IRAQI Academic Scientific Journals
العراقية المجلات الاكاديمية العلمية
Al-Kut University College Journal
ISSN (E) : 2616 - 7808 II ISSN (P) : 2414 - 7419
www.kutcollegejournal.alkutcollege.edu.iq
k.u.c.j.sci@alkutcollege.edu.iq
Special Issue for the Researches of the 5th Int. Sci. Conf. for Creativity for 13-14 December 2023

THE RELATION BETWEEN FROUDE NUMBER AND SCOUR HOLE DIMENSION DOWNSTREAM MULTI GATES

Teba Adnan Naje [1] , Ali Sadeq Abbas [2] , Fadhel Abd Al Abbas Hassan [3]

Abstract

In this study, an experimental investigation of the scour hole dimensions downstream of the multi gates was made. For the model, four iron sluice gates with individual dimensions of 15 cm in width and 25 cm in height were created. where it was investigated how the Froude number affected the size of the scour hole by changing the number of open gates, gate opening, position of the open gate, and discharge. A laboratory channel with a length of 18 m, a width of 1 m, and a depth of 1 m was built by the supervisor using blocks and concrete for the tests. The primary gate that regulates the flow of water into the flume from the main reservoir is 7 meters away from where the laboratory model was built (Hassan, 2015). The many variables causing scour downstream of the gate were described by non-dimensional quantities that were obtained through the application of a dimensional analysis. The experimental test data that was acquired was examined and graphically displayed. Under free flow conditions, it was found that the Froude number significantly affected the scour hole dimension. When only one gate opened and the Froude number and discharge were both at their maximum values, the scour hole depth was at its greatest. The scour hole depth was measured at its lowest point when all open gates were open, the Froude number was at its lowest point, and the discharge was at its lowest point.

Keywords: Multi Gates, Scour Hole, Froude Number, Number of open gates, Experimental Test

Affiliation of Authors

[1, 2] Civil Engineering Department, University of Technology, Baghdad, Iraq,10001

[3] Hydraulic structure and Water Resources Department, University of Kufa, Iraq, Najaf, 54001

[1] tebaadnan1994@gmail.com
[2] 40005@uotechnolgy.edu.iq
[3] fadhil.alshitali@uokufa.edu.iq

[1] Corresponding Author

Paper Info.
Published: June 2024

العلاقة بين رقم فرود وأبعاد حفرة النحر خلف البوابات المتعددة

طيبه عدنان ناجي [1] ، علي صادق عباس [2] ، فاضل عبد العباس حسن [3]

المستخلص

في هذه الدراسة، تم إجراء بحث تجريبي لأبعاد حفرة النحر خلف البوابات المتعددة. تم إنشاء أربع بوابات عمودية حديدية للنموذج بعرض 15 سم وارتفاع 25 سم. حيث تم التحقق من كيفية تأثير رقم فرود على حجم فتحة النحر من خلال تغيير عدد البوابات المفتوحة، وفتحة البوابة، وموقع البوابة المفتوحة، والتصريف. تم إنشاء قناة مختبرية بطول 18 م وعرض 1 م وعمق 1 م من قبل المشرف باستخدام البلوك والخرسانة لإجراء الاختبارات. وتقع البوابة الرئيسية التي تنظم تدفق المياه إلى المسيل من الخزان الرئيسي على بعد 7 متر من بناء النموذج المختبري (حسن، 2015). تم وصف المتغيرات العديدة التي تسبب نحر خلف البوابة بكميات لا بعدية التي تم الحصول عليها من خلال تطبيق تحليل الأبعاد. تم فحص بيانات الاختبار التجريبي التي تم الحصول عليها وعرضها بيانيا. في ظل ظروف التدفق الحر، وجد أن رقم فرود يؤثر بشكل كبير على أبعاد حفرة النحر. عندما تم فتح بوابة واحدة فقط وكان رقم فرود والتفريغ في أقصى قيمهما، كان عمق حفرة التنظيف في أعظمه. تم قياس عمق حفرة النحر عند أدنى نقطة لها عندما كانت جميع البوابات العمودية مفتوحة، وكان رقم فرود في أدنى نقطة له، وكان التصريف في أدنى نقطة له.

