A Web Oriented Reinforced Concrete Design Course

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Introduction

In the last decades, there has been a worldwide revolution on the concepts and techniques of education. New tools have been developed which primary rule is to aid the student's learning process. The basic idea behind this revolution is not discard the traditional classroom teaching method, but to create complementary alternatives, which will aid teachers enhance the student's performance. In this scenario, the use of computers has become an attractive alternative for the development of learning environments. The high interactive interfaces, which computers have through their multimedia resources, graphics, artificial intelligence and virtual realities, will certainly stimulate the student's learning process. The advent of the Internet has pushed the production of computer teaching aids even further. Web based courses provide not only flexibility to students learn according to their time frame and pace but also the possibility of several students being connected simultaneously. The user-friendly interface provided by the Internet browser is another feature, which must not be forgotten.

In the last 80 years, concrete has been the most used construction material worldwide [1]. Consequently reinforced concrete is an important subject of any engineering and architectural major student. A constant and important problem faced by students in a reinforced concrete design course is their difficulty in visualize the main aspects of the behavior, design and detailing of concrete structures. Over the years, the traditional teaching methods have shown expressively this fact, which, in turn, has made professors try different approaches to overcome the problem.

This paper presents the implementation of a Web oriented teaching aid for reinforced concrete design courses. Applets are being developed for the design of reinforced concrete beams under bending and shear. They will be inserted into IdeaGateway, a teaching-learning virtual environment at the Federal University of Minas Gerais. The environment implementation model is based on the client/server architecture. The Java platform has been chosen for its features such as portability, simple maintenance, object oriented programming, and the large number of auxiliary libraries. The applets allow the visualization not only of the design process but also of the detailing of the reinforced concrete beams. With this visualization, in real time, the students will be able to understand much better the basic concepts on the behavior and detailing of reinforced concrete elements that sometimes are difficult to show on the blackboard.

Basic Ideas of the Developed Virtual Environment

The advanced technologies being developed as well as the needs of the job market have placed new demands on educational methods. The traditional transfer of knowledge from teachers to students must change to a methodology in which the students will learn to seek for the information by themselves independently. Students will be no longer mere spectators in a classroom [2]. This is the only way they will be able to enhance and consolidate their knowledge to cope with the fast changing world. A virtual teaching-learning environment seems to fit perfectly these demands.

The developed virtual environment was built under the hypermedia project paradigm. This way apprentices will have autonomy, which, through their findings, will enable them, build concepts and knowledge from their own searching procedures. It is therefore a heuristic type application [3]. In addition students will have access to basic concepts in reinforced concrete, glossary for clarifying technical terms, and visualizations of the design and the detailing of reinforced concrete elements.

To achieve the above-mentioned characteristics, the following pedagogical aspects were considered during the development of the virtual reinforced concrete teaching-learning environment:

- information on the application procedures is always available to the users;
- subjects are presented in a relevant and attractive way in order to stimulate the students' interest;
- constant contextualization of the subject being explained;
- availability of questions to the users and individual feedback which main purpose is to aid students understand the subject and build strategies to solve problems [4];
- the apprentice's path in any activity includes the method, the didactic technique, the multimedia resources and the script, considering that every user is an individual with multiple intelligences [5].

With these premises and hypotheses, a Web based teaching-learning environment, called IDEA Gateway, is being built. The IDEA Gateway (Figure 1) is a collaborative virtual teaching portal centered on the apprentice, whose main objective is to aggregate the existing digital medias to assist students' different learning styles. The portal is composed of several modules, which can be seen in Figure 2. In each module a certain subject is presented with contextualized information and examples, which will enhance the understanding of the matter being taught.

The IDEAStudio module contains the main subjects of the structural engineering area. Its logical project is composed of four complementary environments. Each environment has a pedagogical purpose and consequently will have an appropriate interface. At this research stage, these environments, which are easily linked to each other, are being called:

- visual tutor environment;
- visual animated environment;
- environment of visual 3D navigation; and
- environment of visual interactive models.

