Section II

EFFECTS OF DEPENDENT AND INDEPENDENT OCCURRENCES OF DEBRIS FLOW ON SEDIMENT RUN-OFF

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1 Introduction

In general practices, if debris flows occur in several tributaries, we often treat every debris flow event separately. In real case, a debris flow is influenced by the preceding event, which we call dependent. When we treat the debris-flow in a main stream composed of many tributaries, order of debris flow occurrences in each tributary could greatly influence the debris flow characteristics such as flow-discharge, flow-velocity, sediment-volume and overall size of the debris flow in downstream sections. Present report describes the effects of such dependent events, which are obtained from the numerical simulation on San Julian river basin in Venezuela. The focus was given to dependent and independent solutions and comparative analysis was done, referring to the data available from field visit.

2 Numerical Simulation

(1) Data from Field Measurement

San Julian River drains the area of 23.6 km^2, which is composed of numerous tributaries, out of which three major torrents, abbreviated by T_1, T_2 and T_3, were chosen for debris-flow simulation **Fig.1**. Longitudinal bed profiles of three torrents are illustrated in **Fig. 2**, which has been plotted from the data obtained from the original map drawn in the scale of 1/25000. Some important parameters like flow-width, sediment size, potential erosion depth etc. were determined from the field survey. Upstream boundaries were located at 8210 m, 7560m and 6140 m from the river mouth for T_1, T_2 and T_3, respectively and corresponding drainage areas are 2.63 km^2, 1.42 km^2 and 1.43 km^2. The common downstream boundary was set at 3010m from the river mouth. Physical properties of the bed sediment were specified as e=0.85, d=20 cm, ϕ_s =34 deg., ρ=1.33g/cm^3, c_*=0.52 and fine sediment was assumed 20% by volumetric concentration included in fluid phase. Potential erosion depth (D_p) was chosen as 10 m. Riverbed width (B) from all upper boundaries up to the lower confluence point at 5100m from river mouth was specified as 20 m and 40 m for common reach.

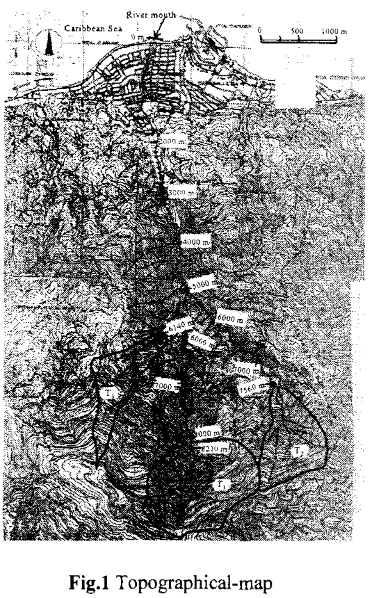

Fig.1 Topographical-map

(2) Flow Model and Computational Condition

One-dimensional governing equations for the flow of sediment-water mixture developed by Egashira et al.[1),2)] are employed. The finite leapfrog difference scheme was used for computations with Δx = 5m and Δt = 0.003 sec.

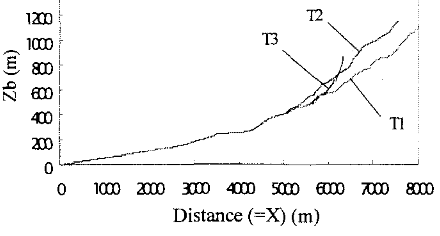

Fig. 2 Longitudinal Profiles

3 Results

Depending upon the hydrographs obtained from independent calculations at the fan head designated at 3,010 m from the river

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mouth **Fig. 3**, peak discharges given by tributaries T_3, T_2 and T_1 are observed at 86, 234 and 268 sec., respectively.

Total sediment independently supplied into the fan by T_3, T_2 and T_1 are given in **Table 1**, considering the original bed-profile as an input to each and every computational case. Egashira et al.[3] reported different types of sediment volume that were deposited in the fan during San Julian debris desaster. Sediment yield that was caused by general bed and suspended loads, was estimated 0.26×10^6 m^3 and due to land slides in small tributaries was 0.35×10^6 m^3. Adding these two separate volumes to the present result, it gives total amount 0.97×10^6 m^3, which is quite close to to the observed value i.e 1.0-1.6 *million* cubic meters. Little difference is due to the other tributarial effects and run-time effect in calculation.

Tributary T_1 was considered to evaluate the debris flow characteristics for the second occurrence of debris-flow event, considering the bed-profile that left by the first event and same amount of rainfall over catchments. **Figure 4** shows the original and final bed slopes along the reach.

On the other hand, in order to compare the independent and dependent effects, we conducted numerical simulations for possible sequences (**Table 2**). Result shows that maximum debris volume supplied into the fan is about 0.35×10^6 m^3 due to T_1- T_3- T_2 sequence and the lowest value i.e. 0.24×10^6 m^3 is given by T_2- T_3- T_1. In all possible incidences, total sediment volume is less than the independently predicted volume where maximum difference observed is 0.12×10^6 m^3. Hydrographs indicate the probable sequence i.e. T_3- T_2- T_1 in San Julian basin that accounts only 0.33×10^6 m^3, which is almost 0.35×10^5 m^3 less than the independent case.

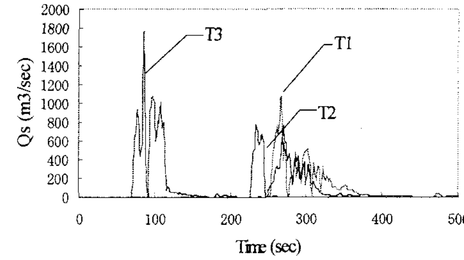

Fig. 3 Hydrographs at the fan head (X=3010 m)

Table 1 Sediment volume transported into the debris fan by tributaries T_1, T_2 and T_3 independently

Sediment / Tributaries	Coarse (m^3)	Fine (m^3)	Sub-Total (m^3)
T1	33,600	75,740	109,340
T2	31,247	97,992	129,239
T3	34,818	87,025	121,843
TOTAL			**360,422**

Table 2 Sediment-yield transported by trail sequences

Sediment / Sequence	Coarse (m^3)	Fine (m^3)	Total (m^3)
T1-T2-T3	84,080	204,853	288,933
T1-T3-T2	96,837	252,415	34,9252
T2-T1-T3	64,956	251,567	316,523
T2-T3-T1	56,006	187,629	243,635
T3-T1-T2	77,559	242,602	320,161
T3-T2-T1	87,883	242,022	329,905

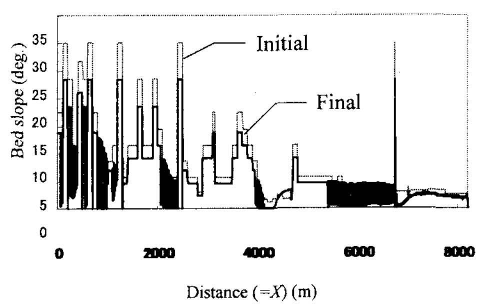

Fig. 4 Initial and Final bed-slopes along

4 Conclusion

Main conclusions are; 1. In single reach, second event transported less amount of debris than the first one because of restricted erodible-bed in upstream reach and smoothened bed-slopes in downstream reach. 2. In independent case, because of bed irregularities are taken in each computation, the sediment discharge is higher than in the dependent case. This shows that the hysteresis of bed shape and slope changes plays an important role on transported sediment volume.

References

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