IFC-based BIM for Civil Infrastructure and Some Cases

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- IFC-based Information Modeling Method
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  - Using User-Defined Property Sets
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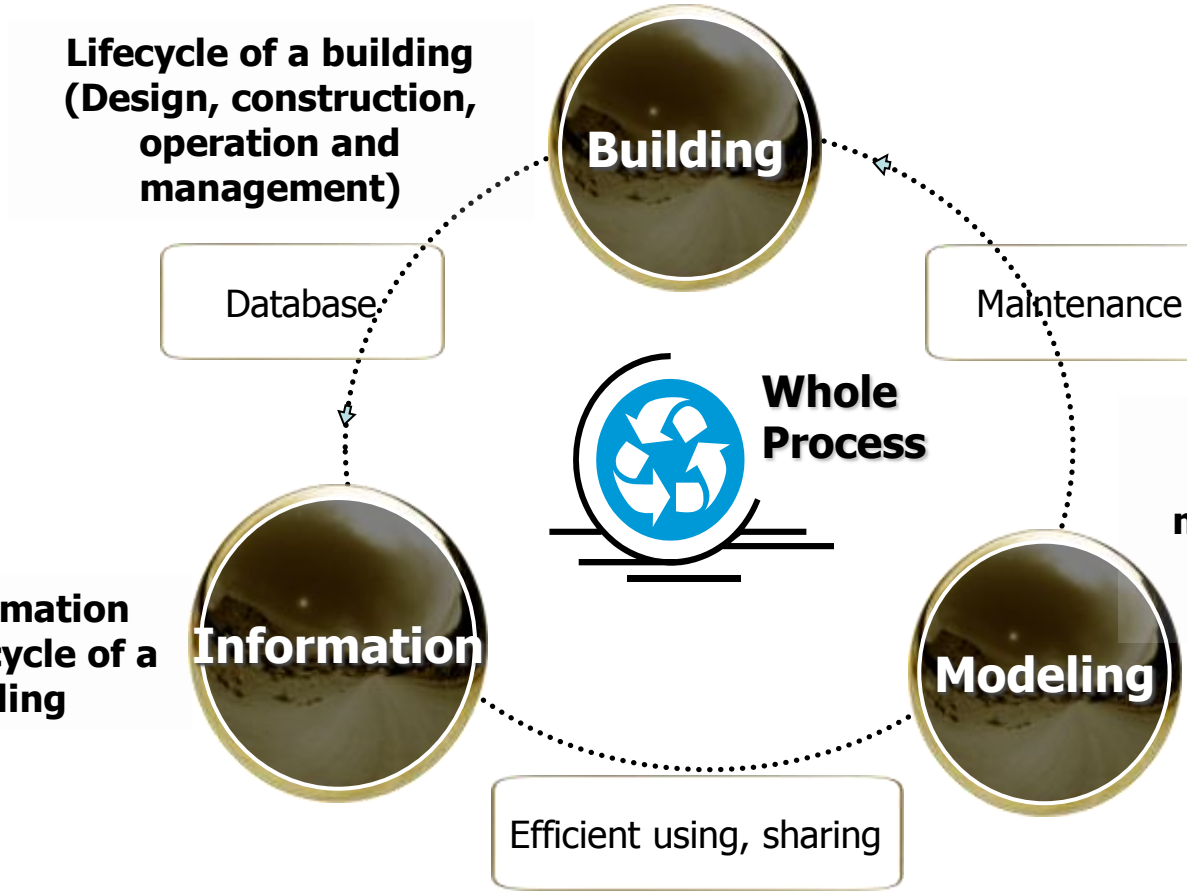
Building Information Modeling



BIM adoption of Ministry of Land, Transport and Maritime Affairs - 國土海洋部

- **National BIM Roadmap (2009)**
  - Base Technology Research for BIM (2011)
  - Government Standard and Delivery Manual Research for BIM (2012)
  - BIM/GIS Integration Research (2013)
- **Master Plans for National Architectural Policy (2010)**
  - Expanding investment for advanced BIM
- **A Common Guide for BIM – Modeling and Delivery (2011)**
  - Version 1 – Architecture (Civil Infrastructure: will be added)
  - Adoption Guide
  - Modeling Guide
  - Delivery Guide
- **Advanced e-Architectural Information System (2012)**
  - BIM: current issue and future goal

BIM adoption of Ministry of Land, Transport and Maritime Affairs - 國土海洋部

- **Architectural BIM Guidelines**
  - National BIM Guidelines (2009)
    - BIM Task Guidelines
    - BIM Guidelines in Technical Support
    - BIM Management Guidelines
    - Application of Guidance
  - National Architectural BIM Guide (2010)
    - BIM Working Guide
    - BIM Technical Guide
    - BIM Management Guide

BIM adoption of Public Procurement Service (PPS) - 調達廳

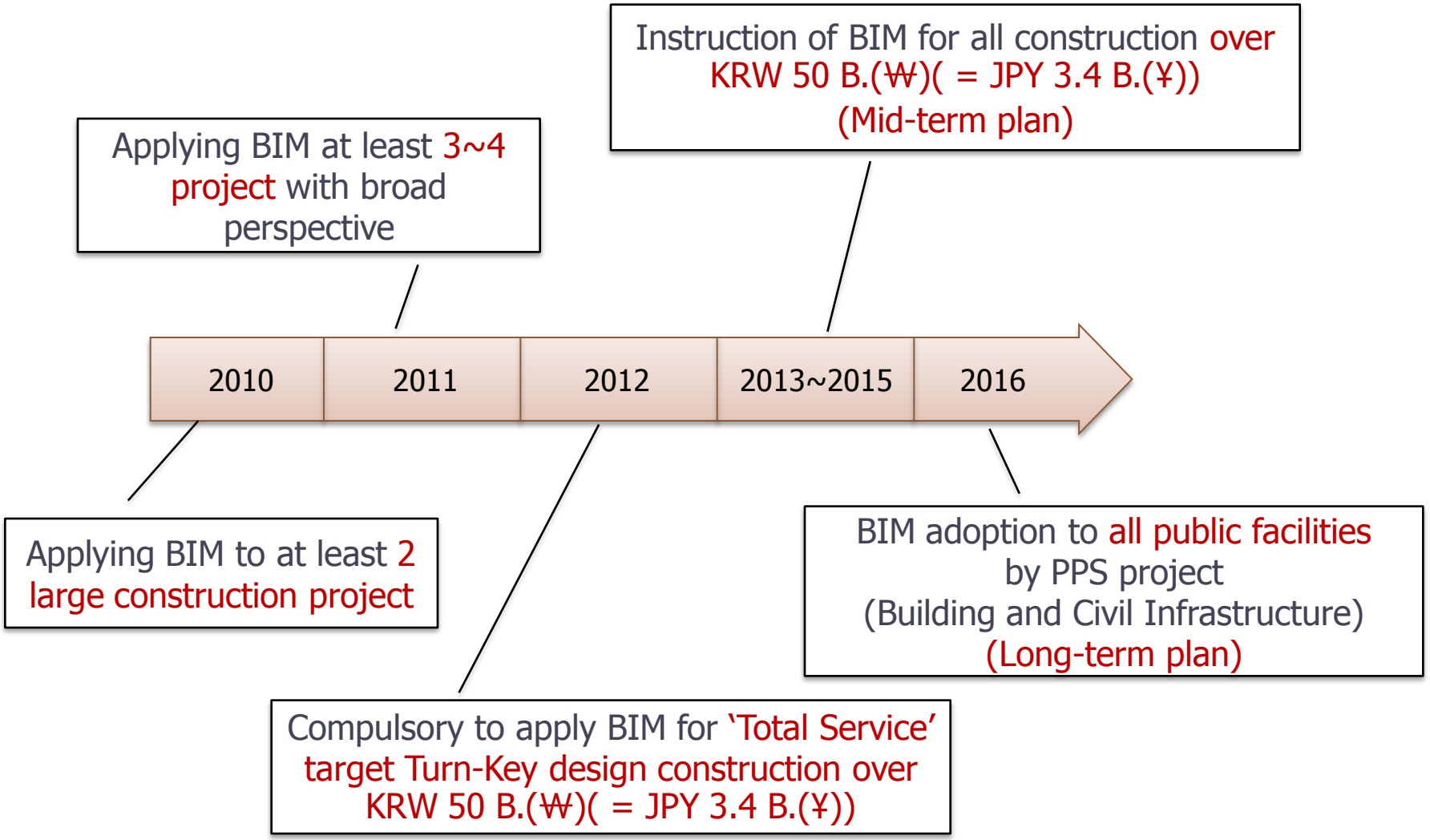
GOAL
Public procurement innovation for design and construction management

Short-tem plan (2010 ~ 2012)
Improvement design quality by expanding BIM adoption

Mid-tem plan (2013 ~ 2015)
Saving budgets by using 4D design management system

Long-tem plan (2016 ~)
Innovation work by expanding application of BIM into whole public facilities

BIM adoption of Public Procurement Service (PPS) - 調達廳



Current BIM Technology in Civil Infrastructure

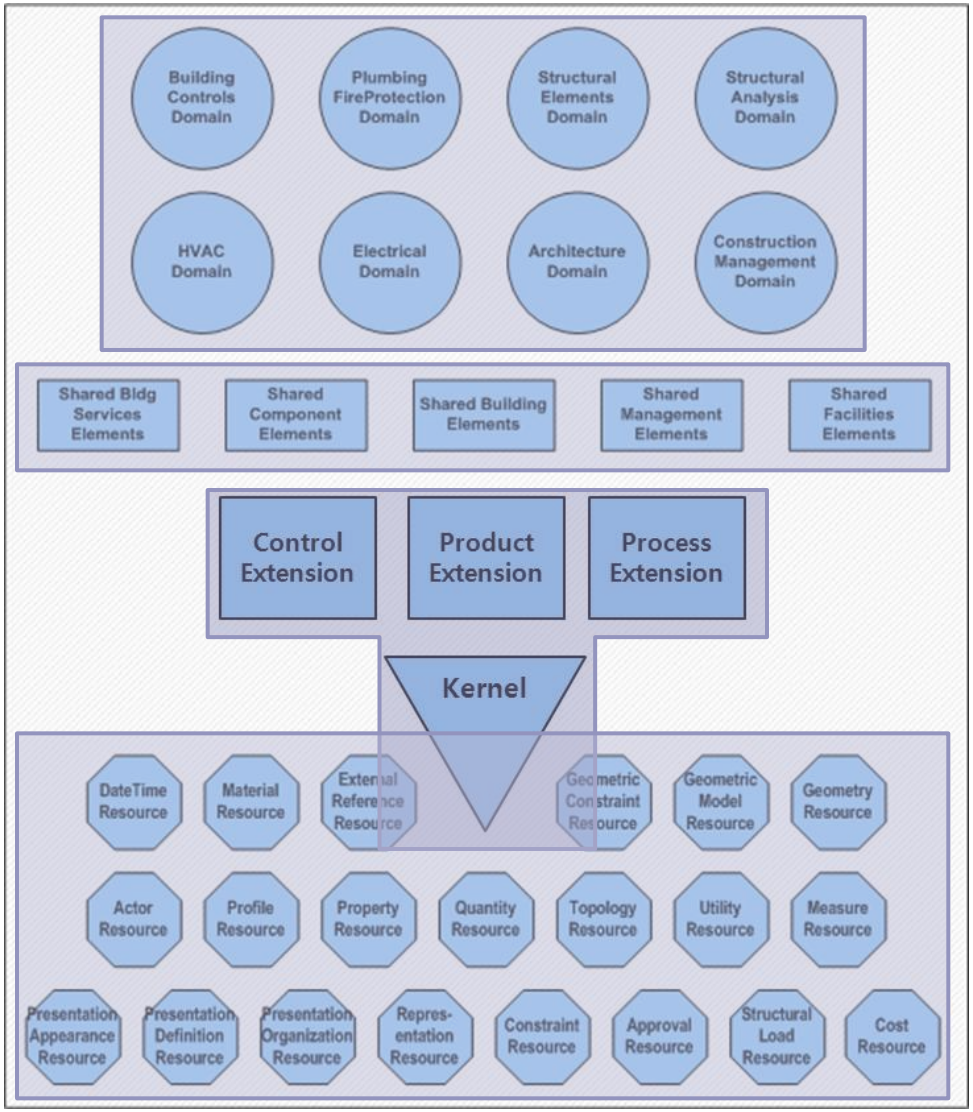
- **Advantages**
  - **Reducing Design Change**: clash detection, aesthetic analysis, constructability analysis, etc.
  - **Increasing Productivity**: automatic quantity tack-off, 4D & 5D based construction management, education for field laborers, etc.
  - **Providing better presentation** (compared 2D drawings) in communication among different disciplines and stakeholders
- **Major Obstacles in Civil Infrastructure Domain**
  - **Lack of Knowledge on BIM**: Still New to civil engineers
  - **Insufficient S/W functions**: Lack of predefined structural component library and parametric rules among the components
  - **Interoperability & Sustainability of Model Data:**
    - Detailed Spatial and Physical Elements are Required