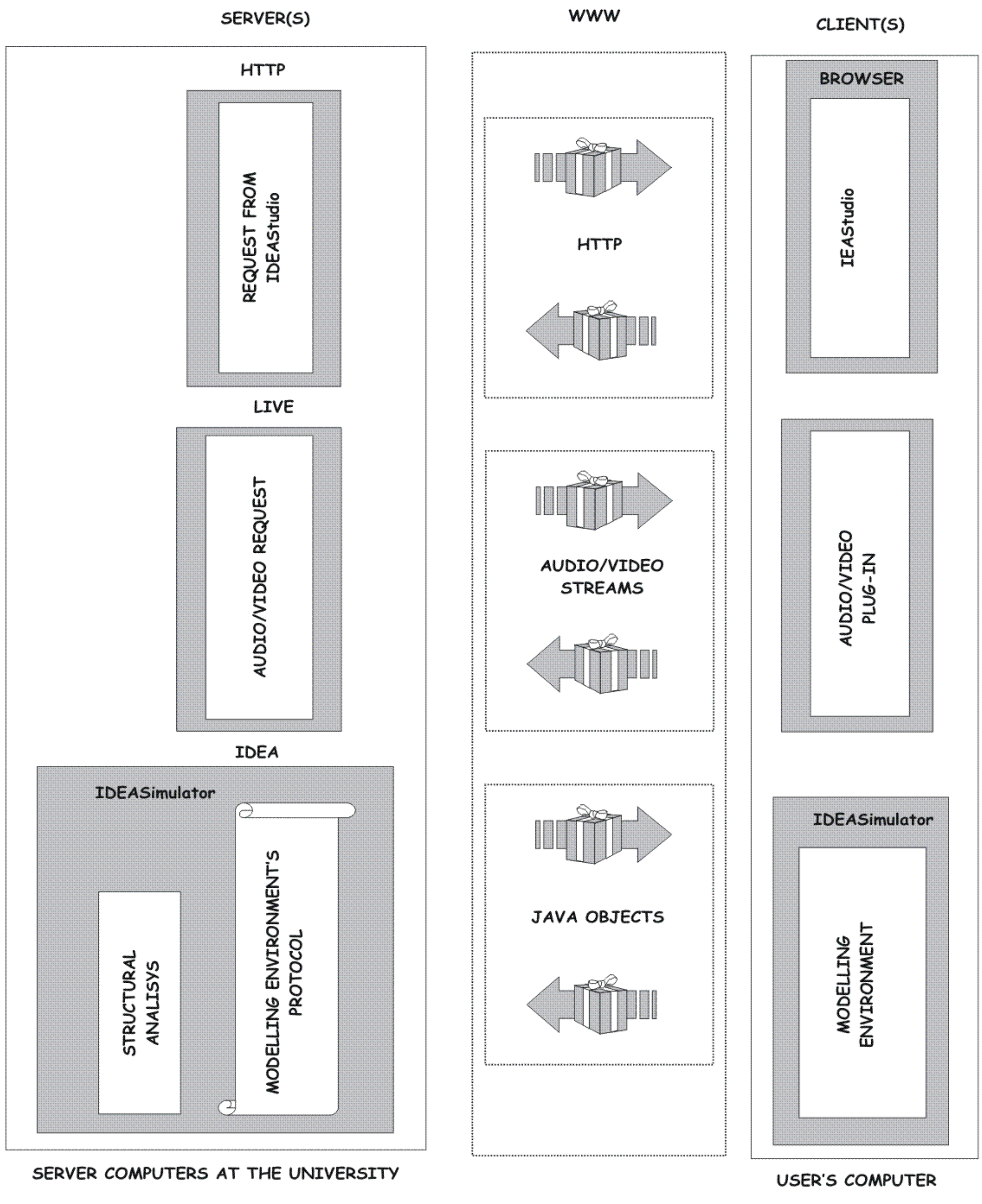

Figure 1 – IdeaGateway web cluster architecture relationship (2004 version).

