Digital Initiatives

Domestic Civil Engineering　Efforts to Improve Construction Productivity and Quality Control

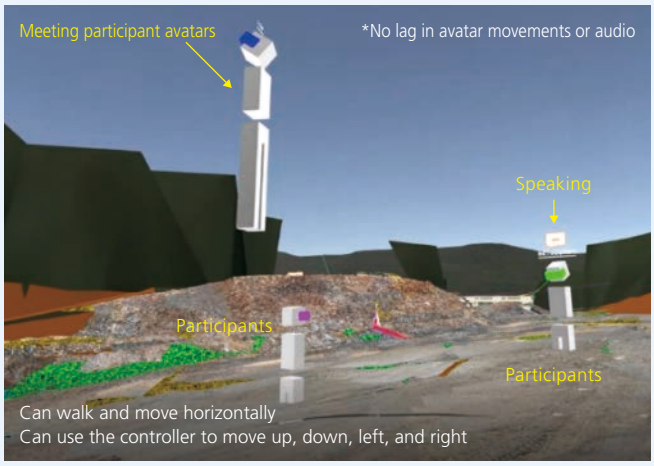
Utilizing the framework of the Cabinet Office's Public/Private R&D Investment Strategic Expansion Program: (PRISM), the Ministry of Land, Infrastructure, Transport and Tourism launched the Project on the Adoption and Use of Innovative Technologies to Dramatically Improve the Productivity at Construction Sites. This project aims to improve productivity and quality control at construction sites by fostering collaboration between construction companies and companies in different industries and sectors, including IoT, AI, and robotics. In addition to supporting i-Construction, which is aimed at improving productivity on conventional construction sites, the project also strongly propels public-private research and development aimed at creating scientific and technological innovation. Penta-Ocean is also actively engaged.

In FY 3/21, consortiums represented by Penta-Ocean were selected in the categories of both "I: Technology to increase construction labor productivity" and "II: Technology to improve construction quality control." A variety of advanced technologies using ICT were tested, centered on the "Penta-Ocean Construction Data Gathering and Sharing System (i-PentaCOL/3D)" at the site of Shitara Dam, which is to be built by Penta-Ocean, in Aichi Prefecture.

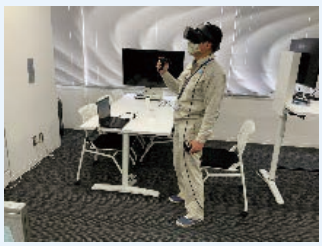
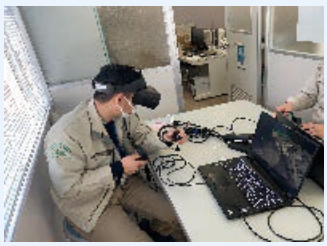
<Consortium Members>
Category I: Penta-Ocean Construction Co., Ltd., Osaka University, K.K. Shoji, Atos Co., Ltd., NIPPON SYSTEMWARE CO., LTD., and NEXTSCAPE Inc.
Category II: Penta-Ocean Construction Co., Ltd., Osaka University Graduate School, K.K. Shoji, and NIPPON SYSTEMWARE CO., LTD.
<Trial Technology>
Category I: Increasing labor productivity　　Category II: Improving quality control
❶ IoT/AI Backhoe　❷ Digital VR Conference　❸ Advanced proof rolling　❹ Surface assessment of soil and soft rocks　❺ Total control of embankment spreading depth

❷ Digital VR conferencing

Clients and construction personnel were immersed in a digital twin reproduction of a construction site, and held meetings in 3D realism
➡ Reduces travel and waiting time for inspectors