الكلمات المفتاحية: البوابات المتعددة، فتحة النحر، Froude Number، عدد البوابات المفتوحة، اختبار تجريبي

انتساب الباحثين

[1، 2] كلية الهندسة، الجامعة التكنولوجية، العراق، بغداد، 10001

[3] كلية الهندسة، جامعة الكوفة، العراق، النجف، 54001

[1] tebaadnan1994@gmail.com
[2] 40005@uotechnolgy.edu.iq
[3] fadhil.alshitali@uokufa.edu.iq

[1] المؤلف المراسل

معلومات البحث
تاريخ النشر: حزيران 2024

Introduction

The majority of heading-up hydraulic regulators that are now in use have many gates, and most

issues that arise downstream from these structures are caused by improper operation. Downstream of the sluice gate, the interaction between the flow and sediment particles may cause the scouring phenomenon and lengthen the scour hole that results beneath the sluice gate foundation. The ability to predict scour depths is crucial for the overall stability of hydraulic infrastructure.

The number of open gates, the depth of the open gate, the discharge, velocity, and the Froude number are all significant factors that affect the scour depth, but the researchers found that the Froude number has the greatest impact, as shown in the following previous studies:

[1]The impacts of significant parameters on equilibrium scour depth are described using experimental results that were derived from the dimensional analysis. The key findings are that, while the scour depth reduces with increasing sediment size and tail water depth, it increases with increasing densimetric Froude numbers. It is determined how long the scour depth will last using an exponential law. With an increase in the densimetric Froude number, the nondimensional time scale falls.

[2] The experimental test revealed that the bottom velocity pattern, gate operation, type of gate (main or emergency), Froude number at the vena contract, and submergence ratio all influence the scour pattern and, consequently, the maximum depth of scour.

[3] Under various densimetric Froude number and input depth circumstances, a number of clear water scour experiments have been carried out in a tilting flume with a circular pier. On the tests, a single 50-mm-diameter pier was placed on a sand bed with a mean particle size of d50 = 0.365 mm. The complete scour geometry, including scour depth, the densiometric Froude number and inflow depth were related to the dimensions of length, width, area, and volume.

[4] Through experimental examination, the impact of various parallel radial gate procedures with various flow conditions on downstream refinement was examined. It was shown that the main influencing elements on the downstream scour are the quantity of opened gates and the optimal operation of the multi-parallel gates. Also The relative scour intensity will rise as the Froude number rises.

[5]By using the numerical solution method Computational Fluid Dynamics (CFD), he simulated the sediment transport and the best operation of the gates of Al-Hay regulator which is constructed on Al-Gharraf River, south of Iraq. He applied a turbulent model to investigate the sedimentation problems with different flow conditions and different options for the opening of the five gates that the regulator consists of, the result show that the maximum scour depth and the quantity of soil removed around the regulator is increased directly with the Froude number.

Experimental Work

A rectangular laboratory flume, built by the supervisor out of concrete and bricks as illustrated in Fig. 1, was used for an experiment. The flume has dimensions of 18 m, 1 m, and 1.1 m. The model of multi gates is positioned 7 meters from the flume's main gate, as shown in Figure (1).

