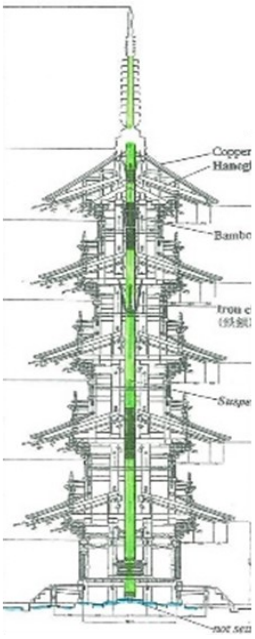
July 2022 No.94
Japanese Infrastructure Newsletter

IDI

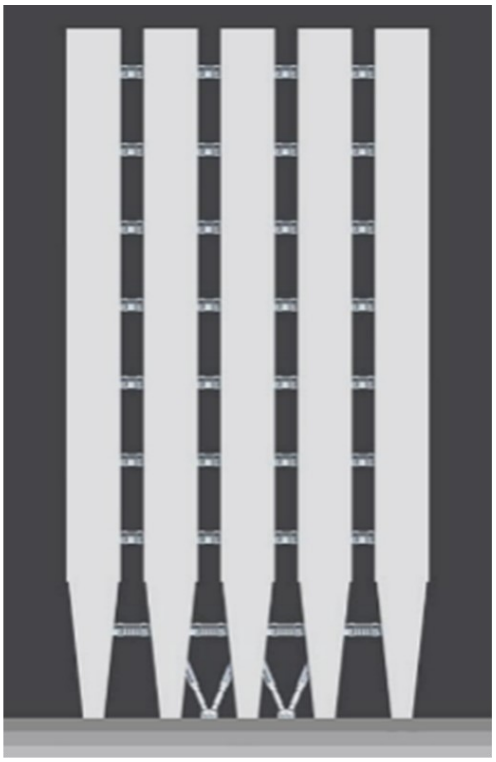
Infrastructure Development Institute—JAPAN

BUILDING STRUCTURAL SYSTEM USING WALL-COLUMN WITH RESPONSE CONTROL SYSTEM AND BASE ISOLATION SYSTEM

TASMO (response control system) and TOLABIS (base isolation system)



Pagodas with central pillars



TASMO (response control system)

TOLABIS (base isolation system)

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Infrastructure Development Institute – Japan (IDI)
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23rd Infrastructure Technology Development Award 2021

Japan Institute of Country-ology and 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, JICE commenced Infrastructure Technology Development Award with Coastal Development Institute of Technology (CDIT) under the auspices of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Forty technologies competed for the 23rd Infrastructure Technology Development Award.
In principle, the applicants' technologies should have been developed within the past five years and applied to the real sites already.

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As a result of examination, institutes and researchers with the following technologies were awarded the 23rd prizes.

The grand prize is "BUILDING STRUCTURAL SYSTEM USING WALL-COLUMN WITH RESPONSE CONTROL SYSTEM AND BASE ISOLATION SYSTEM".
And the two excellence prizes are " Effective utilization method of improved soil with inorganic water absorption agent derived from PS ash",and " Quality Inspection Technology for Foundation Piling Construction Using a Chemical Method: The CW-QUIC System".

The grand prize and the two excellence prizes are introduced below.

For any inquiries/ comments please contact to JICE :
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(Japanese version only)
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BUILDING STRUCTURAL SYSTEM USING WALL-COLUMN WITH RESPONSE CONTROL SYSTEM AND BASE ISOLATION SYSTEM

TASMO (response control system) and TOLABIS (base isolation system)

1. Background and opportunities for technological development

Japan is an earthquake-prone country where medium and even large earthquakes are a frequent occurrence, as demonstrated in recent years. Consequently, the resilience of the national infrastructure is an important and urgent issue. The seismic design of buildings in Japan is based on the ductile frame structure, which is primarily aimed at protecting human life while allowing damage to structural members. However, the ability of a building to maintain functionality has recently become an important design target; this means preventing damage to non-structural members taking into account business continuity planning (BCP). The applicants have proposed the provision of additional horizontal stiffness to buildings, and the effectiveness of this approach has been demonstrated through many projects. On the other hand, the many surviving five-storied pagodas with central pillars (Figure. 1), which have experienced many earthquakes without collapse, demonstrate how important vertical multi-story elements such as central pillars are to enhancing the seismic performance of a building. Based on this thinking, a frame system has been developed that consists mainly of vertically continuous wall-columns similar to a central pillar (Figure. 2) combined with response control system and/or base isolation system. The response control system consists of exchangeable elements that are designed to sustain damage.

