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Spring Rains Bring Torrential Flooding and Damage to the Midwest

By Dan Ghere

During March and April, the Midwest experienced significant rainfall events that resulted in saturated watersheds and full flowing streams through out the region. This weather system was especially burdensome to several counties in northern Illinois. During the week of April 14th, six inches of rain fell in one 12-hour period over the Crow Creek watershed in Marshall County. The cumulative rainfall that week resulted in the worst flooding since the 1943 flood of record on the Illinois River. This flooding threatened county roads, levees, and towns from Ottawa to Meredosa, Illinois. A post-flood inspection revealed some of the flood damage.

Township Road 82

The Township Road 82 (Wilbern Road) bridge is an 80-foot long single span pony truss on closed abutments with spread footings set approximately 6 feet below the sandy streambed of Crow Creek. This bridge, built in 1932, has withstood numerous floods without damage. Longtime local residents reported that this flood, though, encroached on the truss to an elevation higher than ever seen during the life of the bridge. Such flood elevations likely produced pressure flow conditions that resulted in additional scour at the bridge causing both lateral and vertical movement of the south abutment and erosion of the approaches. The township dumped riprap at the north abutment during the flood and reduced damage to the north abutment and approach. After the flood, some of the riprap was observed downstream of the bridge on a sandbar.

The National Bridge Inspection Standards (NBIS) Item 113 code for this bridge was “8”, presumably because of its long history of stability, so no defined Plan of Action (POA) existed. However, because of the severity of the storm the county actively monitored all bridges on Crow Creek. Due to the extent of damage, a total replacement of this bridge will be required.

View of Township Road 82 Bridge looking at South

View of Township Road 82 Bridge looking at the South Abutment from on top of the road.

Benefits of POAs Extend to Other Bridges

Illinois DOT has recently implemented a bridge management tool to notify its inspection personnel of critical flood alerts for scour critical bridges. These alerts enable inspectors to implement the monitoring portion of a Plan of Action (POA). The April flood created the first alert issued by this bridge management tool.

Although the bridges (see page 1) on Crow Creek were not coded scour critical and were not included in the bridge management tool, other Marshall County bridges were included. The flood alert for these scour critical bridges was transmitted at night to the Marshall County inspectors, who then began to monitor the scour critical bridges for scour, inundation, or movement. The inspectors, concerned about rising flood waters at other non-scour critical bridges, began to monitor these other bridges, as well. Hence, the inspectors were able to make timely decisions to protect the bridges and travelling public when these other bridges had scour issues.

Marshall County inspection personnel found the alert from the bridge management tool to be valuable and helpful to mobilize staff during a flood event. The County Engineer is considering adding additional bridges to the bridge management tool even though they are not on the scour critical list.

Post Flood Evaluations

After significant flooding that triggers implementation of the monitoring portion of a Plan of Action (POA), the FHWA recommends assessing the functionality of the POA. One might consider the following questions:

- Were the triggers for initiating action appropriate?
- Was the communication acceptable or were there issues in notifying personnel or management?
- Did the bridge closure, if applicable, proceed as planned?

Adjustments could then be made to the POA to make it more functional during the next flood event.

In addition to assessing the POAs for scour critical bridges, one might also determine if the bridges coded as stable truly were stable during the flood event. For the April flood event in Illinois, the five bridges discussed in this newsletter were each coded “8” or stable for the NBIS Code Item 113. A post flood assessment revealed that four out of the five bridges were stable through the flood event, even though scour revealed the concrete pile foundation of two of them. The scour and the subsequent riprap installed are reasons for the County to reconsider the code for these bridges. Recoding these bridges to a “7”, which means a countermeasure was installed to reduce the risk of scour and potential bridge failure, may be appropriate based on the observed conditions and actions taken.

