Untitled

May 20, 2021

1 Control of Weir Flow by Changing Geometry

1.1 Problem

1.1.1 Statement

We will try and understand how height of fluid over weir affects the flow rate of water across the weir. We will analyse 2 cases for each height. One with laminar flow and another with turbulent.

1.1.2 Properties

- Fixed:
  1. Dimensions of mesh $(l = 25,\ w = 6)$
  2. Width of weir (L) $= 1\ m$
  3. Distance of weir from inlet $= 15\ m$
- Variables:
  1. $H_w =$ Height of weir
  2. $H_s =$ Height of the stream
  3. $H = H_s - H_w =$ Height of the stream above the weir's crest

1.1.3 Geometry:

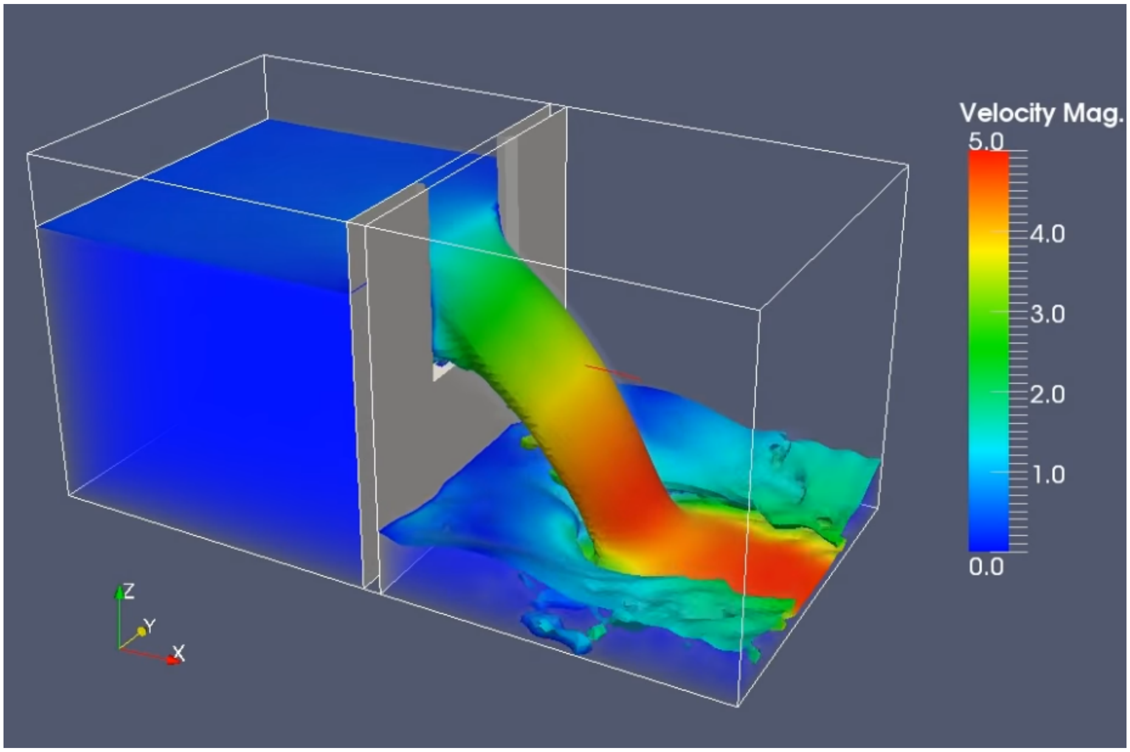


Figure 1.1: 3D geometry of flow over weir

