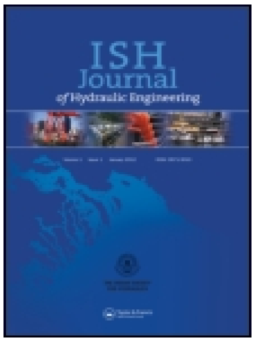

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DISCUSSION

"Temporal variation of scour around circular bridge piers" by U.C. Kothyari and Ashish Kumar, *ISH Journal of Hydraulic Engineering*, 16(Suppl 1), 2010

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The authors are congratulated for developing a new mathematical model and algorithm for computation of local scour in cylindrical bridge piers. It may be pointed out that local scour is only a part of total scour depth composed of (1) general scour, (2) constriction scour, and (3) local scour. Indian codes outline steps for finding total scour depth based on Lacey's regime equation (1930). Other popular mathematical models, for example, Melville and Coleman (2000), HEC-18 (after Richardson and Davis 2001), IAHR (1991), Kothyari–Garde–Ranga Raju (1992a, 1992b) and many other such mathematical equations can be used for finding equilibrium local scour depth d_{se}, which give a conservative value of scour depth around bridge piers. In a paper by the first discusser (Mazumder and Kumar 2006), the total scour depth under equilibrium condition was computed for five major bridges in India by different mathematical models and compared with those by the IRC method based on Lacey's model followed in our country. It was observed that the IRC method overestimates scour depth and the error was found to vary from 2.5% to 275%. The error would have further increased if comparison could be made between measured and computed depths. Unfortunately, there is hardly any reliable measured scour data and governing flow parameters available at bridge sites in our country for validation of mathematical models (Mazumder 2007). The error found between observed and computed scour depths (by HEC-18) under identical conditions in bridges on river Maine in USA is shown in the US Geological Survey report 024229 (USGS 2002).

The new approach of authors for determining local scour depth (d_{st}) through evolution of scour with time appears to be quite promising for prediction of scour. The variation of non-dimensional scour (d_s/d_e) with non-dimensional time (t/t_e), where d_e and t_e are the equilibrium scour depth and the corresponding time to attain it under clear water condition is shown in Melville and Coleman (2000, p. 188, Figure 6.1). It is seen that the scour depth varies significantly with the approach velocity (V) in relation to the critical velocity (V_c) at the threshold condition. Similar variations in scour depth with time occur with shallowness of flow (y/D) and coarseness of sediments (D/d_{50}). In fine-grained materials like sands and gravels, the final or equilibrium scour depth d_{se} is rapidly attained under live bed conditions compared to that under clear conditions as shown in Melville and Coleman (2000, p. 188, Figure 6.1, and p. 214, Figure 6.23).

Time required (t_e) to attain local equilibrium scour depth (d_{se}) with a different approach flow velocity under clear water and live bed conditions is shown by the dotted line in Melville and Colman (2000, p. 214, Figure 6.23). Equilibrium scour depth under live bed conditions is found to fluctuate because of migration of bed forms under live bed conditions. Computation of scour under live bed conditions is a more challenging problem compared to clear water scour.

The title of the paper does not clearly specify that the scour computation procedure developed by the authors is valid for local scour under clear water conditions only. Discussers used the algorithm for finding equilibrium scour depth for a bridge pier in river Kanhan in M.P. Figure 1 illustrates the variation of scour depth with time with input data given by the side of Figure 1. Under the condition $u_{*t}/u_{*c} = 0.5$, the equilibrium scour depth d_{se} is observed as 195 m, which is absurd. The first discusser contacted the first author, who informed that the model is valid under clear water condition only. It will be very useful for the designers if the authors can extend the new methodology of scour computation for live bed conditions since the equilibrium scour depth under design floods in bridges in fine-grained soils mostly occur under live bed conditions.

The discussers felt tempted to find how the new methodology works under clear water conditions in the same bridge on river Kanhan. Corresponding to the mean size of bed material $d_{50} = 1.5$ mm, depth of flow (at $u_* = u_{*c} = 0.033$ for $d_{50} = 1.5$ mm taken from Shields curve) is found as $y = 0.138$ m and the corresponding mean velocity of flow $U = 0.34$ m/sec at a critical state resulting in a discharge intensity $q = 0.047$ cumec/m, which is

