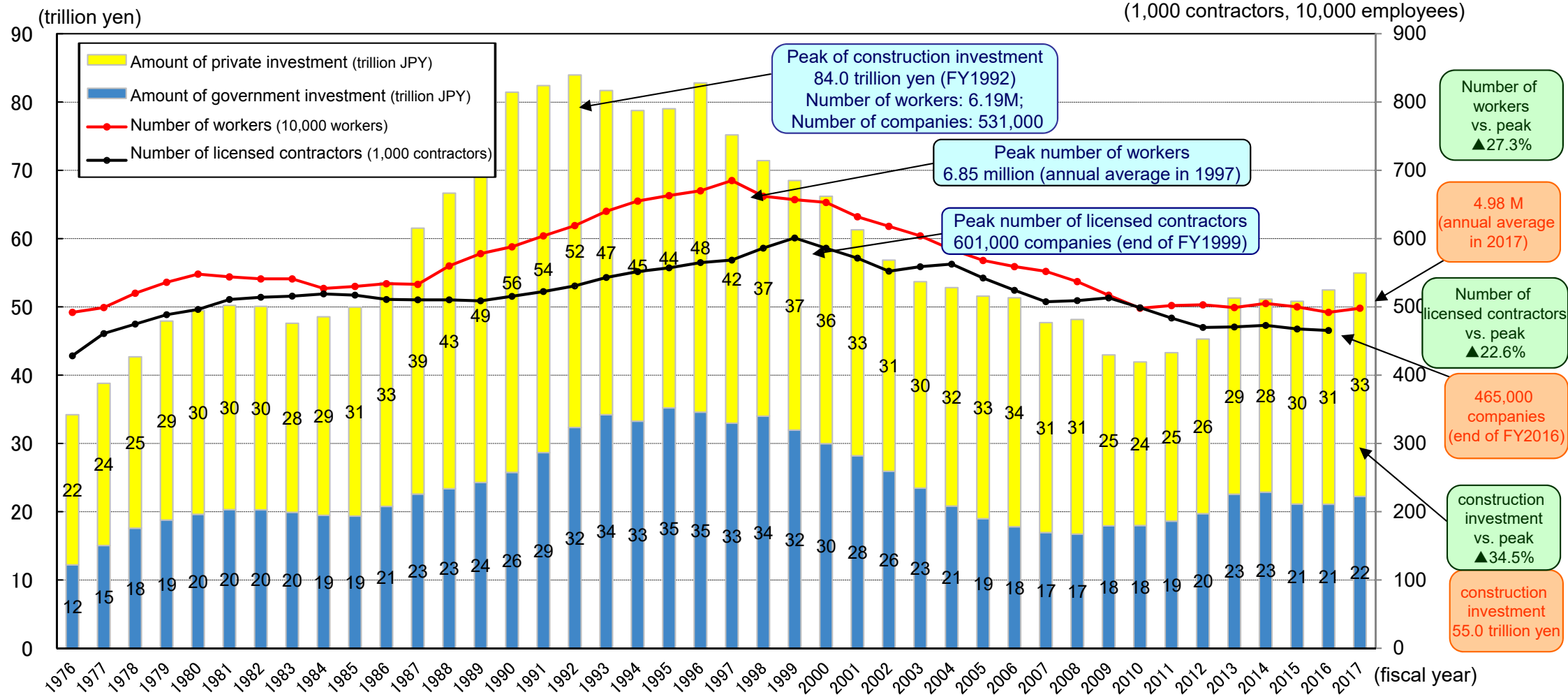
Trends in construction investment, the number of licensed construction companies, and the number of workers in the constrcution industry.

○Amount invested in construction decreased from peak of approx. 84 trillion JPY in FY1992 to approx. 41 trillion JPY in FY2010. It then increased, and is expected to reach approx. 55 trillion JPY in FY2017 (approx. 35% down from the peak).
○The number of workers in the construction industry (annual average in 2017) was 4.98 million, approx. 27% fewer than the peak (average in 1997).
->From a macro perspective, there is no issue regarding construction works for the time being.



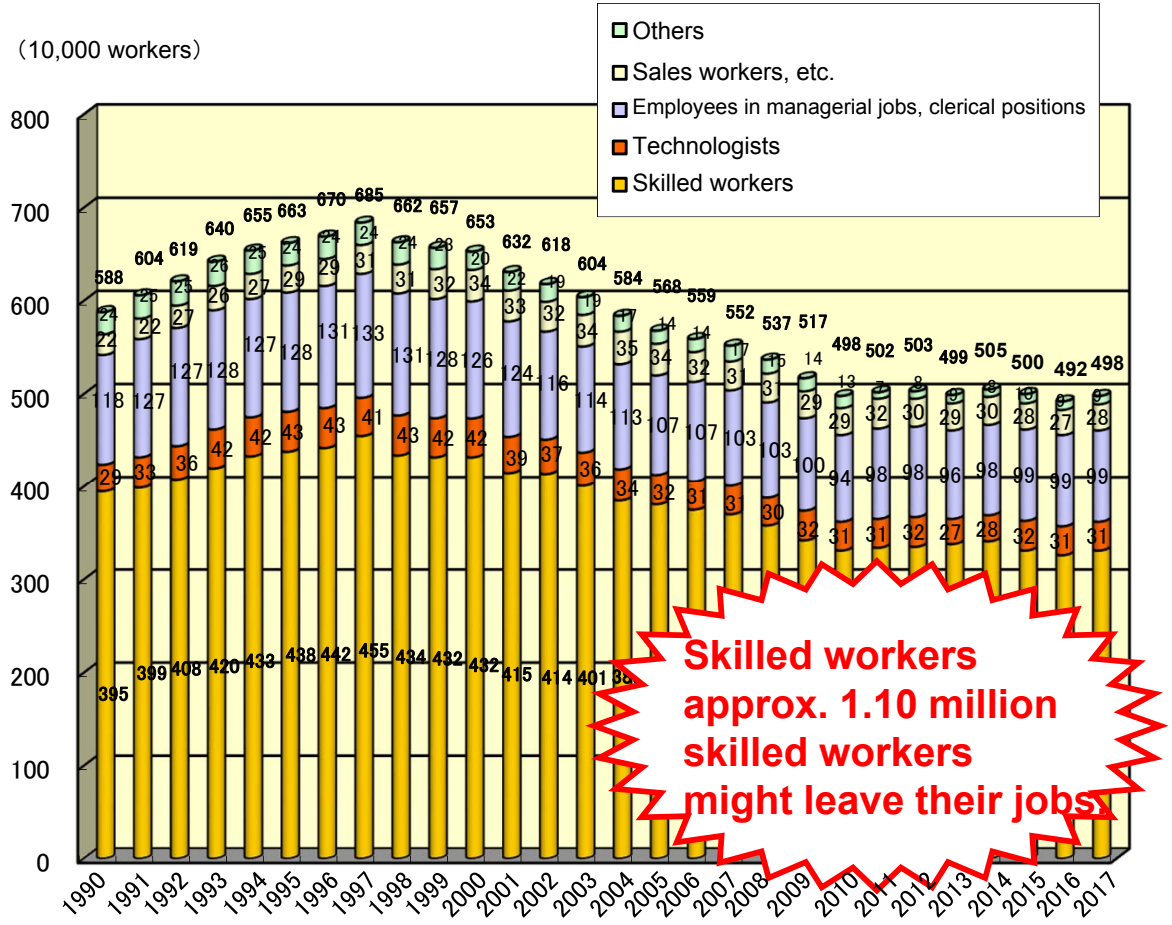
Sources: "Construction Investment Forecast" and "Survey of the Number of Licensed Construction Companies", Ministry of Land, Infrastructure, Transport and Tourism; "Labour Force Survey", Ministry of Internal Affairs and Communications
Note 1: Investment values through FY2014 are actual. Figures for FY2015 and FY2016 are estimates, and figure for FY2017 is forecast.
Note 2: The number of licensed contractors at the end of each fiscal year (end of March in the subsequent year).
Note 3: The number of workers: annual average. FY2011: values for three prefectures affected by the disaster (Iwate, Miyagi, and Fukushima), retrospectively estimated from population estimates based on results of FY2010 national census.

Current status of workers in the construction industry

Trends in skilled workers, etc.

30% down

- ○Workers in the construction industry: 6.85M (H9) → 4.98M (H22) → 4.98M (H29)
- ○Technologists: 0.41M (H9) → 0.31M (H22) → 0.31M (H29)
- ○Skilled workers: 4.55M (H9) → 3.31M (H22) → 3.31M (H29)

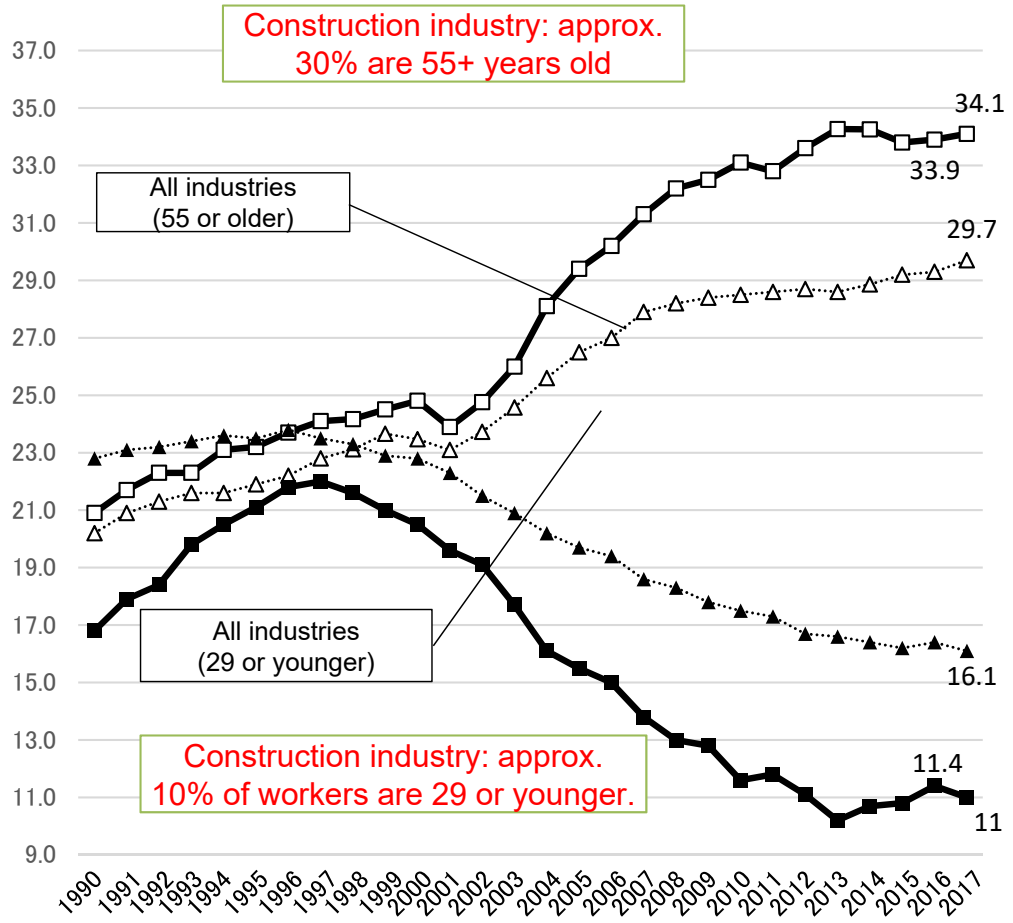


Source: Calculated by MLIT based on "Labour Force Survey" (calendar year averages), Ministry of Internal Affairs and Communications.
(*Data for H23 are estimates due to the Great East Japan Earthquake.)

