Numerical Simulation on Drainage Capacity Loss at a Bar Screen Blocked by Wastes in a Canal

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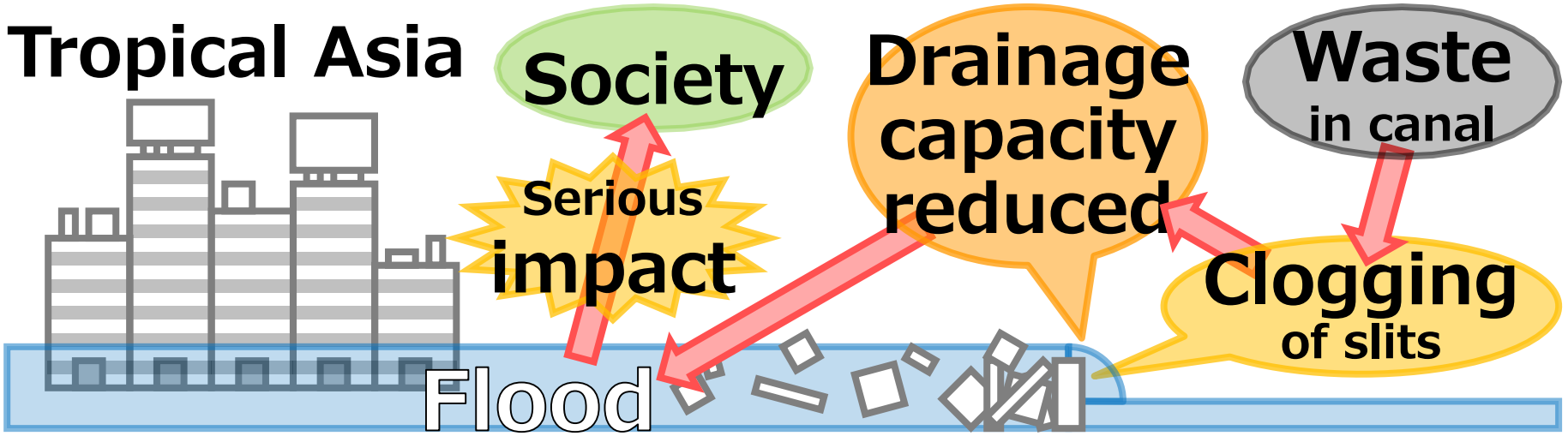
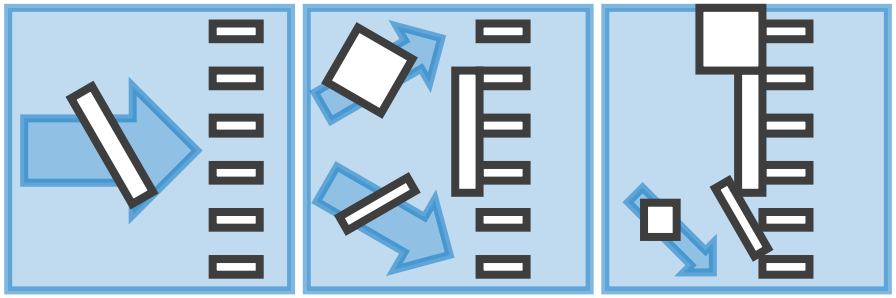
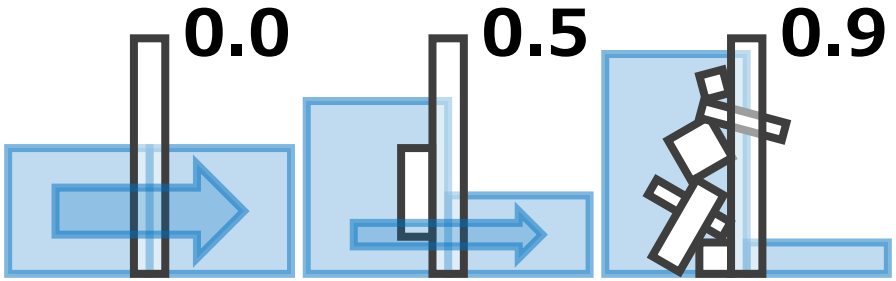
Backgrounds -Flood in urban cities-







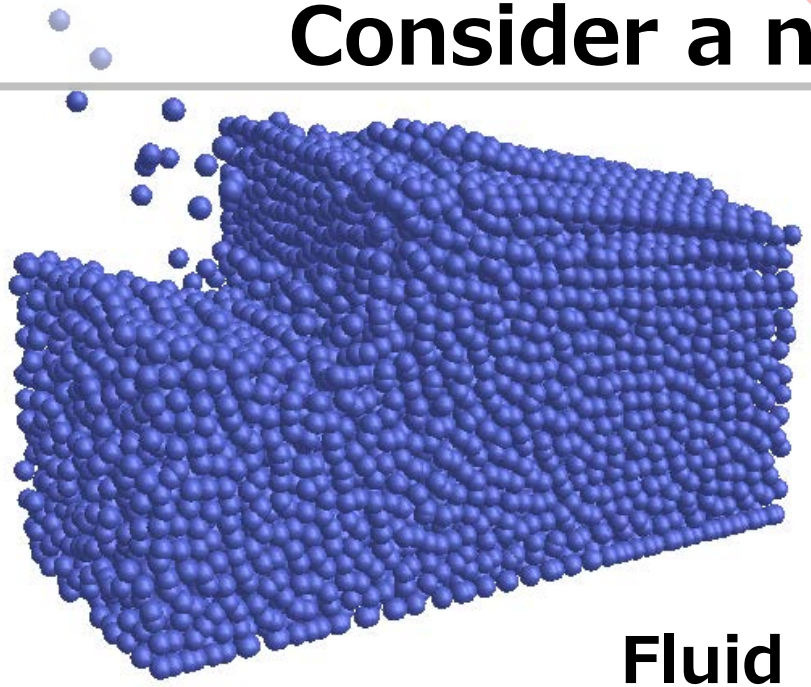
Under what condition slit-like structures are clogged?

How much water flow is interrupted by clogging?

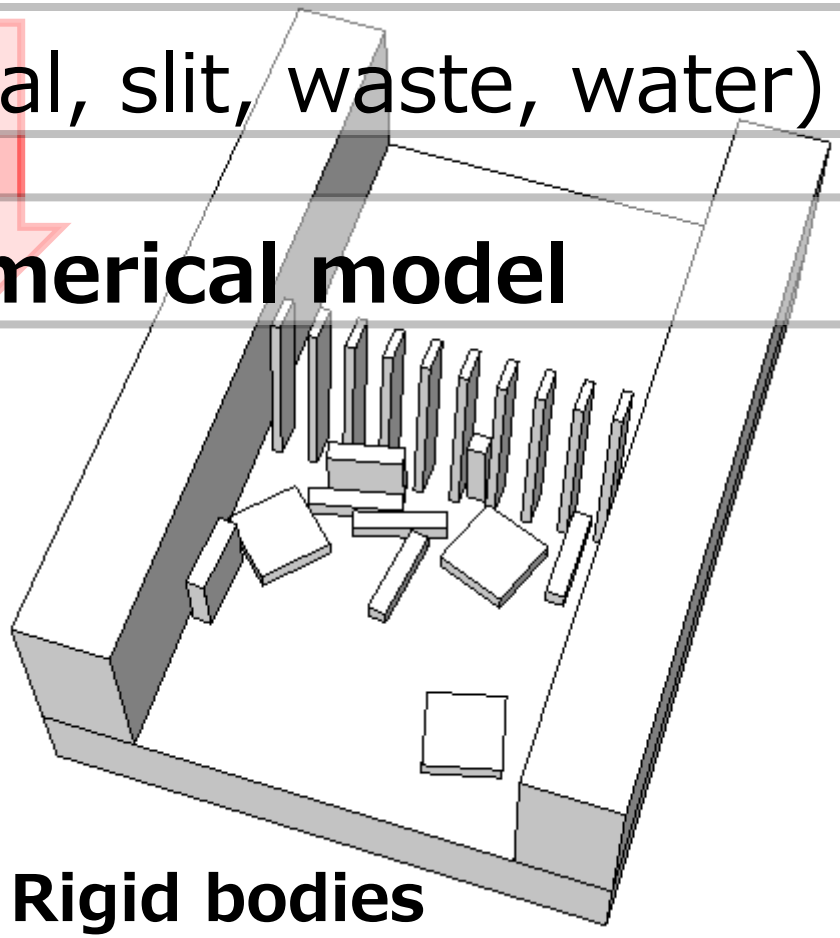
Tool -Numerical model-

Various condition (canal, slit, waste, water)

