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Infrastructure Development Institute—JAPAN

↑Artificial Stones Dumping

Six Months Later →

Artificial Stones for fish-breeding reefs and marine forests

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The 11th Infrastructure Technology Development Award 2009 of JICE

The Japan Institute of Construction Engineering(JICE) has been 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 initiated to co-host Infrastructure Technology Development

Award with the Coastal Development Institute of Technology (CDIT) under the auspices of the Ministry of Land, Infrastructure and Transport (MLIT).

Thirty-two technologies competed for the 11th Infrastructure Development Award. In principle, the applicants' technologies had to have been developed within the past five years and applied to the real sites within the past three years. Both the institutes and the researchers of the applied technologies were entitled to the 11th Award prizes.

Among the applied technologies, the two best excellence prizes were awarded to " The Kajima Cut & Take Down Method ", The development of a new demolition method for high-rise buildings, and "The Key Element Method", A method that makes it possible to eliminate the final joint for a submerged tunnel .

And the two excellence prizes were awarded to "Trapezoidal CSG dam design", a new world-class dam design technique that reduces construction costs and environmental loads, and "Artificial stone (Frontier Stone, Frontier Rock) and Block made from Steel Slag Hydrated Matrix", utilization method of recycled materials that realize conservation of natural resources, reduction of CO_2-emission and remediation of the marine environment.

The best excellent prize technology were in the previous issue of IDI Quarterly (No.49, October 2009) and other two excellence technologies is introduced below.

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Trapezoidal CSG Dam Design

- a new world-class dam design technique that reduces construction costs and environmental loads -

1. Background and objectives

In light of the increasing difficulty of sourcing construction material from quarries and the advent of stricter environmental conditions, there is a pressing need for new dam construction techniques predicated on rationalization of materials to minimize environmental loads and significantly reduce costs.

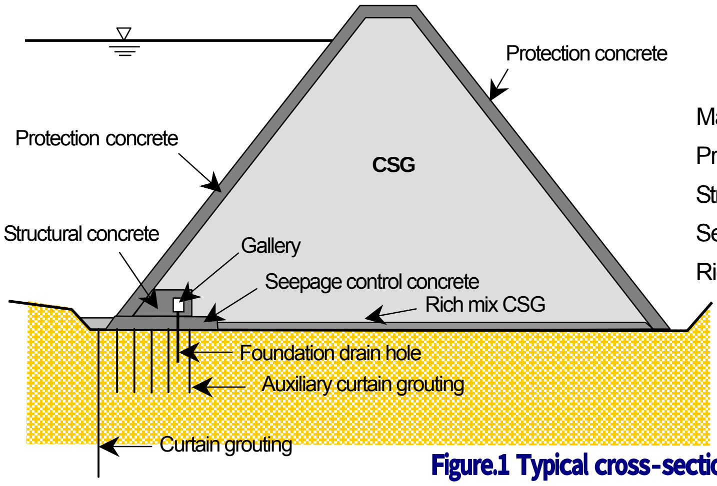
Figure 1 depicts the Trapezoidal CSG Dam method, an all-new world-first design technique featuring CSG (Cemented Sand and Gravel) and a trapezoidal dam shape which reduces construction costs and environment loads. CSG can be prepared easily with simple equipment using materials that are readily available in the vicinity of construction site. The materials do not generally require sorting, size grading or washing; the only necessary processing is the removal or crushing of oversize pieces of materials followed by the addition of cement and water.

2. Brief description

CSG is cheaper than concrete but does not provide the same level of strength. Nevertheless CSG is suitable for use in trapezoidal dams, which do not require as much structural strength as standard right-angled triangle dams.

CSG can therefore help to reduce construction costs and environmental loads.

The Trapezoidal CSG dam method represents a totally new approach to dam body design based on the finite element method. Trapezoidal CSG dams have been demonstrated to provide the same level of safety as conventional embankment dams and concrete dams using numerical simulations. The new method employs the diamond-shape theory of dual control of particle size distribution and unit water content (see **Figure 2**) and provides new methodologies for strength evaluation and quality control of materials. It also includes development of mixing equipment designed for trapezoidal CSG dam construction (see **Figure 3**).



