Current Status of Bridge Maintenance in Korea

(ACECC TC-28 Meeting in Feb. 2024)

Changsu Shim
Chung-Ang University
Korea

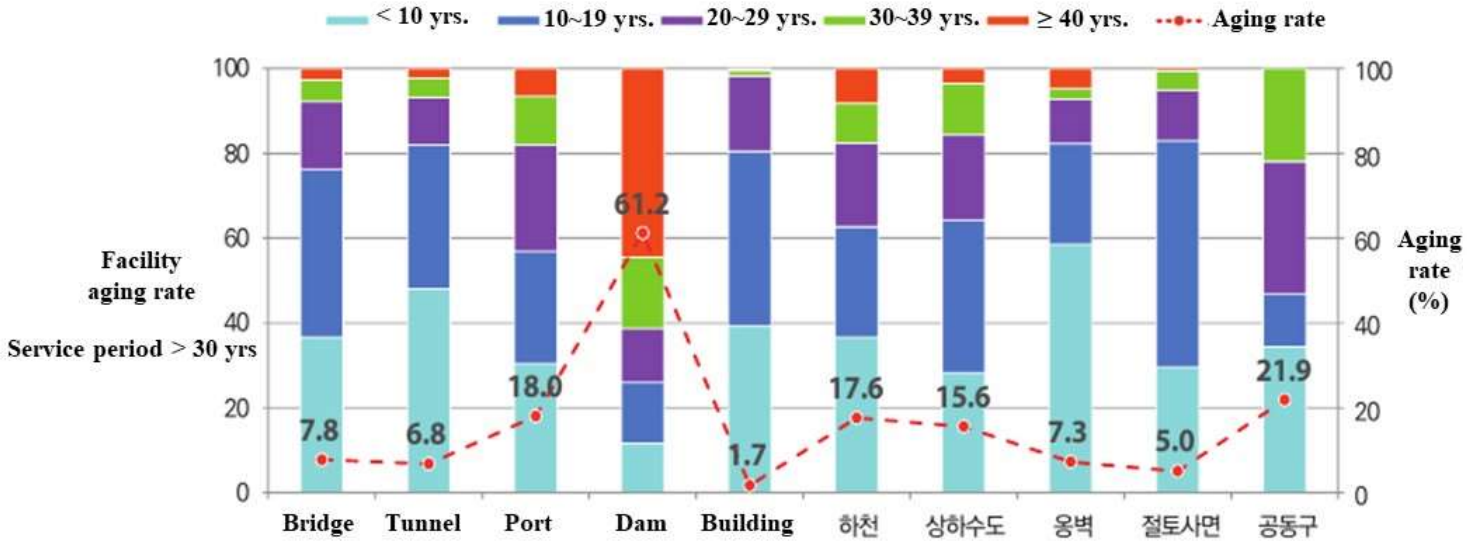
For a Better Quality of Life

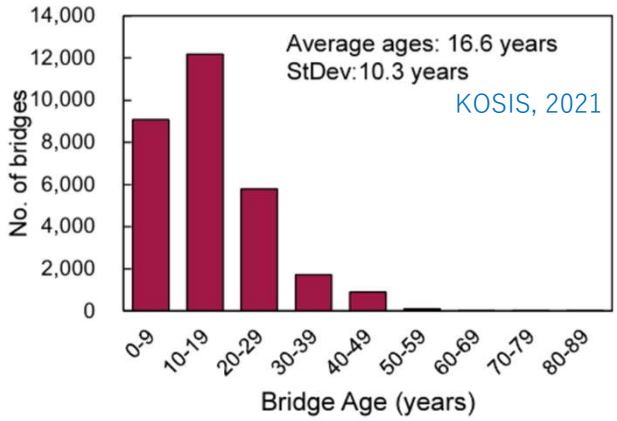
http://www.acecc-world.org/

Outline

1. Recent issues of bridge maintenance in Korea
2. Load tests for common bridges
3. SHM for cable-supported bridges
4. Member-based Data for Bridges
5. Digitalization of Maintenance task
6. Issues of Bridge Maintenance in Korea

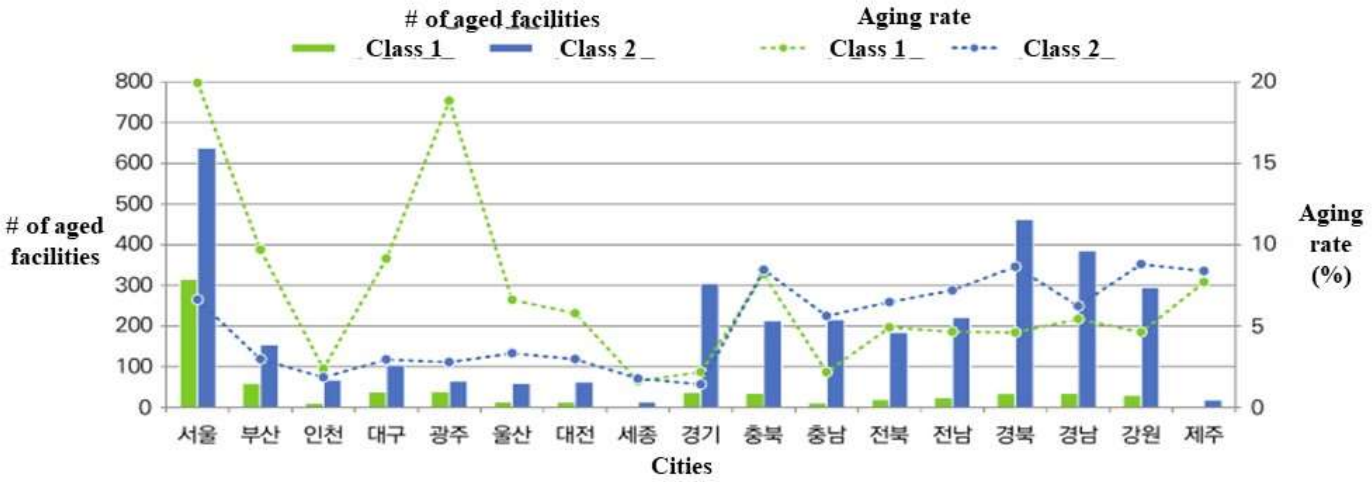
Recent issues of bridge maintenance in Korea





Total # of bridges: 35,902

Length: 3,666,802 m



Recent issues of bridge maintenance in Korea

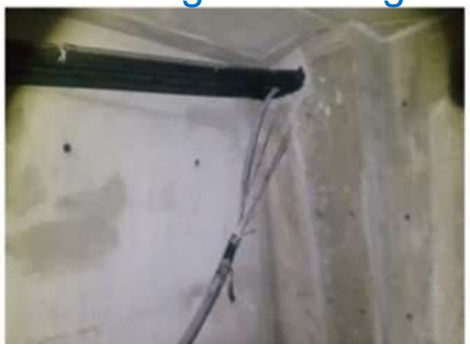
- **Deterioration causing member failure & casualty**

Pavement ➔ cracking ➔ deterioration of concrete ➔ pull-out due to lack of bonding ➔ Failure of the cantilever part

