Quarterly Report

In-situ Scour Testing Device

October 1, 2011~December 31, 2011

Much information and experience was gained from the CFD simulation and the proof-test device. A design of the final lab model was finalized and necessary purchase made. This design combined well-proportioned geometry for flow condition, most compact footprint, and robust instrumentation (Figure 1). Important features include:

1. A long inlet that reduces jet from water supply.
2. Channels of different parts are proportioned so that they:
    a. Minimize the downward jet that may produce excessive scour before test section.
    b. High-speed uniform flow at test section that is capable of entrainment of sediment with prescribed particle size and erosion resistance.
    c. High-speed upward jet that can evacuate heavy particles.

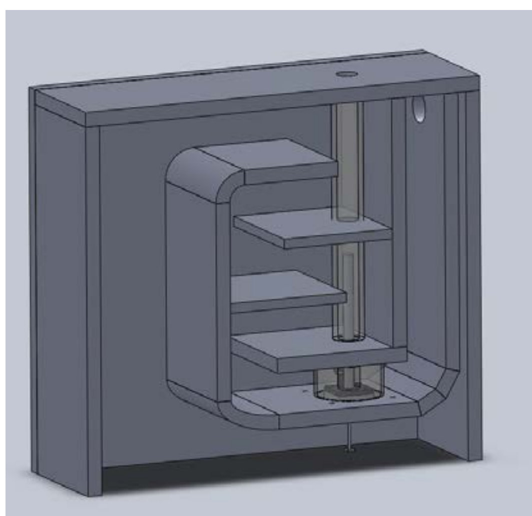

Figure 1 Final design for demonstrative ISTD unit

In order to produce a lab-scale demonstrative testing, a few components must be provided and integrated:

1. Hydraulic component: The hydraulic component must be able to provide a well-conditioned horizontal flow at the testing section that introduces a shear stress to the bed. Channels are proportioned to minimize the downward jet, produce high-speed uniform flow at test section,

and produce a high-speed upward jet that can evacuate heavy particles. This also includes a pump and associated pipelines. The detailed design of the primary channels is shown in Figure 2.

2. <u>Driving component</u>: A proper driving system must be supplied to move the hydraulic component down to the bed level and, as the erosion proceeds, drive the device into the scour hole produced by the hydraulic force. This system needs to be adequately supported by a stable reaction frame and operate at a well-controlled speed so that the main erosion channel can maintain a proper size. A pair of stainless screw jacks with 2-ton capacity (SWJ62I2S-18-STDX-ENCX-X) are selected to perform this task. The screw jacks, driving motor, and gear boxes are fixed on a frame above the testing chamber. The driving speed is controlled to maintain the channel size.

3. <u>Instrumentation</u>: A waterproof LVDT displacement transducer is used to measure the depth of the channel. Combining the reading from the LVDT and that from the flow meter, the velocity of the flow in the testing channel can be calculated. A LabVIEW-based control program is used to coordinate among the LVDT displacement transducer, the flow meter, the pump, and the driving system to accomplish a constant hydraulic stress on the sand bed. The test starts as the screw jack pushes the hydraulic component slightly into the sand bed to the point that the channel of specified size is achieved. The pump then starts to initiate the erosion of the sand bed and eject bed material through the outlet. The foot plate of the LVDT (Figure 4) sits on sand bed and detects the erosion. As the depth of the channel increases because of the erosion, the control program commands the screw jack to speed up and push the device further into the sand bed and therefore return the channel size tot eh preset level. The process stops when the depth reaches a specified value.
   Proximity sensors are also implemented to calibrate the motion and ensure safety of the operation.

4. <u>Test environment</u>: A dual-tank test rig is constructed to provide miniaturized stream bed condition for the demonstration of the ISTD (Figure 5). The environment consists of two tanks. The lower tank provides sufficient water for filling the upper tank and allow draining of the upper tank for the preparation of the sand bed and the ISTD for next test. The upper tank provides water inlet/outlet, access door for test preparation, and holds the sand to be eroded. A view box is also provided to keep the sand from blocking the view of observers.

Figure 6 shows the computer realization of the entire system. Figure 7 is a conceptual sketch of the procedure of the demonstration unit. Figure 8 is a photo of the lab demonstration unit in operation. Water enters the test section from the lower left corner, washes the sand towards the right, and shoots up the vertical channel, then exit the ISTD. Some of the sand from the device cumulates on the top of the view box.

