Procedure and examples of setting standard for critical rainfall for warning and evacuation from sediment-related disasters

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1. Procedures of setting standard for critical rainfall for warning and evacuation from sediment-related disasters

To set critical line （Critical Line：Hereafter，CL）for the occurrence of sediment-related disaster, you need to obtain enough data in regards to rainfall and disasters. However, if you cannot obtain enough information, you can set average CL based on the characteristics of the concerned area. Following are procedures of setting standard CL.

(1) For the area concerning CL setting, select natural conditions to focus. Among the conditions choose applicable items for the concerned area.（Refer to Table-1.1）.

Table-1.1 List of natural conditions

Conditions	Cases
Regional	1. Volcanic regions
	2. Non-volcanic regions
Rainfall	1. Small rainfall area
	2. Medium rainfall area
	3. Large rainfall area
Geological	1. Granite zone
	2. Volcanic ejection zone (active zone)
	3. Volcanic ejection zone(inactive zone)
	4. Tertiary sedimentary

Where

Small rainfall area	:	Probabilistic rainfall of 100 years	less than 250mm/day
Medium rainfall area	:	Probabilistic rainfall of 100 years	from 250 to 350mm/day
Large rainfall area	:	Probabilistic rainfall of 100 years	more than 350mm/day

(2) Select the method of setting CL（Guideline Method A or Committee Method）.

(3) Determine average slope of CL with the CL setting method selected.

※ Where the slope of CL for Guideline Method A：-0.45, for Committee Method：-0.9.

(4) Calculate one third of probabilistic rainfall of 100 years per hour (mean value) and working rainfall (mean value), which corresponds to selected CL setting method, condition and item. (Refer to Figure 1.1~1.3).

(5) Decide the linear line, that will pass one third of probabilistic rainfall of 100 years per hour (mean value) and working rainfall (mean value)（*x, y axis*） calculated in (4) with the slope of CL determined in paragraph (3). This linear line is standard CL, which corresponds to the natural characteristic of the concerned area.

(1) Regional condition

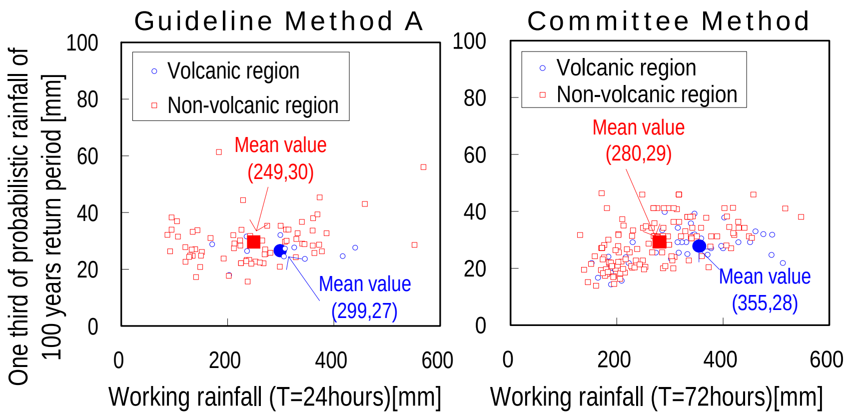

Figure-1.1 Relationship between one third of probabilistic rainfall of 100 years per hour and working rainfall（Regional condition）

(2) Rainfall condition

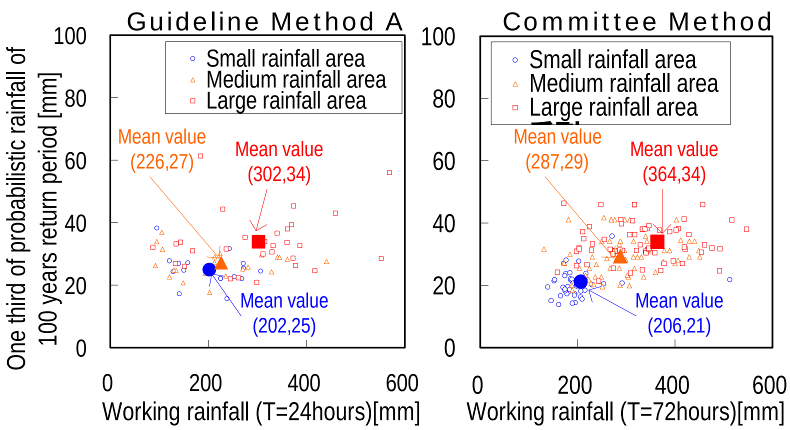

Figure-1.2 Relationship between one third of probabilistic rainfall of 100 years per hour and working rainfall（Rainfall condition）

