STUDY OF THE NEWTON RAPHSON METHOD IN ANALYZING THE DEPTH OF FLUID FLOW IN THE WASTEWATER CANAL U RPS TKRO SMKN 1 CIRUAS USING MATLAB APPLICATION

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Abstract--*Flow Depth can be defined as channel height or open channel flow depth is an important parameter in hydraulic calculations and analysis. The depth of flow in the U channel (U channel) of the Student Practice Room (RPS) for Automotive Light Vehicle Engineering (TKRO) at SMKN 1 Ciruas often causes delayed flow congestion and full channels. Sometimes it is dry if only a few students carry out practical use of room practice and use of water and other waste. The research aim is to find a solution to this problem, namely by knowing the depth of flow in the channel so that in the future when designing waste water drainage channels it can be designed appropriately and in accordance with the volume of waste released. The method is to calculate the flow depth in the U channel using NEWTON RAPHSON numerical analysis and the Matlab application to determine the flow depth. The calculation result is the depth of water flow in channel U, with water flow discharge Q = 0.016 m3/s, Manning coefficient for the roughness of channel walls and base n = 0.025, the slope of channel bottom I = 0.003, and width of channel U B = 0.22 m, at The 11th and 12th iterations flow depth = 0.194864 m. The results of manual exact calculations in the 11th and 12th iterations, the error percentage is 0%, meaning that the flow depth is uniform at a water level of 0.194864 m. Calculations using the Matlab application obtained graphs and the iteration steps were slightly different in the 12th and 13th iterations, the flow depth results were the same = 0.194864 m. The initial guess at flow depth(h)=1, the percentage error is 25%, and the uniform flow depth of the RPS TKRO SMKN 1 Ciruas U channel is 0.194864 m.*

Keywords *: Depth of flow, NEWTON RAPHSON, Open Channel, U Channel, MATLAB*

1. INTRODUCTION

The depth of the flow of the u channel in the Student Practice Room (RPS) / Workshop, Light Vehicle Engineering (TKRO) SMKN 1 Ciruas channels wastewater left over from cleaning vehicles and remaining liquids used for student practice when using the RPS. From the data and real conditions at the location, sometimes the fluid is slow and sometimes the fluid is fast, when used it is necessary to know the depth of the flow so that you can know at what depth the water flows evenly, and in the future you can determine the design of the u channel to get a good design [1] [2] [3] [4]. Numerical analysis uses NEWTON RAPHSON and is equipped with the Matlab application so that there are not too many exact calculations. NEWTON RAPHSON numerical method This approach is suitable for approximate calculations of the depth of flow that occurs. Using Matlab online makes it easier to solve the problem of calculating flow depth in this channel[5] [6] [7]. The sanitation system is an important part of wastewater management, especially in educational institutions such as SMKN 1 Ciruas. The success of wastewater management does not only depend on the physical design of the channel but also on the analysis and optimization of the depth of fluid flow in the channel[8]. U profile or U channel is a type of channel that is commonly used because of its ease of installation and maintenance [8]. Analysis of the depth of fluid flow in sewers requires an accurate mathematical approach to ensure the efficiency and effectiveness of the sewer system [9]. One of the numerical methods commonly used for this analysis is the NEWTON-RAPHSON method. The NEWTON-RAPHSON method is known for its fast convergence speed in finding the roots of nonlinear functions and can be applied in this context to find the depth of fluid flow according to certain flow conditions[10][11]. The MATLAB application is a very effective tool for performing numerical calculations and mathematical modeling. MATLAB provides various functions and toolboxes that you can use to apply the NEWTON-RAPHSON method to detailed fluid flow analysis. The use of MATLAB in this research not only simplifies complex calculations but also improves data visualization and facilitates interpretation of results.

The aim of this research is to apply the NEWTON-RAPHSON method in analyzing the depth of liquid flow in the U-shaped drain channel of RPS TKRO SMKN 1 Ciruas using the MATLAB application. The specific objectives of this research include: To develop a mathematical model to describe the relationship between flow depth and other flow parameters in the wastewater channel of RPS TKRO SMKN 1 Ciruas. Application of the NEWTON-RAPHSON method to solve mathematical models. Applying the NEWTON-RAPHSON method and visualizing the analysis results using MATLAB. To evaluate the performance and accuracy of the NEWTON-RAPHSON method in analyzing the depth of fluid flow in channel flow paths[12]. By conducting this research, it is hoped that a deeper understanding can be obtained regarding the effectiveness of the NEWTON-RAPHSON method and the application of MATLAB information in the analysis of wastewater treatment systems. This research also provides useful recommendations regarding waste water management practices at SMKN 1 Ciruas and other locations.