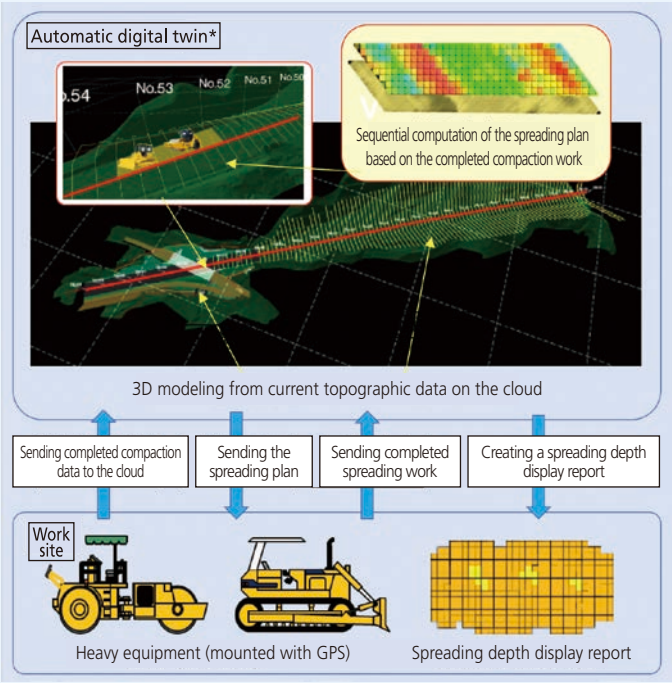


Example of a virtual space in a digital VR conference (earthworks)



Conference participants (earthworks)

❺ Total control of embankment spreading depth

The GPS-mounted heavy equipment has been used to gradually re-engineer the embankment spreading height and totally control the spreading depth
➡ Contributing to the improvement of quality control



*A system that uses IoT, AI, AR, and other technologies to recreate a real-world environment in virtual space and link the real and digital worlds together in real time

i-Penta 五洋施工情報収集共有システム COL/3D

The "Penta-Ocean Construction Data Gathering and Sharing System (i-PentaCOL/3D)" is a cloud system that uses BIM/CIM to collect and share a variety of information on construction sites. It reduces the labor on such tasks and contributes to the improvement of quality control.

The i-PentaCOL/3D system can be customized to fit on-site requirements, and the aforementioned trial technology was developed by improving its functions.

Domestic Civil Engineering　Utilization of BIM/CIM for VR Simulation in Port Construction

BIM/CIM is utilized as a tool for improving productivity throughout the life cycle of infrastructure, including research, design, construction, maintenance, upgrading, and disposal. With BIM/CIM as the core, we centrally manage installation and inspection records, and use data and digital technology to optimize the positioning of skilled workers and machinery in the field, aiming to carry out construction work quickly, accurately, and at optimum cost while maintaining high quality.

<Examples of BIM/CIM utilization at the construction stage>

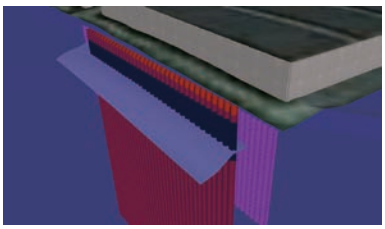
- Visualization (4D simulation made by adding a time axis to a 3D model)
  - Visualizing the situation at the construction site
  - Visualizing the positioning of the work vessel
  - Visualizing work procedures

  } Optimization of construction plan = increased productivity
- Information sharing (sharing visualization data with related parties)
  - Sharing information on the work progress and positioning of work vessels ➡ Safe and smooth operation of ships
  - Linking construction information to the BIM/CIM model ➡ Utilizing the information when maintaining and upgrading the infrastructure

In addition, the BIM/CIM VR (3D/4D) simulations are used for safety training and occupational accident prevention.

Effective Verification Using BIM/CIM Models —Creating an Undersea Terrain Model

We created an underwater topographical model by taking the seabed data obtained by underwater surveys prior to the commencement of the construction, and applying it to the BIM/CIM model. For example, in the case of pile-driving, by making the seabed data three-dimensional in advance, one can better understand the condition of the pile pits (soil layer configuration and ground height). This makes it possible to identify and deal with areas where countermeasures are needed, during at the examination phase, eliminating the need to redo work during the construction phase (e.g., redesign).



