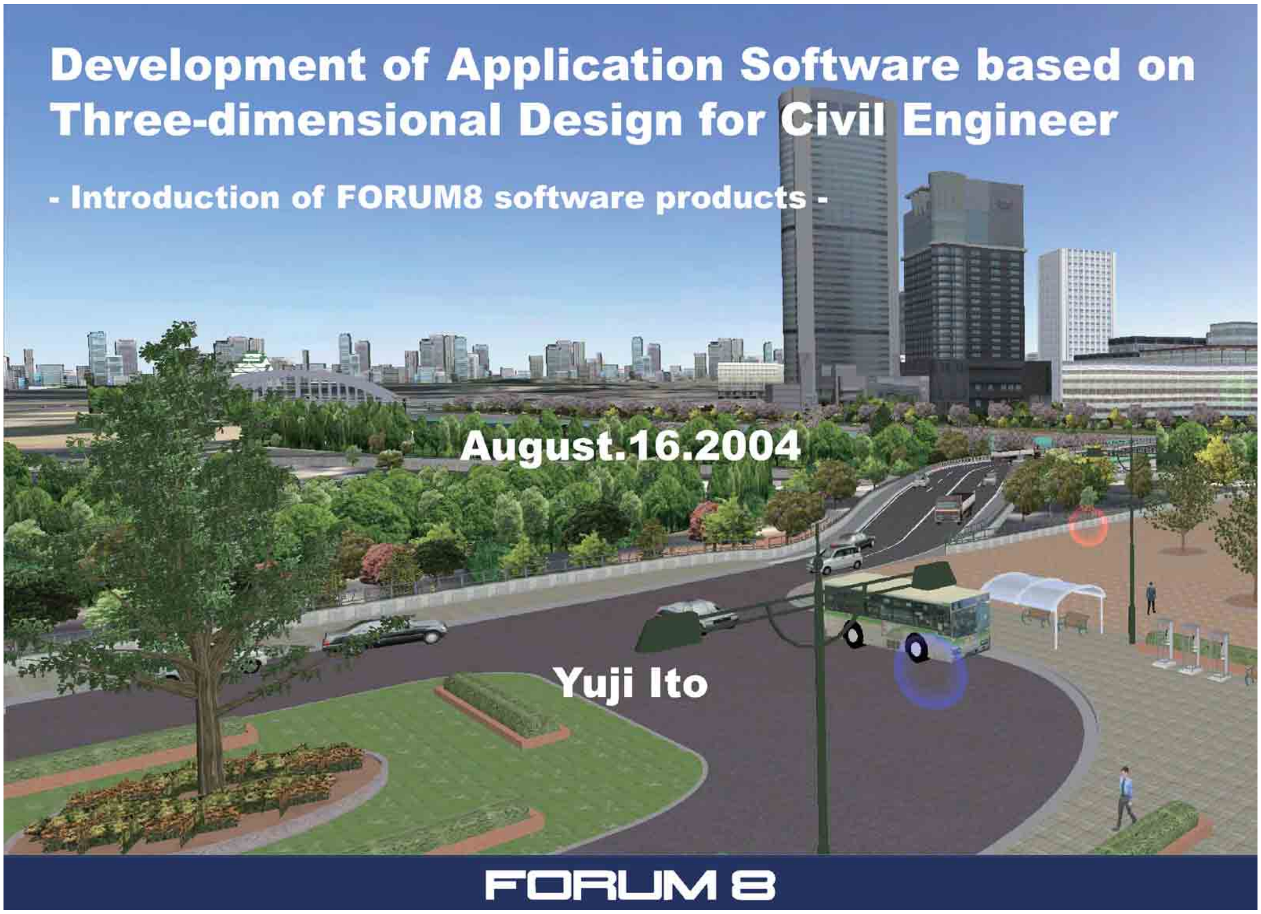

DEVELOPMENT OF APPLICATION SOFTWARE BASED ON THREE-DIMENSIONAL DESIGN FOR CIVIL ENGINEERS

- INTRODUCTION OF FORUM8 SOFTWARE PRODUCTS -

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INTRODUCTION

In Japan, there has been a rapid development of the infrastructure during a high-growth period and a number of civil engineering structures have been constructed. These structural designs have been conducted mainly through the use of software packages which were released around 1982 when personal computers were first introduced.

A number of factors and technological evolutions have contributed to the transition of design software over the past 20 years since they became commonly used. In the beginning, the software could only support particular structures and its calculation features were limited. With the extraordinary improvement in the performance of hardware and basic software, the software has become large-scale and highly sophisticated.

Also, the variety of social events and phenomenon in Japan has greatly affected the designs of civil engineering structures. We vividly remember the reevaluations of the quake-proof standard after the Kobe earthquake. Many of the design standard policies have been modified so frequently that design software has gained an important status in designing. Also in recent years, a wide variety of design methods and high-precision analysis such as application of new performance regulations, materials, construction methods, and so forth have been required. Our efforts have been also directed to globalization requirements such as the shift to the SI units and exchange of electronic data.

We believe that a large part of our expertise in civil engineering software and design developed over a long history in Japan can benefit China. We must continue to be proactive in the face of technological evolutions. In this lecture, we are going to discuss upcoming software technologies and the direction of ideal design software in the future as we introduce new software products.

OVERVIEW

1. Inception of civil design calculation software in Japan

1) Development of software using the supercomputer 1980

2) Birth of personal computers allowing use of Chinese characters and graphics 1981

3) Birth of software package for civil design calculation 1982

2. Advancement of personal computers and its transition of development and usage environments

1) The significant transition of the development and usage environments 1982-2004

2) Changes for the future - complying with ".NET(R)" 2004

3. Changes of the design standards and adjustment of design software

1) Changing the design standards and upgrading software versions

2) Seismic design software after Kobe earthquake

3) Will globalization progress? Japanese design calculation software

4. Future directions of design software

1) Theme of the future <China and Japan>

- *Supporting landscape evaluations, environmental considerations, and consensus building*
- *Supporting high precision design based on 3D technologies*
- *Supporting the latest IT technologies for globalization and standardization*

2) Actual software examples based on 3D designs for achieving the goals

3) Ideal design software in the future

Forum 8 Co., Ltd. (http://www.forum8.co.jp) August 2004.

1. Inception of civil design calculation software in Japan

In Japan, there has been rapid development of the infra structure during a high-growth period and a number of civil engineering structures have been constructed. These structural designs have been conducted mainly through the use of software packages which were released around 1982 when personal computers were first introduced.

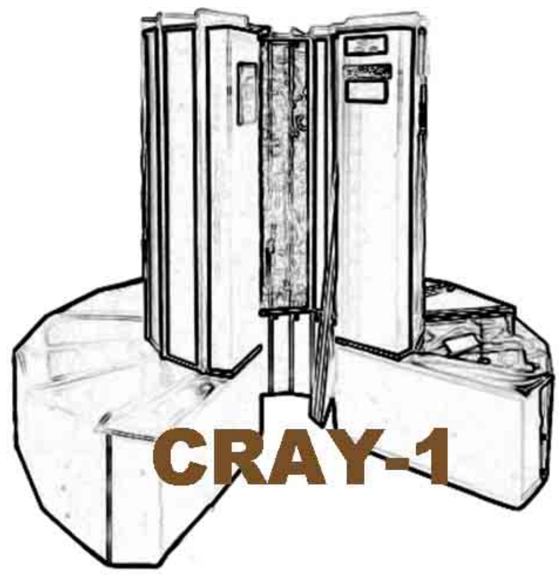
1) Development of software using the supercomputer 1980

In terms of civil engineering structural design application software, we were developing structural analysis programs for general-purpose computers and using the structural analysis software for CDC (control data) G2O. The general-purpose computers were owned by computer centers such as the Itochu computer center (now the CRC Solutions Corp.). The usage fee was expensive and it was rented mainly at a metered-rate. This was the beginning of the development of the structural analysis application programs, when diverse programs were created free of charge in exchange for the use of the computers.

Then the computers increased in size from the CDC6600 to the super-sized super computer CRAY-1, and these programs continued to be used as the structural analysis program STAR Series. The Itochu computer center was the first to import and install the CRAY-1 from Cray Inc. in the States.

