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لم ترد بالأصل

Ain Shams University
Faculty of Engineering
Irrigation and Hydraulics Department

3D-MODELING OF SCOUR AROUND BRIDGE SUPPORTS USING COMPUTATIONAL FLUID DYNAMICS

A thesis submitted in partial fulfilment of
the requirements for the degree of

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STATEMENT

This thesis is submitted as a partial fulfilment of Master of Science in Civil Engineering Engineering, Faculty of Engineering, Ain shams University.

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ABSTRACT

Historically, scour under bridge supports is considered one of the main reasons causing bridge failures across flooding routes and rivers. To account for scour in bridge design, empirical and experimental formulas have always been used worldwide to estimate anticipated scour depths in order to be taken into the design. The empirical approach has been preferred on the engineering level due to the difficulty in simulating the 3D hydrodynamic and sediment transport in the vicinity of bridge supports in a numerical and deterministic approach. In this study a simplified numerical model using 3D computational fluid dynamics is developed to estimate scour depths in the vicinity of bridge supports. The model is called SCFDS (Simplified Computational Fluid Dynamics Scour) and is coded using both ANSYS workbench scripting and C++. The general idea of the model is to lower the riverbed in the vicinity of the flow obstruction until the shear stresses in the vicinity of the obstruction is reduced to certain stable target values.

The model is validated through its application to two different cases of pier configurations: a simple cylindrical pier from the literature and a complex pier of a real bridge over the Nile-River. The results of SCFDS model are then compared to the available data related to each pier's case either from literature or from the available commonly used scour calculation approaches. The outcomes of validation show that the developed model can simulate the scour in the vicinity of bridge supports. The developed approach is an attractive approach especially in cases of complex bridge foundations where no trusted empirical formulas are available.

KEYWORDS: Bridge; Scour; Numerical; CFD; Modelling; ANSYS; Fluent; Programming.

LIST OF SYMBOLS

Symbol	Definition
$\boldsymbol{Q}$	Channel discharge (L^3/T).
$\boldsymbol{n}$	Manning coefficient.
$\boldsymbol{y}$	The averaged flow depth (L).
$\boldsymbol{v}$	The averaged flow velocity (L/T).
$\boldsymbol{k_S}$	Nikuradse's roughness Height *(L)*.
$\boldsymbol{\sigma_g}$	Geometric standard deviation of the grain size distribution *(L)*.
$\boldsymbol{d_{50}}$	The median size of sediments in meters *(L)*.
$\boldsymbol{S_{\max\_guess}}$	A guess for the anticipated final maximum scour depth *(L)*.
$\boldsymbol{E_S}$	Specific Energy *(L)*.
$(\boldsymbol{i},\boldsymbol{j})$	Point indices at a structured grid with a specified resolution.
$(\boldsymbol{m})$	Node index at an un-structured grid that is exported from FLUENT software. It starts from 1 to M.
$\boldsymbol{M}$	The maximum number of nodes at an un-structured grid that is exported from FLUENT.
$\boldsymbol{l_{m\to(i.j)}}$	The distance between a point (i,j) and point (L).
$\boldsymbol{t}$	Trial's number.
$\boldsymbol{\tau_{IO}}$	The shear stress just after obstruction exists (before scour occurs) *($ML^{-1}T^{-2}$)*.
$\boldsymbol{\tau_O}$	The obstructed shear stress (after flow obstruction exists) *($ML^{-1}T^{-2}$)*.
$\boldsymbol{\tau_{target-s}}$	The targeted shear stress value at the locations that are expected to be exposed to scouring effect *($ML^{-1}T^{-2}$)*.

$\boldsymbol{\tau_{target-d}}$	The targeted shear stress value at the locations where sediment deposition is expected *($ML^{-1}T^{-2}$).*
$\boldsymbol{\tau_m}$	The computed shear stress (through FLUENT) at node (L).
$\Delta\boldsymbol{\tau_{O(i,j)(t)}}$	The absolute difference between the targeted and the recent shear stresses at the point (i, j) during the trial t *($ML^{-1}T^{-2}$).*
$\Delta\boldsymbol{\tau_{IO_{max}}}$	The absolute difference between the targeted and the recent shear stresses at the location of maximum shear stress during the first trial *($ML^{-1}T^{-2}$).*
$\boldsymbol{RMS_{\Delta\tau\,(t)}}$	The averaged root mean square of $\Delta\tau_O$ along the bed for trial (t) *($ML^{-1}T^{-2}$).*
$\boldsymbol{C}$	Numerical stability parameter.
$\boldsymbol{K}$	Non-linearity exponent that determines the internal shape of scour hole.
$\boldsymbol{S_{i,j}}$	Maximum expected scour value in meters at the node (i, j) *(L).*
$\Delta\boldsymbol{S_{(i,j)(t)}}$	The resulting fraction of the scour depth at the node (i, j) after processing the trial t *(L).*
$\Delta\boldsymbol{S_{(max)(t)}}$	The resulting fraction of the scour depth at the location of maximum shear stress after processing the trial t *(L).*
$\boldsymbol{Z_{(i,j)(t)}}$	The bed level at node (i, j) in trial t *(L).*

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