Journal of Material Cycles and Waste Management (2022) 24:1216–1227
https://doi.org/10.1007/s10163-022-01411-y

SPECIAL FEATURE: REVIEW

Material Cycles in Construction Works

Material reuse and recycling in construction works in Japan

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Received: 13 January 2022 / Accepted: 4 April 2022 / Published online: 4 May 2022

Abstract

The status of material reuse and recycling in Japan is reviewed with an emphasis on the efforts by the national government. First, the national policy, including the regular survey and action plan, is summarized. Second, the current status of the generation, treatment, and reuse/recycling of construction waste and by-products is provided. Third, efforts to solve three major challenges for material reuse and recycling are discussed. Fourth, the statuses and problems of each waste and by-product generated from construction works are described. Finally, the newest version of the "Material Reuse and Recycling Promotion Plan in Construction Works," which was formulated in 2020, is introduced.

Keywords Construction works · National government policy · Concrete waste · Construction sludge · Excavated soils

Introduction

Rapid economic growth in Japan from the 1950s to the 1970s generated large amounts of waste and by-products. This caused several environmental issues such as illegal dumping and triggered the establishment of the "Waste Management and Public Cleansing Act" in 1971. In addition to this 50-year-old law, regulations related to the construction industry have been implemented. These include the "Law for Promotion of Effective Utilization of Resources" enacted in 1991 and the "Construction Material Recycling Law" enacted in 2000. Recently, sustainable development has been discussed due to limited natural resources. The 3Rs—Reduce, Reuse, and Recycle—have been promoted to achieve a so-called "material-cycle society" where resources such as waste are properly utilized or treated in landfills. Since the construction industry is a major source of generated waste and by-products, reusing and recycling of construction materials have been promoted with remarkable achievements.

This manuscript reviews the status of material reuse and recycling in Japanese construction projects with an emphasis on the efforts by the national government. Section 2 summarizes national policies, including regular surveys and action plans, while Sect. 3 provides the current status of generation, treatment, and reuse/recycling of waste and by-products in the construction industry. Section 4 highlights three major challenges, which are priorities to enhance material reuse and recycling. The status of each waste and by-product generated from construction works are described in Sect. 5. Finally, Sect. 6 introduces the newest version of the "Material Reuse and Recycling Promotion Plan in Construction Works," which was revised in 2020.

General remarks on government policy

It is important to assess the status of material recycling in construction works. There have been several studies about the generation, treatment, and reuse/recycling of construction by-products in Japan [1–3]. Since the mid-1990s, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (established in January 2001) has conducted the "Survey for the Status of Waste and By-products in the Construction Industry" approximately every 5 years to monitor the status of generation, treatment, and reuse/recycling of

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construction by-products in Japan. The results of construction projects over a certain magnitude in both the public and private sectors are summarized and publicized. This series of surveys evaluate the status of materials categorized as "waste" under the national legal system: asphalt-concrete waste, concrete waste, construction wood waste, construction sludge, and mixed construction waste. Additionally, the status of excavated soils and rocks, which are not categorized as waste, is also investigated.

Based on the results, MLIT publishes the "Material Reuse and Recycling Promotion Plan in Construction Works" to promote recycling and the proper disposal of construction by-products. The plan includes a general overview, targets, and measures to promote material recycling in construction works. The fifth edition of the "Material Reuse and Recycling Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality" was formulated in 2020. Previous versions were released in 1997, 2002, 2008, and 2014. The latest plan designates quantitative targets for waste generated and the effective utilization ratio. It also indicates technical and institutional measures needed to achieve the targets. The targets were determined based on the reuse/recycle ratio (the reused and recycled mass divided by the generated mass of the relevant by-product), the reuse/recycle/reduction ratio (reused, recycled, and reduced mass divided by the generation of the relevant by-product), and the discharge fraction (generation of the relevant waste divided by the total waste generation in construction works). Section 6 explains the content of the "Material Reuse and Recycling Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality."

Current status

Waste generation from Japanese households has been declining. In FY2000, approximately 54 million tons were produced, whereas approximately 43 million tons were generated in FY2019. In contrast, waste generation from business activities (the so-called "industrial waste") has remained steady since FY1990. The total amount of industrial waste is approximately 400 million tons annually, of which about 20% is construction waste. The fraction of construction waste in total industrial waste should increase in the future, since other types are expected to decrease due to the declining population. Figure 1 shows the available capacity and the corresponding duration of industrial waste landfills. The duration has increased to 17 years due to the reduced volume of waste reclaimed in landfill sites in recent years. However, only less than 6 years remain in the Tokyo metropolitan area. More efforts are necessary to reduce waste generation due to this tight situation. Reduction of waste and by-product generation and enhancement of reusing construction by-products are important issues.

Here, the status of construction by-products generated in Japan by volume is explained. When the survey began in 1995, approximately 99 million tons of construction waste was generated annually. Figure 2 shows that it decreased to approximately 77 million tons in 2005 and approximately 74 million tons in 2018 [1]. The annual volume of construction waste is clearly decreasing. The reuse/recycle/reduction ratio was around 60% in the 1990s, but reached 97% in FY2018 (Fig. 3). This ratio is comparable to the

