# HYDRAULIC CONDITIONS FOR RILL INITIATION ON STEEP SLOPES

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## ABSTRACT

Rill erosion occurs frequently on steep slopes of development sites with disturbed surface soil. In other to understand the characteristics of the rill initiation, rainfall simulation was conducted in soil box where the inflow water is supplied at the top of the slope. The location and shape of the rill initiation were influenced by rainfall intensity, inflow rate, surface runoff rate, slope, hydraulic characteristics of surface runoff. When rainfall and inflow water generate simultaneously into soil, surface soil was formed newly as it undergoes a constant transport and deposit process. The rill initiation began when the shear velocity of the surface runoff exceed the critical shear velocity. As the slope steepness increased, the location of the rill initiation moved to the upslope, and the formation of rill deepened and widened. Sediment yield including rill erosion increased remarkably with increase of surface runoff and flow velocity.

*Keywords*: Rill initiation, Rainfall simulation, Inflow rate, Steep slope, Sediment yield

## 1. INTRODUCTION

The formation of soil erosion includes the processes of detachment, entrainment, and transport of soil particles by surface runoff. The flow rate at the detachment point is governed by the balance between the flow energy of the surface runoff and the energy consumed by the detachment, entrainment, transport process and surface roughness of the soil. Rills begins to appear when the erosion of surface runoff exceeds the resistance of soil particles. The steeper the slope, the smaller critical shear stress and the more active the rill incision (Yao et al, 2008). Soil particles on steep slope is more easily eroded than those on gentle slope because the surface soil has a high potential energy. In this study, simulation test of rainfall and inflow water was conducted to identify the characteristics of rill erosion development on steep slope. A total of 24 experiments were carried out under the several slope, rainfall intensity, and inflow water.

## 2. RAINFALL SIMULATION

Rainfall simulator installed VeeJet80100 nozzles and half oscillating motor was used to test rill erosion (Fig. 1). Soil boxes are size of 0.6m×0.8m and can collect subsurface runoff as well as surface runoff. Experiments were conducted on three slopes (20°, 24°, 28°) and rainfall intensities of 80 mm/hr and 100 mm/hr. A specific PVC pipe to supply inflow was installed at the upslope end of the soil box as the method presented by Tian et al., (2017). Four inflow conditions were supplied to represent the long hillslope of 3.2m length using 0.8m length of soil box (Fig. 2). The first segment supplied only rainfall without inflow water, while the second, third, and fourth segments supplied both rainfall and inflow increasing with the distance of segments. Velocity of surface runoff in the soil box was determined by analysis of video images recording a dye movement.