(3) Geological condition

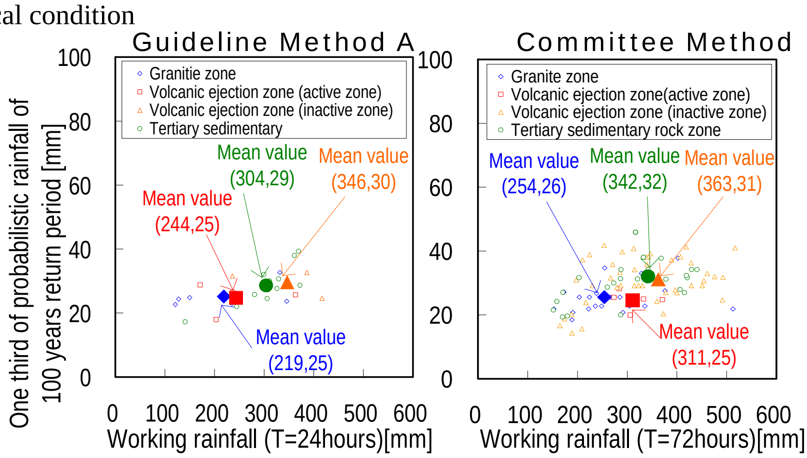

Figure-1.3 Relationship between one third of probabilistic rainfall of 100 years per hour and working rainfall（Geological condition）

2. Examples of setting standard for critical rainfall for warning and evacuation from sediment-related disasters

2.1 Setting CL

For the three conditions mentioned in section 1, we have set CL for both Guideline Method A & Committee Method. Tabel-2.1 as well as Figure-2.1～Figure2.6 show the CL set.

Table-2.1 CL chart

Conditions	Cases	Guideline Method A	Committee Method
Regional	Volcanic regions	y=-0.45x+161.6	y=-0.90x+347.5
	Non-volcanic regions	y=-0.45x+142.1	y=-0.90x+281.0
Rainfall	Small rainfall area	y=-0.45x+115.9	y=-0.90x+206.4
	Medium rainfall area	y=-0.45x+128.7	y=-0.90x+287.3
	Large rainfall area	y=-0.45x+169.9	y=-0.90x+361.6
Geological	Granite zone	y=-0.45x+123.6	y=-0.90x+254.6
	Volcanic ejection zone (active zone)	y=-0.45x+134.8	y=-0.90x+304.9
	Volcanic ejection zone (inactive zone)	y=-0.45x+185.7	y=-0.90x+357.7
	Tertiary sedimentary	y=-0.45x+165.8	y=-0.90x+339.8

