

CAD/CAE IN THE CONSTRUCTION INDUSTRY

Bureau of Engineering Research
The University of Texas at Austin

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The purpose of this publication is to make available to industry the results of research conducted by the Construction Industry Institute (CII). The publication does not necessarily represent the views of all CII member companies, but is offered as a contribution to the industry.

CII was founded in 1983 to improve the cost effectiveness of the nation's largest industry. The members, who represent a broad cross-section of owners and contractors, believe that many of the problems that limit cost effectiveness are common ones, and that real improvements can be best accomplished in a cooperative environment with the benefits being shared by the construction industry at large.

The activities of CII include identifying research needs, conducting research, and aiding implementation of research results. The task forces that provide guidance for specific CII activities are listed below.

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**CAD/CAE
in the
Construction Industry**

**Prepared by
The Construction Industry Institute
Design Task Force**

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EXECUTIVE SUMMARY

Computer aided design (CAD) and computer aided engineering (CAE) are important tools for today's construction industry. They are affecting the way our business is being done.

The construction industry has accepted the use of computers in a variety of ways. Management is concerned that the use of computers is less than cost effective. Largely because of this concern, the Design Task Force sponsored a study to evaluate the usage of CAD and CAE in the member companies of CII.

The study led the Design Task Force to believe that:

- CAD/CAE technology will overwhelmingly be the most important contributor to improvement among CII companies in project quality and efficiency in the foreseeable future.
- The industry is on the verge of an order-of-magnitude improvement in efficiency and benefits resulting from the utilization of computerization.

The primary objective of the task force study was to collect information and to share lessons learned about the computerization efforts of CII member companies.

This report will assist the industry in the task of computerization and point out some key elements of success. Opinions regarding computerization trends for the next five years have been identified and are contained in this report.

Even though CII companies have experienced average home office hour reductions of 26 percent through computerization, CAD/CAE (from the viewpoint of cost by most respondents) has been break-even at best in engineering and home office efforts over the past five years.

Vendors of hardware and software have made this effort more difficult for management by inflating the projected efficiencies of the systems and down-playing the difficulties necessary to use them.

Participants in a September 1988 workshop concluded that benefits are measurable in terms of better designs with improved productivity and schedules. Strong evidence shows that once menus, databases and libraries are created, costs as well as hours can be reduced.

Downstream benefits have been identified and are believed to offer the greatest potential for future realization, but have not yet been broadly realized or quantified by CII member companies.

Obstacles to rapid progress in this process consist of the following:

- Management's lack of understanding of the technology and its potential.
- The difficulty of companies to train and integrate people into a computerized environment.
- A lack of standards among vendors, engineer-contractors and owners.
- The lack of system software and hardware compatibility from system to system.
- The time required for people to adapt to a whole new way of processing information.

The participants in this study predict the future to include the networking of computers in the offices of the engineer, the owner and the construction field office. One source of information will exist, and it will reside in the computer and be accessible by project participants on the basis of need. Different vendors' hardware and software systems will communicate with each other. Object-oriented, database-driven CAD/CAE systems are expected to be in general use. Expert systems, artificial intelligence concepts and dynamic plant walk-through programs are expected to be common tools. Simulation of the conceptual design of projects will be among the engineer-constructor's capabilities.

A computer will be as common as today's hand-held calculator and become the link between a variety of communications and reproduction.

Industries will develop unique databases. Companies will draw information from their own company databases and industry databases to create project databases for construction and other business requirements of owners.

Schedules will be shorter, budgets will be more accurately refined and project quality will improve.

Hardware and software already exist to do the things visualized as the future. A few companies already are performing tasks that are predicted for the future. Management's ability to drive this technology to a cost-effective conclusion on projects and the creation of an educated work force to use it are the obstacles to its realization.

Computerization technology and implementation are moving at a pace that is making today's tools and methodology obsolete at an alarming rate. CAD/CAE usage in the next five years is viewed as an exciting and promising time for the construction industry.

STUDY OBJECTIVE

The Design Task Force began a study in August 1987 to evaluate the use of computer aided design and computer aided engineering in design and construction among CII member companies. Many companies had invested heavily in computerization. In many cases the results were either disappointing or less than those expected. The task force learned quickly that computerization in the construction industry was not limited to CAD and CAE.

The goals of the task force study were:

- To collect and share the computerization experiences of the CII companies and a group of workshop participants.
- To create realistic expectations for management when contemplating computerization of various engineering and construction functions.

The task force findings will offer guidance in more cost-effective use of computers and will help others in avoiding some of the costly mistakes of the past. Through this report, the top management of construction industry firms will be able to identify what computerization can now do and what to expect in the next several years.

The study identifies the areas that need industry attention. This report will serve to promote further collaboration among industry users for more cost-effective computerization.

The products of this study are:

- A summary of the current state of hardware, software and applications of computers in the construction industry.
- Identification of factors that result in cost-effective computerization.
- A description of methods used by CII companies in integrating systems.
- A summary of the collective judgement of workshop participants identifying future trends for the next three to five years.

