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Impact of Flow in Pipe and Box Coverages on Open Channel's Performance

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Keywords
Pipe coverage, Box coverage; Open Channel; Blockage ratio; Scour.

Abstract

This experimental study aims to characterize the behaviour of pipe and box coverages concerning their size, form, and upstream blockage ratio. In an artificial trapezoidal cross-section, five experimental cases were carried out: Case 1 involved an artificial canal without coverage or blockage; Cases 2 and 3 concerned pipe coverages with circular cross-sections (Pipe 1 and 2); Cases 4 and 5 involved box coverages with square cross-sections (Box 1 and 2). While the area of pipe 1 and box 1 are equal, the area of pipe 2 and box 2 is the same and greater than the area of pipe 1 and box 1. Three blockage ratios and three water flow rates were used in the experimental study. Each case included an investigation of the hydraulic performance of the open channel and the scouring pattern downstream of the coverage. In comparison to the case when there was no coverage present at the same condition, the presence of coverage in the open channel and the significant increase in flow rate, blocking ratio, and decreasing inlet area of coverage increased the heading up, head losses, scour depth, and scour length. In the same area and condition, the pipe coverage achieves greater scour depth and length than the box coverage. The box coverage is better for the open channels' performance than the pipe coverage. The research recommended using the box coverage rather than the pipe coverage and checking the maintenance processes to avoid the negative effect on the open channels' performance.

1. Introduction

The culvert is an important hydraulic structure that transports water under roads, railroads, and embankments. Several researchers have investigated these issues because the culvert sometimes performs poorly in the open channel to avoid its negative impacts. [1] investigated the relationship between the discharge rate, tailwater depth, pipe diameter, bed material properties, and the scour hole characteristics at culvert outlets. The study revealed that the scour depth at high and low tailwater depths is 25% and 70% of the maximum scour depth, respectively. [2] investigated the

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scour parameters downstream box coverage using flow-3D software. The results were compared to those obtained from a laboratory in Sorouien, and the comparison indicated that the maximum scours depth was higher in all cases whenever the partially blocked condition was present. According to [3], who examined the effects of box culvert blockage on the hydraulic characteristics of open channels, heading up, head loss, and water level coverage upstream rise with an increase in blockage ratio and a decrease in coverage dimension. [4] examined the scour downstream of different culvert types and indicated that the shape of culverts influences the depth of scouring under identical conditions, and the elliptical culverts cause the least amount of scouring. [5] represented an experimental investigation to remove temporal variations in debris blockage upstream of pipe and box culverts in the case of steady flow. The findings from the research indicated that the pipe culvert is more susceptible to blockage than the box-shaped culvert and that the degree of blockage is unaffected by the rate at which large woody debris is delivered into it.

[6] focused on how large-scale urban debris tends to align itself in the direction of flow and collide with culvert headwalls, as well as how the flow drags the debris downstream and tilts it up towards the headwall. [7] studied the scour downstream of tail escape, the result showed that the increase in flow discharge increases the maximum scour depth and length, and the maximum scour length is nine times greater than the maximum scour depth. [8] proposed a sharp edge sill with different shapes, dimensions, positions, and different flow rates, the results indicate that the scour depths are reduced to 60 % by using the sill relative to the case without a sill. [9] studied the impact of the culvert's blockage ratio on the maximum scour depth, the results showed that the scoured area at the blocked culverts was 20–60% greater than in non-blocked conditions. [10] examined in a lab the effects of pipe covering on the hydraulic characteristics of the watercourse. The results show that the blockage ratio is directly related to the heading up in addition to providing empirical formulae describing the relationship between scour and flow characteristics. [11] proposed using a vertical flow deflector in the lab with a rigid bed at different heights and positions to dissipate flow energy, which significantly reduced the scour parameters downstream of the pipe culvert. [12] examined the effects of inclined headwalls in culverts upstream and downstream on canal efficiency and compared the results to culverts without headwalls. The study revealed that, in the case of using the U.S. headwall only, the 15° inclination angle of the headwall in the opposite direction of the flow under the same upstream water depth produces the greatest results in terms of efficiency.

The issue of culvert blockage was investigated by [13]. The study found that culvert blocking is affected by downstream culverts, culvert material, catchment area, and watercourse characteristics, but that culvert size has the greatest effect on the degree of blockage. [14] investigated methods for transitioning supercritical to subcritical flow to reduce culvert scouring downstream. To reduce energy and water velocity downstream of culverts, three baffle models were developed. The baffles model with the largest surface area coverage had the best performance, and it was advised that energy be lowered as the analysis of the result. [15] evaluated the impact of flow obstruction at rectangular culvert inlets on the upstream culvert's water level and downstream culvert's scour using a hydraulic model that was set up in the lab. The study's most important findings are that debris accumulation increases near-wall scouring, presenting a direct threat to the structure's stability, and that the upstream water level increases as the rate of culvert entry blockage increases. This study investigated the coverage’s performance due to its shape, size, and upstream blockage ratio.

2. Methods and Materials

In the hydraulic laboratory, five cases were evaluated at subcritical flow conditions. Thirty-nine runs were conducted in an artificial water canal with a trapezoidal concrete section of 16.22 m in length, 0.6 m in width, 0.44 m in depth, and a 1:1 side slope. case 1 is the canal with a trapezoidal cross-section without coverage, Cases 2 and 3 are circular pipe coverages (pipe 1 and 2) with inner diameters of 10, and 14.5 cm, respectively, and Cases 4 and 5 (box 1 and 2) are square box coverages with a side length of 8.8 and 12.9 cm, respectively. The coverages were installed in the middle of the physical model, where pipe 1 has the same area as case Box 1 and is smaller in area than pipe 2 and Box 2 of the same area. The five cases were applied with three different water flow rates 2, 8, and 11 L/s and three different coverage blockage ratios 0, 10, and 30% which were simulated by attaching a wood bar to the coverage's inlet. A sand basin of dimension 2.00 m in length, 0.60 m wide, and 0.30 m deep was set up directly downstream of the coverage outlet as indicated in photos (1 & 2). The sand basin was filled with bed material that had a D_{50} of 0.50 mm and was subdivided into 10*12 cm mesh as indicated in the figure (1). Two water velocities were measured upstream and downstream of the coverage in each run at distances of 3.5 and 2.50 times the diameter of the pipe or the side length of the box sections, respectively. Water depths and water surface profiles upstream and downstream of the coverage were also monitored along the canal's centerline. The depth and length of the scour were determined once the scour basin was plotted.
The experimental work was performed according to the coverage's presence, shape, inlet dimension, and blockage ratio as indicated in table (1). The data under investigation are from a research study which was carried out by the Channel Maintenance Research Institute.

