EASY: A HYPERMEDIA LEARNING TOOL

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SUMMARY: *The Web not only distributes classically organized teaching material such as overheads, lecture notes and books, but also encourages new ways of publication and provides the means for content which could not have been printed on paper. In the article we present a tool for teaching earthquake engineering - an Earthquake Engineering Slide Information System (EASY). It uses information technology to present expert knowledge that has been accumulated over the decades by observing structures, damaged by earthquakes. Based on slides taken after major earthquakes such as Northridge, Mexico City and Kobe, a pictorial database of some 500 most descriptive images has been created and carefully annotated with keywords and textual description. By browsing the database and by following hypertext links, the user learns basic pitfalls of earthquake engineering and gains the feeling for the behavior of structures. The system is available both on the Web and on CD-ROM. We describe the system, as well as the design and development process and tools.*

KEYWORDS*: earthquake engineering, education, multimedia*

1. INTRODUCTION

The authors claim that in earthquake engineering we learn from past experience; and that observations of structures and their components, damaged by earthquakes, provide an important source of knowledge. Traditional media have several drawbacks for distribution of such material. Our goal in the project presented was to create a teaching tool that departs from traditional formats of textbooks and exploits some of the possibilities provided by hypermedia.

1.1 Earthquake engineering image information systems

Earthquake engineering is a semi-empirical science and the study of the behavior of structures during (and after) earthquakes provides an important source of knowledge and progress. The photographs taken after earthquakes are suitable media to achieve this goal (e.g. Fig. 1).

Digitized images offer several advantages over conventional slides and photographs, including availability, distribution, enhancement, annotation, and integration with the text (Martini, 1996). But first of all they provide faster access to the relevant information, as well as a possibility for efficient linking and cross-referencing. By adding commentaries and an efficient users interface, an annotated pictorial database can be used as a teaching tool in addition to being a reference source.

Traditionally, such images are distributed either as expensive sets of slides with little or no commentaries. Because of the publication cost, very few selected images are reproduced in engineering textbooks to support the messages, which is written as text. Printing color reproductions is expensive and browsing through such books is inconvenient and time-consuming.

Some on-line picture libraries exist, such as EqIIS - Earthquake Image Information System (EqIIS, 1995); developed by Earthquake Engineering Research Center at University of Berkeley, California. It is certainly the largest source providing 8000 images from 80 earthquakes on the Web. After the Northridge and Kobe earthquakes many new sites of different size and quality have appeared. Although many of them are important references, all of them have rather limited commentaries and browsing options.

FIG. 1: Typical image from the slide library.

1.2 Goals

From the earthquake engineering perspective, the authors wished to create a system, that focuses on the images, but includes rich additional information, such as textual description of the slide, cross references to related slides or to common general information, multiple classifications of the slide by, for example, structure type, cause of failure etc.

From the IT perspective the authors were hoping to create versatile and friendly user's interface which is equally well suited for a novice to multimedia as well as to a power user. We were looking for well-balanced classification systems; providing sufficient detail to correctly tag the slide, but not too detailed, as this would complicate the work both for the author and the end user. Having in mind rather limited marketing possibilities, we wanted to be able to rapidly prototype the system and concentrate on the content, not the programming and the design of user interface. We acknowledged the need that the system should be available on the Web; but because scanned images are quite large, the users would appreciate the speed of a CD-ROM as well. The authors wanted to be able to use one solution for both.

Finally, we were hoping to create something having a textbook value while exploring new multimedia publication formats. Quite a few textbooks are available on the Web, ranging form computer science to structural

engineering, but most simply convert the textbook, which has been prepared for printing, into Web's Hypertext Markup Language (HTML) format. A fresh approach enables the authors to bypass this idea altogether and create a multimedia teaching tool, which lets users choose their own way through the material.

2. SYSTEM ARCHITECTURE

The authors present the system components as an authoring environment implemented as a relational database, and an end user's environment, on both the Web and on CD-ROM. The overall organisation is shown in Fig.2.

2.1 Slides

Five hundred slides covering various aspects of four important earthquakes were selected for the EASY hypermedia system. While Mexico City, Northridge and Kobe earthquakes are well known and publicized, the system includes about one hundred slides from the 1979 Montenegro earthquake which is less known to the engineering community. The first author and other members of the Institute of Structural Engineering in Ljubljana took a great majority of these slides.