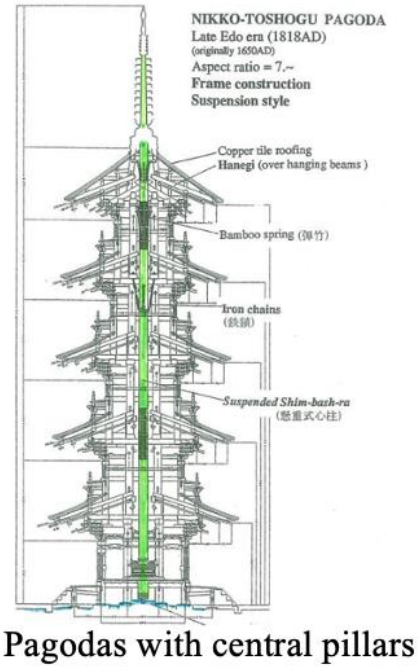

Figure- 1 Nikko-Toshogu pagoda central pillar

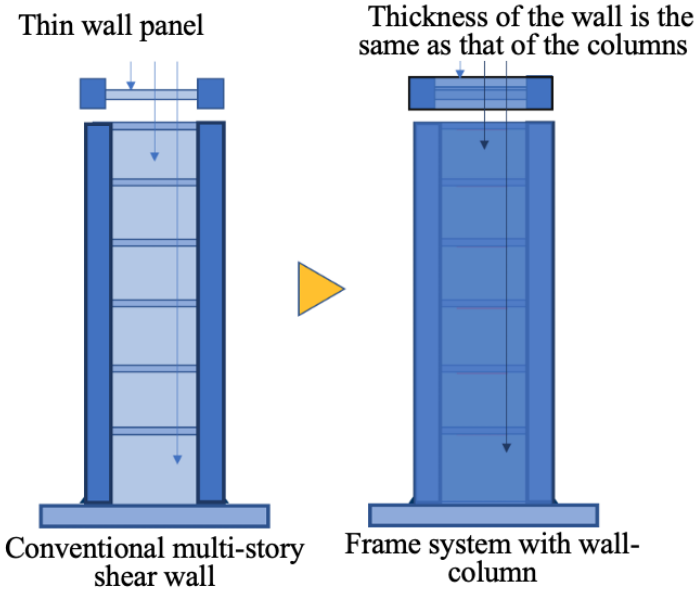

Figure- 2 Conventional multi-story shear wall (left) and frame system with wall-column (right)

2. Contents of the technology

The newly developed structural frame system, which combines a response control system and/or base isolation system with reinforced concrete wall-columns in the core or the perimeter of the building, offers excellent seismic performance. Details of these seismic control systems are presented below.

(1) The TASMO response control system (Figure. 3)

The bases of the wall-columns are fixed to the basement with semi-rigid rotational joints. Ductile beams formed from steel with a low yield point connect the wall-columns, creating a response control system that aims to minimize damage to the main frames. The response control beams are designed to absorb input energy concentratedly during large earthquakes while at the same time possessing sufficient horizontal stiffness.

(2) The TOLABIS base isolation system (Figure. 4)

The wall-columns are arranged around the perimeter of the building and are connected together with reinforced concrete beams, to give a superstructure of high stiffness. The earthquake input energy is then concentrated in the base isolation system, thereby minimizing damage to the building.