Main dam construction material: CSG
Protection concrete: for durability and water cut-off
Structural concrete: such as gallery
Seepage control concrete: to provide enough seepage path
Rich-mix CSG: for durability

Figure.1 Typical cross-section of a trapezoidal CSG dam

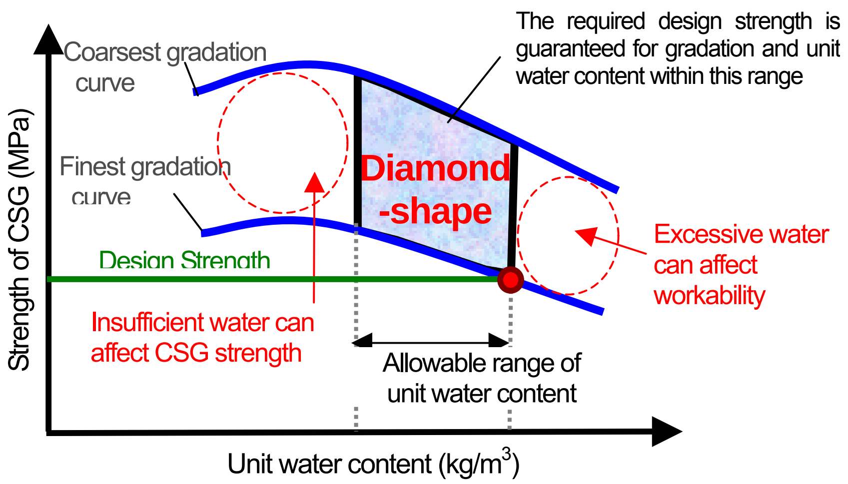
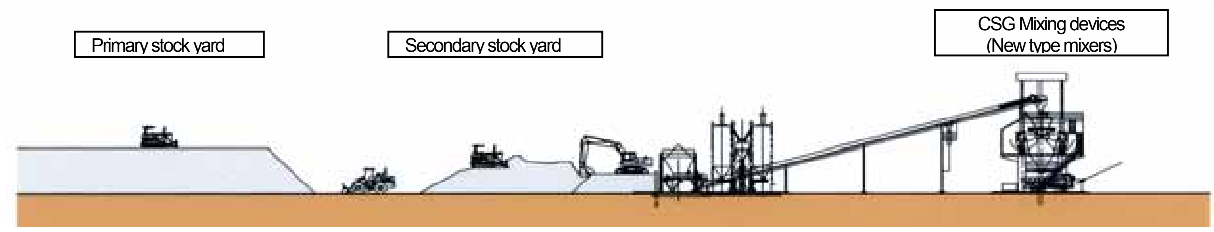


Figure 2 Diamond shape theory for CSG strength (governed by gradation and unit water content range)

CSG strength is distributed within the diamond-shaped range delineated by the two particle size-strength curves and the two vertical lines indicating the allowable range of unit water content. If the lowest strength within the diamond-shape range is taken as the CSG strength, then the CSG materials will exhibit the required design strength at particle size and unit water content within the given range. Unlike concrete strength, which is controlled at fixed ranges of particle size distribution and unit water content, CSG strength is subject to planar (or dual) control.



CSG is a mixture of CSG material together with cement and water. It is prepared in a continuous process using relatively simple equipment. The CSG mixture is laid on site via the planar construction method, as with RCD construction. This can be achieved using standard, general-purpose dam construction equipment such as dump trucks, bulldozers and vibration rollers.

Figure 3 Example of CSG mixing system

Photo.1 Marsh control works at Taiho Dam

3. Benefits

An analysis of total construction-related costs at 13 dams demonstrated the cost savings achieved through the Trapezoidal CSG dam technique. It was found that main dam body construction costs can be reduced by up to 25%.

The shorter construction period also helps to reduce construction costs while allowing the new dam to commence operations sooner.

Trapezoidal CSG dams are built using the planar construction method, which provides a high degree of safety due to the lack of steps and level differences.

