

## Interference of Scouring action between Pier and Abutment: Primary Approach

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### Abstract:

Presented here are the results of a limited experimental program dealing with the problem describing the scour, which is formed around bridge pier neighboring abutment. To achieve this the results shown, generally, that the scour depends on a distance interaction between pier and abutment. A modification factor deals with this distance presented as a multiplicative factor used with an empirical predictive formula of scour depth around bridge pier.

**Key-words : Pier , Scour , Bridge**

### Introduction:

The present work aims to show the effect of pier-abutment on local scour which formed around pier located at a specified location ( i.e neighboring the abutment) . This phenomenon which was not investigated before, where investigators through different approaches invented a variety of equations for estimation of depth and manner of scour around piers only or abutment only .

Many bridges over the world are destroyed or failed during a case of flow situations (Breusers,et al. 1977) some failure were due to a damage in foundation

of last pier neighboring abutment . Accordingly due to necessity of a realistic design investigating the interference manner of local scour is extremely needed .

Analyzing the scour process by using a limited laboratory data to get the empiric coefficient used to improve one of a predictive formula which extracted from previous investigators . It should be noted that this formula deals with a local scour around pier without any interlocking with abutment .

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Test Facilities and Experimental Procedures:

The experiments were performed at the hydraulic laboratory in the university of Technology , Baghdad . The experiments were conducted in closed system , water-recirculating flume that measured 2m long , 0.61m wide , and 0.2m deep . The discharge measured by control panel which contains a pointer moving on calibrated dial to express the flow rate in l/s.

In the present study the maximum discharge used 3.3l/s .

The bottom of the working section is filled with sand at a thickness 8cm and its median diameter is 0.575mm , according to this, the critical shear velocity  $V_c^*$  is 0.01726m/s , which determined using the shield s diagram (Hendersen,1966) .

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The flow depth used is 3cm , so that the approach velocity , V is 0.18033m/s . The clear water scour regime occur for flow velocities up to the threshold velocity for general bed movement ,  $V_c$  , this is called a critical velocity which can be determined from logarithmic velocity profile , its value is ,  $V_c = 0.24416$  m/s . At this situation the experiments were run below the incipient motion velocity for sediment size undertaken , where the flow intensity ,  $V/V_c = 0.739$  .

A total of 7 experiments were performed , two of the test are referred to pier only and abutment only, however , the five experiments are presented to show the effect of spacing between pier and abutment on scour around pier and its pattern . The size and allocation of model used are shown in fig.(1) . The experiments were run for a duration of 6hrs. to achieve an equilibrium scour depth (Maatooq J.S. 1999) .

The distance or spacing between pier and abutment denoted X , is used with five different runs at the same flow conditions , 30cm, 21cm, 16cm, 11cm, 9cm, and 3cm . The run at X=30cm , represent , pier

located at mid point of working section only . When using just the abutment model in experimental run , the distance X considered equal zero . However , the first spacing ,i.e. 30cm , referred that just the pier model were in test .

**Results:**

The extracted experimental data are illustrated in Table(1) . To be in practical approach , it must be emphasized to employ the dimensionless term to express , the spacing ratio between pier and abutment . Because the scour depth were mainly normalized with pier diameter , b accordingly the spacing ratio will be normalized with pier diameter to be in consistent with a predictive equation . However , the distance ratio denoted as , X/b , used as a deterministic value within an empirical equation to give a distance coefficient , used as a multiplicative factor with a selected predictive formula .

Referring to Table(2) , the values of distance ratio X/b and distance coefficient are plotted in fig.(2) , to show the best regression analysis curve with R=0.858 . The scatter around regression line appears uniform and the trend of curve is in consistency with data . The regression provides experimental coefficient that may be useful to modify the following predictive formula (Maatooq,1999) .

$$d_s/b = 0.519 + 2.5(V/V_c - 0.57) y/b \dots\dots\dots (1)$$

The above formula used as recommended by Maatooq(1999), to calculate the equilibrium scour which is formed around bridge pier for clear water with all ranges of flow depth .

If using distance coefficient as a modification factor , Eq.(1) will be in the following form :

$$d_s/b = ( 0.519 + 2.5(V/V_c - 0.57)y/b ) \cdot K_{dis} \dots\dots(2)$$

It should be noted that the  $K_{dis}$  can be taken from fig.(2) or from the following empirical equation :

$$K_{dis} = 1 - 0.013(X/b)^2 + 0.130(X/b) \dots\dots\dots(3)$$

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The above developed formula were examined with  $K_{dis}$  values which extracted from experiments to show the reliability of it for usage as a modification factor to determine the equilibrium scour depth around bridge pier located neighboring abutment .

It can be seen from fig.(3) , the Eq.(3) is overpredicted for more than 70% of the data undertaken , that is refer to the reliability of model Eq.(3) as a modification factor . It should be refer that the present study can be considered as a primary conception to this problem .

