

# Information Technology Applied in Civil Engineering Business

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## Introduction

- JSCE published “Guidebook of Information Technology in Civil Engineering” in 2005
- One of the purposes of the publication is to try to define what Construction IT is.
- First, in this presentation, we will introduce the summary of the first section of the guidebook.
- Second, research activities on Construction IT in Japan will be summarized by using the title and keywords of each technical paper presented in Journal of Applied Computing in Civil Engineering published by JSCE.

## Roles of Civil Engineering and Related Businesses

- Construction, maintenance, and management of infrastructures
- Social contribution through management of infrastructure and serving for safe and comfortable human life and environment

## Strategic importance of Information Technologies

- Improve efficiency of related businesses
- Overcome difficulties relevant to civil engineering businesses.
- Level up of the whole land management  
「Land Space Usage Support Service」  
Plan

## Two Challenges on IT Application and its development in Civil Engineering

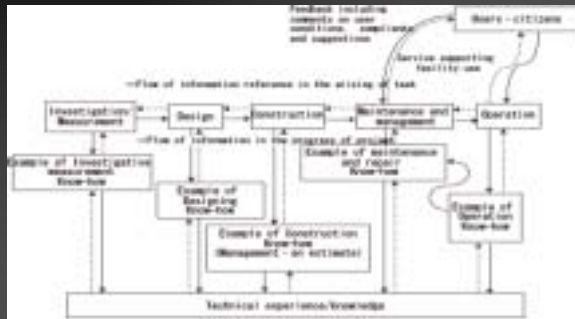
- Inside the civil engineering business:  
Improvement of effectiveness, offer of new services through management of infrastructure
- Out of the civil engineering business:  
Creation of new services by sharing information produced in the civil engineering business with organizations in other business fields

## Expected Roles of Civil Engineers on IT Application

- Information management on the bases of long-term scope.
- A wide variety of flexible activity for improvement of service level
- Design and planning of organization, mechanism to collect, accumulate, and reuse information



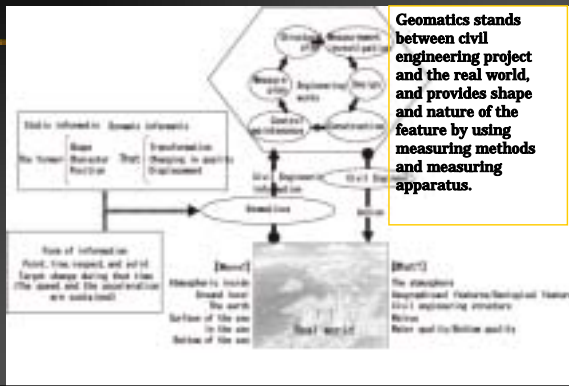
## Life-cycle usage of Information



## Technology for Information Acquisition

- **Geomatics:** Information on shapes and positions ( quantitative information ), and qualitative information
- Usage in a wide variety of occasions in its life-cycle

## A rough idea of the relationship between civil engineering project and Geomatics



## Technology for management and circulation of information(1)

- **Task-based classification:** on weather and water-environment, on structures, on construction works, on disasters, on environment, on comfort of life
- **Management and circulation:** collection, accumulation, exchange or linkage, offer or sharing

## Technology for management and circulation of information(2)

- Importance of extensible Markup Language (XML)
- Standardization, Modeling (SXF, UML, JHDM )
- Management and circulation of dispersedly accumulated information (CMS , RSS , Ubiquitous )

## Technology of Information usage

- **Information usage:** acquire desired information by producing new information from any information collected
- **Required technology**
  - Acquisition: Clear definition of contents and its quality, estimation and choice of contents and quality of existent information)
  - Pre-processing: Format conversion and so forth
- **Software**
  - CAD, GIS, Image processing, various business applications

# An example of the definition for the Civil Information

- A branch of civil engineering to study various activities closely related to the information which is produced in any stage of the civil engineering business and collected, managed, circulated, and used for the efficient and effective realization of the safer and more comfortable society

# Some layers should be set up to define the IT in Civil Engineering or Construction.

- Tasks: Observation/measurement/production, collection/arrangement, management/circulation, usage
- Businesses: acquisition, Investigation, Design, Construction, maintenance, Transportation, Risk management, Weather, Environment, Lifeline
- Related organization: Ordering organization, Suppliers/Contractors, Citizen, Engineers, Experts or specialists

## Activity Layer

Each specific activities introduced in the Guidebook on IT Application in Civil Engineering was mapped on business-IT related task table.