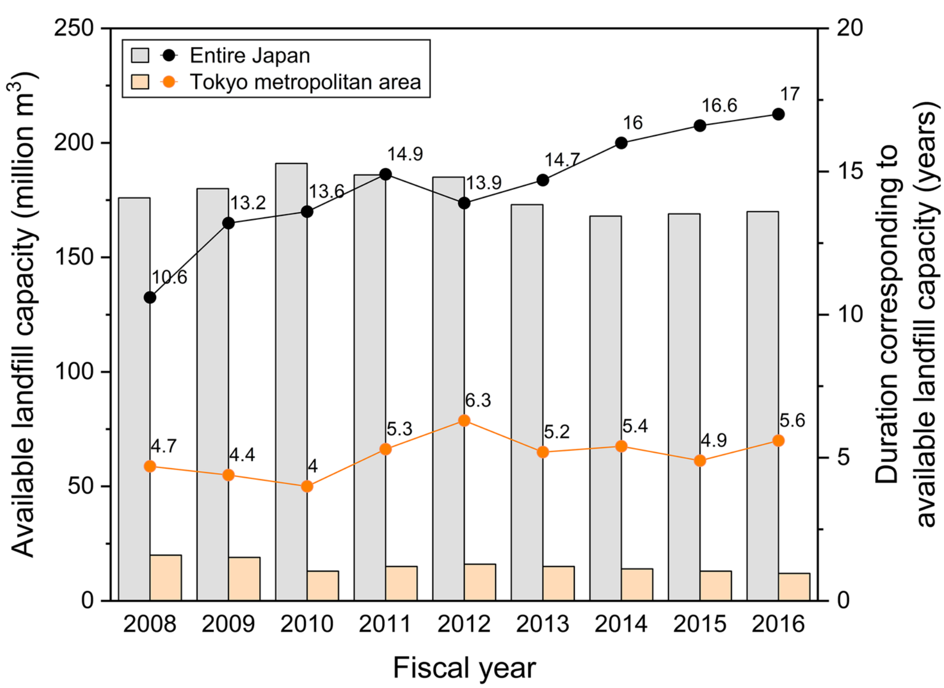


Fig. 1 Available capacity (bars) and corresponding duration (circles with lines) of the industrial waste landfill

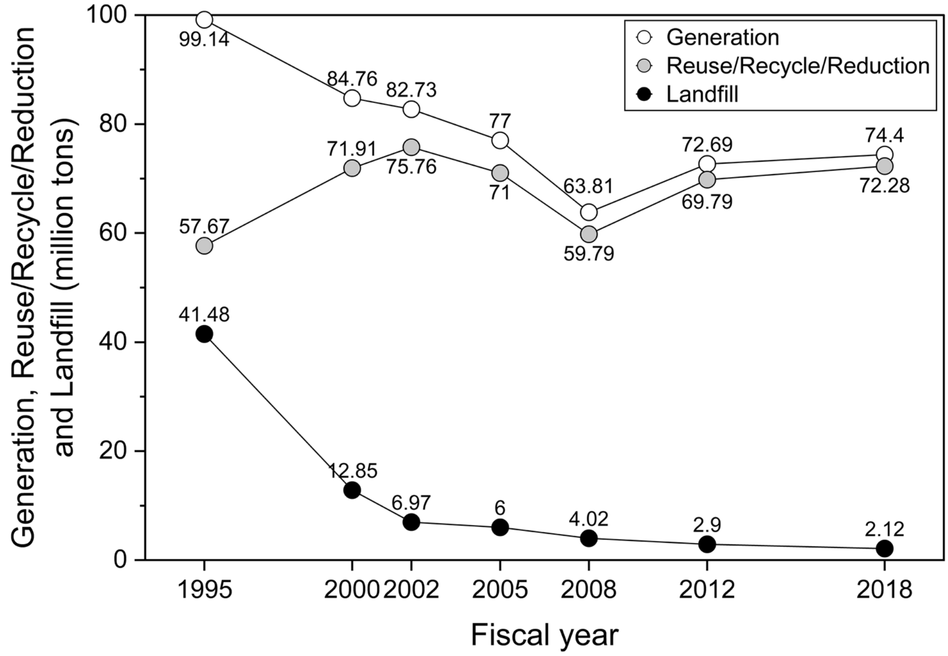


Fig. 2 Generation, reuse/recycle/reduction, and landfill of the wastes from construction works

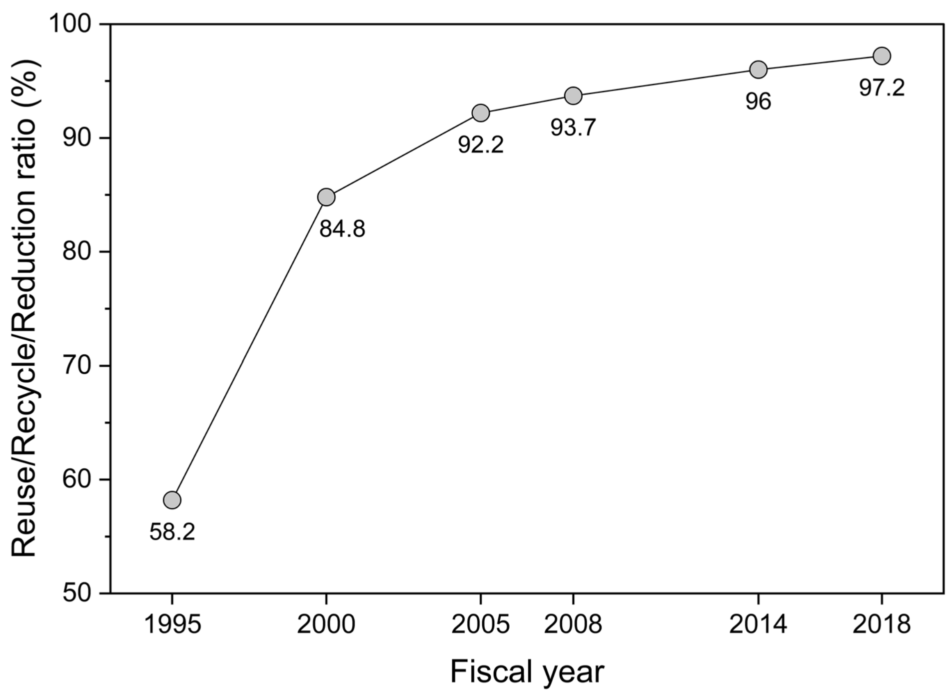


Fig. 3 Reuse/recycle/reduction ratio of the wastes from construction works

reuse/recycle/reduction ratio in other developed countries [4]. Approximately 61% of excavated soils and rocks generated in 2000 were used at construction sites, since a high proportion of new materials was used. The amount of excavated soils and rocks used at construction sites has increased to 83% in 2002 and 89% in 2018, indicating that the soils and rocks are often used onsite.

