OKLAHOMA DEPARTMENT OF TRANSPORTATION
200 N. E. 21st Street
Oklahoma City, OK 73105-3204

February 2, 2005

RE: SCOUR DEPTH INFORMATION FOR ODOT BRIDGE PLANS

Dear Sir:

AASHTO LRFD Bridge Design Specifications Article 3.7.5 require that scour be investigated for two conditions for all spans structures over a waterway. Scour shall be calculated for the 100 year storm and the least occurring of the 500 year storm or the overtopping frequency storm. (ie :use the overtopping frequency storm if the overtopping frequency storm is less than 500 years). HEC-RAS uses the methods outlined in Hydraulic Engineering Circular No. 18 (FHWA, 2001). Before performing a scour analysis with the HEC-RAS software, the engineer should thoroughly review the procedures outlined in the Hydraulic Engineering Circular No. 18 (HEC 18) report.

We ask that the hydraulic data that is put on the general plan and elevation sheets include the scour depths for contraction and pier scour for the events described above. This information is required to be included on the hydraulic data summary sheet submitted with the hydraulic report. The detailed scour evaluation and any soils data used shall be included in the hydraulic report.

If you have any questions, please feel free to contact Zia Siavashpour, P.E. at 521- 6500

Sincerely,

Robert J. Rusch, P.E.
Bridge Engineer

Attachment

LRFD design flood for scour is NOT the design flood for the highway structure. Eight profiles are run for all bridge projects. (2, 5, 10, 25, 50, 100, 500, & overtopping year events) AASHTO DESIGN FLOOD selection guidelines are in Appendix A of the Model Drainage Manual

EXAMPLE ONE IF $Q_{OT} > Q_{500}$

Q_{100} = 8990 cfs
V_{100} = 10.80 fps
CHW_{100} = 1010.27 ft
Pier scour depth = 12.31 ft
Contraction scour depth = 2.45 ft

Q_{500} = 13490 cfs
V_{500} = 13.80 fps
CHW_{500} = 1012.40 ft
Pier scour depth = 14.44 ft
Contraction scour depth = 3.26 ft

EXAMPLE TWO IF $Q_{OT} < Q_{500}$

Q_{100} = 8990 cfs
V_{100} = 10.80 fps
CHW_{100} = 1010.27 ft
Pier scour depth = 12.31 ft
Contraction scour depth = 2.45 ft

Q_{OT} = Q_{289} = 17862 cfs
V_{289} = 18.54 fps
CHW_{289} = 1011.36 ft
Pier scour depth = 15.41 ft
Contraction scour depth = 3.56 ft

EXAMPLE THREE IF $Q_{OT} < Q_{100}$

Q_{100} = 8990 cfs
V_{100} = 10.80 fps
CHW_{100} = 1010.27 ft
Pier scour depth = 6.54 ft
Contraction scour depth = 2.16 f t

Q_{OT} = Q_{29} = 7802 cfs
V_{29} = 9.94 fps
CHW_{29} = 1009.2 ft
Pier scour depth = 12.31 ft
Contraction scour depth = 2.45 ft

2.6.4.4.2 Bridge Scour

As required by Article 3.7.5, scour at bridge foundations is investigated for two conditions:

- For the design flood for scour, the streambed material in the scour prism above the total scour line shall be assumed to have been removed for design conditions. The design flood storm surge, tide, or mixed population flood shall be the more severe of the 100-year events or from an overtopping flood of lesser recurrence interval.

- For the check flood for scour, the stability of bridge foundation shall be investigated for scour conditions resulting from a designated flood storm surge, tide, or mixed population flood not to exceed the 500-year event or from an overtopping flood of lesser recurrence interval. Excess reserve beyond that required for stability under this condition is not necessary. The extreme event limit state shall apply.

If the site conditions, due to ice or debris jams, and low tail water conditions near stream confluences dictate the use of a more severe flood event for either the design or check flood for scour, the Engineer may use such flood event.

Spread footings on soil or erodible rock shall be located so that the bottom of footing is below scour depths determined for the check flood for scour. Spread footings on scour-resistant rock shall be designed and constructed to maintain the integrity of the supporting rock.

Deep foundations with footings shall be designed to place the top of the footing below the estimated contraction scour depth where practical to minimize obstruction to flood flows and resulting local scour. Even lower elevations should be considered for pile-supported footings where the piles could be damaged by erosion and corrosion from exposure to stream currents. Where conditions dictate a need to construct the top of a footing to an elevation above the streambed, attention shall be given to the scour potential of the design.