Demographic aging of workers in the construction industry

○ The construction industry workforce is aging, with approx. 34% being 55 or older, and approx. 11% being 29 or younger. The passing on of skills to the next generation is a key challenge.

* Based on the actual numbers of workers in the construction industry, workers 55 or older increased by approx. 30,000, while those 29 or younger decreased by approx. 10,000.



Source: Calculated by MLIT based on "Labour Force Survey", Ministry of Internal Affairs and Communications.

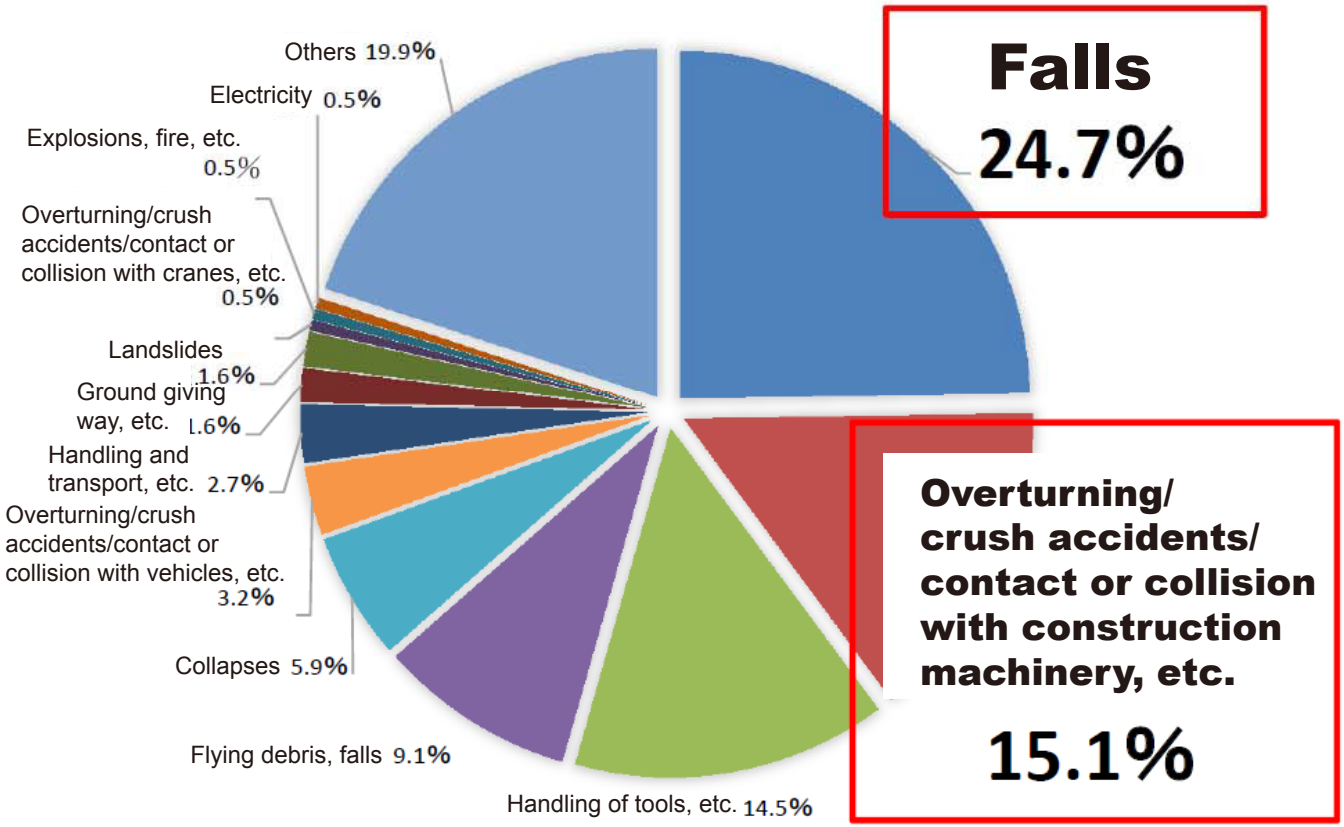
There are still many labor accidents at construction sites.

○Fatal accident rate is 2x that of all industries
(approx.0.5% of annual workers (c.f. approx.0.25% in all industries))
○Accidental contact with construction machinery is the second largest cause of accidents after falls.

Comparison of fatal and injury accident rates

*Deaths and injuries per 1,000 people per year

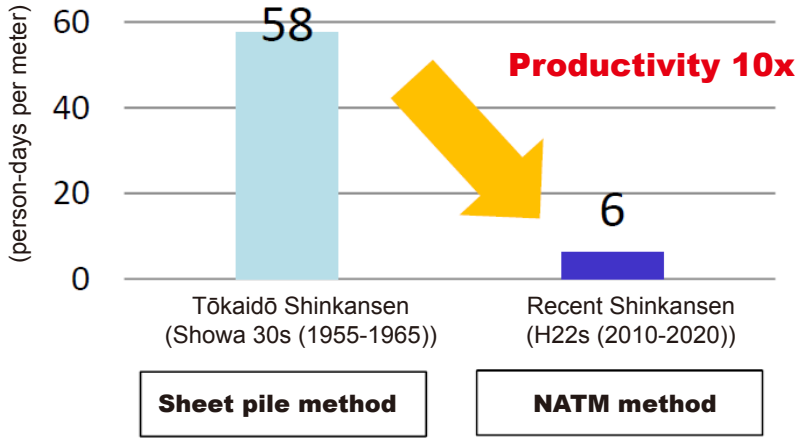
Cause of labor accidents in the construction industry



A major opportunity to improve productivity

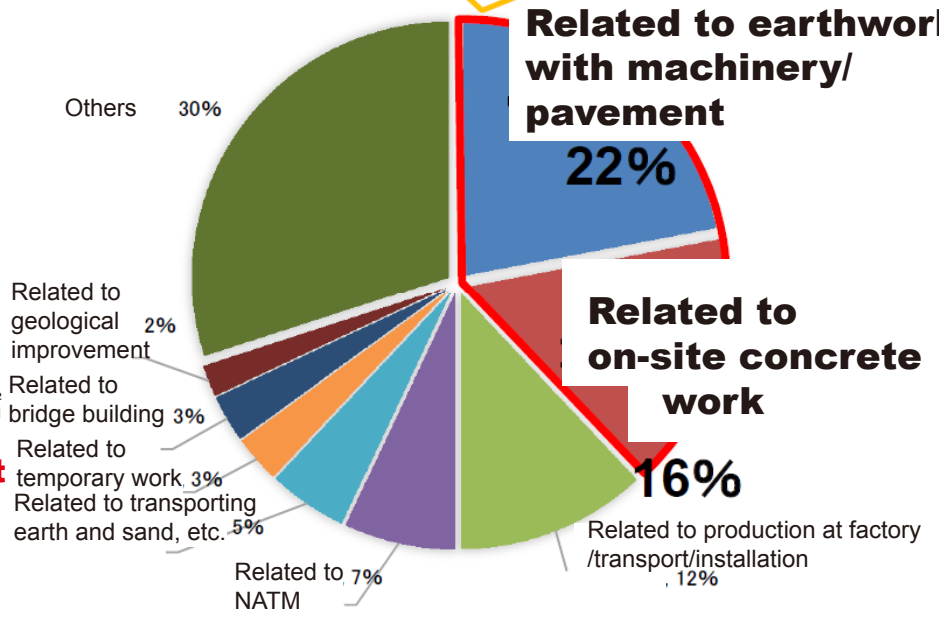
○Productivity in tunnel construction, etc. has increased by up to 10 times over approx. 50 years. On the other hand, room for improvement still exists in construction, concrete, etc.
(construction and concrete workers account for approx. 40% of all skilled workers in directly controlled construction.)

■ Tunnel construction



Source: Construction innovation, Japan Federation of Construction Contractors

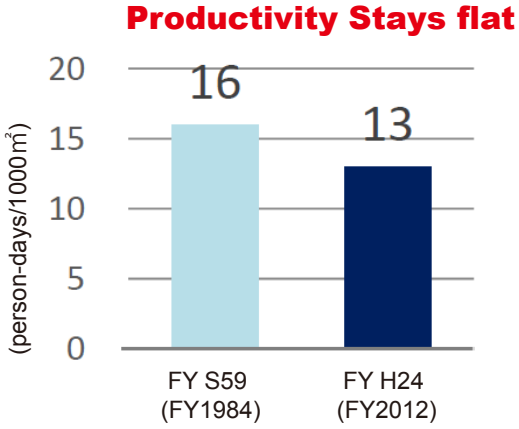
"earthworks with machinery"/" related to on-site concrete works" account for 40% of the total.