Hydraulic Research

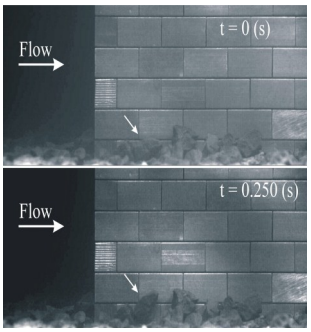
Hydraulic Performance of Shallow Foundations for Support of Bridge Abutments

Researchers at the J. Sterling Jones Hydraulics Research Laboratory (HRL) currently are testing the performance of shallow foundations using a scaled model of a Geosynthetic Reinforced Soil (GRS) vertical-wall bridge abutment. The GRS-abutment is seated on a shallow reinforced soil foundation (RSF) composed of granular fill material compacted and encapsulated in a geotextile. The settlement and external stability (deformation) of the GRS-abutment is monitored with a laser distance sensor.

GRS-Abutment Model

Smart Scour Countermeasure

Researchers at HRL are also using physical modeling and computational fluid dynamics (CFD) to study the performance of various riprap apron layouts at vertical-wall abutments and at rectangular piers. The apron layouts are based on design guidelines from Hydraulic Engineering Circular (HEC) 23 and field



Riprap Initial Failure

installations. The tests are being conducted separately on both fixed and erodible beds using different riprap sizes around a vertical wall abutment and around a rectangular pier. A high-speed camera (62 to 500 frames per second) is used to capture initial failure of the rock within the failure zones.

Research and Contact Information

The two research projects described above should be completed by the end of 2013. For more information about these and other projects, please visit the HRL website:

http://www.fhwa.dot.gov/research/tfhrc/labs/hydraulics/

Followup reports of the research conclusions will be posted in mid-2014. For these reports and other research reports, please visit the website:

http://www.fhwa.dot.gov/research/publications/technical/infrastructure/hydraulics/

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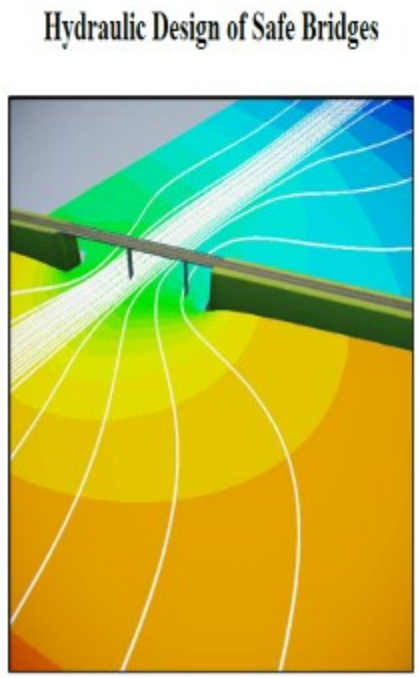
Training Updates

New NHI Training Course 135090- Hydraulic Design of Safe Bridges



The new NHI Course 135090, Hydraulic Design of Safe Bridges, presents the materials found in the recently published Hydraulic Design Series 7 (HDS7) document. The course provides a comprehensive overview of bridge hydraulic analysis and design, including; regulatory topics, hydraulic modeling approaches, model selection, scour, stream stability and sediment transport.

The course is informative and interactive. It will be an excellent introduction for those new to bridge hydraulics, as well as a refresher to more experienced hydraulic engineers.

Interested in registering for or hosting the course? Check out the NHI website:

http://www.nhi.fhwa.dot.gov

or contact one of the FHWA Resource Center Hydraulic Engineers.

Training Webinars

The FHWA Resource Center has recently hosted webinars to brief states on the new guidance documents HDS 7 and HEC 18, 5th Edition. The webinar on HDS 7 highlighted the useful information in HDS 7 regarding bridge hydraulics and also explained the advantages and disadvantages of 1-D and 2-D modeling. The webinar on HEC 18 provided an overview of each chapter in HEC 18. In particular, the webinar focused on the new scour procedures for cohesive soils and rock material, for pressure flow, for three-sided culverts, the Florida procedure, and the NCHRP abutment scour procedure.

If you would like to view a recording of the webinar, please go to the FHWA Hydraulics webpage:

http://www.fhwa.dot.gov/engineering/hydraulics/index.cfm

The recordings are posted in the right column of the site under “Recorded Webinars”.

