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Information Systems Application on Reinforced Concrete Beams Subjected to Shear and Torsion

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Abstract: **Information technology plays a key role in every aspect of structural engineering field. It has been implemented for a long time in all design and construction stages. One of the main objectives of using information technology is saving time and cost. Most of its application was focused on analysis, design, drawings and visual presentations. However, very little research was focused on managing the huge amount of related available information. In this study, a platform for combining both analytical calculations and knowledge management for the design of reinforced concrete elements is investigated. Considering that reinforced concrete design is governed by widely available specifications, the recent developments in information technology should be utilized to facilitate an easier and more reliable design technique. This study investigates the possibility of building a structured database for design limitations, specifications and related information to support designers. An application of the suggested system is introduced for the design of reinforced concrete beams subjected to shear and torsion. In addition, information technology with graphical interface is combined with the aforementioned technique to present a hybrid platform.**

Keywords: Concrete, Beams, Shear and torsion, Information technology

I. Introduction

In the past, information was limited and the human beings culture was narrow. In the twentieth century the pace of science and technology accelerated. This increase created the demand for greater volumes of data to be presented in many forms more quickly and more accurately. Computer performance and capabilities increased rapidly as well. Over the last decade and after the information technology revolution, the amount of research and data resources used in design became too huge to assimilation by the design engineer. The problem is thus, how to enable the engineer to get the needed information about specific field as easily as possible. How to enable the engineer to get any design code limitations applied to the design without searching manually many references wasting his time and effort. Finally, how to enable the engineer to compare between results and limitations of different design codes. Shortly, the problem is how to make the way of getting information easier without losing accuracy. Challenges exist in collecting, sorting, saving and retrieving this amount of data in a simple form.

Previous research in this area is limited especially for reinforced concrete design. In most cases, development of new approaches to facilitate design was left for industry rather than researchers. While industry focus on commercial issues related to customer satisfaction, research is directed to developing techniques not only supports designers but also contribute to more understanding of the effect of different parameters. Yosry et Al [1-2] introduced an attempt to combine both information handling as well as mathematical calculations in a unique graphical interface. The suggested system was applied on the design of reinforced concrete columns.

In this study, a knowledge based system for the design of reinforced concrete beams subjected to shear and torsion is suggested as a part of an integrated analysis – design information project for managing the design of reinforced concrete structures. The system extends the use of computers for the design of reinforced concrete structures to the area of information allocation in a simplified procedure. The algorithms used for the system are employed to simply allocate the necessary information for design and to complete the design process at the same time. The algorithms reflect the different objectives of the system such as searching for information, simplifying design and the possibility of use for educational purposes. This study presents the principles of the system, explains the structure of its knowledge base and discusses various implementation aspects.

For many years the four components of a technical information system have been built using one tool, the high-level programming language. A language such as Visual Basic is used to declare appropriate file structures, encode the necessary operations on files, embed the operations in control structures and manage the terminal screen for user entry and retrieval. However, over the last twenty years there has been a tendency to attempt to separate out each component and provide a separate tool for each job. For instance, database management systems have been developed primarily as a mean of enhancing program-data independence. Knowledge systems can be seen as an attempt to further separate control mechanisms (interface engines) from processes (rules) and data (facts). With the development of direct manipulation interfaces, the tendency has been to supply GUI (Graphic User Interface) tools for the production of specialized interfaces. Many modern analysis and design methods, particularly those under the umbrella of object-oriented propose the separate development of the four components described above.

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II. Information Systems Application on RC Beams

The first aim of developing this information systems platform on reinforced concrete beams subjected to shear and/or torsion (ISAbeam) is to simplify the issue of looking for information on the design of RC beams using recent developments in information systems. Searching for information in codes and documents using manual approach found to be time consuming and in most cases rely on the engineer previous experience. Applying information systems techniques in this regard overcome these drawbacks. Simplicity, time saving, accuracy and completeness are the main characteristics of this application. The suggested system has been developed in Visual Basic 6, which is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model.

The platform provides the user with a database for shear and torsion related information. In addition, it performs design for shear and torsion and allows complete outputs including bar numbers, sizes and spacing. It offers a great deal of flexibility by allowing the user to modify the reinforcement configuration proposed. Three code limitations are included: Egyptian code of practices for the design of RC structures, American Concrete Institute and Canadian Standards Association. The designer can use any of them in designing sections subjected to shear and/or torsion. The application is then used in comparing the results of designing sections by different codes.

In addition, another aim is to demonstrate how the principles and the methods of design of RC beams can be incorporated into a simple, easy to use platform. The components of this platform as shown in Figure (1) are Visual Basic Program, computer, data entry from architectural and structural drawings, design codes, research data and the structural engineer who interacts between all these components.

