Final Technical Report
CRRP2016-07MY-Ishigaki

Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function of Tropical Asian Urban Cities

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Project Overview

Project Duration	**:**	2 years
Funding Awarded	**:**	US$ 35,000 for Year 1; US$ 45,000 for Year 2
Key organisations involved	**:**	[Japan] 1. Tomonori Ishigaki, National Institute for Environmental Studies(NIES), Japan, ishigaki@nies.go.jp 2. Masato Yamada, NIES, Japan, myamada@nies.go.jp 3. Kosuke Kawai, NIES, Japan, kawai.kosuke@nies.go.jp 4. Ryo Tajima, NIES, Japan, tajima.ryo@nies.go.jp 5. Rieko Kubota, NIES, Japan, kubota.rieko@nies.go.jp 6. Kosuke Nakamura, NIES, Japan, nakamura.kosuke@nies.go.jp [Thailand] 1. Sirintornthep Towprayoon, Joint Graduate School of Energy and Environment, Thailand, sirin@jgsee.kmutt.ac.th 2. Chart Chiemchaisri, Kasetsart University, Thailand, fengccc@ku.ac.th 3. Wilasinee Yoochatchaval, Kasetsart University, Thailand, wilasinee.y@gmail.com 4. Komsilp Wangyao*, Joint Graduate School of Energy and Environment, Thailand, komsilp@jgsee.kmutt.ac.th 5. Wachiraporn Meesingha, Bangkok Metropolitan Administration, Thailand, wachi_me@yahoo.com [Vietnam] 1. Pham Khac Lieu, Hue University, Vietnam, pklieu@hueuni.edu.vn 2. Hoang Cong Tin*, Hue University, Vietnam, hoangcongtin@gmail.com

Project Summary

This study aims to exhibit an urban flood risk reduction strategy which solves urban drainage problems by managing solid debris derived from anthropogenic and natural activities, through administrative services on sewage and drainage clearing, waste collection, and citizen's cooperation to waste disposal.

Urban drainage system has developed with the nature of the city and the history of urbanisation and flood disaster. In the case of Bangkok, open canal network has been developed to mitigate urban flood. It had been effective for a long time, but recent intensive precipitation exceeds its capacity. Major source of these solids will be unintentional disposal or runoff of household waste, such as food waste and a plastic bag, from residents in illegal occupation on canal front. It was obviously recognised that the activity of construction and demolition that was related to the project of the redevelopment of canal front had managed the waste inappropriately and some of them were dropped into the canal. In a case of Hue, there is networking of narrow trenches for castle guard, which connects to river water. The major trigger of recent urban inundation is the overflow of the river dyke during the prolonged

precipitation or increase of water level of urban drainage due to the lack of capacity of drain floodwater. The waste group including food waste and household waste was observed to obstruct the flow. Several households confirmed way of improperly discharging waste in current while almost residents sensed the impact of inappropriate disposing on the health and community and significance of fresh environment was high value to their life. Natural derivatives such as leaves & tiny woody trunks which is derived from the deciduous tree were also regarded to be major component in bar screen of drainage, open ditch and the drainage throats. Periodically the debris in open ditches was cleaned every three months while drainage throats have not been concerned to clean that lead to the deposit of soil and rocks and the decrease in drainage function.

It was elucidated that timbers stuck firmly on bar screen, though foam and plastic bottle floated on the water surface. Plastic bag, if it is empty, also floated on the water surface. Once water filled in the plastic bag, it started to be stuck on the bar screen. It was revealed that the head loss coefficient could be estimated by blockage area on the screen. Mechanism analysis indicated that blockage by solid debris with density higher than water regardless of the number. It is expected that blockage effect is affected by the distribution of solid debris. In order to keep drainage capacities of canals, high-density debris and debris with a larger dimension than slit openings should be controlled with higher priority even if their number is small. The blockage is not affecting the drainage capacity directly, but the rising of water elevation is caused by flooding. Blockage area of 50% must be critical criteria to increase the water level followed by floodwater generation.

It is reasonable to assume that unintentional scattering is one of the main sources of household waste in the canals. Conditions at many waste collection points lend themselves to unintentional waste disposal in canals. People are less likely to litter the waste into the canal if they are aware of its negative impact. People who enjoy their current environment and who are willing to take actions to improve the environment are less likely to dispose of waste into canals. Public relation and dissemination tools have been developed for the residents since knowledge and consciousness on the environment, and canal/drainage condition could encourage them to prevent waste scattering. Capacity development of local practitioners has implemented for raising awareness of waste in canals.

We have proposed to reconsider the municipal waste collection frequency, zoning of the collection, or container size in the canals threating to the urban inundation for immediate countermeasures from the viewpoint of flood prevention in addition to appropriate waste management. Also, we have stated that the drainage management section is required to remove the debris not only from the surface but also from the deeper zone of the canals. It is recommended that the debris collection should be conduct intensively before and during the rainy season. On top of that, construction and demolition activity is a key industry. Not only the construction project in canal front but also inappropriate disposal of the debris to the area in canal front or riverside must be regarded as major source of high-density debris in the canals. Appropriate control of this industry will contribute to reducing the urban flood risk.

Keywords: solid waste management, urban flood, drainage, Bangkok, Hue

Project outputs and outcomes

Project outputs:

- Basic data on solid debris that prevent effective urban drain in Bangkok and Hue, including amount, composition, generation rate and potential to inhibit drainage capacity.
- Number of package of comprehensive knowledge about the solid waste management and drainage management in Bangkok and Hue
- Number of capacity building workshops conducted in the project
- Numerical dynamic model expressing solid debris clogging in canals was developed
- Floodwater generation by solid debris clogging was simulated, and blockage area was suggested as key criteria.
- Mechanisms of debris clogging on bar screen were indicated.
- Basic behaviour of residents on waste disposal and scattering to canals were revealed.
- Public communication tool, i.e. educational video clips, aiming to change improper waste disposal behaviours of people living in urban area
- Guideline on appropriate management of construction waste has been provided to local government.

Project outcomes:

- Improved capacity of local officers and practitioners on knowledge of flood-resistant solid waste management
- Increased understanding of maintenance of urban drainage to prevent floodwater generation by administrative services for model cities
- Changed peoples' mind set to raise awareness on prevention of urban flood to avoid inappropriate waste disposal and scattering

Key facts/figures

- 121 datasets on analysis of composition of solid debris in drainage system at 37 locations in total in Bangkok and Hue.
- 355 households in Bangkok and 300 households in Hue were interviewed about their behaviour on waste disposal.
- 95 officers and practitioners have joined the 5 capacity development workshops and inter-department task force meetings.
- 3 young scientists and 11 students were involved in this project by implementing research, participated in the interview surveys and composition analysis and so on.

Potential for further work

Numerical model that expresses the clogging of debris in the waterway will be further developed to simulate the floodwater generation and to evaluate the damage of urban flood. Effect of adaptive countermeasure to attenuate the flood damage will be assessed regarding climate change in future.

Environmental impact of debris in drainages or canals must be considered, especially when it can be a potential source of microplastics which is constantly harming the marine ecosystem and transporting hazardous substances at the same time. Development of the scientific and social aspects on avoidance of overflow of the plastic debris could be prospective research topics for next stage.

The outcome of this project can be directly utilized at target cities, and similar approach on awareness raising for residents and methodology on mechanism analysis of canal clogging that causes could be delivered to urban flood other local government in pluvial Asia.

Publications

1) Kosuke Nakamura, Sutthasil Noppharit, Tomonori Ishigaki, Masato Yamada, Rawit Thaweesub, Chart Chiemchaisri, Numerical dynamic model on canal clogging by waste (in Japanese), Spring Conference of Japan Society of Material Cycles and Waste Management (2018)
2) Kosuke Nakamura, Rawit Thaweesub, Sutthasil Noppharit, Chart Chiemchaisri, Tomonori Ishigaki, Masato Yamada, Solid debris composition analysis for numerical model of canal clogging, Spring Conference of Korean Society of Waste Management (2018)
3) Tomonori Ishigaki, Situation of Construction Waste Management Generated in Public Works in Bangkok Metropolitan Administration (in Japanese), 2018 Symposium on Recycling of Construction Waste and Byproducts (2018)
4) Tomonori Ishigaki, Rawit Thaweesub, Rieko Kubota, Ryo Tajima, Pham Khac Lieu, Chart Chiemchaisri, Investigation on solid debris in urban drainage system in tropical Asian cities, 29th Annual Conference of Japan Society of Material Cycles and Waste Management (2018)
5) Ryo Tajima, Rieko Kubota, Hoang Cong Tin, Soparatana Jarusombat, Suthep Janamporn, Tomonori Ishigaki, Factors related to waste disposal behavior of residents near canals, ISWA World Congress 2018 (2018)

Awards and honours

None

Pull quote

"This research project found that inappropriate solid waste management is one of the major causes of flooding risk in Asian cities with vulnerable waste management system. The research findings paved the way of new viewpoint which appropriate solid waste management leads to the co-benefits of increase in public sanitation and reduction of disaster risk. Based on the research findings from this project, I hope the research on robustness of solid waste management system especially in the Asian cities with high population density will be developed further in the future. I highly respect the team of research collaborators who have achieved the prominent research outputs within the limited duration of time, human resources and budgetary resource. On top of everything, I sincerely appreciate APN which has chosen the theme of this project and given financial contribution."

Dr. Masahiro Osako, Director, National Institute for Environmental Studies

"As a student of Faculty of Environmental Science in Hue University of Sciences, I always effort to possibly accumulate an amount of essential knowledge from my lectures as well as vital experiences due to study activities and realistic practice. Engaging in the solid waste project administered by Hue University of Sciences and National Institute for Environmental Studies, Japan (NIES) was a great luck for me. Thanks to this project, I was likely to enhance specialization and worthwhile ability such as investigate, analysis and approach to actual environment or directly exchange to inhabitants and associated human with expected

problems existing in the ecosystem in order to improve life quality of residents in whole city. Especially, my graduate thesis had a close-knit topic with the project that helps me continue carrying on and able to complete contents more. Student's involvement in this study was not only chance to initially acclimate to prospective occupation, but support for sensing deficiency as well as positive elements that need develop thoroughly and personally, the study helped me recognise numerous issues that I should supplement in several edges and selected Master program to fulfil my own demand. Many thanks to NIES!"

Ho Thi Xuan Tuy, Postgraduate Candidate – M2, Faculty of Environmental Sciences, Hue University of Science

"I had a chance to take part in supporting several activities in project "Appropriate management of solid waste to reduce the risk of flooding through rehabilitation of drainage systems in Asian cities" organised by Hue University of Sciences and National Institute of Environmental Studies. This project is a good opportunity for assisting me in enhancing vital soft skills such as teamwork skill, problem- solving skill, and coordination skill. In addition, I have a better understanding about solid waste sources, the impact of solid waste disposal on urban drainage capacity and people's behaviour to waste discharge, all of which are capable of encouraging me to accumulate my knowledge. Special thanks to NIES!"

Tran Ngoc Khanh Ni, Postgraduate Candidate – M2, Faculty of Environmental Sciences, Hue University of Science

"There are many benefits to participating in the project in the past. Fortunately, with the support of my teachers, I have learned about the international cooperation project at that time. On the one hand, I am a student of a Hue University of Sciences, and my field of study is something revolving around the environment such as: investigating the composition of garbage, the perception of people on the classification home waste and the impact of environmental pollution caused by waste. It is great that this project is in the areas that I am interested in, and I can get the real knowledge through the fieldwork as well. The project has helped me to improve many of the weaknesses in field surveys, build teamwork and work independently when needed. On the other hand, it was a great opportunity to enrich my knowledge. I can meet different people from Japan, so I can even learn different languages. Besides, it allows me to master vital soft skill such as: communication, teamwork and problem – solving skills.
In conclusion, I hope to participate in many international cooperation projects in the next time. I think, without participating this project, I guess I might not have much teamwork skills."

Le Trung Hieu, Environmental Science - B4, Faculty of Environmental Sciences, Hue University of Science

"In this project, I have been involved with the local community to interview about their habit of solid waste disposal in the selected households. Through this activity, I have improved my interviewing skills so effective and flexible. With actual look and acquired knowledge, I have received much understanding of MSW as influence of solid waste disposal to the habitats, importance of the solid waste classification, disposal behaviour of local residence... so that we can propose appropriate management and suitable solutions to overcome the limitation issues."

Nguyen Le Hong Hoa, Environmental Science - B4, Faculty of Environmental Sciences, Hue University of Science

Acknowledgements

The collaborators of this research project sincerely extend our application to the partners who tirelessly devoted their efforts in into this project. They are the officers from Department of Drainage and Sewage, Bangkok Metropolitan Administration (BMA), the officers from Department of Environment, BMA, the officer from Department of Urban Planning, BMA, The People's Committee of Hue, Hue Urban Environment and Public Works State Company (HEPCO), the officers from Department of Construction, Thua Thien Hue Province, the officers from Department of Natural Resources and Environment, Thua Thien Hue Province, and all the other community leaders and residents who willingly participated in the project. We also appreciate the official support by Rector and Vice-Rectors of University of Sciences, Hue University, Dean and Staff of the Faculty of Environmental Science, University of Sciences, Hue University.

1. Introduction

This study aims to exhibit an urban flood risk reduction strategy which solves urban drainage problems by managing solid debris derived from anthropogenic and natural activities, through administrative services on sewage and drainage clearing, waste collection, and citizen's cooperation to waste disposal. A flood often occurs after a high intensity of precipitation in the urban area is mainly caused by comparably low drainage capacity. On top of that, one of the common causes of urban flood in Asian cities is said to be the blockage of drainage by inappropriate disposal of solid waste. In order to remove barriers to urban drainage function, preventing factors, both from physical and social perspectives, must be identified and removed accordingly. For this, this study identifies the amount and composition of solid wastes that potentially clog drainage system, and a science-based guidance on periodic maintenance of drainage system for public service will be proposed. Furthermore, institutional and psychological factors that inhibit residents and businesses to dispose waste properly will also be clarified, and suggestions to improve the current waste management system/policies will be proposed. All activities will feed into the policy for Bangkok, Thailand and Hue, Vietnam, by closely collaborating with local stakeholders and researchers throughout the project.

2. Methodology

2.1 Investigation of current situation of drainage system in Bangkok and Hue

To understand the drainage capacity at normal condition and drainage issues during flood in Bangkok and Hue, the research team composed of members from three countries, will conduct series of in-depth interview surveys to public officers and some other experts relating to the urban drainage such as the ground/road coverage, culvert/open channels, and cleansing/sanitation in each city. Local literature including government publications will be gathered and reviewed.

2.2 Survey on solid waste management system and situation of in Bangkok and Hue

Three key actions to mitigate flood caused by municipal solid waste (MSW) would be 1) Prevention of MSW from scattering, 2) Prevention of MSW from flowing into the drainage, and 3) Prevention of MSW from blocking drainage. These key actions depend on the public services of cities and are divided into several countermeasures as bellow.

1) Prevention MSW from scattering
   - ✓To collect MSW from all areas
   - ✓To designate time and places for MSW disposal
   - ✓To collect MSW frequently
   - ✓To punish littering
2) Prevention MSW from flowing into drainage
   - ✓To clean streets frequently
3) Prevention MSW from blocking drainage
   - ✓To clean drainage frequently

The questionnaire sheet was developed to clarify how appropriately the local authorities manage MSW. We selected three cities in Vietnam and three cities in Thailand, where floods were likely to occur frequently population were similar to Hue city. The researchers involved in this survey which focused on the service provider of MSW management shared the information on the waste management in Hue with the researchers of the survey which focused on the waste generators when developing the questionnaire sheet (**Table 1**). The survey in Hue city was conducted by local Vietnamese collaborators in July 2017. The researchers contacted the Department of Construction and Hue Environment and Public Service Company to collect information on MSW management focusing on the waste collection system. The comparative six cities were selected as shown in **Table 2**. The questionnaire survey was conducted in the selected comparative cities in July 2017 in collaboration with the local consultants in Vietnam and Thailand.

Table 1 Questions on MSW management

- ✓What department of the local government is the main one which administers MSW collection?
- ✓What department of the local government is the main one which administers street cleaning?
- ✓What department of the local government is the main one which administers drainage cleaning?
- ✓Who collects MSW from sources such as households in your city?
- ✓Are citizens legally punished when littering (intentionally throwing waste away on the street or in the river)?
- ✓How many people are provided MSW collection service in your city?
- ✓How often does your city provide MSW collection as a public service for citizens per week?
- ✓How often does your city clean the streets at same places as a public service?
- ✓How often does your city clean the drainage (canals and rivers) at same places as a public service?
- ✓Is MSW collected from households at fixed time?
- ✓Shall citizens discharge at designated time by your city?
- ✓Are MSW collection workers responsible for cleaning streets after collection, if any litter?
- ✓Are households legally responsible for paying collection fee?
- ✓How many households of your city practically pay collection fee?
- ✓Does your city collect MSW from citizens (households) who do not pay collection fee?
- ✓What kind of waste does your city refuse to collect?
- ✓What are annual collection amounts of MSW and population in the city for the past 10 years from 2007 to 2016?

Table 2 Target cities to compare MSW management

Country	City	Population in 2016
Vietnam	Hue	355,095
	Ca Mau	224,345
	Long Xuyen	286,024
	My Tho	228,385
Thailand	Chiang Mai	131,091
	Hat Yai	159,627
	Nonthaburi	255,793

2.3 Composition analysis of solid debris in canal and drainage

Solid waste composition analysis in the study area is used to investigate the amount of solid waste, waste composition. The method consists of waste composition analysis, bulk density analysis and moisture content analysis.

1) Waste composition analysis

Waste composition analysis is used to determine the amount of solid waste that classified. The classification was different from each other according to the features of solid debris in drainage system. Classification in Bangkok is as follows;

(1) Wood (timber from household)
(2) Wood (trim)
(3) Plastic (bottle)
(4) Plastic (packaging)
(5) Plastic (material)
(6) Plant (water hyacinth
(7) Plant (natural plants)
(8) Food waste
(9) Shell and bone
(10) Textile
(11) Sanitary napkin
(12) Paper
(13) Glass
(14) Foam
(15) Metal and aluminium
(16) Rubber

Classification in Hue is as follows;

(1) Paper (Carton, students' notebooks, paper box)
(2) Leaves & tiny trunk (Leaves, trunk falling, flowers)
(3) Large trunk (Trunks have big size, huge wood)
(4) Plastics (Plastic box, PET bottle, etc).
(5) Plastic bags (Plastic bags, nylon, etc.)
(6) Rubber & leather (Tires, leather shoes and bags).
(7) Glass & porcelain (Bowls, cups)
(8) Metals (Aluminium, iron, etc.)
(9) Fabrics & textiles (Clothes, cotton, etc.)
(10) Hazardous (Battery, electronic circuit, fluorescent lamps, etc)
(11) Others (Food wastes, mixed components, etc.)

Waste composition analysis will be conduct at the field. Details are shown in **Table 3**.

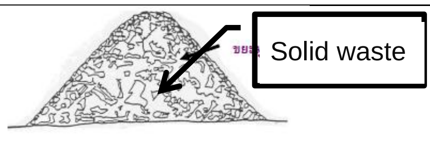
2) Bulk density analysis

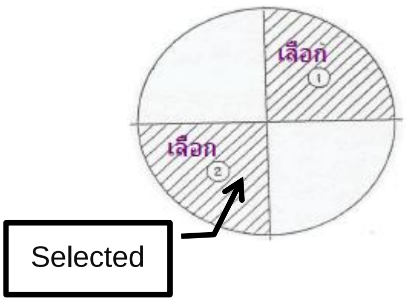
Bulk analysis is used to determine the density of solid waste. The analysis process will be conducted at the field. Details of the methodology is shown in **Table 4**.

3) Moisture content analysis

Moisture content was measured by weight difference after drying of the sample in 105 ^oC for 24 hours. Drying step was repeated until the weight is stable.

Table 3 Method of waste composition analysis

Step	Task
1	Collect 1-2 m^3 of solid waste from canal
2	Mixing the solid waste
3	Divide the solid waste into 4 parts (quartering) and selected 2 parts in the opposite location. 

	
4	Repeat step 3 and 4 until remaining is approximately 100 litre.
5	Physical Classification • Calculate percentage of waste (by weight) in each type $C_i = \frac{W_i}{W} x\ 100$ where C_i = Percent of waste by weight in each type W_i = Weight of waste in each type (kg) W = Total weight of waste (kg) i = Type of waste

Note: Waste composition analysis was conducted in triplicate.

Table 4 Method of bulk density analysis

Step	Task	
1	Collect a well-mixed solid waste (from step.2 of waste composition analysis).	
2	Fill the solid waste into a bucket of a measured volume (for example, 100 litres of quantity)	
3	Hold the bucket above ground for 30 cm then free the bucket to the ground 3 times	

4	If the level of waste in bucket getting low, repeat step.3 until waste level is stable.	
5	Weight the waste and calculate the bulk $$D = \frac{W_1 - W_2}{V}$$ where D = Bulk density (kg/m^3) W_1 = Weight of waste include container (kg) W_2 = Weight of container (kg) V = Volume of container (m^3)	

2.4 Details on composition analysis in Hue

The survey in Hue has been implemented at five wards namely Phu Hau, Phu Hiep, Phu Cat, Phu Binh, and Thuan Loc which are identified as sensitive areas of urban inundation in Hue city. Also, Thuan Loc ward was selected to be a representative of Hue Citadel which was concernedly inundated in raining season. Wards and sampling sites under study are shown in figure 1a-b. Two major campaign was carried out; Phase 1 (dry season) was conducted from 16th to 30th July 2017, and Phase 2 (wet season) was conducted from 15th October to 25th July 2017. The most substantial rainfall in Hue is from October to November.

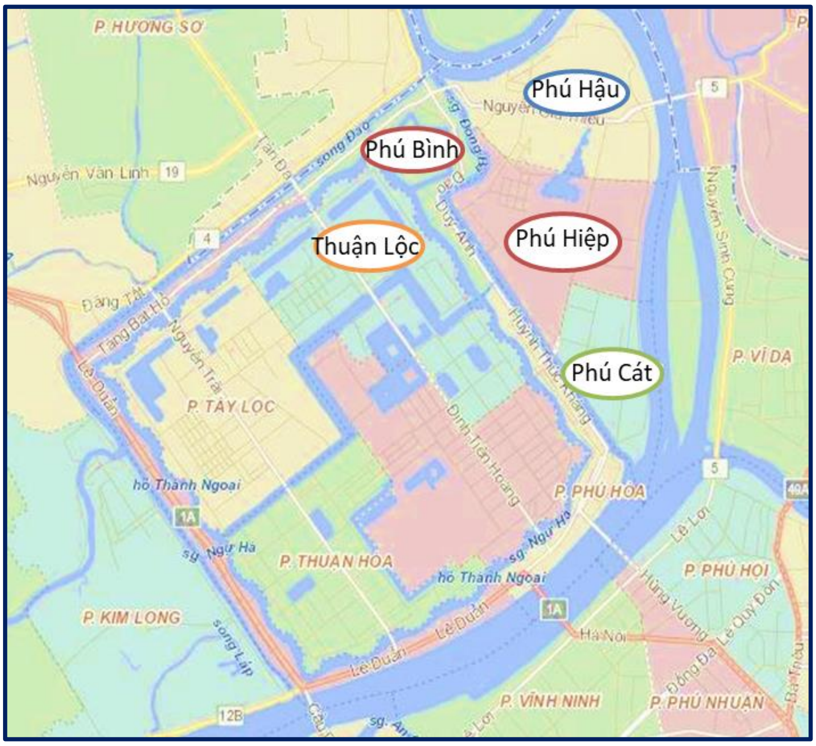


Figure 1 The map of study areas in the Hue Citadel

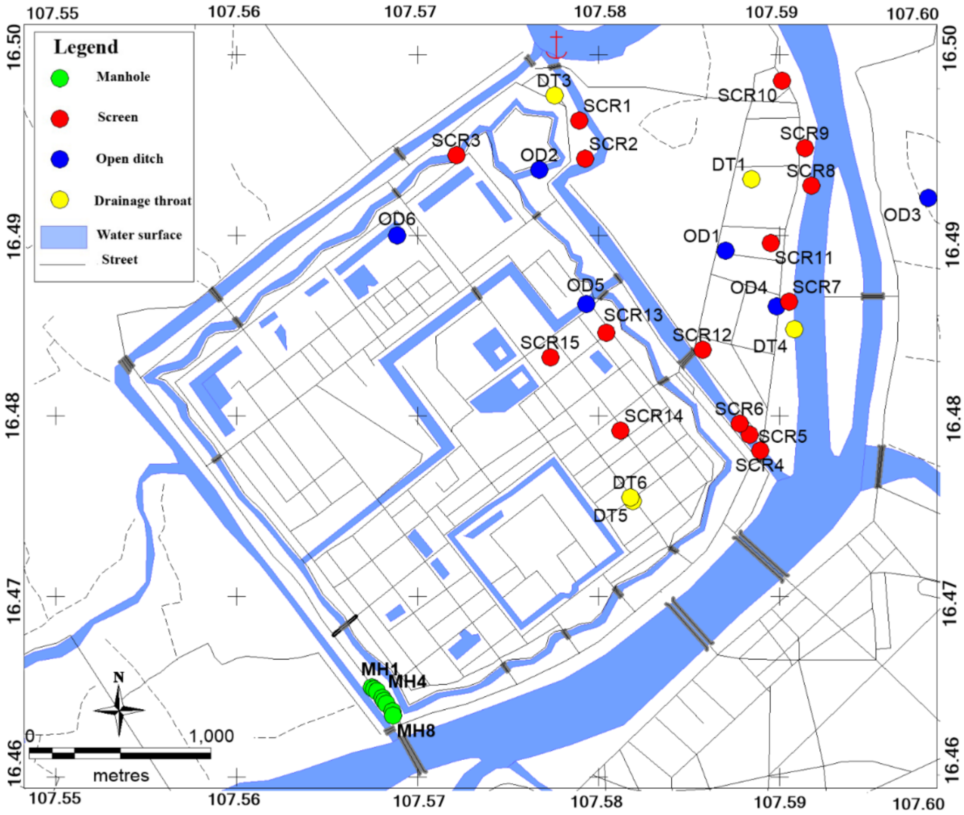


Figure 2 The map of study areas and sampling sites.

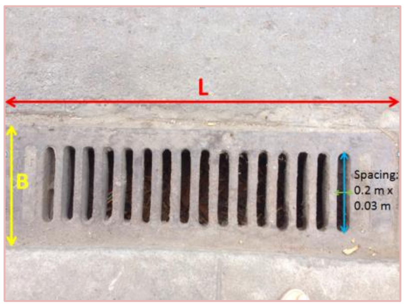
Note: SCR – Screen, OD – Open ditches, DT – Drainage throats;

Table 5 Background information about the selected study areas

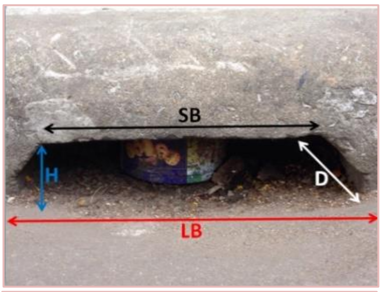
Wards	Area (km^2)	Population (capita)	Population density (capita/km^2)	Number of households (households)
Phu Hau	1.17	10,875	9,295	2,643
Phu Hiep	0.95	12,777	13,521	2,924
Phu Binh	1.26	8,154	6,451	2,090
Phu Cat	0.66	6,069	9,154	2,154
Thuan Loc	1.35	15,520	11,522	3,937
Total	***5.39***	***53,595***	***49,943***	***11.809***

Source: Digital information Hub of Hue City Council (2017).

1) Waste on screens (SCR): Samples were taken at 15 sites. Measured SCR dimension and space between the bars were aimed to conjecture compositions which were possible to enter into the drainage system and deposited in the manholes and sewer.



2) Waste at drainage throats (DT): Samples were taken at 6 sites. Measured DT dimension including height, breadth and depth to calculate waste density at each throat in gram per m^3.



3) Waste in open ditches (OD): Samples were taken at 6 sites. Measured OD dimension including length and breadth to calculate waste density at each throat in gram per m^2. Sampling positions were selected randomly and distributed equally within each ward as well as between the wards (**Table 6**).

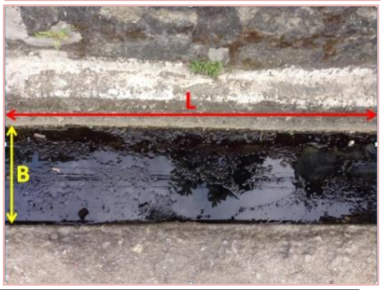


Table 6. Symbol and address of sampling points in throats and open drainage systems

No	Sample symbol	Address	Coordinates	Dimension
1	SCR1	253 Dao Duy Anh str.	N16°29.454’ E107°34.769’	SCR: L = 1m, B = 0,3m Spacing: 0,2m x 0,03m
2	SCR2	227 Dao Duy Anh str.	N16°29.380’ E107°34.786’	As above
3	SCR3	306 Tang Bat Ho str.	N16°29.396’ E107°34.388’	As above
4	SCR4	28 Bach Dang str.	N16°28.512’ E107°35.311’	As above
5	SCR5	56 Bach Dang str.	N16°28.545’ E107°35.285’	As above
6	SCR6	90 Bach Dang str.	N16°28.593’ E107°35.250’	As above
7	SCR7	228 Chi Lang str.	N16°28.943’ E107°35.412’	As above
8	SCR8	342 Chi Lang str.	N16°29.29’ E107°35.486’	As above
9	SCR9	409 Chi Lang str.	N16°29.404’ E107°35.469’	As above
10	SCR10	420 Chi Lang str.	N16°29.607’ E107°35.40’	As above
11	SCR11	22 Ho Xuan Huong str.	N16°29.12’ E107°35.358’	As above
12	SCR12	11 Nguyen Chi Thanh str.	N16°28.803’ E107°35.143’	As above
13	SCR13	191 Xuan 68 str.	N16°28.857’ E107°34.845’	As above
14	SCR14	29 Le Thanh Ton str.	N16°28.563’ E107°34.885’	As above
15	SCR15	41A Le Van Huu str.	N16°28.785’ E107°34.671’	As above
16	DT1	42 Cao Ba Quat str.	N16°29.312’ E107°35.301’	Rectangle section: L=40cm, CC=15cm, CS=35cm (V= 0,021m^3)
17	DT2	02 Chua Ong str.	N16°28.682’ E107°35.219’	Trapezoid section: LB=160cm, SB=100cm,

				H=30cm, D=30cm (V=0,117 m^3)
18	DT3	307 Dao Duy Anh str.	N16°29.572’ E107°34.694’	Rectangle section: L=35cm, H=11cm, D=6cm (V=0,002 m^3)
19	DT4	Trinh Cong Son str.	N16°28.86’ E107°35.428’	Rectangle section n: L=40cm, H=10cm, D=20cm (V= 0,008m^3)
20	DT5	68 Dinh Tien Hoang str.	N16°28.357’ E107°34.917’	Trapezoid section: LB=40cm, SB=30cm, H=7cm, D=50cm (V=0,0123 m^3)
21	DT6	64 Dinh Tien Hoang str.	N16°28.361’ E107°34.914’	Trapezoid section: LB=40cm, SB=30cm, H=10cm, D=50cm (V=0,0175 m^3)
22	OD1	Alley 112 Nguyen Chi Thanh str.	N16°29.098’ E107°35.218’	L=100cm, B=100cm (S= 1m^2)
23	OD2	Alley 7 Mang Ca Nho str.	N16°29.349’ E107°34.644’	L=150cm, B=100cm (S= 1,5m^2)
24	OD3	01 Phung Khac Khoan str.	N16°29.252’ E107°35.857’	L= 41cm, B=13cm (S= 0,0533 = 0.05 m^2)
25	OD4	06 Nguyen Binh Khiem str.	N16°28.929’ E107°35.375’	L=100cm, B=50cm (S= 0,5m^2)
26	OD5	213 Xuan 68 str.	N16°28.944’ E107°34.784’	L=100cm, B=50cm (S= 0,5m^2)
27	OD6	109 Luong Ngoc Quyen str.	N16°29.157’ E107°34.20	L=110cm, B=60cm (S= 0,66m^2)

4) Waste deposited into drainage systems: This survey we collected and weighted waste at eight manholes (MH). The surveyors have worked closely with HEPCO workers who dredge and preserve the drainage systems. The drainage systems are cleaned and maintained twice a year by HEPCO workers. Sampling sites were presented in **Table 7**.

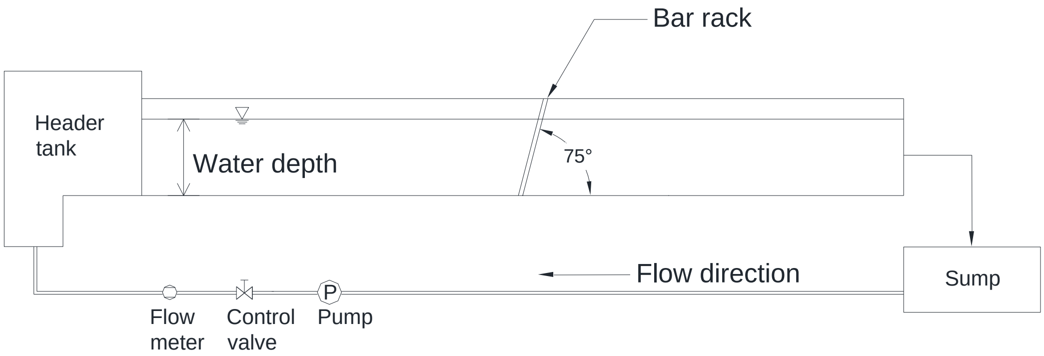
Table 7. Symbol and address of waste sampling points deposited in the manholes

No	Sample symbol	Address	Location coordinates
1	MH1	192 Le Duan str.	N16°27.803’ E107°34.104’
2	MH2	188 Le Duan str.	N16°27.796’ E107°34.110’
3	MH3	180 Le Duan str.	N16°27.790’ E107°34.119’
4	MH4	Alley 168 Le Duan str.	N16°27.773’ E107°34.136’
5	MH5	Alley 160 Le Duan str.	N16°27.762’ E107°34.142’
6	MH6	Alley 152 Le Duan str.	N16°27.752’ E107°34.149’
7	MH7	146 Le Duan str.	N16°27.730’ E107°34.166’
8	MH8	142 Le Duan str.	N16°27.717’ E107°34.168’

Note: MH = Manhole;

2.5 Laboratory experiment for determining the parameters of clogging of debris

Experiments were carried out in a laboratory and use a rectangular-section flume with a dimension of 0.24 m width, 0.4 m depth and 10 m length. Bar rack (screen) made from steel with 6 mm thickness and gap dimension of 35 mm is attached in the flume. The horizontal angle between bar rack and flume is 75 degrees (same configuration at the field). The water flow rate and the level were maintained at 9 l/s and 16.5 cm respectively. Vertical velocity is measured by current meter install on lifting equipment to support an accurate measurement. Water depth was measured by depth meter **(Figure 3)**



(a) Schematic diagram

(b) Flume and velocity meter

Figure 3 Experimental set up

Different solid waste condition at the bar rack was used to determine the reduction of drainage capacity by analysing the energy loss across bar screen from Bernoulli's equation.

$$\frac{v_{up}^2}{2g} + H_{up} = \frac{v_{down}^2}{2g} + H_{down} + H_{loss}$$

Where

v_{up} is velocity at upstream (m/s)

v_{down} is velocity at downstream (m/s)

H_{up} is water depth at upstream (m)

H_{down} is water depth at downstream (m)

g is gravity acceleration (9.81 m/s^2)

H_{loss} is energy loss across bar rack due to solid waste blockage (m)

Energy loss coefficient was used for modelling obtained by

$$H_{loss} = k \frac{v^2}{2g}$$

Where

k is loss coefficient

v is average velocity (m/s)

2.6 Development of numerical model for debris clogging in canal

Situations to be analysed consist of canal beds, slit-like structures, solid debris, and water. Those objects are represented by specific numerical objects to describe kinematic phenomena in canal. Canal beds and slit-like structures of bar screen are expected to have enough material strength against collision with solid debris. This expectation makes their fragmentation and deformation negligible. Then, they are assumed to be rigid bodies in the numerical model. Solid debris has various shape, dimension, density, material strength, etc. Solid debris with small material strength, such as plastic bags, dynamically change their shapes according to applied forces. Then, they are represented by soft bodies instead of rigid bodies in the numerical model. Water requires different representation from those of rigid bodies or soft bodies because it is liquid. Moreover, rigid bodies, soft bodies, and liquid must be allowed to interact with each other in the numerical model.

Physics engines, which can simulate kinematic behaviours and collisions of rigid bodies, have been developed. Some of them are becoming able to handle soft bodies. Physics engines are becoming easier and easier to get even in open source. Bullet Physics Library (Bullet, http://bulletphysics.org) is one of them, which is popular and has been applied to wide range of commercial and private 3D computer graphics software, such as Maya, Blender, and Houdini. Concerning its capability, reputation, and open source distribution, we chose Bullet to represent rigid bodies, soft bodies, and their collisions. However, because of difficulty, we omitted soft bodies in this research. The liquid is a continuum with complicated deformation including free surface flow and moving boundary. Grid-based numerical methods such as finite element method (FEM) and finite difference method (FDM) are not applicable to those complicated flows. Mesh-free numerical methods are designed to overcome the above difficulty. Smoothed particle hydrodynamics (SPH) is one mesh-free numerical method (Lucy, 1977; Gingold & Monaghan, 1977). Like other mesh-free particle methods, SPH represents an analysis object with a finite number of computational nodes. A node is also called “particle”. A particle owns individual mass and volume. A particle is allowed to move and interact with each other. Interactions are described by a discretised form of governing equations such as Navier-Stokes equations. This method is originally designed to solve astrophysical phenomena (Lucy, 1977; Gingold & Monaghan, 1977), which resemble compressible fluid flow problem. This method is later extended to incompressible fluid flow problems (Monaghan, 1994) with great success. It can solve the above-complicated flow problems with relatively simple approach among many mesh-free methods. Then, we chose SPH to represent liquid. Bullet and SPH are initially separated. It was necessary to joint Bullet and SPH by describing interactions between Bullet rigid bodies in SPH particles. This was achieved by attaching Bullet rigid spheres to every SPH particle. This modification makes SPH particles possible to collide with Bullet rigid bodies. It should be noted that those attached Bullet rigid spheres are not allowed to collide with each other. This configuration prevents SPH particles from behaving like a group of beads instead of liquid.

A canal bed is simulated by using rigid bullet boxes (**Fig. 4**). This canal bed consists of flat bottom and vertical wall. This is set to have a width of 100 cm and a depth of 200 cm. Those parameters are based on those of small canals in Lad Prao, Bangkok, Thailand. This canal bottom is set to have slope to use gravitational acceleration as the driving force of water flow. The initial water level is set to be 100 cm (**Fig. 4**). This value is chosen to consider water level during raining. Numerical boundaries at upstream and downstream of this canal are set to be periodic boundaries, where SPH particle is transferred from one boundary to another boundary. This boundary condition is chosen to provide enough space for water flow and solid debris motion while reducing computational effort by reducing number of SPH particles of water. The distance between two boundaries is set to 200 cm. It keeps the amount of water constant through the simulation.

A slit-like structure is of bar screen also simulated by using Bullet rigid boxes (**Fig. 4**). This consists of 5 blades. A blade has a width of 2 cm, the height of 200 cm, and a length of 20 cm. They are placed at 50 cm from the boundary at downstream. Slit openings are set to be 14 to 17 cm. 14 cm is between neighbouring two blades. 17 cm is between a wall and a neighbouring blade. This parameter is based on a measured value of 15.5 cm for a slit-like structure at a pump station in Lad Prao.

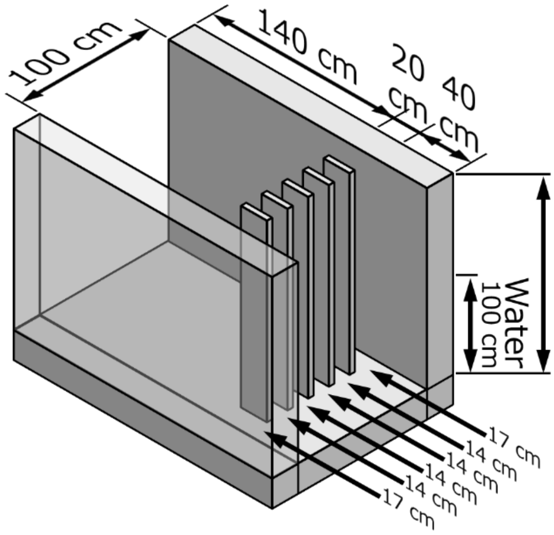


Fig. 4 Dimension and shape of the canal bed and the slit-like structure. Thickness of each slit blade is 2 cm.

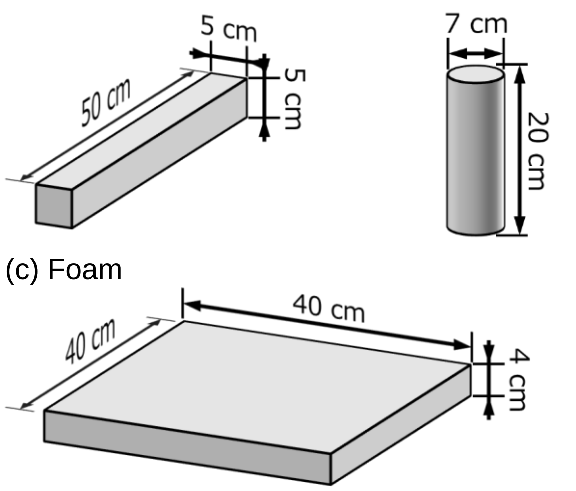


Fig. 5 Dimensions and shapes of (a) a wood timber, (b) a plastic bottle, and (c) a foam.

Table 8 Characteristics of three solid debris.

	Wood timber	**Foam**	**Plastic bottle**
Size [cm]	5×5×50	40×40×4	ϕ7×20
Density [g/cm^3]	1.25	0.033	0.25
Volume [cm^3]	1250	6400	770
Mass [g]	1563	192	211

Three types of solid debris are chosen for the simulation: wood timbers, plastic bottles, and forms (**Fig. 5**, **Table 8**). This is based on their found amount in waste composition analysis at a canal in Lad Prao and different characteristics. Wood timbers were found to have the largest mass ratio of 27.2% in the above analysis. Their shapes are almost box. Their densities are larger than water. They usually have at least a longer dimension than slit openings. Forms have 7th largest mass ratio of 3.9% in the above analysis. Their shapes are almost box. Their densities are smaller than that of water. It should be noted that their volumes are large among solid debris because of their small densities. They usually have at least two longer dimensions than slit openings. Plastic bottles have 13th largest mass ratio of 1.7% in waste composition analysis at a canal in Lad Prao. Their shapes consist of one cylinder and one cone. This is different from wood timbers and forms. Their densities are smaller than that of water. It should be noted that their densities can be larger than those of forms because of remaining beverage in them. They usually have at least a longer dimension than slit openings.

Water is represented by SPH particles. The size of Bullet rigid sphere attached on SPH particle is set to be smaller than half of the slit openings. This allows SPH particles to pass through slit openings. Its parameters are set based on those of pure water.

The blockage effect was evaluated using average flow velocity in the canal. Average flow velocity $\bar{v}$ there was expected to be reduced because of the slit-like structure clogged by solid debris. Average flow velocity is defined as follows: the magnitude of the average velocity vector of all SPH particles. Then, a ratio of two average flow velocities with and without solid debris was used to calculate the blockage effect as follows.

$$k_b = \frac{\bar{v}_b}{\bar{v}} \tag{A1}$$

where, k_b is blockage effect, $\bar{v}$ is average flow velocity without solid debris, $\bar{v}_b$ is average flow velocity with solid debris. k_b is zero when average flow velocity is not reduced by solid debris. k_b is one when water flow is completely blocked.

Clogging processes and the blockage effect was tested in the simulation under different flow velocities and different compositions of solid debris. Flow velocity was controlled by choosing the slope of the canal bed from followings: 2%, 5%, and 10%. Water in the canal was initially still and did not contain any solid debris. This is accelerated by slope for 30 seconds to reach almost constant velocity. After that, solid debris was dropped onto water surface from 50 to 300 cm above. Compositions of solid debris were chosen in stages because the relationship between clogging behaviour and amount of solid debris was unknown.

As the first stage, three types of solid debris were separately tested at a slope of 5%. These tests were to see the clogging processes and the blockage effects without a combination of two or more kinds of solid debris. Amounts of solid debris were chosen to be enough to cover at least 60% cross dimension of the canal, which is under water. Then, tested compositions were chosen as follows: 25 wood timbers, 15 foams, 50 plastic bottles. This simulation was also for 30 seconds. If at least one piece of solid debris stacked on the slit-like structure, this type was tested in the following stage.

As the second stage, three types of solid debris were separately tested in different number from the first stage at slopes of 2%, 5%, and 10%. These tests were to conducted to confirm difference on the clogging processes and the blockage effects by the number of solid debris and flow velocity. Numbers of solid debris were chosen from 1 or 9 for each type of solid debris. Those numbers were chosen to be less than those in the above cases.

As the third stage, a composition which consists of three kinds of solid debris was tested at slopes of 2%, 5%, and 10%. This test was conducted to confirm differences in the clogging processes and the blockage effects due to the combination of a different kind of solid debris.

2.7 Analysis of the effect of solid waste clogging using mathematical model

Storm Water Management Model (SWMM) is used to analyse the effect of solid waste blockage. SWMM is a dynamic rainfall-runoff simulation model that computes runoff quantity and quality from primarily urban areas. The runoff component of SWMM operates on a collection of sub-catchment areas that receive precipitation and generate runoff and pollutant loads. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps and regulators. SWMM tracks the quantity and quality of runoff generated within each sub-catchment and the flow rate, flow depth, and quality of water in each pipe and channel during a simulation period comprised of multiple time steps. The model used in this study is version 5.1. The elevation of sub-catchment, piping and canal in the study area is collected and input in the model. The energy loss coefficient due to solid waste blockage is obtained by laboratory experiment. Data of water level and flow rate was gathered from Water Measurement system by Department of drainage and sewerage (DDS), Bangkok Metropolitan Administration (BMA).

2.8 Analysis of peoples' behaviour on waste disposal and scattering

In order to clarify the factors that inhibit appropriate waste disposal behaviour near canals and waterways, we undertook a series of social surveys both in Bangkok (Thailand) and Hue (Vietnam). In each city, we selected a survey target area where a) people live near a canal/waterway and b) wastes are visible in that canal/waterway (**Table 9**). First, a field investigation and interviews of local officials were conducted to determine the current housing, waste collection, and canal management conditions near canals. Second, face-to-face questionnaire surveys were administered to more than 300 households in each target area (**Fig. 6**) to determine people's waste disposal behaviour and factors that relate to that behaviour for daily household waste and bulky waste. On the basis of the findings of previous studies (e.g. Ajzen 1991, de Leeuw et al. 2015), we tested the following factors that could affect waste disposal behavior: perceived behavioral control (access to waste collection points), perception of risks of dumping waste into canals, attitude towards inappropriate waste disposal, descriptive and injunctive norms, and perceived quality of environment. The questionnaire was designed to cover these and other factors (**Table 10)**. The actual disposal behaviour (i.e. the proportion of the disposed waste by respondent by using different disposal methods, on a 5-point scale) and attributes of the respondents were also asked in the questionnaire. The survey results were summarised, statistically analyzed, and interpreted, taking the social context and current waste collection conditions into account.