The CRAY -1's appearance is still legendary to this day. Its extraordinary tubular shaped structure that minimizes wiring and assists the gas cooling system was impressive. But what really surprised people was its capability. The best performance of the general-purpose computers (mainframe) then was 6-10MIPS; the CRAY -1 achieved 150MIPS. The structural analysis programs evolved into the FANSY-BRIDGE software with the CRAY-1.

It had already become a common practice for bridge manufacturers to own and use computers, such as the Burroughs, for advanced suspension bridge analysis which required large displacement analysis. All analytical programs for the KANMON gateway bridges were developed for our own computers.



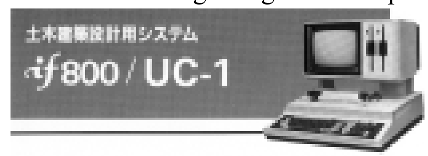
2) Birth of personal computers allowing use of Chinese characters and graphics 1981

As the use of general-purpose computers in civil engineering structural design became a common practice for major corporations, use of the software running on the large computers at computer centers also became a common practice. Having terminals that could connect via phone lines to the large computers to use the software through RJE (Remote Job Entry) also became even more common. Middle-class civil engineering firms installed the pre-PC computers which evolved from microcomputers. But they were still expensive systems, even if not as costly as general-purposes computers.

Up to this point, these application programs had been based on English characters and batch processes. The if800model30 introduced by Oki Electric Industry in 1981 was one of the first domestic, full-blown, personal computers. With its capability of dealing with Chinese characters and graphics, it became the target-platform of application development. The input/output of Chinese characters, graphics, and an interactive interface were very important features which the general-purpose computers were unable to handle. The Oki machine provided these features with no difficulty and had the possibility of revolutionizing the computer world with its economical characteristics. A number of firms saw a great business opportunity in the field of civil engineering software with this computer.

3) Birth of software package for civil design calculation 1982

The table below shows the software package products developed by the development division of Japan structural engineering corporation (now Forum8). The if800model30 was able to process the Basic (O-Basic) as well as the FORTRAN programming language. This allowed the entire software development of the calculation portion by conventional FORTRAN and the input/output portion by Basic, with batch processes being handled internally, while retaining its interactive interface. Input/output is structured in an interactive interfacewith Chinese characters and object interface. With this, it was possible to offer graphical, user-friendly software from the beginning. Since output material was delivered as a product, the capability of easily printing it, when a calculation sheet cost 3000 - 4000 yen, triggered the rapid diffusion of the design computing programs.



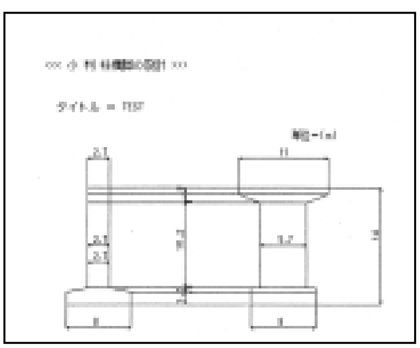
■ if800/UC-1 system

List of software (excerpts from the catalogue)

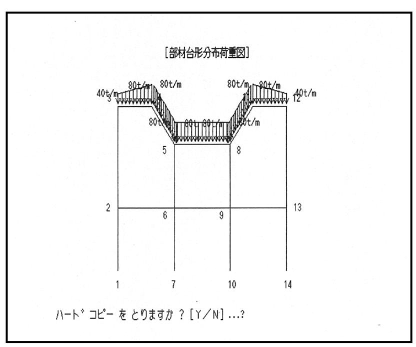
Frame calculation program	
Analysis of arbitrary shape flat framing -RAHMEN-	Creation of frame diagram, load diagram, and stress diagram and combinations of diverse loads are available.
Calculation of Lohse bridge	Creation of influence lines of tubular Lohse bridge
Calculation of deck, through Langer girder	Creation of influence lines, influence weight, and influence area.
Calculation of continuous girder	Various support conditions and calculation of beam supporting elastic bed.
Calculation of grid	Calculation of simple lattice with rigid crossbeam using the bending twisting theory
Cross-section calculation programs	
Calculation of RC cross-section	Calculation of stress intensity against arbitrary two-axle stress Ultimate cross-sectional calculation Cross-sectional calculation of round oval shapes
Calculation of steel cross-section	Calculation of composite/non-composite girders
Substructure design program	
Design of piers	Stability calculation of wall and projecting piers
Calculation of abutment	Stability calculation of reversed T-type abutment and counterforted abutment

■ Output sample

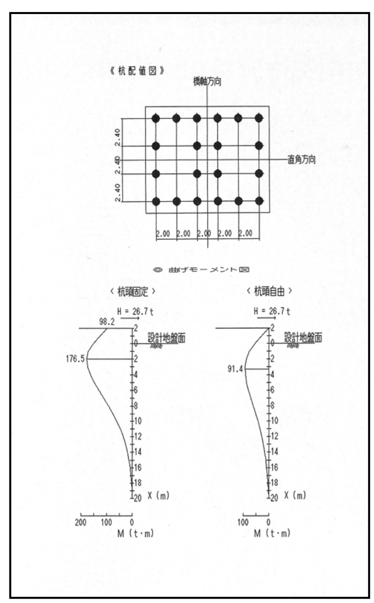
Arbitrary shape flat framing calculation
(Load diagram output view)



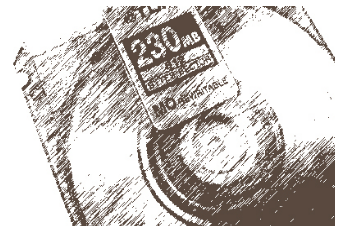
Stability calculation of pier
(Configuration view)



Stability calculation of pile foundation
(Example of printer output)



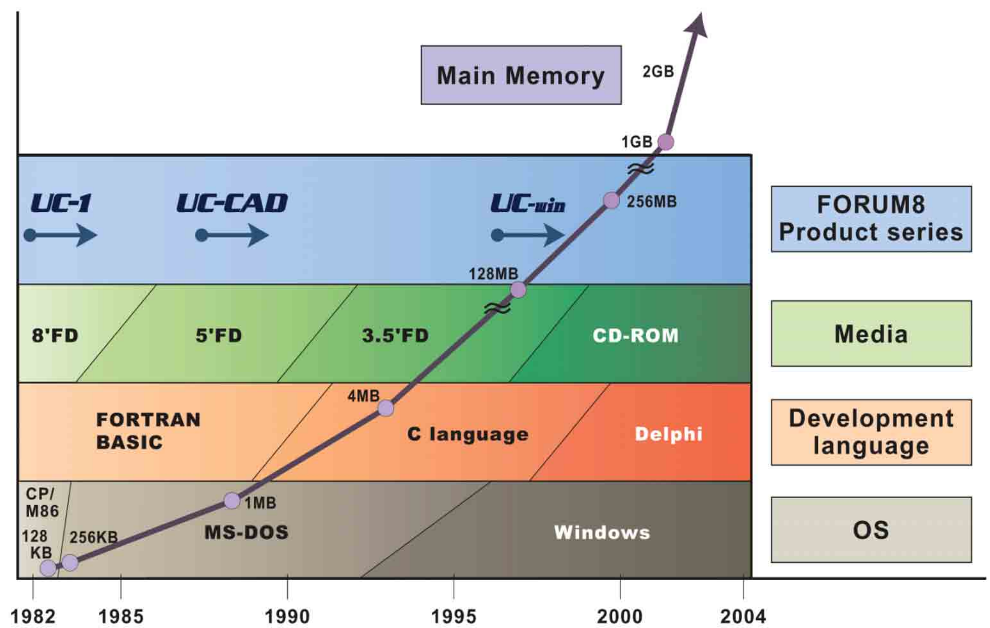
2. Advancement of personal computers and its transition of development and usage environments



A number of factors and technological evolutions have contributed to the transition of design software over the past 20 years since they became commonly used. In the beginning, the software could only support particular structures and its calculation features were limited.

With the extraordinary improvement in the performance of hardware and basic software, the software has become large-scale and highly sophisticated.