The selected slides were scanned as high-resolution bitmap images - 1296 x 864 pixels in true color, 24 bits per pixel, mode. Image processing software such as Paint Shop, Lview, Picture Publisher and Display were used to enhance the contrast, colors, and sharpness of the images, as well as to extract the interesting slide details. The final images were compressed and saved in JPEG format, which provided huge space savings while maintaining image clarity.

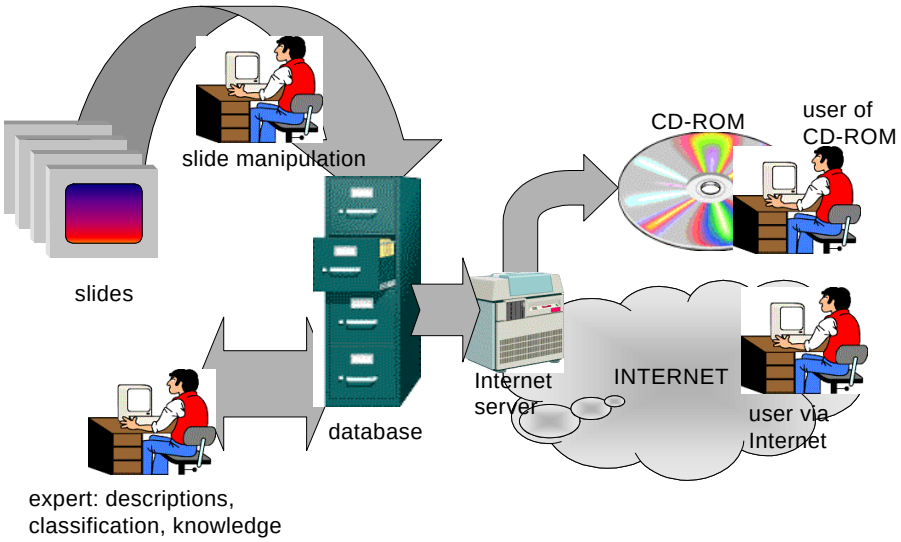

FIG. 2: System components.

2.2 Data structures

Early in the design process the authors decided to use a database to store the information about the slides, and not use hypertext or less structured representations. Since it seems natural to group the information around the slides, earthquakes and failure types, we selected a relational database model. But since we were not capturing an existing business process, it took us quite some time to finalize the database structure. For example, in the information modeling phase it was not quite clear what kind of information we were modeling - the earthquake experts could formalize only vague ideas about which formal attributes that they would like to attach to a slide. On the other hand, the authors wanted to store, in a structured way, knowledge, which is sometimes based on experience and is often intuitive.

Therefore it was very important to design the EASY system incrementally and refine it dynamically during the process of adding textual information to the slides. This was possible because 4th generation (4GL)-database tool - Microsoft Access - was used in the design of the authoring environment. The authoring environment could be modified and changed quickly, using visual tools, and with little or no requirement for re-coding. Close cooperation between the earthquake engineers and IT specialists proved to be an essential element of the project. The resulting database structure is shown in Figure 3 and has three main tables:

- Slide table (labeled main in Fig. 3) which includes the image at several different resolutions, comments, description and keywords;
- General information about the failure types which may include long textual explanations;
- Global comments which can apply to several slides and includes general commentaries about a certain topic.