Construction works designated by the MLIT in H24 (2012) (actual)

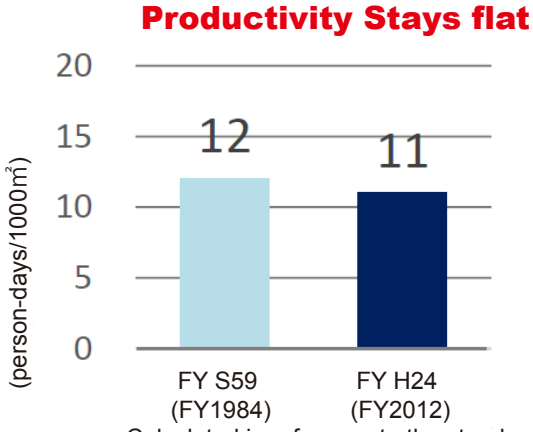
■ Earthworks

Number of workers required per 1000㎡



■ Concrete works

Number of workers required per 100㎡

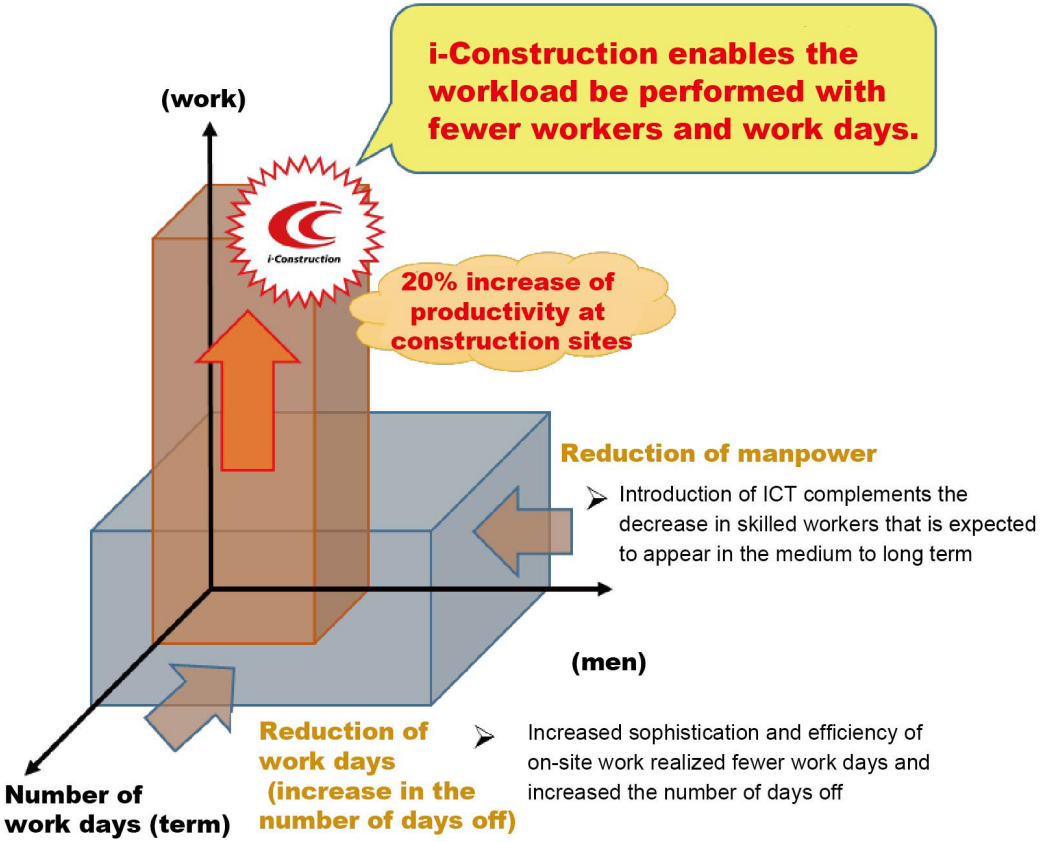


Calculated in reference to the standard productivity

i-Construction - Improve productivity in the construction industry -

○At the Future Investment Committee held on September 12, 2016, Prime Minister Abe announced the policy of achieving 20% improvement in productivity at construction sites by FY2025, towards a "revolution in productivity at construction sites" as part of a fourth industrial revolution.
○Towards this goal, within 3 years, introduce new measures such as drones, etc. for surveying at public work sites such as bridges, tunnels, and dams and connect all processes by 3D data, from construction to inspection.
○With such initiatives, erase the traditional "3K" negative impressions, and attract various human resources to solve the labor shortage as well, thereby improving work sites across the nation dramatically, towards a "New 3K" (good wages, days off available, and with hopes).

[Improvement of productivity]



At Future Investment Committee, Sept. 12, 2016

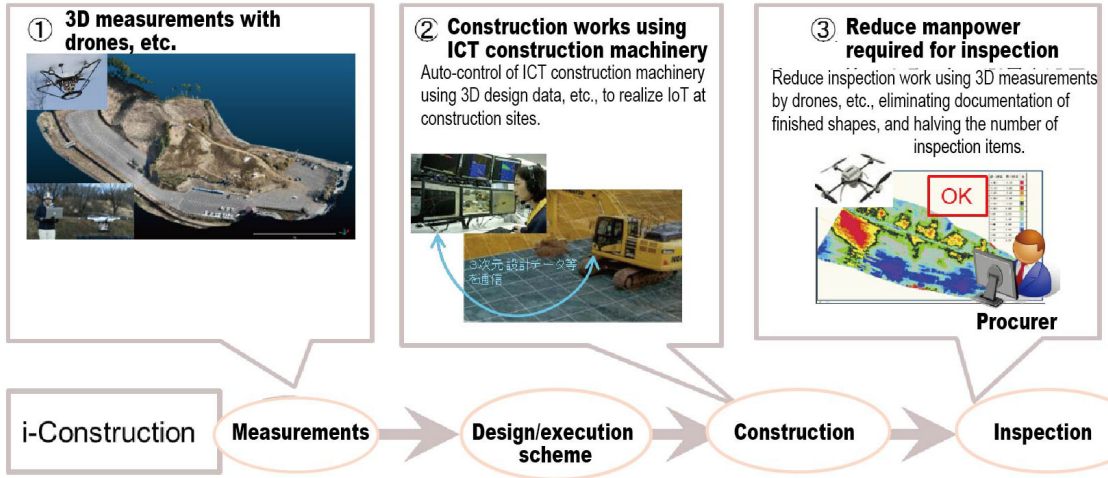


Image of ICT application to earthworks (ICT earthwork)

i-Construction Top Runner Program (H28 -)

Full use of ICT (ICT earthwork)

○Fully use ICT for all construction processes including research/survey, design, construction and inspection.

○ Compile 15 new standards and estimation criteria in order to utilize 3D data.

○For large-scale government earthworks, utilize ICT as specified by procurer. For mid to small scale earthworks, ICT earthwork is possible upon contractor's request.

○All ICT earthworks, after booking necessary costs, will be given extra scores at the evaluation of construction.

[Use case of ICT at construction sites]

《3D measurement》

Reduce the number of days required for survey by utilizing drones, etc.

《3D data design》

Automatically calculate construction volumes based on differences between measured 3D point cloud data and design drawings.

《Construction with ICT construction equipment》

With 3D design data, etc., auto-control ICT construction machinery to realize implementation of ICT at construction sites.

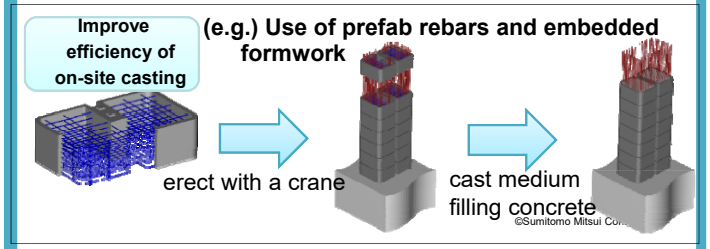
Introduce "full optimization" (standardization of concrete works, etc.)

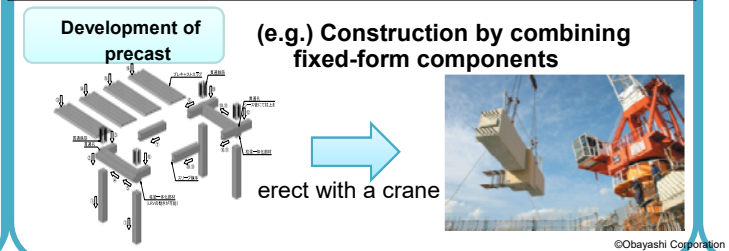
○In order to optimize the whole process including a series of production processes such as design, ordering, material procurement, processing and assembling and maintenance management, introduce the concept of full optimization and aim for better supply chain efficiency and improved productivity.

○In 2016 (H28), draw up a guideline for the use of mechanical rebar reinforcement and concrete with improved fluidity.

○Accelerate factory production of precast products and prefab rebars by setting standards (size, etc.) for parts, with a goal of cost reduction and productivity improvement.

3 elements for improved productivity of concrete work

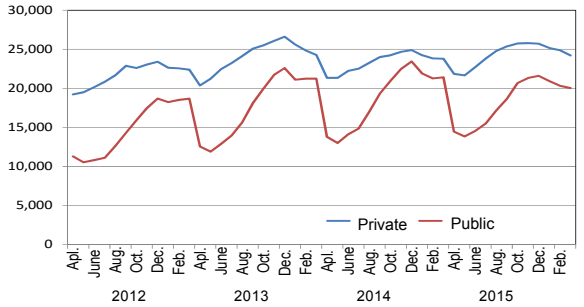




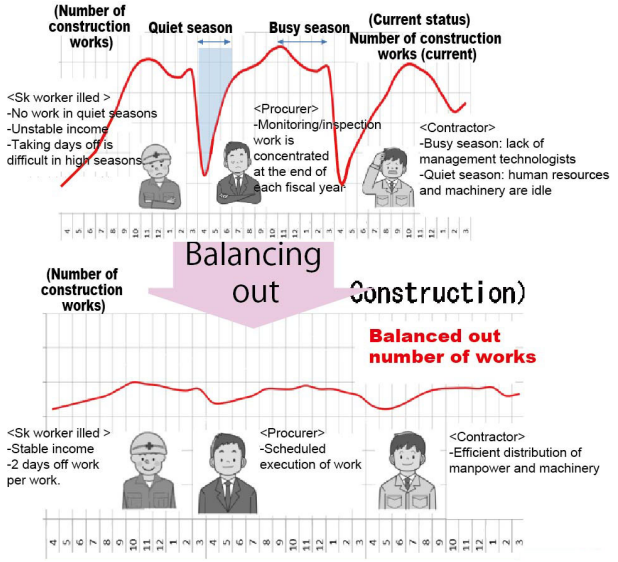
Balancing out the timing of construction

○Public works are unevenly carried out, with fewer works in Q1 (April - June).

○Issue 2-year government bonds in order to secure appropriate construction periods. In the H29 initial budget, a zero government debt target was set for the first time.