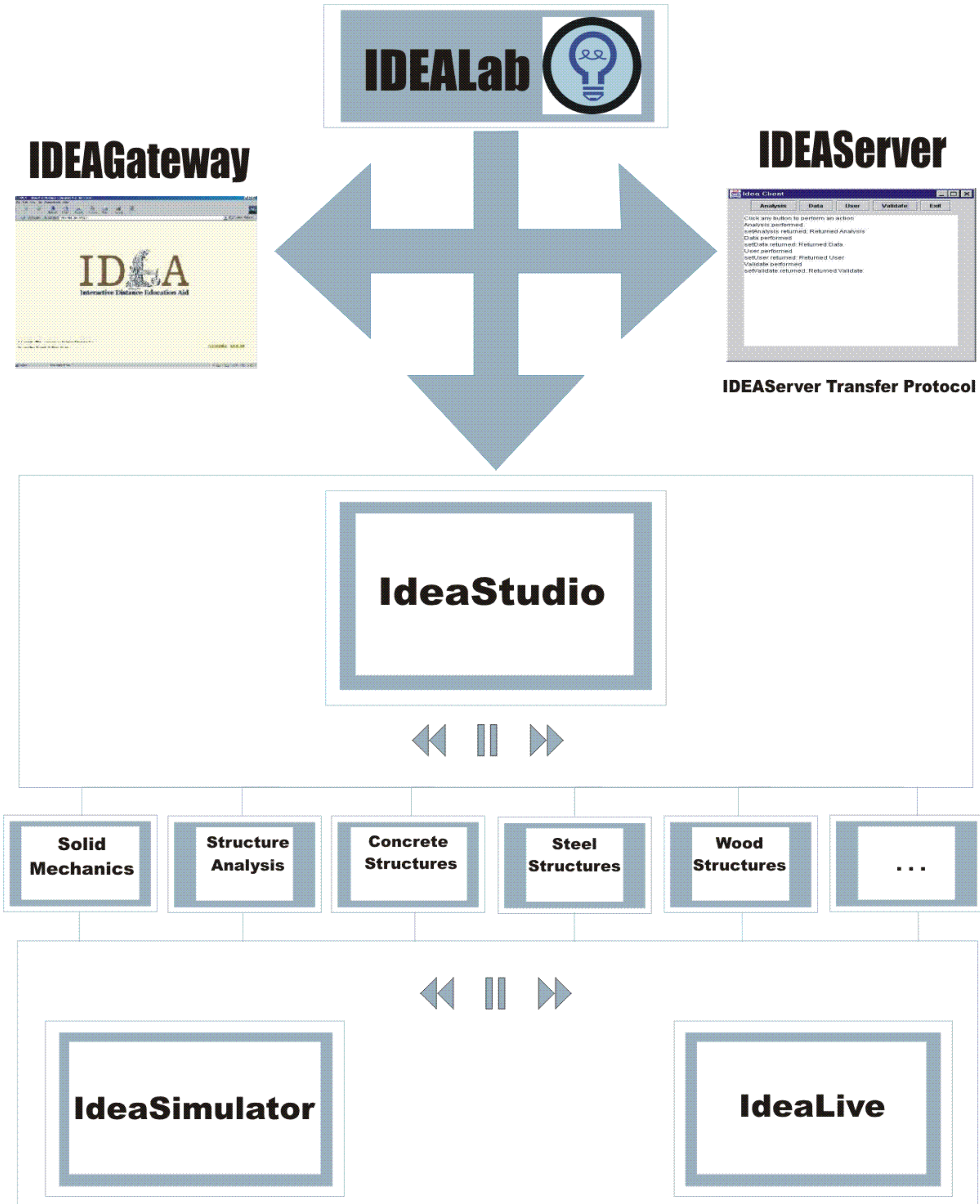

Figure 2 – IdeaGateway design modules (2004 version).

In the visual tutor environment, the basic concepts of each structural engineering subject matter being taught are presented. Through contextualized examples, the resources, placed at the interfaces, will help apprentices build their knowledge, from which they will be able to explore by themselves. Images of well known locally or worldwide structures, allocated at the visual animated environment, will allow students connect between the concepts being taught and their actual application. Apprentices can visualize tri-dimensional objects through different angles at the environment of 3D navigation. Finally, the visual interactive models will assist students consolidate their basic understanding of the subject matter taught, since it allows them change input parameters of structural engineering problems and see the consequences in the results of the process.

The IDEASimulator is the presentation module for structural analysis. The relationship between a simulator and a laboratory is extremely important for the basic understanding of structural behavior and modeling.

The IDEALive module is in the early stages. It will be an audio and video server, in which films, lectures and presentations produced at UFMG and other institutions will be stored.