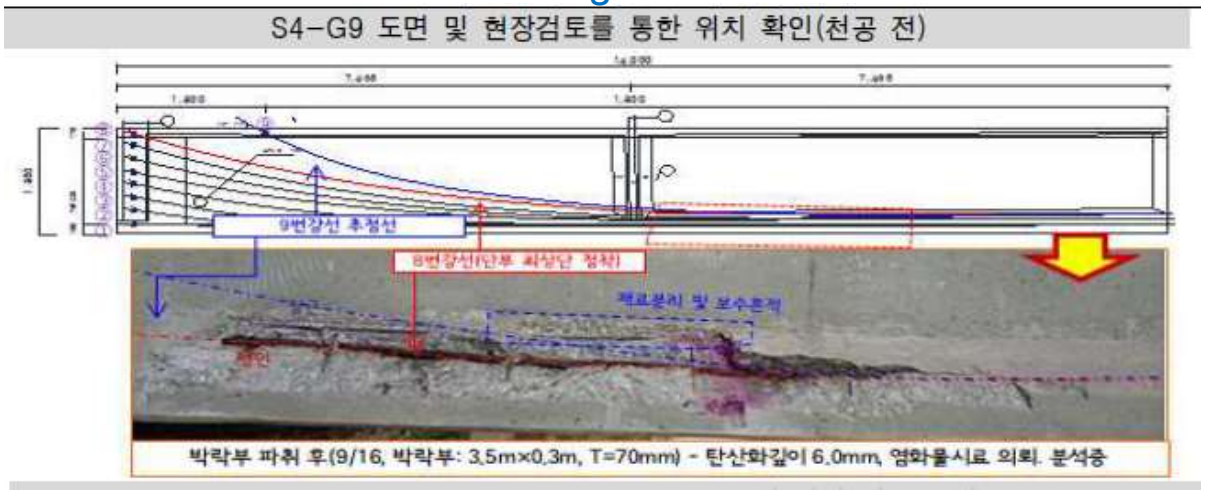
Failure by corrosion of reinforcement

Recent issues of bridge maintenance in Korea

- Safety Issue due to Hidden Damages of Bridges

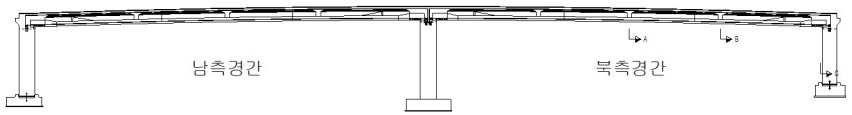
- New Process and Technologies are needed.



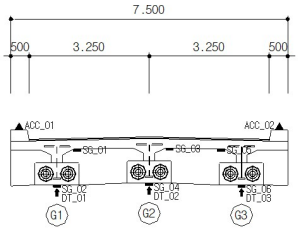


Load tests for common bridges

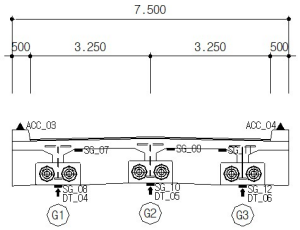
- Load test setup



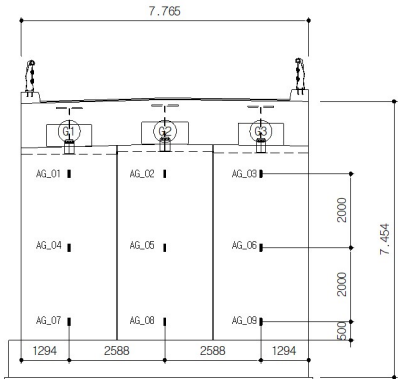
A-A 단면



B-B 단면



C-C 단면



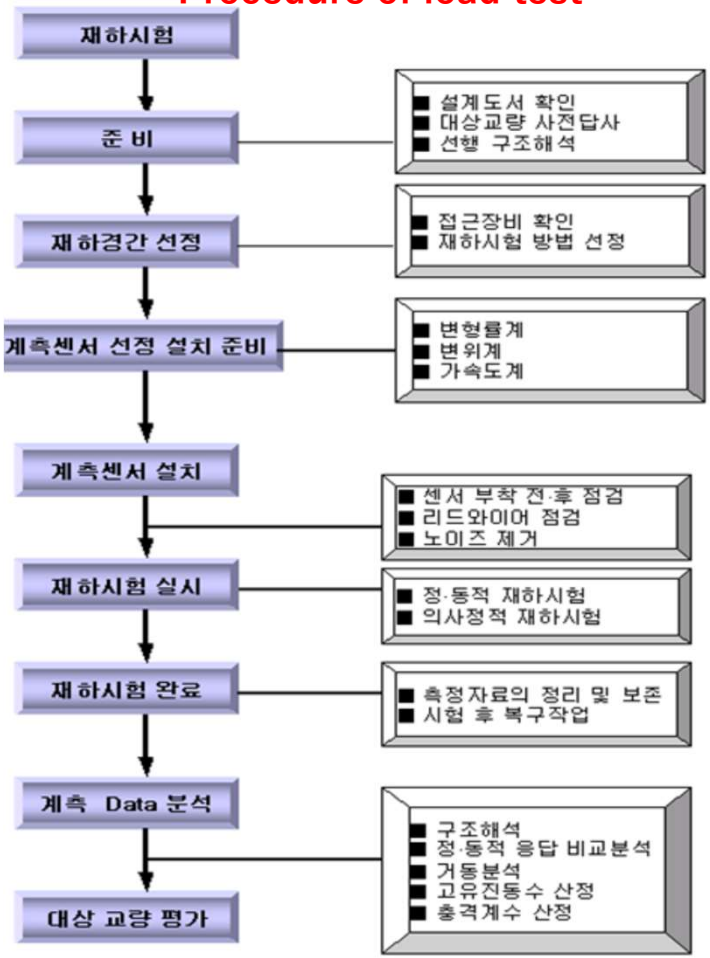
Static test

- stiffness
- load distribution
- stress
- deflection

Dynamic test

- impact factor
- natural frequency

Procedure of load test



Load tests for common bridges

- Load test setup

Load test at night

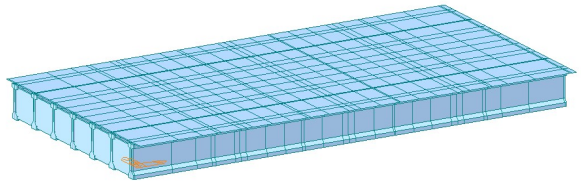
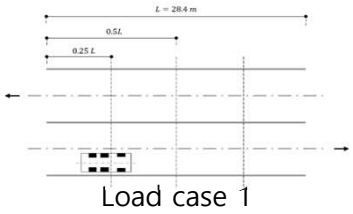


Plate-frame model

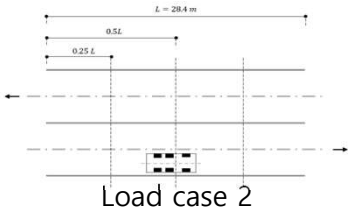
Assessment

$$P = K_s \times RF \times P_r$$

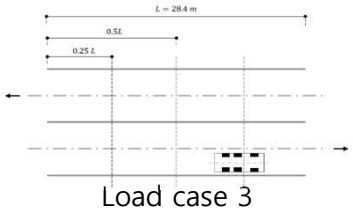
$$RF = \frac{\phi M_n - \gamma_d M_d}{\gamma_l M_l (1+i)}$$