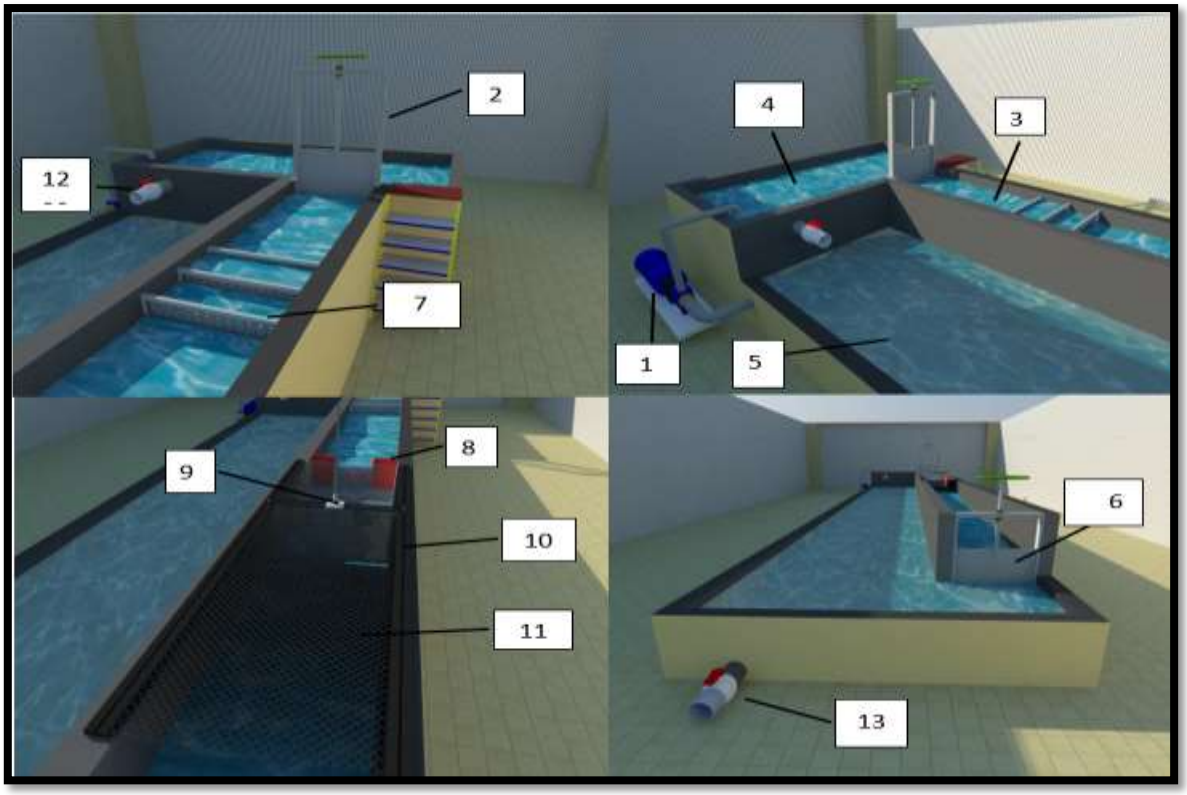


Figure (1): The Flume Parts and Accessories: 1. Main pump, 2. Vertical sluice head gate, 3. The flume, 4. Head basin, 5. Lateral basin, 6. Vertical sluice tail gate, 7. Stilling screens, 8. Iron frame, 9. Gauge point, 10. Rails, 11. BRC mesh, 12. Overflow valve, 13. Exhausting and cleaning valve [6]

To study scouring and develop formulas that characterize the correlations between scour hole size and other hydraulic and geometric characteristics, 150 laboratory tests were conducted.

The model of the multi-gates consists of four vertical gates scaled to the Abu Sakhir regulator, each measuring 25 cm in height and 12.5 cm in breadth with a 7 cm gap between them, as shown in Figure (2).

Figure (2): The Model of Multi Gates that Used in Experimental Tests

Sand was employed in this study as the material for the flume bed, and the sample that was chosen encompassed all sand grades, from coarse to fine, according to USCS categorization [7] The d50 were used for the experimental test equal to 1.5 mm and the sieve analysis in Figure (3).

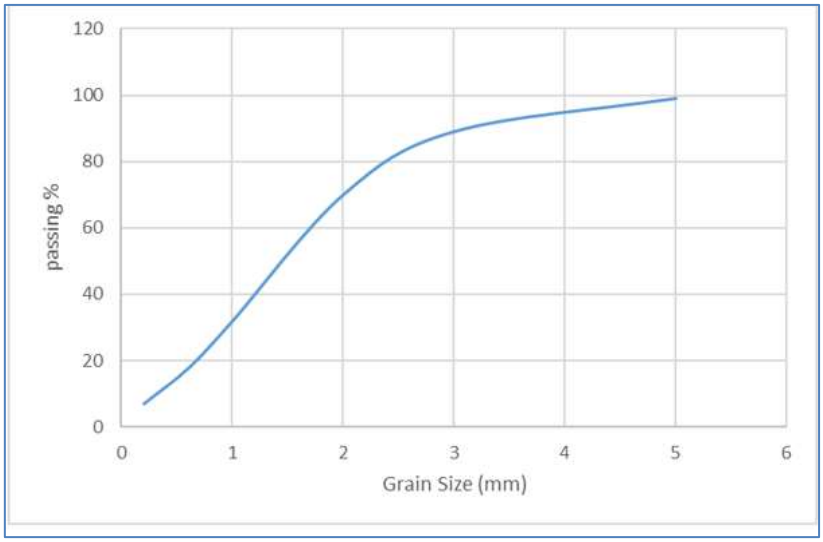


Figure (3): Sieve analysis of Bed Material (d50 = 1.5 mm)