1) The significant transition of the development and usage environments 1982-2004

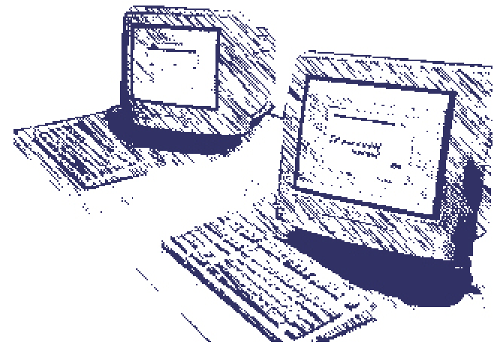


As you all know, the environment of software development and environment of software use by the users have greatly changed with the dramatic advancement of the PC. Specifically, the operating systems used for civil design calculation software development were: first, CP/M86 for a short period of time; second, MS-DOS for a relatively long time; and lastly Windows has taken over. The programs created in the Basic language, which was at first considered relatively easy for anyone to program, were actually found to be troublesome in their need for continuous maintenance and up-grading. The use of structured programming languages for development of packaged software started to increase. In the case of Forum8, the transition of languages has been FORTRAN, Basic, C, and then Delphi, which indicates a transition from calculation-oriented language, to advanced input/output simplified language, to a structured language, and finally to an object oriented language. The modern object oriented languages are well suited to user interface development in windows, although fortran 95 is still favoured for core calculation parts.

Of course, hardware has advanced at a rate almost greater than that of operating systems and other software. Early practical PCs had only 64kb of user and OS main memory space, while current Windows has 4GB. This is an increase of 65536 times by simple calculation. External storage units and storage media have also changed dramatically over the years. But the distribution media has also changed from 8 inch FD to CD-ROM, DVD, or to downloading. These have greatly altered the usage of calculation software, and some users have been left behind by these changes.

Naturally, the size of software has expanded, and the styles of software development have had to change, but this lecture will not particularly discuss this matter.

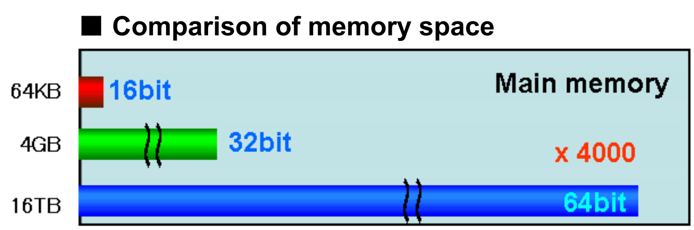
2) Changes for the future - complying with ".NET(R)" 2004



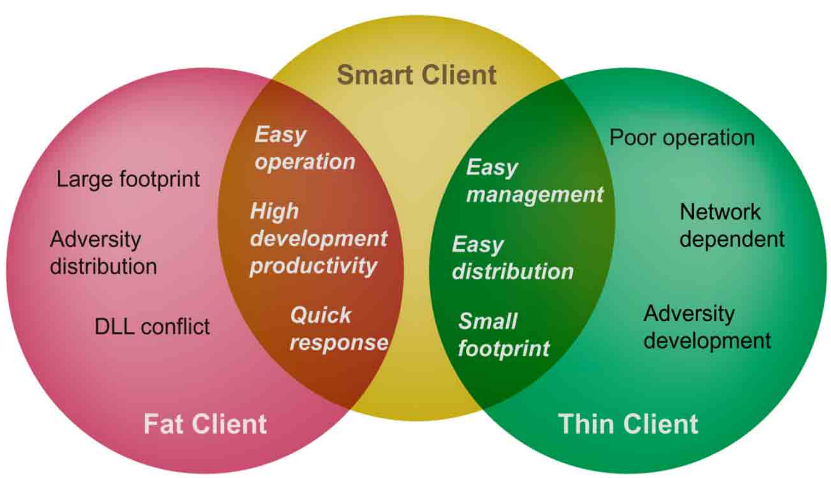
With software creating large 3D models, it has become common practice to equip a PC with GB (giga byte)-levels of memory. A computer running on a 32-bit CPU reaches a 32bit physical memory address limit of 4GB (Windows imposes a 2GB limit for a single application instance, although a special developer feature in the windows operating system permits extending this to 3GB),. Applications are pushing these boundaries.

The physical limitation of the memory address space has been solved by the introduction of 64 bit CPU's. 64-bit processors (AMD Opteron) can handle 16tera bytes of address space which is about 4000 times larger than the 4GB's of the conventional 32bit CPU's. Solving the address space issue is only the first part of the problem. Motherboards still have physical limits as to the amount of memory that can be attached. At the time of writing it is possible to have approximately 8GB per CPU, but this limit will almost certainly increase rapidly as motherboard designs evolve. The new 64 bit CPU's are also generally backward compatible with 32 bit software thereby easing their introduction to the market place and these are now readily available.

Applications must be created specifically for 64 bit environments to use the extra memory. One way to do this is to recompile applications using compilers that support the Microsoft .NET development environment. This will significantly broaden the capabilities of the application. Therefore development of software versions designed for ".NET" (64bit) has to be done as soon as possible. Forum8's, "virtual-reality software" which supports the real-time display of a traffic stream simulation with over a thousand vehicles (3D traffic stream) will benefit from this immediately. The 3D material nonlinear FEM analysis programs such as "COM3", generate very large result sets. The performance of the viewing of large result sets will benefit immediately from increased available memory. In addition, the speed of these calculations will benefit from the new CPU's, but also very importantly, the speed will benefit from Multi Threaded software designs which use multi CPU's on one machine. This is a direction that Forum8 must take also.



As for the change in usage environment, the solution that ".NET" proposes will be realized, and the user environment of Smart Client will be ready on the premise that the physical environment (connection speed, high PC performance, and so forth) is provided. The use of Web or server application programs in civil engineering design should greatly increase in the future. Currently in Japan, use of ASP services in civil engineering is very limited. Even at the construction portal site run by Nifty, Fujitsu's Internet provider - one of the biggest providers in Japan, the use of the service is limited, and is done mostly through downloading, which is almost the same as software rental. Once the environments and application programs noted above are ready, the overwhelmingly weak interface and poor response should be improved compared to local PCs' application programs.



3. Changes of the design standards and adjustment of design software

There have been diverse social events and phenomena in Japan and they have greatly affected civil engineering design. The revision of seismic design after the Kobe earthquake is still fresh in our memories. Many design standards have had to be revised frequently and the design software developed to comply with the revised standards has been gaining importance. Also, in recent years, performance guidelines for diverse design methods and high-precision analysis, and the use of new materials and construction methods, have been required. Of course, the shift to SI units and preparing for globalized electronic data exchange has progressed too.