Table 9 Survey target areas in Bangkok and Hue

City	District (community) name
Bangkok	Huay Kwang (Thai-Yeepun, Lad Phrao 80, Kaow Ha, Lad Phrao Pracha Uthit), Lak Si (Chai Klong Bang Bua, Ruen Mai Pattana, Saphan Mai 2, Saphan Mai 1), Bangkhaen (Samackee Ruam Jai, Klong Bang Bua)
Hue	Phu Binh (being in Hue Citadel), Phu Cat (completely beyond Hue Citadel.), Thuan Loc (conterminous with the Citadel)

Table 10 List of main research items

Scale	Question items and point scale
Access to disposal point	- Please tell us how close your house is to the waste container along the canal (4-point scale) - Please tell us how close your house is to a waste container along the main road (4 point scale)
Risk perception	- How much impact do you think disposal of daily household waste in a public space (e.g. roadside, waterways, etc.) would have on your health? (5-point scale) - How much impact do you think disposal of daily household waste in a public space (e.g. roadside, waterways, etc.) would have on public health? (5-point scale)

	- How much impact do you think disposal of daily household waste in a public space (e.g. roadside, waterways, etc.) would have on flood risk? (5 point scale) - How much impact do you think disposal of daily household waste in a public space (e.g. roadside, waterways, etc.) would have on your social relationship? (5 point scale)
Attitude	- For me, disposing of household waste in a public space is … (1: useful to 5: useless) - For me, disposing of household waste in a public space is … (1: pleasant to 5: annoying) - For me, disposing household waste in a public space is … (1: good to 5: bad)
Descriptive norm	- My family would expect me not to discard waste in a public space (5-point scale) - The community leader would expect me not to discard waste in a public space (5-point scale). - My neighbors would expect me not to discard waste in a public space (5 point scale).
Injunctive norm	- My family would not throw away waste in a public space. (5-point scale) - The community leader would not throw away waste in a public space. (5-point scale) - My neighbors would not throw away waste in a public space. (5 point scale)
Willingness to act	- I am willing to take actions to keep my community clean. (5-point scale) - I am willing to take actions to improve the living environment of my community. (5 point scale)
Environmental value	- Cleanliness of roads and open spaces is important to me. (5-point scale) - Cleanliness of waterways and ponds is important to me. (5 point scale)
Quality of environment	- How clean is the waterway (river, canal, etc.) near your house? (4-point scale) - I am satisfied with my current living environment. (5 point scale)

Figure 6 Pictures of face-to-face questionnaire surveys in Bangkok (left) and Hue (right)

2.9 Capacity development and awareness raising

For Bangkok, the project and BMA organised the BMA task force to facilitate the information/data/knowledge sharing among the related department at BMA which directly or indirectly work on the solid waste management in Bangkok canals. The task force organised three informal and formal meetings during the project to discuss the research findings and how they can be interpreted and formulated into the BMA policy on solid waste management in canals and waterways.

The workshops that aim to develop the capacity of practitioners and stakeholders related to solid waste management of canals were conducted in both Bangkok and Hue. The workshops opted for a participatory approach which allowed the participants discussed freely and shared their ideas and opinions towards the appropriate solid waste management in canals and drainages.

3. Results & Discussion

3.1 Issues and current situation of drainage system in Bangkok and Hue

The series of in-depth interview surveys on public officers and some other experts relating to the urban drainage such as the ground/road coverage, culvert/open channels, and cleansing/sanitation in each city was conducted to understand the drainage capacity at normal condition and the drainage issues during flooding in Bangkok and Hue.

In Bangkok, there is an intensive network of open canal which was designed to mitigate the flood water with certain capacity of drain. The solid debris floating in the canals, which has specific function for mitigation of urban flood, are periodically collected by the municipality. The officers in the responsible sections speculated that the major source of these solids could be scattering or runoff from residents in illegal occupation on canal front, scattering from pedestrians, and aquatic plants were grown at the canal. It was recognised that the activity of construction and demolition that was related to the redevelopment of the canal had inappropriately disposed the waste. Some of the waste was found to be dropped into the canal. The solid debris submerged at the canal was not often collected even though it disrupted the water flow in the canal. Flash flooding of the road or residence after a downpour in the urban area is mainly due to the coverage of screen at the entrance of ditch rather than the lack of capacity of drainage.

In Hue, there is networking of trench for castle guard, which connects to river water. That is not wide and straight, but curved or bent trench, suggesting to generate flood water easily. Underground- ditch drainages are connected to the river. Hue is a historically famous for seasonal flooding caused by monsoon climate. The construction of the dry dam in the upstream can successfully reduce the risk of big flood disaster in a decade though there is still seasonal inundation in the residents every year. The major trigger of urban inundation occurred by the overflow of the river dyke during the prolonged precipitation or an increase of water level of urban canal due to exceeding the capacity of drain floodwater. The highly damaged zone is a residential area of socially vulnerable which is a well-known lowland or bank of urban canal or stream. The household waste that was scattered to the bank of the canal by residents was also observed to obstruct the flow. Periodically the debris in open ditches was cleaned every three months while drainage throats have not been concerned to clean that lead to the deposit of soil and rocks and the decrease in drainage function.

3.2 Survey on solid waste management system in Bangkok and Hue

The waste collection rate refers to the indicator to evaluate a part of performances of MSW management focusing on MSW collection as a public service. The collection rate in Hue was 95-97%, and that in Ca Mau and My Tho were 93% and 59%, respectively. In Long Xuyen, the rate in urban areas was 100%, that in suburban areas was 60% though. The rates in Chiang Mai, Hat Yai and Nonthaburi, were all 100%.

The frequency of public services in the target cities such as MSW collection, street cleaning and drainage cleaning was revealed as shown in **Table 11**. Most of the cities provided daily MSW collection and street cleaning, while Nonthaburi did MSW collection twice a week.

MSW is generally collected without source separation in developing countries. In other words, only one category of waste is being collected, so-called mixed waste. Food waste is one of the major components of MSW and waste generators are eager to dispose of food waste daily because they do not want to keep it more than a day. To keep city sanitary, MSW is often collected daily in Southeast Asia, where it is more humid and hotter.

MSW collection fee should be paid by households in all cities except for Hat Yai (**Table 12**). MSW collection fee would be relatively low compared to the monthly income. The low fee refers that MSW collection service should be a public service covered by municipalities. In addition, we identified that all of the cities provided the MSW collection service for those who do not pay the collection fee. This policy on MSW collection can prevent MSW from scattering as a result of inappropriate disposal of MSW.

The results indicate that all of the contacted cities did their best to prevent MSW from scattering, flowing into the drainage and blocking drainage as a public service. Unintentional scattering of MSW due to the storm may cause flows of MSW into the drainage. Moreover, it is impossible to control rule-breaking behaviour of waste scattering by residents or industries even though perfect public service has been provided.

Table 11 Frequency of public services

Country	City	MSW collection	Street cleaning	Drainage cleaning
Vietnam	Hue	Daily in high population density Twice a week in low population density	Daily	Every 3-6 month
	Ca Mau	Daily	Daily	Monthly
	Long Xuyen	Daily	Daily	Daily
	My Tho	Daily	Daily	Twice a year
Thailand	Chiang Mai	Daily	Daily	28 days a month
	Hat Yai	Daily	Daily	30 days a month
	Nonthaburi	Twice a week	Six times a week	NA

Table 12 Frequency of public services

Country	City	Collection fee	Amount per month	Note
Vietnam	Hue	Yes	24,000-30,000 VND[1)] 67,000-97,000 VND[2)]	[1)] Without business activities, [2)] with business activities
	Ca Mau	Yes	22,000 VND	
	Long Xuyen	Yes	15,000[3)]-20,000[4)] VND	[3)] Suburban, [4)] urban
	My Tho	Yes	15,000 VND	
Thailand	Chiang Mai	Yes	20-40 THB	
	Hat Yai	No		
	Nonthaburi	Yes	40 THB	

3.3 Situation of solid debris in canal in Bangkok

Solid waste composition analysis was conducted in Lad Prao canal and Prem-Prachakon canal (**Fig. 7**). 4 times for Lad Prao canal:16 Mar 2017 (dry season), 12 Sep 2017 (rainy season), 24 Oct 2017 (rainy season) and 29 Jan 2018 (dry season) and 1 time for Prem Prachakon canal on 18 May 2018 (rainy season). The result of composition and bulk density are shown in **Tables 14 and 15** respectively.

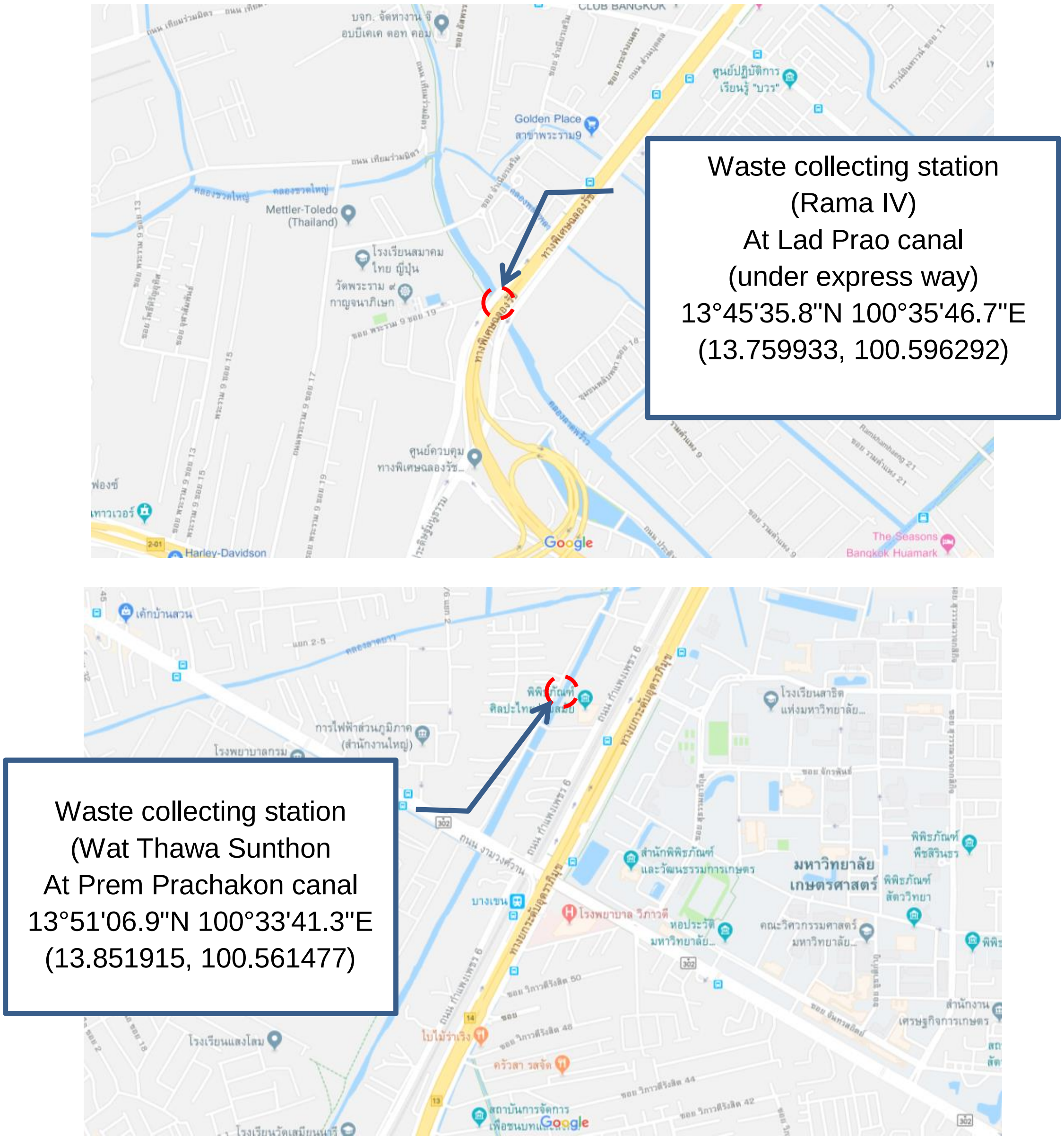


Figure 7 Location of field work in Bangkok

The major portion of waste in Lad Prao canal was timber (27%), which is mainly derived from deteriorated houses in Lad Prao canal by BMA. Other wood debris derived from natural plants (branches and leaves) also occupied a significant portion (18%). Plastic packages for packing use was also high (12%). Food waste is relatively high (8%) with most of it came from untouched food still wrapped in its plastic packaging. The average rate of generation of solid debris in this canal was 130 m^3/month at one bar screen.

The analysis in Prem-Prachakon was conducted for comparing the waste composition, especially the timber. It was found that most wastes came from food waste (36%) because many households are living along the canal. Plastic packing was high at 25%. The timber proportion was 12% which lower than Lad Prao canal.

The bulk density of solid waste in Lad Prao canal ranged from 229 to 277 kg/m^3 (254 kg/m^3 in average) and similar to Prem-Prachakon canal (237 kg/m^3). Moisture content was only conducted in Prem-Prachakon as shown in **Table 16**. It is found that the moisture content of wood (timber and trim) is high (50 and 64% respectively). It needs an amount of thermal energy to reduce the moisture to the appropriate level (<15%) for use as fuel.

Table 14 Composition by weight of solid waste

No.	**Type of solid waste**	**Lad Prao**				**Prem Prachakon**
		No.1	**No.2**	**No.3**	**No.4**	**No.1**
1	Wood (timber from household)	40.2	15.1	26.1	27.1	11.8
2	Wood (trim)	14.1	23.5	21.8	13.1	5.8
3	Plastic (bottle)	0.8	3.4	2.0	1.1	3.4
4	Plastic (packaging)	12.3	13.6	10.4	13.3	25.4
5	Plastic (material)	1.7	4.4	4.2	5.2	1.4
6	Food waste	4.3	12.9	7.3	9.4	35.5
7	Shell and bone	0.2	0.5	1.0	0.4	0.1
8	Textile	3.3	2.4	0.6	1.0	0.2
9	Sanitary napkin and Diaper	0.9	2.4	1.0	3.9	1.2
10	Paper	0.8	1.9	1.5	2.0	2.6
11	Glass	0.9	7.9	5.2	6.4	2.7
12	Foam	1.0	4.7	7.1	3.0	3.4
13	Metal and Aluminum	0.2	0.6	0.7	0.7	0.7
14	Rubber	0.3	3.5	3.3	3.4	2.0
15	Plant (water hyacinth)	5.3	0.9	0.7	2.5	-
16	Plant (natural plants)	13.6	2.4	7.1	7.7	3.8

Table 15 Bulk density

Lad Prao canal				**Prem Prachakon**
No.1	**No.2**	**No.3**	**No.4**	**No.1**
229	277	255	255	237

Table 16 Moisture content

No.	**Type of solid waste**	**Moisture content (%)**
1	Wood (timber from household)	50
2	Wood (trim)	64
3	Plastic (bottle)	15
4	Plastic (packaging)	76
5	Plastic (material)	13
6	Food waste	77
7	Shell and bone	-
8	Textile	68
9	Sanitary napkin and Diaper	88
10	Paper	29
11	Glass	< 1
12	Foam	46
13	Metal and Aluminum	6
14	Rubber	37
15	Plant (water hyacinth)	-
16	Plant (natural plants)	93

3.3 Situation of solid debris in canal in Hue

3.3.1 Waste in the throats and open drainage systems

1) Waste on screens

Wastes converged on bar screens blocked surface flow that caused to deluge and decrease drainage ability in rain season. Waste on screens entered into drainage throats and deposited in manholes. **Figure 8** illustrated the wastes on screens at several places in Hue.

Figure 8. Wastes on screens at Bach Dang street (1), Chi Lang street (2) and Ho Xuan Huong street (3) (4).

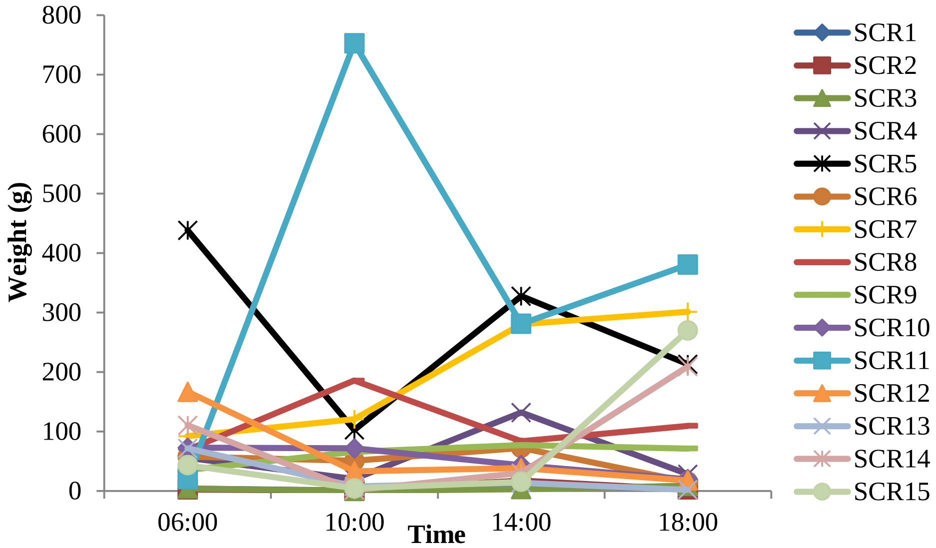


Figure 9 The temporal dynamic of waste on screens at different sampling time per day

The fluctuation of waste within the sampling day (four times per day) on screens over waste sampling results at 15 sites (**Figure 9**). The amount of the waste on screens sharply fluctuated at the difference between sampling time per day as well as survey sites that primarily depend on screen's position, living behaviour of nearby residents and waste collection time of the HEPCO workers. In general, the waste weights have a large amount in the early morning and decrease at noon. In the afternoon, there was a slight rise in the waste weight due to the residents disposing their waste in front of their properties for the HEPCO workers to collect and sanitise. In several areas, wastes were either messily thrown or directed on bar screens that potential factors to block the drainage systems.

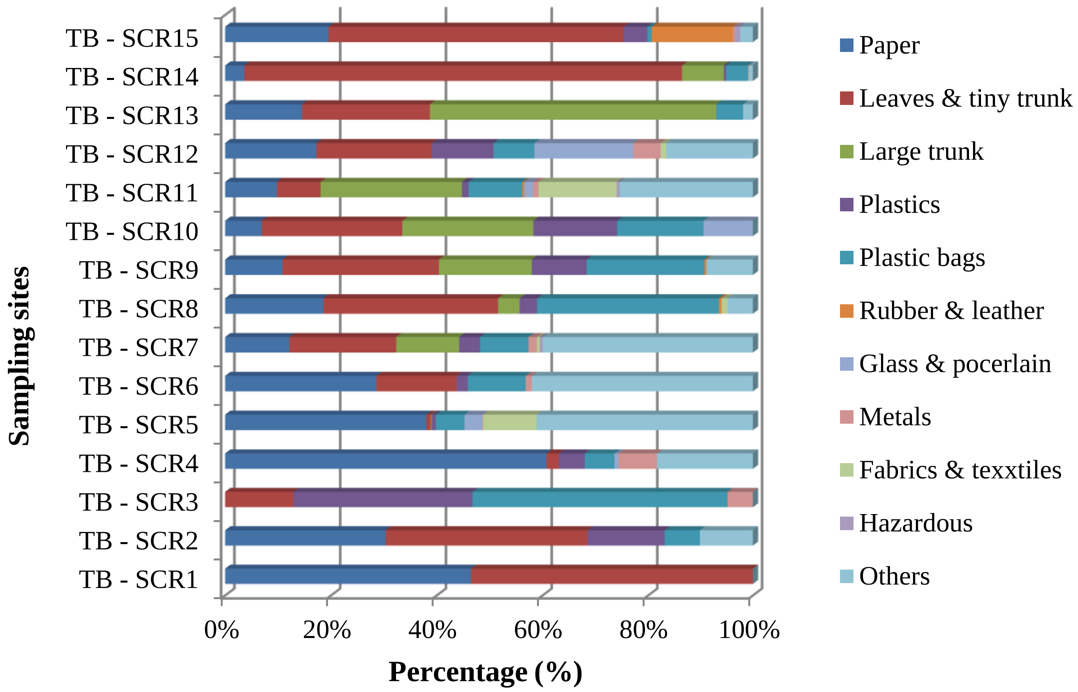


Figure 10. The percentage of waste components on screens.

Figure 10 compares the proportion of waste components on screens. There was a significant difference between screens. Paper, plastic bag and group of leaves and tiny woody trunk accounted large proportion in all categorised components.

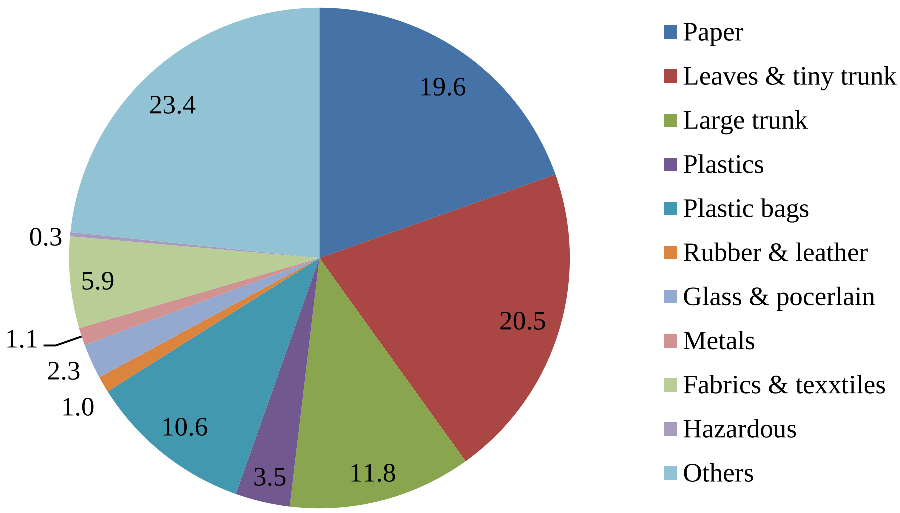


Figure 11. The average percentage of waste components on screens.

Figure 11 revealed that the most significant waste weight on bar-screens was paper, leaves and tiny woody trunks which accounted for 19.6% and 20.5%, respectively. The plastic bags accounted for 10.6%; this type of waste covers the spacing on bar screens and blocks run-off which is a vital reason for partial inundation. The highest ratio came from food waste from households (26.8%). The food waste has various size, ingredient and weight which were disposed improperly on screens. The decomposed waste produces bad smell and pathogens as well as mosquitos which influences the surroundings as well as impacting the residents' health.

2) Waste at drainage throats (frog's mouths)

Drainage throats that are designed like a frog's mouths (**Fig. 12**) are generally unable to avert any unpleasant smell from the manholes and sewers during the dry season. Most of the throats were overlooked and were not sanitised and are only periodically maintain. Soil, sand, and waste disposition diminished the drainage acreage. Soils and sands were heavily deposited in several places such as in Trinh Cong Son, Dao Duy Anh or Dinh Tien Hoang streets. As drainage throats were not regularly dredged and cleaned up, this reduces the drainage role and having higher potential for the waterway to be blocked. Thus, throats were found to not properly function especially considering the weight in this position to hang upon breadth and the depth of the frog's mouths. **Fig.12** showed the realistic waste deposition in throats at several places in Hue.

Figure 12 The wastes at drainage throats on Cao Ba Quat (5) and Chua Ong streets (6).

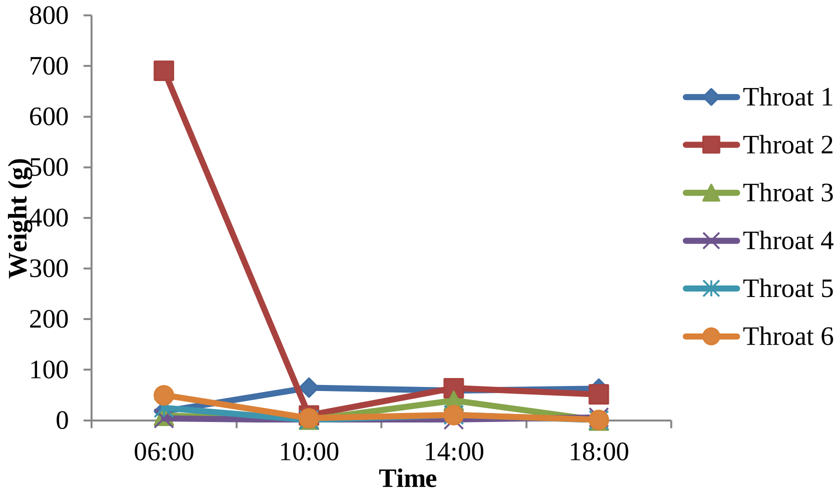


Figure 13 Temporal dynamic of waste at drainage throats at different sampling time per day.

Figure 13 showed that the waste weight of DT2 in the early morning was much larger than other moments as well as other positions by that were likely to accumulate about a few days before starting sampling to study. Besides, the throats had quite a big dimension, and numerous tree around this one compare with remain sites which had the change of waste weight in time were relatively low. Effect of waste scattering was ignorable on these throats.

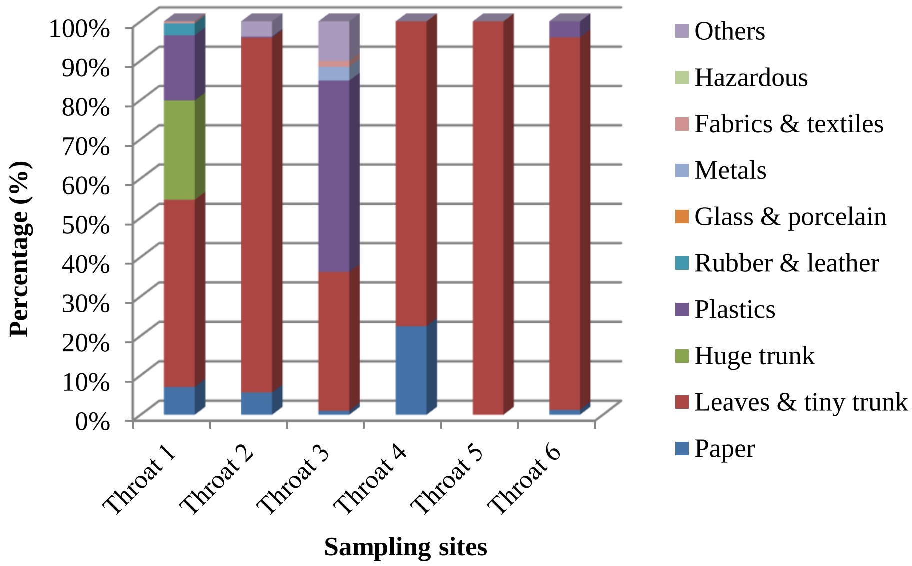


Figure 14 Waste composition at drainage throats.

The waste sampling and determining results at 6 drainage throats were expressed in following **Figure 14**. The bar chart showed that the leaves & tiny woody trunk group were major, ranged from 35.2% to 99.3%. The plastic component was also essential at the DT1, and DT3 with the proportions were 16.2% and 48.7%, respectively. The percentage of plastic bag at DT4 was 22.4%, a high ratio in all components compare with other surveyed site.

Waste densities at six drainage throats were shown in **Table 17**. The fluctuation for each component of the drainage throats over the surveyed sampling times was substantial that might be seen through average and standard deviation value.

Table 17 The surface density waste at drainage throats (in g/m^2)

No	Component	DT1	DT2	DT3	DT4	DT5	DT6
1	Paper	166.7 ± 261.9	95.1 ± 250.1	62.5 ± 242.1	85.9 ± 219.7	0	±41.5
2	Leaves & tiny trunk	1125.0 ±712.7	1519.8±2576.2	2187.5±7110.5	296.9 ± 233.3	726.6 ± 965.2	826.6±1274.2
3	Large trunk	598.2 ± 652.1	0	0	0	0	0
4	Plastics	392.9 ± 497.6	4.8 ± 18.6	3031.3±11740.0	0	0	37.5±138.3
5	Plastic bags	65.5 ± 253.6	58.8 ± 143.8	0	0	5.1±19.7	17.9±48.3
6	Rubber & leather	71.4 ± 189.0	0	0	0	0	0
7	Glass & pocerlain	0	0	0	0	0	0
8	Metals	0	0	218.8 ± 847.1	0	0	0
9	Fabrics & textiles	11.9 ± 46.1	0	93.8 ± 363.1	0	0	0
10	Hazardous	0	0	0	0	0	0
11	Others	0	65.7 ± 175.7	625.0 ± 2420.6	0	0	0
	Total	**2431.5±1897**	**1744.1±2910**	**6218.8±18894**	**382.8 ± 394.0**	**731.7±977**	**829.9±1407**

Note: In all cells: average ± stdev, n = 16, (including 4 times a day of 4 sampling stages).

3) Waste in open drainage systems

The drainage system at some roads in Hue was being built as open ditches and sewer with various section constructions without covering. Because open designed – characteristics, an amount of waste existed that was diverse about components. At soil ditches, flora of which various grasses were major growing strongly that aggravate the drainage operation of the whole system. The waste phenomenon accumulated in the open ditches in the study area (**Figure 15**).

Figure 15. The waste in the open drainage systems at Mang Ca Nho (7), Nguyen Chi Thanh (8) and Nguyen Binh Khiem streets (9).

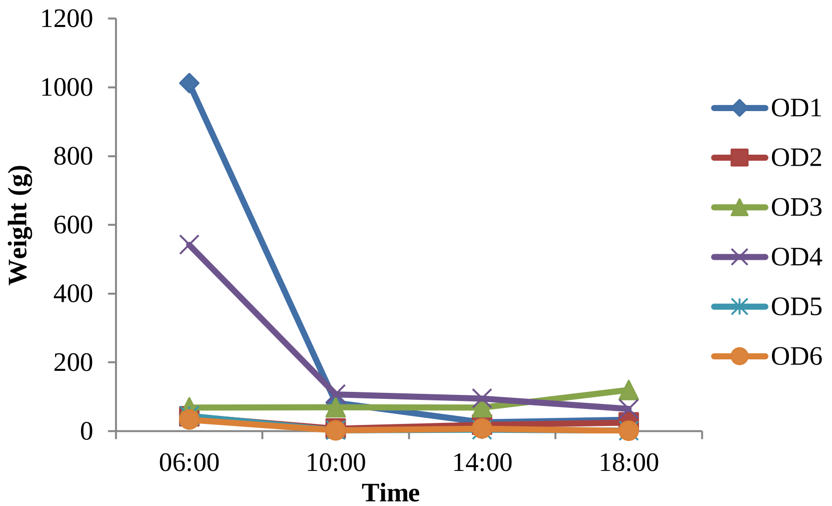


Figure16 Temporal dynamic of waste in open ditches at different sampling time per day.

The fluctuation of waste within the sampling day (four times per day) in the open ditches over waste sampling results at 6 sites (**Figure 16)**. There was an equivalent point in the waste weight fluctuation between the drainage constructions like screens and drainage throats that the amount of waste in open ditches had a large in the early morning in most. Waste there was not sanitised on a daily basis same as on screens or streets. Recurrent preservation has been 4 times a year and was conducted by HEPCO. The change of waste weight at the moments of the day was moderately low. This result demonstrated that a short – time did not significantly impact on waste accumulation in the open ditches.

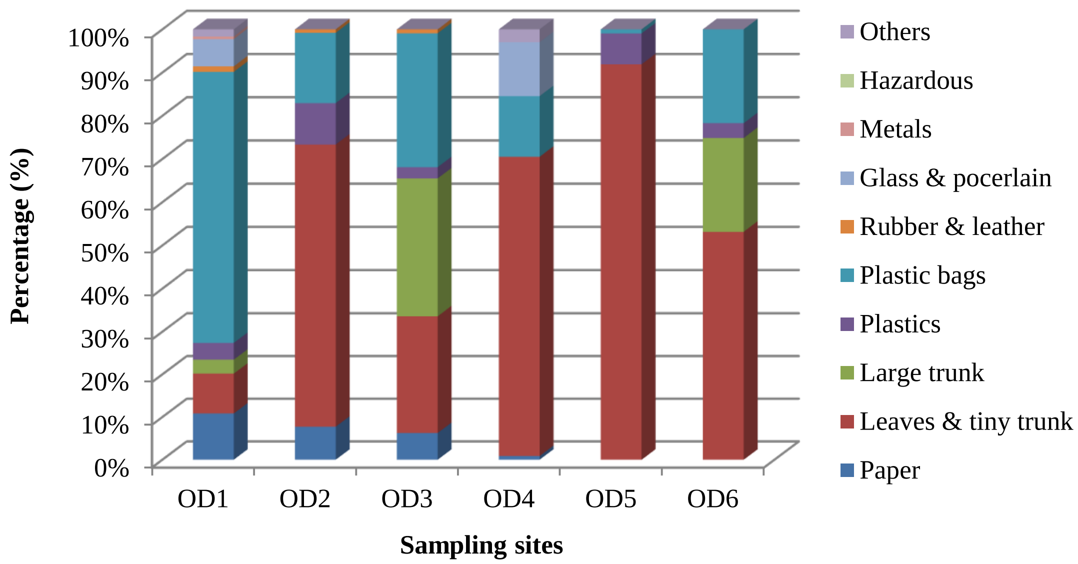


Figure 17. Waste composition in the open ditches.

The waste composition sampling and identifying results in 6 open ditches were expressed in following **Figure 17**. The group of leaves and tiny woody trunk from street trees continued to be major component which changed from 9.3% to 91.9% between sites; the highest percentage was at OD5. Besides, the plastic bags accounted for a fairly large rate, mainly OD1 and OD3 with 62.3% and 31.0%, respectively. Plastic products creates high tension for the drainage capacity during rainy season as waterways are easily blocked. Additionally, the decomposed time is also long that there are immense effects on the quality of water, soil environment as well as the surroundings.

The waste density was inferred from waste weight and section of each sampling site. **Table 18** showed the average density and standard deviation of waste components.

Table 18 The surface density of waste in open ditches (in g/m^2)

No	Component	OD1	OD2	OD3	OD4	OD5	OD6
1	Paper	31.0 ± 111.4	1.2 ± 4.2	102.5 ±143.2	3.5 ±8.3	0	0
2	Leaves & tiny trunk	26.8 ± 29.2	10.3 ± 11.7	446.3 ±246.5	281.5 ±387.7	24.1±37.3	8.8 ±20.5
3	Large trunk	9.4 ± 28.2	0	521.3 ±377.8	0	0	3.6+13.9
4	Plastics	11..3 ± 29.2	1.5 ± 5.8	42.5 ±112.4	0	1.9 ±7.3	0.6 ±1.6
5	Plastic bags	179.8 ± 404.9	2.5 ± 5.1	506.3 ±1194.4	56.8 ±136.3	0.3 ±0.7	3.6 ±9.2
6	Rubber & leather	3.6 ± 14.0	0.1 ± 0.5	58.1 ±15.0	0	0	0
7	Glass & pocerlain	18.1 ± 45.8	0	0	50.5 ±140.0	0	0
8	Metals	4.1 ± 1.8	0	0	0	0	0
9	Fabrics & texxtiles	2.0 ± 7.7	0	0	0	0	0
10	Hazardous	0	0	0	0	0	0
11	Others	4.8 ± 10.1	0	0	43,4 ±12,0	0	0
Total		**2431.5±1896.6**	**288.3 ± 605.8**	**15.6 ± 13.3**	**1633.8 ±1012.4**	**404.3 ±598.7**	**26.3±40.6**

Note: In all cells: average ± stdev, n = 16, (including 4 times a day of 4 sampling stages).

By its open character, the open ditches were a favourable position for waste species to enter and deposit that raised plenty of pathogens and harmful larvae and other environmental issues impacted on nice sceneries, health and life of residences. It became much more severe by the tropical climate of Hue city like hot, wet, high rainfall.

The standard deviation was way high in open ditches as well as drainage throats; it indicated that the change of waste weight was substantial for each category during times of day as well as between sampling sites. That value did not impact slightly to waste enter into the urban drainage system.

3.3.2 Waste deposit in the drainage systems

Waste deposited in the drainage systems had main waste source was from throats, screens and waste in sewers in connection with the combined system of the city. Those wastes were mixed with sludge, sand, wastewater and happened the decomposition in there that speeded up bad odours evaporation in the surroundings from the mouth of the throats or screens. Figure 18 illustrated waste deposition in the manholes in Hue city.

Figure 18. Waste deposition in the manhole (10) and waste components deposited in the manhole after washing (11).

The investigation was conducted to take waste samples at eight manholes on Le Duan street without distributed equally in the whole city because that depends on many factors, of those, the dredged cycle is a vital factor. According to sample treatment steps, the result of waste weight in the manholes was presented by **Table 19**.

Table 19. The waste weight in the manholes (in gram)

No	Component	MH1	MH2	MH3	MH4	MH5	MH6	MH7	MH8	Average
1	Paper	0	3	7	5	0	2	39	20	9.5
2	Leaves & tiny trunk	56	316	199	8	122	138	95	282	152.0
3	Large trunk	0	0	0	0	127	109	0	0	29.5
4	Plastics	0	6	25	79	23	60	16	199	51.0
5	Plastic bags	13	57	12	83	19	87	0	187	57.3
6	Rubber & leather	0	0	0	2	49	112	2	37	25.3
7	Glass & pocerlain	0	0	0	0	0	39	57	71	20.9
8	Metals	27	0	0	2	23	54	11	11	16.0

9	Fabrics & textiles	0	0	0	18	14	20	11	114	22.1
10	Hazardous	0	0	0	0	0	89	0	6	11.9
11	Others	0	0	0	0	0	0	0	0	0
Total		**96**	**382**	**243**	**197**	**377**	**710**	**231**	**927**	**395.4**

Note: Value in all cells of the average column is the average value of 8 manholes;

The waste deposited in the manholes was found to have variety of component. The weight and the percentage of waste component were found to be depended on the nature of the habitat which was near to the position of manholes. According to the HEPCO worker who was in the group of drainage system preservation, waste deposited in the manholes was heavier in areas near the market, restaurants along pavements and streets as well as trading stalls, etc. The percentage of waste components deposit in the manholes was shown in **Figure 19**.

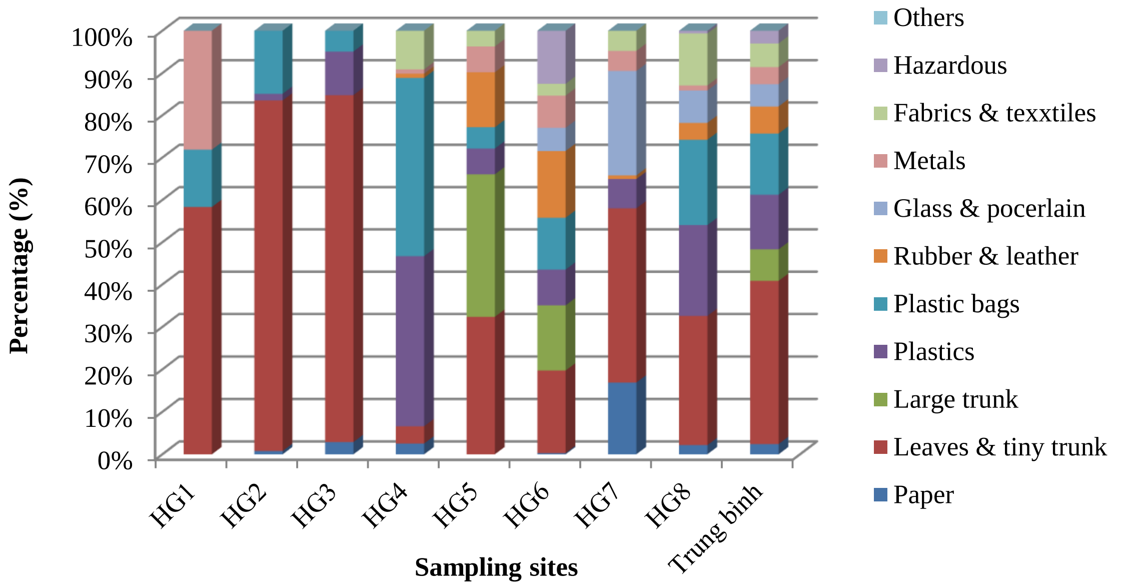


Figure 19 The percentage of waste component deposit in the manholes

The composition of leaves & tiny woody trunks group fluctuated from 4.1% to 82.7%. The percentage of each component was different between manholes. For example, the plastic component was relatively high at MH4 (40.1%) but lower at MH8 (21.5%). The hazardous waste accounted for 3.0% are mainly batteries while the other proportion was 12.6% for MH6. At the moment, the collection and classification for hazardous waste in Hue city have been conducted but it is not as effective as there is a lack of residents' awareness and low enthusiasm to participate in proper waste disposal activity.

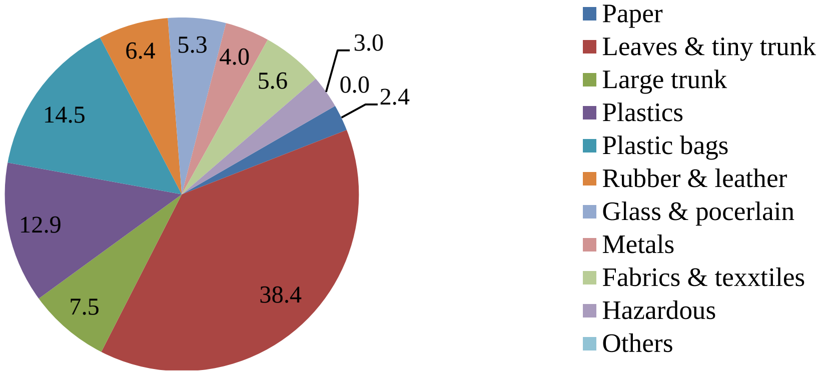


Figure 20 Average composition of waste deposit in the manholes.

Figure 20 shows the highest proportion of waste deposit is made of leaves and the tiny wood trunk (38.4%). Hazardous component that affects soil environment, wastewater quality and aquatic life accounted for 3.0%. The composition of plastic and plastic bags were 12.9% and 14.5%, respectively. Due to the large size of waste (plastic box, big bags, large trunk), these wastes were not able to pass the mouth of throats and spacing of screens. Analysis also found some amount of oil and fat in the manholes which affected the water environment and will become a big challenge for the wastewater treatment plant in Hue when it operates officially.

In conclusion, most of the waste entered into Hue's drainage system was leaves and tiny wood trunk from street trees. This result was similar to a study implemented in Hue citadel. Paper component rate was high on screens. Plastic and plastic bag accounted for a high rate too. Plastic bags have been commonly used and are difficult to replace. Hence, an efficient and proper management policy on producing and trading this component is required. Concurrently, encouragement to produce and use eco-friendly bags as well as implement outreach campaigns for raising awareness of urban residents on appropriately waste disposal activities will be necessary.

3.3 Laboratory experiment for determining the parameters of clogging of debris

Details of waste used in the experimental is shown in **Table 20**. Timber is a major portion while foam is quite low in term of portion by weight but it is a large number of unit. Plastic bottle was selected in term of plastic waste because it has a uniform shape. Plastic bag was also found in large quantity but it can be shrink and transform to the non-uniform configuration which is difficult to identify the impact. A brief experiment of the plastic bag was conducted to reveal the effects.

Table 20 Characteristics of solid waste in the experiment

Sample	Timber	Foam box	Foam plate	Plastic bottle
Picture				
Dimension (cm)	7.5 x 7.5 x 3.5	17.5 x 12.3 x 6.5	14.3 x 20.6 x 1.5	7 dia. x 23 (for 1 unit)
Mass (g)	170	4.3	3.9	22.7 (include tab)
Volume (cm^3)	197	1399	442	528
Density (g/cm^3)	0.9	0.003	0.009	0.04

1) Behaviour of flow and blockage

Timber: Timber was stuck firmly at the bar screen beneath the water surface. The pattern of blockage is non-uniform, especially in case of many timbers. It can overlap (have a void in front of bar screen) or fully obstructed. (**Figure 21)**

Foam: Foam was floated on the surface and was trapped in front of bar screen. The effect of blockage depended on their position and shape when it stuck. If it floated, the effect was less than submerged significantly (**Figure 22**). Normally, foam float on the surface of water unless it contacts with a big or heavy waste then it can depress under the water.

Plastic: Effect of blockage by plastic bottle also depends on the position and shape. Plastic bottle found at field work was empty, occasionally with a lid that always floats on the water. (**Figure 23a and b**). In case of plastic bottle with water, it was submerged and has the potential to clog the bar screen. Plastic bag is classified in 2 types: empty or with object. Empty plastic bags floating in canals seemed to be the less effect (**Figure 23c and d**) but it has the opportunity to fill up by water, and some of them submerged and clogged the bar screen (**Figure 23e and f**). Plastic bag with object also showed the same manner (**Figure 23g and h)**. Mostly object in plastic bag is food waste, and it affects flow capacity and water quality significantly.