Figure 1. RPS TKRO SMKN 1 Ciruas wastewater channel

2. METHODOLOGY

2.1 Numerical Methods

The NEWTON RAPHSON method finds the roots of a function f(x) with one-point approach, the function f(x) has a derivative f'(x), this method is easier than the bisection method *(bisection method*), the approach uses one starting point/initial guess, the closer the starting point we choose the faster it will converge to the root. The shorter the iteration, the faster the solution of the equation and vice versa. If the error valueis zero percent, the iteration is stopped because the calculation approach has been fulfilled [11].

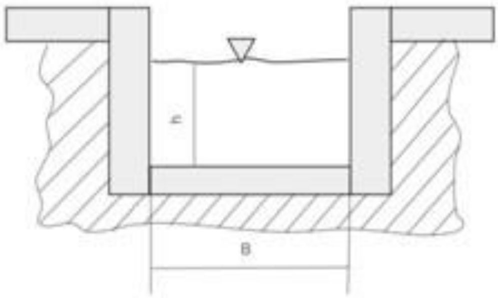


Figure 2. Rectangular Open Section, (h) flow depth, (B) channel width [13].

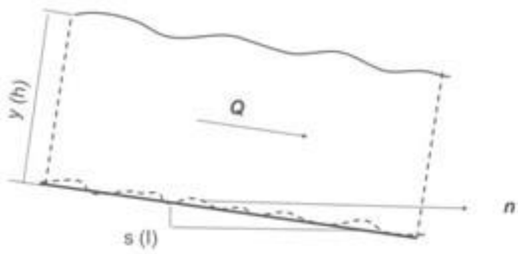


Figure 3. Description of the shape of discharge (Q), wall roughness/base Manning coefficient (n), channel slope s (I),flow depth y (h) in channel u [14].

By deriving Manning's formula (1889) [12][13][14][18].

$$Q = A\,x\,V \quad (1)$$

$$V = \frac{I}{n} x\, R^{\frac{2}{3}} x\, I^{\frac{1}{2}} \quad (2)$$

$$\textit{When } R = \frac{A}{P} \quad (3)$$

$$Q = A\,x\,\frac{I}{n} x \left(\frac{A}{P}\right)^{\frac{2}{3}} x\ I^{\frac{1}{2}}$$

$$\frac{Q.n}{I^{\frac{1}{2}}} = A\,x\left(\frac{A}{P}\right)^{\frac{2}{3}}$$

$$\left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^{3} = \left(A\,x\left(\frac{A}{P}\right)\right)^{3}$$

$$\left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^{3} = A^{3}\,x\left(\frac{A^{2}}{P^{2}}\right)$$

$$A^{5} - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^{3} x\,P^{2} = 0 \quad (4)$$

Tabel 1. Koefisien Manning(n)[14][19].

Material	Manning Coefficient (n)
Coated cast iron	0,014
Glass	0,010
Concrete channel	0.013
Brick coated with mortar	0,015
Stone masonry in cement	0,025
Clean ground channels	0,022
Ground channel	0,030
Channel with rock bottom and grass banks	0,040
Channels in rock excavations	0,040

From the data at SMKN 1 Ciruas, it can be seen that the value of s or I for channel slope is the difference in height divided by the distance or length of the channel:

$$s(I) = \frac{Different\ height\ (m)}{distance\ (m)} \quad (5)$$

$$s(I) = \frac{0{,}1\ (m)}{30\ (m)} = 0{,}003 \text{ m}$$

Channel/base slope (I) = 0.003
Channel width B = 0.22 m
Wet cross section height h = 0.20 m
From the Manning coefficient table for channels made of cemented masonry (n) = 0.025

Hydraulic finger :

$$A = B.h \qquad P = B + 2.h$$ [13].

