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Infrastructure Development Institute—JAPAN

URUP method – Shaftless Shield
(Shield Tunnel Boring Machine to launch and arrive at the ground level without vertical shafts)

CONTENTS

Infrastructure Development Institute – Japan (IDI)
New Kojimachi Bldg, 5-3-23, Kojimachi, Chiyoda-ku, Tokyo, 102-0083, JAPAN
Tel: +81-3-3263-7813 Fax: +81-3-3230-4030 E-Mail: 1bu05@idi.or.jp Homepage: http://www.idi.or.jp/english/00index.htm

The 14th Infrastructure Technology Development Award 2012

The Japan Institute of Construction Engineering (JICE) was established as a public interest corporation to promote construction engineering in Japan by conducting cutting-edge research and development activities.

As more incentives should be provided for construction technology researchers and research institutes to enhance the level of construction engineering more effectively, with Coastal Development Institute of Technology (CDIT), JICE commenced Infrastructure Technology Development Award under the auspices of the Ministry of Land, Infrastructure, Transport and Tourism(MLIT).

Twenty-nine technologies competed for the 14th Infrastructure Technology Development Award. In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites within the past three years.

As a result of examination, institutes and researchers with the following technologies were awarded 14th prizes.

They are the two best excellence prizes, "URUP method - Shaftless Shield (Shield tunnel boring machine to launch and arrive at the ground level without vertical shafts)", and "TECOREP SYSTEM (A new demolition system for high-rise buildings)".

And the three excellence prizes were awarded to "DO-Jet method (A new method to detect, cut and remove underground obstacles, together with improving surrounding ground from inside the tunneling machine)","Double Bit(Bit exchange system to ensure the long-life, simplify and safety work for shield tunnel) " and "Container Hangar (Environment-friendly new container handling method with improved yard usage and high loading/unloading efficiency) ".

One of the best excellent prizes and two of the excellence prizes are introduced below.

And other technologies will be introduced in the next issue of IDI Quarterly.

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Homepage: http://www.jice.or.jp/
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E-Mail: webmaster@jice.or.jp

URUP Method – Shaftless Shield

(Shield Tunnel Boring Machine to launch and arrive at the ground level without vertical shafts)

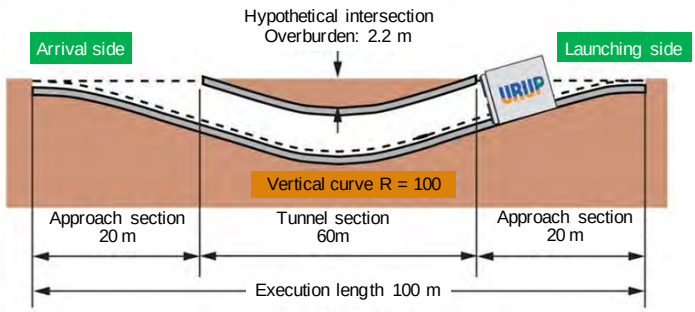
1.Technical Background and Opportunities

Grade separation projects are planned at many intersections in urban regions to mitigate traffic time loss and adverse impact to the surrounding environment due to chronic traffic congestion. However, conventional underpass construction methods require temporary road diversion and occupation of road area, and also need to use heavy construction machines. This causes adverse impact to the surrounding environment due to traffic congestion, noise and vibration during construction. A new underpass construction method has been therefore required that does not cause traffic congestion or adverse impact to the surrounding environment during construction.

2. Description of the Technology

The URUP method is a newly developed shield tunneling method for underpasses at road intersections, railway crossings and other locations. In this method a shield machine is launched at the ground level, a tunnel is driven under a small earth cover without occupation of the ground surface, and the shield machine arrives at the ground level. Compared to the cut/cover method and the conventional tunnel boring method that requires vertical shafts at both ends of the tunnel, the URUP method drastically shortens the construction period and reduces the impacts of noise, vibration and other disturbances on the surrounding environment during the construction. The effects of the URUP technology have been verified through demonstration work and actual projects where this method was applied.

Figure–1 Outline of URUP Method



Figure–2 Outline of URUP Method Proving Test

Photo–1 URUP Method Proving Test Shield Machine

Photo–2 URUP Method Proving Test – Launching

Photo–3 URUP Method Proving Test – Arrival

3.Effects of the Technology

【Shorter construction period】

The construction period can be shortened by executing the following procedure: Ground-level launching without a vertical shaft → Shield driving at the approach section → Shield driving at the tunnel section → Shield driving at the approach section → Arrival at ground level without a vertical shaft.

【Cost reduction】

Vertical shaft construction and protection work for launching and arrival of the shield are not necessary, enabling reduction of costs.