Consider a numerical model



Fluid



Rigid bodies

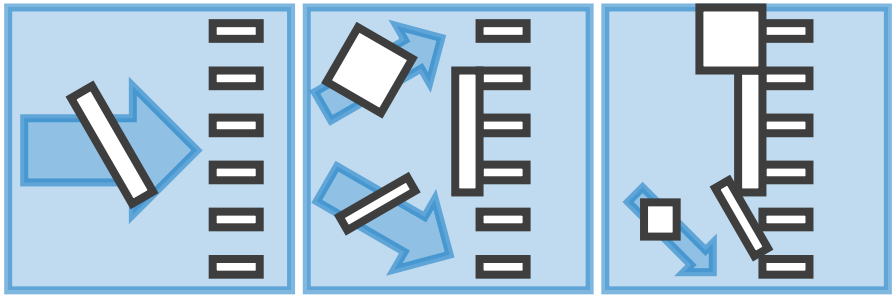
Smoothed Particle Hydrodynamics (SPH)

Bullet Physics Library

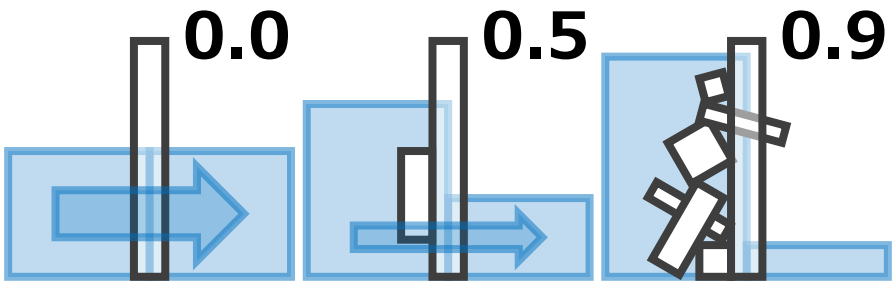
Objective -Model and analysis-

Develop a numerical model for canal flow

(canal, slit, waste, water)



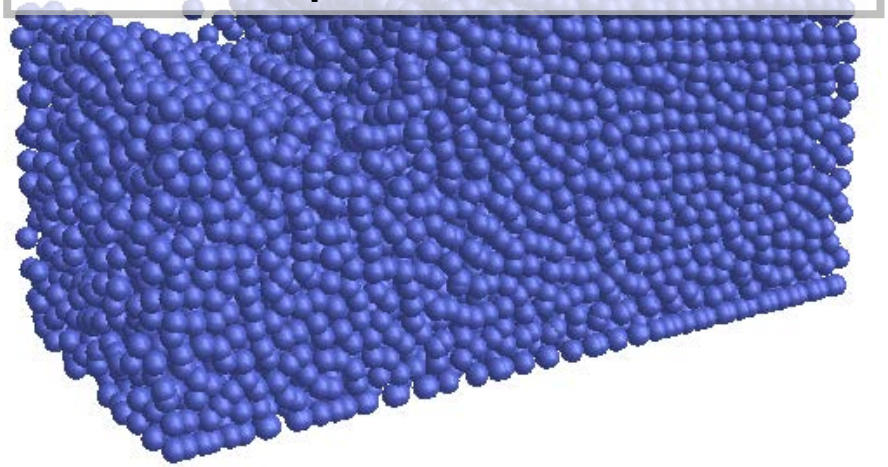
Condition when slit-like structures are clogged

