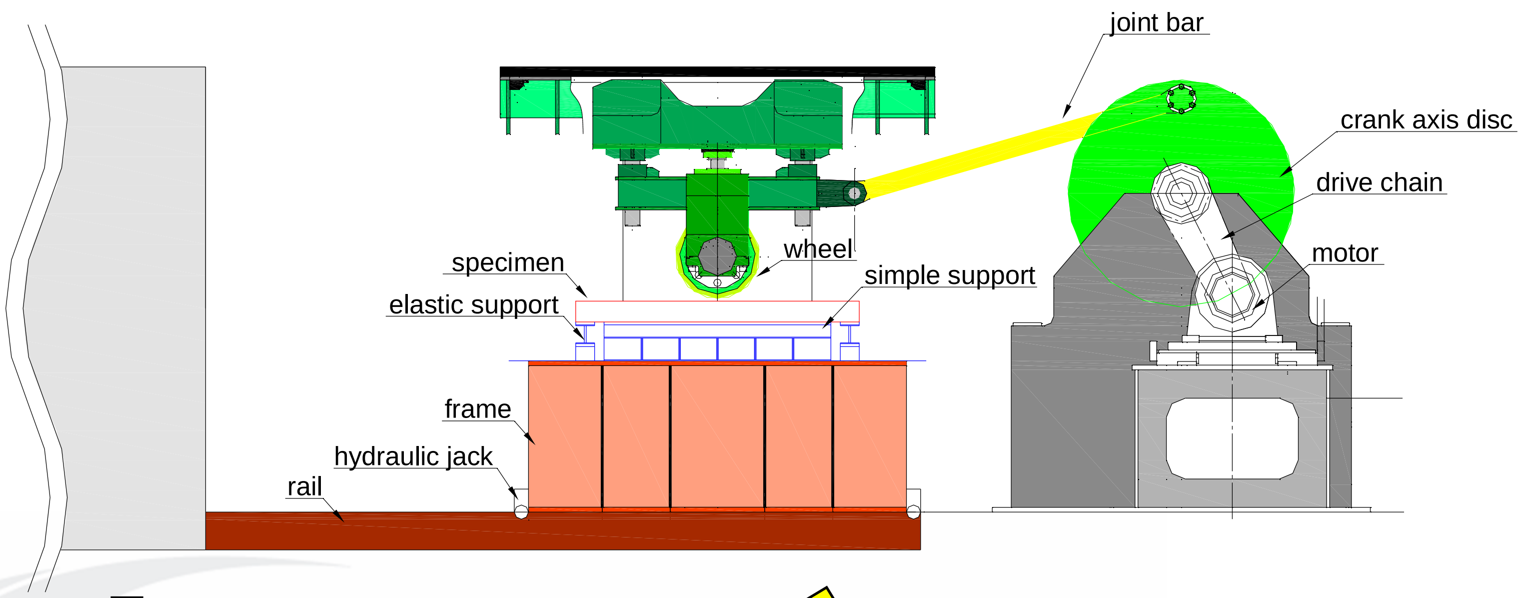
MATERIAL PROPERTIES

Specimen	No.1	No.2	No.3
Compressive strength of slab concrete (N/mm^2)	36.2	37.7	40.4
Young's modulus of slab concrete (kN/mm^2)	30.9	31.4	34.1
Compressive strength of repair material (N/mm^2)	–	–	50.2
Young's modulus of repair material (kN/mm^2)	–	–	27.2
Yield strength of reinforcement (N/mm^2)	337		
Young's modulus of reinforcement (kN/mm^2)	200 (design value)		