Source: Calculated based on Integrated Statistics on Construction Work



i-Construction - Flow ICT earthwork -

1) Create 3D design data

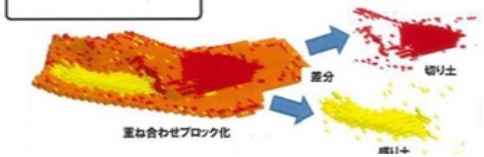
Create 3D design data that will be required to perform earthwork as a computerized construction work.

2) Make the initial measurement 3D

Quickly perform high-density photogrammetric and other 3D measurements using drones, etc.

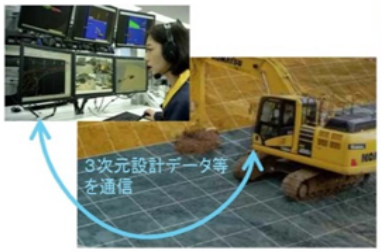
3) Design check and construction plan with

Auto-calculate work volumes (cuttings and embankments) from difference between 3D measurement data (current status of the terrain) and design drawings



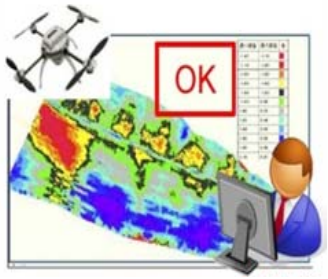
4) Construction work and monitoring of the construction with 3D design data

*IoT (Internet of Things)



*IoT (Internet of Things) describes various objects being equipped with sensors and connected by network.

5) Control finished shape with 3D data



Procurer

New **ICT earthwork**

3D design → I-Con → Initial measurement → I-Con → Design check Construction plan → I-Con → **3D** computerized construction → I-Con → **3D** inspection

2D→3D I-Con H28

Conventional computerized construction (Suggest comprehensive evaluation)

Conventional computerized construction: Create 3D data

- improved efficiency with 1.5x construction volume per day, because staking, etc. become unnecessary.

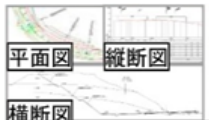
Conventional computerized construction: Create 2D data

2D

Conventional design/construction

2D design → compute rization / Conventional → Initial measurement → compute rization / Conventional → Design check Construction plan → Conventional → **2D** construction → Conventional → **2D** inspection

Perform measurements



Calculate soil volumes from design drawings

Place stakings in accordance with design drawings

Construction in accordance with stakings

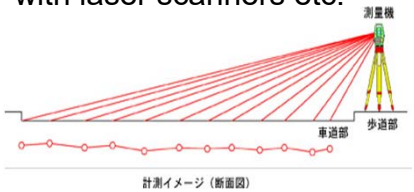
Repeat inspection measurements and construction to adjust the form

Document examination

Expanded use of ICT (pavement from H29)

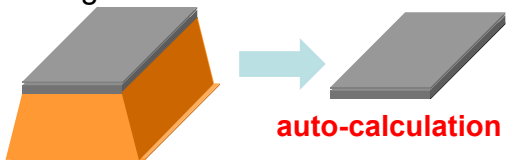
○For further improvement of productivity, the "ICT pavement" initiative (full introduction of ICT for pavement work) was started in FY2017.
○Compile necessary technology standards and estimation standard within FY2016 and apply them to construction works after April 2017.

1) Preliminarily **measurements** with laser scanners etc.



High density 3D measurement in short time with a laser scanner etc.

2) 3D measurement of ICT earthworks **design/construction planning** using data

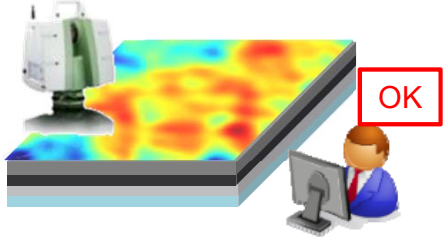


Auto-calculation of construction volume from difference between 3D design data and results of preliminarily measurements

3) **Construction** with ICT grader, etc.

Auto-control of ICT construction machinery using 3D design data etc.

4) Workload reduction in **inspections**



procurer

Halve the volume of documentation by using data from laser scanners etc. for inspections etc.

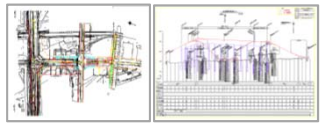
*Core sampling is necessary for quality control.

i-Construction

Conventional method

Measurement → **Design/ construction planning** → **Construction** → **Inspection**

Manual measurements

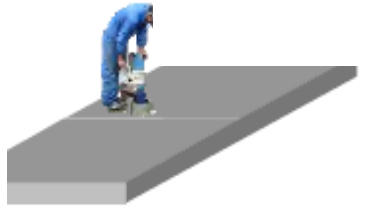


Calculate construction volumes from printed drawings

Staking

Construction in accordance with staking

Repeat inspection measurements and construction to adjust the form



Inspection by core sampling

Status of use and effect of ICT - earthwork/pavement/dredging -

○To perform ICT earthwork, prepare standards etc. for ICT and promote the ICT construction works by adding extra scores to the comprehensive validation at the time of contracting as well as to the evaluation of the construction on completion

○In FY2017, ICT earthwork was performed for 815 construction works, approx. 40% of works that had been contracted as target construction
and confirmed that construction period was shortened by approx. 30%.
○In addition, promote knowledge accumulation, human resource development, and stronger motivation by offering training and sharing best practice cases related to ICT.

■Implementation status of ICT construction

Type of works	FY H28		FY H29	
	Publicly announced construction works	ICT performed	Publicly announced construction works	ICT performed
Earthwork	1,625	584	1,952	815
Pavement work	–	–	197	79
dredging work	–	–	28	24

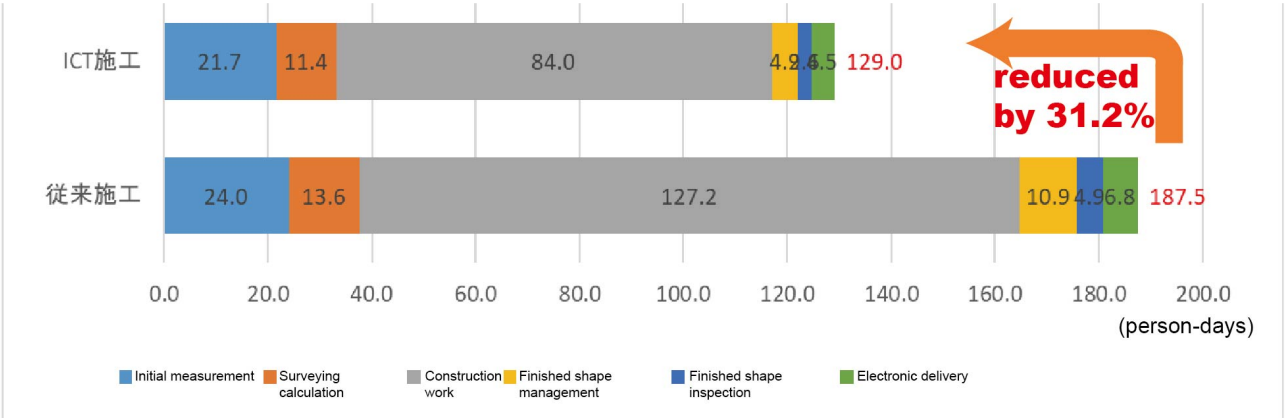
*Prefectures hosted approx. 80 in H28 and approx.870 in H29.

■Training related to i-Construction

	FY H28	FY H29
	frequency*	
For construction companies	281	356
For procurers	363	373
Total	644	729

*There are areas of duplication in “for construction companies” and “for procurers”.

■Effect of ICT construction (H29)



Source: survey of effects on contractors of construction works with ICT (H29, N=274)

■Sharing best practice cases, etc.

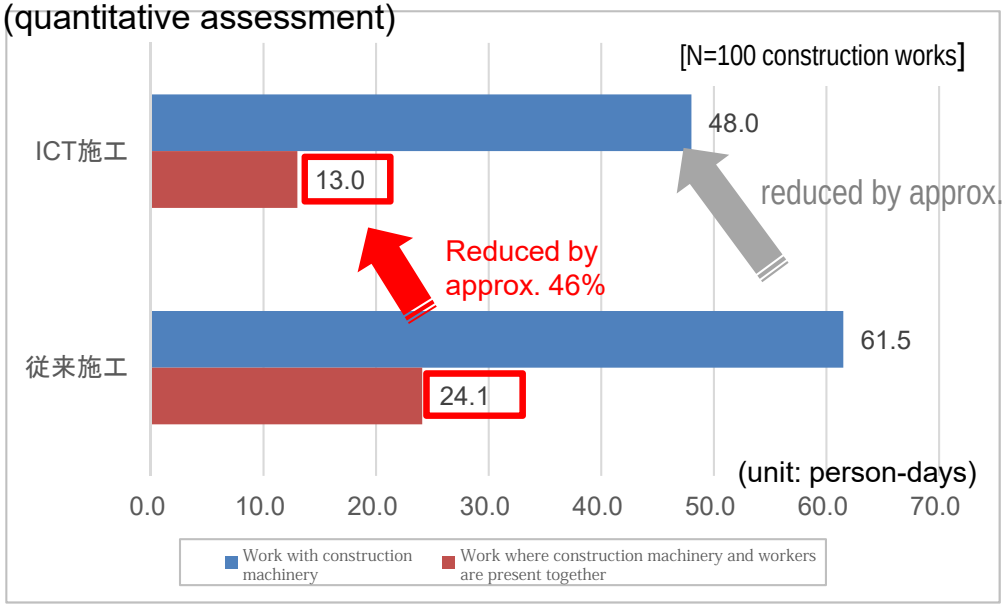
- Prepare a collection of use case
- Host study tours, etc.
- Establish an i-Construction grand prize (ministerial award system)

Host study tours

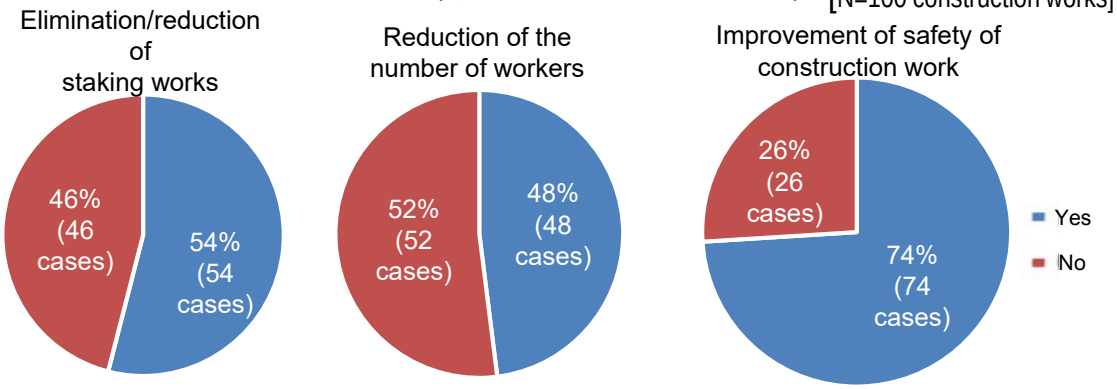
Verifying the effect of using ICT in construction works (earthwork) - reducing works where construction machinery and workers are present together makes sites safer.

