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A COOPERATIVE WEB-BASED DATABASE FOR BENCHMARK TEST OF STRUCTURAL NUMERICAL ANALYSIS UNDER SEVERE EARTHQUAKE MOTIONS

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Abstract

The purpose of this study is to establish a database storing the benchmark test results of structural analysis under severe earthquake motions on Internet. The database type is a distributed collaboration type database. In this study, the central database server in distributed environment has been developed. The central database server stores the metadata of numerical analysis results of structures. The metadata is written in XML following the standard of Dublin Core. Java is used as an interface to enable users to operate the database easily. Accessing the central database server, users can search the metadata, then access the distributed database storing original benchmark test results on Internet.

Introduction

In 1995, a lot of structures in Hanshin district of Japan were damaged due to the strong seismic motion of Hyogoken-Nanbu earthquake. The damage level of structures was depending on the ground condition and the type of structures. This disaster let us reconsider the functional and safety performance of structures, and the performance-based design attracts attention in the fields of civil engineering and architecture. Nonlinear analysis is a tool to proceed the performance-based design of structures under severe earthquake motions. To obtain exact results of the nonlinear analyses, it is necessary that researchers and engineers have enough knowledge and experience of nonlinear analyses. So the researchers and engineers needs benchmark test results to verify the model of the analysis. However, as the most of benchmark test results have been offered with paper media so far, it is difficult to modify the data timely and to add new data frequently.

In this study, an Internet environment to distribute the benchmark test results of structural analysis under severe earthquake motions is suggested, and to modify the data timely and to add new data frequently, web-based database has been developed. The type of the database is distributed collaboration database in which cooperation of many researchers and engineers can be obtained. The distributed collaboration database consists of a central database server and data servers. The central database server stores metadata of analysis results in data servers. In this study, the central database server has been developed by the authors and data servers have been developed by the collaborations. The metadata storing in central database server follows the standard of the Dublin Core. By searching metadata in central database server, users can access analysis results of all data servers. And, by accessing this database, creators of analysis results can add and correct metadata of analysis results easily and efficiently on Internet.

Data and Metadata

The central database server stored metadata of numerical analysis results showing in Table1. The data, which is shown in the report of “Numerical Analysis Benchmark Test Results of Steel Structures under Severe Earthquake Motions and Advanced Seismic Design” published from Japan Society of Civil Engineers (2000), was considered as the first data. In this report, 4 universities and 6 companies gave these results of analysis under different analysis models and analysis methods, and they examined the accuracy of results.

The example models of Table 1 are shown in Figs. 1, 2 and 3 using beam elements. Fig. 1 shows models of static analysis (P: vertical load, H: Horizontal cyclic load). In static analysis, single column type bridge pier, L-shape bridge pier and rigid frame pier are analyzed. Fig. 2 shows models of static cyclic analysis of steel bridge pier using beam and shell elements. In static cyclic analysis of steel bridge pier, T-shape bridge pier model (box section and pipe section) and inverted-L-shape bridge pier model (box section and pipe section) are analyzed. In time-history response analysis of steel bridge pier, T-shape bridge pier model (box section

Table 1: The number of stored data

Type of analysis	**Number of analysis**
Static analysis	33
Static cyclic analysis of steel bridge pier	19
Time-history response analysis of steel bridge pier	106
Time-history response analysis of continuous bridge structure	15