Design Web Usability

The usability of computational systems has become an important issue in their design process. Systems that are easy to learn and user-friendly have been much more successful [6]. According to Nielsen [7], clients nowadays try first the usability of a site before actually start using it. Consequently Web usability is the key feature in the design of any virtual teaching-learning environment since it will govern the apprentice's interest in using the system. In order to achieve the above-mentioned objective, the following characteristics should be included in the design of any interactive environment:

- the colors and contrasts used for the text and background should be chosen in such a way to avoid blurring and tiring the student;
- information must be presented in a harmonic and organized mode;
- subjects must be distributed within a single screen without the need for scrolling;
- use of patterned interfaces in order to make students feel more familiar with the system.

The adoption of these criteria will certainly not only intensify the user's performance but also bring other pedagogical benefits such as motivation and self-esteem [8].

Programming Tools

Object oriented programming and Java are being used in the design of the virtual environment. Java platform allows the creation of dynamic and interactive Web pages as well as applets. Applets can be insert in any HTML or XML documents and are portable, reliable, extendable, reusable and easy to maintain. Besides all that, they make use of the large number of available Java libraries, which facilitate their design [9,10].

Reinforced Concrete Design Prototype

The main objective in structural design is the determination of numerical parameters such as displacements, strains, stresses and actions. These parameters are then compared to limit values prescribed by design codes. Consequently the emphasis in any structural engineering course is the determination of these parameters. With respect to reinforced concrete design, the calculation of the reinforcing steel area of a rectangular section subjected to a bending moment and a shear force is the first topic taught in a course. The reinforcing steel area depends on the size of the rectangular section, on the strength of the concrete and on the value of the bending moment and shear force. Changing these values will certainly modify the amount of the reinforcing steel needed. This procedure can be easily simulated in a computer.

It is well establish that simulation allows students explore a large number of hypotheses in solving a problem. By changing the values of input data and with the immediate visualization of the results derived from it, the apprentice can easily see the influence of the parameters [11].

The interfaces for the design of rectangular reinforced concrete sections subjected to shear and bending are presented in the next paragraphs. The design is based on the Brazilian Reinforced Concrete Code (NBR 6118) [12] and follows the algorithm developed by Tepedino[13]. Two applet interfaces are shown: one for bending design (figure 3) and one for shear (figure 4).

Each interface is divided in two parts: one for inputting the data and the other for presenting the results. Figure 5 shows the input data for the bending design. The user can access a tutorial during the input data phase. By clicking the mouse over any label (figure 6), a message box is opened automatically, which contains information and numerical values allowing the user clarify any doubts that he might still have.

The results, in each interface, are presented gradually allowing the students follow the design process. At the end, all the calculations are shown in a text box (figures 7 and 8).

The applets presented so far correspond to the design phase and will serve as the basis for the detailing part of the reinforced concrete sections. They are a part of the IDEA Studio environment for visual interactive models corresponded to concrete structures. The detailing of the sections will be done through a 3D visual interface built using the VRML language [14]. With this visualization, in real time, the students will be able to understand much better the basic concepts on the behavior and detailing of reinforced concrete elements. The 3D visual interfaces are currently being developed.

Figure 9 presents the objected oriented programming class diagram for the concrete structures module. These classes are grouped in four blocks: interaction control, detailing control, design control and access control. The classes at the first block are responsible for the graphical interface of the visual interactive environment and for the mouse events on the applets. Java's AWT and Swing graphical packages were used in their development. The 2D or 3D view of the detailing of the concrete reinforcement is done at the second block. The third block contains the actual design of reinforced concrete sections under bending and axial force, shear, torsion and punching shear. Finally, the Net class controls the access to the environment. It contains features that allow instructors map the apprentices' navigation path while in the system.

The concrete structures module will be used in the civil engineering and architecture lower division courses at UFMG starting this coming April. Consequently student feed back information will be available after that.