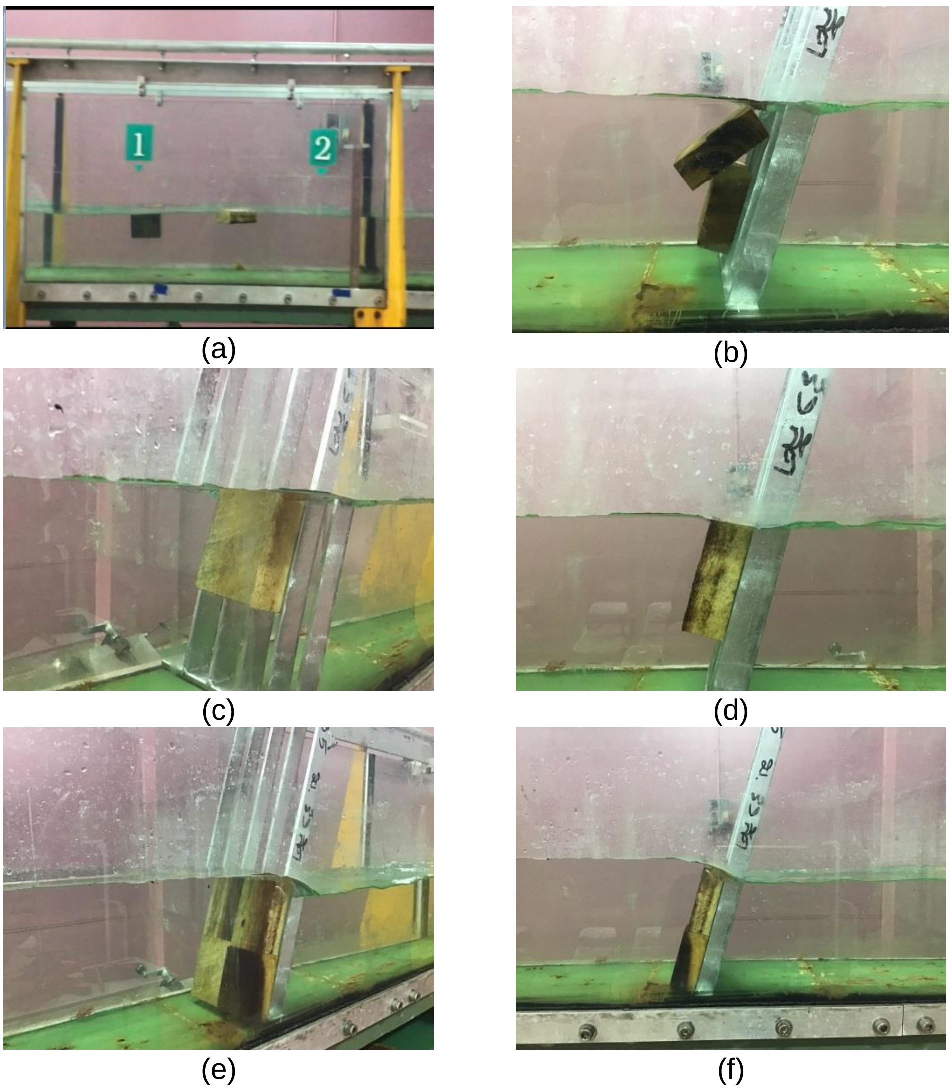


Figure 21 Behaviour of wood in the flume study: (a) and (b) free flow and blockage; (c) and (d) blockage of wood sample 1 unit; (e) and (f) blockage of wood sample 4 unit

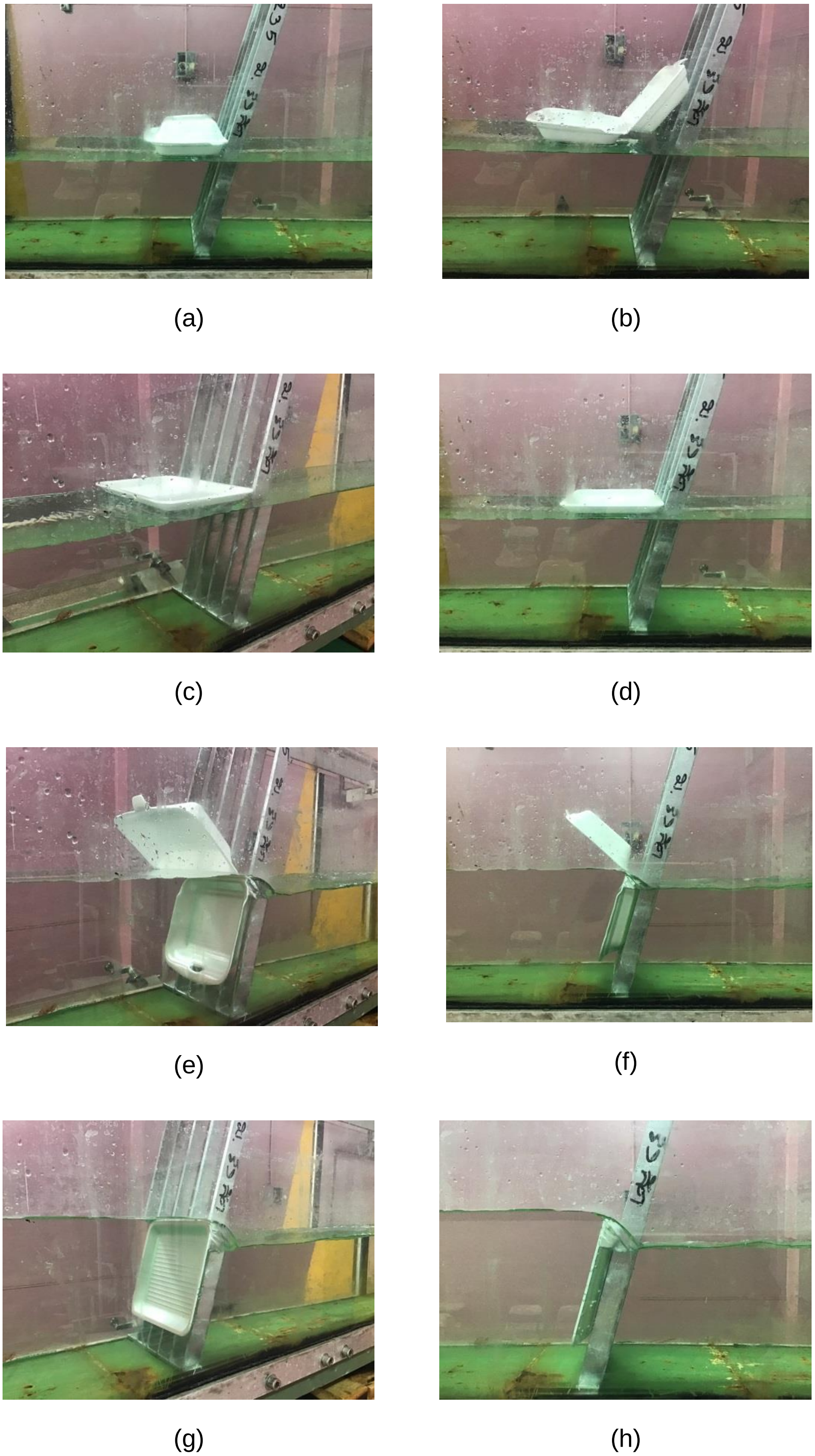


Figure 22 Behaviour of foam in the flume study: (a) to (d) free flow and floating blockage; (e) and (h) submerged and blockage

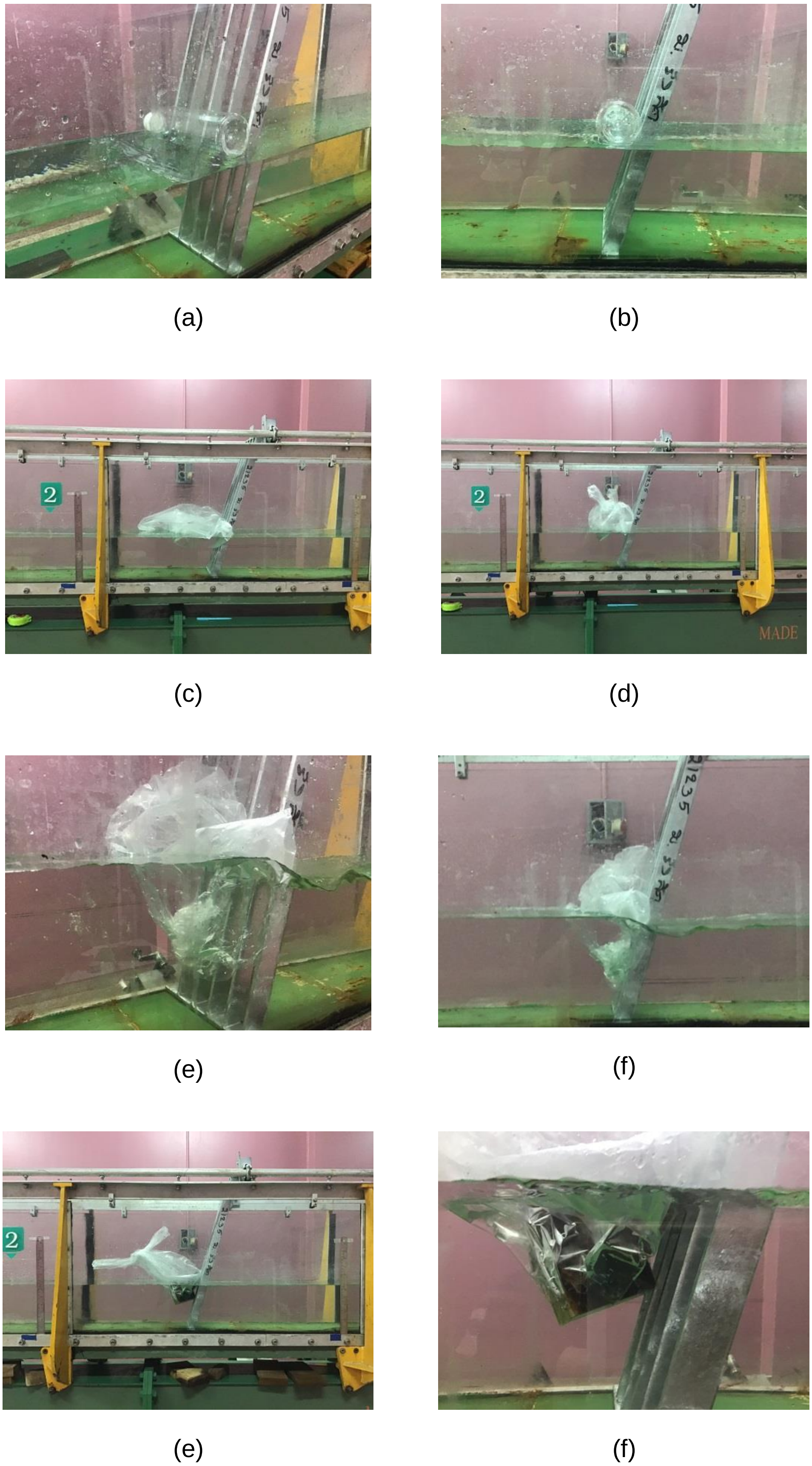
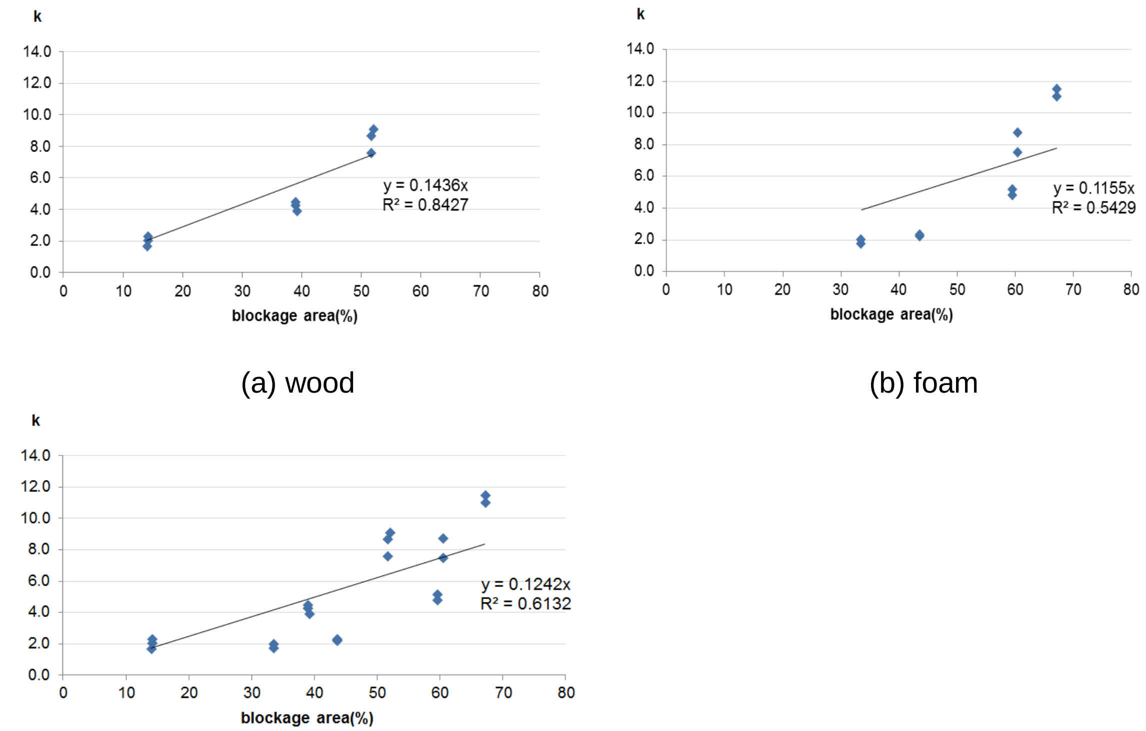


Figure 23 Behaviour of the plastic sample in the flume study: (a) and (b) plastic bottle; (c) and (d) empty plastic bag; (e) and (f) plastic bag filled with water; (g) and (h) plastic bag with object

2) Relationship between blockage area and head loss coefficient

It is clear that the pattern of water flow and blockage depends on the shape of waste stuck in front of the bar screen. Blockage area is major variable and not difficult to estimate at the field. Therefore, during the experiment, waste (wood and foam) was arranged in a certain pattern to investigate the relationship between blockage area and head loss coefficient. The investigation excluded waste from plastic because floating plastic bottle affects a few different of water depth across the bar then it is difficult to measure by depth meter. Meanwhile, the submerged plastic bag was dynamic and did not fix in front of bar screen.

Head loss coefficient from wood and foam is proportional to the blockage area. The relationship from wood is higher R-Squared value (**Figure 24**). The reason may be wood was rigid, dense and rectangular geometry but foam had a round shape and less density that cause the smooth streamline and less energy loss. The relationship from wood was used to calculate the head loss coefficient as an input parameter in SWMM.



(a) wood

(b) foam

(c) Combination of all data

Figure 24 Relationship between blockage area and head loss coefficient

3.4 Analysis of the mechanism of debris clogging in canal using numerical model

Stable flow in the canal with no solid debris at slopes of 2%, 5%, and 10% were obtained (**Table 21, Fig. 25**). The average flow velocity was getting higher with an increase of slope. These average flow velocities were used in following the evaluation of blockage effects.

Table 21 Simulation conditions, average flow velocity, presence or absence of clogging on the slit-like structure, and blockage effects obtained at t = 30s in numerical simulations of the canal, the slit-like structures, and several compositions of solid debris.

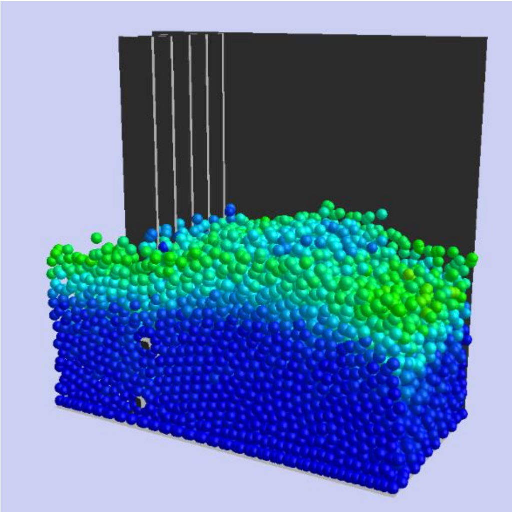
	Slope [%]	Wood timber	Foam	Plastic bottle	Average flow velocity [m/s]	Clogging situation	Blockage effect [%]
2-Control	2	-	-	-	0.30	-	-
5-Control	5	-	-	-	0.94	-	-
10-Control	10	-	-	-	1.90	-	-
5-WT25	5	25	-	-	0.42	Yes (23WT)	55
5-F15	5	-	15	-	0.93	Yes (1, floating)	0
5-PB50	5	-	-	50	0.93	No	0
2-WT1	2	1	-	-	0.27	Yes (1WT)	10
5-WT1	5	1	-	-	0.88	Yes (1WT)	6
10-WT1	10	1	-	-	1.90	No	0
2-WT9	2	9	-	-	0.23	Yes (8WT)	23
5-WT9	5	9	-	-	0.58	Yes (8WT)	38
10-WT9	10	9	-	-	1.89	No	0
2-F1	2	-	1	-	0.30	Yes (1F, floating)	0
5-F1	5	-	1	-	0.94	Yes (1F, floating)	0
10-F1	10	-	1	-	1.90	No	0
2-Mix	2	6	6	3	0.24	Yes (6WT)	20
5-Mix	5	6	6	3	0.66	Yes (6WT)	30
10-Mix	10	6	6	3	1.89	Yes (2F, floating)	1

WT stands for wood timber. F stands for foam.

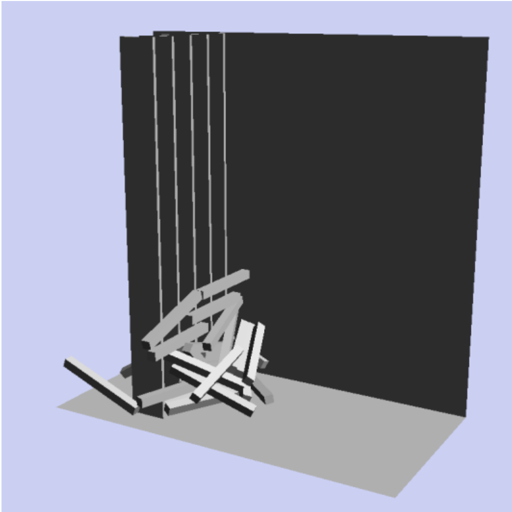
In the first stage, wood timbers and foams stacked on the slit-like structure of bar screen, while no plastic bottle did (**Table 21, Fig. 25**). On the other hand, only wood timbers caused the blockage effect. Forms stuck on the upper part of slit of bar screen, which is not in the water. Then, wood timbers and foams proceeded to the second stage.

In the second stage, wood timbers and foams stacked on the slit at slopes of 2% and 5%, while none of them did at the slope of 10% (**Table 21, Figs. 26-28**). Same as the result in the first stage, only wood timbers caused the blockage effect. Forms were also on the water. Then, 9 forms were not tested. At the slope of 2% and 5%, the more wood timbers are put, the larger blockage effect was observed. In case of 9 wood timbers, the blockage effect was getting larger by increase of slope. This was not observed in the case of single wood timber.

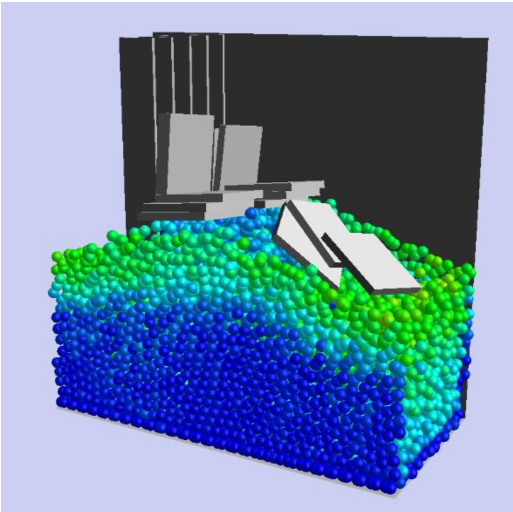
In the third stage, wood timbers stuck on the slit at slopes of 2% and 5%. Foams stacked on it at slopes of 2%, 5%, and 10% (**Table 21, Fig. 29**). No plastic bottle stacked on it. Same as a result in the first and second stage, only wood timbers caused the blockage effect. Forms were also on the water. In this composition, no effect by the combination of different solid debris was observed.



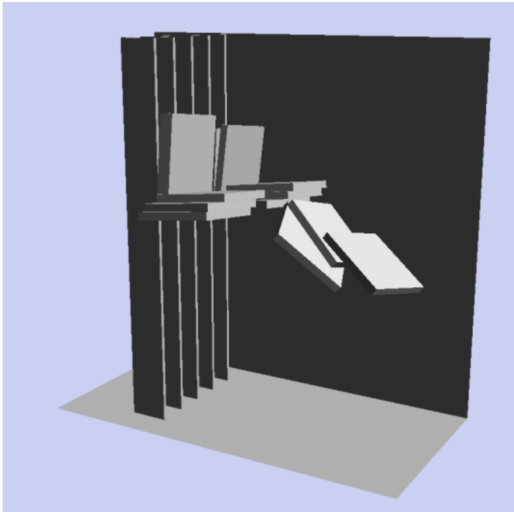
(a) 25 WTs at t = 15 s. Water is visible.



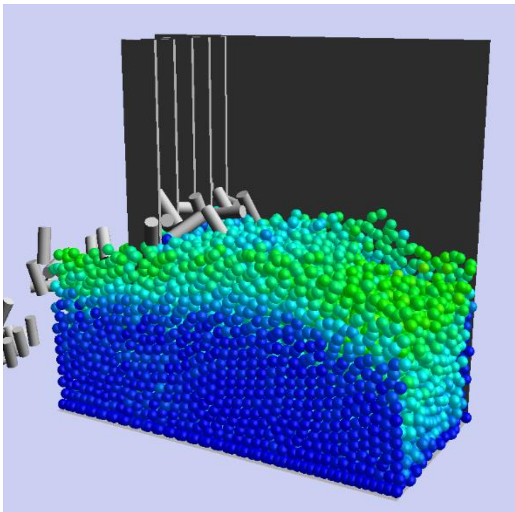
(b) 25 WTs at t = 15s. Water is not visible.



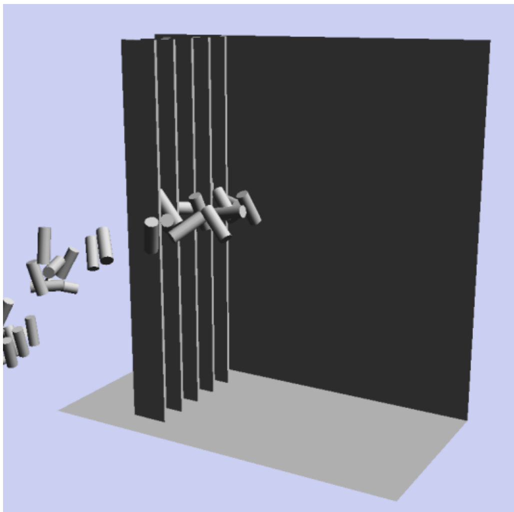
(c) 15 Foams at t = 15 s. Water is visible.



(d) 15 Foams at t = 15 s. Water is not visible.

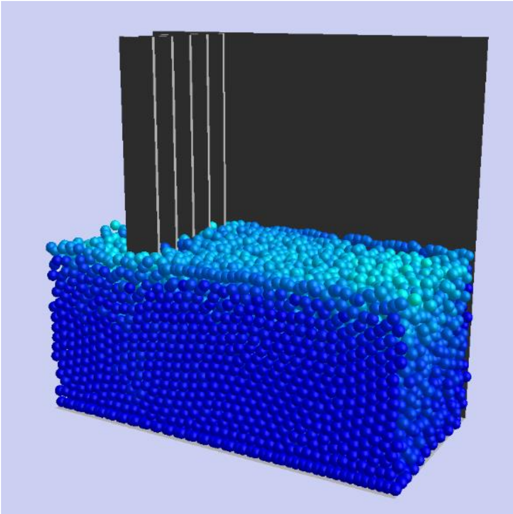


(e) 50 PBs at t = 3 s. Water is visible.

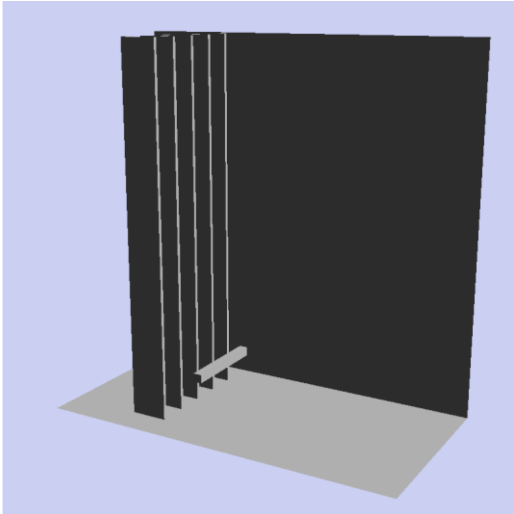


(f) 50 PBs at t = 3 s. Water is not visible.

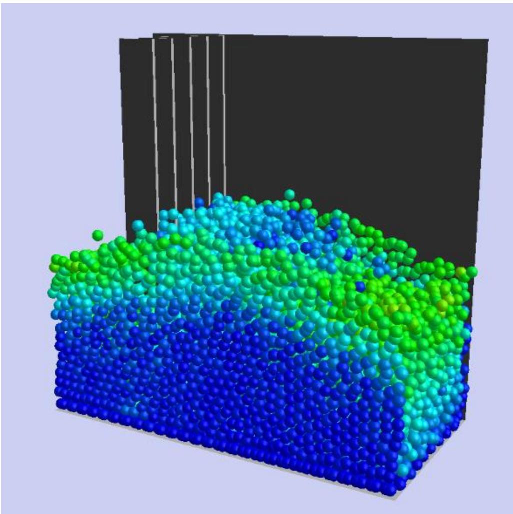
Fig. 25 Simulation results from slope 5%. WT=wood timber. PB=plastic bottle. Spheres=water. Colours indicate their velocity. Blue is 0 m/s and Red is 2 m/s.



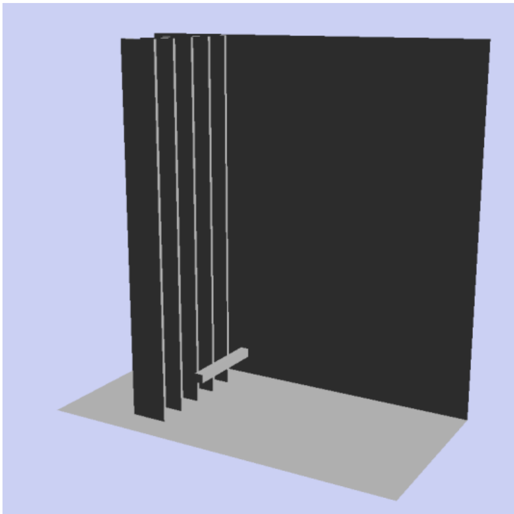
(a) At slope 2%. Water is visualized.



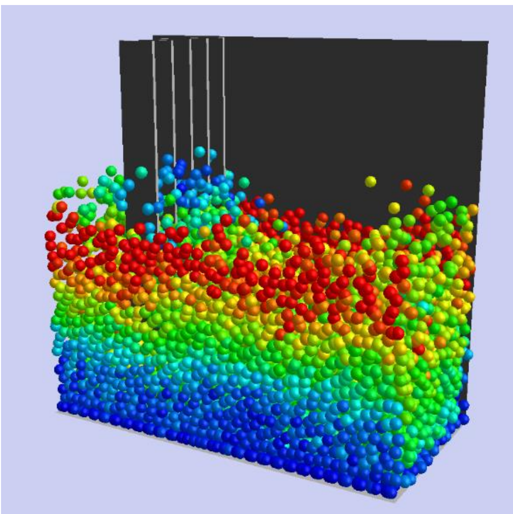
(b) At slope 2%. Water is not visualized.



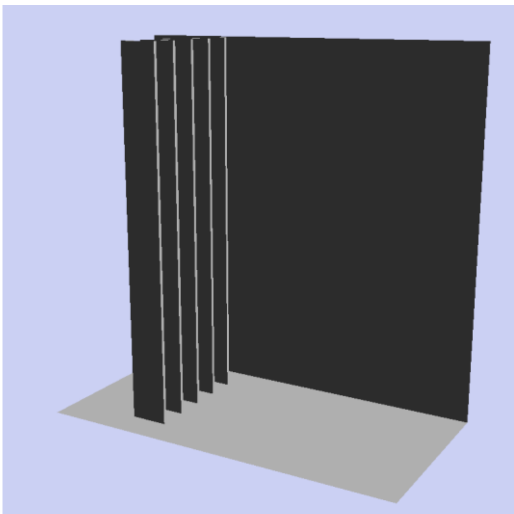
(c) At slope 5%. Water is visualized.



(d) At slope 5%. Water is not visualized.

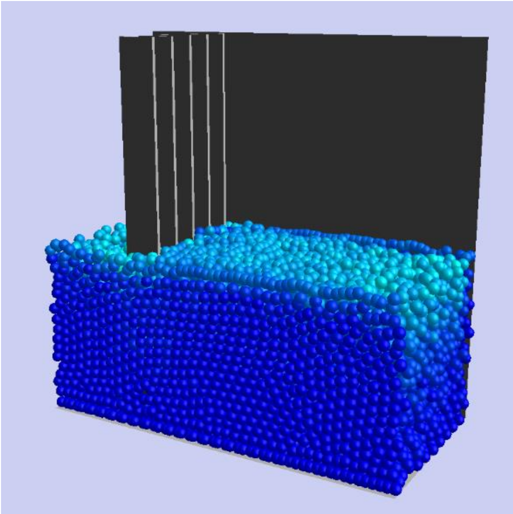


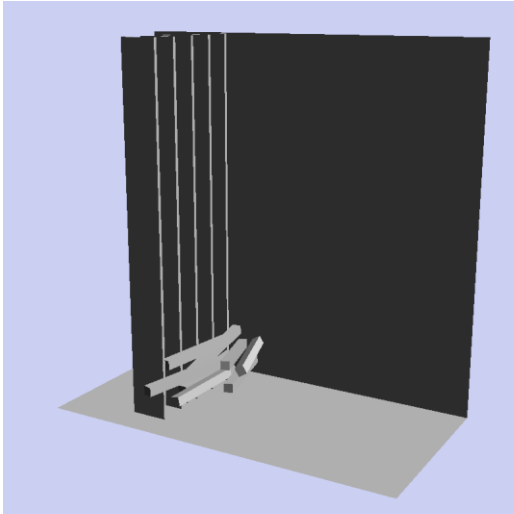
(e) At slope 10%. Water is visualized.

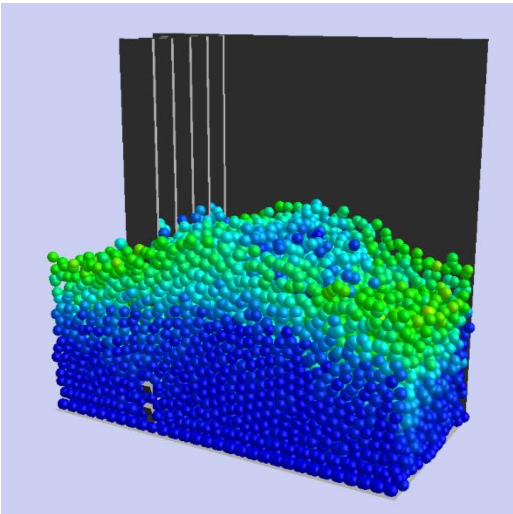


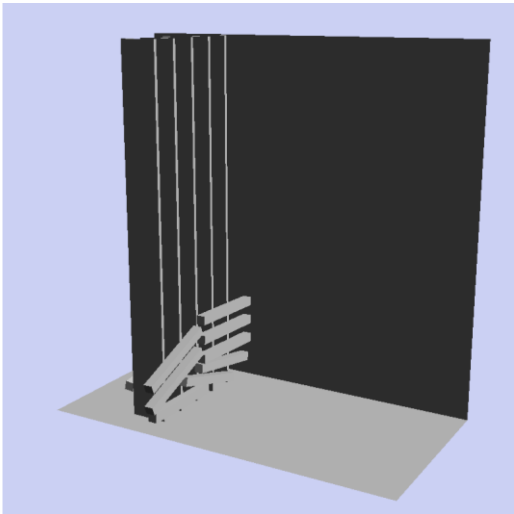
(f) At slope 10%. Water is not visualized.

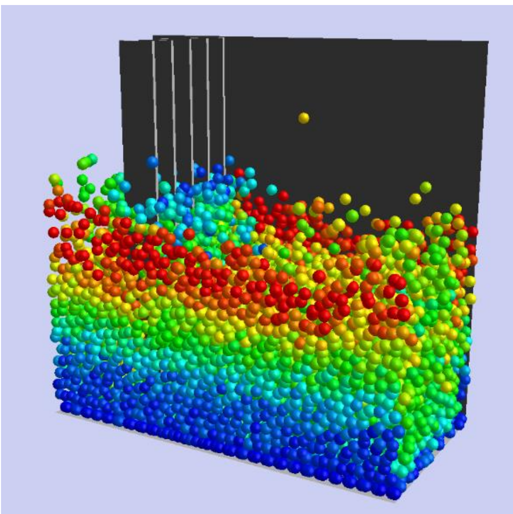
Fig. 26 Simulation results of 1 wood timber at t = 30s. Spheres=water. Colours indicate their velocity. Blue is 0 m/s and Red is 2 m/s.


(a) At slope 2%. Water is visualised.


(b) At slope 2%. Water is not visualised.


(c) At slope 5%. Water is visualised.


(d) At slope 5%. Water is not visualised.


(e) At slope 10%. Water is visualised.

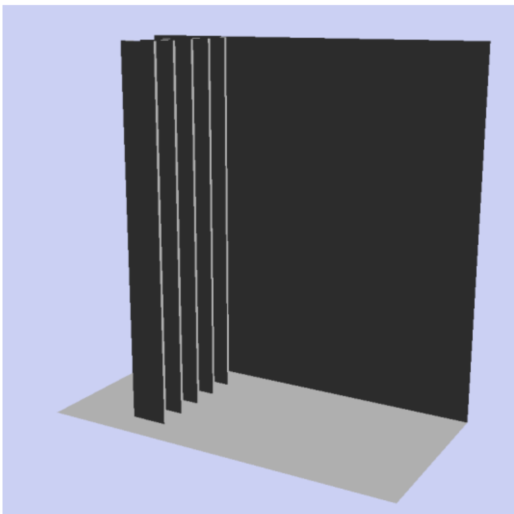
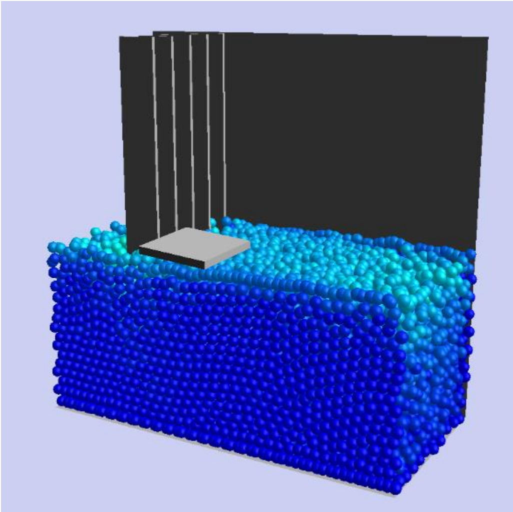
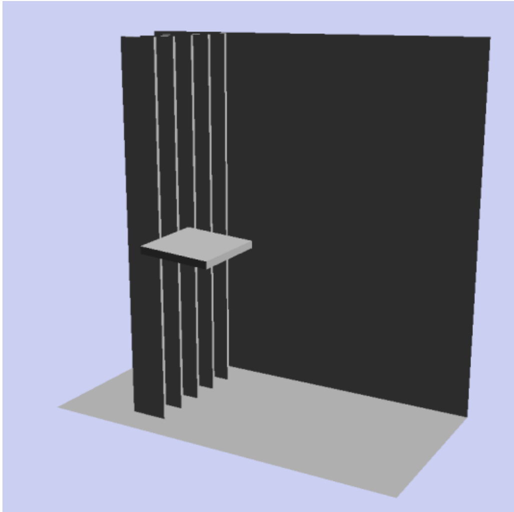

(f) At slope 10%. Water is not visualised.

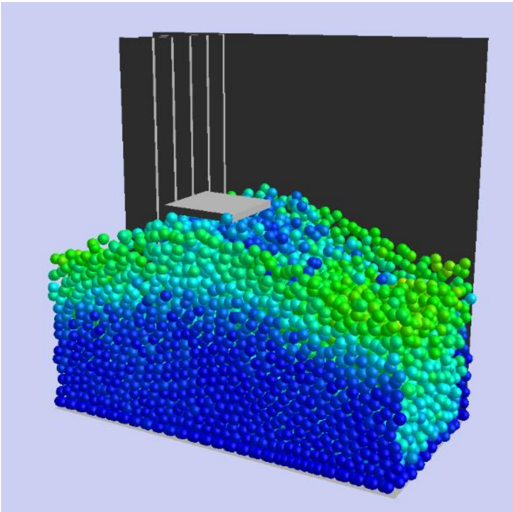
Fig. 27 Simulation results of 9 wood timbers at t = 30s. Spheres=water. Their colours indicate their velocity. Blue is 0 m/s and Red is 2 m/s.



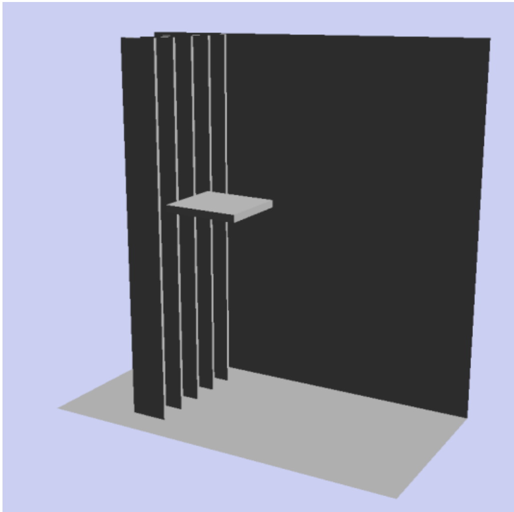
(a) At slope 2%. Water is visualised.



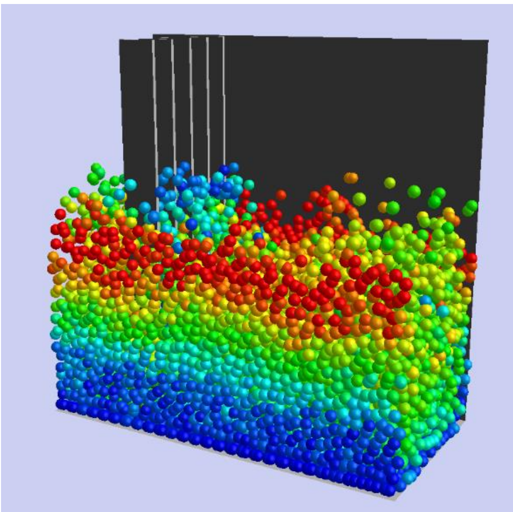
(b) At slope 2%. Water is not visualised.



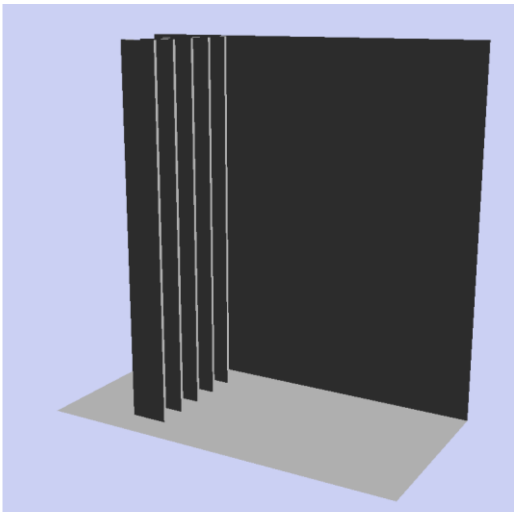
(c) At slope 5%. Water is visualised.



(d) At slope 5%. Water is not visualised.

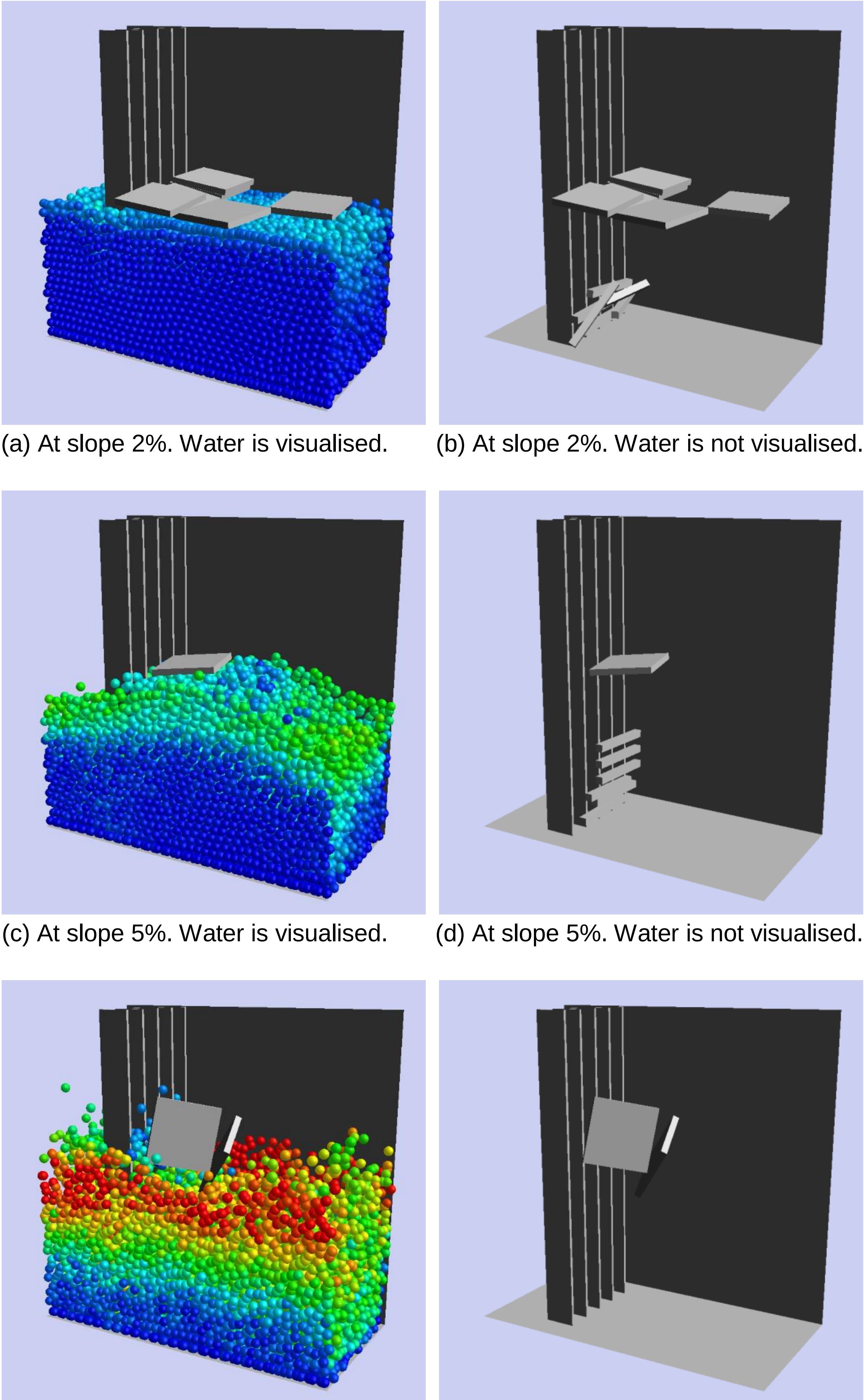


(e) At slope 10%. Water is visualised.



(f) At slope 10%. Water is not visualised.

Fig. 28 Simulation results of 1 foam at t = 30s. Spheres=water. Their colours indicate their velocity. Blue is 0 m/s and Red is 2 m/s.



(a) At slope 2%. Water is visualised.
(b) At slope 2%. Water is not visualised.
(c) At slope 5%. Water is visualised.
(d) At slope 5%. Water is not visualised.
(e) At slope 10%. Water is visualised.
(f) At slope 10%. Water is not visualised.

Fig. 29 Simulation results of 6 wood timbers, 6 foams, and 3 plastic bottles at t = 30s. Spheres=water. Their colours indicate their velocity. Blue is 0 m/s and Red is 2 m/s.

Through all conditions, wood timbers and foams stacked on the slit-like structure, while no plastic bottle did. Significant differences are their sizes. We focused on the longest dimension in one solid debris such as length of the diagonal line. This is expected to affect the range of posture where a piece of solid debris can pass through slit openings. For example, if a line with the above longest dimension is allowed to rotate on the slit-like structure, the line passes through slit openings in the certain range of rotation angle (**Fig. 30**). The following equation can calculate this angle.

$$\theta_p = 4 \sin^{-1}(L_s / L_d) \tag{A2}$$

where θ_p is an angle where the line can pass through slit opening, L_s is slit opening, and L_d is the longest length of a piece of solid debris. The longest dimension in a wood timber, a foam, and a plastic bottle was 50.5 cm, 56.7 cm, and 21.2 cm, respectively. The angle ranges for solid debris to pass through the slit-like bar screen were 64 degrees, 57 degrees, and 165 degrees respectively. From those values, it is expected that plastic bottles have a larger chance than wood timbers and foams. These relationships are consistent with results where plastic bottles firstly passed through the slit and foams remained on it at last.

Moreover, when a piece of solid debris touches only one slit blade, it can rotate around the contact point. This piece is usually asymmetrical to the contact point. Drag by water act on two sides of this piece concerning the contact point becomes uneven. This uneven force causes a torque for the piece rotating. If this piece is large, it still can have another contact point to stuck on the slit. According to the result, solid debris rotated when they hit the slit. This concept is consistent with results where wood timbers and foams usually got two or more contact points for each on the slit, while plastic bottles did not.

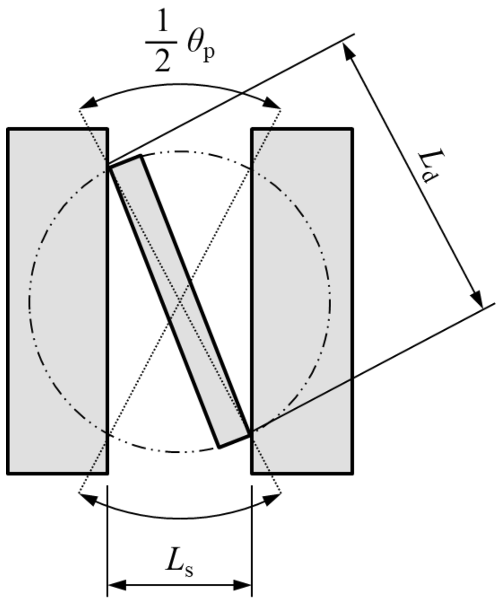


Fig. 30 Definition of angle θ_p where a line with length L_d can pass through a slit with width L_s.

The blockage effect was not linearly related to the amount of wood timbers on the slit-like structures. It is expected to be caused by the distribution of wood timbers. If wood timbers are roughly spaced out on the slit-like structure to form a wall, large blockage effect is expected. This is observed in the case of 9 wood timbers (**Fig. 27(c-d)**), where the blockage effect was 38%. Contrary to this case, 25 wood timbers made a pile on the slit-like structure (**Fig. 25(a-b)**). Its blockage effect was small when it is compared to that of 9 wood timbers considering the difference in the number of wood timbers. From this fact, even a small amount of wood timbers should be taken care of in order to recover drainage capacities of canals.

The blockage effect was different according to the average flow velocity. However, there are no clear relationships between them. At least, it is expected that the difference in blockage effects of 9 wood timbers at the slope of 2% and 5% was caused by the distribution of wood timbers. At the slope of 2%, 9 wood timbers were piled on the bottom in front of the slit-like bar screen. At slope of 5%, 9 wood timbers were roughly spaced on the slit-like structure.

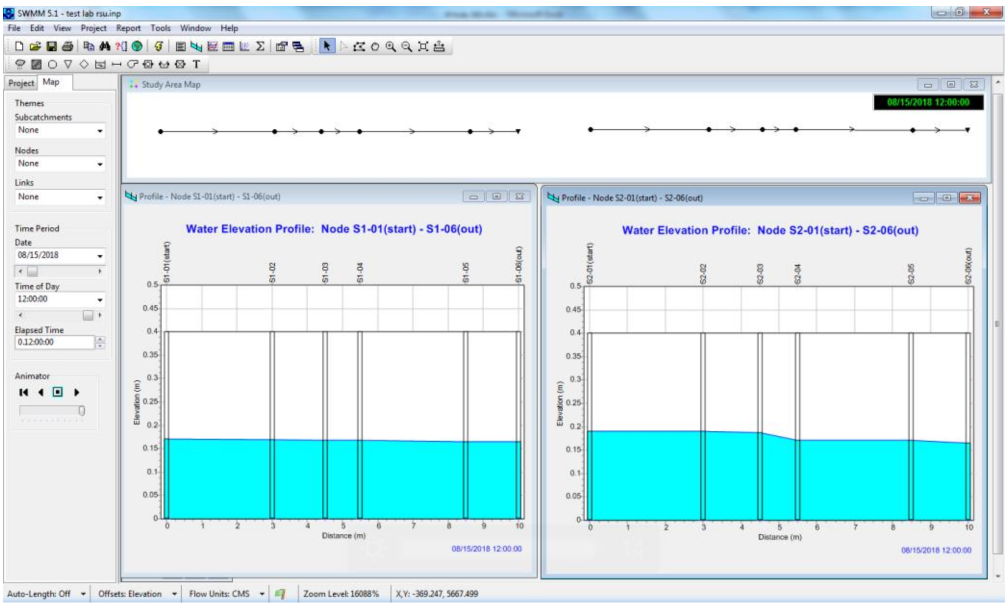
Contrary to wood timbers, foams and plastic bottles cause no blockage effect. In case of foams, they were floating on the water. In case of plastic bottles, they were small enough to pass through slit openings. According to this fact, solid debris which has larger density than that of water and larger dimension than slit openings should be taken care of with higher priority in order to recover drainage function of canals.