The task force had difficulty in identifying succinct examples of cause and effect that indicate if money expended in an area will result in dollars saved in that area. The savings identified by workshop participants tended to be much more subtle because the resulting savings are found in an area other than where the expenditures are made.

METHODOLOGY

This publication results from a study conducted by a research team at the University of California, Berkeley, under the guidance of the Design Task Force. A CII Source Document [1] containing much more data is available from CII.

The study was conducted in four phases: a questionnaire survey, follow-up site interviews with selected CII firms and software vendors, a series of meetings with the CII Design Task Force members and a two-day workshop consisting of inputs from CII and other resources. These phases are described in Appendix B.

COMPUTERS IN CONSTRUCTION TODAY

State-of-the-Art

The use of computers in the construction industry is found primarily in five major areas:

- Minicomputers or mainframes are used for administration and accounting programs.
- Microcomputers are being used in non-graphic engineering applications such as spread sheets, database management and minor numerical analysis.
- Mini or mainframe computers are being used in non-graphic engineering applications such as major numerical analysis that include stress analysis of complicated structures or process systems.
- Micro or minicomputer 2-D CAD systems are in common use among CII member companies.
- Mini or mainframe computers are used by a few companies for 3-D CAD systems.

All applications, except 3-D CAD systems, are widely used and accepted in the industry, although some still question their cost effectiveness. The benefits are measurable in terms of better design with improved productivity, lower home office costs and shorter design schedules. Many member companies have not performed this evaluation and still remain doubtful.

The industry is utilizing the application of 3-D spatial management modeling systems in a limited and cautious manner. The application is not in use by a high percentage of respondents.

The 3-D systems cost much more in terms of hardware, software and training of personnel. Home office benefits from these 3-D systems are not yet as dramatic as from 2-D systems and other engineering computerization efforts.

Workshop participants with experience in 3-D systems concur that such systems do reduce total home office costs. The major obstacle to wider utilization is the size of the investment. The cost of hardware and software can be from \$25,000 to over \$100,000 per operator station. The training time required to become proficient at 3-D CAD can be as much as six months for all team members.

When the design and construction functions are performed by separate companies and the design organization has no share in the field cost savings, the engineer has little incentive to invest in an expensive technology where benefits accrue to the owner and contractor.

The current status in computerization was analyzed through both the study questionnaire and the follow-up interviews. The respondents were asked first to provide a breakdown of their engineering service hours by discipline in the three major engineering tasks. They were then asked to show estimated computerization achieved within each category.

The three major engineering tasks defined by CII respondents for the data analysis are:

- Design and drafting
- Numerical analysis
- Other tasks:
 1. Material takeoff for requisition
 2. Specification development
 3. Other engineering document preparation

The results are summarized in Figure 1.

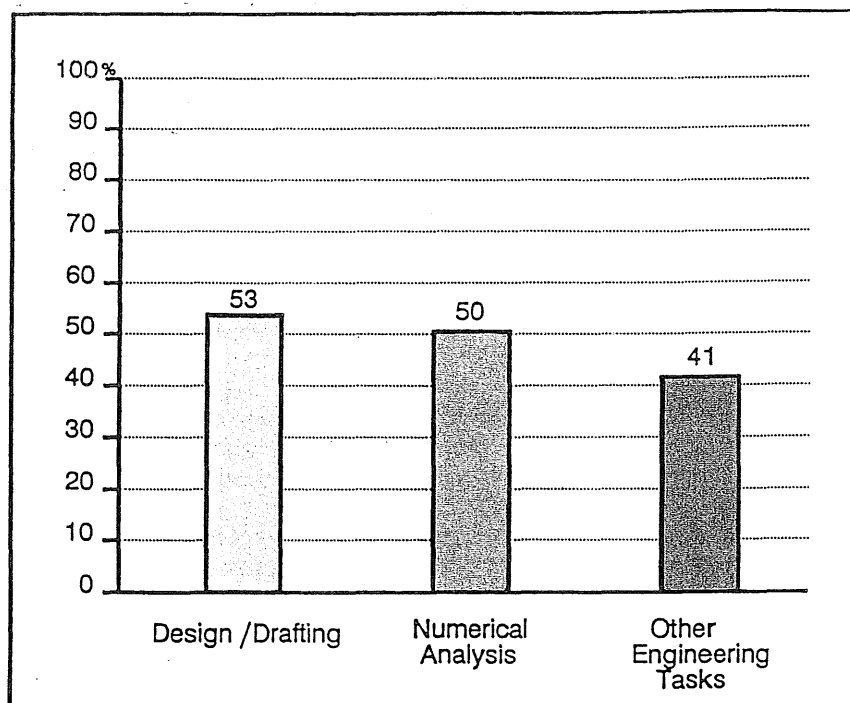


FIGURE 1. Computerization of Engineering Tasks—Present