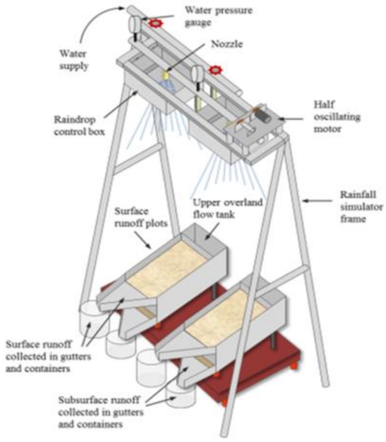


Figure 1. Rainfall simulator and soil box

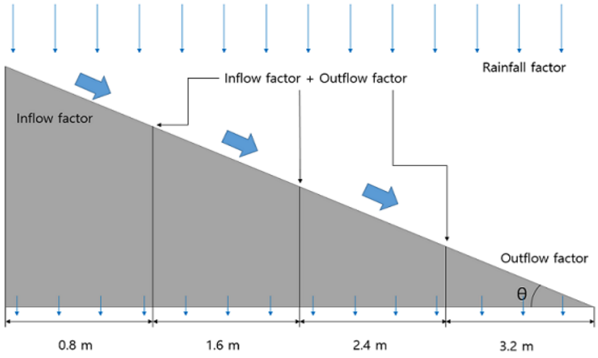
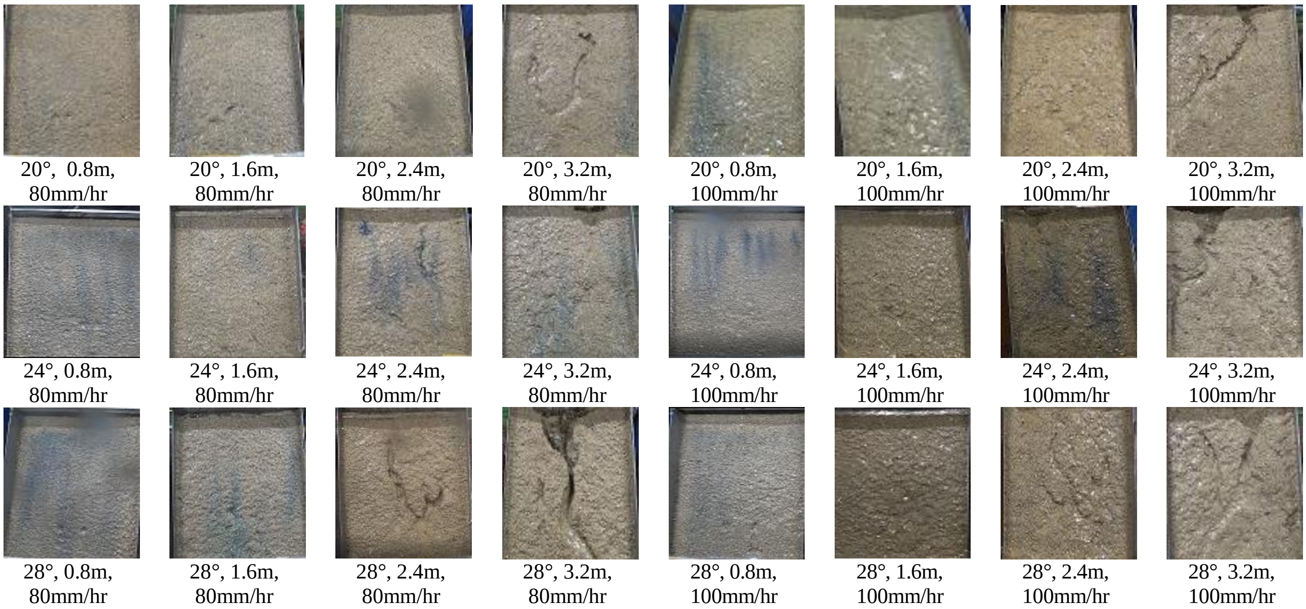


Figure 2. Schematic of the connected segments for long hillslope

## 3. RESULT

The shapes of rill development according to slopes, rainfall intensities, segment distances are shown as in Figure 3. The longer the segment distance, the more clearly active the rill development. Rill incision presented in the 2.4 and 3.2m segments and began between 2 and 4min in the 2.4m segment and 30sec and 1.5min in the 3.2m segment. The velocity of surface runoff was the range of 3.5 to 8.75m/s, which consider the initiating point of the rill incision. The rill initiation was influenced dominantly by the inflow water rather than the rainfall intensity on steep slopes. As the distance of the segment increased, the Froude number and Reynolds number increased (Fig. 4). Sediment yield depended on surface runoff and flow velocity (Fig. 5). After initiating of the rill, the rill become wider and deeper by accelerating the development of the rill in steep slope.


20°, 0.8m, 80mm/hr | 20°, 1.6m, 80mm/hr | 20°, 2.4m, 80mm/hr | 20°, 3.2m, 80mm/hr | 20°, 0.8m, 100mm/hr | 20°, 1.6m, 100mm/hr | 20°, 2.4m, 100mm/hr | 20°, 3.2m, 100mm/hr

24°, 0.8m, 80mm/hr | 24°, 1.6m, 80mm/hr | 24°, 2.4m, 80mm/hr | 24°, 3.2m, 80mm/hr | 24°, 0.8m, 100mm/hr | 24°, 1.6m, 100mm/hr | 24°, 2.4m, 100mm/hr | 24°, 3.2m, 100mm/hr

28°, 0.8m, 80mm/hr | 28°, 1.6m, 80mm/hr | 28°, 2.4m, 80mm/hr | 28°, 3.2m, 80mm/hr | 28°, 0.8m, 100mm/hr | 28°, 1.6m, 100mm/hr | 28°, 2.4m, 100mm/hr | 28°, 3.2m, 100mm/hr

Figure 3. Views of rill development according to slopes, rainfall intensities, and segment distances