IFC-based Information Model

Industry Foundation Classes

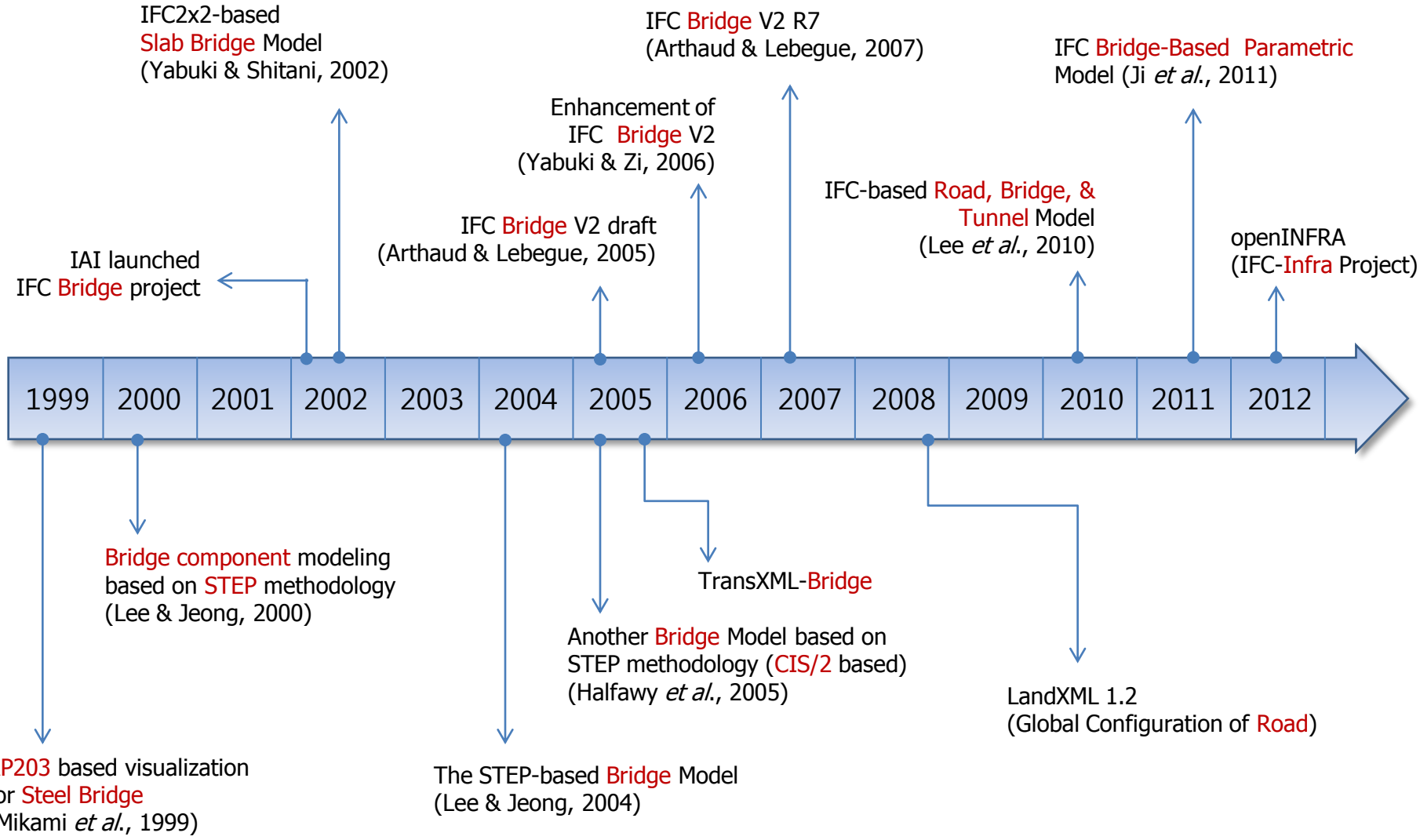
- A definition of a standard format to describe a BIM
- An object-based data model to facilitate interoperability in the architecture, engineering, and construction (AEC) industry
- How information should be provided/stored for all stages of a building projects lifecycle.
- Hold data for geometry, calculation, quantities, facility management, pricing etc.
- Registered by ISO as ISO/PAS 16739

IFC Architecture



- Industry Foundation Classes (IFC): A definition of a standard format to describe a BIM
- Registered by ISO as ISO/PAS 16739
- Core Schemas
  - The fundamental relationships and the common concepts.
- Shared Schemas
  - More specialized objects and relationships shared by multiple domains.
- Domain Schemas
  - Organized definitions according to industry discipline.
- Resource Schemas
  - Sharing identical resource.

(1) IFC-based Bridge Model Adding New Entities



Adding New Entities for Civil Infrastructure

Category	Abstract type	Common components (Roads, Bridges, Tunnel, Retaining Walls)	Domain components
	IfcRoadSpatial Element (below IfcSpatialElement)	IfcRoadSite, IfcLane, IfcSlope, IfcCivilSpatialProxy	IfcBridge, IfcBridgeSpan
	IfcRoadService Element (below IfcElement)	IfcRoadBarrier, IfcTrafficSignal, IfcRoadSignalPost, IfcPost, IfcRoadRailing, IfcCrashCushion	IfcInspectionLadder, IfcRoadStair, IfcBridgeInspectionDeck
	IfcRoadElement (below IfcElement)	IfcPavementLayer, IfcCurb, IfcGutter, IfcSegment, IfcRetainingWall, IfcCivilFooting, IfcCivilPile, IfcCivilCaisson	IfcBridgeMember, IfcBridgeCable, IfcExpansionJoint, IfcPylon, IfcBearingSupport, IfcBridgeSlab, IfcBridgeAbutment, IfcBridgePier
	-	IfcGroundReinforcingElement, IfcMemberConnector (below IfcElementComponents)	IfcBridgeElementPart
	-	IfcRoadSystem (below IfcGroup)	IfcRoadSignalSystem, IfcInspectionSystem, IfcBridgeSytem,

New Common Elements for Road Structures

IfcRoad/IfcBridge/IfcTunnel (Partial/Unit/Complex)

IFC Elements

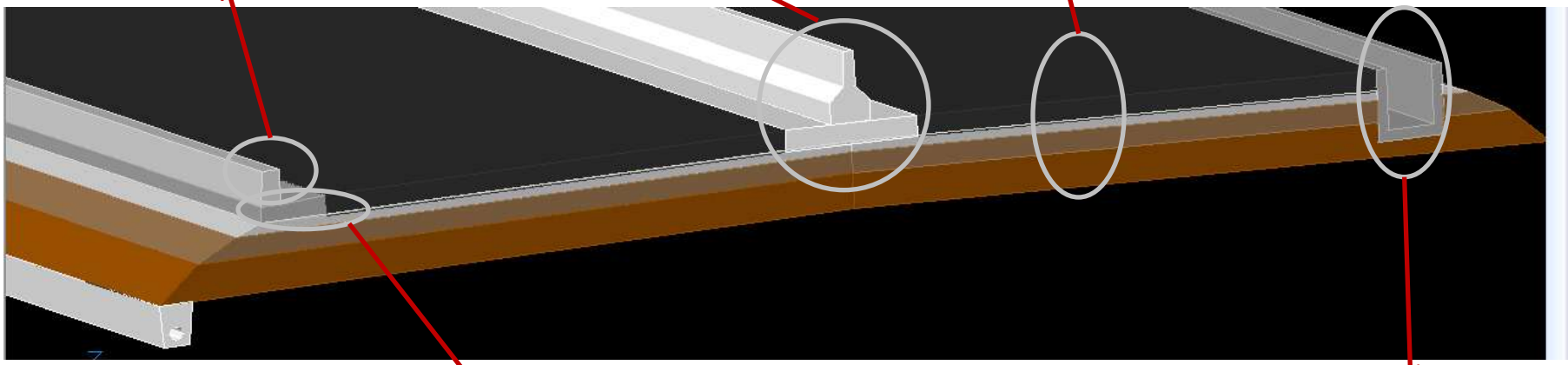
New Elements

IfcRelContainedIn SpatialStructure

IfcCurb

IfcBarrier (Median strip)