The process of extracting materials for dam body construction has less impact in terms of altering the topography and therefore reduces the environmental load.

Since spillway is incorporated into the dam body, there is no environmental impact associated with the conventional practice of constructing spillway in adjacent areas.

4. Scope of application

Dam body: trapezoidal dam body configuration, primarily CSG materials, using CSG construction method— up to 100-meter height class

Associated structures: temporary cofferdam during dam construction, sediment pool dam within dam reservoir, landslide protection works—no restricting conditions

All permanent structures associated with rivers and embankment roadways requiring strength guarantee and quality control techniques

5. Completed structures

Taiho Dam Marsh control works (**Picture** 1), April 2003 – April 2004, plus three other dams

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Artificial Stone (Frontier Stone, Frontier Rock) and Block Mad from Steel Slag Hydrated Matrix

- Utilization method of recycled materials that realize conservation of natural resources, reduction of CO_2 emission and remediation of the marine environment -

1. Background and trigger for the development of the technique

【Background】

(1) Increasing social needs for effective utilizations of by-products and formation of a recycling-oriented society of environmental load reduction.

(2) Increasing social momentum toward measures and actions for preventing global warming.

【Trigger】

Shortage in high-quality materials for large-scale reclamation projects.

Tightening and execution of regulations on the digging for natural resources such as restrictions on the digging of sea sands.

2. Content of the technique

A newly developed construction material named steel slag hydrated matrix (hereinafter referred to as "SSHM") is hardened material manufactured by mixing ground granulated blast furnace slag (hereinafter referred to as "GBFS") binder with steelmaking slag aggregate as alkali activation together with water without industrial cement and natural aggregates..

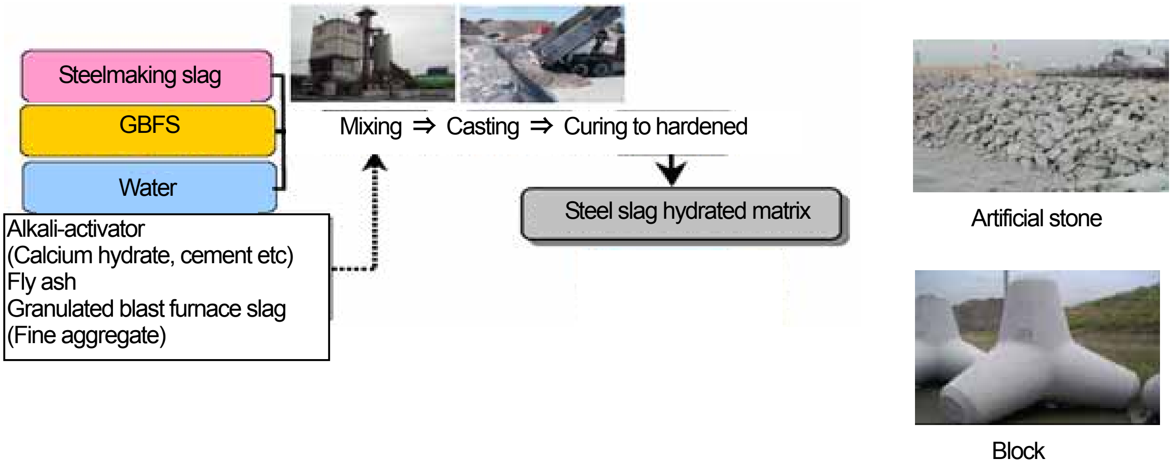

Fig-1. Manufacturing of Artificial stones and blocks made from SSHM

SSHM is utilized as artificial stones classified in intermediate hard stones after crushing hardened SSHM or plain blocks by forming in shaped molds for ports, harbors and airport constructions.

SSHM is mostly composed of by-products generated in iron-making process, so it is expected to contribute to the formation of a recycling-oriented society, conservation of natural resources and reduction of CO_2emission.

SSHM is low-alkali material as compared with steelmaking slag; the pH of seawater almost never rises when SSHM is dumped directly into seawater.