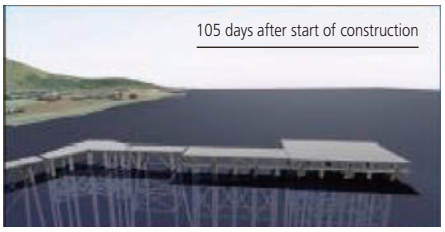
Allowing for Vessel Positioning Adjustments and Confirmation

When using a crane barge in port construction, it is important to consult with relevant parties so as not to impede the safety and smooth operation of ships in the vicinity.

Therefore, in addition to information on the positions and work statuses of the working vessels, the BIM/CIM model includes information on vessels in adjacent berths. This allow for everyone to intuitively understand the positions and relative distances between vessels, thereby reducing labor and increasing the efficiency of coordination efforts.

Preliminary Review of Construction Plans —Increased Productivity Through Front Loading

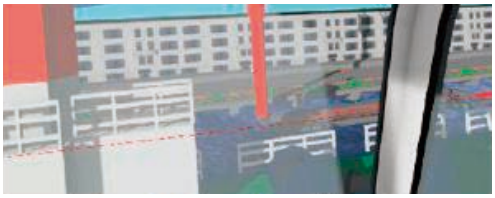
By applying a time axis to the BIM/CIM 3D model, we can create a 4D simulation that can be used for the preliminary review of construction procedures. The construction procedure is visualized, making it possible to check areas of concern before construction begins, such as contact with existing structures and interference with temporary installations, thereby reducing the possibility that rework will become necessary during the construction phase. Additionally, as the simulation enables one to see how the construction site will change over time, it is easier to explain the construction plans to those involved.



Using a 4D simulation to verify the construction procedures

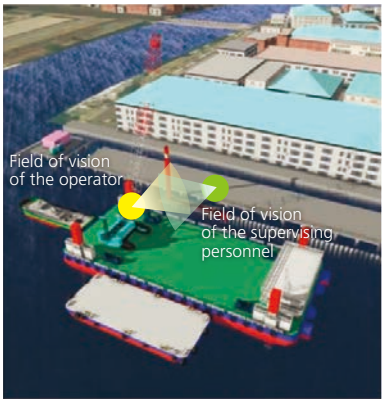
Safety Experience VR —Simulation of Hanging Steel Pipe Sheet Pile or Heavy Machinery Spinning

We carried out a VR simulation, which allows workers to experience a disaster that can occur while operating heavy machinery, namely when a hanging load begins spinning and hits a worker. The simulation was made from several different perspectives, including those of workers atop the guide frame, workers on the platform or crane barge, and employees of the prime contractor who have come to supervise the work. By allowing people to observe the situation from each other's perspectives and share their own views, the simulation raises safety awareness and contributes to the prevention of occupational accidents.



Perspective of the crane operator

Perspective of a worker on the pier



Full view of the work site

Domestic Building Construction　BIM Initiatives for High-rise Buildings

We have been implementing BIM* since 2013, with the aim to improve quality and productivity in building construction. By using three-dimensional BIM models with time axes to simulate construction steps for realistic visualization, we can form a common understanding among parties involved and speed up decision making. In addition, digitized building information is used to ensure consistency between buildings and equipment, to minimize labor in drafting drawings, and to improve the accuracy of quantity calculations.

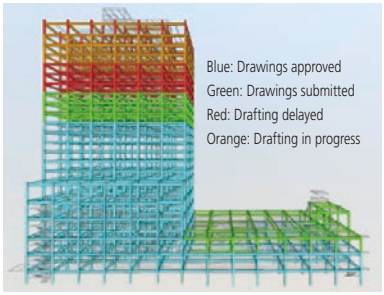
We are currently using BIM in the construction of a full-service hotel in the Fujimi-cho area of Naka-ku, Hiroshima City (provisional name).

*BIM: Application of BIM during the construction stage

(Provisional name) Fujimi-cho, Naka-ku, Hiroshima City
Conceptual drawing of the full-service hotel upon completion

Labor-saving Progress Management with PiCOMS-S

PiCOMS-S, the steel frame construction edition of the "Penta-Ocean Integrated Construction Management System (PiCOMS)," is a cloud system that integrates the management of drafting, fabrication, and construction of structural steel frames, and allows related parties to check the status of progress displayed through BIM in real time. The system is designed so that it can be easily operated with a tablet without any BIM skills or specialized equipment.