3.5 Effect of solid waste clogging on flood water generation

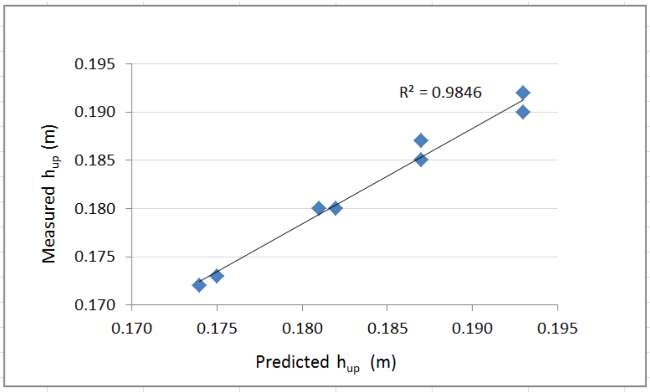
The relationship between blockage area and head loss coefficient obtained by the experiment was used to analyse the effect of the canal block on by SWMM model. In order to confirm the application of SWMM, the model was used with laboratory experiment for comparing the result then apply to the study area.

1) Model with the laboratory experiment

Data from laboratory experiment were used in SWMM in order to compare the water depth at the upstream (h_{up}) at different blockage condition (**Figure 31a**). It was found that the predicted water depth had an accurate result by comparing with the water depth measured in the experiment (**Figure 31b**) that ensure the application of SWMM.



(a) Water elevation profile by SWMM



(b) Predicted water depth and measured at the different blockage ratio

Figure 31 SWMM model by laboratory experiment data

2) Model with bar screen at San-Sab tunnel

Waterway and bar screen at San-Sab tunnel was used in the model (**Figure 32**). Rainfall intensity of 60 mm/hr for 1 hour was simulated with blockage condition of 0 (no blockage) and 50%. In the case of no waste, the difference between water elevation across the bar screen was very small. In contrast, a big difference was observed at 50% blockage and the water elevation at the upstream also higher and closer to water elevation at the starting node (**Figure 33**). Comparing of water depth at the time of highest rainfall intensity is shown in **Table 32**.

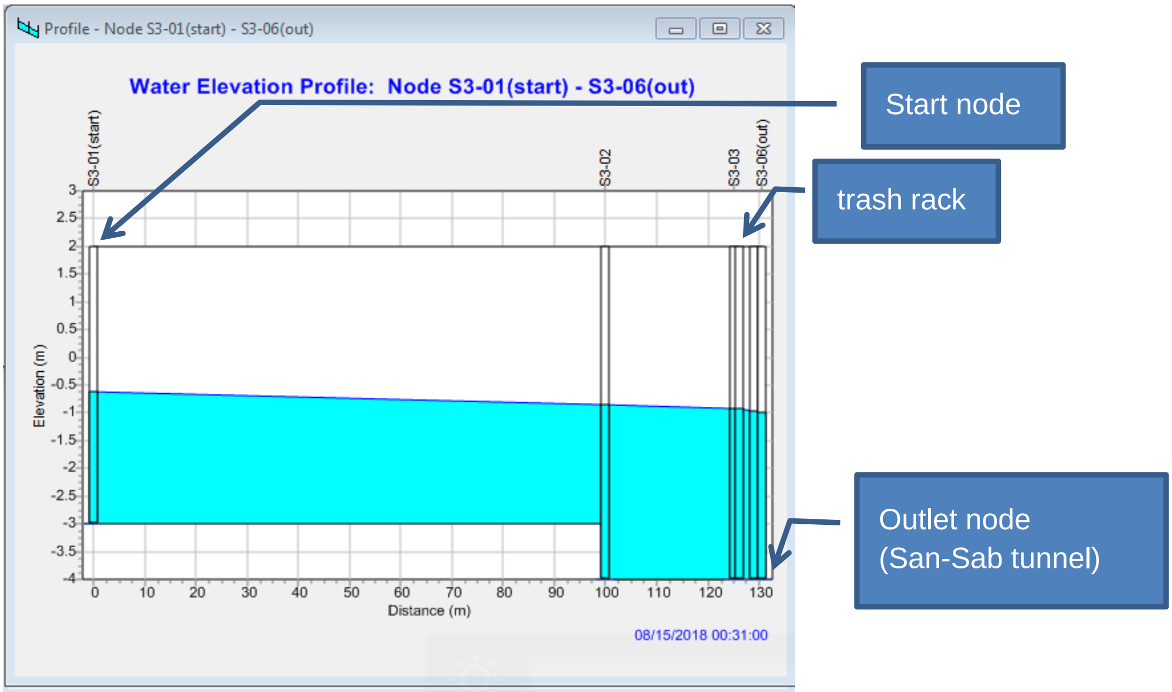


Figure 32 Simulation of waterway and trash rack at San-Sab tunnel.

Table 22 Water depth at 0 and 50% blockage

Blockage ratio (%)	0	50
Water depth at start (m.MSL.)	-0.623	-0.232
Water depth before trash rack (m.MSL.)	-0.914	-0.440
Water depth after trash rack (m.MSL.)	-0.930	-0.977
Different level across trash rack (m.)	0.016	0.535

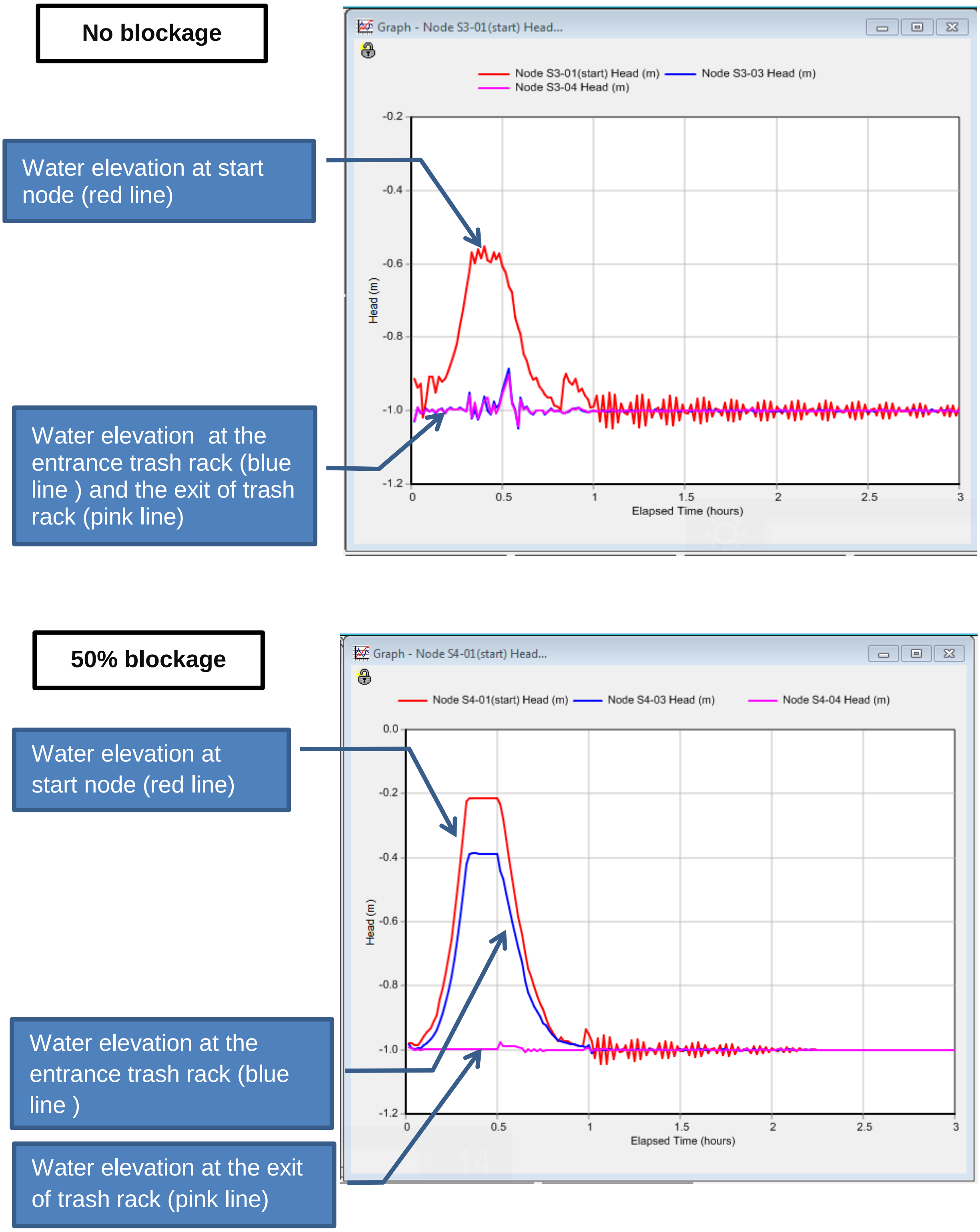


Figure 33 Water elevation at start node, entrance and exit trash rack at 0 and 50% blockage

The blockage does not affect the drainage capacity directly, but the rising of water elevation is caused by flooding (**Figure 34**). In other words, the drainage system has the potential to serve the system appropriately by itself, but the solid waste blockage reduces the capacity indirectly and cause inundation of flood water.

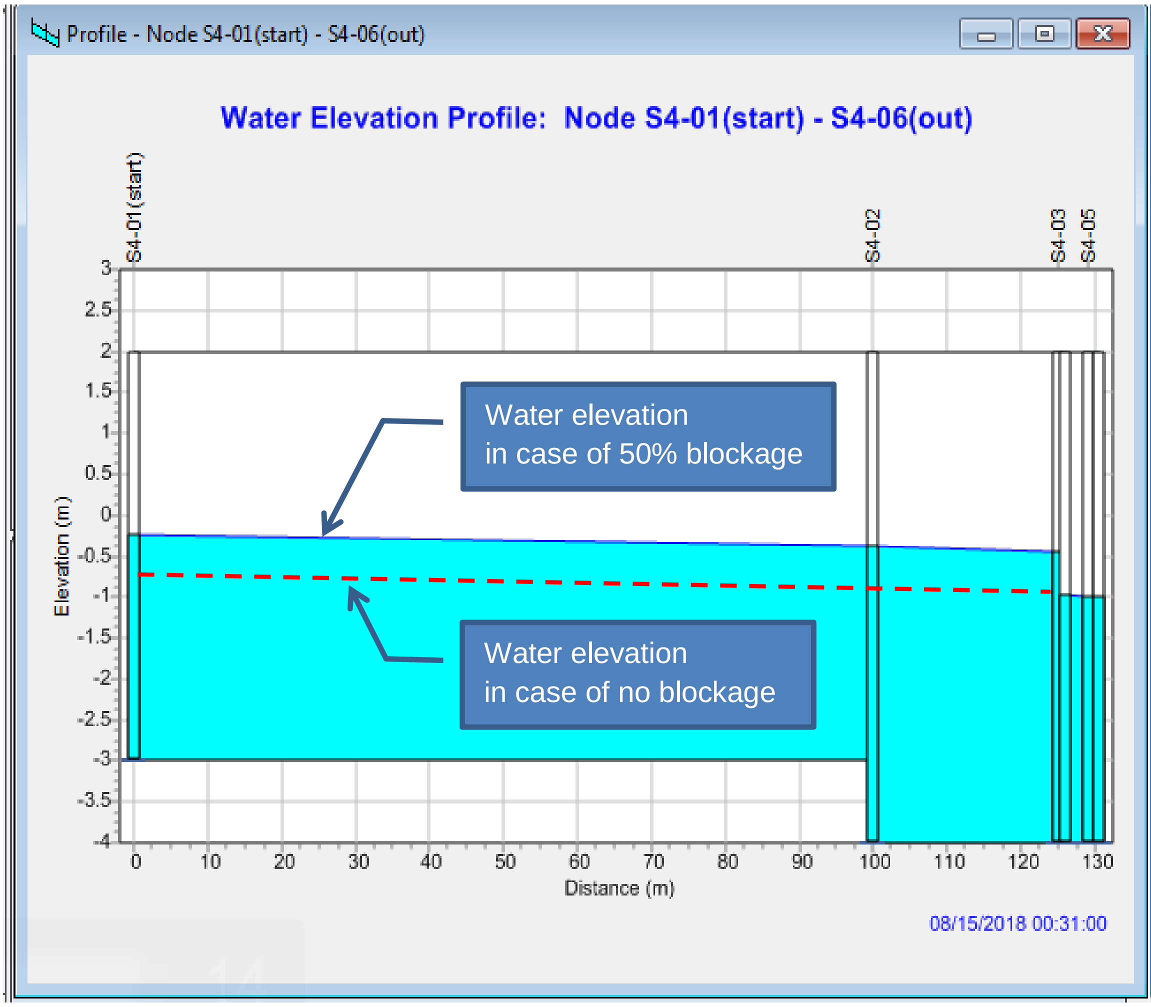


Figure 34 Comparing the water elevation between no blockage and 50% blockage

3) Model with Lad Prao canal

SWMM model was applied on Lad Prao canal. Starting at Lad Prao gate 56 to San-Sab tunnel with total distance of about 6.1 km **(Figure 35).** Simulation of rainfall intensity 60 mm/hr for 1 hour was simulated with blockage condition of 0 (no blockage) and 50%. The result of water elevation shows that 50% blockage at the bar screen of San-Sab canal cause the water rising to the warning level at PraCha-Utid level station (**Figure 36**). However, the accuracy of the model depends on many parameters such as cross-sectional elevation, slope, inflows, especially manning roughness coefficient then. It needs the further work.

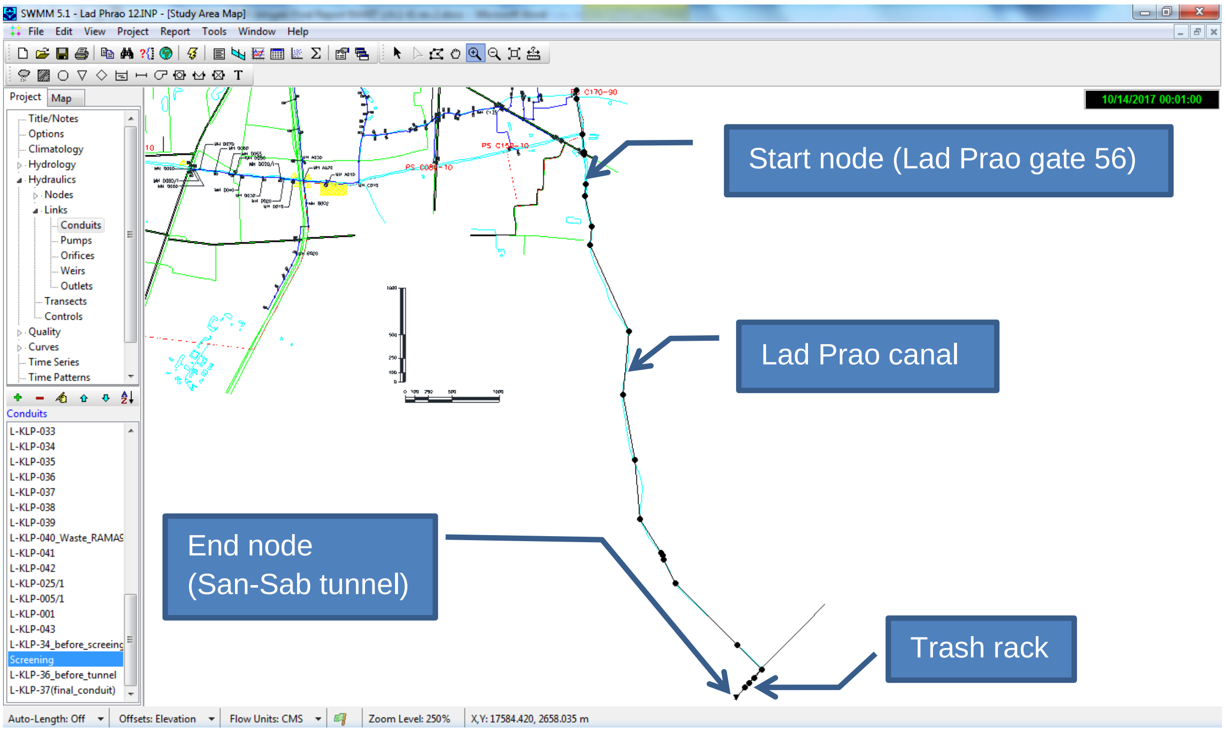


Figure 35 SWMM model of Lad Prao canal

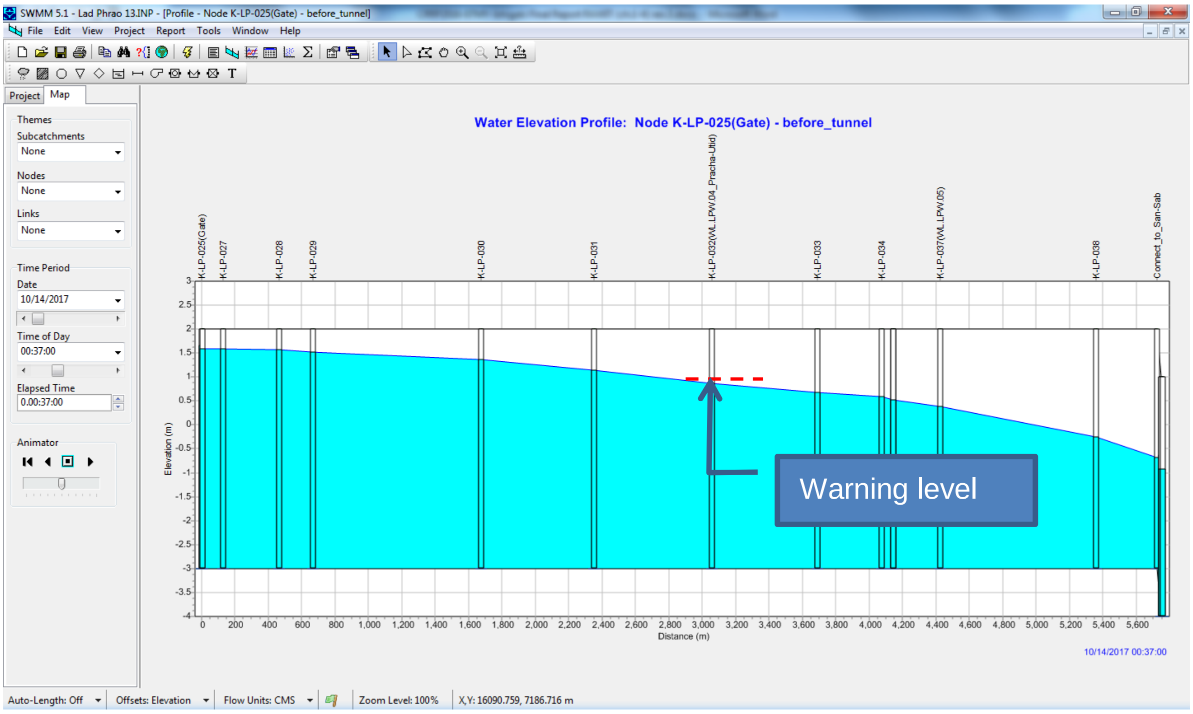


Figure 36 Water elevation along the Lad Prao canal

3.6 Analysis of peoples' behaviour on waste disposal and scattering

1) Waste disposal behaviour in the target area of Bangkok

District officers collected daily household wastes from municipal waste bins located at collection points (**Figure 37**). District officers use boats to access these collection points and collect the waste directly from the boat, and all household wastes at these collection points are supposed to be collected every day. On top of that, BMA has started a new system by which residents can send a text message to the waste collection officer if they want to request a collection. Bulky wastes such as sofas, mattresses, and other large household items are also disposed of at the collection points and are collected once a week. It is also common for residents to give bulky wastes to junk buyers.

Fig. 37 A waste collection point near the canal

Figures 38 and 39 show the frequencies of use of the different waste disposal methods for household wastes and bulky wastes, respectively. Most of the respondents said that they used the municipal containers for household waste, but 12% said that they dropped it into the canal. About 58% of the respondents said that the container they usually use for waste disposal was regularly full. For bulky waste, very few people said that they used the waste containers, but only 4% of respondents said they dumped it into the canals.

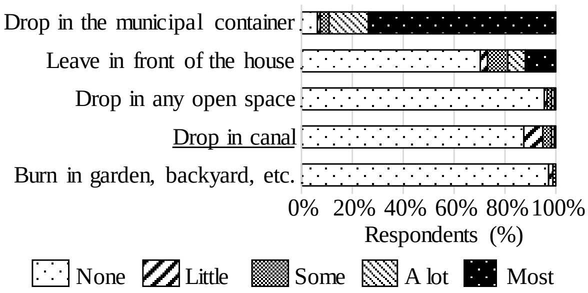


Fig.38 Household waste disposal behavior in the target area of Bangkok (*n*=355)

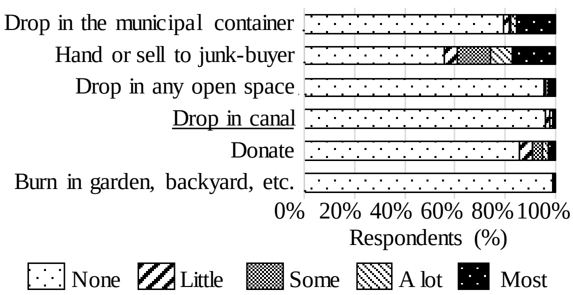


Fig. 39 Bulky waste disposal behavior in the target area of Bangkok (*n*=355)

2) Waste disposal behaviour in the target area of Hue

Daily household wastes were collected by local contractors either from the municipal waste bins located at collection points or from the personal waste bins placed in front of individual houses (**Figure 40**). Some of the municipal waste bins are located near waterways, but unlike the district officers in Bangkok, the local contractors access these collection points by land. All household wastes at these collection points are supposed to be

Figure 40 Waste collection point (left) and a personal waste bin (right)

collected every day. Bulky wastes also disposed of at the collection points. It is also common for residents to give bulky wastes to junk buyers

Figures 41 and 42 show the frequencies of use of the different waste disposal methods for household wastes and bulky wastes, respectively. Most of the respondents said that they used the municipal containers for household waste, but the percentage was lower than Bangkok. This was because 64% of the respondents answered they wait at home until the waste collector comes to pick up their waste. Only 0.7% said that they dropped it into the canal. About 41% of the respondents said that the container they usually use for waste disposal was regularly full. For bulky waste, 61% said that they used the waste containers, 69% hand or sell to junk-buyers, but only 0.7% of respondents said they dumped it into the canals. In general, it seems that the survey respondents in Hue have better access to public waste collection services compared to those in Bangkok.

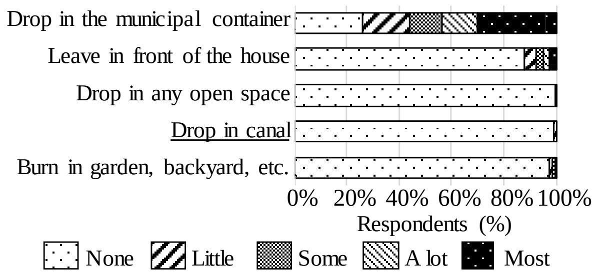


Fig 41 Household waste disposal behavior in the target are of Hue (*n*=300)

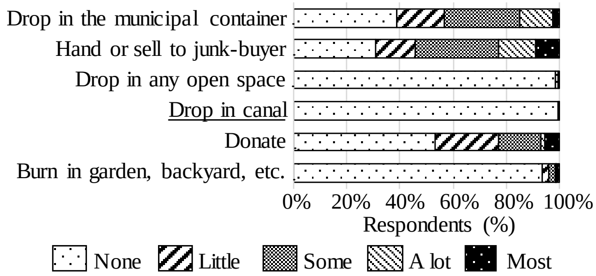


Fig 42 Bulky waste disposal behavior in the target area of Hue (*n*=300)

3) Factors related to waste disposal and scattering behaviour

The remaining of this section will focus on our survey in Bangkok because too few respondents in Hue (0.7%) said that they had discarded waste into canals.

We separated the 355 respondents into two groups and compared their responses: the group who disposed none of their household waste into the canal (=Never dispose group) and the group who at least discarded some of their waste into canals (=Dispose group). We averaged the scores in each of the seven scales of the questionnaire survey shown in **Table 10** and compared the results (*t*-test, $\alpha = 0.05$; Figure 8). People who disposed of waste into the canal had significantly lower scores for risk perception, descriptive and injunctive norms, willingness to act for the betterment of the environment, and environmental value than those who disposed of none of their waste. Somewhat surprisingly, the difference in access to a disposal point between the two groups was not statistically significant.

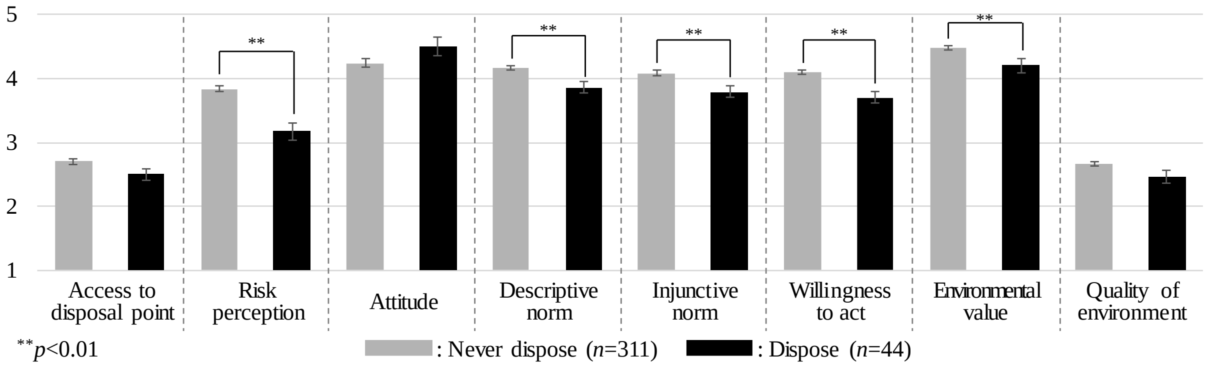


Fig 43 Comparison of questionnaire results between those who never dispose of waste into canals and those who do (mean survey scores, error bars show SE)

We also conducted a binomial logistic regression analysis to identify factors related to waste disposal into to canals. The seven factors presented in **Table 10** were initially selected as independent variables, with the dependent variable being a binary variable taking a value of 1 when a person dropped waste into the canal (at least some proportion of their waste) and 0 if the person did not (none of their waste). By the results of the analysis (AIC of the tested models and test of significance for each of the coefficients in the models), we omitted several independent variables from consideration. The results presented in **Table 23** suggest that higher risk perception, greater willingness to act for community cleanliness, and higher perceived quality of the environment lead to a lower chance of waste disposal in canals. However, other factors should still be considered in future studies, because the model had a low Nagelkerke R^2 (0.18).

Table 23 Logistic regression results

	β	SE	P-value	Exp(β)
Intercept	5.516	1.382	0.000	173.502
Risk perception	–0.896	0.217	0.000	0.408
Willingness to act	–0.644	0.310	0.038	0.525
Quality of environment	–0.562	0.269	0.037	0.570

*Hosmer-Lemeshow goodness-of-fit test: P = 0.967.

3.9 Capacity development and awareness raising

The formation of the BMA task force aimed to facilitate the communication among the multiple departments of BMA about the solid waste disposal issue in the Bangkok canals. At each task force meeting, the director of the department and/or decision-making level officers have attended to convey direct input of research findings and suggestions from the project collaborators. The comments from the director of DDS implies that there is no such coordination meeting at BMA on the issue of solid waste management until the moment. Both departments draw a clear line on the demarcation of the treatment process of solid waste in the canals. Whereas DDS is responsible for the collection of solid waste in canals, and DOE is responsible for the collection, transportation, and final disposal of the solid waste from the collection points on the ground where DDS primarily collects from canals. DOE is also in charge of the awareness-raising campaign to the residents and commercial entities. The demarcation here means no communication between the two departments as long as the solid waste is collected from canals by DDS and they are collected and transported to the landfill by DOE. As we presumed, there were no communication, or very little communication among the departments. Hence, no coordination in making an effort in reducing the amount of solid waste in Bangkok canals. Through organising the BMA task force meetings, we acknowledged the better sharing of ideas and opinions of DDS and DOE for each other's policy in managing solid waste in canals.

The participants of the capacity development workshops find that there is a lack of coordination between the municipality and district or community level. For example, usually, the primary waste collection is conducted by the district office of Bangkok. District offices are not guided officially by BMA headquarters the frequency of waste collection in canals. Lack of human resources and boat equipment would be the cause of less frequent waste collection in the canal. Moreover, DOE has issued the letter of communication to all 50 district officers of Bangkok about the establishment of construction and demolition waste treatment centre in one of the transfer stations. However, the announcement was not reached to the appropriate officers of district offices who has supervised the demolition works of the redevelopment project in Ladphrao canal. Such miscommunication in delivering necessary information should be avoided through organising thematic task force meeting or the training sessions for officers of multiple departments of BMA.

4. Conclusions

Following findings have been obtained through this research.

- All of the contacted cities did their best to prevent MSW from scattering, flowing into the drainage and blocking drainage from the viewpoint of public service. Unintentional scattering due to storm or limitation of service capacity may cause flows of MSW into the drainage. And also, it is impossible to control rule-breaking behaviour of waste scattering by residents or industries.
- The urban drainage system has developed with the nature of the city and the history of urbanisation and flood disaster. In the case of Bangkok, open canal network has been developed to mitigate urban flood. It was effective for a long time, but recent intensive precipitation exceeds its capacity. Solid debris floating in the drainage system may be also possible reason to cause flooding. Primary source of these solids will be disposal or runoff from residents in illegal occupation on canal front. It was obviously recognised that the activity of construction and demolition had managed the waste inappropriately and dropped it into the canal. In a case of Hue, there is networking of narrow trenches for castle guards, which connects to river water. A major trigger of recent urban inundation is the overflow of the river dyke during the prolonged precipitation or an increase of water level of urban drainage due to the lack of capacity. Household waste that was disposed to the bank of the trench by residents was also observed to obstruct the flow. Periodically the debris in open ditches was cleaned while drainage throats have not been concerned to clean that lead to the deposit of soil and rocks and the decrease in drainage function.
- The seasonal difference of composition of solid debris in a canal in Bangkok was observed. Natural plants such as water hyacinth which was actively grown in open canal were found as major component in the rainy season. Household waste such as food waste, plastic bag was occupied in the composition regardless of seasons. Wood timber

or other construction waste accounted for major component since the surveyed canal was targeted by re-development project.

- The most common component of debris in bar-screen of the canal was the group including food waste from households in the urban drainage system in Hue. Natural derivatives such as leaves & tiny woody trunks which is derived from a deciduous tree in the street, garden, or park were also regarded to be major component even though public service and individual cleaning activity are conducted. At the drainage throats, leaves & tiny woody trunk group was still dominant. Plastic products also accounted the highest at several throats. Plastic bags were relatively large proportion in open ditches. Leaves & tiny woody trunks group continued to be a vital component. Transfer along with the flow of the urban drainage system, the solid waste entered and deposited into the manholes and sewer that cause to block surface run-off drainage operation when was being heavy rain. Leaves and tiny woody trunks, plastic products and plastic bags were also a major component of debris in manholes and sewer. Subsequently, it is recommended that separate the hazardous waste at source in order to lessen the environmental damage as well as public health risk which is required necessary attention.
- Properties of solid debris for reducing drainage capacity was obtained by laboratory experiment. Timber stuck firmly on bar screen, though foam and plastic bottle floated on the water surface. Plastic bag, if it is empty, also floated on the water surface. Once water filled in the plastic bag, it started to be stuck on the bar screen. It was revealed that the head loss coefficient could be estimated by blockage area on the screen.
- A numerical model was developed to elucidate the mechanism of clogging at a slit-like structure by solid debris. Solid debris with smaller dimensions passed through a slit-like structure with more substantial possibility. The blockage was observed, but the number of solid debris was not linearly related to the blockage effect. It is expected that blockage effect is affected by the distribution of solid debris. In order to keep drainage capacities of canals, high-density debris and debris with a larger dimension than slit openings should be controlled with higher priority even if their number is small.
- Effect of screen blockage by solid debris on floodwater generation was estimated by the numerical model. The blockage does not affect the drainage capacity directly but the rising of water elevation is caused flooding. Blockage area of 50% must be critical criteria to increase the water level followed by floodwater generation. In other words, the drainage system has the potential to serve the system appropriately by itself, but the solid waste blockage reduces the apparent drainage capacity indirectly and cause inundation.
- Based on the behavior analysis in Bangkok, considering that household wastes are easily observed in the canals, and most of the residents said they mostly used municipal containers for waste disposal and dropped none of their waste into the canal, it is reasonable to assume that unintentional disposal is one of the main sources of household waste in the canals. This is also supported by the fact that nearly 60% of the respondents stated that the municipal containers they used were always full, suggesting that conditions at many waste collection points lend themselves to unintentional waste disposal in canals (i.e., overflowing or loose waste may fall from the waste disposal point into the canal). It is also possible that non-residents (passersby, tourists, etc.) are sources of canal waste, or the respondents to our survey did not completely disclose their waste disposal behaviour, but further investigation is required to validate this statement. The logistic regression analysis also suggested that people are less likely to dispose of waste into the canal if they are aware of its negative impact. It was also suggested that people who enjoy

their current environment and who are willing to take actions to improve the environment are less likely to dispose of waste into canals.

- In Hue, several households confirmed way of improperly discharging waste in their daily lives routine while majority of the residents sensed the impacts of inappropriate disposing on their health and community. Additionally, most resident stated that a fresh environment adds high value to their life. Comparing to actual environments, a wide range of waste have been disposed in several public space, good management of waste, enhancing waste collection capacity and training for locals people are essential jobs to develop a sustainable city.
- Through organising the BMA task force meetings, we acknowledged the better sharing of ideas and opinions of DDS and DOE for each other's policy in managing solid waste in canals.
- The participatory workshops in Bangkok and Hue allowed the knowledge sharing an opportunity for dialogue among the different stakeholders. The workshops where research findings were shared and discussed has improved the awareness and understanding of the practitioners and stakeholders in both cities. Especially the research findings from waste composition analysis and residents survey have provided the new findings because the analysis is never conducted at both municipalities.

From these results, we propose the following recommendations to local municipalities to reduce the urban flood risk in line with adaptation to climate change.

- Even if the public waste collection services are provided enough and appropriately for residents from the viewpoint of solid waste management, the impact of solid waste that is unintentionally disposed to canal must be strong on increase flood risk. It is necessary to reconsider the collection frequency, zoning of the collection, or container size in the canals threating to the urban inundation for immediate countermeasures in terms of long-term sustainable management, redevelopment of canal front and public welfare for low-income residents.
- Behaviour of high-density debris in the canal is essential to increase the water level and inundation area. Drainage management section is required to remove the debris not only from the surface but also from the deeper zone of the canals. It is recommended that the debris collection should be conduct intensively before and during the rainy season. Aquatic plants are not strongly affecting the floodwater generation.
- On top of that, construction and demolition activity is a key industry. Not only the construction or demolition project in canal front, but also inappropriate disposal of the debris to the area in canal front or riverside must be regarded as major source of high-density debris in the canals. Appropriate control of this activity will contribute to reducing the urban flood risk.
- Public relation and dissemination to the residents will be effective because knowledge and consciousness on environment and canal/drainage condition could encourage them to prevent waste scattering.

5. Future Directions

The research activity in terms of adaptation of climate change will be conducted under the framework and policy implementation of the Government of Japan. Numerical models on canal blockage by debris and flood water generation will be expanded to the model to be expressed to predict the inundation hazards in the urban cities. Impact of debris overflow from canals on the environment will also be surveyed. Emphasized should be put on plastic debris as it is contributing to marine litters and should be constantly monitored. Also, the outflow impacts from the canal and other source from inland can also be considered for estimation.

The knowledge dissemination and education for all stakeholders such as residents, commercial sectors as well as building capacity for the local practitioners will be implemented with the collaboration from the local municipalities. The outcome from this activity is to change their mind and behaviour and also to conduct periodically investigations and revising the action plan accordingly.

The harmonization of inter-department on drainage works and waste collection, or other related departments of municipalities will be continued through organizing a thematic task force meetings covering opics such as solid waste in canals, as well as aiming to collectively reduce solid waste in canals and waterways which blocked the water flow especially during high precipitation period.

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7. Appendix

1) Animated clips for the awareness-raising campaign to “no waste in a canal.”
Based on the results of the waste composition analysis we conducted in Ladphrao canal in Bangkok, we identified three different types of waste that need to be avoided getting into the canal. Namely, 1) Packaging waste and pet bottle, 2) Bulky waste such as furniture, and 3) Construction and Demolition waste. To spread the concept of “no waste in a canal”, we concluded that the most powerful way of message dissemination is to use social media where many people have access to through the internet. We used the simple language and simple storyline to deliver our message not to throw waste in a canal. The animated clips have been handed over to the DDS and DOE for them to publicise the clips in their awareness-raising campaign. Besides, the animated clips are now available on the YouTube channel page of National Institute for Environmental Studies.
URL=https://www.youtube.com/user/nieschannel/videos)

2) Translated guidelines for the demolition of wooden-structured buildings (See Annex A) One of the most identified volume of waste in Lad Prao canal in Bangkok was construction and demolition waste. By comparing with the nearby canal in Bangkok, it was found that the redevelopment project of replacing old wooden housings along Lad Prao canal seem to effect on the considerable amount of construction and demolition waste disposed into the canal. This was not effectively controlled due to the no rules and regulation under the contract between Department in charge of the redevelopments project of BMA and construction companies who were entrusted the demolition works. To control the disposal of construction and demolition waste, the translated guideline for the demolition of wooden-structured buildings would help in understanding the effective demolition method of wooden-structured buildings for them to be reused, recycled and recovered. However, the major concern is the lack of communication between the department in charge of the redevelopment project (it should be Department of Social Department though not confirmed), Department of Urban Planning and DOE which is in charge of waste management. The officers of BMA should be aware that whenever waste-related issues are involved in their project, DOE should be consulted and DOE should give appropriate countermeasures to assist the department in execution how to properly dispose or treat waste. The guideline is expected to fill the gap of lack of proper knowledge on how to demolish wooden-structured buildings and contract preparation for any future redevelopment projects that involve demotion of housings.

Conferences/Symposia/Workshops

See Annexes B and C

Funding sources outside the APN

None

List of Young Scientists

"This project gave me a good chance for me to joint two numerical models for the first time. This project also allowed me to witness situation about waste in canals around Thailand and Viet Nam. Thanks to this project, I think I got better not only in numerical technique but also in knowledge about actual fields. Thank you very much."

Kosuke Nakamura, numerical analysis, National Institute for Environmental Studies

Glossary of Terms

BMA Bangkok Metropolitan Administration
F Foam
FDM Finite Difference Method
DDS Department of drainage and sewerage
DEM Discrete Element Method
DOE Department of Environment
DT Drainage throat
FEM Finite Element Method
HEPCO Hue Urban Environment and Public Works J.S.Co.
MH Manholes
MSW Municipal Solid Waste
OD Open ditches
PB Plastic bottle
SCR Screen
SPH Smoothed Particle Hydrodynamics
SWMM Storm Water Management Model
WT Wood timber

Manual for Sorted Demolition of Wooden Buildings

[Purpose of preparing this manual]

The "Law on Recycling Construction-Related Materials (Construction Material Recycling Law)" requires sorted demolition and recycling of specified construction material waste (concrete mass, asphalt concrete slab, wood generated in construction) in object construction works larger than a certain scale.

Among those materials, wood generated in construction can be recycled for various purposes, such as the use of materials as raw material for recycled materials and thermal use as a heat source. However, under the existing circumstances, the recycling rate of wood generated in construction is lower than that of other specified construction material waste, and a further increase in the recycling rate is required from the viewpoint of effective use of resources.

To achieve this increase, it is extremely important to conduct appropriate sorting in the demolition of wooden buildings where a large amount of wood is generated.

This manual describes standard procedures for sorted demolition of wooden buildings according to the execution flow for such work specified in the Construction Material Recycling Law, for the purpose of promoting the recycling of wood.

Committee for the Promotion of Recycling of Construction By-product

Flow of standard demolition work for wooden buildings

General procedures when demolishing wooden buildings having a total floor area larger than 80 m^2 subject to the Construction Material Recycling Law are as follows. Even if the total floor area is less than 80 m^2, it is preferable that the demolition work is conducted according to this law.

Preliminary survey

The preliminary survey is a survey of a work place, carrying-out routes, existence or non-existence of remaining articles, attached substances, and others to be conducted before the object construction work specified in the Construction Material Recycling Law is implemented.

The preliminary survey is essential for preparing a sorted demolition plan and selecting a demolition method. Please make sure to conduct it.

[Rough estimate of the amount of wood generated from wooden buildings]

When a common wooden house with a floor area of 100 to 120 m^2 (30–40 tsubo) is demolished, approximately 10-t wood is generated. The amount of wood generated per the total floor area of 1 m^2: Approx. 85 kg (Approx. 280 kg per tsubo).

The amount of wood generated from demolition (t) ≈ 0.085 × Total floor area (m^2)

Plan for demolition work

Develop a plan for the demolition work based on the results of the preliminary survey. Major items of such plans include selection of a demolition method, a plan for temporary facilities (such as scaffolding and curing sheets), a plan for carrying in and out equipment and materials, a safety plan, a waste disposal plan, and processes for the work.

Quantity survey and estimate

The quantity survey is conducted based on the preliminary survey and plan for demolition work. It is preferable to indicate the estimate by clearly classifying the cost of demolition work, collection and transportation costs and disposal costs.

Advance preparation

Conduct a series of the following tasks prior to the implementation of demolition work: (i) prior explanation to the owner; (ii) conclusion of a contract for demolition work; (iii) submission of a notification form by the owner; (iv) notification to the subcontractor; (v) conclusion of a subcontract; (vi) various notifications, arrangements and confirmation; and (vii) implementation of advance measures.

Demolition work

The demolition work is conducted based on the established plan after completion of the preliminary survey and advance preparation.

(i) Management of demolition work (including posting of signs, issuance of the industrial waste management slips, and confirmation of the plan for demolition work), (ii) Safety management, (iii) Preparatory work and temporary facilities, (iv) Demolition work.

[Sorting standards for wood generated in construction]

As for wood generated in construction, sorted demolition and recycling are required by the Construction Material Recycling Law.

Wood chips having quality meeting the standards (A to D) can be manufactured by classifying and sorting the wood generated in demolition work according to the generated part such as pillar member, beam member, brace, stud, roofing board or plywood, which leads to correct use of them when they are recycled. Implementation of such sorting also leads to reduction of disposal costs of wood.

* About fifty percent of generated wood is derived from constructional materials having a large cross-sectional area (such as pillars and beams) and about thirty percent is derived from semi-constructional materials such as braces and studs. Even fittings which are small in amount (such as doors, shoji-screen frames and fusuma sliding-door frames) can be used as chips if they are properly sorted.

Proper disposal

Please sort waste generated in demolition work by item and consign the disposal to a good waste disposal company with which you have made a consignment contract. The industrial waste management slip (manifest slip) will be issued by the person who has received the contract for the work directly from the owner (discharging enterprise).

1. Construction Material Recycling Law

The Construction Material Recycling Law provides that specific materials, such as wood, shall be demolished, sorted, and recycled in demolition work on buildings having a total floor area larger than 80 m^2.
* Even if the total floor area is less than 80 m^2, it is preferable that the demolition work is conducted according to this law.

1.1 Mandatory sorted demolition and recycling

- The Construction Material Recycling Law provides that construction materials subject to sorted demolition and recycling are concrete, materials composed of concrete and iron, wood, and asphalt concrete.

(Specified construction materials) Concrete Construction materials composed of concrete and iron Asphalt concrete Wood	Sorted demolition ⇨	(Specified construction material waste) Concrete mass Asphalt concrete slab Wood generated in construction	Recycling ⇨	Recycled concrete aggregate Recycled asphalt mixture Wood chip, etc.

(Explanation)

Specified construction materials and waste

The following materials are specified by the government ordinance as specified construction materials which require sorted demolition and recycling:

(i) Concrete (ii) Construction materials composed of concrete and iron (iii) Wood (iv) Asphalt concrete

Specified construction material waste means specific construction materials which have become waste due to demolition or the like.

Scale standards for sorted demolition

The Construction Material Recycling Law and its enforcement regulations provide standards for construction work on which the obligation to implement sorted demolition and recycling is imposed (hereinafter referred to as "object construction work") as the "standards for execution methods concerning sorted demolition."

Object construction work

Types of construction work	Scale standards
Demolition of buildings	**Total floor area: 80 m^2**
New construction and extension work on buildings	Total floor area: 500 m^2
Work, such as repair and remodeling (including renovation), on buildings *1	Contract price: 100 million yen *3
Construction of structures other than buildings *2	Contract price: 5 million yen *3

*1 Work such as repair and remodeling: Work, such as new construction related to buildings, which does not fall under the category of new construction and extension work.

*2 Construction of structures other than buildings: Demolition work, new construction, and the like related to those other than buildings.

*3 The contract prices include consumption tax.

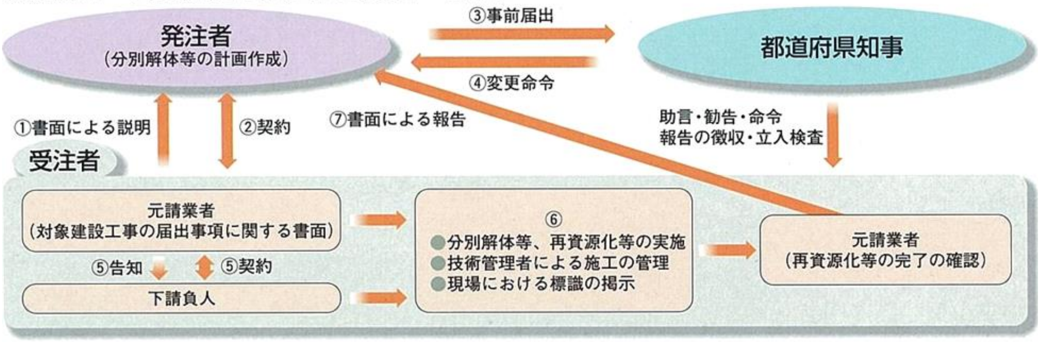
1.2 Notifications pursuant to the Construction Material Recycling Law

The contractor of the object construction work should deliver a written document to give a description of the plan for sorted demolition to the owner prior to the conclusion of the contract. (The owner should notify the prefectural governor of the plan for sorted demolition no later than seven days before the starting date of construction.) Furthermore, at the completion of recycling related to said construction, the contractor should inform the owner in writing of its completion.

(Explanation)

Note) You should confirm who would perform the tasks assigned to the prefectural governor. In a municipality or a special ward that has a building official, the mayor may perform these tasks.

分別解体・再資源化の発注から実施への流れ



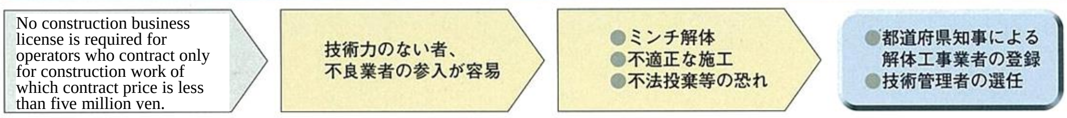
①受注者から発注者への説明（受注者（元請）の義務）
②契約　③事前届出　④変更命令　⑤告知・契約
⑥分別解体等、再資源化等の実施、技術管理者による施工の管理（建設業許可業者の場合は主任技術者又は監理技術者による施工の管理）、現場における標識の掲示（受注者全体（元請・下請とも）の義務）
⑦再資源化等の完了の確認及び発注者への報告（受注者（元請）の義務）

1.3 Registration system for demolition operator

To implement demolition work for buildings, a construction business license under the Construction Business Act or registration of the demolition operator under the Construction Material Recycling Law is required.

(Explanation)

- To ensure implementation of proper demolition work, registration of an operator who intends to run a demolition business and assignment of an engineering manager to a demolition work site are required. Note that no registration of demolition operator is necessary for contractors having construction business licenses for the civil engineering business, architectural, and construction business, or scaffolding and civil engineering business.