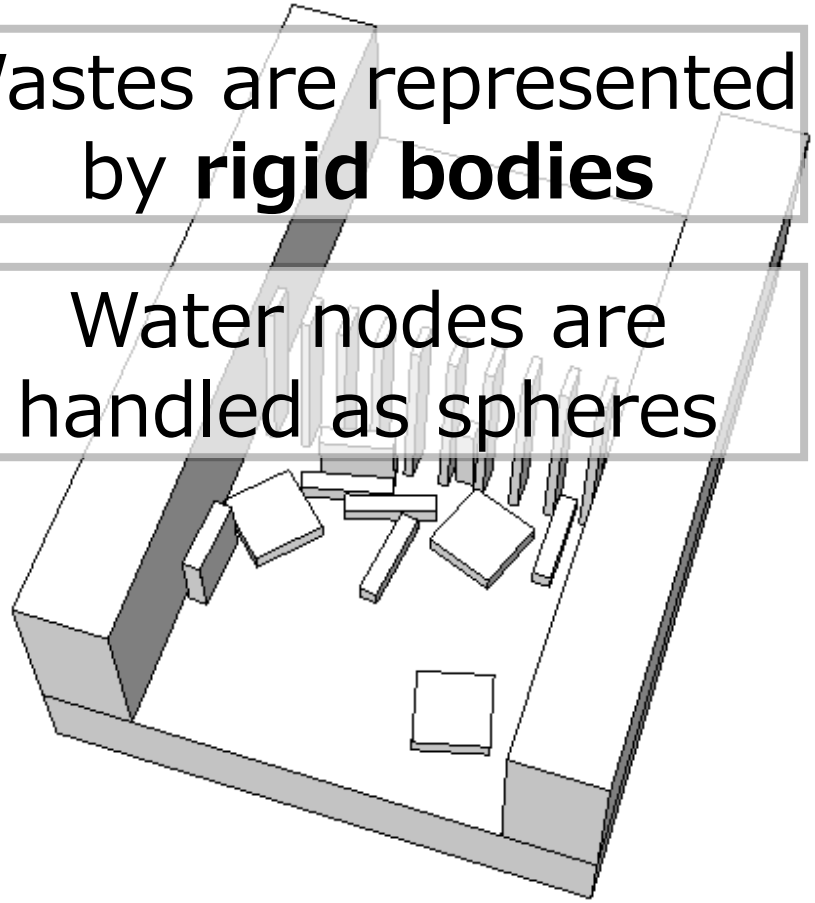


Blockage effect on canal water flow by clogging

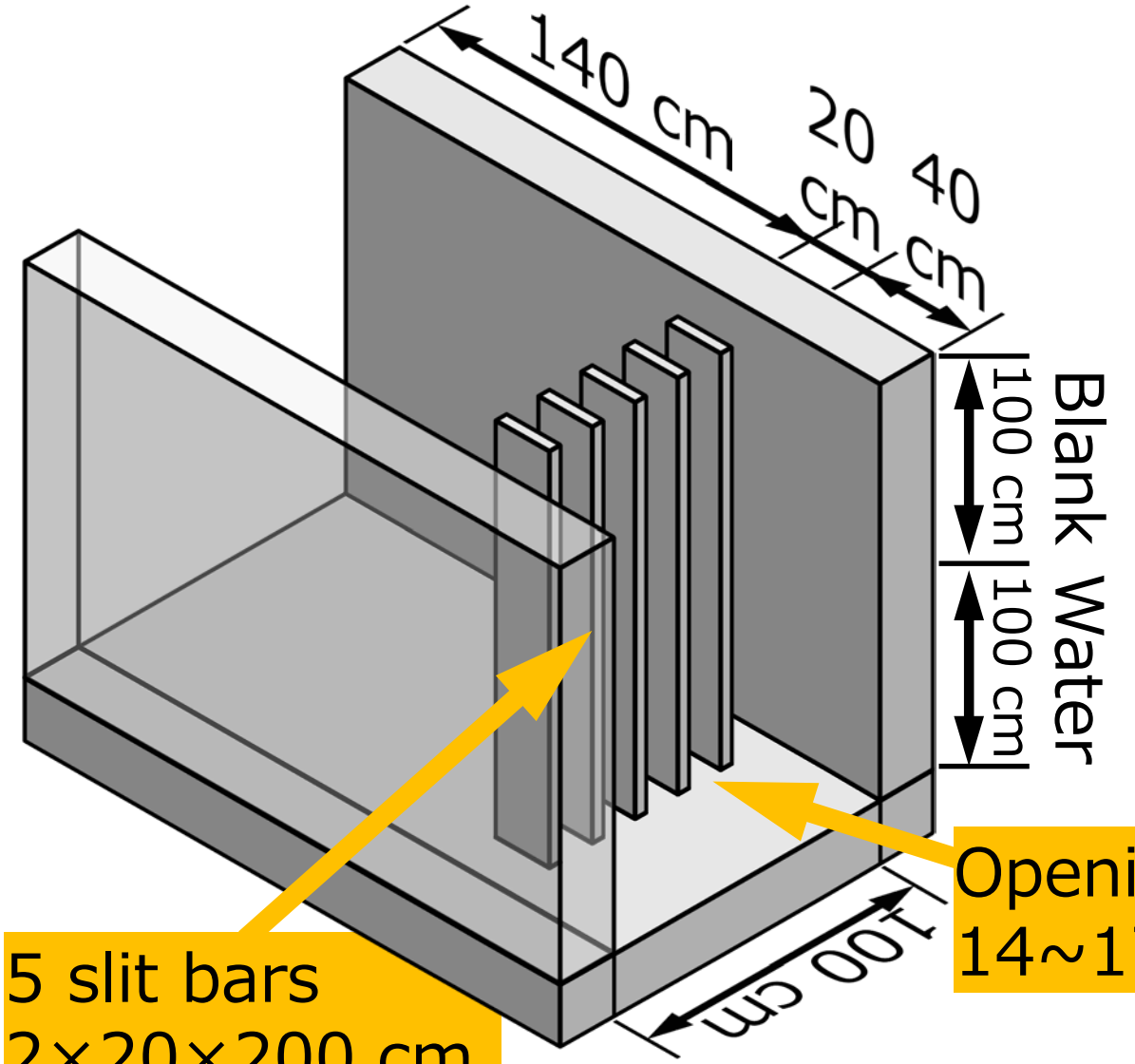
Method -Coupled two models-

Smoothed Particle Hydrodynamics (SPH)	Bullet Physics Library
Fluid is represented by **particles (nodes)**	Wastes are represented by **rigid bodies**
Navier-stokes equation with equation of state	Water nodes are handled as spheres





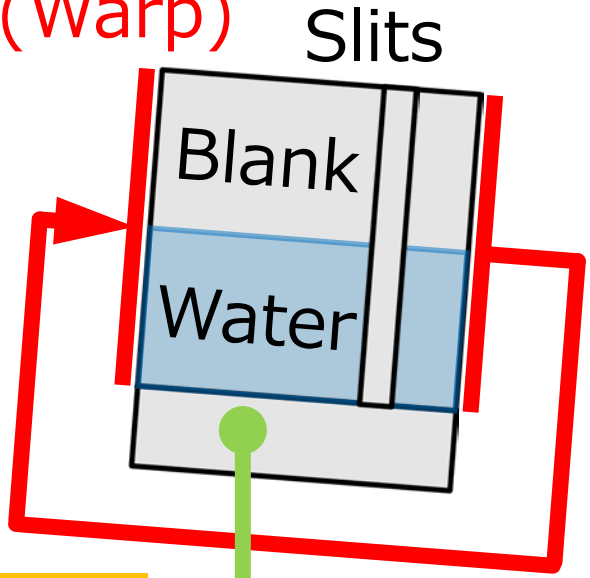
Method -Canal-



5 slit bars
2×20×200 cm

Opening
14~17 cm

Re-circulation for steady state with less nodes
(Warp)

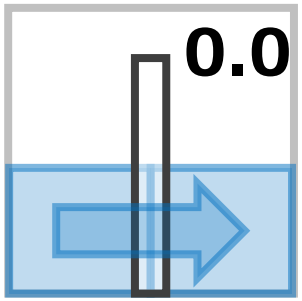


Gravity driving force

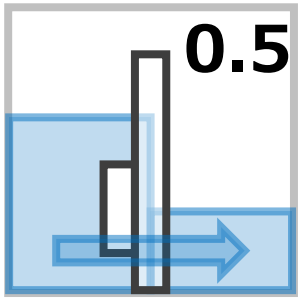
Method -Evaluation of flow-

Clogged or not? → **Is there any waste on slits?**

Blockage effect → $1 - \dfrac{\text{Average flow velocity}}{\text{Control average flow velocity}}$

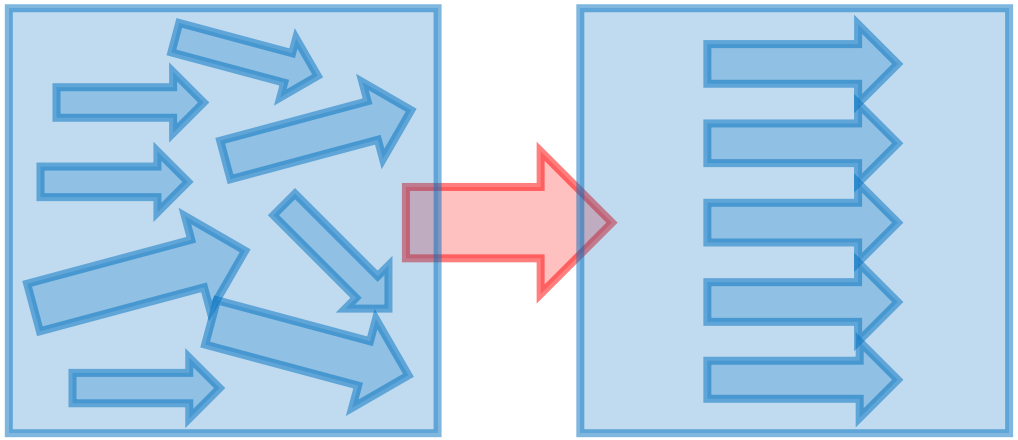


Control average flow velocity



Average flow velocity

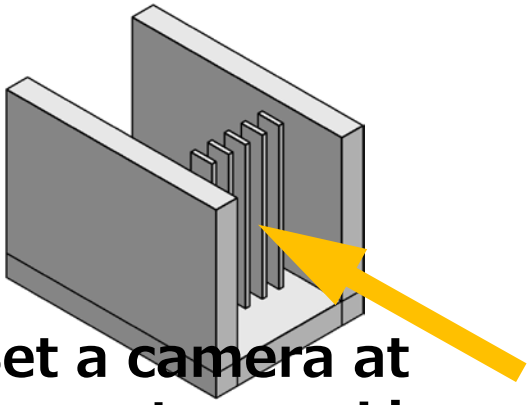
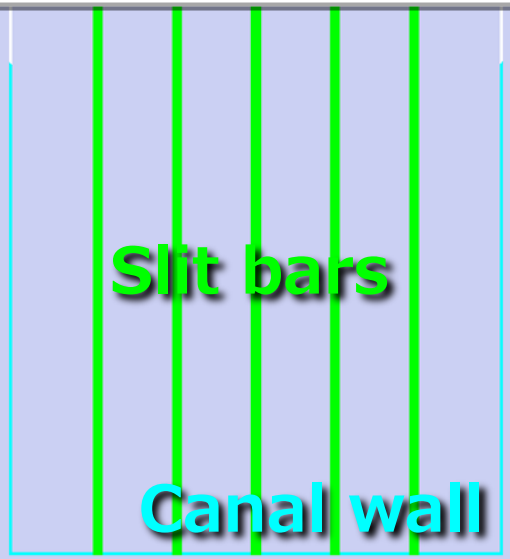
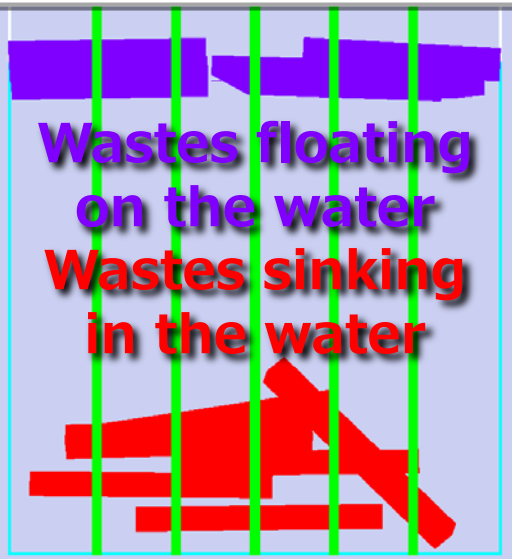
Average flow velocity



