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Local scour: A Review for Hydraulic Engineers

Ayush Vashisth[1*], Bhawana Arora[2#]
[1]Dept. of Civil Engineering, GLA University Mathura, U.P. India.
*e-mail: er.ayushvashisth@yahoo.co.in
[2]Dept. of Civil Engineering, HCTM Technical Campus, Kathail, Haryana India.
[#]e-mail: arora.bhawana@yahoo.com

ABSTRACT: Over the past 100 years numerious studies have been conducted and équations were developed to predict bridge-pier scour. Most of these equation were developed using laboratory data and sometimes tested using limited field data. Untill recently , there have been very limited data to test the equations for existing problems and so there is considérable uncertainity in the use of these equations to predict scour in field settings.The purpose of this study is to develop the collectively review for an hydraulic engineers. The limitations of each of the equations will be examined for the purpose of providing guidance of hydraulic engineers concerned with scour at bridge piers.

Keywords - *River, scour, hydraulic, river bed, sediment*

Introduction:

The subject of local scour at bridge piers has attracted great deal of research interest for more than 100 years and there are hundreds of publications on local scour at piers. A majority of these deal with laboratory scale model studies of local scour. In the last thirty years, several comprehensive literature of local scour at pier foundations have been published. Despite of several studies on local scour below hydraulic structure have been made, the results appear still inconclusive, especially in regards to live bed morphology. The physic of local Scour is a challenging phenomenon requiring an initial analysis assessment of the problem and its solution. This assessment should be directed towards providing insight into and understanding of significant physical characteristics and processes. All influences on the bridge crossing need to be considered in this assessment, that is, runoff from the watershed to the stream (hydrology), sediment delivery to the channel (watershed erosion), sediment transport capacity of the stream (hydraulics), and response of the stream to these factors (geomorphology and river mechanics). Recent literature reviews are given by different investigator reported earlier. Here, scour physic were also studies in which the hydraulic jets were caused by flows over weirs are considered.

Comparative scour analysis equations:

The process of local scour is essentially time dependent. Equilibrium between the erosive capability of the flow and the resistance to motion of bed materials is progressively attained by erosion of the flow boundary and weakening of the erosion capacity. Subsequent quantitative engineering analyses utilizing basic relations for hydrologic, hydraulic and geomorphologic processes can then build on this understanding. Depending on scour depth prediction concerns at a particular field site, numerical or mathematical model studies may be required provide additional information. Scouring phenomenon of river bed can be influence by natural phenomena as well as by human imposed structures like bridge piers and abutments. The obstruction to the flow caused by the bridge piers is primarily responsible for the scour process. For example, the depth of scour at a pier is strongly dependent on the width of the pier as the width factor strongly obstructs the flow. In fine-grained materials (sands and gravels), the equilibrium depth of local scour d_{se} is rapidly goes to equilibrium state in live-bed conditions, but nearly the same equilibrium scour depth results rather more slowly in clear-water scour conditions. Although, Live-bed conditions occur at very high velocities in which the flow is often laden with bed sediments which tend to fill up the hole but the scouring process comes in to play to clear hole and the scour hole fluctuates with time. At very low velocities there is no such type of action of filling up of the scour hole by the bed sediment and clearing by the flow condition and the conditions are so called clear-water scour conditions. So therefore, a comparative empirical formula is given in a tabular form for future research for hydraulic engineers.

Table No. 1

Investigator	**Empirical formulae**
Laursen (1958)	$\frac{B}{D} = 5.5\frac{d_s}{D}\left[\left(\frac{d_s}{11.5D}+1\right)^{1.7} - 1\right]$ (1)
Laursen (1963)	$\frac{B}{D} = 5.5\frac{d_s}{D}\left[\frac{\left(\frac{d_s}{11.5D}+1\right)^{7/6}}{\left(\frac{\tau_1}{\tau_c}\right)^{0.5}} - 1\right]$ (2)
Larras (1963)	$d_s = 1.05 K_s K_\theta B^{0.75}$ (3)
Neill(1964)	$d_s = 1.35 B^{0.7} D^{0.3}$ (4)
Breusers (1965)	$d_s = 1.4B$ (5)
Blench (1969)	$\frac{d_s + D}{D_r} = 1.8\left(\frac{B}{D_r}\right)^{0.25}$ (6)
Shen et al. (1969)	$d_s = 0.000223\left(\frac{UB}{\nu}\right)^{0.619}$ (7)

