Special Sediment-related Disaster Hazard Area Etc

Setting Procedure

Contents

1. Setting the Range of Sediment-related Disaster Warning Area Etc.

The objects of this setting are natural phenomenon of debris flow due to hillside collapse or debris flow along mountain stream mingled with water as a whole. And the object ranges are hazardous land where the occurrence of a debris flow disaster is predicted and torrents where there is a risk of causing debris flow.

The above-mentioned torrent is the place where it is valley-shaped on the 1/25,000 topographic map.

2. Setting the Range of Special Sediment-related Disaster Hazard Area

2.1 Method of setting the Range of Special Sediment-related Hazard Area

Method of setting the range of Special Sediment-related Hazard Area is composed of three different stages. The details of each stage are described in the Table-2.1.

Table-2.1 The details of each stage

Stage	Item	Details
1	Topographic Survey	① Setting reference point ② Gradient of torrent bed ③ Measurement of area river basin ④ Grasping torrent bed condition
2	Geological Survey	① Survey of soil parameters
3	Setting the Range of Special Sediment-related Disaster Hazard Area Etc	① Computing quantity of earth and rock etc at the reference point ② Setting direction of debris flow ③ Computing peak discharge of the debris flow ④ Computing hydrodynamic force of debris flow acting on buildings and strength of normal buildings ⑤ Setting range of special sediment-related disaster hazard areas ⑥ Setting range of sediment-related disaster warning area

2.2 Topographic Survey

2.2.1 Setting reference point

Reference points are "points where debris flow comes into the alluvial fan area at the foot of a mountain" in the " Law related to Promotion of Measures for Sediment-related Disaster Prevention in a Restricted Area etc. due to Sediment-related Disaster " and set with the attention on the items below.

Table-2.2 Topographical condition considered when setting reference points

Topographical condition	Situation
Outlet of valley	A point where valley becomes open and the valley width becomes wider
Top of alluvial fan	Top point of alluvial fan where the valley becomes wider and the gradient of torrent bed becomes gentle
Hook	Hook of channel (Due to the straight movement of debris flow, it floods towards outer revetment)
Changing point of gradient	A point where the gradient of torrent bed suddenly becomes gentle from a steep one
Outlet of narrow pass	A point where narrow valley (narrow pass) suddenly becomes wide
Past debris flow flood point	A point where past debris flow started to flood