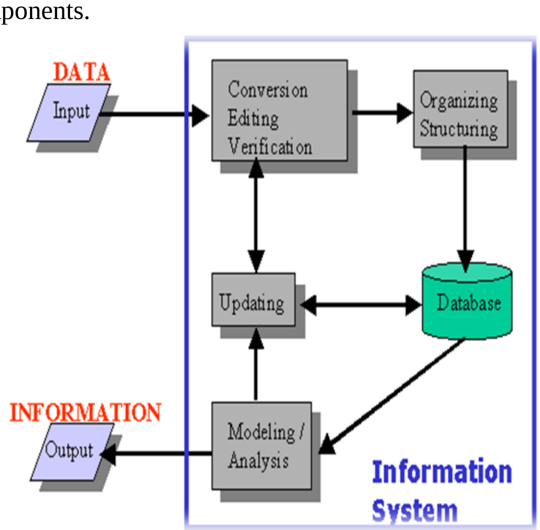

Figure 1. Information system mechanism

The ISAbeam platform is an integrated system applying information systems techniques and consists of interrelated components. The platform interface is considered user-friendly as it makes user familiar with the program in a short period of time. Furthermore, this interface can warrant the accuracy of the input data and output results by checking them according to the used design code. This well-designed user interface can reduce end user training time and results in a higher level of user satisfaction. The interface includes the menu system, the data entry forms, the results forms, and messages system. So, the platform is handled with main menu and many sub-menus. Each sub-menu contains a list of related options or data entry, which provides an access to one of the application functions. An easy data entry features is incorporated with free format input and error-detecting and correction facilities. The platform output is presented in a clear unambiguous form, possibly using graphics to enhance the presentation of the output.

The main window of the program contains a menu bar and toolbar of picture buttons (icons). The complete functionality of ISAbeam program is available via the menu bar and the toolbar serves as iconic shorthand to access the menu bar functionality. As shown in Figure (2), the main menu consists of three frames: the first frame is “Code Design” this frame consists of the three codes in the program, Egyptian code of practices for the Design of RC Structures, American Concrete Institute and Canadian Standards Association. The second frame is “search” which allows the user to search for information either in code requirements or related research database. The third one is “Section” which presents the types of sections, which can be designed by the program. The program can design four cross section types: rectangular, box, T- and I-section.

Figure 2. Input form

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By choosing the required design code and section type, the detailed input screen shown in Figure 3 appears. The input data form consists of four frames, picture box and two command buttons. The first frame is "material properties" which allows the user to input the material properties for concrete and reinforcement including concrete compression stress and yield stress of different types of reinforcement. The second frame is stress and yield stress of different types of reinforcement. The second frame is "Applied Forces" which permits the user to display factored loads. The third frame is "section properties" including concrete dimensions and reinforcement details. The fourth frame consists of definitions of symbols in the first frame of material properties. The picture box shows the section shape and symbols used. The first command button is "Run", by clicking this button the input data will be processed. After the user input the data and run the program, the results will appear as shown in Figure (4). Results screen includes the required reinforcement for the given section to resist the applied forces. A graphical detail of section reinforcement is provided including bar number, size and spacing. Also it allows the user to change the input parameters by going back to het input screen and change reinforcement bars, spacing or numbers to get more economic section.

The output screen consists of three or four frames which depend on the type of reinforcement used in the chosen design code. The first one is "Stirrups" containing the area steel of the reinforced stirrups, the required spacing and bar sizes. The second frame is "Bent Bars" which is found on the Egyptian code of practice. The third frame is "Longitudinal reinforcement" which contains the required bar numbers and sizes. The fourth frame is "Section Adequacy" which presents the section adequacy and if the section needs to be increased. It contains also a picture box showing a graphical representation of the section with dimensions and reinforcement.

