

An Investigation of Object-Oriented Specifications for Iowa DOT and Urban Standards

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ABSTRACT

Currently, individuals including designers, contractors, and owners learn about the project requirements by studying a combination of paper and electronic copies of the construction documents including the drawings, specifications (standard and supplemental), road standards, design criteria, contracts, addenda, and change orders. This can be a tedious process since one needs to go back and forth between the various documents (paper or electronic) to obtain the complete picture. There are also special provisions as well as standard specifications referenced in the contract documents that need to be understood. As transportation projects become more complex to design and build with fewer resources available, it is important to take advantage of appropriate innovative technologies that make it easier for designers and construction personnel to grasp the project requirements in a quick and efficient manner. This could ultimately reduce the chance of error, improve quality, decrease rework, and shorten the project duration. The use of object-oriented computer aided design (OO-CAD) to graphically portray information is one such technology. OO-CAD allows users to point and click on portions of an object-oriented drawing that are then linked to relevant databases of information (e.g., specifications, procurement status, and shop drawings). This paper presents the research method and primary results of an investigation of the use of OO-CAD specifically for providing more direct specification linkages to standard details used for designing and constructing projects. The study involves integrating both the Iowa Department of Transportation and urban specifications into one graphical database using OO-CAD for use by designers and construction personnel involved with any type of transportation project in Iowa. This would centralize the specification process, thus, saving on resources and providing a visual format for accessing specifications. OO-CAD would also make it easier for designers and contractors to more readily understand project requirements.

Key words: animation—drawing—object-oriented computer-aided design—specifications—three-dimensional image

INTRODUCTION

Today, members of the project team including designers, contractors, and owners do not have enough time to fully understand the project details and are in need of a tool to help them become more efficient. A graphical navigation approach can solve this problem. Currently, individuals learn about the project requirements by studying a combination of paper and electronic copies of the construction documents including the drawings, specifications (standard and supplemental), road standards, design criteria, contracts, addenda, and change orders. This can be a tedious process since one needs to go back and forth between the various documents (paper or electronic) to obtain the complete picture. There are also special provisions as well as standard specifications referenced in the contract documents that need to be understood. As transportation projects become more complex to design and build with fewer resources available, it is important to take advantage of appropriate innovative technologies making it easier for designers and construction personnel to grasp the project requirements in a quick and efficient manner. This could ultimately reduce the chance of error, improve quality, decrease rework, and shorten the project duration. The use of object-oriented computer-aided design (OO-CAD) to graphically portray information is one such technology. OO-CAD allows users to point and click on portions of an object-oriented drawing that are then linked to relevant databases of information (e.g., specifications, procurement status, and shop drawings). This study investigates the development of an OO-CAD specification system for providing more direct specification linkages to standard details used for designing and constructing projects.

LITERATURE SEARCH

OO-CAD systems have long been touted as the way forward for more intelligent CAD systems. In an object oriented design, the object contains all of the data necessary to fully describe that object. The idea behind this concept is that the design involves several objects that have information associated with them. When the user clicks on an object, information pertaining to that object appears. This information can be fixed or dynamic in a sense that the information about that object changes with time. Only a few OO-CAD systems have been previously developed, and most of these are on high-end UNIX machines that are not affordable by the majority of practitioners in the construction industry. This appears to be changing with the introduction of OO components in many of the popular systems (e.g., AutoCAD with objects defined in C++) (1). Major CAD packages such as AutoCAD and MicroStation are presently working towards greater interoperability in the Windows environment by supporting such emerging tools as aecXML (Architect/Engineer/Contractor eXtensible Markup Language) (2). Other object oriented animation programs such as Flash and Shockwave are also available.

Two efforts are currently underway to make it easier to find required specifications and provide unification of the many different city and county specifications that are used in Iowa. In order to make it easier for design and field personnel to locate Iowa DOT specifications (3), an Electronic Reference Library (ERL) (4) has been created. This is a hyperlinked electronic version of the standard specifications, supplemental specifications, Material Internal Memoranda, Standard Road Plans, and Construction Manual that has been copied to a CD ROM format for statewide distribution (thousands of copies have already been distributed). State agencies, local agencies, and construction contractors using the Iowa DOT specifications can quickly and efficiently identify relevant specifications using the key word search capability. New CDs are released on a six-month basis reflecting updates to the specifications. It is important for projects under design to have the most current information. Thus far, users (i.e., designers, contractors, inspectors, field engineers, suppliers, FHWA, counties, cities, and other state DOTs) have found electronic specifications to be useful for quickly locating information.

