JAVA and VRML based Interactive Reinforced Concrete Design Course Studio

Mohammed E. Haque, Amarneethi Vamadevan, Selvan Duraimurugar, and Yoganand Gandlur

Western Michigan University, Michigan 49008

Abstract

The teaching of reinforced concrete design for undergraduate students presents a major challenge to the civil engineering instructors because of the need to instill creative and innovative attitudes within a discipline of physical behavior. Conventional instructor-based approaches to teaching do not lend themselves to open-ended problem solving in reinforced concrete design due to some identifiable difficulties. The main difficulties are lack of teaching aid to clearly explain the complexities of the various structural design principles, inability of individualized tutoring and inadequate or non-existent of visual learning environment, and inability to inspire students to interactively study structural design concepts. The teaching methodology presented in this paper is based on presenting students with an individualized, interactive and guided learning environment. The main elements of this approach are: a means of assimilating the students interactive learning knowledge and behavior (user model), representation of the instructor's guidance and assessment knowledge (tutor model), utilization of motivational techniques such as multimedia, animation (visual model) and navigation of designed model (VRML model). Several principles are taken into consideration when designing such learning environment. These include the structuring of the courseware material with respect to the content, presentation, modularity, identifying and utilizing the teaching strategies involved in the learning process. The approach adopted in this research is that of intelligent interactive learning environment, which is developed, using VRML and Java programming languages. This contains basic interrelated definitions (concepts), various diagrams of structural behaviors such as stress and strain diagrams, procedures and VRML using Java applets for dynamic structural design. Although the presented approach is being applied to reinforced concrete design, it employs a generic architecture, which is discipline independent and may be adapted to any other similar domain which will certainly promote and enhance students' understanding.

I. Introduction

Construction related reinforced concrete design education demands the accumulation of a large amount of complex technical knowledge from the students. Currently this is largely effected through a traditional lecture format with the main principle being that of information transfer. Clearly, whatever knowledge "traditional" teaching methods may have imparted, they have frequently failed to produce design understanding[1]. There is a range of problems in this method of instruction. Some of the problems experienced and cited are as follows:

- Lack of teaching aid to vividly explain the intricacies of the various reinforced concrete structural design principles.
- Lack of time to teach whole detailed structural design.
- Non-existent or inadequate visual learning environment.
- Inability of individualized tutoring due to increasing student numbers.
- Inability to excite students to study structural design concepts interactively.
- Difficulty in teaching students to make connection between theory and application of reinforced concrete design.
- Inability to address students who do not participate or view the traditional teaching as a chore.

Acknowledging the above problems, one of the methods of solving this is to use simple models which demonstrate basic structural design concepts which can be used to enhance the students understanding[2]. But general relevance of their lessons may not be always understood in teaching reinforced concrete design since when the required knowledge base increases, the ability of the student to effectively absorb the relevant information is reduced[1]. There is, therefore, an identifiable need to establish alternative sources of information and modes of learning for students.

It is in response to this need that the computer based interactive prototype courseware model was conceived. As with other interactive computer aided learning,[3,4,5] this allows the students to proceed at their own pace, motivated by a curiosity about "what happens" interactivity and " the need to know" the design principles. This can also simulate a virtual design class and each student can participate and learn the difficulties of various reinforced concrete design principles. In addition, this prototype learning tool can be very valuable in enhancing learning, evaluating learning outcomes and solving most of the problems outlined above. The main objective of this research was to implement a computer aided system prototype learning studio for reinforced concrete design. This was achieved by providing a tailored educational courseware suited to the open ended nature of design problems.

II. Proposed Approach

The principal element of the proposed approach is to assimilate the students' learning knowledge and behavior by providing individualized guidance and assessment tool. This includes-

- Structuring of the reinforced concrete design course material with respect to content.
- Presenting, modularizing and tailoring the presentation according to each student's level of competence.
- Identifying and utilizing the teaching strategies involved in the learning process. This involves the use of multimedia to enhance learning experience leading to increased motivation and better visualization and more learner participation.
- Accommodating a flexible interactive reinforced concrete design and step by step navigation.