○Accidental contact with construction machinery is the second largest cause of accidents after falling.
○ICT construction eliminates almost all staking work, and therefore assistant workers in the vicinity of the construction machinery.
This reduces the time of high risk of accidental contact between workers and construction machinery by approx. 46% and significantly contributes to improving safety.

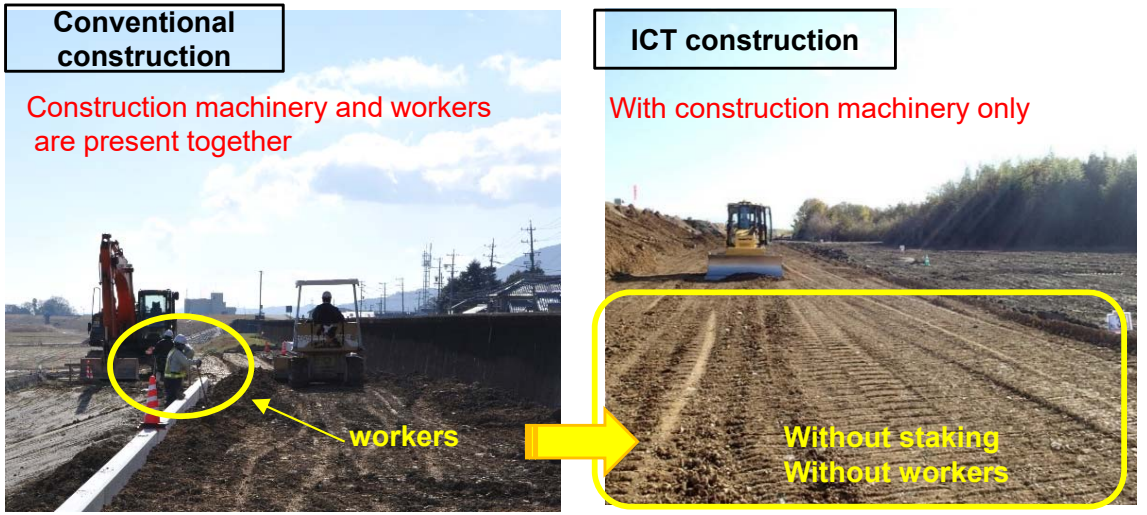
○Total work time around construction machinery (person-days) (quantitative assessment)



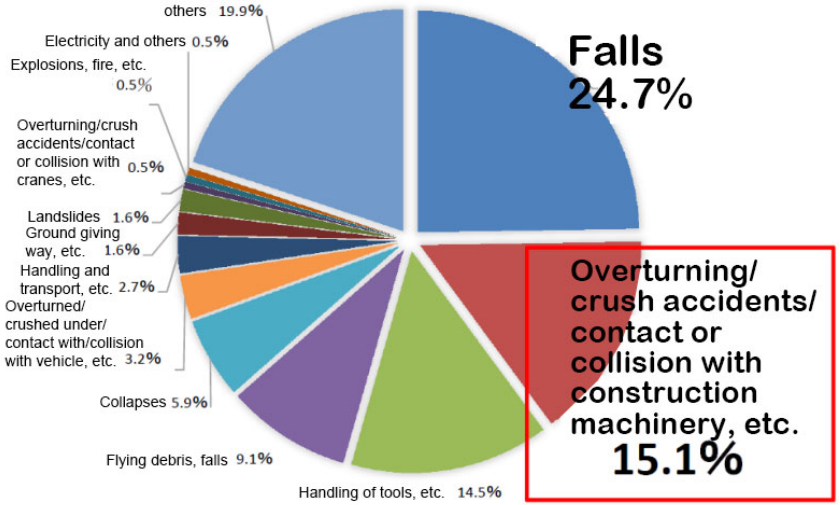
○Works at time of construction (qualitative assessment)



○Comparison between conventional and ICT constructions



○Cause of labor accidents in the construction industry*



*Cited from "Accidents in the construction industry", published by MLIT

○Voice from the sites

Measurement and assistant workers are not required when shaping sloped surfaces, preventing accidental contact in the blind zone of heavy machinery and averting risks of falling from/on the slope.

Introduction of overall optimization (standardization of concrete works, etc.)

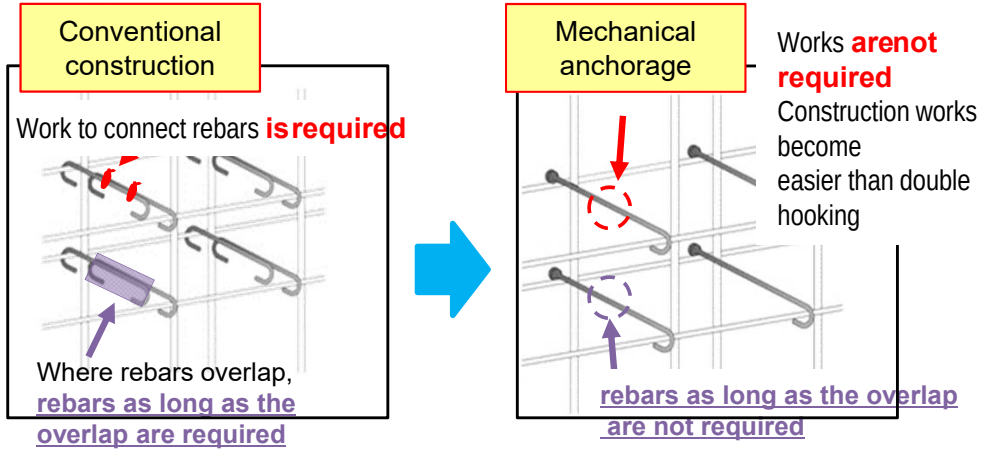
○Aim to improve productivity of concrete work by promoting techniques that improve construction efficiency through properties of on-site placement and concrete precasting (product from factory)

Introduce technology / construction methods for more efficient construction work

○ Compile guidelines for introducing and using each technology to facilitate widespread use and promote these technologies

⇒ In H28, guidelines for "mechanical rebar fixation" etc. were drawn up

⇒ As mechanical rebar fixation was employed, work volume/work period with rebars was reduced from conventional cases by approx. **10%**.



[Technologies for which guidelines are currently under preparation]

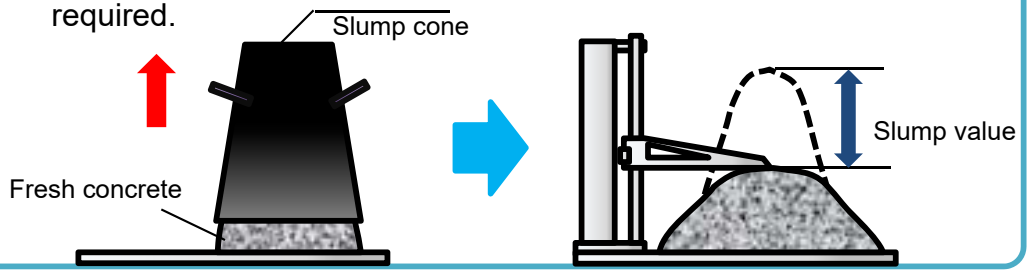
Technology/work method	Timing of drawing up
Mechanical rebar fixation	Drawn up in 2016 (H28)
Use of concrete with improved fluidity	
Mechanical rebar joint	Drawn up in 2017 (H29)
Embedded formwork	
Use of prefab rebars	
Expand application range of precasting	

Efficiency improvement of concrete placement

○ In order to improve the efficiency of placing concrete, procurers' regulations are reviewed so that the optimal concrete for each building can be used. (* slump value was increased from 8cm to 12cm for general reinforced concrete buildings.)

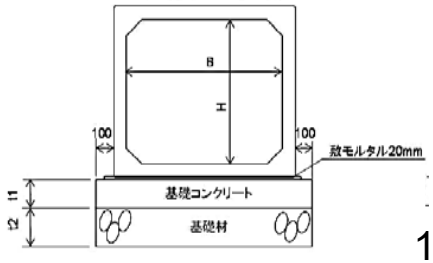
⇒ Volume of concrete placed per hour **was increased by approx. 20%**, saving **approx. 20% of the number of workers**

(*) slump value
- An index of softness and fluidity of concrete.
- The larger the value is, the higher the fluidity, and therefore the higher the efficiency of construction, but chemical admixture is required.



Use of precasting

○ Use guidelines that stipulate standard specifications when using precasting in order to improve design efficiency.
(L-shaped retaining wall, side gutter, box culvert)



Standardization of concrete work

○For concrete buildings, carry out part of on-site work (formwork placement, rebar assembly, etc.) at factories or nearby construction yards , aiming to improve the efficiency of on-site operations and thus productivity by reducing manpower and the number of work days on-site
○Draw up guidelines regarding embedded formwork/ prefabricated rebars, to promote new methods such as half precasting.

Draw up guidelines regarding embedded formwork/prefabricated rebars

Embedded formwork

○Retain formwork, that used to be removed after concrete placement and following certain curing period,
as external wall, etc. after confirming its unity with the main concrete and its durability.
○Produce formworks at factory or nearby production yard.
○By eliminating the removal of formwork, the number of working days on-site can be reduced.

Bridge bottom
Embedded formwork of piers

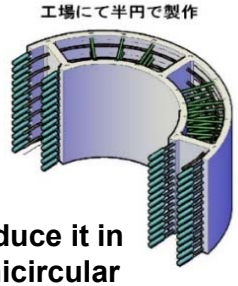
Retaining work
Embedded formwork
of external walls

Prefabricated rebars

○Prior to concrete placement, carry out some work at factories or nearby production yards, including processing of rebars that will be assembled in the formwork
○By preparing these in parallel with the on-site works, the number of working days on-site can be reduced.
○Improve efficiency of work such as binding rebars where work space is tight.