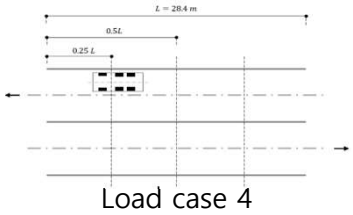
Load case 1



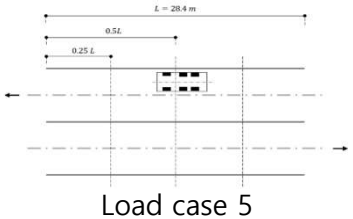
Load case 2



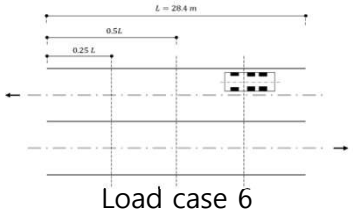
Load case 3



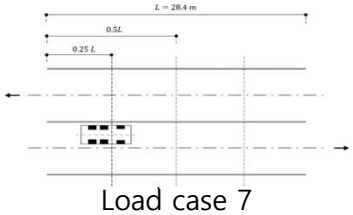
Load case 4



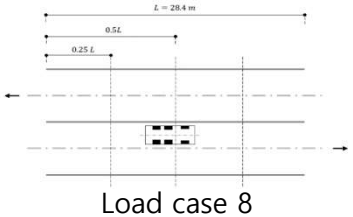
Load case 5



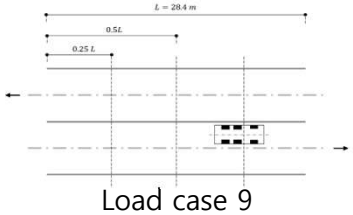
Load case 6



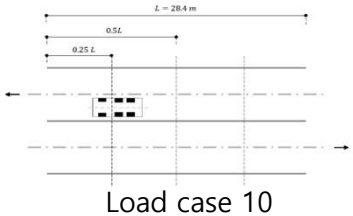
Load case 7



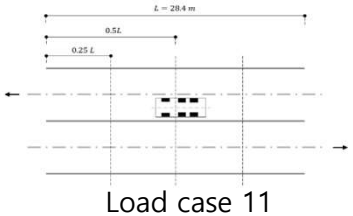
Load case 8



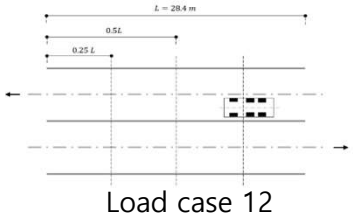
Load case 9



Load case 10



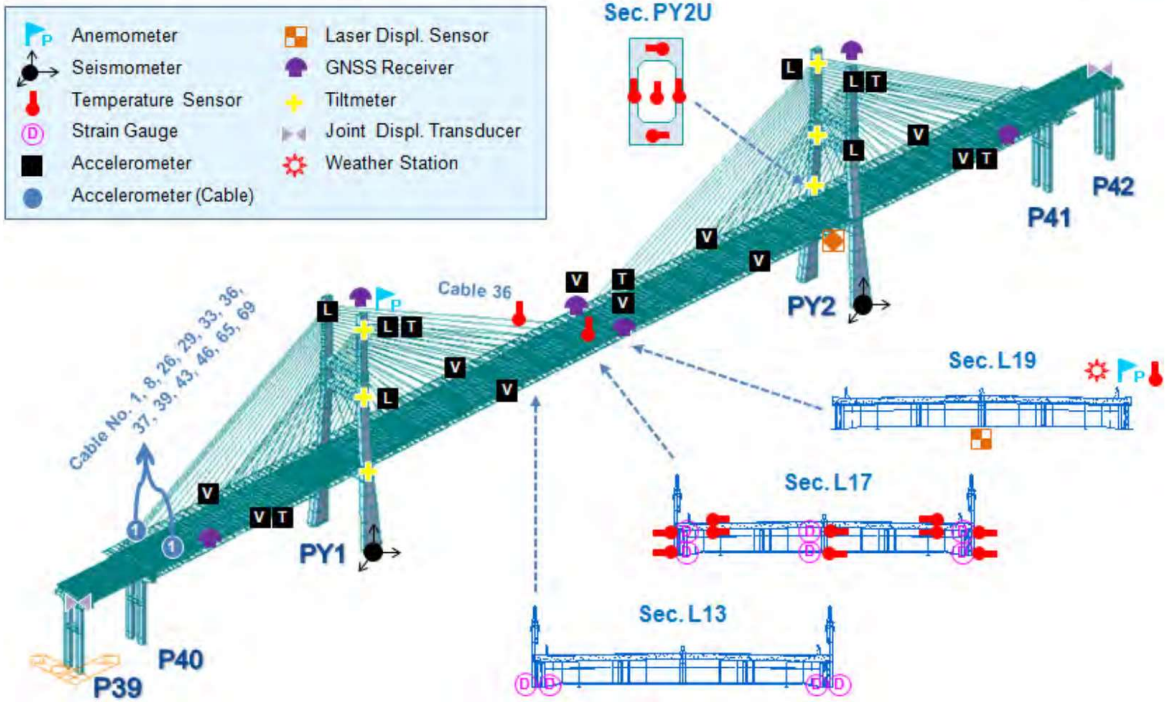
Load case 11

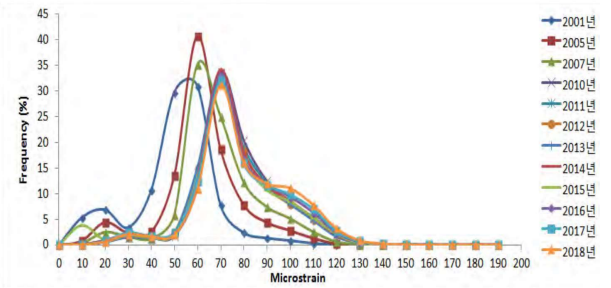


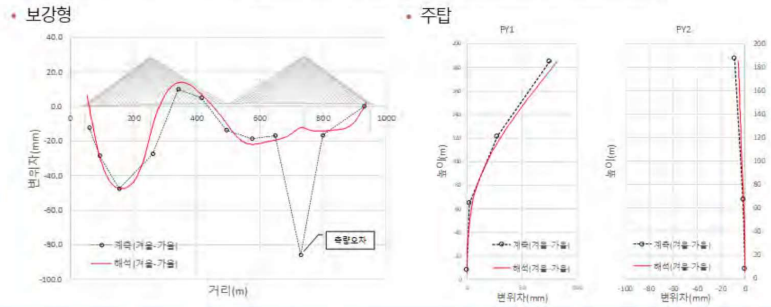
Load case 12

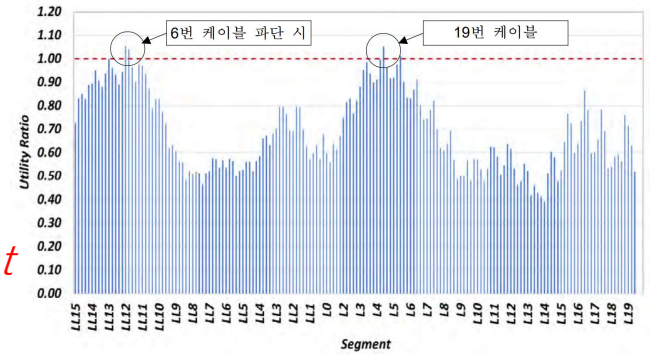
SHM for cable-supported bridges

- SHM: new generation SHM





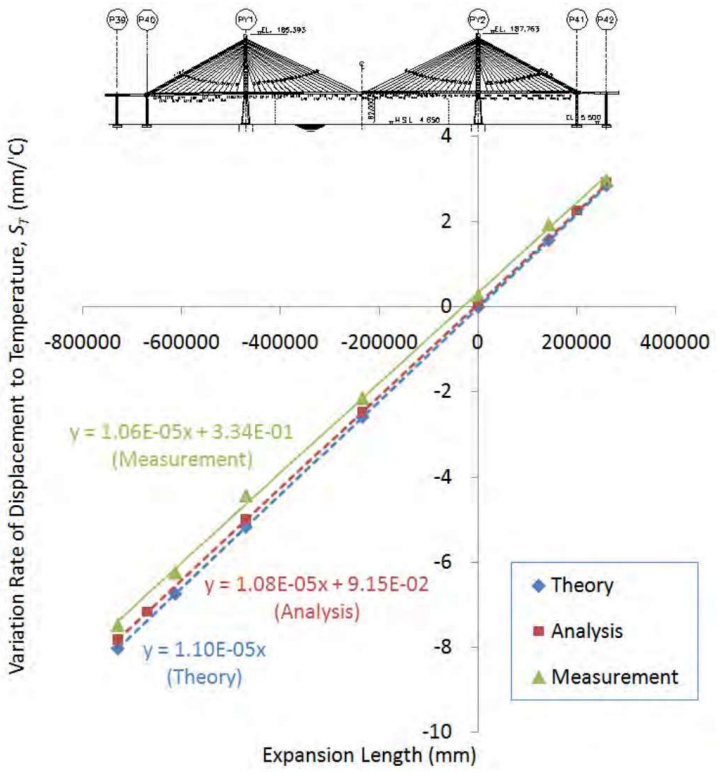


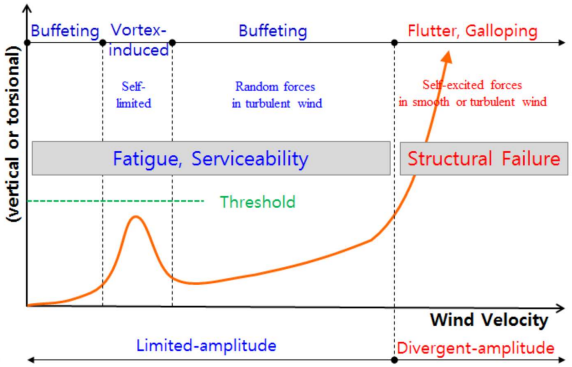


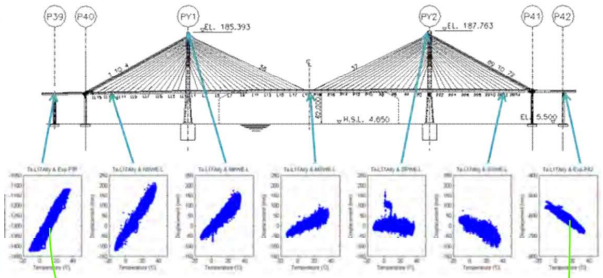
- maintenance decisions are based on SHM data➔ design improvement