Construction by-products are often reused or recycled. Efforts such as setting clear and reasonable targets and continuous implementation of reuse/recycling initiatives in cooperation with related industries based on the formulation of the "Material Reuse and Recycling Promotion Plan in Construction Works" have been fruitful (Sect. 2). It should be noted that the quantity of construction by-products has entered a stable period after the developing period in the 1990s and 2000s. Therefore, an improved "reuse/recycle quality" will be demanded in the future. This aspect is included in the "Material Reuse and Recycling Promotion Plan in Construction Works 2020," which is described in Sect. 6.

Some issues have yet to be solved. First, waste generated from the construction industry corresponds to approximately 80% of the total illegal dumping. Second, improper management of surplus soils generated from construction sites has caused several issues. Surplus soils are the unused excavated soils and rocks that are moved offsite. The country has witnessed several cases of displacements, slides, and failures of soil fills due to improper management, particularly the rapid filling of soil fills to extreme heights [5, 6]. Countermeasures to prevent illegal dumping and improper management are necessary. In recent years, there have been discussions about developing a system to track excavated soils and rocks from their generation to treatment and utilization to realize their proper management [7]. In addition to such national initiatives, regional efforts are needed to address region-specific issues.

Aside from waste reuse/recycling innovations, Aldieri et al. [8] note that incentives to foster more integration between different industries are also important factors in improving waste reuse/recycling. Changes in society may also significantly affect reuse/recycling/reduction of waste and by-products in the construction industry. Examples include efforts towards a material-cycle society, linkage with infrastructure maintenance and renewal, and improvements in production. The United Nations' Sustainable Development Goals (SDGs), which are global initiatives, call for a significant reduction in waste generated by 2030 by controlling the waste generation, recycling, and reuse. Because the construction industry must adapt to achieve SDGs, the reuse/recycle/reduce concept must be promoted.

Major challenges

Although the reuse/recycle/reduce concept of waste and by-products in construction works has made great strides, especially in terms of "quantity," some challenges remain. The three main issues include: (1) maintaining a high reuse/recycle/reduction ratio, (2) linking maintenance and renewal of aged infrastructure, and (3) enhancing productivity. Below each area is explained.

Formation of a material-cycle society with a high reuse/recycle/reduction ratio

According to the survey of construction by-products in FY2018, the recycling and reduction ratio of construction waste was approximately 97%. Although the recycling ratio is high, the amount of waste generated slightly increased compared to the previous survey (FY2012). In addition, the survey indicated issues with the illegal dumping of surplus soils. Efforts to maintain these high ratios should be continued.

In the fourth "Basic Plan for Establishing a Sound Material-Cycle Society" [established by the Ministry of the Environment (MOE) for the entire material usage process and approved in June 2018], soils, rocks, and other construction by-products are listed as materials for reuse and recycling. The reuse and recycling of by-products should consider both conventional targets for the generator and the "quality" of recycling for the end-user. Together, these may realize a society with high-quality recycling. In the plan, "resource productivity (= GDP/input of natural resources)" is used as a comprehensive index of how effectively industries and people's lives utilize resources. This index does not consider the fact that infrastructure has a long lifetime or its stock effect. In the field of material reuse and recycling, proper evaluation methods considering the characteristics and situations specific to the construction industry must be established.

Linkage with maintenance and renewal of the aging infrastructure

Infrastructure constructed during the rapid economic growth period in the 1950s and 1970s is aging. Construction recycling should be promoted in anticipation of maintenance and renewal of the aged infrastructure. The cost for maintenance and renewal in 30 years is expected to be 1.3 times higher than that of FY2018. Additionally, the waste generated from infrastructure built with reused and recycled materials should be reused and recycled in the future. These issues might change the status of waste and by-product generation of the construction industry. Another aspect relates to the maintenance and renewal of infrastructure. Since the development of "high-quality" infrastructure and extension of its service life will reduce the generated amount of waste and by-products, quality should be a factor when constructing infrastructure.

Another crucial consideration related to this manuscript is disaster waste generation. In recent years, huge earthquakes, typhoons, and heavy rains have frequently occurred due to climate change. They generate a significant amount of waste and by-products. Disaster waste affects the reuse and recycling of materials in the construction industry. Hence, plans should consider rapid changes due to such effects.

Enhanced productivity

The Japanese workforce is declining, and consequently, the Japanese government is promoting efforts to improve productivity. In the construction industry, efforts focus on enhancing the productivity of construction sites through "i-Construction"—an initiative to promote onsite use of ICT (Information and Communication Technology). As "Society 5.0" is implemented, data on manufacturing, supply, quality, and traceability are accumulating through Building Information Modeling (BIM) and Construction Information Modeling/Management (CIM). Such data can help improve the quality of recycled materials in construction projects. ICT is also an effective way to efficiently monitor construction by-products such as excavated soils and rocks, and should be used to enhance the efficiency of various procedures and statistical surveys for recycling.

Status by type of waste and by-product

Overall, reuse, recycling, and reduction initiatives in the construction industry have been successful. The recycling and reduction ratio of construction waste increased from 58% in 1995 to over 90% in 2002 and reached 97.2% in 2018. Despite the high total reuse/recycle ratios, problems in individual categories of waste and by-product remain. For example, Fig. 4 indicates a high landfill ratio of mixed construction waste. Issues regarding each type of waste and by-product are described below.