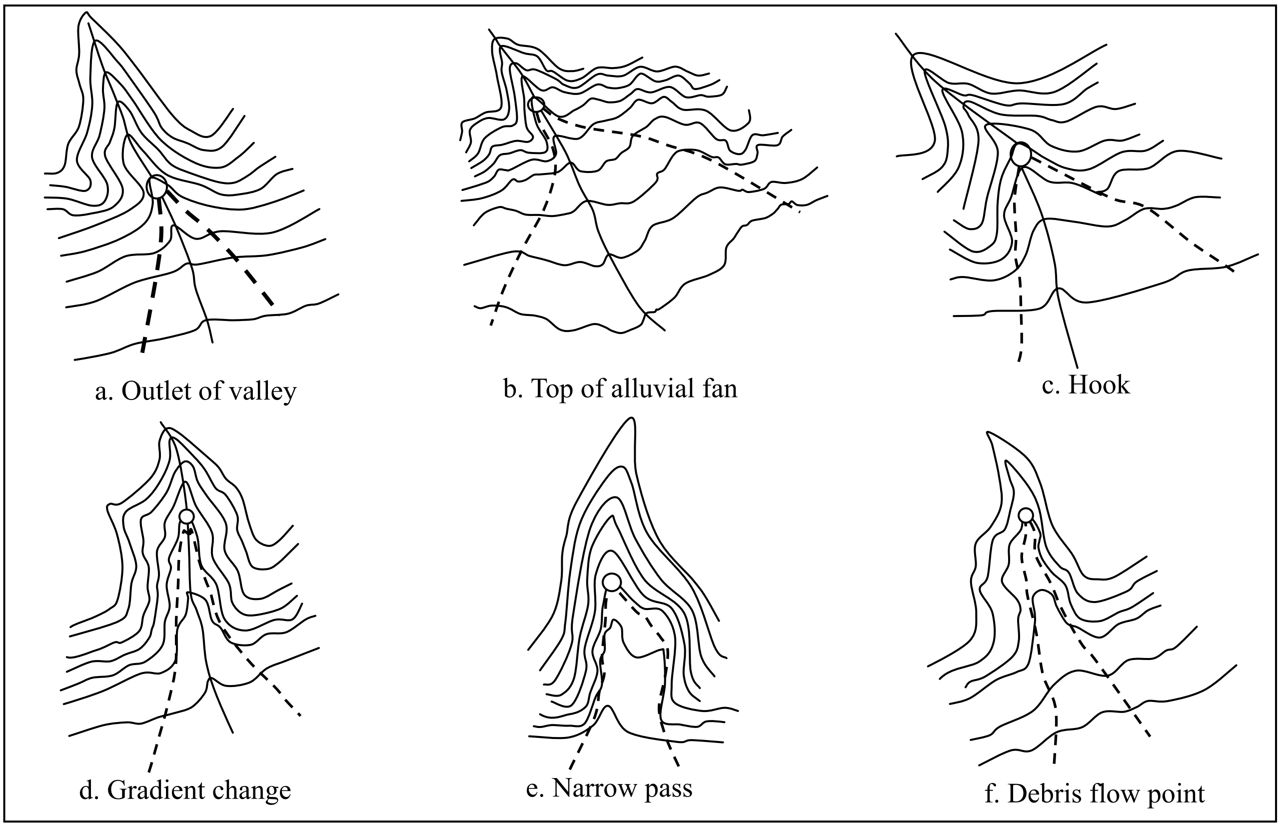

Figure-2.1 Example of reference point setting

2.2.2 Gradient of torrent bed

Gradient of torrent bed is calculated between two points: reference point and a point on the flow route separated only by a stipulated horizontal distance upstream from the reference point.

2.2.3 Measurement of area river basin

Measurement of area river basin starts from the reference point and measures upstream area.

2.2.4 Grasping torrent bed condition

For torrent bed condition, grasp possible erosion sectional area by each stream order.

2.3 Geological survey

Survey soil parameters on land where the occurrence of a debris flow disaster is predicted and torrents where there is a risk of causing debris flow.

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2.4 Setting Special Sediment-related Disaster Hazard Area

2.4.1 Computing quantity of earth and rock etc at the reference point

V_0 is the smaller of the volume of deposition on the torrent bed (Ve') and the volume of sediment that can be transported by surface flow due to rainfall (Vec). Ve' is the maximum value in the flow upstream from the reference point. The flow in this case is the flow along a line drawn upstream from the reference point.

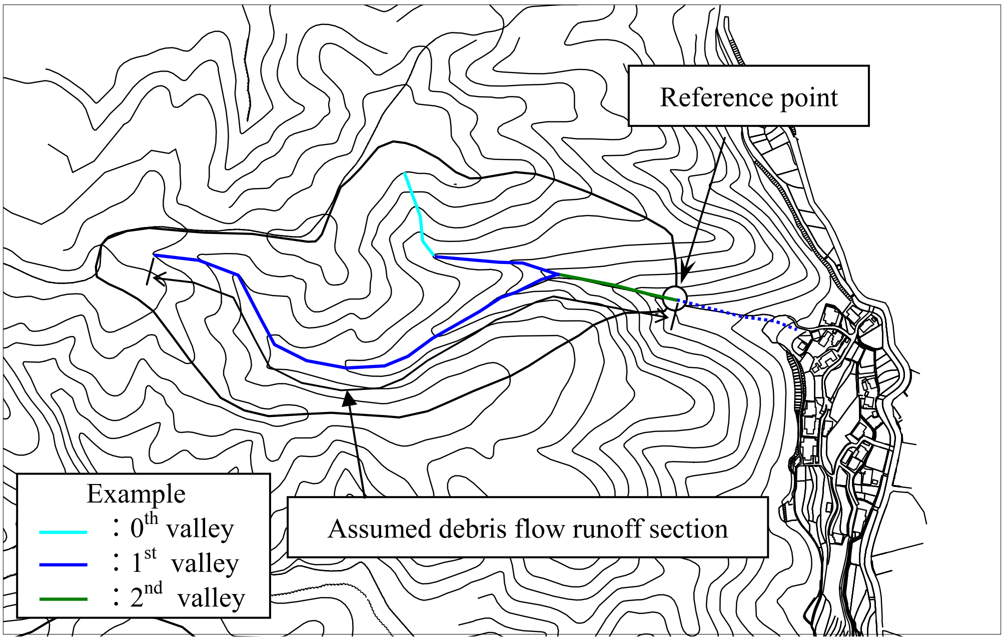

Figure-2.2 Example of assumed debris flow runoff section setting

Ve' is computed from Equation（2.1）.