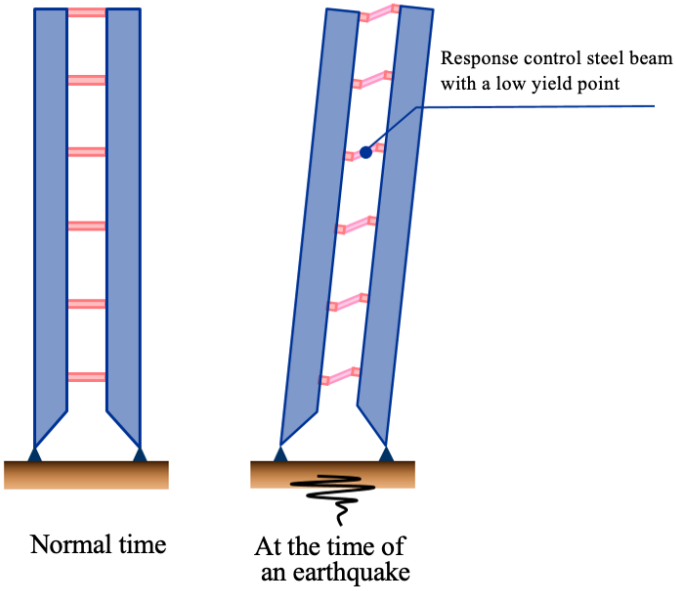

Figure-3 Wall-column response control system TASMO

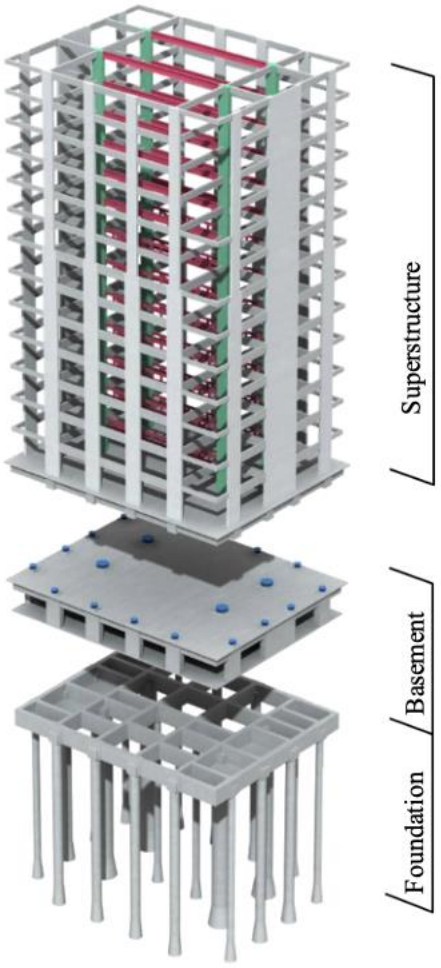

Figure-4 Wall-column base-isolation system TOLABIS

3. Scope of application of the technology

These systems are suitable for application to medium- and high-rise buildings.

4. Effects of the technology

Frame structures consisting of wall-column elements combined with a response control system and/or base isolation system offer excellent structural safety. They provide high stiffness while avoiding brittle failure. At the same time, these systems allow for building designs that match architectural and environmental planning requirements. In terms of architectural planning, the perimeter wall-column structure makes column-free internal spaces possible, offering planning freedom and rich opportunities when change of use is necessary (Figure. 5). On the other hand, in a structural frame with wall-columns designed to take the horizontal load at the core of the building, the peripheral columns and beams can be smaller. This also creates a space with maximum planning freedom. In terms of environmental planning, the pitch and size of outer wall-columns can be adjusted for structural performance and also for outer wall opening ratio, which means heat loading can be improved. It is feasible to achieve CASBEE S class super eco performance.

Figure-5 Column-free interior space realized with the wall-column frame system

5. Social significance and potential of the technology

Framing plans that incorporate multi-story shear walls are becoming more popular, both in projects completed by the applicants' company but also by other companies. We consider that this advanced system will make a great contribution to large earthquake resilience and that it will come to have great social significance. In the future, it will expand in applicability, such as in structural systems for multi-story wooden structures and for use in higher skyscrapers.

6. Track record of the adoption of the technology

(Tentative name) Keikyu Group Headquarters new office construction project, July 2017-September 2019, two other examples

7. Contact Information

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Effective utilization method of improved soil with inorganic water absorption agent derived from PS ash

Soil improvement using “Wattle”

1. Background and opportunity for technological development

In the case of processing muddy soil such as dredged soil or construction sludge with high water content, sun drying or solidification treatment with cement or lime has been used. However, due to issues such as time, cost, and alkalinization, the effective use of soft construction-generated soil has not progressed. On the other hand, there is an increasing need to "actively use" such generated soil for the purpose of repairing and reinforcing embankments of rivers and the like, as well as restoring the environment of lake ecosystems. Therefore, we have developed an improving material that improves low-quality soil into high-quality soil on-site at a relatively low cost, a technology for utilizing improved soil that can be used for general purposes in ground structures.