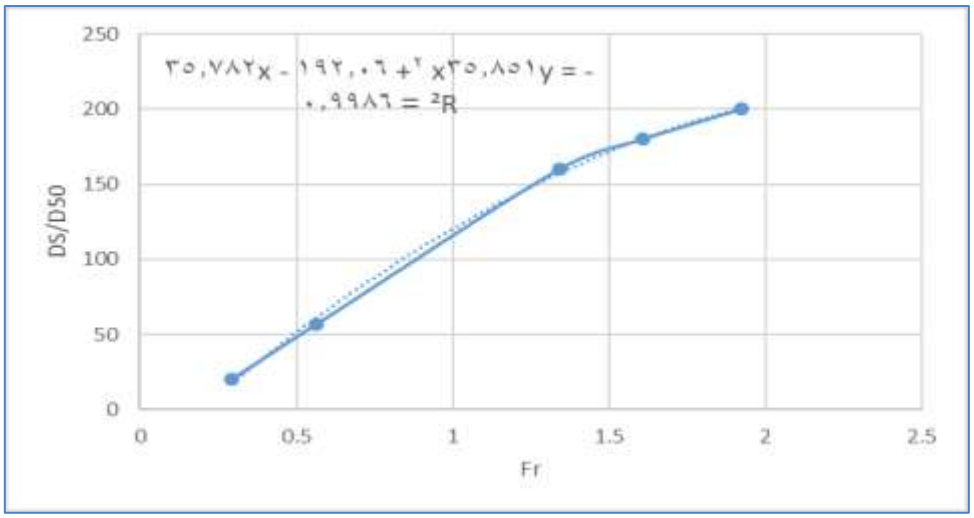
Results and Discussion

This section will demonstrate how the Froude number's value effects on local scour with different numbers of open gates, gate location, discharge, and gate opening, where 5 discharges (37, 31, 26, 11, 6) L/sec were used, and two gate openings 12.5 cm and 25 cm.

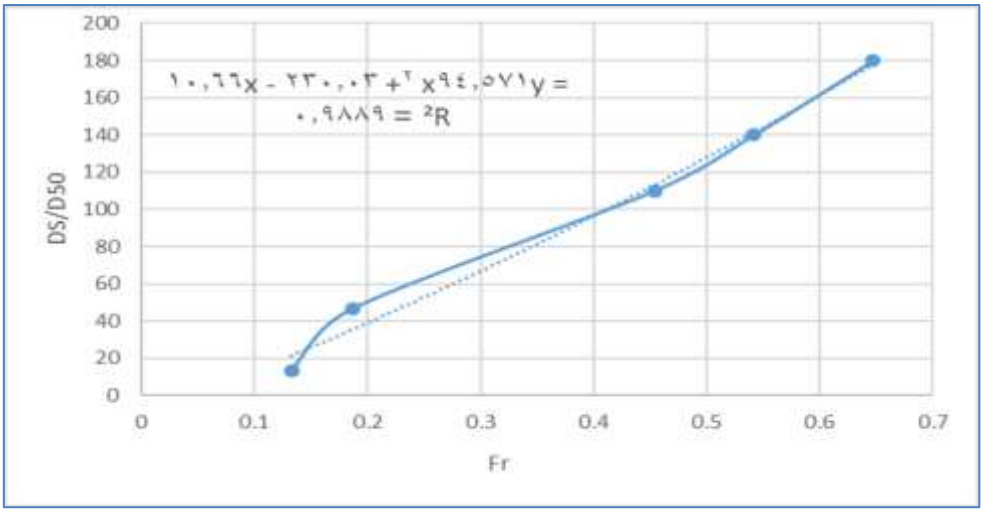
Effect of Froude Number on DS/d_{50} in Case of One Open Gate

Froude number is main hydraulic parameter which effect on the value of local scour and its value increasing with increase in the velocity. In this instance, 40 laboratory experiments were carried out, the gate location, discharge value, and gate opening were changed, and the scour depth was calculated. The highest value of the scour was obtained when the gate located on the edge next to the wall was opened with a gate opening of 12.5 cm and a discharge of 37 liters / second and less in this instance, the middle gate opened to a 25-cm opening with a discharge rate of 6 L/sec. This can be explained by the fact that the Froude number increases whenever the discharge is increased and the gate opening is decreased because their relationship is direct.