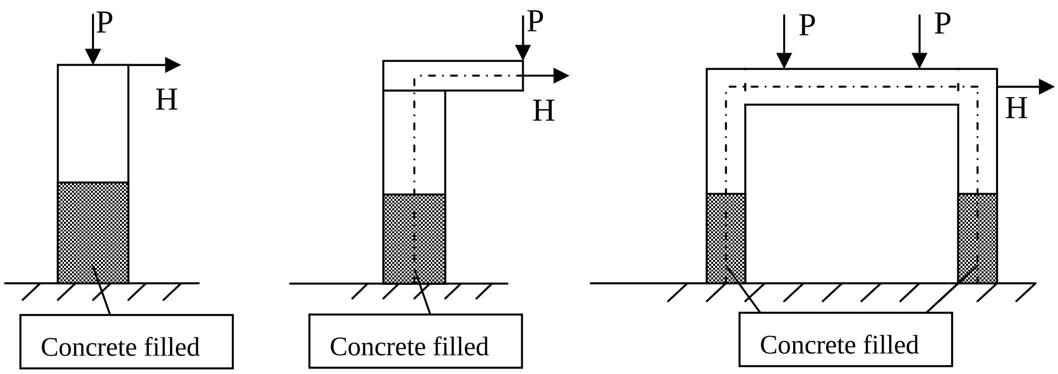

Fig. 1: The models of static analysis

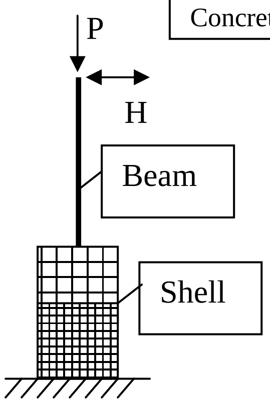

Fig. 2: The model of static cyclic analysis

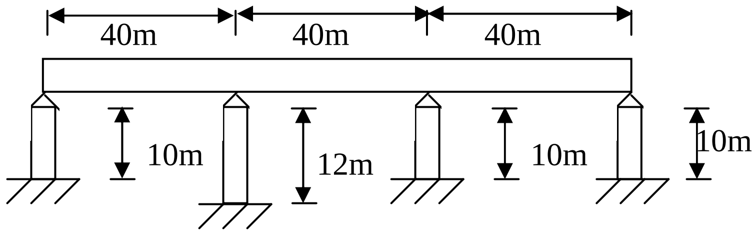

Fig. 3: The model of time-history response analysis of continuous bridge structure

and pipe section) and inverted-L-shape bridge pier model (in-plane load and out-of-plane load) are analyzed. Fig. 3 shows models of time-history response analysis of continuous bridge structure. In time-history response analysis of continuous bridge structure, movable bearing model, fixed shoe model, horizontal force distribution shoe model and LRB (Lead Rubber Bearing) model are analyzed.

Metadata in central database server is established following a standard of Dublin Core (Dublin Core Metadata Element Set). By using Dublin Core, users can search data smoothly on Internet (Wazaki and Itoh, 1999; Gilliland, Anne, Yasmin, and William, 2000). In Dublin Core, 15 fundamental elements ware defined. Table 2 shows metadata elements in this system, which follows Dublin Core. The items from (1) to (15) are standard items defined in Dublin Core. The item (16) was added in order to store the properties on data type and URL of benchmark test files.

Architecture of System

The system developed in this study has the architecture shown in Fig. 4. It is the distributed collaboration database system. By using the distributed collaboration database system, the analysis data are shared efficiently. In the system, the original analysis data are released and managed by researchers and engineers who conducted the numerical analyses, and the system administrator of the central database server gives only the suggestion how to install the original data onto data servers. The main role of the system administrator is management of

Table 2: The contents of metadata on structural analysis

	Contents	Examples
(1) Title	Title of analysis	Time-history response analysis of steel bridge pier
(2) Creator	The person or institution having responsibility about the contents	Nagoya University
(3) Subject	Model of analysis	Hummer head pier
(4) Description	Method of analysis	SDOF Model
(5) Publisher	The person who made information resources	Itoh laboratory, Nagoya University
(6) Contributor	The person or institution contributing the contents of a document	Nagoya University
(7) Date	Year of analysis	2000
(8) Type	Benchmark test of structural analysis	Benchmark test of structural analysis
(9) Format	File format	xml, jpg
(10) Identifier	ID number	1
(11) Source	The source of metadata	Nagoya University
(12) Language	Language for description	Japanese/English
(13) Relation	Quoted reference	Numerical Analysis Benchmark Test Results of Steel Structures under Severe Earthquake Motions and Advanced Seismic Design
(14) Coverage	(Empty)	(Empty)
(15) Rights	URL of copyright description	http://neptune.cirse.nagoya-u.ac.jp/bmdb/
(16) Data	Data type and URL of detailed data	Numerical results of analysis, http://neptune.cirse.nagoya-u.ac.jp/ bmdb/csv/