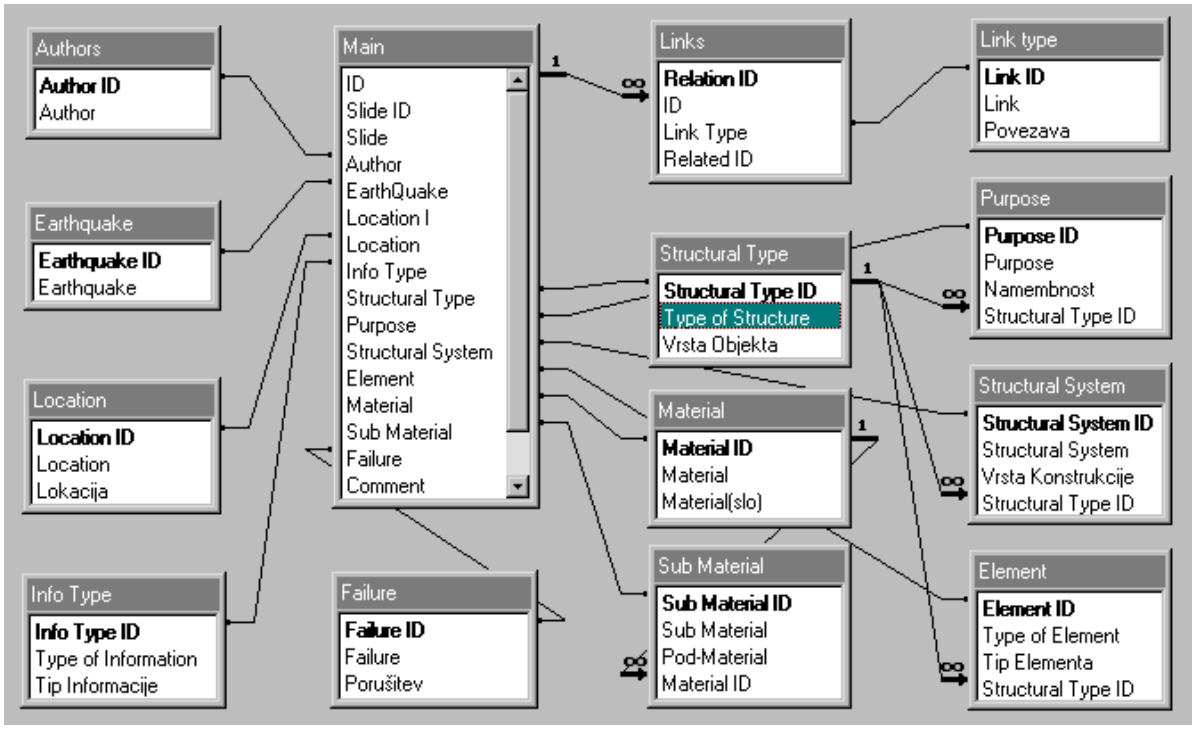

FIG. 3: Structure of the relational database. Note that some field names are in Slovenian language. They represent the Slovenian translation of the English field above. The whole system was designed to be bilingual.

As shown in Figure 3 several attributes and classifiers are attached to each slide, for example information about the author, earthquake, micro-location, type of location, type of structure, structural system, structural element, material and sub-material, type of failure and any additional comments. This last field contains the residue of the knowledge structuring process - information that does not fit into any of the other fields. Most of the fields are presented as lists - the author selects one of the predefined values. The sets of values were also developed dynamically; in the beginning there was a tendency towards a very detailed keyword system while during the data entry fewer important keywords emerged. Sample field data is shown in the form on Figure 4.

The authoring environment was developed in the Microsoft Access relational database and runs in the Windows environment both in English and Slovenian language. The main input form (Figure 4) was prepared to facilitate the data input. Pull-down menus with controlled keywords enabled quick and efficient data entry. The main benefits of using this 4GL development environment are the excellent response times and easy changes to the database structure - typically this can be accomplished without programming, by using the graphical user environment.

2.3 Commentaries

Extensive commentaries are probably the most distinguished feature of the EASY hypermedia system. The commentaries include short captions, detailed global descriptions and general descriptions of different causes of failure. Short captions provided by the slide author, such as “Shear failure of a column. -- Note large spacing of stirrups”, are essential for the identification of the slide and provide considerable additional information for both the slide author and the users.

There are several topics, however, which demand more detailed and longer explanation, e.g. “Structural aspects of traditional wooden houses in Kobe”. These commentaries are usually related to several slides with similar information. Such detailed global descriptions can be prepared separately and linked to several slides in the main input form.

The most important topic is the explanations of the typical causes of failure. The descriptions of causes of failure (e.g. of “Shear behavior and failure”), are also linked to the failure keywords. These explanations actually cover an important part of classical textbooks of earthquake engineering. In the EASY system they are supported with pictorial information and hyperlinks.

Additional commentaries are provided on the general characteristics of an earthquake, and on the lessons learned from them.

