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INVESTIGATION OF TIME DEPENDENT LOCAL SCOURING İN GEOCELL REINFORCED DOWNSTREAM OF HYDRAULIC STRUCTURES

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Abstract - Hydraulic structures such as dams, diversion weirs, open channels and rivers beds are always confronted with problems of scouring. Base scouring may cause hydraulic structures to be damaged or even destroyed. For this reason, additional hydraulics are made to control the energy of flow. Geosynthetic products have become available in many areas of civil engineering in recent years. Geocell materials provide great benefits in areas such as soil strengthening and slope stability. These materials are useful for protecting hydraulic structures against scouring problems. In this study, the effect of the maximum depth of scouring of geocell material placed in the discharge channel downstream with a 50 degree base angle and the variation of the maximum depth of scouring due to time was investigated. The results obtained were interpreted to try to understand the time-dependent change in the mechanism of scouring on the geocell-restricted zone.

Keywords - Cellular confinement systems, Geocell, Hydraulic structures, Scour, Time Depent Local Scouring

INTRODUCTION

Even if the energy of the flow is dissipated by the stilling basin, it is sometimes possible to see scouring in the natural river bed. Scouring is a phenomenon of nature that occurs with the energy of the water in the flow. Scouring also changes the morphological structure of the rivers. The shape of the topography of the scouring is affected by many parameters such as submergence, tail water depth, water jet energy dissipation rate etc. The scouring has been an important research area for large dams, diversion structures, energy breaker pools, and orifices (Tuna and Emiroglu, 2011).

Dargahi (2003) USACE has done some scouring experiments with an apron placed in the standard ogee profiled spillway downstream. The mean median diameter (d_{50}) and unit discharge (q) were used as variable parameters in the study. As a result of these experiments, he observed the maximum depth of scouring in the spillway downstream. He produced an equation expressing that the depth of scouring is related to the energy head, material grain diameter, unit discharge.

Oliveto et al. (2011) reported that the main parameters effective in the scouring mechanism are the tailwater densimetric Froude number, relative time, and relative tailwater flow depth. It also revealed that particle motion began to act on densimetric froude numbers, which are much smaller than the traditional Shield's conditions.

In rivers, there is clear water scouring or moving base scouring occurs depending on the state of sediment load at upstream. Basically, the scouring in the rivers can be examined under three main headings: narrowing scouring, local scourings and long-time base scourings. In situations where the flow conditions remain unchanged, clear water scouring shows a rapid change at the beginning, while the rate of increase in scouring decreases over time and asymptotically approaches a stable depth of scouring (Yanmaz, 2002). In literature, it is understood that when examining the expressions of the depth of clear water scouring versus time, it takes a very long time to achieve a balanced depth of scouring. Some researchers have proposed some criteria about the time required to achieve a well-calibrated depth (Simarro-Grande and Martín-Vide 2004, Melville and Chiew 1999, Cardoso and Bettess 1999). The fact that the increase in depth of scouring in the course of an experiment of 24 hours in general is below a limit value has led to the assumption that stable conditions of deformation are achieved. In another study, Setia (2008) stated that even a 100-hour-old study in laboratory conditions was not sufficient to reach a fully balanced depth of scouring. Using this value, a typical period of time can be found in nature. For this purpose, it is observed that 4 hour experiments performed under laboratory conditions, for example 1/50 scale, have a value of 28 hours in nature compared to the Froude model. In our country and regions with similar hydro-meteorological conditions it is not possible to flood for such a long time. The use of the Cellular confinement systems (geocell, etc.) is still new in the literature. Simpson et al. (2018) examined the effect of the cell confinement system on sediment transport. This researcher generated currents at two different velocities on clay grounds with cellular filling system at 3 different widths and at 2 different heights and observed sediment motion inside the cell. As a result, he stated that the cellular filling system significantly reduces sediment transport.