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#### **Recommendations:**

The present work is concerned with the local scour which is formed around bridge pier neighboring abutment dealing with this problem . The description of scour as it has been resulting from limited experimental program , shows a dramatic

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#### ***Appendix II : Notation***

- b = width of pier or abutment .  
 $d_s$  = maximum scour depth .  
 $V$  = flow velocity .  
 $V_c$  = critical flow velocity .  
 $V_{c^*}$  = critical shear velocity .  
 $X$  = spacing between pier and abutment .  
 $y$  = flow depth.  
 $K_{dis}$  = distance coefficient .

complexity of the problem . Accordingly , an extended experimental program must be used to arrive to a more reliable deterministic modification coefficient which can be considered as a universal form used to determine the scour depth around pier neighboring abutment . To achieve this the

following recommendations can be suggested for further studies :

- 1- Extending experiments by taking a wide range of flow conditions and distance ratio .
- 2- Taking different size of pier and abutment .
- 3- To improve the results several sizes of bed material must be considered .
- 4- To be in a universal situation it must be taking into consideration a live bed regime , i.e, the intensity of velocity  $V/V_c$  greater than unity .

#### ***Appendix I :References***

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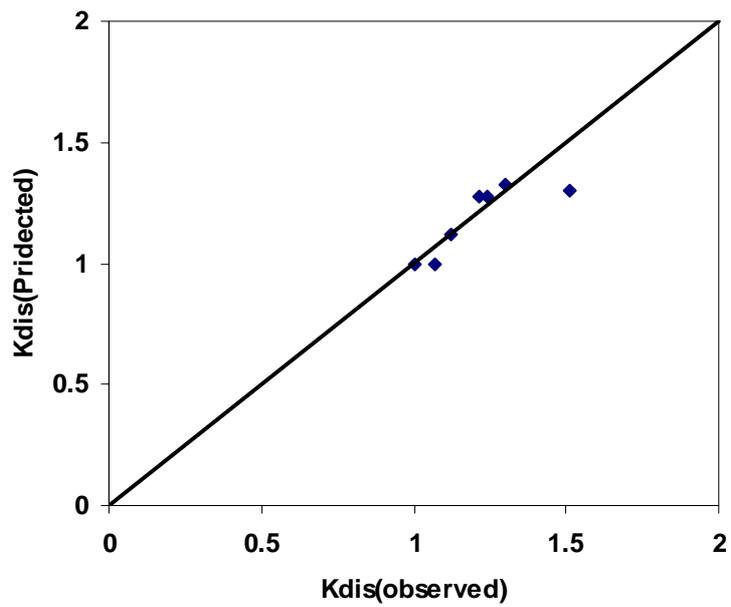
**Table(1):Experimental Results for Max. Scour Around Pier**

Run	X(cm)	ds(cm)	Remarks
1	30	3.3	Pier only in Test
2	21	4.1	
3	16	4.3	
4	11	4.98	
5	9	4.01	
6	3	3.7	
7	0	3.53	Abutment only in Test

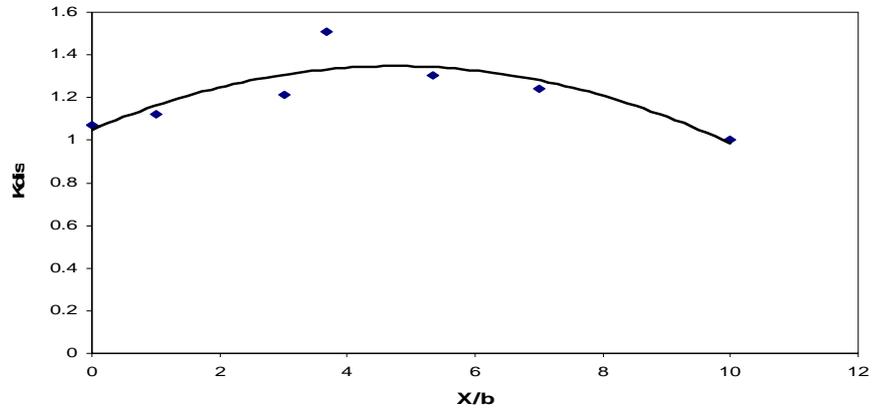
**Table(2):Distance Ratios and Coefficients**

Run	X/b	ds/b	$K_{dis} = \frac{ds/b(\text{from experiments})}{ds/b(\text{for pier only})}$
1	10	1.1	1
2	7	1.367	1.243
3	5.33	1.433	1.303
4	3.67	1.66	1.509
5	3	1.337	1.215
6	1	1.233	1.121
7	0	1.177	1.07





**Fig.3: Comparison Between Predicted and Observed Spacing Coefficient**



**Fig.2: The Fitted Curve for Distance Coefficient**