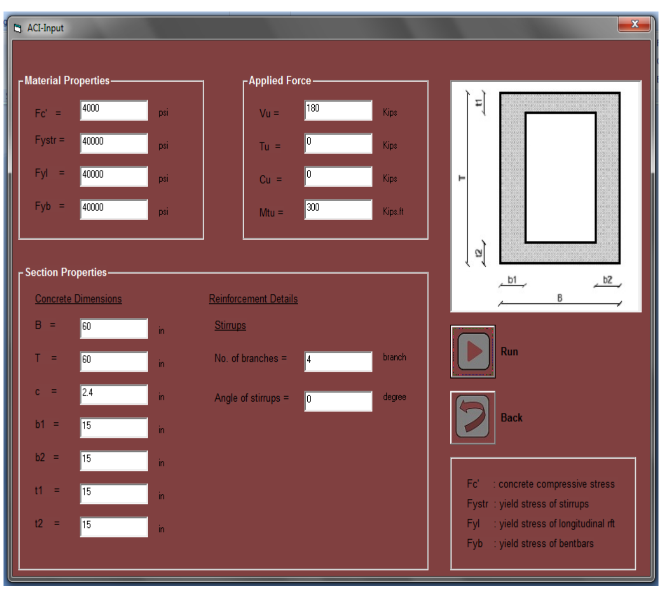

Figure 3. Input data for box section

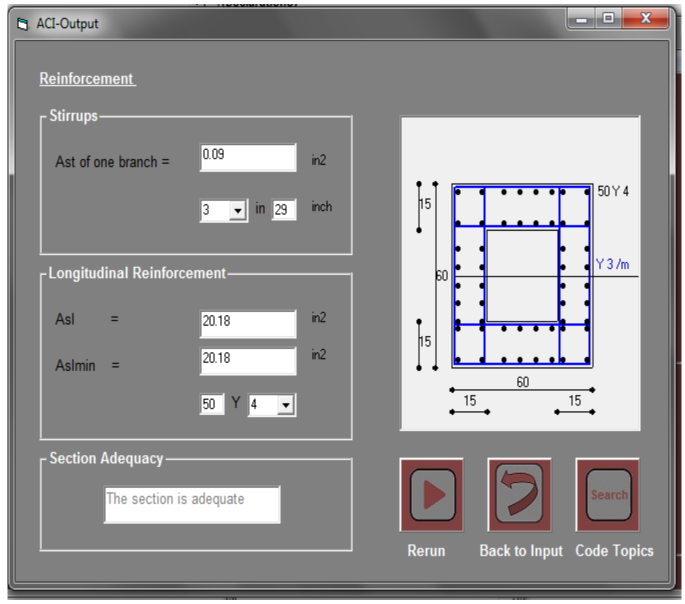

Figure 4. Output data for box section

It also contains three command buttons: "Return" button allowing the user to change reinforcement configuration such as the arrangement, bar size and spacing. The second button is "Back to input" allowing the user to go back to the input data frame. The third one is "Search" allowing the user to search for code limitations and related information in literature.

III. Searching for Information

The main purpose of developing this application is to make the process of searching for any design code information much easier by applying information systems techniques. There are different methods of searching; search by design topic and search by keyword.

Figure 5 shows the main screen for searching by design topic. It allows the user to have an overall view of the design code and to get the relevant code limitations. The figure shows an example of searching by topic in the Canadian standards. By clicking on any link, such as "11.3.8 Maximum spacing of transverse reinforcement" another frame shall appear as shown in Figure 6.

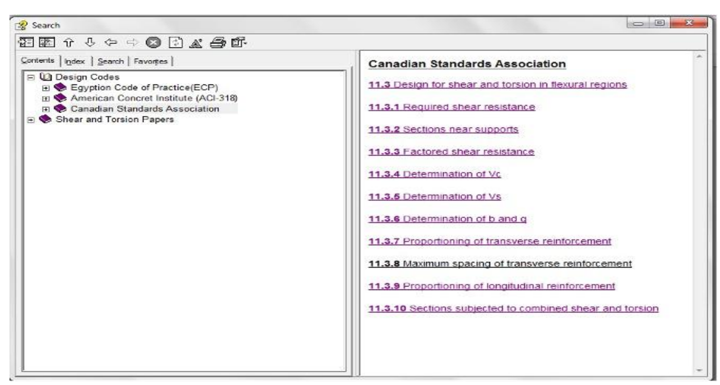

Figure 5. Searching by design topic

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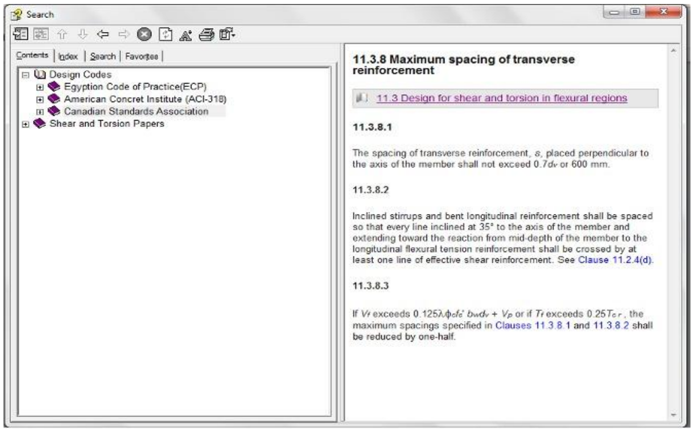