Photo-1 Inorganic water absorption agent ”Wattle”

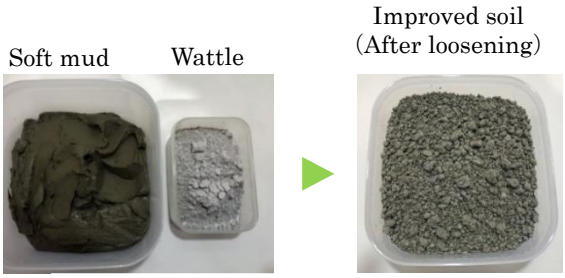

Photo-2 Change in properties through improvement

2. Contents

The technology is to improve mud soil by mixing with “Wattle”, which is an inorganic water absorption agent based on paper sludge ash (PS ash; Photo-1), that can be used to improve the quality of soil (Photo-2 -Photo-5). Although PS ash-based agent have existed in the past, this technology has the following unprecedented features (Figure-1).

- High-quality soil conversion by immediate improving and subsequent loosening granulation (Figure-2, Figure-3)
- Can be used as an embankment material by conventional construction management .
- Simplification of compounding design
- Promoting the neutralization of improved soil and inhibiting leaching of heavy metals by loosening granulation.

Photo-3 Mixing work

Photo-4 Granulation by loosening

Photo-5 Reusing improved soil for embankment material

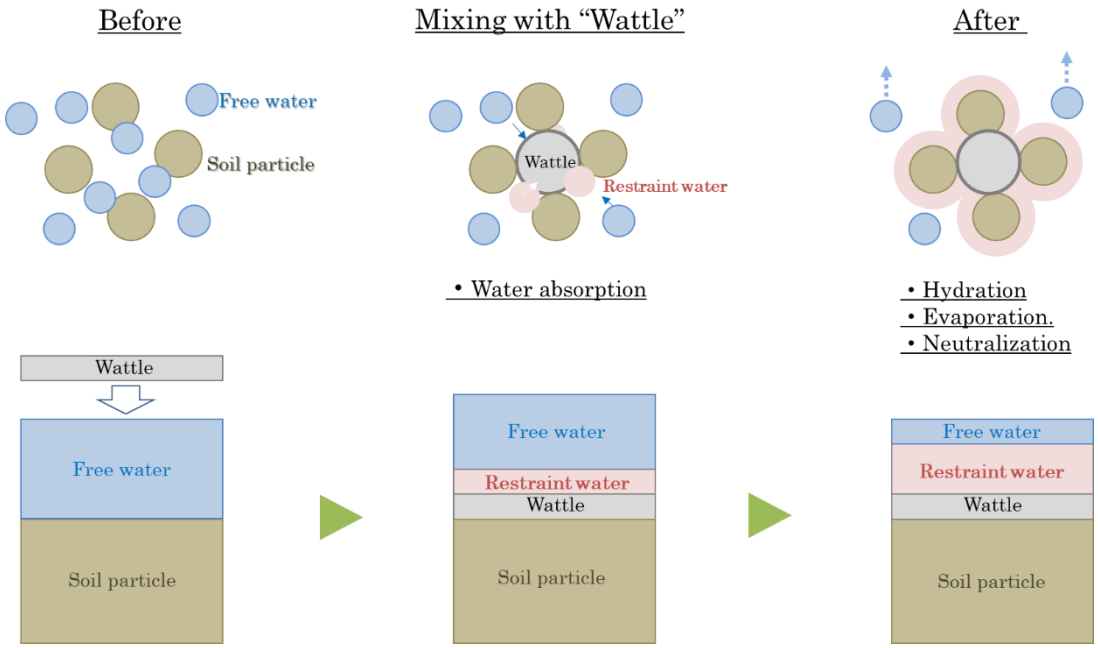

Figure-1 Mechanism of soil improvement using "Wattle"