The proposed reinforced concrete design course studio consists of four individual models as follows:

1. Tutor Model: For teaching and learning of structural design concepts by providing an individualized guided and interactive personalized tailored course materials.
2. Visual Model: For providing the students with a variety of scaffolding visual techniques, such as digital images, annotated version of manipulated images, etc. to built up their interest in the domain topics.
3. User Java Model: For increasing student's appreciation and utilization of basic engineering skills involved in the simple design process.
4. VRML (Virtual Reality Modeling Language) Model: For designing simple structure, such as a simple beam and navigating in a three-dimensional space with user interactions.

The development methodology for each the individual model is described in the following sections. Figure 1 shows the first screen of the proposed design studio.

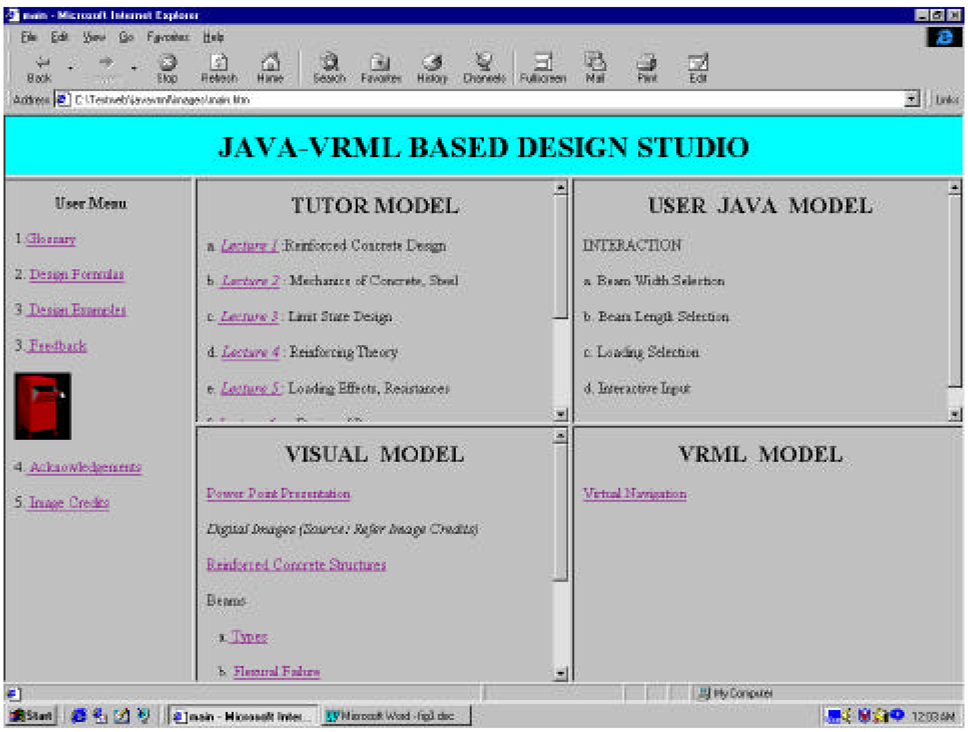


Figure 1. First Screen of the Design Studio

1. Tutor Model

The tutor model adopted differs from most other attempts of teaching reinforced concrete design. With expert teaching experience indicate[6], at a gross level, students can be partitioned in to two groups.

Group 1: Students who learned basic mechanics before and have forgotten some of the procedural skills.
Group 2: Students who have never successfully learned the material before.

Although this is an over-generalization, as students will retain fragments of what they have learned previously, but it illustrates the wide variation in incoming student knowledge. The lecture topics include the areas covered by most of the textbooks used by the undergraduate civil/construction major.

