Analysis of landslide dams formation based on topographical characteristics in Kii Peninsula, Japan

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INTRODUCTION

Types of movement and deposition of deep-seated landslides' collapsed materials are roughly classified as landslide dams and debris flows. Landslide dam, as in landslide's collapsed material deposition in the river course, may last for several minutes or several years depend on many factors; the volume of collapsed material, seepage, inflow into the water inundation, etc. The dam breaking caused mostly by overflowing will create large surge that is dangerous to downstream area. Although a lot of studies about landslide dams were conducted until now, prediction of landslide dam formation is still uncertain.

Kii Peninsula is commonly damaged when typhoon hit Japan as it is mostly steep mountainous area and strongly affected by heavy rainfall. It was severely damaged by Typhoon Talas in 2011 which brought maximum total precipitation about 1,800 mm and caused many sediment related disasters with total amount of sediment ap-proxi-mately 100 million m^3. Research on landslide dam formation in Kii Peninsula is necessary considering the very high frequency of estimated landslides in this area (MLIT 2010) and the big threat of landslide dams that might formed by the collapsed materials. Hence, this research aim to analyze the formation and duration of landslide dam formed in Kii Peninsula due to Typhoon Talas in 2011 based on topographical characteristics and predict the run-out distance of collapsed materials which useful to draw hazard maps of landslide dam formation.

METHODOLOGY

Digital Elevation Model and aerial photographs were used as main data in ArcGIS analysis to obtain the landslides' failure zone and topographical characteristics. Travel ratio is comparison between failure zone length and travel length (from the bottom of failure zone to the end of main body of collapsed material's deposition). Landslides with travel ratio less than two and had depositions more than 10 m height in the river channels were classified as landslide dams. Landslides with travel ratio more than two were classified as debris flows. Topographical characteristics were examined to find significant factors that influenced the formation and duration of landslide dam. Equivalent coefficient of friction (ECF) for each landslide was calculated as indicator of run-out distance. Prediction of run-out distance based on topographical characteristics was analyzed with multiple regression analysis.

RESULT

Although 10 debris flows generated by deep-seated landslides were found in the research area, there were 21 landslide dams found by the deposition of collapsed materials of deep-seated landslides. Based on the condition of material deposition, it classified into 14 long-term landslide dam, 5 temporary landslide dam, and 2 landslide dam inside reservoir. Collapsed materials of deep-seated landslides located in catchment area of streams with inclination more than 10° and confluence angle less than 60° would likely form debris flows. On the contrary, deep-seated landslides in streams with inclination less than 10° and confluence angle more than 60° formed landslide dams. Due to large confluence angle, the collision of collapsed material and stream lost large amount of energy, thus collapsed material mobilization stopped and form landslide dam. Also, the low stream inclination support the landslide dam formation due to gentle streambed, slow water flow, and able to carry only small amount of very fine sediments. Furthermore, regardless the area of failure zone, landslide dam with less than 10,000 ha upstream watershed would likely to form long-term landslide dam. Other than that, it would likely to be temporary landslide dam due to large

amount of water discharge that washed away the deposition of collapsed material.
ECF is height difference per total travel length of collapsed material, from the top of failure zone to the end of deposition zone. It is widely used as an indicator of run-out distance and size of hazard area (Scheidegger 1973), and also useful to draw hazard maps of potential disaster areas caused by deep-seated landslides. It was found that landslide dams in research area have ECF more than 0.26 which implies short fluidization of collapsed material, collapsed material deposited near the failure zone, and small hazard area.
Multiple regression analysis was done as an attempt to predict run-out distance. ECF was used as dependent variable due to its ability to represent run-out distance and degree of fluidization of collapsed material. Characteristics of deep-seated landslides were used as independent variables; failure zone length (l), failure zone inclination (i1), distance to stream (d), watershed of failure zone (ws1), upstream watershed (ws2), etc. Figure 1 shows the relations between ECF calculated by the equation and the ECF observed from the ArcGIS analysis. The equation obtained could be used to predict run-out distance of deep-seated landslides' collapsed material and the places in which landslide dam formed.

CONCLUSION

Collapsed material of deep-seated landslides which located in catchment area of stream with inclination less than 10° and confluence angle more than 60° would likely to form landslide dams. Landslides with upstream watershed area less than 10,000 ha would form long-term landslide dams, otherwise it would form temporary landslide dams. The regression result equation of landslide dams showed the correlation of topographical characteristics to equivalent coefficient of friction and may be used to predict ECF. Deeper studies on ECF to predict the formation of landslide dam are needed for for developing hazard maps.

REFERENCES

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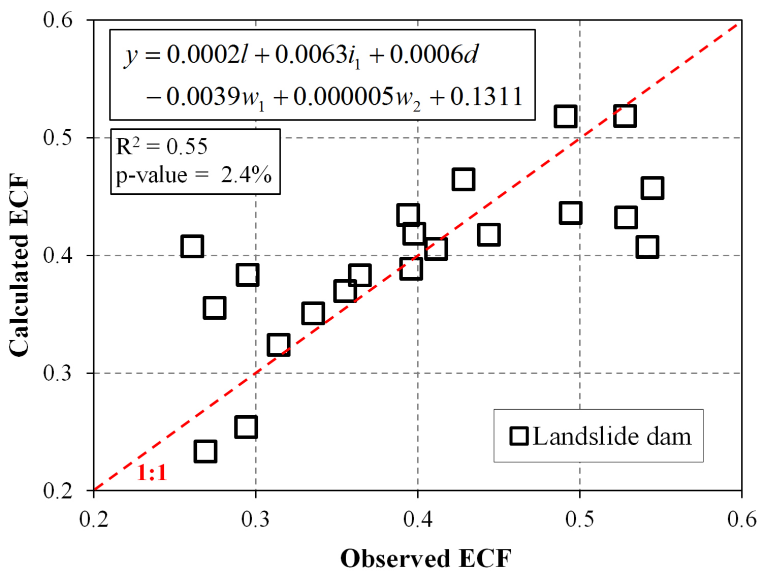

Figure 1. Equivalent coefficient of friction for landslide dam

KEYWORDS

landslide dam; kii peninsula; topographical characteristics; typhoon talas

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