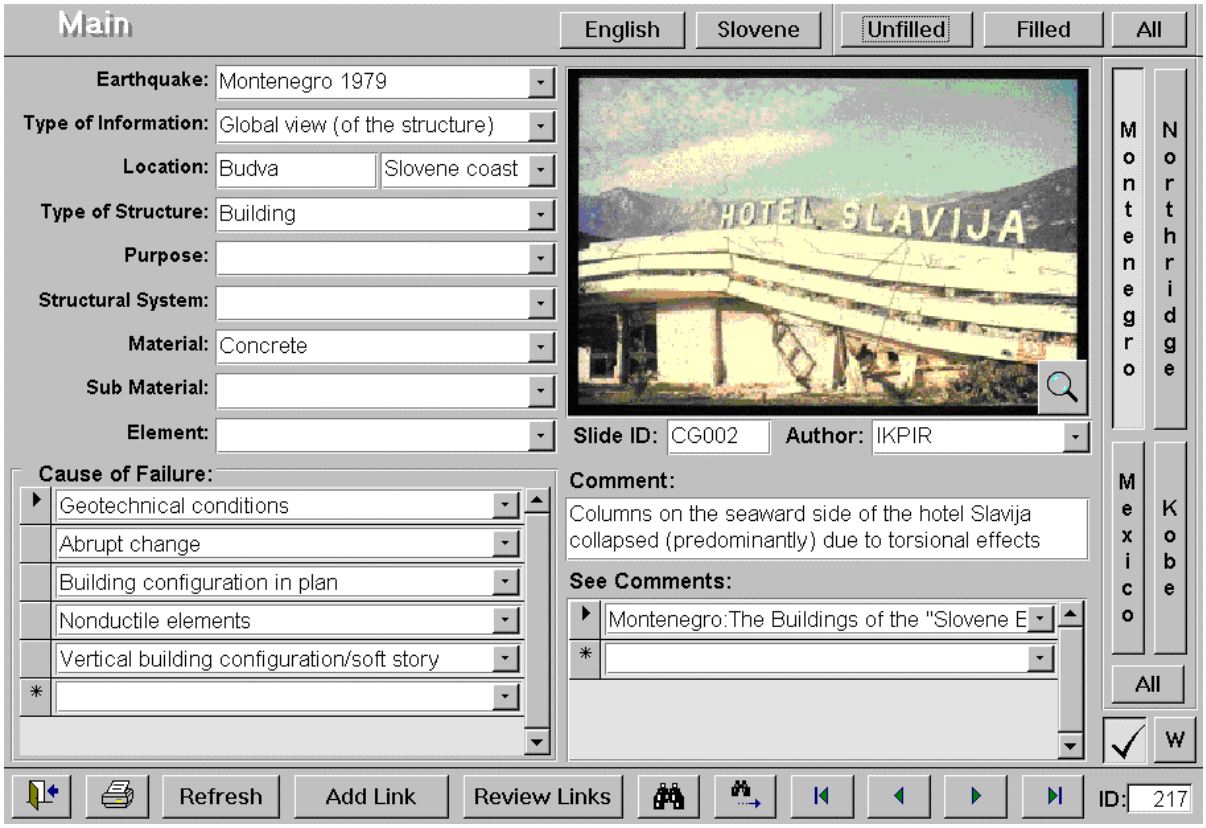

FIG. 4: Main input form of the authoring environment (compare with Fig. 5).

2.4 Links to related information

There are several types of links:

a) Links to related slides;
b) Links to global comments; and

c) Links to the commentary on the cause of failure.

The typical relation in type (a) links is from the construction site to the structure and structural detail (and vice versa). Other links (e.g. “similar damage” or “the same structure”) are also provided.

As mentioned in the section 2.3, links of type (b) include general comments that apply to several slides that may need longer explanation. Short titles of these commentaries are provided to the user within the search result. The global comments are reversely linked to all slides to which the comment applies.

Links of type (c) were also mentioned in section 2.3; full descriptions of typical causes of failure are the central point of the system. They are linked to the specific slide in the same way as the global comments.

3. IMPLEMENTATION

We describe the implementation phase briefly below; however, details are depicted in the Appendix and can be examined live on the Web at http://www.ikpir.fagg.uni-lj.si/easy/.

User friendliness for the novice, as well as quick and efficient access to the information and knowledge for an experienced user, are the main goals of the system. A carefully designed structure for the relational database is a precondition to this; a versatile graphical user interface, however, is equally important. In the last few years, Web browsers, such as NCSA Mosaic, Netscape Navigator or Microsoft Explorer, have established themselves as a universal gateway to all kinds of information. Millions of users are now familiar with hypertext navigation through information. The authors have therefore decided that end users should use this type of hypertext tool to access the EASY database. Although there are some commercial products which present MS Access data on the Web, the authors decided to use an in-house developed WODA Web Oriented Database (Turk, 1995) because WODA allows faster prototype development with less explicit page design than many commercial tools.