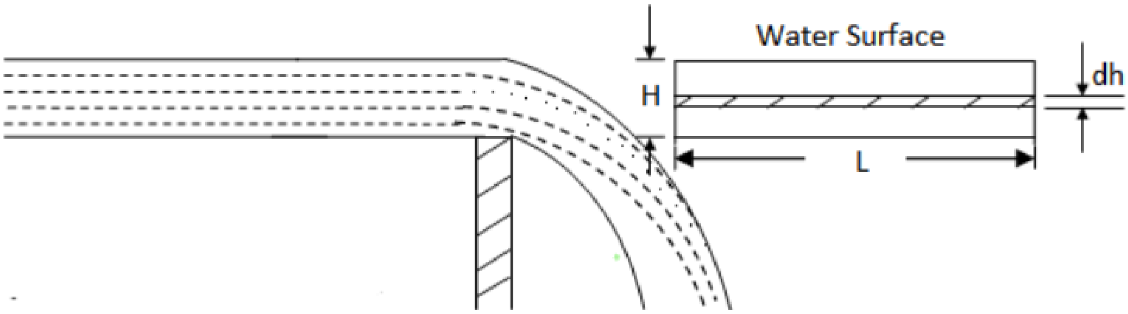


Figure 1.2: Cross section view

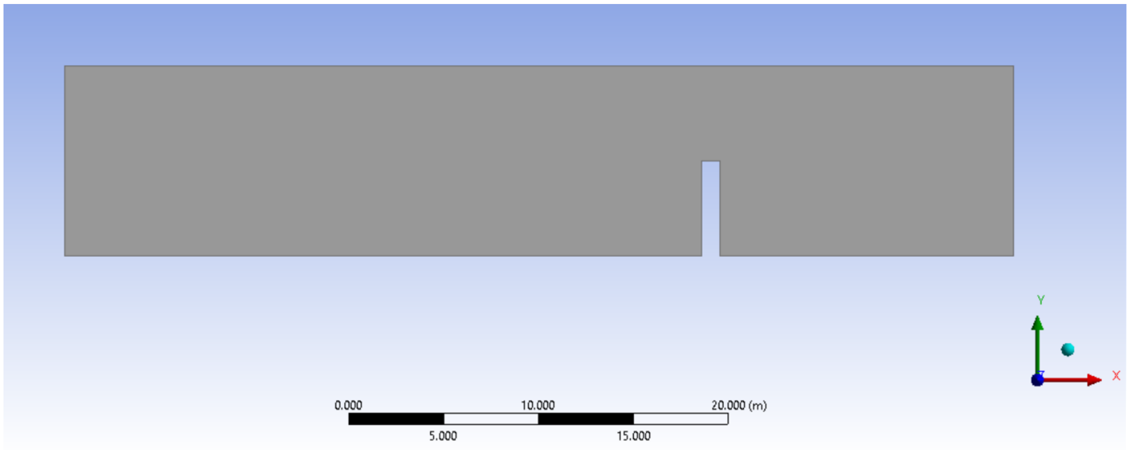


Figure 1.3: Mesh cross section view

1.1.4 Boundary conditions:

1. No slip condition on the stream bed & the surface of weir.
2. Plug flow in the inlet stream.

1.1.5 Solving

- K-epsilon turbulence model (2 equations) is used.
- Divisions per unit length in the mesh = 2.
- Volume ratio used is modified high resolution schemes for interface capturing (HRIC).

1.2 Geometry - `Gmsh file`

1.2.1 Case 1: $H = 0\ m$

Properties $H_s = 3\ m, H_w = 3\ m$

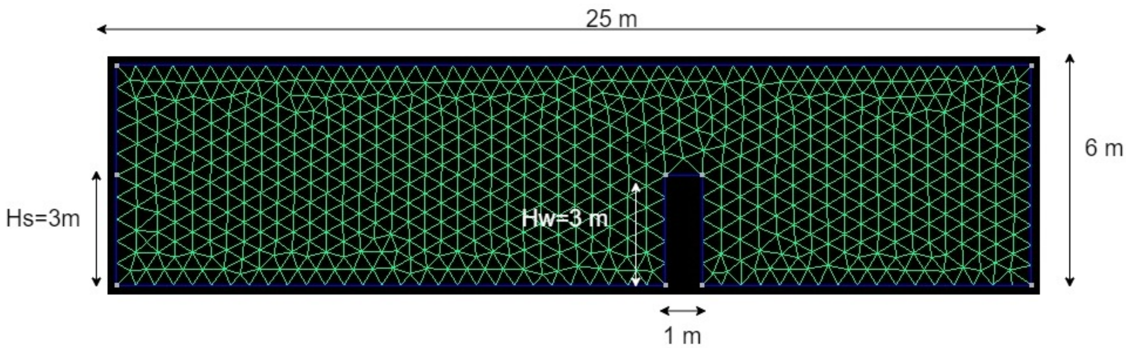


Figure 2.1: 2D mesh for case 1 (H=0)