Mixed construction waste

Although the basic concept to reduce waste generation and to promote reuse and recycling is to separate construction waste to the extent feasible from other waste, some portions will remain in a mixed state. The amount of mixed construction waste treated offsite was approximately 10 million tons in 1995, approximately 3 million tons in 2005, but decreased to approximately 2 million tons in 2018. This indicates that proper separation of mixed waste either at construction sites or intermediate treatment plants helps reduce mixed construction waste.

Figure 5 shows the material flow of mixed construction waste based on the survey in 2018. Approximately 36.8% of generated mixed construction waste was landfilled, which is the highest value compared to other waste and by-products in construction works. The high landfill ratio may be because underground obstacles are mixed with waste materials instead of being separated as new construction materials. Due to the declining capacity of industrial waste landfills, efforts are needed to reduce the amount of waste in landfills.

Plastic waste

Countermeasures against plastic waste have become a critical environmental issue. The construction industry should consider plastics, but neither the previous survey in 2012 nor the Material Reuse and Recycle Promotion Plan in Construction Works in 2014 focused on plastics. Prior to 2017,

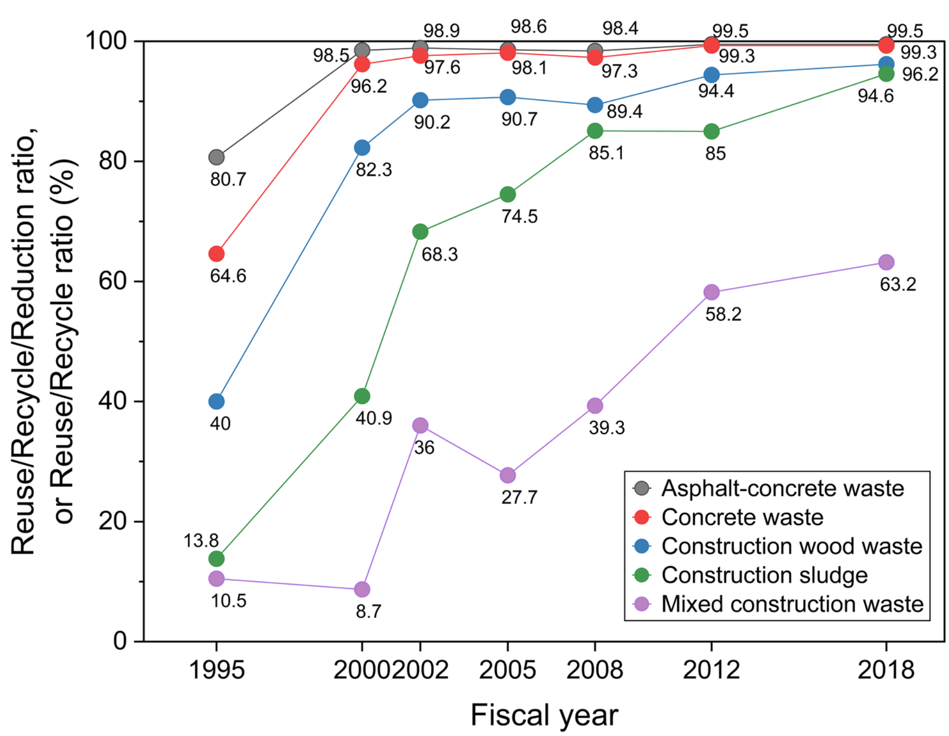


Fig. 4 Status of reuse, recycle, and reduction of wastes from construction works

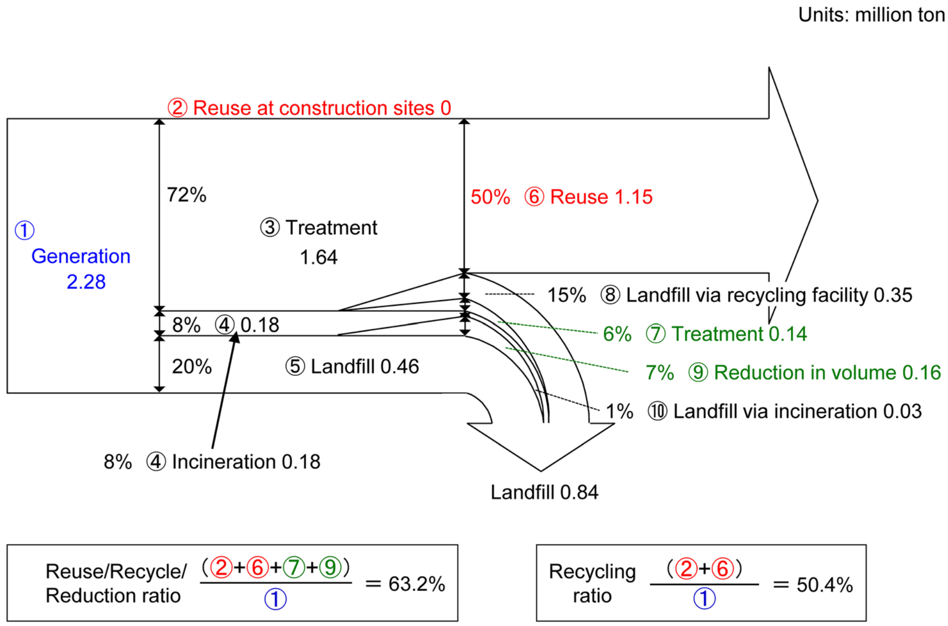


Fig. 5 Material flow of mixed construction waste based on the survey in 2018

plastics were exported to other countries, but this practice has been banned. As SDGs call for action to realize zero plastic waste by 2030, the 3Rs for plastic waste must be implemented. MLIT's survey on construction by-products in 2018 estimated that approximately 30% of plastic waste was disposed of at landfill sites. If plastic waste generation from construction works is assumed to be 600,000 tons, which is only the estimation but within the reasonable range based on various available information, approximately 180,000 tons are disposed of. This amount is larger than that of asphalt-concrete waste for disposal (100,000 tons). This estimation highlights the necessity of reducing plastic waste for disposal. With the newest version of the Material Reuse and Recycling Promotion Plan in Construction Works, the national government seeks to promote the separation and recycling of plastics generated in the construction industry.