Continued attention has been made to improve design and construction coordination between project team members. Currently, there are two concerns facing the transportation design and construction organization. The first one is resource availability, which is becoming more constrained due to budgetary reductions. This is particularly true in the area of maintaining specifications and design standards where updates are disseminated every six months at the Iowa DOT. Local specifications are not typically updated as frequently. With the move toward an integrated specification approach between the state, cities, and counties there is an opportunity to make more efficient use of resources in this area. The other is documentation readability. Individuals learn about the project requirements by studying a combination of paper and electronic copies of the construction documents. These documents include, for example, the drawings, specifications (standard and supplemental), road standards, contracts, addenda, and change orders. This can be a tedious process since one needs to go back and forth between the various documents (paper or electronic) to obtain the complete picture. Also, it can be quite time consuming for new designers to learn design standards and specifications. Therefore, the need exists to use information technology to develop a new specification system that can help designers and contractors and improve the project performance.

STUDY OBJECTIVES

The purpose of this study is to develop a prototype model of object-oriented specifications. This model will be used to test the feasibility of the concept above and assess its impact on the design and construction of transportation projects. Both Iowa DOT and urban specifications (5) are included in an object-oriented format to demonstrate the concept. The end product will be a graphical or visual front-end system for the ERL. Full-scale development and maintenance issues will also be addressed as part of this project.

STUDY METHODOLOGY

The methodology involved includes several steps:

1. Develop an understanding of the user requirements through a series of meetings and face-to-face interviews with designers and field personnel.
2. Coordinate selection of formatting issues for plans and specifications (CAD, paper based, HTML, PDF, etc.) with Iowa DOT and SUDAS (Statewide Urban Design and Specifications).
3. Research various OO-CAD software packages and make a selection.
4. Develop a prototype model in object-oriented format and link it to certain provisions of appropriate specifications.
5. Obtain user feedback and modify the model.
6. Conduct a study of the operational feasibility of this concept. The operational feasibility would investigate how such an approach would affect the Iowa DOT's standard operating procedures.

INVESTIGATION AND PRIMARY RESULTS

At this point in time, the study has not been completed yet. However, much progress has been made and the investigation shows good indications of usefulness of such a system. The following discussion presents a few key perspectives of the investigation.

Prototype

Several types of images have been used to illustrate the concept and one prototype has also been developed during the investigation. Figure 1 shows how this concept works. This figure depicts a typical cross-section of a roadway. The user is able to point and click on any aspect of the design; a popup menu appears that directs the user to the database containing the relevant specification information for that portion of the design. In Iowa different specifications are used depending on the project type and location. Iowa DOT specifications are used on state, federal, and county highway projects. Urban specifications are used primarily on city projects. These specifications might be different depending on the location in Iowa. For example, Loess soil conditions in western Iowa might require different design requirements than in other parts of Iowa.