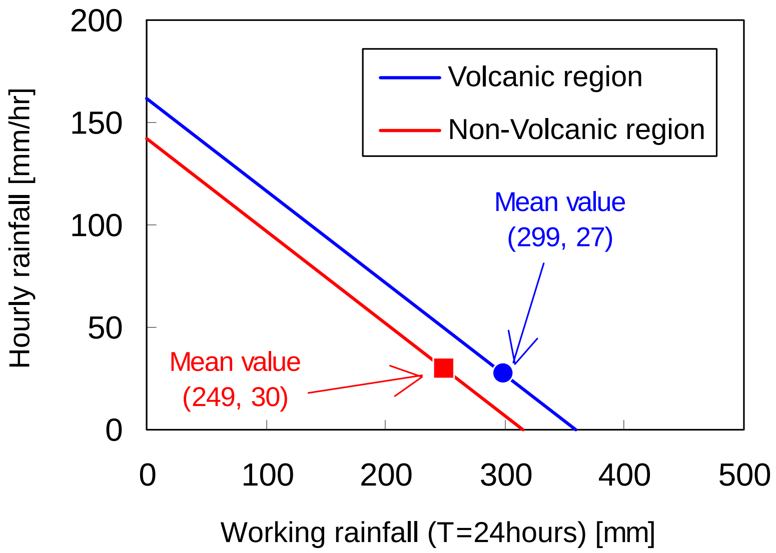

Figure-2.1 Standard CL with Guideline Method A（Regional condition）

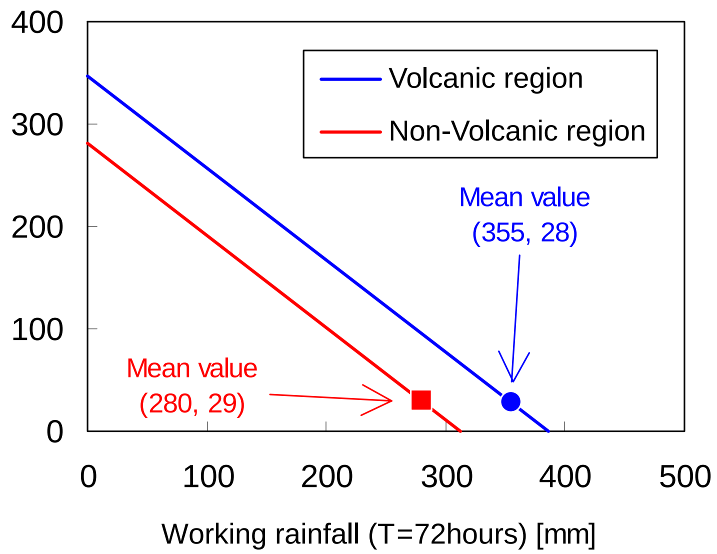

Figure-2.2 Standard CL with Committee method（Regional condition）

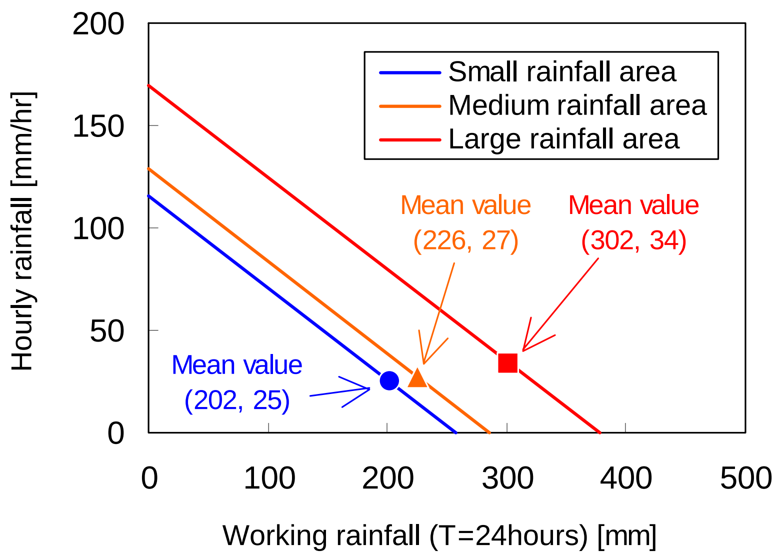

Figure-2.3 Standard CL with Guideline Method A（Rainfall condition）

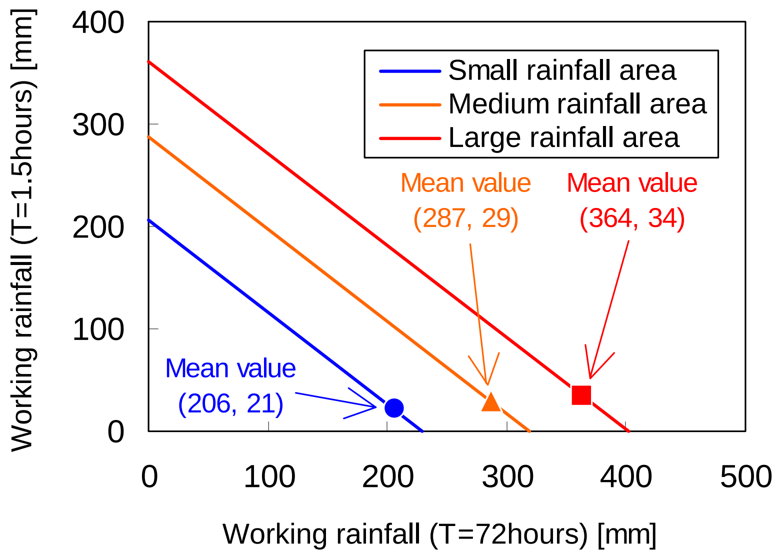

Figure-2.4 Standard CL with Committee method（Rainfall condition）

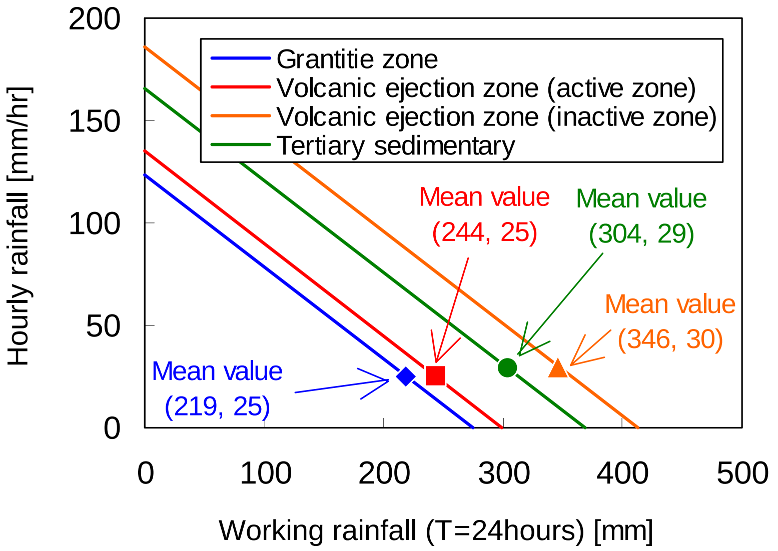

Figure-2.1 Standard CL with Guideline Method A（Geological condition）

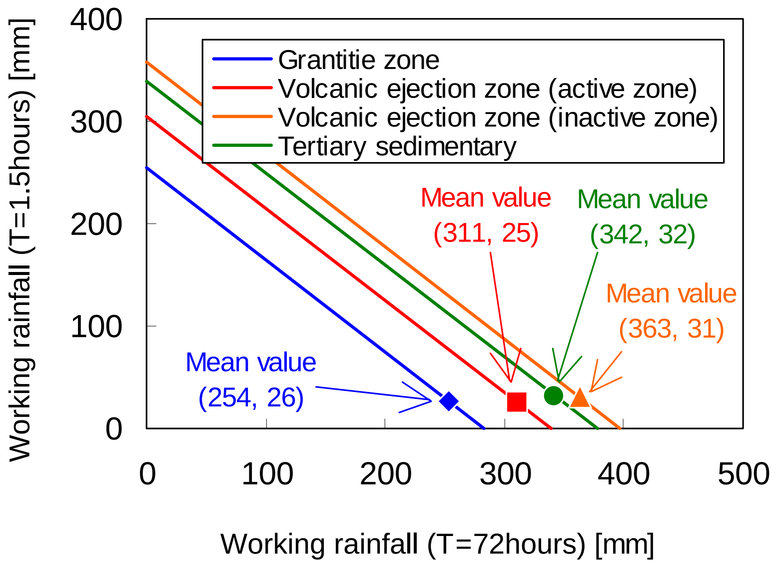

Figure-2.2 Standard CL with Committee method（Geological condition）

2.2 Verification of CL precision

We verified the concerned CL precision with the rainfall (snake line), which caused major sediment-related disasters in Japan during the year 2004 against CL set in the paragraph 2.1.

Place, date, and natural conditions of each region, where major sediment-related disaster occurred during the year 2004 are shown in the table-3.1. CL and snake line set for each area are shown on Figure-3.1 ~Figure 3.11. Regarding geological condition of Kamikatsu (Tokushima pref.), Niihama (Ehime pref.) and Miyakawa (Mie pref.), it was out of setting conditions, therefore, it is excluded here.

From the figures, regarding the CL based on the rainfall condition, both Guideline Method A and Committee Method have predicted sediment-related disasters which are object for verification, which means its validity has been confirmed. However, regarding the regional and geological conditions, sediment-related disasters occurred before the snake line reached CL in some areas. Therefore, when you actually apply those methods, you need to consider standard deviation in data.

Considering above-mentioned facts, in case there is not enough data for rainfall and sediment-related disaster, selecting the CL based on rainfall condition among the three conditions mentioned is most effective.

Table-3.1 Places where sediment-related disaster occurred and their natural conditions

Place of occurrence	Date of occurrence	Regional	Rainfall	Geological
Tochio (Niigata pref.)	July 13, 2004	Volcanic	Small rainfall	Volcanic ejection zone (active zone)
Miyama (Fukui pref.)	July 18, 2004	Non-volcanic	Small rainfall	Tertiary sedimentary
Kamikatsu (Tokushima pref.)	August 1, 2005	Non-volcanic	Large rainfall	Other zone
Niihama (Ehime pref.)	August 17, 2005	Non-volcanic	Medium rainfall	Fracture zone
Miyagawa (Mie pref.)	September 29,2004	Non-volcanic	Large rainfall	Other zone