Asphalt-concrete waste and concrete waste

Figure 6 shows the material flow for asphalt-concrete waste and concrete waste based on the survey in 2018. Asphalt-concrete waste and concrete waste are used as a recycled hot asphalt mixture or a recycled roadbed material. The recycling ratio was 99.5%, which was the highest among different types of construction waste. They are mainly reused as asphalt and aggregates. Since crude oil, the raw material for asphalt, is mostly imported, reusing asphalt is critical from the perspective of recycling quality. However, recycled hot asphalt mixtures are sometimes mixed with recycled roadbed materials without recovery of asphalt. The use of asphalt-concrete waste as a recycled hot asphalt mixture should be promoted while ensuring the quality.

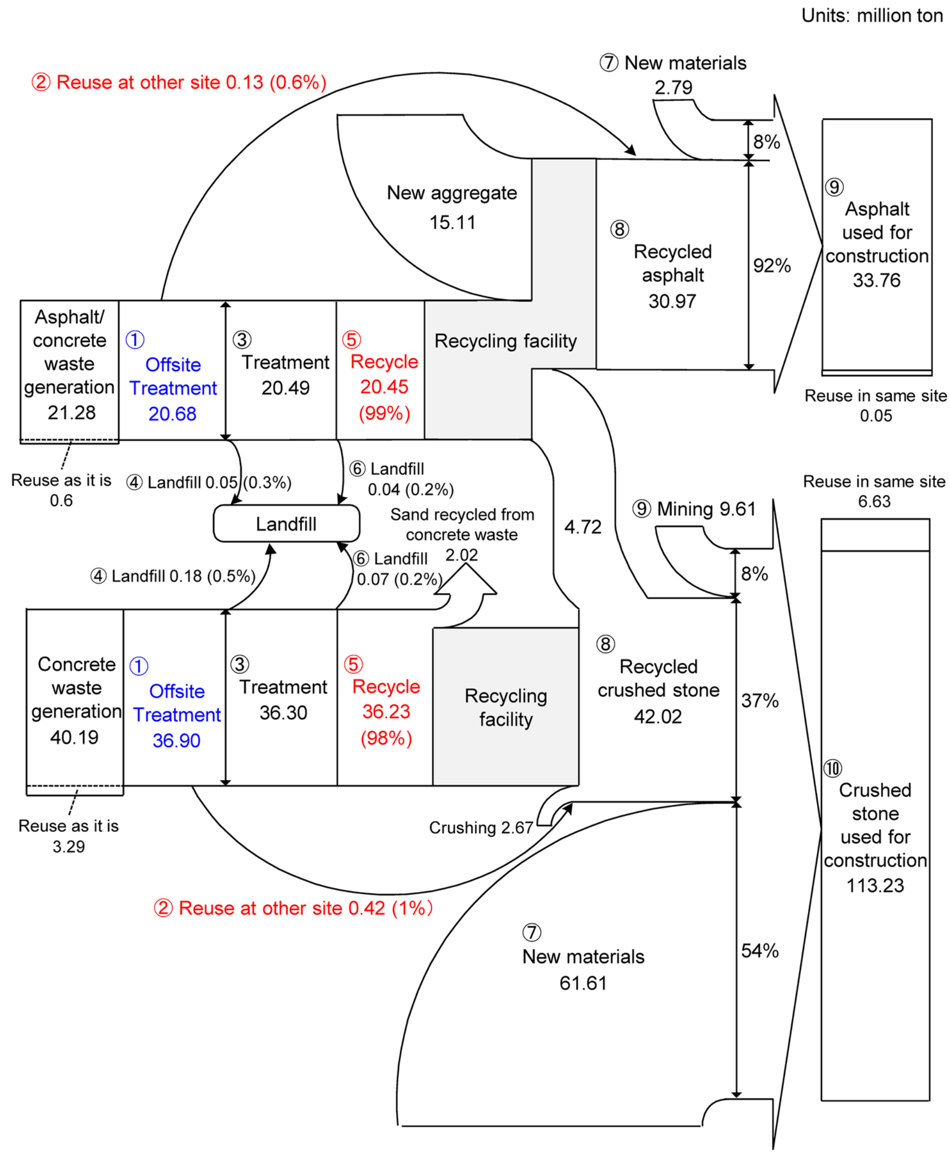
Concrete waste is recycled as "recycled crushed stone (recycled crusher run)," recovered sand, and recycled concrete aggregate. Detaching the cement paste from the aggregate is necessary to re-produce aggregates from concrete waste. A study by Tam [3] pointed out that recycled aggregates from Japan have a higher quality than recycled aggregates from other countries, which can be attributed to Japan's use of advanced technology. The "heating abrasion method" can generate a satisfactory quality of aggregates for use as cement concrete. The stripped fine particles can be used as raw materials for cement. However, such high quality of reuse is extremely limited.

Excavated soils and rocks

Figure 7 shows the material flow for excavated soils and rocks based on the survey in 2018. Approximately 290 million m^3 of soils and rocks were excavated. Of this, approximately 160 million m^3 was used onsite. Approximately 130 million m^3 of surplus soils were transported to different sites. Of this, 60 million m^3 was transported to inland reclamation, which accounts for more than 40% of the transported surplus soils. This includes soils transported to soil reclamation sites and those that have yet to be used in construction works. These soils have the potential of being dumped illegally. Appropriate transportation and reclamation of surplus soils, as well as their traceability, is strongly demanded.