$$Ve' \quad Ae \times Lme \qquad \cdot\cdot\cdot (2.1)$$
$$Ae = B' \times De$$

Where: Ve’：sediment deposition volume on torrent bed [m^3], Ae：erosion possible sectional area of sediment deposition on torrent bed (m^2), Lme：assumed debris flow runoff section length [m], B’：erosion width [m], D_e：erosion depth [m].

And Vec is computed from Equations（2.2）and（2.3）.

$$fr = 0.05(\log A - 2.0)^2 + 0.05 \qquad \cdot\cdot\cdot (2.2)$$

$$Vec = \frac{10^3 \cdot R_T \cdot A}{1-\lambda}\left[\frac{Cd_0}{1-Cd_0}\right]fr \qquad \cdot\cdot\cdot (2.3)$$

Where: fr：outflow correction factor, A：area river basin [km^2], R_T：amount of rainfall in 24 hours [mm/24hrs.], λ：void ratio of deposition. C_{d0} is sediment concentration of the debris flow at the reference point and is computed by Equation（2.4）.

$$C_{d0} = \frac{\rho \cdot \tan\theta_0}{(\sigma-\rho)(\tan\varphi - \tan\theta_0)} \qquad \cdot\cdot\cdot (2.4)$$

Where: ρ：density of flowing water [kN/m^3], σ：density of gravel [kN/m^3], θ_0：gradient of the ground at the reference point [degrees], φ：angle of internal friction of gravel [degrees].

2.4.2 Setting the direction of debris flow

Direction of debris flow is set upon consideration of current watercourse, torrent bed plane configuration, straight movement of debris flow and the result of site investigation.

- Direction of flow at a point just above the reference point
- Plane configuration (how the topography expands) at downstream of outlet of valley (the point where topography start to expand)
- Direction of current watercourse at the points just before or after the outlet of valley
- Straight movement of debris flow
- Current watercourse
- Overflow at the hook and at the bend

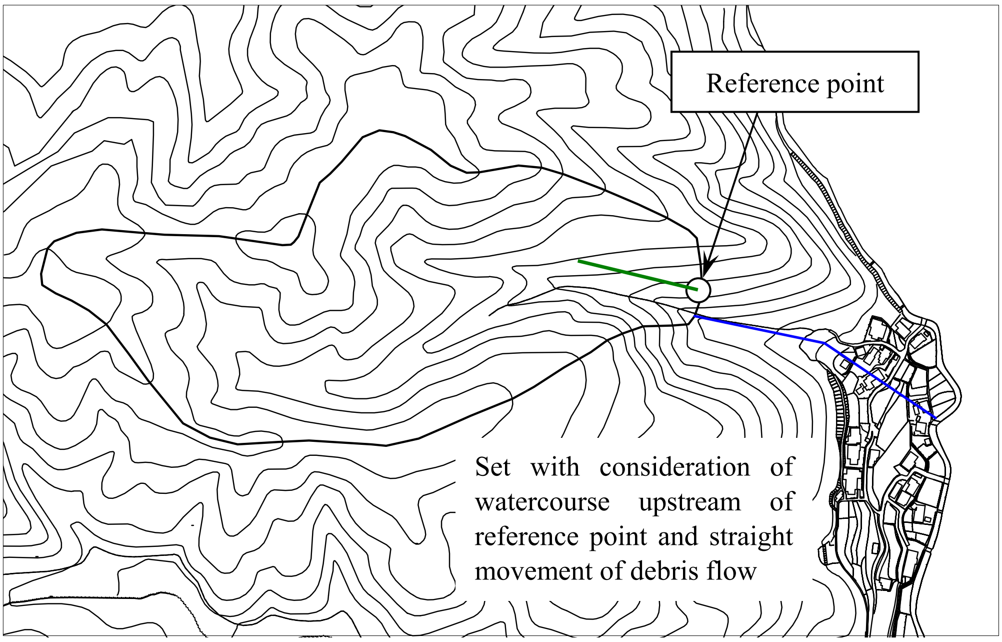

Figure-2.3 Example of debris flow direction setting

2.4.3 Estimation of the peak discharge of debris flow

The peak discharge of debris flow at the reference point is computed by Equation（2.5）.