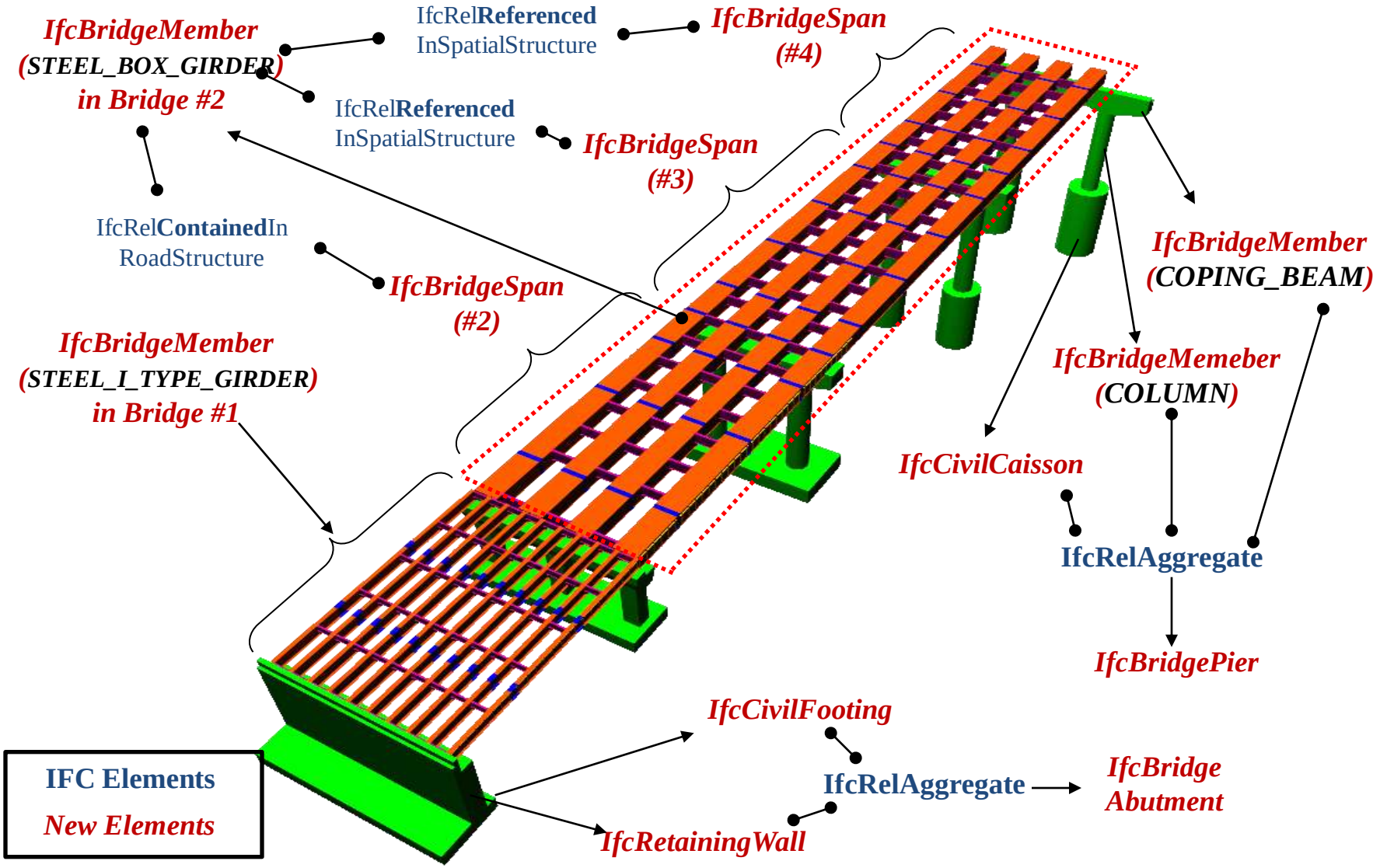
IfcPavementLayer



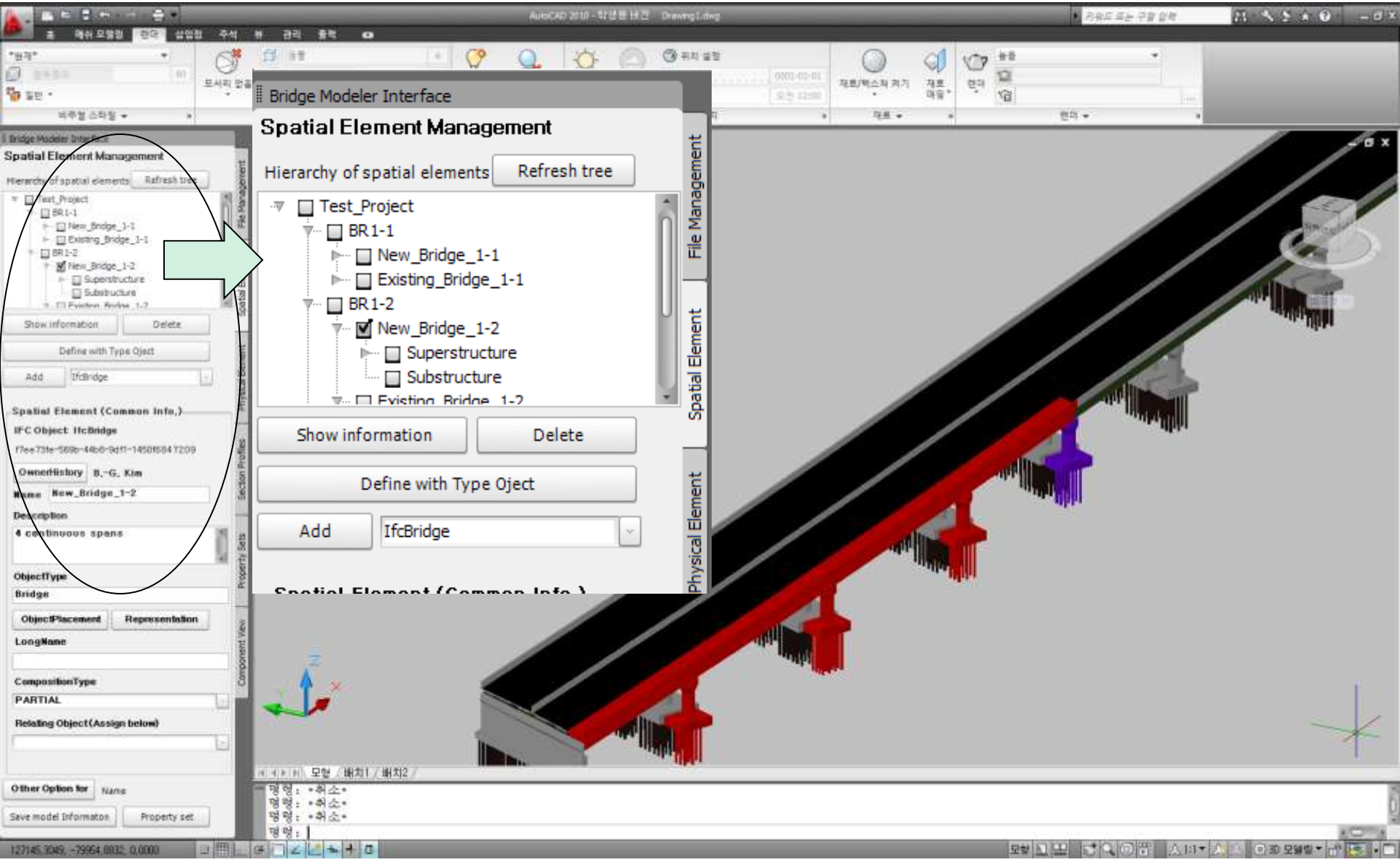
IfcGutter (L-type)

IfcGutter (U-type)

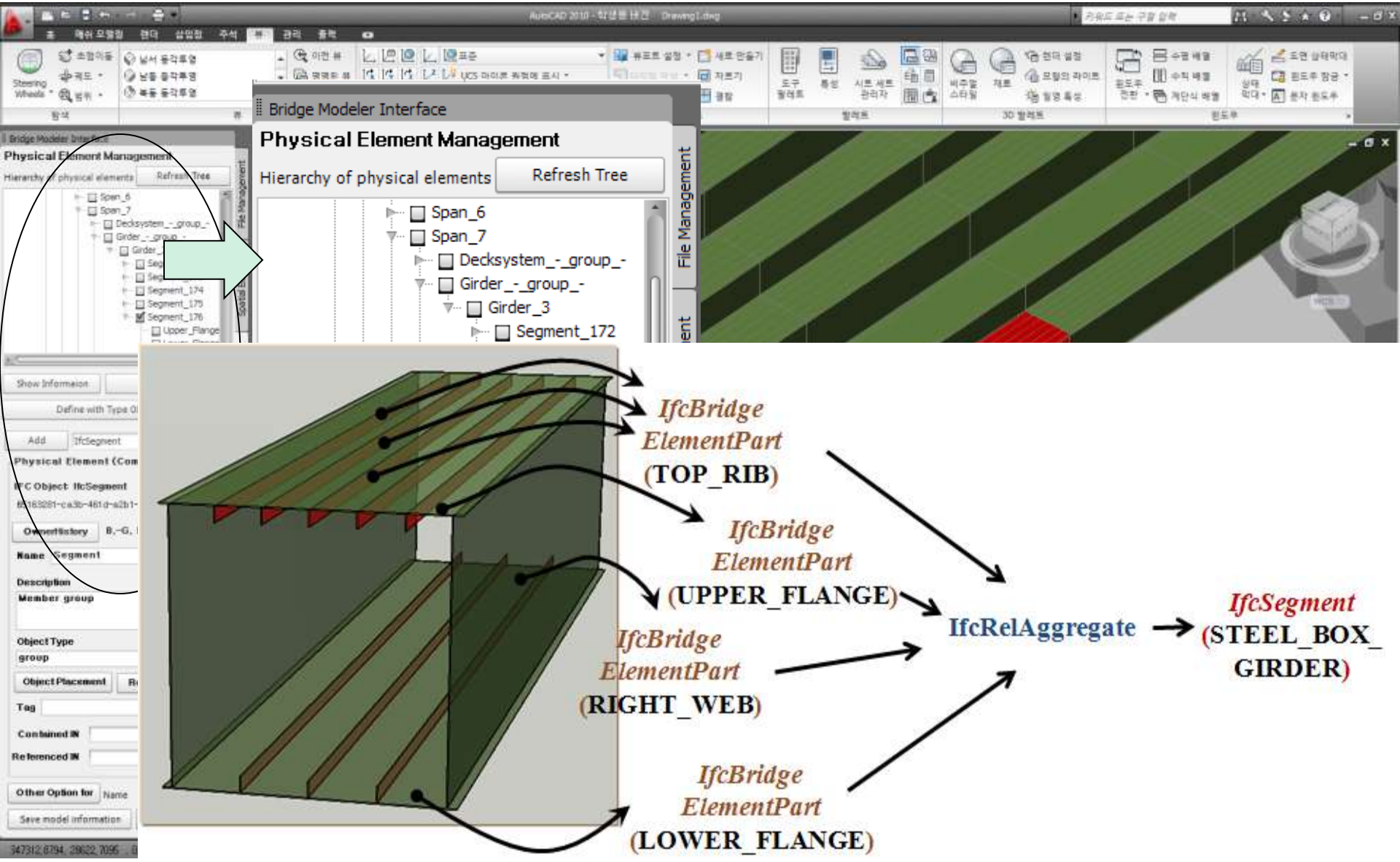
Example of New Physical Element Resource



Validation Example

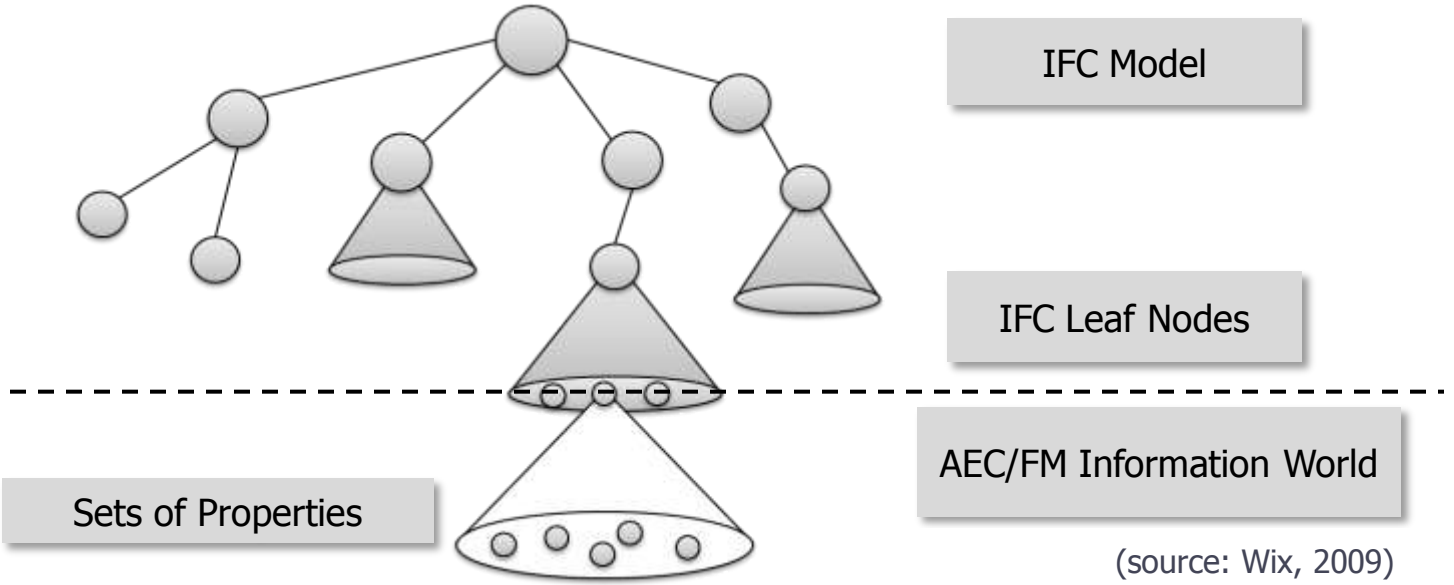


Validation Example



(2) Civil Infrastructure Model Using User-Defined Property Sets

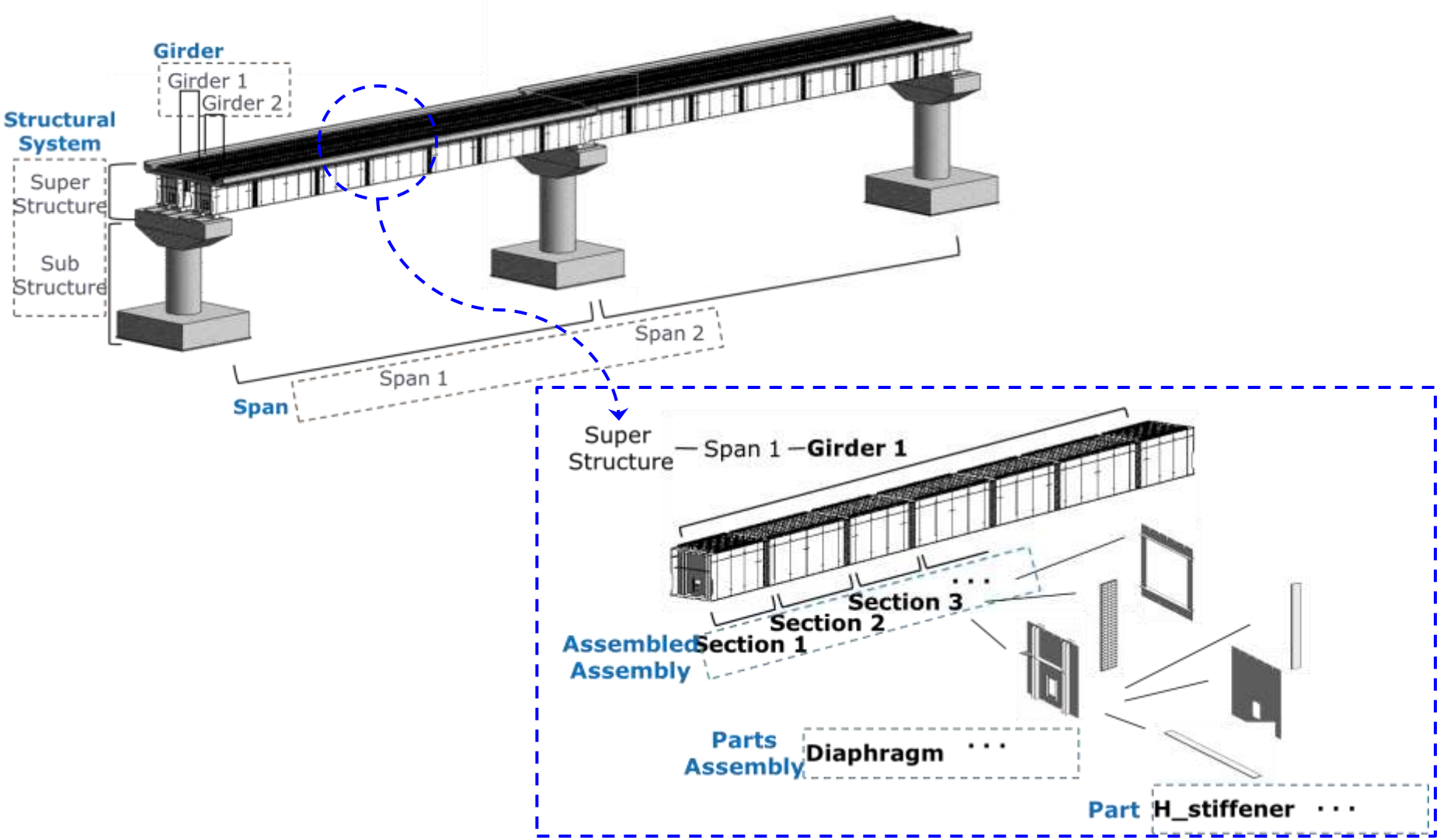
- **Property sets**
  - A special capability in the IFC model
  - Allow for extension of the IFCs without changing the model
  - Provide a framework for user-defined information
- **Advantage**
  - Easy to use, IFC framework
- **Disadvantage**
  - There are some problems to identify definite semantic information of each element of the civil infrastructure.



