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Computer-Aided Design (CAD) Technique — Use of computers for the preparation of construction drawings

Conception assistée par ordinateur (CAO) — L'ordinateur comme outil de préparation des dessins de construction

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Foreword

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The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

— type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development requiring wider exposure;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical reports are accepted for publication directly by ISO Council. Technical reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10127, which is a technical report of type 3, was prepared by Technical Committee ISO/TC 10, *Technical drawings.*

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Introduction

This report has been prepared by Working Group 12 of ISO/TC 10/ SC 8, investigating the Computer-Aided Design (CAD) Technique to prepare the way for the acceptance of standards in the sense of common rules for the CAD Technique in the construction industry.

This report will identify major differences between the manual drawing practice and the CAD Technique and will attempt to rationalize the use of the CAD Technique in the construction industry.

The major questions and queries brought forward by the group were concerning:

- Removing the mystique of the CAD Technique
- Assisting CAD Technique development to reflect international standards
- Clarifying the definition of terms such as drawings, files, updates, and databases when related to both manual and automated procedures
- Summarizing the advantages and disadvantages of the CAD Techniques when compared to conventional technical drawing methods
- Explaining the opportunities for standardization with this new technology
- Extending the manual standards into the CAD environment
- Identifying ISO's role in the standardization of the CAD Technique

The advent of the new CAD Technique has necessitated the investigation of currently accepted drawing practice, conventional storage methods, updating procedures, and information representation. This new technology can be a boon to technical drawing if well accepted and properly implemented.

Software for technical drawings using the CAD Technique has been developed over the years independent of the standards encouraged by the national and international standards writing groups. Standards could assist the development of CAD technical drawing packages and the CAD Technique could increase the distribution of standards for technical drawings.

It is necessary to define "drawings" and similar terms, as there is a variation of definitions of drawing terms and how the CAD Techniques relate to this well accepted ''manual draughting'' vernacular. A vocabulary of CAD terms would point out the similarities in the two methods for presenting technical drawing information.

The advantages and disadvantages of both systems have to be discussed so as to identify opportunities for standardization.

Computer-Aided Design (CAD) Technique — Use of computers for the preparation of construction drawings

1 Definition of Drawings

Design documentation, including drawings, is the information required to produce a product; in the construction industry this is a building project or a civil work. A drawing is conventionally viewed as an analogical presentation of information; normally a graphical two-dimensional representation in plan and elevation view of a product. There are various levels of abstraction for the product starting at the concept drawings and proceeding to drawings for designing, production, manufacturing, construction, administration , maintenance, etc. In addition to the graphical information (lines) in the form of drawings are the related alphanumeric data (words) in the form of specifications and a wide accumulation of discipline knowledge consisting of codes, company standards, discipline conventions, and design and site changes. These may or may not be represented in the design documentation. In many countries, the specifications, or written part of the construction documentation, take precedent over the "drawings" or graphical part. Therefore one cannot conceive of drawings as simply the graphical representation but must also include all the information necessary to produce a product.

In most countries, it is generally accepted that concept drawings and working drawings serve the function of testing design concepts and recording design decisions, respectively, and that drawings for production and manufacturing are a communication tool used to transfer information from the designer to the

constructor and to the fabricator. Drawings are recording devices and information transfer tools; therefore one must not view drawings as an end in themselves, but rather as a growing information base of design and site decisions used in the process of building a product.

In the manual world it is extremely difficult to imagine a static drawing as a growing information base; a major dilemma with paper, erasers, and pens. The existing drawings are always supplemented by additional information: specifications, detail lists, manufacturers guides, codes, and associated standards; all of which augment the information provided on a set of drawings. This information also includes updates to the drawings, new drawings, revisions, design change orders, site change orders, and fabrication drawings; all of these forming part of the ever growing information database. In the past, this information has been handled reasonably well by the construction industry; although an awkward procedure, it has served the construction industry well over the past millenia

There are, however, two major problem areas with these methods that take an inordinate amount of time: cross-referring information and updating information. This is where the CAD Technique will provide a valuable tool for the designer, fabricator, and the constructor, not to mention the initiator and final recipient in the design-build cycle, the owner.

