Discussion on the paper "Prediction of Scour Septh Around Bridge Piers using M5 Model Trees" by Arun Goel, Published in CBIP 'Water and Energy International', Vol. 61, RNI No. 4, July 2018

Names of Discusser :

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The paper discusses the use of M5 Model Trees for estimation of local scour in bridge piers by use of flume data of Kothyari, Garde & Ranga Raju (1992).Author uses correlation co-eff. and RMSE techniques to prove the superiority of M5 tree modelover otherempirical formulae used for scour estimation.

Total scour in bridgepiers is the sum of general scour, contraction scour, and local scour. Author's model is applicable for local scour only. Recent mathematical Models e.g. Dey (2005-06), Melville and Coleman (2000), HEC-18 (Richardson and Davis,1995) , Kothyari –Garde-RangaRaju (1992), IAHR (Brussers et.al 1977) discuss methodology for computing all the three components of scour- both under clear water and live bed conditions. HEC-18 model has been validated by field data. All these models predict scour both for clear water and live bed conditions. Author compares his model with those of Laursen &Toch, Ettema, Shen, Haunch,USDot, Bruessers most of which are quite old and do not distinguish between live bed and clear water scour. In case of non-uniform sediments, there is armoring effect which reduces scour considerably as in the case of gravelly and bouldery beds. Effect of bed forms e.g. dunes and antidunes are also considered in the models by Richardson and Davis and other recently developed mathematical models mentioned above.

Models based on Model Tree and ANN are, indeed, data-driven models and are widely used for problems related to prediction and forecasting. However, the user must use them with caution as they are so called "Black-Box" models and all the pre-processing exercises, which are the basic requirements of setting up such models must be carried out.

In this paper, the author has utilized the 73 datasets referring to a case study (Ref.14). It is expected that the data intervals or the frequency of observations are mentioned in the paper. Also, the paper should at least feature the information, such as description of the experiment which has been referred or any model study that has been described in the referred paper. It seems that the author wants the readers to read two papers; the current one and the referred one.

The author has selected two statistical measures for the performance evaluation of the various models in terms of results and they are:

(i) correlation co-efficient, and

(ii) RMSE

Now, it is not understandable that how could correlation co-efficient be a measure to check the accuracy of the results of models; a poorly matched result could also exhibit a higher correlation co-efficient. On the other hand, RMSE is a correct measure to check the presence of errors.

The author has set up the M5 Model Tree models as given in Table 1 in the functional form:

$$ds = f (U, Uc,D, \ldots)$$

However, it is quite surprising that the author is silent on whether the parameters in the functions are qualified to be taken as input parameters for model (M5) development. Neither any correlation chart displaying the correlation between (ds) and the considered input parameters has been displayed nor does the paper give any information anywhere. It seems that these models have been selected randomly rather than investing efforts to check whether it is right to do so. As mentioned earlier, for error estimates, the correlation co-efficients have been tabulated in Table 1 and Table 2; which are least significant to examine a predicted result. It seems that the author has paid more (not recommendable) attention to the results rather than correctly conceptualizing the problem and deriving a correct function for the M5 model development.

While comparing the inferences from M5 models with the results of other empirical methods, it must be examined whether the M5 models are specific to the case study or they do contain the spatially observed data. As most of the empirical formulae are based on experiments at various sites, in principle, the spatial nature of the data is already encapsulated in them, thereby fetching wide attentions. Therefore, it is seemingly injudicious to examine the results of a specific case study using Model Tree and then comparing them with that of the empirical methods, when both have varying observational mechanisms. It is rather vital to study the limitations of the empirical methods before setting a hypothesis that they are correct or incorrect. Moreover, the scour depths used by the author and the one given in the empirical methods shall be conforming to the same point of references so that the basic definition of total scour depth is preserved for better understanding. The paper, indeed, represents a half the cup job or an incomplete work.

It is regretted that even though efficient and universal mathematical models are now available, Indian codes e,g. IRC-78(2000), IRC-5(1998) continue to prescribe Lacey's model for bridge scour estimation. IRC recommends that maximum scour depth in a pier is 2R below HFL i.e.R below bed level. Lacey(1930) developed his equation [R=0.475(Q/f)1/3]in canal flow in incoherent fine alluvium with steady discharge The same formula is used to find regime flow depth (R) above river bed also, although river flow is entirely different from canal flow. IRC recommends that the maximum scour depth is R below bed also.