※500万円未満の建設工事のみを請け負う業者は建設業許可不要　※機械さえあればミンチ解体を行うことで解体工事が可能

2. Preliminary survey

When the object construction work specified in the Construction Material Recycling Law is implemented, a preliminary survey on the work place, carrying-out routes, existence or non-existence of remaining articles and attached substances, and others must be conducted. The preliminary survey is essential for developing an appropriate construction plan and estimating construction costs. Furthermore, appropriate estimation of construction costs is also important for conducting proper disposal of waste.

(Explanation)

(1) Purposes of preliminary survey

The Construction Material Recycling Law provides standards for the preliminary survey and the method of sorted demolition in object construction works.

The preliminary survey is positioned as a survey necessary for sorted demolition and, additionally, provides useful information on the following matters:

(i) Selection of a demolition method, determination of machines to be used, required workers, and processes for demolition work

(ii) Prediction of the amount of construction waste to be generated and calculation of construction costs

(iii) Securing safe demolition work

(2) Implementation of preliminary survey

The Construction Material Recycling Law provides that the owner must notify the prefectural governor of an object construction work within seven days, before the planned start of the work. After the preliminary survey, it is necessary to prepare a plan and conduct a quantity survey, estimate, and make advanced preparations for the demolition work. Therefore, as a guide, the preliminary survey should be conducted with time to spare, about two weeks before the start of the work.

2.1 Content of preliminary survey

The content of the preliminary survey should include the following:

(1) Confirmation of existence/non-existence of design documents for the object building

(2) Confirmation of the object building

(3) Confirmation of conditions of the surrounding area

(4) Confirmation of workplace

(5) Confirmation of carrying-in/out routes

(6) Confirmation of the existence/non-existence of remaining articles

(7) Confirmation of recycling facilities

(8) Confirmation of the existence/non-existence of substances attached to specified construction materials, and other surveys of the object building (e.g.: Confirmation of the existence/non-existence of hazardous substances)

(Explanation)

(1) Confirmation of existence/non-existence of design documents for the object building

The Construction Material Recycling Law provides that design drawings of the building and clear photographs which show current conditions should be attached to the notification of the object construction work. Confirm in advance if the owner has design documents for the object building (drawings and specifications), written application for confirmation, electric wiring diagrams, and documents which show the history of extensions and/or reconstruction of the building.

Note that as for building materials containing asbestos, the Ordinance on Prevention of Health Impairment due to Asbestos (hereinafter referred to as “Asbestos Ordinance”) based on the Industrial Safety and Health Act provides that the owner shall make efforts to notify the contractor of the usage conditions of asbestos in the building (such as design documents).

Design documents of the object building are required to accurately grasp the amount of construction waste generation. Therefore, if there is no design document, it is preferable to prepare various drawings of the building to be demolished, which facilitates estimation of a proper and reasonable cost for the demolition work. Furthermore, such drawings are useful to the owner when determining if the cost burden is proper because the drawings make it possible to give the owner an explanation based on sufficient information.

(2) Confirmation of the object building

(i) Structure, scale, height, number of stories, and foundation construction method of the object building (a building to be demolished)

Confirm the scale, height, number of stories, construction method, foundation construction method, interior and exterior finishing materials, etc. of the building. Furthermore, investigate and confirm plants and structures in the site such as a gate, wall, porch, terrace, storage, carport, septic tank, or excrement tank.

(ii) Scope of demolition (removal)

Clarify the extent of work included in the scope of demolition work.

(iii) Conditions of defects (such as depressions or cracks) of buildings other than the object building

Investigate buildings and adjoining facilities other than the object building in advance to find any parts having defects, such as depressions or cracks, and record these conditions by means such as photography.

(3) Confirmation of conditions of the surrounding area

(i) Understanding surrounding environment and neighborhood situation

Understand in advance the influence of demolition work on the surrounding areas, such as vibration, noise, dust, odor, and traffic disturbance.

(ii) Confirmation of neighborhood facilities

Investigate and confirm locations and extent of facilities on which the demolition work may have influence, such as hospitals, schools, kindergartens, welfare facilities for the elderly, food manufacturing facilities, and facilities with precision instruments installed.

(iii) Distance from adjacent buildings

Investigate and confirm distances and height differences between the object building, adjacent buildings, and their adjoining facilities to select a construction method and consider methods of temporary facility construction and curing.

(iv) Conditions of defects in neighboring buildings

Investigate neighboring buildings in advance to find any defects, such as horizontal/vertical inclination, cracks or dirt on neighboring buildings, and record the conditions of the defects by means such as photography.

(4) Confirmation of workplace

(i) Working space for sorting, etc.

Confirm existence/non-existence of working space necessary for sorting construction material waste by item and carrying them out.

(ii) Parking spaces in the site

Investigate space in the site to confirm if there is space for storage and parking heavy machines and vehicles.

(iii) Relation between road and site

Investigate the condition of the adjacent road and the difference in height to confirm the approach for vehicles to carry in/out heavy machines.

(iv) Existence/non-existence of underground obstacles

Obtain a layout drawing of water supplies, drainage pipes, and gas pipes buried under the ground to confirm their positions, and also investigate existence/non-existence of septic tanks and basins in order to confirm presence/absence of influence on the work.

(v) Strength of the ground and nature of the soil

Investigate matters necessary for selecting heavy machines and taking measures against settlement and vibration of neighboring buildings by investigating the strength of the ground and the nature of the soil, and confirm presence/absence of influence on the work.

(vi) Existence/non-existence of obstacles in the air

Investigate electric wires, telephone wires, and trees which can be obstacles to the demolition work, and confirm presence/absence of influence on the work.

(5) Confirmation of carrying-in/out routes

(i) Entrance-restricted areas

Investigate roads in the area surrounding the demolition work site up to the main highway for one-way streets, restrictions on passable periods, vehicle regulations, school routes, and pedestrian walkways, and confirm the carrying-in/out routes.

(ii) Traffic volume

Investigate roads in the surrounding area to consider possible rerouting of vehicles and pedestrians during the construction period, arrangement of security guards, and posting of signs, and confirm safety during the demolition and carrying-in/out work.

(iii) Obstacles

Perform an investigation to consider measures to be taken when public equipment, such as guardrails and signs, requiring removal, and confirm if removal is necessary or not.

Ask the owner to dispose of specified kinds of home appliances according to the Law for Recycling of Specified Kinds of Home Appliances (Home Appliance Recycling Law) and other waste as general waste.

(6) Confirmation of the existence/non-existence of remaining articles

Confirm if there are air conditioners, television sets, refrigerators, or washing machines which are specified by the Home Appliance Recycling Law, or furniture or other home appliances remaining in the object building.

Note that these remaining articles must be disposed of by the owner.

Table 2-1: Major remaining articles

Specified kinds of home appliance	Wall-mounted air conditioners (indoor unit, outdoor unit), television set, refrigerator, washing machine (as of March 2007)
Home appliance	Lighting equipment, stereo, radio set, vacuum cleaner, etc.
Furniture	Cupboard, desk, chair, shoe cupboard, bookshelf, bed, etc.
Carpeting	Carpet, mat, etc.
Kitchen articles	Gas range, table-top water heater, tableware, plastic bucket, etc.
Houseware	Bedclothes, books, clothes, curtain, etc.

(7) Confirmation of recycling facilities

To appropriately grasp costs required for recycling, it is preferable to investigate and confirm the carry-out distance to a recycling facility where specified construction material waste and other construction waste are to be carried out, and the cost to dispose of them.

You can also search and investigate construction waste disposal facilities on the following websites:

National Federation of Industrial Waste Management Associations
http://www.zensanpairen.or.jp/

Japan Industrial Waste Management Foundation
http://www.sanpainet.or.jp/

Japan Construction Information Center Foundation
http://www.recycle.jacic.or.jp/

(8) Confirmation of the existence/non-existence of substances attached to specified construction materials and investigation of other substances (such as hazardous substances)

Confirm whether or not substances, such as sprayed asbestos, are attached to specified construction materials used in the object building and if the object building uses construction materials containing hazardous substances (such as building materials containing asbestos, CCA-treated wood, gypsum boards containing arsenic or cadmium, PCB, or fluorocarbon).

<Handling of hazardous substances is regulated by various laws.>

The following laws are applied to each hazardous substance. It is also a requirement to conduct the preliminary survey, advance measures, execution of works, and waste disposal in compliance with these laws.

* Radioactive waste or infectious waste may be generated in facilities such as hospitals and research institutes. Most of this waste is generally considered “remaining articles” and the owner should dispose of such waste beforehand.

・アスベスト関連：労働安全衛生法・大気汚染防止法・廃棄物の処理及び清掃に関する法律（廃棄物処理法）
・ＰＣＢ関連：ポリ塩化ビフェニル廃棄物の適正な処理の推進に関する特別措置法（ＰＣＢ廃棄物特別措置法）
廃棄物処理法
・フロン：特定製品に係るフロン類の回収及び破壊の実施の確保等に関する法律（フロン回収破壊法）
特定家庭用機器再商品化法（家電リサイクル法）
地球温暖化対策の推進に関する法律（地球温暖化対策法）
・特定家電：家電リサイクル法・廃棄物処理法
・その他：廃棄物処理法

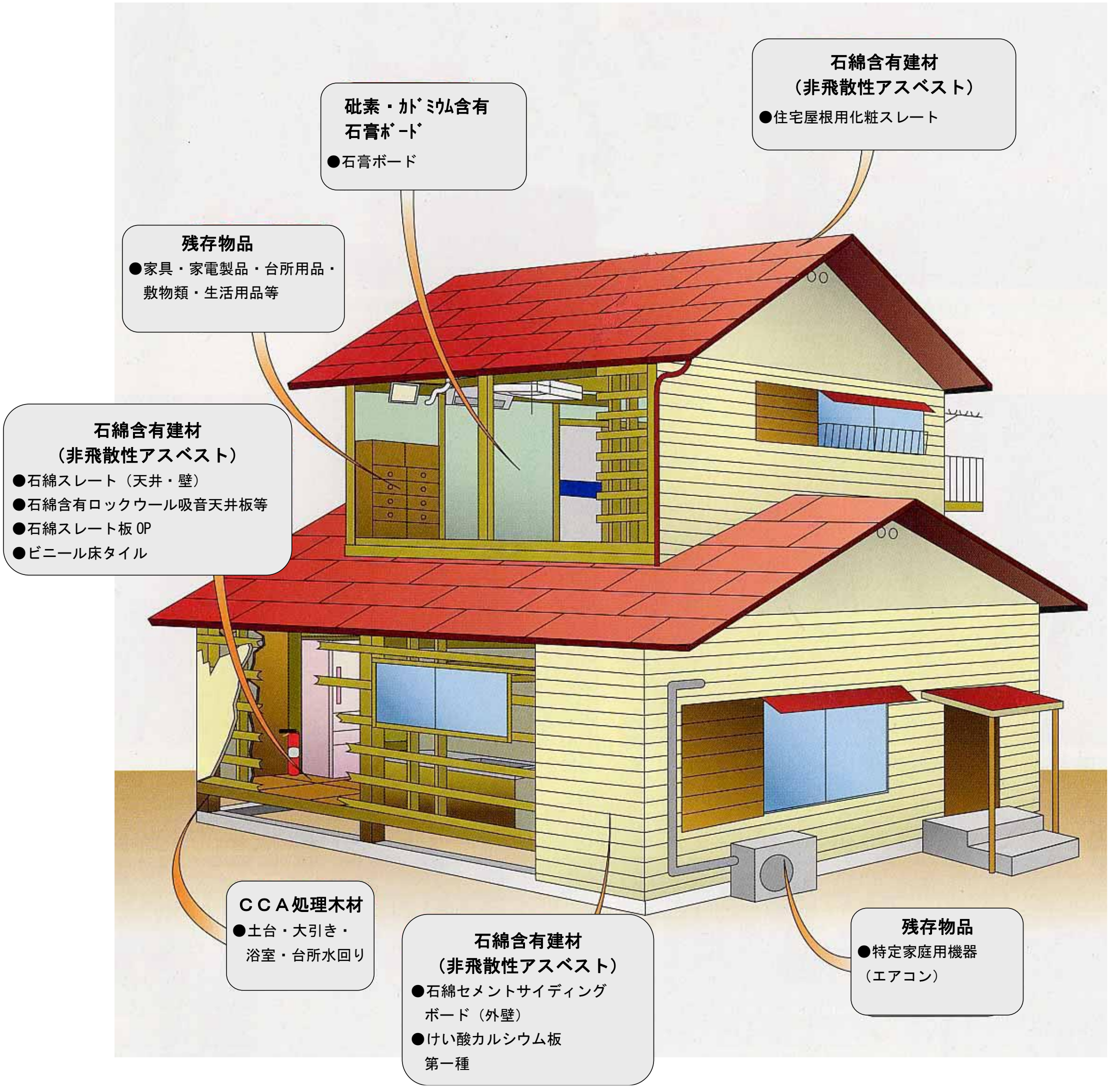
Note: Names in parentheses are abbreviated names.

<Examples of attached substances and hazardous substances>

		Substances attached to specified construction materials (*1)	Materials which require advance measures	Materials which require sorted demolition
Asbestos	Scattering (including those equivalent to scattering asbestos)	Sprayed asbestos Sprayed rock wool containing asbestos Heat insulating material containing asbestos	Calcium silicate board containing asbestos (Type 2) (Fireproof coating board) Piping heat insulating material	
	Non-scattering	Vinyl floor tiles		Asbestos cement board (*2) Calcium silicate board containing asbestos Extrusion molded cement board Asbestos cement board for house roofs Asbestos cement board for house exterior walls
Other attached substances		Sprayed rock wool Pearlite spraying Wood wool cement board for placing Wood chip cement board for placing Expanded polystyrene board for placing Sprayed urethane foam		
Others			Materials containing PCB (containing PCB waste or PCB-contaminated waste) Refrigerant fluorocarbon from refrigerator Refrigerant lithium bromide from refrigerator Storage battery Fluorescent light	Roofing Tatami mat Gypsum board containing arsenic or cadmium Other interior materials

(*1) Attached substances which are required to be removed in advance, according to the Construction Material Recycling Law.
(*2) If it has possibility of scattering due to demolition or repair work, advance measures are required.

Major hazardous substances used in wooden buildings (low-rise buildings) are as shown below.



* Detailed information on the handling of some hazardous substances is given at the end of this manual.

3. Plan for demolition work

Figure out a plan for the demolition work based on the results of the preliminary survey, and prepare a plan and process chart. Furthermore, submit a "plan for sorted demolition" in writing to the owner prior to the start of the work to give an explanation for it.

3.1 Selection of demolition method

There are two types of sorted demolition methods specified by the Construction Material Recycling Law: "Sorted demolition method by manual operation" and "Sorted demolition method by both manual and machine operations." You must select an appropriate method of sorted demolition according to the enforcement regulations.

(Explanation)

When selecting a demolition method, select a sorted demolition method according to the enforcement regulations, based on the preliminary survey, after having fully known characteristics of each demolition work. Principal information necessary for selecting a sorted demolition method is as shown in the Table 3.1-1.

Table 3.1-1: Principal information necessary for selecting a sorted demolition method

Environmental conditions	Information on structures, residents, and road/traffic conditions in the surrounding areas of the work site
Building conditions	Information on structure, area, construction materials used, degree of damage or deterioration and use conditions of the object to be demolished, and existence/non-existence of attached substances
Site conditions	Information on area, difference in height and shape of the site
Working conditions	Information on securing labor force and working capacities
Procurement conditions	Information on procurement of demolition machines, materials for temporary facilities, and others
Treatment conditions	Information on legal regulations for industrial waste and recycling
Conditions for recycling and collecting/transporting	Information on types of specified construction material waste and other construction wastes, amount of generation, sorting, loading time, and distance to the disposal facility
Regulation conditions	Information on legal regulations concerning traffic, road, and pollution
Contract conditions	Information on work budget, method of payment, and work period

The sorted demolition method by both manual and machine operations, which has been commonly adopted, has reached a demolition technique level which enables the promotion of recycling for specified construction material waste, which is required to be recycled according to the Construction Material Recycling Law.

As for construction waste, other than specified construction material wastes, it is preferable to increase the number of items (types) for sorting and improve the accuracy of the sorting. Therefore, even when selecting the sorted demolition method by both manual and machine operations, it is important to select the method taking this into consideration.

3.2 Plan for demolition work

A plan for demolition work is a comprehensive overview of the work schedule, demolition method, selection of machines and vehicles, recycling of specified construction material waste, sorting method of construction waste, allocation of labor, and a set of other items related to the demolition work, based on the conditions obtained from the results of the preliminary survey and the conditions concerning other necessary items, and it is essential the demolition work to progress safely, properly, and smoothly.

(Explanation)

A plan for demolition work is a comprehensive overview of the work schedule, demolition method, selection of machines and vehicles, recycling of specified construction material waste, sorting method of construction waste, allocation of labor, and a set of other items related to the demolition work.

(1) Plan for preparatory work

Preparatory work is essential to conduct before the demolition to ensure it is performed safely and smoothly. If the plan for preparatory work is developed simultaneously with or after the implementation of the preliminary survey, it makes it possible to link this plan with other plans and enables smooth a progression of work. Therefore, the plan for preparatory work should be developed based on the information obtained from the preliminary survey to plan treatment and necessary measures. The plan is developed based on the conditions shown in Table 3.2-1 and the conditions concerning other necessary items.

Table 3.2-1: Main information necessary for developing the plan for preparatory work

Neighborhood conditions	Plan appropriate measures as necessary, based on information on residents around a demolition site who will be affected by demolition work and facilities, such as hospitals, schools, and precision instrument factories which are expected to be significantly affected by noise and dust.
Obstacle conditions	Information essential for performing demolition work safely and smoothly. Plan necessary treatment and measures to be taken before the start of the work based on this information. Information on service piping - Confirm if utilities, such as gas, water, and sewage, are treated as prescribed, and plan measures to be taken when they are not yet treated. Information on overhead wires - Plan measures to be taken when overhead wires, such as electric wires or telephone wires, could affect demolition work. - Information on obstacles on road. - Plan treatment/measures to be taken when removal of public equipment, such as guardrails or signs, is required. - Information on trees, walls, and underground obstacles - Plan treatment/measures to be taken based on information on how to handle them, e.g. removal, transfer, protection, or leaving as it is.
Regulations/traffic conditions	Plan treatment and measures for approval/notification concerning road use, arrangement of traffic guards, and safety for third persons.

(2) Plan for temporary facilities

Temporary facilities mean facilities and equipment which are installed temporarily to conduct demolition work safely and smoothly. A plan for temporary facilities varies depending on the shape, scale, and site conditions of an object to be demolished, but it should basically be prepared with consideration for safety, economy, and efficiency. A plan for temporary facilities includes the following:

(i) Scaffolding plan

Scaffolding plays an important role in ensuring safety, as well as preventing noise and damage due to dust and the scattering of debris in demolition work. If the use of construction materials containing asbestos for exterior wall materials and roofing is approved, scaffolding will be indispensable. The scaffolding plan should be developed with consideration for sufficient safety and strength.

(a) Scaffolding

There are two types of scaffolding as shown in Table 3.2-2. Before developing and preparing a scaffolding plan, conditions of demolition work, as well as the safety and strength of scaffolding should be comprehensively examined. The plan should be prepared using tube-and-coupler single-row scaffolding or prefabricated scaffolding whenever possible. Furthermore, matters to be considered when examining scaffolding are shown in Table 3.2-3.

Table 3.2-2: Types of scaffolding

Prefabricated scaffolding	This type is excellent in strength and safety. It needs more space for installation as compared to the tube-and-coupler single-row scaffolding.
Tube-and-coupler single-row scaffolding	This type is inferior to the prefabricated scaffolding in terms of strength and safety, but it can be installed even in a narrow space.

Table 3.2-3: Matters to be considered

Material	Material(s) having required strength should be used.
Structure	Structures which can secure the safety of work and can be expected to have high efficiency should be used. Specifically, strength sufficient for wind and rain should be secured by reinforcing with braces, wall ties, stays, horizontal angle braces, etc.

(b) Curing sheets/panels

Curing sheets/panels are divided into the following types, as shown in Table 3.2-4. A plan for them should be prepared by selecting those which can properly cope with the potential fire, noise, dust, etc. generated along with demolition work.

Furthermore, matters to be considered when selecting materials are shown in Table 3.2-5.

In general demolition work, flameproof sheets are used.

If loud noise is expected to be generated, use soundproof sheets or panels.

Table 3.2-4: Types of curing sheets/panels

Flameproof sheet	A commonly used sheet which is used when demolition work is accompanied by the generation of sparks or heat at the time of gas cutting.
Soundproof sheet	Used when generation of relatively loud noise is expected and when special consideration for noise in the neighborhood is required.
Soundproof panel	Used when higher performance than that of the soundproof sheet is required as a measure against noise.

Table 3.2-5: Matters of concern

Material	Use material which generates less sound due to wind and rain and is not hard to tear. It should have no tears or dirt, and it is also preferable to consider the aesthetic appearance.

(ii) Other plans

When a building to be demolished has deteriorated or is at risk of collapsing due to the vibration associated with demolition work, a plan for reinforcement should be prepared. When the building has a risk of collapsing in the vertical direction, use supports, and when it has a risk of falling down in the horizontal direction, use braces.

In other cases, where there is the possibility of subsidence and defects on a road used by carrying in/out vehicles and heavy machines, a plan for the reinforcement and repair should be prepared in advance.

(3) Plan for demolition work

A plan for demolition work has a large effect on the environmental load associated with proper disposal and recycling of construction material waste as well as the safety, work method, work period, budget, and demolition. Therefore, an appropriate plan for demolition work should be developed based on the results of the preliminary survey and the information obtained in items (1) to (6).

If materials such as construction materials containing asbestos and CCA-treated wood are used, consider a method for removing them and reflect the method in the plan for demolition work.

Particularly for construction materials containing asbestos, the following items should be included so as to comply with the Ordinance on Prevention of Health Impairment due to Asbestos (Asbestos Ordinance).

(i) Work method and sequence

The sequence of the demolition work of the whole building is to be specified and, additionally, removal methods for each removed part are to be included.

(ii) Method for preventing and controlling dispersion of dust

Conduct wetting (spraying/sprinkling water, chemical application, etc.) suitable for the type of construction material containing asbestos to be removed and the work method. If it is difficult to conduct wetting, the reason and appropriate alternatives are to be included in the plan.

For details concerning hazardous substances, please refer to the information given at the end of this manual.

(4) Plan for recycling/disposal of construction material waste

(i) Estimate of the amounts of construction material waste generation

From the results of the preliminary survey, estimate the amount of construction material waste generation for each item, including specified construction material waste. Particularly, in the case of object construction work, estimated amounts for each type of specified construction material waste should be included in the "plan for sorted demolition."

The amounts of construction material waste generated are required to be properly reflected in a contract in terms of costs for recycling and proper disposal. Therefore, prediction with higher accuracy is required.

Furthermore, as for industrial waste containing asbestos and CCA-treated wood, the parts should be identified from the results of the preliminary survey and generated amount should be calculated to properly dispose of them.

(ii) Rough estimate of the amount of wood generated in construction

The amount of wood generated by the demolition of a wooden house is thought to be approximately 85 kg per 1.0 m^2 of floor area. When a common wooden house having a floor area of 100 to 130 m^2 (30–40 tsubo) is demolished, approximately 10-t wood would be generated. Table 3.2-6 shows the list of rough estimates of the amount of wood generated from the demolition of a wooden house.

The amount of wood generated from demolition (t) ≈ 0.085 × Total floor area (m^2)

Table 3.2-6: Rough estimate of the amount of wood generated from the demolition of a wooden house

Total floor area (m^2)	Rough estimate of wood amount (t)	Total floor area (tsubo)	Rough estimate of wood amount (t)
60 m^2	5.1	10 tsubo	2.8
80 m^2	6.8	20 tsubo	5.6
100 m^2	8.5	30 tsubo	8.4
120 m^2	10.2	40 tsubo	11.2
140 m^2	11.9	50 tsubo	14.1
160 m^2	13.6	60 tsubo	16.9
180 m^2	15.3	70 tsubo	19.7
200 m^2	17.0	80 tsubo	22.5

Approximately 50% of the amount of generated wood shown in the table above is derived from relatively firm constructional members having a cross-sectional area of approx. 50 cm^2 or larger.

(iii) Plan for recycling/disposal

In cases of object construction work, recycling must be implemented for concrete mass, wood generated in construction, and asphalt concrete slabs which are specified construction material waste. (Note that, in cases of wood generated in construction which is designated construction material waste, reduction (such as incineration) is sufficient for such waste if certain conditions are met.)

Moreover, regardless of whether it is the object construction work or the specified construction material waste, and as for construction works and construction material waste other than these, recycling is required to be implemented whenever possible, and it is also important to implement proper disposal for construction material waste which is difficult to recycle.

When the disposal is consigned to another person to implement recycling and proper disposal, a company treating industrial waste is required to be selected.

(5) Plan for sorting/carrying-out

For wood generated in construction and concrete masses, which are designated as specified construction material waste, a plan for sorting them by item and carrying them out must be developed. Furthermore, for construction material waste other than this, including recyclable articles such as scrap metal, it is preferable to develop a plan for sorting it by item and carry out it whenever possible.

In demolition work of low-rise buildings, such as wooden buildings, since the site may be limited in area, specified construction material waste and construction material wastes may be carried out concurrently with the demolition work. For that reason, the propriety of a carrying out method has a large effect on the progress of the demolition work. Therefore, the contractor of the object construction work should develop an appropriate sorting/carrying-out plan with consideration for improvement in efficiency when loading and carrying out waste.

(6) Safety and environmental protection plan

The contractor of the object construction work must organize the necessary safety management system, including appointment of an overall safety and health controller based on laws and regulations.

As for working facilities and safety facilities associated with the demolition work including scaffolding, working floors, and passages, develop a plan for matters related to environmental protection, such as noise, vibration, dust, and odor, after comprehensively considering such matters and prepare a written version of the developed plan while making efforts to secure safety of individual facilities.

3.3 Development of the process plan and preparation of the process chart

To complete demolition work within a period as initially planned, develop a process plan while linking it with the preliminary survey and the plan for demolition work. Additionally, the influence of the weather, etc. should also be taken into account.

(Explanation)

To complete demolition work within a certain period as planned, develop a process plan while taking the influence of the weather, etc. into account.

In demolition work for a wooden building having a total floor area of 30–40 tsubo (100–130 m^2), it is estimated to take about two weeks to complete the work. Table 3.3-1 shows an example of a process chart.

Table 3.3-1: Example of a process chart for demolition work (floor area of wooden framework structure: 138.5 m^2)

	作業内容	解体工事工程																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		月	火	水	木	金	土	日	月	火	水	木	金	土	日	月	火	水	木	金	土	日	月
事前措置	作業場所・搬出経路の確保等	■	■	■																			
準備作業	作業スペース・搬入路確保								■														
	足場設置・養生シート掛け・仮囲い								■	■													
解体作業	住宅設備類撤去(複合材)										■	■											
	内部建具撤去										■	■											
	外部建具障子撤去										■	■											
	塩ビクロス等剥離										■	■											
	石膏ボード撤去											■											
	外部金属部品取外し												■										
	屋根材撤去												■	■									
	外装材・建物本体解体															■	■	■					
	品目分別作業										■	■	■	■		■	■	■	■	■			
	足場・仮囲い・養生シート撤去																		■				
	基礎・土間コンクリート撤去																		■	■			
	地中構造物・基礎ぐい撤去																		■	■			
	整地																			■	■		
	清掃作業																			■	■		
	予備日																						■

3.4 Preparation of a "plan for sorted demolition"

In object construction work under the Construction Material Recycling Law, the contractor must give the owner an explanation in writing about the developed "plan for sorted demolition." Furthermore, the above-mentioned written explanation may be prepared by utilizing a form which the owner uses when submitting notification to the prefectural governor.

(Explanation)

Items required to be included in the plan for sorted demolition are as follows:

(i) Structure of the building

(ii) Results of the preliminary survey (conditions of the building, surrounding areas, work place and carrying-out routes, existence/non-existence of remaining articles and substances attached to specified construction materials, and others)

(iii) Contents of advance measures (securing of work place and carrying-out routes, confirmation of carrying-out of remaining articles, removal of attached substances, and other measures to be taken prior to the start of the work to secure proper implementation of sorted demolition related to specified construction materials)

(iv) Time of the start of work

(v) Work contents of each process and a method for sorted demolition (and a reason if it is difficult for the method to follow the prescribed order)

Step 1: Building equipment, interior materials, etc.; Step 2: Roofing; Step 3: Exterior materials and upper structural parts; Step 4: Foundation and foundation piles; Step 5: Others.

(vi) Order of demolition work (and a reason if it is difficult for the order to follow the prescribed order)

(vii) Estimated amount of construction materials used for the building

(viii) Estimated amount of specified construction material waste of each type and the sections of the object building where specified construction material waste is expected to be generated

4. Quantity survey and estimate

The contractor of the work is to conduct a quantity survey and estimate of the cost of the work based on the plan for demolition work. In so doing, it is preferable to prepare a quantity survey and estimate by clearly showing the breakdown of the cost of demolition work, the collecting and transporting cost, and the disposal cost.

(Explanation)

It is important to explain the plan for demolition work, as well as the composition and grounds of the work cost to the owner, and to properly show the cost for the demolition. The composition of the work cost related to the demolition is generally as shown in Figure 4. Furthermore, the possible classifications for the costs of demolition work and detailed items in the classification are shown in Table 4.

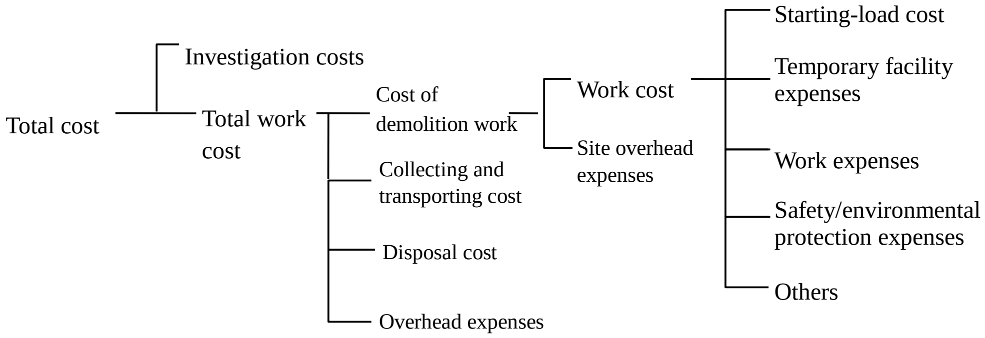


Figure 4: General composition of costs of demolition work

Table 4: General classification of costs of demolition work and detailed items

Composition of work cost					Detailed items of the composition and brief descriptions
Total cost	Investigation cost and cost for measures				Expenses required for preliminary survey and expenses required for advance measures
	Total work cost	Cost of demolition work	Work cost	Starting-load cost	Expenses required to remove/transfer objects which can be obstacles to the demolition work, and expenses associated with securing carrying-in/out routes for materials/construction waste and removal/transfer of plants
				Temporary facility expenses	Expenses for temporary facilities required for the whole process of the demolition work, such as scaffolding, curing sheets, water supply, and electricity
				Work expenses	Expenses for each division of demolition work (building facility and equipment removing work, main body demolishing work, accompanying work and appurtenant work), such as labor cost, expenses for carrying in/out materials/equipment related to demolition, and rent for them
				Safety/environmental protection expenses	Expenses related to safety of work and protection of the work environment and the surrounding environment
			Site overhead expenses		Overhead expenses in the demolition work site
		Collecting/transporting cost			Expenses associated with loading sorted specified construction material waste and construction waste and transporting them from the work site to recycling facilities or intermediate treatment (final disposal) facilities
		Disposal cost			Expenses associated with the recycling and disposal of sorted specified construction material waste and other construction waste
		Overhead expenses			Expenses associated with management of various works/businesses

Table 4 is based on workflows which have been commonly adopted so far and content shown in the Construction Material Recycling Law. Even costs for work other than those shown in Table 4 should be included if the reason for such costs can be judged to be proper.

* An example of a written estimate for demolition work is shown at the end of this manual.

5. Advance preparation (including advance measures)

Advance preparations include implementation of the following works: (i) Prior explanation to the owner; (ii) Conclusion of contract for demolition work with the owner; (iii) Submission of a notification form by the owner; (iv) Notification to the subcontractor; (v) Various notifications, arrangements, and confirmation; and (vi) Implementation of advance measures.

(Explanation)

(i) Prior explanation to the owner

The contractor of the object construction work gives an explanation to the owner about matters concerning notification of the plan for sorted demolition prior to the contract agreement for demolition work. The Construction Material Recycling Law requires that the following matters should be explained:

a) Structure, etc. of building to be demolished

b) In cases of new construction, types of specified construction materials to be used

c) Starting time for the work and outline of processes

d) Plan for sorted demolition

e) In cases of demolition work, estimated amount of construction materials used in a building to be demolished

f) Others

(ii) Conclusion of contract for demolition work with the owner

The contractor of the object construction work concludes a contract agreement for demolition work with the owner. When concluding the agreement, it is desirable to present a written estimate for the work.

The document includes the following items specified in the Construction Material Recycling Law, in addition to necessary items specified in the Construction Business Act:

- Method of sorted demolition
- Cost required for demolition work
- Name and address of a facility for recycling
- Cost required for recycling

(iii) Submission of a notification form by the owner

The owner of the object construction work notifies the prefectural governor of the object construction work no later than seven days before the starting date of the work. (By means of power of attorney, the contractor of the object construction work may conduct such notification as a representative of the owner.)

* The Form No. 1 of the Notification Form of Demolition Work and the Attached Table 1 of the Form of the Plan for Sorted Demolition are shown at the end of this manual.

(iv) Notification to the subcontractor

The main contractor notifies the subcontractor of matters on which the owner notified the prefectural governor prior to the subcontract.

(v) Various notifications, arrangements, and confirmation

The owner, or the contractor, of the object construction work confirms notifications to administrative agencies and arrangements concerning the work which are made prior to demolition work.

* Lists of examples of permit applications and notifications submitted by the owner and the demolition operator are shown at the end of this manual.

(vi) Implementation of advance measures

The contractor of the object construction work takes the following measures prior to the start of the work.

- Securing work place
- Securing carrying-out route
- Confirming removal of remaining articles

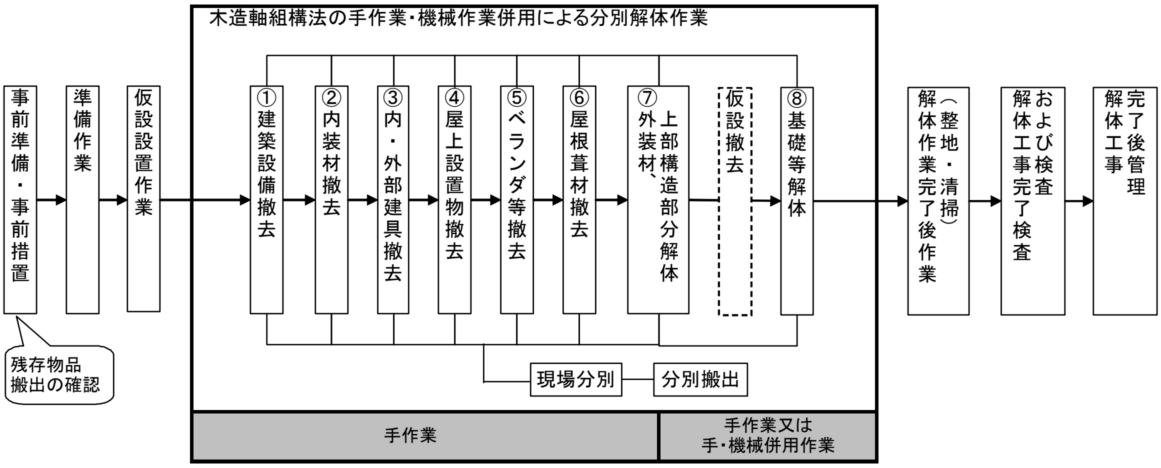
- Removal of attached substances and other measures to be taken prior to the start of the work to secure proper implementation of sorted demolition related to specified construction materials

6. Demolition work

Demolition work is conducted based on the plan, after completion of the preliminary survey and advance preparation.

(i) Management of demolition work (including posting of signs, issuance of the industrial waste management slip, and confirmation of the plan for demolition work), (ii) Safety management and environmental protection, (iii) Preparatory work and temporary facilities, (iv) Demolition work.

The general flow of demolition work, according to the sorted demolition method, is as shown below.



(Note) Even in the sorted demolition method by both manual and machine operations, construction materials containing asbestos are to be manually demolished.

The Construction Material Recycling Law requires sorted demolition and recycling of specified construction material waste. The classification of recycled chips (A to D) becomes clear by further sorting the wood generated in demolition work according to the part from which the wood has been generated, such as pillar, beam, rafter, brace, girth, sleeper, floor joist, or roofing board, which can improve the recycling rate.

Furthermore, promotion of recycling and reduction of mixed waste can be achieved by making efforts to sort and accumulate waste by item whenever possible, even in cases of items other than specified construction materials.

As for CCA-treated wood and construction materials containing asbestos generated in demolition work, they must be properly treated in compliance with related laws and regulations.

* Detailed information on handling of hazardous substances is given at the end of this manual.

(Explanation)

6.1 Management of demolition work

- The contractor of the object construction work performs the management tasks described below at a demolition work site.

(1) Posting of signs

(i) Posting of signs showing that a construction business license or a registration of demolition operations has been obtained

The contractor of the object construction work posts a sign at each site showing that they have a permit for construction business if they have obtained a construction business license, or a sign at each demolition work site showing that they have been registered as a demolition operator if they have obtained a registration as a demolition operator under the Construction Material Recycling Law.

(ii) Prohibition of trespassing on demolition work site and installation of no trespassing signboard

Put a sign at an easily visible place at the entrance of the demolition work site, saying that trespassing by persons other than demolition work-related personnel is prohibited.

(iii) Notice of measures implemented to prevent exposure to asbestos

* The operator is required to put a sign including the following content in an easily visible place at the working site to make the content of measures implemented to prevent exposure to asbestos in demolition work of a building using asbestos known not only to related workers but also to nearby residents.

- If measures to prevent exposure to asbestos and measures to prevent scattering of asbestos particulates must be taken (work of level 1 and 2), put a sign at an easily visible place in the working site to let nearby residents, as well as related workers, know the fact that notification based on the Asbestos Ordinance has been completed and the content of measures implemented to prevent exposure to asbestos, etc.
- Similarly, if no notification is required for the work or no measures to prevent exposure to asbestos, etc. must be taken (work of level 3), put a sign indicating the content of measures implemented to protect exposure to asbestos, etc.
- As for work such as demolition of a building using no asbestos, put a sign indicating that no asbestos is used.

* In a column for the appointment of an operations chief of asbestos, enter the name of an operations chief of asbestos selected from those who obtained the qualification of an operations chief of specified chemical substances after completing the skill training course for operations chief of chemical substances (until March 31, 2006) or those who obtained the qualification of an operations chief of asbestos after completing the skill training course for operations chief of asbestos (since April 1, 2006).

* This is based on "About notice of measures implemented to prevent exposure to asbestos, etc. when performing work such as demolition of buildings" issued on August 2, 2005 by the Health, Labour and Welfare Ministry.

(2) Arrangement of engineering manager, etc.

(3) Arrangement and confirmation of qualified personnel required for the work

(4) Sorting, temporary storage, and carrying out of construction material waste, and issuance of the industrial waste management slip (manifest)

(i) Issuance of manifest

When carrying out waste, issue a manifest describing necessary matters to a collector/transporter in the presence of the on-site personnel of the contractor of the work.

(5) Confirmation of the plan for demolition work

(i) Confirmation of the plan for demolition work

The contractor of the object construction work confirms the implementation status to proceed with the work based on the plan for demolition work.

(ii) Confirmation of completion of demolition work

The contractor of the object construction work confirms whether or not the work has been completed according to the plan after the completion of the demolition work.

6.2 Safety management and environmental protection

The contractor of the object construction work appropriately manages demolition work based on the "safety and environmental protection plan" prepared in "3. Plan for demolition work."

6.3 Preparatory work

The preparatory work is appropriately implemented based on the "plan for preparatory work" prepared in "3. Plan for demolition work."

(1) Approval, notification, etc.

If permissions for using road and/or protection of electric wire are required, complete the procedures for each of them by the prescribed deadlines.

(2) Matters concerning demolition work

Secure a work space in the site, a carrying-in route for machines/equipment, a place for sorting/accumulating construction material waste, and a carrying-out route. Points to consider in this work are described below:

(i) Preparation of the plan for demolition work

(ii) Proper selection of materials and equipment and carrying them into the site

(iii) Treatment for electricity, gas, water supply, telephone, etc.

(iv) Treatment for plants and trees, installed objects, etc. which are to be removed, transplanted, or transferred

(v) Treatment when construction materials containing asbestos are used

- Marking of places where construction materials containing asbestos are used

- Deployment of wetting apparatus (Preparation of sprayer, sprinkler and wetting (scattering prevention) agent if necessary)
- Preparation of cleaning tools (such as a vacuum cleaner with HEPA filter)
- Preparation of containers for sorting (strong containers or secure packaging)

* Detailed information on handling of hazardous substances is given at the end of this manual.

6.4 Temporary facilities work

The temporary facilities work is to be appropriately implemented based on the plan for temporary facilities developed in "3. Plan for demolition work."

The temporary facilities work means installing scaffolding (such as prefabricated scaffolding and tube-and-coupler single-row scaffolding), curing sheets (such as flameproof sheets and soundproof sheets), etc. used in the whole process in the object building.

(1) Temporary facilities

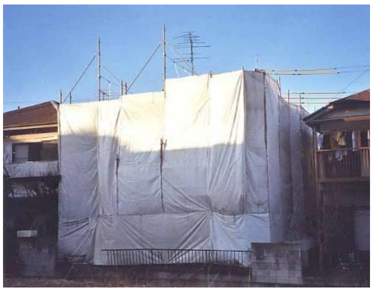
(i) Scaffolding (prefabricated scaffolding, tube-and-coupler single-row scaffolding, etc.)

Scaffolding is to be reinforced with braces, wall ties, stays, horizontal angle braces, etc. to secure strength sufficient to withstand wind and rain, based on the plan for temporary facilities and complying with the safety provisions (Articles 559 to 575) of the Ordinance on Industrial Safety and Health. Heights and dimensions of each part should be equal to or greater than the standards provided by the Industry Safety and Health Act. During the work, always wear a protective helmet and a safety belt, paying sufficient attention to safety.

Furthermore, the name, blood type, contact address, and telephone number of the worker should be shown on a protective hat.

(ii) Curing sheets (flameproof sheets, soundproof sheets, etc.)

Curing sheets should be installed on the outer periphery of scaffolding at the same height as the scaffolding. Furthermore, sheets are to be adhered to each other without gaps between them to prevent materials to be demolished, tools, dust, or noise from leaking out from gaps between the sheets. During the installation work, always wear a safety belt, paying sufficient attention to safety.



Example of work curing tube-and-coupler
single-row scaffolding with flameproof sheets

(2) Reinforcement

There are few examples of reinforcing structures themselves when demolishing them in cases of low-rise buildings, such as general wooden buildings. However, if a plan for reinforcement work is developed when a building has become deteriorated and there is a risk of collapse due to vibration caused by the demolition work, perform reinforcement work according to plan.

If there is a risk of collapse in a vertical direction, use supports, and if there is a risk of falling down in a horizontal direction, use braces, and the like. In such a case, sufficient survey should be conducted to confirm that safety during the reinforcement work will also be secure.

6.5 Demolition work

Implement the demolition work properly based on developed plans and a selected demolition method after confirming the completion of procedures, including advance measures.

The various developed plans mean the "plan for demolition work," "plan for recycling/disposal," "plan for sorting/carrying-out," "safety and environmental protection plan," and "process plan" developed in "3. Plan for demolition work." Furthermore, the previously selected demolition method means either the "sorted demolition method by manual operation" or the "sorted demolition method by both manual and machine operations" indicated in the description of the selection of a demolition method.

To properly proceed with the demolition work, it is required to perform it steadily according to the original plan.

(1) Work procedures for sorted demolition of buildings constructed by the wooden framework method

(i) The general flow of the sorted demolition method by manual operation for buildings constructed by the wooden framework method is as shown in Figure 6-1.

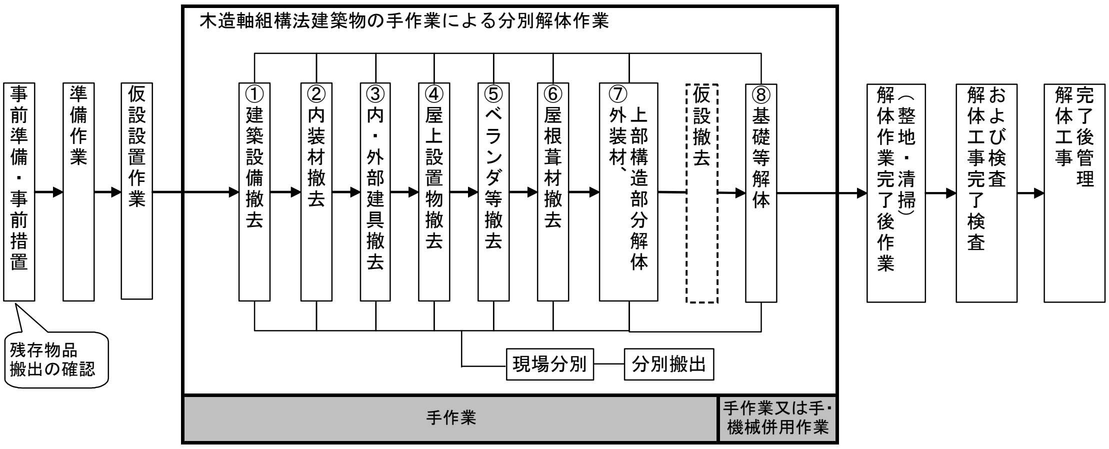


Figure 6-1: Example of the flow of sorted demolition work by manual operation for buildings constructed by the wooden framework method

(ii) The general flow of sorted demolition work by both manual and machine operations for buildings constructed by the wooden framework method is as shown in Figure 6-2.

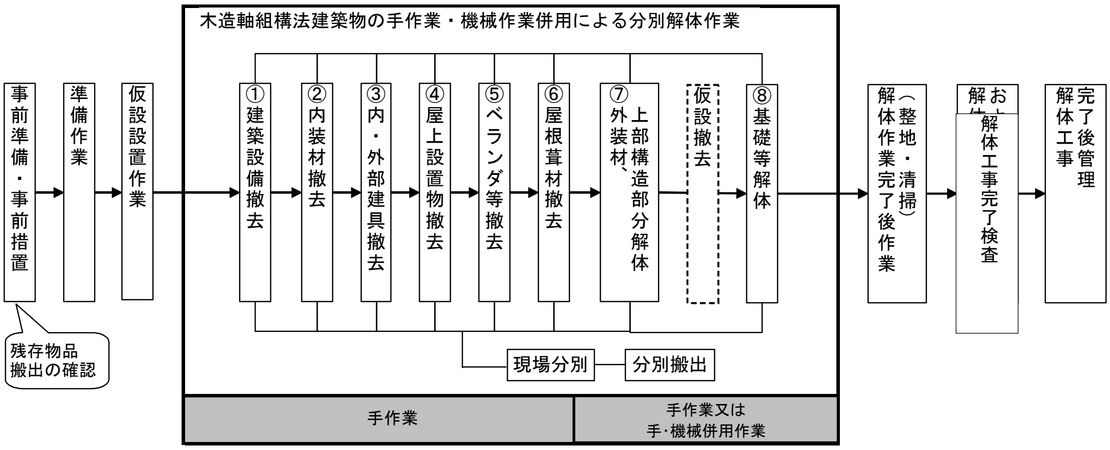


Figure 6-2: Example of the flow of sorted demolition work by both manual and machine operations for buildings constructed by the wooden framework method

(Note) Even in the sorted demolition method by both manual and machine operations, construction materials containing asbestos are to be manually demolished.