Furthermore, SSHM excels in bio-fouling due to minerals such as iron contained in steelmaking slag so it is expected to remedy the marine environment

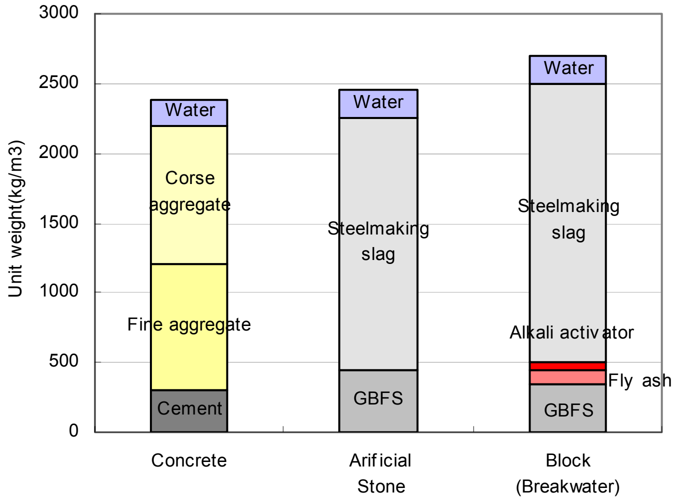

Fig-2. Example of comparison of composition between SSHM and ordinary concrete

Quality items \ Materials		Artificial stone of SSHM	Sand stone debris
Unconfined compression strength of parent rock (JIS A 1108)		18.8-32.1	-
Effective grain size D_{10} (mm) Grain size corresponding 10% finer by weight		0.5-10.0	0.07-3.0
Coefficient of uniformity U_c ($U_c=D_{60}/D_{10}$)		5.5-19.5	15-355
Absolute dry density (g/cm^3) (JIS A 1109)		2.33-2.47	2.55-2.65
Water absorption (%) (JIS A 1109)		8.6-12.0	-
Angle of shear resistance ϕ_0(degree) (JGS 0524-2000)	σ_c=100kPa	39.8-46.6	38.6-41.3
	σ_c=200kPa	38.1-41.2	38.8-40.2
	σ_c=400kPa	36.2-40.6	37.7-39.8
Slaking ratio (%) (JHS 110)		0.2-0.4	13.1-58.7
Rate of secondary consolidation (%)*		0.009-0.017	0.015-0.083

*Gradient in log time - axial strain curve derived from long-term one-dimensional compression tests, in which vertical stress is loaded constantly at 400kPa to the steel containers of 300mm diameter and height stuffed with stones without compaction and void saturated with water under lateral deformation is confined.

Table-1 Properties of SSHM (As compared with natural stones classified as intermediate hard stones)

3. Effects of the technique

(1) Achievement of zero use of natural aggregates

This material has been practically applied to 410 km^3 substitutes of natural stones and 19 km^3 substitutes of plain concrete. In all applications, the composition of SSHM was designed and adopted without natural aggregates and cement. As a result of these practices, 600k tons of natural stone has been saved.

(2) Establishment of methods for manufacturing high-grade artificial stone with by-products generated in the steel-making process.

Realization of manufacturing high quality artificial stone with several properties as follows by controlling and adjusting the basic composition of SSHM and grading.

1) The same strength and ductility as natural stones classified as intermediate hard stone.

2) SSHM is low-alkali and can be directly dumped into seawater. Due to its high-permeability, it remains un-liquefied without compaction during earthquake.

Reduction of CO_2 emission

(3) Manufacture of SSHB produces 76% less CO_2 emission than concrete using ordinary Portland cement and 60% less than using concrete with blast furnace cement.