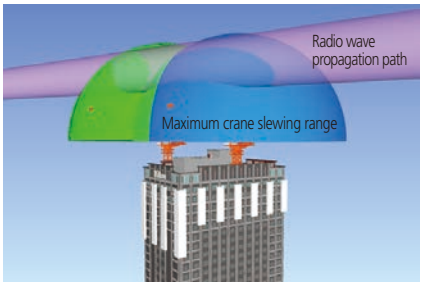


Screen for confirming the progress of structural steel frame works

In this construction project, the schedule for each phase of drafting, fabrication, and construction was determined by consensus among the parties involved through simulation while sharing a PiCOMS-S screen. Each process was checked for timely progress according to schedule, and when delays occurred, causes were identified, improvements were made, and the schedule was revised.

Discussion on a BIM-based Construction Plan: Planning the location of the Tower Crane to Avoid Interference to Radio Wave Propagation Paths

Since there was a possibility that during operation, the tower crane would interfere with public radio waves above the construction site, information on its propagation paths obtained from the broadcasting company was digitized and superimposed on the BIM model for assessment. As a result, it was found that the maximum slewing range of the crane would interfere with some of the propagation paths, but the BIM construction simulation revealed that the construction would not be hampered even if the crane was operated to avoid the propagation paths. We carried out the construction after sharing our findings with the broadcasting company for them to confirm.



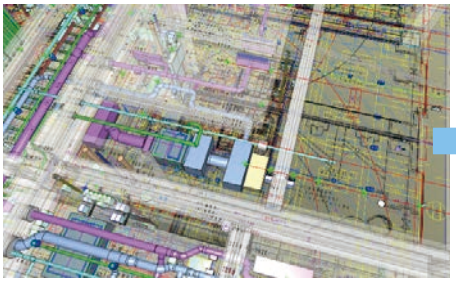
Confirmation of radio wave interference by the tower crane through BIM

Production of Construction Drawings from BIM Models

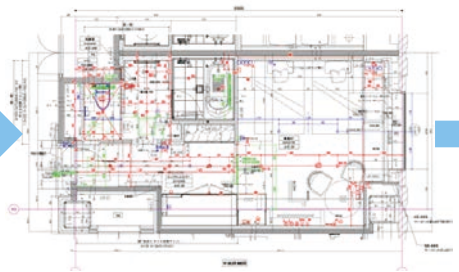
To produce construction drawings, we integrated the BIM models of the building and equipment, adjusted the fit. The construction and integrated drawings were drafted after confirming the fit of each section. Smooth construction work was made possible by producing construction drawings from the adjusted BIM models.

Utilization of Digital Mockups to Determine Finishing Materials

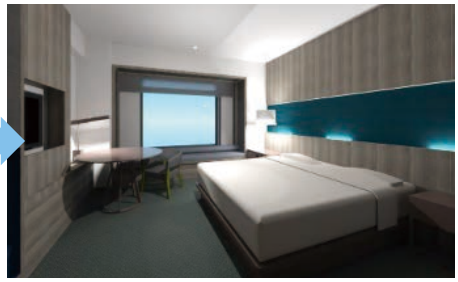
Digital mockups were created by using a cloud-based rendering system by adding information for finishing touches such as interior design, furniture, and fixtures to the BIM model used to produce the construction drawings. Compared to selecting finishing materials using samples for each area, it was easier to grasp the spatial image, and decisions on the materials could be made quickly.



Fit adjustment using an integrated model of the building and facilities



Comprehensive drawing of the guest room plan



Example of digital mockup

Fabrication of Components from BIM Models

In the fabrication of structural steel frames, PC panels for exterior walls, and ventilation ducts, the digital information from the BIM model with finalized layouts was reflected in the fabrication drawings. This has led to a reduction in labor and human error in factory fabrication.