	BUSI NESS	OBSERVATI ON MEASUREMENT PRODUCTI ON	COLLECTI ON ARRANGEMENT	MANAGEMENT CIRCULATI ON	USAGE
CONSTRUCTI ON, MAINTENANCE, AND MANAGEMENT OF INFRASTRUCTURE	CONTRACT		ELECTRONIC BIDDING		
	I INVESTIGATI ON	ELECTRONIC CONTROL POINTS	GEOLOGY DATA	TISS	
	DESIGN	SOPHISTICATED OF STRUCTURAL DESIGN			
	CONSTRUCTION	CAD/CAM/CIM	DATA SHARING		
	MAINTENANCE	OBSERVATIONS CONSTRUCTION	CHART ELECTRONIC DELIVERY		
	TRANSPORTATI ON	DIAGNOSIS	BRIDGE MANAGEMENT SYSTEMS		
		VEHICLE	VIC	ETC	
		ITS(AHS)			
		DISASTER PREVENTI ON	DISASTER FORECAST	SUPREME. UREDAS	
	LAND SPACE USAGE SUPPORT SERV ICE	WEATHER FORECAST	GLOBAL SIMULATOR		
ENVIRONMENTAL MANAGEMENT					
LI FE LINE		REALTIME UPDATE OF EXISTING REAL TIME MONITORING			
IT BASE	ELEMENTS	SENSING, GPS, RS, DB, AGENT	STANDARDIZATION, SVX, GIS, MAP		
	GLOBAL	JHEM, ELECTRONIC LAND SPACE MODEL, LCOM, JCCS, PRODUCT MODEL, CYBERJAPAN			

## Technology Layer

Each specific technology appeared in the Guidebook on IT Application in Civil Engineering was mapped on the same table.

	BUSI NESS	OBSERVATI ON MEASUREMENT PRODUCTI ON	COLLECTI ON ARRANGEMENT	MANAGEMENT CIRCULATI ON	USAGE
CONSTRUCTI ON, MAINTENANCE, AND MANAGEMENT OF INFRASTRUCTURE	CONTRACT		EDI	E-SIGNATURE	TIMESTAMP
	I INVESTIGATI ON	RS (GPS/IMU)	CG (FRACAL)	INFORMATION BANK	
	DESIGN	RTK-GPS, BEM	CG (FRACAL)	ATTRIBUTE EXCHANGE	
	CONSTRUCTION	2D CAD	KNOWLEDGEBASE		
	MAINTENANCE	GA	CG (FRM)		
	LAND SPACE USAGE SUPPORT SERV ICE	FAHRI CXTI ON	CAD/CAM ROBOT ASSEMBLY	MACHINE CONTROL	DATA SHARING
		ENVIRONMENTAL MANAGEMENT	NUMERICAL SIMULATION	KALMAN FILTER	
		LI FE LINE	MEASUREMENT, INVERSE ANALYSIS	E-CHART	
	IT BASE	ELEMENTS	RTK-GPS, MEMS, POA	EXPERT SYSTEM (GENERAL NETWORK)	OPTIMIZATION
		GLOBAL	RFID, IC CARD, XML, GML, E-SIGNATURE	AGENT	WEB-GIS

## Research Trend

Keywords appeared in the papers included in the Journal of Applied Computing in Civil Engineering published in the past five years

	BUSI NESS	OBSERVATI ON MEASUREMENT PRODUCTI ON	COLLECTI ON ARRANGEMENT	MANAGEMENT CIRCULATI ON	USAGE
CONSTRUCTI ON, MAINTENANCE, AND MANAGEMENT OF INFRASTRUCTURE	CONTRACT				
	I INVESTIGATI ON	RS	CG	TISS	
	DESIGN	RTK-GPS	CG		
	CONSTRUCTION	CAD/CAM	DATA SHARING		
	MAINTENANCE	OBSERVATIONS	CHART		
	TRANSPORTATI ON	VEHICLE	VIC	ETC	
		ITS(AHS)			
		DISASTER PREVENTI ON	DISASTER FORECAST	SUPREME. UREDAS	
		WEATHER FORECAST	GLOBAL SIMULATOR		
	LAND SPACE USAGE SUPPORT SERV ICE	ENVIRONMENTAL MANAGEMENT			
LI FE LINE		REALTIME UPDATE OF EXISTING REAL TIME MONITORING			
ENVIRONMENTAL MANAGEMENT					
IT BASE	ELEMENTS	SENSING, GPS, RS, DB, AGENT	STANDARDIZATION, SVX, GIS, MAP		
	GLOBAL	JHEM, ELECTRONIC LAND SPACE MODEL, LCOM, JCCS, PRODUCT MODEL, CYBERJAPAN			