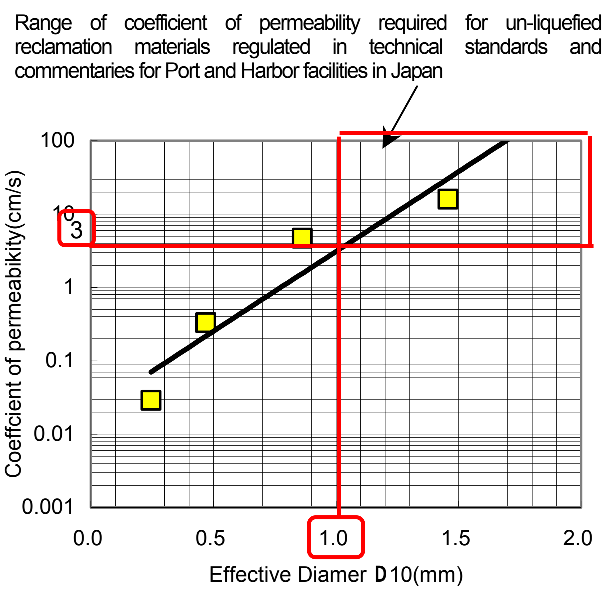

Fig-3. Relation between D_{10} and coefficient of permeability

4. Applicable scope of the technique

(1)Substitute of natural stones

Un-liquefied materials for reclamation and those for back-fill of quay-walls and revetments, sloping breakwaters, sloping revetment, fish-breeding reefs and marine forests etc

(2)Substitute of plain concrete blocks

Various types of blocks such as those for fish-breeding reefs and marine forests, break-water blocks for fixing caisson on rubble stones

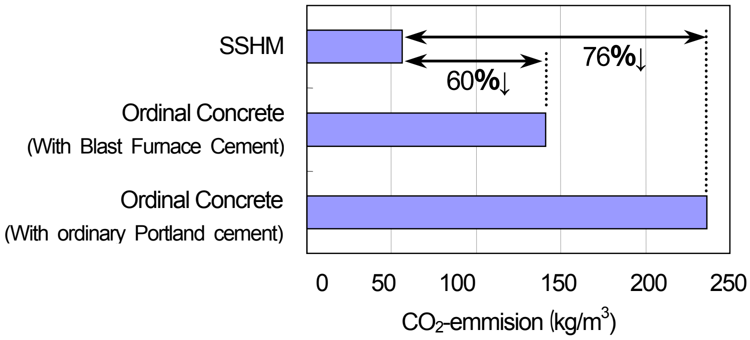

Fig-4.Comparative Example of CO_2-emission between SSHM and Concrete

5. Application achievements of the technique

SSMH has been applied for reclamation materials for a new runway (D-runway) of Tokyo International Airport (Haneda Airport) from 2008.5 to 2009.3 and another 20 cases.

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Implementation of the “Housing Eco-Point System”

The Japanese government decided to promote the use of ecological products, in the three fields of home electric appliances, automobile and housing, as the economic stimulus measures announced in December 2009. This is an effort aiming to mediate global warming as well as economic recovery.

“Housing Eco- Point System” was introduced as a specific step of this policy. Those people who newly start Eco-House construction or renovate their housing into Eco-House by the end of December 2010 can get “Eco-Point”, and the “Eco-Point” can be changed to goods, products and services.

The Eco- Point can be saved regardless of own house, or rented house, or single family house or a condominium.

Renovation work for Eco-House

Eco-Point will be given for, ①Thermal insulation of windows, ②Thermal insulation of outer wall, roof, ceiling and floor. The barrier-free work simultaneously done with ① or ② will also be a subject.

①”Thermal insulation of windows” means the renovation work such as the change from single layer glass into double layer glass, addition of inner glass window, total exchange of windows into low-emissivity ones.

②"Thermal insulation of outer wall, roof, ceiling and floor" means the renovation work with specified quantity of non-chlorofluorocarbon(CFC) insulation materials.

And the barrier-free modification work simultaneously carried out with ① or ② will also be a subject of Eco-Point. Barrier-free work covers installation of banister, eliminate difference in level on the floor, widening of passage and doorway.

Newly-Built Eco-House

In order to be approved as an Eco-House for the newly built housing, the following requirements should be fulfilled.

- ①Thermal insulation of windows and outer wall and others, and also equipped with ②High efficiency hot-water supply and air conditioning system.
- ① plus ③High efficiency air ventilation and air conditioning system.
- ① plus ④Solar power generation system.
- A wooden house that satisfies energy saving standard is also admitted as an Eco-House.

