OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50214215 Date 6/27/12 Initials DeT Region (A B C D)

Site _____ Location East River Blvd & Big Sioux

Q_{100} = 53300 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 53300 (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

Bridge *Width* = 416 ft. Flow angle at bridge = 55 ° Abut. Skew = 40 ° Effective Skew = 15 °

Width (W_2) iteration = 401.83 372.85 397.80 396.03

Avg. flow depth at bridge, y_2 iteration = 16.2 18.3 17.7 17.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 396.03 ft* $q_2 = Q_2/W_2$ = 134.6 ft²/s

Bridge Vel, V_2 = 8.2 ft/s Final $y_2 = q_2/V_2$ = 16.4 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.7 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,

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

Water Surface Elev. = 01.6 ft

Low Steel Elev. = 21.1 ft 30.1

n (Channel) = 0.050

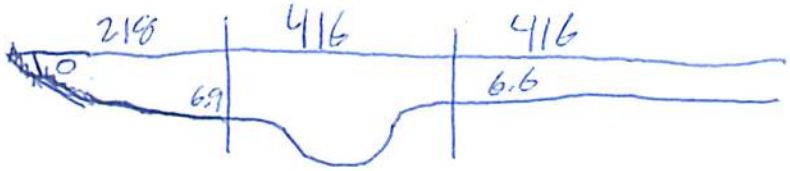
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 3 ft

Pier Length = 27.5 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 416 ft 6.9, 3/3 13.8/3 4.6

Width of left overbank flow at approach, W_{lob} = 216 ft Average left overbank flow depth, y_{lob} = 9.6 ft

Width of right overbank flow at approach, W_{rob} = 416 ft Average right overbank flow depth, y_{rob} = 6.6 ft

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

x = 9.42 From Figure 9 W_2 (effective) = 394 ft y_{cs} = 16.3 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

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

PGRM: Pier

L/a ratio = 9.2 Correction factor for flow angle of attack (from Table 1), K2 = 2.1

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 16.7 Pier scour y_{ps} = 19.3 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.6 ft right abutment, y_{aRT} = 6.6 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} = 14.3 and ψ_{RT} = 17.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50214215 Date 6/27/12 Initials LaT Region (A B C D)

Site _____ Location East River Blvd & Big Stone

Q_{500} = 65000 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 65000 (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

Bridge Width = 416 ft. Flow angle at bridge = 55 ° Abut. Skew = 40 ° Effective Skew = 15 °

Width (W_2) iteration = _____ _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = _____ _____ _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 401.83 ft* $q_2 = Q_2/W_2$ = 211.5 ft²/s

Bridge Vel, V_2 = 10.3 ft/s Final $y_2 = q_2/V_2$ = 20.5 ft Δh = 2.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 22.7 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,

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

Water Surface Elev. = 610 ft

Low Steel Elev. = 21.1 ft

n (Channel) = 0.050

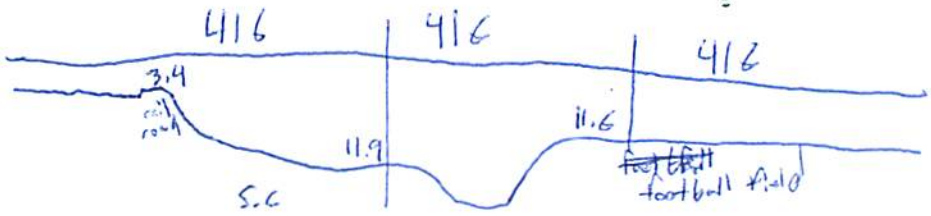
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 3 ft

Pier Length = 27.5 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 416 ft

Width of left overbank flow at approach, W_{lob} = 416 ft Average left overbank flow depth, y_{lob} = 4.5 ft

Width of right overbank flow at approach, W_{rob} = 416 ft Average right overbank flow depth, y_{rob} = 11.6 ft

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

x = 17.43 From Figure 9 W_2 (effective) = 389.8 ft y_{cs} = 16.3 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 9.2 Correction factor for flow angle of attack (from Table 1), K2 = 2.1

Froude # at bridge = 0.4 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 14.6 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 4.5 ft right abutment, y_{aRT} = 11.6 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} = 14.1 and ψ_{RT} = 22.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 22.7 ft

96° 42' 3.24"
43° 32' 11.76"

96.7009
43.5366

Route East River Blvd Stream Big Sioux River MRM _____ Date 6/27/17 Initials DAT

Bridge Structure No. 502142I5 Location East River Blvd & Big Sioux

GPS coordinates: N 43° 32' 11.5" taken from: USL abutment X centerline of ↑ MRM end _____

W 96° 42 8.41" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 3770 sq. mi.

The average bottom of the main channel was 30.1 ft below top of guardrail at a point 163 ft from left abutment.

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

6/13

2	5540
5	13300
10	20400
25	31700
50	41900
100	53300
500	85000

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 53300			Q_{500} = 85000		
Estimated flow passing through bridge	53300			85000		
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? ____Yes ____No X Marginal some pier/contraction

Evidence of past Scour? X Yes ____No ____Don't know

Debris Potential? ____High ____Med X Low

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

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). left OB
2). main channel
3). right OB
4). pier
5). pier scour
6). left abutment
7-8). right abutment
9). left abutment
10). main channel

Summary of Results

	Q100	Q500
Bridge flow evaluated	53300	85000
Flow depth at left abutment (yaLT), in feet	4.6	4.5
Flow depth at right abutment (yaRT), in feet	6.6	11.6
Contraction scour depth (ycs), in feet	10.3	16.3
Pier scour depth (yps), in feet	19.3	19.6
Left abutment scour depth (yas), in feet	~~14.3~~ 14.3	14.1
Right abutment scour depth (yas), in feet	~~17.9~~ 17.9	22.7
1Flow angle of attack	15	15

See Comments/Diagram for justification where required