	BUSINESS	OBSERVATION MEASUREMENT PRODUCTION	COLLECITON ARRANGEMENT	MANAGEMENT CIRCULATION	USAGE
CONSTRUCTION, MAINTENANCE, AND MANAGENENT OF INFRASTRUCTUT ES	CONTRACT		ELECTRONIC BIDDING		
	INVESTIGATION	ELECTRONIC CONTROL POINTS		GEOLOGY DATA TIOSS	
	DESIGN	SOPHISTICATION OF STRUCTURAL DESIGN			
	CONSTRUCTION	CAD/CAM/CIM	DATA SHARING CINET ELECTRONIC DELIVERY		
	MAINTENANCE	DIAGNOSIS	CHART BRIDGE MANAGEMENT SYSTEMS		
LAND SPACE USAGE SUPPORT SERVICE	TRANSPORTATIO N	VICS		ETC ITS(AHS)	
	DISASTER PREVENTION	DISASTER FORECAST	SUPREME, UREDAS		
	WEATHER FORECAST	GLOBAL SIMULATOR			
	ENVIRONMENT	ENVIRONMENTAL MANAGEMENT			
	LIFELINE	REALTIME UPDATE OF EXISTING CONDITIONS REALTIME MONITORING			
	RISK MANAGEMENT	RISK EVALUATION		DECISION MAKING	
IT BASIS	ELEMENTS	SENSING, GPS,RS		DB, AGENT STANDARDIZATION, SXF,GIS, MAP	
	GLOBAL	JHDM, ELECTRONIC LAND SPACE MODEL, LCDM, JCCS, PRODUCT MODEL, CYBERJAPAN			

# TECHNOLOGY LAYER

	BUSINESS	OBSERVATION MEASUREMENT PRODUCTION	COLLECITON ARRANGEMENT	MANAGEMENT CIRCULATION	USAGE
CONSTRUCTION, MAINTENACE, AND MANAGENENT OF INFRASTRUCTUT ES	CONTRACT		EDI	E-SIGNATURE TIMESTAMP	
	INVESTIGATION SURVEY PLANNING	RS GPS/IMU RTK-GPS DEM	CG VRML FRACTAL	INFORMATION BANK	
	DESIGN	2D CAD NN GA	DATABASE KNOWLEDGEBASE CG VRML	ATTRIBUTE EXCHANGE	
	FABRICATION CONSTRUCTION	CAD/CAM NUMERICAL SHOP ASSEMBLY	ROBOT MACHINE CONTROL KALMAN FILTER MEASUREMENT, INVERSE ANALYSIS		DATA SHARING
	MAINTENANCE	RTK-GPS MEMS	EXPERT SYSTEM NEWRAL NETWORK OPTIMIZATION PDA	E-CHART	
	LIFECYCLE	RFID, IC CARD UML MEMS	XML,GML SOAP PRODUCT MODEL, OBJECT MODEL, DB, CAD, GIS DATA EXCHANGE STANDARD	E-SIGNATURE TIMESTAMP	AGENT
LAND SPACE USAGE SUPPORT SERVICE		LANGUAGE PROCESSING SIMULATION ETC VICS	TIOSS AHS	WEB-GIS	