$$Q_{sp0} = \frac{0.01}{C_{d0}} C_* \cdot V_0 \quad \cdots (2.5)$$

Where: Q_{sp0} : peak discharge of debris flow at the reference point [m^3/s], V_0 : volume of earth and rock etc in the debris flow at the reference point (including void) [m^3], C_* : density of a unit of sediment deposition, C_{d0} : sediment concentration of debris in the flow

2.4.4 Computing hydrodynamic force of debris flow acting on buildings and strength of normal buildings

Hydrodynamic force of debris flow acting on buildings and strength of normal buildings are computed at the points set on the flow route of debris flow (from now on, these points are called " calculation points " in this document). In this document, calculation points are set on every point where the gradient of the ground is measured.

At first, compute the flow velocity and the flow depth of the debris flow at the calculation point. Table-2.5 is the flow-chart showing how to compute those. The flow velocity and the flow depth of the debris flow are computed by uniform flow calculation and the cross-sectional directions should be perpendicular to the watercourse of the debris flow.

In case the watercourse is clear, compute "flow width of the debris flow B" by changing the value for " debris flow cross-sectional area A " in Equation (2.6) so that the peak discharge of debris flow Q_{sp}＝discharge Q.

$$U = \frac{Q}{A} = \frac{1}{n} R^{\frac{2}{3}} I_b^{\frac{1}{2}}$$

$$Q = \frac{1}{n} \cdot \left(\frac{A}{S}\right)^{\frac{2}{3}} (\sin\theta)^{\frac{1}{2}} \cdot A \qquad \cdots (2.6)$$

Where: Q：Discharge [m^3/s], A：Cross-sectional area of flow [m^2], n：roughness coefficient, S：wetted perimeter (S＝A/R, R：hydraulic radius), θ：gradient of the ground [degrees].

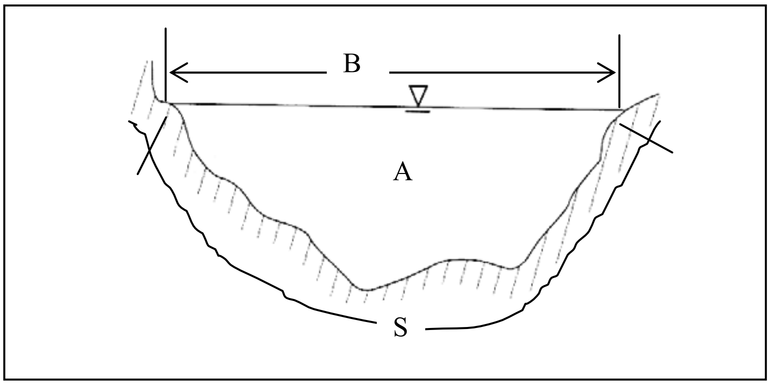

Figure-2.4 Calculation of debris flow width by cross-section flow capacity

Value for B is calculated by uniform flow calculation as shown in the figure, however since both banks are predicted to be fairly distant at the calculation points on the alluvial fan, assume maximum value for B. If the relationship between B and Q_{spi} can be described in regime formula, you will obtain the below Equation（2.7）.