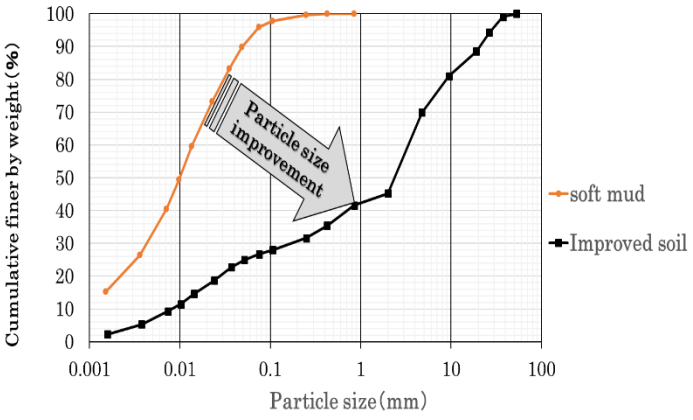

Figure-2 Particle size distribution; effect of loosening

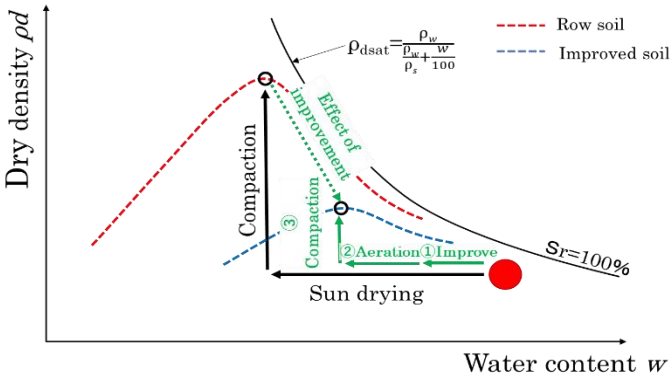

Figure-3 Compaction curve, change by improvement

3. Scope of application

- Construction sites to reuse dredged soil in rivers, lakes and harbors
- Construction work to improve mud discharged from shield tunnels, etc.

4. Effect of technology

In some cases, soil generated on site is so soft that it cannot be used for any purpose, and is unavoidably solidified with cement or lime, later disposed. However, by using this technology, the soil can be improved to high-quality at a low cost. In detail, the material cost is reduced by 21% compared to quicklime., and in an example compare the cost of off-site disposal after cement solidification, with the cost of reusing improved soil through this technology, a cost reduction of 30% was achieved

5. Social significance and development of technology

Excavated soft soil and dredged soil from rivers, lakes and harbors, which have not been utilized so far, can be used as geotechnical structures on land. It contributes to improving the recycling rate of construction by-products and is in line with the Ministry of Land, Infrastructure, Transport and Tourism's 2020 policy of "recycling with an emphasis on quality". In addition, it can be used as an embankment material that can be planted by improving alkaline construction sludge with loosening granulation technology.
Furthermore, carbon dioxide gas is fixed as carbonate in the improved soil, which is expected to contribute to carbon recycling.

6. Actual implementation of the technology

FY2017-2019 Shinmachi River bridge foundation work (part 2), February 2018-March 2021, etc. More than 20cases

7.Contact Information

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Quality Inspection Technology for Foundation Piling Construction Using a Chemical Method: The CW-QUIC System

1. Background to and Impetus for the Development of the Technology

In November 2014 a problem occurred in condominiums supported by existing piles, which brought problems in foundation pile construction to the attention of the public in Japan. Prompted by this event, in 2016 the Ministry of Land, Infrastructure, Transport and Tourism issued Notification No. 468, and in March 2016 the Japan Federation of Construction Contractors issued “Guidelines for Construction Management of Existing Concrete Piles”, which requires existing piles to be properly constructed and that records to be properly retained.

To check the construction of foundation piles, not only must it be confirmed that the pile tip has reached the supporting stratum, but it is also extremely important to inject and agitate cement milk in the muddy water and check the strength of the soil-cement (Figure. 1) formed at the pile tip or around the pile. Therefore, this technology has been developed to enable an immediate check on the construction quality, as opposed to the conventional method (Figure. 2).

