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Creating the Construction Sites of the Future

[Special Issue]

Hitachi Construction Machinery ICT Solution for Construction & Industry

**Hitachi Construction Machinery Group** 

# **Creating the Sites of the Future**



Digital transformation is now accelerating in all industries around the world.

In the construction industry, the use of digital technology is getting attention as a solution to the shortage of workers, but in practice, it is not permeating much.

We want to take the lead in applying ICT, to solve the construction industry's productivity and safety challenges, and to adapt to an ever-changing market environment.

We present content such as hints for readily deployable ICT applications in construction and an introduction to trends in ICT construction in the world.

# Take the first step in ICT application from the small kaizen that's right in front of you

The use of i-Construction is making steady progress and yielding results. That trend will spread to small-scale and private-sector construction in future. The wave of transformation is coming fast, backed by the rapid advance of technological evolution. For this special issue, we talked to professor Kazuyoshi Tateyama of Ritsumeikan University College of Science and Engineering about readiness for that change.



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**Ritsumeikan University College of Science and Engineering** Professor, Department of Civil and Environmental Engineering Ministry of Land, Infrastructure, Transport and Tourism i-Construction Committee member

### Kazuyoshi Tateyama

Graduated from the Faculty of Engineering, Kyoto University, in 1980. Worked as an assistant professor at the same before becoming a professor at Ritsumeikan University in 2004. Standing director of Ritsumeikan University from 2013. His specialist fields are construction science, computer-aided construction, the development of new construction technologies, and geotechnology. He has been working to streamline construction through the application of ICT, with appointments including Chair of the Ministry of Land, Infrastructure, Transport and Tourism Computer-Aided Construction Promotion Council, and member and chair of the Japan Society of Civil Engineers Construction Robots Committee.

## — i-Construction began five years ago. What results and achievements has it yielded so far?

Tatevama i-Construction started in 2016 with the aim of sweeping away the conventional image of work in the construction industry as difficult, dirty, and dangerous, and making it an attractive industry. One of the aims of i-Construction is to apply 3D design data throughout all stages, from surveying through construction to operation and management, in order to raise construction site productivity. The development of remote inspection, remote control, robots, and other technologies usable on construction sites has been moving forward, with backing from the Cabinet Office's Public/Private R&D Investment Strategic Expansion PrograM (PRISM).

## - Efforts to use ICT to improve safety have also been increasing.

Tateyama Health and safety education, using VR (virtual reality) and AR (augmented reality), has also been expanding and improving. The Japan Construction Occupational Safety and Health Association (JCOSHA) has been databasing real near-miss cases in an effort to identify and share the factors behind occupational accidents, including workload, physical and psychological conditions, and the like. It is about to start developing preventive maintenance systems that use AI to analyze these factors and issue warnings when risk factors are suspected. Venture companies are also moving into this field, and there is a real sense that new digital technologies are spreading through construction sites. That was not envisaged when i-Construction first started.

 ICT construction is applied to around 80% of the civil engineering works under the direct management of the Ministry of Land, Infrastructure, Transport and Tourism. On the other hand, the implementation rate is stagnating in small-scale construction works.

Tateyama One factor is that, considering the investment costs, it is difficult to take the first step into ICT. But rather than applying ICT comprehensively to a series of processes, I think it's important to start by trying out ICT by applying it partially, to just surveying, or just construction. A lot of accessible and convenient ICT Solutions for Construction & Industry are coming out now, such as generating 3D data from data surveyed with a smartphone, or retrofitting machine guidance functions to existing construction machinery. Start from whatever you can, then accumulate your own expertise, and share learned information about good tools and how to use them. It's good enough to start small and gradually spread out.

## **Bigger Jobs With Fewer** People

--- Mindset change is the necessary first step to changing how people work on site.

Tateyama That's right. The change of thinking, from a conventional labor-intensive approach to "safe and easy ways to profit", will propel the spread of ICT transformation.