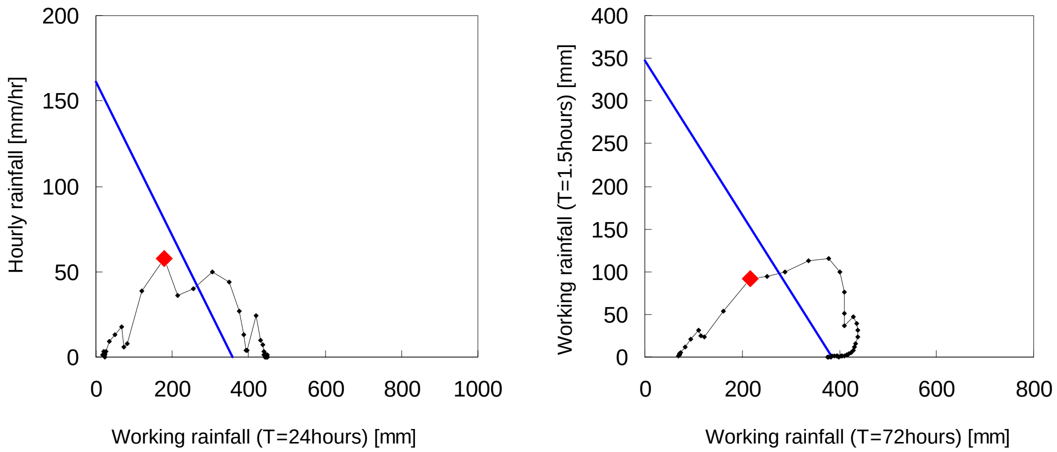

Figure-3.1 Case study in Tochio, Niigata pref.（Regional condition：volcanic）

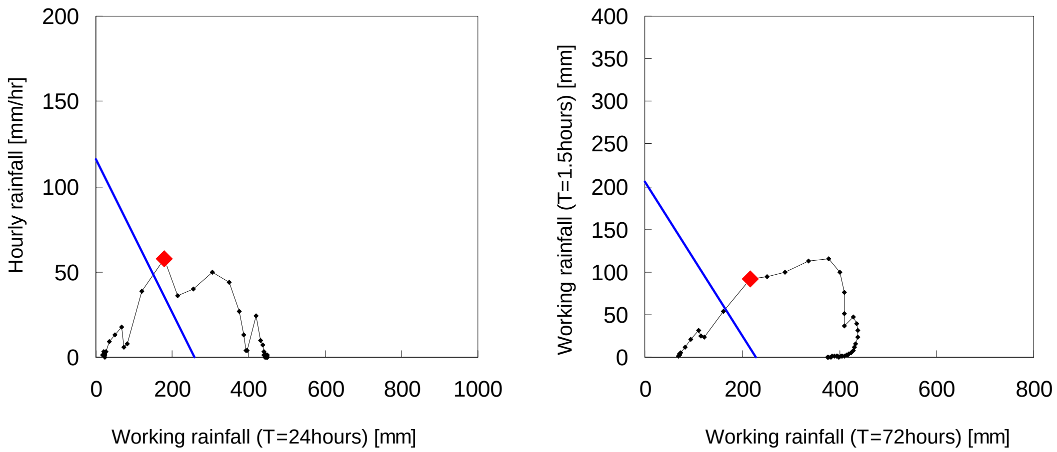

Figure-3.2 Case study in Tochio, Niigata pref.（Rainfall condition：small）

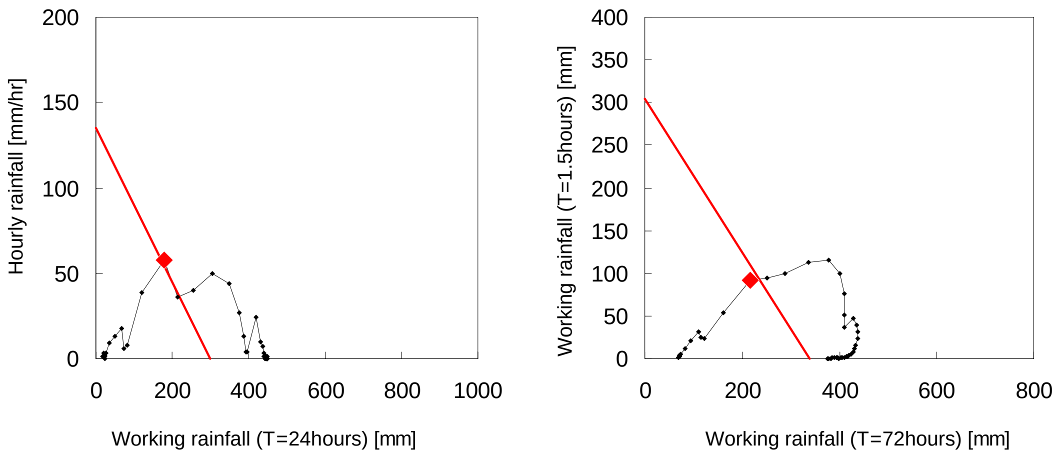

Figure-3.3 Case study in Tochio, Niigata pref.（Geological condition：Volcanic ejection zone (active zone)）

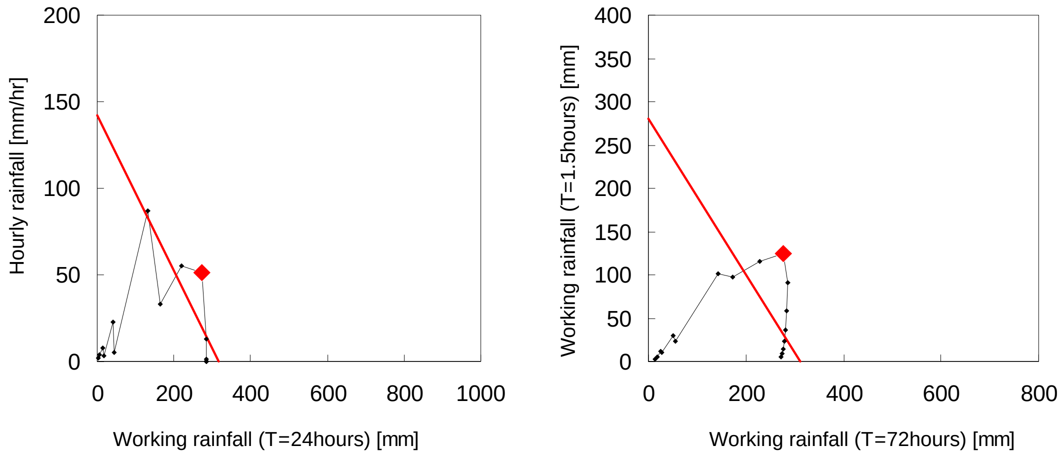

Figure-3.4 Case study in Miyama, Fukui pref.（Regional condition：non-volcanic region）

