Computer Graphic Tools to Identify Reinforcement Placement Problems

Program under development seeks easier constructibility check for designers

BY SCOTT R. SMITH, NADER PANAHSHAHI, AND LUKE M. SNELL

It is fairly common for reinforcement placing problems to occur during construction. Reinforcement schedules specified during the design stage sometimes create bar interferences at the intersections of members. Often these interferences are not detected until workers begin building the reinforcement cages.

At that point, workers may move reinforcing bars before the concrete is placed. This type of reinforcement adjustment can reconfigure the members' structural capacity; workers are frequently unaware of structural integrity and seismic considerations. This solution to the congestion problem is then buried in concrete. When engineers do not regularly visit the construction site, they may not realize their design is being altered because of constructibility issues. All these reasons make it difficult, but necessary, to develop a computer program that detects possible reinforcement placement problems.

There are other logistics that need to be addressed if a computerized solution can be of assistance. It is up to the concrete industry to decide whether something should be done about the situation, guide those who can develop computerized tools, and be committed to using such tools (by purchasing these and funding their development). Our research focused on ways to approach and further define the technical aspects of this type of computer program development. We will demonstrate our findings to date, though more refinement is needed along with reasonable estimates of what resources are required to further develop a working tool for the concrete industry.

IN THE BEGINNING

We developed our initial computer applications as an internally funded

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university research project at Southern Illinois University-Edwardsville (SIUE). Based on ideas formulated in meetings with the advisory task force of the Concrete Construction Resource Unit, professors and graduate students developed pilot, proof-of-concept applications. These applications allow the user to interactively view the reinforcement placement between beam and column members for a hypothetical building design (Fig. 1).

We have produced algorithms that, for certain intersection types, detect reinforcement interferences and other placement problems. The ultimate goal would be to produce a software tool that allows viewing reinforcement layout in any area of a building and automatically detecting all reinforcement placement problems. Ideally, this program would work for any building and use data that was already entered into the computer for other design and analysis programs.

Thus, with little added effort, designers can see and communicate

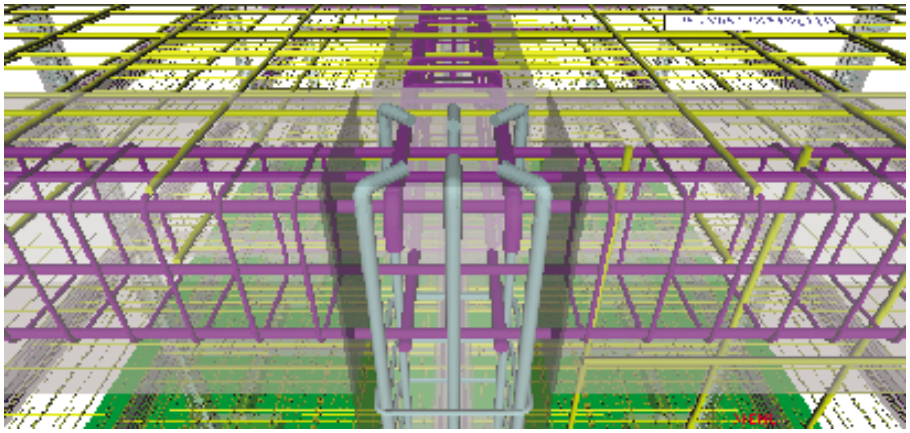

Fig. 1: Close-up view of a beam-column connection

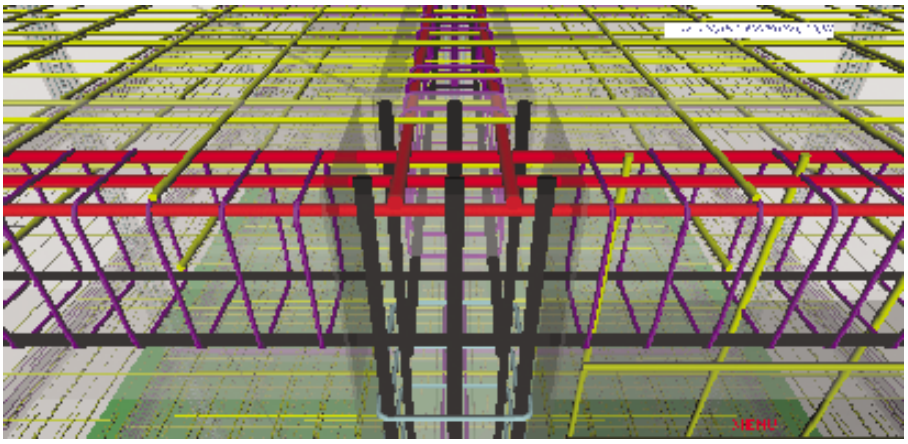

Fig. 2: Red color shows reinforcement interference

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what they have specified. The authors believe a tool that allows the designer to show placement details in 3-D would be useful to construction workers who could use both the design drawings and the visualizations during construction.

There are several questions the authors have asked throughout the explorative project, such as:

- Who would use this program?;
- What should the program do?;
- How much further development effort would it take to provide those capabilities?; and
- What amount of time would a user invest in learning and/or using the tool?

REINFORCEMENT VISUALIZATION APPLICATIONS

A four-story, 2 x 3 bay building was designed according to standard engineering guidelines.[1,2] We created a model from the design showing the building's concrete member details using virtual reality modeling language (VRML). A personal computer with the proper web browser plug-in (a VRML viewer) was used with the visualization application to see the locations of reinforcement within concrete beams, columns, footings, floors slabs, and walls. The program allows the user to zoom into member intersections and visually inspect them for reinforcement conflicts and constructibility.

We have also developed a program that automatically searches a structure and points out locations of conflicting reinforcement (Fig. 2). The algorithm in this program actually detects failure to meet minimum spacing requirements.

Based on our research, it is feasible to produce working graphics to show reinforcement bars that conflict in construction situations. Almost anything can be done given enough programming time—the real question is whether the tools that are developed are useful to those in the industry. As we explored automatic ways of creating reinforcement visualizations, we investigated using industry standard design input mechanisms for our tools.

That is, we sought to use information from preexisting software applications, but found we could not. It is true, however, that designers re-enter data into many software applications during the course of design (the plan drawing software and the design analysis tools, for example, each require redundant entry).

Failing to find an industry standard data-entry mechanism, we mimicked the data-entry mechanism for a design analysis package. So, even though the users have to reenter the data, they do so in a manner and format that is familiar to them. Certainly, further development of our program should include better ways to make use of data extracted from other programs. A useful tool has to be proficient—and reentering data could be a hindrance to this program's adoption.

TO GO FURTHER

The project we have completed demonstrates the potential of using computer graphics tools to help alleviate problems due to reinforcement congestion and incorrect reinforcement placement. Our results show what can be done and are meant to help direct the next stage of development. To pursue this development, we would like to share our work with various design and/or construction companies, both to get feedback and suggestions, and to solicit support for the next phase.

References

1. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-99) and Commentary (318R-99)," American Concrete Institute, Farmington Hills, MI, 1999, 369 pp.

2. International Code Council, "The 2000 International Building Code (IBC)," Falls Church, VA, 2000.

Selected for reader interest by the editors.

Scott R. Smith is a professor of electrical and computer engineering at Southern Illinois University-Edwardsville (SIUE). He has developed a virtual reality and visualization laboratory and research program. He is involved in projects applying 3-D computer graphics and simulation technologies to show reinforcement steel within concrete structures, earthquake damage to buildings and possible retrofits, and a construction site's planning and progress.

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