This tutor model will help group-1 students to remember topics in the mechanics and design curriculum they may have forgotten. This model starts by showing individualized lecture topics (Figure 2). Since these students do fairly well in developmental mechanics and design courses, and the success of the tutor can be measured by how quickly it enables them to complete the curriculum.

For group-2 students, who have never successfully learned this material before, presentation is more difficult. Traditional instruction enables only a few students from this group to pass the course. The success for this group of students should not simply be measured by getting them through the material (i.e. time should not be the primary factor, which can be achieved through web teaching). The instructional strategies for the tutor model for the second group of students include “concrete design principles”, with each technical term defined in glossary. By selecting visual representations within tutor model (which is also part of visual model) these students are allowed to explore the connection between real world objects and design theories.

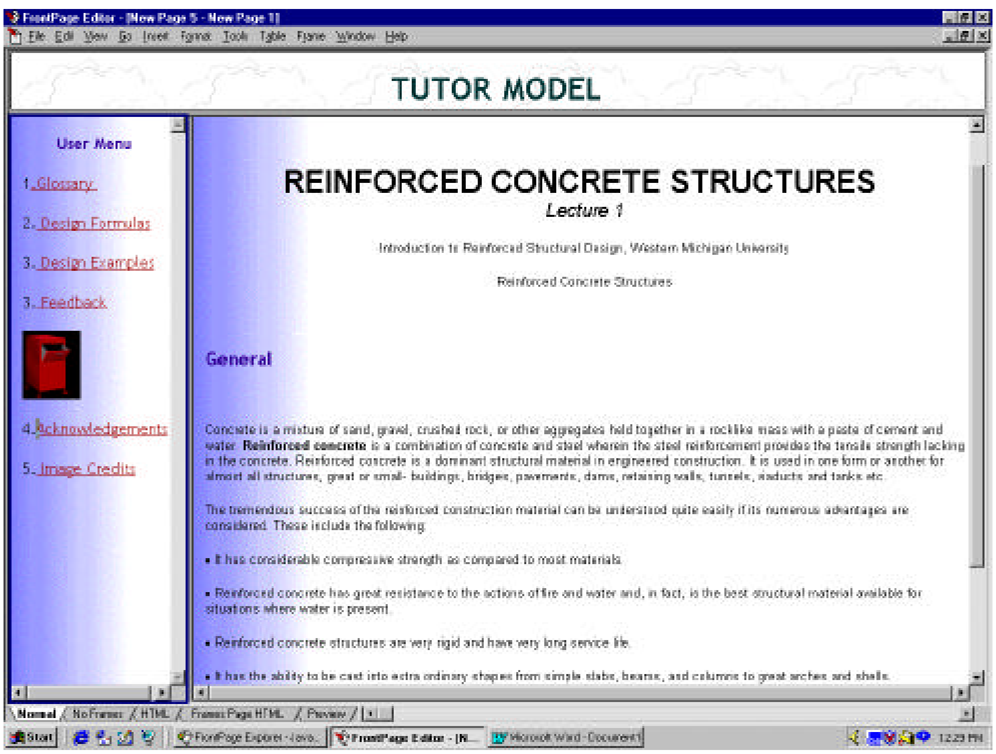


Figure 2. Sample Screen of the Tutor Model

2. Visual Model

In order to aid students in attaining procedural skills, this model provides a variety of scaffolding visual techniques. Each design topic is composed of various sub skills, which themselves are topics. Before a topic is presented in its abstract form, students are shown a concrete representation of the problem. For example, when demonstrating the mode of reinforced concrete failure behavior, this will show appropriate digital manipulated images with power point subject presentation. The manipulated images are powerful tools for teaching design courses. If a student has difficulty with a complex problem, these annotated version of manipulated images explicitly show the foundations of the design mechanics by breaking up problems into their natural components, and showing the connectivity between those components. For example, Figure 3 shows the arrow notation used by the model to explain the shear failure modes in a reinforced concrete structures.

