Development of Design Support System for Steel Girder Bridges using JAVA

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【Abstract】   Even though electronic drawing is becoming increasingly popular in some courses on design practice in educational organizations, it is still laborious for college students to refer to design specifications during the design process. Thus, quite a few organizations have introduced a computer-aided design system for practicing design.

In this study, a computer aided design system has been developed for use in college courses for practicing the designing of steel girder bridges. The developed system was described by means of JAVA and HTML and linked with electronic specifications described by HTML in order to facilitate referencing by college students during the design process.

【Keywords】 Steel bridge, Design support system, JAVA, HTML, Electronic specifications

1. Introduction

Due to the recent progress of software technology and the basic infrastructure for the Internet, we are rapidly realizing a transfiguration to Internet-based information systems for design support and education. In this research, we constructed a system for supporting the design of steel plate girder bridges for educational use. We used HTML and JAVA languages so that the system can be distributed on the Internet.

There are many educational support systems using the WWW, for example Sumita's interactive system for calculation dynamics education[1], Matsuda et al.'s distribution of linguistics study materials by WWW[2], and the practice of project-type lessons by making use of the Web for Senoh's human society-system curriculum[3]. However, basically in most cases systems are constructed based on exchanges on networks of electronic data described in HTML.

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There is also much applied research related to information exchange by HTML. For instance, Urano et al. are investigating the methodology of information exchange by HTML to place different types of information including theses onto databases and enable horizontal information publicizing of construction information[4]. Sengoku has developed a system for presenting information of a bus-system net by using data standardized in HTML and GIF images[5]. Also, Kuwabara et al. are describing technical standards as concrete examples by HTML aimed at personal EWS[6].

Meanwhile, the development of systems using VRML is also thriving at the research level. Hagiwara et al. are developing variance landscape simulation systems by VRML and JAVA, by which not only can information providers such as entrepreneurs open up landscape information, but users in residential areas can interactively create landscapes of their own liking and can gather results from them[7]. Ishikura et al. are using systems in-house to perform high-level analysis and plot via networks using the WWW via a GUI[8]. Here also, they are using VRML to visualize the analytical results. Also, Usagi et al. are constructing bridge databases using VRML and using them

in environmental designs to verify their validity[9]. Makinae et al., to enable the sharing of information on networks, are discussing the description of structural data by VRML for designing road alignment and its future potential[10].

There are currently many examples of information-exchange HTML and their use in describing Web pages is widening. However, this is thought to stem from the easy-to-use nature of HTML. VRML must be used to realize virtual realities on the Web by CG. Since the treatment of CG data in design support systems in business is important, the use of VRML is expected to increase more and more hereafter. However, among the learning support systems that target large numbers of students, because the load on servers must be lightened as much as possible, there are thought to be few actual examples in which VRML is used.

In application research of object-oriented programming, Yamada et al. are researching the development of traffic flow simulation[11], Fujita et al. are developing structural analysis systems[12], Inoue et al. are constructing bridge plan design support systems[13], etc. However, JAVA language is a powerful tool for sharing and exchanging of information on the Internet.

As for the significant progress seen in computerizing the drawing of various designs in educational institutions, the referencing of design standard types is an extremely difficult task for the student or novice engineer[14]. This difficulty prevents progress in the computerization and automation of the design itself and occurs because educational sites do not want a simple automation and of the design process.

In this respect, in this research we have constructed a system that supports the designing of steel plate girder bridges by novice civil engineers and civil engineering students and emphasizes the particularly educational aspects of the process. We used HTML and JAVA in development to provide a design environment that is identical regardless of the OS. We created a conversation-type system so that the user can be aware of the design process. Also, we have linked the system with computerized (HTML-ized) design specifications to enable the user to easily reference regulations corresponding to design standards as necessary.