The word "drawing" was derived from "withdrawing" as in "withdrawing information", so "drawing" could mean both the graphical and associated alphanumeric information; this has considerable more meaning and importance when dealing with computers. Specifically, computer-aided design draughting has precipitated a new question regarding the word "drawing": - can a database be a drawing, or the reverse, is a drawing a database?

Computer technology has also introduced new definition problems with terms such as: Computer-Aided Design (CAD), Geometric Modelling, Computer-Aided Design Draughting (CADD), and Computer-Aided Engineering (CAE).

Computers have introduced new parameters to the design process: a dynamic ability to rapidly access and change information and a possibility to cross-reference related pieces of information in an easy manner. These are not new features recently introduced by CAD, but rather new opportunities to deal with drawings in the conventional definition. In addition, the CAD technique will introduce different ways to access building information and will develop new techniques for using the information, many of which are unknown at this time.

To assist in the explanation of these concepts, Figure 1 has been developed to outline the layout of a drawing system using the CAD Technique. This has an analogy to conventional draughting practice: the database is the design representation in the mind of the designer(s), the filters are the manual tasks to produce specific information needed for evaluation or bidding procedures, the drawings are the output product of the design cycle.

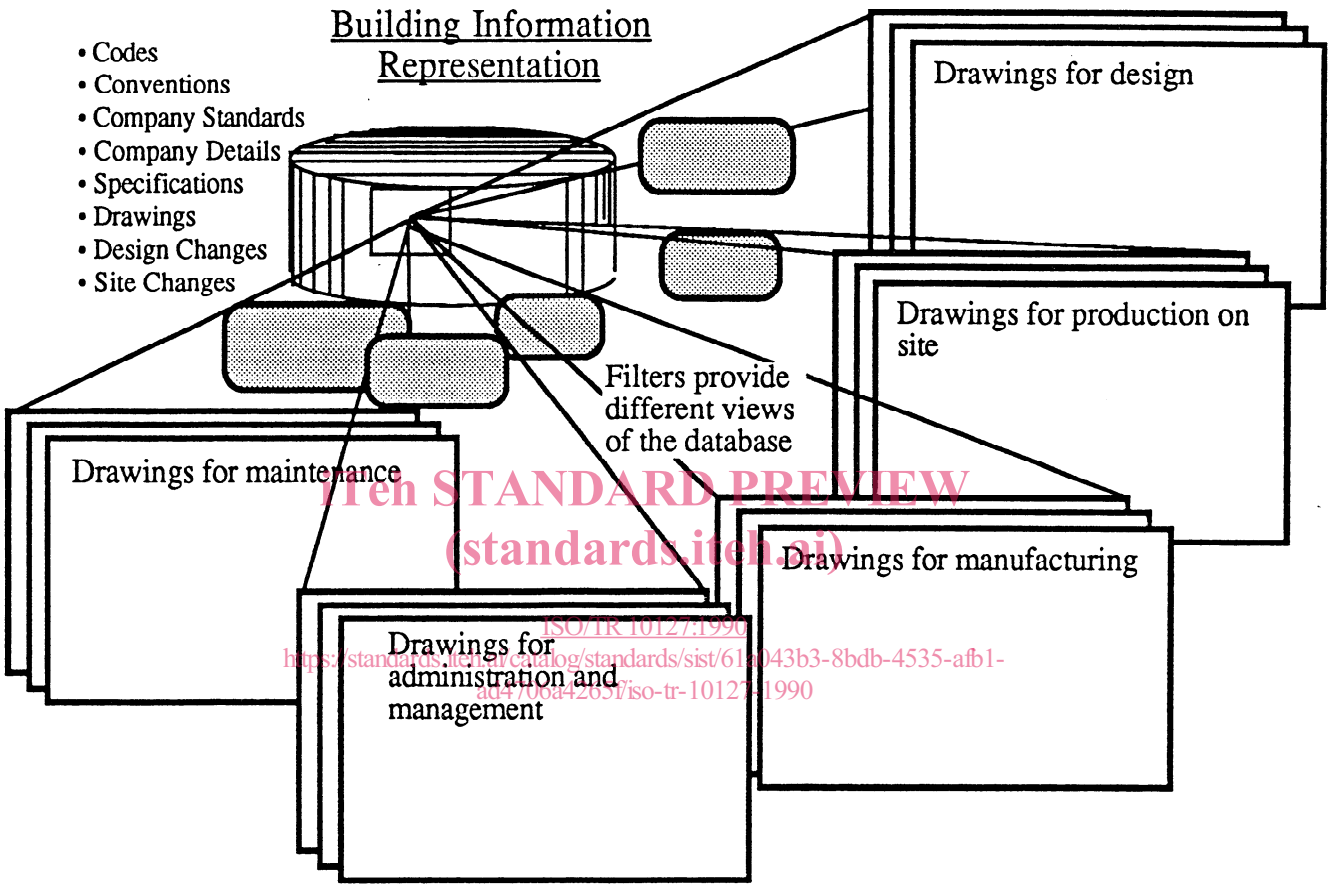

Figure 1

2 CADD Paradox

2.1 Limitations of the CAD Techniques

The limitations of the CAD Technique fall into three categories: display and resolution deficiencies, programming limitations, and functionality uncertainty. This is not intended to be an exhaustive list, but

one that identifies major limitations. These will be overcome in the near or intermediate future by technological advancements.

Display Deficiencies: The manual drawing process has an advantage over the automated with respect to the amount of information displayable at one time. Five sheets of A0 drawings can be placed on a table and the information on all can be scanned and cross-referred. The automated system only permits one small portion of one drawing to be displayed on the screen at one time. This disadvantage is temporal; with the advent of better user interface techniques, faster disks, better software design, and larger computer memory and disk space, this will eliminate the existing restrictions in one or two generations of hardware and software (3 to 5 years).

Resolution Deficiencies: Manual draughting displays all information at the same resolution: different scales are used on the drawings to present smaller details, but all the information is readable by the "average" reader, normally ± 0,1 mm on the drawing. The CAD Technique permits the information to be displayed at different scaling factors. Therefore, one can zoom into the drawing to obtain more information. The closer one is, the more detailed is the data, however, there is a loss of information display because the overall picture is not there at that small scale.