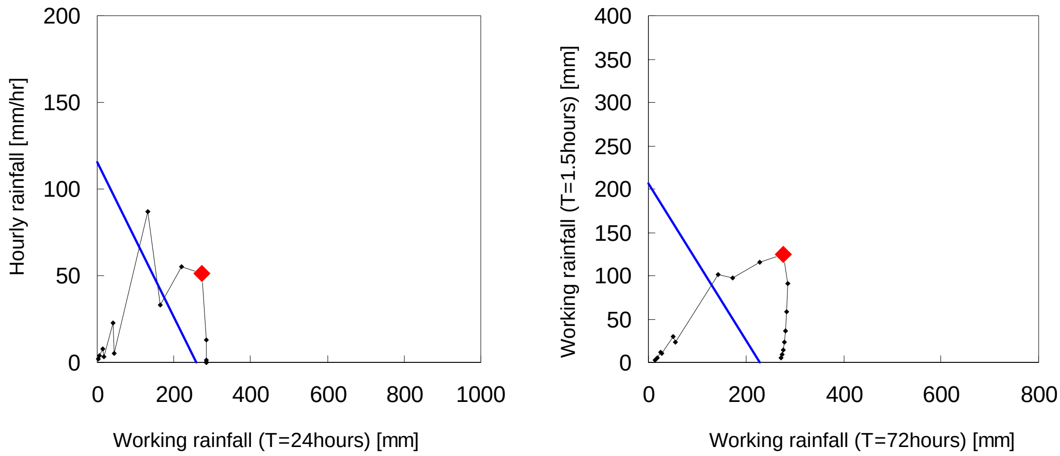

Figure-3.5 Case study in Miyama, Fukui pref.（Rainfall condition：small）

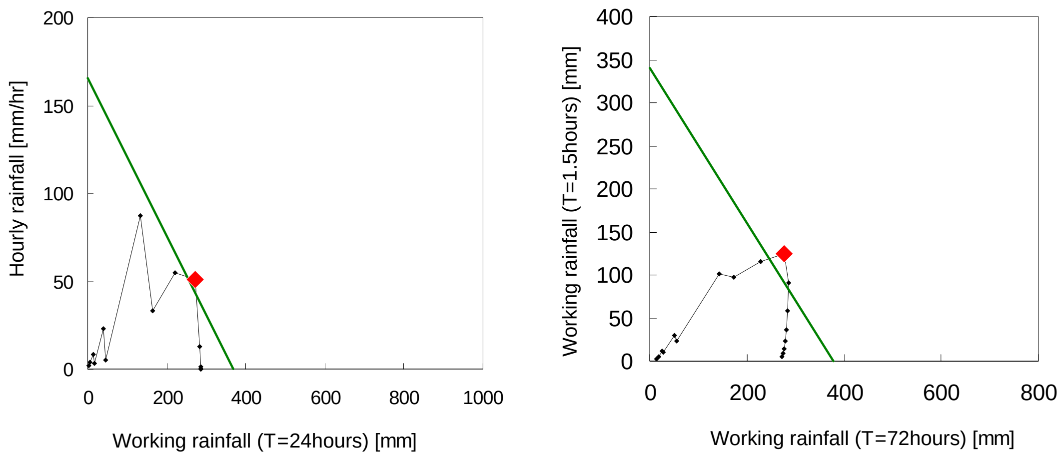

Figure-3.6 Case study in Miyama, Fukui pref.（Geological condition：Tertiary sedimentary）