2. Significance of Developing the System using JAVA and HTML[15]

2.1 JAVA

JAVA is a language that was announced by Sun Microsystems in 1995. It incorporates the object-oriented concept. Since JAVA can be executed via an interpreter on various OS, including Microsoft Windows 95/NT 4.0, Sun Solaris, MacOS, Unix, etc., the software could be opened up on the Internet.

Like other high-level languages, the source code is compiled in JAVA. In the case of JAVA, a file output by a compiler is written in "words" for a "temporary machine" called "byte codes", which must be executed by an interpreter. However, since the words used by byte codes do not depend on the model or OS, they can be executed on any OS if you have an interpreter. Accordingly, by using the Internet technology, which is rapidly diffusing, JAVA software can be executed on any model or OS.

2.2 HTML

HTML (Hypertext Markup Language) is an application of the hypertext of the text structure description language, SGML (Standard Generalized Markup Language), which is the international standard[16]. Thus, it increases the interchangeability of text data, inheriting from SGML the property of classifying structures and the method of viewing. Since tags are prepared in HTML for embedding JAVA programs, it can be operated on WWW using JAVA compiled in applet format. In this way, you can execute the same software on networks if you have a JAVA interpreter and an appropriate browser.

3. Designing of Steel Plate Girder Bridges

The object is a simple non-synthetic steel plate girder road bridge of the main girder parallel form. The conditions set when designing are:

2

Bridge span

Width

Pedestrian/vehicle lane distinction

Live load (Live load A or live load B)

Slab type

In addition the user sets the following safety features:

1) Conforms with the latest common edition and steel bridge edition of the road bridge specifications.

2) Factory production of all welding, and on-site assembly with high-strength bolts.

3) Maximum of a 15-meter hauling distance to the site.

4) The steel plates used are of standard thickness.

5) Uniform material types are used in the principal section configured of I girders.

6) The difference between the hypothetical steel weight and actual steel weight is within 5 percent.

7) When deciding the span length of the slabs, the vehicle wheel interval of a T load is considered.

8) F10T/M22 is used when using high-strength bolts.

9) The edge distance of high-strength bolts is to be 40 mm as a general rule.

10) In the coupling unit at the site, the coupling plates are to be separated at least 20 mm from the taper unit for modifying the surface of the base metal.

11) There is at least 100 mm between fillet welding and butt welding.

12) Welding to the flanges of vertical stiffeners

(a) For support units, welding to both expansion/compression flanges to ensure a flow of strength

(b) For the horizontal girder mounting unit and transverse bracing mounting unit, welding only to the compression flange and metal touching the expansion flange

(c) For other locations, welding only to the compression flange, leaving a space with the expansion flange

13) As a general rule, one step of horizontal stiffeners of the main girder is used. Also, the fillet welding of the horizontal stiffener and web plate is to be 4 mm.

The applicable specifications are the latest versions of

the road bridge specifications and the steel bridge edition and common-use edition of the same commentary as published by the Japan Road Association[17]. Because there are many types of standards, it is not necessarily easy for novice engineers and students to reference these specifications.

4. Development System

4.1 Development environment

The environment of the system developed in this research used Microsoft Windows 95 as the OS, and JAVA Development Kit (Ver. 1.02)[18],[19] (hereafter, JDK) was used for developing the JAVA program. Netscape Navigator TM Version 3.01 Gold (ja) was used as the browser. The JAVA program and HTML that configure the system mentioned below are the source of all the system environments described above. Referring to literature[20]-[23], the authors independently wrote the program using no development tools in particular other than JDK, which provided the JAVA language development source.

4.2 Class design

A class is an object for inheriting common information. **Figure 1** shows a class configuration of a developed system. Since JAVA can dynamically link classes, by making functions divided into parts into classes, a class can correspond to extending and rearranging classes of those parts even if the calculation and checking methods are changed in the future.