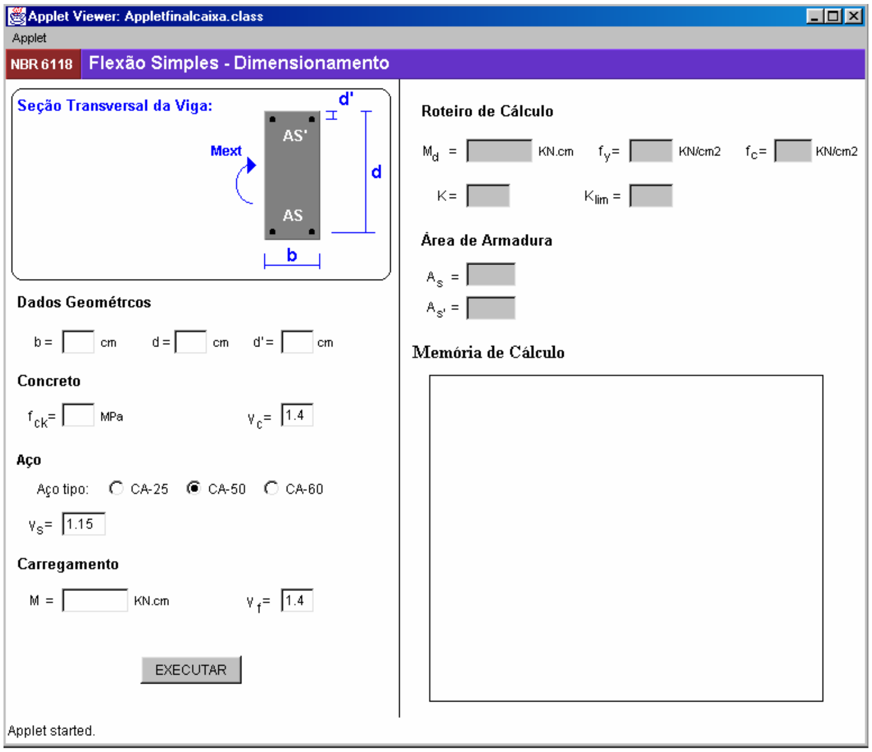

Figure 3 – Applet interface for bending design

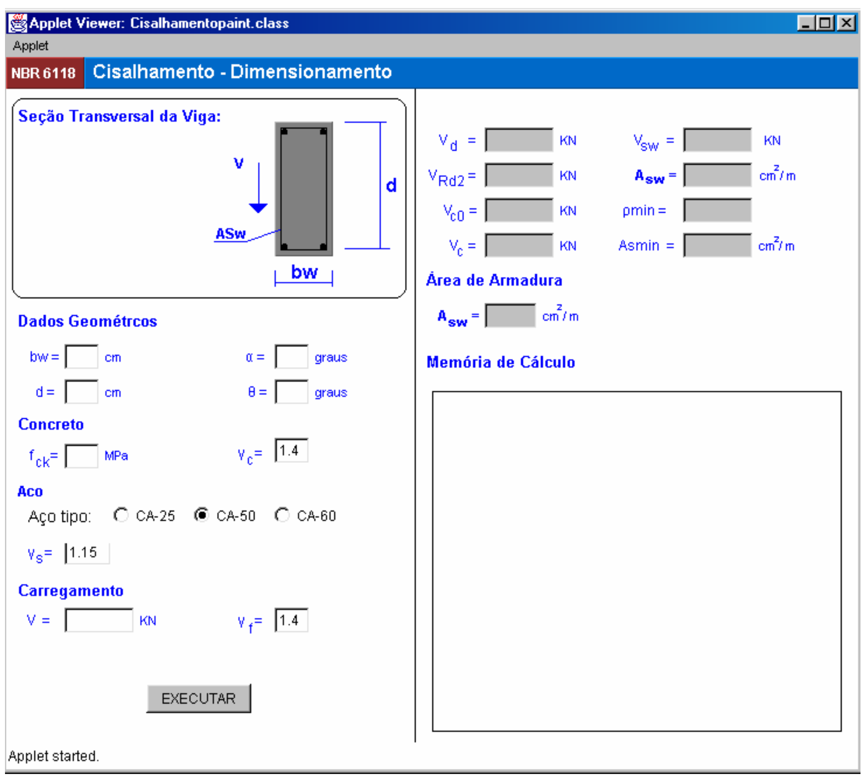

Figure 4 – Applet interface for shear design

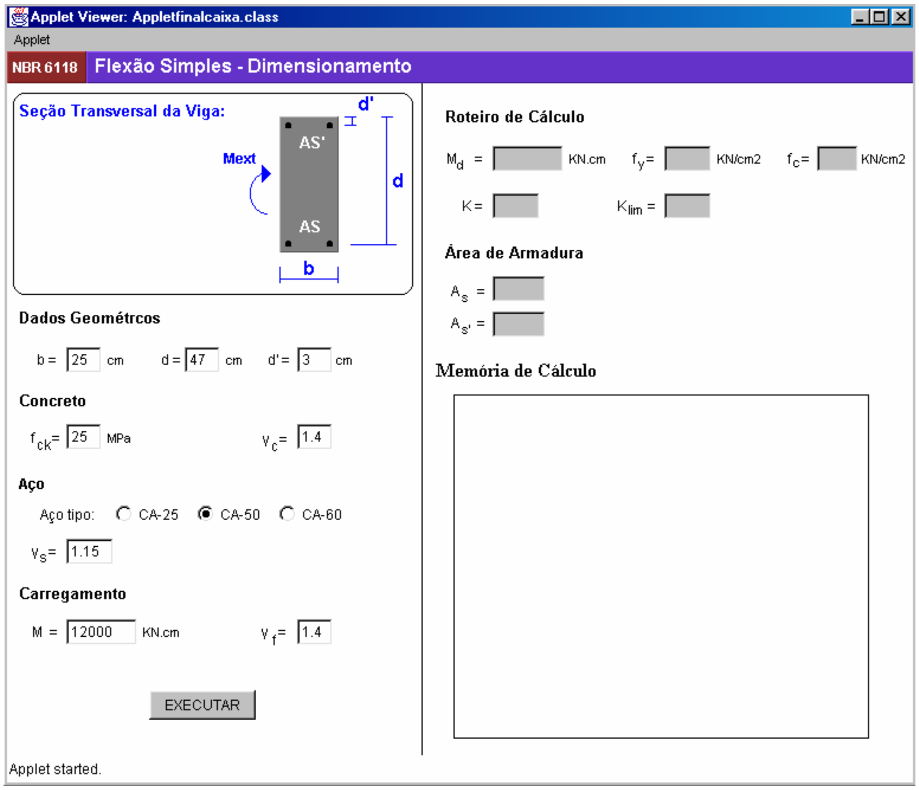

Figure 5 – Input data for bending design

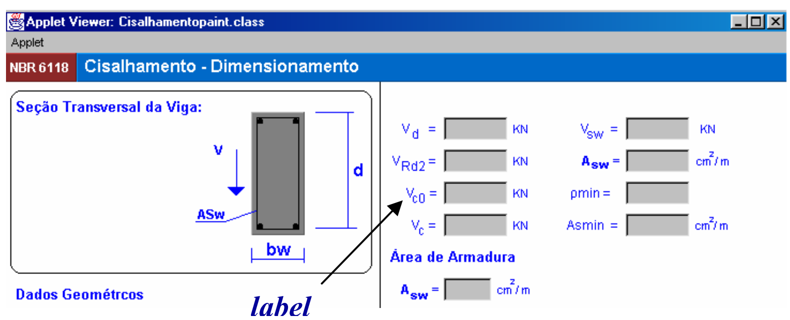

Figure 6 – Detail of a label

Concluding Remarks

The purpose of this research is not discard the traditional classroom teaching method, where the instructor is essential, but to create complementary alternatives, which will aid teachers enhance the student's performance. Web based virtual teaching-learning environments are the ideal alternatives since they allow students learn in a flexible and fast way according to their time frame and pace.

Simulation by itself is not always more stimulating than certain traditional classroom activities. It does not also assure that learning was achieved. Consequently, instructors must always evaluate students[11].

