New Building Materials - Knowledge Transfer via the World Wide Web

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Summary

Web-based interactive information systems create new ways to transfer knowledge from civil engineering research institutions to practicing engineers. Although various systems have been developed, the search for sophisticated technical knowledge is still unsatisfactory for architects and civil engineers. The full text searches commonly used today do not fulfill the complex information needs on the rapidly expanding Internet. This paper describes the reasons for the current situation and it suggests, by example of the knowledge-based system "BiM-Online", solutions for better information retrieval of materials data using metadata structures. In a first example the metadata is modeled in a local relational database on a Web server. In section 5, the same concrete metadata structures are modeled using the machine readable Resource Description Framework (RDF) standard, an XML application that allows searches on independent information systems on the Web.

Keywords

Retrieval of building material information, Internet, WWW, BiM-Online, Metadata, material testing database, knowledge based dialog, XML, RDF

1. Introduction

The World-Wide-Web (WWW) is currently the world's fastest growing medium for information exchange. Most knowledge can be easily documented in a web-compatible format and thus becomes accessible to a huge group of professional users. The enormous potential of this type of knowledge transfer, however, is not yet fully utilized in the field of civil engineering. Today, more than 5 years after the breakthrough of the Web as a global information medium, architects and civil engineers will find it quite hard to gather useful information within their field using standard search engines or www-indices. Particularly in the fields of new building materials, products or techniques the potential of the Internet should be exploited to facilitate communication between scientists, engineers and innovative companies. In addition to aiding in the beginning of a research program, there is an opportunity for an efficient information retrieval of the published work. When a new topic is more or less unique on the Internet, and is concentrated on one website, standard search tools and indices are very effective for gathering information. As a topic spreads across the Web, how-

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paper ecce-2001-38.content

ever, traditional search engines and indices become overcrowded with useless information being referenced by the relevant keywords. This type of system misbehaviour is often the central difficulty of professional internet use. The „start-up-situation" of a new research project allows the user to bypass this problem, however, we recommend that central websites, that deal with new materials or procedures, be an obligatory part of every research program, thus insuring sustained access to the knowledge [1].

2. Scientific metadata about concrete

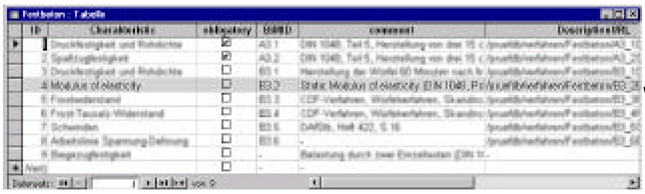
During the German research program "Life Cycle of Concrete and Masonry Structures" (Baustoffkreislauf im Massivbau, BiM), which has been awarded second prize by the German Industry and Trade (GIT) federation in the environmental technologies category, the scientific work was accompanied by the development of an online information system. The aim of the BiM program was to establish the foundations for optimal recycling of mineral building materials. The material properties of recycled concrete and the technological processes associated with this material had to be defined in such a way that future projects using recycled material could be easily realised. To make the results of this nation-wide, interdisciplinary scientific work quickly accessible to professionals, two sub-projects concerning the systematic work up of BiM's results were integrated into the program [2]. At the Institute for Construction Materials at the University of Stuttgart, a central, topic specific online information system has been developed that contains the documentation of the work of nearly 70 scientists. Before the scientists' reports could be published on the Internet, however, a great deal had to be done to edit the documents manually to integrate them into the framework of BiM-Online. Because the documents differed in their representation of the results, an efficient retrieval (e.g. for the results of material tests) was not possible without appending the reports with a hidden, machine readable structure. Thus, in addition to the digitalisation of incoming documents, the HTML source code had to be modified to designate paragraphs that contained testing results and further information sources (e.g. the bibliography, etc.). Instead of storing related sections of the original documents separetly, descriptions of these marked paragraphs were stored as metadata in a relational database. In the example of the BiM-Online testing results database, database structures contained the information shown in Table 1.