(2) Implementation of sorted demolition desirable for recycling of wood (to guarantee the quality of wood chips)

The Construction Material Recycling Law provides for sorted demolition and recycling of specified construction material waste, but the quality of wood generated in demolition work varies depending on the conditions, such as the area where the wood was generated.

In cases of buildings constructed by the wooden framework method, woods such as pillars and beams having a large cross-sectional area can be disposed of at low cost and sometimes may be traded for a fee, which enables the cost of demolition work to be reduced.

The wood generated in demolition work is to be accumulated after sorting them by part, such as pillar, beam, rafter, brace, girth, sleeper, floor joist, and roofing board, and delivered to waste disposal companies.

Furthermore, though the amount generated is small, fittings such as doors, shoji-screen frames, and fusuma sliding-door frames are also to be accumulated after sorting them by type.

Table 6: Types of constructional members and chips, and estimated uses of recycled chips

Sorting at demolition site		Handling at chipping facilities (recycling facilities)		Remarks
Names of members	Cross-sectional areas of wood	Types of chips	Major uses of chips	
Pillars, beams, etc. made of solid wood Sills Sleepers Girths	Cross-sectional area: Large	A	Papermaking raw material, ethanol raw material, charcoal, etc.	CCA-containing wood, plywood, paint-adhering wood and foreign materials such as metal must not be included.
	↓	B	Papermaking raw material, fiber boards (MDF, etc.), particle boards, ethanol raw material, charcoal, mulching material, bedding, compost, etc.	
Floor joists Rafters Rails Roofing boards Flooring Wall materials Ceiling materials Fittings	↓	C	Particle boards, fuel, bedding, cement material, ethanol raw material, etc.	
	Cross-sectional area: Small	D	Fuel, blast furnace reducing agent, cement material, etc.	CCA-containing wood and foreign materials such as metal must not be included, and chips containing much moisture must be excluded.
Particulate objects of the above-mentioned materials generated at the time of chip manufacturing		Dust	Fuel, bedding, charcoal, etc.	

* This table shows standard uses for each classification of chips. Chips of upper levels can also be used for the uses for chips of lower levels.
* A standard chip size is approximately 5 cm or smaller, but the size varies depending on the use.
* CCA-containing wood must not be included. Moreover, wood and other waste must be thoroughly separated.
(Note) Acceptance criteria for foreign materials, such as metal, differ depending on the equipment of the chipping factory.

(3) Work cases according to the work procedures for sorted demolition of buildings constructed by the wooden framework method

Equipment is to be carried in a prescribed place, organized, and stored according to the plan for sorting/carrying-out.

(i) Removal/carrying-out of building equipment

Building equipment must be removed manually regardless of the demolition method.

- Building equipment means lighting equipment, prefabricated baths, kitchen cabinets, built-in air conditioners, etc.
- When removing them, if asbestos, PCB, chlorofluorocarbon gas, etc. clearly exist, appropriate measures must be taken according to the related laws and regulations.

Removing kitchen cabinet and sink

- Fluorescent tubes are to be accumulated so as to avoid mixing them with other construction material waste.
- Most of building equipment is a combination of woody board and metal-based or plastic-based material. If it is difficult to sort them, deliver each of them as they are to the respective collection operator.

(ii) Removal/carrying-out of interior materials

Interior materials must be removed manually regardless of the demolition method.

○ Removal/carrying-out of cloth

- Many of inner walls and ceilings of low-rise buildings, such as wooden buildings, are finished with cloth over gypsum lath boards. Peel off the cloth before removing the gypsum boards.
- Cloths are to be bundled up as compact as possible using bands or the like and carried out as a single item.


Removing cloths


Bundling cloths

○ Removal/carrying-out of boards

- Boards are to be removed after sorting them by the quality of material (gypsum-based, plywood-based, and rock wool-based).
- Sort them as much as possible on site and deliver them as single items.
- If gypsum boards containing arsenic or cadmium clearly exist, they are to be carried out separate from other waste.


Removing gypsum boards

Gypsum boards

When disposing of gypsum boards, they must be disposed of at a controlled final disposal site.

All waste mixed with gypsum boards must be disposed of at a controlled final disposal site. Therefore, it is important to separate gypsum boards from other waste.

When gypsum boards are recycled, since treatment of gypsum boards at a recycling facility becomes difficult when they get wet with water, treat them in a way that prevents them from getting wet with water.

○ Removal/carrying-out of heat insulating materials

- In some cases, glass wool may be used as a heat insulating material for ceilings, floors, and exterior walls. When removing the glass wool, try to keep its original form as much as possible.
- When sprayed asbestos or rock wool containing asbestos is used, the use of such materials should be confirmed at the stage of preliminary survey.
- Since heat insulating materials have high porosity, they are to be bundled with bands or the like and delivered as a single item after taking measures, such as removing enclosed air, so that the volume can be reduced as much as possible.


Heat insulating materials being removed


Heat insulating materials being bundled

(iii) Removal/carrying-out of inner/external fittings

In cases of the object construction work, inner/external fittings must be removed manually regardless of the demolition method.

(iii)-1 Removal/carrying-out of inner fittings/tatami mats

- Removal is to be started from the lowest floor.
- When removing/transferring fittings with glass, be careful not to damage them or get injured by them.
- Removal of tatami mats is to be conducted after the removal of fittings.

Floorboards, after tatami mats have been removed, may decay or come off from floor joists. These parts require adequate attention because they may cause accidents, such as treading on a sharp point or falling down, and it is necessary to ensure the safety of the work by spreading the removed fittings, tatami mats, and the like over these parts.

- Do not throw the removed fittings and tatami mats down from a high place.
- Carry out the removed fittings and tatami mats after sorting and accumulating them in the work place.

Removing inner fittings

Removing a tatami mat

(iii)-2 Removal/carrying-out of external fittings

- External fittings include doors, windows, and rain shutters and most of them are made from a combination of metal, glass, wood, and woody boards.
- When removing them, if materials, such as glass, are broken, such breakage not only increases the risk at work, but also requires labor to collect the broken pieces or leads to as increase in the amount of mixed waste. Therefore, when removing fittings with glass, break the glass in a dedicated container or on a cargo bed of a carrying-out vehicle after removing it in a way that prevents it from breaking.
- Carry out them after sorting them by item.
- When breaking glass, wear protective equipment such as goggles.

Removing external fittings (window glass)

(iv) Removal/carrying-out of rooftop-installed objects

Rooftop-installed objects must be removed manually regardless of the demolition method.

- When equipment using sunlight or solar heat and antennas are installed on a roof surface, they are to be removed before removal of roofing.
- Some of this equipment may use heavy metal, such as lead, so adequate attention is required when removing or carrying out them.

Breaking window glass using a bathtub

Rooftop-installed object (solar water heater)

Removing a balcony made of metal

(v) Removal/carrying-out of balconies

Balconies must be removed manually regardless of the demolition method.

- The timing for removing balconies is determined in relation to other works. Since most balconies are made of metal, they are to be efficiently removed in accordance with the timing for removing other metal parts.

(vi) Removal /carrying-out of roofing

Roofing must be removed manually regardless of the demolition method.

Roofing for low-rise buildings, such as wooden buildings, includes roof tiles, decorative slate boards for house roofs (or construction materials containing asbestos), and metal (including galvanized sheet iron and copper sheets).

○ Removal/carrying-out of roof tiles

- Roof tiles can be divided broadly into clay roof tiles and cement roof tiles.
- When carrying out roof tiles, they are delivered by hand. When throwing roof tiles down from a rooftop to a cargo bed of a truck (especially in cases where the height is 3 m or lower), throwing-down equipment must be used.

○ Removal/carrying-out of metallic roof

- A special tightening method may have been adopted for metallic roofs and, in some cases, welding may have been applied to them. It is difficult to manually demolish them even when tools are used. In such a case, cutting tools are required. If sparks are generated during cutting work, sufficient measures should be taken.
- Most of metal can be recycled as valuables.

(vii) Demolition of external materials and upper structural parts

Demolition of external materials and upper structural parts is to be conducted manually in the demolition method by manual operation and conducted using both manual and machine operation in the demolition method by both manual and machine operations.

However, when handling construction materials containing asbestos, they must be demolished manually even in the demolition method by both manual and machine operations.

(vii)-1 Removal/carrying-out of external materials

- Exterior walls for low-rise buildings, such as wooden buildings, include wood, mortar, and finishing coating (spraying material), mortar and tiling, ceramic siding (also including construction materials containing asbestos), thin ALC panels, and metal siding.

[In the case of the sorted demolition method by manual operation]

- Mortar exterior walls often use woody backing, and they can be demolished relatively easily by using tools such as a crowbar and hammer. Carrying them out can be conducted in a manner similar to that used for other materials capable of controlled disposal (Any building paper or the like attached to them should be removed.).
- Thin ALC panels are fixed to woody backing with screws or nails. Therefore, they can be demolished relatively easily by using tools such as a crowbar and hammer.
- Demolition and carrying-out of metal siding are conducted according to the method for metallic roofs.


Demolishing a mortar exterior wall

[In the case of the sorted demolition method by both manual and machine operations]

- In the case of demolition by machine operation, a gripping machine (fork grabber) is generally used.
- Sorting work of construction material waste is conducted in the same way as the manual operation.
- When demolishing outer peripheral structural parts by the overturning method, a part of exterior wall may be left.

(vii)-2 Removal/carrying-out of upper structural parts

Upper structural parts in buildings constructed by the wooden framework method means sills, floor framing, pillars, beams, crossbeams, and roof trusses.

[In the case of the sorted demolition method by manual operation]

○ Removal of joint metals

- Even if buildings were constructed by the wooden framework method, specifications for joints differ according to the date of construction. Buildings constructed in old times use less joint metals and such joint metals can be easily removed, but, as the dates of construction get closer to the present time, the number of types of joint metals and the amount used have been increasing.

- As tools, crowbars, screwdrivers, spanners, hammers, etc. are used. Work efficiency will be improved by using tools such as impact wrenches.
- Removal is to be conducted in order from the upper parts to the lower parts. Furthermore, in some cases, safety measures, such as reinforcement of braces, are required to be taken.

Removing joint metals

○ Removal of members

- When removing members, start with members from which joint metals have been removed.
- Even after removing joint metals, removal of joints and couplings is required. For old buildings, safety measures similar to those taken when removing joint metals are required.
- The order of removal of members is the same as that of joint metals.

Removing members

○ Demolition of outer peripheral constructional members

- Not only in demolition work of low-rise buildings such as wooden buildings, but also in the demolition of reinforced concrete buildings, it is common to leave outer peripheral structures to be demolished last. The reason is that leaving the outer peripheral parts can reduce the risk of collapse and a curing effect against noise and dust can be expected.
- Make the outer peripheral parts fall down inside of the foundation/sills of the building by the overturning method, and, after that, remove remaining joint metals and members. In this case, measures are required to prevent the members from rebounding due to impact of falling down and dust from scattering as much as possible.

○ Carrying-out of upper structural parts

Wood materials from the removed upper structural parts are to be sorted by member before carrying them out. Those having a large diameter and having less deterioration in quality and less damage may be reused.

[In the case of the sorted demolition method by both manual and machine operations]

○ Demolition/carrying-out of upper structural parts

- Joint metals may sometimes be removed in advance if needed, but upper structural parts are generally demolished as they are using a gripping machine (fork grabber). Joint metals are to be removed instantaneously after demolition.
- Adopt the overturning method for outer peripheral parts. Overturning work is performed by a gripping machine (fork grabber) and the demolition of the outer peripheral parts is to be completed on the same day for safety reasons.
- Matters to be considered when performing the overturning are the same when performing the sorted demolition work by manual operation.

Demolition work of outer peripheral parts by the overturning demolition method

- A gripping machine (fork grabber) is also used for sorting work of wood generated in construction.

[Removal/carrying-out of CCA-treated wood]

- Confirmation of CCA-treated wood

CCA-treated wood is generally used for sills and sleepers, but, to surely confirm use of CCA-treated wood, confirm whether or not CCA-treated wood is used, apply a reagent (such as diphenylcarbonohydrazide, diphenylcarbazide or PAN. The reagent develops a color ranging from light reddish brown to reddish purple at infiltrated parts.) to sills after demolishing the upper structural parts.

Situation after demolishing upper structural parts with foundations being left

Reagent for CCA-treated wood

Checking for CCA-treated wood using a reagent

- Removal of CCA-treated wood

Before the removal of CCA-treated wood (such as sills and sleepers), carry out demolished materials around the sills to secure a work place. Manually remove anchor bolts and nuts, then separate and remove CCA-treated wood (such as sills and sleepers) from the foundation using tools such as a crowbar.

Removing sills

- Sorting and accumulation

Carry CCA-treated wood (such as sills and sleepers) which has been removed from the foundation to an accumulation place by hand and accumulate it after clearly sorting it from other types of wood.

Carrying CCA-treated wood by hand work

Accumulating CCA-treated wood

- Carrying-out work

Load CCA-treated wood into a dedicated transport truck (a heavy machine can be used) and carry out CCA-treated wood to a disposal facility.

* Detailed information on handling of hazardous substances is given at the end of this manual.

(viii) Removal of foundation and foundation piles

Concrete and reinforced concrete of the foundation and foundation piles can also be removed manually but it is common to remove them by using manual operation in combination with machine operation by machines such as a crusher.

- Even in buildings constructed by the wooden framework method, foundations have concrete or reinforced concrete structures. Furthermore, in some cases, floor concrete is placed. Equipment used for demolition work differs depending on the concrete strength and the amount of reinforcing steel. When the concrete strength is weak, use a bucket, and when strong, use a crusher. In some cases, a hand breaker or giant breaker may be used.

- Prevent dirt and foreign materials from being mixed into removed concrete mass.

Note that sufficient consideration is required because the removal of the foundation using these heavy machines is accompanied by vibration and noise.

(4) Other removal work

Gates, walls, underground buried structures, septic tanks, trees, and plants, etc. accompanying demolition work are to be removed in a way that does not adversely affect the surrounding area.

(i) Removal of gates/walls

Types of gates/walls include metal, concrete and concrete block gates/walls, hedges, etc. They are to be properly removed according to the type.

(ii) Removal of underground utilities

Underground utilities include water supply, drainage pipes, and gas pipes. When digging up them to remove them, do it manually based on the results of the preliminary survey.

(iii) Removal of septic tanks

Before removing a septic tank, scoop up residues and clean the tank.

A septic tank is often installed near a boundary with adjacent land. Therefore, the tank is to be removed with sufficient attention so as not to damage objects, such as boundary walls. The materials include reinforced plastic and concrete. In the case of a concrete septic tank, use equipment such as a crusher to remove it.

(iv) Removal of trees and plants

When removing trees and plants by pulling them out by heavy machinery, perform the removal work so as not to cause damage or overturning, while paying attention to the locations of underground utilities and boundary walls with the adjacent land. If roots of trees and plants enter under boundary walls with the adjacent land or pipes, remove the trees and plants after cutting the roots.

Removing a septic tank

Removing trees and plants

(5) Sorting, accumulation, storage, loading, and carrying-out of construction material waste

Sorting, accumulation, storage, loading, and carrying-out of construction material waste is conducted as described below:

(i) Sorting and accumulation

Generated construction material waste is to be accumulated after sorting it into those to be recycled, those to be carried into an intermediate treatment facility, and those to be carried into a final disposal site based on the above-mentioned plan for sorting/carrying-out.

Not only wood generated in construction and concrete masses, which are designated as specified construction material waste, but also other construction waste, including recyclable articles such as scrap metal and cardboard, are to be accumulated after sorting them by item as much as possible.

Waste which has a risk of being mixed with other waste during the accumulation work are to be packed in bags or accumulated in small boxes or dedicated containers. Furthermore, types of construction material waste are to be displayed at the accumulation places and containers for sorting so that workers on site can easily sort them.

(ii) Storage

Those sorted on site are required to be promptly carried out of the site. However, if they must be temporarily stored in the site, you should pay attention to the following points while complying with the storage standards specified in the Waste Management Act so that the living environment around the site can be adequately preserved.

a) Store each type of construction material waste separately, indicating that this is a storage place for each waste.

b) In particular, if there is industrial waste containing asbestos or CCA-treated wood, they are to be stored separately from other waste until they are carried out, indicating that this is a storage place for each of them.

(iii) Loading

Basically, each item of waste is to be loaded as a single item. Furthermore, as for those light in mass and having large bulkiness, the volume is to be reduced by appropriately bundling them and the loading efficiency is to be improved within a range not exceeding the loading standard by using materials such as plywood which has already been demolished.

(iv) Carrying-out

When carrying out the waste, the efficiency will be improved by carrying out the waste systematically after comprehensively assessing the demolition, sorting, and accumulation situations.

Even if proper sorting and demolition have been implemented, wastes which cannot be sorted are generated on site. In this case, such waste is to be carried out to facilities, such as a separating facility, as a mixed waste.

6.6 Work after completion of demolition work

After completion of demolition work, the following works are to be properly conducted:

- Removal of scaffolding and curing sheets
- Leveling of ground
- Cleaning
- Other works

(1) Removal of scaffolding and curing sheets

Scaffolding and curing sheets are to be removed after the completion of demolition work, or before or after the demolition of the foundation.

(2) Leveling of ground

Leveling of ground is to be conducted after the completion of all work.

(3) Cleaning

Cleaning is to be conducted when it has become unnecessary for vehicles to come in and out of the site. Clean the site and the surrounding roads by means such as sprinkling water.

(4) Others

After completing the above-mentioned cleaning in (3), confirm the following:

- After carrying out heavy machines, conduct a final examination of whether or not curbstones are damaged.
- Confirm boundary stakes and boundary walls.

Submit documents and reports stored to provide a report and explanation of the completion.

7. Proper disposal

- To transport and dispose of construction waste generated from demolition work, direct contract with an operator having an applicable license is required (Waste Management Act).
- When transportation and disposal of construction waste are consigned to another party, an industrial waste management slip (manifest) must be issued (Waste Management Act).
- As for specified construction materials, completion of recycling must be confirmed and reported to the owner in writing.

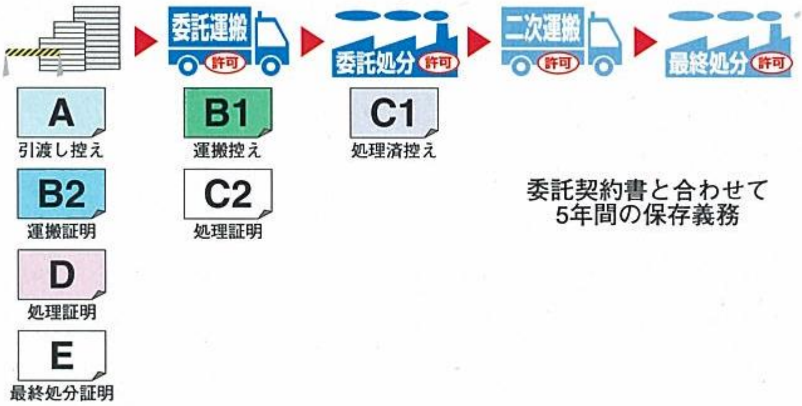
Consignment contract and industrial waste management slip

(Explanation)

The discharging company must conclude a consignment contract for waste disposal in writing with the collector/transporter and the disposal operator, respectively.

A consignment contract for waste disposal should stipulate the fees to be paid by the consignor to the consignee and the address of the final disposal site, in addition to the types of waste and the amount of waste. (Note that there is a standard format prepared by the "Council of Nine Construction Contractors for Countermeasures against By-products" as a format of a consignment contract for construction waste disposal.) Furthermore, the discharging company confirms completion of the final disposal through the industrial waste management slip (manifest).

The manifest must be issued for the discharging company to grasp the flow of the waste. The discharging company is required to manage, check, and retain the manifest after its issuance until the completion of the disposal is confirmed. The manifest is a set of seven sheets and the discharging company checks three sheets (B2, D and E in the figure) returned to it against one of the sheets kept as a duplicate (A in the figure).



* Operation of electronic manifests using a personal computer and a mobile phone has been expanding.

When recycling is completed, the completion is to be reported to the owner in writing and a record relating to the implementation status of recycling is to be created and maintained.

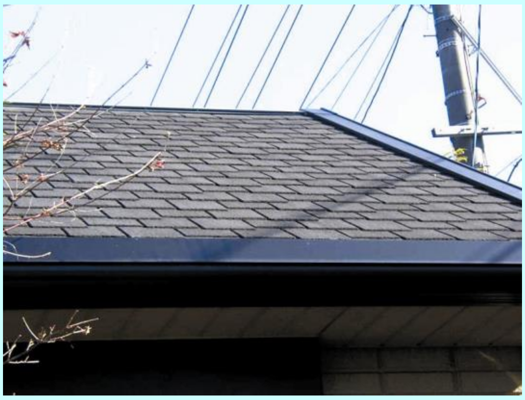
A fine not exceeding 500,000 yen will be imposed breaches of the regulation stipulating the implementation of obligation to recycle, and a non-penal fine not exceeding 100,000 yen to breaches of the obligation to report to the owner.

Reference at the end of the book

Other construction materials containing asbestos (such as molded plates) [Level 3]

Asbestos cement slates (roofs and exterior walls)

Vinyl floor tiles containing asbestos (floors)



Decorative slates for house containing asbestos (roofs)

Asbestos boards (ceramic siding)

Calcium silicate boards containing asbestos

Asbestos cement slates (ceilings)

Confirmation method

Sections where products containing asbestos are used (Operators are required to confirm them by the Industrial Safety and Health Act (Ordinance on Prevention of Health Impairment due to Asbestos).)

The presence/absence of the use of asbestos is required to be surveyed by checking the construction materials and manufacturing time (refer to P.10), and by means of visual inspection, drawings, and specifications, and if it is impossible to be determined, it is required to take samples and analyze them.

Applicable laws and regulations and main contents of regulation

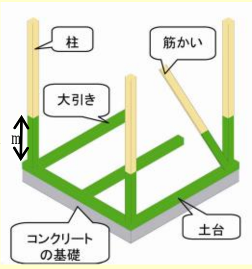
Industrial Safety and Health Act	:	Preliminary survey (Article 3 of Ordinance on Prevention of Health Impairment due to Asbestos)/Preparation of work plan (Article 4 of Ordinance on Prevention of Health Impairment due to Asbestos) Appointment of operations chief of asbestos/Special education for workers/Authorized personnel only/Use of respiratory protective equipment and other dust-proof measures as necessary
Waste Management Act	:	Legal regulation (Refer to the "Technical Guideline Concerning Handling of Non-scattering Asbestos Waste.")
Construction Material Recycling Law	:	Corresponding to attached substances or others described in the "plan for sorted demolition." Notification required.

Contents of main measures

<When demolishing>	Entry prohibited/Posting of signboards/Adequate wetting when removing Removal by human-powered work in principle Workers wear protective masks and work clothes (using materials from which dust can be easily removed). Presentation (Notification concerning work such as demolition of building: Refer to P.10.)
<When disposing>	Asbestos slates and the like are to be disposed of as "glass waste, concrete waste, and pottery waste" or "debris" of industrial waste. Vinyl floor tiles are to be disposed of as "waste plastic" of industrial waste. Disposal is to be consigned to licensed contractors of industrial waste (collection/transport and disposal). Cover a carrying-out vehicle with a sheet to prevent scattering. Crushing of waste at an intermediate treatment facility is prohibited in principle. Waste is to be buried at a least-controlled final landfill site. Describe as "object containing asbestos" or "non-scattering asbestos" in a space of the columns for "Types of industrial waste" in the consignment contract for waste disposal and the manifest.

Heavy metals (CCA-treated wood)

■Used for sills and sleepers (green parts).



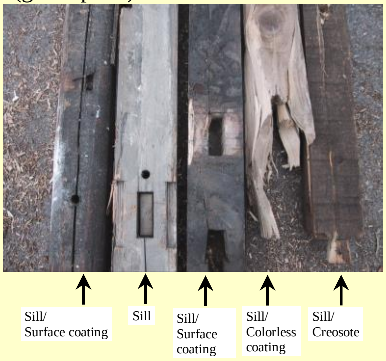


Photo showing that woods treated with agents such as CCA are used.

Confirmation method

Used for sills and sleepers (within a range 1 m above sills).

In some regions, used for other parts.

(Used from the late 1960s to the 1990s)

Contents of main measures

Separate and sort CCA-injected parts from other parts.
CCA-injected parts are to be incinerated according to the Waste Management Act. Other parts are to be recycled.
If separation and sorting is difficult, all of them are to be incinerated and buried according to the Waste Management Act.
Preliminary survey according to the Construction Material Recycling Law.

Arsenic and cadmium (gypsum boards containing arsenic or cadmium)

Gypsum boards containing arsenic or cadmium

Decorated gypsum boards

Confirmation method

Used mainly in eastern Japan, especially in the Tohoku region. Confirm a label attached to the back of a board, with description as shown below.

Gypsum board containing arsenic

Iwaki Plant of Onahama Yoshino Gypsum Board:
Those manufactured from 1973 to April 1997
Label at the back of a board: 吉野石膏 OY (Yoshino Gypsum OY)
Lot number: 03 73 241050C
(March) (1973)

Gypsum board containing cadmium

Hachinohe Plant of Nitto Gypsum Board: Those manufactured from 1992 to 1997

Contents of main measures

<When demolishing> Sorted demolition
<When disposing> Collected by a manufacturer (refer to P.14) or buried at a controlled final disposal site.

PCB (polychlorinated biphenyl)

Ballast for fluorescent lamp

Transformer

Capacitor

Confirmation method

Ballast for fluorescent lamp
Ballast for mercury lamp : Mainly for two 40W lamps or a 110W lamp of the rapid start type (FLR). PCB is not used for general households.

PCB is present in products manufactured from 1957 to 1972.

If it is not clear, make an inquiry to the manufacturer or the Japan Lighting Manufactures Association.

Transformer/capacitor : Confirm with the manufacturer or the Japan Electrical Manufacturers' Association (TEL: 03-3556-5885 URL: http://www.jema-net.or.jp).

Or, confirm with the register of the Prefectural Waste Management Department of the Regional Bureau of Economy, Trade and Industry

Applicable laws and regulations and main contents of regulation

PCB Special Measures Law : Notification required
(Storage, change of state from use to storage, and change of storage location)
(Transfer and reception during storage is prohibited.)

Electricity Business Act : Report use, change of use, disuse, or suspension of use of PCB-containing electric facilities to the chief of the competent Regional Bureau of Economy, Trade and Industry.

Outlines by prefectures : Notification required
(Discovery, loss, missing, accident, etc. of PCB-containing products in use)

Waste Management Act : Assignment of “Manager of special controlled industrial waste” (Notification by prefecture required)

Construction Material Recycling Law : Preliminary survey/advance measures

Contents of main measures

<Disposal Method> The construction owner stores PCB waste based on the Waste Management Act until disposal at a disposal facility described on the next page.

Storage standards: Entry prohibited, installation of signboard (clearly indicating the presence of PCB waste), measures to prevent leakage

PCB waste must be disposed of, until 2016, according to the PCB Special Measures Law.

解体工事見積書の例

工　事　区　分	数量	単位	人工数	単価	金額	備考
1. 仮設工事						
1)外部足場架払損料		㎡				親綱
2)養生シート		㎡				養生シート・防音シート・防音パネル
3)搬出入路の保護養生		㎡				敷鋼板・砕石・コンパネ・他
4)仮設水道		式				
5)仮設トイレ		式				
6)清掃・片付け		㎡				延床面積
小　　計						
2. 住宅設備機器撤去工事						
1)浴槽・ユニットバス撤去		ヶ所				人工×賃金
2)キッチン・洗面化粧台撤去		ヶ所				人工×賃金
3)屋根上設置物撤去		台				太陽温水器、テレビアンテナ
4)エアコン撤去		台				処分費＋運搬費
小　　計						
3. 本体解体工事						
1)内部建具類等撤去		ヶ所				手解体・単品搬出　畳
2)塩ビクロス剥離		㎡				手解体・単品搬出
3)石膏ボード撤去		㎡				手解体・単品搬出
4)外部建具撤去		ヶ所				手解体・単品搬出
5)外部金属部分撤去		㎡				手解体・単品搬出
6)屋根ふき材撤去		㎡				手解体・単品搬出　瓦・セメント・瓦棒・住宅屋根用化粧スレート板
7)躯体撤去		㎡				手・機械併用分別解体 木造軸組・2×4・木質プレハブ・軽量プレハブ・その他
8)基礎撤去・コンクリート撤去		㎡				手・機械併用分別解体
9)小規模建物割増		式				20坪以下上記単価に加算
小　　計						
4. 付属工事						
1)有筋基礎・有筋深基礎割増		㎡				㎡／人工
2)ベタ基礎割増		㎡				㎡／人工
3)ベランダ・バルコニー		㎡				木製・アルミ・鉄製
4)物干し台		組				木製・アルミ・鉄製
5)外部屋根付鉄骨階段・廊下・踊り場		㎡				㎡×人工 木製・アルミ・鉄製
6)小運搬費		m				人力・機械
小　　計						
5. 付帯工事						
1)土間コンクリート　無筋		㎡				㎡／人工　厚15cm以下　カッター入れ別途
有筋		㎡				㎡／人工　厚15cm以下　メッシュ入り含む　カッター入れ別途
2)ブロック塀　軽量		㎡				㎡／人工　カッター入れ別途
重量		㎡				㎡／人工　カッター入れ別途
3)万年塀		㎡				㎡／人工　カッター入れ別途
4)大谷石塀		㎡				㎡／人工　カッター入れ別途
5)RC塀		㎡				㎡／人工　カッター入れ別途
6)板塀・フェンス		㎡				㎡／人工　カッター入れ別途
7)物置		㎡				木造・鉄製
8)車庫		㎡				木造・鉄製・アルミ
9)浄化槽　FRP		台				一般家庭用・汲み取り清掃別途
10)浄化槽　RC		台				一般家庭用・GL800カット・汲み取り清掃別途
11)便槽		台				一般家庭用・汲み取り清掃別途
12)樹木伐採		本				機械・人力
手作業割増		㎡				
13)井戸埋め戻し		ヶ所				
14)整地作業		㎡				労務費＋重機リース代
15)特殊工事		㎡				山留め・切土・地下等
16)重機回送費		回				往復
17)その他(　　　　　　)						
小　　計						
6. 安全管理費						誘導員・道路使用許可
7. 1～6の工事費計						円／㎡ ・ 円／坪単価
8. 運搬費						
1)運搬車両　2t		台				2回転　人工＋リース料＋燃料代
2)運搬車両　4t		台				2回転　人工＋リース料＋燃料代
3)その他運搬車両		台				
小　　計						
9. 産業廃棄物処分費						
1)特定建設資材廃棄物						
①コンクリート		㎡				
②コンクリート及び鉄から成る建設資材		㎡				
③アスファルト・コンクリート		㎡				
④木材						
躯体材(木くず)		㎡				
板材(木くず)		㎡				
合材(焼却木くず)		㎡				
伐採・伐採材(木くず)		㎡				
2)他の建設資材廃棄物						
①廃プラスチック類		㎡				
②金属くず(スクラップ)		㎡				
③ｶﾞﾗｽくず、ｺﾝｸﾘｰﾄくず及び陶磁器くず		㎡				
④がれき類(コンクリートがら)		㎡				
⑤紙くず(障子、襖)		㎡				
⑥繊維くず(畳)		枚				
⑦廃石膏ボード		㎡				
⑧安定型混合廃棄物		㎡				
⑨管理型混合廃棄物		㎡				
小　　計						
10. 1～9の合計						
11. 諸経費						円／㎡ ・ 円／坪単価
12. 消費税						
総　合　計						

資料１

解体工事届出書の様式

（様式第一号）　　　　　　　　　　　　　　　　　　　　　　　　　　（Ａ４）

届　出　書

平成　　年　　月　　日

知事
＿＿＿＿＿＿＿＿市区町村長　殿

フリガナ
氏名（法人にあっては商号又は名称及び代表者の氏名）＿＿＿＿＿＿＿＿印
（郵便番号　　－　　）電話番号　　－　　－

住所＿＿＿＿＿＿＿＿＿＿＿＿

建設工事に係る資材の再資源化等に関する法律第10条第1項の規定により、下記のとおり届け出ます。

記

1．工事の概要
①工事の名称＿＿＿＿＿＿＿＿
②工事の場所＿＿＿＿＿＿＿＿
③工事の種類
□建築物に係る解体工事　□建築物に係る新築又は増築の工事
□建築物に係る新築工事等であって新築又は増築の工事に該当しないもの
□建築物以外のものに係る解体工事又は新築工事等
④工事の規模
建築物に係る解体工事　　用途＿＿＿、階数＿＿＿、工事対象床面積＿＿＿m2
建築物に係る新築又は増築の工事　　用途＿＿＿、階数＿＿＿、工事対象床面積＿＿＿m2
建築物に係る新築工事等であって新築又は増築の工事に該当しないもの
用途＿＿＿、階数＿＿＿、請負代金＿＿＿万円
建築物以外のものに係る解体工事又は新築工事等　　請負代金＿＿＿万円
⑤請負・自主施工の別：□請負　□自主施工

2．元請業者（請負契約によらないで自ら施工する場合は記載不要）
フリガナ
①氏名（法人にあっては商号又は名称及び代表者の氏名）＿＿＿＿＿＿＿＿
（郵便番号　　－　　）電話番号　　－　　－
②住所＿＿＿＿＿＿＿＿
③許可番号（登録番号）
□建設業の場合
建設業許可＿＿＿□大臣□知事＿＿＿号
主任技術者（監理技術者）氏名＿＿＿＿
□解体工事業の場合
解体工事業登録＿＿＿知事＿＿＿号
技術管理者氏名＿＿＿＿

3．対象建設工事の元請業者から法第12条第１項の規定による説明を受けた年月日
（請負契約によらないで自ら施工する場合は記載不要）
平成　　年　　月　　日

4．分別解体等の計画等
（建築物に係る解体工事については別表１
建築物に係る新築工事等については別表２
建築物以外のものに係る解体工事又は新築工事等については別表３
により記載すること。）

5．工程の概要
＿＿＿＿＿＿＿＿
（できるだけ図面、表等を利用することとし、記載することができないときは、「別紙のとおり」と記載し、別紙を添付すること。）

□欄には、該当箇所に「レ」を付すこと。

※受付番号＿＿＿＿＿

別表１　　　　　　　　　　　　　　　　　　　　　　　　　　（Ａ４）

建築物に係る解体工事

分別解体等の計画等

建築物の構造※	□木造　□鉄骨鉄筋コンクリート造　□鉄筋コンクリート造　□鉄骨造　□コンクリートブロック造　□その他（　　）	
建築物に関する調査の結果	建築物の状況	
	周辺状況	
	作業場所の状況	
	搬出経路の状況	
	残存物品の有無	
	付着物の有無	
	その他（　　）	
工事着手前に実施する措置の内容	作業場所の確保	
	搬出経路の確保	
	残存物品の搬出の確認	
	その他（　　）	

工事着手の時期※	平成　年　月　日		
工程ごとの作業内容及び解体方法	工程	作業内容	分別解体等の方法
	①建築設備・内装材等	建築設備・内装材等の取り外し□有　□無	□手作業　□手作業・機械作業の併用　併用の場合の理由（　　）
	②屋根ふき材	屋根ふき材の取り外し　□有　□無	□手作業　□手作業・機械作業の併用　併用の場合の理由（　　）
	③外装材・上部構造部分	外装材・上部構造部分の取り壊し　□有　□無	□手作業　□手作業・機械作業の併用
	④基礎・基礎ぐい	基礎・基礎ぐいの取り壊し　□有　□無	□手作業　□手作業・機械作業の併用
	⑤その他（　　）	その他の取り壊し　□有　□無	□手作業　□手作業・機械作業の併用
工事の工程の順序	□上の工程における①→②→③→④の順序　□その他（　　）　その他の場合の理由（　　）		
建築物に用いられた建設資材の量の見込み※	トン		

廃棄物発生見込量	種類	量の見込み	発生が見込まれる部分（注）
特定建設資材廃棄物の種類ごとの量の見込み及びその発生が見込まれる建築物の部分	□コンクリート塊	トン	□①　□②　□③　□④　□⑤
	□アスファルト・コンクリート塊	トン	□①　□②　□③　□④　□⑤
	□建設発生木材	トン	□①　□②　□③　□④　□⑤

（注）①建築設備・内装材等　②屋根ふき材　③外装材・上部構造部分　④基礎・基礎ぐい　⑤その他

備考

※以外の事項は法第９条第２項の基準に適合するものでなければなりません。
□欄には、該当箇所に「レ」を付すこと。

別表２　　　　　　　　　　　　　　　　　　　　　　　　　　（Ａ４）

建築物に係る新築工事等（新築・増築・修繕・模様替）

分別解体等の計画等

使用する特定建設資材の種類※	□コンクリート　□コンクリート及び鉄から成る建設資材　□アスファルト・コンクリート　□木材	
建築物に関する調査の結果	建築物の状況	
	周辺状況	
	作業場所の状況	
	搬出経路の状況	
	付着物の有無（修繕・模様替工事のみ）	
	その他（　　）	
工事着手前に実施する措置の内容	作業場所の確保	
	搬出経路の確保	
	その他（　　）	

工事着手の時期※	平成　年　月　日	
工程ごとの作業内容	工程	作業内容
	①造成等	造成等の工事　□有　□無
	②基礎・基礎ぐい	基礎・基礎ぐいの工事　□有　□無
	③上部構造部分・外装	上部構造部分・外装の工事　□有　□無
	④屋根	屋根の工事　□有　□無
	⑤建築設備・内装等	建築設備・内装等の工事　□有　□無
	⑥その他（　　）	その他の工事　□有　□無

廃棄物発生見込量	種類	量の見込み	発生が見込まれる部分又は使用する部分（注）
特定建設資材廃棄物の種類ごとの量の見込み並びに特定建設資材が使用される建築物の部分及び特定建設資材廃棄物の発生が見込まれる建築物の部分	□コンクリート塊	トン	□①　□②　□③　□④　□⑤　□⑥
	□アスファルト・コンクリート塊	トン	□①　□②　□③　□④　□⑤　□⑥
	□建設発生木材	トン	□①　□②　□③　□④　□⑤　□⑥

（注）①造成等　②基礎　③上部構造部分・外装　④屋根　⑤建築設備・内装等　⑥その他

備考

※以外の事項は法第９条第２項の基準に適合するものでなければなりません。

□欄には、該当箇所に「レ」を付すこと。

別表３　　　　　　　　　　　　　　　　　　　　　　　　　　（Ａ４）

建築物以外のものに係る解体工事又は新築工事等（土木工事等）

分別解体等の計画等

工作物の構造（解体工事のみ）※	□鉄筋コンクリート造　□その他（　　）	
工事の種類	□新築工事　□維持・修繕工事　□解体工事　□電気　□水道　□ガス　□下水道　□鉄道　□電話　□その他（　　）	
使用する特定建設資材の種類（新築・維持・修繕工事のみ）※	□コンクリート　□コンクリート及び鉄から成る建設資材　□アスファルト・コンクリート　□木材	
工作物に関する調査の結果	工作物の状況	
	周辺状況	
	作業場所の状況	
	搬出経路の状況	
	付着物の有無（解体・維持・修繕工事のみ）	
	その他（　　）	
工事着手前に実施する措置の内容	作業場所の確保	
	搬出経路の確保	
	その他（　　）	

工事着手の時期※	平成　年　月　日		
工程ごとの作業内容及び解体方法	工程	作業内容	分別解体等の方法（解体工事のみ）
	①仮設	仮設工事　□有　□無	□手作業　□手作業・機械作業の併用
	②土工	土工事　□有　□無	□手作業　□手作業・機械作業の併用
	③基礎	基礎工事　□有　□無	□手作業　□手作業・機械作業の併用
	④本体構造	本体構造の工事　□有　□無	□手作業　□手作業・機械作業の併用
	⑤本体付属品	本体付属品の工事　□有　□無	□手作業　□手作業・機械作業の併用
	⑥その他（　　）	その他の工事　□有　□無	□手作業　□手作業・機械作業の併用
工事の工程の順序（解体工事のみ）	□上の工程における⑤→④→③の順序　□その他（　　）　その他の場合の理由（　　）		
工作物に用いられた建設資材の量の見込み（解体工事のみ）※	トン		

廃棄物発生見込量	種類	量の見込み	発生が見込まれる部分又は使用する部分（注）
特定建設資材廃棄物の種類ごとの量の見込み（全工事）並びに特定建設資材が使用される工作物の部分（新築・維持・修繕工事のみ）及び特定建設資材廃棄物の発生が見込まれる工作物の部分（維持・修繕・解体工事のみ）	□コンクリート塊	トン	□①　□②　□③　□④　□⑤　□⑥
	□アスファルト・コンクリート塊	トン	□①　□②　□③　□④　□⑤　□⑥
	□建設発生木材	トン	□①　□②　□③　□④　□⑤　□⑥

（注）①仮設　②土工　③基礎　④本体構造　⑤本体付属品　⑥その他

備考

※以外の事項は法第９条第２項の基準に適合するものでなければなりません。

□欄には、該当箇所に「レ」を付すこと。

施主（所有者）が行う主な許可申請及び届出の例

分類	許可申請・届出	提出先	提出期間	関係法令	備考
建物	建物減失登記	法務局出張所	解体後 1 月以内	不動産登記法 93 の 6	
	家屋取毀届	市町村税務課		地方税法 382	
	官民境界確定願	財務局	2～3 ヶ月前	国有財産法 31 の 3	
各種廃止届け	低圧電灯電力撤去申込	電力会社	廃止 7 日前	電気事業法 73	
	自家用電気廃止申込	電力会社	廃止 30 日前	電力会社供給規程	
	需要設備廃止報告書	通産局	廃止後遅滞なく		
	電話機撤去申込	電話会社	約 7 日前		電話連絡
	水道使用中止届	水道局	約 7 日前		電話連絡
	ガス装置撤去申込	ガス会社	約 7 日前		電話連絡
	危険物貯蔵所廃止届	消防署	遅滞なく	消防法 12 の 6	ｵｲﾙﾀﾝｸ等
	消防指定水利廃止届	消防署	着工前	消防法 21	
	ボイラー廃止報告書	監督署	遅滞なく	ボイラー則※1 48	
	昇降機廃止届	都道府県		建築基準法 12 の 2	
PCB 使用	PCB 含有電気工作物変更報告	当該施設の設置の場所を管轄する経済産業局長	遅滞なく	電気事業法電気関係報告規則第 4 条	
	PCB 含有電気工作物廃止報告			電気事業法電気関係報告規則第 4 条	
PCB 保管	PCB 廃棄物の保管事業場の変更届出書	変更前・変更後の事業場の所在地を所管する都道府県知事	変更した日から 10 日以内	PCB 処理特別措置法※2　施行規則第 5 条	
その他	保存区域内の行為届	都道府県	あらかじめ	古都保存法※3 7,8	
	埋蔵文化財区域内の届	文化庁長官	着工 30 日前	文化財保存法 57 の 2	

※1 ボイラー及び圧力容器安全規則

※2 ポリ塩化ビフェニル廃棄物の適正な処理の推進に関する特別措置法

※3 古都における歴史的風土の保存に関する特別措置法

以上のように分類することにより、木材チップの区

工事施工者が行う許可申請及び届出の例

分類	許可申請・届出	提出先	提出期限	関係法令	備考
建物	建築物除却届	市町村役所	解体前	建築基準法15	
仮建物	工事用仮設建物概要報告書	市町村役所	使用開始7日前	建築基準法12、85	
	防火対策物使用届	消防署	使用開始7日前	火災予防条例	仮建物
道路	道路占用許可申請	道路管理者	使用30～40日前	道路法32	
	道路自費工事許可申請	道路管理者	使用25～40日前	道路法24	
	特殊車両通行許可申請	道路管理者	20～30日前	道路法47の2	
	道路使用許可申請	警察署	使用3～7日前	道路交通法77	
	通行禁止道路通行許可申請	警察署	使用3～7日前	道路交通法8	
環境	特定施設設置届	市町村役所	開始30日前	騒音規制法6	
	特定建設作業実施届	市町村役所	開始7日前	騒音規制法14、振動規制法14	騒音、振動
	指定建設作業実施届	市町村役所	開始7日前	地方自治体条例	騒音及び振動
掘削	沿道掘削願	道路管理者	開始30～40日前	道路法44	沿道区域内
	河川護岸裏掘削願	河川管理者	開始30日前	河川法55	河川保全区域内
	各種近接工事協議書	近接物管理者	開始約30日前	指導事項	JR、営団他
消防	工事中の消防計画届	消防署	遅滞なく	消防法8、8の2	供用建物の解体
	危険物仮貯蔵仮取扱届	消防署	開始15日前	消防法10	10日以内の貯蔵
	圧縮アセチレンガス貯蔵取扱	消防署		消防法90の2	40kgf以上
	場煙行為届	消防署	開始3日前	消防条例	
電気	臨時電灯電力申込	電力会社	使用30日前	電気事業法70	50kw未満
	自家用電気使用申込	電力会社	使用40日前	電気事業法70	50kw以上
給排水	敷地内旧水道撤去願	水道局	7～10日前	条例	
	給水装置新設工事申込	水道局	15～30日前	条例	
	下水道一時使用申告書	水道局	約7日前	条例	
安全衛生	適用事業報告書	監督署	遅滞なく	労働基準法8	
	特定元方事業開始報告	監督署	開始7日前	安衛則664 注)1	
	建設工事計画届	監督署	開始14日前	労働安全衛生法88	31m超の建物
	機械等設置移転届	監督署	開始30日前	労働安全衛生法88	足場(60日以上)
	クレーン設置報告	監督署	あらかじめ	クレーン等安全規則11	3tf未満
	クレーン設置届	監督署	設置開始30日前	労働安全衛生法88	3tf以上
	事故報告書	監督署	遅滞なく	安衛則96	
火薬類	火薬類譲受許可申請	都道府県	30日前	火薬類取締法17	
	火薬類消費許可申請	都道府県	30日前	火薬類取締法25	
	取扱保安責任者選任届	都道府県	30日前	火薬類取締法30	
	火薬類運搬届	公安委員会	1～2日前	総理府令 注)2	
石綿	アスベスト使用建築物に係る事前調査報告	市町村役所	着工前	条例	
	アスベスト除去工事計画書	監督署	開始14日前	労働安全衛生法88、安衛則90	
	特定粉じん排出等作業実施届	都道府県	開始14日前	大気汚染防止法18の15	
	アスベスト使用建築物に係る解体撤去工事完了報告書	市町村役所	完了後	条例	

注)1 安衛則:労働安全衛生規則

注)2 総理府令:火薬類の運搬に関する総理府令

この手引きに関するお問い合わせは下記まで

建設副産物リサイクル広報推進会議

[事務局]**財団法人 先端建設技術センター 企画部**

TEL **03-3942-3991**／FAX **03-3942-0424**

※問い合わせは FAX でお願いします

H20.2

APN project on "Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function of Tropical Asian Urban Cities "
BMA taskforce meeting agenda

Referring to the letter "Ref. 16075/22 November 2016", National Institute for Environmental Studies would like to organize the 1st BMA Taskforce meeting as following.

Please be invited as participant and discussant to the meeting.

