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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 55060438 Date 10-10-12 Initials RFT Region (A B (C) D)

Site ________ Location 1.8 mi S Hwy 12 on 455 Ave

Q_{100} = 1000 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 1000 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 37 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 37 ____ ____ ____

Avg. flow depth at bridge, y_2 iteration = 7.4 ____ ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 36.86 ft* $q_2 = Q_2/W_2$ = 27.1 ft²/s

Bridge Vel, V_2 = 3.7 ft/s Final $y_2 = q_2/V_2$ = 7.4 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 7.6 ft

** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

moved approach upstream to get out of ditch

Water Surface Elev. = dry ft

Low Steel Elev. = 9.0 ft

n (Channel) = .033

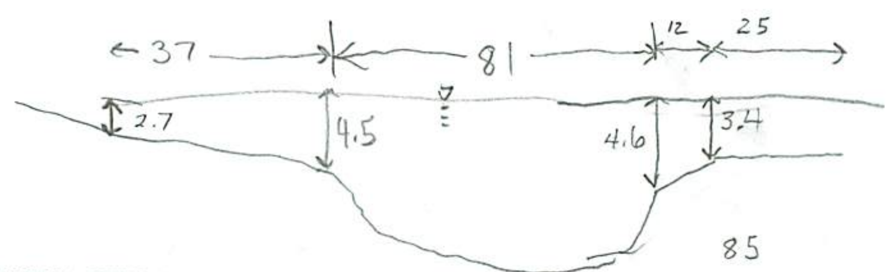
n (LOB) = .030

n (ROB) = .030

Pier Width = 1.33 ft

Pier Length = 1.33 ft

\# Piers for 100 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 81 ft

Width of left overbank flow at approach, W_{lob} = 37 ft Average left overbank flow depth, y_{lob} = 3.6 ft

Width of right overbank flow at approach, W_{rob} = 37 ft Average right overbank flow depth, y_{rob} = 3.6 ft

~~Live Bed Contraction Scour (use if bed material is small cobbles or finer)~~

~~x = ________ From Figure 9 W_2 (effective) = ________ ft y_{cs} = ________ ft~~

riprap lines channel through bridge. Assume CWCS

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.6 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 0.85 ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 13.21 ft/s

If $V_1 < V_c$ and D_{50} >= 0.2 ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.01 ft If $D_{50} >= D_{c50}$, χ = 0.0 (circled)

Otherwise, $\chi = 0.122 y_1[q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = ________ From Figure 10, y_{cs} = 0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.24 Using pier width a on Figure 11, ξ = 5.9 Pier scour y_{ps} = 4.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.6 ft right abutment, y_{aRT} = 3.6 ft

Shape coefficient K_1= 1.00 for vertical-wall, (0.82) for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 12.6 and ψ_{RT} = 12.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 18.7 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 55060438 Date ____ Initials ____ Region (A B (C) D)

Site ____ Location 1.8 mi S Hwy 12 on 455 Ave

Q_{500} = 1600 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 1600 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 37 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 37

Avg. flow depth at bridge, y_2 iteration = 9.3

Corrected channel width at bridge Section = W_2 times cos of flow angle = 36.86 ft* $q_2 = Q_2/W_2$ = 43.4 ft²/s

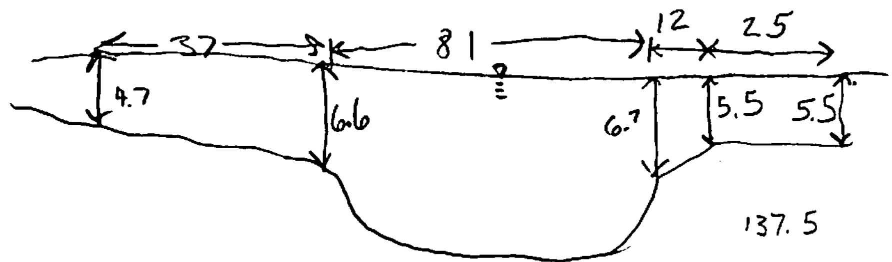
Bridge Vel, V_2 = 4.7 ft/s Final $y_2 = q_2/V_2$ = 9.3 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.7 ft

** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

Water Surface Elev. = dry ft
Low Steel Elev. = 9.0 ft
n (Channel) = .033
n (LOB) = .030
n (ROB) = .030
Pier Width = 1.33 ft
Pier Length = 1.33 ft
Piers for 500 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 81 ft

Width of left overbank flow at approach, W_{lob} = 37 ft Average left overbank flow depth, y_{lob} = 5.65 ft

Width of right overbank flow at approach, W_{rob} = 37 ft Average right overbank flow depth, y_{rob} = 5.69 ft

Live Bed Contraction Scour (use if bed material is small cobbles or finer)

x = ____ From Figure 9 W_2 (effective) = ____ ft y_{cs} = ____ ft

riprap lines channel through bridge Assume CWCS

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.6 ft Average approach velocity, $V_1 = Q_{500}/(y_1 W_1)$ = 1.06 ft/s

Critical approach velocity, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 13.76 ft/s

If $V_1 < V_c$ and D_{50} >= 0.2 ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.017 ft If $D_{50} >= D_{c50}$ ($\chi = 0.0$)

Otherwise, $\chi = 0.122 y_1 [q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = ____ From Figure 10, y_{cs} = 0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 5.9 Pier scour y_{ps} = 4.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.65 ft right abutment, y_{aRT} = 5.69 ft

Shape coefficient K_1= 1.00 for vertical-wall, (0.82) for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 16.2 and ψ_{RT} = 16.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 24.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 24.2 ft

Route 455 Ave Stream Big Sioux River MRM ________ Date ____________ Initials ________

Bridge Structure No. 55060438 Location 1.8 mi S. Hwy 12 on 455 ave

GPS coordinates: N 45° 18.014' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

W 97° 06.171' Datum of coordinates: WGS84 ✓ NAD27_____

Drainage area = 13.14 sq. mi.

The average bottom of the main channel was 13.5 ft below top of guardrail at a point 8.0 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ____drainage area ratio X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 1000			Q_{500} = 1600		
Estimated flow passing through bridge	1000			1600		
Estimated road overflow & overtopping	0			0		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		✓				✓
Chance of Pressure flow		✓		✓		
Armored appearance to channel			✓			✓
Lateral instability of channel		✓			✓	

Riprap at abutments? ✓ Yes ____No ____Marginal Riprap has been placed all throughout bridge

Evidence of past Scour? ✓ Yes ____No ____Don't know past contraction, abutment and pier scour

Debris Potential? ____High ____Med ✓ Low

Does scour countermeasure(s) appear to have been designed?

Riprap ✓ Yes ____No ____Don't know ____NA

Spur Dike ____Yes ____No ____Don't know ✓ NA

Other ________________ ____Yes ____No ____Don't know ✓ NA

Bed Material Classification Based on Median Particle Size (D_{50}) see photos

Material	Silt/Clay____	Sand____	Gravel____	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

* riprap will likely mitigate some of the estimated abutment scour

str. no.
approach from bridge
ROB from bridge
LOB from ditch
bridge from ditch
left abut.
rt. abut.
riprap lining bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	1000	1600
Flow depth at left abutment (yaLT), in feet	3.6	5.65
Flow depth at right abutment (yaRT), in feet	3.6	5.69
Contraction scour depth (ycs), in feet	0	0
Pier scour depth (yps), in feet	4.8	4.8
Left abutment scour depth (yas), in feet	* 18.7	* 24.1
Right abutment scour depth (yas), in feet	* 18.7	* 24.2
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required