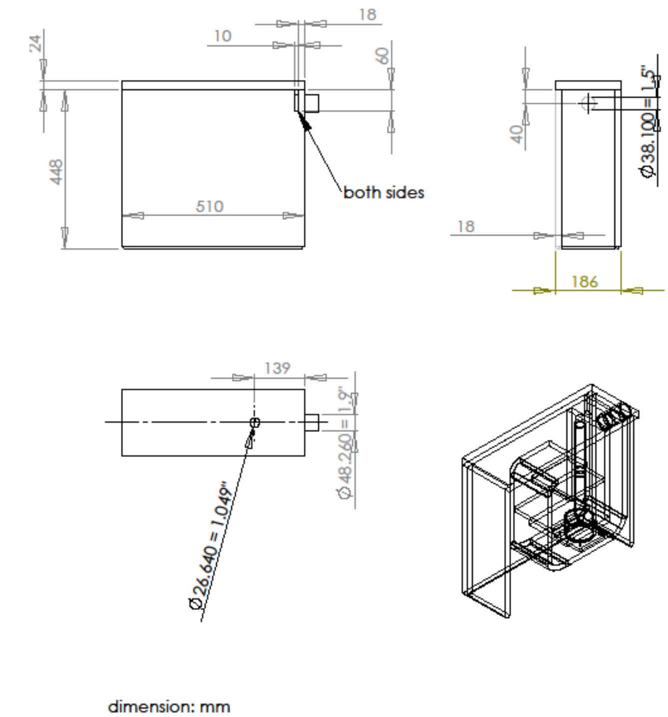

Figure 2 Dimensions of the main hydraulic components

Figure 3 Screw jack driving system

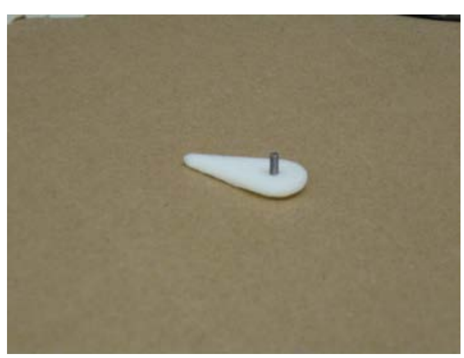

Figure 4 Foot plate of the LVDT

Figure 5 Demonstration tanks

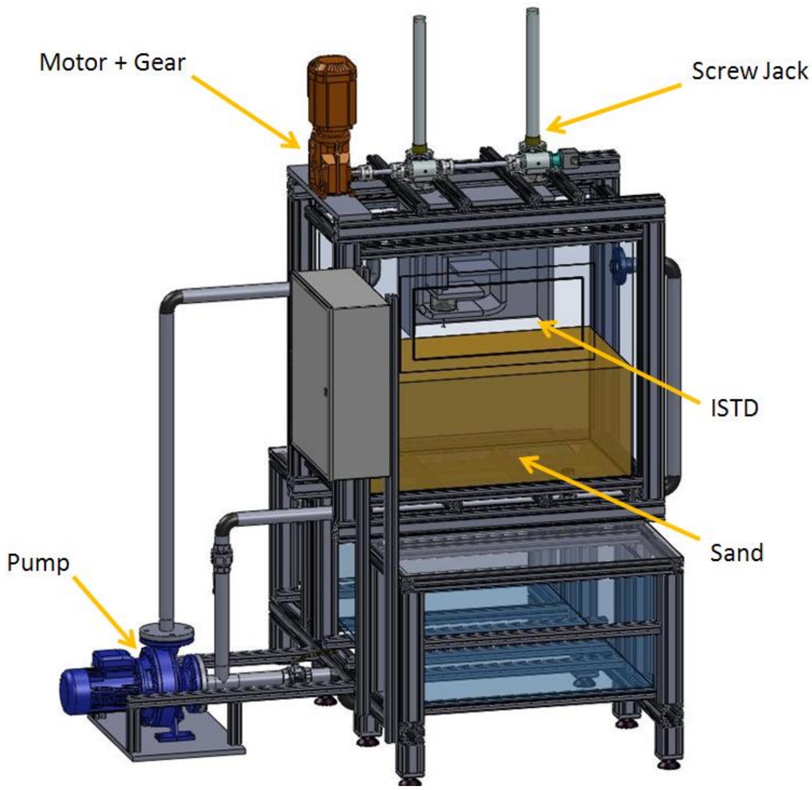

Figure 6: Solid Works drawing of the demonstration apparatus

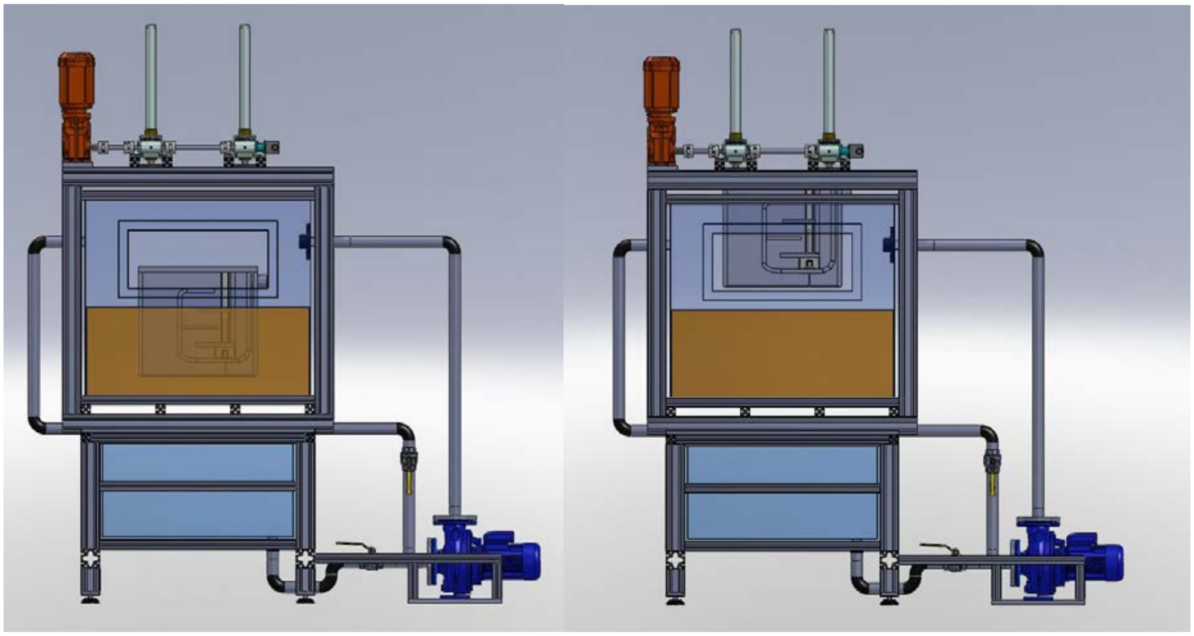

Figure 7 The ISTD lowers into the sand bed

Figure 8 ISTD lab unit in operation

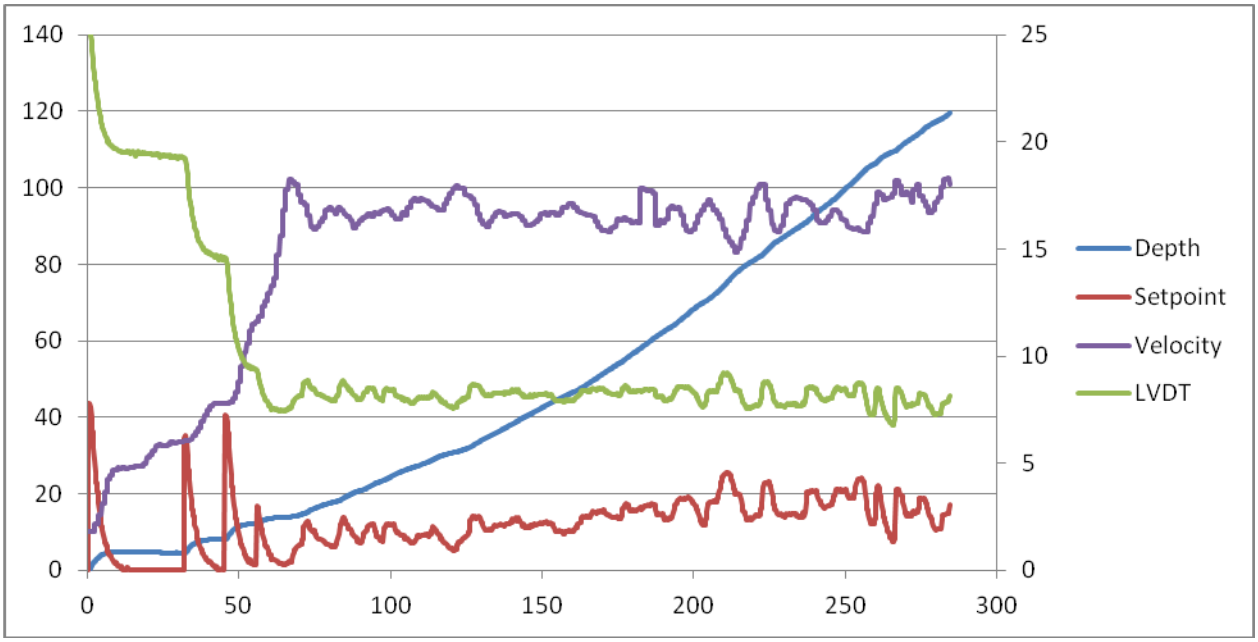

Figure 9 Controlled motion of the ISTD showing the depth of the device, setpoint of the control system, LVDT reading, and velocity of the movement