	BUSINESS TASKS	OBSERVATION MEASUREMENT PRODUCTION	COLLECITON ARRANGEMENT	MANAGEMENT CIRCULATION	USAGE		
CONSTRUCTION, MAINTENACE, AND MANAGENEMT OF INFRASTRUCTUT ES	CONTRACT						
	INVESTIGATION PLANNING	05-01 05-08 05-16	03-15 01-12 01-17 01-21	03-06 01-08	03- 04		
	DESIGN	05-03 05-15	01-11 01-23	04-27 03-20 02-01 01-20 01-24	02-05 01-19 01-01	05-02 04-22	04-04 04-28 03- 21
	CONSTRUCTION	05-10 05-18 04-25	04-31 04-32 03- 10	05-13 04-01 04-22 04-24	04-29 04-30 02- 08 01-18	05-02 04-26 01-16	04-33 03-09 02-07
	MAINTENANCE	05-04 03-12 03-13		05-17 04-05 04-15	04-17 01-03 01-14	04-18 03-05 03-11	01-15
LAND SPACE USAGE SUPPORT SERVICE	TRANSPORTATION	05-07 04-02 04-03	04-08 03-08 03-14 01-22	05-06 04-12 03- 07	03- 16 02-04 01-09	03-03	05-05 04-13 01-07
	DISASTER PREVENTION	05-11 05-12		03-17 01-02 01-10		03-19	
	WEATHER FORECAST						
	ENVIRONMENT LANDSCAPE	05-14 04-20 03-18	02- 06 02-09 01-25	04-09 04-14 03-02	02-03		
	LIFELINE	05-03 05-13		01-13			
	RISK MANAGEMENT						
IT BASIS	ELEMENTS	RS 02-10 01-05	GIS 04-06 04-10 04-16 04-19	SXF 02-02	MAP 0411	DB 01-06	
	GLOBAL	JHDM 03- 01 01-04	PRODUCT MODEL 02-05 04-21				

## Keywords appeared in the papers included in the Journal of Applied Computing in Civil Engineering published in the past five years.

[2005]

- 05-1 Flood Analysis by Finite Elemental Method using Laser Measurement Data**  
*laser measurement data, flood analysis, finite element method, automatic attribute distinction*
- 05-2 Research of Document Data Identity Verification Component for Electronic Delivery**  
*electronic delivery, document processing, layout analysis, natural-language processing, identity verification*
- 05-3 Automatic Generation of 3-D Water Way Model from Center Line of Water Way on GIS**  
*3-D urban model, automatic generation, center line of water way, CG (Computer Graphics), GIS (Geographic Information System), 3-D water way model*
- 05-4 Risk Evaluation of Concrete Bridge Deterioration**  
*bridge condition, concrete deterioration mechanism, deterioration risk, risk evaluation, GIS*
- 05-5 Some Fundamental Examinations on the Usability of Optical Beacon Information in Traffic Signals Control**  
*optical beacon, up-link information, traffic signals control, neuron model*
- 05-6 About Effective Use of the Laser Measurement Data by the Automatic Attribute Distinction Method**  
*laser measurement data, automatic attribute distinction, 3D city model, flood analysis*
- 05-7 Research Development on People Flow Measurement in Crowded Space**  
*road traffic census, people flow measurement, background subtraction method, smoothing process, labeling process, area lap percentage*
- 05-8 Development of Efficient City Modeling Using Pictorial Map**  
*pictorial maps, 3D reconstruction, virtual Reality, computer graphics*
- 05-9 Proposal of Bridge Maintenance Engineer Education System by Virtual Reality Technology**  
*virtual reality, engineering education, student-problem score table analysis, technique inheritance, bridge management*
- 05-10 Study on the Modeling Method Suitable for Pavement Rutting**  
*rutting, pavement rutting model, EVEN data, road profile, CARSIM*
- 05-11 Development of Simulation System of Spreading Fire Occurring Simultaneously in Many Places in an Earthquake Using Petri-net**  
*Petri-net, spreading fire, earthquake*
- 05-12 An Automated Detection Method of House Damage Areas due to Earthquakes using Vertical Aerial Photographs**  
*automated detection, the 1995 Kobe earthquake, collapsed wooden house area, vertical aerial photograph, CIE L\*a\*b\* colorimetric system, fractal dimension, grey scale fractal dimension*
- 05-13 Recursive Modeling and Unsteady Flow Computation of Open Channel Networks with Object Oriented Programming**  
*open channel network, unsteady flow, recursive structure, object oriented programming, design pattern*
- 05-14 Simulation of Diffusion Phenomena of Chlorine on through Soil Using Cellular Automation Method**  
*cellular automaton, diffusion phenomena, chlorine ion, immobile water*
- 05-15 Support System for Seismic Design of RC-pier using GA and SOM**  
*Genetic algorithm, SOM, RC pier, detail design assistance*
- 05-16 A Empirical Research on Movement Grasp in City used of Mobile Telecommunications Technology**  
*mobile telecommunications, GPS, urban infrastructure planning, location information, GIS*
- 05-17 Bridge Management System Application**  
*bridge management, deferred maintenance accounting, asset management, life cycle costing*
- 05-18 The Structuralization of Basic Design Information of Road Structures for Using at the Site Management**  
*civil design, construction management, basic design information, data model, CAD, survey, road ground work, coordinate systems*
- 05-19 A New Method to Progress Control of Working Form in Paving Work by using Information Technology**  
*observational construction, electronic data, asphalt paving work, progress control of working form*

