Investigation of the Characteristics of Woody Debris in the Disaster Areas due to Tropical Storm Nanmadol 2017

Tohoku University Graduate Student ○ Thapthai CHAITHONG
Tohoku University Member Daisuke Komori
Tohoku University Member Yuto Sukegawa

1. BACKGROUND

Woody debris is a natural component in the ecosystem which can define as the fallen trees, logs, branches, and the other wood. The woody debris plays an important role in the nature but often neglected component of the ecosystem (Harmon et al, 1986). Considering the source of woody debris, the landslide is a significant woody debris producer. There were previous researchers reporting cases of the woody debris recruitment caused by landslides and flood after the tropical cyclone attack. Murakami et al (2008) reported that the volume of woody debris recruitment due to slope failures was approximately 57,100 m^3 in the Appetsu River basin. Chen et al (2013) reported that 580 m3 transported downstream after Typhoon Morakot in Qijiawan catchment, Taiwan. Benda and Sias (2003) proposed the volumetric mass balance of large woody debris in a unit length of channel. The volumetric mass of large woody debris presents in equation 1.

$$\Delta S_c = \left[L_i - L_o + Q_i / \Delta x - Q_o / \Delta x - D \right] \Delta t \qquad 1)$$

where ΔS_c is a change in storage within a unit length of stream Δx over the time interval Δt . L_i is woody material recruitment. L_o is woody debris dam at river bank or hillslope. Q_o is outflow of wood segment caused by fluvial transport. Q_i is input of wood segment caused by fluvial transport. D is in-situ decay.

Considering to the both of volumetric mass balance of woody debris, they showed that the woody material recruitment and storage of woody material play the critical factors in the volumetric mass balance. Woody material recruitment to the watershed represents several types of supply such as toppling of trees caused by windstorms, stream bank failures, landslides, debris flows. Therefore, the aim of this study is to summarize the characteristics of woody debris in Asakura city, Fukuoka prefecture, southern Japan where was affected by Tropical Storm Nanmadol during 4th – 8th July 2017. 8 sites in Asakura city were investigated by our team.

2. CHARACTERISTIC OF RAINFALL CAUSED BY TROPICAL STORM NANMADOL 2017

Tropical Storm Nanmadol made landfall on 4th July 2017 about 40 km east of Nagasaki city on Kyushu. **Fig 1** shows the hourly rainfall and cumulative rainfall of Asakura rain gauge station of JMA (Japan Meteorological Agency) during 4th-7th July 2017. Characteristic of rainfall caused by this tropical storm is the storm delivered a high intensity rainfall in a short time; in addition, the pattern of rainfall is similar advanced rainfall pattern. Cumulative rainfall at Asakura rain gauge station was approximately 630 mm. The maximum hourly rainfall was 106 mm on 5th July 2017 at 16:00 p.m., moreover, the high intensity rainfall occurred around 4 hours and delivered approximately 300 mm of rain.

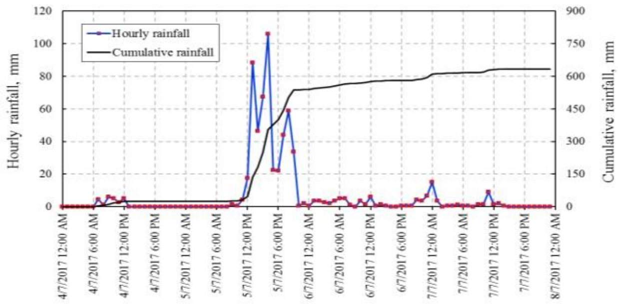

Fig.1. Hourly and cumulative rainfall at Asakura rain gauge station during 4th-7th July 2017

3. CHARACTERICTIC OF LANDSLIDES AND WOODY DEBRIS RECUITMENT

Fig 2 shows the location of landslide scars occurred in Asakura city, Fukuoka prefecture, Japan. The landslide scars are obtained from the aerial photos of Geospatial Information Authority of Japan. Total area of landslide scars is approximately 1.19 km^2.

In this study, we calculated the landslide ratio that is representative of area to damage by landslides per total target area. Consideration the relationship plots, we found that the slopes with gradients of 10º to 50º had a high density of landslide occurrence and the high landslide ratios appeared in the slope gradient between 20º to 50º.