To be recognized as an "Eco-House" by the government, approval by the third party certification organization is necessary.

The term "High efficiency" in the ②hot-water supply and air conditioning system and the③air ventilation and air conditioning system, means that those system can save primary energy by 10% down from conventional housing equipments. Such system includes high efficiency hot-water system, hot water saving apparatus, heat exchanger type air ventilation and high efficiency air conditioning system.

The application form for the " Eco-Point" should be submitted by the owner of the housing, regardless of individuals, corporate body, client and purchasers.

Person-Trip Survey in the Tokyo Metropolitan Area

"Tokyo Metropolitan Traffic Planning Council" has implemented "Person-Trip Survey" in the Tokyo Metropolitan Area, in order to clarify and analyze present travel pattern and then to figure out most preferable traffic system in this area. Tokyo Metropolitan Area includes Tokyo and surrounding four prefectures ; Kanagawa, Saitama, Chiba and parts of Ibaragi.

The unit used to measure travel is the trip. A trip is the movement of an individual person from one place to another to achieve a purpose. Even if the traveler has changed from one travel method to another during trip, for example, from bus to train, still this is one trip.

"Person-Trip Survey" catches all the travel movement on daily basis and clarify, What kind of person did travel? When did they travel? For what purpose they travel? From where to where they travel?

Data on trips were collected by interview surveys asking 730,000 people of 34,000 households (which were selected at random) about their travel. This survey was carried out on weekdays during October-November period in 2008. The result is shown below.

1. Total number of trips in the Metropolitan Area has increased by 7% due to population growth

Total number of trip has increased around 7% from 79 million trips (1998) to 85 million trips (2008) due to population growth in this area. Central Tokyo region has shown top trip number and growth rate is 11%.

For a decade of 1998-2008, central Tokyo has been increasing population while local towns and villages in northern Saitama, southwest Chiba, east Chiba and south Ibaraki have been decreasing population.

2. Average daily trip number per person has increasing due to trip increase by elderly people

Daily trip number per person had been decreasing up to 1998, but in the 2008 survey, daily trip number per person is showing upward trend, especially for elderly people above 60.

3. Private purpose trip from outside the home has increased

For the breakdown of trip purpose, each items are, ① commuting to work from home ②commuting to school from home ③business purpose from home ④private purpose from home ⑤return home ⑥on-duty, in business ⑦private purpose from outside the home.

Among this lineup, "⑦private purpose from outside the home" has increased from 1998 survey. Other item shares the same level as 1998 position.

4. Average trip hour for total purpose is increasing,

especially business and private trip

Average trip hour per day for the total trip purpose has increased by 2.3 minutes in 2008 from 1998, and ③ business purpose from home has increased by 8.7 minutes in 2008, ④private purpose from home has increased by 4.3 minutes in 2008.

5. Share of each mode of transportation - Automobile is decreasing, railroad is increasing, this trend is remarkable in urban district, and for the purpose of commuting and business

When the traveler has changed transportation method in one trip, the main portion of the trip is called typical traffic method. When we sum up the trip generated and the trip flew into certain area, the railroad's share has increased in all the Tokyo Metropolitan Area. Automobile has decreased in the whole Metropolitan Area but only south Ibaraki shows increase. The 40% of automobile decrease is attributed to the decrease in central Tokyo. While share of automobile is decreasing for the purpose of commuting and business, railroad is increasing for this purpose. On the contrary, use of automobile is increasing ⑦private purpose from outside the home.

The changing trend of automobile use is due to population increase in the central Tokyo and development of railroad infrastructure in this region. Furthermore, rapid gasoline price hike in this period might affect people's car use.

Population distribution has also changed for a decade of 1998-2008. Central Tokyo has population growth but local towns and villages in northern Saitama, southwest Chiba, east Chiba and south Ibaraki have shown shrink of populations.

As to the relation of population distribution and railroad station, population within 1.5km radius from railroad station has increased by 1,880,000 but other area's increase remain only 70,000. So it is apparent that population is remarkably growing around railroad station.