[2004]

- 04-01 Development and Commercial Viability of Cooperate System between SSL-VPN and Biometrics System for Small-scale Construction Sites and Loaned Employees**  
*network, SSL-VPN, construction site, loaned employee, Security, certification, fingerprint*
- 04-02 Development of Web-based Slope Stability Evaluation System (SSE-web)**  
*slope stability evaluation, network environment, satellite remotely sensed data, geographical information, quantification method, spatial data integration and analysis*
- 04-03 Development of GIS-based Spatial Three-dimensional Slope Stability Analysis System: 3DSlopeGIS**  
*GIS, slope stability, slope disaster, spatial three-dimensional, slope unit, natural slope, GUI*
- 04-04 One Proposal about Data Application of a River Project Model**  
*Construction CALS/EC, product model, river project model, River XML*
- 04-05 Development of an Internet-based Measurement Apparatus Database System for Bridge Inspection**  
*bridge management, inspection, Measurement apparatus, Web applications, DB, XML*
- 04-06 Practical Use and Cost Effectiveness of GIS in a Road Field**  
*GIS, maintenance, practical use, cost effectiveness*
- 04-07 An Action of Computerization of Maintenance and Management Activities for Expressways**



*CALS, CAD, drawing of road management, maintenance and management, information-sharing system*

**04-08 Study on Monitoring System for Railway Slope Disaster Prevention**

*slope disaster prevention, monitoring system, IT, maintenance management, spectrum spread wireless transfer system*

**04-09 A Study on Color Harmony Evaluation of Bridge Landscapes using Image Questionnaire**

*bridge landscape, color harmony, Semantic Differential technique, color selection*

**04-10 Development of 3D Simulation System for Electric Wave Route of Satellite**

*3D-GIS, measured Satellite, stationary Satellite, simulation system for electric wave route*

**04-11 Fundamental Research of System for Extracting Attributes of Digital Map by Automatic Search on WWW**

*GIS, Web, digital map, attribute, natural-language processing*

**04-12 A Hazard Map for Estimating Infrastructure Damage Caused by Land Subsidence**

*land subsidence, Geographical Information System, infrastructure, spatial distribution, Geographical Information, satellite image*

**04-13 The Development of Earthquake Damage Prediction System and Operation System of Emergent Goods Transportation in Earthquake Disaster Considering Utilization of Convenience Store**

*earthquake damage prediction, emergent goods transportation, intelligent transportation systems, convenience store*

**04-14 Internet-based Supporting System on the Alternatives for Consensus Building at the Aesthetic Design of Girder Bridges**

*girder bridge, consensus building, alternatives, Web applications, XML*

**04-15 Road Pavement Management Accounting System Application**

*road pavement, management accounting, deferred maintenance accounting, asset management, life cycle costing*

**04-16 Improvement in Functional on GIS Management System with Attribute Data**

*CAD, CALS, attribute data, drawing of road management*

**04-17 To-be Model of Maintenance Stage for Concrete Highway Bridges**

*concrete highway bridges, maintenance, to-be model, information model, project management*

**04-18 Standardization and Input System to be more efficient for Inspection Data of Bridge**

*BMS (Bridge Management System), XML, CALS/EC, damage figure drawing support system, Tablet PC, class diagram*

**04-19 Improvement in Functional on 3-D GIS Prototype System with Virtual Reality**

*achieve consensus, 3-dimensional GIS, virtual reality, real time CG*

**04-20 Development of Measurement System for the State of Rampart Using 3-D Laser Profiler**

*3D-laser profiler, CAD, CG*

**04-21 Reference Investigation Concerning with Utilization Use of the 3D Information in Construction Industry**

*3D information, constructionIndustry, CALS/EC, reference investigation*

**04-22 A Research and Development about the Automatic Creation System of the 3-dimensional Model by using the Digital Video Camera**