SHM for cable-supported bridges

- SHM: Data source for DTM, Resilient bridge strategy







위 치		EXP-P39 (P39)	NSWE-L (North Span)	NPWE-L (PY1)	MSWE-L (Mid Span)	SPWE-L (PY2)	SSWE-L (South Span)	EXP-P42 (P42)
L (m)		-730	-613	-470	-235	0	143	260
S_T (mm/℃)	이 론	-8.030	-6.743	-5.170	-2.585	0	1.573	2.860
	해 석	-7.827	-6.557	-5.000	-2.467	0.067	1.642	2.927
S_m	계 측	-7.487	-6.225	-4.380	-2.099	0.399	1.981	3.020
$(S_m-S_i)/S_i$ 오차(%)		-6.8	-7.7	-15.3	-18.8	-	25.9	5.6

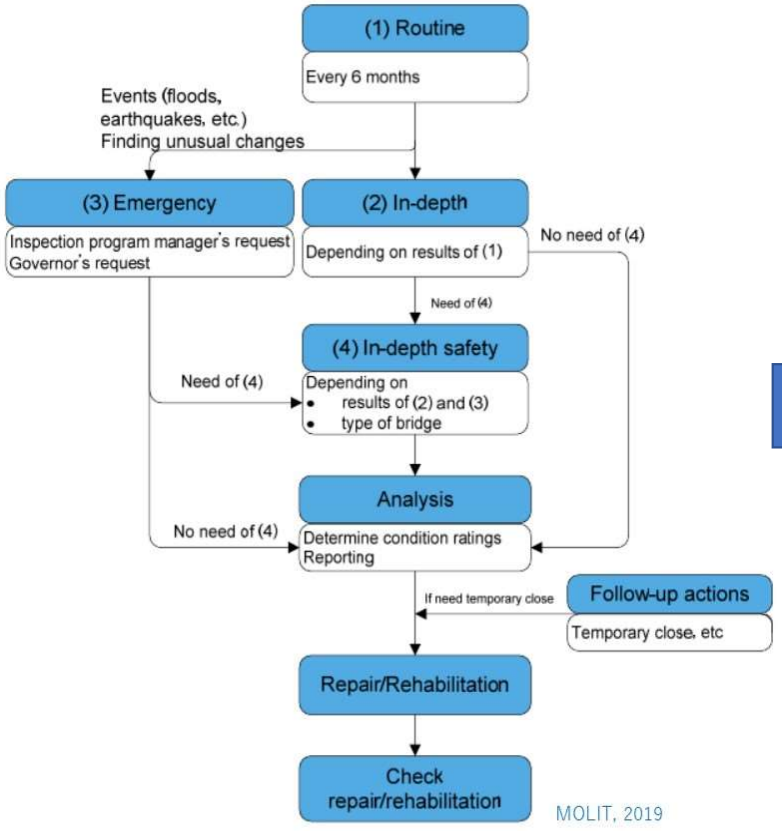
Note: Applying α=0.000011 in case of theory and analysis

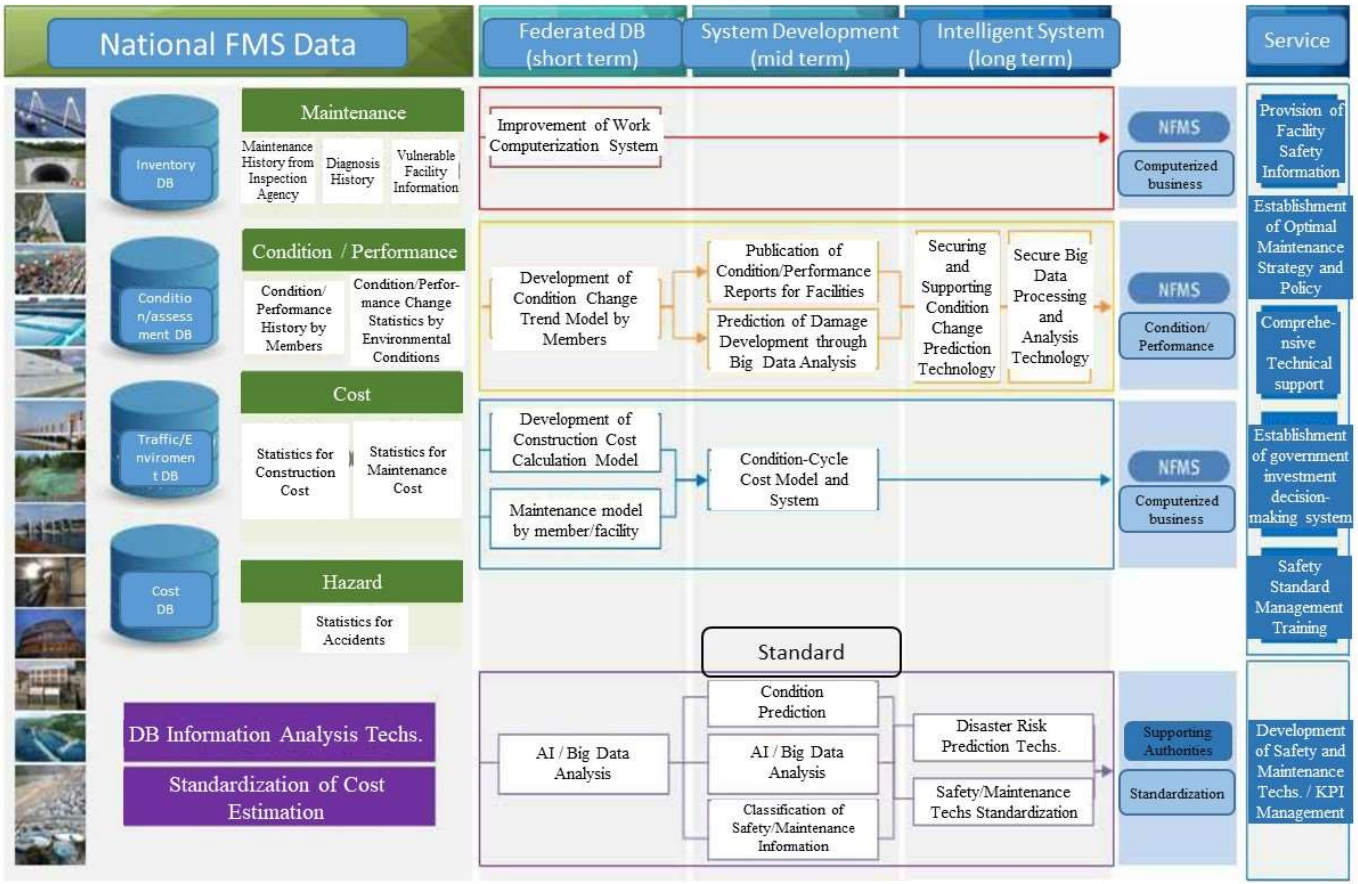
RWIS(Road Weather Information System)