The maximum value that recorded of DS/d_{50} was 200 when the Fr equals to 1.92, while the minimum value was 13.3 when the Fr equals to 0.1327 as in the figure (4).



(A)

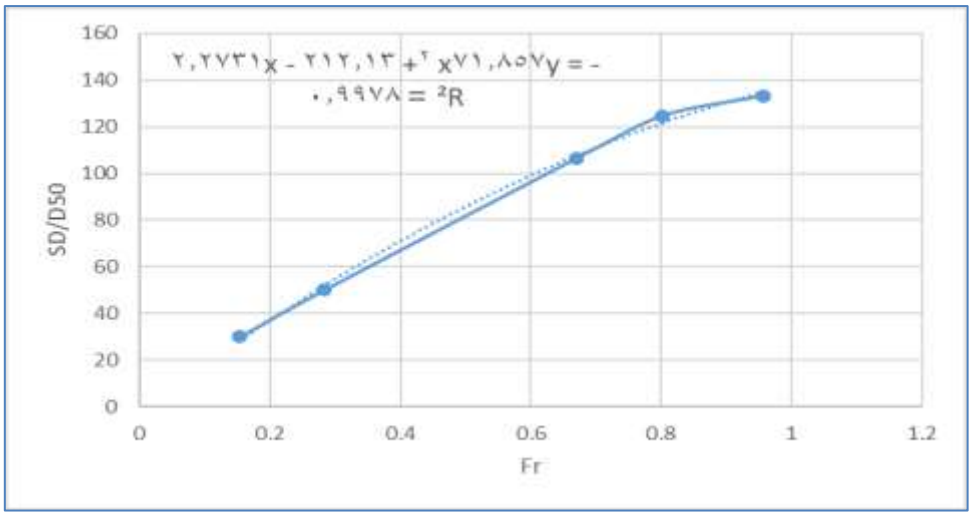


(B)

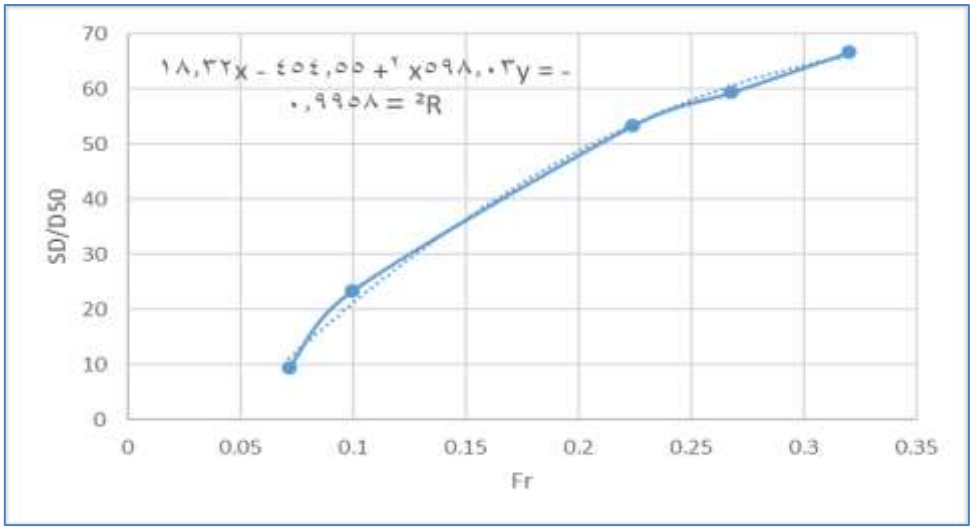
Figure (4): (A) the maximum value was scour depth, (B) minimum value of scour depth.

