

An Information Management and Sharing System in Civil Engineering Industry

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Abstract

Civil engineering projects have their own characters, such as vastness, complexity, etc. Therefore, it is difficult for the students to participate in practical projects. But on the other hand, this kind of training is necessary for them. So it is suggested to develop various construction management systems with information and network technology to serve the construction projects.

Being the foundation of our information exchange system, CG-CICC is introduced in this paper. Afterwards, as two case studies, its successful application in Tajima Dam construction project and Sashiki Bridge construction project are presented in detail.

Through the application of CG-CICC system, the relationship between laboratory work and construction projects is enhanced. The knowledge of students is strengthened. Meanwhile, construction projects benefit from universities. Consequently social benefits and economic profits are greatly achieved.

1. Introduction

Because of the speciality (such as vastness, complexity and so on.) of civil engineering, it is difficult for students to participate in practical projects, but this kind of training is indispensable to their future work. Engineering students concentrating on computer applications cannot be isolated from the real practical world of engineering including their familiarity with engineering site and working procedure.

On the other hand, due to industry segmentation and the fierce market competition, collaboration with shared information tends to be difficult. Effective information sharing is rarely accomplished [1]. This supplies more difficulties to our educational activity.

With the rapid development and application of communication and computer technology, human being's styles of life and work have witnessed great changes during the last ten years. How to utilize these new technologies to serve our educational activities is becoming a new question that we must face.

In order to solve this problem, it will be a

breakthrough to develop various construction management systems with information and network technology to help the construction projects. By participating in construction management through the Internet, students can learn some knowledge that is impossible to be gained in classroom. Meanwhile, enterprises can get help from academies to make their construction process more profitable and efficient. New relationship between university and companies is illustrated in figure 1.

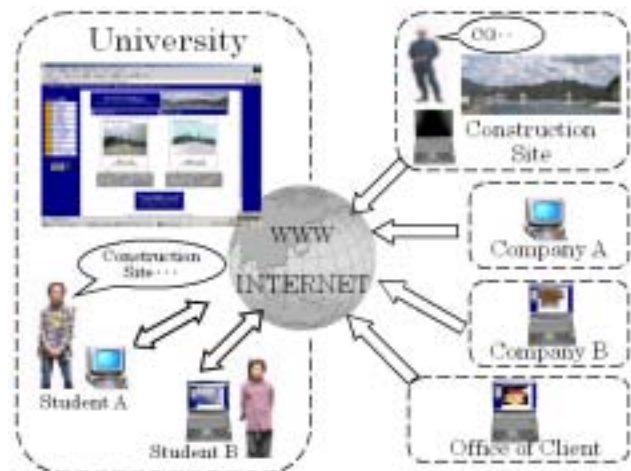


Figure 1 Relationship between university and companies

In our laboratory, researches related to practical projects have been done. As a result, a management system called CG-CICC had been used in Tajima Dam and Sashiki Bridge successfully. This system is proved to be very effective by experiments. It can supply the project construction with many functions, such as simulating construction sites in order to grasp the whole process, finding flaws existed in technique, consensus making for the residents on the project and so on. Furthermore, our construction management system can help administrators, engineers, and workers to exchange their opinions in several information forms.

2. Outline of CG-CICC system

Accurately, this is the application of CG (Computer Graphics) on the Web technology supported system for collaborative construction management. It is based on Collaborative Integrated Communications for Construction (CICC), a European significant application-oriented research and development project. The system is named CG-CICC [2].

Since 1997 the CG-CICC has been developing from our CG researches and Web researches. The CG-CICC aims to: supplying computer integrated communication to construction management, accessing general information of the construction life cycle by visualization; improving the competitive advantage of the civil engineering industry; offering personal information and by the construction CALS/EC share information with digital data (CAD drawings, text documents, photos of the construction site) by unifying general information. All the information unified can be simply interacted in the Web. In this case, distributed members can work collaboratively from different locations using the Internet to exchange general information. Team members using their own personal computers from different locations easily access the database through the network. The system allows members of the construction to access the database faster and easier, delivering precise information. So the primary goal of realization of CICC is to improve information accessibility between remote team members and construction sites. Dispersed participants can work collaboratively as if they were in a same location using the Internet to get information effectively. Though the process of the CG-CICC system differs from CICC in some ways, it has approximately the same orientation and purpose [3].

Information integrated in CG-CICC briefly includes: computer graphics information, CAD information, BBS information, PIF information, photo information, document information and so on.

2.1. Computer Graphics Information (Figure 2)

Computer graphics information is divided as follows:

a). Frame Accurate Animation (FAA)

This animation is effective for the construction management stage. Because FAA cannot be influenced for volume of CG data when it plays, FAA approximately recreates the construction site scene condition and its construction stages.

b). Real Time Animation (RTA)

The animation is effective for building up agreement between related members on construction design stage. RTA can offer site scene free angle and free visual point movement in the virtual world.