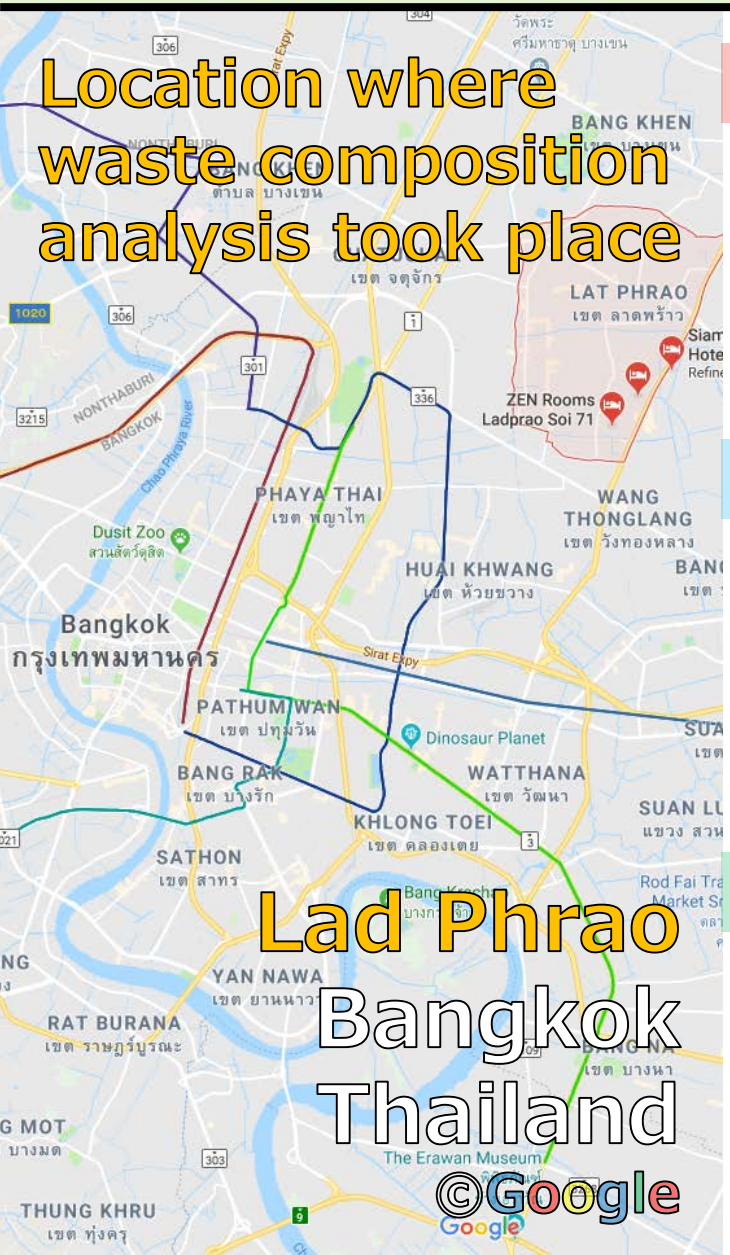
Method -Evaluation of blockage-

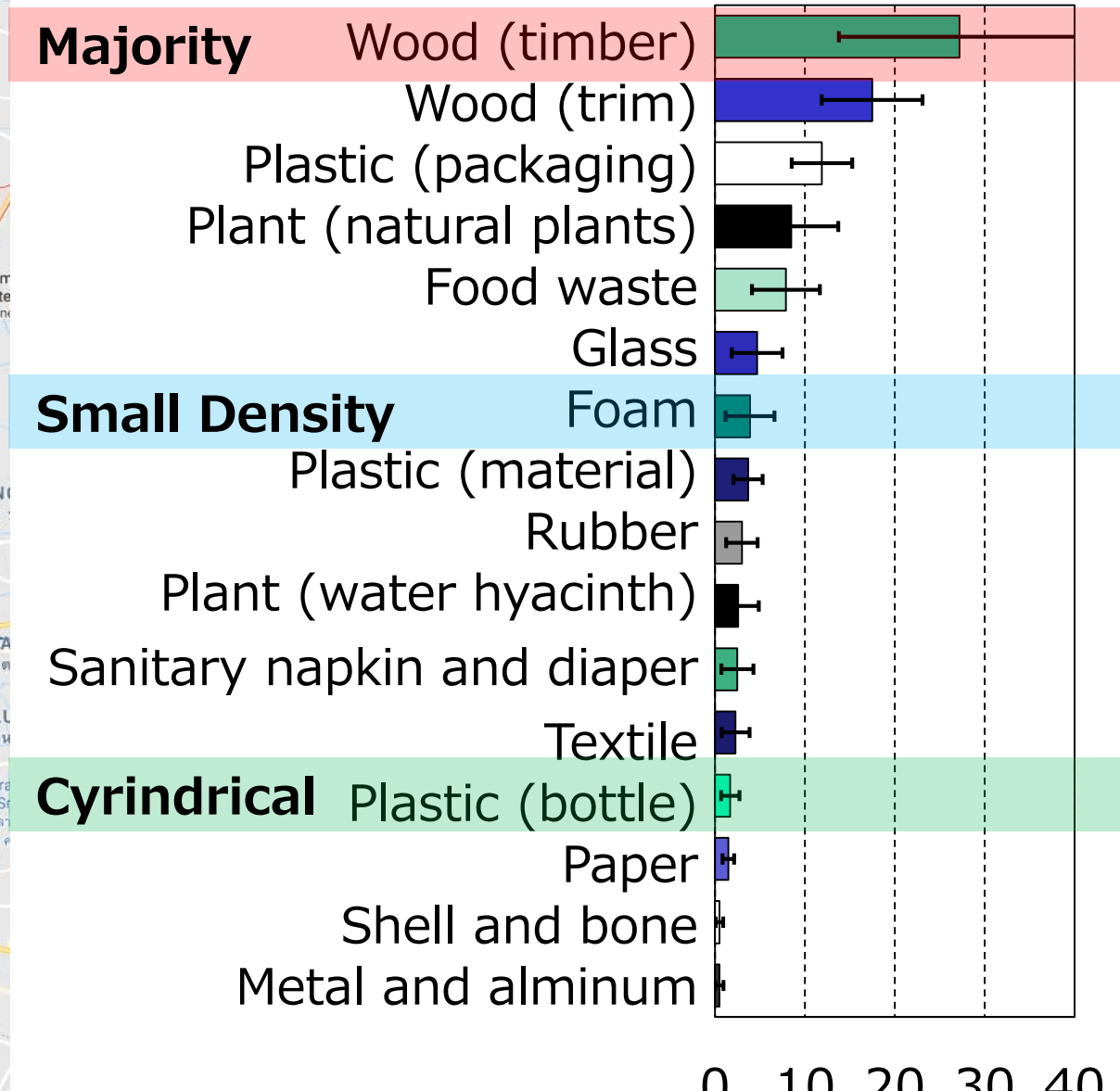
Evaluation of clogged area over slits

Area where is clogged by wastes is evaluated using a picture taken from a camera at downstream.
Area is calculated from **pixels occupied by wastes**.