Additional training webinars are being developed for late Summer. If you would like additional information on these webinars, please contact one of the FHWA Resource Center Hydraulic Engineers:

http://www.fhwa.dot.gov/resourcecenter/teams/hydraulics/index.cfm

2014 National Hydraulic Engineering Conference in Iowa!

The Steering Committee for the 2014 National Hydraulic Engineering Conference (NHEC) has selected Iowa Department of Transportation (DOT) to host the 2014 NHEC. The conference will be held in Iowa City in late summer 2014.

The 2014 Steering Committee hopes to select the dates and location for the conference by August or September 2013. Solicitation for presentation abstracts will begin in Fall 2013.

The 2014 Steering Committee consists of representatives from the AASHTO Technical Committee on Hydrology and Hydraulics (Casey Kramer of Washington State, Andrea Hendrickson of Minnesota, and Steven Sisson of Delaware), from the TRB AFB60 Subcommittee on Hydrology, Hydraulics, and Water Quality (Scott Taylor of RFB Consultants and Linda Narigon of Iowa DOT), from the Corps of Engineers Cold Regions Lab (Len Zabilansky), Iowa DOT (David Claman), and FHWA Hydraulics (Brian Beucler, Abhi Kapoor, and Cynthia Nurmi).

For more information on the 2014 NHEC, please contact:

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Spotlight on Iowa -

The 2014 NHEC will be held in Iowa City, Iowa. Is Iowa a new unexplored place for you? Let's look at some of the highlights:

First, the Iowa DOT is a leader in hydraulic related issues. Iowa DOT was one of the first DOT's to implement a statewide system to manage scour critical bridges during flood events. This system has been invaluable during significant long lasting floods in 2008 and 2011.

Iowa DOT is currently a pilot state for the FHWA's Climate Resiliency Pilot Program. Iowa DOT will assess the vulnerability of highway structures due to climate change impacts. The project will monitor, predict, assess and provide alerts when vulnerable highway infrastructure assets are at risk from extreme rainfall events.

Second, Iowa City is home to one of the America's oldest Hydraulic Engineering Labs—the IIHR. Hydraulic research began in the 1920's at the IIHR, with a flume in a small brick building along the Iowa River. The IIHR facility has evolved from studying industry and defense work in the 1930's to environmental hydraulics in the 1960's to a blended effort today with numerical and physical modeling. (For more information contact:

http://www.iihr.uiowa.edu/)

Third, the IIHR has established the Iowa Flood Center, which focuses just on studying floods. Some research topics are real-time sensors, mapping tools, and precipitation forecasting. Partners include NASA, ASCOE, USDA, and NOAA. (For more information:

http://iowafloodcenter.org/)

Software Updates

New Release of SMS (Surface-Water Modeling System) Two-Dimensional Modeling Graphical Interface

The latest release of SMS, version 11.1, has many new feature upgrades and bug fixes. Some new features include:

- Dynamic Images – automatic links to online image sources
- Coordinate Projection on the Fly – all data imported to SMS is automatically converted to the specific project projection
- New GIS capabilities
- New data input formats
- New annotation capabilities

SMS includes the FHWA recommended 2-D model FST2DH.

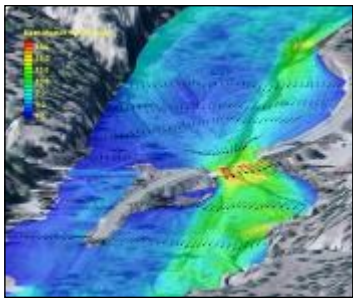

Image of 2-D Model Results

New release of WMS (Watershed Modeling System)

WMS version 9.1 has many new feature upgrades and bug fixes. Some new features include:

- Improved Online Data Tools – links to new sources of online images, maps, and data
- Coordinate Projection on the Fly – all data imported to WMS is automatically converted to the specific project projection
- DGN, DWG, and other CAD file support
- Additional GIS Data features
- Image texture mapping - images can be draped onto a surface
- Flood mapping from HEC-RAS water surface elevations

Licensing and Downloading SMS and WMS

All State DOT and FHWA employees can obtain a license for SMS and WMS through a contracting agreement between FHWA and Aquaveo, LLC.