EXPERIMENTAL INSTALLATION

Freezing room

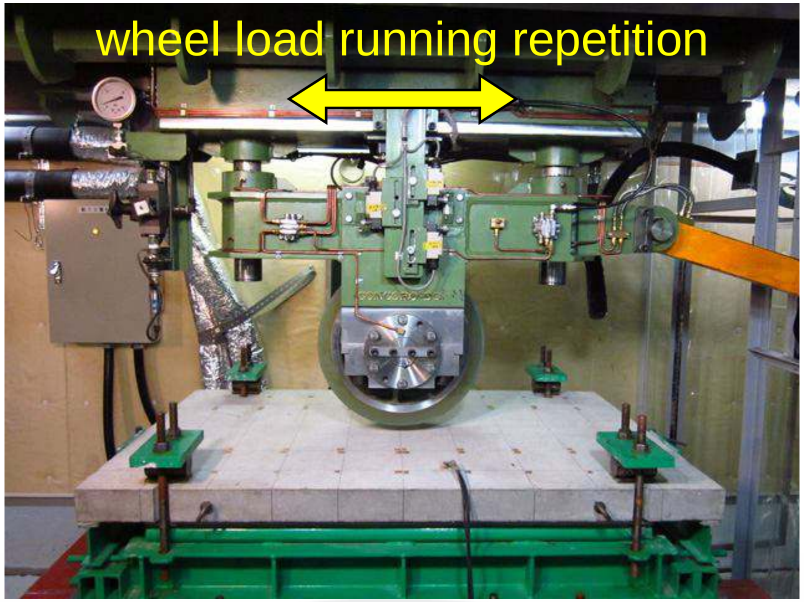
Wheel load running machine



Internal air can be cooled down to -20˚C.

Repetition of moving load reproduces damage-failure process of RC slabs.

WHEEL LOAD RUNNING MACHINE



Specifications of test machine

running	load	10 to 40 kN
	range	1,000 mm
	speed	24 round trips/min (48 cycles/min)
wheel	material	urethane
	outer diameter	480 mm
	width	170 mm

- Rotation of crank disc supplies power of wheel running.
- Hydraulics continuously applies wheel load on a specimen.

TEST PROGRAM

Freezing

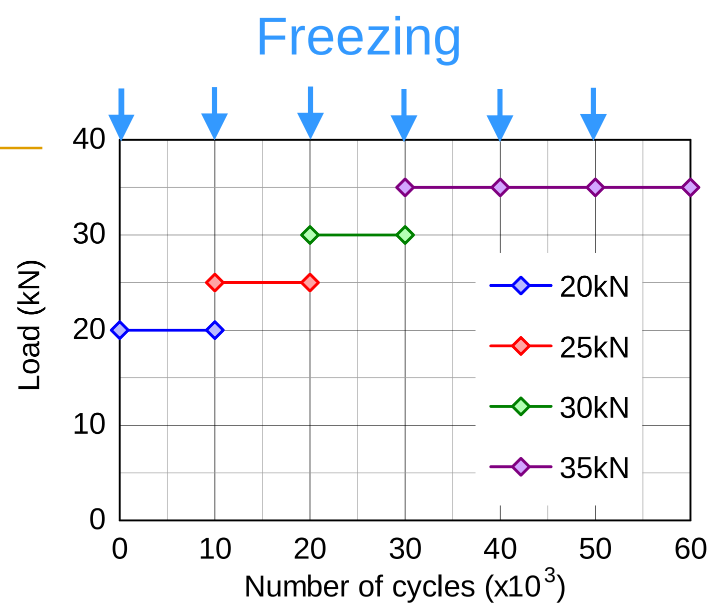
freezing specimen down to -18˚C

↕ repeating every 10,000 running cycles until failure

Wheel load running

stepwise increase loading program

- Freezing and fatigue actions are alternately applied, not simultaneously.
- Specimens are frozen down to -18˚˚C every 10,000 cycles.



Equivalent number of cycles

$$N_{eq} = \sum \left(\frac{P_i}{P} \right)^m N_i$$

N_{eq} : Equivalent number of cycle

P_i : Fatigue load (kN)