Geocell based on the cell confinement method restrains the movement of flow to a great extent by trapping the ground in a cell. In this study, water flow through a chute with a slope of 50 degrees was left to an unhindered apron. The time dependence of the maximum depth of scouring was investigated by experiments with using different discharges.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

Experiments were carried out in Inonu University Engineering Faculty Hydraulic Laboratory of Civil Engineering Department. Experiments were carried out in the experimental setup schematically shown in Fig. 1. The depth of the sand floor in the channel is 40cm and the cell depth of the geocell used is 15cm. The dimensions of the channel and geocell are 100 cm x 200 cm and 100 cm x 100 cm, respectively. Experiments were carried out with three different dsicharges of 5, 10 and 15 l / s. The discharges were regulated with the help of a valve and measured with high precision through the flow meter. The water pumped into the upper tank by means of the pump and then transferred to chute channel. The water falling to an flat apron at the end of the chute was circulated until reaching the equilibrium scouring depth and then the maximum depth of scouring was measured.

A granulometry curve was created by conducting a sieve analysis experiment of sand bed. The grain diameter characteristics of the sand floor are as shown in Table 1. The specific weight of the sand floor was calculated as Gs = 2.55 ton / m3. The properties of the GeoCell product used to strengthen the sand bed are supplied from the manufacturer and are given in Table 2.

Table 1: Properties of the grain diameter of sand base used in study

d_{10}	d_{50}	d_{60}	d_{85}	d_{90}
0.53 mm	2.41 mm	2.55 mm	3.35 mm	3.63 mm

Table 2: Physical properties of Geocell made from High Density Polyethylene (HDS) material

Physical properties	Unit	Value
Polymer density	g/cm^3	0.935-0.965
Carbon black	%	2-3
Cell depth	cm	15
Thickness	cm	0.2
Tensile Strength	kN/m	20
Tensile Strength-Perforated	kN/m	12
Attachment Strength	kN/m	12

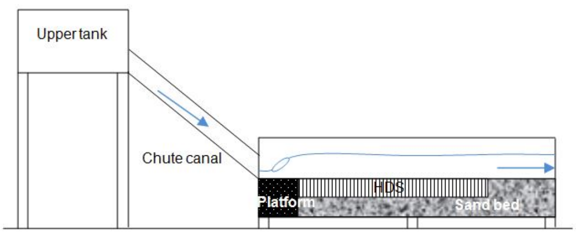

Figure 1: Schematic representation of the experimental setup

In Figure 2, it is seen that the geocell system is placed in the sand floor. Figure 3 shows the stage before the experiment begins. The experiment was started after the surface of the ground was checked with the aid of a water balance.


Figure 3: View of the channel before the experiment begins

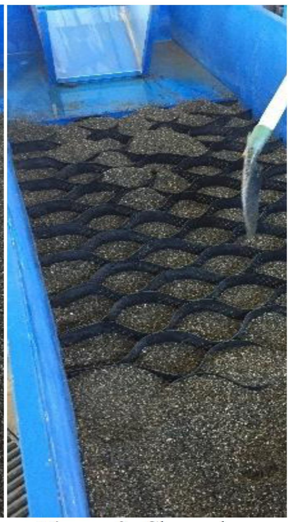
Figure 2: Channel placement of Geocell

In the study, time-dependent local scouring depths for geocell-reinforced sections were investigated. Experiments were performed on different deburls for the Geocell reinforced and unreinforced bearing, and the depths of scouring were determined at the end of the experiment.

III. RESULTS AND DISCUSSION

Experimental studies have been carried out to investigate the maximum depth of scouring depending on the time for different flow values in geocell reinforced sandy soils. It also examines how geocell reinforcement impacts the maximum depth of scouring. As shown in Fig. 4, the maximum depth of scouring varies depending on the time in the geocell-reinforced sand bed. As seen in Figure 4, the depth of the scouring showed a direct increase in the first stages of the experiment, but not much later in the experiment.