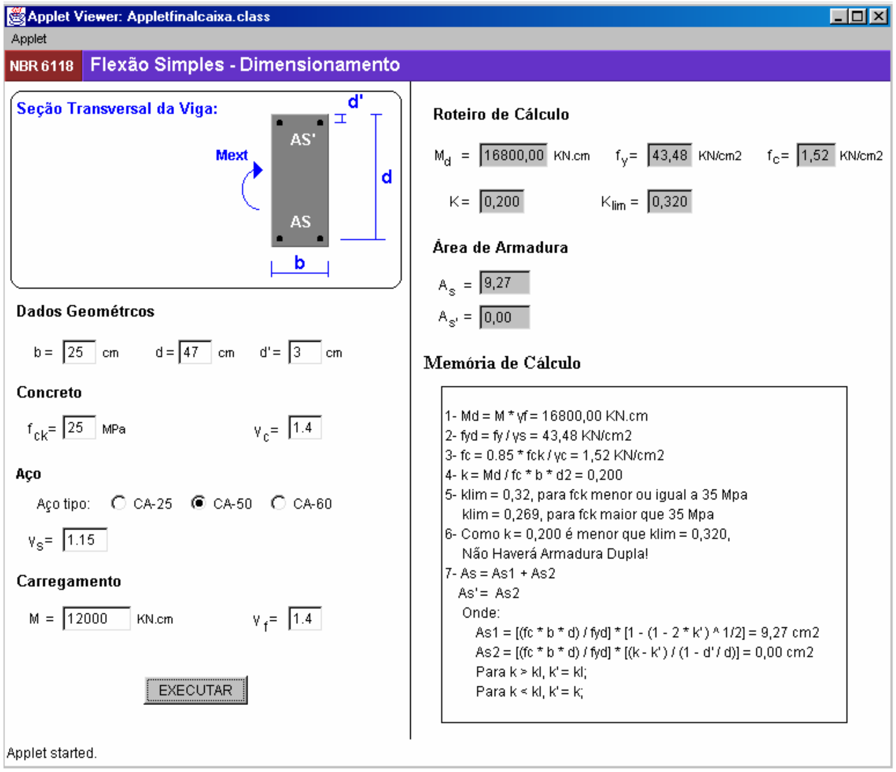

Figure 7 – Results for bending design

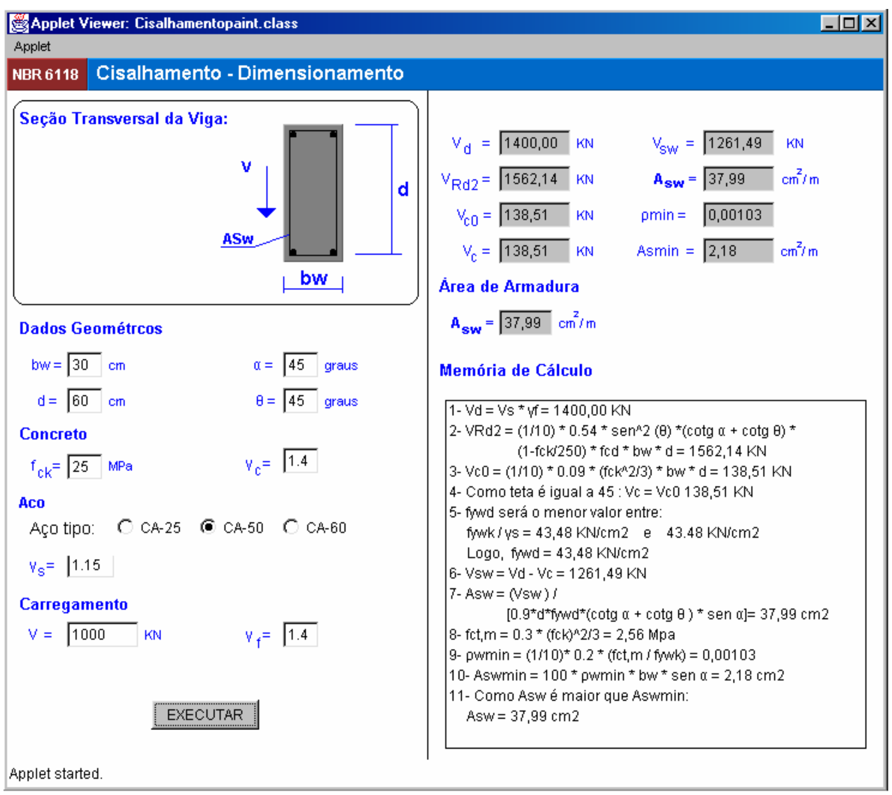

Figure 8 – Results for shear design

According to Piaget, a number is an abstraction, which does not express the real thing, but its place in a series or scale [15]. The numerical character of structural engineering must be always contextualized and visualized to help students understand the basic concepts of structural design. This paper is a contribution towards this goal.