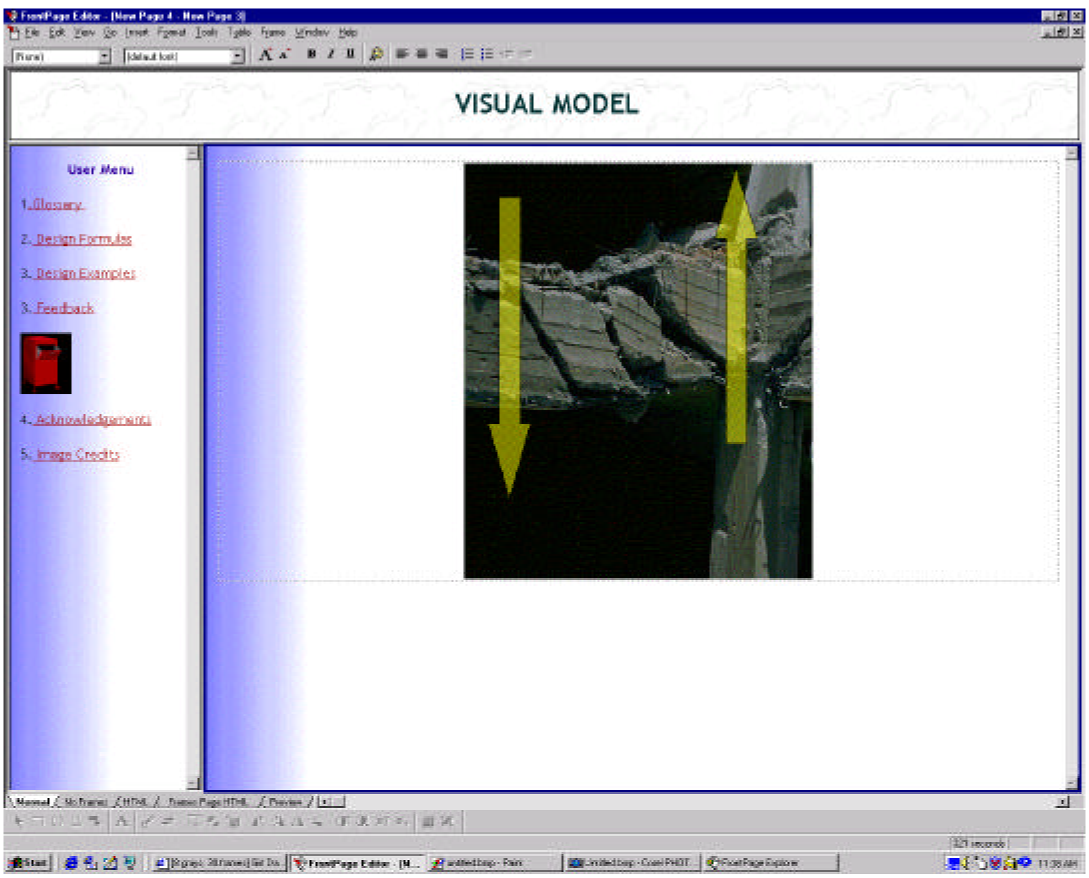


Figure 3. Sample Screen of the Visual Model

3. User Java Model

Design based user are considered potentially powerful design tools by their ability to generate sets of designs adhering to user specified constraints. The conceptual principle adopted here is to reinforce students understanding of the behavior of concrete beams with the aid of simple structure such as simply supported beam with a point load on center of the beam. As the load is increased moment, deflection and shear forces increase. Figure 4 shows Java model screen where user is allowed to define the load and beam geometry values. Next the user can interact with the beam by varying the structural load using up and down arrow keys. Once the designed critical moment values are exceeded, animation sound of concrete cracking with message box and calculated stresses are displayed. Results such as beam deflection, bending moment and shear force values are also shown on each user interaction with loads. This critique feature is used to confirm user understanding of design loading. For running this model on a PC needs Java plug-ins, which are freely available in many Websites.