1) Changing the design standards and upgrading software versions

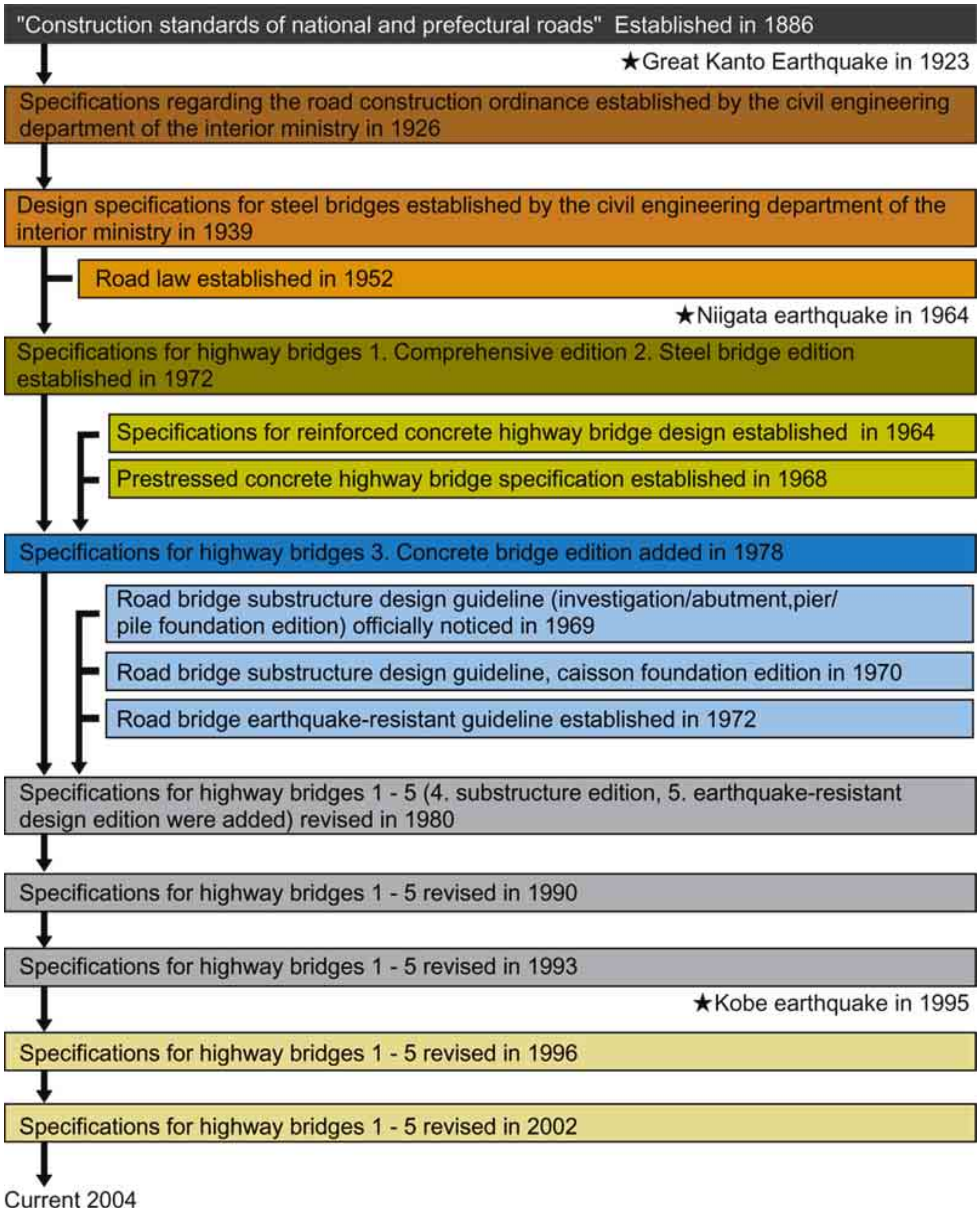
Here, we'll discuss the changes in design standards, and the subsequent software up-grading, taking a look at the "specifications for highway bridges", the most well-known Japan Road Association civil engineering standard in Japan, and road bridges in particular. The specification originated in the "construction standards of national and prefectural roads" established in 1886. The civil engineering department of the interior ministry also established the "specifications regarding the road construction ordinance" in 1926, following the Great Kanto Earthquake in 1923. In 1939, the "design specifications for steel bridges" was established, and this was followed by the "specifications for highway bridges" (comprehensive edition and steel bridge edition) in 1972.

As for reinforced concrete bridges, there were specifications for reinforced concrete highway bridge design (in 1964) and the prestressed concrete highway bridge specification (in 1968). The "specifications for highway bridges" (concrete bridge edition) was added in 1978.

Design calculation software for PCs began to refer to these standards from the time of the concrete bridge edition in 1978, and the specifications for highway bridges (1. comprehensive edition 2. steel bridge edition 4. substructure edition and 5. seismic design edition) in 1980. The main purpose of the design calculation described above was to support designs based on these standards. However, the specifications for highway bridges were further revised in 1990, 1993, 1996, and 2002, and these required major revisions in related software. In addition to the advancement of the software, swift adjustment to these changes had to be made every few years. Conversely, without the compatible calculation software, civil engineering design would have been significantly hindered.

■ Specifications for highway bridges (issued between 1970 and 1996)

<Revision history of the specifications for highway bridges>



<Example of recent revisions of specifications for highway bridges>

	Revision overview	Revision overview of the earth-quake resistant edition
Specifications for highway bridges 1 - 5 revised in 1990	Accumulated technical knowledge was reflected.	Revision based on the research concerning earth-quake resistant design and on the implementation of a verification method for the horizontal capacity of reinforced concrete piers in earthquakes.
Specifications for highway bridges 1 - 5 revised in 1993	Part of the policies concerning reinforced-steel concrete floor slabs and floor slab bridges were revised, responding to increased vehicle size, and improving durability.	(no revision)
Specifications for highway bridges 1 - 5 revised in 1996	Revision mainly of earthquake-resistant design provision	Revision mainly requiring protection from earthquakes of magnitudes as large as 7 on the Richter scale for inland earthquakes
Specifications for highway bridges 1 - 5 revised in 2002	Revision trying to achieve the level of performance in a specified technical standard. Basically required that provisions and qualified conventional provisions were written next to each other.	Revisions clarifying bridge's earthquake-resistant specifications and expanding application of dynamic verification method

<The most recent specifications for highway bridge revisions and up-grading examples>

The most recent revision was a shift to performance specification in 2002 from the prescriptive 1996 edition. The 2002 edition was more flexible in the way that it stipulated required specifications, and required satisfaction of certain degrees of performance specifications. The previous editions provisions were also included as a means of compliance. Also, verification methods are stipulated by expanding the application range of the dynamic verification method.

The table below shows examples of the software after the revisions. Software products that reflect the latest program development technologies are also provided to support the dynamic verification method.

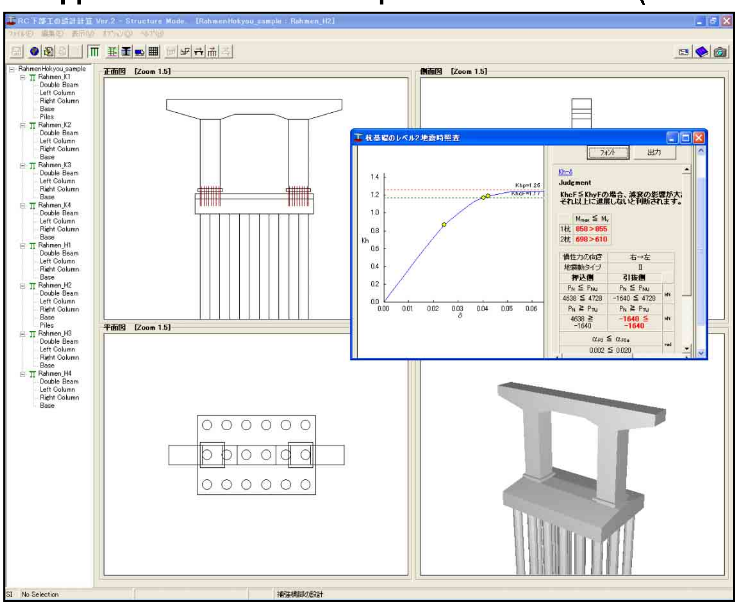
Type	Revision Overview	Software product name						
		Pier design	Abutment design	Calculation of Seismic intensity (bearing design)	Design Calculation of RC substructure	Pile foundation design	Design calculation of foundation	Caisson frame
Footing	* Available width where upper tension is applied * Shearing span definition * Definition of the tension side upon shearing durability calculation	○	○	−	○	○	○	−
Spread foundation	* Cross-sectional verification upon level 2 earthquake * Consideration of scale effect upon bearing apacity calculation	○	○	−	○	−	○	−
Pile foundation	* Revisions on end-bearing capacity and peripheral frictional force * Addition of Steel pipe soil cement piles * Addition of SC piles * Addition of ready-made pile preboring method * Addition of vibro-pile driver method	−	○	−	○	○	○	−
Caisson foundation Steel pipe sheet pile foundation Cast-in-site diaphragms wall foundation	* Revisions on end-bearing capacity and peripheral frictional force	−	−	−	−	−	○	−
Abutment	* Earth pressure during earthquake according to the modified part/Okabe method (applied to verification of level 1 and 2 earthquake) * Footing cross-sectional verification upon level 2 earthquake * Verification of foundation upon level 2 earthquake	−	○	−	○	−	○	○
Earthquake-proof	* Design displacement of bearing upon level 2 earthquake * where plastic strain of piers is considered: horizontal force equivalent of horizontal urability of piers * where plastic strain of foundation is considered: horizontal force equivalent of maximum response displacement of foundation	○	○	○	○	○	○	−

2) Seismic design software after Kobe earthquake

The Kobe earthquake which occurred on January 17, 1995, took the lives of countless people and caused great damage to buildings as well. In particular, restoration of Hanshin Expressway, one of the arterial highways that collapsed during the earthquake, was hurried. The Ministry of Construction issued "specifications for restoration of highway bridges collapsed during the earthquake (plan)" on February 27 and passed it on to concerned government agencies. This specification was then officially issued on May 25, 1995 as the "restoration specification" and used temporarily for newly-established and reinforced buildings.