Tentative Date: 15th of March, 2016
Tentative Time: 10:00-15:00
Tentative Venue: BMA conference room (if possible)
Participants, BMA taskforce members (DDS, DOE, DSD) and APN project collaborators from Japan and Thailand

Agenda:

1. Introduction of the APN project
   1) Overview of the project
   2) Research components
2. Introduction of the task force and its members
3. Waste management of the Bangkok canals conducted by DDS with statistics data of waste
4. Waste management activities for the Bangkok canals conducted by DOE (including educational campaign)
5. Resident's awareness raising for an appropriate waste disposal by DSD
6. Discussion on the necessary measures and actions to reduce waste in canals
7. Future actions and meetings

APN project:

Appropriate Solid Waste Management towards Flood Risk Reduction Through Recovery of Drainage Function in Tropical Asian Urban Cities

2017.5.30 Kick-off meeting, Hue, Vietnam

Contents of this presentation

-Overview
-Background
-Description of the project
-Quotes from existing literatures
-Objectives
-Project deliverables (outputs)
-Project methodology
-Project schedule

Overview of the project

-Duration: 2 years from 2016.8-2018.7
-Total funding from APN: USD 80,000 (year 1: USD35,000, year 2: USD45,000)
-Target country: Vietnam and Thailand
-Project leader: Dr. Tomonori Ishigaki
-Partner Institutions: National Institute for Environmental Studies (Japan), Hue University (Vietnam) King Mongkut's University of Technology, Thonburi, Joint Graduate School of Energy and Environment, Kasetsart University, Thammasart University (Thailand),

Background

– By 2070s, the top Asian cities in terms of population exposure (including all environmental and socioeconomic factors) to coastal flooding are expected to be Kolkata, Mumbai, Dhaka, Guangzhou, Ho Chi Minh City, Shanghai, Bangkok, Rangoon, and Hai Phòng.

- *In Asian region, due to the climate change, Asian urban cities have been experiencing high precipitation which causes urban flood.*

- *Urban flood has been caused by the lack of drainage capacity.*

Quotes from existing literatures

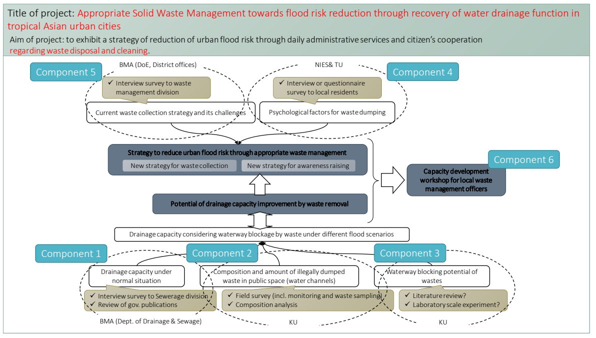
-*Conventional drainage system designs are inappropriate because they fail to take the potential for flooding into account (Kolsky, 2000)*

- *Non-structural approaches are important complementary measures, focusing on actions to prevent and mitigate problems related to flooding, as well as those related to pollution and deterioration in environmental health conditions. A participatory approach is recommended within a strategic framework of urban stormwater planning (Parkinson, 2003)*

Objectives

1) To clarify the impact of waste dumping on water drainage capacity
2) To identify the waste dumping behavior of people, and its institutional/psychological reasons
3) To develop, implement, and disseminate strategy/tool to remove waste and to raise awareness towards appropriate disposal

Based on achieving above objectives, we will aim to clarify and propose effective measures and strategy to remove and prevent waste from becoming barriers to urban drainage function.



Deliverables/outputs

1) Basic data on solid waste that prevents effective urban drainage in Bangkok and Hue (amount, composition, potential to inhibit drainage capacity)

2) Knowledge of flood-resistant SWM

3) Guidance of maintenance of urban drainage by administrative services for Bangkok and Hue

4) Capacity building of the local officers and practitioners based on the guidance

5) Public communication tool, educational materials and programs aiming to change improper waste disposal behaviors of people in urban area

Project methodology

Field investigation

Mathematical modelling

Social surveys

Workshop

Outreach

Detailed activities by component

Component 1

Conduct a series of in-depth interviews to local officers and local experts to understand drainage capacity at normal condition and drainage blockage issues during flood in Bangkok and Hue. Literature reviews shall be also conducted.

Component 2

Investigate an amount and composition of waste that affects urban drainage. Monitor an accumulation trend of waste in drainage system and elucidate the major reasons of blocking on drainages. Also standardize the quantitative parameters.

Detailed activities by component

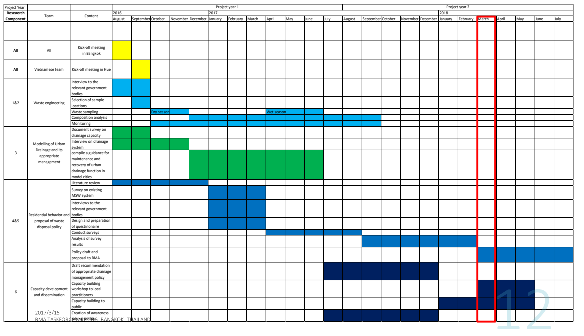
Component 3

Quantitatively examine the impact of the natural and anthropogenic accumulation of debris in drainage systems by mathematical modelling based on the different flood scenarios in urban cities in tropical Asian region.

Integrating the results of components 1-3, we can clarify the impact of informal disposal on the waste drainage capacity, and also indicate the effectiveness of regular removal of waste from urban drainage.

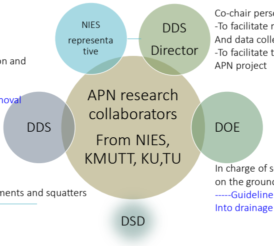
Component 4

Examine the behaviours, psychological factors and institutional factors related to waste dumping and flood response of local people in targeted areas of Bangkok and Hue. In-depth interviews, face-to-face interviews will be conducted to local people to clarify the actual waste disposal behaviours in the locality. Gathered data will be analysed based on the Theory of Planned Behavior.



Tentative idea on BMA task force on
Municipal solid waste removal from Urban drainage in Bangkok

In charge of physical structure of drainage and Sewage and Operation and Maintainance (including waste removal)
-----Guideline for regular waste removal



Co-chair person
-To facilitate research activities
And data collection
-To facilitate the policy proposal from APN project

In charge of solid waste management on the ground
-----Guideline to prevent waste dumping
Into drainage and sewage

In charge of human settlements and squatters

Abbreviation:
DOE: Department of Environment
DDS: Department of Drainage and Sewage
DSD: Department of Social Development
NIES: National Institute for Environmental Studies
KMUTT: King Mongkut's University of Technology, Thonburi
KU: Kasetsart University

Overview of BMA task force

(1) Relationship of this Task force to the above project:

Research collaborators of the above project will be a member of Task Force

(2) Expected functions of the Task force:

1) Sharing of the views and opinions on how the research activities shall be implemented
2) Attendance to the meetings with our research project members to share research results and discuss on policy proposals and program plan
3) Provision of recommendation to relevant department to plan and implement the policy proposals and program plan from this research project
4) Monitoring of the implementation of policy and program

(3) Task Force members:

Co-chair persons: Representative of NIES, Director of Department of Drainage(DDS) and Sewage and Department of Environment(DOE)

Task Force members: APN Project research collaborators, Representative of DDS, DOE and *Department of Social Development(DSD)*

(4) Duration of the Task Force enactment:

Same as research project duration

Kickoff meeting on " Appropriate Solid Waste Management towards flood risk reduction throug recovery of drainage function in tropical Asian urban cities", 25 August, 2016

Literature review related to the project

Tomonori Ishigaki
National Institute for Environmental Studies

BKK Governor: Rubbish-free drains to help prevent floods (15 June 2015)

- Bangkok governor Sukhumbhand Paribatra has ordered his city workers to speed up collection of drain-clogging rubbish in the city to prevent future flash floods as heavy rain is expected to hit the capital again this week.

Bangkok streets flooded, heavier rain warned (3 October 2015)

- Heavy rain continued in Bangkok on Saturday(3 Oct.) morning, causing flooding at 11 locations, while 32 provinces across the country are on full alert for heavy rain, possible flash floods, forest runoff and landslides in risk areas from tomorrow to Tuesday

Ratchaphisek Road near the Lat Phrao-Ratchada intersection

Living with floods in a Bangkok soi (23 June 2016)

- A community in Bang Khen district has been forced to live with floodwater for at least three full days
- all 180 houses in Soi Ramintra 34 were still flooded after the district suffered an unusually heavy downpour that struck right across BKK in the early hours of Tuesday. After 3 hours of heavy rain, the water level in the soi off Ramintra main road rose sharply, and yesterday was still 50 cm high, forcing people to leave their cars at home.

Bangkokians warned of prolonged flooding (24 June 2016)

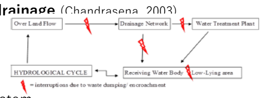
- Bangkok residents are being warned about the potential for severe flooding as the capital is expected to be hit hard by torrential rainfall in September to November.

Socio-economic factors inhibiting the adoption of modern solutions for problems of urban drainage in developing countries (Silveria, WS&T 2002, 45, 31-40;)

(1) In matters of urban drainage, 19th-century sanitary philosophy still dominates
(2) Both legal and clandestine land settlement limits the space that modern solutions require
(3) Contamination of storm runoff by foul sewage, sediment and garbage prevents adoption of developed-country practices
(4) Climatic and socio-economic factors favour the growth of epidemics where runoff is retained for flood-avoidance and to increase infiltration
(5) Lack of a technological basis for adequate drainage management and design
(6) Lack of the interaction between community and city administration that is needed to obtain modern solutions to urban drainage problems

Drainage capacity and the lost by waste blocking

Importance of Solid waste-resistant Urban drainage (Chandrasena, 2003)



i. The pattern of flash flood occurrence
ii. The pattern of solid waste disposal
iii. Failing factors of existing storm drainage system

Estimation of litters in waterways by waste disposal patterns (Armitage et al,1998)

T = Σ fsci(Vi + Bi)Ai

where T: total litter load in the waterways (m^3/yr)
fsci: street cleaning factor for each land use (from 1.0 for regular street cleaning to about 6.0 for nonexistent street cleaning / complete collapse of services)
Vi: vegetation load for each land use (from 0.0 m^3/ha·yr for poorly vegetated areas to about 0.5 m^3/ha·yr for densely vegetated areas)
Bi: basic litter load for each land use (commercial= 1.2 m^3/ha·yr industrial= 0.8 m^3/ha·yr residential= 0.01 m^3/ha·yr)
Ai :area of each land use (ha)

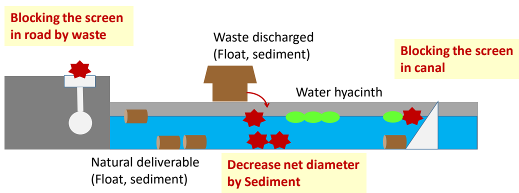
Theoretical mechanisms of blockage of drainage and importance of regular maintenance.

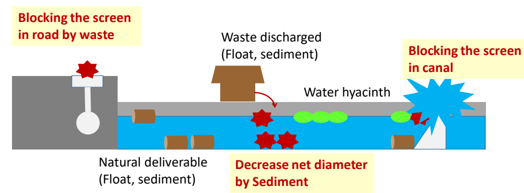
Formula of head loss estimation (Kirschmer, 1926)

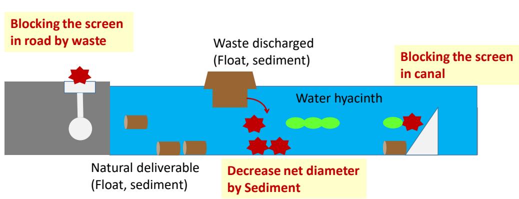
$$hr = fr \cdot \frac{v_1^2}{2g} = \beta \sin\theta \left(\frac{t}{b}\right)^{4/3} \cdot \frac{v_1^2}{2g}$$

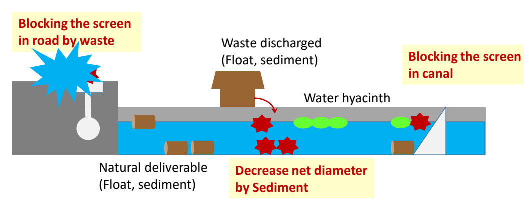
where
hr: Head loss by screen
v1: upstream velocity
fr: Coefficient of head loss
β: Coefficient of cross sectional shape of screen
θ: Angle of screen
b: interval of lattice
t: thickness of lattice

type	Proposed "β"	
b=100 mm, t=12 mm b=40 mm, t=5 mm	2.42 2.42	
b=100 mm, t=12mm b=40 mm, t=5 mm	91.9 91.9	
b=100 mm, t=12mm b=40 mm, t=5 mm b=20 mm, t=6 mm	91.9 91.9 46.9	
b=100 mm, t=12mm b=40 mm, t=5 mm b=20 mm, t=6 mm	91.9 91.9 46.9	Considering bottom 0.85 m accumulation

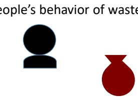








People's behavior of waste discharge



Block the curbside drainage gate

Block the canal/drainage gate

Block the pump station screen

APN project on "Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function of Tropical Asian Urban Cities "
BMA 2nd taskforce meeting agenda

Referring to the letter "Ref. 16075/22 November 2016", National Institute for Environmental Studies would like to organize the BMA 2nd Taskforce meeting as following.

Please be invited as participant and discussant to the meeting.

Tentative Date: 27th or 28th of March, 2018
Tentative Time: 10:00-15:00
Tentative Venue: BMA conference room (Room to be identified later)
Participants: BMA taskforce members (DDS, DOE, DSD etc.) and APN project collaborators from Japan and Thailand
Other expected participants:

1) Department which is in charge of public works project on resettlement
2) Department which is in charge of construction management of public works project

Agenda:

1. Opening
2. Brief introduction of the APN project
3. Introduction of the task force and participants
4. Progress report of research out from each component
5. Waste management of the Bangkok canals conducted by DDS with statistics data of waste
6. Waste management activities for the Bangkok canals conducted by DOE (including recent campaigns on appropriate waste dumping)
7. Resident's awareness raising for an appropriate waste disposal by DSD
8. Discussion on the future joint activities in the project
   1) Policy recommendation to BMA on the reduction of waste in canals
   2) Policy recommendation to BMA on the management of construction and demolition waste from the resettlement project
   3) Awareness raising videoclip to prevent the waste dumping in canals
9. Future meetings and housekeeping issues
10. Closing

Component 5
Current waste collection strategy and its challenges

Progress on survey of MSW collection services in comparative cities

27th March 2018

Kosuke KAWAI
National Institute for Environmental Studies, Japan

Key mitigation actions to prevent flood derived from MSWM

Three key actions to mitigate flood derived from municipal solid waste (MSW) management:
1) Prevention MSW from scattering
2) Prevention MSW from flowing into drainage
3) Prevention MSW from blocking drainage
These three key actions depend on the public services of cities and are divided into several countermeasures as bellow.

Prevention MSW from scattering

To collect MSW from all areas

To designate time and places for MSW disposal

To collect MSW frequently

To punish littering

Prevention MSW from flowing into drainage

To clean streets frequently

Prevention MSW from blocking drainage

To clean drainage frequently

Comparative cities

Vietnam

City	Population in 2016
Huế	355,095
Cà Mau	224,345
Long Xuyên	286,024
Mỹ Tho	228,385

Thailand

City	Population in 2016
Chiang Mai	131,091
Hat Yai	159,627
Nonthaburi	255,793

Organizations in charge of public services on sanitation

Country	City	MSW collection	Street cleaning	Drainage cleaning
Vietnam	Huế	HEPCO	HEPCO	HEPCO
	Cà Mau	MSW collection team of CAMENCO	Street sweep team of CAMENCO	Drainage team of CAMENCO
	Long Xuyên	MSW collection team of An Giang URENCO	Street sweep team of An Giang URENCO	Drainage team of An Giang URENCO
	Mỹ Tho	Environmental sanitation team of My Tho URENCO	Environmental sanitation team of My Tho URENCO	Road construction, drainage team of My Tho URENCO
Thailand	Chiang Mai	Office of the Engineer, Division of Public Works	Office of Kwaeng, Division of Public Cleansing	Office of the Engineer, Division of Maintenance
	Hat Yai	Environment Office	Environment Office	Environment Office
	Nonthaburi	MSW Management Services	MSW Management Services	Night Soil Management Services

Coverage of MSW collection

Country	City	Coverage rate
Vietnam	Huế	95-97%
	Cà Mau	93%
	Long Xuyên	100% in urban areas 60% in suburban areas
	Mỹ Tho	58.86%
Thailand	Chiang Mai	100%
	Hat Yai	100%
	Nonthaburi	100%

Frequency of public services

Country	City	MSW collection	Street cleaning	Drainage cleaning
Vietnam	Huế	Daily in high population density Twice a week in low population density	Daily	Every 3-6 month
	Cà Mau	Daily	Daily	Monthly
	Long Xuyên	Daily	Daily	Daily
	Mỹ Tho	Daily	Daily	Twice a year
Thailand	Chiang Mai	Daily	Daily	28 days a month
	Hat Yai	Daily	Daily	30 days a month
	Nonthaburi	Twice a week	Six times a week	NA

Time to dispose of household waste

Country	City	Time	Note
Vietnam	Huế	Designated time	6pm-9pm
	Cà Mau	Anytime	
	Long Xuyên	Anytime	
	Mỹ Tho	Anytime	
Thailand	Chiang Mai	Designated time	
	Hat Yai	Designated time	
	Nonthaburi	Designated time	

MSW Collection fee for household

Country	City	Collection fee	Amount	Note
Vietnam	Huế	Yes	24,000-30,000 VND per month[1)] 67,000-97,000 VND per month[2)]	[1)] Without business activities, [2)] with business activities
	Cà Mau	Yes	22,000 VND per month	
	Long Xuyên	Yes	15,000[3)]-20,000[4)] VND per month	[3)] Suburban, [4)] urban
	Mỹ Tho	Yes	15,000 VND per month	
Thailand	Chiang Mai	Yes	20-40 THB per month	The collection fee depends on cities. Each city may set the punishment according to Law 2535 (1992)
	Hat Yai	No	–	
	Nonthaburi	Yes	40 THB per month	

MSW Collection service for those who do NOT pay collection fee

Country	City	MSW collection service
Vietnam	Huế	Yes
	Cà Mau	Yes
	Long Xuyên	Yes
	Mỹ Tho	Yes
Thailand	Chiang Mai	Yes
	Hat Yai	Yes
	Nonthaburi	Yes

Legal punishment for littering

Country	City	Punishment	Amount	Note
Vietnam	Huế	Yes	3,000,000-7,000,000 VND	Decree No.155/2016/ND-CP However the implementation of the Decree has yet to be properly enforced.
	Cà Mau	No	–	
	Long Xuyên	No	–	
	Mỹ Tho	No	–	
Thailand	Chiang Mai	Yes	2,000 THB	The punishment depends on cities. Each city may set the punishment according to Law 2535 (1992)
	Hat Yai	No	–	
	Nonthaburi	Yes	5,000 THB	

กองระบบคลอง
สำนักการระบายน้ำ

การบำรุงรักษาคูคลอง โดยการจัดเก็บขยะ วัชพืช ผักตบชวา

ความเป็นมา

กรุงเทพมหานคร มี คู คลองทั้งหมด จำนวน 1,682 คลอง ความยาวรวม 2,604 กิโลเมตร และดูแลบึงรับน้ำ จำนวน 21 แห่ง มีปริมาตรทั้งหมด 12,729,999 ลูกบาศก์เมตร

สำนักการระบายน้ำ ดูแลรักษา จำนวน 213 คลอง ความยาวรวม 953 กิโลเมตร คู ลำราง ลำกระโดง จำนวน 5 แห่ง ความยาวประมาณ 8 กิโลเมตร รวม 218 คลอง ความยาวประมาณ 961กิโลเมตร

สำนักงานเขตต่าง ๆ ดูแลรักษา จำนวน 948 คลอง ความยาวรวม 1,319 กิโลเมตร คู ลำราง ลำกระโดง จำนวน 516 แห่ง ความยาวประมาณ 324 กิโลเมตร รวม 1,464 คลอง ความยาวประมาณ 1,643 กิโลเมตร

แนวทางปฏิบัติในการ กำจัดผักตับชวา และวัชพืช

1. การใช้แรงงาน

2. การใช้เครื่องจักร

- รถงับผักตบชวา

2. การใช้เครื่องจักร

- เรือกำจัดผักตบชวา

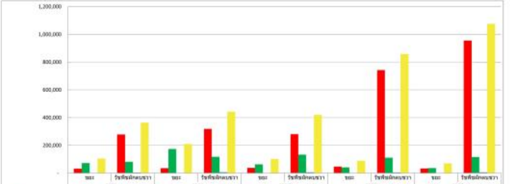
สถิติข้อมูลการเก็บขยะ วัชพืชผักตบชวา ในลำราง คู คลอง บึงรับน้ำ และแม่น้ำ ปีงบประมาณ 2555 – 2559 ในกรุงเทพมหานคร

หน่วยงานที่รับผิดชอบ	ปี 2555	ปี 2556	ปี 2557	ปี 2558	ปี 2559
1.สำนักงานเขต 50 เขต	310,762	356,663	320,357	791,511	988,506
2.สำนักการระบายน้ำ	152,688	298,178	194,824	151,289	151,648
3.สำนักสิ่งแวดล้อม	3,724	5,412	5,090	4,307	5,129
รวมขยะ-วัชพืช (ตัน)	467,177	652,262	520,271	947,107	1,145,283

ผักตบชวา ประมาณ 90 – 95% ขยะ ประมาณ 5 – 10%

สถิติข้อมูลการเก็บขยะ วัชพืชผักตบชวา ในลำราง คู คลอง บึงรับน้ำ และแม่น้ำ ปีงบประมาณ ๒๕๕๔ - ๒๕๖๐
ในกรุงเทพมหานคร

ลำดับที่	หน่วยงานที่รับผิดชอบ	ปริมาณที่จัดเก็บปีงบประมาณ / ตัน									
		๒๕๕๕		๒๕๕๖		๒๕๕๗		๒๕๕๘		๒๕๕๙	
		ขยะ	วัชพืชผักตบชวา	ขยะ	วัชพืชผักตบชวา	ขยะ	วัชพืชผักตบชวา	ขยะ	วัชพืชผักตบชวา	ขยะ	วัชพืชผักตบชวา
๑	สำนักงานเขต ๕๐ เขต	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
๒	สำนักการระบายน้ำ	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
๓	สำนักสิ่งแวดล้อม	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	รวมทั้งสิ้น	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	รวมขยะ-วัชพืชผักตบชวา	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	



	2555 ขยะ	2555 วัชพืชผักตบชวา	2556 ขยะ	2556 วัชพืชผักตบชวา	2557 ขยะ	2557 วัชพืชผักตบชวา	2558 ขยะ	2558 วัชพืชผักตบชวา	2559 ขยะ	2559 วัชพืชผักตบชวา
สำนักงานเขต 50 เขต	32,288	278,474	36,521	320,142	38,880	281,477	48,013	743,498	33,853	954,653
สำนักการระบายน้ำ	71,648	81,040	173,182	117,005	62,344	132,480	40,652	110,637	35,769	115,879
สำนักสิ่งแวดล้อม	75	3,652	108	5,304	102	4,988	87	4,220	104	5,025
รวมทั้งสิ้น	104,011	363,166	209,811	442,451	101,326	418,945	88,752	858,355	69,726	1,075,557

สาเหตุและปัญหา

1. ผักตบชวาจะมีมากในพื้นที่เขตชั้นนอกฝั่งพระนคร เช่น เขตคลองสามวา มีนบุรี หนองจอก ลาดกระบัง และฝั่งธนบุรี เช่น เขตทวีวัฒนา ตลิ่งชัน
2. ผักตบชวาเกิดขึ้นในพื้นที่และไหลมาจากนอกพื้นที่นอกกรุงเทพมหานคร เช่น คลองหกวา คลองมหาสวัสดิ์
3. ผักตบชวาเป็นวัชพืชน้ำที่มีการเจริญเติบโตอย่างรวดเร็วมาก
4. ทำให้การระบายน้ำไม่สะดวก
5. ทำให้มีปัญหาการสัญจรทางน้ำ

ปัญหาอุปสรรค

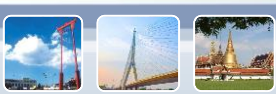
1. สภาพพื้นที่คู คลอง อยู่ห่างจากถนน มีสิ่งสาธารณูปโภคกีดขวาง เป็นอุปสรรคในการขนย้ายขยะ วัชพืช ผักตบชวา

2. สภาพคลองมีบ้านเรือนประชาชนและสิ่งปลูกสร้างรุกล้ำ

ปัญหาอุปสรรค

3. สภาพเขื่อน ค.ส.ล. เป็นอุปสรรคต่อการเก็บขยะทางเรือ
4. การนำขยะ วัชพืช ผักตบชวา ซึ่งไม่สามารถทิ้งข้างตลิ่งได้ไปทิ้งที่โรงงานกำจัดขยะมูลฝอยของกรุงเทพมหานครซึ่งมีระยะทางไกล ทำให้การขนย้ายล่าช้า
5. ไม้ไผ่ที่ทำแพดักขยะ ผักตบชวา ถูกทำลายจากประชาชนที่จับสัตว์น้ำ จึงต้องมีการจัดทำใหม่อยู่ตลอดเวลา
6. ต้องจัดเก็บผักตบชวาในคลองที่มีปริมาณหนาแน่นจากที่ไหลมาจากพื้นที่ภายนอกอย่างต่อเนื่อง ทำให้แรงงานไม่เพียงพอในการดำเนินการ
7. ข้อจำกัดของอัตรากำลัง เครื่องมือ อุปกรณ์ ยานพาหนะ ที่ใช้ในการปฏิบัติงานมีไม่เพียงพอ เนื่องจากต้องช่วยสนับสนุนหน่วยงานอื่นในการป้องกันและแก้ไขปัญหาน้ำท่วม
8. ขาดการมีส่วนร่วมของประชาชนริมคลองในการอนุรักษ์ และพัฒนาคู คลอง

Solid Waste Collection in the River of Bangkok

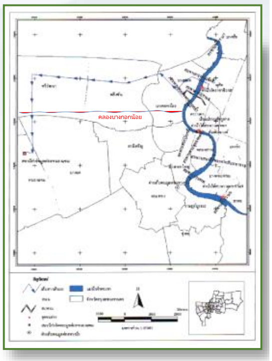


Department of Environment
Bangkok Metropolitan Administration

Area of Solid Waste Collection

Department of Environment has a mission on solid waste collection in the river, covering the area of

1. The Chao Phraya River in Bangkok, from Rama 7 Bridge (Bang Sue District) to Wat Yothin Pradit (Bangna District).
   - Distance 34 Km. covered 17 district
2. Klong Bangkok Noi, from upstream to Klong Mahasawas
   - Distance 4.2 Km.



Solid Waste Collection Boats

A Waste Collection Boat
Size 2x6 m

A Waste Collection Boat
Size 2x8 m

Solid Waste Collection Boats

A Waste Collection Boat
Size 4x14 m

A Conveyor Boat
Size 6x14 m

An Investigator Boat
Size 2x6 m

A Truck Crane

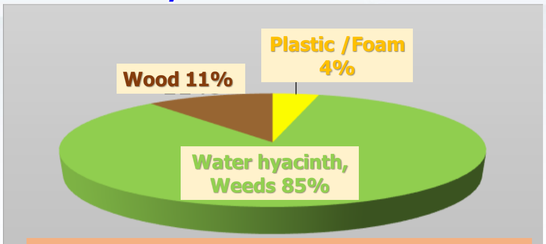
Solid Waste Collection in the River

- Water hyacinth
- Weeds
- Woods
- Debris
- etc.

Amount of Collected Solid Waste in the Chao Phraya River (in 2013 – 2017)

Type	Amount (tons)				
	2013	2014	2015	2016	2017 (Oct 16-Feb 17)
Weeds, Hyacinth	4,170	3,679	3,853	2,994	1,263
Wood	508	788	482	187	688
Plastic, Foam, etc.	153	263	144	187	344
Total	4,831	4,730	4,479	3,368	2,295

Solid Waste Composition in the Chao Phraya River



Waste Composition from Chao Phraya River between 2013 - 2016

Amount of Collected Waste in the Chao Phraya River ~ 12 Tons/Day

Problems

1. **In the rainy season, water hyacinth and weeds in the Chao Phraya River float and scatter on the surface of water, causing the difficulties of collection**

   - The collection can be performed only daytime.

2. **The heavy traffic in the river and the fluctuation of tide would effect in water hyacinth collection.**
3. **Less awareness on public participation of waste management in the waterfront communities**

The Project on Environmental Management by Community

Project: Solid Waste & Wastewater Management by Community (12 Surrounded Canals, 12 Districts)

- To study the pattern of Solid Waste & Wastewater Management by Community.
- Research on Public Participation on Solid Waste & Wastewater Management by Community in Pilot Project

Step 1: Reduce Waste, Waste Separation and Utilization
Step 2: Organizing & Collecting for Waste Separation
Step 3: Water Treatment, Recovery the Canal/River
Step 4: Improve Community Environment

Klong-Suanluang, Bangkorleam District
Klong-Pravateburirom, Ladkrabang District
Klong-Jorakekob, Pravate District
Klong-Ladmayom, Talingchan District
Klong-Mon, Bangkok-noi and bangkok-yai District
Klong-Bangkok-yai, Pasrichalern and Bangkok-yai District
Klong-Bangsue, Phayathai District
Klong-Prakanong, Klong-toey district
Klong-Song, Sai-mai District
Klong-Sansap, Bangkapi District
Klong-Bangprom, Taweewatana District
Klong-Bangchak, Bangkare District

10

Suggestions

1. **Research & Develop for Hyacinth Utilization due to the Possibility for Raw Material in Nong Khaem & Onnut Nightsoil Composting Plant**
2. **Collaboration Between Upstream & Downtream Province Before Chai Nat Dam to Control the Amount and Dispose all the Hyacinth**
3. **Collaboration in Educational Institute (Such as Navamindradhiraj University) to Study the Amount and Life Cycle of Hyacinth for Controlling**
4. **DoE and District Office would Survey the Amount of Hyacinth and Set Up the Management**
5. **Incentive and Promoting for Public Participation in Hyacinth Disposal in the River**

Development of numerical model on river and solid debris

Kosuke Nakamura

1. Introduction

A flood in tropical Asian urban cities is serious for citizens and companies. It happens when storm sewage is excessive for drainage capacity of a canal. Drainage capacity is reduced by obstacles in a canal. One possible obstacle is a slit-like structure such as a slit dam which is clogged by solid debris. Solid debris include plants, woods, plastics, forms, sediment, etc. However, the process of clogging slit-like structures is unknown. In addition, effects on the above process by flow velocity in canals and composition of solid debris are not discovered. In this study, we have considered a numerical model describing clogging of slit-like structures.

2. Method

A canal is assumed to consist of canal bed, slit-like structures, solid debris and water. Canal bed and slit-like structures is represented by rigid bodies. Solid debris are represented by rigid bodies and soft bodies. We chose Bullet Library (Fig.1) to describe their kinetic behavior. Water is a difficult analysis object with free surface flow and moving boundary. Grid-based numerical methods were not applicable. A mesh-free numerical method was necessary. We chose smoothed particle hydrodynamics (SPH, Fig.2) method which has been used to describe complicated flow. Parameters for each component were measured in Rad Phrao canal. Parameters include density, shape, size, etc. The numerical model will be validated by comparing results from the model and experiments.

3. Progress

We visited Lad Phrao canal to obtain parameters of solid debris. In addition, we could have an interview to an officer in a pump station connected to Rama IV tunnel. According to the gathered information, we got rough information of kinematic behaviors of solid debris.

During a flood, water flow in a canal is vigorous so that every solid debris does not stay on a water surface nor on a canal bed. This does not happen without a flood. Then, kinematic behaviors of solid debris are expected to be strongly affected by flow velocity. Relationships between kinematic behaviors of solid debris and flow velocity will be tested.

In addition, a process of clogging slit-like structure is expected to occur with increasing speed. When a part of a slit-like structure is blockaded by a solid debris, cross-sectional area of a flow passage is reduced. This reduction makes flow faster. Faster flow pushes solid debris onto slit-like structure with stronger force. This flow bypasses solid debris on a slit-like structure. This change in streamline help solid debris to blockade remaining flow passage. The above behavior will be tested by numerical model.

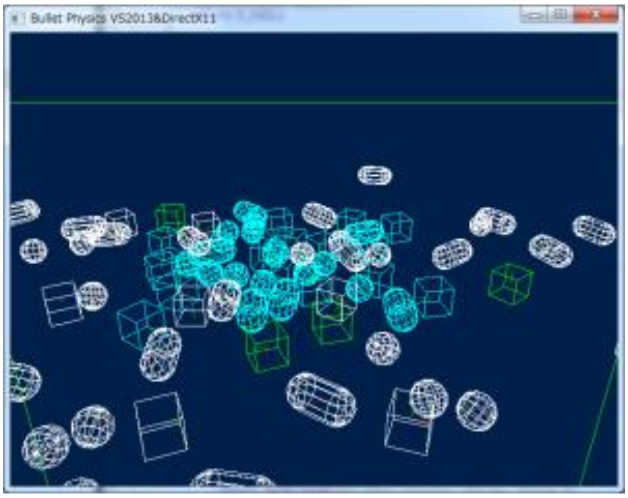


Fig.1 Rigid body kinematics by Bullet Library

(Source: http://zerogram.info/?p=1558)

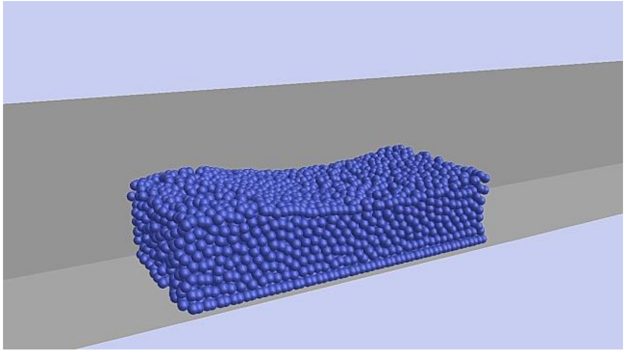


Fig.2 A simple flow in a virtual canal with periodic boundary by Smoothed particle hydrodynamics (SPH)

APN project 2nd BMA Taskforce meeting

Date: 27th of March, 2018 10:00am-15:00pm

Participants: Chaired by Khun Suthimol (Deputy director of DDS)

6 other officers from DDS

Khun Wachiraporn of Department of Environment

Khun …. Department of Public Works

APN project collaborators (Ajarn Chat, Ajarn Sirin, Ajarn Pueng, Ajarn Komsilp, Mr. Rawit, Dr. Ishigaki, Dr. Tajima, Ms. Kubota)

Future steps:

1) KU will conduct the composition analysis of part of canal near KU which does not have redevelopment project to compare the waste composition from Ladphrao canal where the redevelopment project is implemented. It will be conducted within a few month.
2) For capacity building training, it will be held in the early part of June. DDS will contact NIES soon about the date proposal. Khun Suthimol recommended to invite the community in Bangkok with successful case on community-based wastewater/solid waste management to the training. She shared that it is very critical that communities actively take part and set their own rules for solid waste management to keep their communities clean. NIES acknowledged the importance of the active engagement of communities and will integrate her idea into the training program. NIES will communicate to DDS with the detailed program for the training and submit it together with the official letter.
3) For awareness raising tool, Khun Suthimol recommended to refer to the existing BMA tool such as "Canal Guardians" from 2015 not to duplicate the idea. DDS shared the material and NIES will further study to target different stakeholders when preparing the awareness raising tool.

END

Annex C

"No waste in canals" Capacity development training for BMA decision-makers
Date: 13th of June, 2018 Time: 9:30-15:00
Participants: Directors, Management level officers of BMA department and district officers
Venue: Century Park Hotel, Bangkok, Thailand

	Time	Contents	In charge	Remarks
	9:00	Registration starts		
	9:30	Opening remarks	Dr. Yamada	
	9:40	Opening remarks from BMA	TBD	
	9:50	Group photo session		
	10:00-10:20	Introduction of the issue in "waste in canals" and the APN project	Dr. Ishigaki Translation: Dr. Pueng	
	10:20-10:45	Research findings from waste composition analysis in Bangkok canals	KU Translation: Khun Rawit	
	10:45-11:10	Research findings from the development of empirical model for determining the reduction of drainage capacity under different waste blockage condition	KU&Dr. Nakamura Translation: Khun Rawit	
	11:10-11:35	Research findings from the waste management practices of Bangkok and other cities in Thailand and Vietnam	Dr. Kawai Translation: Dr. Komsilp	
	11:35-12:00	Research findings from residents survey on their waste disposing behavior in Bangkok and Hue	Dr. Tajima and TU Translation: Khun Suthep	
	12:00~13:00	Lunch		Ask Dr. Pueng to order the lunch box
	13:00~13:15	Introduction of awareness raising tools based on research outputs	Ms. Kubota Translation: Dr. Komsilp	
	13:15~14:55	Preparation of action plan in respective department/distrcit offices for reduction of waste dumping in canals and sewages 1. Filling a sheet of action plan (15) 2. Sharing of idea by group (45) 3. Sharing with audience (30)	Overall facilitator: Aj. Sirin Translation: Dr. Pueng	4-5 persons in each group 1. Prepare big paper 2. colored pens
		4. Wrap-up (15)		
	14:55-15:00	Closing remarks	Aj. Chart	

"No waste in canals" Capacity development training for BMA decision-makers
Date: 12th of June, 2018 Time: 9:30-14:30
Participants: Directors, Management level officers of BMA department and district officers
Venue: BMA conference room, Bangkok, Thailand

	Time	Contents	In charge
	9:00	Registration starts	
	9:30	Opening remarks	Dr. Yamada
	9:40	Opening remarks from BMA	TBD
	9:50	Group photo session	
	10:00-10:20	Introduction of the issue in "waste in canals" and the APN project	Dr. Ishigaki Translation: Dr. Pueng
	10:20-10:45	Research findings from waste composition analysis in Bangkok canals	KU Translation: Khun Rawit
	10:45-11:10	Research findings from the development of empirical model for determining the reduction of drainage capacity under different waste blockage condition	KU&Dr. Nakamura Translation: Khun Rawit
	11:10-11:35	Research findings from the waste management practices of Bangkok and other cities in Thailand and Vietnam	Dr. Kawai Translation: Dr. Komsilp
	11:35-12:00	Research findings from residents survey on their waste disposing behavior in Bangkok and Hue	Dr. Tajima and TU Translation: Khun Suthep
	12:00~13:00	Lunch	
	13:00~13:15	Introduction of awareness raising materials based on research outputs	Ms. Kubota Translation: Dr. Komsilp
	13:15~14:25	Discussion on necessary policy intervention by BMA	Overall facilitator: Aj. Sirin Translation: Dr. Pueng
	14:25~14:30	Closing remarks	Aj. Chart

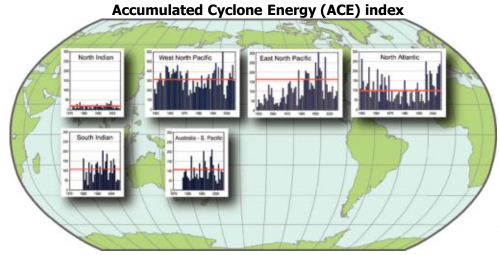
Introduction of the issue in "waste in canals" and the APN project

Tomonori ISHIGAKI
National Institute for Environmental Studies

Century of High Disaster Risk

Frequency and **Intensity** of extreme events has been increased as a result of human influences on climate. Climate change may be perceived most through the impacts of extremes, although these are to a large degree dependent on the system under consideration, including its vulnerability, resiliency and capacity for adaptation and mitigation. (ref IPCC AR4)

Accumulated Cyclone Energy (ACE) index



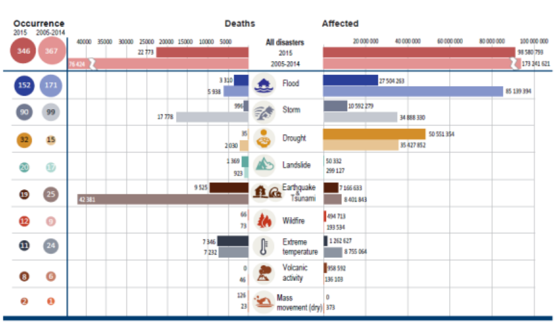
Major Natural Disaster

- Cyclone (Hurricane, Typhoon)
- Tornado
- Flood
- Earthquake and Tsunami
- Eruption of Volcano
- Drought
- Cold wave
- Abnormal Weather (continues rain, rain in dry season, etc)

Recent Disaster: Typhoon Haiyan

"we cannot afford to procrastinate on climate action"

Damages by Natural Hazards



Bangkok hit by flash floods (15 Oct. 2017)

Areas of Thailand's capital, Bangkok have been severely disrupted after being hit by flash floods. The floods triggered by an overnight downpour were the heaviest Bangkok had seen in 25 years and overwhelmed the city's drainage system. The water took six hours to recede in some area of the capital. At least 55 major roads were submerged by floodwater which caused traffic jams across the capital with locals forced to wade through thigh-deep water.

BKK Governor: Rubbish-free drains to help prevent floods (15 June 2015)

Bangkok governor has ordered his city workers to speed up collection of drain-clogging rubbish in the city to prevent future flash floods as heavy rain is expected to hit the capital again this week.

Living with floods in a Bangkok soi
(23 June 2016)

- A community in Bang Khen district has been forced to live with floodwater for at least three full days
- all 180 houses in Soi Ramintra 34 were still flooded after the district suffered an unusually heavy downpour that struck right across BKK in the early hours of Tuesday. After 3 hours of heavy rain, the water level in the soi off Ramintra main road rose sharply, and yesterday was still 50 cm high, forcing people to leave their cars at home.

APN project:
Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function in Tropical Asian Urban Cities

Overview of the project

- Duration: 2 years from 2016.8-2018.7
- Total funding from APN: USD 80,000 (year 1: USD35,000, year 2: USD45,000)
- Target country: Thailand and Vietnam with Japanese Researchers
- Project leader: Dr. Tomonori ISHIGAKI
- Partner Institutions: National Institute for Environmental Studies (Japan), King Mongkut's University of Technology, Thonburi, Joint Graduate School of Energy and Environment, Kasetsart University, Thammasart University (Thailand), Hue University (Vietnam)
- Collaboration: Bangkok Metropolitan Authority, Hue Environmental Protection Company

Objectives and Output

- To clarify the impact of waste dumping on water drainage capacity
- To identify the waste dumping behavior of people, and its institutional/psychological reasons
- To develop, implement, and disseminate strategy/tool to remove waste and to raise awareness towards appropriate disposal

Based on achieving above objectives, we will aim to propose effective measures and strategy to reduce urban flood risk through removing and preventing waste from becoming barriers to urban drainage function, by daily administrative services and citizen's cooperation .

Project Methodology

Field investigation

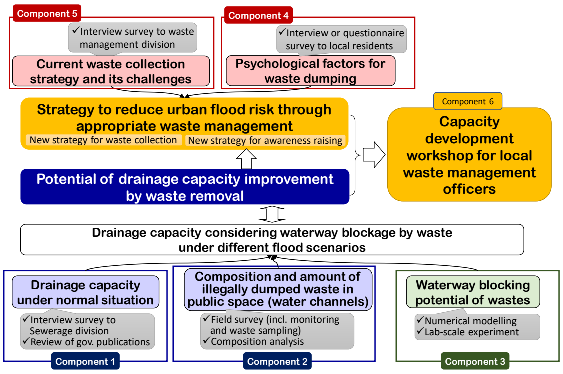
Mathematical modelling

Social surveys

Workshop

Outreach

Outline of the Project



Detailed activities by component

Component 1

- Conduct a series of in-depth interviews to local officers and local experts to understand drainage capacity at normal condition and drainage blockage issues during flood in Bangkok and Hue. Literature reviews shall be also conducted.

Component 2

- Investigate an amount and composition of waste that affects urban drainage. Monitor an accumulation trend of waste in drainage system and elucidate the major reasons of blocking on drainages. Also standardize the quantitative parameters.

Detailed activities by component

Component 3

- Quantitatively examine the impact of the natural and anthropogenic accumulation of debris in drainage systems by mathematical modelling based on the different flood scenarios in urban cities in tropical Asian region.
- Integrating the results of components 1-3, we can clarify the impact of informal disposal on the waste drainage capacity, and also indicate the effectiveness of regular removal of waste from urban drainage.

Component 4

- Examine the behaviours, psychological factors and institutional factors related to waste dumping and flood response of local people in targeted areas of Bangkok and Hue. In-depth interviews, face-to-face interviews will be conducted to local people to clarify the actual waste disposal behaviours in the locality. Gathered data will be analysed based on the Theory of Planned Behavior.