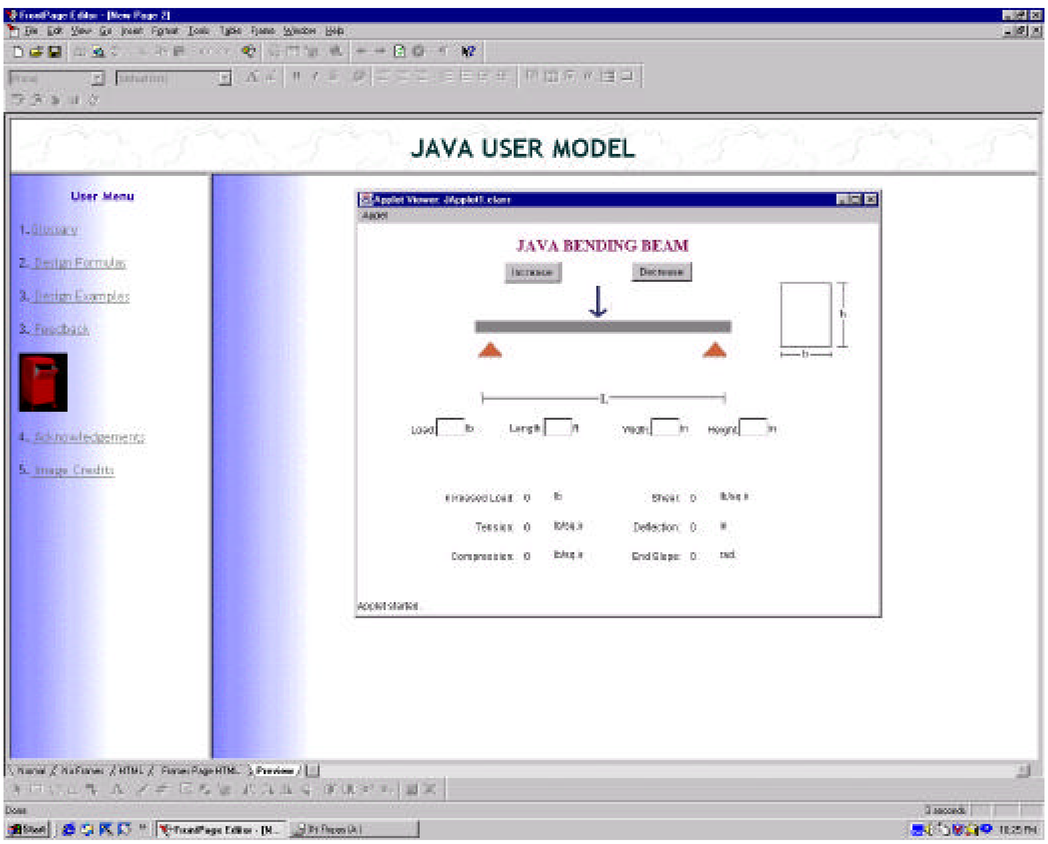
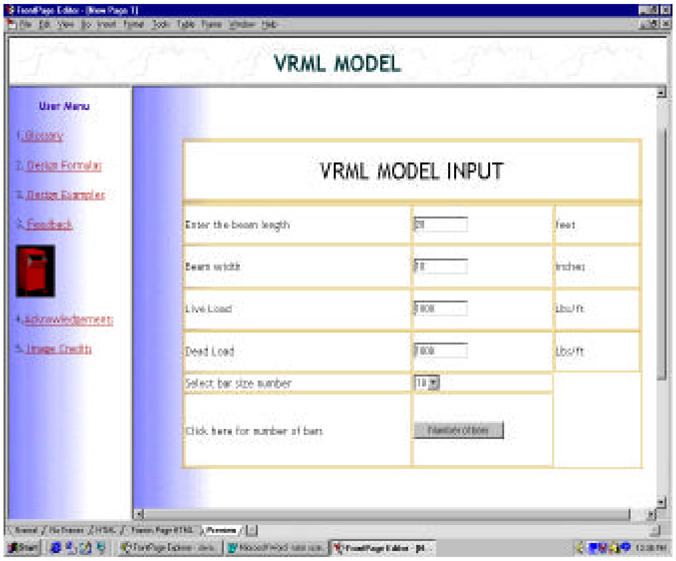