Mesh file

```
// Gmsh project created on Mon May 10 10:15:28 2021
SetFactory("OpenCASCADE");
Point(1) = {0, 0, 0, 1.0};
Point(2) = {15, 0, 0, 1.0};
Point(3) = {15, 3, 0, 1.0};
Point(4) = {16, 3, 0, 1.0};
Point(5) = {16, 0, 0, 1.0};
Point(6) = {25, 0, 0, 1.0};
Point(7) = {25, 6, 0, 1.0};
Point(8) = {0, 6, 0, 1.0};
Point(9) = {0, 3, 0, 1.0};
Line(1) = {1, 2};
Line(2) = {2, 3};
Line(3) = {3, 4};
Line(4) = {4, 5};
Line(5) = {5, 6};
Line(6) = {6, 7};
Line(7) = {7, 8};
Line(8) = {8, 9};
```

```
Line(9) = {9, 1};
Curve Loop(1) = {8, 9, 1, 2, 3, 4, 5, 6, 7};
Plane Surface(1) = {1};
Physical Curve("inlet", 10) = {9};
Physical Curve("outlet", 11) = {6, 5};
Physical Curve("ambient", 12) = {7};
Physical Curve("fw", 13) = {8, 1, 2, 3, 4};
Physical Surface("Area1", 14) = {1};
Transfinite Curve {7} = 50 Using Progression 1;
Transfinite Curve {6} = 12 Using Progression 1;
Transfinite Curve {8} = 6 Using Progression 1;
Transfinite Curve {9} = 6 Using Progression 1;
Transfinite Curve {1} = 30 Using Progression 1;
Transfinite Curve {5} = 18 Using Progression 1;
Transfinite Curve {2} = 6 Using Progression 1;
Transfinite Curve {4} = 6 Using Progression 1;
Transfinite Curve {3} = 2 Using Progression 1;
```

1.2.2 Case 2: $H = 0.5\ m$

Properties $H_s = 3\ m, H_w = 2.5\ m$

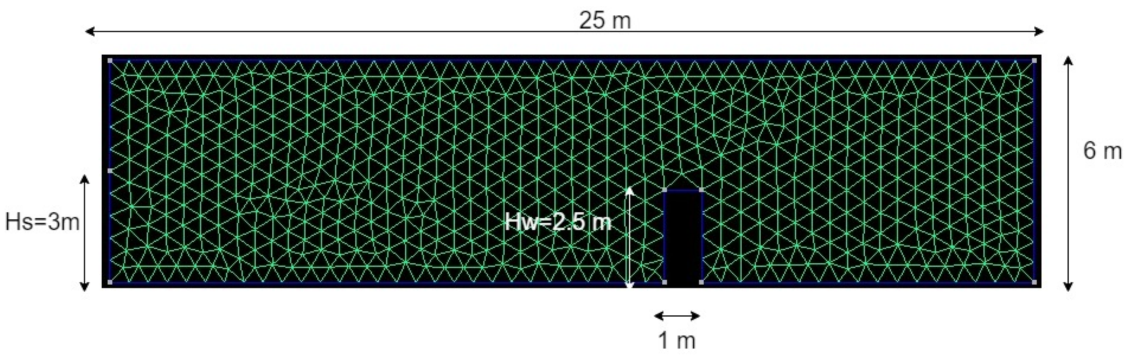


Figure 2.2: 2D mesh for case 2 (H=0.5)

Mesh file

```
SetFactory("OpenCASCADE");
Point(1) = {0, 0, 0, 1.0};
Point(2) = {15, 0, 0, 1.0};
Point(3) = {15, 2.5, 0, 1.0};
Point(4) = {16, 2.5, 0, 1.0};
Point(5) = {16, 0, 0, 1.0};
Point(6) = {25, 0, 0, 1.0};
Point(7) = {25, 6, 0, 1.0};
Point(8) = {0, 6, 0, 1.0};
Point(9) = {0, 3, 0, 1.0};
Line(1) = {1, 2};
Line(2) = {2, 3};
Line(3) = {3, 4};
```

```
Line(4) = {4, 5};
Line(5) = {5, 6};
Line(6) = {6, 7};
Line(7) = {7, 8};
Line(8) = {8, 9};
Line(9) = {9, 1};
Curve Loop(1) = {9, 1, 2, 3, 4, 5, 6, 7, 8};
Plane Surface(1) = {1};
Physical Curve("inlet", 10) = {9};
Physical Curve("outlet", 11) = {6, 5};
Physical Curve("ambient", 12) = {7};
Physical Curve("fw", 13) = {8, 1, 2, 3, 4};
Physical Surface("Area2", 14) = {1};
SetFactory("OpenCASCADE");
Transfinite Curve {7} = 50 Using Progression 1;
Transfinite Curve {6} = 12 Using Progression 1;
Transfinite Curve {8} = 6 Using Progression 1;
Transfinite Curve {9} = 6 Using Progression 1;
Transfinite Curve {1} = 30 Using Progression 1;
Transfinite Curve {5} = 18 Using Progression 1;
Transfinite Curve {2} = 5 Using Progression 1;
Transfinite Curve {4} = 5 Using Progression 1;
Transfinite Curve {3} = 2 Using Progression 1;
```

