**Overview**

Conventionally, earthwork in civil engineering projects has been done depending on on-site physical stake markers. Modern ICT-based earthwork technology *1, which is already widely employed in road construction projects, makes stake markers unnecessary as positions are electronically measured by the power machinery using GNSS signals. However, absence of stake markers makes it difficult to visually confirm on-site that if the earthwork is to be completed exactly as originally planned. Use of AR*2 technology allows projecting the three-dimensional design image over the actual view to facilitate earthwork quality control operation.

*1 ICT-based earthwork: Earthwork technology where all the processes from surveying, design, on-site work, inspection through to delivery are implemented based on three-dimensional electronic data

*2 AR: Augmented Reality

**Features**

- **Real-time data sharing**
  Operators and work supervisor with a wearable device can view three-dimensional models and other electronic data in a safe, real-time manner without using hand-held tablets.

- **Efficiency improvement**
  AR technology is employed to virtually project the design data over the actual view, enabling work management fully without using physical stake markers.

- **Productivity improvement**
  Use of this technology cuts the amount of work hours approximately by half in a U-shaped gutter installation project, greatly improving productivity.

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**Difference between conventional and ICT-assisted earthwork**

- **Conventional earthwork**
  - Place stake markers
  - Work by referring to the marker positions
  - Check the completed shape according to the markers

- **ICT-assisted earthwork**
  - Create a three-dimensional design data
  - Work according to the monitor display
  - Check the completed shape using AR

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* No stake markers required
* AR by HoloLens*3

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*3 HoloLens by Microsoft

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**AR image overlay with a wearable device**

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**Operator using a wearable device**

* HoloLens by Microsoft

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**Installation with a wearable device**

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**Projected lines (top of U-shaped gutter)**

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**Operator using a wearable device**

* HoloLens by Microsoft

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Worker Safety Control System “Envital”
For centralized worker health management

"Envital"

■ Overview
Traditionally, worker health management against heatstroke has depended on taking WBGT*1 measurements and reminding the workers to take liquid and salt frequently and to rest regularly, but the tendency to heatstroke differs greatly from person to person and also depending on the work content and location of work being done. Envital is a centralized worker health management system that uses a combination of vital sensors and environmental sensors to measure each worker’s heart rate and obtain the environmental heat index in a real time manner for individualized monitoring of each worker’s condition.

*1 Wet Bulb Globe Temperature: A heat index proposed in US in 1954 for heatstroke prevention

■ Features
● Individualized worker risk level monitoring
The heart rate from the wearable sensor and the WBGT measurement obtained from the Heat Index WatcherTM*2 are uploaded to the cloud to monitor each worker’s heatstroke risk level.

● Cloud-assisted centralized management
The controller can monitor and manage all the workers’ data single-handed. Analysis of the collected data allows precise determination of the heatstroke risk level, triggering an e-mail alert message to be sent to the controller whenever necessary.

● Compatibility with multiple platforms
The system is compatible with a wide range of web-based platforms including mobile devices and PCs.

*2 Heat Index WatcherTM: A WBGT monitoring device originally developed by Obayashi. A proprietary wireless communication network allows centralized data monitoring and management.

■ Implementation records
The system was implemented in 23 work sites covering a total of 462 workers, only one of whom was diagnosed with heatstroke. (This single failure case was a result of negligence to follow the system implementation rules).

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GCP-less UAV
For greater UAV measurement efficiency in earthwork projects
طائرات مسيرة بدون نقاط مراقبة أرضية
تحسين عمليات قياس أعمال الحفر الهندسية التي تقوم بها الطائرات المسيرة

■ Overview
UAV-assisted photograph measurement in earthwork projects has been an extremely time-consuming work as numerous GCPs*1 have to be installed on the ground.

Our “GCP-less UAV” is a UAV*2 technology that employs high-precision positioning data to enable photograph measurement operation to be completed without using ground GCPs.

The system mainly comprises a general-purpose UAV and a PPK*3 processing system and is ideal for speedy geometrical measurements of fills and cuts in road construction projects.

*1 GCP: Ground Control Point
*2 UAV: Unmanned Aerial Vehicles
*3 PPK: Post Processing Kinematics
PPK technology implements correction from the reference point after independent positioning.

Data processing requires the use of the “KLAUPPK” program supplied by Geolink Japan Co., Ltd.

■ Features
● Excellent measurement accuracy
Photograph measurement accuracy using the GCP-less UAV system is assured to be the actual measured position ±50 mm or finer*4 at a validation point. The system sufficiently offers measurement accuracy required for successful UAV-based management of finish shape.

● Productivity improvement
Unlike the conventional UAV-assisted photograph measurement using GCPs, the GCP-less UAV technology does not need the installation and measurement of ground control points and thus realizes 30% improvement in productivity.

● Greater safety
Elimination of on-site GCP installation and measurement tasks contributes to greater worker safety.

*4 The Ministry of Land, Infrastructure, Transport and Tourism specifies, in its "Aerial Photograph-based (Unmanned Aircraft-assisted) Surveying for Finish Shape Management" (Earthwork version), establish that the UAV-assisted photograph measurement accuracy should be ±50 mm or less.