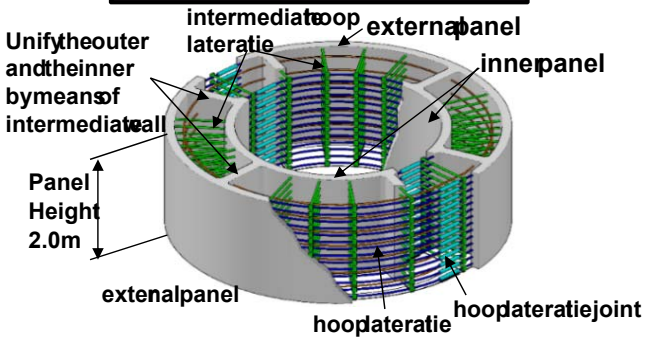
Prefabricated rebars

half precast



Produce it in semicircular shape at a factory

Carried from the factory to the site



Assembled on-site

Hung and placed with a crane

BIM/CIM, the engine of productivity revolution

○BIM/CIM (Building/Construction Information Modeling Management)
introduce 3D models from planning, research, and design phases, and use them while enhancing the data at the following construction work and maintenance/management phases, while sharing such data with stakeholders across the project, with the goal of improving work efficiency and enhancing the work of both procurers and contractors in the production system.

3D model coordination and establishment by phase

Research/measurement/design

[Data to be created/added]
- Terrain data (3D)
- Detailed design (incl. attributes) (data that can be prepared more efficiently at the construction stage will be left as overview)

3D model (design phase)

[Effects to be obtained]
- Interference checks, reduction of design errors
- structural calculations, analysis
- Comparison of rough estimates
- Clarify image of buildings
- Auto-calculate quantities

(procurer)
[Effects to be obtained]
- Improve the efficiency of contracting operations (auto-estimate)
- Prevent miscalculation
- More efficient calculation of construction volumes (by lot)

Construction work (before start)

[Data to be created/added]
- Results of initial measurements
- Detailed design (Detailed drawing of rebar placement, on-site attachment etc.)

3D model (construction phase)

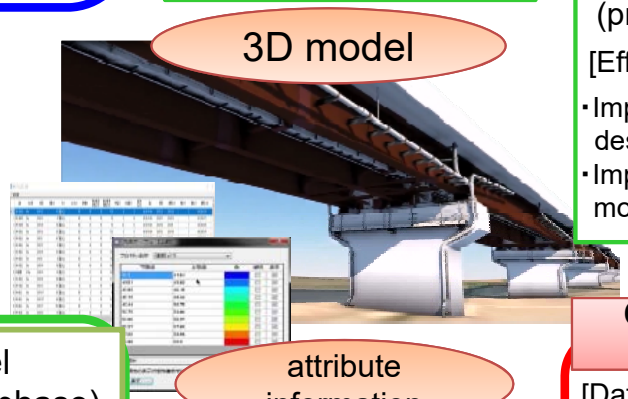
[Effects to be obtained]
- Interference check, reduce reworking
- Promote computerized construction works

(procurer)
[Effects to be obtained]
- Improve efficiency of design changes
- Improve efficiency of monitoring/inspection

During the construction work

[Data to be added]
- Time frame (4D)

[Effects to be obtained]
- Improve efficiency of on-site management
- Optimize construction plans
- Improve safety
- Improve efficiency of design changes



(procurer)
[Effects to be obtained]
- Appropriate renewal of facilities
- Use of 3D management model

Maintenance /management

[Data to be created/added]
- History of inspection/repair work
- Coordinate with on-site sensors (IC tag, etc.)

3D model (management phase)

[Effects to be obtained]
- Improve efficiency/advance management
- Real-time monitoring of changes

Construction work (at completion)

[Data to be created/added]
- Construction work data (location, standard, finished shape/quality, quantity)
- Set up equipment for maintenance/management

3D model (construction-completion phase)

[Effects to be obtained]
- Improve accuracy and sophistication of finished data

CIM use case 1; Upper bridge

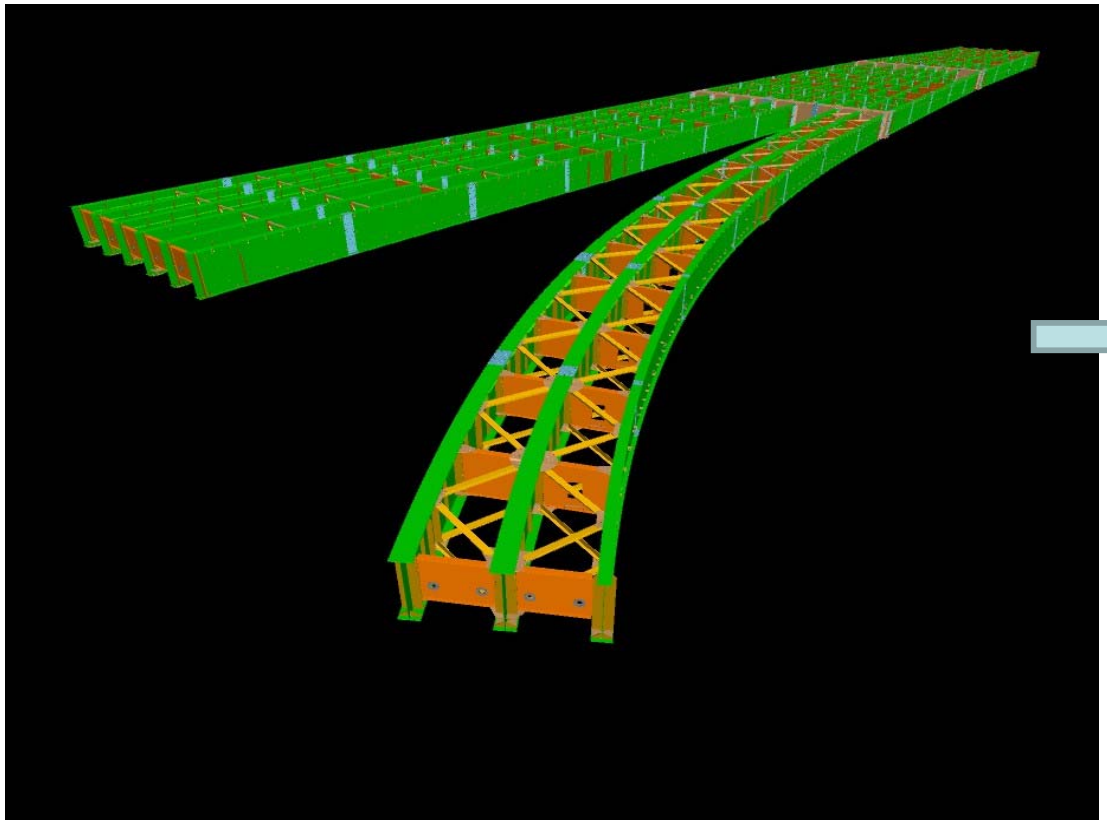
Construction work of upper Hagigawa bridge on the south side (Toyooka Office of River and National Highway)

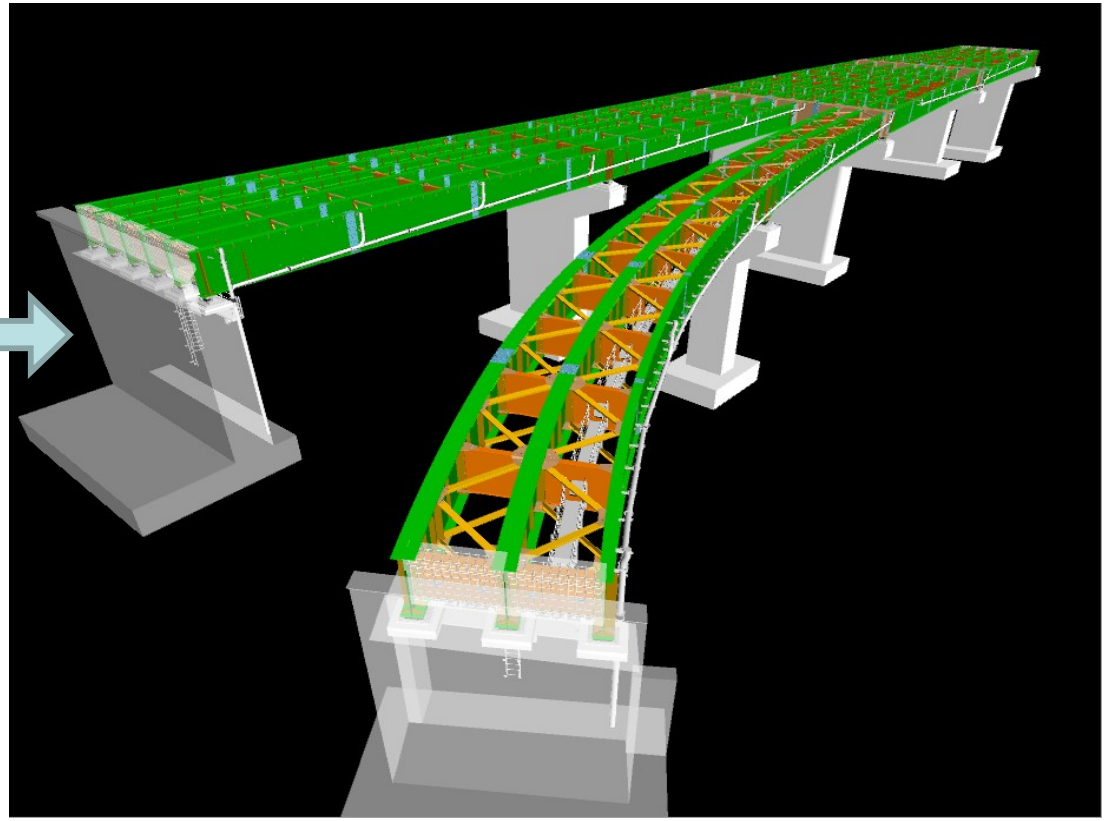
Bridge type: 4 span continuous non-composite girder bridge (bridge length: 155m, steel weight: 896t)

Construction period: May 23, 2015 (H27) - November 30, 2016 (H28) Opening scheduled for: FY2016 (H28

	Items where CIM is performed	Usage stage
1	Interference check, including attachment and substructure works, using 3D model <enhance interference checks>	Design/check
2	Check of rebar placement process and interference for jacket concrete rebar, by using its 3D model <enhance interference checks>	On-site construction work
3	Create 3D model of finished image, including the surrounding terrain of the bridge <Improve efficiency of agreement process>	
4	Confirm with 3D models of route/place for inspection at the time of maintenance/management using <Improve efficiency of maintenance and management works>	Maintenance/management
5	Add a link on the 3D model to information on finished shape of factory/on-site painting <Improve efficiency of maintenance and management work>	