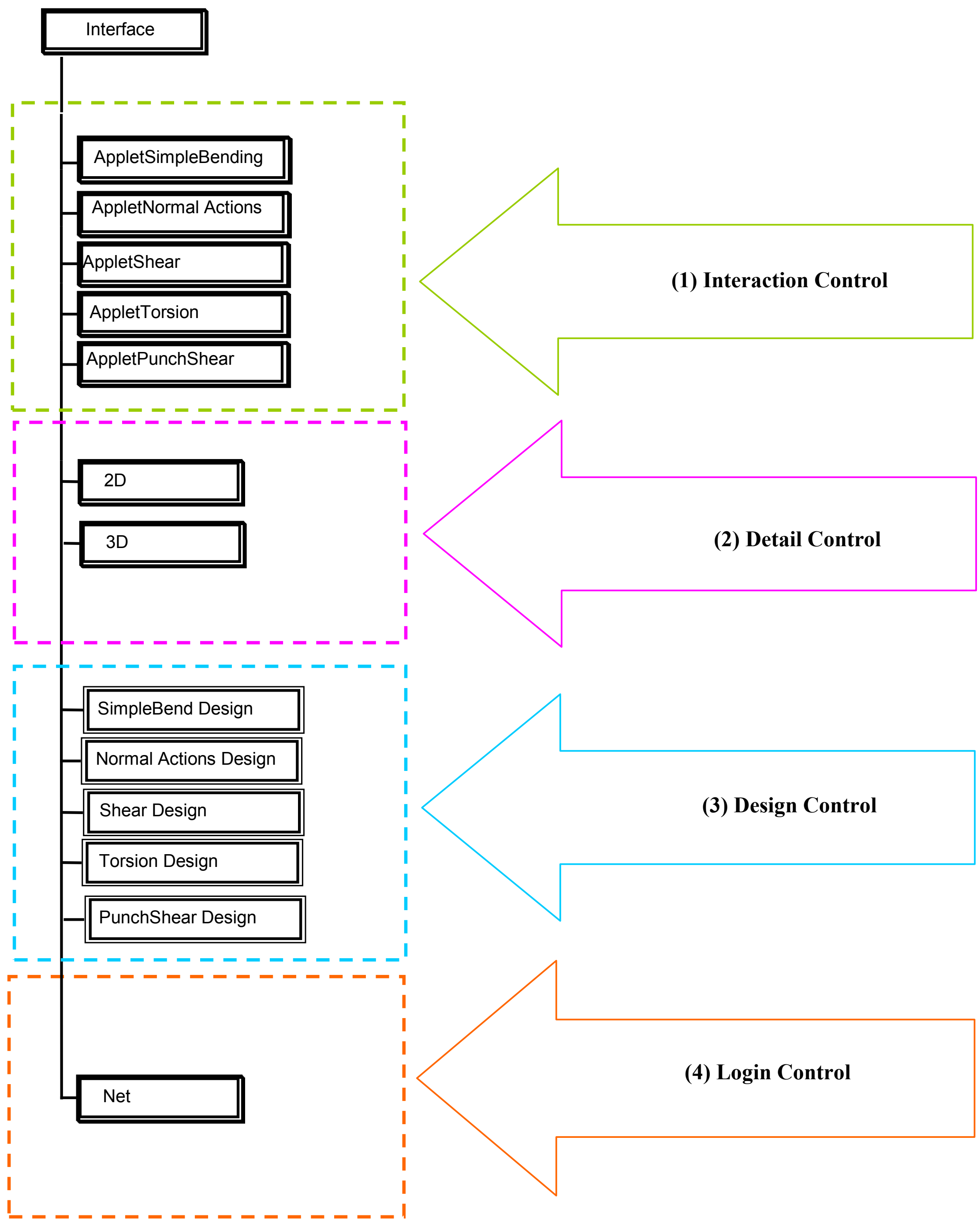

Figure 9 – Objected oriented programming class diagram for the concrete structures module (2004 version).

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