$$B = \alpha \cdot Q_{sp}^{\ \beta} \qquad \cdots (2.7)$$

Where α・β：coefficient

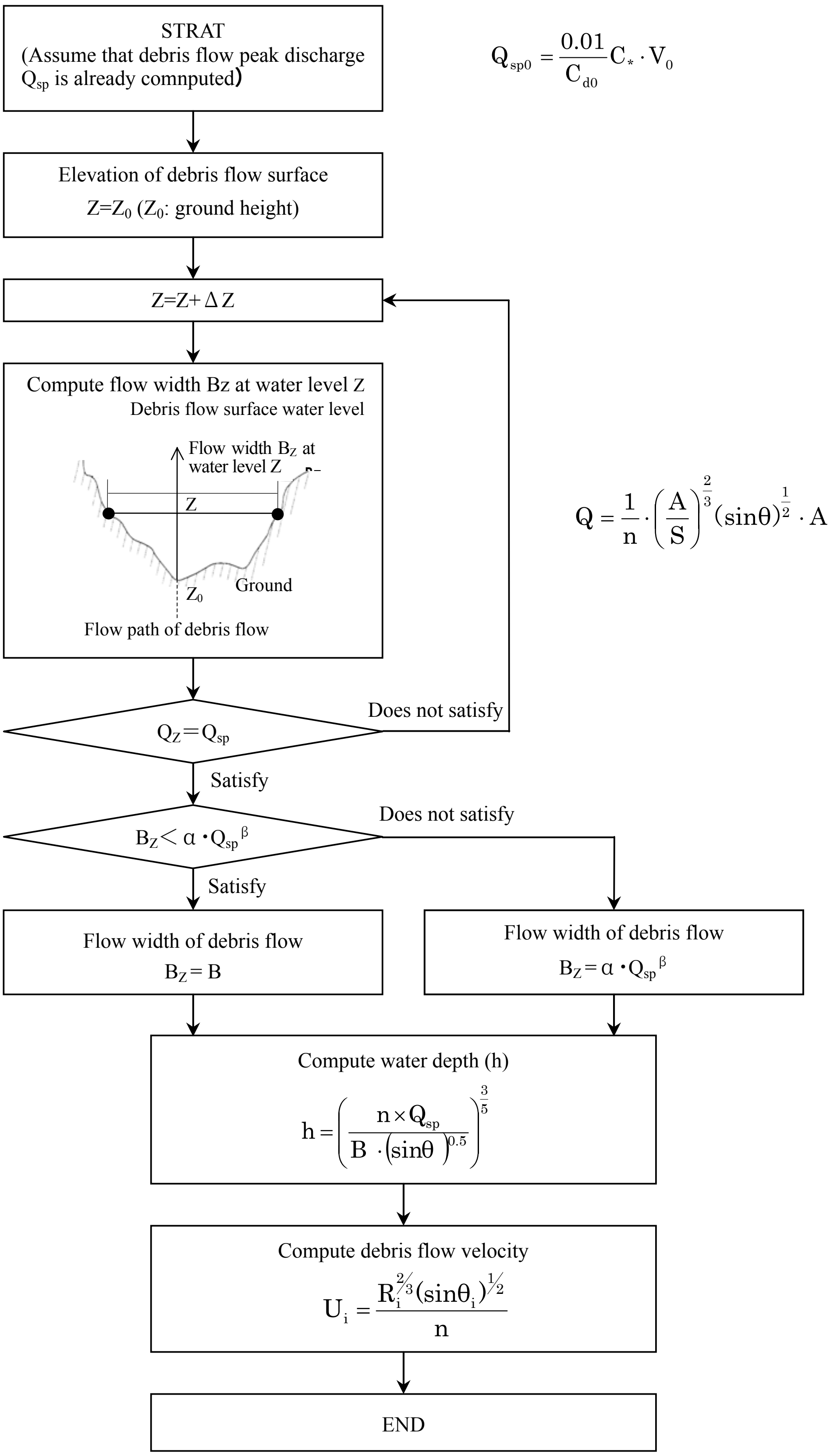

Figure-2.5 Flow-chart of flow width and water depth of debris flow at each calculation point

Debris flow velocity can be computed as Equation (2.8) when approximating Manning formula.

$$U_i = \frac{R_i^{2/3}(\sin\theta_i)^{1/2}}{n} \quad \cdots (2.8)$$

Where: U：flow velocity of the debris flow [m/s], n：roughness coefficient, h：flow depth of the debris flow [m], θ：gradient of the land [degrees] The value of θ is calculated between two points: the concerned calculation point and a point on the flow route separated only by a stipulated horizontal distance upstream from the calculation point. Flow depth of the debris flow is computed by Equation（2.9）.Debris flow cross-section is approximate to rectangle.

$$h = \left\{ \frac{0.01 \cdot n \cdot C_* \cdot V_0 \cdot (\sigma - \rho)(\tan\varphi - \tan\theta)}{\rho \cdot B \cdot (\sin\theta)^{1/2} \tan\theta} \right\}^{\frac{3}{5}} \quad \cdots (2.9)$$

When Equations （2.4）and （2.5）are substituted into Equation（2.9）, it becomes Equation （2.10） which gives the flow depth of the debris flow.

$$h = \left(\frac{n \times Q_{sp}}{B \cdot (\sin\theta)^{0.5}} \right)^{\frac{3}{5}} \quad \cdots (2.10)$$