*3D model, photogrammetry, corresponding point, digital video camera, digital animation, optical flow*

**04-23 Analysis of granular flow by Cellular Automata**

*Cellular Automata, grain, flow, friction*

**04-24 Drain Simulation on Road Surface of Bridge Using Cellular Automaton**

*Cellular Automaton, drain of load surface, bridge*

**04-25 Application and Development of the Highway Design-Information-Model Utilizing the Parametric Alignment Model**

*Product Model, highway alignment, highway geometry, 3D-CAD, Design-Information-Model*

**04-26 A Product Model-Based Design System for Steel Girder Bridges Using Virtual Reality**

*virtual reality, stereograph, product model, IFC, 3D-CAD, steel bridge, immersion, interactivity*

**04-27 Fundamental Investigation on the 3D Product Model for Steel Girders based on Basic Lines and Surfaces**

*product model, steel bridge, steel girder, basic line, surface, XML, DTD, 3D CAD*

**04-28 Research for Generating 3D Wire Frame Model Data from Orthographical Three Views**

*CAD, orthographical three views, 3D wire frame model data*

**04-29 A Converter Program for the Product Model of Pre-tressed Concrete Bridges and a Simple On-Site Size Checking System**

*product model, IFC, 3D-CAD, digital image, size checking, digital camera*

**04-30 Development a New Construction Support System for the Earthwork Using 3D Product Data**

*CAD, GPS, earthwork, machine construction, project management, information construction system, 3D-Product data,*

**04-31 Verified Experiment of Road Working-form Management by using IT Technology**

*IT-construction, Electronic data, Working-form management, Road construction*

**04-32 A New Method to Check the Surface of Road Construction Work by using IT Technology**

*IT construction, next generation CALS/EC, road construction, topographic checking, rock border checking*

**04-33 Study on Framework of Construction Profile for Collaborative and Intelligent Construction**

*Collaborative and intelligent construction, framework of construction profile, construction profile assessment, XML*

[2003]

**03-01 A Study of Developing JHDM for the Superstructure in Metal bridge.**

*CAD, CALS, XML, UML, GIS, road, bridge, superstructure, Product Model*

**03-02 A Fundamental Study on Color Image Scale of Bridge Landscapes**

*bridge landscape, color design, Semantic Differential technique, color image*

**03-03 Management of Digital Road Map Database based on DRM Standard Format 21**

*digital road map database, spatial temporal information, update archive data, spatial temporal differential data, ISO, KIWI+ format, simple topology & spatial temporal - open database schema (ST2-ODS), temporal schema*

**03-04 Method of Making and Updating Spatial Data by Using RTK-GPS Survey**

*RTK-GPS, FKP, GIS, location reference point, update, private sector data*

**03-05 Information Models for Maintenance Stage of Concrete Highway Bridges**

*concrete highway bridges , maintenance , information models , CALS , UML , XML*

**03-06 Development of Spread Sheet-based Supporting System for Land-use Concept Planning**

*spread sheet environment, network environment, cooperating system, land use conception plan, satellite remote sensing data, spatial data integration and analysis, quantification method, Analytic Hierarchy Process(AHP)*

**03-07 Stochastic User Equilibrium Assignment Adopting Expressway Diversion Function**

*traffic flow estimation, expressway, expressway diversion function, stochastic user equilibrium assignment*

**03-08 The Highway Traffic Noise Simulation Utilizing 3D Sound Library**

*traffic noise, audio simulator, virtual reality, traffic flow simulation*

**03-09 Development of Comprehensive Use Planning System of a Dam Material**

*data-base , graph theory , process plan , network plan , transportation problem , ahp theory , integrated information system*

**03-10 Remote Monitoring of Ground Vibration During Tunnel Excavation by Mobil Communications**

*tunnel excavation, underground vibration, vibration measurement, remote monitoring, mobile communication*

**03-11 Practical Application of Database System for Bridge Maintenance Management**

*BMS(Bridge Management System), Web-DB, DBSBM(DataBase System for Bridge Maintenance management), IRPS(Inspection Report Preparation System), XML, CALS/EC*