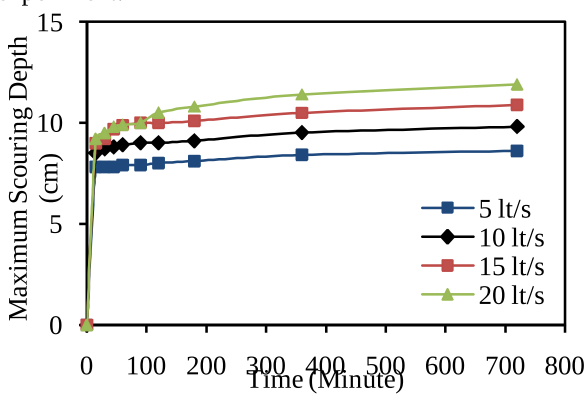

Figure 4: Maximum scouring depths varying with time in Geocell-reinforced sand bed

Figure 5 compares the maximum depth of scouring of GeoCell-reinforced and unreinforced sections. As seen in Figure 5, the use of GeoCell has reduced the maximum depth of scouring for all flow rates. In addition, with increased flow rates, the maximum depth of scouring is increased for both GeoCell-reinforced and un-reinforced sections.

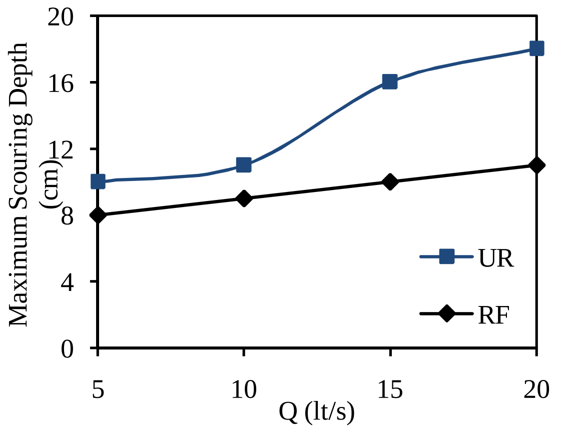

Figure 5: Comparison of strengthened and unaugmented experiments with no tail water condition

The movement of ground particles moving through the cell within the geocell was observed during the experiment (Figure 6). As a result of this observation, it has been observed that the ground particles are largely obstructed by the geocell system's ability to trap sand particles. In addition, the carvings formed at the end of the experiment in the cells of GeoCell are as shown in Fig. 6. As shown in the Fig. 6 maximum scour depth occur in the second cell. In Figure 6, it is understood that each cell is scour at the beginning and deposited at the exit. The shapes of the scourings inside the cells indicate that the currents are turbulence in the opposite direction.

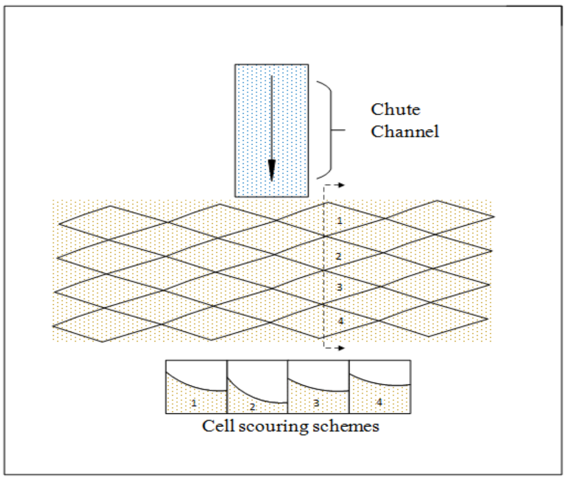

Figure 6: Scouring at the end of the experiment in Geocell's cells

CONCLUSIONS

This study investigates the time-dependent maximum depth of scouring in geocell-reinforced sections. In addition, the effect on the scouring event of GeoCell was investigated by comparing the maximum scouring that occurred in the GeoCell reinforced and unreinforced sections. In all experiments, water transmitting through a chute with a gradient of 50 degrees was left in an unobstructed apron. Experiments have been carried out on different discharges for the Geocell reinforced and unreinforced sand beds.

According to the findings obtained from experimental studies, the following results were obtained.

• The maximum depth of scouring has increased with increasing discharges

• The use of Geocell reduces the maximum depth of scouring for all discharges

• In the Geocell-reinforced sections, the depth of the scouring showed a direct increase in the initial stages of the experiment, but not much later in the experiment.

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