$$A = 0{,}22\ x\ 0{,}20$$

$$A = 0{,}044\ m^2$$

$$P = B + 2.h$$

$$P = 0{,}22 + 2\ x\ \ 0{,}20$$

$$P = 0{,}62\ m$$

$$\mathrm{R} = \frac{\mathrm{A}}{\mathrm{P}}$$

$$\mathrm{R} = \frac{0{,}044}{0{,}62}$$

$$\mathrm{R} = 0{,}0709 \text{ m}$$

$$\mathrm{V} = \frac{\mathrm{I}}{\mathrm{n}} \mathrm{x}\ \mathrm{R}^{\frac{2}{3}} \mathrm{x}\ \mathrm{I}^{\frac{1}{2}}$$

$$\mathrm{V} = \frac{\mathrm{I}}{0{,}025} \mathrm{x}\ 0{,}0709^{\frac{2}{3}} \mathrm{x}\ 0{,}003^{\frac{1}{2}}$$

$$\mathrm{V} = 0{,}371\ \mathrm{m}^3/s$$

$$\mathrm{Q} = \mathrm{A}\ \mathrm{x}\ \mathrm{V}$$

$$\mathrm{Q} = 0{,}044\ \ \mathrm{x}\ 0{,}371$$

$$\mathrm{Q} = 0{,}016\ \mathrm{m}^3/s$$

Flow rate *(flow rate)* is the volume of the flowing water for a certain time through a cross-section[20].

Step by step to determine the depth of fluid flow as follows:

a) Calculate the wet cross-sectional area (A) and the wet cross-sectional perimeter (P)

$$A = B.h \qquad P = B + 2.h \quad (6)$$

$$A = 0{,}22\ x\ 0{,}20$$

$$A = 0{,}044\ m^2$$

$$P = B + 2.h$$

$$P = 0{,}22 + 2\ x\ \ 0{,}20$$

$$P = 0{,}62\ m$$

b) Substitute wet cross-sectional area (A) and wet cross-sectional perimeter (P)

$$F(h) = (B.h)^5 - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^3 x\ (B + 2.h)^2 \quad (7)$$

Manning Formula is entered [14].

$$A^5 - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^3 x\ P = 0$$

c) Derivative of the function F'(h)

$$F'(h) = 5\ B^5 h^5 - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^3 x\ 4(B + 2.h)$$

(8)

d) Use the NEWTON-RAPHSON Methode

$$h_{i+1} = h_i - \frac{F\ (h_i)}{F'(h_i)} \quad (9)$$

$$eror\,\% = \left|\frac{(h_{i+1} - h_i)}{(h_{i+1})}\right| x\ 100\% \qquad (10)$$

e) Iteration Using NEWTON-RAPHSON

2.2 Solution using Matlab.

3. RESULTS AND DISCUSSION

From the formula above and data at SMKN 1 Ciruas regarding the depth of flow in this U channel:

a) Determine the initial guess poi-t

$$h_i = 1$$

$$F(h) = (B.h)^5 - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^3 x\ (B + 2.h)^2$$

$$F(1) = (0{,}22.1)^5 - \left(\frac{0{,}016x0{,}025}{0{,}003^{\frac{1}{2}}}\right)^3 x(0{,}22 + 2.1)^2$$

$$F(1) = 0{,}00051344363$$

$$F'(h) = 5\,B^5h^4 - \left(\frac{Q.n}{I^{\frac{1}{2}}}\right)^3 x\ 4(B + 2.h)$$

$$F'(h) = 5\ x\ 0{,}22^5 1^4 - \left(\frac{0{,}016x0{,}025}{0{,}003^{\frac{1}{2}}}\right)^3 x\ 4(0{,}22 + 2.1)$$

$$F'(h) = 0{,}00257335731$$

$$h_{i+1} = h_i - \frac{F\ (h_i)}{F'(h_i)}$$

$$h_{i+1} = 1 - \frac{0{,}00051344363}{0{,}00257335731} = 0{,}800477132$$

$$eror\,\% = \left|\frac{(h_{i+1} - h_i)}{(h_{i+1})}\right| x\ 100\%$$

$$eror\,\% = \left|\frac{0{,}800477132 - 1}{0{,}800477132}\right| x\ 100\% = 25\ \%$$

The iteration count is calculated until an error of 0% from the exact calculation is obtained in steps 11 and 12, in step 11 it is already 0% and the same number in the 12th iteration.