**03-12 A Application of Digital Image Processing to Crack Recognition of Concrete Surface**

*Digital camera, Image processing, Inspection Support, Crack, Concrete structure, Genetic Algorithms*

**03-13 Study on the Data Processing of Road Profile Using the Wavelet Packet Transform**

*Wavelet Packet Transform , Wavelet Transform , road profile , PIARC EVEN data*

**03-14 Development of Bus Traffic Alternative Simulation on Its Background Image by Petri Net Simulator**

*transportation planning, bus priority alternative, micro traffic simulation, improvement of software.*

**03-15 A research for Producing Web/3D Model House from 2D Digital Pictures**

*3D Model House , photogrammetry , corresponding points, convergence photography , digital picture , Web , VRML*

**03-16 On the Study of Traffic Safety Evaluation at Intersection Part by Micro-traffic Simulation**

*traffic safety measure , traffic accident , simulation , intersection , evaluation*

**03-17 Construction of Convenient Simulation System of Spreading Fire at an Earthquake Using Digital Residential Maps**

*simulation system of spreading fires, earthquake, digital residential map, shortest route problem*

**03-18 Study on Dynamic Colored Petri-net Simulator for Evaluation Support System of Infrastructure Planning from Regional Climate Creation Viewpoint**

*infrastructure planning, bridge, Petri net, image of regional climate, dynamic simulator, improvement of software*

**03-19 Development of Distant Sound Information Database Using Web Services for Facility Diagnosis**

*sound, hammering sound, bolt, diagnosis, SOAP, web service, database*

**03-20 A Mechanism of KANSEI (sensitivity) Evaluation of 3D Shape Primitives for Development of an Aesthetics Design Support System of Civil Infrastructures**

*landscape, aesthetics, SD method, 3D-CAD, primitive, fuzzy set theory, KANSEI (sensitivity)*

**03-21 Development of a Comprehensive Design Support System Using a Product Model**

*product model, IAI, IFC, XML, 3D-CAD, design checking, constructability, covering*

**03-22 Design Support for Steel Frame Structures Using Web Services and Multi-Agents**

*multi-agents, web service, SOAP, product model, IFC, XML*

[2002]

**02-01 A 3D-CAD Environment with a Multi-Agent System and a Product Model**

*multi-agent, product model, IAI, IFC, XML, 3D-CAD, design checking*

**02-02 Development of SXF Browser for Modifying CAD Drawings**

*CALS , ISO , STEP , CAD , SXF*

**02-03 Construction of the Kansei Database of the Riverine Landscape in the Shikoku Region**

*riverine landscape , Kansei database , aesthetic of landscape , public involvement*

**02-04 Fundamental Research of System for Producing Guide Map by using Digital Map 2500**

*GIS , digital map 2500(spatial data framework) , cognitive map , guide map*

**02-05 Development of a 3 Dimensional Product Model for Pre-stressed Concrete Hollow Slab Bridges Based on Industry Foundation Classes(IFC)**

*IAI, IFC, XML, product model, pre-stressed concrete hollow slab bridge, 3D-CAD, CALS/EC*

**02-06 Applying SOM to Scenery Evaluation and Classification of Girder Bridge**

*SOM , aesthetic of landscape , girder bridge , Kansei Engineering*

**02-07 The Construction Management System for Earthwork Using Web-GIS**

*CAD, GIS, GPS, earthwork, quality control, project management*

**02-08 An On-Site Inspection Support System Using RFID, PDA and Voice Technologies**

*RFID , PDA , voice input/output , inspection , knowledge management*

**02-09 The Acquisition Method of the Moving Vehicle Information in Public Garbage Collection Work Using Handy GPS and GIS**

*public garbage collection , collecting vehicle information , easy acquisition method , GPS , GIS*

**02-10 Development of the Internet-based Satellite Data Processing and Analysis System**

*satellite data processing and analysis, software library, network environment, data resource management*

[2001]

**01-01 Establishment of a Cooperative Database for Benchmark Test of Structural Analysis under Severe Earthquake Motion on the Web**

*structural analysis, Benchmark data, metadata, XML, Java, database, Dublin Core*

**01- 02 Study on Development of Information Mapping System for Regional Vulnerability to Fire Spreading.**

*vulnerability to fire spreading, decentralization of power, regional fire prevention plan, land use classification map, fire spreading simulation, regression model, colored map*