Camera position	No blockage	Blockage by wastes
 **Set a camera at downstream. Line of sight and canal wall are in parallel.**		

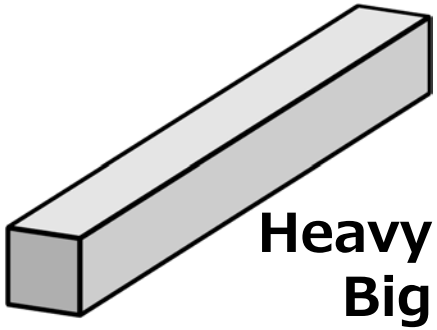
Condition -Composition of wastes-





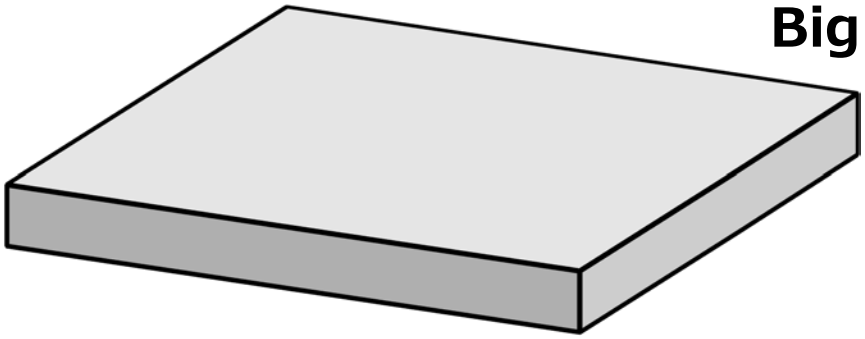
Condition -Properties of wastes-

	Wood (Timber)	Plastic (Bottle)	Foam
Dimension [cm]	5×5×50	Φ7×20	40×40×4
Density [g/cm³]	1.25	0.25	0.033
Volume [cm³]	1250	770	6400
Mass [g]	1563	211	192



Heavy
Big

Light
Small



Light
Big

Wood (Timber)

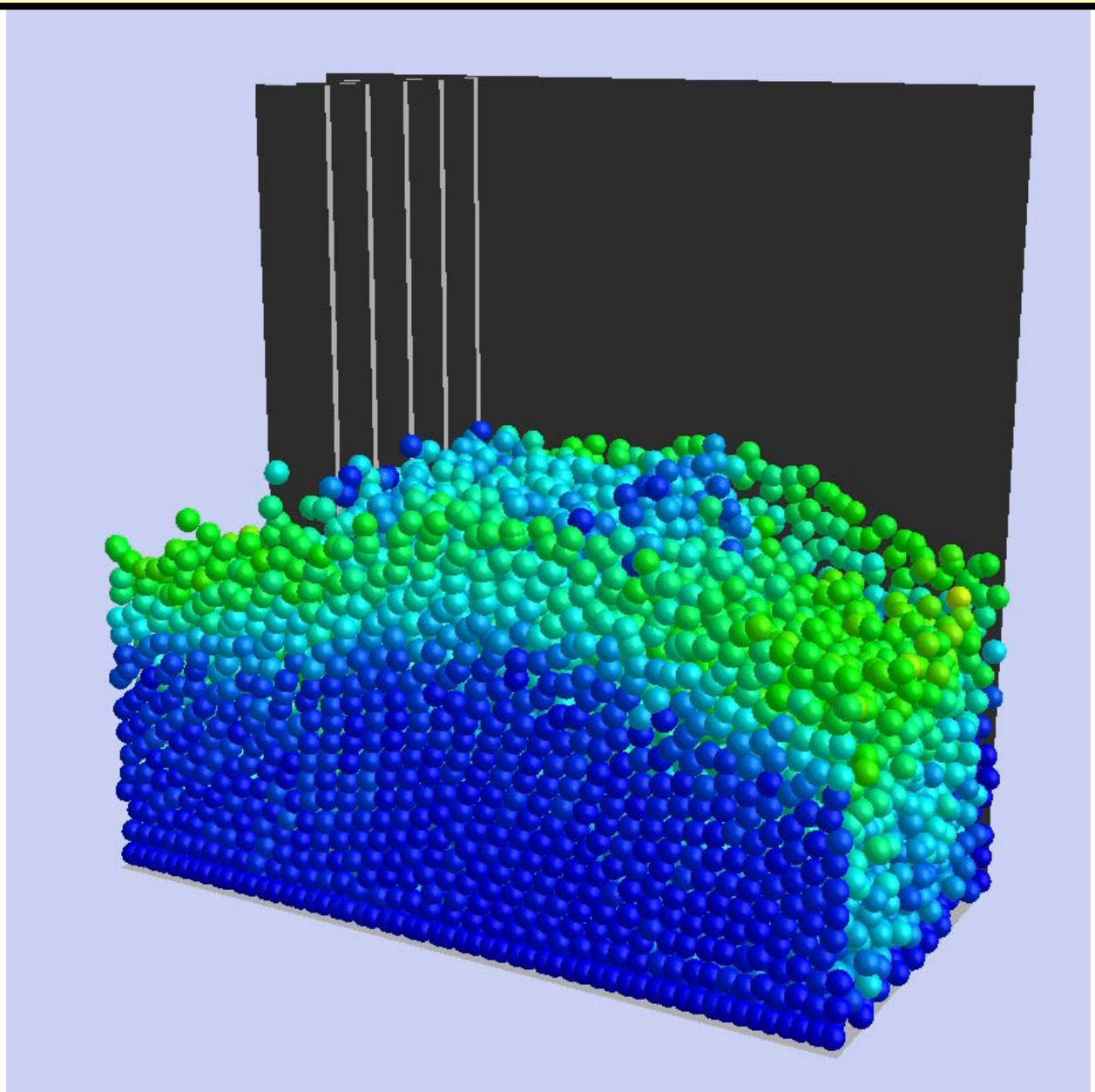
Plastic (Bottle)