(source: Wix, 2009)

Bridge Member Identification Concept with User-Defined Property Sets

Property set name: Pset_BridgeMemberIdentification



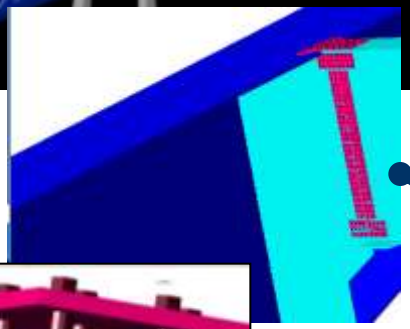
Application Examples in Civil Infrastructure Domain

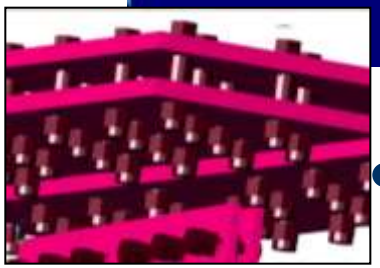
- Document Retrieval with Extended IFC Model
- Field Inspection with Extended IFC Model and user-defined property sets
- Bridge Model by LOD with Property Sets
- Construction Cost Estimation with Property Sets
- Calculating CO2 Emission with Property Sets
- 4D Simulation with Software for BIM

(1) Document Retrieval with Extended IFC Model

Basic Concept for Document Search

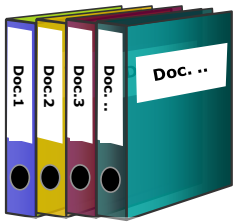
3D Model Information
(Structured format)





Structure
Subsystems
Components
Members/
Joints
Parts

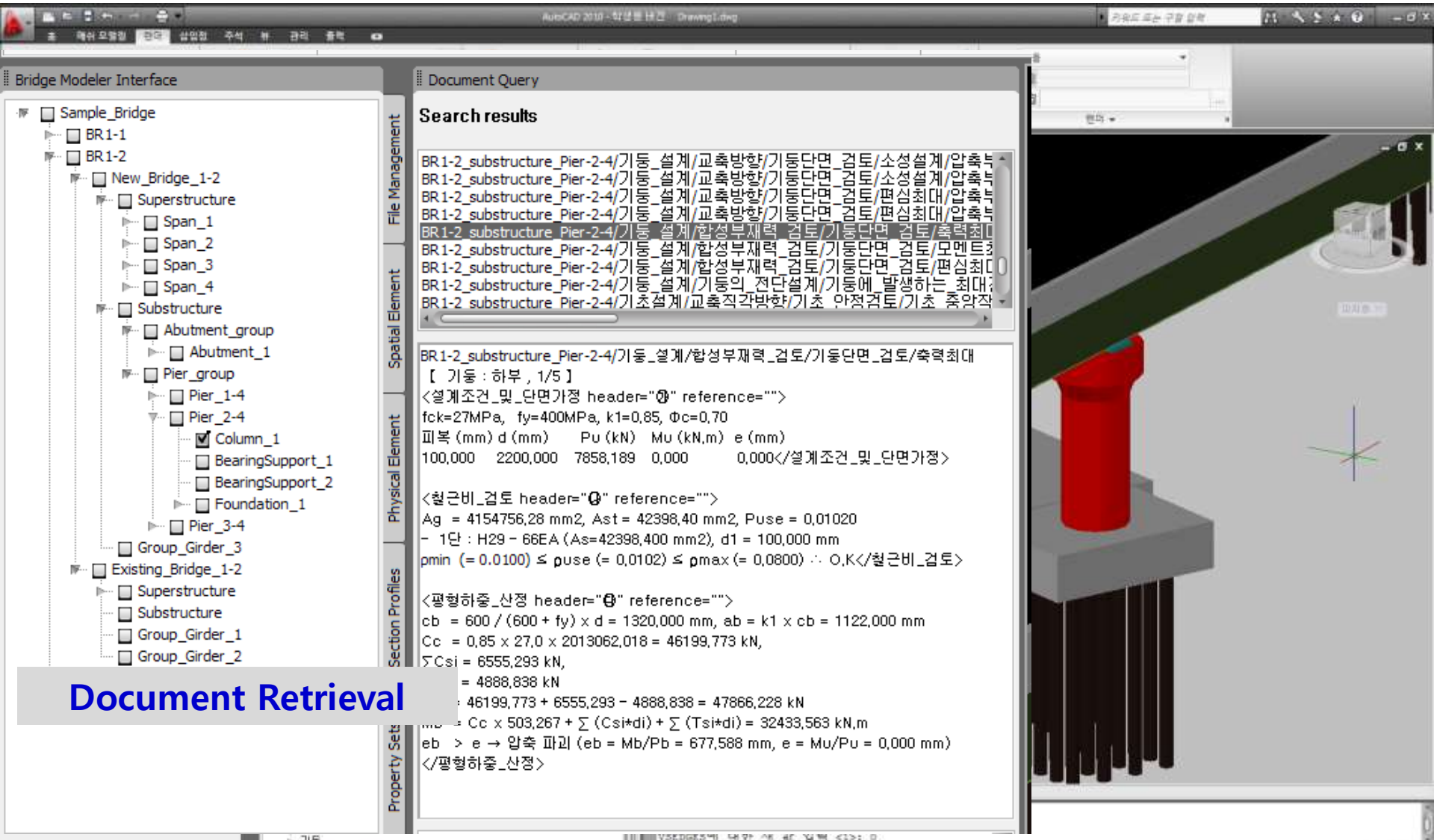
Engineering
document



Unstructured
format

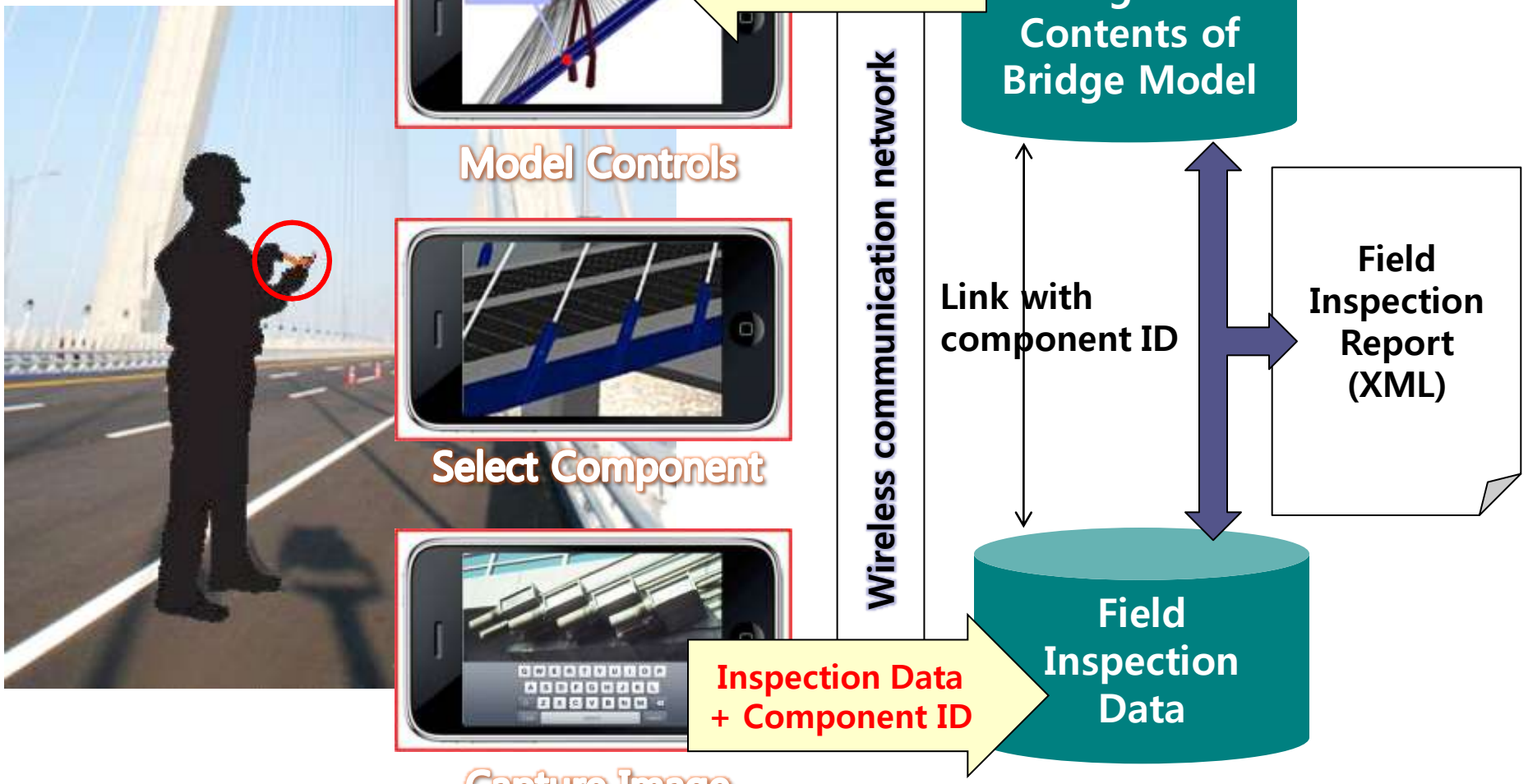
(semi-)
structured
format

(1) Document Retrieval with Extended IFC Model



Document Retrieval

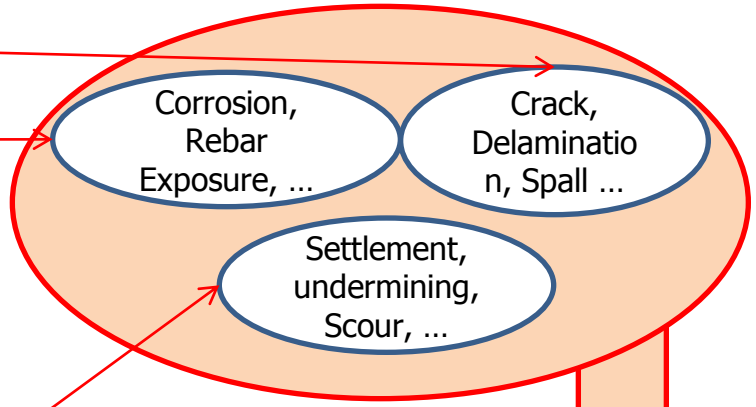
(2) Field Inspection with Extended IFC Model and user-defined property sets



(2) Field Inspection with Extended IFC Model and user-defined property sets

Classification of bridge damages

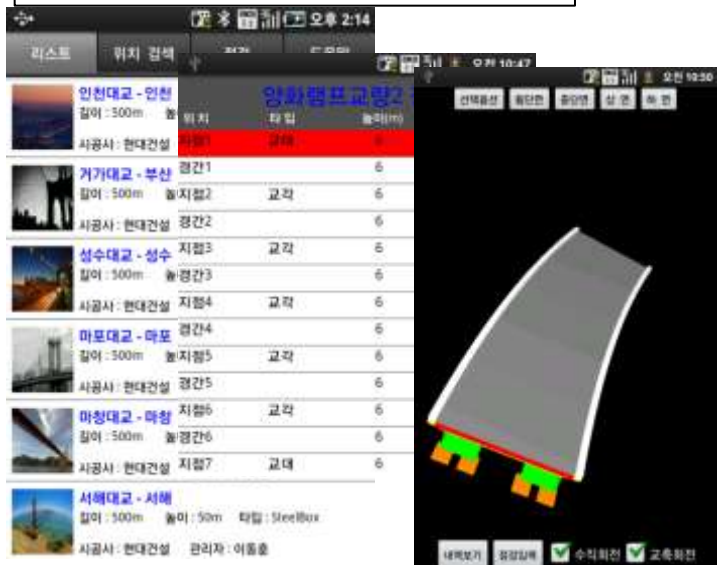
Material Facet	Concrete
	Steel
	Rebar
	Prestressing System
	Asphalt
	Cable
Role Facet	Deck Wearing-Surface
	Deck
	Expansion Joint
	Main Girder
	Cross Beam
	Secondary Element
	Bearing
	Connection
	Pier
	Abutment
	Foundation
	Pylon
	Drainage System
	Inspection Approach
	Lighting System
	Traffic Sign



