Many organizations and departments are involved in construction and improvement projects in railway business, and handoff between organizations at individual work process stages as the project progresses is done mainly by paper diagrams. Such handoff jobs are carried out in a manner that is far from efficient because a large amount of time is put into diagram drawing and modification at individual handoff jobs and data is kept scattered about the individual departments. In order to improve those situations along with the quality of structures, the Frontier Service Development Laboratory aims to build a next-generation construction project delivery system whereby project information at individual departments can be unified and consistently utilized from the conceptualization/planning stage through survey/design, construction and maintenance/management stages while adding new information to the unified information. This article will explain the concept of that system and report past efforts.

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Keywords: Construction project delivery system, 3D CAD, 3D platform, Unification

1 Introduction

Construction and improvement projects in railway business are made up of many stages from conceptualization/planning through survey/design, construction and maintenance, and many people from many organizations are involved in each stage. Handoff between organizations at individual work process stages as the project progresses is done mainly by paper diagrams, and data used is kept by the individual department. That means information being scattered at each handoff and necessary data not being sufficiently and properly distributed, making the current system one of the causes of lower quality and reworking at the construction stage. Time- and labor-consuming paper documentation for diagrams and ledgers at individual work processes is another problem of the current system by which work is done.

Aiming at solving those issues and improving work efficiency and structural quality, we have come up with and defined a new construction project delivery system in this research. We have also identified technical issues to be overcome in efforts toward practical use of that system.

2 Current Status of the Construction Project Delivery System of JR East

Railway construction involves a variety of departments and organizations. For example, in construction for stations, departments directly involved in the construction work include those related to architecture, civil engineering, tracks, mechanical equipment, station facilities, contact wires, lighting and electric power, signaling, communications, and land acquisition and management, as well as maintenance and back-office sections of each of those are also involved.

In the current construction project delivery system, those departments create their own databases to store their own data, and management and handoff are done by paper diagrams. Although paper media has many advantages such as being easy to read, easy to write to, and easy to carry, it also has disadvantages such as needing time- and labor-consuming drawing and modification of diagrams at each stage and being a stand-alone medium with which information distribution and sharing is difficult. Construction using diagrams with insufficient information can be a cause of lower structural quality and reworking. With structures based on more than one design drawing, there have actually been events where inconsistencies between the drawings not detected at the design stage were discovered for the first time at the construction stage, requiring design and construction methods to be revised at the worksite.

Furthermore, the number of personnel in an individual project has been decreasing year by year, so labor-consuming jobs need to be reviewed and streamlined. This is necessary because the same volume of work should be done with a smaller workforce without lowering quality.

In light of these circumstances, we have to improve construction efficiency and structure quality by creating a new system. With such a system, the current paper-dependent jobs must be reduced by computerizing them, details that are often overlooked on the 2D diagrams must be clarified by making them 3D, design accuracy must be improved, and information sharing between people concerned must be facilitated by unifying information management. We therefore decided to establish a new construction project delivery system that utilizes ICT to enable information sharing between the departments involved and consistent information management from the conceptualization/planning stage through survey/design, construction and maintenance stages.

3 Efforts in the Construction Industry

As the productivity in the construction industry is low, it has made many efforts to improve efficiency and productivity of construction work.

(1) CALS/EC

The Ministry of Land, Infrastructure, Transport and Tourism

Frontier Service Development Laboratory, Research and Development Center of JR East Group

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(MLIT) started operation of the Continuous Acquisition and Life-cycle Support/Electronic Commerce system (CALS/EC, Fig. 1) in fiscal 2001 based on the fiscal 1996 Construction Law. CALS Initiative to computerize paper-dependent information and share information over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects. In this context, the objective of utilizing electronic data and sharing over networks for higher productivity and cost reduction of public projects.

The Chubu Regional Bureau of MLIT formed the Society for Construction ICT Studies in November 2008 (which later underwent reorganization), aiming at improvement of productivity, administration service and frontline technology by utilizing ICT. It has been promoting computer-aided construction such as Machine Control (MC) and Machine Guidance (MG) that utilize technologies including Total Station (TS) and Global Navigation Satellite System (GNSS), mainly for large-scale construction work. It is anticipated that those could be applied in the future to a wider range of construction and a similar system could be actively developed and promoted to stages such as design and maintenance/management other than construction.

(2) BIM

The architecture sector introduced the Building Information Modeling (BIM) method in Japan in around 2008. That is a method of applying 3D product models to the total life cycle of a building from design and construction through to maintenance/management, so as to accumulate, share, use, and manage data of individual buildings. BIM has come to be increasingly employed in recent years with the trial use of BIM for MLIT’s own maintenance and repair programs from fiscal 2010 and the start of coordinated operation between BIM software and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE), application of which has been made obligatory by local governments. Use of BIM has is catching on at the stages from planning to construction indeed, but BIM data is not always effectively used for building management and maintenance, because owners and operators of buildings are often different from each other. That is the current issue to be overcome for BIM.

(3) CIM

In light of those situations, Naoyoshi Sato, Vice-Minister for Engineering Affairs of MLIT at that time, advocated Construction Information Modeling (CIM) in April 2012. The aim of CIM is to introduce the BIM method to large construction projects to effectively use information, optimize design, and achieve more efficient management and maintenance, because owners and operators of buildings are often different from each other. That is the current issue to be overcome for BIM.

Fig. 1 Overall Image of CALS/EC

Fig. 2 Concept of CIM
efficient and advanced construction and maintenance work (Fig. 2).\(^6\) CIM was tested with 10 design projects in fiscal 2012, followed up with trial projects in fiscal 2013. Development of criteria for general use of CIM is planned to commence in fiscal 2014, drawing attention to its process and situation.