Table 2 Exact calculation results of NEWTON-RAPHSON Numerical Method Iteration.

i	hi	f(hi)	f'(hi)	hi+1	E
1	1	0,000513444	0,002573	0,800477	25 %
2	0,800477	0,000168087	0,001055	0,641175	25 %
3	0,641175	5,49676E-05	0,000433	0,514277	25 %
4	0,514277	1,79323E-05	0,000178	0,413705	24 %
5	0,413705	5,81817E-06	7,39E-05	0,334921	24 %
6	0,334921	1,86343E-06	3,1E-05	0,274882	22 %
7	0,274882	5,78018E-07	1,35E-05	0,232106	18 %
8	0,232106	1,64832E-07	6,41E-06	0,206402	12 %
9	0,206402	3,70872E-08	3,69E-06	0,196353	5 %
10	0,196353	4,20102E-09	2,88E-06	0,194893	1 %
11	0,194893	7,93175E-11	2,77E-06	0,194864	0 %
12	0,194864	3,0051E-14	2,77E-06	0,194864	0 %

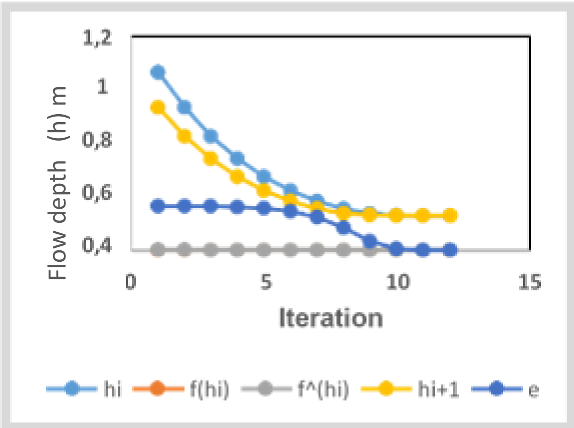


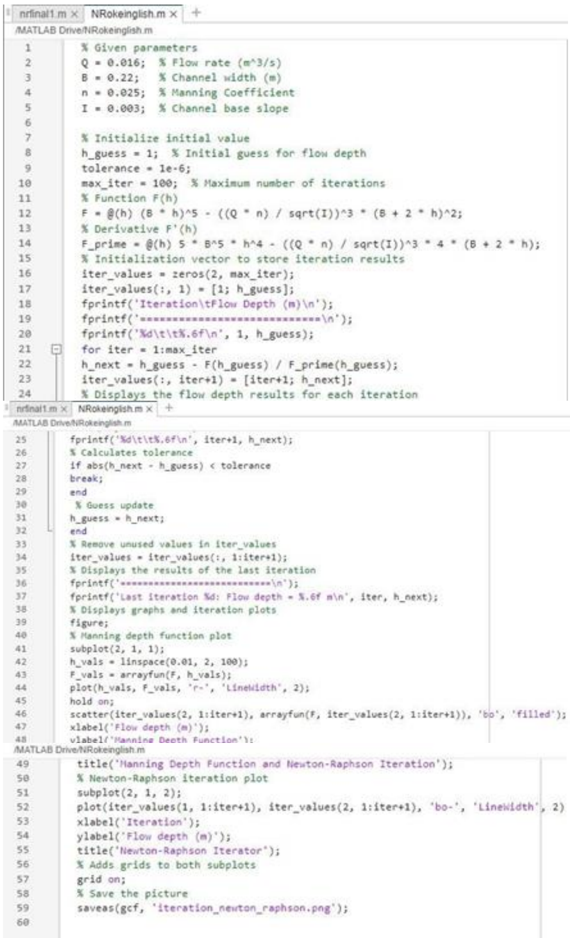
Figure 4. Graph of exact calculation results from the NEWTON RAPHSON iteration

Table 2 and Figure 4 show the results of the NEWTON RAPHSON iteration, showing that the calculation step using the exact calculation obtained in steps 11 and 12 obtained a flow depth = 0.194864 m.