VMS(Variable Message Signs) with CCTV

Member-based Data for Bridges

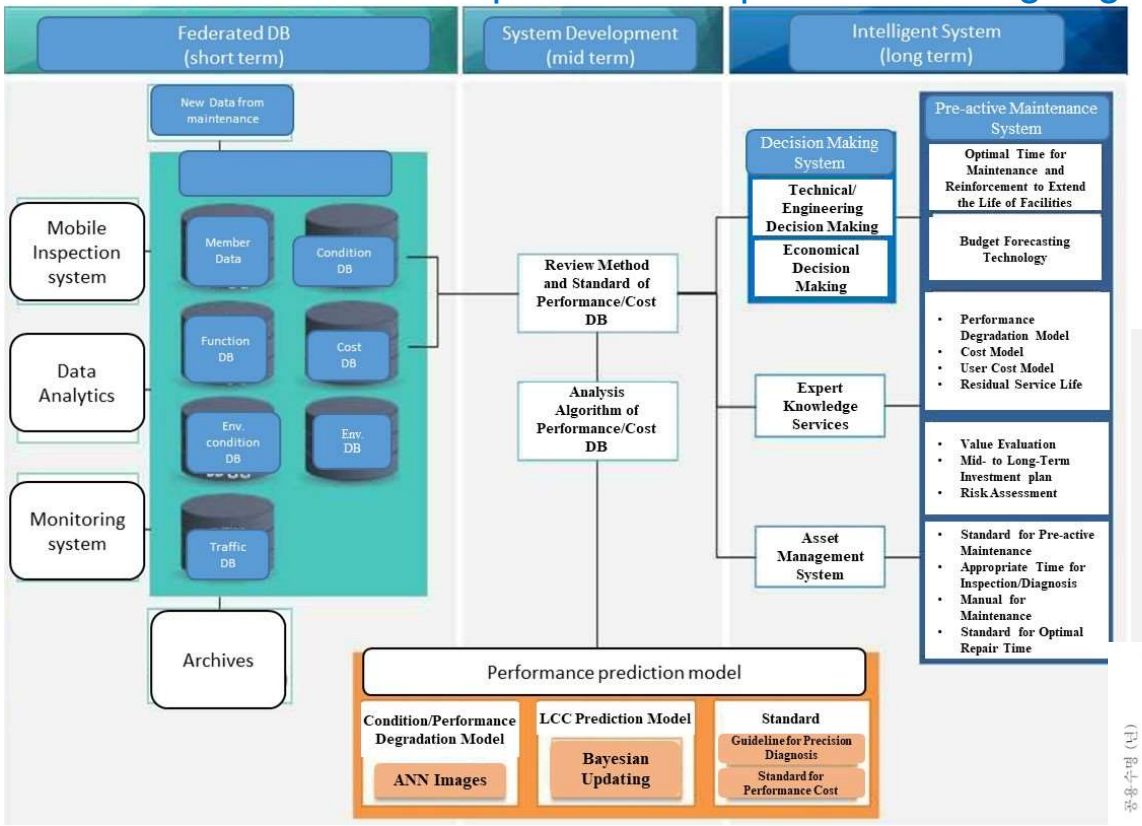
- Visual inspection data : FMS starts to accumulate member-based data

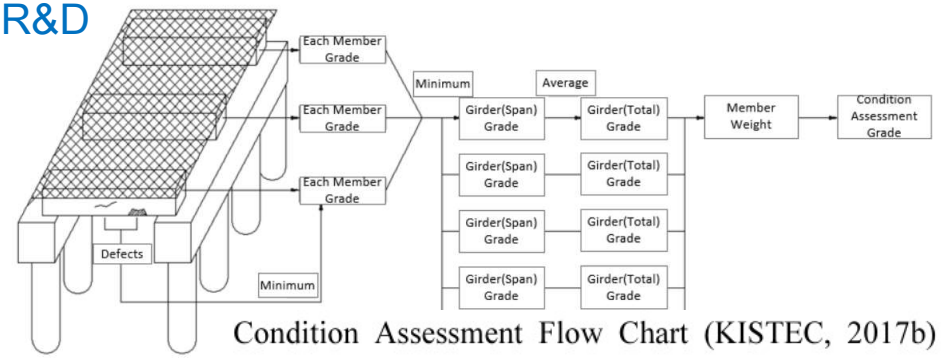




Member-based Data for Bridges

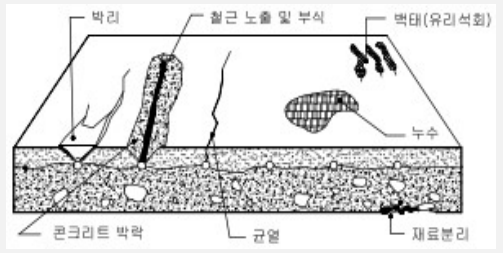
- Data collection and performance prediction : on-going R&D

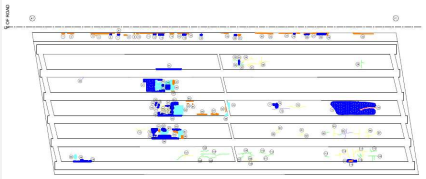


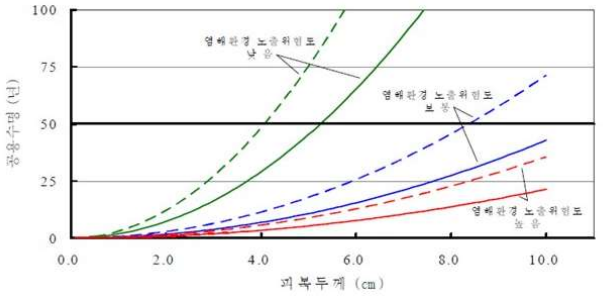


Condition Assessment Flow Chart (KISTEC, 2017b)

- Bridge Slab



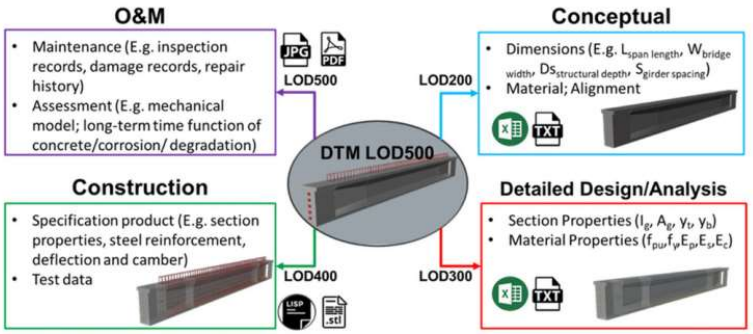




Deterioration model For prediction

Digitalization of Maintenance task

- Digitalization of existing maintenance data & bridges



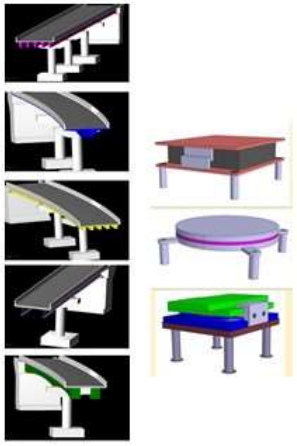
Data labeling Unique ID

Section①	Section②			Section③				Section④
1	2	3	4	5	6	7	8	9
940	-	SG	04	I	T	UR	-	E02D01SD01AS05 - 161228

Division	Item		Notation
Section ①	Bridge Identification		
Class 1.	*Bridge Identification*	940	Corresponding Bridge
Section ②	Inspection Elements		
Class 2.	*Structural Member (Part)*	SG04	Stiffening Girder #04
Class 3.	*Structural Member (Position)*	IT	In-Top
Class 4.	*Inspection Member*	UR	U-shape Rib Member
Section ③	Damage Types		
Class 5.	*Member Detail*	E02	Element Detail(E02) - Steel Girder
Class 6.	*Damage Type*	D01	Damage Detail(D01) - Basic Material and Joint Damage
Class 7.	*Specific Damage*	SD01	Specific Damage(SD01) - Part Cracking
Class 8.	*Assessment Standard*	AS05	Assessment Standard(AS05) - Overall Cracking in Element
Section ④	Inspection Data		Year. Month. Day
Class 9.	*Inspection Date*	161228	Inspection Data 16-12-28