【Reduction of impacts on surrounding environment】

Noise and vibration are reduced due to non-use of pile drivers and other heavy construction machines because of no vertical shafts, and compared to the cut/cover method, traffic congestion caused by the construction is reduced because of smaller road occupation, and CO_2 emissions are also reduced by decreasing the number of construction vehicles used to transport excavated soil, backfill soil and other materials.

【Prevention of surrounding ground deformation】

The URUP method is able to prevent ground deformation of the sides in the approach sections with its driving technology, enabling the passage of normal vehicles next to excavation locations. In the tunnel section, it is also able to prevent ground deformation with its driving technology under small earth cover, enabling excavation of tunnels under the existing roads and railways.

4.Applicable Range of the Technology

- Construction of underpasses below roads, railways, rivers, marine and other locations
- Tunnel construction with small earth cover
- Applicable to all ground and soil condition that can be bored by the shield tunneling work
- No limitations on diameter or shape (circular, rectangular) of the shields
- The construction can be extended to the same length that shield tunneling work can be executed. (Utilization together with cutter bit replacement technology enables execution over long distances.)

5.Technology Application Results

Construction of the Central Circular Route, Shinagawa Line Oi Area Tunnel from June 2008 to January 2012, and two other projects

Figure-3 Central Circular Route, Oi Area Tunnel

Photo-4 URUP Shield Launching from Ground Level

Photo-5 URUP Shield Arrival at Ground Level

Technology Developer : Obayashi Corporation

Contact
MASUMI MUTO
Obayashi Corporation
E-Mail: muto.masumi@obayashi.co.jp
TEL: +81-3-5769-1062
FAX: +81-3-5769-1984

Double Bit

(Bit exchange system to ensure the long-life, simplify and safety work for shield tunnel.)

1.Technical Development Background and Motivation

Shield tunneling is the main method used for building tunnels in overcrowded urban areas. In japan, deep underground developments are becoming increasingly frequent in many places using the deeper underground law / act which came into force in Japan in April 2001.

This requires shield machines with durable cutter bits and secure bit exchange technology, particularly for deep tunnel construction with long distance excavation. Various safety and accident prevention measures are essential to allow workers to carry out bit replacement work on the front parts of the shield machine, where bits are exchanged by hand in the narrow working space between the machine and the ground being cut.

A mechanical bit exchange technology has been developed, but there are issues of flexibility and cost associated with such a complicated mechanism.

In response to this situation, double bit technology was developed. A double bit makes it possible to exchange a bit safely and automatically, without the need for mechanical or manual exchange. (Figure -1, Photo-1)

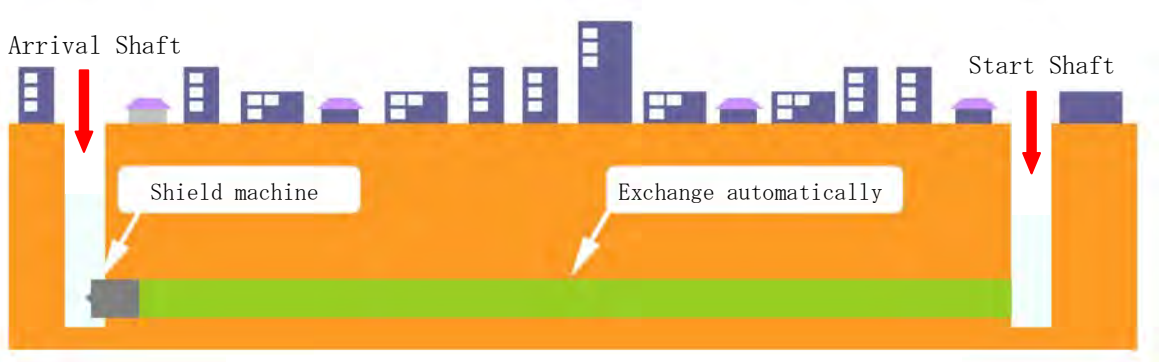


Figure 1 Cutter bit exchange image figure by the double bit

2.Technical Contents

A double bit is assembled with two bits piled up, with the outside bit as a primary one and the inside bit as a secondary one.

The mountain-type primary bit is worn out as the excavation progresses, and the top part of the primary bit divides and separates automatically.

The secondary inside bit then appears and continues to excavate. (Figure -2).