Overseas Coherent Use of Digital Data from Design to Maintenance Management

In Singapore, the digitalization of construction systems is being actively promoted, with BIM for the endorsement of applications being made mandatory in stages since 2013. This trend started with the introduction of BIM and has evolved into the digitization of the entire building process from design to construction. In recent years, the use of digital technology has evolved to include the entire lifecycle of a building, to operation and maintenance.

Integrated Digital Delivery (IDD) is the Singaporean version of construction DX, which refers to the integration of construction work processes and the use of digital technology to connect the parties involved in a project. It is expected to contribute to the efficiency of construction work by utilizing digital technology throughout the building lifecycle: design, fabrication, construction, and maintenance.

Examples of IDD Initiatives —Integrated Management of Design to Construction Using BIM Models

We are also accelerating our efforts in IDD. At Offshore Marine Center 2 in Singapore (construction of the quay area, work yard, and administrative office building), we are working to enhance construction management and improve productivity and quality through integrated data management (including BIM models) for design to completion using the IDD platform.

To reform our workstyles and improve productivity, we will further promote DX, by integrating construction DX in Japan and IDD in Singapore through inter-departmental collaboration, which is one of our strengths.

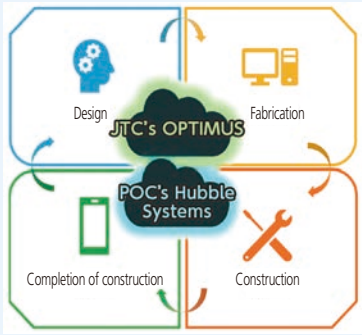
Offshore Marine Center 2 (construction of quay area, work yard, and administrative office building)
(Source: Aurecon Group's website)

Digital Design

Providing stakeholders with optimal designs that meet the client's requirements as well as the requirements of back-end processes (fabrication, construction, and maintenance)

Digital Asset Delivery and Management (digital maintenance management)

Real-time monitoring for building operations and maintenance that increases asset value



Digital Fabrication

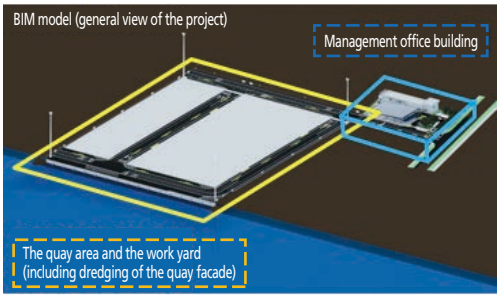
Convert designs into standardized components suitable for factory production

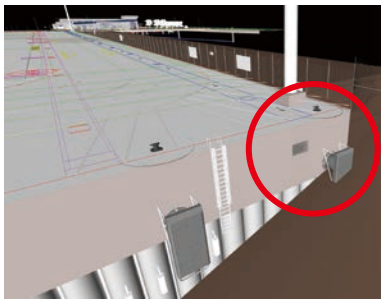
Digital Construction

Real-time monitoring of construction to reduce rework and increase productivity

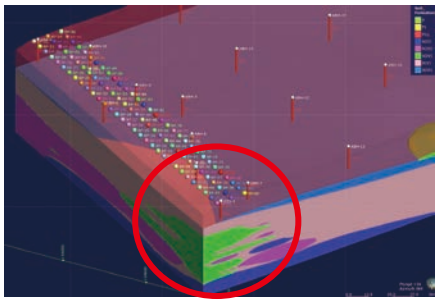
IDD Platform (digital data integration system)

Design Phase —Design Review Using the BIM Model and the 3D Soil Model





Design review and interference assessment using the BIM model



3D soil model created from soil survey records
Visualization of complex and non-uniform soil properties

Fabrication and Construction Phase

Real-time management of the progress of pile production and installation

Record pile production, quality, delivery, and the status of pile driving on an IDD platform by scanning QR codes

IDD platform and QR codes (pile surface)

Linkage between construction records (digital data) and BIM models

Link construction records (digital data) on the IDD platform to the BIM model, to assess progress and construction records on the BIM model

➡Utilization in maintenance management and renewal

Digital inspection Construction records

Dynamo scripting (BIM link program)

Construction record model (pile length and progress update of actual construction)