OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 60190165 Date 7/10/12 Initials RAL Region (A B (C) D)

Site ________ Location East of Okoboji on 291 Ave

~~Q_{100}~~ = Q_{25} 3750 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 3750 (should be Q_{100} 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 = 94 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 92.57 ft* $q_2 = Q_2/W_2$ = 40.5 ft^2/s

Bridge Vel, V_2 = 4.5 ft/s Final $y_2 = q_2/V_2$ = 9 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.4 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,

9.5 +1.7 = 11.2 8.6 −1.5 = 6.9

Water Surface Elev. = 11.1 ft

Low Steel Elev. = 9.5 ft

n (Channel) = ~~0.040~~ 0.035

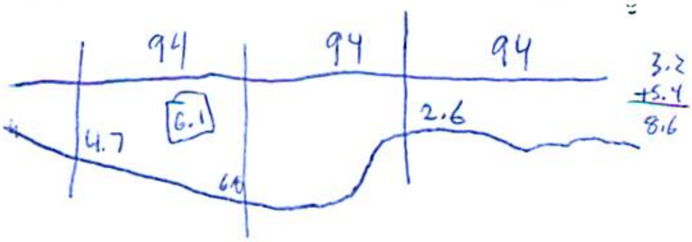
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.3 ft

Pier Length = 2.15 ft

\# Piers for 100 yr = 2 ft



PGRM: Contract

CONTRACTION SCOUR

2.1·⅔ 1.4 6.8−4.7

Width of main channel at approach section W_1 = 94 ft

Width of left overbank flow at approach, W_{lob} = 94 ft Average left overbank flow depth, y_{lob} = 6.1 ft

Width of right overbank flow at approach, W_{rob} = 94 ft Average right overbank flow depth, y_{rob} = 2.6 ft

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

x = 7.72 From Figure 9 W_2 (effective) = 88 ft y_{cs} = 8.6 ft

PGRM: CWCSNEW

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

Note: large amount of cobbles under bridge: consider clear water contraction

Estimated bed material D_{50} = ________ ft Average approach velocity, $V_1 = Q_{100}/(y_1W_1)$ = ________ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = ________ 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, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = ________ From Figure 10, y_{cs} = ________ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 0.935 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.26 Using pier width a on Figure 11, ξ = 8.9 Pier scour y_{ps} = 7.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6.1 ft right abutment, y_{aRT} = 2.6 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} = 17 and ψ_{RT} = 10.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 30.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 60190165 Date 7/10/12 Initials RAT Region (A B (C) D)

Site ______ Location E of Okoboji on 291 Ave

Q_{500} = Q_{50} 5960 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 4196 (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 = 94 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 92.57 ft* $q_2 = Q_2/W_2$ = 45.3 ft^2/s

Bridge Vel, V_2 = 4.8 ft/s Final $y_2 = q_2/V_2$ = 9.5 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10 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. = 0 ft

Low Steel Elev. = 9.5 ft

n (Channel) = 0.035

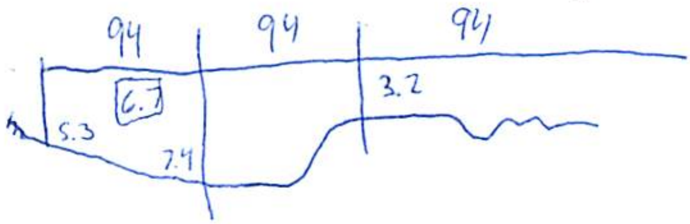
n (LOB) = 0.030

n (ROB) = ~~0.035~~ 0.03

Pier Width = 2.3 ft

Pier Length = 2.15 ft

\# Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 94 ft

Width of left overbank flow at approach, W_{lob} = 94 ft

Width of right overbank flow at approach, W_{rob} = 91 ft

7.4 − 5.3

Average left overbank flow depth, y_{lob} = 6.7 ft

Average right overbank flow depth, y_{rob} = 3.2 ft

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

x = ~~8.65~~ 8.95 From Figure 9 W_2 (effective) = 88 ft y_{cs} = ~~9.6~~ 9.8 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, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = ____ 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 = 0.935 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 = 8.9 Pier scour y_{ps} = 7.3 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.7 ft right abutment, y_{aRT} = 3.2 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} = 18.1 and ψ_{RT} = 11.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 32.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 21.6 ft

Route 291 Ave Stream Okoboja Ck MRM________ Date 7/10/12 Initials LaT

Bridge Structure No. 60190165 Location East of Okobojo on 291 Ave

GPS coordinates: N 44° 39' 24.8" taken from: USL abutment × centerline of ⇑ MRM end ______

W 100° 19' 28.2" Datum of coordinates: WGS84 × NAD27______

Drainage area = 396 sq. mi.

The average bottom of the main channel was 15.3 ft below top of guardrail at a point [illegible] ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = Q_{25} 3750			Q_{500} = Q_{50} 5960		
Estimated flow passing through bridge	3750			4196		
Estimated road overflow & overtopping	0			1764		
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	

7/2

2	160
5	800
10	1730
25	3750
50	5960
100	8870
500	15700

Riprap at abutments? ____Yes ____No X Marginal - moderate amount of cobble stones at abutment/spilling into main channel

Evidence of past Scour? X Yes ____No ____Don't know - minor pier/contraction

Debris Potential? ____High ____Med X Low

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

Riprap ____Yes X 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 X	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
4-5). left abutment
6) pier
7-8). right abutment
9). channel bed
10). main channel

Summary of Results

	Q100 Q_{25}	Q500- Q_{50}
Bridge flow evaluated	3750	4196
Flow depth at left abutment (yaLT), in feet	6.1	6.7
Flow depth at right abutment (yaRT), in feet	2.6	3.2
Contraction scour depth (ycs), in feet	8.6	~~9.6~~ 9.8
Pier scour depth (yps), in feet	7.3	7.3
Left abutment scour depth (yas), in feet	30.4	32.8
Right abutment scour depth (yas), in feet	19.3	21.6
1Flow angle of attack	10	10

- Note: bed channel is about 50% cobbles/50% silt, consider clear water contraction scour, pic 9.

See Comments/Diagram for justification where required