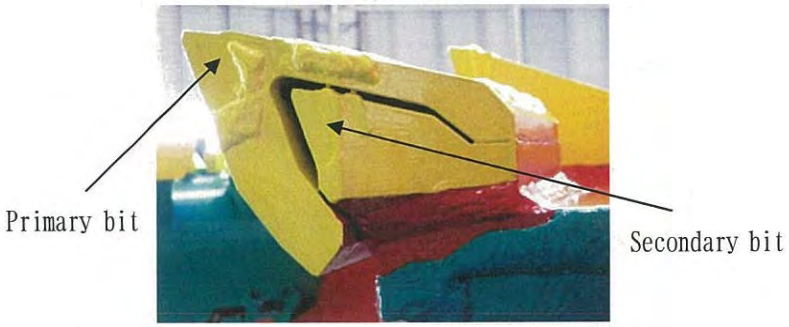


Photo 1 Double Bit

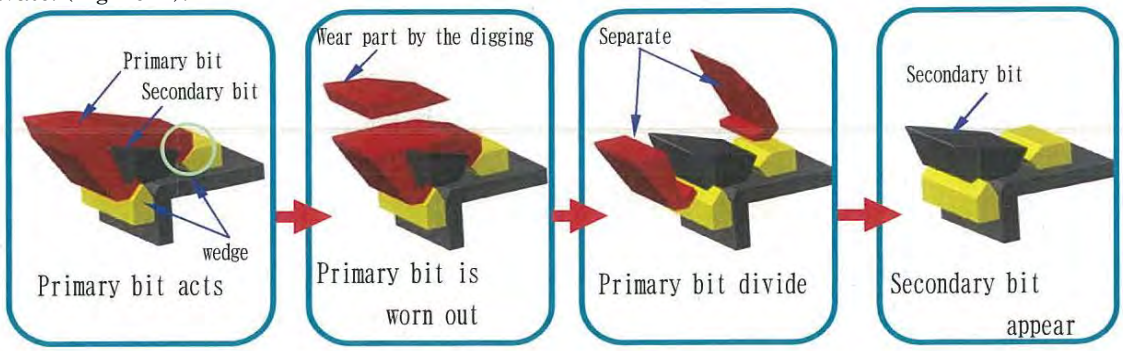


Figure-2 Mechanism image of the cutter bit exchange by the double bit

The features of this technology are as follows.

(1) Increased safety through automatic unattended bit exchange.

(2) Space saving through installing two bits in one cutter space.

(3) Smooth muck flow by smooth cutter face.

(4) Performance of secondary bit secured by primary bit's protection.

3.Technical Effect

Reference in Route No. 25 Midosuji Utility-tunnels construction project.

For the purpose of verifying the characteristics safety, durability, and life-prolongation of the bit for long and high speed excavation in gravel conditions, we placed a double bit at the outermost circumference, which has a long sliding distance. (Photo -2, 3, 4).

(1) Construction and productivity;

Excavation work was completed successfully and workers' safety was ensured by the double bit, which simplified the cutter bit exchange process.

(2) Reduction of inefficiencies;

Excavation work was carried out without stopping excavation.

(3) Environmental effect;

Noise, oscillating problems and traffic congestion with road occupancy in the surrounding area were avoided by skipping the process of intermediate shaft construction in order to exchange bits. (duration: about 6months)

Photo-2 Whole View

Photo-3 Installation situation of the double bit

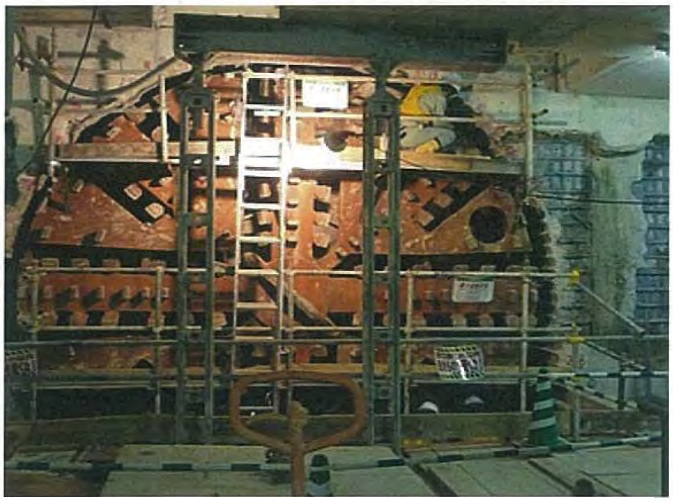


Photo-4 Arrival situation of the shield machine

(4) Cost effect;

Costs were reduced in expenses for exchanging the cutter bit (although this depends on conditions, it should be around a 4-5million yen reduction) and for constructing the intermediate shaft for this purpose (10-300million yen, depending on conditions).

4.Scope of Technical Application

Double bit technology can be adapted to both large and small diameter shield tunnel,

Moreover, double bits can be applied for boring routes with a gravel layer or other types of boring which expects more cutter wear not necessarily only for long-distance excavating.

5.Technical Application References

Route No.25 Midosuji Utility-tunnels construction, August 1, 2010 (start), October 4, 2011 (completion) with seven (7) other references in total.