Programming Limitations: Not all of the functionality currently possible with the CAD Technique can be made available in all CAD systems at any point in time. There is now enough information about automated draughting to know what is required for most production draughting operations. CAD systems will evolve to meet the new specifications of the designers, so the existing problem is temporal. All CAD software producers will try to make all of the required features available on their machine (or they will not succeed financially).

Functionality Uncertainty: This is a new medium - the refinement of which may take several years. How machines will be used or what will be the best way of performing specific draughting or design functions will not be known until several generations of hardware implementations and software programs have been tested and refined. An example is a graphical input device - a primary function for any graphical system; various input devices were used for decades in research and practice before the digitizing tablet and the mouse were accepted as a universal default for simple graphical entry. This brings forth a major dilemma, how can one standardize before a technology has matured?

2.2 Limitations of the manual system

In the manual system the drawing was the database and standards were developed according to accepted conventional practice. Computer technology has rendered some standards obsolete, but has also introduced the need for more standardization, such as data transfer between different CAD systems. The manual system with its associated standards do not address the complex information world of the CAD Technique and the standards will have to be augmented.

In the conventional manual system the overall structure of the information for any construction project is in the mind of the designer and the user. At times the various information components are held together in a few documents, but there is not an integrated database of information. Computers must deal with information in an ordered, logical fashion, therefore there must be a structure for this construction data. The manual system works fine as is, but if this loosely related system of information is applied to the CAD Technique the automated system may not perform as well as its manual counterpart.

The teaching of a designer and draughtsman is a pure heuristic function, this learning evolves over time and with experience in the construction industry. Many of the opportunities can not be duplicated in a school setting and must be acquired through the trial and error process. Computers have advantages over the manual system in that the system can hold the rules and the knowledge for the user and the user can supply the facts and details. This could greatly reduce the time required to assimilate the knowledge essential for producing technical drawings, thereby producing better designers and buildings.