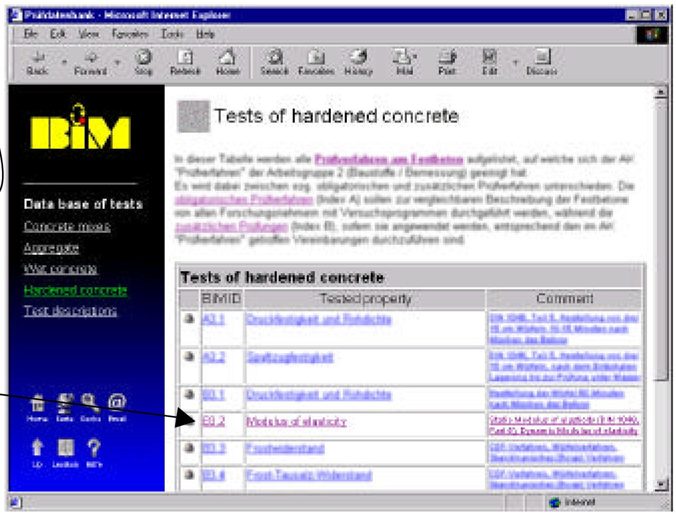
Table 1 Structure of the meta-tables for storing the BiM testing result records

Fieldname	**Field content**	**Example**
Testclass / TestID, Testdescription	Description of the test	Hardened concrete / 395 / „Dependence of the elastic modulus on the amount of recycled concrete rubble used for the aggregates"
ProjectID	Short name of the sub-project that carried out the test	E03
Month / Year	Date of the test	09 / 98
URL	Web address (URL) of the report with the reference number of the mark (anchor tag) in the source code	http://www.b-i-m.de/reports/ E03/E03z0998.htm#2
RelevanceTestgroup	Degree of relevance concerning the main topic of the corresponding sub-project	5

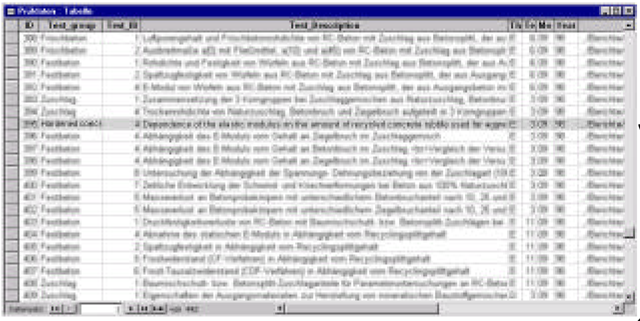
In contrast to a conventional preformatted data coverage using templates, declaration of the documents' content offers a way to leave the information in its original context. The document is preserved in the original structure as the author intended it to be.

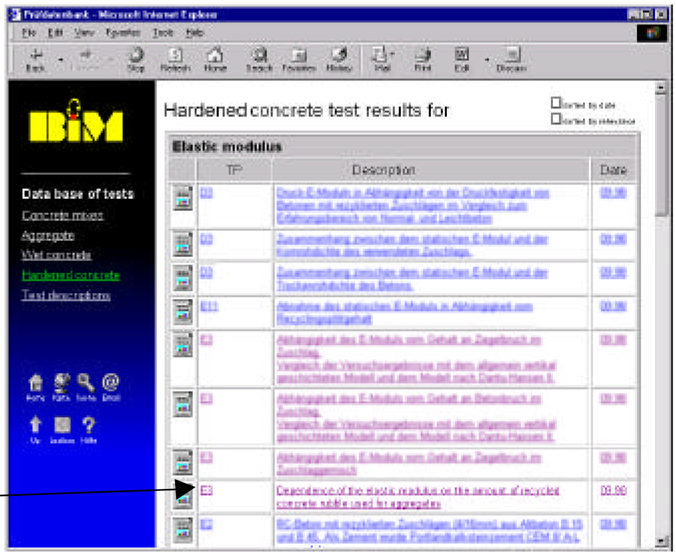
On top of this meta-database structure for material testing results, a uniform user interface has been integrated into the central website for the research project. It provides direct and easy to use access to the material testing results of all the individual sub-projects (Fig. 1). With the concept described above, the differently formatted contents in the documents could be made accessible from a homogeneous user interface. This approach of an indirect description of building material data fulfilled the demand for searchable data. To allow for more complex tasks, further development of these metadata structures is conceivable and desirable. Common metadata, for example information about patents, will require specifications and more detailed comments about the authors and should be considered in future metadata structures.