Potential Damages of Bridge Pier

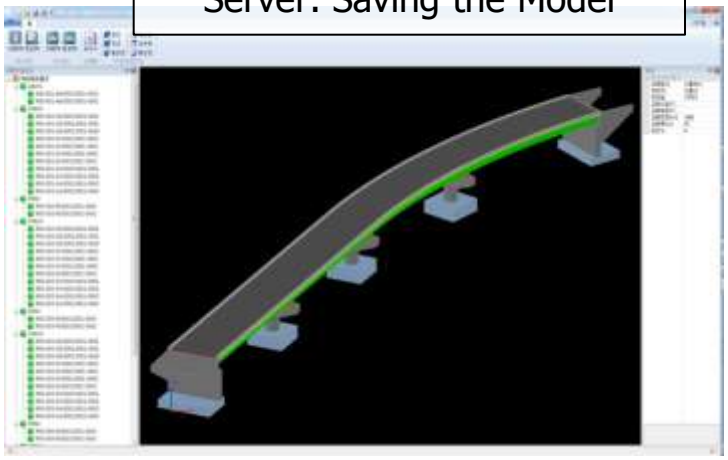
(2) Field Inspection with Extended IFC Model and user-defined property sets

Mobile: Member Selection



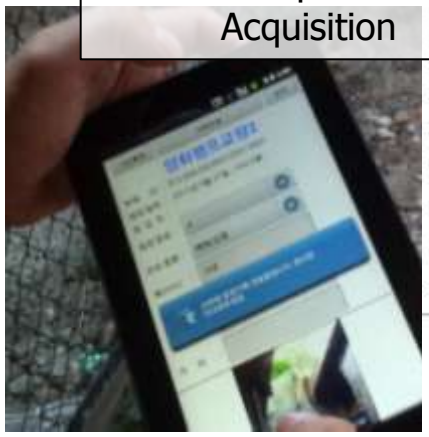
OpenGL

Server: Saving the Model



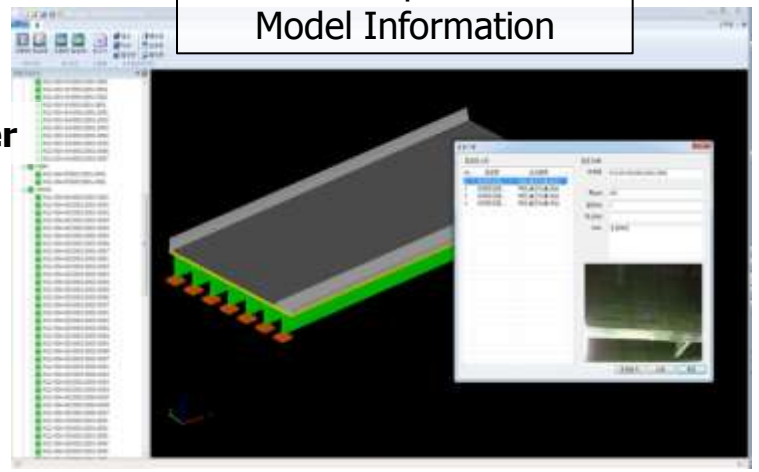
Data Update

Mobile: Inspection Data Acquisition



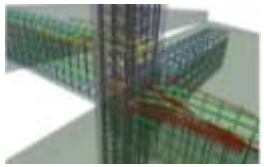
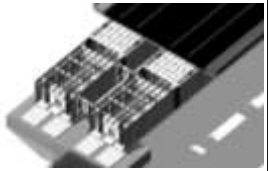
Transfer

Server: Update the Model Information

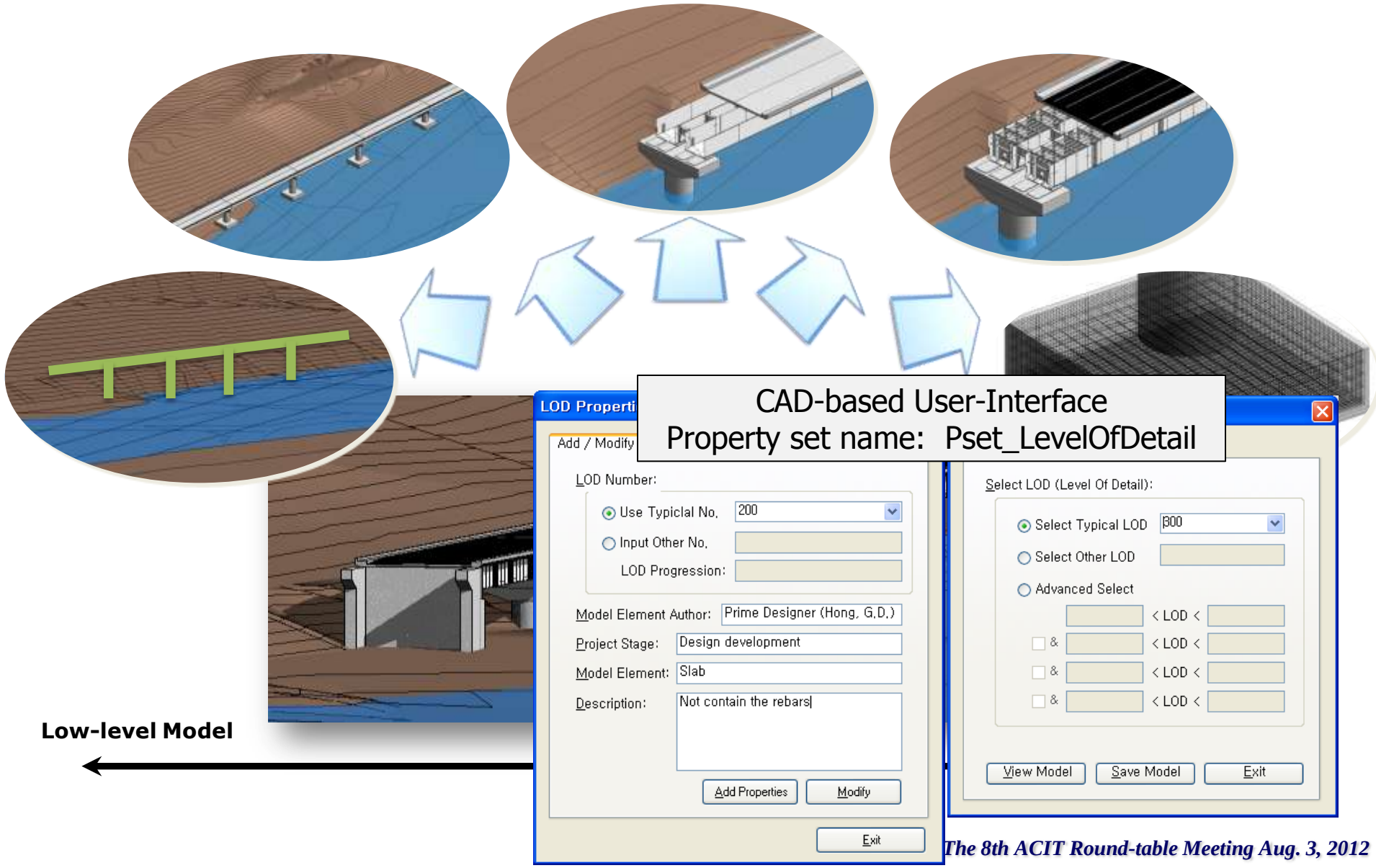


(3) Bridge Model by LOD with Property Sets

- **Level of Detail (LOD)**
  - Efficient rendering for model
  - Geometry definition by construction phase
  - In BIM Project: use for project progress

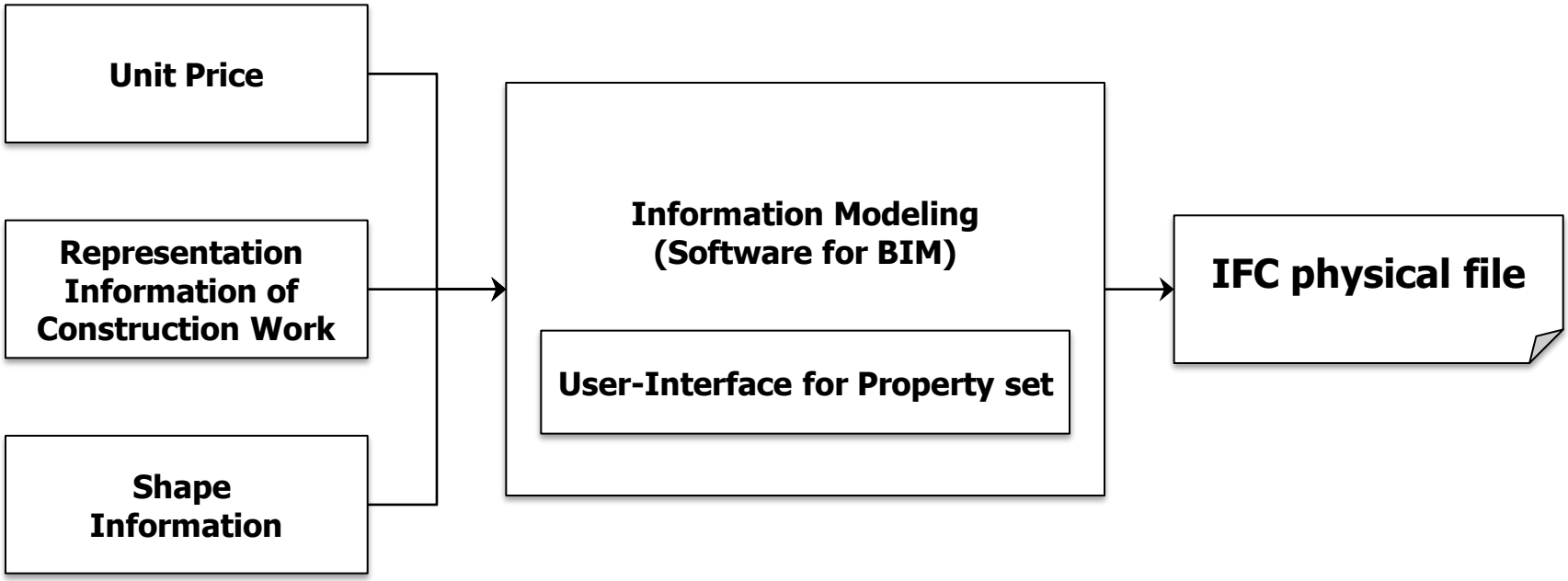
LOD level		LOD 100	LOD 200	LOD 300	LOD 400	LOD 500
		Conceptual Geometry	Approximate Geometry	Precise Geometry	Fabrication	As-built
Use		Planning	Conceptual Design	Detail Design	Construction & Produce	M & M
Model	Building					
	bridge					

