ok RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50210018 Date 9-11-10 Initials KKL Region (A B (C) D)

Site _____ Location in S.E. Dell Rapids

Q_{100} = 32,900 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = ~~22,582~~ 22,583 (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 = 243 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 243

Avg. flow depth at bridge, y_2 iteration = 13.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 239.31 ft* $q_2 = Q_2/W_2$ = 94.4 ft^2/s

Bridge Vel, V_2 = 6.9 ft/s Final $y_2 = q_2/V_2$ = 13.7 ft Δh = 1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.7 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. = 5.4 ft

Low Steel Elev. = 13.7 ft

n (Channel) = 0.028

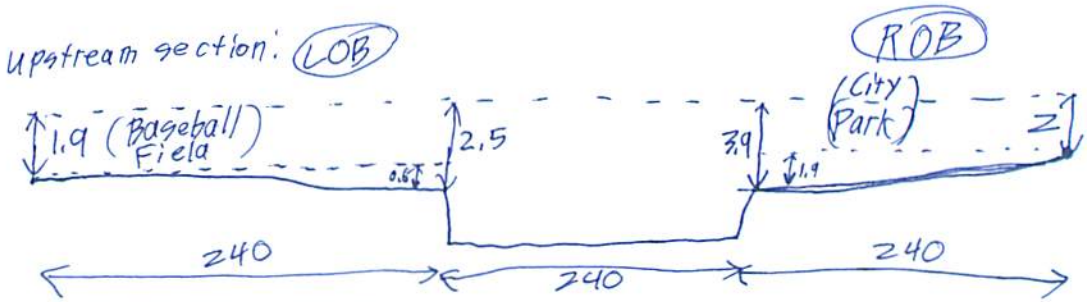
n (LOB) = 0.029

n (ROB) = 0.032

Pier Width = 3.0 ft

Pier Length = 30 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 240 ft

Width of left overbank flow at approach, W_{lob} = 240 ft Average left overbank flow depth, y_{lob} = 2.2 ft

Width of right overbank flow at approach, W_{rob} = 240 ft Average right overbank flow depth, y_{rob} = 2.95 ft

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

x = 2.39 From Figure 9 W_2 (effective) = 227.3 ft y_{cs} = 2.9 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 = 10 Correction factor for flow angle of attack (from Table 1), K2 = 1.8

Froude # at bridge = 0.33 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 16.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 2.2 ft right abutment, y_{aRT} = 2.95 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} = 9 and ψ_{RT} = 11.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50210018 Date 9-11-10 Initials TRL Region (A B C D)

Site _____ Location in S.E. Dell Rapids

Q_{500} = ~~95,000~~ 55,100 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 22,582 (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 = 243 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 243

Avg. flow depth at bridge, y_2 iteration = 13.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 239.3 ft* $q_2 = Q_2/W_2$ = 94.4 ft^2/s

Bridge Vel, V_2 = 6.9 ft/s Final $y_2 = q_2/V_2$ = 13.7 ft Δh = 1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.7 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,

(See 100 yr Diagram)

Water Surface Elev. = 5.4 ft

Low Steel Elev. = 13.7 ft

n (Channel) = 0.028

n (LOB) = 0.029

n (ROB) = 0.032

Pier Width = 3.0 ft

Pier Length = 30 ft

Piers for 500 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 240 ft

Width of left overbank flow at approach, W_{lob} = 240 ft Average left overbank flow depth, y_{lob} = 2.2 ft

Width of right overbank flow at approach, W_{rob} = 240 ft Average right overbank flow depth, y_{rob} = 2.95 ft

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

x = 2.39 From Figure 9 W_2 (effective) = 227.3 ft y_{cs} = 2.9 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 10

Correction factor for flow angle of attack (from Table 1), K2 = 1.8

Froude # at bridge = 0.33

Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 16.3 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 2.2 ft right abutment, y_{aRT} = 2.95 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} = 9 and ψ_{RT} = 11.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17 ft

Route Garfield Ave, Stream Big Sioux River MRM _____ Date 9-11-16 Initials RLL

Bridge Structure No. 50210018 Location in S.E. Dell Rapids

GPS coordinates: N43° 49.239' W96° 42.397' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 3035.45 sq. mi.

The average bottom of the main channel was 20.5 ft below top of guardrail at a point 85 ft from left abutment.

Method used to determine flood flows: ___Freq. Anal. ✓ drainage area ratio ___regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 32,900			Q_{500} = 55,100		
Estimated flow passing through bridge	22,582			22,582		
Estimated road overflow & overtopping	10,318			32,518		
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 X No ___Marginal

Evidence of past Scour? X Yes ___No ___Don't know

Debris Potential? ___High X Med ___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	___No	X 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-Road Surface
2-Bridge From Left Overbank
3-Middle of Bridge
4-Left Abutment
5-Looking Upstream
6-Looking Downstream
7-Right Abutment
8-Left Overbank
9-Right overbank

Comments: City park in right floodplain. Baseball field in left floodplain.

Summary of Results

	Q100	Q500
Bridge flow evaluated	22,582	22,582
Flow depth at left abutment (yaLT), in feet	2.2	2.2
Flow depth at right abutment (yaRT), in feet	2.95	2.95
Contraction scour depth (ycs), in feet	2.9	2.9
Pier scour depth (yps), in feet	16.3	16.3
Left abutment scour depth (yas), in feet	13.5	13.5
Right abutment scour depth (yas), in feet	17	17
1Flow angle of attack	10	10

See Comments/Diagram for justification where required