ID	4
Property	Elastic modulus
Obligatory	No
BiMID	B3.2
Comment	Static el. modulus (DIN 1048 T.5)...
Descr.-URL	/tests/hard_concrete/B3_2EMod.htm





ID	395
Test_group	Hardened concrete
...	...
Test_descript.	Dependence of the el. modulus on...
...	...
URL	... .de/reports/E03/E03z0998.htm#2
...	...

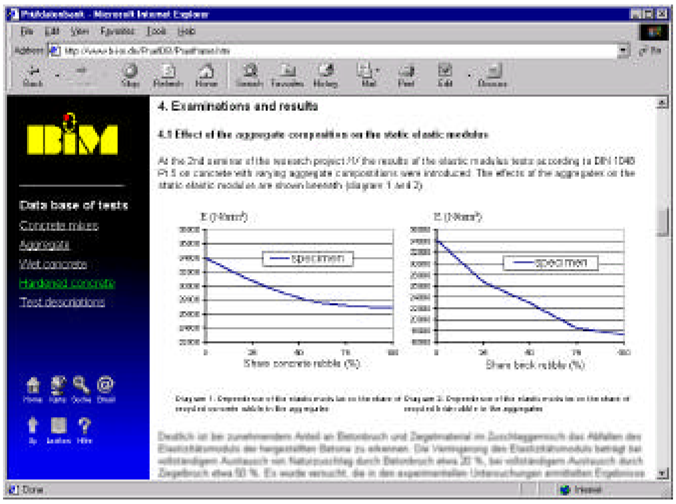


Fig. 1 The selection lists of the testing results database are generated by relational database tables depending on the user input. The user is lead to the text paragraphs in the document pool containing the wanted information in just a few steps.

3. Practical knowledge about concrete

The BiM-Online system was not only developed for the documentation of compiled data. At least as important was the desire to structure the knowledge of how to produce and build with concrete made of recycled aggregates. To more rapidly get this know-how into the daily planning and working processes, the information system offers the knowledge based component “BiM-Online Dialog” [3]. Unlike the “content based” structure of most online applications, a “problem based” inference component has been developed to access project results. It guides the user through a man-machine dialog in which the computer tries to find an answer based on the relevant decision parameters. The goal was to provide the direct solution to the user’s problem without forcing him to browse the vast scientific documentation of the project.

An example of such a dialog is the composition of a concrete mixture with recycled aggregates. It begins with a series of three online forms. In the forms, the user can specify the desired concrete properties, the grading curve, the composition and the special characteristics of the recycled aggregates. If the user’s input exceeds the specifications of the current German design code “DAfStb - Guideline: Concrete with recycled aggregates”, the system notifies the user with an appropriate pop-up message (Fig. 2a). The first result provided by the system is the volumetric mixture design. In the volumetric mixture design, the additional amount of absorbed water and the initial humidity of the recycled aggregates are considered. After only four steps, the dialog “mixture composition calculation” ends with a printer-friendly summary of the concrete properties (Fig. 2b). The complete formula for the concrete laboratory, an estimation of the expected elastic modulus and remarks on the design code conformance of the designed concrete are provided by BiM-Online Dialog.

