



## Occurrence condition of the viscous debris flow

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The debris flow is a flow with the mixtures of boulder, gravel, sand, silt, clay and water. There are some kinds of debris flow, and a flow of them is called "viscous debris flow". This viscous debris flow is characterized that the volume concentration of sediment is very high as about 70 % or more, the flow is high velocity as 5 ~ 10 m/s or more on the 3 ~ 5 degrees gentle slope and lots of surge flows are intermittently occurred as similar of roll waves on the sheet flow. It is an interesting thing to make clear the reasons on the occurrence of the intermittent and many surge flows, and it is an important thing for the mitigation planning the hazard.

It will be proved by the model of instability flow. Under the rectangular wide channel, the instability condition of the flow is obtained as  $F_r \geq \frac{1}{\sqrt{9-5\beta}}$ , here,  $F_r = \frac{U}{\sqrt{gh \cos \theta}}$  is Froude number. In the case of the velocity distribution of the viscous debris flow by T. Takahashi, the momentum correction factor on the uniform concentration is  $\beta = \frac{6}{5}$ . Therefore, the instability condition of the flow which is the condition of the occurrence of viscous debris flow, is

$$F_r \geq \frac{1}{\sqrt{3}}$$

Many experimental results on the high viscous flow with solid particles and some observed results of actual viscous debris flow in China show good fitting above theoretical results.

Therefore, a conclusion is that the intermittent surges of viscous debris flow are occurred in instability of the flow above the condition.