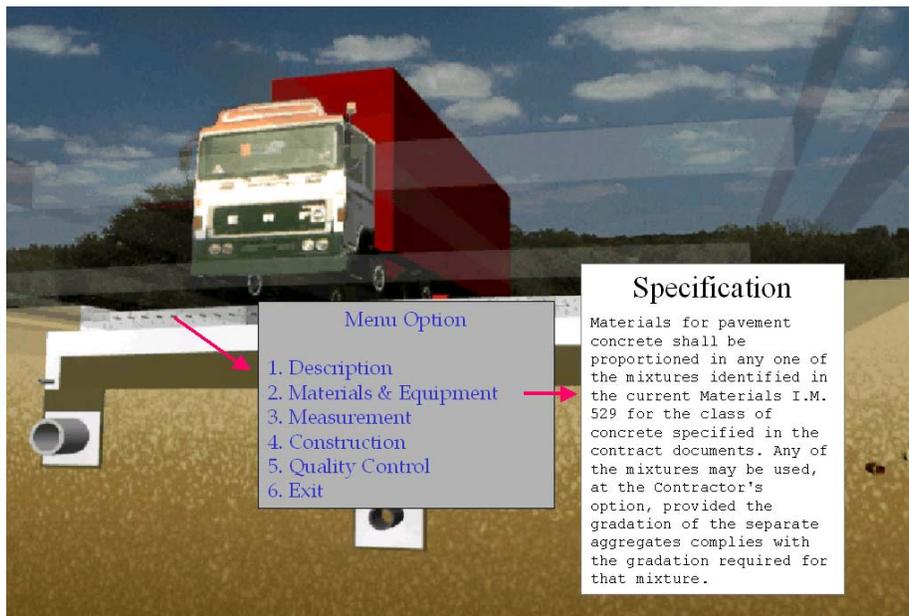


FIGURE 1. Object-oriented Specification Illustration

Figure 2 illustrates the major features of the final product. The system should be constructed by building a repository of high quality, reusable components of specifications, which project engineers can combine in various ways to produce new reusable components at higher and higher levels of abstraction. Therefore, a set of reusable components of specifications are constructed, each of which is built from a few fundamental sub-elements. Specification objects in transportation systems - pavements, base and sub-bases, curbs, traffic pole - store non-graphical data in a logical structure together with the standard graphics that, in three dimensions, are in object-oriented CAD formatted files and are carefully structured and managed. The system accommodates multiple specifications (Iowa DOT and Urban) in one system. The common and different components should be clearly indicated and the relationships should be well established. The system uses an interactive image (middle of figure 2) instead of a movie or picture. The non-graphical data is easy cut and pasted.

OO-specs System



FIGURE 2. Object-oriented System Features

Figure 3 shows an example of a system element—traffic signal poles. The signal pole was constructed by components in three dimensions using Macromedia Director. The image can be rotated, panned, and zoomed. Each component is associated with certain specification information, which is stored in a central database. Users can easily locate information and project requirements from the graphics as shown in the figure.

Mapping

To manage the specification data and the graphics more meaningfully, a mapping technology has been employed in the study. Figure 4 illustrates a mapping flowchart of a traffic signal pole. Mapping means that all the information related to a major component in the specification is pulled out and reorganized into different layers and matched to the graphics. In the figure, the traffic signal poles are divided into traffic signal mast arm poles (TSMAP), pedestals, and signs. The TSMAP, for example, is further split into standards and processes, materials, strength, welding, testing and appurtenances. The details of the specification associated with each of these items will be linked and stored in an external base. The mapping structure functions as a bridge between the graphics and the database.