These two CG animations work mutually so both CG animations can be used on construction management stage (Figure 2). Moreover, there is no additional cost to

access the CG information except it is necessary to install the offered plug-in Mpeg play software and Viscape5.15 as well.

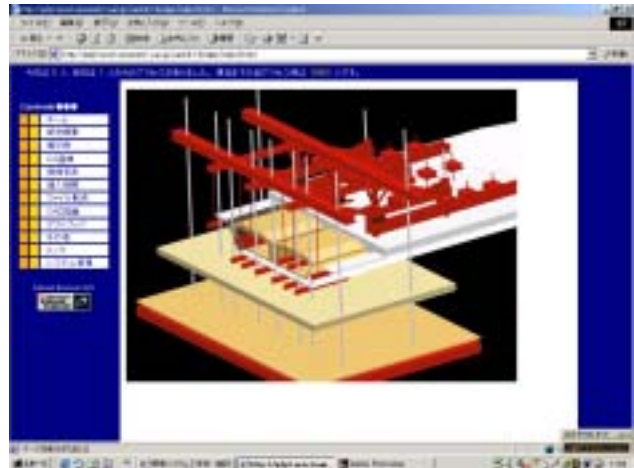


Figure 2 Computer Graphics Information

2.2. CAD Information (Figure 3)

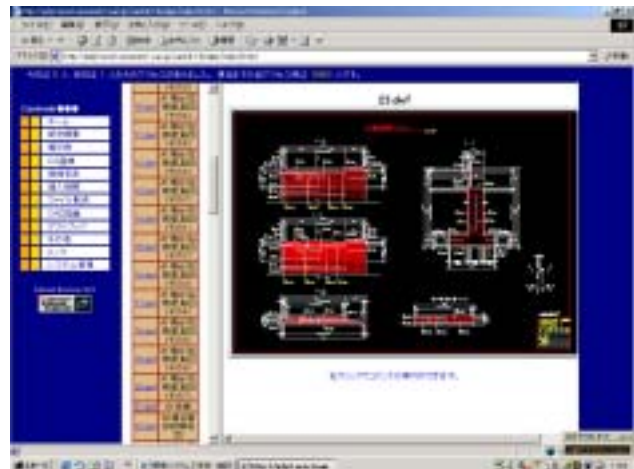


Figure 3 CAD Information

Managing and sharing CAD drawing on Web have been well used in civil engineering and construction field. AutoCAD R14j has functions such as storage the data by DWF (Drawing Web Format), cooperation with browser and attaching URL to figure. DWF is the format released by AutoDesk Company in order to exchange 2D vector data on Web. Converting the 2D vector data for file information limited we achieved the files size to be better adapted during Internet access. Depending on the situation, WHIP (the plug-in program) can be visualized on the DWF file and on the existing browser Internet Explorer and Netscape Communicator. During CAD drawing execution the data can be applied enough for CG information because 3D modification is simply easier to use.

2.3. BBS (Bulletin Board System) Information

CG-CICC related members are located in different remote places and do different works. Because their own business is often outside the bounds of possibility they meet each other in order to communication and exchange ideas. Communication and adjust ideas on BBS is quite important, except for CG-CICC informal information. The BBS information is e-mailed to all related persons automatically because it is convenient for them to check daily activities by the Bulletin Board. Additionally, e-mail system is probably the most single and important Internet feature users expect and very effective to exchange critical information with colleagues so all the related members have up-to-the-minute information. Also, they use the Bulletin-Board facility to search personal history information.

2.4. PIF Information (Virtual Name Card)

PIF (People and Information Finder) or virtual name card introduce the member identity (name, facial portrait, age, field of expertise, professional affiliation and e-mail address), provide general and personal electronic information in order to improve communication among related members. By using the Bulletin Board the user can put their opinions and request a specific person to answer their questions. In the CG-CICC each related member has their own web site with their facial portrait on and PIF registration.

2.5 Photo Information (Figure 4)

The Ministry of Construction of Japan made a statement on revision plans of photograph management standard include cut the number of site photograph for efficiency of work. These prescriptions permitted photographs and JPEG files that used digital camera for submitting. On CG-CICC, 810 thousands of pixel digital camera is used to get the construction site photograph data. Photo information will be versioned up as an album system on web.

2.6. Document Information

CG-CICC deals with PDF (Portable Document Format), the standard document files format suggested by Adobe



Figure 4 Photo information

System Co., Ltd. Unifying format in PDF enable the user to keep and transmit original layout of used document file. Users can search for properties stored on files such as author, subject, file size and date. PDF can be prospected that not only movie, sound and multimedia information can be linked but also can be pasted directly on the file.