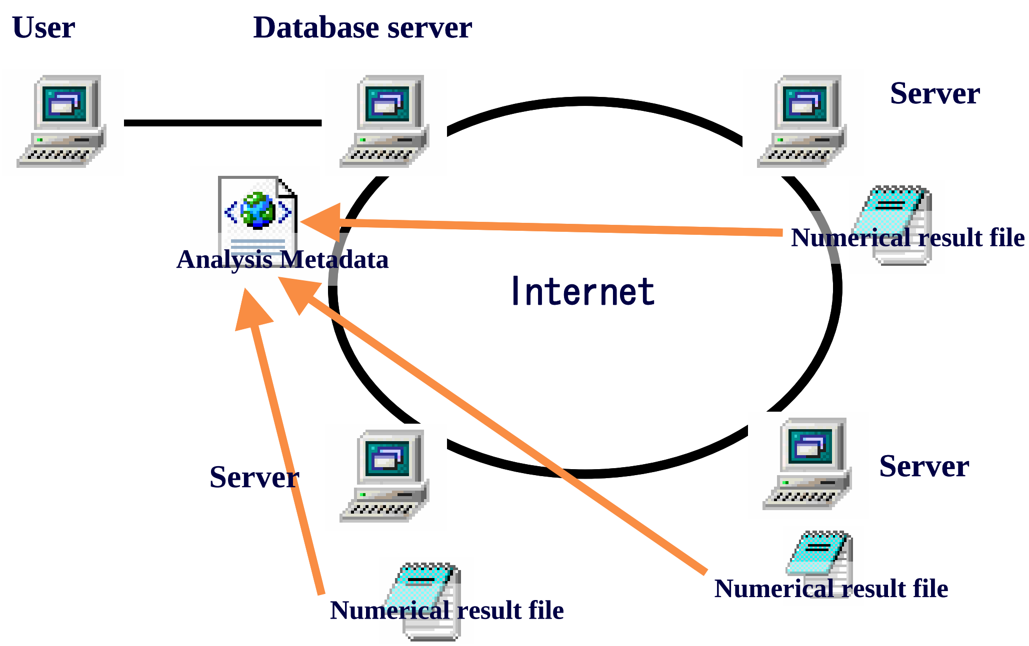

Fig. 4: Distributed Collaboration Database

the metadata having the properties of original data. Under the distributed collaboration system, users can refer all of data through accessing to the central metadata server. There are the following advantages in the system.

(1) The burden of network and server load is less than that of ordinary databases.
(2) The trouble occurred at the server side is avoidable to some extent.
(3) The whereabouts of responsibility are clear because the released range of analysis data is left to discretion of each data creator.
(4) Each data creator can easily update the data at his/her own server.

In this study, the central database server storing metadata of analysis results has been established in Nagoya University. XML (eXtensible Markup Language) was used to describe the metadata.

Database software to store metadata of analysis results was eXcelon (the product made from eXcelon) in which XML was stored directly. Java was also used for the process between a database server and users. Fig. 5 shows the processes in a database server when the users search the metadata. The database server receives strings following SQL. Then a database server searches the metadata or adds new metadata on analysis results following the strings. Java translates searching keywords inputted by users into SQL strings that database can deal with.

The files of numerical analysis results such as restoring force history curve are prepared as CSV file format in remote servers. Moreover, the server has the function that draws graphs from a file of numerical values of analysis results. The outline of drawing graphs