## - So how will the application of ICT change how people work?

Tateyama Let's take a look at the example of using ICT for snow clearing. It's now getting difficult to find people to work as snow clearing operators. One example, which is still at the develop-

ment stage, is the addition of machine guidance functions etc. to snow ploughs, allowing the use of 3D map data, so that snow clearance work which previously required a two-person team can be done by a single operator. If the application of this technology makes good progress, the benefits of reducing workforce and raising efficiency could be returned to wages. In this way, we should be thinking, more than ever, of "easily doing double the work with one person".

## ---- So it's important to think about how to use ICT to solve problems on site.

Tateyama Yes. For example, discussing what kind of technology to use to reduce workforce and shorten construction times is an important process. Changing to ICT must not be made into the objective. The objective is to identify problems on site and advance discussion of kaizen to solve them. It's important to have the approach of using ICT as a means to that end.

### ---- How should we build that kaizen perspective?

Tateyama I think the "lean manufacturing" that Toyota Motor Corporation systematized to cut away waste between processes is an instructive example. In lean manufacturing, work is classified into the three classifications of ① value-adding work, 2 ancillary work, and 3 waste, and the method cuts the total cost and construction period for the entire process. If we apply that approach to road earthworks, the ① value-adding work is work that is intrinsic to the construction, which means using construction machinery for excavation, carrying, leveling, and compaction. If we try to streamline that, it is necessary to replace the machines themselves with construction robots etc., and major *kaizen* is needed. 2 Ancillary work is necessary to achieve the value-adding work. Here it means surveying, document preparation, and measurement of the finished form. For example, abandoning the hand-written construction blackboard that shows the progress of construction works, and saving onsite work by using a digital version, automatically generating reports from soil loading data, and digitalizing ancillary work, can free workers to focus on their real jobs and reduce overall work quantities. 3 Waste is work that is not genuinely necessary, such as waiting time associated with inspections between processes. Remote environments have spread amid the pandemic, and there is growing interest in "remote presence", by which video is used on construction sites to check things on site. Time for traveling to inspection meetings is eliminated, so this is a good example of reducing waste. Finding inconvenient and tiresome things and applying kaizen connects to the idea I mentioned earlier of "safe and easy ways to profit". — What are your expectations

for the application of ICT to the construction industry in future?

Tateyama In manufacturing, factory automation was advancing in the 1990s, but automation in the construction industry has been left behind. Of course, in contrast to manufacturing, which carries

	Illustration of " <i>kaizen</i> " in re
1	<ul> <li>Value-adding work: Tasks intrinsic to construction</li> <li>Efficiency improvement and labor saving etc. through the application of unmanned construction systems and construction robots</li> </ul>
2	Ancillary work: Tasks necessary for the attainment of value-adding work
	<ul> <li>Surveying, capture and management of site photographs, better organization of document creation, etc.</li> </ul>
3	Waste: Work that is not genuinely necessary.
	• Elimination of waste, such as time for coordination between processes, and time waiting for inspections

on stable production of fixed products, construction has many uncertain elements, such as dealing with the natural environment and not knowing the detailed ground composition without digging below the surface to see, and that has been an impediment. But with the use of AI in future, work will be supported by functions able to make autonomous judgments according to site conditions. Furthermore, I expect to see progress in the AI-based autonomy of construction machinery and in labor saving.

— As the application of ICT and Al move forward, construction will become an industry which even young people find very attractive.

Tateyama As industry-academia partnerships and open innovation get stronger, students in the fields of data processing and electronics, as well as civil engineering and construction, will increasingly see this as an industry to aspire to. In small and medium enterprises, hiring foreign exchange students with strong digital skills might become an option. At this time, as we face a time of major transformation in how we deal with changing to ICT, there should be steady progress in interaction in knowledge and technology. I expect diversity and inclusion to spread and stimulate the construction industry, leading to new innovation.





