Effect of rainfall intensity and energy on the protective technical measures under heavy storm

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P. Kavka*[1], T. Laburda[1], M. Neumann[1], D. Zumr[1]

1 Department of , CTU Prague, Czech Republic

*Corresponding author: petr.kavka@fsv.cvut.cz

Abstract

Extreme rainfall events with high peak intensity and high kinetic energy cause fast water runoff, often accompanied with soil erosion and sediment transport. Soil degradation due to the rainfall usually occurs on steep and bare slopes. The slopes do not need to be extremely long. Even earth embankments without vegetation protection along the roads, railroads or rivers are endangered. Unprotected bare slopes are also present in urban areas, typically on construction sites or along the transport infrastructure. In the conditions of the Central Europe the earthworks stage usually overlaps with the period of sudden heavy rainstorms with very high erosivity factors, which is typical for June and July. This causes mobilization of large amounts of soil from the construction sites to the surrounding environment.

For systematic evaluation of the soil erosion and sediment transport processes one needs a large amount of data of various combinations of soil types, soil surface treatments, hillslope inclinations and rainfall characteristics (peak intensity, amount, duration, kinetic energy, raindrops distribution). This is difficult to obtain as the monitoring equipment is costly and the rainfall events unpredictable. Therefore, the research concentrates on simulated conditions in the laboratories.

The specific goal of this research is the experimental testing of various mechanical and technical surface protection measures and evaluation if it's effectivity in relation to soil erosion. We investigate quick and easy technical measures that have a potential to protect the slopes against the splash erosion, rills development and the topsoil sliding.

The experiments are done on the 4 m long inclined plots with different inclination. Three of the plots, encapsulated in large steel containers, are equipped with a nozzle rainfall simulator, with sediment and runoff collection system and with soil water regime and temperature regime monitoring. We analyze the runoff, soil loss and surface topography changes (sliding, soil compaction and rills development) for various rainfall, slopes and protection measures scenarios.

Fig 1: Experimental setup for evaluation of the effectivity of the protection surface cover. On the left is the surface protected with jute geotextile, on the right bare unprotected slope.

Beside the permanent plots, we do additional experiments in the laboratory. We have constructed a new rainfall simulator, which is capable of mimicking real rainfall events by implementation of variable intensity and kinetic energy. The used nozzles are able to replicate natural rainfall characteristics as closely as possible. The simulated rainfall characteristics and its spatial distribution within the soil sample area were tested with use disdrometer (LPM 5.4110, Thies Clima, Germany). The soil container is constructed the way that it allows quick changes of different tested materials, protection measures and inclinations.

Basic rainfall simulator characteristics:

- Maximum size of the soil sample is 1.5 x 6 m
- Variable height of the nozzles above the surface, ranging between 2 and 2.8 m.
- Inclination up to 45°.
- Variable rainfall intensity
- Two systems of rainfall generation: (i) puls type; (ii) swing type

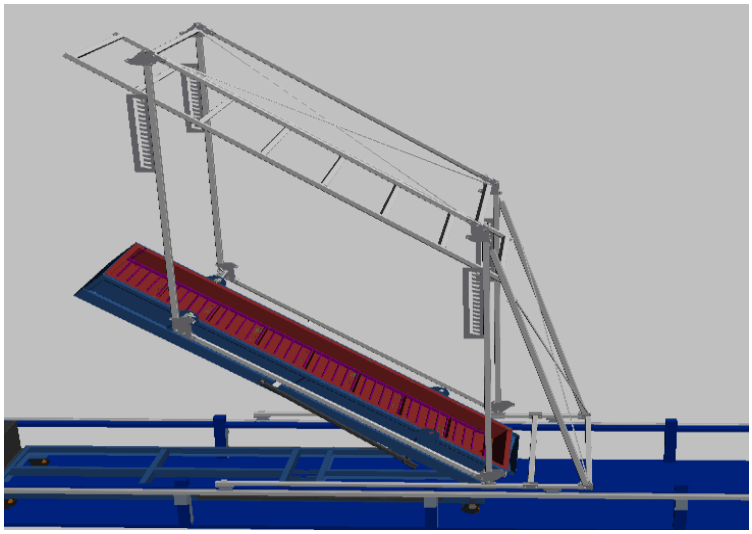

Fig 2: Laboratory rainfall simulator

Based on the primary results we can conclude that the unprotected slopes generate twenty times larger amount of sediment. Shortly after the start of the rainfall with intensity that exceeds the soil infiltration capacity we observed surface runoff followed by development of rills. On contrary, even lightly protected slopes produce only minimal soil loss, even though the water runoff stays comparable to the bare soil. The protected surface is not seriously affected by splash erosion, we haven't recorded severe crusting, soil compaction nor rills.

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