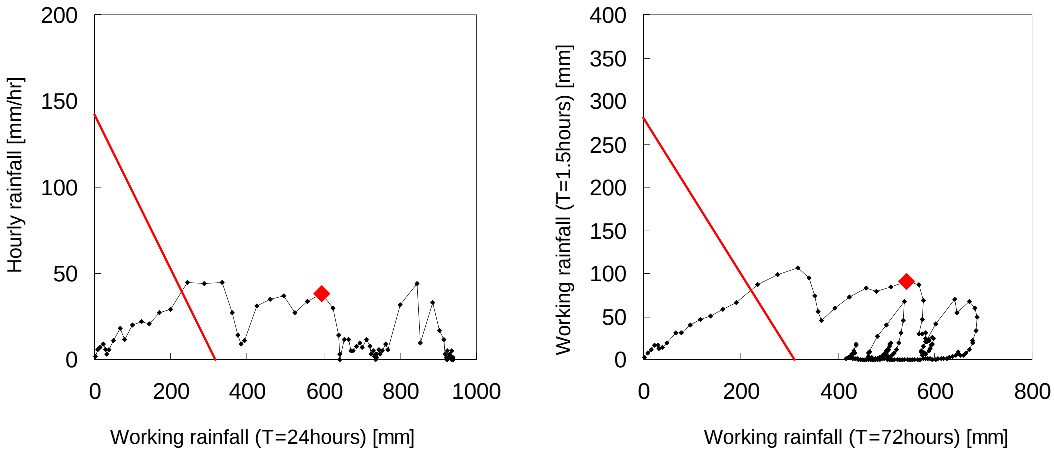

Figure-3.7 Case study in Kamikatsu, Tokushima pref.（Regional condition：non-volcanic）