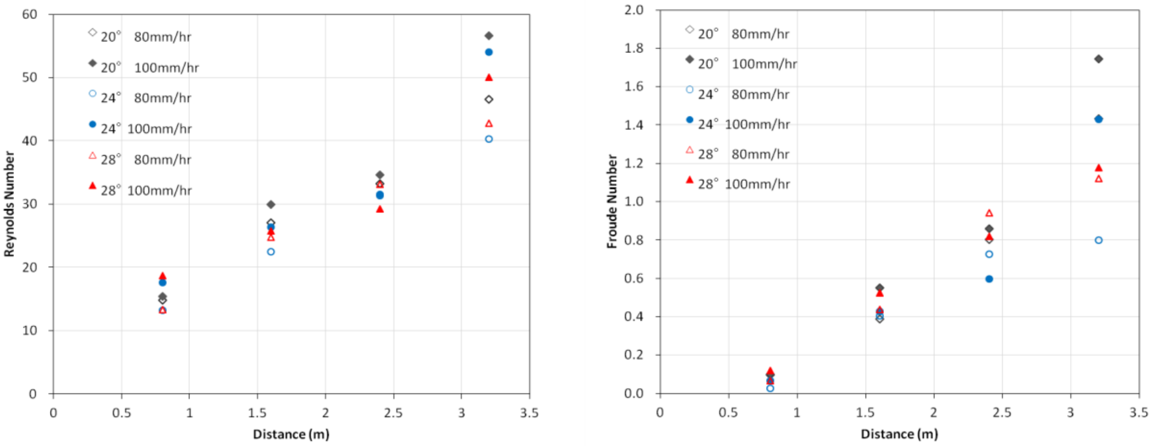


Figure 4. Variations of Reynolds number and Froude number with the segment distance.

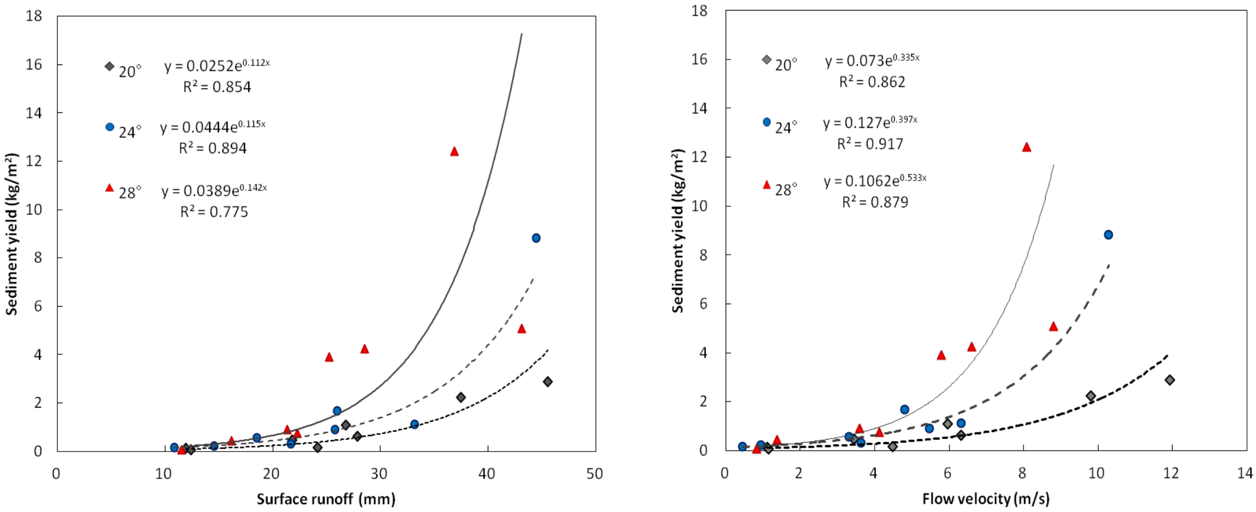


Figure 5. Relationship between sediment yield and the surface runoff and flow velocity

## 4. CONCLUSION

Sediment yield for rill erosion increased significantly with increase of rainfall intensity, slope steepness, and segment distance. The development of the rill was active when the segment distance was the range from 2.4 to 3.2m of high inflow and surface runoff. The critical shear velocity for rill initiation was estimated that the range is 3.5 to 8.75 m/s. The rill initiation depended greatly on the inflow water rather than rainfall intensity. Sediment yield including rill development from steep hillslope increased rapidly with increase of surface runoff and velocity.

## ACKNOWLEDGMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2019R1A2C1009285).

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