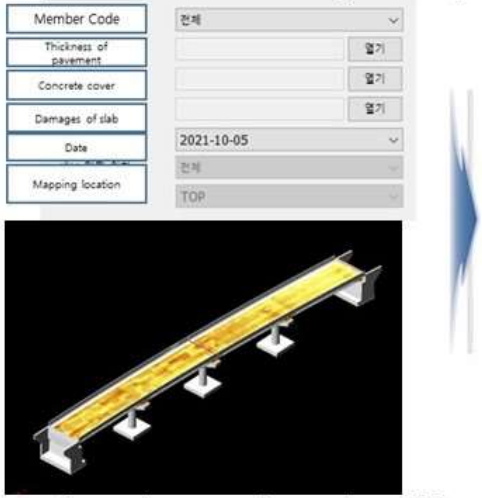
Algorithm-based model generation

Data template for BMS model authoring

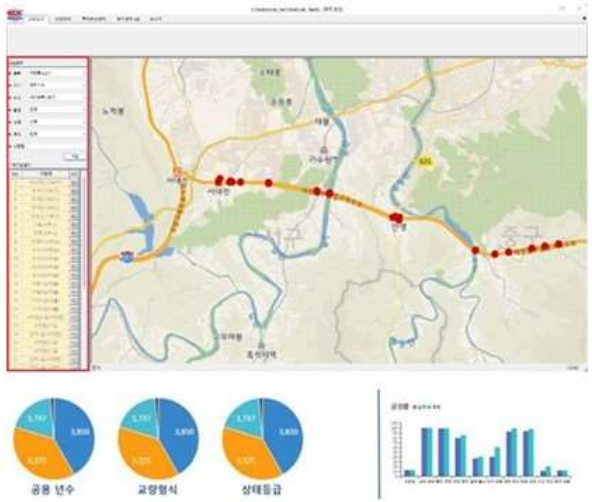


Automatic generation of digital models by data

Inspection, NDE, condition, repair history



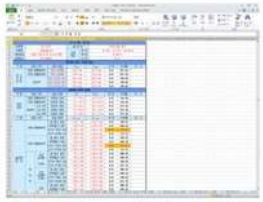
Accumulate maintenance data to the model



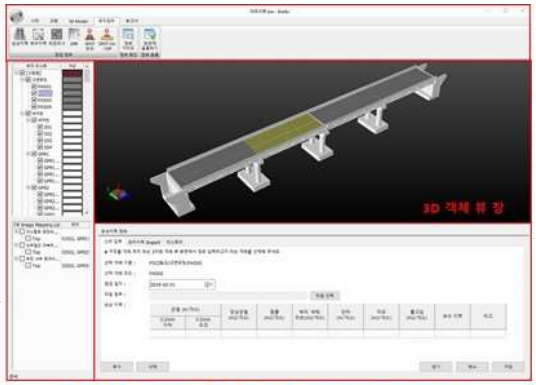
GIS based BMS and Dashboard for bridge owners

Digitalization of Maintenance task

- New BMS for Korea Expressway Corporation

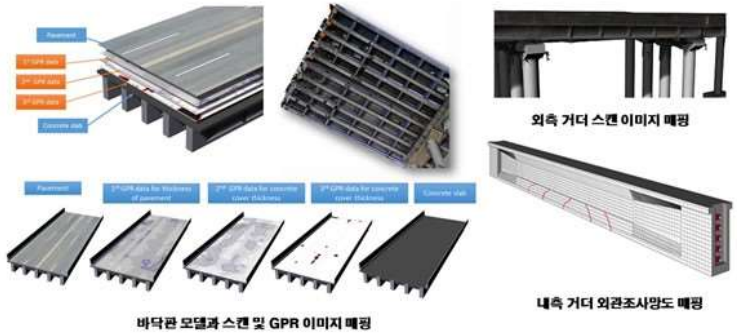


Design dataset

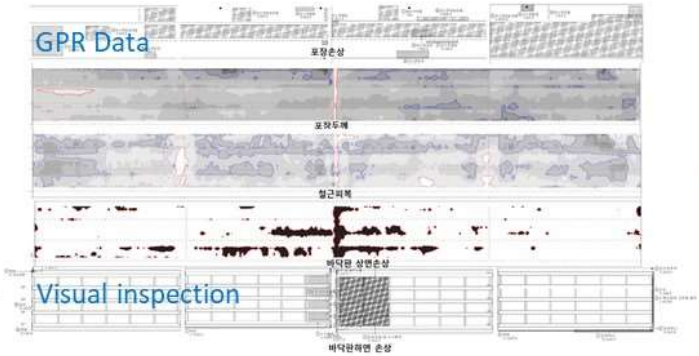


Platform : DEM generation

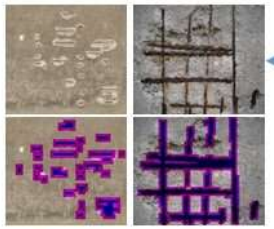
Data collection
& analytics for future
performance prediction