(3) Bridge Model by LOD with Property Sets



(4) Construction Cost Estimation with Property Sets

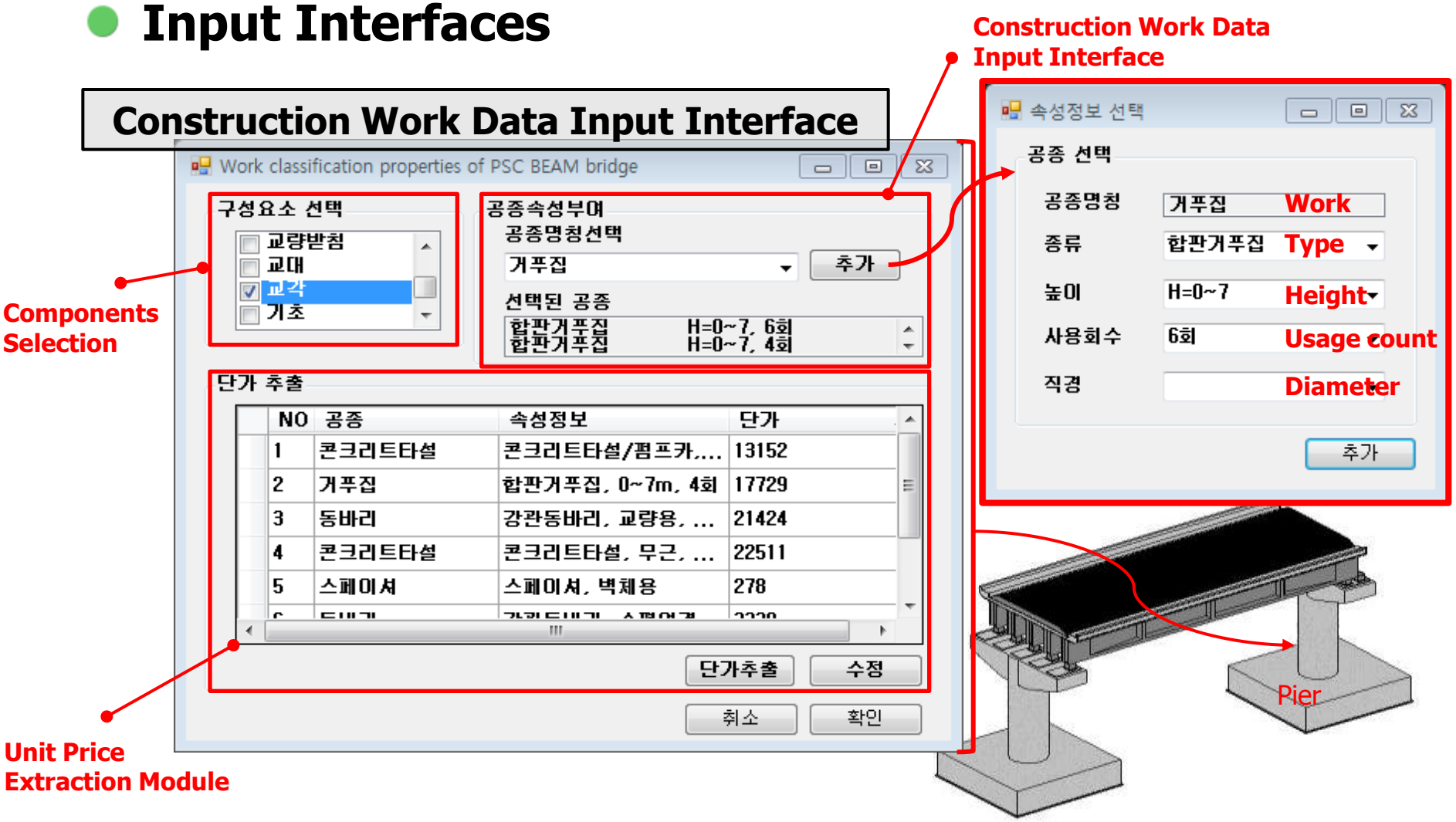
Basic Framework



(4) Construction Cost Estimation with Property Sets

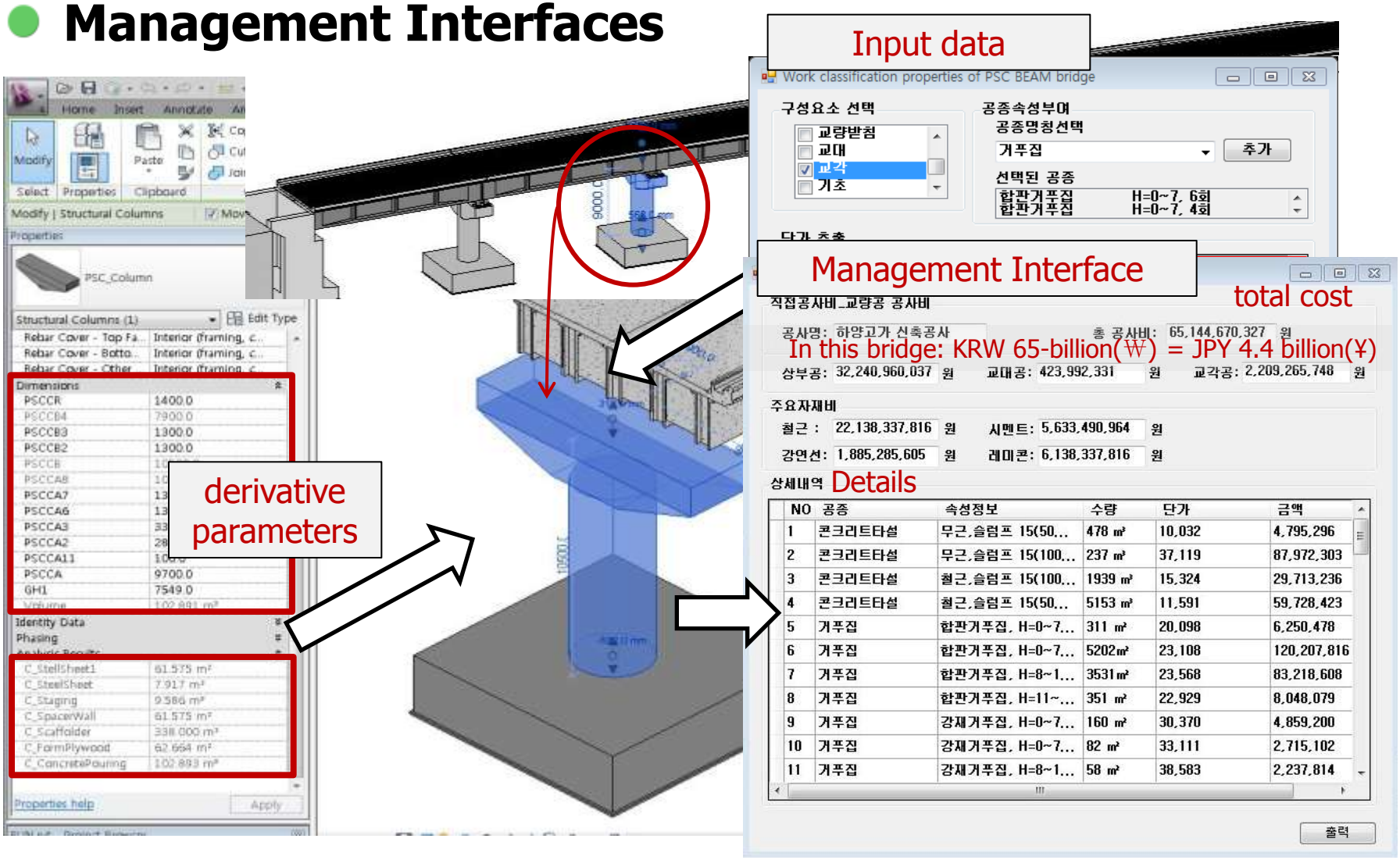
Input Interfaces

Construction Work Data Input Interface



(4) Construction Cost Estimation with Property Sets

Management Interfaces



(5) Calculating CO2 Emission with Property Sets

Backgrounds

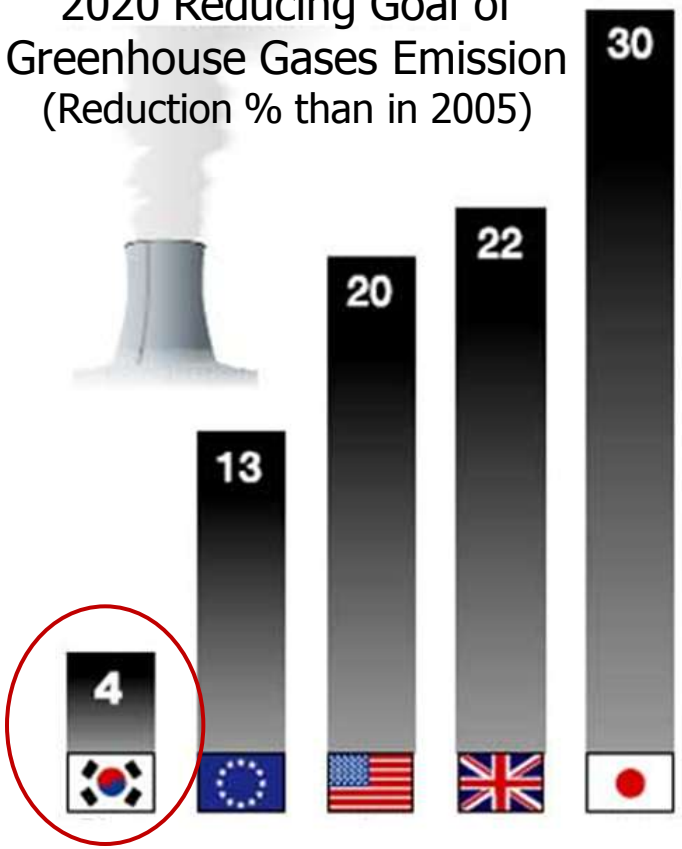
1990's	• The Climatic Change Convention (1994) • Publication of 1st IPCC Guideline by UNFCCC (1996) • Kyoto Protocol (1997)
2000's	• Publication of 2nd IPCC Guideline by UNFCCC (2006) • Publication of Low-carbon Green Growth Fundamental Law by Ministry of Environment (2009) • Republic of Korea -> One of Annex from 2013 • Publication of Several Guidelines about Green-house gases emission by domestic institutions

2010's	• Publication of Guideline to calculate the quantity of Carbon emission by MLTM (2011)
	  • Participation in Policy of government to decease 30% of Business As Usual (BAU) in 2020
	  • Insufficiency of studies in Green-house gases from bridges

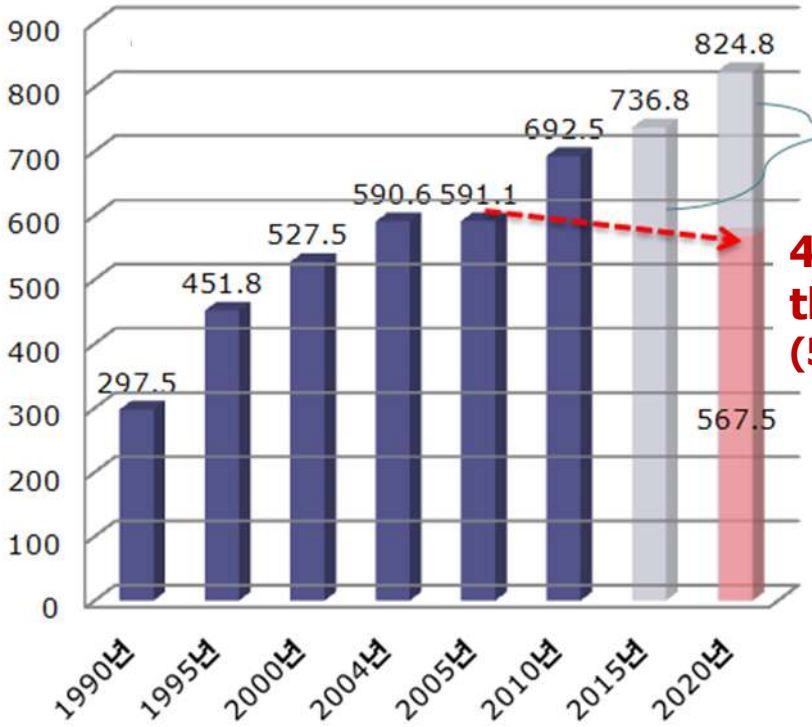
Purpose: **Management of information about CO2 and Calculation of CO2 emission quantity** in design phase using bridge information model based on IFC

(5) Calculating CO2 Emission with Property Sets

2020 Reducing Goal of Greenhouse Gases Emission
(Reduction % than in 2005)



Total Emission of CO2 in Korea (million ton)

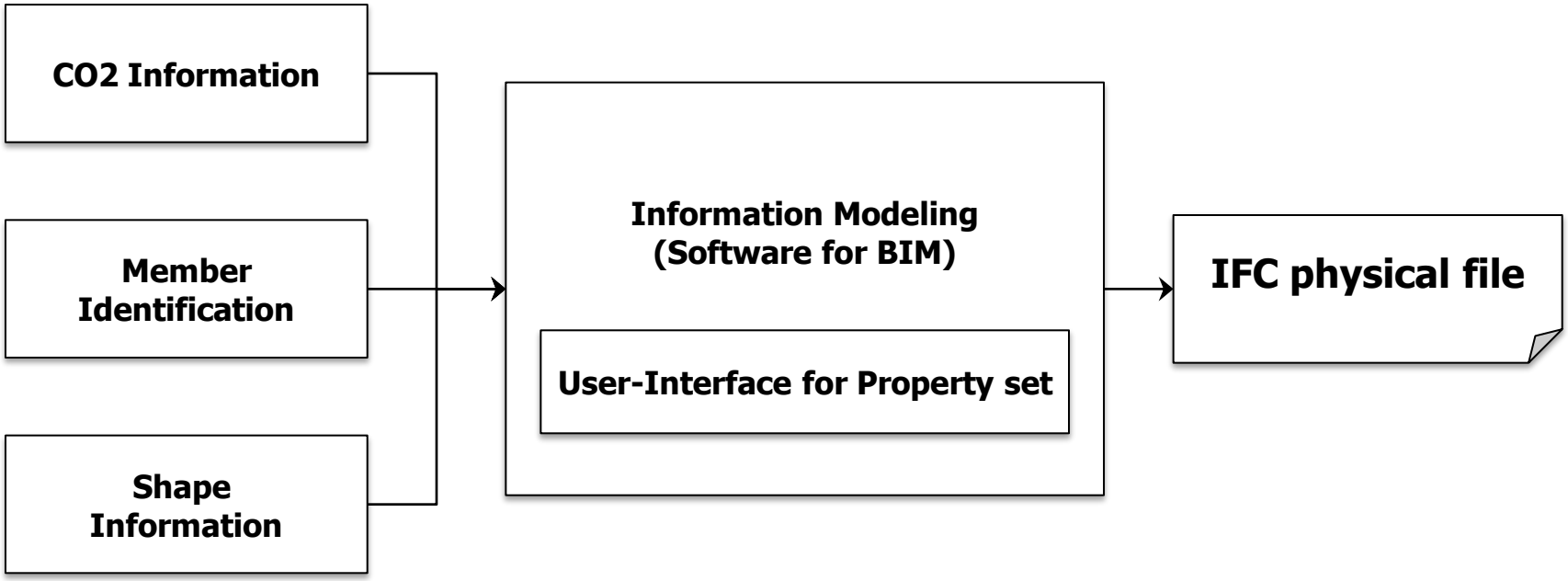


source: Green Growth Korea

CO2 1-ton = EUR 3(€), EUR 1(€) = KRW 1398(₩), EUR 1 = JPY 96(¥)
567.5 – 591.1 = 23.6-million ton = EUR 70.8 million(€) = KRW 98.9 billion(₩) = JPY 6.7 billion(¥)