Otaki I want to help customers to solve their challenges, such as improving safety, improving productivity, and cutting lifecycle costs, through the use of ICT Solutions for Construction & Industry. Hoda I've had a close-up view of customers struggling with problems such as labor shortage, and ICT Solutions for Construction & Industry are the starting point for solving those problems. Kubota I think the purpose of ICT

Solutions for Construction & Industry is to eliminate labor shortages and raise the productivity of the work itself, in construction works of all sizes. When they hear "ICT", I think many people imagine large-scale earthworks using i-Construction, but we offer ICT Solutions for Construction & Industry which can solve smaller problems that are nearer to hand. **Otaki** The Solution Linkage that Hitachi Construction Machinery offers generates synergy effects by linking the solutions to customers' problems, and one of its greatest attractions is that it is a relatively simple way to realize construction DX on site.

Hoda Solution Linkage boosts construction DX that can solve on-site problems in small-scale earthworks and private sector construction works, and we offer a diverse lineup of options.

Kubota For Example, Solution Linkage

# **Hitachi Construction Machinery ICT Solutions** for Construction & Industry fit closely with

customers' challenges

Looking towards the spread of ICT construction to small and medium construction companies, Hitachi Construction Machinery Group is focused on proposing ICT applications that adapt to small-scale construction works and fit closely with customers by facilitating the introduction of ICT construction.

The Client Solutions Group of Hitachi Construction Machinery handles diverse services that use ICT and IoT technologies. Here, the department's members describe its attitude.

Survey can easily manage soil quantities with a smartphone, and Solution Linkage Mobile can easily manage vehicle movements using onboard terminals and smartphones. These solutions are starting points for ICT.

Hoda Many customers are worried that ICT deployment involves large capital investment and, emotionally, that there is a lot to learn. I want them to know that Solution Linkage is a convenient and readily deployable solution tailored to each customer's circumstances.

Otaki When customers just try it and see, we hear many say that starting construction DX was simpler than they expected and solved their site issues. Kubota Site environments are going through dizzying changes. I think ICT

technologies like these are certain to be necessary tools for adapting to change. To that end, I want customers to study what tasks ICT can be applied to, and to accumulate expertise in ICT construction and construction DX in their own companies. We want to serve as a "close and dependable partner" to solve customers' challenges and help them to accumulate expertise.

Otaki In future, we will maintain our attitude to open innovation, promoting collaboration with companies, universities, research agencies, and other bodies with advanced technologies, to adopt superior solutions in service of our customers' construction DX. I think our mission is to achieve growth together with our customers and solve social problems.



"Not hard, dirty, and dangerous" We want to use ICT to solve the problem of "difficult, dirty, and dangerous" and make this an attractive industry!



Client Solutions Group Construction Solutions Divisi Construction Solutions Development Department Solution Development Planning Group assistant manage Kazuki Otaki



lient Solutions Group Construction Solutions Division Product Planning Department, assistant manage



# **ICT Solutions for Construction & Industry** to solve customers' problems

There are countless challenges on construction sites, like "I want an easy way to check on-site progress", "I want less accidents", and "skills are not propagating to the next generation". Now we're going to look at how Hitachi Construction Machinery's ICT Solutions for Construction & Industry solve some typical problems.

We want to try ICT construction, but it looks difficult.

I'm also worried about the introduction costs.



"I want to get started with ICT construction to improve productivity and safety, and also to win more orders. But my concern is whether the results will justify the investment. Nobody inside the company knows much about ICT, so it's hard to take the first step

Solution Linkage Point Cloud makes it simple to convert drone surveying to point clouds



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> With the number of workers in the construction industry falling as the population of working age declines, change is gradually emerging in the industry. One option is the approach of looking to the future but starting ICT with what you can do right now, then gradually expanding applications while enjoying the benefits of ICT.

> Another smart approach is to consider introducing ICT in ways that fit your company's future progress, such as starting by using rented ICT construction machinery to build up expertise around a series of ICT construction processes.