Foam

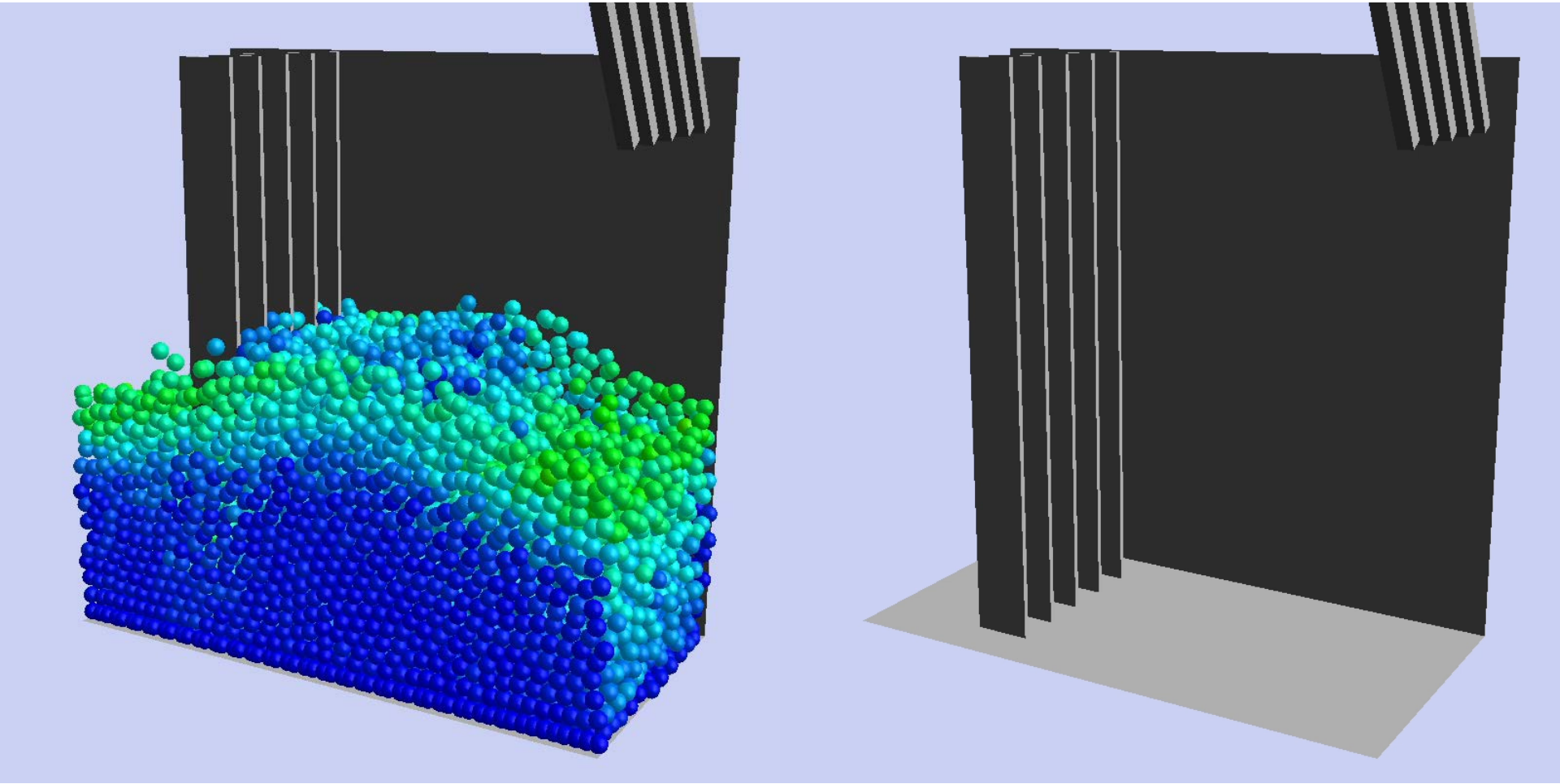
Condition -Composition-

	Slope [%]			Wood (Timber) [pcs]	Plastic (Bottle) [pcs]	Foam [pcs]
Control-2	2			-	-	-
Control-5	5			-	-	-
Control-10	10			-	-	-
WT25-5	5			25	-	-
PB50-5	5			-	50	-
F15-5	5			-	-	15
WT1-2/5/10	2	5	10	1	-	-
WT9-2/5/10	2	5	10	9	-	-
F1-2/5/10	2	5	10	-	-	1
Mix-2/5/10	2	5	10	6	6	3