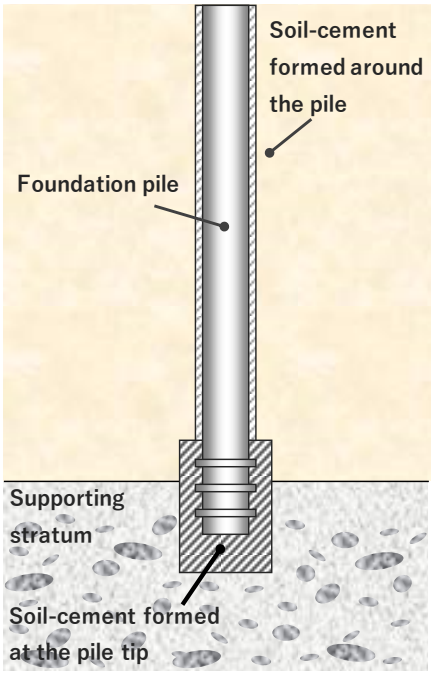

Figure-1 Overview of foundation pile construction

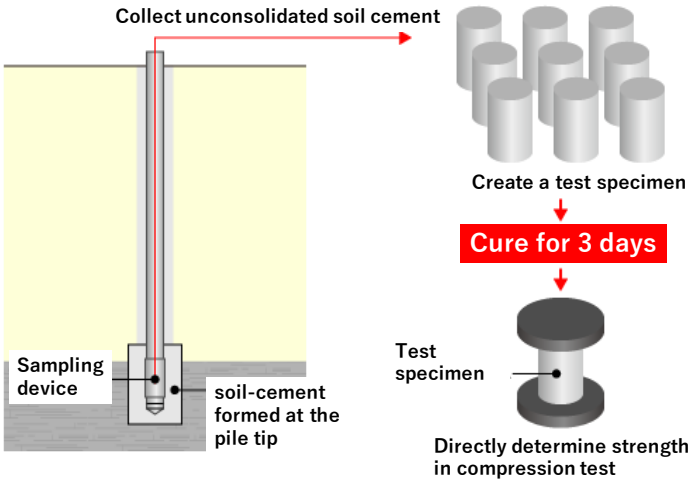

Figure-2 Conventional method of rapidly checking quality using compression tests

2. Details of the Technology

By performing a simple chemical analysis of the composition of the soil-cement on a construction site, the strength of the soil cement can be estimated within one hour. First, it has been found that for each supporting stratum soil, there is a strength correlation between the water cement ratio of the foot protection soil cement and its 28-day strength, and thus a correlation equation between the C/W ratio and the strength is set on the safe side for quality control for each soil (Figure. 3).

Moreover, to perform material composition analysis on site, simplified methods have been developed to obtain the water content by heating and drying, as well as the cement content from the neutralization reaction, using about 10 cc of the soil-cement obtained in the unhardened state (Figure. 4).

Using the conventional method of estimating the 28-day strength from the 3 -day strength, it was determined that the estimation accuracy of this technology is high. In addition, the technology has been applied on site more than 200 times, and thus it has been sufficiently verified (Figure. 5).