Photo 1: The pipe coverage

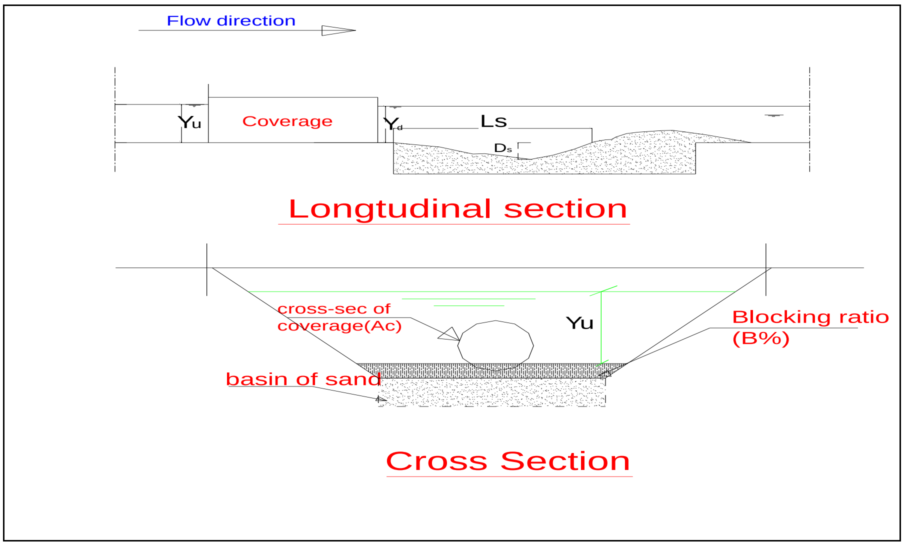
Photo 2: The Box coverage

Table (1) Experimental Tests

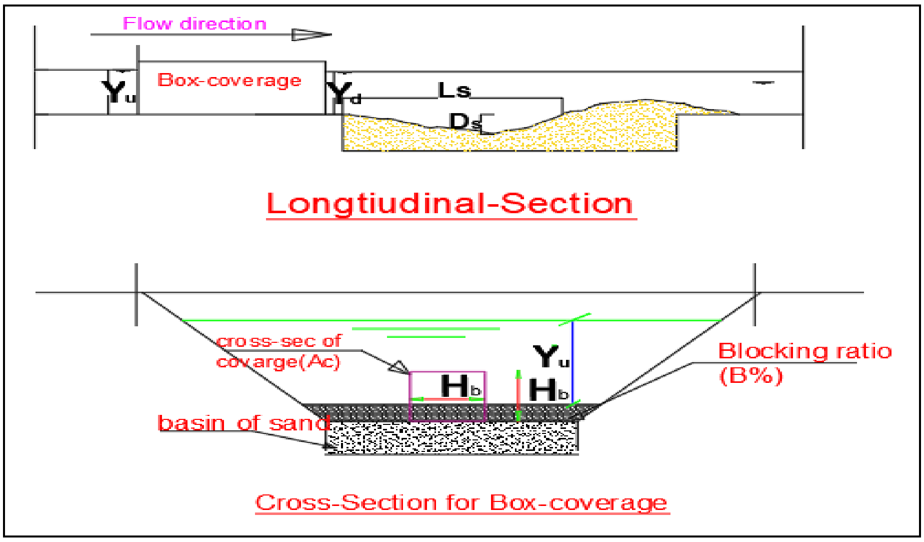
Cases	Coverage shape	Cross–section Dimensions	Flow rate (L/s)	Blocking ratio %	No. of runs
Case (1)	(No Coverage)	(60 cm bed width &1:1 side slope)	2	-	3
			8	-	
			11	-	
Case (2)	Circular section (pipe$_1$)	(D_p = 10 cm)	2	0	9
			8	10	
			11	30	
Case (3)	Circular section (pipe$_2$)	(Dp = 14.50 cm)	2	0	9
			8	10	
			11	30	
Case (4)	Square Box-	(H_b = 8.80 cm)	2	0	9

	section (Box_1)		8	10	
			11	30	
Case (5)	Square Box-section (Box_2)	(H_b =12.90 cm)	2	0	9
			8	10	
			11	30	
Total runs					39

Notice: D_p is the pipes inside diameter, and H_b is the side length of the square box section



a: The flume structure and its scoured soil basin for Pipe Coverage



b: The flume structure and its scoured soil basin for Box Coverage

Figure 1: The flume structure and its scoured soil basin for Pipe and Box Coverage

3. Results and Discussions

The experimental results were provided for each case, and the hydraulic parameters were evaluated concerning various coverage shapes, sizes, flow rates, and blockage ratios upstream coverage.

3.1. The effect of coverage blockage on the water surface level, heading up, and head loss

The results showed that the presence of coverage in the open channel, the increase in flow rate and blocking ratio, and decreasing the inlet area of coverage led to an increase in the water surface level upstream coverage, heading up, and head losses in comparison with the case of not having coverage in the open channel at the same condition. Figures 3 and 4 depict the worst-case scenario for pipe 1 coverage, which had a 30% blockage and 11 L/s flow rate. In this scenario, the heading up of pipe 1 and box 1 was 135 and 125%, respectively, while for pipe 2 and box 2, it was 27 and 24%. Additionally, the head losses for pipe 1 and box 1 were 134 and 130%, while those for pipe 2 and box 2 were 29 and 28%, indicating that the pipe coverage reduces the open channel's hydraulic performance more than the box coverage.