As for software response to the event, development of RC pier's bearing force verification programs was hurried. Releases of temporal versions were repeated in quick succession, responding urgently to the demands of design consultants. For temporal design work, the software was then distributed as an evaluation version at no charge. We developed a restoration-ready version of "horizontal resistance of pile foundation" and these programs were integrated later to develop pier design calculation software.

■ Application software example for Rahmen Pier (FORUM8 UC-1 Series)



3) Will globalization progress? Japanese design calculation software

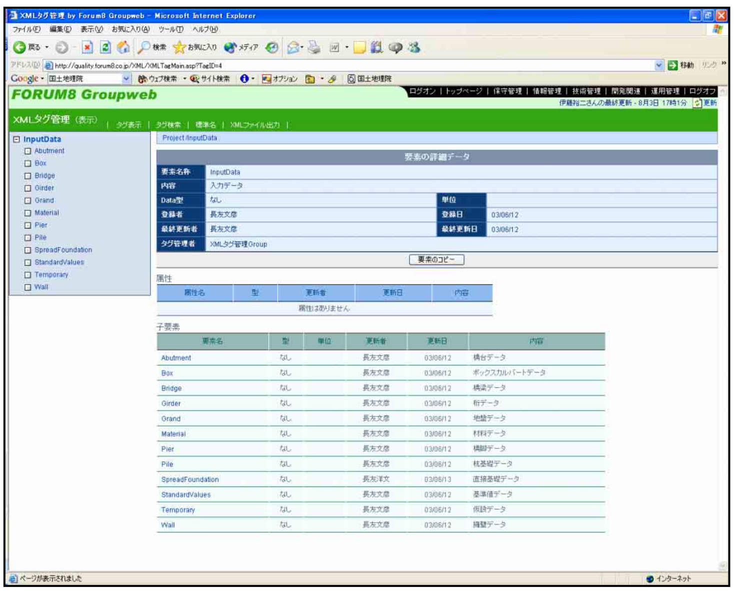
As for international standardization, many organizations, including the Japan Society of Civil Engineers, JACIC, SCOPE, and so on, are actively involved. One of the recent events that greatly influenced the standardization of calculation software was the shift to SI units. The "measurement law" which was revised entirely in 1993 prohibited the use of non-SI units as of October 1999. With calculation software, it was required, during the period when the use of both measurement systems was allowed, to be able to switch between the SI units and conventional units when inputting and outputting, and this was relatively easy to deal with. Currently, the conventional units are no longer in use.

As of April 2002, with the revision and enforcement of "survey law", the shift from the Tokyo Datum, based on Bessel's ellipsoid, to the World Geodetic System has been undertaken. As for the software affected by this shift, the Geographical Survey Institute offered "coordinate conversion program TKY2JGD for Sokuchi-seika 2000", which was available through a simple registration and verification procedure, allowing a relatively easy shift in the software. However, there are still a large number of graphical resources created using the Tokyo Datum, so these conversion features should continue to be necessary for a very long time to come.

Aside from that, domestic and international software standardization based on the XML data exchange standard must be considered. The "electronic delivery standard plan" by the National Land and Transportation Ministry stipulates management of electronically delivered materials and graphical files compliant with XML. But the current standard for electronic delivery of design calculation uses original files such as word-processing documents, and print image files, such as PDF files. Use of the XML format in calculation documents should be standardized in the future as product models of structures are developed.

In the Forum8 UC-1 series, all input/output data of all programs has been made in the XML format by the Forum8 standard. However, XML tag names are managed by groupware, and product models are yet to be standardized. The output editing tool "FORUM8 document server" coming up in the future will support WORD, PDF native output, and XML mapping features. XML data will then be utilized step by step. If domestic and overseas standardization progress as expected, data structures will be supported quickly. For example, in the near future, Land-XML is scheduled to be supported.

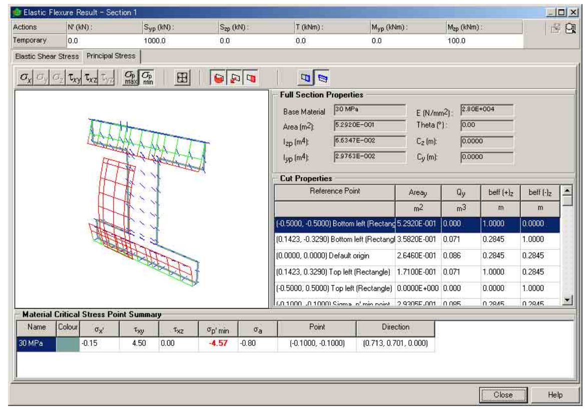
■ XML tag management groupware

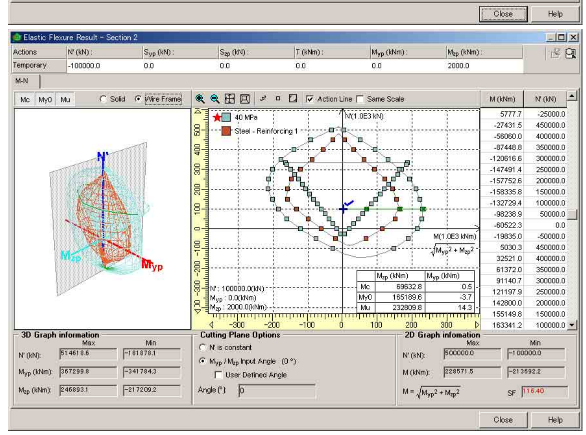


In order to demonstrate the possibility of international standardization of design calculation software, part of the results of a UC-1 series software cross-section calculation program are shown below. Readiness of BS(British Standard)8110 and JSCE concrete standard specifications (structural performance verification edition) and Forum8 UC-win/Section Ver.1.04 are shown in the table.

In this report, development man-hours, including software development, coding, testing, documentation, and so forth, is estimated at about 9 man-months. Of course, verifications through field-testing and software support after development is important. But design standards should be based on existing, time-tested software, so that the workload of design and development of the input/output interface, which takes the most man-hours, is reduced. This should have a huge advantage in development speed, software reliability, and cost.

Readiness table of BS8110 and JSCE concrete standard specifications (structural performance verification edition) and UC-win/Section1.04.00 features





<Standard-readiness comparison overview>
The readiness table shows the items involving cross-sectional calculation of BS8110:part1 and part2, in an effort to see if there are similar items provided in the JSCE concrete standard specifications(structural performance verification edition). It also shows, in a simple view, the features among them that are supported by Forum8 products(UC1RC cross-sectional calculation Ver.3 and UC-win/Section1.04.00 critical stage design calculation).

The comparison results are as follows:
1) The items involved in cross-sectional calculation in BS8110:part1 have different permissible values but most of them are also covered by JSCE.

2) In the cases of UC-1RC cross-sectional calculation Ver. 3, and UC-win/Section, they are limited to the items of JSCE's beams and pillars.

3) In 2), great differences between JSCE and BS8110:part1 and part2 are:

a. part1: Shearing verification of RC materials in the ultimate limit state (3.4.5, 4.3.8)
b. part2: Concrete stress-intensity strain curve (2.3)
c. part2: Torsional verification (2.4)
d. part2: Cracking width formula (3.8)
e. part2: Treatment of lightweight aggregate (5)

As for the other items, JSCE verifies almost the same contents. Part2 is verified in the manner in which it's added to Part1.

4) Factor of safety and material database
It is optional to choose whether verification is performed only with Part1 or with Part2 added. Because output differs depending on the choice, development man-hours are greater in the tasks related to these output formats, and results display view control rather than creation of the calculation parts. Currently, the most time-consuming task in development is translation of the output dialogues into English.