**01- 03 Title Web-based Seismic Damage State Evaluation System for Bridge Structures**

*Bridge structure, Seismic damage state, Evaluation system, WWW system, Java, Response time*

**01- 04 A Fundamental Study of Developing Japan Highway Data Model**

*CAD, CALS, XML, UML, GIS*

**01- 05 Development of the Providing and Management System for the Evaluated-information on the Satellite-data Characteristics**

*evaluation of image characteristics, satellite remote sensing data, Data Set Management*

**01- 06 A CALS-Oriented Study on Representation of CAD-DATA for Using GIS**

*CALS/EC, GIS, CAD, geodetic reference positions, STEP, ISO/TC211*

**01- 07 Utilization of Road Register for GIS Base Map And Making Method of Drawings Using RTK-GPS Survey**

*distribution and common of GIS data, location reference point, road register, raster data, RTK-GPS*

**01- 08 Quality Evaluation of Private Sector Survey Result And Possibility of Use by GIS**

*practical use of private sector survey results, quality evaluation, GIS, Geographic Information Standard, city datum point, location reference point*

**01- 09 Development of Supporting System for Public Transportation Planning in Space of Human Activities**

*planning supporting system, public transportation network, GIS, planning information, space of human activities*

**01- 10 A Study on Emergency Information System of Highway Bridges for Typhoon and Heavy Rain**

*bridges, GIS, emergency information, information management, feature, UML*

**01- 11 A Web-based Collaborative Finite Element Analysis System Using a Distributed Object Technology**

*distributed object technology, distributed computing, object-oriented, finite element analysis, WWW*

**01- 12 Assembling Tools for Problem Modeling by Using Different Viewpoints**

*KJ Method, ISM, viewpoints, card-handling support, opinion publicity of the government*

**01- 13 An Inspection Data System of Penstocks by a 3D Product Model and Electronic Tags**

*3D Product Model, 3D-CAD, GIS, electronic tag, voice input/output, inspection*

**01- 14 An Application of Web3D Technology to Road Facility Management Systems**

*web 3D, facility management system, VRML, XML, highway guided sign*

**01- 15 A System on 3D-Model Libraries for Maintenance of Steel Highway Bridges**

*steel highway bridges, maintenance, 3D-models, Web applications, CG*

**01- 16 Scaffolding Sharing in GA Applied Bridge Repair Planning**

*bridge repair, Genetic Algorithm, sharing of scaffold*

**01- 17 Modeling of Maintenance Strategies for Highway Bridges by Using Multi-layer Genetic Algorithms**

*genetic algorithms, multi-layer, highway bridges, maintenance strategies, optimization*

**01- 18 On the Study of an Auto-navigation System for Discharge-Type Micro-tunneling Machines**

*micro-tunneling, acemole, automatic control, Kalman filter, Optimal control*

**01- 19 Supporting System on the Seismic Design for RC Piers with SOM**

*SOM, systems for design, estimation on stability, quality control*

**01- 20 An Integrated Design System for Connections of Steel Structures**

*XML, 3D-CAD, product model, steel structures, connections, integration, design generation, design standards, conformance checking*

**01- 21 A Proposal for Evaluating Road Improvement Plan by Combining Traffic Assignment and Traffic-Flow Simulation**

*road improvement plan, support system for survey and planning, traffic-flow simulation, traffic assignment, saturation of an intersection, evaluating methodology, evaluation of public works, accountability*

**01- 22 A Study on Developing Optimum Route Extraction System for Subway Transportation Considering Transfer Resistance and Timetable Information**

*sSubway, public transportation, hHandy-capped passengers, optimum route extraction*

**01- 23 Fast Calculation Method of Earthwork Quantity for Vertical Alignment for Digital Terrain Data**

*vertical alignment, digital terrain data, average cross section method, earthwork quantity calculation, DXF*

**01- 24 Integration of Conformance Checking and Estimation of Pre-stressed Concrete Hollow Slab Bridges by a Product Model**

*Product model, 3D-CAD, conformance checking, estimation, pre-stressed concrete hollow slab bridge, XML*

**01- 25 A Study of Landscape Value by Using Various Fractal Dimensions of Colors**

*fractal dimension, landscape feature, spatial fluctuation*