■ Application example
・Finish shape measurement in earthwork project

Measurement operation using the GCP-less UAV system

Overview of GCP-less UAV

Aircraft for GCP-less UAV

Result of photograph measurement by GCP-less UAV

Operation
Special antenna
Correction terminal

GNSS
UAV
30~100m
Operator
Watcher

Obayashi Corporation
https://www.obayashi.co.jp/en/
① Suitable for building high bridge piers: Hybrid Slipform Method

■ Overview
The Hybrid Slipform Method is a frame construction technique designed for making steel-pipe-and-concrete composite bridge piers. A highly rigid steel pipe structure is stood up first to support the operational counterforce, and then the integrated formwork/scaffold unit is moved up and down along the structure with a stabilized mechanism to construct the pier.

The Hybrid Slipform Method helps reduce workload in various pier construction tasks (steel reinforcement assembly, formwork handling, scaffold preparation) and greatly reduces the overall construction work time.

<<Recommended use>>
- 30m or higher bridge piers, especially those located in mountainous or other difficult-to-work areas

■ Features
● Manpower saving
  - The rigid truss-structure formwork unit does not require a separator and therefore can be automatically lifted and lowered by a jack system.
  - Steel PC strands, used in place of tie hoops, are mechanically installed by a self-travelling winder into a continuous spiral shape, significantly reducing steel reinforcement assembly workload.
  - Elimination of intermediate tie hoops further reduces manpower requirement.
● Speedy Construction
  - The favorable characteristics of steel pipes and PC strands enable the work time to be reduced by 20% compared to that of an ordinary elevated formwork system.
  - Steel pipes and reinforcements are assembled in one operation through to the highest level, followed by a series of single-lift-per-day concrete casting operations (single lift height of 1.8 to 2.4 m).

■ Installation records
Successfully employed for highway bridge pier construction projects, etc. (pier height of 30 m to 80 m)

② Suitable for low bridge piers: Hybrid Honeycomb Method

■ Overview
The steel-pipe-and-concrete composite pier system consists of hollow-core hexagonal precast column components and steel pipes, which are integrated to form individual column units. Use of precast concrete components in bridge pier construction traditionally involved operational concerns such as those concerning jointing between components and lift-up weight. The present process solves these concerns by inserting and stacking hollow precast column components around each steel pipe and jointing them in the height direction at a regular interval.

The system offers bridge pier weight reduction, durability improvement and speedy installation.

<<Recommended use>>
- Relatively low bridge piers of overhead bridges in urban areas

■ Features
● Greater durability and earthquake resistance
  - Use of steel pipes improves shear strength and toughness.
  - External protection by factory-fabricated precast column components
● Quality improvement
  - Easily installable and therefore not prone to work errors
● Lightweight
  - The nearly shell-shaped cross section contributes to weight reduction
● Manpower saving and speedy construction
  - Significant manpower saving in steel reinforcement assembly and formwork handling

Steel-pipe-and-concrete composite bridge pier

Steel pipe and reinforcement assembly completed
Slipform system in operation

Connected Steel components
Steel-composite honeycomb structure
Deck Slab Replacement Technology

Slim Fastener

For speedy jointing of precast bridge deck slab components

This technique allows speedy jointing between precast deck slab components in a bridge structure and is ideal for replacing the deck slab on old bridges. Our originally-developed mortar, "SLIM-Crete," reduces the jointing width to approximately half that of conventional jointing technique and also eliminates the need for on-site steel reinforcement assembly work, which significantly shortens the overall work time.

Another advantage is that absence of steel reinforcement joints and other obstructing features makes the structure free from deck slab thickness restriction, allowing greater flexibility and economy in deck slab design.

*UHPFRC (SLIM-Crete) with Compressive Strength of 180 MPa by Ambient Temperature Curing

Its main ingredients include cement-based special powder and ultra-high-strength steel fiber. The product achieves a compression strength of 180 MPa greater can be achieved without special curing and is suitable for both cast-in-place and onsite precast installation. With the superb fluidity, the product self-fills the tightest corners of the formwork (post-cast compaction is unnecessary). The product is designed for more than 100 years of durability against neutralization and salt damages and is about eight times as wear-resistant as an ordinary concrete mix.

**Recommended applications**
- Jointing between precast deck slab of bridges (for installation of new floor base or replacement of existing ones)

**Features**
- **Work time reduction**
  - The shortened jointing width of approximately 200 mm and the elimination of transverse steel reinforcement greatly reduce the overall work time.
- **Lower maintenance and management cost**
  - The joint cross section consisting of multiple shear keys increases the shear strength and adhesion of the joint, effectively reducing gap-opening and cracking risks and consequently alleviating maintenance and management workload.

**Installation record**

Road bridge deck slab replacement project:
- Existing deck slab was removed and a new deck slab was installed and jointed over a section of approximately 150 m. The overall work time was about 30% shorter than that by a conventional construction method (conventional 20 days ⇒ shortened to 14 days).