British Standard 8110:part1 Legend : ✔ Section Calculation item, -Not section calculation item,		Japanese Standard of Concrete design by JSCE [Structural Performance Design] Comment: Difference point from BS8110	Supported in win/Section
1. General	-		
2. Design objectives and general recommendations	-		
2.1 Basis of design	-		
2.2 Structural design	-		
2.3 Inspection of construction	-		
2.4 Loads and material properties			
2.4.1 Loads	✔	✔ Safety factors	✔
2.4.2 Material properties	✔	✔ Safety factors	✔
2.4.3 Values of loads for ultimate limit state (ULS)	✔	✔ Safety factors	✔
2.4.4 Strength of materials for the ultimate limit state	✔	✔ Safety factors	✔
2.4.5 Design load for serviceability limit states	-		
2.4.6 Material properties for service ability limit states	-		
2.4.7 Material properties for durability	-		
2.5 Analysis			
2.5.1 General	-		
2.5.2 Analysis of structure	✔	✔	✔
2.5.3 Analysis of sections for the ultimate limit states	✔	✔ Same shape of stress-strain curve, but constants are different	✔
2.5.4 Analysis of sections for serviceability limit states	✔	✔	✔
2.6 Design based on tests	-		
3. Design and detailing: reinforced concrete			
3.1 Design basis and strength of materials			
3.1.1 General	-		
3.1.2 Basis of design for reinforced concrete	-		
3.1.3 Alternative methods	-		
3.1.4 Robustness	-		

3.1.5 Durability of structural concrete	-		
3.1.6 Loads	-		
3.1.7 Strength of materials	✓	✓ BS4449, 4482, 4483 standard are not in JP	✓
3.2 Structures and structural frames			
3.2.1 Analysis of structure	✓	✓ Combination factor	✓
3.2.2 Redistribution of moments	-		
3.3 Concrete cover to reinforcement			
3.3.1 Nominal cover	-		
3.3.2 Ends of straight bars	-		
3.3.3 Cover against corrosion	-	Numbers of conditions	
3.3.4 Exposure conditions	-	Numbers of conditions	
3.3.5 Method of specifying concrete for durability	-		
3.3.6 Cover as fire protection	-		
3.3.7 Control of cover	-		
3.4 Beams			
3.4.1 General	-		
3.4.2 Continuous beams	-		
3.4.3 Uniformly-loaded continuous beams with approximately equal spans: moment and shears	-		
3.4.4 Design resistance moment of beams	✓	✓ Same shape of stress-strain curve, but constants are different	✓ 1
3.4.5 Design shear resistance of beams	✓	*2 By strength. Requirement of shear reinforcement check is none. Allowable shear stress (In the Structural details)	*2
3.4.6 Deflection of beams	-		
3.4.7 Crack control of beams **※Crack width check is in part2**	✓	✓ by crack width	✓
3.5 Solid slabs supported by beams or walls	✓	(not investigate)	
3.6 Ribbed slabs (with solid or hollow blocks or voids)	✓	(not investigate)	
3.7 Flat slabs	✓	(not investigate)	
3.8 Columns			
3.8.1 General	-		
3.8.2 Moments and forces in columns	-		
3.8.3 Deflection induced moments in solid slender columns	-		
3.8.4 Design of column section for ULS ※Based on the part of Beam	✓	✓ Axial strength calculation, Checks of Bi-axial member	✓
3.8.5 Deflection of columns	-		
3.8.6 Crack control in columns	-		
3.9 Walls			
3.10 Staircases			
3.11 Bases			
3.12 Considerations affecting design details			
4. Design and detailing: prestressed concrete			
4.1 Design basis			
4.1.1 General	-		
4.1.2 Alternative methods	-		
4.1.3 Serviceability classification	-		
4.1.4 Critical limit state	-		
4.1.5 Durability and fire resistance	-		
4.1.6 Stability, robustness and other considerations	-		
4.1.7 Loads	-		
4.1.8 Strength of materials	-		
4.2 Structures and structural frames			
4.2.1 Analysis of structure	-		
4.2.2 Relative stiffness (=2.5.2)	✓	✓	✓
4.2.3 Redistribution of moments	-		
4.3 Beams			
4.3.1 General	-		
4.3.2 Slender beams	-		
4.3.3 Continuous beams	-		
4.3.4 Serviceability limit state for beams ***No regulation for crack width**	✓	✓	✓
4.3.5 Stress transfer for beams	✓	✓	✓
4.3.6 Deflection of beams	-		
4.3.7 Ultimate limit state for beams in flexure	✓	✓ Material safety factor, Resistant moment calculation is none	✓ 1

4.3.8 Design shear resistance of beams	✔ ✔	✔ Shear strength calculation, shear reinforcement check is none (not investigate)	✔
4.4 Slabs	✔	✔	
4.5 Columns ***Same as 3.8**	✔		✔
4.6 Tension members	-		
4.7 Prestressing	-		
4.8 Loss of prestress, other than friction losses	-		
4.9 Loss of prestress due to friction	-		
4.10 Transmission lengths in pre-tensioned members	-		
4.11 End blocks in post-tensioned members	-		
4.12 Considerations affecting design details			
5. Design and detailing: precast and composite construction	✔	(not investigate)	
6. Concrete, materials, specification and construction			
6.1 Material specification	-		
6.2 Concrete construction	-		
7. Specification and workmanship: reinforcement	-		
8. Specification and workmanship: prestressing tendons	-		

※1 Stress brock method is not used

※2 BS8110part1use the comparison of average shear stress & allowable stress. JSCE use the comparison of shear strength and force.

British Standard 8110:part2 Legend : ✔ Section Calculation item, -Not section calculation item,		Japanese Standard of Concrete design by JSCE [Structural Performance Design] Comment: Difference point from BS8110	Supported in win/Section
1. General	-		
2. Method of analysis for the ultimate limit state			
2.1 General	-	—	—
2.2 Design loads and strength	✔	✔ safety factor	✔
2.3 Non-linear method	✔	✔ Concrete stress-strain curve	*3
2.4 Torsional resistance of beams	✔	✔ Calculation	*3
2.5 Effective column height	-		
2.6 Robustness	-		
3. Serviceability calculations			
3.1 General	-		
3.2 Service ability limit state	-		
3.3 Loads	✔	✔ Importance of live load	✔
3.4 Analysis of structure for serviceability limit states	✔	✔	✔
3.5 Material properties for calculation of curvature and stresses	✔	✔ ✔ Young's modulus of concrete	✔
3.6 Calculation of curvatures	-	✔	✔ *4
3.7 Calculation of deflection	✔	✔	
3.8 Calculation of crack width		✔ Crack width calculation method	*3
4. Fire resistance	-		
5. Additional considerations in the use of light weight aggregate concrete	✔	✔ Characteristics of light weight aggregate concrete	*3
6. Autoclaved aerated concrete	-		
7. Elastic deformation, creep, drying shrinkage and thermal strains of concrete	✔	✔	
8. Movement joints	-		
9. Appraisal and testing of structures and components during construction	—		

※3 Different stress-strain curve of concrete

※4 un-cracked section (=Elastic) theory is used only in the crack width check.

4. Future directions of design software

We believe that a large part of our expertise in civil engineering software and design developed over a long history in Japan, can benefit China. We must continue to be proactive in the face of technological evolutions. In this lecture, we are going to discuss upcoming software technologies and the direction of ideal design software in the future as we introduce new software products.

1) Theme of the future <China and Japan>

We have been involved in package software development in Japan for more than 20 years. Our expertise is in "application development for civil engineering designers". Although there have been some changes along the way, our best efforts have been directed to the development of software complying as closely as possible with the standard specifications. These are most in demand by civil engineering designers. It seemed that the recession following the bubble economy might largely change needs and development trends. But in fact, the needs of the designer didn't seem to change as much during that period.

As for the development direction, Tadaharu Wada, the chairman of Forum8, announced, during the speech at Exhibition 1999 hosted by Forum8 in 1999, that the following software themes were considered as design software development principles for the future, indicating a major change in the direction of investment in software development.

■ Forum8's development directions announced at Exhibition1999

* Development of integrated software
* Landscape architecture support software development
* Advanced analysis software development

(Tokyo/Osaka/Nagoya, November 1999)

In Japan, with an already well-developed recession, and a reduction in building investment, the conventional mass-production era of civil engineering structures was coming to an end. It was expected that it would be the survival of the fittest for civil engineering designers. Senior engineers would design structures all by themselves through the use of software and information technologies, and structures would be efficiently designed in a cost-effective way by comparing diverse methods and materials. For these, it was considered vital to use integrated software in an integrated environment. Forum8 integrated most of the software they'd developed and released, based on "calculation-CAD" and "mutual calculation", and provided these as totally integrated solo software. Specifically, for piers, abutments, retaining walls, box culverts, temporal structures and foundations where calculation-CAD are integrated, diverse foundation support programs were integrated, and so were most Forum8 products, including diverse analysis software and cross-sectional software. As a result of these integrations, and with its excellent maintenance capability, the quality of the software products was improved and the prices were reduced.