3.1 WODA

WODA is a Web Oriented DAtabase system written in the Perl language. The WODA environment makes it very easy to create a multimedia database that can then be maintained, augmented, modified, and queried through the Web. It could be readily used for the author's environment as well, however, because WODA is a Web based client-server application this adds some overhead which makes it slower in simple data entry operations than the Access database that runs locally on a workstation.

The WODA engine automatically generates all the required web pages for the maintenance, browsing, searching and other navigational needs, so the developers are spared of the tedious work of developing individual pages and forms. To navigate through the database, WODA provides two types of interfaces: (1) browse interface and (2) search interface.

3.2 Browsing

The browse interface is aimed at novice users and does not expect much knowledge from the user - neither is the user expected to know keywords or controlled vocabulary or how to formulate a question to the database’s search engine. The browsing menus present various tables of contents, following the structure of the keywords: *Earthquake*, *Location*, *Type of information*, *Type of structure*, *Structural system*, *Material*, *Structural element*, *Cause of failure*, and *Author*.

Slightly more advanced, but more powerful, are the matrix searches where a combination of two attributes may be queried. For example in a matrix with "type of structure" in rows and "earthquake" in columns, the user can easily request a search for all slides related to "wooden structures" and "Kobe earthquake". Some of these combinations are predefined, but the users are also free to invent their own combinations.

The most powerful browse option displays a list of keywords. The user checks the interesting keywords, and WODA returns a list of slides matching the keywords. The slides are sorted according to their relevance to the keywords.