Possible Deliverables/Outputs

- Basic data on solid waste that prevents effective urban drainage in target city (amount, composition, potential to inhibit drainage capacity)
- Knowledge of flood-resistant SWM
- Guidance of maintenance of urban drainage by administrative services for target city
- Capacity building of the local officers and practitioners based on the guidance
- Public communication tool, educational materials and programs aiming to change improper waste disposal behaviors of people in urban area

Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function of Tropical Asian Urban Cities

by

National Institute for Environmental Studies (NIES)
KASETSART University (KU)

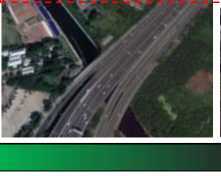
Solid Waste Composition Analysis

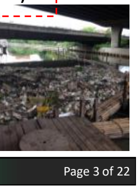
- Lad Prao canal (4 times)
- Prem Prachakon canal (1 time)

Lad Phrao canal

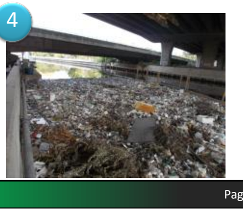
Waste collecting station (klong Lum-Pie)

Waste collecting station (Rama IV)





Waste composition analysis 4 times (2 @ dry season, 2 @ rainy season)



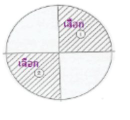
Prem Prachakon canal

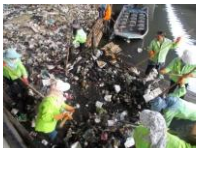
Waste composition analysis 1 time (@ dry season)

Waste collecting station (Wat Thawa Sunthon)

Methodology

1. Collect 1-2 m^3 of solid waste in canal
2. Mixing solid waste
3. Divide solid waste into 4 parts (quartering) and selected 2 parts in the opposite location
4. Repeat step 3 and 4 until remaining is approximately 100 litre





Methodology (continue)

Bulk density analysis

1. Fullfill the solid waste into known bucket
2. Hold the bucket above ground for 30 cm then free the bucket to the ground for 3 times
3. If level of waste in bucket getting low, repeat step2 until level is stable
4. Calculate bulk density

$$\textbf{bulk density} = \frac{W_1 - W_2}{V}$$

W_1 = Weight of waste include container (kg)
W_2 = Weight of container (kg)
V = Volume of container (m^3)

Methodology (continue)

Waste composition analysis

1. Classify waste to 16 type:

1) Wood (timber)
2) Wood (trim)
3) Plastic (bottle)
4) Plastic (packaging)
5) Plastic (material)
6) Food waste
7) Shell and bone
8) Textile
9) napkin and diaper
10) Paper
11) Glass
12) Foam
13) Metal and aluminum
14) Rubber
15) Plant (water hyacinth)
16) Plant (natural plants)

2. Calculate portion by weight

$$\textbf{\% by weight} = \frac{W_i}{W} \times 100$$

W_i = Weight of waste in each type
W = total Weight of all waste

Methodology (continue)

Moisture content analysis

1. Classify waste to 16 type:

1) Wood (timber)
2) Wood (trim)
3) Plastic (bottle)
4) Plastic (packaging)
5) Plastic (material)
6) Food waste
7) Shell and bone
8) Textile
9) napkin and diaper
10) Paper
11) Glass
12) Foam
13) Metal and aluminum
14) Rubber
15) Plant (water hyacinth)
16) Plant (natural plants)

2. Put in oven 105°C for 2-3 days
3. Calculate portion by weight

$$\textbf{\% Moisture} = \frac{W_{before} - W_{after}}{W_{before}} \times 100$$

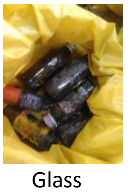
W_{before} = Weight of waste before drying
W_{after} = Weight of waste after drying

Timber

Trim

Foam

Papar



Glass

Plastic (packaging)

Water hyacinth

Result

Portion by weight (%) and Bulk density (total)

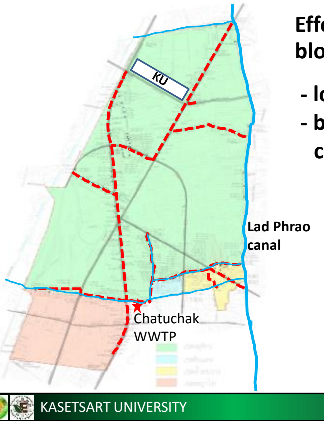
No.	Type of waste	Lad Phrao				Prem Prachakon
		No.1 (Mar)	No.2 (Sep)	No.3 (Oct)	No.4 (Jan)	No.1 (May)
1	Wood (timber from household)	40.2	15.1	26.1	27.1	11.8
2	Wood (trim)	14.1	23.5	21.8	13.1	5.8
3	Plastic (bottle)	0.8	3.4	2.0	1.1	3.4
4	Plastic (packaging)	12.3	13.6	10.4	13.3	25.4
5	Plastic (material)	1.7	4.4	4.2	5.2	1.4
6	Food waste	4.3	12.9	7.3	9.4	35.5
7	Shell and bone	0.2	0.5	1.0	0.4	0.1
8	Textile	3.3	2.4	0.6	1.0	0.2
9	Sanitary napkin and Diaper	0.9	2.4	1.0	3.9	1.2
10	Paper	0.8	1.9	1.5	2.0	2.6
11	Glass	0.9	7.9	5.2	6.4	2.7
12	Foam	1.0	4.7	7.1	3.0	3.4
13	Metal and Aluminum	0.2	0.6	0.7	0.7	0.7
14	Rubber	0.3	3.5	3.3	3.4	2.0
15	Plant (water hyacinth)	5.3	0.9	0.7	2.5	0.0
16	Plant (natural plants)	13.6	2.4	7.1	7.7	3.8
	Bulk density (kg/m³)	**229**	**277**	**255**	**255**	**237**

Summary

No.	Type of waste	Dry (% by weight)	Rainy (% by weight)	Moisture Content (%)
1	Wood (timber from household)	34.3	21.4	50
2	Wood (trim)	13.6	22.5	64
3	Plastic (bottle)	1.0	2.6	15
4	Plastic (packaging)	12.8	11.8	76
5	Plastic (material)	3.3	4.3	13
6	Food waste	6.6	9.7	77
7	Shell and bone	0.3	0.8	-
8	Textile	2.2	1.3	68
9	Sanitary napkin and Diaper	2.2	1.6	88
10	Paper	1.3	1.7	29
11	Glass	3.4	6.3	< 1
12	Foam	1.9	6.1	46
13	Metal and Aluminum	0.4	0.6	6
14	Rubber	1.7	3.4	37
15	Plant (water hyacinth)	4.1	0.8	-
16	Plant (natural plants)	10.9	5.1	93
	Bulk density (kg/m³)	**242**	**266**	

Development of empirical model for determining the reduction of drainage capacity

Effect of solid waste blockage in the canal compare with TRAFFIC JAM



Effect of solid waste blockage in Lad Phrao canal

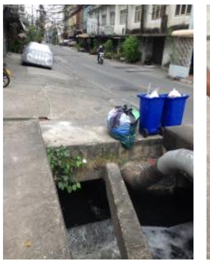
- location of flooding
- back flow into wastewater collection system

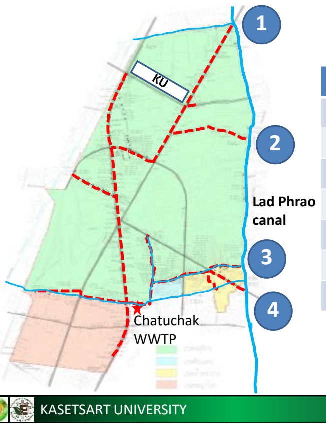
Chatuchak Wastewater Treatment Plant report (data of wastewater collection system)

----- Intercepting sewer

—— canal

Back flow into wastewater collection system

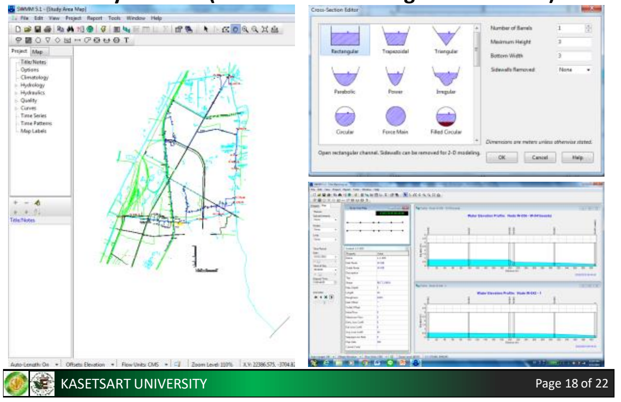


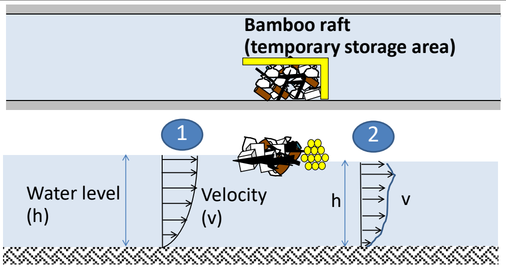


Elevation

Location	TOP	INV
1	37.370	34.020
	36.230	34.100
2	36.420	33.300
	36.640	33.210
3	36.829	34.489
4	36.417	34.020
	36.017	34.997

Model by SWMM (Storm Water Management Model)





Develop an empirical formula

$$\left(\frac{v^2}{2g}+h\right)_1 = \left(\frac{v^2}{2g}+h\right)_2 + \textbf{friction}$$

energy loss coefficient

Selected solid waste **Identify the typical value of each waste**

1. Wood (Timber)
2. Wood (Trim)
3. Plastic (packaging)
4. Glass
5. Foam
6. Plant (water hyacinth)
7. Plant (natural)

Experiment Set up

Water flume

Flow meter

THANK YOU

for your attention

[Component 4] Social survey regarding waste disposal behavior

Ryo Tajima[1], Suthep Janamporn[2], Soparatana Jarusombat[2]

[1] National Institute for Environmental Studies, Japan
[2] Thammasat University

Aim of the research and this survey

"Why do people throw away waste into canals?"

- How do people living along canals throw away their daily/bulky waste?
- What kind of people throw away waste inappropriately?
- Why do people behave in such way?
  - Is it an issue of awareness? Or is it the collection system?

Recommendation for awareness raising action/program

Recommendation for improving waste collection system

Survey framework

- Target of the survey
  - Residents in community where scattered wastes are observed in public space (incl. waterways, canals, reservoirs)

- Survey method
  - Face to face questionnaire survey
  - Interviewers (TU students) were trained in advance, and the collected sheets were checked by the supervisor

Survey framework

- Reponses were collected from people residing along Lad Phrao canal (n=355)

Community Name	Number of collected responses		Number of Houshold	Waste Collected by···		Redevelopment status		
				Boat	Car	Completed	Partially	planned
Thai-Yeepun	40	62%	65	✓			✓	
Lad Phrao 80	38	29%	129	✓				✓
Kaow Ha	35	15%	227	✓	✓			✓
Lad Phrao Pracha Uthit	32	39%	82	✓	✓		✓	
Chai Klong Bang Bua	37	10%	372	✓				✓
Ruen Mai Pattana	40	19%	210	✓	✓	✓		
Saphan Mai 2	45	22%	206	✓			✓	
Saphan Mai 1	28	26%	106	✓			✓	
Samackee Ruam Jai	26	19%	136	✓	✓	✓		
Klong Bang Bua	34	26%	129	✓	✓	✓		

- Figure : location of target communities plotted on a map → Khun Suthep, can you help please?

Survey items

Awareness and opinion on the new BMA waste collecting system

Please tell us about your daily waste disposal behavior
- Where and how people dispose their waste in general

Situation of household regarding waste disposal opportunities
- Distance from collection point, etc.

Opinion on disposing daily household waste in public space

Opinion on disposing bulky waste in public space

Attributes of the respondent
- Gender, age, satisfaction on environment, etc.

Main results – residents' perception on waste collection system

Most of the people are aware of the new BMA waste collection system (appointment time, appointment place). Some improvements could raise the community satisfaction, especially for bulky waste

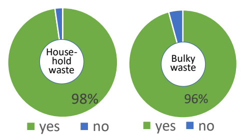


Fig.1 Awareness of the new BMA waste collection system: household waste (left) and bulky waste (right)

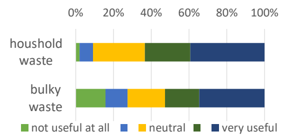


Fig.2 Evaluation of the new system by the residents

Main results – residents' perception on waste collection system

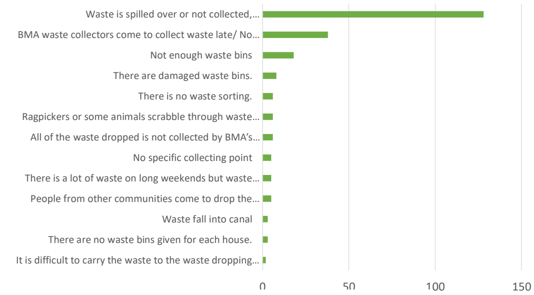
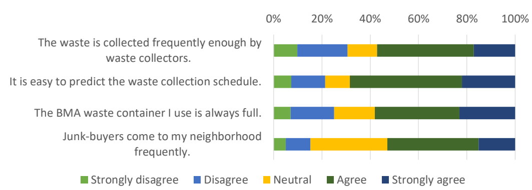


Fig.3 Perceived issues on waste disposal

Main results – residents' perception on waste collection system



Main results – residents' perception on waste collection system

Fig.4 Opinion on how to improve waste collection

Main results – waste disposal behavior

Most of the people use the waste container to dispose. However, 12% of them drop household waste and 4% drop bulky waste into the canal (more or less).

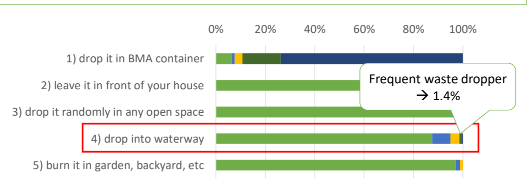


Fig.5 How residents along Lad Phrao canal dispose their daily household waste

Main results – waste disposal behavior

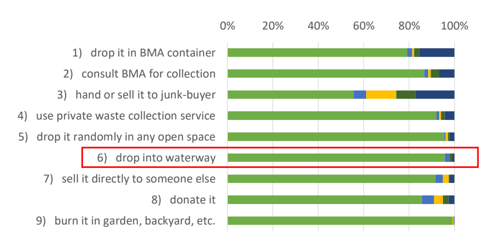


Fig.6 How residents along Lad Phrao canal dispose their bulky waste

国立環境研究所
National Institute for Environmental Studies

Main results – attributes of inappropriate waste disposal

(So far..)* Some personal attributes and psychological / institutional factors seem to be related to waste disposal into the canal.

*further work needed to firmly establish cause-effect relationship

- Dependent variable: whether or not one dispose waste into canal (0 or 1)
- Independent variables: Gender / Age group / Economic situation / Academic background / Type of residence / Years of residence / Progress of redevelopment / Norm consciousness / Environmental value / Willingness to act / Perceived environmental quality / Risk perception / Subjective norm / Attitude towards inappropriate waste disposal / Access to waste disposal points
- Analysis technique: binominal logistic regression analysis, statistical significance test (e.g. t-test)

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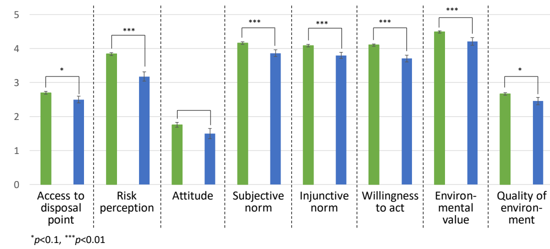
Main results – attributes of inappropriate waste disposal



*p<0.1, ***p<0.01

Fig.7 Comparison of attributes between those who never dispose waste into canals and those who do (more or less)

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National Institute for Environmental Studies

Conclusions and Recommendations

The survey results suggest that the amount of waste intentionally dropped into the canal by nearby residents is limited

Residents find that the sanitary condition of collection point should be improved

Those who dispose waste into canals have lower risk perception, norm consciousness, willingness to act, and environmental value, compared with those who don't

Community based initiatives to manage waste collection points should be enhanced, with some support by the government

The capacity and predictability of waste collection should be enhanced

Demolition and Recycling

A brief introduction

National Institute for Environmental Studies

Masato YAMADA

20180613

National Institute for Environmental Studies, Japan

CDW from House

Roof/Window Frame/Reinforcements...
Metals
(Iron, Aluminum, Others)

Pillar/Wall/Floor...
Wood

Base/Wall...
Concrete
Brick

Roof/Floor/Pipes/Insulator..
Plastics

CDW from House and Recycling

Metal Products

Roof/Window Frame/Reinforcements...
Metals
(Iron, Aluminum, Others)

Pillar/Wall/Floor...
Wood
Paper
Boards
Fuels

Base/Wall...
Concrete
Brick
Sub-Base Materials

Roof/Floor/Pipes/Insulator..
Plastics
Fuels (excluding PVC)

Demolition, Sorting and Quality

LOW — Quality of Recovered Materials — HIGH

Minch Demolition and Mechanical Sorting

Dismantling and Sorting by Heavy Machinery

Dismantling and Sorting by Hand

Demolition, Sorting and Quality and Waste

LOW — Quality of Recovered Materials — HIGH

Minch Demolition and Mechanical Sorting

Dismantling and Sorting by Heavy Machinery

Dismantling and Sorting by Hand

HIGH — Amount of Waste — LOW

Mixing makes waste, separating makes resources.

Which is wise for our sustainable society?

Thank you for your attention

"No waste in canals" research findings seminar in Hue city
Date: 14th of June, Time: 9:45-14:30
Participants: HEPCO officers, community leaders
Venue: Conference room in Hue

Time	Contents	In charge
9:45	Registration starts	
10:00	Opening remarks	Dr. Yamada
10:05	Opening remarks from Hue University	Rector of HU-University of Sciences
10:10	Group photo session	
10:20-10:35	Introduction of the issue in "waste in canals" and the APN project	Dr. Ishigaki Translation:
10:35-10:55	Research findings from waste composition analysis in Bangkok canals	KU Translation:
10:55-11:15	Research findings from the development of empirical model for determining the reduction of drainage capacity under different waste blockage condition	KU&Dr. Nakamura Translation:
11:15-11:35	Research findings from the residents survey in Hue	Dr. Tin and HU student
11:35-12:00	Research findings from residents survey on their waste disposing behavior in Bangkok and Hue	Dr. Tajima and TU Translation:
12:00~13:00	Lunch	
13:00~13:15	Introduction of awareness raising materials based on research outputs	Ms. Kubota Translation:
13:15~14:25	Discussion on necessary intervention for the improvement of waste dumping in canals and public space	Overall facilitator: Dr. Lieu? Translation:
14:25~14:30	Closing remarks	Dr. Ishigaki

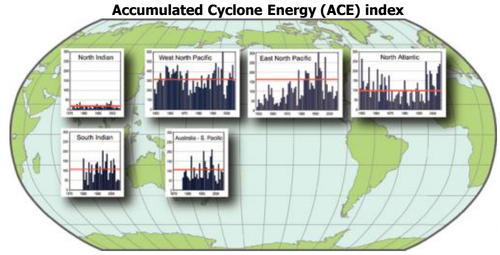
Introduction of the issue in "waste in canals" and the APN project

Tomonori ISHIGAKI
National Institute for Environmental Studies

Century of High Disaster Risk

Frequency and **Intensity** of extreme events has been increased as a result of human influences on climate. Climate change may be perceived most through the impacts of extremes, although these are to a large degree dependent on the system under consideration, including its vulnerability, resiliency and capacity for adaptation and mitigation. (ref IPCC AR4)

Accumulated Cyclone Energy (ACE) index



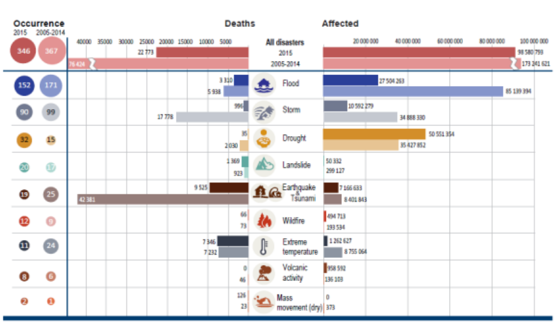
Major Natural Disaster

- Cyclone (Hurricane, Typhoon)
- Tornado
- Flood
- Earthquake and Tsunami
- Eruption of Volcano
- Drought
- Cold wave
- Abnormal Weather (continues rain, rain in dry season, etc)

Recent Disaster: Typhoon Haiyan

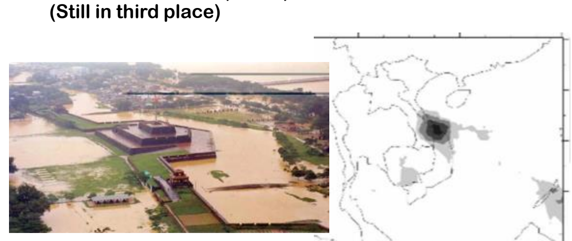
"we cannot afford to procrastinate on climate action"

Damages by Natural Hazards



World's Heaviest Rainfall

1630 mm in 24 hour, Truoi, 1999
(Still in third place)



Hue had also received 1,433 mm of rainfall in 24hours
622 people died, 42,000 houses were destroyed

Traditional flood in Hue (Case in 1995)

"Historic" Flood in Hue (7 Nov. 2017)

Continuous heavy rains have worsened the inundation due to heavy floods that occurred on Sunday morning in central Thừa Thiên-Huế Province. Water covered almost all roads connecting the districts with National Highway No. 1A, which opened to traffic late Monday afternoon when water receded following the nearly two-day inundation.
Residents in the province blamed power plants located at the upper parts of two local main rivers of Hương and Bồ for the unannounced release of water into the rivers. However, the responsibility for this fell on district and commune authorities, as last Friday, local newspaper had carried related announcements.

Dam is expected to control flood

APN project:

Appropriate Solid Waste Management towards Flood Risk Reduction through Recovery of Drainage Function in Tropical Asian Urban Cities

Overview of the project

- Duration: 2 years from 2016.8-2018.7
- Total funding from APN: USD 80,000 (year 1: USD35,000, year 2: USD45,000)
- Target country: Thailand and Vietnam with Japanese Researchers
- Project leader: Dr. Tomonori ISHIGAKI
- Partner Institutions: National Institute for Environmental Studies (Japan), King Mongkut's University of Technology, Thonburi, Joint Graduate School of Energy and Environment, Kasetsart University, Thammasart University (Thailand), Hue University (Vietnam)
- Collaboration: Bangkok Metropolitan Authority, Hue Environmental Protection Company

Objectives and Output

- To clarify the impact of waste dumping on water drainage capacity
- To identify the waste dumping behavior of people, and its institutional/psychological reasons
- To develop, implement, and disseminate strategy/tool to remove waste and to raise awareness towards appropriate disposal

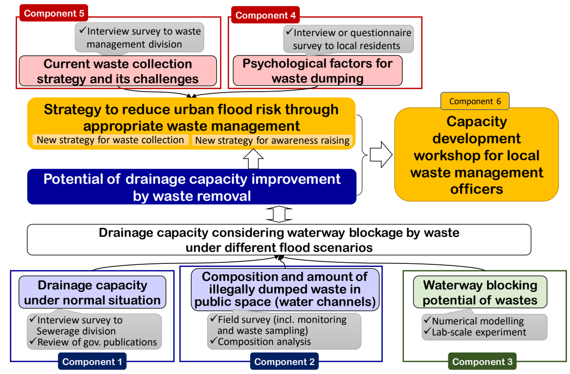
Based on achieving above objectives, we will aim to propose effective measures and strategy to reduce urban flood risk through removing and preventing waste from becoming barriers to urban drainage function, by daily administrative services and citizen's cooperation .

Project Methodology

Field investigation | Mathematical modelling | Social surveys

Workshop | Outreach

Outline of the Project



Detailed activities by component

Component 1

- Conduct a series of in-depth interviews to local officers and local experts to understand drainage capacity at normal condition and drainage blockage issues during flood in Bangkok and Hue. Literature reviews shall be also conducted.

Component 2

- Investigate an amount and composition of waste that affects urban drainage. Monitor an accumulation trend of waste in drainage system and elucidate the major reasons of blocking on drainages. Also standardize the quantitative parameters.

Detailed activities by component

Component 3

- Quantitatively examine the impact of the natural and anthropogenic accumulation of debris in drainage systems by mathematical modelling based on the different flood scenarios in urban cities in tropical Asian region.
- Integrating the results of components 1-3, we can clarify the impact of informal disposal on the waste drainage capacity, and also indicate the effectiveness of regular removal of waste from urban drainage.

Component 4

- Examine the behaviours, psychological factors and institutional factors related to waste dumping and flood response of local people in targeted areas of Bangkok and Hue. In-depth interviews, face-to-face interviews will be conducted to local people to clarify the actual waste disposal behaviours in the locality. Gathered data will be analysed based on the Theory of Planned Behavior.

Possible Deliverables/Outputs

- Basic data on solid waste that prevents effective urban drainage in target city (amount, composition, potential to inhibit drainage capacity)
- Knowledge of flood-resistant SWM
- Guidance of maintenance of urban drainage by administrative services for target city
- Capacity building of the local officers and practitioners based on the guidance
- Public communication tool, educational materials and programs aiming to change improper waste disposal behaviors of people in urban area

TRƯỜNG ĐẠI HỌC KHOA HỌC
ĐẠI HỌC HUẾ
HU – University of Sciences

VIỆN NGHIÊN CỨU MÔI TRƯỜNG QUỐC GIA
NHẬT BẢN
National Institute of Environmental Studies

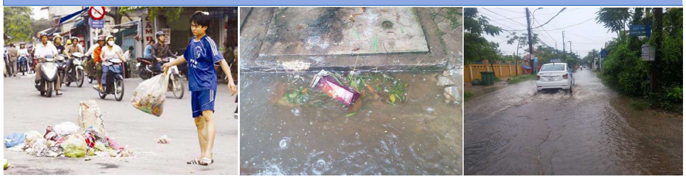
SURVEY ON SOLID WASTE COMPOSITION ENTERING THE URBAN DRAINAGE SYSTEM IN HUE CITY

Dr. Pham Khac Lieu
Dr. Hoang Cong Tin
M1. Ho Thi Xuan Tuy

Hue, 06/2018

Contents

Introduction



Improper waste disposal | Solid waste | Urban flood inundation

- ✓ Identifying the compositions, sources of waste entering drainage system.
- ✓ Understanding how people dispose waste regularly.

⇨ Improving the waste collection system of the city.
⇨ Reducing damages and enhance the quality of habitat.

Survey on solid waste composition entering drainage system in Hue city.

1.1. Study Objectives

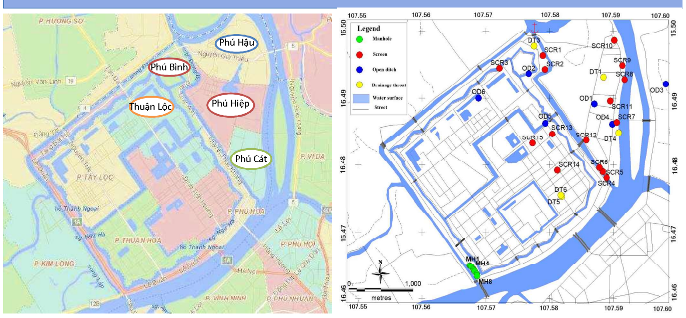
1. To identify composition, sources and consequence of waste releasing that impact on the urban drainage system capacity.
2. To clarify the behavioral and psychological factors of local people associated with waste discharge into public places.

1.2. Study periods

Phase 1 (dry season): From 16th July to 30th July, 2017.

Phase 2 (wet season): From 15th October to 25th October, 2017.

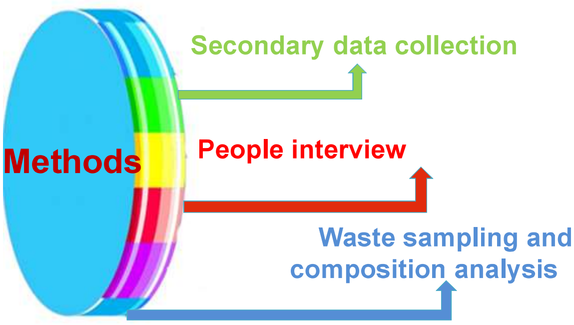
1.3. Study area



The map of study areas.

The survey have been implemented at five wards of Hue City namely Phu Hau, Phu Hiep, Phu Cat, Phu Binh, and Thuan Loc.

2. Methods



2. Methods

Secondary data collection

- Collect all documents → Scientific journals, magazines, project reports,…
- The data of Hue City's drainage systems → Hue Urban Environment Public Works J.S.Co. (HEPCO)

2. Methods

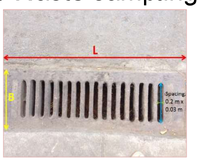
People interview

Ward	Number of households	Number of households to be interviewed	Proportion (%)
Thuan Loc	3,937	144	48,0
Phu Binh	2,090	77	25,7
Phu Cat	2,154	79	26,3
Total	**8,181**	**300**	**100**

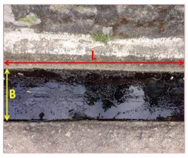
2. Methods

Waste sampling and composition analysis

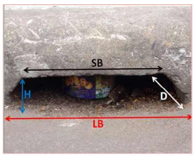
a. Waste sampling



Waste on screens



Waste in open ditches



Waste at drainage throats

Waste in manholes

Note:
L = Length
B = Breadth
H = Height
D = Depth
LB = Large bottom
SB = Small bottom

2. Methods

Waste sampling and composition analysis

b. Waste composition analysis

1. Paper

2. Leaves & tiny trunk

3. Large trunk

4. Plastics

5. Plastic bags

6. Rubber & leather

2. Methods

Waste sampling and composition determining methods

b. Waste composition determining method

7. Glass & pocerlain

8. Metals

9. Fabrics & texxtiles

10. Hazardous

11. Others

2. Methods

Waste sampling and composition determining methods

b. Waste composition determining method

Proportion of waste components

The proportion of each category (M) was calculated in the formula below:

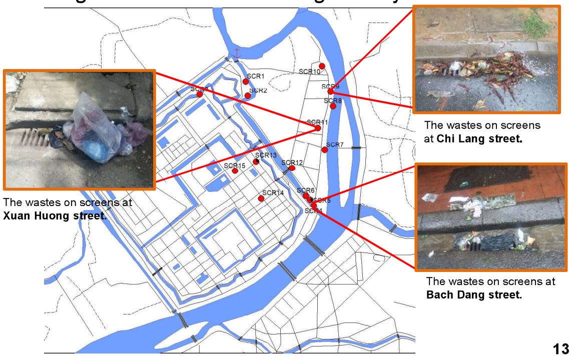
$$M\ (\%) = \frac{a}{A} \times 100 \qquad (1)$$

where: a – The weight of each category (g);
A – The total weight of categories (g);

3. Results

3.1. Waste on screens

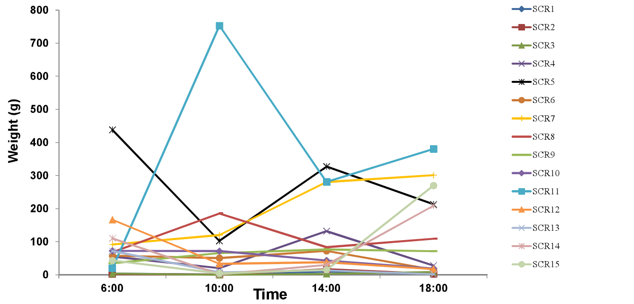
Wastes converge on bar screens thwarted surface flow that caused to deluge and decrease drainage ability in rain season



3. Results

3.1. Waste on screens

The temporal variation of waste on screens



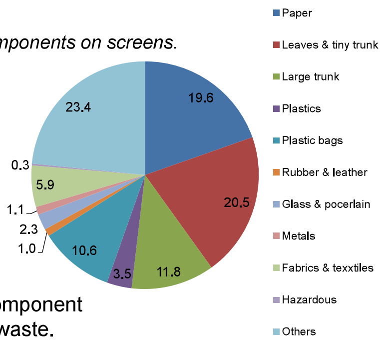
The amount of the waste on screens sharply fluctuated at difference between sampling time per day.

Depend on: Screen's position, Living behavior of residents and waste collection time.

3. Results

3.1. Waste on screens

Average percentage of waste components on screens.



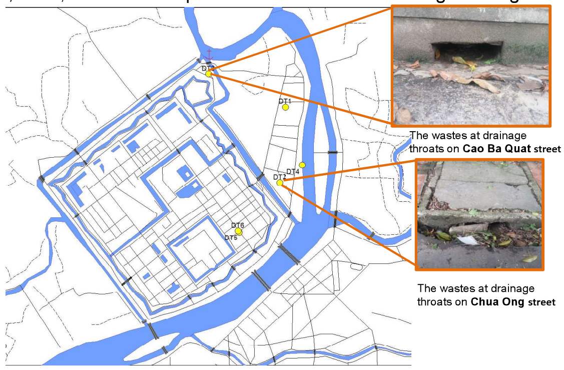
The highest ratio was other component group (23.4%) including food waste.

The remarkable component was leaves & tiny trunk (20.5%) and paper (19.6%).

3. Results

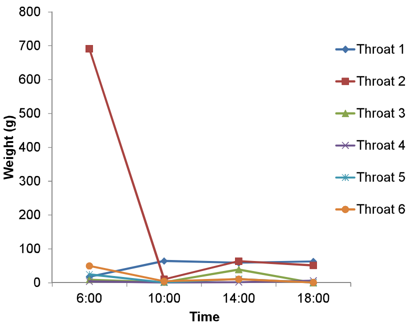
3.2. Waste at drainage throats ('frog mouths')

Almost those throats had not been concerned to sanitize and periodically maintain. Soil, sand, and waste disposition diminished the drainage acreage.



3. Results

3.2. Waste at drainage throats ('frog mouths')



The temporal variation of waste at drainage throats at difference sampling time per day.

The waste weight of DT2 in the early morning was largest -> accumulate about few days before starting sampling to study.

Other several throats were not noticeable.

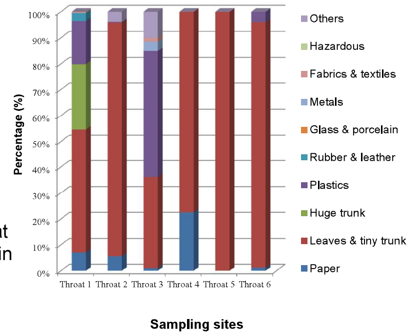
3. Results

3.2. Waste at drainage throats ('frog mouths')

The leaves – tiny woody trunk group was major, ranged from 35.2% to 99.3%.

Plastic component was also essential at the DT1 (16.2%) and DT3 (48.7%).

The percentage of plastic bag at DT4 was 22.4% -> a high ratio in all components.



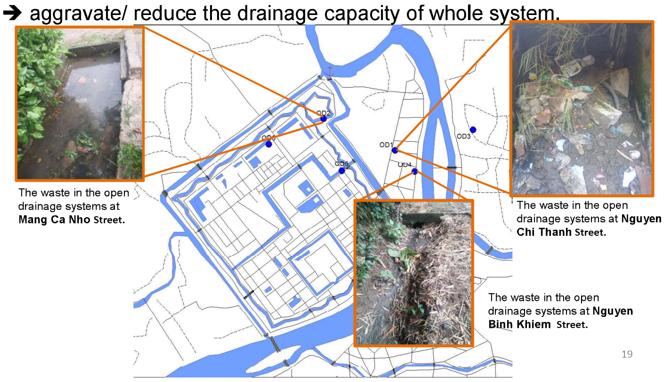
Waste composition at drainage throats.

3. Results

3.3. Waste in open drainage systems

- An amount of waste existed with diverse components.
- Grasses grew strongly at soil ditchs

➔ aggravate/ reduce the drainage capacity of whole system.



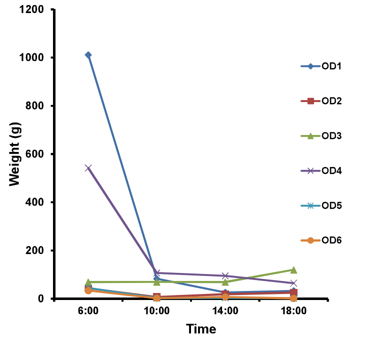
3. Results

3.3. Waste in open drainage systems

The waste in open ditches had a large in the early morning.

The change of waste weight at the moments of day was moderately low.

⇒ Short – time did not significantly impact on waste accumulation in the open ditches.



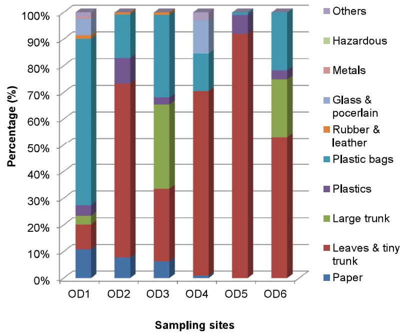
The temporal variation of waste in open ditches at difference sampling time per day.

3. Results

3.3. Waste in open drainage systems

Significant component was leaves and tiny woody trunk, changed from 9.3% to 91.9%. The highest percentage was at OD5.

The plastic bags accounted a fairly large rate in OD1 (62.3%) and OD3(31.0%)



Waste composition in open ditches.

3. Results

3.4. Waste deposit in drainage system

Waste deposition in the manhole (10) and waste components deposited in the manhole after washing (11).

From throats, screens and waste in sewers.
The waste deposited in the manholes was diverse component.
Those wastes were mixed with sludge, sand, waste water.

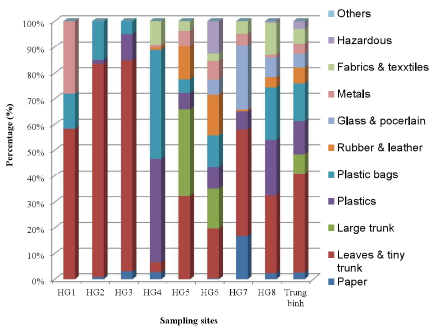
3. Results

3.4. Waste deposit in drainage system

Leaves – tiny woody trunks group fluctuated from 4.1% to 82.7%.

Plastic component was high at MH4 (40.1%) and MH8 (21.5%) but was fairly low at other one.

The hazardous waste accounted for 3.0% and mainly batteries, the biggest surveyed proportion was 12.6% at MH6.



The percentage of waste component deposit in the manholes

3. Results

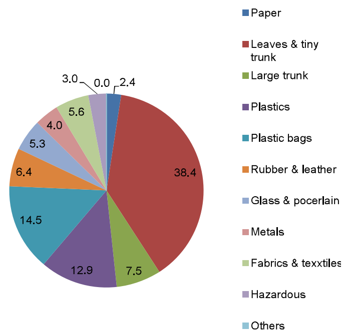
3.4. Waste deposit in drainage system

Leaves and tiny woody trunk was major with 38.4%.

The hazardous component accounted 3.0%.

Plastic and plastic bags were 12.9% and 14.5%.

Waste, oil and fat ➔ impact on the water environment and was a big challenge for the wastewater treatment plant in Hue city.



Average composition of waste deposit in the manholes.

4. Remarks/ Findings

The waste entered into drainage system in Hue city had main components:

- Leaves and tiny woody trunks group from street-side trees (percentage of average on screens were 20.5%, manholes: 9.3 - 91.9 %, open ditches : 9.3% - 91.9%, drainage throats: 35.2% - 87.1%).
- Paper component rate was rather high on screens (19.6%).
- Plastic and plastic bag accounted a high rate ➔ have been commonly used and being difficult to replace difficult to replace.

➔ An efficient management policy on producing and trading this component properly is also required.

4. Remarks/ Findings

- Leaves and tiny woody trunk group is the most popular disposing in drainage systems, a selection in street trees need be considered to mitigate blockage potential.
- Plastic wastes have been commonly used and being difficult to replace, an efficient management policy is also required.
- Poor drainage system designs and maintenance are unable to opera its function efficiently causing urban inundation issues.
- Appropriate municipal solid waste management and drainage capacity improvement can contribute to solve significantly in part of urban flood inundation issues.

Survey photos

Interviewing local people about waste discharging

Waste sampling

Waste sampling in throats, open drainage systems and the manholes

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ĐẠI HỌC HUẾ
HU – University of Sciences

APN
ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

VIỆN NGHIÊN CỨU MÔI TRƯỜNG QUỐC GIA NHẬT BẢN
National Institute of Environmental Studies

THANK YOU FOR YOUR ATTENTION

[Component 4]
Social survey regarding waste disposal behavior

Ryo Tajima[1], Suthep Janamporn[2], Soparatana Jarusombat[2]

[1] National Institute for Environmental Studies, Japan
[2] Thammasat University

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Aim of the research and this survey

"Why do people throw away waste into canals?"

- How do people living along canals throw away their daily/bulky waste?
- What kind of people throw away waste inappropriately?
- Why do people behave in such way?
  - Is it an issue of awareness? Or is it the collection system?

Recommendation for awareness raising action/program

Recommendation for improving waste collection system

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Survey framework

- Target of the survey
  - Residents in community where scattered wastes are observed in public space (incl. waterways, canals, reservoirs)

- Survey method
  - Face to face questionnaire survey
  - Interviewers (TU students) were trained in advance, and the collected sheets were checked by the supervisor

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Survey framework

- Reponses were collected from people residing along Lad Phrao canal (n=355)

Community Name	Number of collected responses		Number of Houshold	Waste Collected by…		Redevelopment status		
				Boat	Car	Completed	Partially	planned
Thai-Yeepun	40	62%	65	✓			✓	
Lad Phrao 80	38	29%	129	✓				✓
Kaow Ha	35	15%	227	✓	✓			✓
Lad Phrao Pracha Uthit	32	39%	82	✓	✓		✓	
Chai Klong Bang Bua	37	10%	372	✓				✓
Ruen Mai Pattana	40	19%	210	✓	✓	✓		
Saphan Mai 2	45	22%	206	✓			✓	
Saphan Mai 1	28	26%	106	✓			✓	
Samackee Ruam Jai	26	19%	136	✓	✓	✓		
Klong Bang Bua	34	26%	129	✓	✓	✓		

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1. Thai-Yeepun
2. Lad Phrao Pracha Uthit
3. Lad Phrao 80

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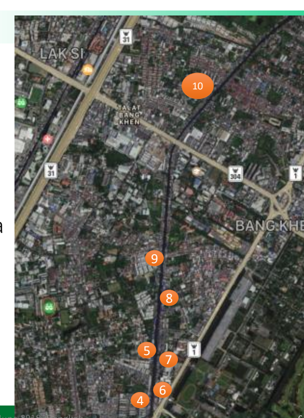
4. Saphan Mai1
5. Saphan Mai 2
6. Samackee Ruam Jai
7. Klong Bang Bua
8. Ruen Mai Pattana
9. Chai Klong Bang Bua
10. Kaow Na



Survey items

- Awareness and opinion on the new BMA waste collecting system
- Please tell us about your daily waste disposal behavior
  - Where and how people dispose their waste in general
- Situation of household regarding waste disposal opportunities
  - Distance from collection point, etc.
- Opinion on disposing daily household waste in public space
- Opinion on disposing bulky waste in public space
- Attributes of the respondent
  - Gender, age, satisfaction on environment, etc.

Main results – residents' perception on waste collection system

Most of the people are aware of the new BMA waste collection system (appointment time, appointment place). Some improvements could raise the community satisfaction, especially for bulky waste

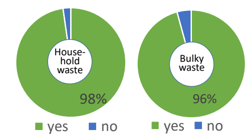


Fig.1 Awareness of the new BMA waste collection system: household waste (left) and bulky waste (right)

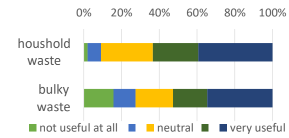
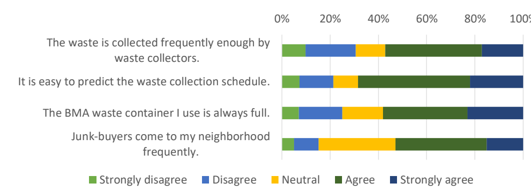


Fig.2 Evaluation of the new system by the residents

Main results – residents' perception on waste collection system

Fig.3 Perceived issues on waste disposal

Main results – residents' perception on waste collection system



Main results – residents' perception on waste collection system

Fig.4 Opinion on how to improve waste collection

Main results – waste disposal behavior

Most of the people use the waste container to dispose. However, 12% of them drop household waste and 4% drop bulky waste into the canal (more or less).

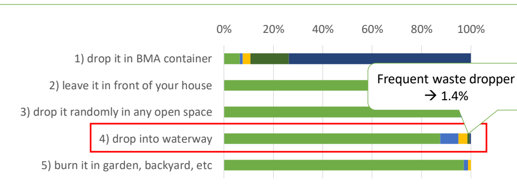


Fig.5 How residents along Lad Phrao canal dispose their daily household waste

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Main results – waste disposal behavior

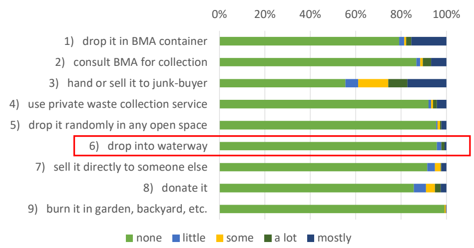

Fig.6 How residents along Lad Phrao canal dispose their bulky waste

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Main results – attributes of inappropriate waste disposal

(So far..)* Some personal attributes and psychological / institutional factors seem to be related to waste disposal into the canal.

*further work needed to firmly establish cause-effect relationship

- Dependent variable: whether or not one dispose waste into canal (0 or 1)
- Independent variables: Gender / Age group / Economic situation / Academic background / Type of residence / Years of residence / Progress of redevelopment / Norm consciousness / Environmental value / Willingness to act / Perceived environmental quality / Risk perception / Subjective norm / Attitude towards inappropriate waste disposal / Access to waste disposal points
- Analysis technique: binominal logistic regression analysis, statistical significance test (e.g. t-test)

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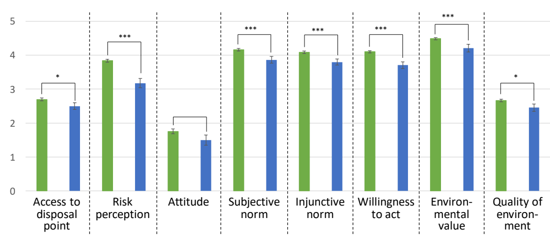
Main results – attributes of inappropriate waste disposal



*p<0.1, ***p<0.01

Fig.7 Comparison of attributes between those who never dispose waste into canals and those who do (more or less)

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Conclusions and Recommendations

The survey results suggest that the amount of waste intentionally dropped into the canal by nearby residents is limited

Residents find that the sanitary condition of collection point should be improved

Those who dispose waste into canals have lower risk perception, norm consciousness, willingness to act, and environmental value, compared with those who don't

Community based initiatives to manage waste collection points should be enhanced, with some support by the government

The capacity and predictability of waste collection should be enhanced

"Is flooding natural disaster?"
Awareness raising tools from research findings to Hue city, Vietnam

Rieko Kubota and APN collaborators
National Institute for Environmental Studies

Is flood natural disaster?

- Flooding can be human-made disaster
- Cause of flooding can be controlled
- One way to control is by controlling the amount and type of waste that gets into canals and waterways

Why human-made disaster?

- Asian cities' vulnerability to floods can also be primarily attributed to poor and fragmented urban planning and management.
- Better planning and management would have partially halted rapid buildup of slums along coasts and riverbanks.
- Improving urban planning and management requires **breaking silos, unlearning fragmented thinking, and avoiding short-term measures.**

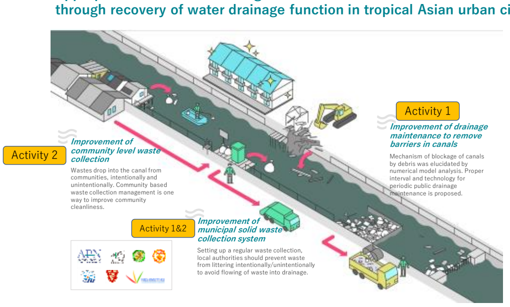
Human intervention lessen flood risk

Overall objective of awareness raising

- To reduce the amount of waste dump into the canal

-Plastic/Packaging waste

Appropriate Solid Waste Management towards flood risk reduction through recovery of water drainage function in tropical Asian urban cities



Activity 1: Capacity building seminar

“No waste in canals” seminars

Objective:

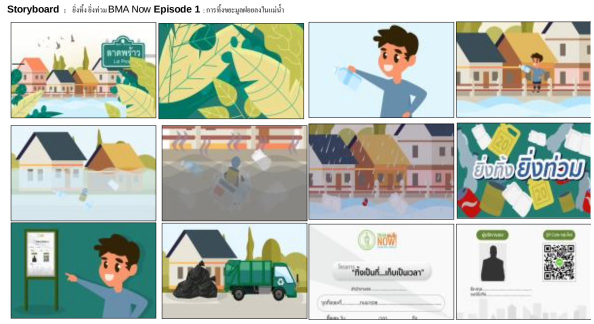
- Share the research findings of our APN project
- Recognize the effect of disposing waste in the canal
- Share knowledge about canal waste without boundaries of department
- Discuss the possibility to improve the solid waste management in Hue city and how to introduce policy

Activity 2: Motion graphic for awareness raising campaign in youtube

Objective:

- To inform general public in Hue city, the impact of “illegal solid waste dumping in the canal can lead to clogging and flooding”.
- To deliver simple and impacting message

Storyboard : ยิ่งทิ้ง ยิ่งท่วม BMA Now **Episode 1** : การทิ้งขยะมูลฝอยลงในแม่น้ำ



Storyboard : ยิ่งทิ้ง ยิ่งท่วม BMA Now **Episode 2** : การทิ้งขยะชิ้นใหญ่ลงในแม่น้ำ

Storyboard : ยิ่งทิ้ง ยิ่งท่วม BMA Now **Episode 3** : การทิ้งสิ่งปลูกสร้าง

Other output: Preparation of draft demolition waste management guidelines

Guideline on appropriate separation and disposal of C&D waste

Objective:

- To acquire knowledge of appropriate demolition waste management
- To systematize the appropriate demolition waste management in the contracts with contractors

Translation of guideline on “wooden-made building separation demolition”

- Prepared by Japanese industrial alliance to promote recycling of construction and demolition waste
- Useful guideline to attach when contracting out the demolition of buildings to contractors


木造建築物の分別解体の手引き

建設副産物リサイクル広報推進会議

- Contents
- What is construction and demolition waste recycling law in Japan?
- Pre-demolition site survey
- Demolition planning (including how to separate waste)
- Cost estimation
- Preparation
- Demolition
  - Demolition schedule management
  - Safety management
  - Waste separation
  - Preparation of space, temporal working ladders
  - Demolition
- Appropriate treatment
  - You must ask the waste recyclers who has license for appropriate treatment

Appropriate Solid Waste Management towards flood risk reduction through recovery of water drainage function in tropical Asian urban cities