2.3 Similarities of both systems, manual and automated

All technical innovations alter in a small way the conventional technology. In some way the application of the CAD Technique to technical drawings is no different from the introduction of quill pens, french curves, dry transfers, or micro-filming for construction drawings. It optimizes some operations and makes the overall product more efficient. It produces the same results in a different process, format, or time frame. The product is virtually the same for technical drawings: design and fabrication documentation to assist in the construction of buildings or civil works. The main difference with the CAD Technique is the process by which the information is entered and recorded. Experience in the CAD industry has shown the output product of this new technology should duplicate the output of existing technologies.

2.4 Differences

The CAD Technique is not only the automation of the manual process, but it also provides the opportunity to do operations in new ways that were previously impossible or cost restrictive. Solids modelling is one clear example, another is interference checking.

Another difference between the manual and the automated world is the framework of existing computer systems and computer standards that are currently available internationally. This includes the Initial Graphics Exchange Specification (IGES), Graphical Kernel System (GKS), Programmers Hierarchical Interactive Graphics System (PHIGS) and the Open Systems Interconnection (OSI). In the automated world all of the parts of the computer system must fit together properly, in the manual world many of the parts could exist by themselves. Any standard developed using the CAD Technique will have to relate to existing standards, specifically IGES, GKS, PHIGS, and OSI. Anyone purchasing CAD systems will have to base their purchase in some way on these standards, as a major feature of a CAD system is the ability to upgrade information and capabilities and to transfer data from one CAD system to another and from one designer to another. This provides compatibility with other systems and reduces obsolescence of systems purchased. With current CAD technology it would be foolhardy to purchase an orphan CAD system, running on an orphan machine with an orphan operating system and no data transfer mechanism. In the future this will be even more foolhardy.

Other differences between the two include updates and revisions to plans and drawings on a computer database. This is one that directly affects the technical drawing disciplines. The information provided by the CAD systems can be obtained faster and more accurately by users. This enables designers, contractors, and fabricators to access data in new, innovative ways to date untried. Information access can be considered as instantaneous, thereby providing the users with unlimited access to correct, cross-referred data.

New methods and standards for archiving information will also be required with the CAD Technique. Many questions arise: How long will the data on a disk stay current, will one be able to edit the data in 10 years, what will the cost be of keeping this information up-to-date, etc.? These problems have been addressed with micro-filming standards, but will have to be addressed again with the advent of the CAD Technique.

2.5 Correlation between existing manual drawing practice and CAD

There is a strong correlation between the two methods specifically the output product and the information entry. The current CAD systems rely heavily on the *status quo* for the entry of information into the CAD system and for the output product. It may be decades before the method of presentation of information for technical drawings will be changed drastically. Research into the relationships of data for buildings information is currently on-going and it may be years before a unified structure for building information will be available. Other similarities exist in both the manual and the CAD Technique system: the two produce designs for product fabrication, provide working models for development of design schemes, enable the designer to compare alternatives in an easy, orderly fashion, and provide a working tool for others to access and modify. It is hoped that the advantages of the computer systems will eliminate some manual disadvantages and that the disadvantages of the CAD Technique discussed in the previous sections will be overcome by technological innovations.

2.6 Dilemma

The discussions of the limitations of both the manual and CAD systems in addition to the presentation of the differences and similarities of the two and the correlation between the two has provided insight into the dilemma of the CAD Technique. These deficiencies and conflicts can be clearly identified as the following:

- Computer technology has limitations: display and resolution
- Programming and functionality limitations exist with the CAD Technique
- There is a need for the maturing of CAD Techniques
- Manual recording methods and devices do not take advantage of the newer, faster, more efficient computer technology
- Manual standards need updating
- There is a lack of strong structures in manual presentation of information
- Heuristic nature of learning manual system is slow and time consuming
- Common formats are needed for presentation of information: "drawings"
- Similar data entry methods needed for CAD systems
- There is a need for relationships with other computer standards
- New opportunities are provided by CAD Technique (3D, databases, etc)
- There is an ability to transfer CAD data between different designers/firms
- Easy updates of information exist with the CAD Technique
- Strong cross-referring is possible with CAD information