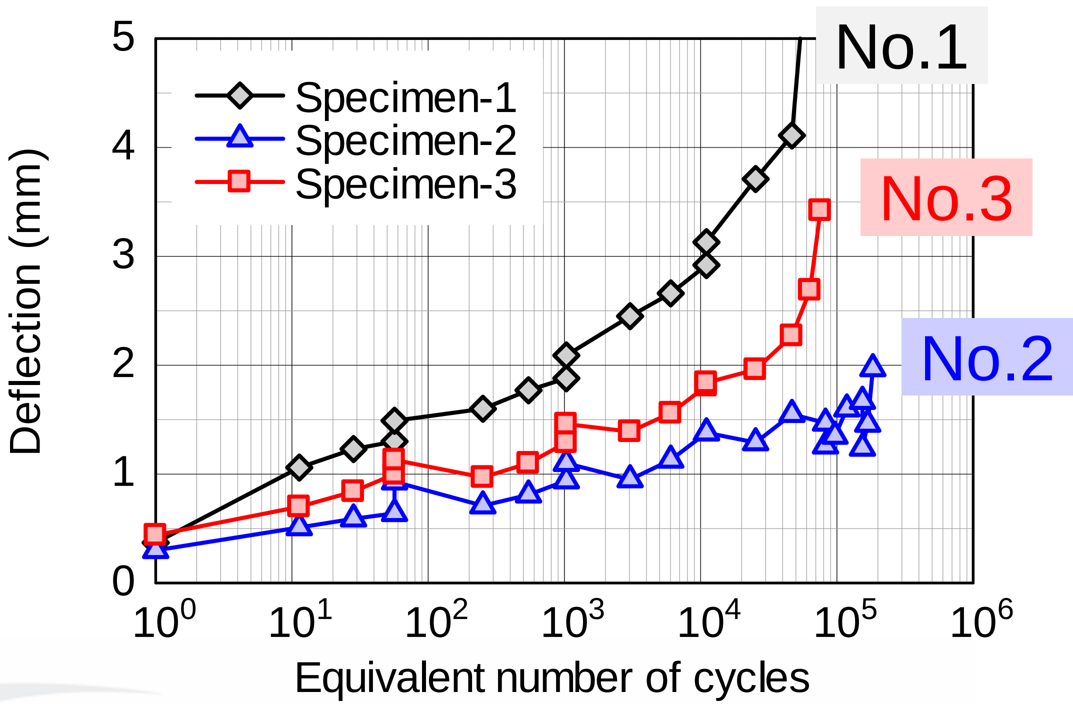
P : Imposed load (kN) (=30kN)

m : Slope of S-N diagram (=12.7)