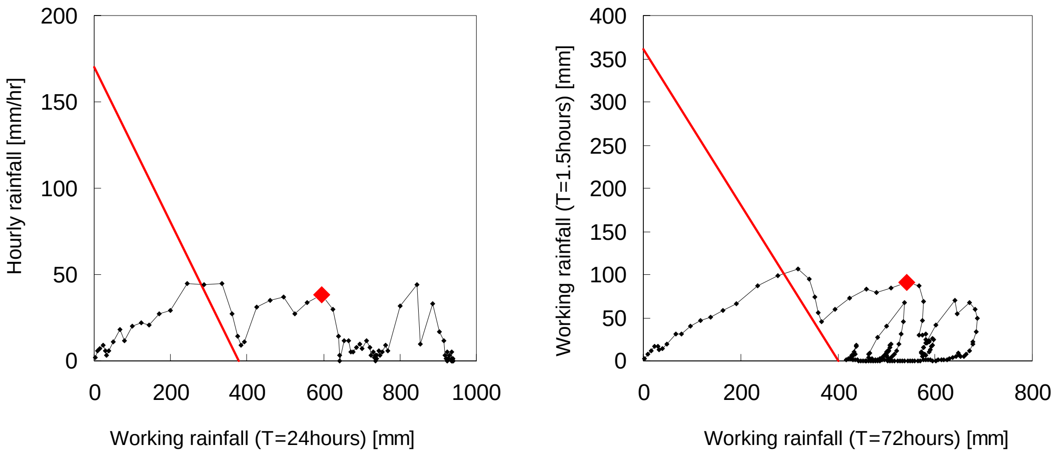

Figure-3.8 Case study in Kamikatsu, Tokushima pref.（Rainfall condition：large）

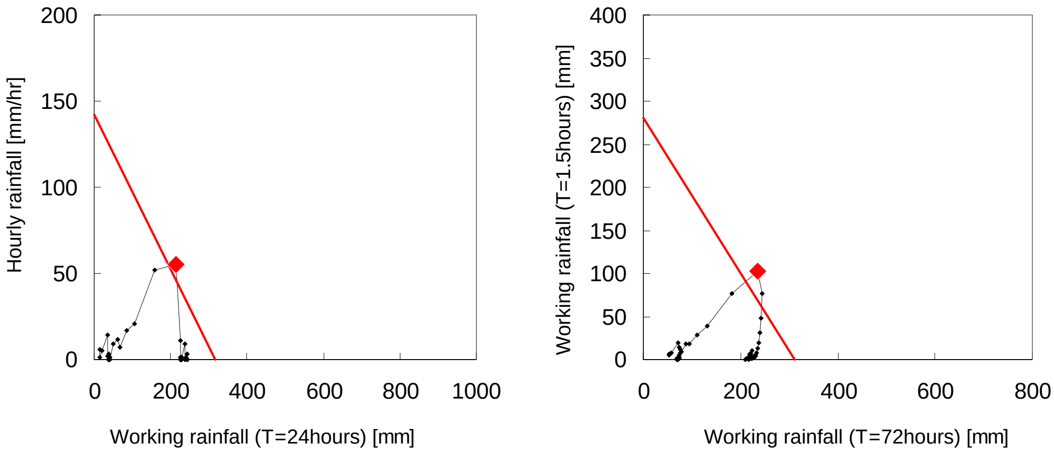

Figure 3.9 Case study in Niihama, Aichi pref.（Regional condition：non-volcanic）

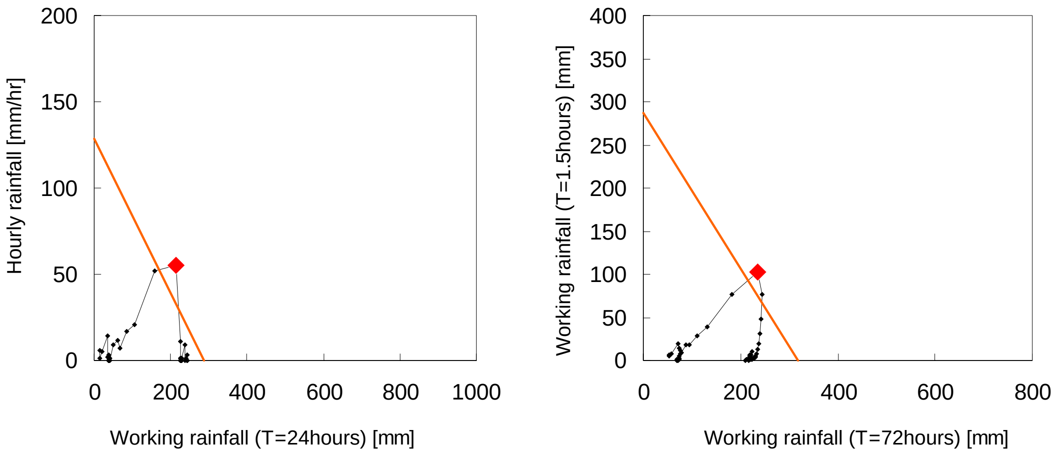

Figure-3.10 Case study in Niihama, Aichi pref.（Rainfall condition：medium）

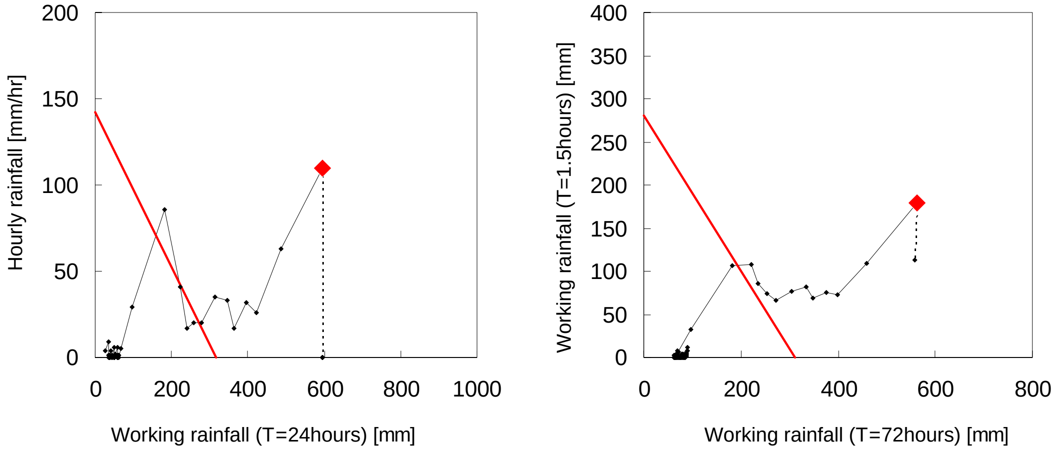

Figure-3.11 Case study in Miyakawa, Mie pref.（Regional condition：non-volcanic）

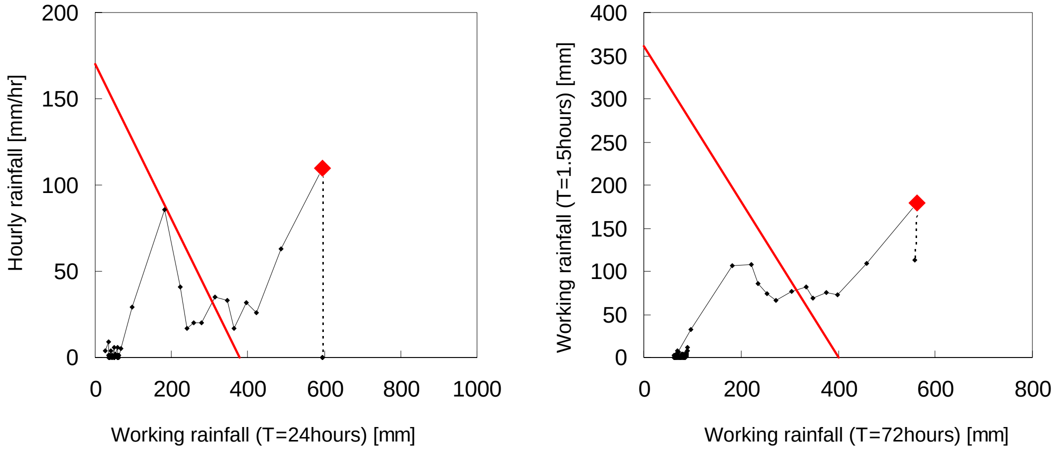

Figure-3.12 Case study in Miyakawa, Mie pref（Rainfall condition：large）