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Image Analysis-based Automatic Crack Detection
AI-assisted speedy infrastructure inspection

■ Overview
Images of a concrete structure recorded by a special high-performance camera are processed by an AI-assisted image analysis system to automatically and speedily detect concrete surface cracks, accurately determining the width and length of each crack.
The system is designed to allow the recorded data to be easily stored and managed, contributing to manpower reduction in concrete structure maintenance and management operations.

<<Recommended applications>>
Concrete structures (box culverts, bridges, tunnel lining, etc.)

Crack detection example

■ Features
- **Automatic conversion into electronic data**
  - Automatically detects concrete surface cracks from recorded images and determines the crack position, width and length.
  - The crack detection result can be stored as a CAD data (DXF format).
  - Multiple photographs can be automatically stitched to create an expanded image.
- **Greater inspection operation efficiency**
  - On-site work involves crack photographing only.
  - No large-scape equipment such as an inspection scaffold or aerial platform is required, which potentially reduces inspection cost.
  - Use of a special high-performance camera enables photographs to be taken over a long distance (approx. 50 m).
  - The required number of shots can be reduced to about 1/6 of that by a common SLR camera (20 million pixels), further reducing labor cost.
  - The system is designed to facilitate comparison with past inspection results.
- **Enables inspection in dark places**
  - Images can be recorded with existing work light only even in dark places such as the inside of a tunnel.

■ Application records
Have been successfully applied to concrete tunnel lining inspection.

* Image analysis requires the use of “Infrastructure Photo Analysis Cloud Service” supplied by Fujifilm Corporation.
High Durable Concrete with Seawater
Useful for post-disaster restoration or infrastructure projects on a remote island or in other locations where freshwater is hard to come

Overview
This product is designed to be mixed with seawater and uses industrial byproducts (blast furnace slags, fly ash, etc.) and special additives so that strength starts to develop in early stages and will be sustained over a long period of time.

The unique product composition also contributes to quality enhancement such as greater durability and water blocking effect. Furthermore, unwashed sea sand can be mixed into the product. With the use of non-corrosive reinforcement, the product can be used for making steel-reinforced concrete structures. Manufacturing and installation processes are identical to those of common freshwater-mixed concrete product.

This is a first-of-the-world technology developed in and originating from Japan.

<<Recommended applications>>
- Structural construction on remote islands or dry climate areas where freshwater is hard to come by
- Construction work after a natural disaster or in other situations where freshwater is hard to come by
- Structures to be build around rivers, ports and along pavements where both initial and long-term strength is critical
- Structures such as those in a radioactive industrial waste facility where superior water blocking functionality is required

Features
● Greater strength
  - When blast furnace cement is used, the compression strength is approximately 60% better than that of freshwater-mixed concrete.
  - Strength starts to develop in early stages.

● Greater water blocking effect
  - Use of seawater causes the microstructure to be denser than with freshwater mixing, decreasing the water permeation coefficient to approximately 1/70 of freshwater-mixed product and thus achieving greater water blocking effect.

● Steel reinforcement corrosion control
  - Use of non-corrosive reinforcement component enables the structure to be designed in the same way as common steel-reinforced concrete.
  - With the use of epoxy resin-coated reinforcement, a design service life of 100 years is assured.
  - With the use of stainless steel or carbon fiber rod reinforcement, a design service life of over 100 years is assured.

● Cost reduction
  - Use of locally procurable ingredients (seawater and sea sand) makes material cost reduction possible.

● CO₂ emission reduction
  - Use of industrial byproducts and locally procured material can reduce CO₂ emission in the manufacturing process by 50%.

Application records
- Pavement using blast furnace slags
- Prepacked concrete block using concrete debris
- Revetment block for seaport protection

Wave-dissipating block fabrication as part of post-disaster restoration effort
(Soma Port, Fukushima Prefecture)
Next-generation Automatic Quality Inspection System
BIM-assisted speedy steel reinforcement inspection

Overview
All concrete structure construction works require the inspection of steel reinforcement, we must make sure that numerous reinforcement bars are assembled in correct quantity and spacing (pitch) and that the diameter, length and material type of each bar is as instructed in the design drawing. However, it is difficult to clearly indicate the arrangement of all reinforcement bars on two-dimensional design drawings. It therefore used to take long experience to be able to conduct drawing-based steel reinforcement inspection.

This solution is an automatic quality control assistance system assisted with image recognition technology, three-dimensional data capability, BIM and mixed reality.

Comparison of the three-dimensional image shown on a tablet and the actually-assembled reinforcement immediately makes it clear if the steel reinforcement is assembled exactly to the design drawing, minimizing human error risks and significantly reducing inspection time.

Features

● Precision positioning
Use of composite sensor capability enables precision indoor positioning without the use of GPS or Wi-Fi

● Automatic measurement
Number of reinforcement bars, diameter and spacing can be automatically obtained from real-time three-dimensional data

● Productivity improvement
BIM model comparison based on three-dimensional measurement result can expedite the steel reinforcement inspection operation, cutting the overall inspection time approximately by half.

Application records
This system can be used for inspection in various reinforced concrete structures.

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