Technology developer: Taisei Corporation

Joint developers: Japan Tunnel Systems Corporation

Contact

Yasushi Morita,

Civil Engineering Technology Development Department

Taisei Corporation

E-mail : morityan@ce.taisei.co.jp

TEL : +81-45-814-7229

FAX : +81-45-814-7252

Container Hanger

(Environment-friendly new container handling method with improved yard usage and high loading / unloading efficiency)

1. Background and opportunity for development of technology

【Background】

(1) The Oi Container Terminal at the Port of Tokyo plays a central role in international logistics in the Tokyo Metropolitan area, and container cargo demand is continuing to increase. However, because this facility is located in a large urban area, where no major

expansion of yards into the hinterland is possible, its handling capacity was reaching its limits. For this reason, there has been a strong need for more effective usage of yard land and improvement of loading and unloading efficiency.

(2) In container handling work with conventional rubber tired gantry (RTG) cranes, it is necessary to perform container shifting work such as moving the upper containers in order to reach the containers at the bottom of a stack when delivering those containers to receiving trailers. This work also causes waiting time, and was a cause of increased social costs and reduced service, for example, freight backlogs, trailer congestion, and the like.

(3) RTG cranes are driven by diesel engines and consume large amounts of energy, resulting in heavy CO_2 emissions. Thus, reduction of energy consumption and CO_2 emissions were also necessary from the viewpoints of energy conservation and environmental countermeasures.

【Opportunity】

As a solution to the above-mentioned problems, Nippon Yusen Kaisha (NYK), which leases and operates No. 6 and 7 berths at the Oi Container Terminal, and the Tokyo Port Terminal Corporation, which is the owner of the container terminal, proposed the concept of introducing a new container handling system that would enable efficient handling of large volumes of containers within the limited area of the terminal.

An exhaustive study was carried out, assuming that a new system in which containers are stored in a 3-dimensional automated rack facility and loaded/unloaded by electrical equipment offered an effective solution to these problems. As a result, a decision was made to introduce the world's first "container hangar," and construction was carried out by the Tokyo Port Terminal Corporation.

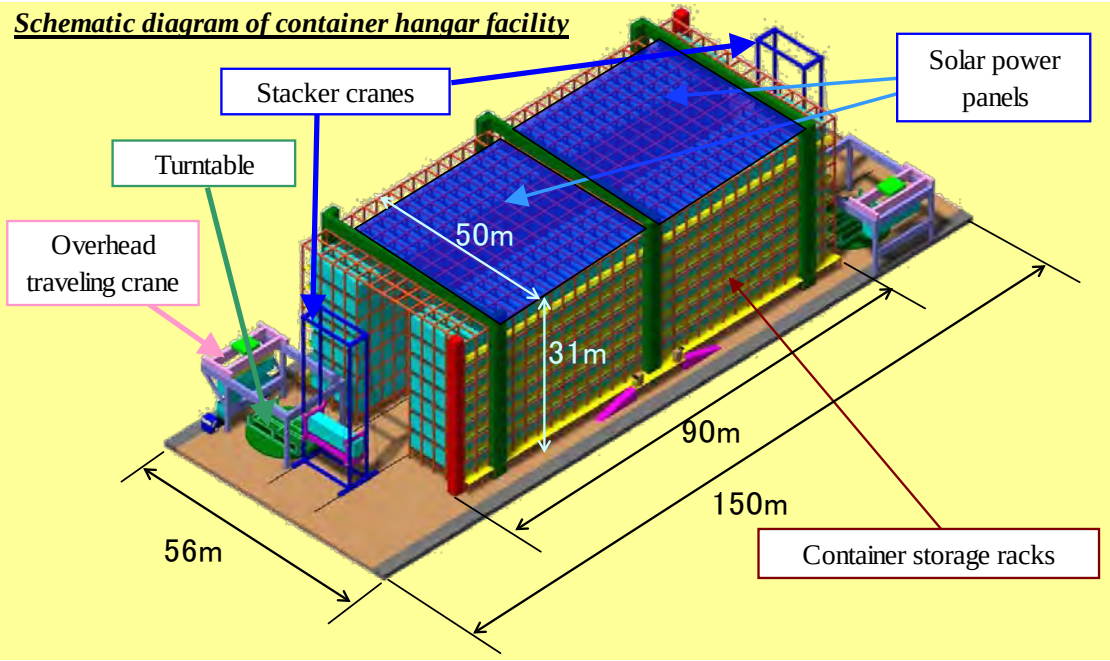


Figure – 1 Schematic diagram of the container hangar facility

Photo – 1 General view of container hangar

Photo – 2 Transfer of container to trailer at container hanger(lower left)

2. Description of Technology

In the existing yard, marine containers (freezer and refrigerating "reefer" containers) had been stacked in 3-4 levels. In contrast, in the new "container hangar" system, these containers are stored in 3 dimensions, on seven levels of racks, and all loading/unloading work from receiving and storage to delivery to the customer are performed in an integrated operating system.