In public construction projects, contractors are usually required to decide the reclamation site that will accept excavated soils and rocks. The national government designates the reclamation site for almost all public construction projects. However, this is not the case for projects ordered by

Fig. 6 Material flow of asphalt-concrete waste and concrete waste based on the survey in 2018



Asphalt/concrete waste	
Reuse/Recycle/ Reduction ratio	(②+⑤) / ① = 99.5%

Concrete waste	
Recycling ratio	(②+⑤) / ① = 99.3%

local governments. In fact, approximately 14% of public construction projects do not have a designated reclamation site. Designating the reclamation site is important to reduce soil with unclear (and possibly improper) treatment in construction projects ordered by local governments. Some excavated soils and rocks may be illegally dumped, leading to environmental issues.

There are three ways to deal with surplus soil. First, good quality soil can be utilized as filling or for embankments without any treatment. Second, other kinds of soil can be reused after improvement. Third, some soil is not used, and is simply disposed of with or without treatment. MLIT has established a classification system to promote the reuse of excavated soil (Table 1). Slurry or sludge on the bottom line is regarded as industrial waste.

Construction sludge

Construction sludge is a muddy mixture, which mainly consists of soil generated during excavation work for tunnels, cut-off trenches, etc. Construction sludge is recycled as stabilized construction sludge, flowable soil, and recovered sand and gravel. Figure 8 outlines the material flow for construction sludge based on the survey in 2018. Approximately 83% of offsite treated sludge was reused. About half was

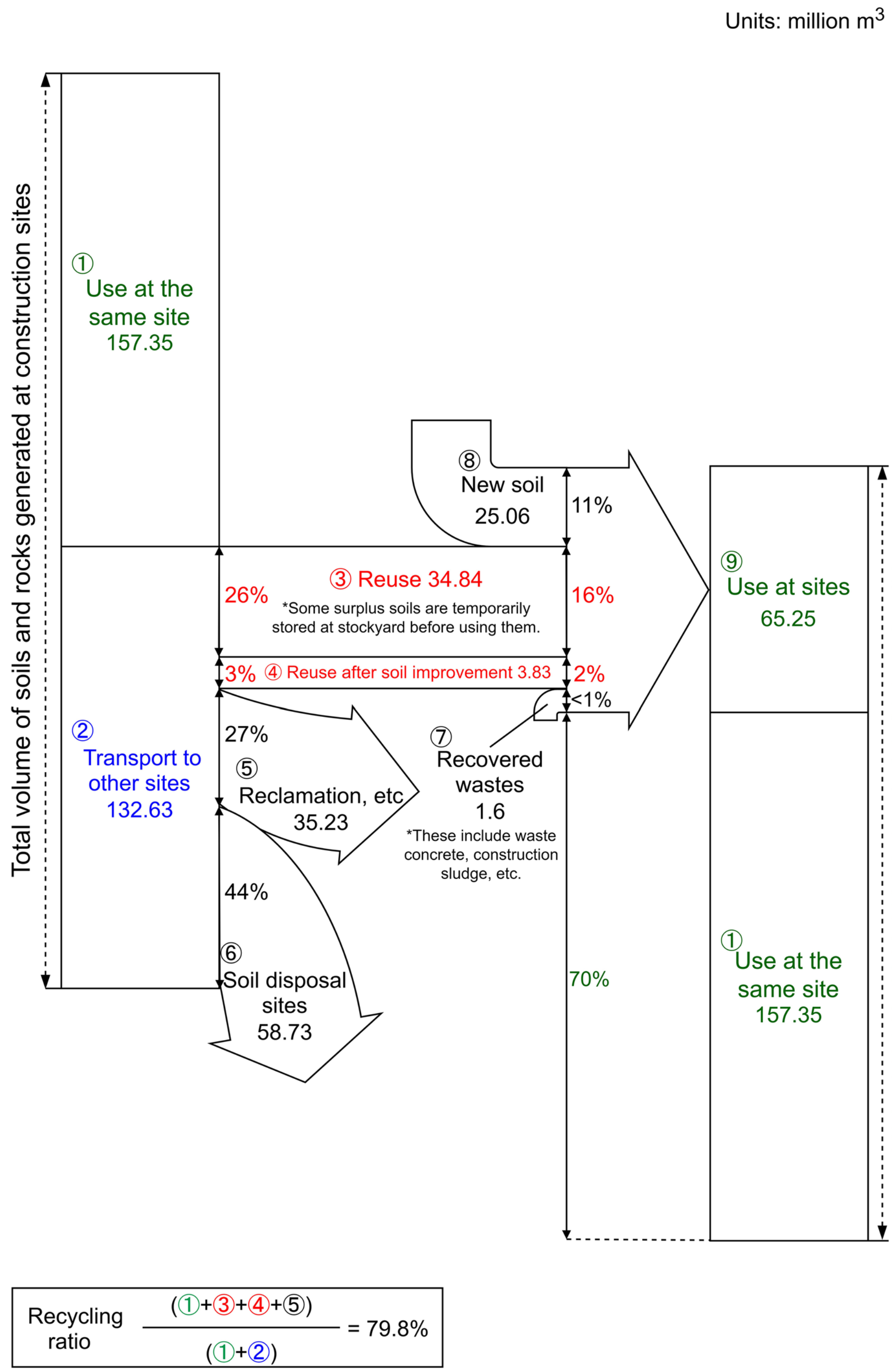


Fig. 7 Material flow of excavated soils and rocks based on the survey in 2018

used as treated construction sludge for embankments, 13% for flowable soil, and 11% was recovered sand and gravel.