3. Two Pilot Applications

3.1. Application in Tajima dam construction Management

CG-CICC system is firstly used in a dam construction project, Tajima dam [4]. Being a part of comprehensive development project of Takano River, it is a multi-purpose dam located in Fukushima prefecture, northern part of Japan's main island. The dam is a gravitational concrete dam, 36.0m in height, 523,000m³ in water storage capacity. It is designed to control floods and provide water supply for drinking and agriculture. The construction lasted from October 1996 to March 1999. The dam construction consisted of different activities such as excavation, existing river rerouting, improvement of riverbed, casting dam concrete and so on. Each work has its own technicians and crews. Extreme effort is needed to coordinate such a variety of specialists. The project should be planned very well. The delay in one activity may cause serious delay in the whole project since the site is located in the snowy region of Japan. The construction work had to be ceased in winter.

In this system, we mainly used computer graphic animation technology (CGA) to implement the following tasks.

3.1.1 Simulation of concrete casting with CGA

Dam concrete casting process was simulated with construction machines moving. As shown in Figure 5, construction crews can grasp work status and the sequence of concrete casting from the bird's eye view. Figure 6 shows the operator's viewpoint from the cockpit of a crane. The operator can check dangerous spots in advance and this ability can be contributed to safety enhancement. Moreover, it can help site engineers to grasp the layout of construction equipments and the status of the schedule. The simulation with CGA can also be used as a tool of safety education.



Figure 5 Concrete casting



Figure 6 View from the crane

3.1.2 Status of temporary construction machines and facilities with CGA

The status of working machines' movement and the arrangement of temporary construction facilities were simulated as shown in Figure 7. In this way, the visualization can help site engineers to manage cost problem. The animation can be used as a tool for evaluating site arrangement alternatively.

Figure 7 Temporary construction facilities



3.1.3 Visualization of lift scheduling with Real-time animation (Figure 8)

The animation visualized the result of calculations. It allowed site engineers to analyze what-if scenarios of lift schedules side-by-side on the same computer screen. The animation enabled to visualize any portion of the casting site at any level of progress anytime from any point of view before actual construction activities take place. Thus, it is easier to find flaws or misinterpretations on the lift schedule since every lift can be three-dimensionally visualized.



Figure 8 Visualization of lift scheduling

Once a problem is found, the lift schedule can be re-calculated with the lift scheduling system and the revised version of the lift schedule can soon be visualized with the animation only by re-inputting the data file. The actual lift schedules tend to be changed due to the weather condition, resource availability and so on. Simply preparing another lift schedule, it can realize a side-by-side comparison on the computer. When there are many available alternatives, the best lift plan can be chosen by comparing them.

3.2. Application in construction of Sashiki Bridge

CG-CICC was also applied to a bridge construction project, which is called Sashiki Bridge and is located in Ashikita district, Kumamoto Prefecture, Japan (Figure 9). The project aims at the development and stability of agriculture by improving logistics. The project emphasizes low manufacturing cost and component quality that could be consistently delivered at competitive prices [5].

Details of the Sashiki Bridge construction project are described as follows [6]:

Description: Construction of 3 clear span extra-dosed pre-stressed concrete bridge.

Length of main span: 225m.

Width of Bridge: 9.25m - 12.25m.

Duration of construction: March, 1998-November, 2000.



Figure 9 Web page of Sashiki Bridge construction

This project consists of the owner of construction site (Ashikita town, Kumamoto Prefecture), investors (Ashikita office, Kumamoto prefecture), construction companies from Osaka, Tokyo and Kumamoto, Ministry of Construction, and CG students from Kumamoto University. As a big team, there is a great deal of information to be exchanged in its daily routine, including administrative and technical information. Adopting criteria that were recommended as information infrastructure by the Construction CALS/EC Investigative Commission of Japan Society of Civil Engineering, CG-CICC is suitable for the construction project well. Meanwhile, this supplies students a chance to be familiar with real project.

System supports the information exchanging among participators, mainly including:

- (1) Comparison and choice of several plans;

- (2) Imitate application of limitation condition to construction;

- (3) Examination of schedule management before an actual construction;

- (4) Modification of schedule management during the construction;

- (5) Confirmation condition of construction works;

In this way, it is possible for participants to examine and revise the project at a distant site. Construction activities on the actual construction site will be more economical and efficient.

The hardwares used in this system are only PC and Internet. The software can be chosen from Microsoft Project 98 and VRT (Virtual Reality Toolkit, a software of Superscape PLD [7]).

Three examples of application are as follows.