Where: Q_{sp}：peak discharge of debris flow [m^3/s], B：flow width of the debris flow[m]. Q_{spi} at the calculation point is computed by Equation（2.11）.

$$Q_{spi} = \frac{0.01}{C_{di}} C_* \cdot V_i \quad \cdots (2.11)$$

Where: C_*：density of a unit of sediment deposition, C_{di}：sediment concentration of debris flow at the calculation point, V_i：amount of sediment that can be transported by the debris flow at the calculation point (including void) [m^3]. C_{di} is computed by Equation（2.12）.

$$C_{di} = \frac{\rho \cdot \tan\theta a}{(\sigma - \rho)(\tan\varphi - \tan\theta a)} \quad \cdots (2.12)$$

In general, the reference point is conceived of as being at the apex of alluvial fan, so the watercourse of the debris flow is considered to be the section where debris is deposited. In other words it is necessary to consider the deposition of sediment when computing V_i. Assuming that the debris flow has sediment concentration C_{di} and that sediments are deposited with the density of a unit C_*, Q_{spi} becomes as in Equation（2.13）.

$$C_{d0} \cdot Q_{SP0} = C_{di} \cdot Q_{SPi} + C_* \cdot (Q_{SP0} - Q_{SPi})$$

$$\therefore Q_{spi} = \frac{C_{d0} - C_*}{C_{di} - C_*} Q_{sp0} \quad \cdots (2.13)$$

Substituting Equations (2.5) and (2.11) into Equation (2.13), and simplifying the expression for V_i we obtain Equation (2.14).

$$V_i = \frac{C_* - C_{d0}}{C_* - C_{di}} \cdot \frac{C_{di}}{C_{d0}} V_0 \qquad \cdots (2.14)$$

In addition, the watercourse of the debris flow, which is the object of the calculation, is a deposition section, so it is unnatural for Q_{spi} to become larger as it proceeds downstream. To prevent Q_{spi} from becoming larger as it proceeds the downstream, if, at (and only at) the time when Equation (2.14) is calculated, the gradient of the land θ_a at a certain point a is greater than the gradient of the land θ_b at a calculation point b which is upstream from the concerned point ($\theta_a > \theta_b$), then we take $\theta_a = \theta_b$.

The hydrodynamic force of debris flow acting on buildings is calculated by substituting U , which was computed by applying equations (2.8) into Equation (2.15)

$$F_{di} = \rho_{di} \cdot U_i^2 \qquad \cdots (2.15)$$

Where: F_{di} : hydrodynamic force of debris flow acting on buildings[kN/m^2], ρ_{di}: density of debris flow[kN/m^3]. Density of debris flow is computed in Equation (2.16)

$$\rho_{di} = \frac{\rho \tan\varphi}{\tan\varphi - \tan\theta_i} = \sigma \cdot C_{di} + \rho(1 - C_{di}) \qquad \cdots (2.16)$$

And the strength of buildings is computed by substituting h_i which was computed by applying equations (2.10) into Equation (2.17). However, the maximum flow depth of the debris flow is 2.8m and even if it is above that it is set on 2.8m.

$$P_i = \frac{35.3}{h_i \cdot (5.6 - h_i)} \qquad \cdots (2.17)$$

Where P_i : the strength of buildings [kN/m^2]

2.5 Method of illustrating the range of special sediment-related disaster hazard areas

To achieve the range of special sediment-related disaster hazard area, compare F_{di} and $P_{i,}$ which were computed in Section 2.4 , and find out the calculation points that satisfy the Equation（2.18）.

$$F_{di} > P_{di} \qquad \cdots (2.18)$$

Next, draw a straight line on the plane figure which is the flow width of the debris flow and is perpendicular to the watercourse of debris flow at the calculation points that satisfy the Equation (2.18)