After CFD modeling and physical proof-testing of the impeller design, the alternative worm-design ISTD is under construction during this period. The device is self-supported on a tripod-style stand. Inside the outer circular encasement is a hollow steel tube with helical blade resembling and auger. Further inside is an off-center driving shaft, for which the lower end is connected to the inner gear of an impeller. At the very center of the device is a displacement transducer that measures the amount of the bed erosion. The impeller revolves at a short distance from the bed and produces a significant shear stress that entrains the sediment. The auger-tube provides a continuous upward motion at the interface to the soil. This serves two purposes: removal of the eroded material, and preventing jamming of the device. The auger-tube and the impeller can be controlled independently to achieve a number of different erosion scenarios.

The fabrication of the device is near completion at the end of the last period. It will be shipped to the Hydraulics Laboratory at TFHRC for programming and testing. Benchmark testing will be conducted to calibrate the device and provide a reliable representation of shear stress from the device.

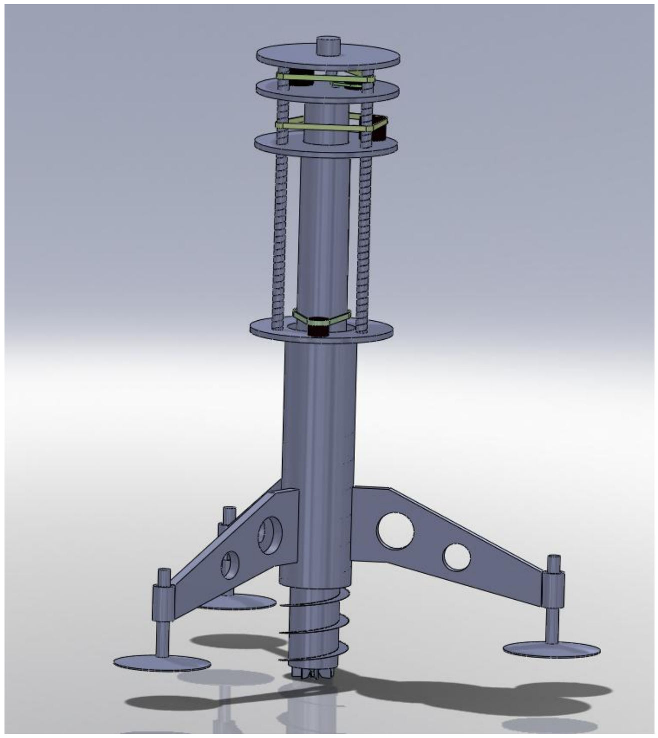

Figure 10 Overview of the worm design

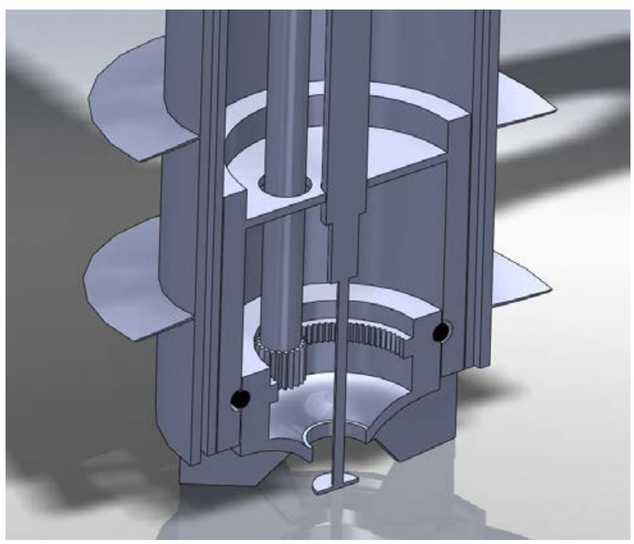

Figure 11 Close-up view of the erosion head of the worm design