1) Interference check, includi attachment and lower part of work, using 3D model





3D data created by actual sizing system

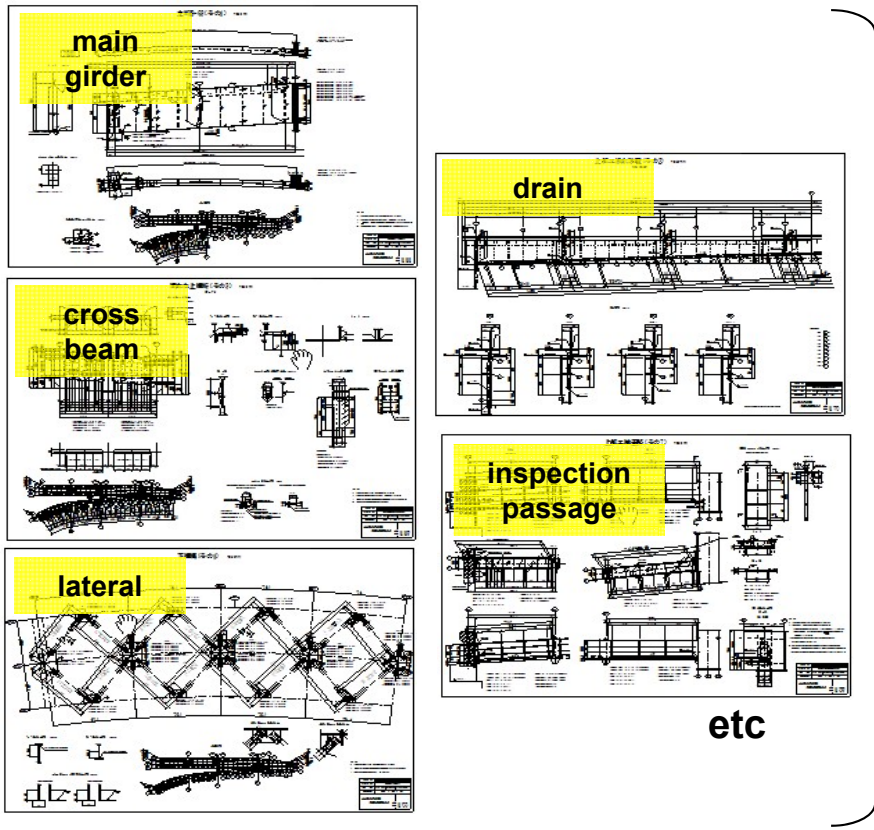
Additional 3D data created to trial CIM

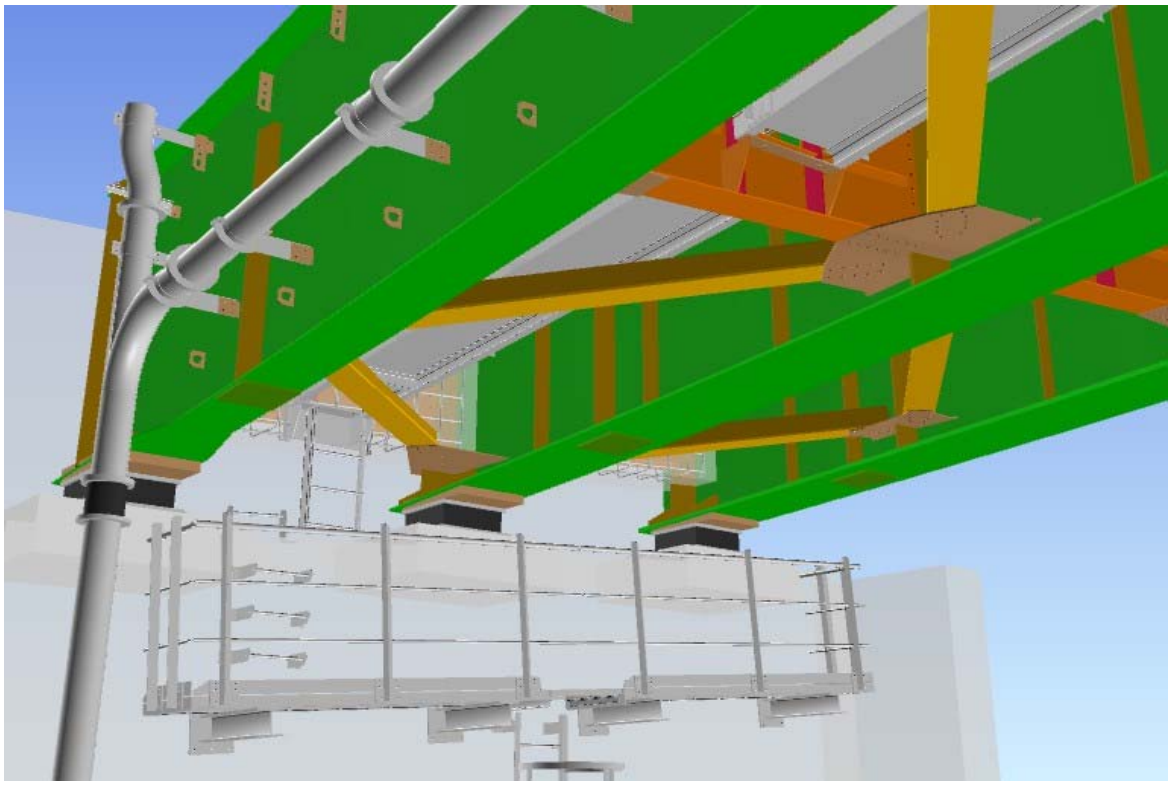
Main structures only → **+**

Inspection route for upper part/ inspection route for lower part/
Drain system for upper part/drain system for lower part
Bridge bearing/bottom works/jacketed concrete

***Always prepared for production at factories**

1) Interference check, includi attachment and lower part of work, using 3D model





[Conventional]

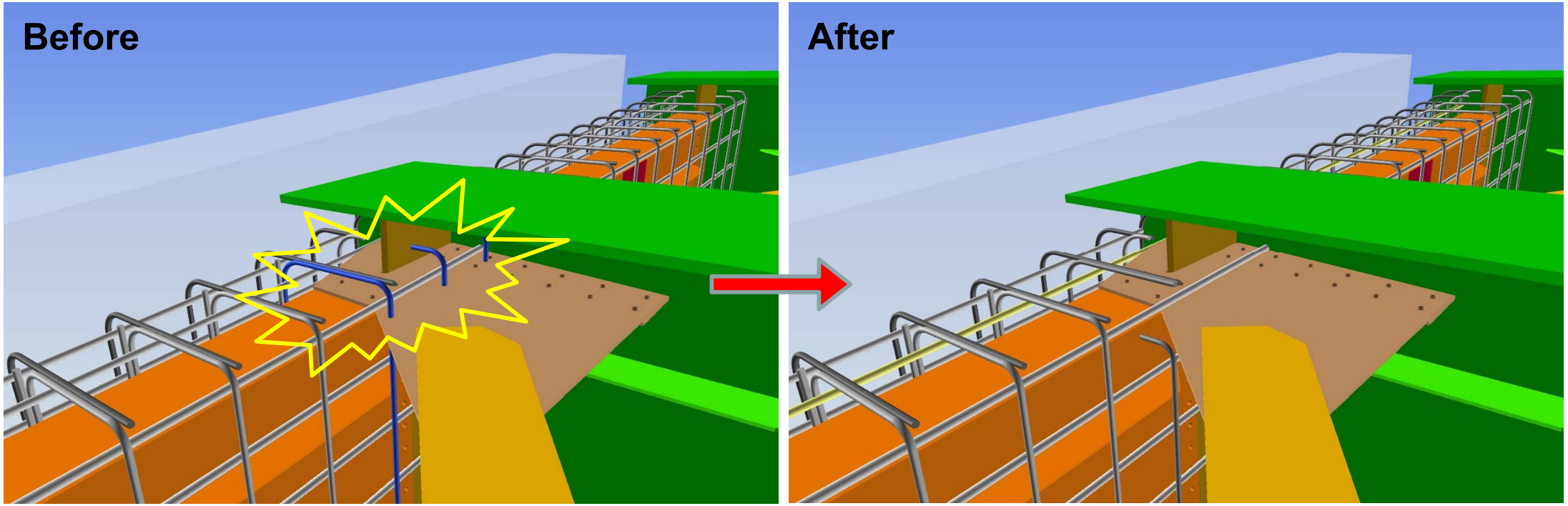
- Viewing multiple drawings to form and check a mental image of the 3D structure
- Overlap and align multiple drawings in 2D and check

[CIM trial model]

- Model all related parts in 3D

Improve the standard of drawing checks and interference checks

2) Interference che for jacket concrete rebar, by using its 3D model



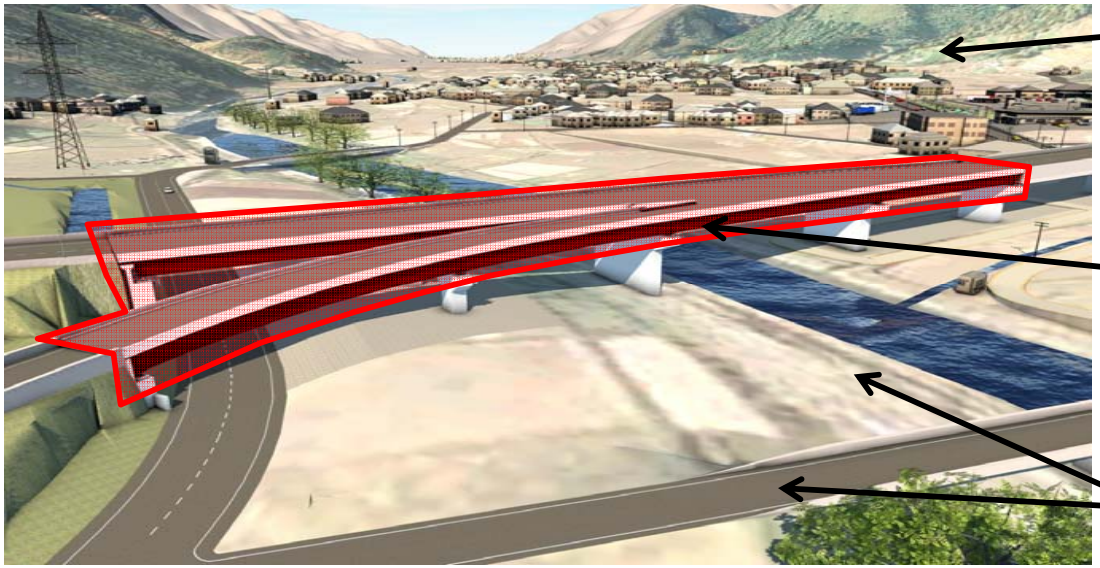
[CIM trial model]