As the object container can be loaded and unloaded directly from the storage rack by the container handling equipment (stacker crane), it is not necessary to move stacked containers in order to extract the container at the bottom of a stack for shipment. This greatly improves both loading / unloading efficiency and yard efficiency, and enables advanced usage of the yard. Workability and accuracy are also improved. At the same time, the facility has a high CO_2 reduction effect, as electric drive equipment is used.

Photo – 3 Stacker crane

3. Effects of Technology

① Unit handling capacity: Increased from 36,000TEU /year to 60,000TEU/year (estimated)

② Container handling efficiency: Conventionally 36 containers/hr to 48 containers/hr by using container hangar (estimated)

③ CO_2 reduction effect: CO_2 reduction of approximately 63% (estimated) in comparison with existing RTG cranes (diesel power generation drive)

Photo – 4 Solar power generation system (generated output: 200kW)

4. Scope of Application of Technology

This technology is applicable to container handling work at container terminals that currently use RTG cranes or other conventional cargo handling equipment.

5. Record of Application of Technology

The container hangar was manufactured and installed at Oi Container Terminal No. 6 berth in FY2008.

Technology developer: Tokyo Port Terminal Corporation

Joint developers: Nippon Yusen Kaisha (NYK), JFE Engineering Corporation,

Contact
YOICHI ARAKAWA
Tokyo Port Terminal Co.Ltd
E-Mail:arakaway@tptc.co.jp
TEL:+81-3-3599-7457
FAX:+81-3-3599-7492

Manipulator Controlled Decontamination of Surfaces in Nuclear Power Plants

This manuscript was contributed by Prof. Dr.-Ing S. Gentes and Dipl.-Ing. P .Kern
Karlsruhe Institute of Technology (KIT), Institute for Technology and Management in Construction, Technology and Management for the Decommissioning of Nuclear Facilities, Karlsruhe, Germany

Contact:
Karlsruhe Institute of Technology (KIT)
Institute for Technology and Management in Construction
Technology and Management for the Decommissioning of Nuclear Facilities
Prof. Dr.-Ing. Sascha Gentes
Phone: +49 721 608-46546
E-Mail: sascha.gentes@kit.edu
Dipl.-Ing. Patrick Kern
Phone: +49 721 608-48221
E-Mail: patrick.kern@kit.edu

1.Institute mission and topical numbers

Within the German Excellence Initiative Program the Karlsruhe Institute of Technology (KIT) is one of the first Cluster of Excellence which has been established by a merger between the Research Center and the University of Karlsruhe. The world's first professorship for Technology and Management for the Decommissioning of Nuclear Facilities (TMRK) was established in June 2008 at KIT. The TMRK is part of the Institute of Technology and Management in Construction and headed by Prof. Dr.-Ing. Sascha Gentes.

The TMRK's research focuses on the two special fields of technology and management. In the management field, the research team aims to improve and optimize the whole process from procurement, awarding the tender, execution of decommission until the final disposal of radioactive material. One example in this respect is the implementation of the Lean Management Principles to the Decommissioning of Nuclear Facilities.

In the technology field, the research team develops new practical technologies and improves and automates the existing tools, machines and technologies for the decommissioning of nuclear facilities. The main objectives in this area are to minimize the nuclear radiation which endangers staff working at nuclear facilities and to achieve an environmentally friendly and effective decommissioning process. In addition to the introduction of TMRK institute and its activities this paper will present in general the current research projects from different disciplines like the measurement, ablation, and decontamination technique.

2. AMANDA I & MANOLA – Two manipulator controlled systems for decontamination of surfaces

Automated systems are being employed for the decommissioning of nuclear plants for quite some time now, since they allow a remote controlled work close to the core. More and more semi-automated and fully autonomous manipulators are used for the decontamination of surfaces. Consequently, the dose rate for the executive staff in both application areas will be minimized and effective and safe working conditions are guaranteed. Following, the two systems AMANDA I and MANOLA are presented in detail.

With the construction of the AMANDA manipulator for decontamination work (Figure 1), the Institute for Technology and Management in Decommissing of Nuclear Facilities (TMRK) has already shown that it is possible to construct a manipulator system that also carries a milling machine. Without auxiliary systems, the support system is remotely controlled using vacuum technology. It can be used on different surfaces in conventional and nuclear areas.