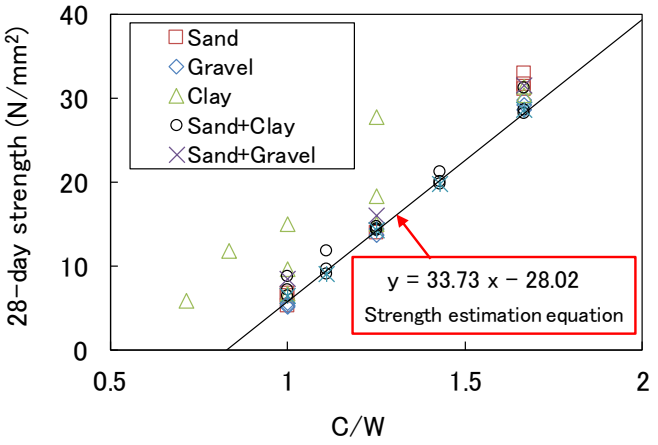

Figure-3 Strength estimation equation used in this technology

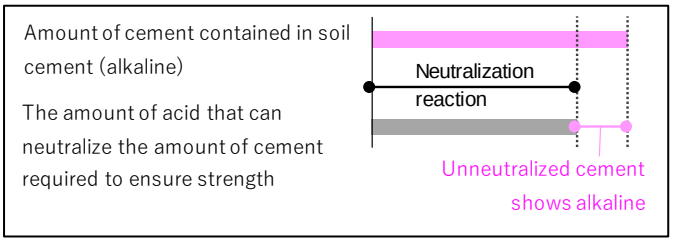

Figure-4 Overview of Estimation

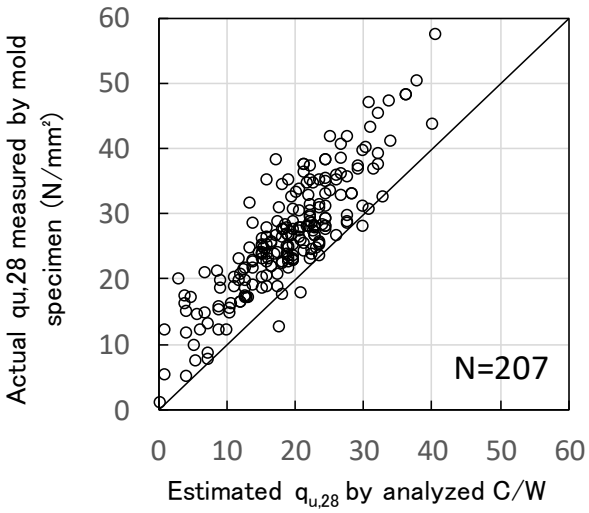

Figure-5 Relationship between 28-day strength(qu,28) estimated using the technology and qu,28 measured using molded specimens

3. Scope of Application of the Technology

(1) **Soil**: Soil classified as gravel, sand, or clay, with a pH in the range of about 4 to 11
(2) **Cement**: Ordinary Portland cement, blast furnace cement type B (JIS-compliant product)
(3) **Estimated strength**: 60 N/mm^2 or less

4. Result of the Technology

Determining the cement quantity using conventional laboratory analysis equipment took several hours, but this method, which uses the neutralization reaction, can be rapidly implemented on site without requiring special skill, indicating that this is a breakthrough. From the water quantity and cement quantity obtained through the usage of the C/W – strength correlation equation referred to above, the 28-day strength can be immediately estimated.

Using this technology, the construction of foundation piles can be checked within one hour, having an effect of speeding up quality verification and preventing defects , resulting in the quality of pile construction being ensured and productivity improved.

5. Social Significance and Extendibility of the Technology

This technology greatly contributes to ensure the construction quality and productivity of buildings supported on foundation piles. In recent years the societal need to ensure the quality of construction for foundation piles is very high, and this technology can be widely used in the building or civil engineering industries through licensing, indicating that it is not restricted to Shimizu. Therefore, the social significance of this technology is extremely large. Also, in principle the technology can be extended to cements with different overseas standards, and to control the quality of cement-stabilized foundation soils.

6. Experience of Application of the Technology

206 projects, including the Moka Power Station Construction Project (MPP) from June 2016 to October 2016

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About “JAPAN Construction International Award”

Ministry of Land, Infrastructure, Transport and Tourism established the “JAPAN Construction International Award (Honored by the Minister of Land, Infrastructure, Transport and Tourism)” in 2017, and it has become a global showcase of “Quality Infrastructure,” which commends (1) overseas construction projects which demonstrate Japan’s strengths, and (2) small and medium-sized construction companies which play active and leading roles overseas.

Through this award, the Ministry of Land, Infrastructure, Transport and Tourism aims to promote global understanding of the Japanese companies’ competitiveness and expect more projects to be carried out by Japanese companies.

In commemoration of the 5th anniversary, MLIT established the "Special Award (Pioneering Activity Category)" to commend activities that have been highly evaluated for their contributions to infrastructure development around the world.

The 5th Japan Construction International Award ceremony was held on June 17, 2022. For the 5th Japan Construction International Award, 4 projects were awarded for the “Construction Project Category,” 1 company was awarded for the “Small and Midium-sized Enterprises Category,” and 3 projects were awarded for the “Special Award (Pioneering Activity Category).”

Please check about the 5th Japan Construction International Award from the link below.
https://www.mlit.go.jp/JCIA/en/award/5/

You can also download the 5th Japan Construction International Award brochure from the link below.
https://www.mlit.go.jp/JCIA/en/content/Japacon_brochure_5th.pdf

About IDI and IDI-quarterly

Infrastructure Development Institute-Japan (IDI) is a general incorporated association operating under the guidance of Ministry of Land, Infrastructure, Transport and Tourism of Japanese Government.
IDI provides consulting services to facilitate international assistance to developing countries, to promote international exchange of information and human resources, and to support globalization of project implementation systems targeting both developed and developing countries in the field of infrastructure.

IDI has been publishing a free quarterly journal called “IDI Quarterly” since1996 to introduce information related to public works and construction technologies developed in Japan, to foreign countries. We have distributed the journal to administration officials in more than 90 countries around the world via e-mail.

It will be highly appreciated if you could send us your opinions, impressions, etc. regarding the articles.
We also welcome your specific requests regrading technologies you would like to see on following Quarterly issues.