Figure 4. Sample Screen of the User Java Model

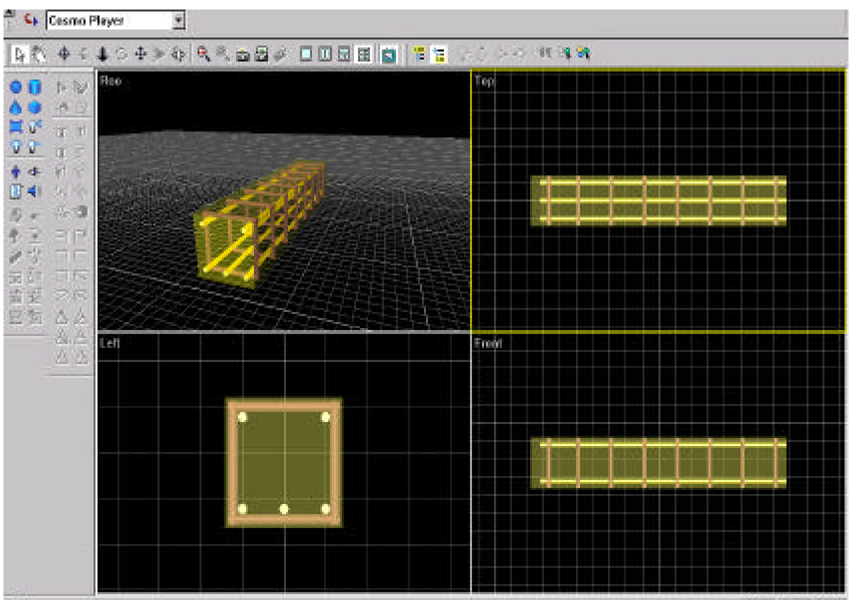
4. VRML Model

The primary capabilities of VRML Model include calculating number of reinforcement for simple structures such as beam, generating the position of this reinforcement and plotting the 3-

D navigational structure. Inputting beam dimensions and load information (Figure 5a) in a JavaScript based program, this generates the information in a VRML world file for view from any direction/angle and walk through the designed structure. It requires a web browser for interpreting standard html and JavaScript, such as Netscape or Internet Explorer, and a VRML browser such as Cosmo Player (Figure 5b).



(a)



(b)

Figure 5(a) Beam Design Data Input Screen; (b) VRML World File of the Designed Beam

In practice VRML is a text based language, where objects are defined as geometries in this modeling language. Figure 6a describes the VRML 2.0 programming code for the beam dimensional features with reinforcement. Java, as a scripting language, it offers programming tools to a much wider audience because of its ease of syntax, specially built in functionality, and minimal requirement for beam reinforcement creation. VRML plug-ins are responsible for interpreting and displaying the three dimensional data. In addition, embedded JavaScript was used for calculation of beam reinforcement. Figure 6b shows a sample Java Code used to the display the initial screen.

```
#VRML V2.0 utf8
DEF Main Transform {
    translation 0 0 0
    rotation 5 3 2 1
    scale 1 1 1
        children [
            Shape {
          appearance Appearance {
            texture ImageTexture {
              url "avi.jpg"
              repeatS FALSE
              repeatT TRUE
                      }
          material Material {
              diffuseColor 0.8 0.2 0.2
              shininess .99
                      }
                      }
          geometry Box {
                  size 2 2 2
                    }
        },
    DEF TOUCH TouchSensor {      }
    ]
    }
```