A judgment class is set for each design process below[24].

process1.class: Setting of design conditions

process2.class: Input of design conditions

process3.class: Design of slab

process4.class: Calculation of main girder load/stress resultant

process5.class: Determination of main girder cross section

process6.class: Design of main girder stiffeners

process7.class: Design of main girder field joint

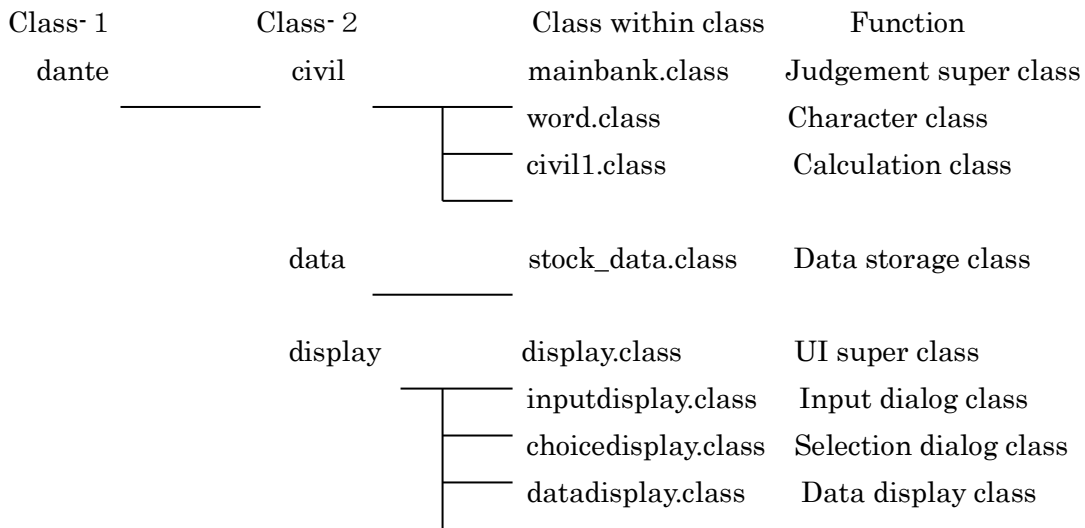process8.class: Design of transverse bracing

Class-1	Class-2	Class within class	Function
dante	civil	mainbank.class	Judgement super class
		word.class	Character class
		civil1.class	Calculation class
	data	stock_data.class	Data storage class
	display	display.class	UI super class
		inputdisplay.class	Input dialog class
		choicedisplay.class	Selection dialog class
		datadisplay.class	Data display class

Figure 1. Class configuration of developed system

process9.class: Design of horizontal girders
process10.class: Design of lateral bracing
process11.class: Checking of production warps and deflection
process12.class: Check of steel weight

The judgment super class is set as the high-order class of each of these classes. The calculation class includes as a static method the calculation expression executed within the judgment class. The character class stores unicoded Japanese. By including unicode in the class, it is set to target JDK1.02 bugs, which are errors that occur when recompiling. The data storage class makes the data part into a class and succeeds each class. The UI (User Interface) super class possesses functions, for example, numerical value input and result display, with each class of input dialog box, selection dialog, and data display being the low-order classes.

4.3 Execution format and screen configuration

Since tags are defined in HTML for embedding JAVA programs, change a created JAVA language class group to formats embedded in HTML called JAVA applet formats to create HTML files and execute them via a browser. After execution, refer to each type of displayed diagram and text and proceed with the design according to the GUI (Graphical User Interface).

Figure 2 shows screen configuration displayed on the browser. The following three screens were configured.