・Rather than creating 3D model of all rebars, focused on “yardarm jacketed concrete part” that caused trouble frequently in the past, and performed interference check on 3D model. Possible trouble at on-site construction work was averted at the design phase

Selected accuracy and places for model creation considering <u>cost-effectiveness</u>

3) Creating image of finished brid with 3D model, including surrounding terrain

Use of 3D models



[Surrounding terrain model]
Used data from Geospatial Information Authority of Japan
Model accuracy: low

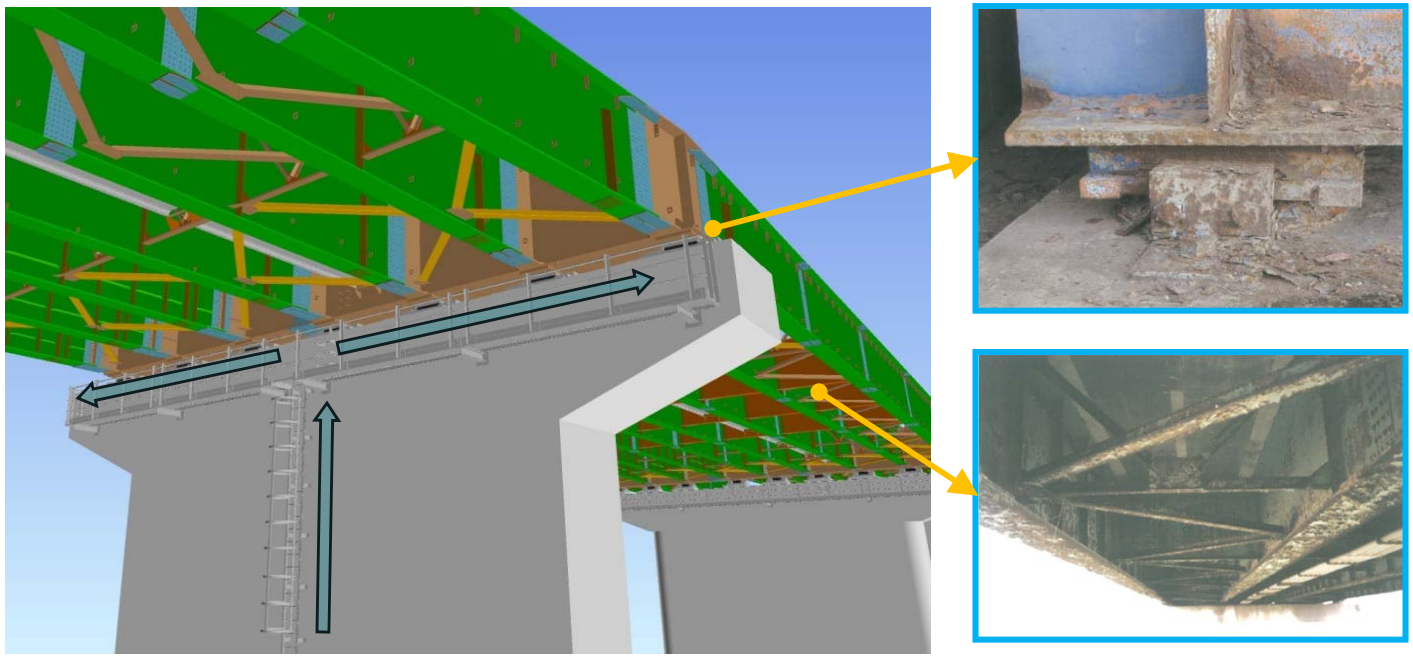
[Model of the bridge part]
Used 3D models of the main structure + attachments
Model accuracy: high

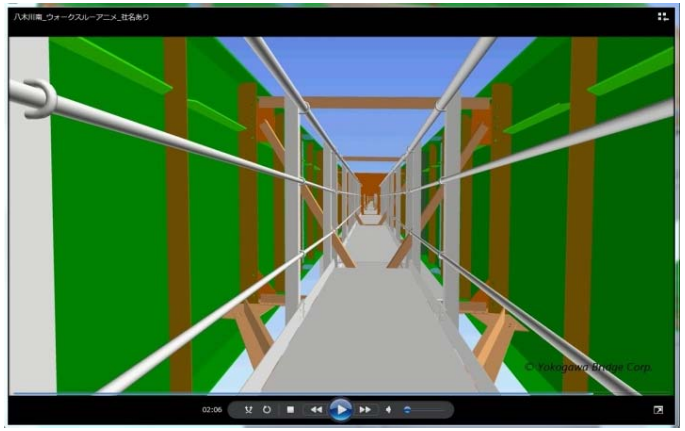
[River, road, building]
Used map information from Geospatial Information Authority of Japan
Model accuracy: low

・Used 3D models for construction sign boards and resources for local explanatory meeting

Contributed to improved efficiency in reaching agreement

4) Confirmation wi　3D models of routes/places for inspection at maintenance/management time





Walk-through animation

[Conventional]

Check with drawings including completion drawing

[CIM trial model]

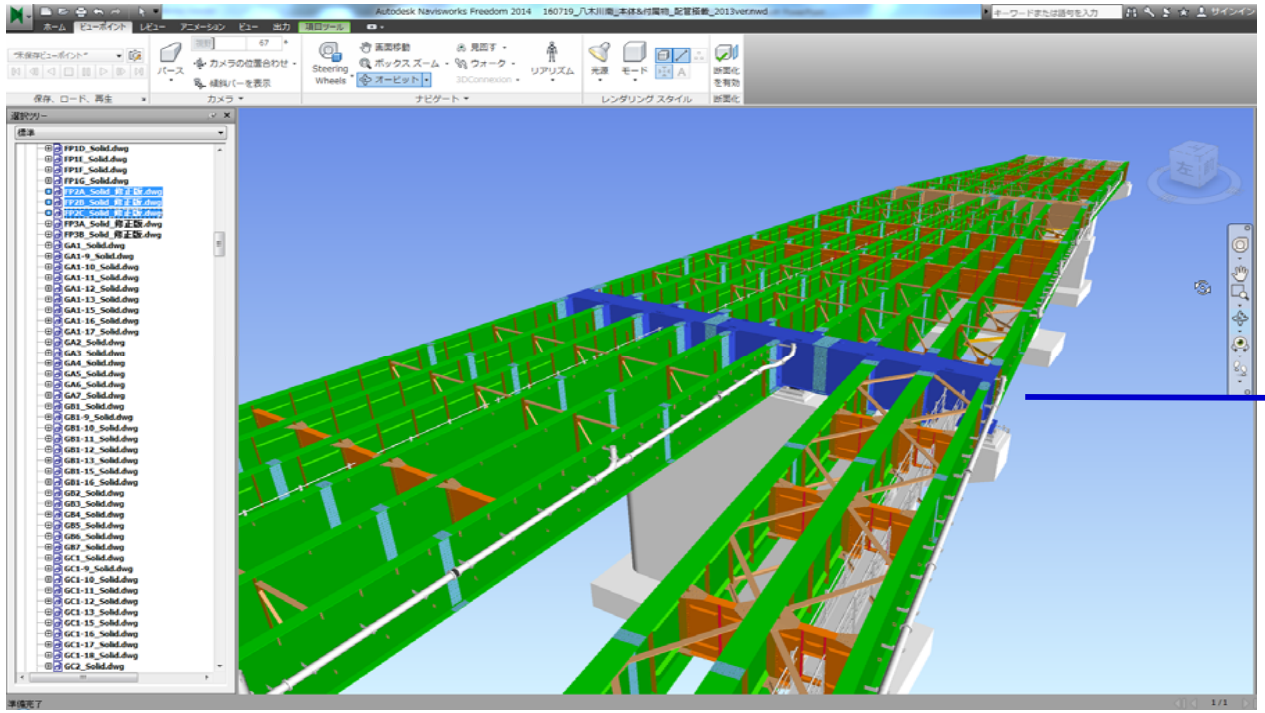
Using 3D models, clearly indicate routes and points for inspection at maintenance/management time
Confirmation of inspection routes using walk-through animation

⇒

Improved efficiency of inspection planning in future maintenance/management work

5) Adding a link to information on finished shape for factory/on-site painting

Example of adding information to finished shape for factory painting



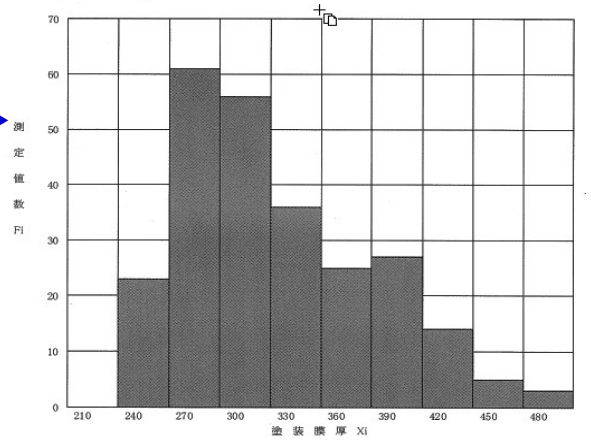
Details of painting inspection record

塗膜厚の度数分布表

塗装系	外面 C-5	工種	上塗
測定時期	工場塗装後（吹付け後）		
測定年月	平成27年9月1日～2日		

膜厚（μm） Xi	測定点個数 Fi	膜厚（μm） Xi	測定点個数 Fi
210 － 239	0	360 － 389	25
240 － 269	23	390 － 419	27
270 － 299	61	420 － 449	14
300 － 329	56	450 － 479	5
330 － 359	36	480 － 509	3
		合計	250

統計値	
平均値	332 μm
標準偏差	56.1 μm
最大値	486 μm
最小値	240 μm



[Conventional]

Confirmation with complete drawing and complete books

[CIM trial model]

Add a link button on the 3D model to resources required for maintenance and management

⇒ **Improvement of efficiency of searching resources**

Creating data base models (tentative) for future maintenance/management

Trends in the number of cases where BIM/CIM are used

○3D design (BIM/CIM) performed since FY2012 (H24) shows tendency of increase over time.
○In FY2018 (H30), using "research expense for promotion of introducing new technology" etc. the target is set to be total 200.