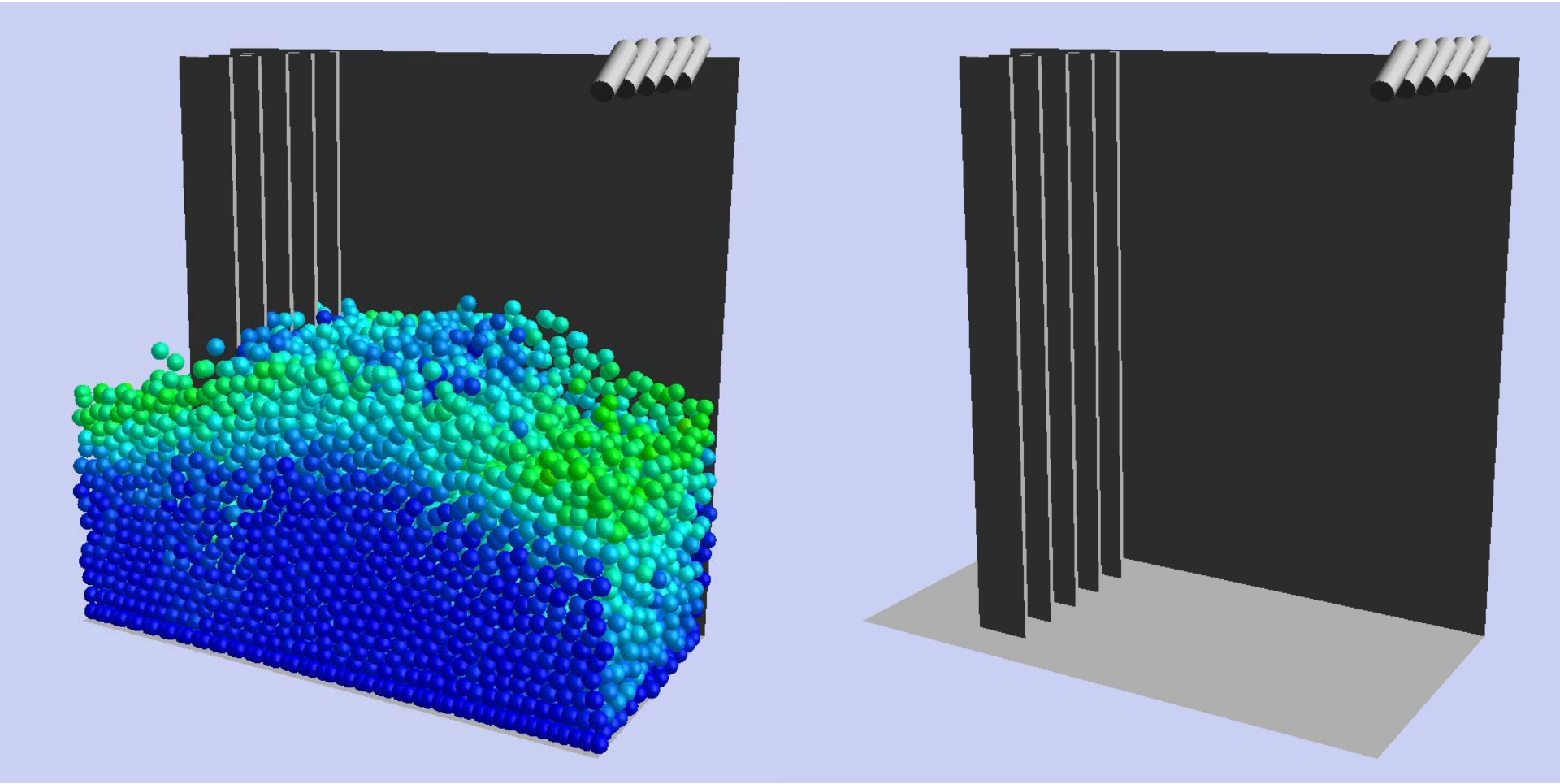
Results -Control 5%-



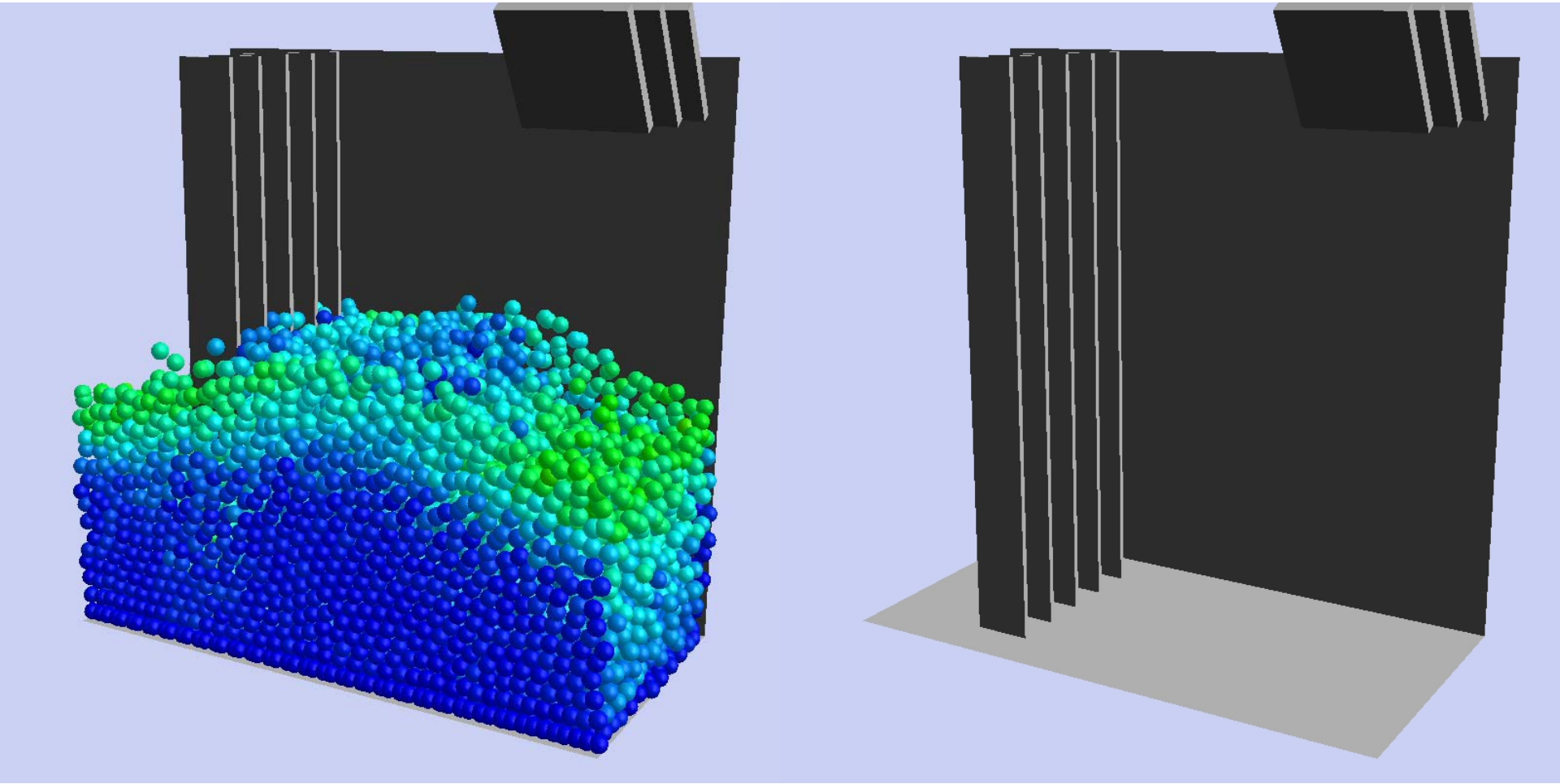
Results -Wood(Timber) 25-5%-



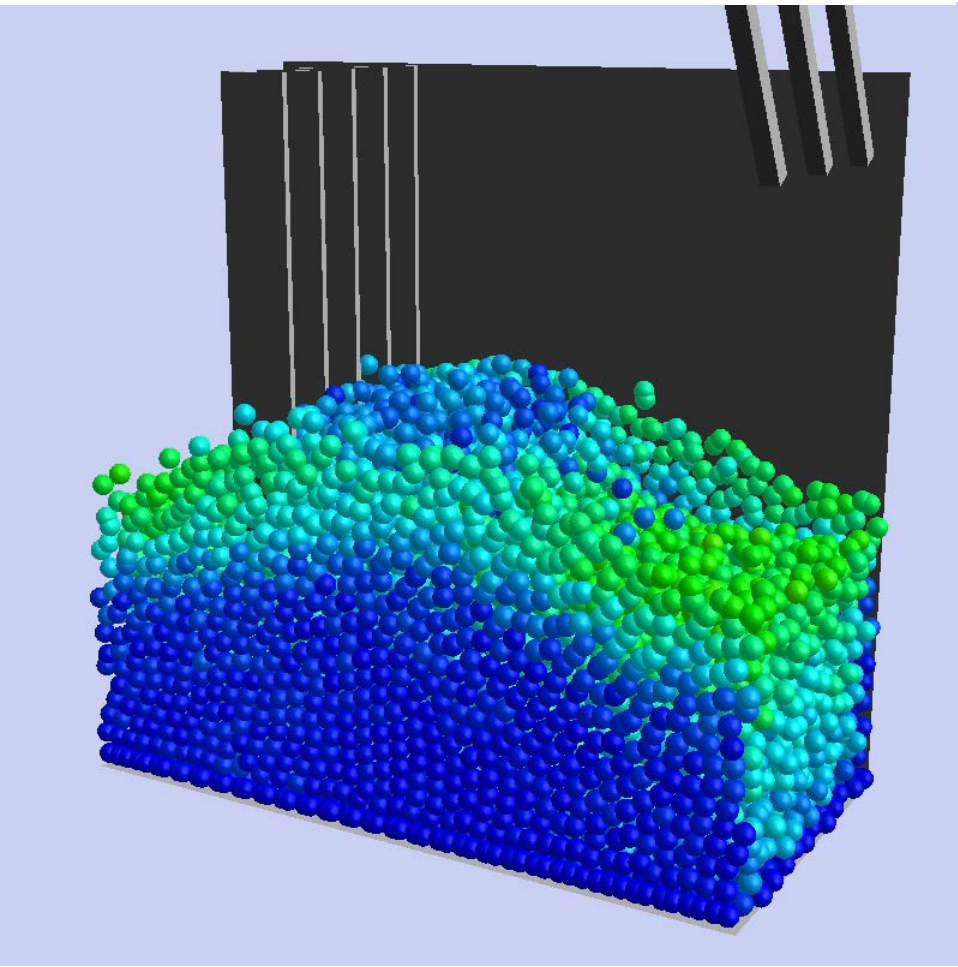
Results -Plastic(Bottle) 50-5%-

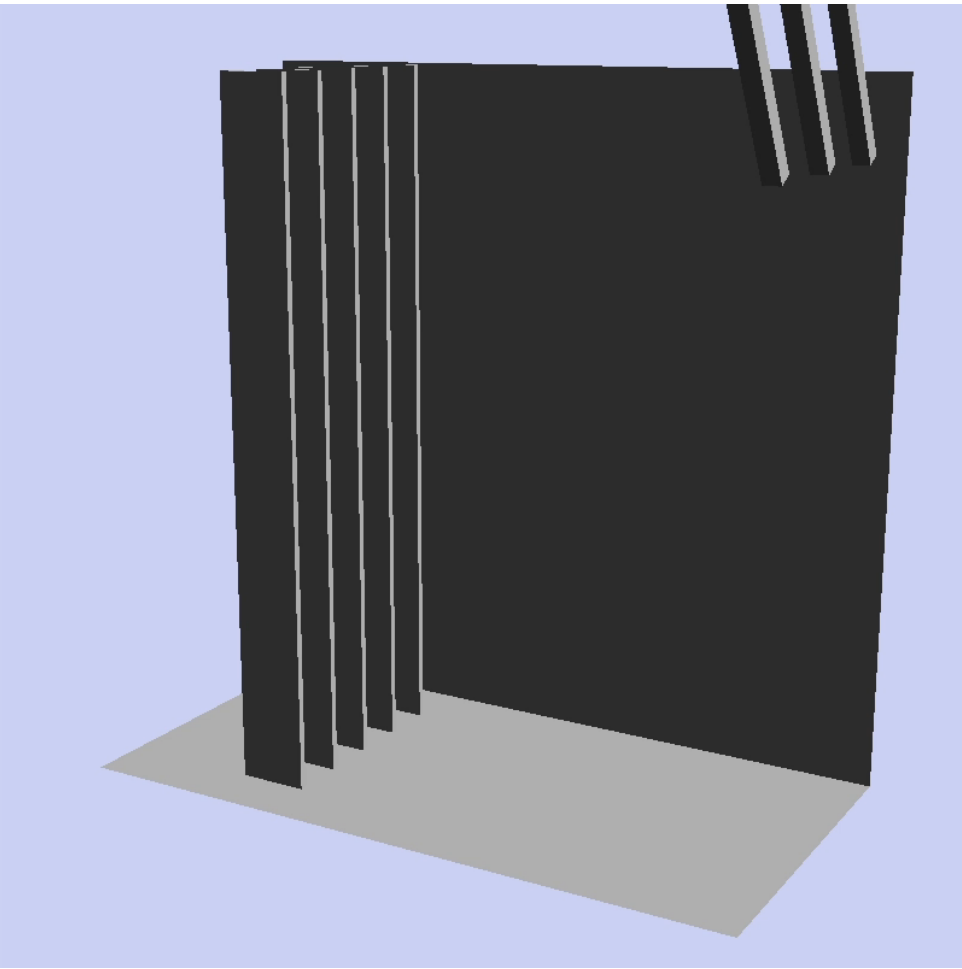


Results -Foam 15-5%-



Results -Mix-5%-

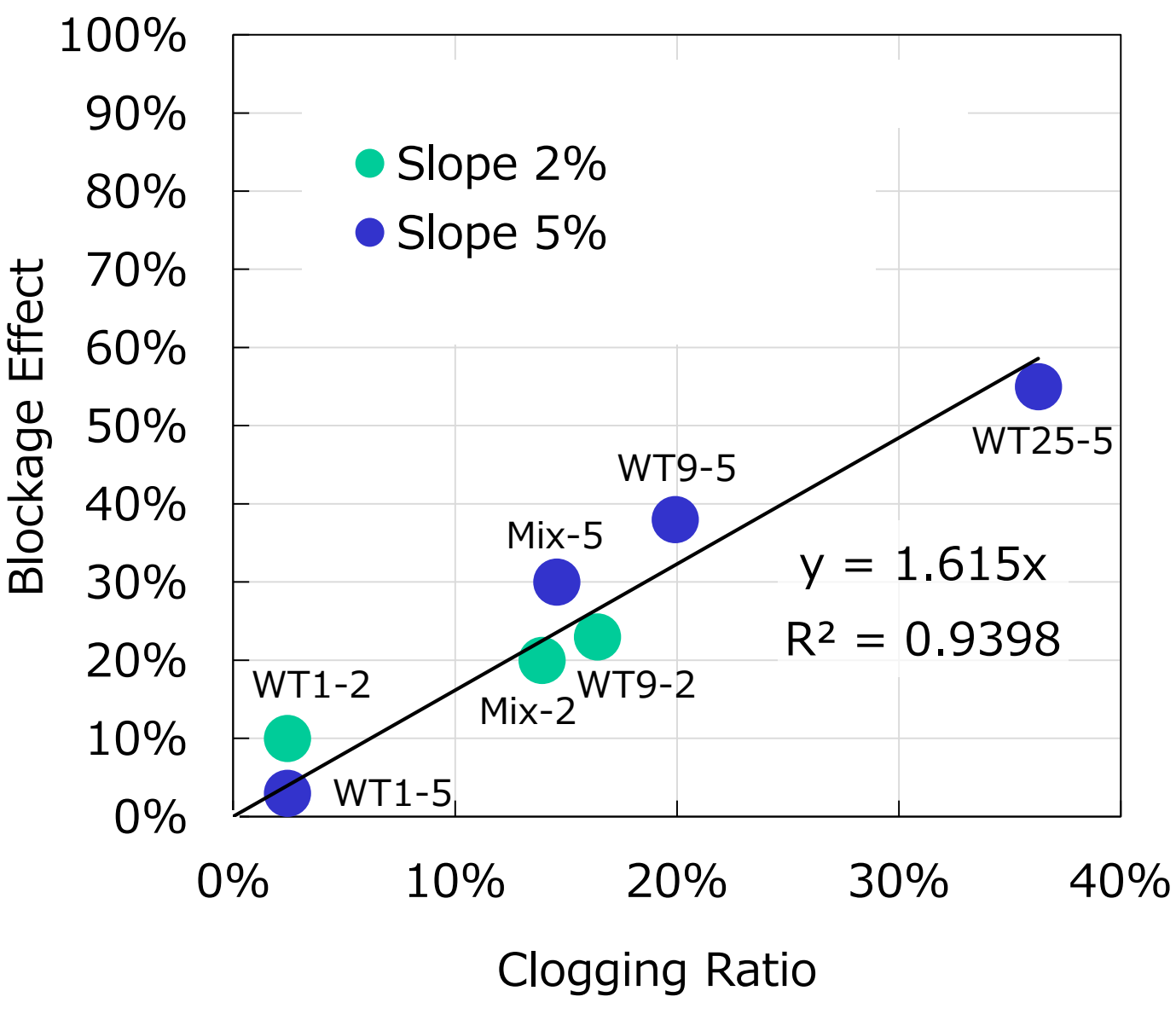


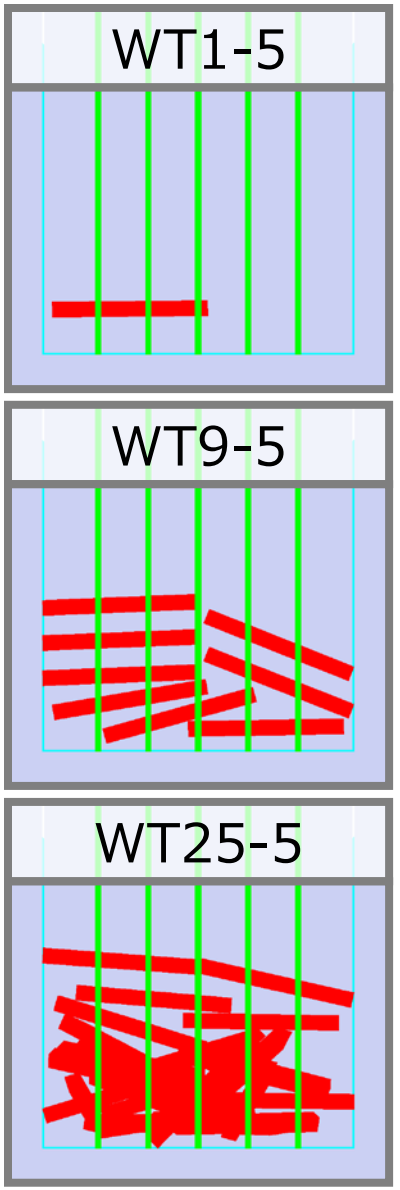


Results -Blockage effect-

	Average flow velocity [m/s]	Clogged?	Blockage effect [%]
WT25-5	0.42	Yes, WT23	55
PB50-5	0.93	Passed	-
F15-5	0.93	Floated	0
WT1-2	0.27	Yes, WT1	10
WT1-5	0.88	Yes, WT1	6
WT1-10	1.90	Passed	-
WT9-2	0.23	Yes, WT8	23
WT9-5	0.58	Yes, WT8	38
WT9-10	1.89	Passed	-
F1-2	0.30	Floated	0
F1-5	0.94	Floated	0
F1-10	1.90	Passed	-
Mix-2	0.24	Yes, WT6	20
Mix-5	0.66	Yes, WT6	30
Mix-10	1.89	Floated	1

Results -Clogged area-





Discussion

Condition when slit-like structures are clogged

- **Waste sinks in water**
- **Waste > slit opening**

Blockage effect on canal water flow by clogging

Blockage effect **55%** by **36% clogged area**.

Blockage effect and clogged area had linear relationship (R^2=0.94). On the other hand, blockage effect and number of wood timbers on slit bars and had less relationship (R^2=0.74). **Even first layer of clogging can have large effect.**

Conclusion

A numerical model for canal flow developed

Condition of clogging

- **Waste sinks in water**
- **Waste > slit opening**

Blockage effect

Blockage effect **55%** by **36% clogged area**.

To prevent clogging…

- **Heavy wastes** should be removed.
- **Larger wastes** should be given higher priority. (they might cause clogging involving small wastes)
- **Even first layer of clogging** should be removed. (though they look thin, they effectively block)

Future plan

Concerning future precipitation

Our present model is for a short canal with bar screen.
・**Blockage effect** is utilized in the following model.

Our future numerical model will be…
・Connected to **future precipitation model**
・Covers larger area (possibly a **city**)
・Analyse a **network of multiple canals during a precipitation event**

This model will be utilized in evaluation of **flood prevention effect by waste management**.