4. Limitations of local metadata

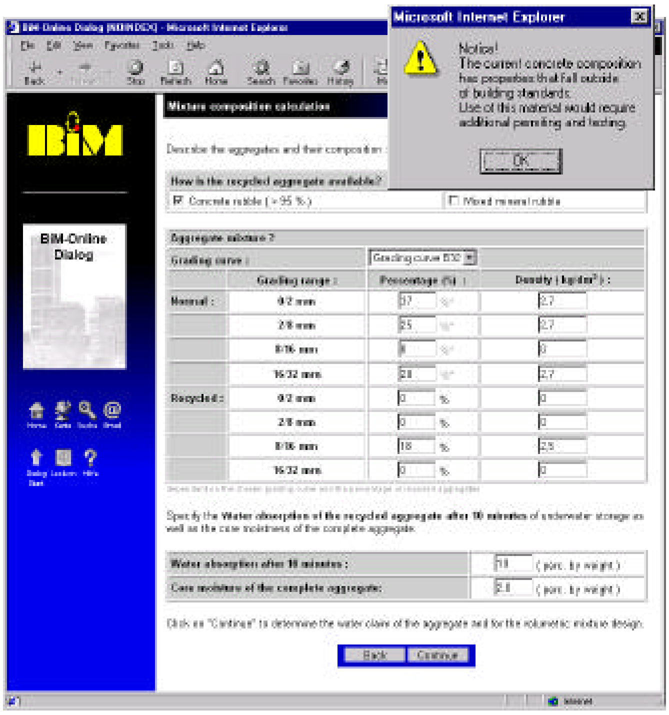
Many of the problems encountered during the collaboration and presentation of distributed research projects can be solved with modern information technology. During the research stage of a project, rapid documentation in an online system creates synergistic effects, as well as the opportunity to increase the interest of external parties that might become users of the research results. When the research project is completed, the detailed online documentation can be used as a practical working basis for scientists and engineers.

Websites like BiM-Online, which are supported by databases, allow for rapid access of the needed information in the site due to their content oriented structure and optimised query tools. These labor intensive to design and often complex database structures can not yet be understood by search engines with access from outside the web server. When a search robot scans the contents of such a system, metadata information stored in relational database tables is not considered. Because there is no link between the testing data hidden in the relational metadata tables and other Web applications, a locally highly structured, but isolated “knowledge island” has been created in the WWW.

5. Metadata for the Web

As long as a research project is presented by means of a single central website, good coverage and indexing by the popular search services on the Web can be guaranteed. With increased popularity of the research topic, efficient retrieval of data becomes more difficult. Metadata concepts that spread over a large number of different information resources are necessary to solve this problem. A technological basis for such concepts called „Resource Description Framework“(RDF) has recently been presented by the WWW Consortium as an application of the „eXtendable Markup Language“ (XML) [4].

The concept of XML is considered by practically all major internet software developers as the central technology for the future Web. Related to the present standard HTML, XML offers many more possibilities that evolve out of the division of content and formatting of documents. XML documents contain instructions that describe their semantic structure and certain attributes of the information. These instruction are included in the source code as so-called “tags”, similar to HTML. Unlike with HTML, the vocabulary of XML tags is freely extensible. In addition to the XML concept, many sub-standards have been created and more are still being developed. The style sheet standard “eXtensible Stylesheet Language” (XSL) for the formatting of XML documents and the



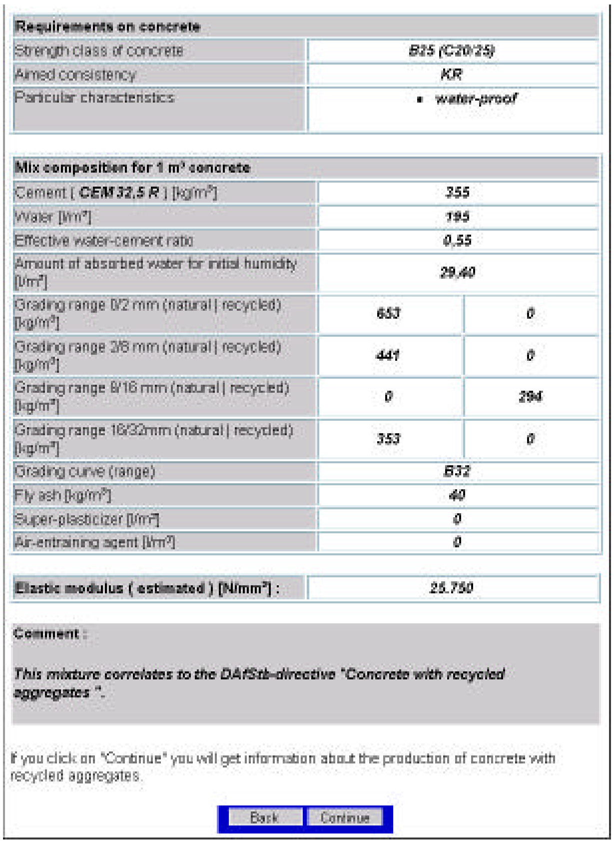


Fig. 2a The screen "Characterisation of the aggregates" in the dialogue "Composition of a concrete with recycled aggregates.".