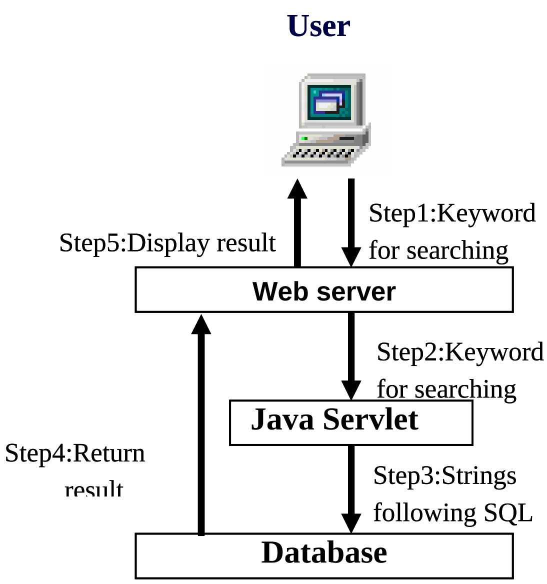

Fig. 5: The role of Java

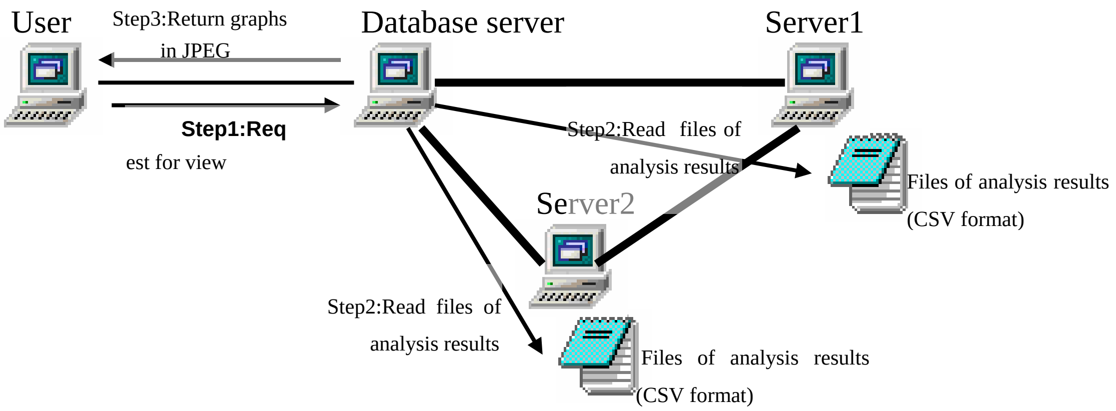

Fig. 6: The function of drawing graphs

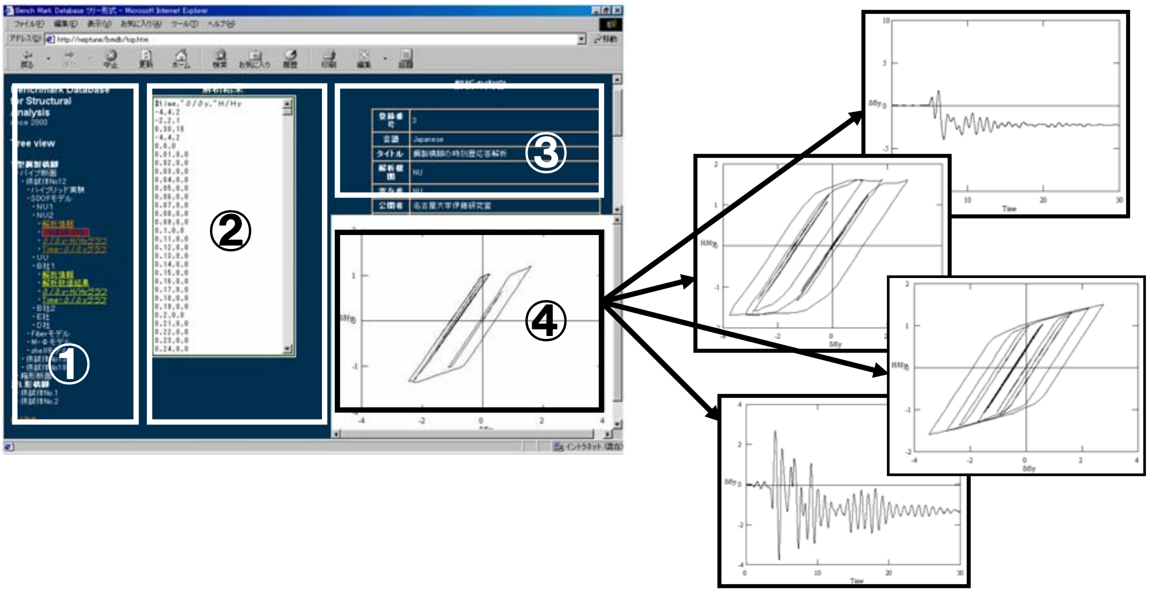

Fig. 7: Example of Display

function is showed in Fig. 6.

Step1: The database server receives a request of viewing graphs from users.

Step2: The database server read corresponding CSV file (file of numerical results of analysis) requested by users.

Step3: The database server generates graphs from the numerical results.

Step4: Using Java, the database server returns graphs in JPEG format to users. This function allows us to avoid preparing the picture file of graph in advance and to add data with simple procedures. These merits can promote cooperation of data creators.

Outline of System

The system in this study provides the retrieval function of benchmark data, the addition function of benchmark data and the correction function of benchmark data.

In retrieval of benchmark data, retrievals by keywords on an analysis title, an analysis organization, a creator of the data, an analysis model, and an analysis year are available. The typical retrieval keywords are embedded to each item in advanced so that even users with little experience can operate this system easily.

Creators of analysis data can install, correct and delete the data that contain 15 Dublin Core elements, the URL of data file of numerical results and a file for explaining the analysis models (for example, graphics, photos and text files).

In the cases of installation, corrections and deletions of metadata of the benchmark data on Internet, the registration as a data creator of the database is required. This is for preventing registering unrelated data and an alteration of benchmark data being performed by unjust use.

The perusal page of tree view was developed about the data prepared. On this system, numerical values, graphs, and metadata can be compared simultaneously. Then, a display was divided into four fields shown in Fig. 7: i.e. 1: menu field, 2: analysis result display field, 3: metadata display field and 4: graph display field. Users can download numerical results files and graph files in JPEG format.

Since the system is WWW-base, only Web browser is required to use the system. Netscape Navigator over 3.0 version of Netscape Communications or Internet Explorer over 3.0 version of Microsoft is available and anyone can use the system from "http://neptune.cirse.nagoya-u.ac.jp/bmdb/english/".

Conclusions

The main conclusions are as follows.

(1) A database system, which deals with benchmark test data of structural numerical analysis under severe earthquake motions, has been established.

(2) The database system displays graphics, photos and text such as load hysteretic curve and time-response displacement curve in order to be understood easily by users.

(3) Dublin Core, that was standard for searching efficiently on Internet, can be applied to the metadata of numerical analysis results of structures under severe earthquake motions.

(4) By establishing the distributed collaboration database system, the system administrator managing the metadata server, and the data creators can easily enhance the system efficiently to release the benchmark test results.

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