Steps to obtain licenses:

http://www.fhwa.dot.gov/engineering/hydraulics/software/sms_wms_instructions.pdf

Download SMS and WMS at:

http://www.aquaveo.com/downloads

Licensing/Technical Support:

Scott Hogan
720-963-3742
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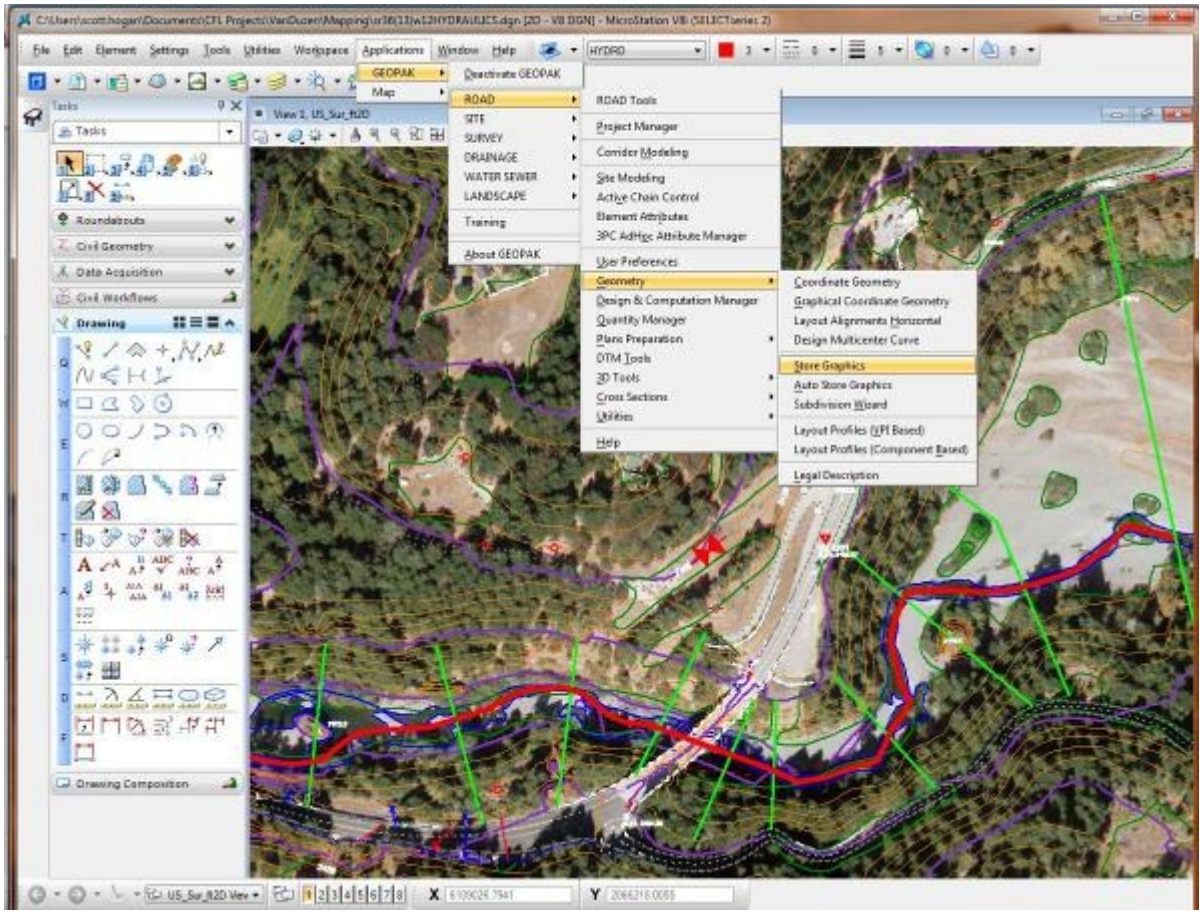
Software Tips and Tricks

Compiling a HEC-RAS model using MicroStation



MicroStation (V8i with GEOPAK) can be a very helpful tool in compiling a HEC-RAS model. All you need is your project mapping data and the horizontal and vertical datum information.

After drawing the channel alignment and cross section locations in MicroStation, use the HEC-RAS Report feature in GEOPAK to export a *.geo* file that can then be imported into HEC-RAS.