We then tried to create software intended to support landscape evaluation to promote high quality civil engineering projects. Also, with a concept of advanced analysis, package programs for non-linear analysis and dynamic-analysis for general designers were developed. Software products were built with these concepts; "UC-win/Road" was released in May 2000, and this was followed by "UC-win/COM3(Fiber)" in December 2000, and "UC-win/FRAME(3D)" in November 2002.

The number of construction projects in China has been increasing at a pace the same as, or even greater than, that during Japan's high growth period. I want to stress that the design calculation software that now support their design engineers are based on the know-how accumulated in Japan, and that they are extremely capable, low-cost, and high quality.

Also, since we've already experienced the diverse problems that are expected in China in the future, I believe we can foresee most of them. By doing so, information technologies can be utilized to prevent or deal with the problems as they may arise. As solutions to those issues, I'd like to discuss the following themes in terms of software and engineering service.

- Supporting landscape evaluations, environmental considerations, and consensus building
- Supporting high precision design based on 3D technologies
- Supporting the latest IT technologies for globalization and standardization

2) Actual software examples based on 3D designs for achieving the goals

- Supporting landscape evaluations, environmental considerations, and consensus building

Landscape examination and environmental impact are themes more important than ever in construction services such as public construction and road projects. These construction projects excite much controversy. They are social issues in Japan. Diverse efforts based on landscape and environmental considerations are used for building consensus among the people involved. But there's a need for linguistic tools which the government, constructors, and residents can equally understand. Although a single tool can't offer a complete solution, when it is provided as a software tool it should have to be 3-D based so that anybody can easily understand the issues.

I'd like to introduce Forum8 's current solutions offered in Japan, and how we expect to expand these in the future.

<Package software>
"UC-win/Road" 3D real-time virtual-reality software

This package allows creation and use of virtual reality (VR) in simple operations, featuring outstanding capability in 3D-space production and display, aimed mainly at construction projects, such as public projects and private developments. Real-time dynamic 3D spaces can be represented, supporting diverse consensus building in diverse presentations and design configurations. Since its release in May 2000, it has been aiding landscape evaluation, design/construction with environmental/safety considerations, evaluation of comparative plans, technological presentations, and so forth.

The features added recently include:
* Creation of 3D trees and representation of trembling leaves, etc. (May 2003)
* Creation of movies in formats such as AVI and so forth (May 2003)
* Automatic generation of 3D traffic flow and automatic control of 3D traffic models (May 2004)
* Generation, editing of 3D human models, and configuration of motions such as walking (May 2004)
* Presentation of support features such as automatic operation using scripts (May 2004)
* Representation of night time and "fake light" features using automatic switching of textures (May 2004)

The following features and development themes are planned in the future:
* Generation of forests based on tree configuration (scheduled in August 2004)
* Reinforcement of landform 3D edit feature (scheduled in August 2004)
* Support of 64bit using UC-win/Road for ".NET" (scheduled first half 2005)
* 3D traffic simulation supporting various traffic controls (scheduled first half 2005)
* Disaster 3D modeling, detour simulation, various environmental simulations (schedule undecided)

<Engineering services>
"UC-win/Road support system" Virtual reality (VR) data service

Providing comprehensive engineering services based mainly on virtual reality (VR) generation service. It has made a great many achievements in domestic construction projects with the Land, Infrastructure and Transportation Ministry, prefectural and city governments, and private corporations. Every year, we hold a VR data created by UC-win/Road contest. In 2002, Tokai Ring Expressway, VR data by the Tajimi construction office of the Land, Infrastructure and Transportation Ministry, won the grand prize. In 2003, Ebina North Junction VR data, by the Atsugi construction office of Japan Highway Public Corp., won the grand prize.
Although many achievements have been made by government organizations, those by private entities are equally impressive, such as Fuji Speedway F1 circuit renovation (by Taisei Corporation and Fuji Speedway, winner of the outstanding performance award in 2003), and private corporations' construction simulations to explain new construction methods. The process is also increasingly used when residents, such as the Machidukuri conference and NPO groups, make suggestions or plans.

As for the themes in the future, data generation support service by Chinese corporations is possible through transfer of technical information in the same way as CAD drawing transfer is. This will allow our business expansion in China. As for application to Korean language based projects, we have already had experience with the Korea Highway Corporation (KHC) and **Korea Agriculture** and Rural Infrastructure Corporation(KARICO). Our theme for the future is the expansion of our applications to international projects.

- Supporting high precision design based on 3D technologies

It goes without saying that 3D-based technologies are not just limited to 3D representations. In the field of civil engineering design practice, PC performance and application software development is still undeveloped and 3D-based technologies are not common yet, even in Japan. But it is obvious that 3D high-precision analysis leads to economical and rational designs.
Here, we'll look at the 3D-based graphical representation and application programs integrated with 3D analysis technologies, and our engineering services available to propagate those programs.

<Package software>
"UC-win/FRAME(3D)" 3D dynamic non-linear analysis software

Static/dynamic 3D frame element, non-linear analysis program. It allows geometrical and material non-linear analysis of dynamic and static loads. The advanced interface also allows general linear analysis and elastic analysis. It’s a general purpose application that can be applied to diverse structures, shapes, and materials. In addition to basic elastic frame elements, various non-linear elements are also available such as springs for general use and bridge bearing modeling, fiber elements and M-φ elements.
The 3D graphics produced can be exported to UC-win/Road.

Recent new features include:
* Live loads by influence line analysis, including automatic determination of critical load types (“L” load or “T” load). Simultaneous loading of multiple bridges over common supports (March 2004)
* Input of PC steel materials and effective prestress force(March 2004)
* Reinforcement of model generator (arch bridge, truss bridge, pier, and pile models are added) (March 2004)

The future plans and development themes include:
* Non-linear analysis of RC materials by M-φ model [Takeda model] (scheduled in August 2004)
* Multi run averages for dynamic loads. (scheduled August 2004)
* COM3 option, COM3 material hysteresis and isoparametric formulation (scheduled in August 2004)
* Nonlinear fiber analysis of PC member (scheduled by the end of 2004)
* COM3 nonlinear material plate element (scheduled by the end of 2004)

"UC-1 Geotechnical analysis series" Dynamic analysis and 3D analysis software for ground analysis

The package was released in March 2004 as an advanced-analysis software series for ground analysis.

* Dynamic effective stress analysis (UWLC) of ground and dynamic deformation analysis program for ground using the finite element method(FEM)
* 3D Slope Stability Analysis (LEM), stability analysis program for 3D reproduction of landform and slide surface. Piling design is available as a stabilization method.

The future themes and development themes include:

* Variably saturated groundwater flow analysis (VGFlow) (August 2004)
* 3D Elasto-plastic geotechnical analysis (GUNDA) (planned)

<Engineering services>

"UC-win/FRAME(3D) analysis support service" Analytical modeling and data generation support service for various structures

This analysis service supports 3D modeling of various structures including bridges. Its support extends to creation of initial models using the dynamic verification method in the "specifications for highway bridges, seismic design edition". This is a technical service to support users who create new bridge forms complying with specifications and design cross sections.

