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

الخلاصة:

تقدم هذه الدراسة نتائج مختبرية محدودة لبيان تداخل حفرة الأنجراف المتشكلة حول الدعامة المجاورة للكتف في الجسور . وقد بين العمل المختبري أن عمق حفرة الأنجراف حول الدعامة المشار اليها يعتمد على المسافة بين تلك الدعامة وكتف الجسر . لقد قدمت الدراسة معامل لابعدي سمي بمعامل المسافة يستخدم كمعامل ضرب في المعادلة المستخدمة لحساب عمق الأنجراف حول دعامات الجسور . ان العمق المحسوب بأستخدام هذا المعامل يشير الى عمق الأنجراف المتشكل حول الدعامة المجاورة للكتف وليس باقي الدعامات المتشكل منها الجسر . أعتبرت نتائج هذه الدراسة كأقتراب أولي من المسألة نتيجة لمحدودية النتائج المختبرية المستحصلة .

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-rercerculating 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 .

Refering 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) .

$d_s/b = 0.519+2.5(V/V_c – 0.57)\ y/b$ ……….. (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 :

$d_s/b=(0.519+2.5(V/V_c – 0.57)y/b) \, . \, K_{dis}$ …..(2)

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

$K_{dis} = 1 – 0.013(X/b)^2 + 0.130(X/b)$ ……….(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 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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Appendix II : Notation

b = width of pier or abutment .
ds = maximum scour depth .
V = flow velocity .
Vc = critical flow velocity .
Vc* = critical shear velocity .
X= spacing between pier and abutment .
y= flow depth.
K_{dis} = distance coefficient .

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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

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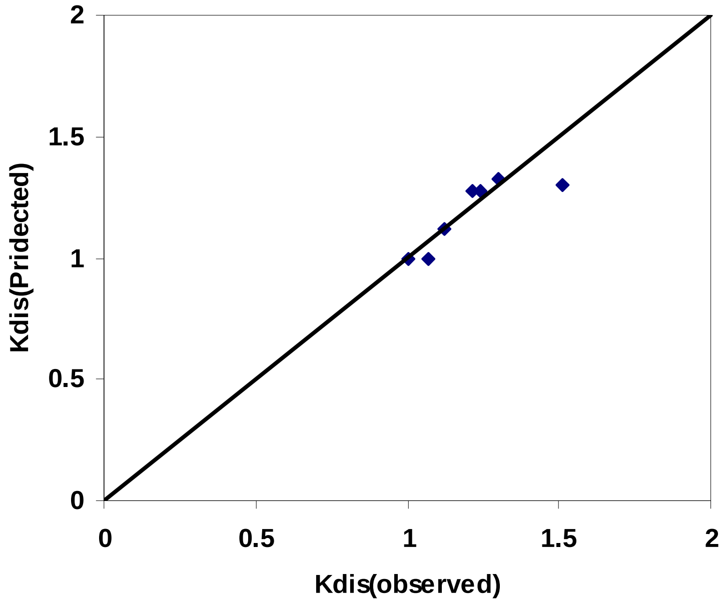

Fig.3:Comparison Between Pridected and Observed Spacing Coefficient

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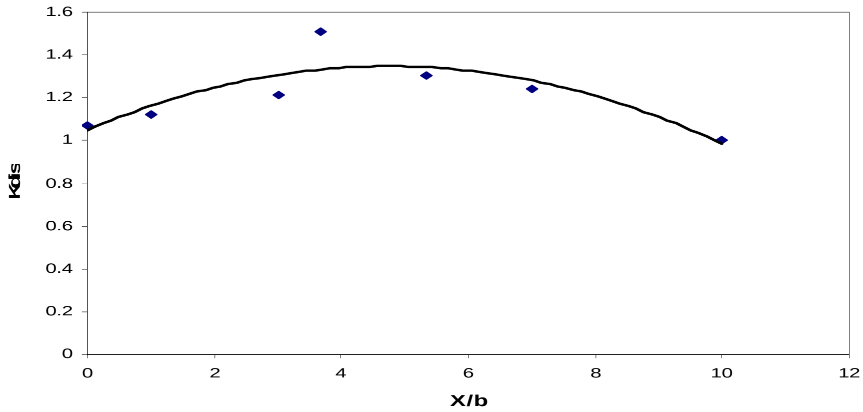

Fig.2:The Fitted Curve for Distance Coefficient

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