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FACULTY OF ENGINEERING
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**PROTECTION MEASURES FOR SCOUR
AROUND BRIDGE PIERS**

BY

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Thesis

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STATEMENT

This dissertation is submitted to Ain Shams University for the M.Sc. Degree in Civil Engineering, Irrigation and Hydraulics.

The work included in this thesis was carried out by the author, at Ain Shams University, Faculty of Engineering, Irrigation and Hydraulics Department and The Higher Technological Institute, 10th of Ramadan City, from November 1997 to January 2001.

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

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DEDICATION

It is a great pleasure to dedicate my
M.Sc. Thesis
To the most four persons I love in my life;

My father, my mother,

My wife, and my child

To all of them my deepest gratitude

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ABSTRACT

The study presented deals with the problems caused by the scouring process around the bridge piers in alluvial channels. It is motivated by the need to decrease the scour depth around the bridge piers. An experimental study has been conducted to investigate the local scour depth at the bridge pier nose. Five different groups of protective piles at different pile-pier spacing upstream the pier were utilized. The pier has a rectangular shape with cylindrical ends and the piles are circular in cross section. The bed material is uniform fine sand of ($D_{50}=0.355$ mm), ($D_{84}=0.64$ mm). Froude number upstream the bridge site ranges from 0.155 to 0.212.

The experimental work included 90 runs conducted at the Higher Technological Institute (HTI), 10th of Ramadan City. The scour depth was measured under clear water scour condition. The aim of this study is to decrease the scour depth around bridge piers to safe guard the bridge foundation.

The experimental results showed that using a group of piles is more effective than using one pile in front of the pier. The arrangement, which gives the maximum reduction in scour depth, is when the piles are arranged in two rows such that the projected width of the piles group is larger than the pier width. The pile-pier spacing, which gives the minimum scour depth equals to two to three times the pier width.

The use of the described group decreases the scour depth from 30% to 95% depending upon the flow conditions.

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LIST OF SYMBOLS

b	Pier width for rectangular piers or pier diameter for circular piers
b_p	Projected pier width
B	Spacing between piers (span)
d	Pile diameter
D_{50}	Mean diameter of sediment
D_{50a}	Mean sediment size of the coarsest armor layer
D_{84}	Particle size for which 84% are finer
d_i	Scour depth at any time
d_s	Maximum scour depth
d_{se}	Equilibrium scour depth
F_c	Threshold Froude number
F_n	Froude number
F_p	Pier Froude number
g	Gravity acceleration
h	Water depth
K_d	Sediment size factor
K_h	Flow depth adjustment factor
K_i	Flow intensity factor

K_s	Pier shape factor
K_α	Pier alignment factor
K_σ	Sediment gradation factor
L	Pier length
l_1	Spacing between the protective piles in the flow direction
l_2	Spacing between piles perpendicular to the flow direction
N	Number of piles
n	Manning coefficient
Q	Discharge passing
R_n	Reynolds number
R_{ng}	Grain Reynolds number
R_p	Pier Reynolds number
S	Shield's parameter
t	Time
t_{max}	Time for equilibrium scour depth to develop
U_*	Bed shear velocity of approach flow
U_{*c}	Critical shear velocity (threshold condition)
U	Mean velocity of the approach flow
U_a	Mean approach flow velocity at the armor peak $=0.80U_{ca}$
U_c	Critical velocity (threshold velocity)

U_{ca}	Mean approach flow velocity beyond which armoring of channel bed is impossible
X	Distance from the upstream pier nose to the edge of the pile group
Δ	Relative submerged density
ρ	Fluid density
ρ_s	Sediment density
σ_g	Geometric standard deviation of the particle size distribution
τ	The average bed shear stress
τ_c	The critical bed shear stress
ν	Fluid kinematic viscosity

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Scour is a natural phenomenon caused by the erosive action of the flowing water on the bed and the banks of alluvial channels. Bridges are one of the most common waterway structures. Bridge piers in alluvial rivers and streams cause a type of scour called “Local Scour”. Local scour is defined as the abrupt decrease in bed elevation in the vicinity of an obstruction as a consequence of the influence of the obstruction on the flow. Local scour at obstructions such as bridge piers may occur in two cases; when there is a general movement of sediment along a river channel, called live-bed scour and when there is no such general movement, called clear-water scour.

Scour induced bridge failures occur during flood flows. It is very important for the designer to find out a convenient method to prevent or minimize the scour depth to keep the foundation of the bridge piers and abutments in safe conditions. Scour depth depends upon the properties of the flow, the bed material in the stream, and the bridge foundation geometry at the bridge site. The problem is often further complicated by the large variety of the piers shape, alignment, and flow approach. So, it is not surprising that the various existing scour depth formulae give widely different results.

Various studies of the scouring process and the flow structure at the bridge piers have been investigated. Some of these studies were concentrated on the prediction of the scour depth around the bridge piers for different flow condition and bed material, other studies introduced empirical equations estimating the local scour depth for different shapes of bridge