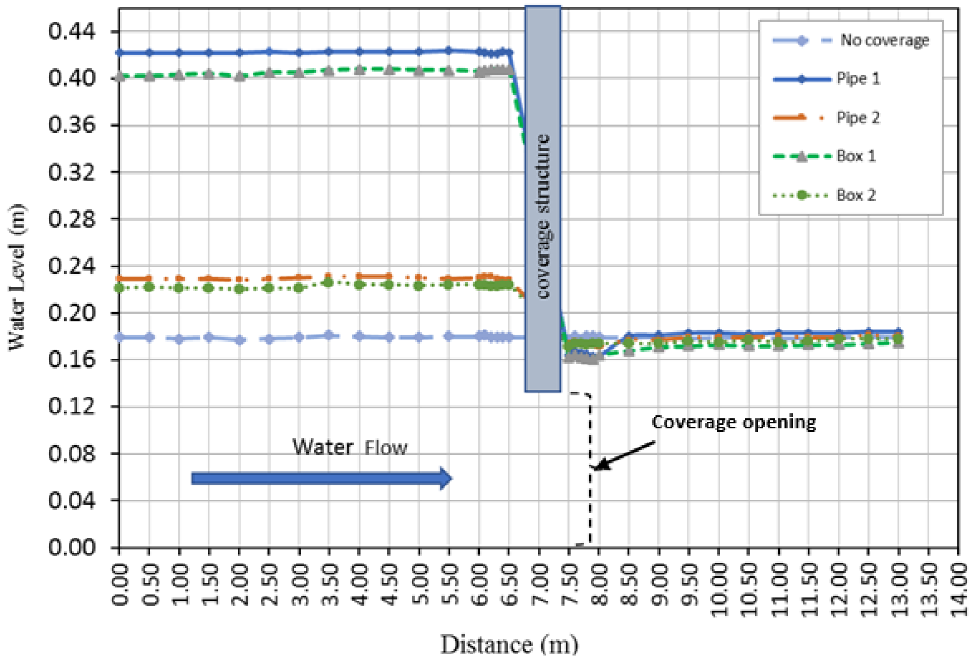


Figure 2: Water surface profile for different coverage shapes at a constant blockage ratio of 30% and water flow rate of 11 L/s.

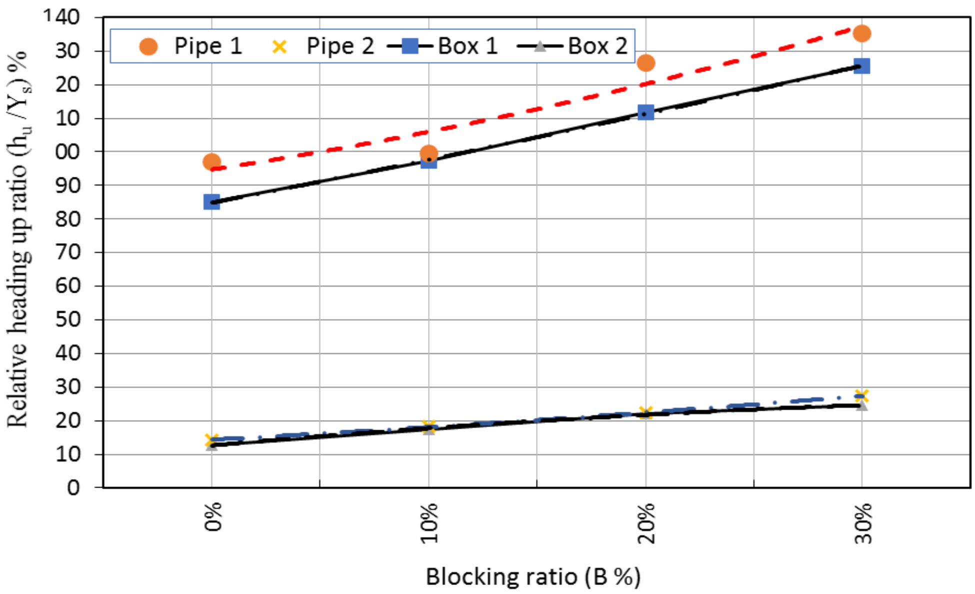


Figure 3: Variation of relative heading up with blocking ratio for pipe 1, pipe 2, box 1, and box 2 at a water

flow rate of 11 L/s.

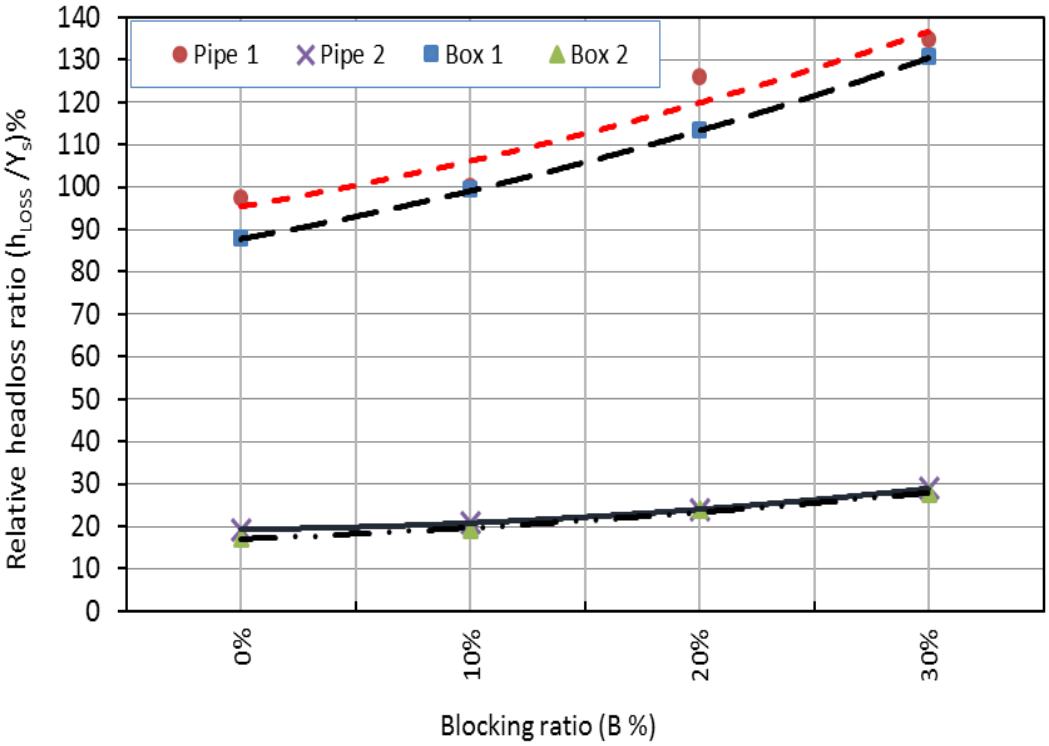


Figure 4: Variation of relative head loss and blocking ratio for pipe 1, pipe 2, box 1, and box 2 at a water flow rate of 11 L/s.

3.2. The effect of coverage shape and dimensions on local scour's depth and length

To demonstrate the impact of the coverage area, shape, flow rate, and blocking ratio on the scour hole downstream coverage, the scour depth and length for each case were measured, and relationships between the blockage percentage and maximum depth and length of the scour downstream coverage were plotted as shown in figures (5, 6, and 7). The data analysis and results showed the following:

- The increase in the flow rate, the blocking ratio upstream coverage, and a decrease in the coverage area led to an increase in the scour depth and length, where the maximum scours depth and length were 0.17 m, and 1.61 m respectively, and occurred in case of pipe 1 at a flow rate of 11 l/s and blocking ratio of 30 %.
- The pipe coverage achieved more scour depth and length than the box coverage of the corresponding identical area under the same condition, where the maximum scours depth at a flow rate of 11 l/s and blocking ratio of 30 % were 0.17 and 0.15 m respectively for pipe 1 and box 1 and were 0.09 and 0.07 m for pipe 2 and box 2 respectively. Also, the maximum scour lengths were 1.61 and 1.42 m respectively for pipe 1, and box 1, and were 0.90 and 0.76 m respectively for pipe 2 and box 2.