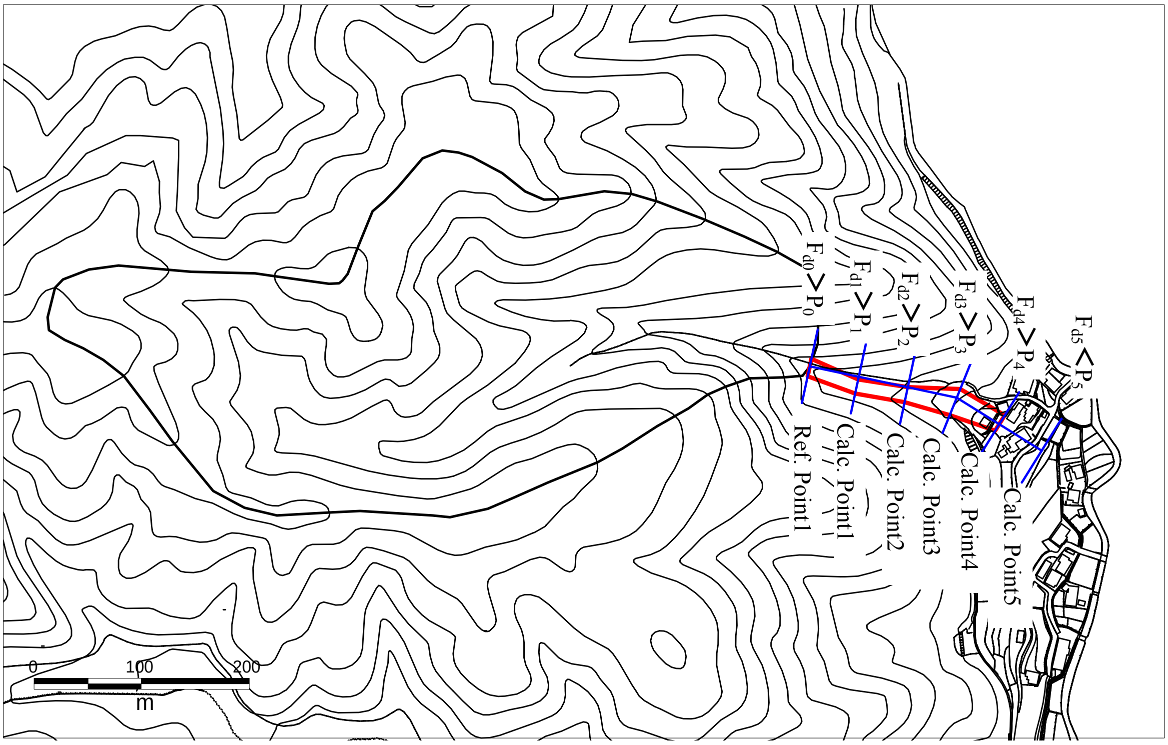

Figure-2.6 Special Sediment-related Hazard Area Setting Example

3. Setting Sediment-related disaster warning area

Sediment-related disaster warning area is set on the area where gradient of ground is more than or equal to 2 ° in the range from reference point (top of alluvial fan) to downstream, where the torrent area river basin is smaller than or equal to $5km^2$. The area where it is obvious that the debris flow will not reach due to the topographic features is excluded.