(5) Calculating CO2 Emission with Property Sets

Basic Framework

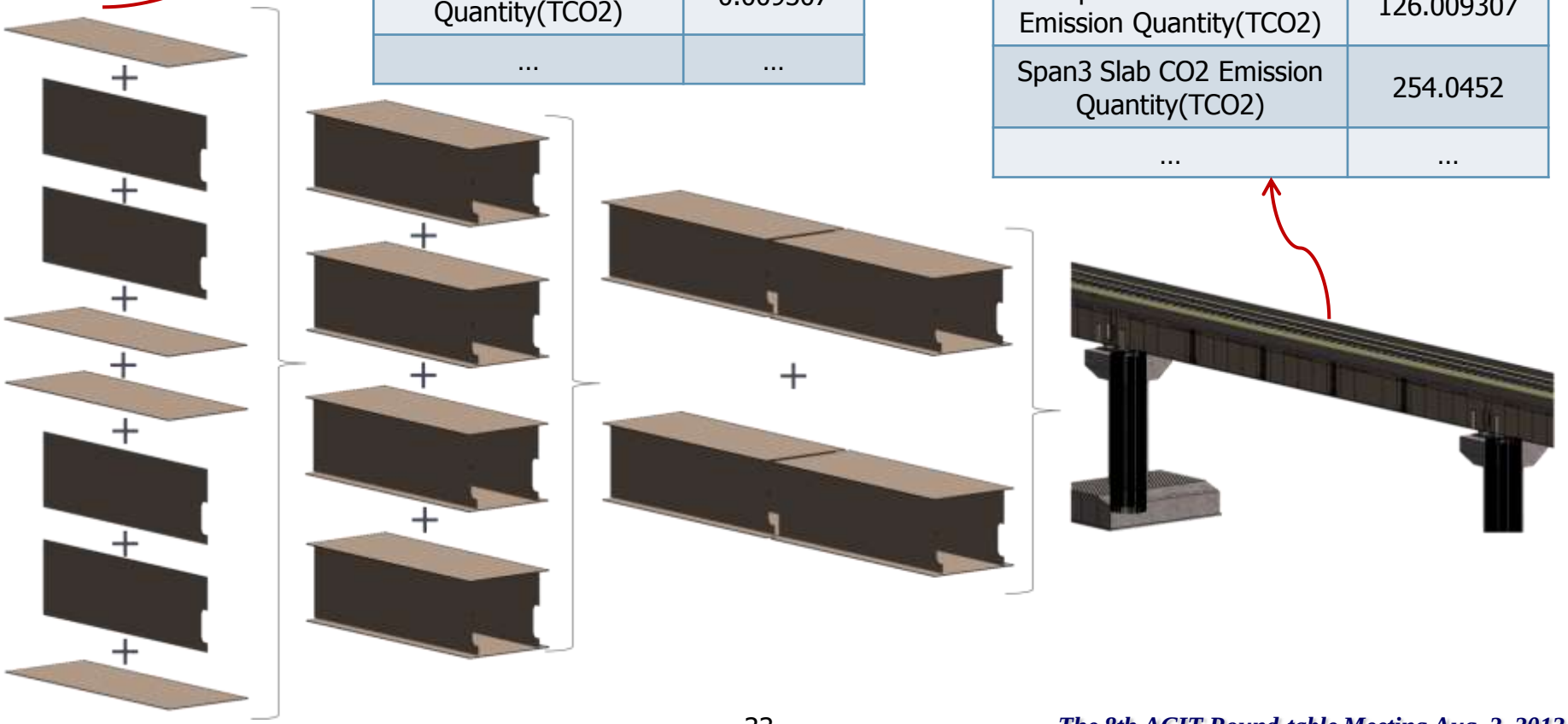


(5) Calculating CO2 Emission with Property Sets

Basic Concept of Calculating the CO2 Emission

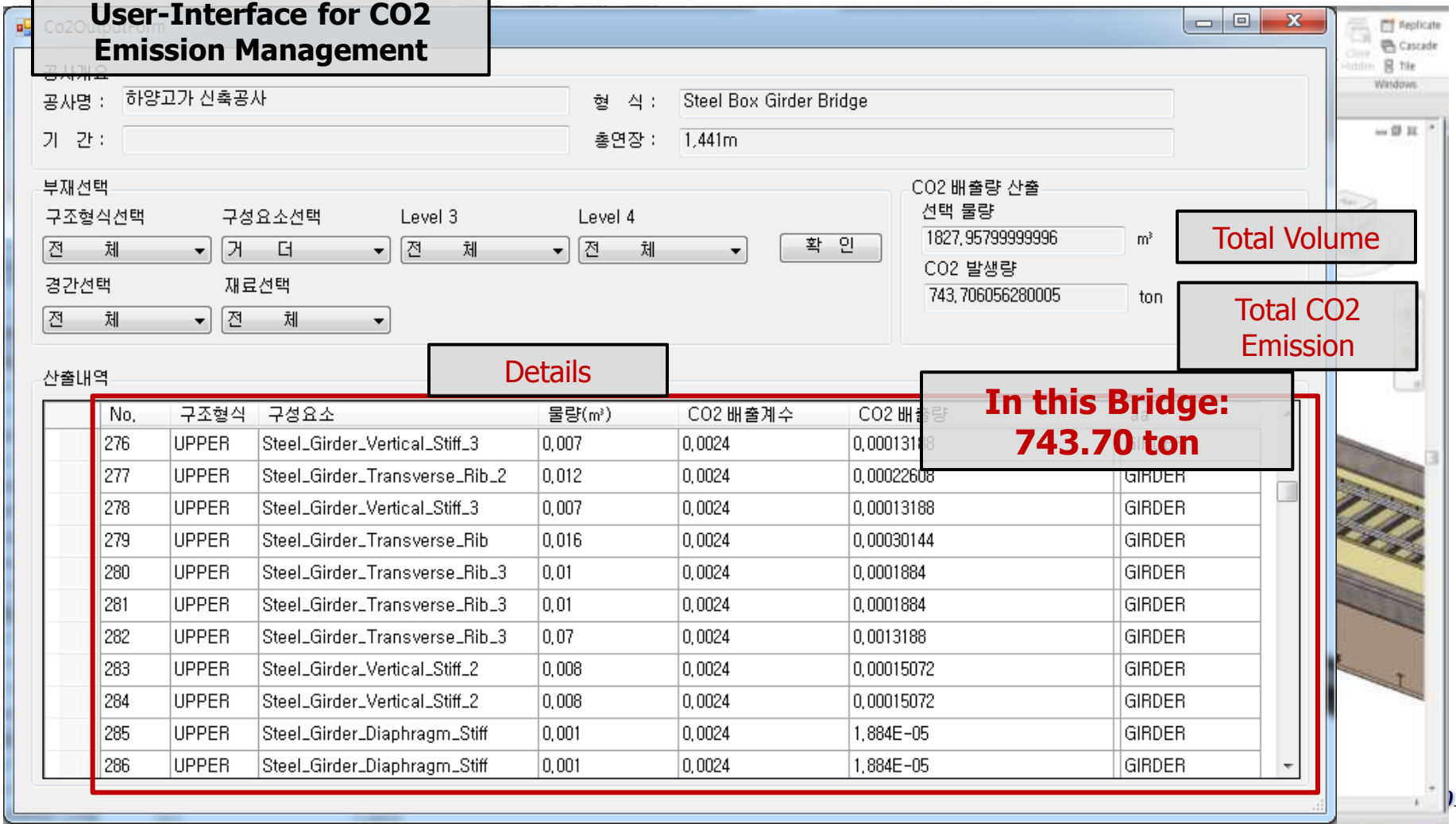
Material Quantity	3.8879
CO2 Emission Factor	0.0024
CO2 Emission Quantity(TCO2)	0.009307
…	…

Span3 Girder CO2 Emission Quantity(TCO2)	126.009307
Span3 Slab CO2 Emission Quantity(TCO2)	254.0452
…	…



(5) Calculating CO2 Emission with Property Sets

- **Bridge Information Model and User-Interface for Calculation of CO2 Emission**



No.	구조형식	구성요소	물량(m³)	CO2 배출계수	CO2 배출량	
276	UPPER	Steel_Girder_Vertical_Stiff_3	0.007	0.0024	0.00013188	GIRDER
277	UPPER	Steel_Girder_Transverse_Rib_2	0.012	0.0024	0.00022608	GIRDER
278	UPPER	Steel_Girder_Vertical_Stiff_3	0.007	0.0024	0.00013188	GIRDER
279	UPPER	Steel_Girder_Transverse_Rib	0.016	0.0024	0.00030144	GIRDER
280	UPPER	Steel_Girder_Transverse_Rib_3	0.01	0.0024	0.0001884	GIRDER
281	UPPER	Steel_Girder_Transverse_Rib_3	0.01	0.0024	0.0001884	GIRDER
282	UPPER	Steel_Girder_Transverse_Rib_3	0.07	0.0024	0.0013188	GIRDER
283	UPPER	Steel_Girder_Vertical_Stiff_2	0.008	0.0024	0.00015072	GIRDER
284	UPPER	Steel_Girder_Vertical_Stiff_2	0.008	0.0024	0.00015072	GIRDER
285	UPPER	Steel_Girder_Diaphragm_Stiff	0.001	0.0024	1.884E-05	GIRDER
286	UPPER	Steel_Girder_Diaphragm_Stiff	0.001	0.0024	1.884E-05	GIRDER

