**Equilibrium Local Scour Depth Equations for Single, Simple Structures**

In the clear-water scour range ()



In the live-bed scour range below the live-bed peak velocity ()

,

and in the live-bed scour range above the live bed velocity ()

,

where

,

,

,

.

The effective diameter, D\*, is defined as:

,

where

Ks = shape factor (equations for computing shape factors for common pier shapes are given in Table 3‑1),

Ka = flow skew angle factor, i.e., the projected width of the structure (can be approximated for the shapes in Table 3‑1 by the expression:

,

w = structure width, and



In using the equations in Table 3‑1, note the general constraints given near the top of the table and the more restrictive constraints associated with some of the equations.

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Table 3‑1 Shape factor for common pier shapes.

|  |  |
| --- | --- |
| Structure Shape (Plan View) | Shape Coefficient, Ks |
|  | |
|  |  |
|  |  |
|  |  |

Table 3‑1 Continued

|  |  |
| --- | --- |
| Structure Shape (Plan View) | Shape Coefficient, Ks |
|  | |
|  |  |
|  |  |

LIST OF SYMBOLS

b pile width (diameter)

bcol column width

bm model pile width

bp prototype pile width

bpc pile cap width

d\* dimensionless particle diameter

D\*col effective diameter of the column

 minimum value for the column effective diameter when the base of the column is buried

 maximum value for the column effective diameter

 attenuated effective diameter for the column

 maximum value for the pile cap effective diameter

D\*m effective diameter of the model pier tested

D\*p effective diameter of the prototype pier

D\*pc effective diameter of the pile cap

D\*pg effective diameter of the pile group

D16 sediment size for which 16 percent of bed material is finer

D50 median sediment diameter

D84 sediment size for which 84 percent of bed material is finer

D90 sediment size for which 90 percent of bed material is finer

f weighted average value for the pile cap extension, (3f1+f2)/4

f1 distance between the leading edge of the column and the leading edge of the pile cap

f2 distance between the side edge of the column and the side edge of the pile cap

F1 represents the functional dependence of the scour depth at a simple pier on the ratio of water depth to pier width (y0/D\*)

F2 represents the functional dependence of the scour depth at a simple pier on the ratio of depth averaged velocity to sediment critical velocity (V/Vc)

F3 represents the functional dependence of the scour depth at a simple pier on the ratio of pier width to median sediment diameter (D\*/D50)

Fr Froude number, 

Frc critical Froude number = 

g acceleration of gravity = 32.17 ft/s2

Hcol distance between the bed (adjusted for general scour, aggradation/degradation, and contraction scour) and the bottom of the column

Hpc distance between the bed (adjusted for general scour, aggradation/degradation, contraction scour, and column scour) and the bottom of the pile cap

 distance from the original bed and the sand water interface

Hpg distance between the bed (adjusted for general scour, aggradation/degradation, contraction scour, column scour, and pile cap scour) and the top of the pile group

 distance from the bed to the top of the pile group after adjusting the bed for the scour caused by the column and pile cap, ys(col+pc)

k bed roughness height

Kbpc buried pile cap attenuation coefficient

Kbpg buried pile group attenuation coefficient

Kcp peak value of normalized clearwater scour depth

Kd sediment-size factor

Kh coefficient that accounts for the height of the pile group above the adjusted bed

KI flow intensity factor

Klp dimensionless scour depth magnitude at the live bed peak scour

Km number of piles in the direction of unskewed flow

Ks shape factor

Ksp pile spacing coefficient

Ks(pile) individual pile group pile shape factor

Ks(pile group) pile group shape factor

K1 factor for shape of pier nose

K2 factor for angle of attack of flow

K flow skew angle coefficient

K factor for the gradation of sediment

L length of pier

lcol column length

Lm model scale length

Lp prototype scale length

lpc pile cap length

q discharge per unit width

RR relative roughness of the bed, 

Rep pier Reynolds number, 

s distance between centerlines of adjacent piles in a pile group

sm distance between centerlines of adjacent piles in line with the flow in a pile group

sn distance between centerlines of adjacent piles perpendicular to the flow in a pile group

sg ratio of sediment density to the density of water 

t time

te reference time

t90 time to reach 90% of equilibrium scour depth

T pile cap thickness

Tr dimensionless parameter in van Rijn’s bed form equations

V mean depth averaged velocity

Vc critical depth averaged velocity

Vlp depth averaged velocity at the live bed peak scour depth

V0 depth averaged velocity upstream of the pier

Wp projected width of the piles in the pile group

Wpi projected width of a single unobstructed pile

y1(max) limiting water depth for which the column scour is impacted

y2(max) limiting water depth for which the pile cap scour is impacted

 limiting water depth for which the pile group scour is impacted

ys equilibrium scour depth

ys m model equilibrium scour depth

ys p prototype equilibrium scour depth

ys(col) scour due to the column in a complex pier

ys(col)(max) maximum column scour depth

ys(pc) scour due to the pile cap in a complex pier

ys(pc)(max) maximum pile cap scour depth

ys(pg) scour due to the pile group in a complex pier

yo water depth adjusted for general scour, aggradation/degradation, and contraction scour

 water depth adjusted for general scour, aggradation/degradation, contraction scour and scour caused by the column and pile cap, ys(col+pc)

yst time dependent scour depth

 flow skew angle in degrees

 dynamic viscosity of water

 kinematic viscosity of water

 mass density of water

s mass density of sediment mineral (example: s for quartz sand = 165 lb/ft3)

 measure of the sediment gradation = 

 stream bed shear stress

c critical stream bed shear stress

u upstream bed shear stress

0 maximum bed shear stress in local scour hole

 factor for pier shape

≡ symbol for “identically equal to” (or “defined as”)