Fig. 2b "Summary of the results" in the same dialogue

general metadata concept of RDF are of particular importance for the publication of building materials information on the Internet. RDF allows for the provision of additional information to the contents of documents that can in turn be automatically used by search engines or further applications.

The essential characteristics of the RDF standard are its machine readability, the independence of the metadata storage and the logic structure of the described documents. With the RDF standard it is possible for scientific documents published online to remain under the administration of the web servers of the authors. The integration of a document's contents over RDF records can then be realised on another server. This flexibility is an important simplification for the development of information systems. Further characteristics of RDF are its ability to combine different metadata records and the independence of metadata from the format of the described resource.

The RDF description shown in Table 2 of the previously described example "Dependence of the elastic modulus on the amount of recycled concrete rubble used for aggregates" should clarify the implementation of RDF for a certain resource in an HTML document. The first paragraph in the RDF source code must define the namespace (here xmlns:BiMTest) that is used. The namespace defines the meaning of the field names and their respective tags to assure a unique definition for each tag. Every XML tag has to relate to a namespace in which it is unique. As the described resource in line 4 which begins "<Description about = ...>", the HTML anchor tag #2 in the source code of the HTML document has been chosen. This internal HTML mark makes it possible to jump directly to the text passage that contains the test data. In this example, the anchor tag must be set by the author. As soon as the XML sub-standard "XPointer" is supported by browser applications, this HTML construction can be substituted by directly addressing certain images and paragraphs in XML documents without the need to change the targeted document. The following lines contain data fields with the same sample data as shown in Table 1. For RDF search engines, it will not matter if this code is stored in the document itself or in a separate RDF file with other RDF descriptions on another web server.

Table 2 RDF source code for a BiM testing result record

```
<?xml version="1.0"?>

<RDF xmlns="http://w3.org/TR/1999/PR-ref-syntax-19990105#"
   xmlns:BiMTest="http://iwb.de/BiMTest#">

      <Description about="http://www.b-i-m.de/reports/E03/E03z0998.htm#2">
            <BiMTest:Testclass> hardened concrete </BiMTest:Testclass>
            <BiMTest:Testtype> elastic modulus </BiMTest:Testtype>
            <BiMTest:Testdescription> Dependence of the elastic modulus on the amount of recycled
            concrete rubble used for the aggregates </BiMTest:Testdescription>
            <BiMTest:Testlocation> TU Musterstadt, Institute for building materials </BiMTest:Testlocation>
            <BiMTest:Testedby> M. Mustermann </BiMTest:Testedby>
            <BiMTest:Testdateday> 09 </BiMTest:Testdateday>
            <BiMTest:Testdatemonth> september </BiMTest:Testdatemonth>
            <BiMTest:Testdateyear> 1998 </BiMTest:Testdateyear>
            <BiMTest:Relevance> high </BiMTest:Relevance>
      </Description>
</RDF>
```

For the application of RDF, three fundamental problems still have to be solved:

- Definition of namespace and schema standards to define the fields in the metadata records [5].
- Provision of a software tool (RDF-Editor) that allows the user to create the described metadata records in an easily.
- Installation of central „search engines“ on the Web that use these metadata structures.

The first prototypes of RDF-Editors and RDF based search engines are already available on the WWW. Current work at the Institute for Construction Materials at the university of Stuttgart is concerned with the application of these new technologies. A more detailed XML namespace, which allows uniform metadata representations for building materials information and its practical use, is currently under development.

6. Vision

With the introduction of new internet technologies like XML and RDF, the realization of more detailed information services for civil engineers has become possible. These services, furthermore, will provide a higher quality of information retrieval compared to current search engines,
In addition to the development of vast, topic-related vertical services on the WWW, the creation of comprehensive concepts for a standardized content description for the great number of online resources will play an important role in the future of materials knowledge exchange. With such concepts it will be possible to realize portal sites for distributed resources that consider the special needs of the building industry. These concepts will combine the advantages of two worlds - the ease of use of printed media and the speed and accessibility of information in electronic information systems.

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