Effect of Froude Number on DS/d_{50} in Case of Two Open Gates

Six scenarios, totaling 60 experimental tests, were run in this instance when two gates were opened simultaneously, such as the first and second gates, the first and third gates, the first and fourth gates, and so on for the remaining gates. The gate opening, discharge, and gate location were all modified in addition to the gate's new location. According to the results, the first and fourth-side gates were opened at a discharge of 36 L/sec and a 12.5 cm opening to obtain the highest scour depth value (DS/d_{50} = 133.3, Fr = 0.956), and the second and third gates were opened jointly at a discharge of 6 L/sec and a 25 cm opening to obtain the lowest scour depth value (DS/d_{50} = 9.3, Fr = 0.0714), as shown in figure (5).



(A)



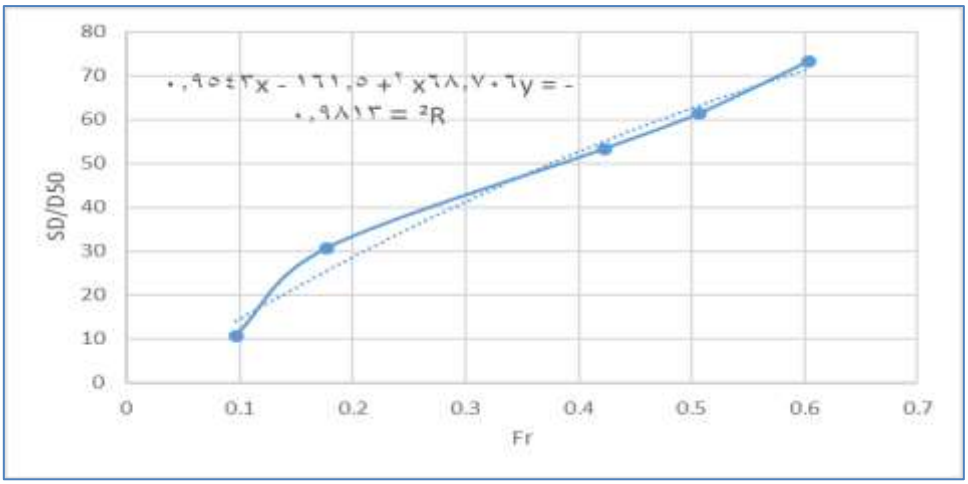
(B)

Figure (5): (A) the maximum value was scour depth, (B) minimum value of scour depth.

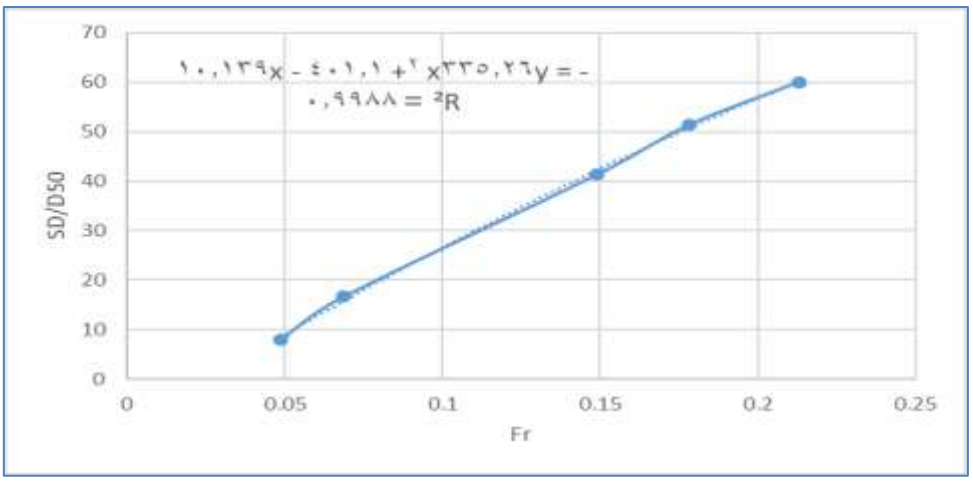
Effect of Froude Number on DS/d_{50} in Case of Three Open Gates

In this instance, there were four different scenarios, and 40 experimental tests were done where one of the multi-gate model's four gates was shut. The scour depth was at its highest value when the second or third gate was closed while the other three gates remained open, and at its lowest when the gates were open. closing the gate that is on the right or left, i.e., gate number 1 or gate number 4, after three consecutive gates.

The results that recorded the maximum value of DS/d_{50} was 73.3, Fr = 0.604 and the minimum value of DS/d_{50} = 8, Fr = 0.0496, as shown in figure (6).