Frame (1): Calling a JAVA program
Frame (2): Displaying a design process or a manual
Frame (3): Displaying reference literature and diagrams

Along with design functions, this system has educational functions that present design manuals for self-study of design methods. In the above-mentioned Frame (2), either the process or manual that is selected is displayed. When using the design functions, the design process is displayed in Frame (2) matching the status of your design process. The text, figure or table is automatically displayed in Frame (3) by reference literature at the necessary place during numerical value input, etc. While viewing the display of Frames (2) and (3), the user inputs appropriately in the selection dialog box or input dialog box displayed instantaneously in conversational format and proceeds with the design.
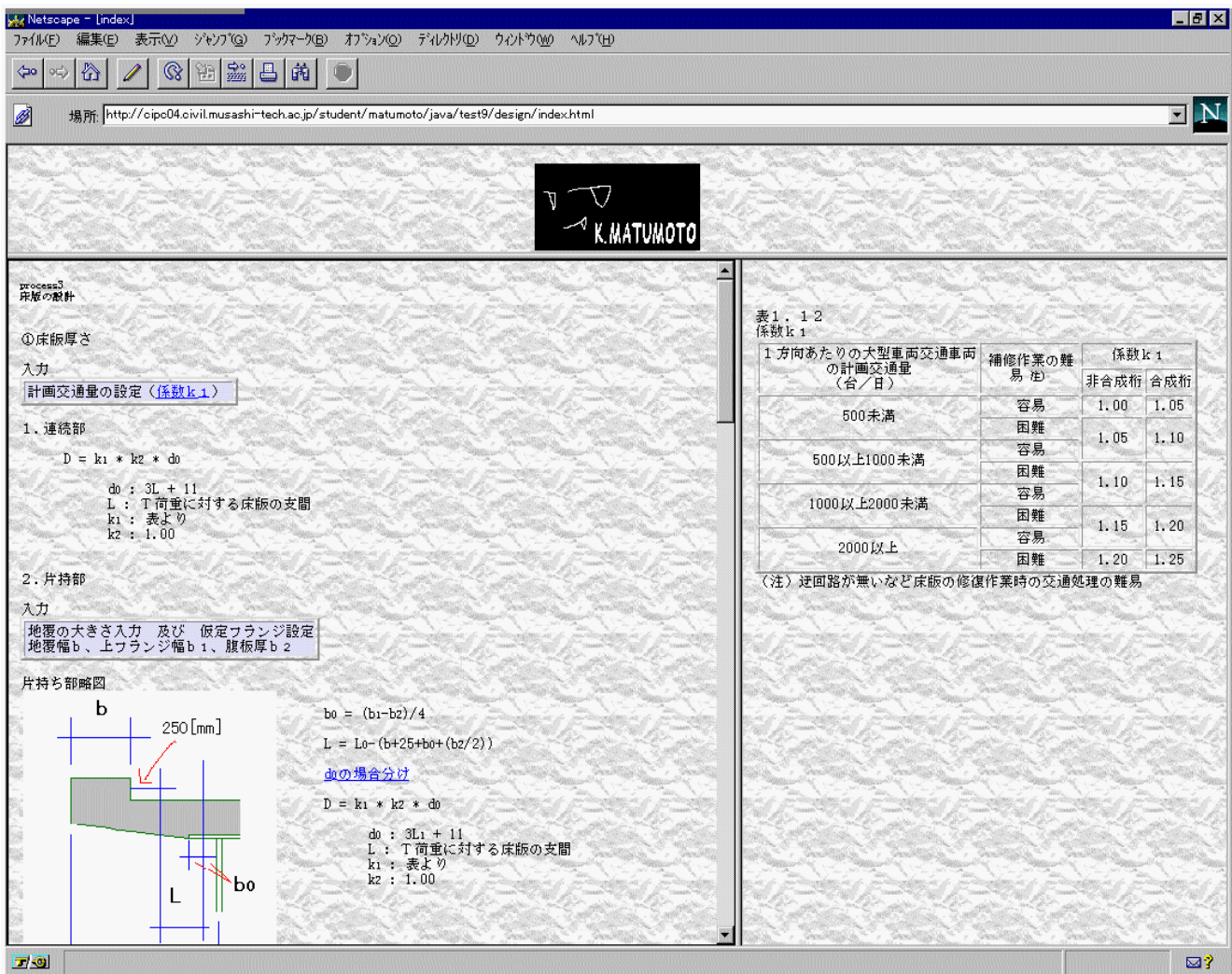

Figure 2. Screen configuration: (1) JAVA execution, (2) Design process, manual display, (3) Reference text, diagram display.