Menggunakan Matlab
Formula NEWTON-RAPHSON

```
% Given parameters
Q = 0.016;    % Flow rate (m^3/s)
B = 0.22;     % Channel width (m)
n = 0.025;    % Manning Coefficient
I = 0.003;    % Channel base slope
```

```
% Initialize initial value
h_guess = 1;  % Initial guess for flow
depth
tolerance = 1e-6;
max_iter = 100;  % Maximum number of
iterations
% Function F(h)
F = @(h) (B * h)^5 - ((Q * n) /
sqrt(I))^3 * (B + 2 * h)^2;
% Derivative F'(h)
F_prime = @(h) 5 * B^5 * h^4 - ((Q *
n) / sqrt(I))^3 * 4 * (B + 2 * h);
% Initialization vector to store
iteration results
iter_values = zeros(2, max_iter);
iter_values(:, 1) = [1; h_guess];
fprintf('Iteration\tFlow Depth
(m)\n');
fprintf('===========================\
n');
fprintf('%d\t\t%.6f\n', 1, h_guess);
for iter = 1:max_iter
h_next = h_guess - F(h_guess) /
F_prime(h_guess);
iter_values(:, iter+1) = [iter+1;
h_next];
% Displays the flow depth results for
each iteration
fprintf('%d\t\t%.6f\n', iter+1,
h_next);
% Calculates tolerance
if abs(h_next - h_guess) < tolerance
break;
end
 % Guess update
h_guess = h_next;
end
% Remove unused values in iter_values
iter_values = iter_values(:,
1:iter+1);
% Displays the results of the last
iteration
fprintf('==========================\n
');
fprintf('Last iteration %d: Flow depth
= %.6f m\n', iter, h_next);
% Displays graphs and iteration plots
figure;
% Manning depth function plot
subplot(2, 1, 1);
h_vals = linspace(0.01, 2, 100);
F_vals = arrayfun(F, h_vals);
plot(h_vals, F_vals, 'r-',
'LineWidth', 2);
hold on;
scatter(iter_values(2, 1:iter+1),
arrayfun(F, iter_values(2, 1:iter+1)),
'bo', 'filled');
xlabel('Flow depth (m)');
ylabel('Manning Depth Function');
title('Manning Depth Function and
Newton-Raphson Iteration');
% Newton-Raphson iteration plot
subplot(2, 1, 2);
plot(iter_values(1, 1:iter+1),
iter_values(2, 1:iter+1), 'bo-',
'LineWidth', 2);
xlabel('Iteration');
ylabel('Flow depth (m)');
title('Newton-Raphson Iterator');
% Adds grids to both subplots
grid on;
% Save the picture
saveas(gcf,
'iteration_newton_raphson.png');
```



```
% Given parameters
Q = 0.016;  % Flow rate (m^3/s)
B = 0.22;   % Channel width (m)
n = 0.025;  % Manning Coefficient
I = 0.003;  % Channel base slope

% Initialize initial value
h_guess = 1;  % Initial guess for flow depth
tolerance = 1e-6;
max_iter = 100;  % Maximum number of iterations
% Function F(h)
F = @(h) (B * h)^5 - ((Q * n) / sqrt(I))^3 * (B + 2 * h)^2;
% Derivative F'(h)
F_prime = @(h) 5 * B^5 * h^4 - ((Q * n) / sqrt(I))^3 * 4 * (B + 2 * h);
% Initialization vector to store iteration results
iter_values = zeros(2, max_iter);
iter_values(:, 1) = [1; h_guess];
fprintf('Iteration\tFlow Depth (m)\n');
fprintf('============================\n');
fprintf('%d\t\t%.6f\n', 1, h_guess);
for iter = 1:max_iter
h_next = h_guess - F(h_guess) / F_prime(h_guess);
iter_values(:, iter+1) = [iter+1; h_next];
% Displays the flow depth results for each iteration
fprintf('%d\t\t%.6f\n', iter+1, h_next);
% Calculates tolerance
if abs(h_next - h_guess) < tolerance
break;
end
 % Guess update
h_guess = h_next;
end
% Remove unused values in iter_values
iter_values = iter_values(:, 1:iter+1);
% Displays the results of the last iteration
fprintf('==========================\n');
fprintf('Last iteration %d: Flow depth = %.6f m\n', iter, h_next);
% Displays graphs and iteration plots
figure;
% Manning depth function plot
subplot(2, 1, 1);
h_vals = linspace(0.01, 2, 100);
F_vals = arrayfun(F, h_vals);
plot(h_vals, F_vals, 'r-', 'LineWidth', 2);
hold on;
scatter(iter_values(2, 1:iter+1), arrayfun(F, iter_values(2, 1:iter+1)), 'bo', 'filled');
xlabel('Flow depth (m)');
ylabel('Manning Depth Function');
title('Manning Depth Function and Newton-Raphson Iteration');
% Newton-Raphson iteration plot
subplot(2, 1, 2);
plot(iter_values(1, 1:iter+1), iter_values(2, 1:iter+1), 'bo-', 'LineWidth', 2)
xlabel('Iteration');
ylabel('Flow depth (m)');
title('Newton-Raphson Iterator');
% Adds grids to both subplots
grid on;
% Save the picture
saveas(gcf, 'iteration_newton_raphson.png');
```