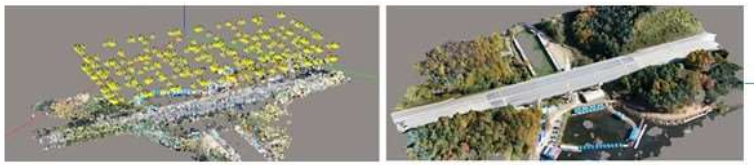
Digital Models for Maintenance



Concrete Slab Twin Model



Damage Data

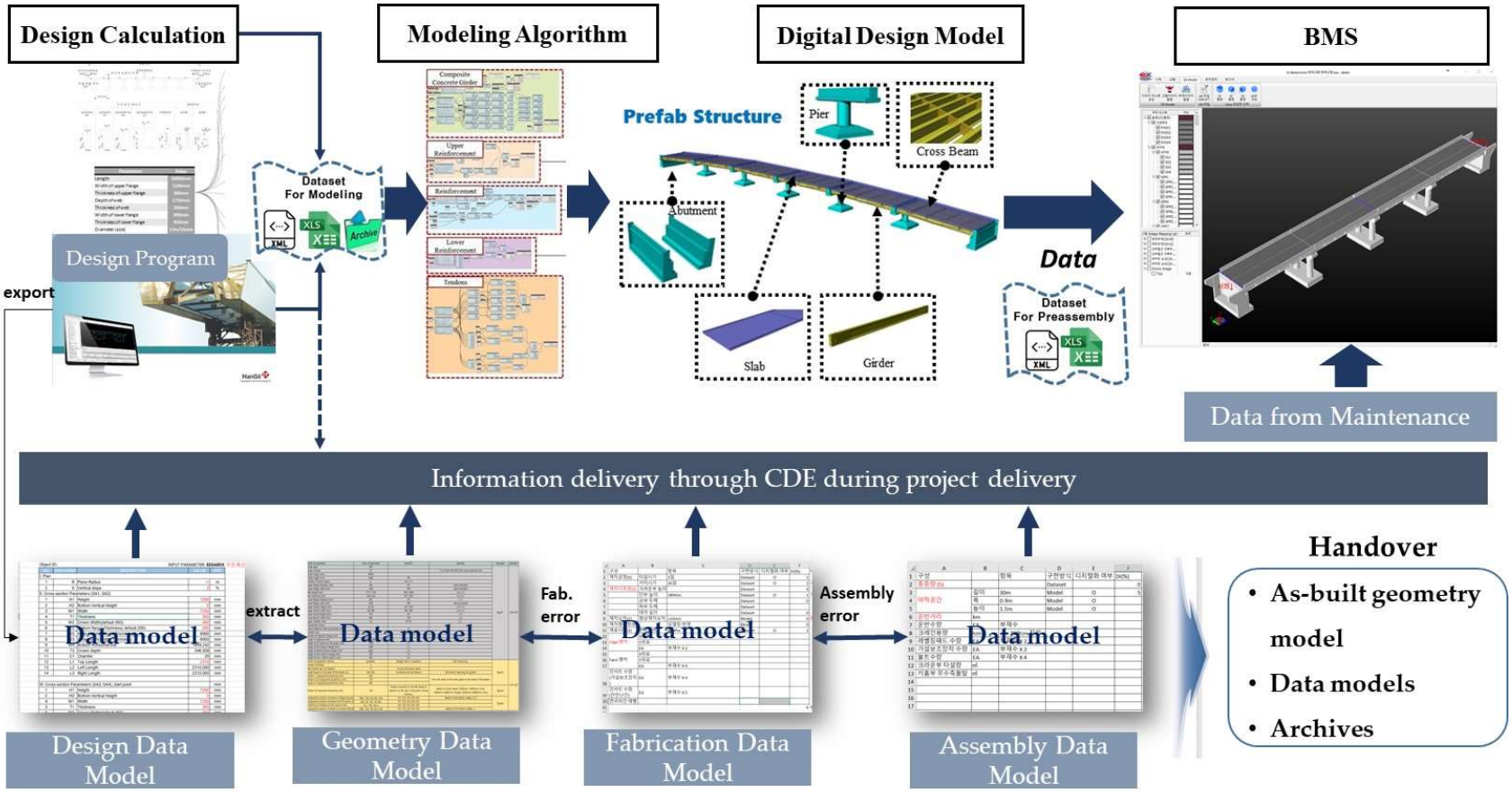


Reality Model by UAV Scanning

Scanned Image DB

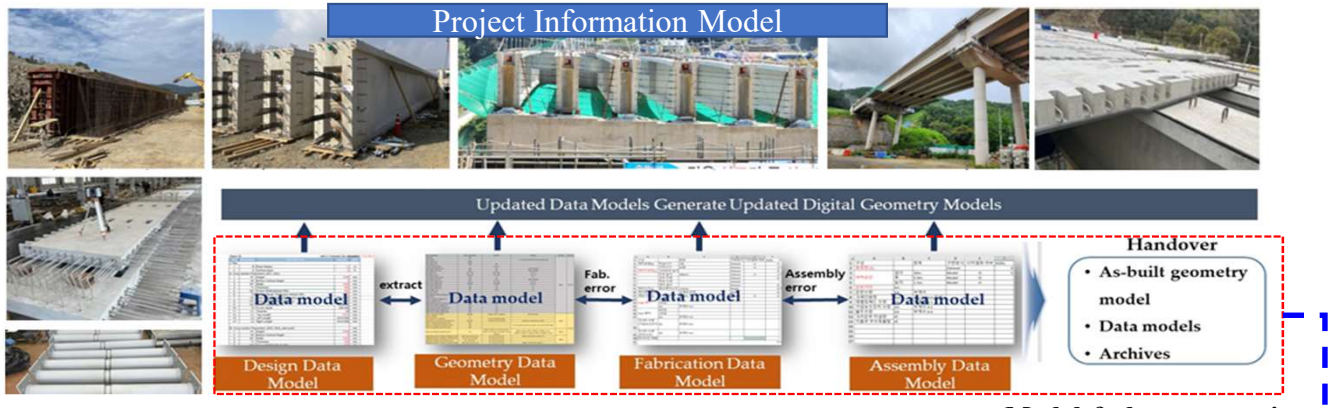
Digitalization of Maintenance task

- As-built BIM deliverables for Maintenance : on-going national R&D

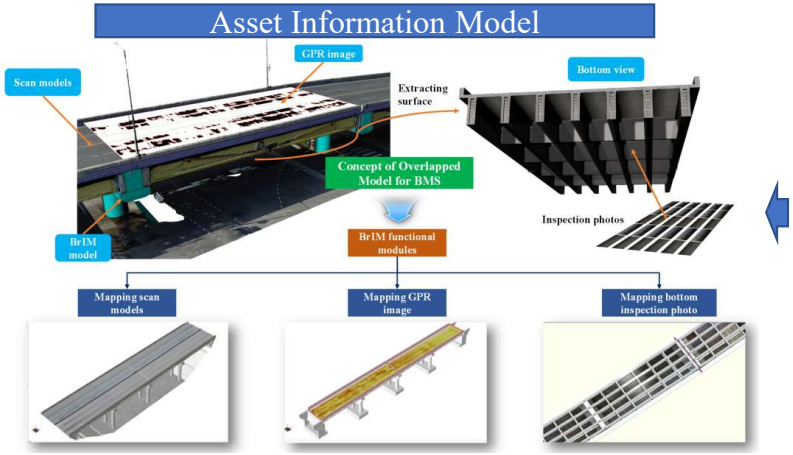


Digitalization of Maintenance task

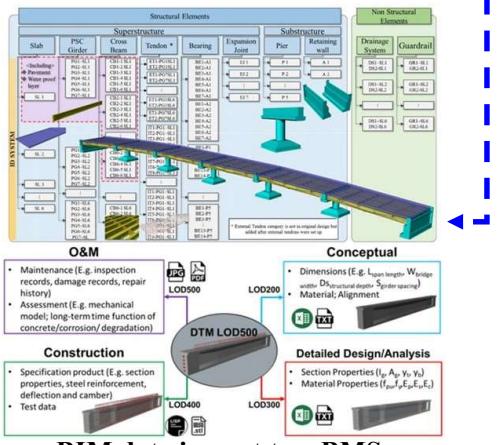
- As-built BIM deliverables for Maintenance : on-going national R&D



Model & data conversion



New data from maintenance

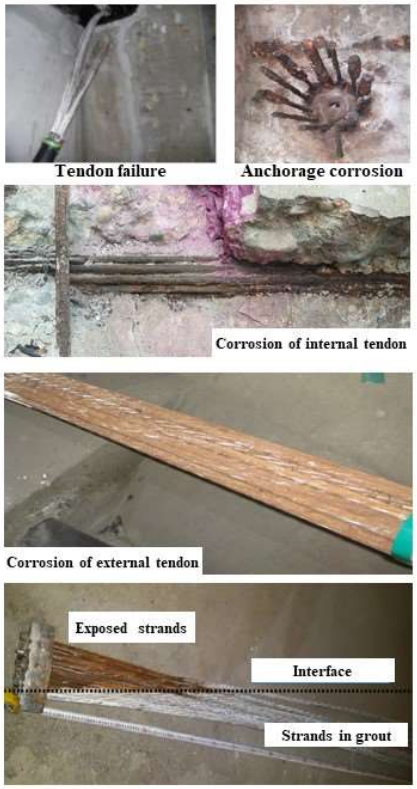


BIM data import to a BMS

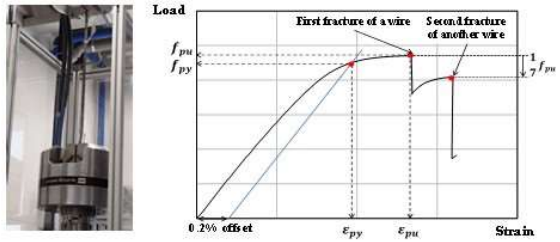
Data standard for Information delivery from PIM to AIM

Issues of Bridge Maintenance in Korea

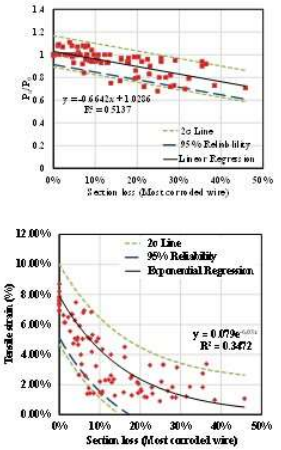
- Invisible deterioration of bridges (new inspection methodology & future prediction data ?)