Input numerical values and calculation results are displayed for each process. Since access to files is prohibited by JAVA applet restrictions (although access restriction disappears when files are created as applications, they cannot be run on a browser), the user records necessary results. The checking results are displayed one by one, and the user repeats the design process as necessary. Also, when using design manual functions, the user can self-study design methods by displaying the manual in Frame (2).

5. Use Examples

5.1　Design function

We will take a part of above-mentioned process 5 "determination of the main girder surface" as an example design process. In process 5, the design process is automatically displayed in Frame (2) as shown in **Figure 3** and the user proceeds with the design as follows while viewing the screen.
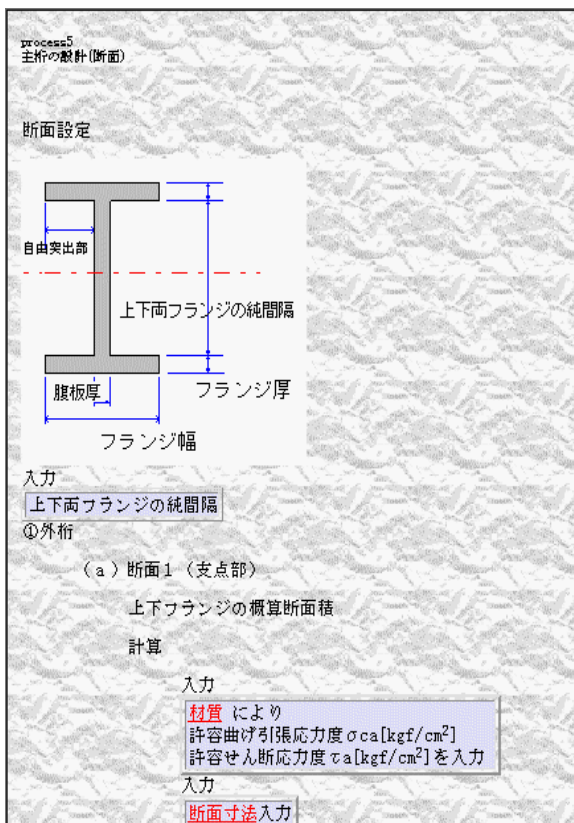
1) Confirm the surface design drawing, and input the pure interval of both the upper and lower flanges by keyboard in the displayed input dialog box.
2) The program progresses to the surface calculation of the external girder support units,
3) Set the tolerable bending expansion stress and tolerable shearing stress. The input dialog box and reference diagrams in **Figure 4** are simultaneously displayed for these settings. The user inputs numerical values while referring to the table.

5.2　Design manual function

Reference diagrams and design manuals displayed according to the progress of the program described in HTML can be displayed on a browser as shown in the left-side frame of **Figure 5** without having to run a JAVA program. Moreover, suitable links are set within the manual,

Figure 3. Example of design process.