Figure 6(a) Sample VRML 2.0 Code for Beam Dimensional Features

```
*/
package java.applet;
import java.awt.*;
import java.awt.image.ColorModel;
import java.net.URL;
import java.net.MalformedURLException;
import java.util.Hashtable;
import java.util.Locale;
/**
 * An applet is a small program that is
intended not to be run on
 * its own, but rather to be embedded
inside another application.
 * <p>
 * The <code>Applet</code> class must
be the superclass of any
 * applet that is to be embedded in a Web
page or viewed by the Java
 * Applet Viewer. The
<code>Applet</code> class provides a
standard
 * interface between applets and their
environment.
```

Figure 6(b) Sample Java Code describes the initial display screen.

III. Evaluation

Before finalizing the implementation, the design studio courseware must be appraised by the students along with their feedback for improvement. The appraisal is intended to investigate a number of key issues regarding the value of the courseware as a computer aided learning for teaching structural reinforced concrete design, its usefulness, and the ease of use. During the tutorial sessions (tutor model) the students are encouraged to simply explore the program, as they feel appropriate, with the aim of satisfying prescribed learning objectives. These objectives take the form of self-assessed questions posted at the outset of the tutorial session. Thus, rather than simply wandering aimlessly through the matrix of information forming the media base of design education program, the students should be allowed to search for specific information (user model) interactively and coming into contact with other relevant design concepts in the process. During the lecture sessions, the design studio model will be used as a source of illustrations to enhance the traditional lecture scenario and replaced with more usual visual aid material (Visual model).

IV. Concluding Remarks

Multimedia based design studio courseware can be valuable aids not only in teaching design in the class room but also effective self directed tools for open learning. By adopting a model of experiential learning in the higher education sector and encouraging remote and direct interactivity with multimedia aided deign courseware to enhance other existing forms of teaching and learning, positive results can indeed be achieved. Although multimedia is generally considered as an individual pursuit, authors' study suggest that its use in classes with a large audience can be accommodated, provided that it is linked directly to the achievement of a specific group of learning objectives. In this sense the proposed design studio model is seen to act as a navigator rather than as an oracle or source of knowledge. One of the true benefits of the proposed courseware model is its flexibility of usage in design education. The informal feedback from students has been positive in that they see it as being a useful self-learning mechanism. Although the presented approach is being applied to reinforced concrete design, it employs a generic architecture, which is discipline independent and may be adapted to any other similar domain which will certainly promote and enhance students' understanding.

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MOHAMMED E. HAQUE

Mohammed E. Haque is an Assistant Professor and Graduate Program Advisor of the Department of Construction Engineering and Management at Western Michigan University. He has over fifteen years of professional experience in analysis, design, and investigation of building, bridges and tunnel structural projects of various city and state governments and private sectors. Dr. Haque is a registered Professional Engineer in the states of New York (1990), Pennsylvania (1991) and Michigan (1998), and members of ASCE, ACI and technical committee members of ACI Committees 342 Evaluation of Concrete Bridges and Bridge Elements and 345 Concrete Bridge Construction, Maintenance and Repair. Dr. Haque received a BSCE in 1982 from Bangladesh University of Engineering and

Technology, a MSCE in 1986 and Ph.D. in Civil/Structural Engineering in 1995 from New Jersey Institute of Technology.

AMARNEETHI VAMADEVAN
Amarneethi Vamadevan is currently a graduate student in Construction Engineering and Management at Western Michigan University. He received his BSCE from University of Moratuwa, Sri Lanka in 1996.

SELVAN DURAIMURUGAR
Selvan Duraimurugar is currently a graduate student in Computer Science at Western Michigan University. He received his BE in Electronics and Communication from University of Madras, India in 1997.

YOGANAND GANDLUR
Yoganand Gandlur is currently a graduate student in Computer Science at Western Michigan University. He received his BE in Mechanical Engineering from Bharathiyar University of Coimbatore, India in 1998.