N_i : Number of cycles under P_i

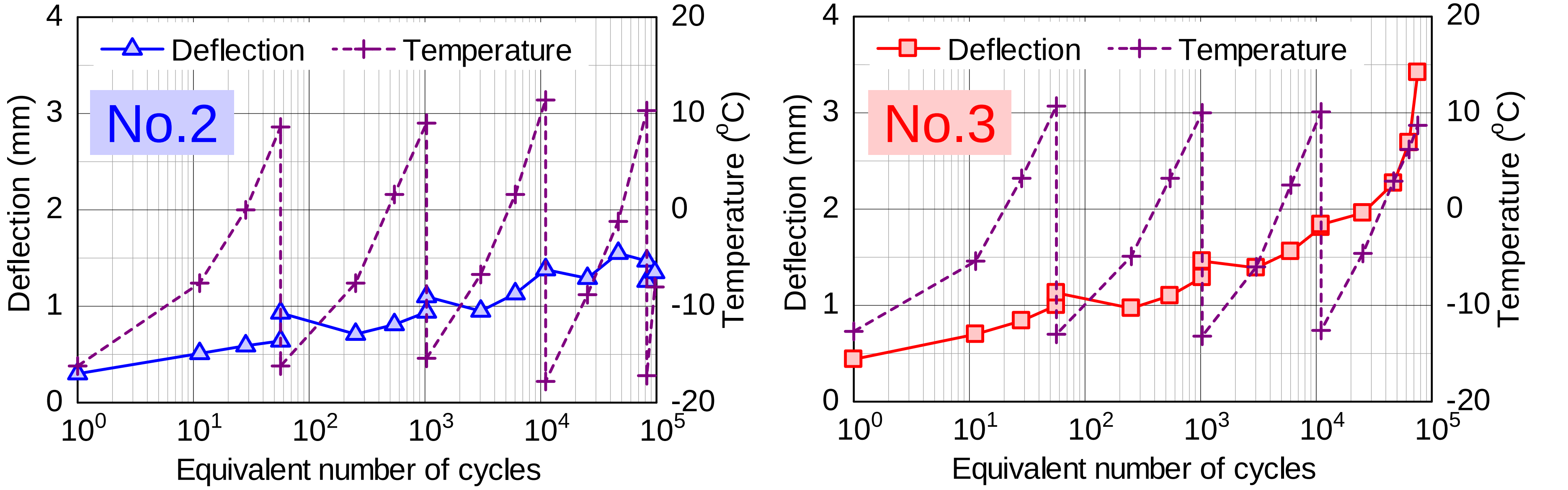
3. RESULTS AND DISCUSSIONS

DEFLECTION CHANGE



- No.1 shows rapid increase in deflection after gradual and stepwise increasing.
- No.2 and No.3 show serrated shape deflection change at the smaller deflection level than No.1.

TEMPERATURE CHANGE DURING RUNNING

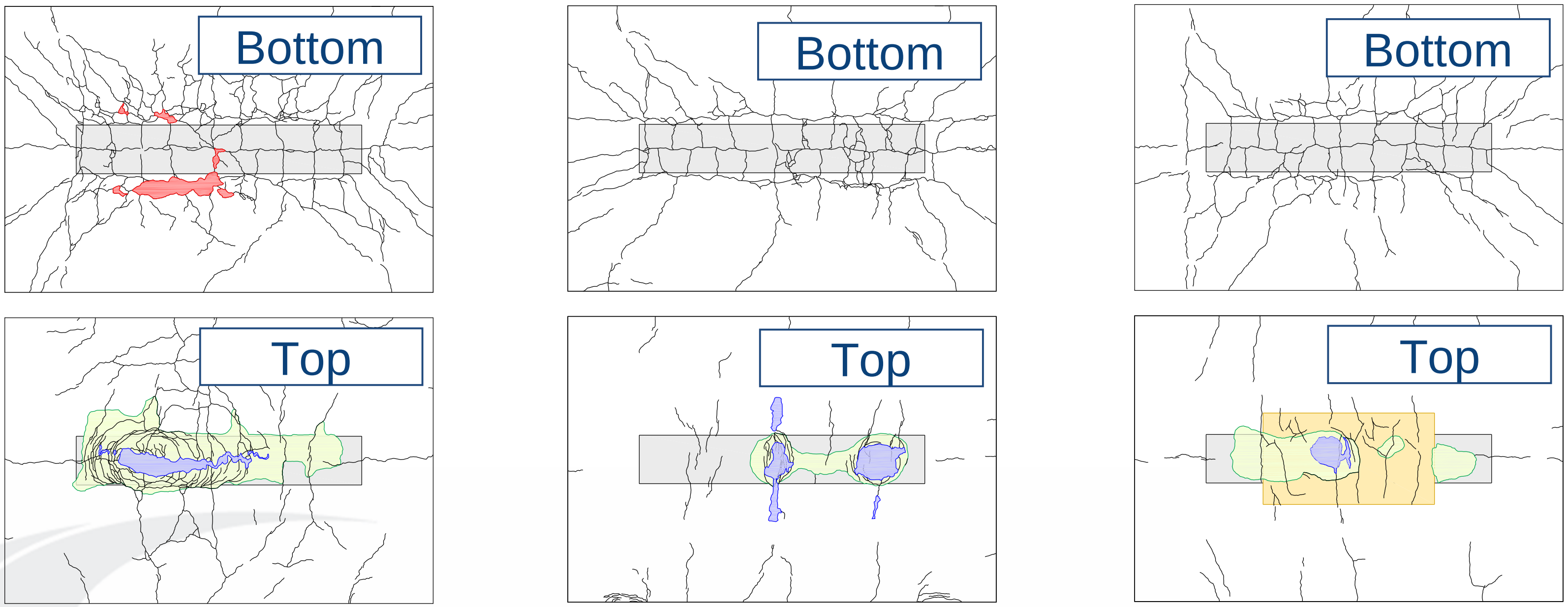


- Deflection went up and down subjected to temperature condition.
- Frozen environment improved apparent slab stiffness and prevented fatigue deterioration from developing.