The cross section data and channel alignment are geo-rectified to the specified coordinate system.

Once the cross section data are imported, add the reach lengths, bank stations, Manning's n values and boundary conditions to create a complete HEC-RAS model.

A PDF file with detailed instructions is available on the FHWA Hydraulics Web Site under the Software section:

(http://www.fhwa.dot.gov/engineering/hydraulics/)

(HEC-RAS Tools).

Midwest Flooding and Damage, cont.

Township Road 68

Township Road 68 bridge, downstream of the Township Road 82 bridge on Crow Creek, was also inundated during the flood. The bridge is a 162 foot long, three span deck beam bridge on stub abutments in sand and was built in 1983.

During the flood, water flowed against the deck beams and large debris partially choked the opening. The bridge experienced little apparent scour or damage, in part due to the low lying approaches that provided relief to flood flows. The abutments did not have riprap countermeasures but were not significantly damaged since they were somewhat protected by the old abutments that were left in place 30 feet upstream.

Both approaches were extensively damaged by overtopping flow.

Although this bridge was coded “8” for NBIS Item 113, the township road commissioner was concerned about losing this bridge so it was watched closely during the flood. Further post flood and debris removal inspections will determine the extent of scour and if repairs or counteremeasures are needed at the piers or abutments.

Upstream View of Bridge

FAS Route 371/County Highway 12

The FAS Route 371/County Highway 12 bridge is a 3-span open abutment structure located on a sharp right angle bend of Crow Creek located one mile upstream of the Township Road 82 bridge. Riprap armoring on the embankment slope above the sheet pile toe on the inside of the bend was lost during the flood. Riprap was also lost at the abutment on the opposite stream bank. No sign of a filter was seen under the riprap at either location. Some bank erosion was observed on the downstream side of bridge but no apparent scour or other damage was observed.

View of Upstream Abutment Cone

The railroad shown in the background suffered an embankment slide failure and loss of track during the storm. This is a major rail freight line and the tracks were restored and back in service in a matter of days.

View of Upstream Face Outside Bend

County Highway 3

bridge, approximately 3 miles further upstream on Crow Creek, consists of a 131-foot long, 3-span slab bridge on spill through abutments.

View of Straight Alignment Upstream

During the flood, one abutment scoured and the concrete pile foundation was exposed. The soil at this site was a silty sand and the tially straight.

View of Riprap Placement on Abutment

There were signs that broken concrete had been placed along the south upstream bank because of prior bank erosion.

Riprap was being placed to fully armor the abutment cone during our site inspection. The stone was being dumped off the corner of the abutment and then positioned with a bobcat underneath. A granular bedding was used under the riprap instead of a geotextile filter.

View of Riprap Being Dumped

This structure had an NBI coding of “8” for Item 113. It will be reevaluated based on this recent flood event.

FAS Route 2368/County Highway 19

FAS Route 2368/County Highway 19 bridge over Big Sandy Creek is a 119-foot long 3-span deck beam bridge on spill through abutments with concrete piles. During the flood, scour exposed the piling at the north abutment.

The stream bed soil at this site is a silty sand. The stream alignment immediately upstream of the bridge was straight but then turned 90 degrees to the north for several hundred yards resulting in the stream and floodplain flowing parallel with the roadway embankment. This overbank flow paralleling the embankment at a high velocity and requiring a sharp turn at the abutment is the probable cause of the abutment scour.

View of Upstream Channel and Floodplain

Riprap was placed at the abutment to repair the scour. Installation of a guide bank could further protect the abutment from future scour.

View of Riprap Armor at Abutment

Acknowledgements

We would like to thank the following for their support and provision of information for the lead article “Spring Rains Bring Torrential Flooding and Damage to the Midwest”:

Illinois DOT Bridge Management Unit:
Curt Evoy
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Ed Andrews

FHWA Division Office:
Dan Brydl
Abe Ramirez

FHWA Hydraulic Contacts

The FHWA Hydraulic Staff are available to assist you with FHWA Hydraulic related issues. A list of Hydraulic Staff may be found at:
http://www.fhwa.dot.gov/engineering/hydraulics/staff.cfm.

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