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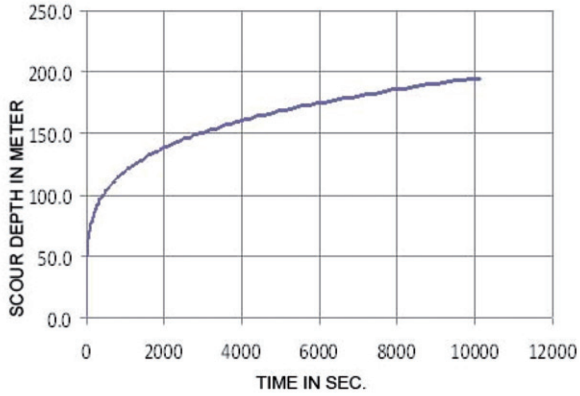
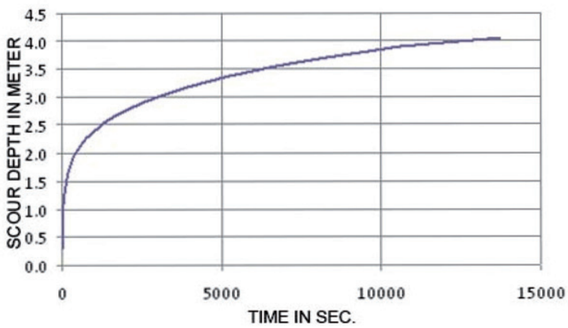


Note:-

Input Data for Kanhan River Bridge :-

b = 2m, h = 6.02 m, S = 0.0008, B = 20 m, $t_{for(l-1)}$ = 0 sec, γ_{fl} = 1000 kg/m^3, g = 9.8 ms^{-2}, d_{st} = 0 at t = 0, ϕ = 30°, d_{50} = 0.0015 m, $\Delta\gamma_s$ = 1600 kg/m^3, τ_u 4.816 kg/m^2.

Figure 1. Temporal Variation of Scour Depth d_{st} with time t in Kanhan River Bridge in Madhya Pradesh with Live Bed.



Note:-

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b = 2 m, h = 0.138 m, S = 0.0008, B = 20 m, $t_{for(l-1)}$ = 0 sec, γ_{fl} = 1000 kg/m^3, g = 9.8 ms^{-2}, d_{st} = 0 at t = 0, ϕ = 30°, d_{50} = 0.0015 m, $\Delta\gamma_s$ = 1600 kg/m^3, τ_u 4.816 kg/m^2.

Figure 2. Temporal Variation of Scour Depth d_{st} with Time t in Kanhan River Bridge in Madhya Pradesh under Clear Water Condition.

insignificant when compared with the design flood discharge $q_d = 55$ cumec/m in river Kanhan. At the design flood intensity $u_* = 0.217$ and $u_*/u_{*c} = 6.575$, which indicates live bed conditions at design flood. The temporal variation scour depth at $u_*/u_{*c} = 0.5$ as found from the algorithm given by the authors is illustrated in Figure 2, which appears to be again absurd because the equilibrium scour depth (4.05 m) appears to be too high compared to the value of 6.8 mm only by IRC method.

Input data for Kanhan River Bridge

The discussers will be grateful if the authors kindly clarify the discrepancies as pointed above so that the new approach for local scour computations can be used in prototype structures where the scour takes place mostly under live bed conditions during the passage of design flood. They also wish to bring to the notice of authors some additional points as mentioned below for further improvement in future.

(1) The title of the paper should have been modified as 'Temporal Variation of Local Scour Around Circular Bridge Piers Under Clear Water Flow Condition'
(2) Although the abstract of the paper mentions about 'scour depth around prototype circular bridge during the passage of flood hydrograph', the tests are performed under steady-state flow only, as stated in Table 1.

(3) The algorithm developed does not consider (a) varying flow intensity, (b) flow shallowness, and (c) sediment coarseness, which have significant effects on time scale and equilibrium scour depth. This discrepancy may be one of the reasons why in many cases the test results are found to be different from computed values, as seen in Figure 3(A), (B), and (C).
(4) The models are run for 7 hours only whereas the t_e values are found to be much higher in many cases.
(5) In computing u_{*c}, due consideration should be given to the slope of scoured surface for stability.
(6) Flow through scoured surface will be separating, resulting in production of high levels of turbulence in the separating shear layer and winnowing of bed materials in the scoured zone. Unless the model considers parameters like Reynolds number etc., there is a likelihood of error in prediction of scour depth under prototype flow conditions.
(7) Since $g' = 1.6\,g$, the term *reduced gravitational acceleration* may be replaced by *reduced gravitational force*.
(8) The authors have verified the model with scour data observed in laboratory flume only. For making use of the model for design purpose, the model should be calibrated with prototype scour data.
(9) Scour data observed in a single pile, as in the present case, implies that there is no mutual interference in scour from adjoining piers or in other words for large spacing of piers only.
(10) Because there is no mention of bed slope of the channel anywhere, the flow at the test section was non-uniform. Authors have not given the surface flow profile under which the tests were conducted.
(11) There is no figure giving the typical scour profile under teh equilibrium condition.
(12) In Figure 3(A), (B) and (C), the authors could have made the scour depth d_{st} and time t non-dimensional by replacing d_s with d_s/d_{se} and t by t/t_e.

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