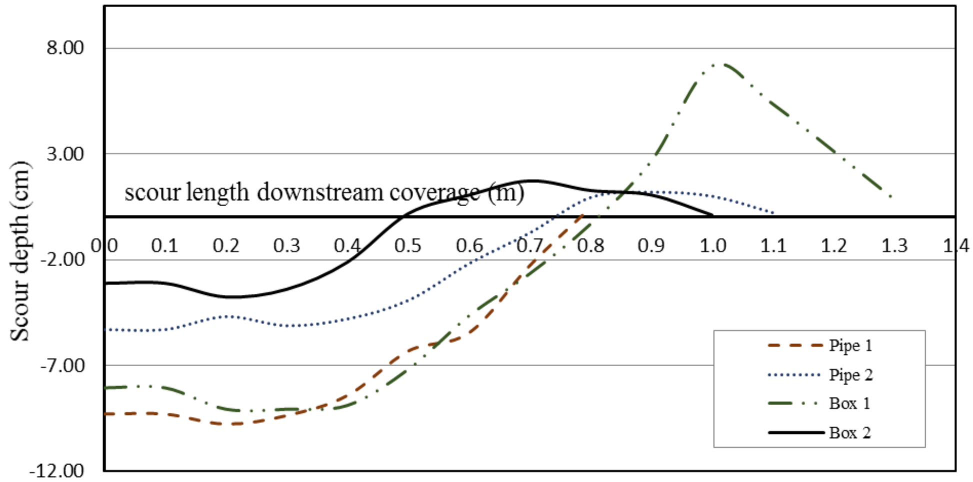


Figure 5: Scour hole profiles downstream coverage for pipe 1, pipe 2, box 1, and box 2 at a water flow rate of 11 L/s, and a blocking ratio of 30%.

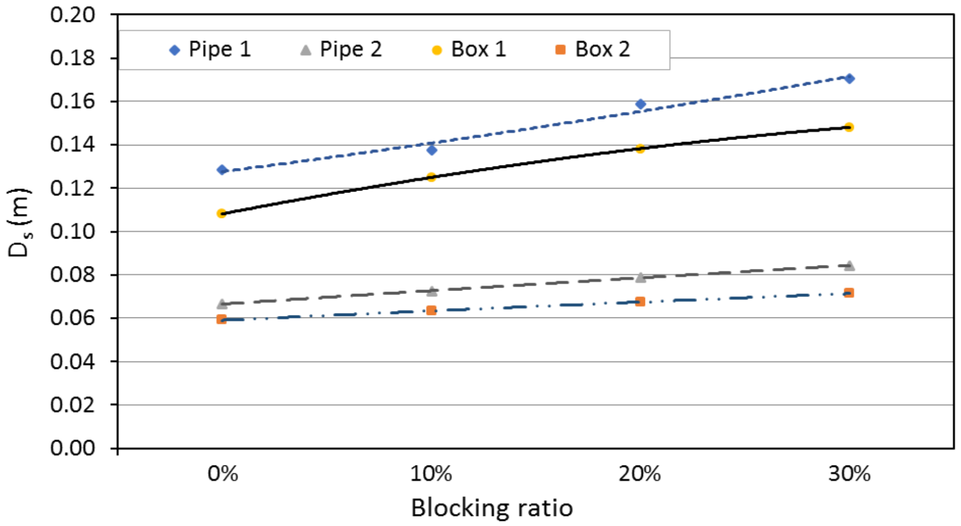


Figure 6: Variation of scour depth (Ds) with blocking ratio of 30 % for pipe 1, pipe 2, box 1, and box 2 at a water flow rate of 11 L/s.

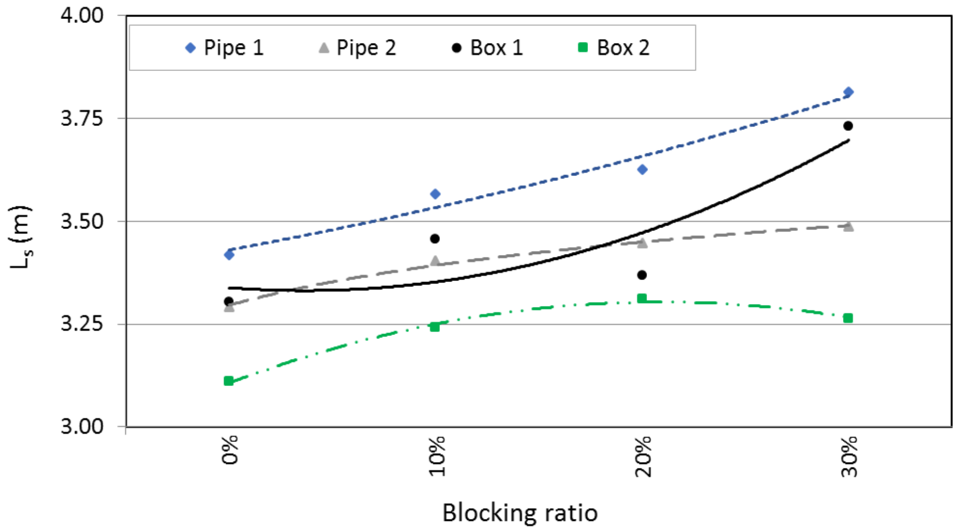


Figure 7: Variation of scour Length (Ls) with blocking ratio of 30 % for pipe 1, pipe 2, box 1, and box 2 at a water flow rate of 11 L/s.