> Another key point of ICT application is to gain the ability to do 3D surveying by drone (UAV) and generate 3D design data in-house. But many companies complain of problems, such as the time it takes to create point cloud data. Hitachi Construction Machinery offers Solution Linkage Point Cloud, our solution that automatically processes the creation of point clouds, which used to take hours, just by uploading drone-captured images to the Cloud. For example, the process to complete deliverables from conventional surveying used to take three days, but in some cases that can be shortened to just one day from drone imaging to finished 3D data. This is an accessible solution which can be started immediately if automated drone flight is possible.

On-site soil volume surveying is the source of many problems. It consumes large work quantities, including time for tasks such as reporting to clients. Solution Linkage Survey is a smartphone-based volume measurement solution that simplifies the whole series of tasks while also providing a quantitative grasp of the situation. It can ascertain the volume (soil guantity) of excavation on a civil engineering site just by shooting video with a dedicated smartphone app. Sharing point cloud data for a site allows people involved to monitor progress and soil quantities on site in real time, even from remote locations.

It is common for time to be spent waiting for dump trucks to arrive on site. Solution Linkage Mobile is a solution for site visualization, to see the state of work on the site and dump truck movement. Dump truck wait time losses can be eliminated by the entry notification function. Functions for tracking numbers of truck trips and for compiling daily reports automatically are highly regarded, and can cut the work required for daily report writing, which used to be a manual task for administrators. Applying ICT to areas which seem inconvenient on site can shorten working times and raise efficiency.





Solution Linkage Survey. Soil quantities can be measured by just taking a smartphone and making a loop around an em

We want to move forward with working method transformation by cutting and rationalizing on-site work quantities.

"We have to allocate working time to the everyday on-site tasks of measuring soil quantities produced and managing progress, and processing documents etc. is a hassle.

We want to raise productivity and adapt to working method transformation, but how can we use ICT for better efficiency?



The New Model 7 Newly-developed machine control raises working speed and reduces operator workload



Solution Linkage Assist is our proprietary machine control function, developed to assist operator control in civil engineering works and building foundation construction. It is implemented on Hitachi Construction Machinery's new ZX135USX-7, ZX200X-7, and ZX330X-7 models of ICT hydraulic excavator. These models are equipped with assistance functions that enable even young workers to work accurately on diverse sites. If the front attachment of a hydraulic excavator approaches a set boundary during slewing, the new area control function slows the movement to a stop, helping to improve safety on sites that are narrow or have obstructions.

also a function to compile and analyze detection information within the site and report near miss information to the administrator. This information enables measures such as sharing near misses and ensuring awareness, and can be used in operator education and safety management situations such as preparing patrol plans and danger prediction activities.

We want to promote visualization and kaizen activities on site and optimize work.

"Couldn't we get a real-time grasp of the actual state of construction, and whether it's proceeding according to the construction plan? We also want to share the site situation and cut out wasteful movement?

As Professor Tateyama pointed out, it is necessary to identify waste in construction and apply ICT to it in order to begin kaizen towards working efficiency. In particular, site administrators must keep track of information in real time and share it with multiple parties concerned with the construction work. We want to use the power of ICT for that

Solution Linkage Work Viewer is a solution for using a smartphone to keep track of hydraulic excavator work processes. Video from a 360° camera and front camera mounted on the machine is recorded to a recorder. The videos can be viewed on a smartphone that connects to the recorder.

Solution Linkage Work Viewer Cloud dedicated communications unit can be retrofitted to allow immediate remote sharing of the on-site situation to anywhere. That function can support progress management from anywhere, even an office away from the site. The recorded video is time plus video (fast-forwarding at 15x speed), so that work in an eight-

> hour day can be reviewed in around 30 minutes, to keep track of changes during construction. Details of construction work can be conveyed quickly and accurately to interest parties off site.



## We want even younger workers with little experience or proficiency to be able to work safely and correctly

"Operating a hydraulic excavator is complicated, so working efficiency and result quality are affected by operator proficiency. Operators get older, and it takes time to get young workers ready for duty...'