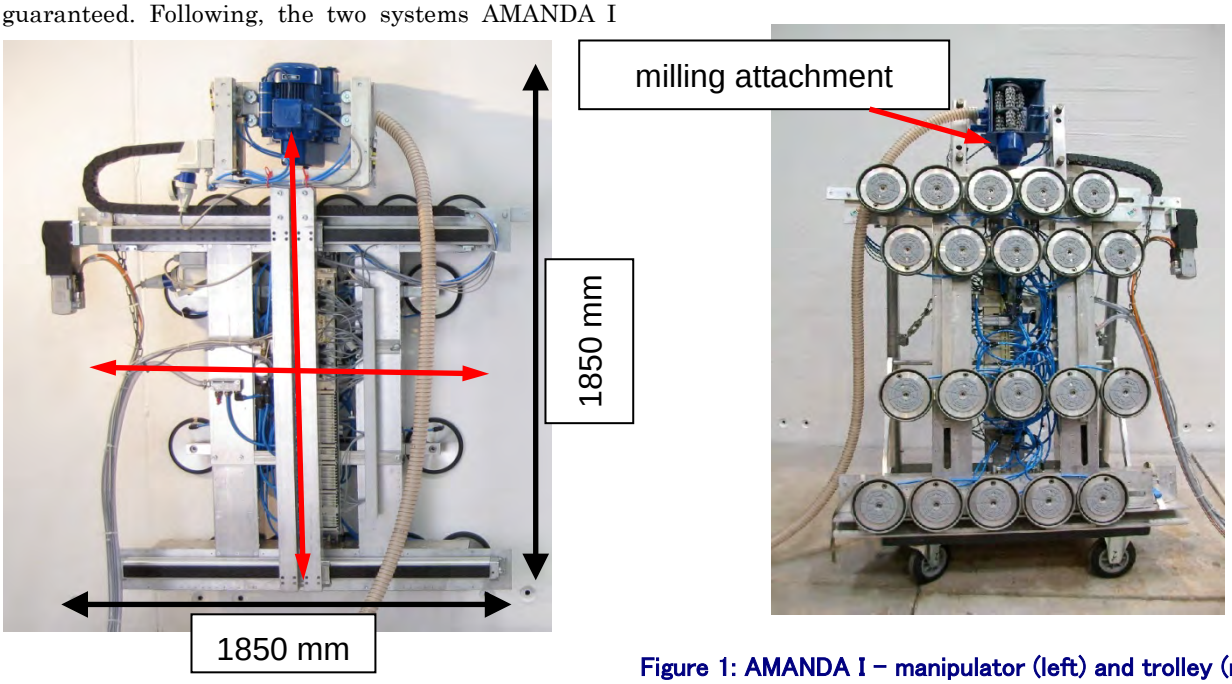


Figure 1: AMANDA I – manipulator (left) and trolley (right)

Within the research project MANOLA (manipulator-controlled laser ablation of surfaces) a carrier system has been developed which offers significant advantages over AMANDA, e.g. regarding locomotion on the surface.

While AMANDA can only move in both vertical and horizontal directions at the ablation surface, the carrier device MANOLA (Figure 2) is also equipped with a rotary actuator to improve maneuverability in corners and around openings or obstacles. Under complex spatial conditions and by using the additional rotatory module, it can therefore work more flexibly and more precisely. Multiple suction units with continuously monitored pressure also ensure safe navigation along the surface. The carrier system MANOLA is currently designed to carry a laser working head which was developed by the Technical University of Dresden, Institute for Energy Technology (WKET). The externally generated laser beam is directed at the radioactively contaminated concrete surface via a special lens, creating a melt with a rectangular profile of approximately 45 x 10 mm^2.