Figure 6. Topic detail of search by design code

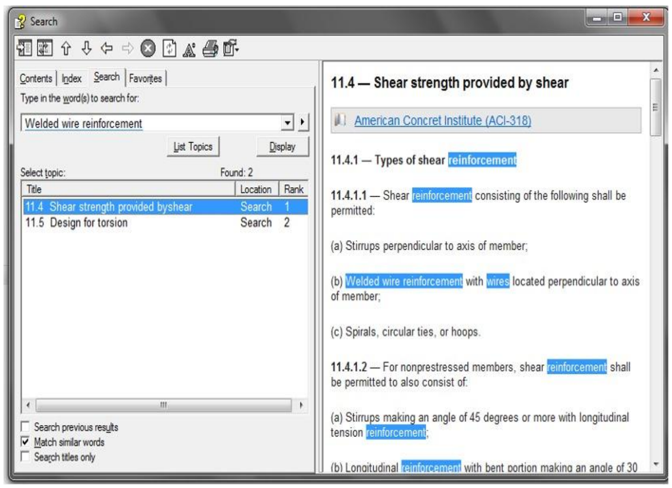

Figure 7. Search by keyword

The main search engine is provided through searching by keywords. For example, searching for keyword “reinforcement”, it will search for this word in all the design code and it will be highlighted to be more obvious for the user, as in Figure 7.The search engine allows another flexibility to save time and effort by adding favorite content of the design code topic. This is simply done be clicking on the tap favorites and click add.

In many cases, the need for searching information in relevant research exists specially for non-traditional structures. The ISAbeam platform presented a unique search engine to search the literature database. Previous research related to shear and torsion in beams is classified according to many parameters to facilitate this purpose. The classification parameters include, but not limited to, title, subject, author, publisher, date, etc. For example, searching by title is shown in Figure (8). Clicking on the required title link, another frame will show up containing the summary and conclusions of the paper.

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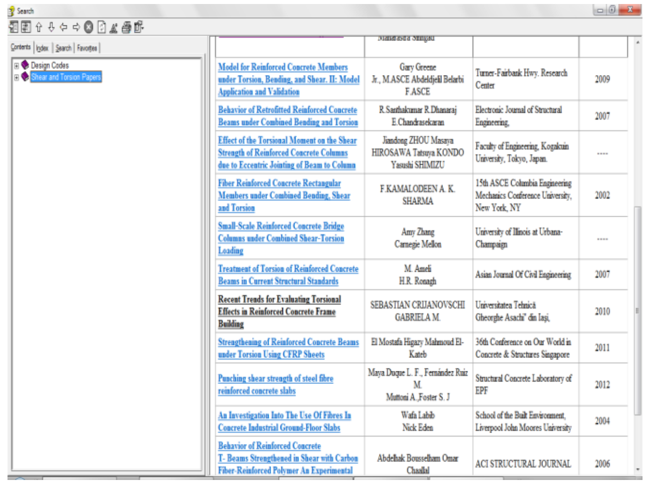

Figure 8. Searching research database for related topics

Another effective mean of searching for information in the platform is to search by keyword. Searching for a word in the literature and highlighting the word to be clearer for the user is considered an easier approach for searching. In addition, there are three options of searching by keyword: searching previous results, match similar words and searching titles only. This approach allows the user flexibility and simplicity in searching for any information.

IV. Further Developments

The suggested approach is considered as a direct application of the information technology revolution to the design of reinforced concrete structures. Further developments to the system can be made in two directions; a) To widen and expand the knowledge base of the suggested system to include other information sources such as text books and periodicals. b) to extend the platform to include other elements of structures subjected to different types of straining actions. In addition, expanded research on search engines to improve the quality of retrieving information should be studied.

Evaluation of the advantages of applying information technologies on RC design is still not standardized. In other words there is no well known scale to measure the advantages of saving time and effort when using a certain approach. This was one of the main difficulties that was encountered during this study and recommendations are made to devote separate studies for this issue.

V. Conclusions

This study presented a structured database for design limitations, specifications and related information to support structural designers. The research is limited at this stage to the design of beams subjected to shear and torsion. Advanced search engines is customized and utilized to provide structural engineers with the required data. The main advantage of the ISAbeam platform is accessing design codes topics and related

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research easily with many approaches for searching for information. In addition, the platform includes the design of reinforced concrete beams subjected to shear and torsion using advanced graphical interface. Applying the suggested platform has been proved to be effective, accurate and saves time and effort.

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Conflicts of Interest: The authors declare that there is no conflict of interest.

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