Huge Engineered Riffle -
Groundbreaking Grade Control on the Pedu River

The weir crest nearly complete, about 18" to go.

This article describes the technology transfer and actual construction of innovative river training methods in Malaysia in August 2014. The technology involved was an Engineered Rock Riffle (Newbury Rock Weir / Riffle), a Bendway Weir, and the use of well-graded (self-launching) stone. The methodology was described in NCHRP Report 544 – Environmentally Sensitive Channel and Bank Protection Methods (2005, J. McCullah, D. Gray) that covers design criteria, con-

Above: Very hot and humid, followed by 1"/hr rainstorms. In the background - turbidity of the river went from 18 NTUs to over 1800 NTUs in 3 hours. Below: We placed 6000T of rock. Here the crew is working through a heavy rainstorm.

struction specifications, detailed drawings, references and, case studies.

Malaysia has a very heightened environmental awareness. Over the last decade the Malaysian Government, Malaysian Universities and NGOs have been inviting education on soil erosion and sediment control and the tangential fields of study so EnviroCert International, Inc. has been very active in providing CPESC, CPSWQ and CESSWI training and certifications. IECA members and EnviroCert trainers like Eric Bernsten, Susan Clark, Ted Sherrod, and Wing Leong have been incredible ambassadors and leaders. I myself have been invited several times to be a guest speaker and teacher and then reciprocated by twice hosting Malaysian professionals to Shasta College. In 2013, Wing and I hosted a group from the Malaysian Urban Drainage Association to tour Northern California and visit some of the River Restoration projects I have been involved with.

These educational associations are how Tuan Haji Abu Bakar, head of Department of Irrigation and Drainage for the state of Kedah, Malaysia, came to invite Wing and myself to help solve a challenging problem on the Sg. Pedu (Pedu River). In addition to solving a very real problem, the solution was hoped to feature aspects of a demonstration project with opportunities for technology transfer of new environmentally sensitive stream stabilization techniques.

The Problem

The Pedu River Project is located in northern Malaysia, not far from the border with Thailand. About 20km upstream of the site is a large flood control dam, which has annual controlled releases of approximately 5000 cfs. The actual site was the location of Pedu River Irrigation Project pumps. The pumps were developed to provide irrigation for thousands of hectares of agriculture (rice and rubber tree plantations). As the river adjusted to upstream impacts it became incised and the water surface elevation dropped such that the pump intakes were "in the dry" during low flows.

The engineered riffle was chosen as a cost-effective alternative to a large "check dam" – needed to ensure that the upstream Pedu River Irrigation Project pumps remain submerged during low flow. A large, rock-filled gabion check dam structure was built a couple of years previous but the high flows soon flanked the structure.

Challenges

The low-flow water surface elevation needed to be raised almost 2.5 meters. In addition, the structure needed to withstand over 5,000 cfs (the Q_{5000} has an anticipated water surface of 2m over the structure--the Newbury Riffle we designed was over 40m long by 20m wide) and had a slope of about 20:1. Another design challenge was the available rock couldn't exceed 1m diameter. The 10-wheel dump truck beds and long distances had to be considered, as this project required over 250 dump truck loads.

The project presented many other construction challenges. We developed

Downstream section completed. Note that the eroded and scoured right bank did not need protection - it became a flood terrace that refilled and maintained itself.

construction strategies that complied with self-imposed water quality standards – turbidity downstream couldn't exceed a 10 NTU increase from upstream sample. One morning the NTUs increased from 18 NTUs to over 1800 NTUs in just 3 hours – all from the upstream watershed (illegal logging we heard). One afternoon we received almost 6-inches of rain in less than 2 hours and the river rose 4ft overnight.

Our first order of business was to remove the gabions by dis-assembling, removing the wire and leaving the lower course as a stable low-flow crossing. This came in very handy to evacuate equipment and workers from the right bank as river levels could rise rapidly.

The design structure was built with over 6000 T of "self-launching", self-adjusting, well-graded stone (ranging from 3" to 32" mean diameter). This may seem like extremely small stone for a river structure receiving 5000-10000cfs over 3-6ft high, but the gradations are such that the angular stone adjusts and forms a maximum number of frictional points of contact. Most importantly, the structure must be built from the downstream toe up to the crest. And the riffle must be built "under compression", meaning the equipment operators must place and compact the rock against the previously laid stone in a downward and downstream direction.

The operators on our job were very skilled, but they were also humbly willing to learn some new construction methods. Language barriers were diminished with the help of Mr. Osmond and by using the universal construction language of hand signals and arm waving! A new construction technology paradigm we introduced was the use of a front-end loader (the local term was "shovel") to deliver the stone to the excavators. The excavators can then stay in place while the operator selects, places and compact the stone. A good loader operator, as we had, can pretty much set the pace by anticipating the size needed, selecting that fraction from the stockpile, then loading and delivering it to the excavator operators. Maintenance of the delivery routes also becomes important for cost-effective construction.

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The project took about 35 days to complete. I was there for the first 18-days and then Wing and Mr. Osmond took over construction oversight. There were a couple of days with monsoonal rains, which were quite anxiety producing, because of the long distance communication problems. I soon realized that one of the equipment operators and a couple of the young helpers could use their smart phones to post pictures and videos on Facebook for me. I could then monitor the progress from California and send instructions and feedback almost immediately.

JPS wanted this project to demonstrate and transfer new technology. Therefore we also provided a one-day workshop for the JPS Kedah engineers and designers. Challenges were turned into opportunities.

It has now been almost a year and the reports from the area very positive. The area along the right bank, which had eroded (receded) over 50ft when the gabions were flanked has continued to fill in naturally. The bendway weir built 50ft upstream of the riffle crest is effectively directing the thalweg through the center of the riffle. The chances of another high flow flanking are reduced because of the bendway weir and our longitudinal stone toe has a tieback running 100-ft into the forest. **L&W**

Gabions with water over.

by John McCullah

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