4. Empirical Relationship

Dimensional analysis and statistical software packages were employed to establish empirical relationships between the dependent and independent variables as in equation (1).

$$f\ (y_u, y_d, V_u, V_d, Q, L_s, D_s, V_s, A_{we}, A_p, A_c, A_b, h_u, \rho, g, \mu, \rho_s, D_{50}, \varphi, B, y_s) = 0 \quad \dots\dots\dots\dots\dots \ (1)$$

The multiple regression analysis was performed using a 95% confidence level. Quadratic functions were found to provide the best-fit data. From dimension analysis and multiple regression analysis, the hypothetical relationships can be as follow.

$$(L_s/Y_u, h_u/Y_u, Y_S/Y_u, D_s/Y_u) = (Fr_u^2/Fr_d^2, Q/Y_u^2 * V_u, A_r, B/Y_u) \dots\dots\dots\dots\dots\dots\dots\dots \ (2)$$

Where: (μ) is the dynamic water viscosity (Kg/m.s), (g) is the gravitational acceleration (m/s^2), (ρ) is the water density (Kg/m^3), (Y_u) is the upstream water depth in presence of coverage (m), (Y_d) is the downstream water depth in presence of coverage (m), (Y_s) is the water depth in the case where there is no coverage (m), (Q) is the water flow rate (L/s), (B) is blocking ratio, (A_r) is the relative wetted area of coverage, and equal (A_p) / (Awe) (where (Awe) is a wetted area of canal upstream coverage (m^2), and (A_p) is the area passing water through coverage of box section (m^2)), (V_u) is water velocity upstream coverage (m/s), (F_{ru}) is the Froude number of the flow upstream the coverage, (F_{rd}) is the Froude number of the flow downstream the coverage, the heading up (h_u) is the difference between the water depth upstream coverage and case of no coverage (m), and the head losses (h_{loss}) is the difference between the upstream and downstream water depth for the same case.

Tables (2 and 3) display the correlation matrix for the hypothetical relationships, which depicts the strength of the relationship between the independent and the dependent parameters for Pipe-coverage and Box-coverage cross-sections.

Table (2): The correlation matrix for the hypothetical relationships between the independent and the dependent variables for the Pipe-coverage cross-section (Pipe 1 and Pipe 2)

	A_r	Ln (A_r)	Fr_d	Fr_u	hu	hu/y_u	y_u/y_s	D_s	D_s/y_u	L_s	L_s/y_u
Ar	1										
Ln (A_r)	0.959	1									
Fr_d	-0.390	-0.427	1								
Fr_u	0.316	0.366	0.604	1							
hu	-0.755	-0.875	0.699	-0.123	1						
hu/y_u	-0.805	-0.879	0.771	-0.008	0.971	1					
y_u/y_s	-0.779	-0.898	0.670	-0.155	0.998	0.970	1				
Ds	-0.733	-0.823	0.803	0.088	0.948	0.963	0.944	1			
D_s/y_u	-0.613	-0.625	0.837	0.390	0.717	0.809	0.710	0.897	1		
L_s	-0.771	-0.876	0.740	-0.048	0.988	0.972	0.986	0.977	0.794	1	
L_s/y_u	-0.722	-0.714	0.714	0.204	0.716	0.773	0.714	0.859	0.911	0.812	1

Table (3): The correlation matrix for the hypothetical relationships between the independent and the dependent variables for the Box-coverage cross-section (Box 1 and Box 2)

	A_r	Ln (A_r)	Fr_d	Fr_u	hu	hu/y_u	y_u/y_s	D_s	D_s/y_u	L_s	L_s/y_u
Ar	1.00										
Ln (A_r)	0.96	1.00									
Fr_d	-0.42	-0.46	1.00								
Fr_u	0.24	0.30	0.63	1.00							
hu	-0.74	-0.86	0.73	-0.06	1.00						
hu/y_u	-0.79	-0.870	0.800	0.07	0.97	1.00					
y_u/y_s	-0.76	-0.885	0.714	-0.07	1.00	0.98	1.00				
Ds	-0.72	-0.806	0.841	0.17	0.95	0.96	0.95	1.00			
D_s/y_u	-0.63	-0.644	0.869	0.44	0.75	0.83	0.75	0.92	1.00		
L_s	-0.76	-0.858	0.801	0.07	0.98	0.98	0.98	0.98	0.84	1.00	
L_s/y_u	-0.74	-0.732	0.841	0.38	0.77	0.84	0.77	0.89	0.94	0.87	1.00

4.1. Relation Between the Coverage Characteristics and heading up upstream coverage (h_u)

4.1.1. Regression summary output for Pipe and Box-coverage

The results of the ANOVA test of relative heading up and the relevance of the varying coefficients (a, b, c) and (a_1, b_1, c_1) of the different variables for pipe and box coverage are shown in Tables 4 and 5 respectively.

Table (4). Results of ANOVA test for relative heading up (Pipe coverage)

Regression Variable Results				
Variable	**Value**	**Standard Error**	**t-ratio**	**Prob(t)**
a	0.36	0.02	16.27	0
b	4.38	0.28	15.56	0
c	-0.19	0.01	-21.59	0
95% Confidence Intervals				
Variable	**Value**	**95% (+/-)**	**Lower Limit**	**Upper Limit**
a	0.36	0.045	0.316	0.406
b	4.38	0.567	3.813	4.947
c	-0.19	0.018	-0.211	-0.175

Table (5). Results of ANOVA test for relative heading up (Box coverage)

Regression Variable Results				
Variable	**Value**	**Standard Error**	**t-ratio**	**Prob(t)**
$\mathbf{a_1}$	0.34	0.02	14.47	0
$\mathbf{b_1}$	4.34	0.28	15.61	0
$\mathbf{c_1}$	-0.18	0.01	-19.57	0
95% Confidence Intervals				
Variable	**Value**	**95% (+/-)**	**Lower Limit**	**Upper Limit**
$\mathbf{a_1}$	0.34	0.047	0.292	0.386
$\mathbf{b_1}$	4.34	0.560	3.781	4.901
$\mathbf{c_1}$	-0.18	0.019	-0.203	-0.165

The empirical governing equations which relate the heading up with the hydraulic and blockage characteristics for pipe and box coverage are shown in equations 3 and 4.

$$\left(\frac{h_u}{y_u}\right) = (b\ Fr_{d-}\ c\ Ln\ (Ar) + a) \qquad (for\ pipe\ coverage) \quad R^2 = 0.96 \qquad \ldots\ldots\ldots (3)$$

$$\left(\frac{h_u}{y_u}\right) = (b_1\ Fr_{d-}\ c_1\ Ln\ (Ar) + a_1) \qquad (for\ Box\ coverage) \qquad R^2 = 0.96 \qquad \ldots\ldots\ldots (4)$$

Also, the relationships between the relative heading up and the relative wetted area of coverage for the pipe and box coverage and the comparison between them were plotted as shown in figures 8, 9, and 10.