DAMAGE CONDITION

- Separation of aggregate
- Falling of cover concrete
- Debonding of cover concrete
- Repair part
- Running position

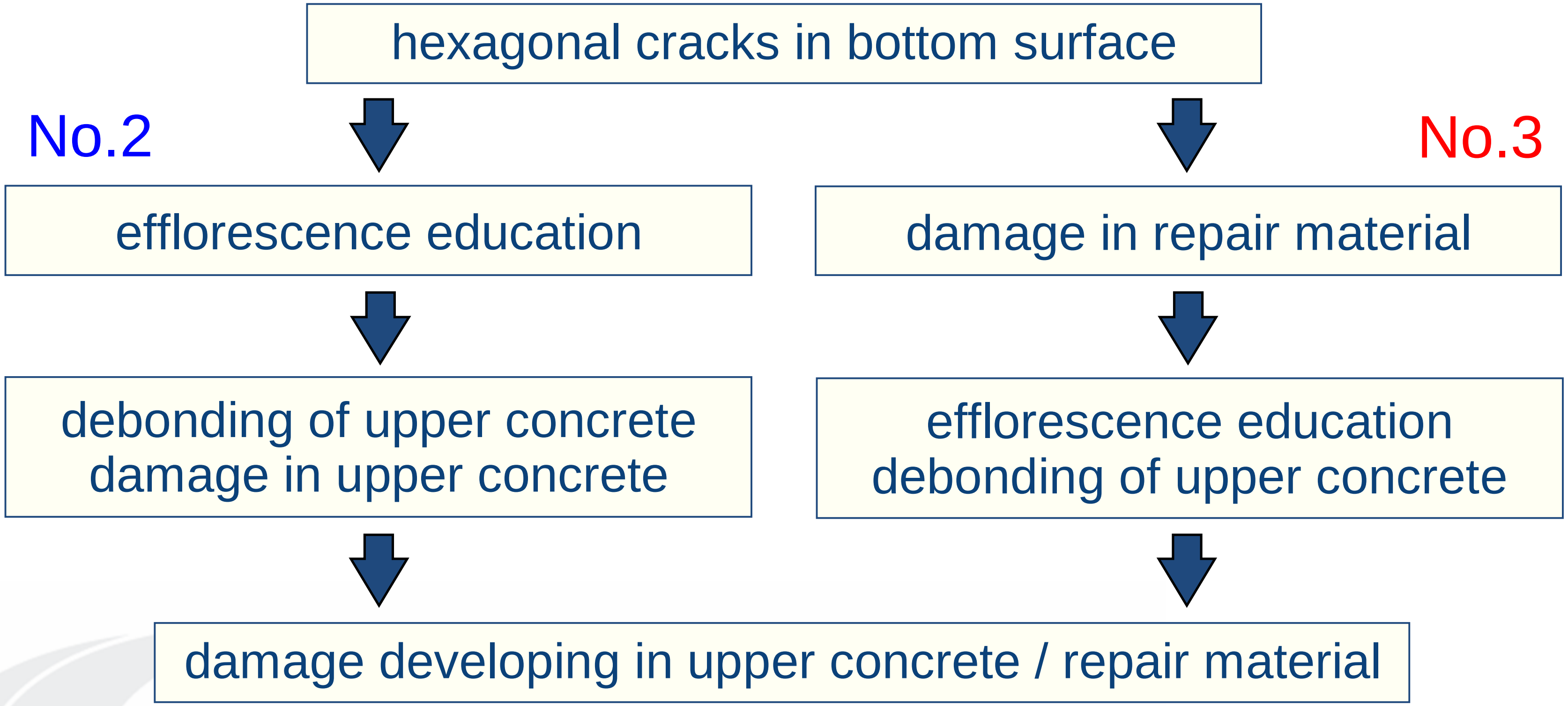
No.1 | No.2 | No.3



continuous upper damage

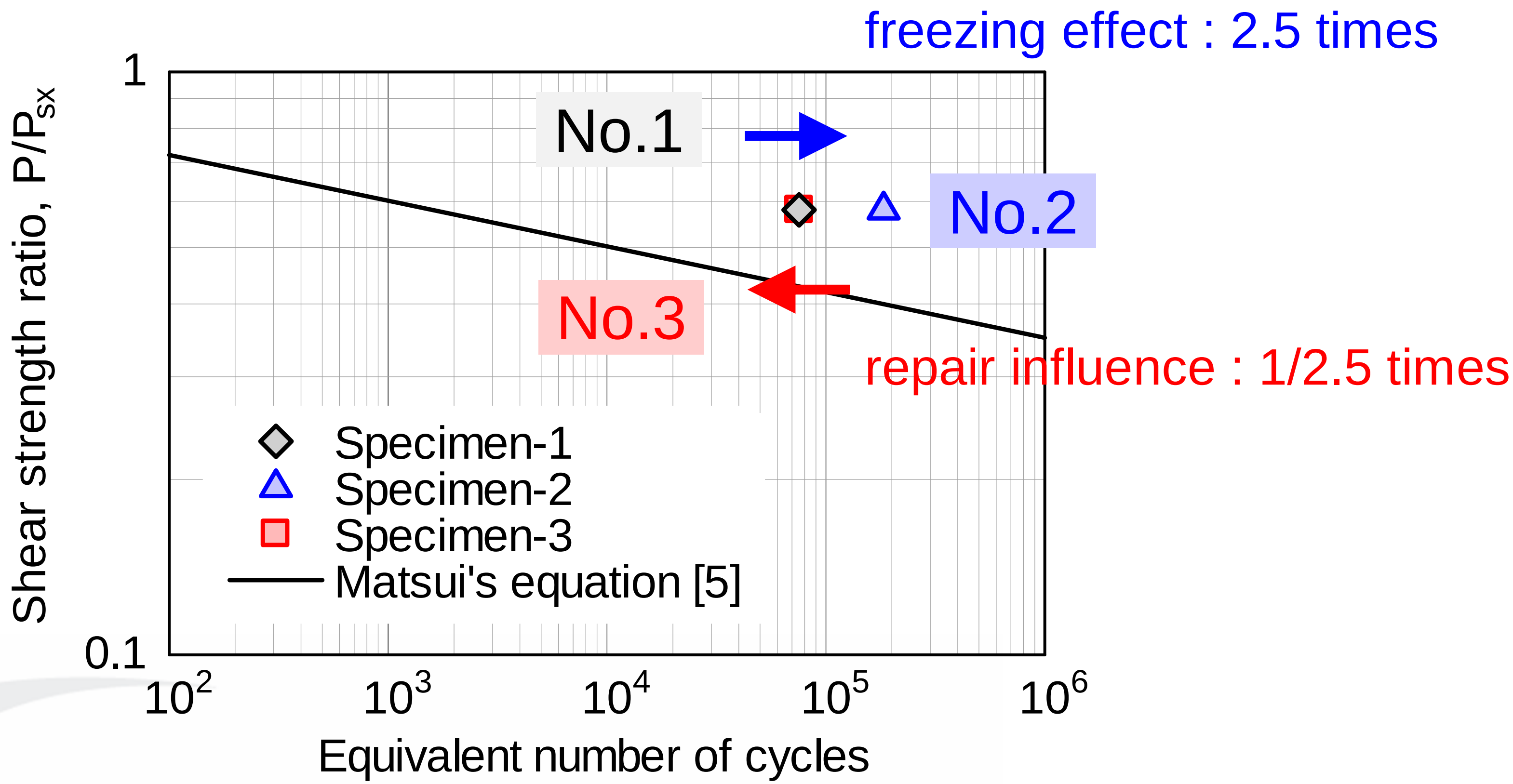
Separated upper damage

DAMAGE PROCESS



- In No.3, damage of repair material initiated prior to efflorescence educating.

FATIGUE LIFE



- Frozen environment might bring fatigue life extension.
- Repair material with low frost damage resistance affect fatigue durability.

4. CONCLUSIONS

CONCLUSIONS

- Under cold temperature, apparent increase in slab stiffness under negative temperature improved fatigue durability and extended fatigue life of RC slabs.

- Using low durable materials against frozen environment to upper repair decreased slab thickness earlier and resulted in bringing smaller repair effect in cold environment.

- In the future studies, the influence of material deterioration due to long-term freezing-thawing cycles on fatigue durability will be evaluated.