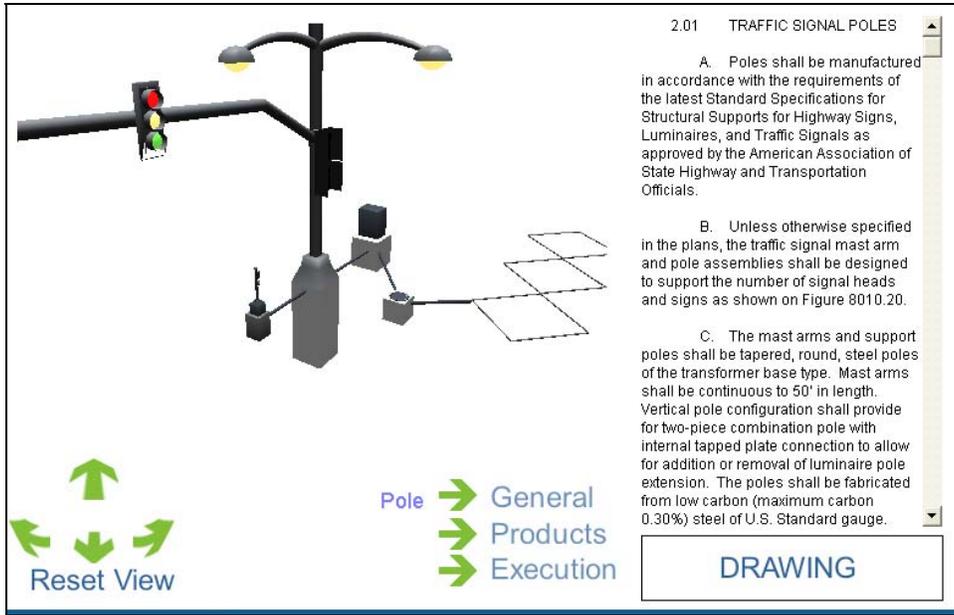


FIGURE 3. Object-Oriented Traffic Signal Poles

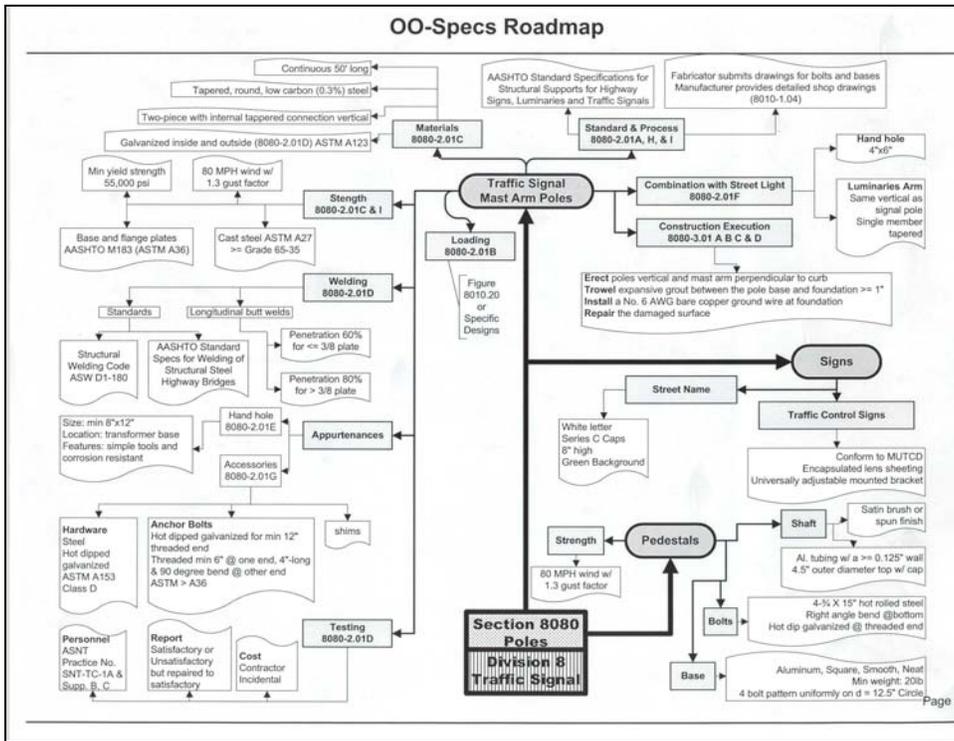


FIGURE 4. SUDAS Specification "Roadmap" (Signal Poles)

User Requirements

The concept and prototype have been presented to the specification committee (designer, contractor, contract engineers, etc.) to gather some end-user requirements and additional meetings will occur later. The primary end-user requirements through this channel are implemented to the prototype model and summarized as follows.

- Design a standard picture/scene to allow the user to get specification information by clicking on the various objects.
- Consider the issues related to updating standards or specifications.
- Use standard features instead of unique features of project.
- The graphics must cover all pertinent specifications.
- The system should facilitate quick decision-making and help new engineers learn.
- The system should be useful to anybody in the civil and construction fields.
- Integrate the various codes and plans.
- Provide a search function for end users.

POTENTIAL BENEFITS

Some feedback has been obtained from designers, contractors, and other engineers. Several benefits are anticipated by developing and applying such an object-oriented specification system.

1. It will be easier for designers, field personnel, contractors, suppliers, and manufacturers to find the specifications relevant for a specific portion of the design. This should improve the efficiency of preparing the design documents and interpreting them in the field.
2. This graphical approach will make it easier for new designers to learn about standards and specifications more quickly.
3. This approach will make it easier to combine both the Iowa DOT and urban specifications as is currently being considered by the SUDAS committee. The specification updating function might ultimately become more centralized, thus freeing up resources at the city and county level to help maintain the system.
4. Additionally, it will help Iowa transportation agencies in maintaining a cutting-edge presence in information technologies since this may be a new paradigm in which projects will be constructed in the future.

However, further testing should be done before drawing the final conclusions.

CONCLUSIONS

This study involves integrating both the Iowa DOT and Urban specifications into one graphical database using OO-CAD for use by designers and construction personnel involved with any type of transportation project in Iowa. This would centralize the specification process, thus, saving on resources and provide a visual format for accessing the specifications. It would also make it easier for designers and contractors to more readily understand project requirements. However, because the study is still ongoing, the formal conclusion should be drawn after the study is completed.

ACKNOWLEDGMENTS

The authors thank the Iowa Department of Transportation and Iowa Highway Research Board for sponsoring this research project. The authors are also very grateful to all the individuals who provided assistance.

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