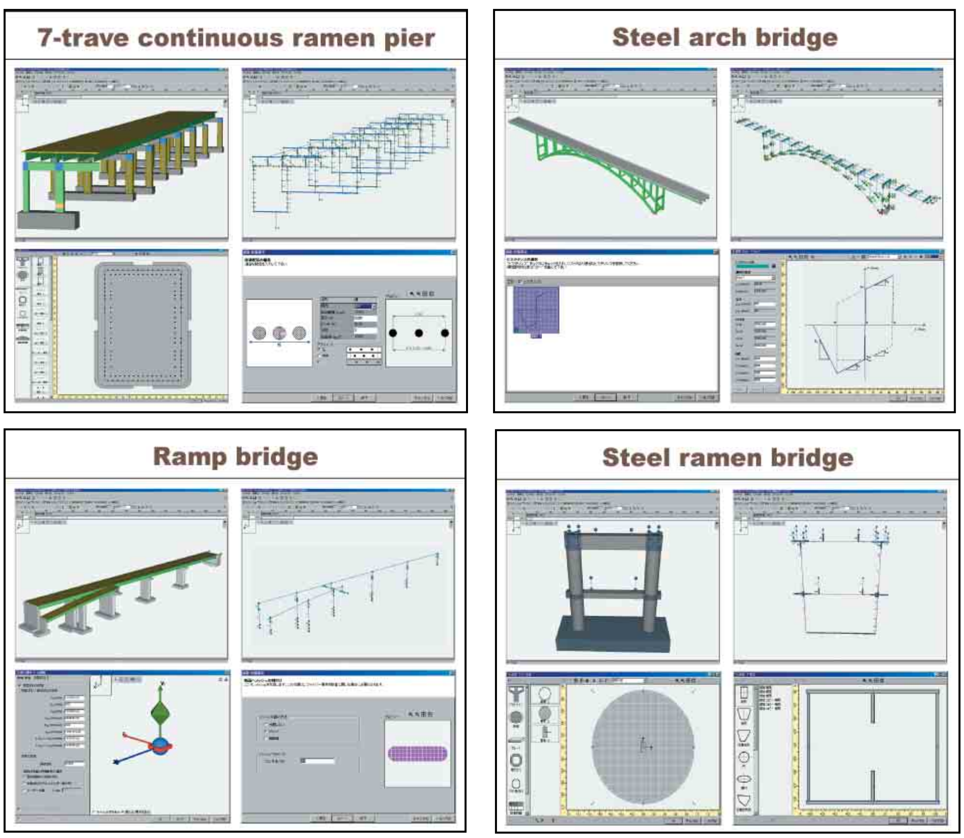
Examples of analysis services include:

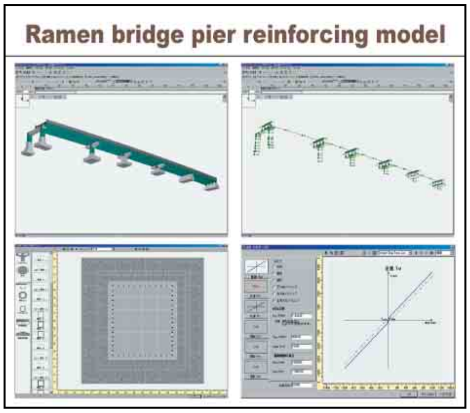
7-trave continuous ramen pier/steel arch bridge

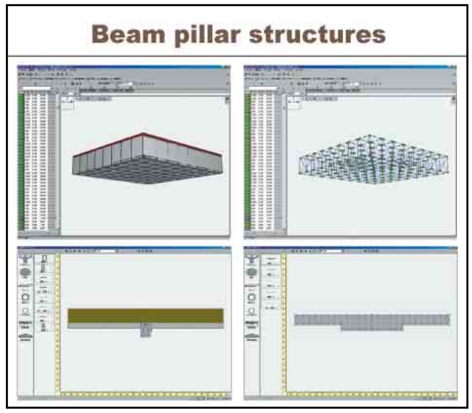
Ramp bridge/steel ramen bridge

Ramen bridge pier reinforcing model/beam pillar structures

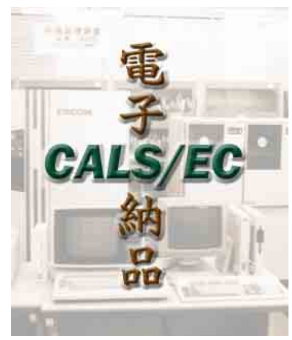
We are planning to offer "geotechnical analysis support service" using the geotechnical analysis software series in the future.




Ramen bridge pier reinforcing model


Beam pillar structures

- Supporting the latest IT technologies for globalization and standardization



Globalization and standardization of the information technologies in the construction industry requires use of the latest IT technologies. When offering solutions supporting these cutting-edge technologies, it is necessary to integrate the technologies before they are universally in common use.

I believe that the solutions introduced earlier, such as readiness for ".NET", and the shift to 64bit, are within this range of development. But here we will discuss examples of the software, always exploring possible uses of the latest Internet technologies.

<Package software>

"Groupware GSS base system" Groupware basic system software

Accessories such as schedule management, route guidance, various BBS systems, document management, email, and so on, are integrated in this groupware. In addition to the SQL server system, it supports Linux in the "GSS for Linux" version released in 2004. It allows use of open source on the servers and database programs, allowing creation of low-cost systems.

OS: Red Hat Linux9
Web server: Apache (open source)
Development language: PHP (open source)
HTML template: Smarty (open source)
Database: PostgreSQL (open source)

"Electronic delivery support system (Internet-ready)"

Groupware managing electronic products created according to the electronic delivery standard of civil engineering design and construction.

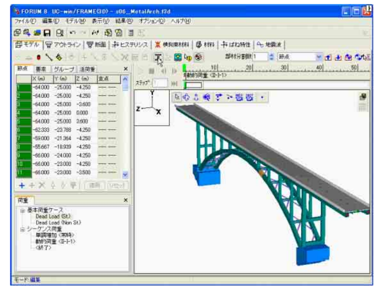
By installing to the web server, it allows registering, viewing, searching, and version management of electronic products on the web. It supports file updating and management of saving destinations, realizing data sharing with clients and associated firms.

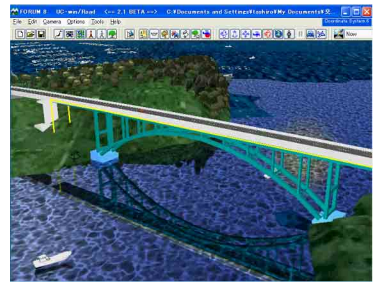
<Engineering services>

"Groupware support system GSS" Customizing groupware base system and consigned development services

Customization system/examples of consigned development
* Electric delivery support system
* Inquiry support maintenance system (for software developers)
* Bug-tracking system BTS (for software developers)

3) Ideal design software in the future



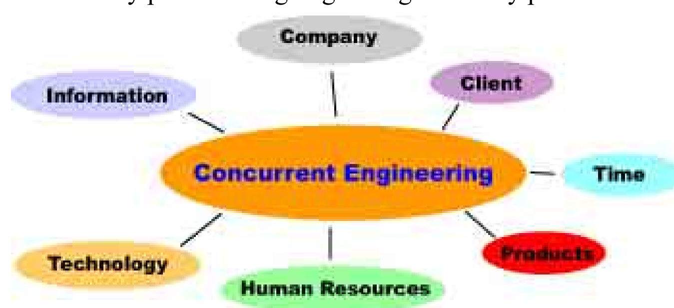


Traditionally, the tasks of the civil engineering design practice in Japan have always been divided into design calculation, calculation sheet creation, creation of drawings, and so forth. Experts in each field have been cultivated, and they have grown their expertise. As stated earlier, having capable technicians deal with the design all by themselves can result in high-quality, cost-effective civil engineering design and structures. This possibility has expanded with use of data sharing and integrated software. However, design engineers also undertake such tasks as landscape evaluation, environmental consideration, consensus building, and so on. These days, performing sales support activities, such as the preparation of technical proposals, have become their added responsibility.

Development of integrated design software combining "calculation-CAD" and "calculation - calculation" has progressed. This still needs to be taken one step further with the development of "interactive software" that allows seamless bi-directional data exchange between different programs.

For example, while we can accurately analyze bridge shapes and pier shapes by 3D non-linear analysis, and conduct landscape evaluation in a 3D VR view of the landforms and buildings, 3D verification of a 3DS format model created by another landscape designer is still not feasible in a seamless manner. Thus software that's capable of exchanging data easily in planning phases and in actual designing phases is in demand. Of course it is better if one software set can realize this; there are options of XML cooperation and development of data exchange programs.

Currently, software packages alone cannot support entire design steps, and advanced analysis and VR data creation are provided through the engineering services, because this is only possible on going through so many processes using diverse software and information technologies. Efforts toward concurrent engineering have been made in the design industry just as in other industries. It has been desired that the concurrent processes of design tasks in product development focus on planning division, landscape design division, structural design division, sales division, and so forth. I believe that the direction of software development should also consider "concurrent engineering support software".



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