OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50222192 Date 9-19-10 Initials RRL Region (A B C D)

Site _____ Location Bahnson Ave in NE Sioux Falls

Q_{100} = 34,500 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 34,500 (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 = 346 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 Effective Skew = 10 °

Width (W_2) iteration = 320 330 329

Avg. flow depth at bridge, y_2 iteration = 14.8 14.5 14.6

Corrected channel width at bridge Section = W_2 times cos of flow angle = 324 ft* $q_2 = Q_2/W_2$ = 106.5 ft^2/s

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 14.6 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.6 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.

Water Surface Elev. = 571 ft

Low Steel Elev. = 25 ft

n (Channel) = 0.03

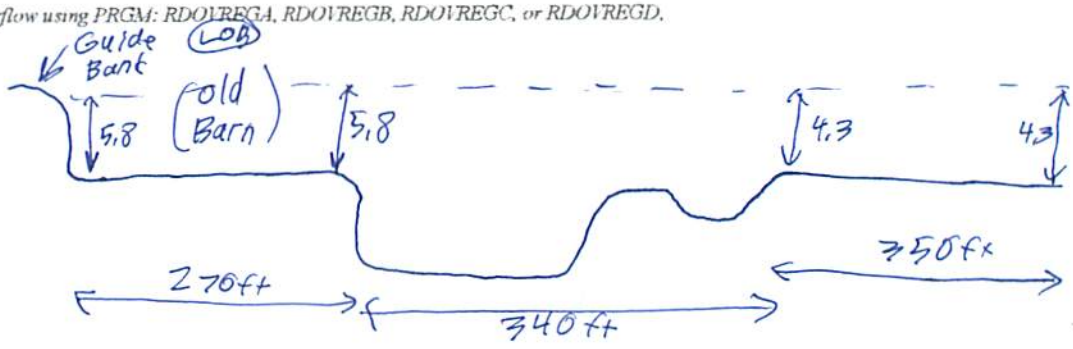
n (LOB) = 0.035

n (ROB) = 0.05

Pier Width = 3.5 ft

Pier Length = 3.5 ft

Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 340 ft

Width of left overbank flow at approach, W_{lob} = 270 ft Average left overbank flow depth, y_{lob} = 5.8 ft

Width of right overbank flow at approach, W_{rob} = 350 ft Average right overbank flow depth, y_{rob} = 4.3 ft

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

x = 4.75 From Figure 9 W_2 (effective) = 313.5 ft y_{cs} = 5.4 ft

PGRM: CWCSNEW

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

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

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ 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} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

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

Froude # at bridge = 0.34 Using pier width a on Figure 11, ξ = 11.9 Pier scour y_{ps} = 10.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.8 ft right abutment, y_{aRT} = 4.3 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} = 16.5 and ψ_{RT} = ~~16.5~~ 13.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~17.8~~ 16.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 13.8 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50222192 Date 9-19-10 Initials RRL Region (A B C D)

Site _____ Location Bahnson Ave. in NE Sioux Falls

Q_{500} = 99,300 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 59,300 (should be Q_{500} 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 = 346 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 Effective Skew = 10 °

Width (W_2) iteration = 335 332

Avg. flow depth at bridge, y_2 iteration = 18.9 19

Corrected channel width at bridge Section = W_2 times cos of flow angle = 326.96 ft* $q_2 = Q_2/W_2$ = 181.4 ft²/s

Bridge Vel, V_2 = 9.6 ft/s Final $y_2 = q_2/V_2$ = 19 ft Δh = 1.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 20.9 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. = 5.7 ft

Low Steel Elev. = 25 ft

n (Channel) = 0.03

n (LOB) = 0.035

n (ROB) = 0.05

Pier Width = 3.5 ft

Pier Length = 3.5 ft

Piers for 500 yr = 3 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 340 ft

Width of left overbank flow at approach, W_{lob} = 270 ft Average left overbank flow depth, y_{lob} = 10.2 ft

Width of right overbank flow at approach, W_{rob} = 350 ft Average right overbank flow depth, y_{rob} = 8.7 ft

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

x = 9.4 From Figure 9 W_2 (effective) = 316.5 ft y_{cs} = 10.3 ft

PGRM: CWCSNEW

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

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

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ 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} = _____ ft

PIER SCOUR CALCULATIONS

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

Froude # at bridge = 0.39 Using pier width a on Figure 11, ξ = 11.9 Pier scour y_{ps} = 10.3 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 10.2 ft right abutment, y_{aRT} = 8.7 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} = 21.5 and ψ_{RT} = ~~21.5~~ 20.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = ~~20.3~~ 21.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20.3 ft

Route Bahnsen Ave Stream Big Sioux River MRM _____ Date 9-19-10 Initials RRL

Bridge Structure No. 502221927 Location Bahnsen Ave. in NE Sioux Falls

GPS coordinates: N43° 34.236' W96° 41.084' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 3782.08 sq. mi.

The average bottom of the main channel was 32.5 ft below top of guardrail at a point 113 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓ drainage area ratio ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 34500			Q_{500} = 59300		
Estimated flow passing through bridge	34500			59300		
Estimated road overflow & overtopping	0			0		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X			X	
Chance of Pressure flow		X			X	
Armored appearance to channel		X			X	
Lateral instability of channel			X			X

Riprap at abutments? X Yes ____No ____Marginal

Evidence of past Scour? ____Yes ____No X Don't know

Debris Potential? ____High X Med ____Low

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

Riprap	X Yes	____No	____Don't know	____NA
Spur Dike	____Yes	X No	____Don't know	____NA
Other _____	____Yes	X No	____Don't know	____NA

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

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

Comments, Diagrams & orientation of digital photos

1 - Bridge Deck
2 - Looking Upstream
3 - Looking Downstream
4 - Left Overbank
5 - Right Overbank
6 - Left Abutment
7 - Piers
8 - Right Abutment
9 - Road near Right Abutment.

Summary of Results

	Q100	Q500
Bridge flow evaluated	34500	59300
Flow depth at left abutment (yaLT), in feet	~~16.5~~ 5.8	~~21.5~~ 10.2
Flow depth at right abutment (yaRT), in feet	~~13.8~~ 4.3	~~20.3~~ 8.7
Contraction scour depth (ycs), in feet	5.4	10.3
Pier scour depth (yps), in feet	10.1	10.3
Left abutment scour depth (yas), in feet	16.5	21.5
Right abutment scour depth (yas), in feet	13.8	20.3
1Flow angle of attack	10	10

See Comments/Diagram for justification where required