The Aerial Angle Step IV operation assistance system, new on sale now, is an option for the ZAXIS-7 Series that helps to reduce damage from contact with machines and obstacles. An administrator using a Solution Linkage Alert Viewer that is linked with Aerial Angle Step IV can receive notifications when any object is detected within the working range. There's





Area control is a function which automatical ly reduces speed to a stop when a set boundary is approached. That reduces the burden of watching surroundings for operators.



## — Case Study of Use Between Japan and Overseas —

# What's happening? Overseas ICT construction

i-Construction is leading the way for the gradual spread of ICT construction in Japan. Advanced ICT is also in use in Europe. We can look for hints to possible applications by comparing how ICT construction is evolving in Japan and overseas.



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> We work from the sustomer's position to openly propose ways forward for ICT application!

Hitachi Construction Machinery Europe Solution Linkage Manager Ryo Kurihara



## How is ICT construction spreading?

### Japar i-Construction is speeding the spread of ICT

In Japan, where there is a shortage of workers in the construction industry as a whole due to the shrinking working-age population, and social infrastructure is deteriorating, i-Construction was launched in 2016 as a government-led initiative to raise productivity on construction sites. It aims to introduce ICT into the whole series of operations from surveying through design to construction and management. The use of ICT construction is spreading in public works projects under the jurisdiction of the Ministry of Land, Infrastructure, Transport and Tourism. In 2018, the application of Al, the IoT, and other new technology as an element in the Cabinet Office's Public/Private R&D Investment Strategic Expansion PrograM (PRISM) accelerated efforts to raise productivity in construction-related work. These technologies are expected to be even more widely applied to private sector construction works and small-scale construction.

### Global Centered in Europe, with BIM/CIM as the mainstream.

Advanced ICT construction is also in use in Europe. Finland and Norway face emerging problems similar to those in Japan, such as shortage of skilled engineers and difficulty improving productivity, so they moved guickly to deploy ICT construction in the 2000s. In the UK, semi-autonomous operation technology is being applied to raise productivity and safety by strengthening assistance to experienced operators, and the use of drones is reducing on-site personnel. That trend is also expanding in France, Germany, and Holland. The private sector is characteristically leading ICT construction to save labor and raise efficiency

BIM (Building Information Modeling)/ CIM (Construction Information Modeling) is making particularly rapid progress overseas. This is a platform for using 3D data from the planning stage of buildings to computerize the whole series of construction-related processes. It has become the norm in project management in Europe. In the UK, BIM is mandatory for the design and construction of civil engineering and building projects above a certain size that are ordered by government offices. BIM is moving towards becoming mandatory in many European countries. In Singapore, electronic submission using BIM is mandatory for all applications for confirmation, and the same trend is spreading around Asia. Japan is at the stage of starting to apply such measures in earnest.

## Topic\_ (2)

## An attitude of "getting closer to the customer" is in demand around the world

Trends towards falling working-age population are also under way around the world, while demand for safety assurance, higher productivity, and lifecycle cost reduction on construction sites is rising. Hitachi Construction Machinery is aligning itself with such calls and focusing its efforts on expanding and supporting ICT functions which raise safety and productivity through simpler operation. In Europe, technical support for ICT construction is commonly provided directly from surveying equipment manufacturers to their customers. In that context, Hitachi Construction Machinery UK is training "HCT\* engineers" as ICT specialists, and providing setup and general support for ICT construction machines and their attachments. Customer attitudes and skills for ICT vary between countries. It is important to have an approach of providing support adapted to issues, through communication based on correct knowledge and experience \*Hitachi Connected Technology



## Efficiency improvement in construction management through the use of data

Equipping construction machinery with mobile communications system and applying telematics technology to monitor positions and performance, is advancing rapidly in Europe and North America as an element in DX. On real construction sites it is not uncommon for machines from various manufacturers to be mixed together, but centralized tracking and checking of data from all machines is essential. To meet that need, Hitachi Construction Machinery Europe and the major telematics company ABAX are developing a proprietary operation management system (illustrated below). At the same time, they are working with Hitachi Construction Machinery to develop an API (Application Programming Interface) to achieve optimization of data management with machinery. These systems interconnect, so that customers can receive every 10 minutes the data that they used to receive every 24 hours. Users have this fleet management solution, which does not dictate any choice of devices, so they can keep track of location and operation information about all their construction machinery, tools, vehicles, and other assets. This system can also be linked to remote monitoring by Con-Site, which is Hitachi Construction Machinery's service solution, to visualize fuel consumption and CO<sub>2</sub>, as a way to meet the need for machine lifecycle cost reduction.