When fendering or other pier protection systems are used, their effect on pier scour and collection of debris shall be taken into consideration in the design.

C2.6.4.4.2

A majority of bridge failures in the United States and elsewhere are the result of scour.

The added cost of making a bridge less vulnerable to damage from scour is small in comparison to the total cost of a bridge failure.

The design flood for scour shall be determined on the basis of the Engineer's judgment of the hydrologic and hydraulic flow conditions at the site. The recommended procedure is to evaluate scour due to the specified flood flows and to design the foundation for the event expected to cause the deepest total scour.

The recommended procedure for determining the total scour depth at bridge foundations is as follows:

- Estimate the long-term channel profile aggradation or degradation over the service life of the bridge;

- Estimate the long-term channel plan form changes over the service life of the bridge;

- As a design check, adjust the existing channel and floodplain cross-sections upstream and downstream of bridge as necessary to reflect anticipated changes in the channel profile and plan form;

- Determine the combination of existing or likely future conditions and flood events that might be expected to result in the deepest scour for design conditions;

- Determine water surface profiles for a stream reach that extends both upstream and downstream of the bridge site for the various combinations of conditions and events under consideration;

- Determine the magnitude of contraction scour and local scour at piers and abutments; and

- Evaluate the results of the scour analysis, taking into account the variables in the methods used, the available information on the behavior of the watercourse, and the performance of existing structures during past floods. Also consider present and anticipated future flow patterns in the channel and its floodplain. Visualize the effect of the bridge on these flow patterns and the effect of the flow on the bridge. Modify the bridge design where necessary to satisfy concerns raised by the scour analysis and the evaluation of the channel plan form.

Foundation designs should be based on the total scour depths estimated by the above procedure, taking into account appropriate geotechnical safety factors. Where necessary, bridge modifications may include:

- Relocation or redesign of piers or abutments to avoid areas of deep scour or overlapping scour holes from adjacent foundation elements,
- Addition of guide banks, dikes, or other river training works to provide for smoother flow transitions or to control lateral movement of the channel,
- Enlargement of the waterway area, or
- Relocation of the crossing to avoid an undesirable location.

Foundations should be designed to withstand the conditions of scour for the design flood and the check flood. In general, this will result in deep foundations. The design of the foundations of existing bridges that are being rehabilitated should consider underpinning if scour indicates the need. Riprap and other scour countermeasures may be appropriate if underpinning is not cost effective.

The stability of abutments in areas of turbulent flow shall be thoroughly investigated. Exposed embankment slopes should be protected with appropriate scour countermeasures.

Available technology has not developed sufficiently to provide reliable scour estimates for some conditions, such as bridge abutments located in areas of turbulence due to converging or diverging flows.

2.6.4.5 Roadway Approaches to Bridge

The design of the bridge shall be coordinated with the design of the roadway approaches to the bridge on the floodplain so that the entire flood flow pattern is developed and analyzed as a single, interrelated entity. Where roadway approaches on the floodplain obstruct overbank flow, the highway segment within the floodplain limits shall be designed to minimize flood hazards.

Where diversion of flow to another watershed occurs as a result of backwater and obstruction of flood flows, an evaluation of the design shall be carried out to ensure compliance with legal requirements in regard to flood hazards in the other watershed.

C2.6.4.5

Highway embankments on floodplains serve to redirect overbank flow, causing it to flow generally parallel to the embankment and return to the main channel at the bridge. For such cases, the highway designs shall include countermeasures where necessary to limit damage to highway fills and bridge abutments. Such countermeasures may include:

- Relief bridges,
- Retarding the velocity of the overbank flow by promoting growth of trees and shrubs on the floodplain and highway embankment within the highway right-of-way or constructing small dikes along the highway embankment,
- Protecting fill slopes subject to erosive velocities by use of riprap or other erosion protection materials on highway fills and spill-through abutments, and
- Use of guide banks where overbank flow is large to protect abutments of main channel and relief bridges from turbulence and resulting scour.

Although overtopping may result in failure of the embankment, this consequence is preferred to failure of the bridge. The low point of the overtopping section should not be located immediately adjacent to the bridge, because its failure at this location could cause damage to the bridge