The "Waste Management and Public Cleansing Act" defines three procedures to use construction sludge: "sell," "self-use," and "certification/designation systems." No problem exists if the treated construction sludge is of sufficient quality to be used and, consequently, sold ("sell"). However, this has limited uses as it is economically prohibitive in most situations. "Self-use" refers to reusing construction waste generated by a business institution that has treated it (self-treatment) to a state that allows it to be sold for a fee (valuable material). There are two types of "certification/designation systems." One is the "ministerial certification system" in which the MOE certifies recyclable materials that meet certain requirements such as not being a hindrance to the preservation of the living environment. Sludge with this

Table 1 Classification of excavated soil from construction works set by MLIT, with the selected properties

Class of soil	Content (type and state)	Cone penetration strength, q_c (kPa)	Water content (%)
1st-class soil	Sand or gravel; improved soil	–	–
2nd-class soil	Sandy soil or gravely soil; improved soil	> 800	–
3rd-class soil	Sandy, silty or clay soil which can easily be executed on; improved soil	> 400	< 40% (except for volcanic cohesive soil)
4th-class soil	Clay soil, expect for 3rd-class soil; improved soil	> 200	40–80%
Sludge	Slurry state soil or sludge	< 200	> 80%

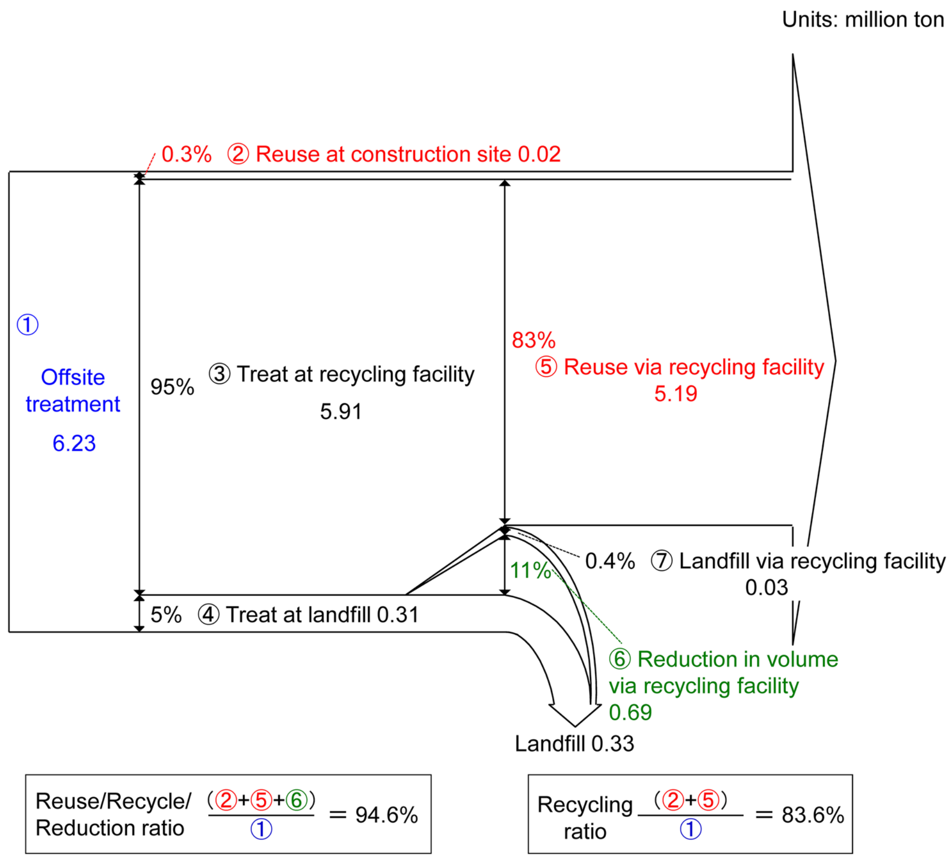


Fig. 8 Material flow of construction sludge based on the survey in 2018

certification does not require a permit for the disposal business or installation of facilities. The second is the "individual designation system" in which prefectural governors designate those who are engaged in the treatment of industrial waste. Designees operate a recycling business and do not require a license for an industrial waste treatment business.

Stabilized construction sludge competes with excavated soil when it is utilized as an embankment material. Since excavated soil can be obtained free of charge, the selling of stabilized construction sludge is not realistic. Based on the "Guidelines for Recycling of Construction Sludge," which was established by the MLIT in June 2006, the use of stabilized construction sludge through "self-use" or "certification/designation systems" should be promoted [9].

"Material Reuse and Recycling Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality"

Background of its formulation

MLIT has been working with related industries to promote material reuse and recycling in construction projects by formulating the fourth version of "Material Reuse and Recycling Promotion Plan in Construction Works," which outlines the basic concept, goals, and specific measures for the promotion of material recycling in construction projects. Consequently, the recycling and reduction rate of construction waste was 97% in 2018. The recycling of construction by-products is stable. In the future, improving the "quality" of recycling will be an important issue. Based on the "Proposal for the Next Material Reuse and Recycling Promotion Plan in Construction Works (March 2020)" by the Advisory Board of MLIT, in which the second author served as the chair, the fifth version, "Material Reuse and Recycling Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality" was formulated in 2020 [10].

Target values

Table 2 shows the target values set in this plan, including the reuse/recycle or the reuse/recycle/reduction ratio. Because the majority of mixed construction waste is properly separated onsite and less is transported to intermediate treatment facilities, it is becoming extremely difficult to improve the reuse/recycle/reduce ratio. Therefore, the target value for the reuse/recycle/reduce ratio is not set for mixed construction waste, but is a reference value for monitoring. Only a target value for the discharge fraction is set.