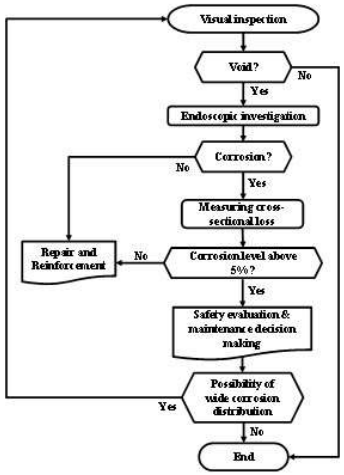
Corrosion cases in Korea



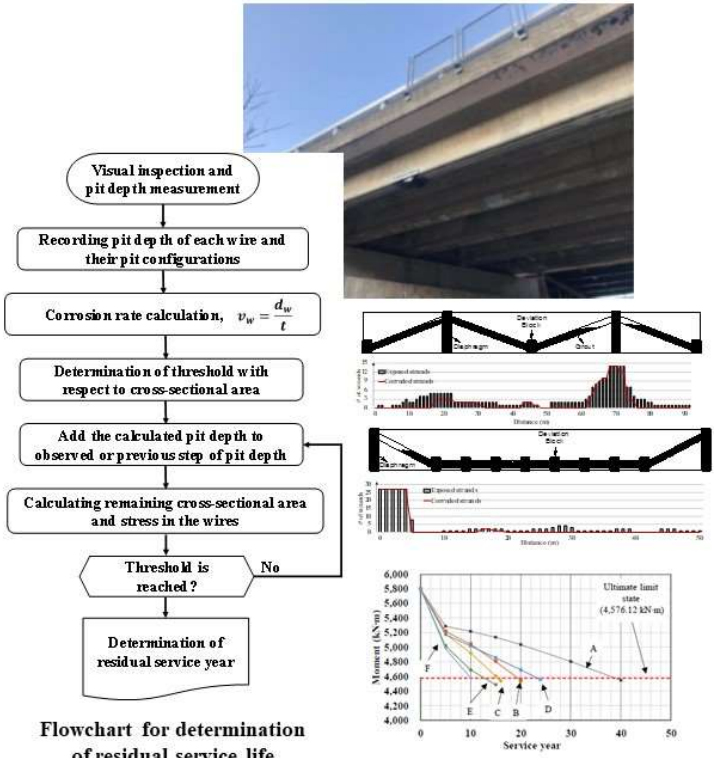
Tensile test of corroded strands



Tensile strength and strain



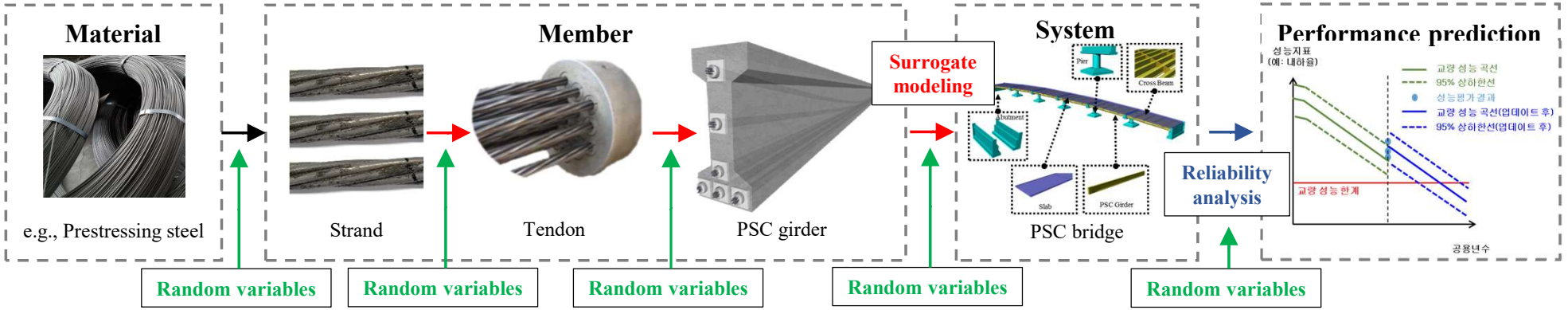
Corrosion inspection flowchart



Flowchart for determination of residual service life

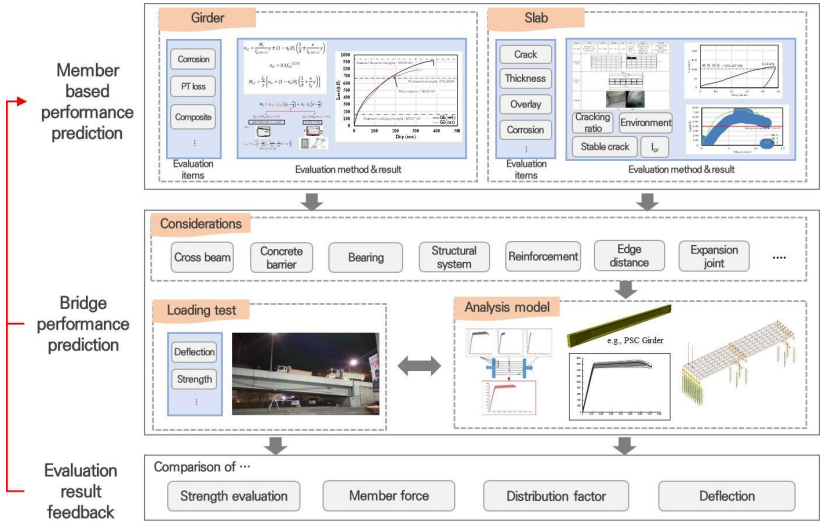
Performance prediction based on corrosion scenarios

Issues of Bridge Maintenance in Korea



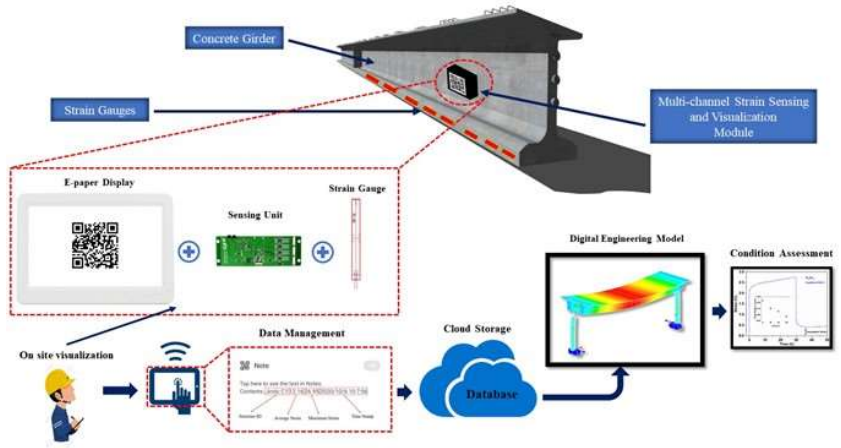
▪ Collaborative Effort

- Bridge owners : allow detail inspection for replaced bridges
- Public agencies for maintenance: digitalization of data and open-data
- Academics: AI-based prediction (Key performance indicator)
- International : IABSE TG 5.6 “BIM for existing structures”



Issues of Bridge Maintenance in Korea

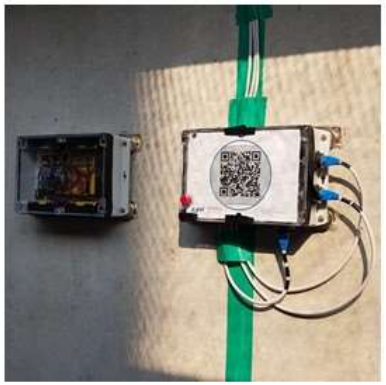
- **Data pipeline for Digital Twins**



- Simple & durable
- Minimum measurement
- Easy data collection








Issues of Bridge Maintenance in Korea

- Digitalization of Inspection tasks: Manual to UAV, robots
- Validate existing maintenance data / reconstruct missing data for existing bridges
- Standard Digital Twin Models for Bridges and their data delivery system
- ML and AI technologies for maintenance tasks
- Network-based maintenance system (Dash board and decision making system)