(5) Calculating CO2 Emission with Property Sets

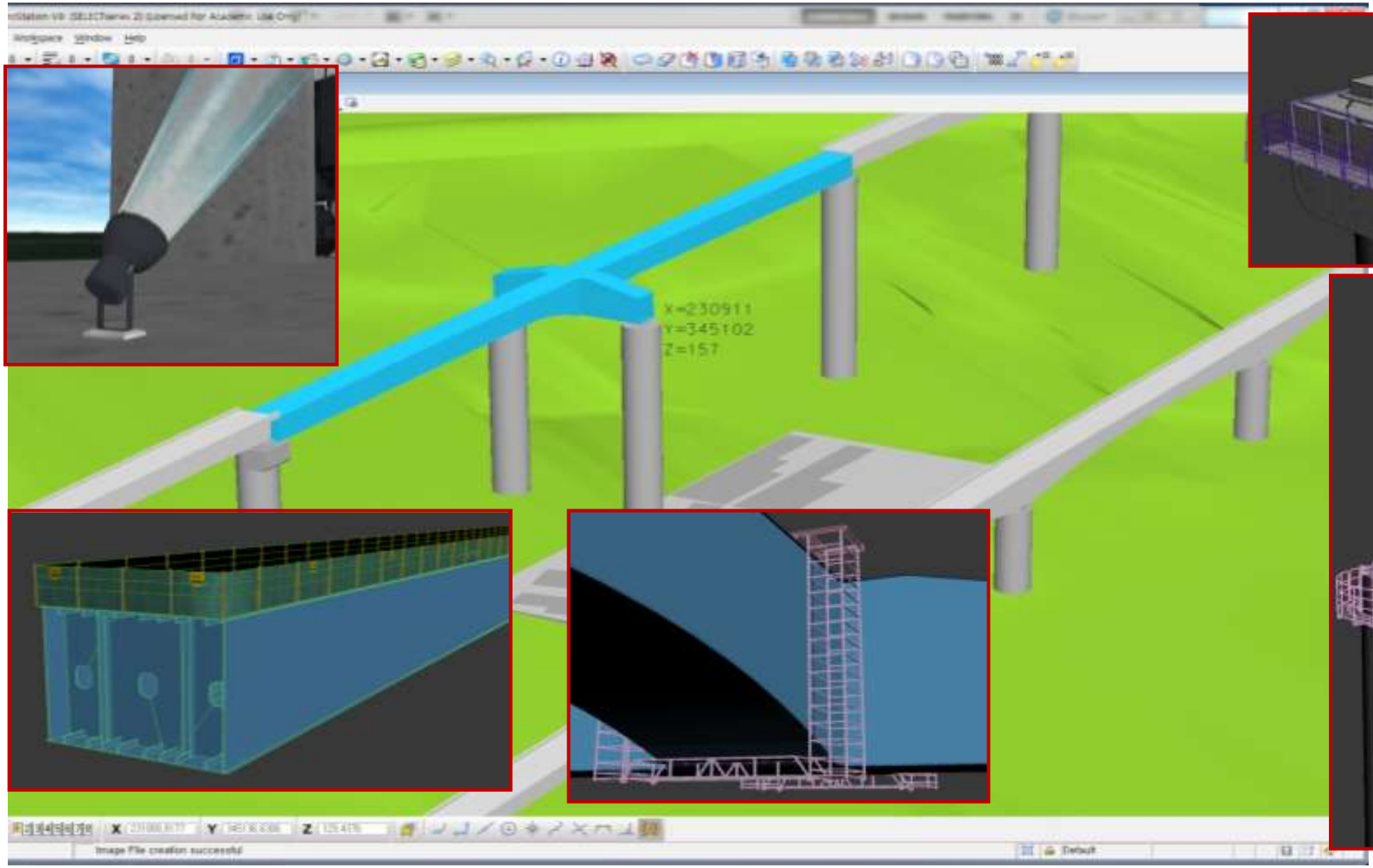
Assembled Member	Member	Material	Specification	CO_2 Emission
Deck	Concrete	Concrete	30MPa	201.25
	Rebar	H.T.Deformed Steel Bar	SD40H25	0.006
			SD40H22	0.044
			...	...
	Ballast	Gravel	-	1.45
Girder	Flange	Steel Plate	SM520B	0.05
	Web	Steel Plate	SM520B	0.025
	Rib	Steel Plate	SM520B	0.025
	...	...	...	...
Abutment	Concrete	Concrete	24MPa	152.7
	Rebar	Deformed Steel Bar	SD40D29	0.046
			SD40D25	0.025
			...	...
Column	Concrete	Concrete	24MPa	239.52
			18MPa	97.48
	Rebar	Deformed Steel Bar	SD40D29	0.005
			SD40D25	0.012
			...	...
POT Bearing	Concrete	Concrete	24MPa	0.80
	Shoe	Steel	4000KN	0.001
	Soul Plate	Steel	4000KN	0.001
Total				**743.70**

(6) 4D Simulation with Software for BIM

Overpass bridge for KTX crossing over KTX rail way
(The World's first overpass bridge for high-speed line)

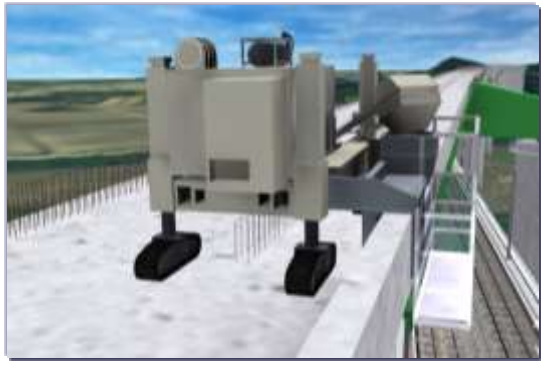
(6) 4D Simulation with Software for BIM

- **Geometric Modeling of Bridge**



(6) 4D Simulation with Software for BIM

- **Construction Equipment Modeling and Labor Avatar**

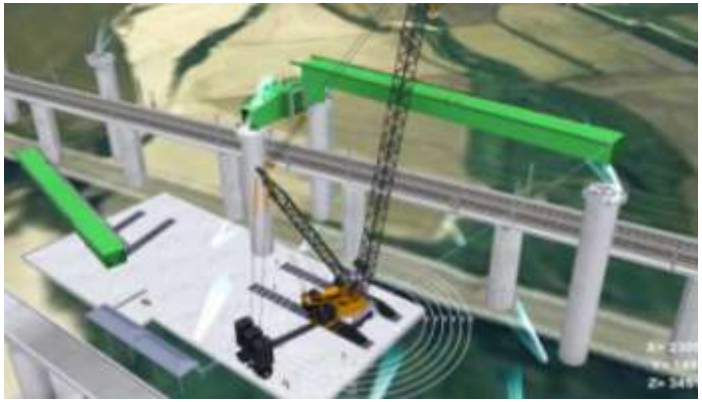


(6) 4D Simulation with Software for BIM

- **Points of BIM**

Crane movement

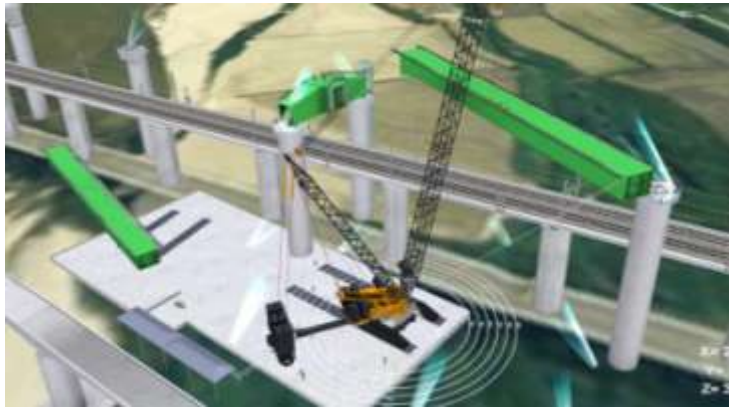
Loading simulation



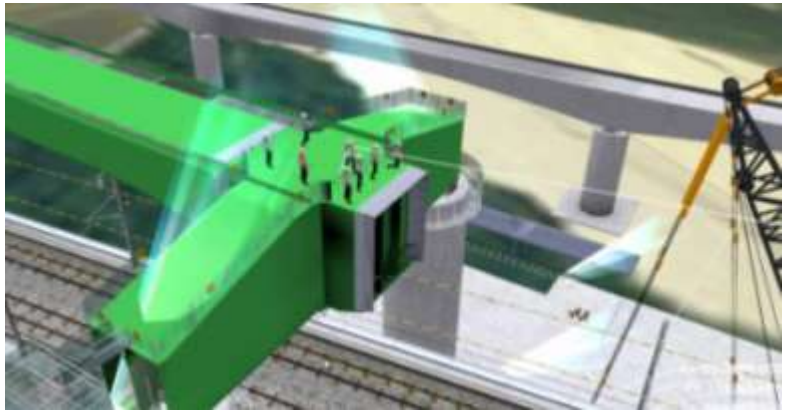
(6) 4D Simulation with Software for BIM

- **Points of BIM**

Conflict check



Joining simulation

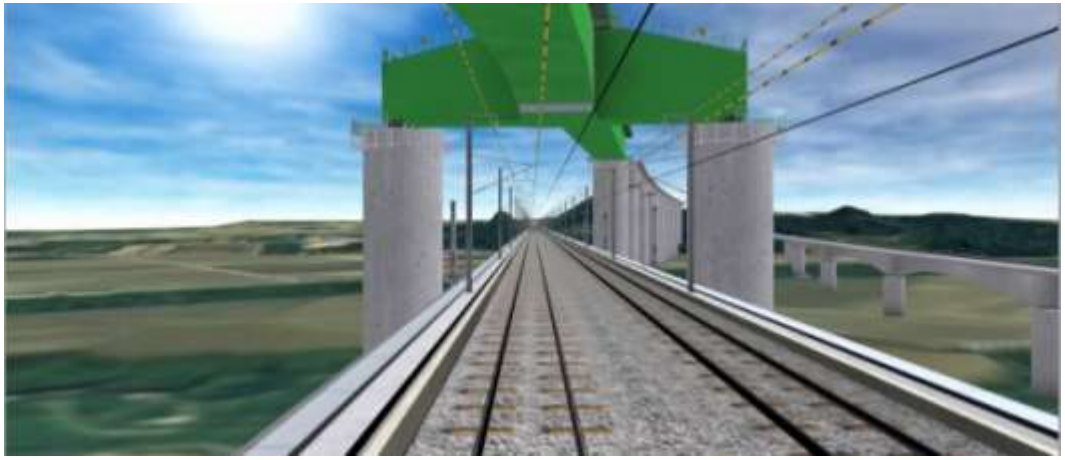


(6) 4D Simulation with Software for BIM

- **Points of BIM**

Labor movement

Education for drivers



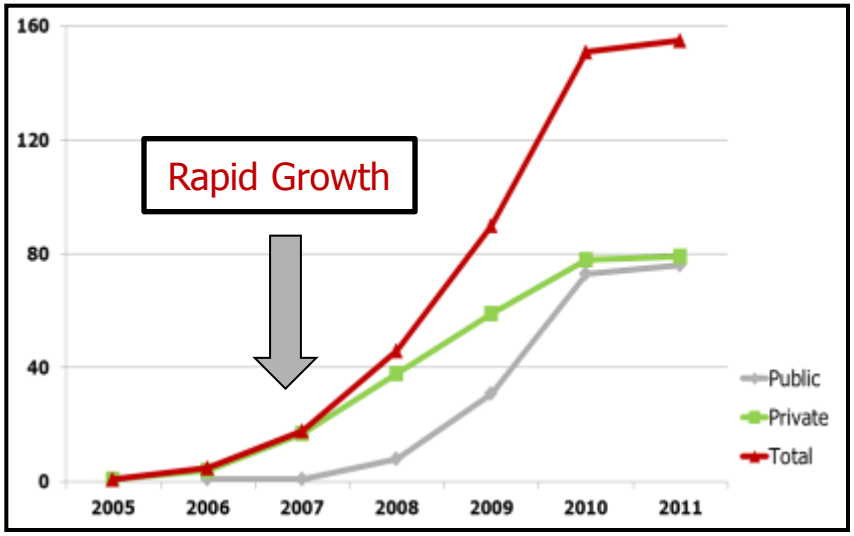
(6) 4D Simulation with Software for BIM

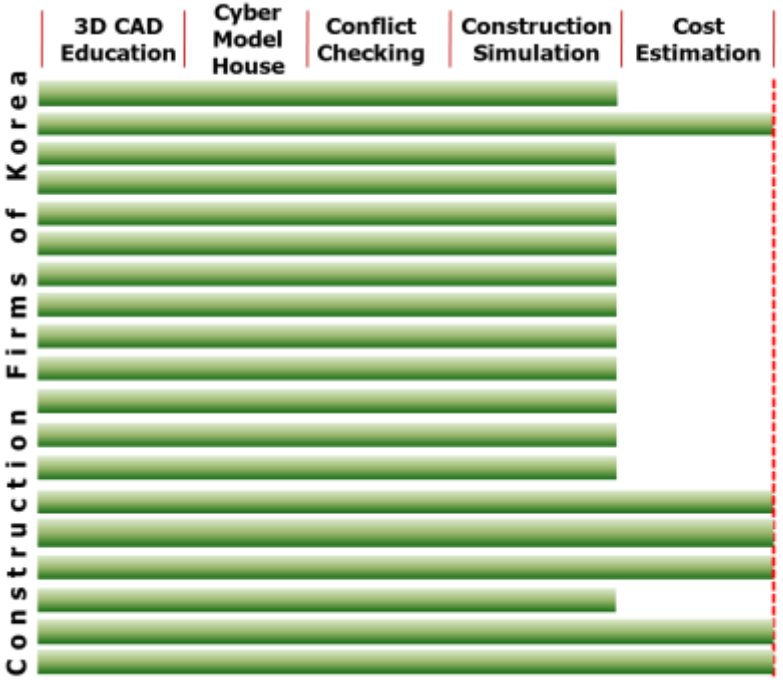
Main works

Transverse Girder	Vertical Girder (Start point)	Vertical Girder (End point)
• 26 meter, 400 ton • 00:50 ~ 03:20 (150 min.) • April 6th, 2012	• 80 meter, 600 ton • 00:50 ~ 04:20 (210 min.) • April 10th, 2012	• 80 meter, 600 ton • 00:50 ~ 04:20 (210 min.) • April 12th, 2012

Concluding Remarks

- Korea BIM Trend





- Korea Construction Firm
  - 50% Construction firms use 3D CAD in the top 20 ranks for checking the conflict
  - 35% of firms have used BIM for construction simulation
  - Cost estimation using BIM is being planned
- International Collaboration for Standardization of Model Data used in Civil Infrastructure Domain