Major general contractors in the UK use the API to enhance on-site ef-

ficiency and reduce life cycle costs, and they have actually succeeded in cutting idling time and fuel consumption. Demand is also expanding rapidly in France, and the API is used in stone crushing sites. Construction management is becoming more efficient and advanced around the world.



Hitachi Construction Machinery Europe's fleet management solution

## Topic\_ (4)

## Trends in ICT construction machinery





i-Construction has been spreading, and ICT construction machinery is now being introduced on many construction sites. There are two categories of ICT construction machinery: Machine control (MC), which uses 3D design data to automatically control machinery through construction in real time, and machine guidance (MG), which uses positional information to support operation. This ZAXIS200X hydraulic excavator by Hitachi Construction Machinery, which is equipped with ICT functions, is a well-trusted machine, widely used by customers around Japan, on both a rental and a purchase basis. The ZX200X-7 is its latest version. Hitachi Construction Machinery's machine control technology, which is the distillation of control technologies, can achieve high-precision work, regardless of the operator's proficiency level. The ICT hydraulic excavators which Hitachi has been supplying in Japan are now in use in demonstrations around Europe, as Hitachi aims to spread into the European market.





hydraulic and drive equipment in line with that judgment. Hitachi Construction Machinery uses these platforms, which have great potential for scalability and growth, to accelerate the development of autonomous construction machinery while adding and scaling functions to meet the needs of its current customers. Expectations are also growing for remote control as a way to ensure operator safety and achieve remote work on construction sites, and also for operation in disaster areas where people cannot enter. Hitachi is focusing its efforts on developing transmission channels to connect between sites and remote offices. It is working on proving trials of Solution Linkage Wi-Fi wireless LAN and equipment, which allows a single operator in one remote control chair to work over a regular 5G line and switch between multiple machines, picking the right one for each task. Preparing for the coming construction environment of the near future.

The favorite ICT construction machinery is different ir every country!



## A tilt rotator is essential

Global

In Japan it is common to change construction machinery to suit the content of the task. In Europe, in contrast, multiple attachments are used on the same hydraulic excavator to suit the task at hand. In that context, it is seen as common sense by now to equip them with a tilt rotator. A tilt rotator is an attachment for a hydraulic excavator that makes diverse tasks possible by rotating the bucket to any desired angle. Construction work in confined spaces is common in Europe, so this attachment is particularly well liked for making it possible to work efficiently without any action at the controls. In France, it is widely used for tasks such as forming slope angles and excavating ditches while checking the depths of gas pipes. This function is usable in a wide range of situations, and it is good for the environment because it leads to enhanced working efficiency and better fuel economy on site. with fewer bucket changes. Hitachi Construction Machinery UK, moving fast

to meet widespread demand for adaptation to ICT, supplies products such as ICT hydraulic excavators which work with tilt rotators and machine control





Expectations are rising for autonomous operation of construction machinery as a way to ensure safety while raising productivity by saving labor. Hitachi Construction Machinery paints a picture of the future of construction sites with the concept of "harmony between people and machines". It has developed autonomous construction machinery, and the "ZCORE" system platform, which facilitates functional expansion. This approach uses mechanical systems to handle the series of processes of recognition. judgment, and execution by the on-site operator. "ZCORE" has two main components. The data processing platform gathers information from various onboard sensors and communications networks and makes judgments. The vehicle control platform controls optimum movements of