In order to improve current work processes and enhance construction efficiency and structural quality, we need to reduce paper-dependent work and information exchange through computerization and establish unified information management to facilitate information sharing and utilization among people involved as well. It is desirable to upgrade 2D drawings to 3D ones in conjunction with computerization to clarify details that might be overlooked in 2D drawings, thereby leading to improvement of accuracy of design and construction. We thus have aimed at establishing a system where information kept by individual departments is shared on a 3D platform and information at the stages from conceptualization/planning through survey/design, construction and maintenance is consistently managed. We called that the “next-generation construction project delivery system,” and we explored specific details of such a system.

Fig. 3 is a conceptual image of the next-generation construction project delivery system. Employing this system will enable sharing, distribution, and coordination of information on railway structures between departments and work processes over a network. It visualizes terrain and structures using 3D models and coordinates such visual information with information on conceptualization/planning, survey/design, construction and maintenance/management on the database. That will allow visual images of the finished structure to be shared at each stage and allow identification of any problem in design, construction, and structural details before undertaking actual construction. Furthermore, making the system able to incorporate the results of current technical development for more advanced worksite quality control and construction control will result in more efficient quality control and consequently cost reduction. Those as a whole will achieve higher quality and productivity through life cycle of railway structures.

In order to achieve the next-generation construction project delivery system, we have to establish a 3D platform to share information and the tools to utilize 3D information at each job process. We are now carrying out some projects to achieve those.

Systems for information sharing need to have functions such as those for centralizing information in a unified manner, utilizing information from various sources, and updating and delivering information. In order to improve the current situation where information is scattered, we are now examining a new information sharing system with a view of establishing a 3D platform in the future.

(1) Information exchange and coordination between departments
The information needed in construction and in maintenance/management differ greatly even on the same structure, so construction and maintenance departments have many different types and formats for information on their own databases. But some data, such as design diagrams, is often required by other departments, and such data is passed on as needed. Thus, for smooth information exchange, it is helpful to sort out information to share between departments and establish a new cross-sectional database other than current individual databases. This is done upon investigating the needs of individual departments. We are now discussing the specifications and studying the method to arrange content and store data with the new database.

(2) Coordination with design and construction companies
Information that design and construction companies require from the contractee includes diagrams, criteria, and guidelines. Diagrams are provided by the contractee at ordering, while standards, guidelines and the like have to be the latest versions at the stage of actual work as they are reviewed and revised as needed. However, it sometimes takes time for the latest information to be made available. We therefore believe it would be effective to establish a system for sharing information between the contractor and contractee for timely information exchange. In light of that, JR East started operation of a railway construction information portal site in fiscal 2010, where the latest specifications, manuals, railway construction accident information and more are distributed via the Internet to users. The objective of this site is to distribute information, so it currently does not have a function to exchange design diagrams. But we are now studying sharing use of that site in the future to share 3D data.

(3) Building a platform
Diagrams and data on planning and construction are mainly on paper, with only a part of them computerized. Being paper-dependent, necessary data is often closed data within individual work

Fig. 3 Overall Image of Next-generation Construction Project Delivery System
processes and not distributed, leading to problems. It would therefore be effective to completely computerize all data and build a platform where data can be managed in a unified manner and shared. As an example, maintenance departments have already completed and put into practical use a 3D railway GIS system (Fig. 4) where digitalized city maps and line ground plans are given attribute data such as kilometerage, track centers, stations, and railway facilities. It has integrated diagram control with the maintenance and asset register database and achieved information sharing among the departments involved. We are thus studying building a 3D platform based on that system, in which construction department data can be linked and coordinated.

(4) Unification of data dimensions
3D computerized base data has been created and continuously improved on for topographical data, 3D line ground plans have been introduced for line data, and 3D surveying is often conducted. Currently, however, such 3D data is not used for design or construction; instead, it is converted to 2D data for use. We thus have to develop a 3D model designing method and create a flow of work from 3D surveying to 3D design and computer-aided construction. That will allow the data to be used at any work process, leading to an improvement in efficiency.

6 Efforts in Utilization of 3D Data

JR East group has introduced a computerized line ground plan system. With this system, arbitrarily operable simulated 3D birds-eye views can be created based on topographical data, aerial photographs, and the like, allowing easy identification of topographical conditions of and around railway facilities. As we plan to enhance diagrams by adding product models of structures to computerized line ground plans, we studied whether or not 3D models of structures could be input to the electronic line ground plan system to synthesize integrated diagrams.

Specifically, we unified data of over-track road bridges and the computerized line ground plan data and plotted those on a 3D topographical platform. As those files were in different formats, we converted them, linked attribute data, and then integrated using Autodesk Navisworks Manger by Autodesk. Fig. 5 is an example of the integrated data.

In adding the structure data into the topographical data, location displacement occurred both in the track longitudinal direction and in the vertical direction. This was caused by the difference in adjustment of the roundness of the globe between vendors of the CAD software programs we used. Thus, the larger the distance from the reference point is, the larger both vertical and horizontal displacement becomes. When integrated data on a long structure such as continuous grade separation, the displacement of the location of that structure becomes remarkable and mismatch occurs at the joints with existing structures. We therefore need to discuss standardization of the coordinate system among people concerned to advance information coordination on the 3D platform.

7 Conclusion

Although progress has been made to some extend in developing tools to use 3D data at the individual stages of planning, construction, and maintenance/management, we unfortunately have not reached a point where we can make use of such data in a construction project delivery system as a whole. We will thus make further efforts to create a system that allows sharing, exchange, and coordination of information in construction project delivery as a whole, including maintenance departments and departments related to building and electric other than civil engineering, so as to improve efficiency and reduce costs.

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