3.2.1 Simulation of Re-bar Arrangements of a Pier with FAA (Figure 10)

We visualized the re-bar arrangements of a bridge pier with FAA and helped site engineers in examining better installation processes. The re-bar arrangements of the bridge pier were designed independently among its base, column and beam. By this animation, the engineers decided to place all re-bars in advance on the computer to see where the interference was observed and how they can re-arrange them.



Figure 10 Study of Arrangements

3.2.2 Overall Construction Schedule (Figure 11)

It's important for project participants, such as engineers, workers, clients and local community, to grasp the whole process of the project in the early stages of the construction. In this way, possible flows can be found and avoided in advance. In this specific application, the FAA was created with the function of the bridge structure turned on or off, showing the major work schedule from start to completion. Through the application, the whole process of the project including geographical features was visualized.

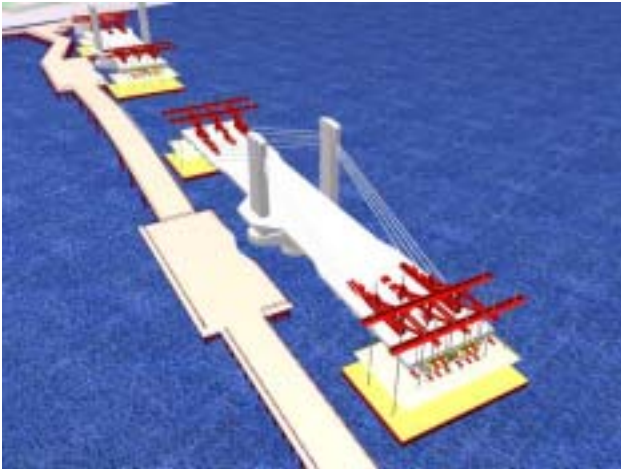


Figure 11 Overall Construction Schedule

3.2.3 Change Order Approval for Main Tower (Figure 12)

In order to express the changing schemes of the construction sequence of the main tower and cantilever construction, FAA was created showing both original and changed designs side by side. It would be critical if engineers found any problem on the construction site with everything set up, such as working space shortage. FAA should be used to rehearse several site layouts of construction by comparing the working space in advance.



Figure 12 Change Order Approval for Main Tower

4. The application significance of CG-CICC

Through the application of CG-CICC system, our students experienced the actual construction project by themselves. They learnt what knowledge the project needs. This will be very instructive for their future work. Meanwhile, their abilities and talents were displayed very well.

Thanks to taking part in practical projects, the partnership between university and enterprise has been

established, and the knowledge of students is strengthened. Consequently social benefit and economical benefit are all greatly achieved. After the application, engineers and administrators showed great interest to our system. They gave high evaluation to it.

But frankly, there are some flaws existed in our system that restrained its usage. For example, it is difficult for inexperienced users to operate the system. It will be necessary to improve the flexibility of our system in future. Another problem of the system is its lack of reality. It will be ideal to introduce the rapider animation such as real-time video meeting system. In this way, users of the system can exchange their opinion without delay.

5. Conclusion

Because of the specialty of civil engineering, it is difficult to establish the partnership between industries and universities. But being a very important scenario, it is indispensable for educational activities. Therefore, as a major breakthrough, we developed CG-CICC. In this way, students became familiar with the real project. On the other hand, the project managers got assistance from academic department. Their competitive ability in the market has been improved greatly. Both of them won their benefits from this CG-CICC.

6. References

- [1] Seigo Ogata etc. "Advantages of Web-technology Supported VM for Consensus Making", The 8th International Conference on Computing in Civil and Building Engineering, Proceedings of the 8th International Conference (ICCCBE-VIII), ASCE, USA, 2000.8, Volume 1, pp.31-38
- [2] Yuji Hoshino etc. "Visualization in Collaborative Construction Management Decision Support System on Bridge Construction Project", The 8th International Conference on Computing in Civil and Building Engineering, Proceedings of the 8th International Conference (ICCCBE-VIII), ASCE, USA, 2000.8, Volume 1, pp.534-541
- [3] Yujiro Hirai etc. "Development and Application of Web-Based Construction Management Support System", INSITE 2000, Hong Kong, 2000.1, pp.887-895
- [4] Yoshihiko Fukuchi etc. "CG Animation for Collaborative Integrated Communications for Construction Management", Journal of Civil Engineering Information Processing System, Japan Society of Civil Engineering, Tokyo, Japan, 1998.11, pp.177-184
- [5] Seigo Ogata etc. "Information Embodiment by Virtual Model for Construction Project", INSITE 2000, Hong Kong, 2000.1, pp.566-574
- [6] <http://gdp1.erec.kumamoto-u.ac.jp/sashiki-bridge>
- [7] <http://www.superscape.com>