Ain Shams University
Faculty of Engineering
Irrigation and Hydraulics Department

MODELING FLOW BEHAVIOR OVER BUCKET SPILLWAY USING COMPUTATIONAL FLUID DYNAMICS

A Thesis

Submitted in partial Fulfillment of the Requirement for the Degree of

Doctor of PHILOSOPHY IN CIVIL ENGINEERING

Submitted by

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STATEMENT

This dissertation is submitted to Ain Shams University, Faculty of Engineering for the degree of PhD. in Civil Engineering.

The work included in this thesis was carried out by the author in the department of Irrigation and Hydraulic, Faculty of Engineering, Ain Shams University, from November 2018 to March 2022.

No part of the thesis has been submitted for a degree or a qualification at any other University or Institution.

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيم
الرَّحْمَنُ (١) عَلَّمَ الْقُرْآنَ (٢) خَلَقَ
الإِنْسَانَ (٣) عَلَّمَهُ الْبَيَانَ (٤) الشَّمْسُ وَالْقَمَرُ
بِحُسْبَانٍ (٥) وَالنَّجْمُ وَالشَّجَرُ يَسْجُدَانِ (٦) وَالسَّمَاءَ
رَفَعَهَا وَوَضَعَ الْمِيزَانَ (٧) أَلا تَطْغَوْا فِى الْمِيزَانِ (٨)

صدق الله العظيم

DEDICATION

This work took a period from my life. I wish to dedicate it to whom suffered to educate, prepare, build capacity and help myself to be as I am,

To my beloved mother and beloved father

To my beloved husband

Finally to

My main supervisor

"Who opened for me the path of scientific research with freedom of thought"

ABSTRACT

Spillway associated with flip bucket structure is considered as an effective evacuation tool in dam structural components. Huge destructive flood can be dissipated safely through this structure. Poor geometrical, structural and hydraulic design of this structure may cause serious damage followed by failure in the dam's stability.

The main aim of the study was orientated to introduce practical proposed modifications to avoid the critical damage zones in a real ogee spillway flip bucket structure. Proposed solutions were calibrated and assessed based on the numerical simulation process using computational fluid dynamics (CFD). Optimum modification was classified according to its high ability in dissipating the dangerous flood energy away from the dam's body. Disposed hyper flood was carried to safe qualified location to ensure the downstream stability.

This main aim was preceded by an initial another aim of assessing the most reliable turbulent model in simulating this multiphase flow type. Four different turbulent models were examined such as: standard k-epsilon model (SKE), realizable k-epsilon model, renormalization group model (RNG) and detached eddy simulation model (DES). The multiphase water-air flow process was simulated using volume of fluid (VOF) method. The ANSYS FLUENT software was used in simulation analysis.

Results of each turbulent model were compared with results of physical (or experimental) model. Several physical models were investigated for ogee spillway and flip bucket individually and in other combined case. Multiple

comparing criteria of flow profiles, velocity values, and pressure values were examined. Detached eddy simulation (DES) process achieves the most reliable results for all cases.

Subsequently, DES was used for the main analysis of the damage simulation analysis and its modifications. Several constraint modifications of path curvature and its inclination angle were examined. Successful geometrical adjustment was developed for solving the damage problem.

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