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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06170056 Date 8/17/10 Initials CW Region (A B C D)

Site 06479800 Location from N edge Bruce, SD - 5 E, 1.5 N on 471 St.

Q_{100} = 8870 by: drainage area ____ flood frequency anal. V regional regression eq. ____

Bridge discharge (Q_2) = 6080 (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 = 75 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 75

Avg. flow depth at bridge, y_2 iteration = 15.5

Corrected channel width at bridge Section = W_2 times cos of flow angle = 73.46 ft* $q_2 = Q_2/W_2$ = 82.3 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 12.8 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.6 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,

$Y_2 = 15.5 > LS = 12.7 \Rightarrow$ RD Overflow Q = 6080

Water Surface Elev. = ____ ft

Low Steel Elev. = 12.7 ft

n (Channel) = 0.033

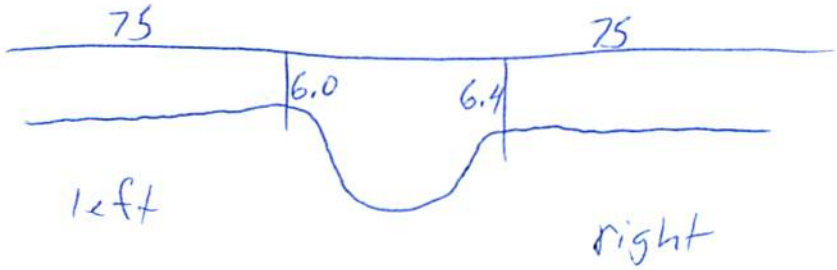
n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 1.7 ft

Pier Length = ~~10~~ 10 ft

Piers for 100 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 120 ft

Width of left overbank flow at approach, W_{lob} = 75 ft Average left overbank flow depth, y_{lob} = 6.0 ft

Width of right overbank flow at approach, W_{rob} = 75 ft Average right overbank flow depth, y_{rob} = 6.4 ft

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

x = 16.22 From Figure 9 W_2 (effective) = 72.2 ft y_{cs} = 15.6 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 5.44 Correction factor for flow angle of attack (from Table 1), K2 = 1.49

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 7 Pier scour y_{ps} = 8.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.0 ft right abutment, y_{aRT} = 6.4 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} = 16.8 and ψ_{RT} = 17.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 25.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 26.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06170056 Date 8/17/10 Initials CW Region (A B C D)

Site 06479300 Location from N edge Bruce, SD - 5E, 1.5N on 471 St.

Q_{500} = ~~25300~~ 22800 by: drainage area____ flood frequency anal. ✓ regional regression eq. ____

Bridge discharge (Q_2) = 6080 (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 = 75 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 75 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 24.8 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 73.86 ft* $q_2 = Q_2/W_2$ = 82.3 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 12.8 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.6 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,

$y_2 = 24.8 > LS = 12.7 \rightarrow$ RD Overflow

Water Surface Elev. = _____ ft

Low Steel Elev. = 12.7 ft

n (Channel) = 0.033

n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 1.7 ft

Pier Length = 10 ft

Piers for 500 yr = 1 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 120 ft

Width of left overbank flow at approach, W_{lob} = 75 ft Average left overbank flow depth, y_{lob} = 6.0 ft

Width of right overbank flow at approach, W_{rob} = 75 ft Average right overbank flow depth, y_{rob} = 6.4 ft

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

x = 16.22 From Figure 9 W_2 (effective) = 72.2 ft y_{cs} = 15.6 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

PGRM: Pier

L/a ratio = 5.44 Correction factor for flow angle of attack (from Table 1), K2 = 1.49

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 7 Pier scour y_{ps} = 8.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.0 ft right abutment, y_{aRT} = ~~6.4~~ 6.4 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} = 16.8 and ψ_{RT} = 17.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 25.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 26.1 ft

Route 471 St. Stream North Deer Creek MRM _____ Date 8/17/10 Initials CW

Bridge Structure No. 06170056 Location 5E, 1.5N from North edge Bruce, SD

GPS coordinates: N 44° 27' 43.9" W 096° 47' 13.8" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 48.03 sq. mi.

The average bottom of the main channel was 14.4 ft below top of guardrail at a point 18 ft from left abutment.

Method used to determine flood flows: ✓ Freq. Anal. ____drainage area adjustment ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 4870			Q_{500} = 22800		
Estimated flow passing through bridge	6080			6080		
Estimated road overflow & overtopping	2790			16,720		
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? ____Yes ____No X Don't know Possible abutment scour but under water → hard to tell

Debris Potential? ____High ____Med X Low

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

Riprap ____Yes ____No ____Don't know X NA

Spur Dike ____Yes ____No ____Don't know X NA

Other _____ ____Yes ____No ____Don't know X 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

1121- Bridge #

22- US

23 - US RB

24- US LB

25- US face of bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	6080	6080
Flow depth at left abutment (yaLT), in feet	6.0	6.0
Flow depth at right abutment (yaRT), in feet	6.4	6.4
Contraction scour depth (ycs), in feet	15.6	15.6
Pier scour depth (yps), in feet	8.8	8.8
Left abutment scour depth (yas), in feet	25.1	25.1
Right abutment scour depth (yas), in feet	26.1	26.1
1Flow angle of attack	10	10

See Comments/Diagram for justification where required