(A)



(B)

Figure (6): (A) the maximum value was scour depth, (B) minimum value of scour depth

Effect of Froude Number on DS/d_{50} in Case of Four Open Gates

The best scenario is thought to be this one. In this case, ten experiments were carried out, four gates were opened with two distinct openings, the lowest scour depth was attained (DS/d_{50} = 5) and the Freud number was at its lowest value (Fr = 0.0486), as shown in figure (7).

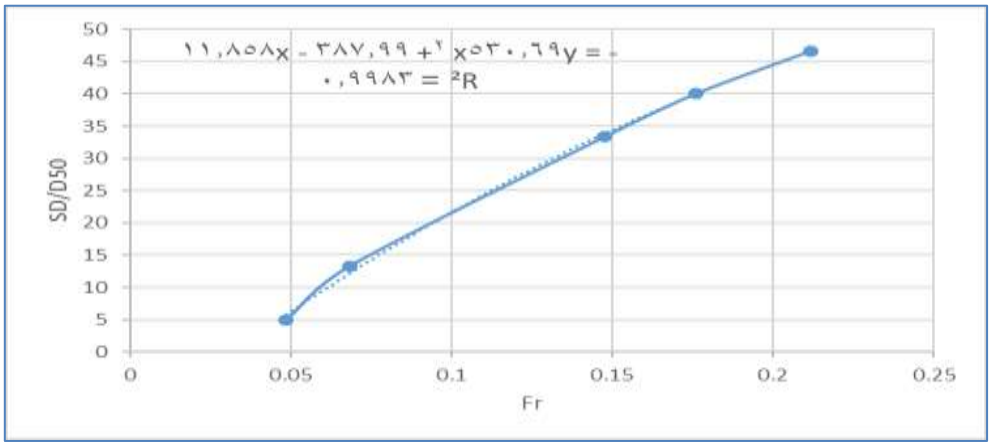


Figure (7): Relationship between DS/d_{50} and Fr in case of open four gates

CONCLUSIONS

1. Laboratory tests have demonstrated that the maximum scour hole values were observed when only one gate was opened, particularly gate number 1 or gate number 4, and the gate opining is 12.5cm. the value of maximum DS/d_{50} was 200 with the maximum value of Q_{act} and Fr.

2. The Froude number is the hydraulic factor that has the most control over the depth of the scour hole, and it always has a positive relationship with the depth of the scour for all experiments.

3. The depth of the scour hole is clearly influenced by the position of the open gate, with the largest depth being recorded when the gate is opened towards the end.

4. The number of open gates and the depth of the scour pit are inversely related. When the four gates were opened, less depth was recorded because the depth decreased with the number of open gates.

5. When the gate's aperture was reduced, the depth of the scour hole increased along with the amount of discharge that could travel through it.

REFERENCES

[1] Dey S, Raikar R V. Scour below a High Vertical Drop. J Hydraul Eng [Internet]. 2007 May;133(5):564–8. Available from: https://ascelibrary.org/doi/10.1061/%28ASCE%2907339429%282007%29133%3A5%28529

[2] Negm AM, Abdel-Aal GM, Elfiky MM, Mohamed YA. Effect of Multi-Gates Regulators Operations on Downstream Scour Pattern under Submerged Flow Conditions. Elev Int Water Technol Conf. 2007;11:753–67.

[3] Khwairakpam P, Ray SS, Das S, Das R, Mazumdar A. Scour hole characteristics around a vertical pier under clearwater scour conditions. ARPN J Eng Appl Sci. 2012;7(6):649–54.

[4] scour Downstreamofsubmerged.pdf.crdownload.

[5] MAJEED HQ, ABED BS, SHAMKHI MS. Cfd simulation for the operation effect of gates openings of al-hay regulator on the local erosion. J Eng Sci Technol. 2021;16(2):1098–109.

[6] Omran HA, Khassaf SI, Hassan FA. the Effect of Flow Conditions and Geometric Parameters on the Scour Value Downstream Composite Structures of Weir and Gate. Kufa J Eng. 2016;7(1):115–28.

[7] Murthy VNS. Geotechnical Engineering-Principles and Practices of Soil Mechanics and Foundation Engineering. Taylor Fr. 2003;6(October):1056.