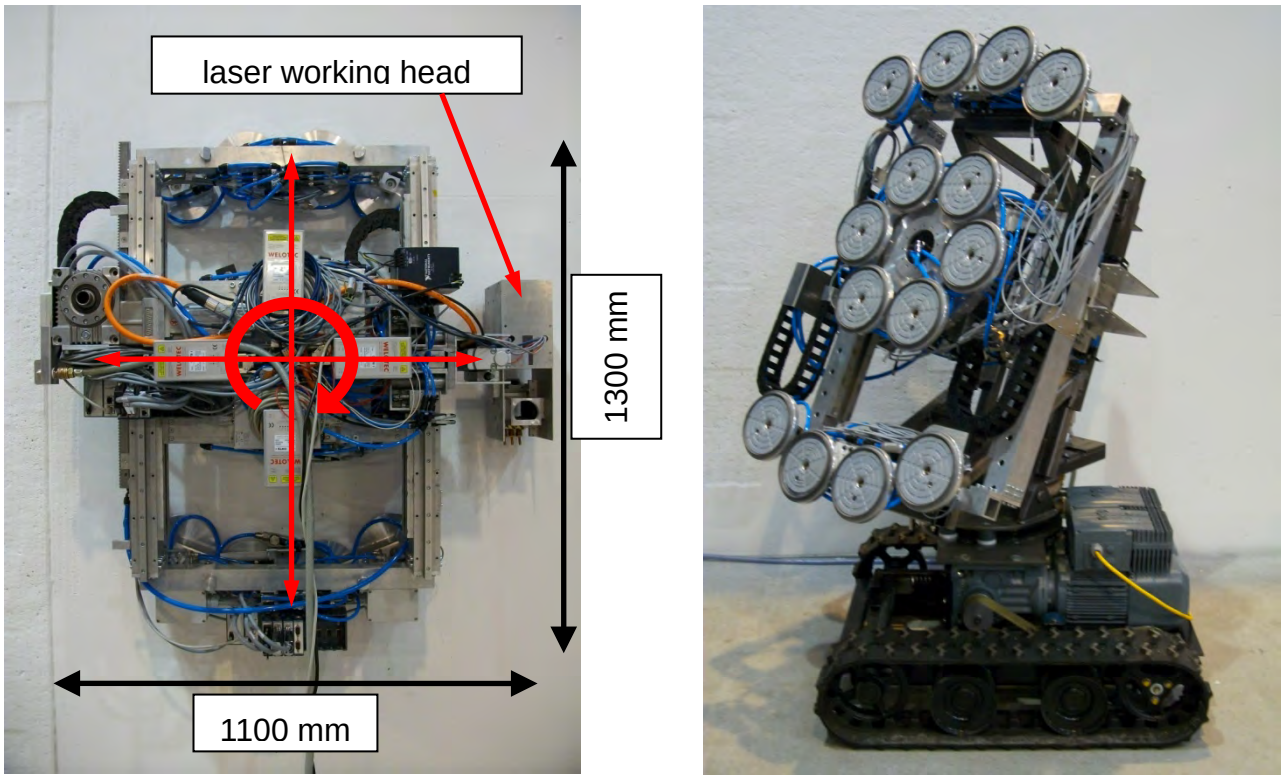


Figure 2: MANOLA – manipulator (left) and trolley (right)

Since September 2011, the research project MAFRO uses the work and results of MANOLA for the development of an extension to the existing system by improving the maneuverability of the manipulator and replacing the manual motion control with autonomous functions such as environment model generation, optimal path planning, and collision-free path execution. Currently, a second tool for contamination measurement is designed containing a sensor to measure the remaining radiation. The data collected from the sensor will be used to identify areas that may have to be processed in a second step and to document the results of the decontamination process. It is a new cooperation between the Institute for Technology and Management in Construction (TMB) and the Institute for Process Control and Robotics (IPR) at the Karlsruhe Institute of Technology (KIT), also funded by the German Federal Ministry of Education and Research (BMBF).

Road Stabilizer Method Featuring Environmentally-Friendly Paving Technology

Sakai Heavy Industries, LTD

1.Description of the Road Stabilizer Method

The road stabilizer method can conduct in-place base course construction or subgrade rehabilitation by using a road stabilizer that crushing and mixing materials with lime, cement, or asphalt emulsion.

This method can be applied for ①Strengthening soft subgrade by stabilization ②Stabilization of granular material ③Construction of base course by utilizing

existing gravel road ④In-place base course recycling by using existing asphalt and base course materials.

2.Advantages of the Road Stabilizer Method

Advantages of this method are the followings.

① Cost-saving: Construction cost can be reduced by 30-40% comparing with *conventional reconstruction or replacement method (actual record in Japan).

② Resource-saving: Existing materials are recycled on site.

③ Shorter construction period: Construction time can be shortened by 2/3 or less compared with *conventional reconstruction or replacement method.

Therefore, this is an environmentally-friendly and economical technology.

* Conventional reconstruction or replacement method : A method that removes whole existing worn-out pavement to construct a completely new pavement.

3.Outline of the "Road Stabilizer PM550"

Our "Road Stabilizer PM550" is a machine vehicle that can carry out a series of crushing, mixing work simultaneously in one-pass on the road. PM550 is composed of high-powered engine and driving mechanism, rotor system that implement crushing and mixing operation (drum and hood having conical bit), and water spray, emulsion spray equipment. The appearance and specifications are shown in Photo-1 and Table-1.

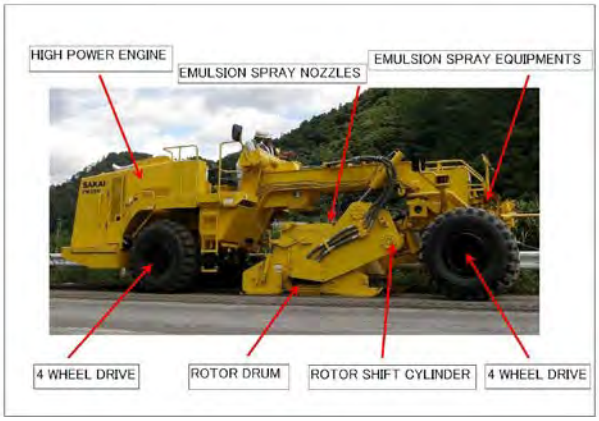
Followings are the characteristics of the "Road Stabilizer PM550".