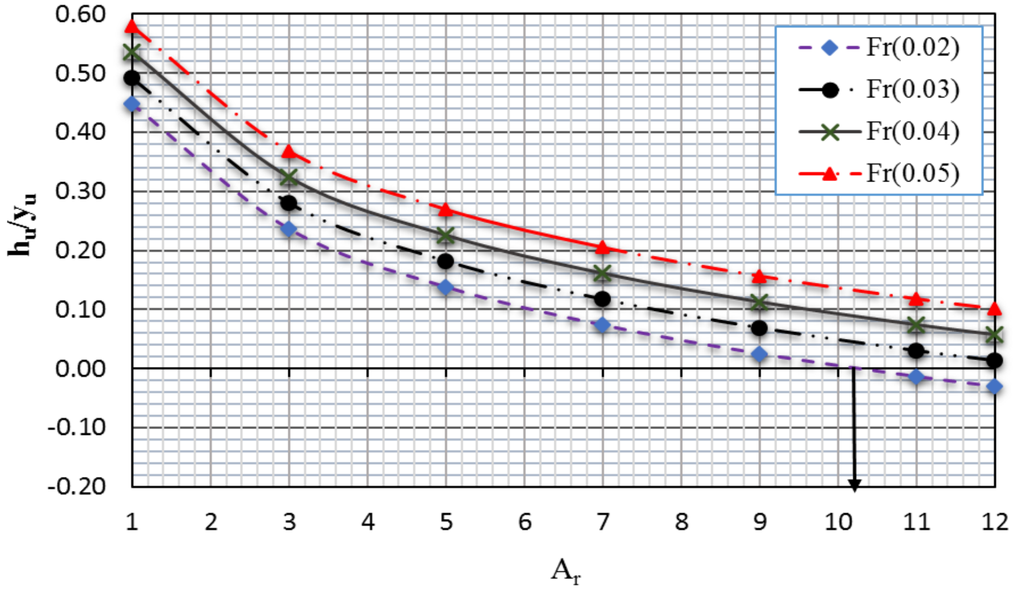


Figure 8: The relation between h_u/y_u with a relative wetted area (A_r) for pipe coverage

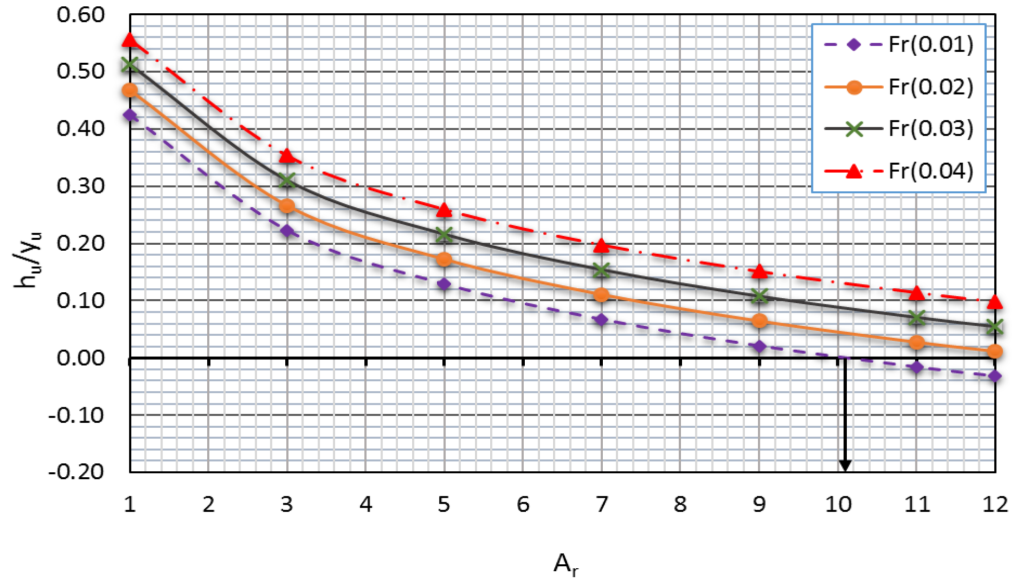


Figure 9: The relation between h_u/y_u with a relative wetted area (A_r) for box coverage

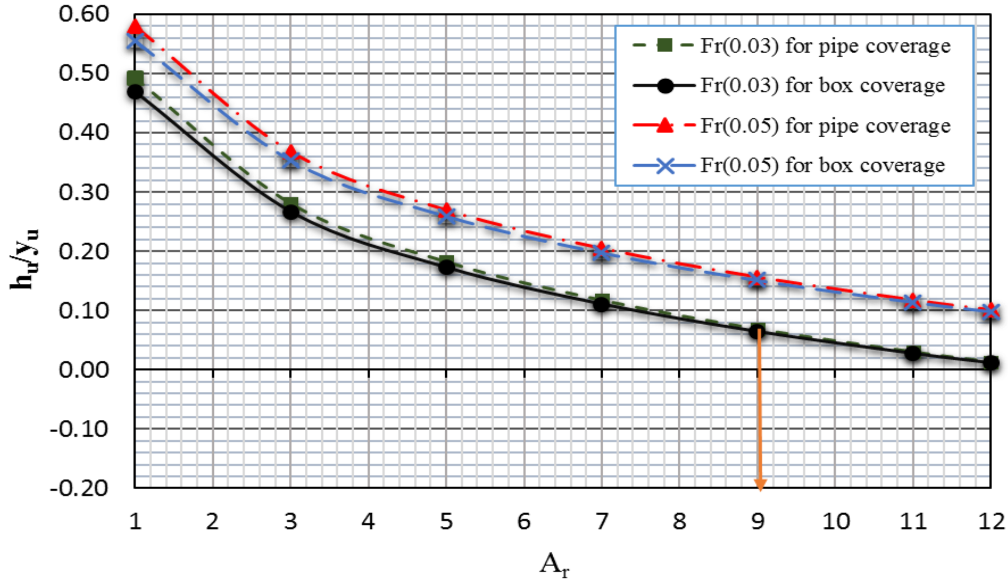


Figure 10: The relation between h_u/y_u with a relative wetted area (A_r) for Pipe and Box coverage

The following findings were observed after evaluating Figures 8, 9, and 10:

- The increment of A_r by 2.2% with each 0.01 rise in F_{rd} might prevent the influence of pipe and box coverage on increasing the heading up in the open channel.
- While A_r remained constant with a 0.01 increase in F_{rd}, the h_u/y_u ratio increased by 4.4% and 4.3%, respectively, for pipe and box coverage. Up until A_r is 9%, box-sec had a smaller impact on h_u/y_u than circular-sec.

4.1.2.Relation Between the Coverage Characteristics and Ds/yu for Pipe and Box-coverage

The results of the ANOVA test of relative scour depth and the relevance of the varying coefficients (a_2, b_2, c_2) and (a_3, b_3, c_3) of the different variables for Pipe and Box coverage are shown in Tables 6 and 7 respectively.