Inglis and co-workers(1949) measured actual scour at the nose of piers in bridges on lower Ganges flood plain and found that on an average the maximum depth of scour at the nose of piers is about 2R below HFL. Sediments in the river beds where scour were measured are very fine. Moreover, all the piers are on well foundations. Regime depth above river bed has nothing to do with scouring below river bed since scouring mechanism is altogether different from regime depth, regime width, regime velocity etc. Whereas, the regime depth above bed may be governed by Q and d50 in fine alluvial soil, maximum scour depth below bed is a function of several other parameters as mentioned by the author and taken care of in all the recently developed mathematical models. Lacey's equation, however, considers only two parameters i.e.Q and d50 for determining maximum scour depth which is irrational.

In a paper(Mazumder and Kumar,2005), it wasshownthat maximum total scour depth in fine soil computed by IRC formula always exceeded those predicted by mathematical models. In a recent paper by the author(Mazumder and Dhiman,2014), first author found that in course soil (gravely /bouldery), IRC method gives local scour as high as 4.32 times more than that found by mathematical models.(see annexure-I: Tables:.1a,1b &1c) and 7.69 times the observed maximum scour. From the analysis of results obtained, first author concluded that, IRC equation based on Lacey's theory may be used for determination of scour only for fine soil with d50<2mm and non-uniformity coefficient (σ=(d84/d16)0.5 less than 1.3. For coarse soil with d50>2mm and σ>1.3, IRC method give excessive scour and it will be wise to predict scour by using mathematical models.

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ANNEXURE – I

Table 1(a) : Different Parameters used for Computing Scour in Bridge Piers on Non-Cohesive Coarse Alluvial Soil

FLOW AND GEOMETRIC DATA OF BRIDGE PIERS IN MISSOURI RIVER BASIN, USA										
Bridge Site	Flow Depth (y_0 in m)	Flow Velocity (V_0 in m/s)	Pier Geometry			Sieve size of Bed Material in mm				
			Width (b in m)	Nose Shape	Obliquity of flow (α)	D_{16}	d_{50}	d_{84}	d_{95}	σ_g= √(d_{84}/
1	2.29	2.29	0.61	Sharp	0°	40.5	102	176	269	2.0
10	0.98	1.72	0.854	sharp	0°	29.9	79.8	149	253	2.2
11	1.44	1.22	0.915	Round	0°	2.58	17.1	44.1	82.9	4.1
16	4.85	1.91	1.0	Sharp	0°	5.91	22.3	57	89.6	3.1
22	2.92	4.5	1.83	Sharp	0°	7.36	22.7	44	59.3	2.4
M&C	9.21	4.34	1.81	Round	0°	7	20	44.1	100	2.5

Table 1(b) : Comparison of Local Scour Depths in Piers on Coarse Soil (Observed and Predicted by Different Methods)

Note : Values in bracket indicate Y_s/R

Bridge Site	Observed Scour Depth (y_s' in m)	Predicated Scour Depth (y_s in m)					
		Lacey(R)	Blench	HEC-18	Melville & Coleman	IAHR	K-G-R
1	0.35 (0.15)	2.29 (1.00)	2.29 (1.00)	0.69 (0.30)	0.57 (0.25)	0.43 (0.19)	0.46 (0.20)
10	0.24 (0.25)	0.98 (1.00)	1.22 (1.24)	0.76 (0.77)	0.99 (1.01)	0.38 (0.39)	0.90 (0.92)
11	0.42 (0.42)	1.44 (1.00)	1.44 (1.00)	0.98 (0.68)	1.27 (0.88)	0.33 (0.23)	1.02 (0.71)
16	0.63 (0.12)	4.85 (1.00)	4.85 (1.00)	1.44 (0.29)	1.70 (0.35)	1.39 (0.28)	1.34 (0.27)
22	0.91 (0.25)	3.69 (1.00)	5.27 (1.43)	2.21 (0.60)	2.19 (0.59)	0.90 (0.21)	1.67 (0.45)
M & C	--	9.21 (1.00)	11.22 (1.22)	5.24 (0.57)	4.34 (0.47)	2.35 (0.25)	4.17 (0.45)

Table 1(c) : Comparison of Local Scour Depths in Piers on Coarse Soil by Different Methods

Bridge Sites →	**1**	**10**	**11**	**16**	**22**	**M&C**
Observed Scour Depths (in m)	0.35	0.24	0.42	0.63	0.91	----
Average Scour ((in m)predicted by Different Math. Models	0.53	0.75	0.90	1.46	1.74	4.02
Lacey's Scour Depth (in m)	2.29	o.98	1.44	4.85	3.69	9.21
Average Scour/Observed Scour	1.51	3.12	2.14	2.31	1.91	----
Lacey's Scour/Observed Scour	6.54	4.08	3.42	7.69	4.05	-----
Lacey's Scour/ predicted Average Scour	4.32	1.30	2.37	3.32	2.12	2.29