Coleman (1971)	$\frac{U}{\sqrt{2gd_s}} = 0.6\left(\frac{U}{B}\right)^{0.9}$ (8)
Hancu (1971)	$\frac{d_s}{B} = 2.42\left(\frac{2U}{U_c} - 1\right)\left(\frac{U_c^2}{gB}\right)^{1/3}$ (9)
Neill (1973)	$d_s = K_s B$ (10)
Breusers et al. (1977)	$\frac{d_s}{B} = f\left(\frac{U}{U_c}\right)\left[2.0\tanh\left(\frac{D}{B}\right)\right]K_s K_\theta$ (11)
Jain and Fischer (1980)	$\frac{d_s}{B} = 1.86\left(\frac{D}{B}\right)^{0.5}(Fr - Fr_c)^{0.25}$ (12)
Jain (1981)	$\frac{d_s}{B} = 1.84\left(\frac{D}{B}\right)^{0.3} Fr_c^{0.25}$ (13)
Chiew (1984)	$d_s \approx 2BK(B/d_{50})K(D/B)$ (14)
Chitale (1988)	$d_s = 2.5B$ (15)
Melville And Sutherland (1988)	$\frac{d_s}{B} = K_I K_{DB} K_d K_s K_\theta$ (16)
Froehelich (1988)	$\left(\frac{d_s}{B}\right) = \left(\frac{D}{B}\right)^{0.62}\left(\frac{V}{(gD)^{0.5}}\right)^{0.2}\left(\frac{B}{d_{50}}\right)^{0.08}$ (17)
Breusers and Raudhivi (1991)	$\frac{d_s}{B} = 2.3K_{DB} K_d K_s K_\sigma K_\theta$ (18)
Kothyari *et al* (1992b)	$\frac{d_s}{D} = 0.88\left(\frac{B}{d_{50}}\right)^{0.67}\left(\frac{D}{d_{50}}\right)^{-0.60}\left(\frac{B^{'} - B}{B^{'}}\right)^{-0.30}$ (19)
Gao et al.(1993)	$d_s = 0.46K_\varsigma B^{0.60} D^{0.15} d^{-0.07}\left[\frac{U - U^{'}_c}{U_c - U^{'}_c}\right]^\eta$ (20) $U_c = \left(\frac{D}{d_{50}}\right)^{0.14}\left[17.6\left(\frac{\rho_s - \rho}{\rho}\right)d_{50}\right. + 6.05\times10^{-7}\left.\left(\frac{10 + D}{d^{0.7}}\right)\right]^{0.5}$ $U^{'}_c = 0.645\left(\frac{d}{B}\right)^{0.053} V_c$

	where d_s, B, D, d, V, V_c, V_c' are in S.I. units.
Ansari and Qadar (1994)	$d_s = 0.86 b_P^{3.0}$ $\quad b_P < 2.2$ m $d_s = 3.60 b_P^{0.4}$ $\quad b_P > 2.2$ m (21)
Richardson and Devis (1995)	$\frac{d_s}{B} = 2K_s K_\theta K_3 K_4 \left(\frac{D}{B}\right)^{0.35} Fr^{0.43}$ (22)
Melville (1997)	$d_s = K_{DB} K_I K_d K_s K_\theta$ (23)
Dey (1999)	$\frac{d_s}{B} = 0.393\left(\frac{D}{B}\right)^{0.15} \times \left\{21.28\left[\frac{\tau_0/\tau_{cr}}{1+1.02\,\mathrm{sgn}(T_u)^{0.67}\left(\frac{D_e}{d_{50}}\right)^{0.53} T_u}\right]^{1.754} - 1\right\}^{0.5}$ (24)
Oliveto and Hager (2002)	$\frac{d_s}{L_R} = 0.068 N \sigma^{-1/2} F_d^{\;1.5} \log(T)$ $\quad F_d \rangle F_{di}$ (25)
Rahman and Haque (2003)	$\frac{d_s}{B} = \left[0.47 M^{1/3}\left(1+4.5\frac{B}{D}\right)^{1/3} - 1\right] \times \left(\frac{D}{B}\right)$ $\quad where\ M = \frac{\psi B u_{*c}}{1.76 d_{50}^{\;0.5} D^2}$ (26)
Sheppard et al (2004)	$\frac{d_s}{B^*} = 2.5 f_1\left(\frac{D}{B^*}\right) f_2\left(\frac{U}{U_c}\right) f_3\left(\frac{B^*}{d_{50}}\right)$ (27)

CONCLUSION

The result of this study point will give the need for additional research on the scour physic for the different cases. The most commonly cited formulae used for calculation of local scour at pier sites were selected for engineers to validate both experimental and predicted data. Some of the selected formulae appear to be over predicted the scour depth especially when compared with field data observation study. Though a large number of studies have been carried out on local scour at different piers and abutments, and all the experimental and theoretical investigations bring us nearer to better understanding of the problem, it remains unexplored in many cases. In model studies, internal flow characteristics do not truly represent prototype bridge abutment scouring in rivers in view of large-scale distortion of the models. Also, from the available literature, it is revealed that the exact scour mechanism and effects of different parameters on scour depth are yet to be fully understood or explored. However, most of these experimental studies are restricted to specific sediments. As natural riverbed sediments are not a uniform and at the upper reaches of hilly rivers, armouring of beds occurs due to natural sorting of bed sediments by the high velocity flow.

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