The utilization of excavated soils and rocks is gradually improving. Currently, the utilization ratio is 79.8%. The excavated soils treated offsite are expected to be used in other construction projects. Thus, the quantity, quality, and timing should be matched to other projects. The slightly lower utilization ratio of excavated soils and rocks compared to the previous target value may be due to the complexity of the matching between construction projects.

The target values for other construction waste remained the same or increased compared to the previous Plan, because high recycling and reduction ratios were achieved in the 2018 survey. As mentioned before, recycling focusing on "quality" should be promoted. As for plastic waste, the target values should be considered while monitoring the trends in the generated amount and recycling ratio of plastic waste.

Measures for the promotion of material recycling in the construction industry

Considering the three major issues involving material reuse and recycling in construction mentioned in Sect. 4 as well as issues of specific waste and by-products described in Sect. 5, the Plan outlined 11 measures (Table 3). MLIT will coordinate with local governments and the private sector to address these measures. In addition, regional measures or those in the previous versions of the "Material Reuse and Recycling Promotion Plan in Construction Works" will be continuously addressed. The fifth measure, "reducing waste generation under a change in social circumstances," is explained below.

- *Revising current guidelines* The guidelines on material recycling in construction works or "Recycling Rule" are revised. The "Guidelines for Materials Recycling in Construction Works" was compiled in 2002 to provide specific measures and cost estimates at each stage of a construction project. Measures to reduce the generation of construction by-products will be discussed in the revision of the "Guidelines for Materials Recycling in Construction Works," particularly those to reduce waste generation in the planning stages of projects. The "Recycling Rule" was identified in 2006 to encourage the use of recycled materials and recycling facilities for construction projects conducted by MLIT that meet certain requirements. MLIT is considering revising the current rules for recycling. Initiatives include limiting the distance for transfer or the designated recycling facilities to control discharge or enhance recycling.
- *Linking maintenance and renewal of infrastructure (Continuing measure)* Extending the service life of infrastructure should reduce both waste and by-product generation. This is called preventive maintenance. The linkage between maintenance and renewal of the infrastructure should be promoted by enhancing preventive maintenance and developing new technologies.

Table 2 Target values described in "Material Reuse and Recycle Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality"

Category	Index	2018 target value (%)	2018 actual value (%)	2024 target value (%)
Construction waste	Reuse/Recycle/Reduction ratio	> 96	97.2	> 98
Asphalt-concrete waste	Reuse/Recycle/Reduction ratio	> 99	99.5	> 99
Concrete waste	Reuse/Recycle/Reduction ratio	> 99	99.3	> 99
Construction wood waste	Reuse/Recycle/Reduction ratio	> 95	96.2	> 97
Construction sludge	Reuse/Recycle/Reduction ratio	> 90	94.6	> 95
Construction mixed waste	Discharge ratio	< 3.5	3.1	< 3.0
Construction mixed waste	Reuse/Recycle/Reduction ratio*	> 60	63.2	–
Excavated soil	Recycling ratio	> 80	79.8	> 80

* Reference value

Table 3 Eleven measures described in "Material Reuse and Recycling Promotion Plan in Construction Works 2020—Towards Recycling with an Emphasis on Quality"

Measures	Remarks
(1) Promote the use of materials recovered from wastes and by-products	Establishing quality standards and assurance methods for recycled materials, and promoting their use through green procurement
(2) Use proper treatment facility for recovery	Promoting high reuse/recycling ratio of waste and by-products
(3) Enhance the recycle of construction mixed waste	Thorough onsite separation of mixed construction waste Promoting the separation and recycling of waste plastics (New measure). Data on plastic waste is analyzed to promote the separation and recycling of generated plastic waste. Efficient onsite separation methods are considered
(4) Promote utilization and proper management of excavated soil	The supply and demand of excavated soils are analyzed. Considerations are made on how to mitigate improper soil management
(5) Reduce the generation of construction waste under the changed social circumstances	The guidelines on material recycling in construction works or "Recycling Rule" are revised (New measure) Linking maintenance and renewal of infrastructure Extending the service life of houses and documenting building information Extending the life of government facilities
(6) Understand the usage and logistics of recycled crushers	Understanding the usage, logistics, etc., of recycled crushers
(7) Responses to severe disasters	Promoting recycling of wastes in the event of a disaster
(8) Enhanced monitoring of construction by-products	Efforts are made to electronically record and distribute information about construction by-products generated, treated, and disposed of
(9) Use traceability system to promote proper management of excavated soil	A traceability system is considered to monitor soil transportation from the excavation site to the reclamation site by utilizing ICT (New measure)
(10) Enhance public relations	Linking with relevant stakeholders to effectively use waste and by-products
(11) Promote the use of new technologies	This involves the use of NETIS (new technical information provision system) and the promotion of testing and research on waste materials

- *Extending the service life of houses and documenting building information (Continuing measure)* Houses built to last are promoted. Information on buildings (design, materials, manufacturers, etc.) is organized to promote high-quality material recycling in construction projects.
- *Extending the life of government facilities (Continuing measure)* The service lives of existing governmental facilities are extended by public construction and renovation projects. Government facilities should be maintained by utilizing the government facility information management system.

Concluding remarks

Herein, the status of material reuse and recycling in the Japanese construction industry is explained. The "Material Reuse and Recycling Promotion Plan in Construction Works" has been updated almost every 6 years. The national government, local governments, and private sectors (construction companies, industrial waste companies, material manufacturers, consultants, etc.) have worked together to meet the target values described in the plan. These efforts have realized successful results in terms of the quantity of material reuse and recycling in the construction industry. However, further studies are needed to improve the "quality", and enhance material reuse and recycling in the construction industry.

Acknowledgements Members of the Ministry of Land, Infrastructure, Transport and Tourism helped prepare the manuscript. The authors are grateful for the contribution of Mr. Tomohiro Kato and Dr. Lincoln Gathuka (Kyoto University), who provided editorial support in preparing this manuscript.

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