Table (6). Results of ANOVA test for relative scour depth for pipe coverage

Regression Variable Results				
Variable	**Value**	**Standard Error**	**t-ratio**	**Prob(t)**
a_2	0.24	0.03	7.80	0
b_2	3.60	0.39	9.19	0
c_2	-0.05	0.01	-4.31	0.00009
95% Confidence Intervals				
Variable	**Value**	**95% (+/-)**	**Lower Limit**	**Upper Limit**
a_2	0.24	0.062	0.179	0.303
b_2	3.60	0.789	2.813	4.392
c_2	-0.05	0.025	-0.079	-0.029

Table (7). Results of ANOVA test for relative scour depth for box coverage

Regression Variable Results				
Variable	**Value**	**Standard Error**	**t-ratio**	**Prob(t)**
a_3	0.20	0.03	6.81	0
b3	3.63	0.34	10.62	0
c_3	-0.05	0.01	-4.56	0.00004

95% Confidence Intervals				
Variable	**Value**	**95% (+/-)**	**Lower Limit**	**Upper Limit**
a_3	0.20	0.058	0.138	0.254
b3	3.63	0.688	2.938	4.313
c_3	-0.05	0.023	-0.076	-0.029

The empirical governing equations which relate the scour depth with the hydraulic and blockage parameters for pipe and box coverage are shown in equations 5 and 6.

$$\left(\frac{D_s}{y_u}\right) = (b_2\,Fr_{d-}\,c_2\,Ln\,(Ar) + a_2) \quad (for\ \ pipe\ \ coverage) \qquad R^2 = 0.79 \qquad \ldots\ldots\ldots (5)$$

$$\left(\frac{D_s}{y_u}\right) = (b_3\,Fr_{d-}\,c_3\,Ln\,(Ar) + a_3) \quad (for\ Box\ \ coverage) \qquad R^2 = 0.83 \qquad \ldots\ldots\ldots (6)$$

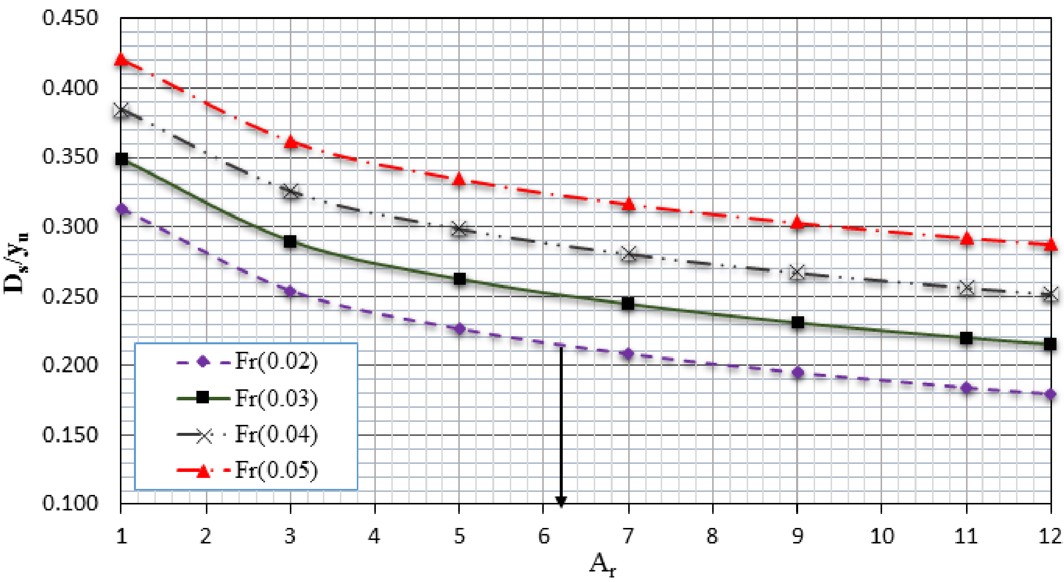


Figure 11: The relation between D_s/y_u with a relative wetted area (A_r) for pipe coverage

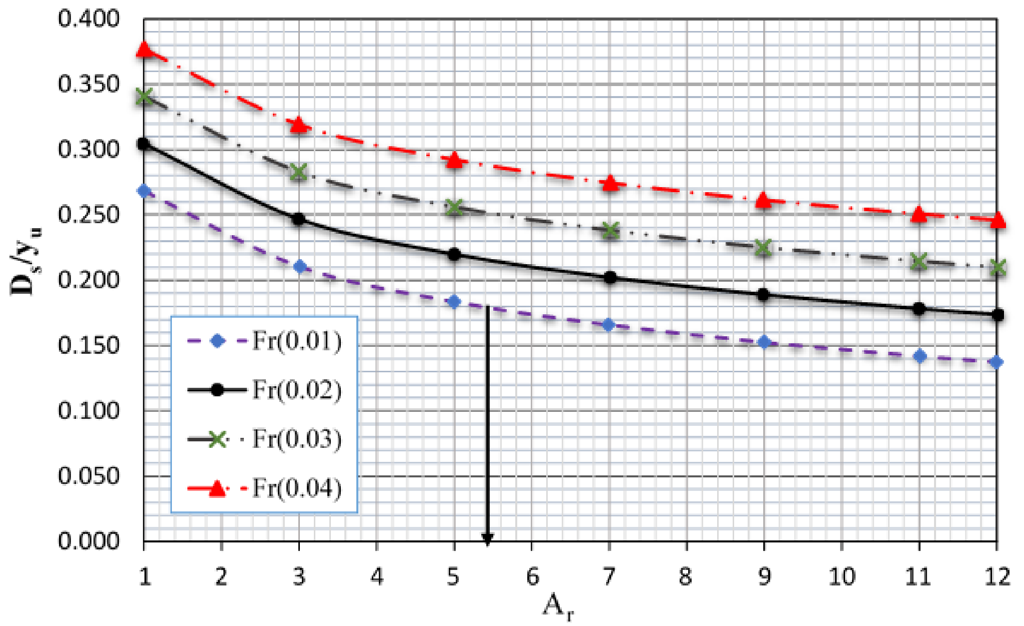


Figure 12: The relation between D_s/y_u with a relative wetted area (A_r) for Box coverage