① Wheel type: PM550 employed four-wheel drive system and ensures consistent traction even on a slippery road surface and other severe conditions.

② The lateral shift of the rotor hood is 500mm on each side, ensuring safe operation even along soft shoulders of a road.

③ Maximum mixing depth: 430mm

④ Console panels are arranged on the right and left of the operator's station to provide better visibility to the conditions of crushing and mixing so that they can be easily and carefully controlled during operation.



Photo–1 Appearance of Road Stabilizer

Operating weight	22,500kg
Overall length	9,280mm
Overall width	2,650mm
Overall height	2,915mm
Rated output	370kW(496HP)
Travelling speed	0-14km/h
Operating speed	0-48m/min
Rotor speed (L/H)	100/130rpm
Mixing width	2,000mm
Max mixing depth	430mm
Number of bit	98(conical) /8(roof)
Shift stroke	500mm(left and right)

Table–1 Specification of Road Stabilizer PM550

4.Work execution example

We will introduce an example case of the paving work implemented in the Philippines (Lanao del Norte Province, Mindanao). Test pavement was conducted

on the province road using two types of pavement, ① reconstruction of pavement using existing asphalt and base course was adopted for the work section A, ② strengthening soft subgrade by stabilization was adopted for the work section B as shown on Table-2 . Photo 2～4 shows the gravel road before pavement, ongoing stabilization work, and after completion.

By using stabilization method, surface smoothness and drainage capacity are increased and achieved grade-up of the road performance.

Photo-2 Existing gravel road

Photo-3 Mixing of cement and asphalt emulsion by PM550

Photo-4 After surface finishing works

Work section	Extension	Existing condition	Implemented paving work
A	50m	Heavily damaged, hot mix asphalt surface layer	Existing asphalt layer 8cm + Existing base course → 15cm (Recycled base course stabilized with cement and asphalt emulsion)
B-1	50m	Gravel road	Existing gravel → Placing crushed stone on the existing gravel 20cm → 20cm (Cement + Asphalt emulsion stabilization)
B-2	950m	Gravel road	Existing gravel → Placing crushed stone layer on the existing gravel 20cm → 20cm Cement stabilization
・Surface course is HMA (Hot mix asphalt) or DBST (Double bituminous surface treatment)			

Table-2 Test section of the paving work implemented in the Philippines

5.Conclusion

In the newly developing countries looking for low cost and efficient road paving method, road stabilizer method can be applied not only for the main road repair work, but also can contribute to upgrade living environment as a low cost road pavement for daily service road as mentioned in the case example as shown above.

Through the technical transfer of stabilization method by using road stabilizer, which is capable of wide application, we would like to contribute to the development and popularization of road construction technology.

Contact
Yasutsugu KANAMORI, Ph.D.
Deputy General Manager
TECHNICAL LABORATORY
SAKAI HEAVY INDUSTRIES,LTD.
Tel:+81-480-52-6131 Fax:+81-480-52-0117
e-mail:y-kanamori@sakainet.co.jp

About IDI and IDI-quarterly

The Infrastructure Development Institute (IDI)-Japan is a not-for-profit organization under the Ministry of Land, Infrastructure, Transport and Tourism Japan
IDI provides consulting services for Japanese official development aids (ODA), facilitates exchange of specialists around the world and exchange information about both developed and developing countries in the field of infrastructure.

IDI has been publishing the free quarterly journal "IDI Quarterly" since1996 for the purpose of introducing information relating to our public works and construction technology to foreign countries. We have distributed the journal to administration officials in more than 90 countries around the world by e-mail.

We also welcome project information from your country. If you have a manuscript, please send to us. We may include it as an article in our journal IDI-Quarterly. Please refer an example article "Water Pipeline Projects" from Mongolia. (Refer IDI Quarterly No.52) and "Manipulator Controlled Decontamination of Surfaces in Nuclear Power Plants" of this issue. If you have an interest, send manuscripts to us according to the instructions below.

Instructions for contributors:

- Texts must be written in English within 800 words.
- Ms-word.doc or text.txt files are acceptable.
- Figures and photos should be supplied in an electric format.
- All manuscripts will undergo some editorial modification.
- The editor reserves the right not to publish manuscripts that are not appropriate for this journal.
- Manuscript fee will not be paid.
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