Figure 5. NEWTON RAPHSHON Matlab formula for flow depth in the U channel of RPSTKRO SMKN 1 Ciruas

```
Command Window
>> NRokeinglish
Iteration          Flow Depth (m)
============================
1                  1.000000
2                  0.800477
3                  0.641175
4                  0.514277
5                  0.413705
6                  0.334921
7                  0.274882
8                  0.232106
9                  0.206402
10                 0.196353
11                 0.194893
12                 0.194864
13                 0.194864
===========================
Last iteration 12: Flow depth = 0.194864 m
>>
```

Figure 6. Matlab NEWTON RAPHSHON iteration of flow depth in the U channel ofRPS TKRO SMKN 1 Ciruas

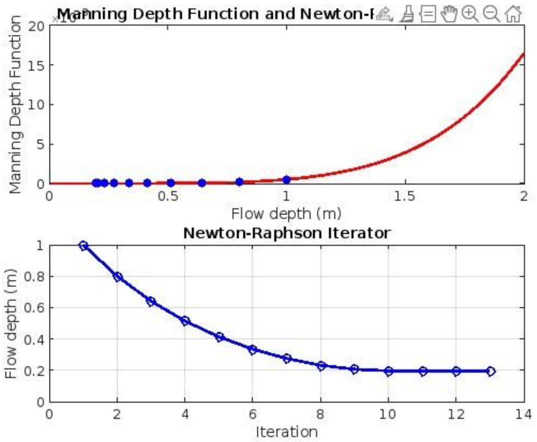


Figure 7. Matlab Iteration Graph NEWTON-RAPHSHON flow depth in the U channel of RPS TKRO SMKN 1 Ciruas

Figure 5 shows the process of inputting the Matlab Online 2024 formula and running the formula to obtain the correct and efficient flow and steps according to the steps in NEWTON RAPHSON, while in Figure 6 the similarity value of flow depth occurs in the 12-13th iteration step, flow depth = 0.194864 m, Figure 7 is an iteration graph compared to flow depth (m) and a graph of flow depth compared to the Manning depth function.

4. CONCLUSION

From calculations using the NEWTON RAPHSON method with the Manning formula applied to open channels to find the flow discharge, the slope of the channel bed is obtained from the difference in channel height divided by its length. Meanwhile, the channel roughness can be obtained from the Manning coefficient table, the hydraulic radius is obtained from the wet cross-sectional area divided by the perimeter of the wet channel, while the flow velocity is obtained V= 0.371 m^3/s. Steps in determining the depth of flow, calculate the wet cross-sectional area, the wet cross-sectional perimeter, substitute the wet cross-sectional area and the perimeter f(h), reduce the equation to f'(h), use the NEWTON RAPHSON method and obtain the iteration, determine one point or points initial (guess) initial guess h=1. While using the Matlab online 2024 application there is a slight difference in the number of iterations, in the exact calculation with NEWTON RAPHSON in the 11th iteration but the approach value is almost the same, in the 11-12th iteration the error value = 0%, meaning that at the flow depth of the U channel / faceted open channel four there are flow equations, in Matlab iterations 12-13. With channel width data u = 0.22 m, the flow discharge calculation results Q = 0.016 m^3/s and base slope I = 0.003 and wall/base roughness Manning coefficient n = 0.025, flow depth = 0.194864 m. The steps in Matlab are entering parameters, initial guess values, convergencetolerance, iteration, plotting the results of the iteration so that it is more visible on the graph and the results of the solution. So the similarity of flow in the channel is obtained at a height of 0.194864 m.

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