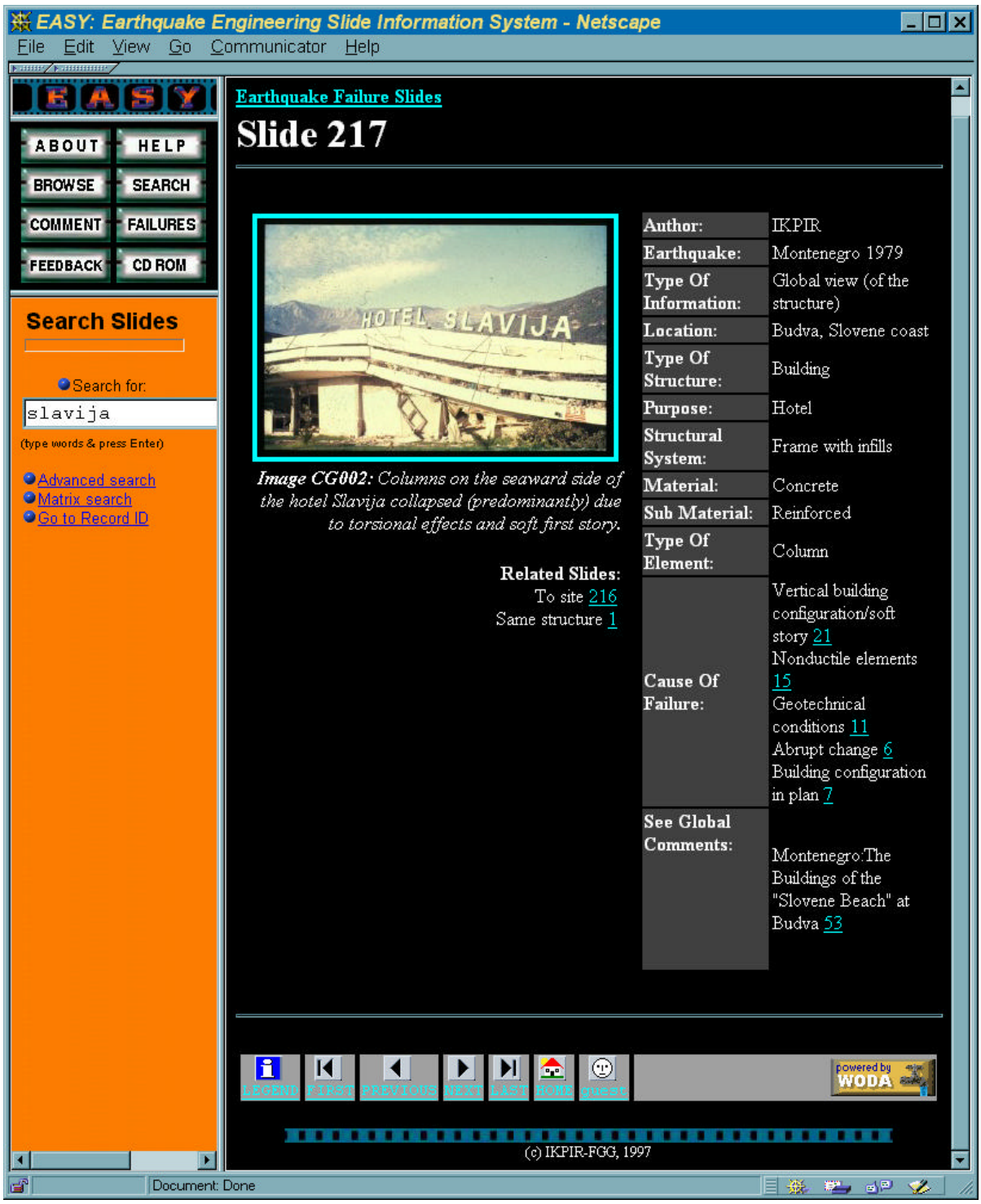

FIG. 5: Data entered in Fig.4 presented in a Web browser.

3.3 Searching

The search interface allows users to explicitly search on keywords or any phrases. The search can be done either in the full text of the database or restricted to preselected fields. The user is required to type in a few words into the search form without any special syntax. More ambitious users, however, can use a fairly simple search syntax, which is very close to that found in other Web services, such as Digital's Alta Vista (http://altavista.digital.com/). Prefixing a word with a "+" sign (i.e. +Kobe) means, that the user wants the word to be part of the slide information. Likewise, prefixing a "-" sign (i.e. -steel) means to exclude "steel" from the search. The search can be restricted to a specific field by prefixing the field name (i.e. +Earthquake:Kobe); this will return only slides where word Kobe appears in the Earthquake field. The more knowledgeable users can use Perl logical expressions to define the search.

3.4 Results

The results of both the search and browse operations are generated by WODA using the same internal "find" routine. A listing of the results is returned providing the vital information about the slide, as well as a thumbnail image. Clicking on that image opens a higher resolution image (see Appendix for examples of sessions using the EASY system).

3.5 CD-ROM

In designing the CD-ROM solution, the authors were faced with two alternatives: (1) provide programs which could be installed on user's personal computer (PC) and offer similar functionality as the database on the Internet server or MS Access, or (2) provide only the data but richly linked in hypertext format.

The authors estimate that many users are not computer experts and might be intimidated by the first option, which would require installing complex software on their PC. Also, the users would be restricted to a single operating system. Therefore, the authors selected the second alternative and decided to put only the hypertext files and pictures on the CD so those users could browse the contained data with any standard Web browser. A Web robot, similar to the one that is described by Turk (1997), was used to crawl through the EASY Web pages and create the required pages. The results are thousands of HTML pages which look and work exactly like the pages dynamically delivered from the web with two exceptions:

- they are delivered much, much faster from the CD ROM than from Web server;
- any functionally which requires a user to type (e.g. a search for some user defined text) is routed to the Web server in Ljubljana, Slovenia because the data on the CD-ROM is static and a search engine is not included.

Because this CD ROM alternative does not include any programs, but only files in standard HTML, GIF and JPEG formats, the data and images can be viewed on any platform and any operating system which supports CD-ROMs and runs a Web browser. The CD-ROM also includes free browsers for both the Windows and Macintosh operating systems.

4. CONCLUSION

The authors believe that combining state-of-the-art information technology with expert earthquake engineering knowledge and experience provides a valuable reference source and an efficient teaching tool - not only to students, but to practicing engineers as well. The EASY team have gained considerable experience on how to use Web technology to provide pedagogical material as well as how to develop simultaneously for Web and CD-ROM applications..

Some ideas for future work are already taking shape:

- Add a sub-system which could be used to verify the user's knowledge level; for example to show a slide and ask the user to find the cause of failure, or to answer simple multiple choice questions and, if the answer is wrong, provide pointers to reference slides in the database.

- Provide guided tour through the main parts of the material to assist novices. An example of such a guided tour is in the appendix to this paper.
- Integrate EASY with other components of an on-line knowledge base related to earthquake engineering. These include theoretical foundations, computational examples and software, regulations and experiences all linked together using hypermedia technology.

The Web version of EASY is available free of charge at http://www.ikpir.fgg.uni-lj.si/easy/.

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The authors would also like to editor-in-charge and the ITcon reviewers for helpful and constructive comments.

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APPENDIX: SAMPLE SESSION WITH EASY

The sample session is available electronically at http://www.ikpir.fagg.uni-lj.si/easy/tour.htm. Part of it is shown below.