From field survey, we found huge amount of woody debris recruitment caused by Tropical storm Nanmadol 2017. The tree density data in 9 places in Asakura city were obtained in this field survey. The average of tree density is 0.15 trees per m^2. The average diameter of woody debris is 0.24 m and the average length of woody debris is 9.3 m, hence, the average volume of woody debris per 1 piece is approximately 0.42 m^3. Hence, the volume of woody debris recruitment caused by Tropical storm Nanmadol is approximately 69,800 m^3.

4. WOODY DEBRIS CHARACTERISTIC AND FAMATION OF WOODY DEBRIS DAMS

Fig. 3 shows the histogram of diameter of woody debris. The woody debris diameter of 20 cm to 25 cm is 28.5% of total that is the highest ratio of total. **Fig. 4** shows the plot of volume of woody debris dam for 8 sites. The maximum volume of woody debris dam is approximately 953 m^3 in station 1 that width of woody debris dam is approximately 42.1 m, the height of woody debris dam is approximately 5.4 m. Considering to the

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Tohoku University, 6-6-20 Aoba Aramaki, Aoba-Ku, Sendai 980-8579, Japan. Tel & Fax: +81-22-795-7455

cause of woody debris dam, the slope failure and transported woody debris due to fluvial process are the main mechanisms of woody debris formation. Moreover, the sabo dam plays an important role to form the woody debris in an ecosystem as show in **Fig 5**.

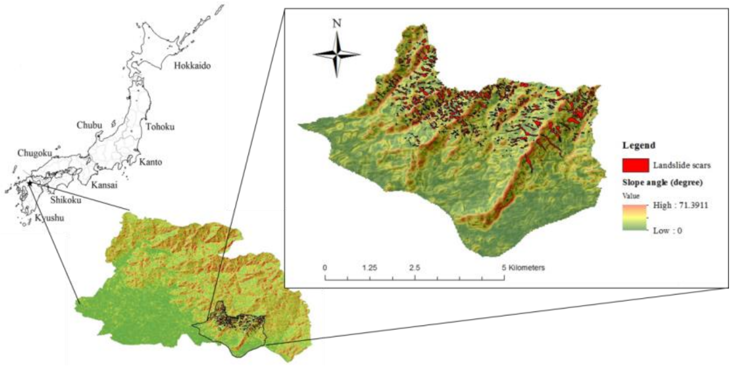

Fig.2. Location of shallow landslides occur in the Asakura city, Fukuoka, Japan caused by Tropical storm Nanmadol 2017

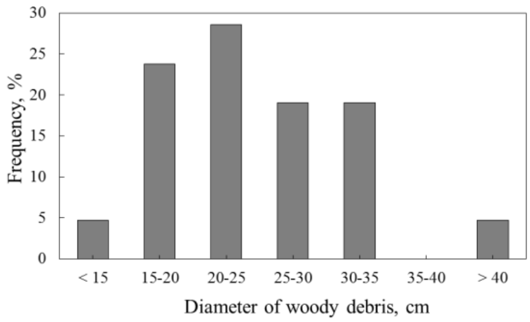

Fig.3. Histogram of diameter of woody debris.

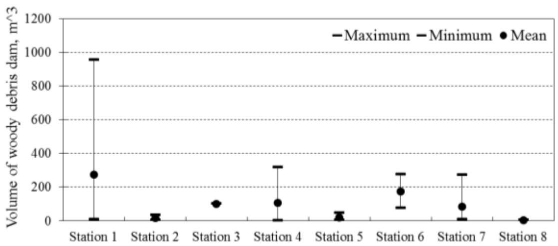

Fig.4. Volume of woody debris dam for 8 sites

Fig.5. Woody debris trapped at the sabo dam

5. CONCLUSION

The woody debris is one of debris as consequence of storm-induced landslide. It may increases the intensity of debris flow to destroy the house or infrastructure. There are approximately 69,800 m^3 of woody debris that were produced by Tropical Storm Nanmadol 2017. The maximum volume of woody debris dam due to Tropical Storm Nanmadol is 953 m^3. As mention above, the woody debris recruitment and storage are the important parameters to study the woody debris-related disaster. The significant challenge of woody debris study is the variance of tree density for woody debris estimation and the limitation of exploring the real amount of woody debris in the big catchment.

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