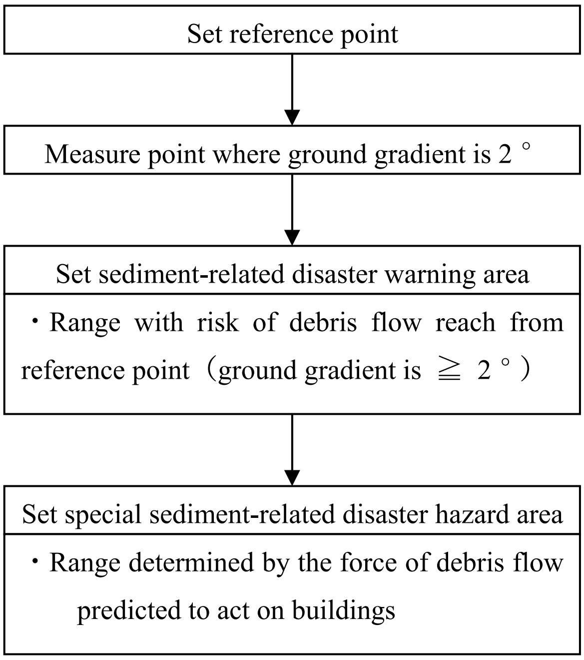

Figure-3.1 Sediment-related disaster warning area setting flow-chart

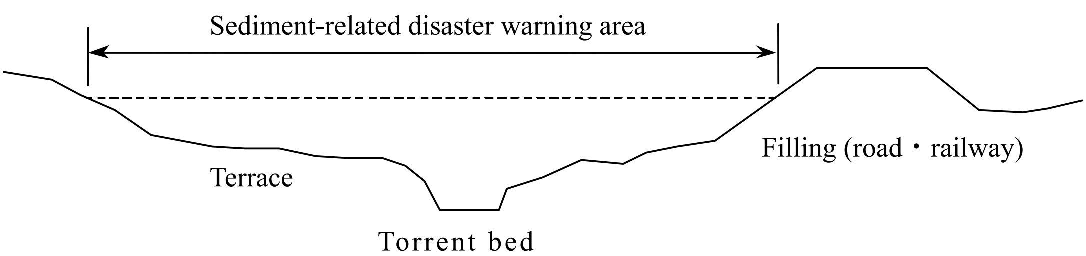

Figure-3.2 Image of sediment-related disaster warning area cross-section setting

3.1 Measurement of the points where gradient of ground is 2 °

Measure gradient of grounds on topographic map or by site reconnaissance around the downstream of debris flow danger area and determine the downstream end of sediment-related disaster warning area (points where ground gradient is greater than or equal to 2 °).

3.2 Setting range of sediment-related disaster warning areas

Set debris flow dispersion angle based on the topography of the outlet of valley, and determine the expanse of debris flow in cross-section direction. Debris flow dispersion angle should be in the range of 10～60 ° . However, the maximum expanse of debris flow in cross-section direction is 30 times of flow width of debris flow at the reference point.

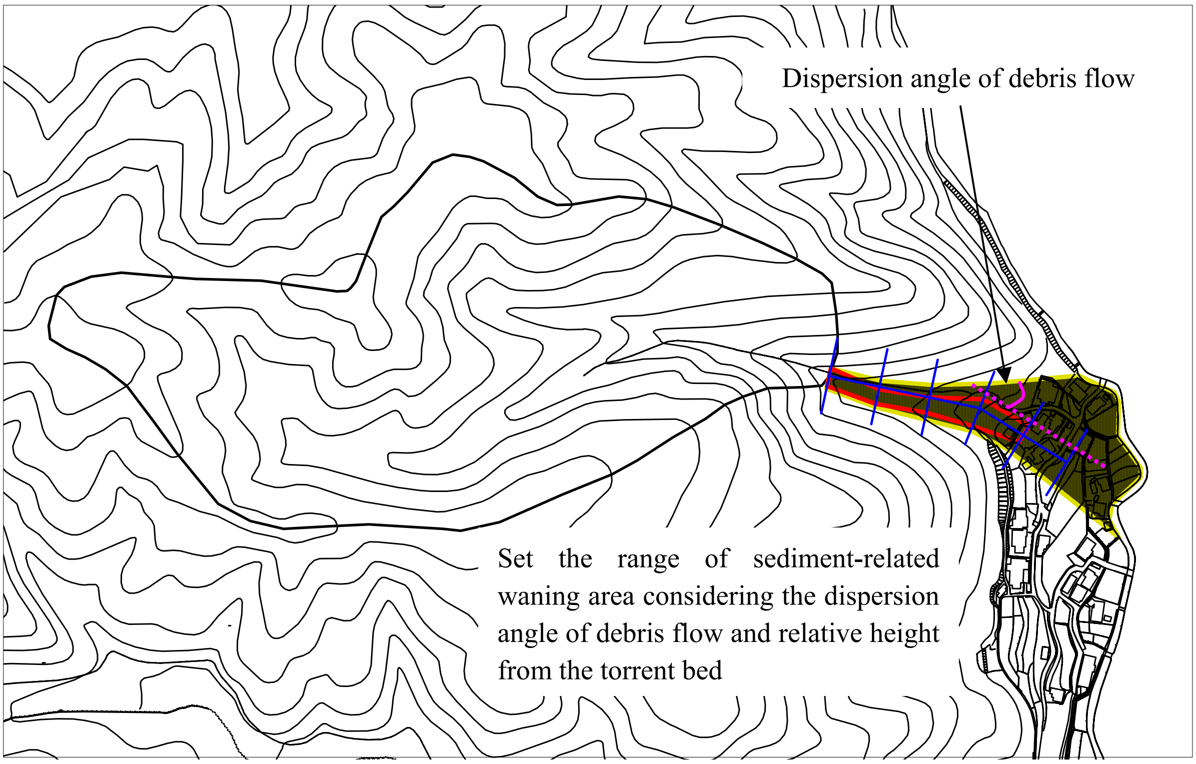

Figure-3.3 Example of setting of sediment-related disaster warning area etc.