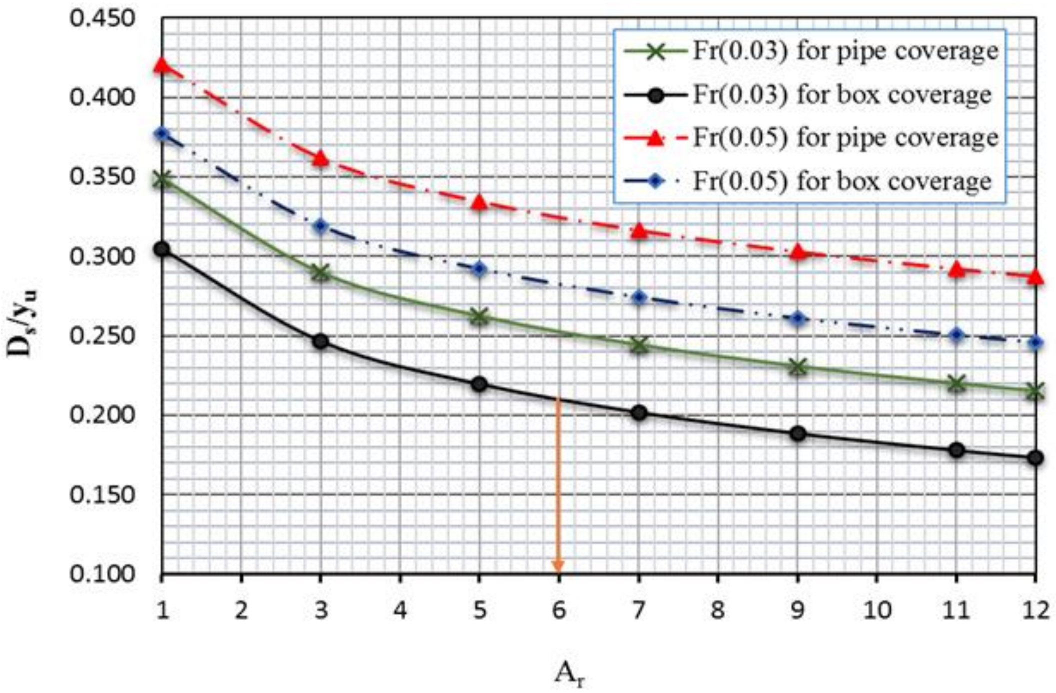


Figure 13: The relation between Ds/yu with a relative wetted area (Ar) for Pipe and Box coverage

It is observed from figures 11, 12, and 13 the following: -

- The relative scour depth increased with a reduction in the relative wetted area of both coverages.
- The relative maximum scours depth increases as F_{rd} increases.
- The ratio of D_s/y_u increased by 3.6% for the pipe and box coverage While A_r was constant and F_{rd} increased by 0.01,
- The Characteristics effect of the box-section on D_s/y_u was less than the circular-section with an average value of 4.3%, which means the best section was Box-section.

5. Conclusion and Recommendations

This experimental study examined the performance of the coverage in the presence of sub-critical flow considering its shape, size, and upstream blockage ratio. Findings from the study revealed that:

- The presence of coverage in the open channel and the increasing flow rate, blocking ratio, and decreasing inlet area led to an increase in the water surface level upstream coverages, heading up, head losses, scour depth, and scour length downstream the coverage.
- The worst case was the pipe 1 coverage of the smallest size (10 cm inner diameter), where the heading up value was approximately 135 % relative to the water depth in the case of no coverage, 10 % more than box 1 of the identical area, and 108, 111 % for pipe 2 and box 2 respectively which have more areas than pipe 1 and box 1. Also, the head losses values for pipe 1 were 105, 4, and 106 % more than the values for pipe 2, box 1, and box 2 respectively.
- The pipe coverage achieves greater scour depth and length than the box coverage of the identical area and the same condition. The maximum scours depth values for pipe 1 were 53, 12, and 59 % more than the values of pipe 2, box 1, and box 2 respectively. Also, Pipe 2, Box 1, and Box 2 all had scoured length values that were 44, 11, and 53% fewer than pipe 1's value.
- While A_r remained constant with a 0.01 increase in F_{rd}, the h_u/y_u ratio increased by 4.4% and 4.3% respectively for pipe and box coverage.
- While A_r was constant and F_{rd} increased by 0.01, the D_s/y_u *ratio* increased by 3.6% for the pipe and box coverage.
- The Characteristics effect of the box cross-section on D_s/y_u was less than the circular cross-section with an average value of 4.3%, which means the best section was the Box cross-section.
- The box coverage is better for the performance of the open channel and causes fewer problems than the pipe coverage.

The research recommended using the box coverage more than the pipe coverage, studying the design of the coverage carefully, the appropriate choice of the best type of coverage, and the maintenance methods to avoid the negative effect on the performance of the open channels.

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تأثير التدفق في التغطيات ذات القطاعات الدائرية والصندوقية على أداء القناة المفتوحة

تهدف هذه الدراسة المعملية إلى تحديد تأثير التغطيات ذات القطاعات الدائرية والصندوقية من حيث أبعادها وشكلها ونسبة انسداد المدخل على الأداء الهيدروليكي للقنوات المائية المكشوفة. تم إجراء خمس حالات تجريبية في نموذج فيزيقي ذو مقطع شبه منحرف: الحالة ١ تضمنت قناة اصطناعية بدون تغطية أو انسداد؛ تتعلق الحالتان ٢ و٣ بتغطية المواسير ذات المقاطع العرضية الدائرية (انبوب ١ و٢)، والحالتان ٤ و٥ بالتغطيات الصندوقية (صندوقي ١ و٢). مساحة الأنبوب ١ والصندوقي ١ متساوية، ومساحة الأنبوب ٢ تساوى الصندوقي ٢ وأكبر من مساحة الأنبوب ١ والصندوقي ١. تم استخدام ثلاث نسب انسداد وثلاثة معدلات تدفق للمياه في هذه الدراسة المعملية. تضمنت كل حالة تقييم الأداء الهيدروليكي للقناة المفتوحة والنحر خلف التغطية. بالمقارنة مع حالة عدم وجود تغطية، فإن وجود التغطية في القناة المفتوحة والزيادة الكبيرة في معدل التدفق، ونسبة الانسداد، وتناقص مساحة مدخل التغطية أدت إلى ارتفاع سطح المياه أمام التغطية، وزيادة عمق وطول النحر خلف التغطية عند نفس الظروف. تغطية الأنبوب تسبب عمق وطول أكبر للنحر من التغطية الصندوقية. التغطية الصندوقية أفضل لأداء القنوات المفتوحة من تغطية الأنبوب. يوصى البحث باستخدام التغطية الصندوقية بدلاً من تغطية الأنبوب وفحص عمليات الصيانة لتلافي التأثير السلبي على أداء القنوات المفتوحة.