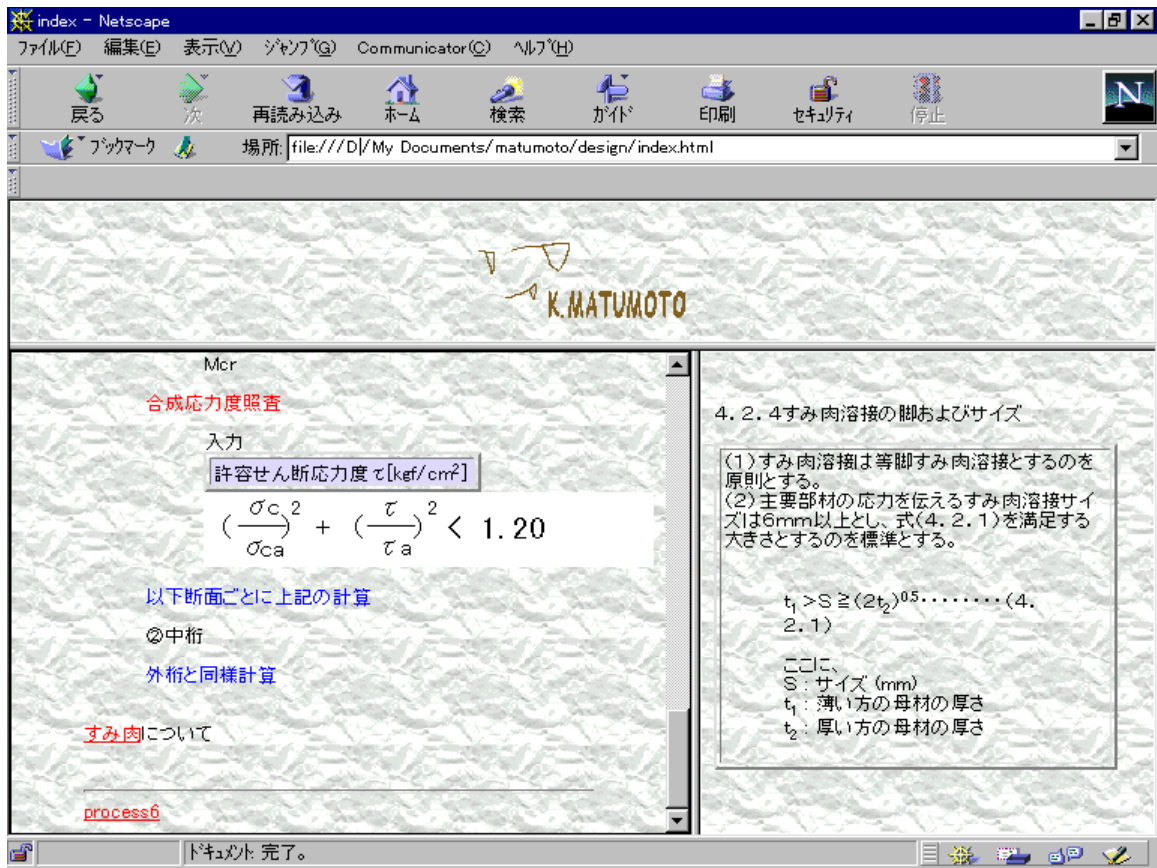Figure 4. Regulations of specifications referenced during design.

Figure 5. Display of specification regulations by linking
with manual display on design manual screen.

and in the design process you only need to mouse-click to display specification regulations and diagrams and text for reference in the right-side frame that displays reference diagrams. In this example, we click the link concerning fillet welding to display a commentary of regulations on the right-side frame.

6. Conclusion

In this research, we developed a system to support the designing of pure steel plate girder bridges using JAVA and HTML that can be distributed on the Internet. The development system enables (1) the execution of design tasks while dynamically referencing related specifications, and (2) the study of design procedures while referencing specifications by hyper linking on the Web. The user can experience the design process while easily referencing specifications described by arranged items. Also, since

numerical value calculations are executed within the system, the user can concentrate on finding a favorable design. Furthermore, by selecting a browser as the execution environment, the user can open and execute on the Internet. By using the Internet open environment, many users can practically use the expandability of JAVA and create various programs as a result. However, because JAVA itself is still a new language, many of its parts are immature. One problem is that the interpreter is incomplete. Since the design support system developed by JAVA language was optimized in Windows 95 as an execution environment, it is hard to say if a difference OS would have realized the exact same execution environment. However, by using a GUI environment and computerizing a design process that requires much labor and referencing of design standards, we think we have constructed a support system that can raise efficiency without lowering the educational effect.

Matsumoto (currently employed at Toyo Construction

K.K.) summarized this thesis related to developed systems while attending the Musashi Institute of Technology based on the guidance of Minagawa.

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