1.2.3 Case 3: $H = 1\ m$

Properties $H_w = 2\ m, H_s = 3\ m$

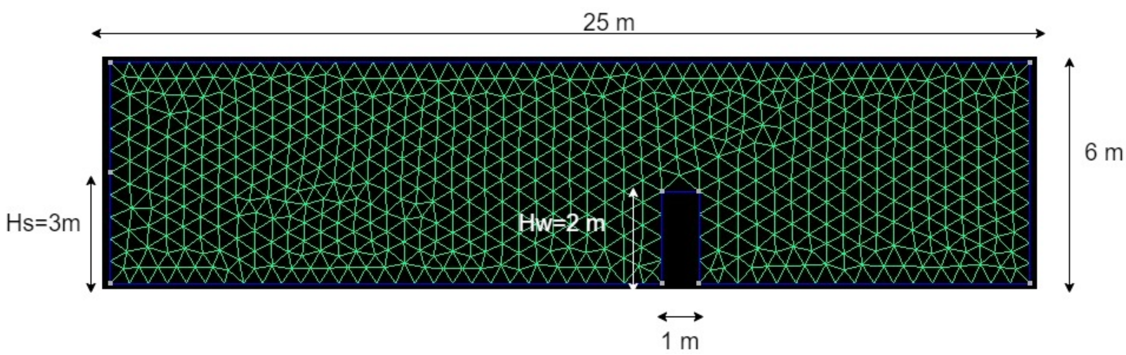


Figure 2.3: 2D mesh for case 3 (H=1)

Mesh file

```
SetFactory("OpenCASCADE");
Point(1) = {0, 0, 0, 1.0};
Point(2) = {15, 0, 0, 1.0};
Point(3) = {15, 2, 0, 1.0};
Point(4) = {16, 2, 0, 1.0};
Point(5) = {16, 0, 0, 1.0};
Point(6) = {25, 0, 0, 1.0};
```

```
Point(7) = {25, 6, 0, 1.0};
Point(8) = {0, 6, 0, 1.0};
Point(9) = {0, 3, 0, 1.0};
Line(1) = {1, 2};
Line(2) = {2, 3};
Line(3) = {3, 4};
Line(4) = {4, 5};
Line(5) = {5, 6};
Line(6) = {6, 7};
Line(7) = {7, 8};
Line(8) = {8, 9};
Line(9) = {9, 1};
Curve Loop(1) = {8, 9, 1, 2, 3, 4, 5, 6, 7};
Plane Surface(1) = {1};
Physical Curve("inlet", 10) = {9};
Physical Curve("outlet", 11) = {6, 5};
Physical Curve("ambient", 12) = {7};
Physical Curve("fw", 13) = {8, 1, 2, 3, 4};
Physical Surface("Area3", 14) = {1};
Transfinite Curve {7} = 50 Using Progression 1;
Transfinite Curve {6} = 12 Using Progression 1;
Transfinite Curve {8} = 6 Using Progression 1;
Transfinite Curve {9} = 6 Using Progression 1;
Transfinite Curve {1} = 30 Using Progression 1;
Transfinite Curve {5} = 18 Using Progression 1;
Transfinite Curve {2} = 4 Using Progression 1;
Transfinite Curve {4} = 4 Using Progression 1;
Transfinite Curve {3} = 2 Using Progression 1;
```

1.3 Results

1.3.1 Case 1: $H = 0\ m$

Laminar flow ($v = 0.005\ m/s$)
Figure 3.1 A: Velocity profile diagram under laminar conditions with height of stream over weir = 0 m

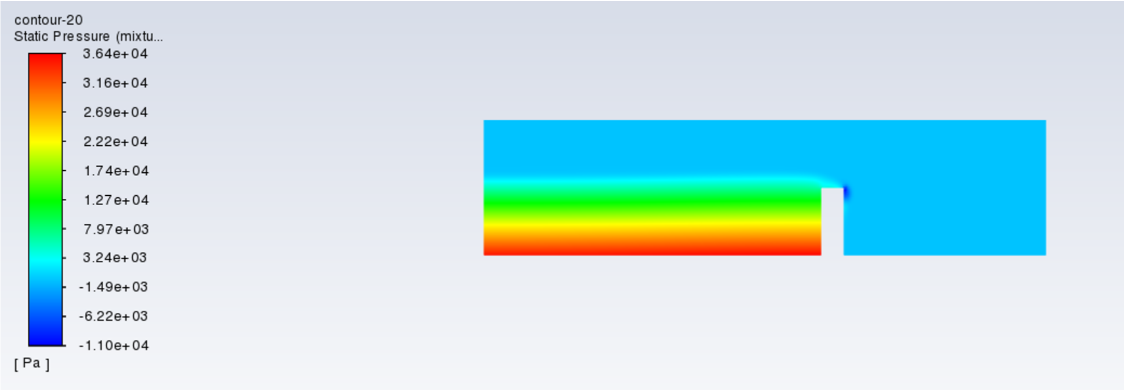


Figure 3.1 B: Pressure field diagram under laminar conditions with height of stream over weir = 0 m

Turbulent flow $(v = 5\,m/s)$

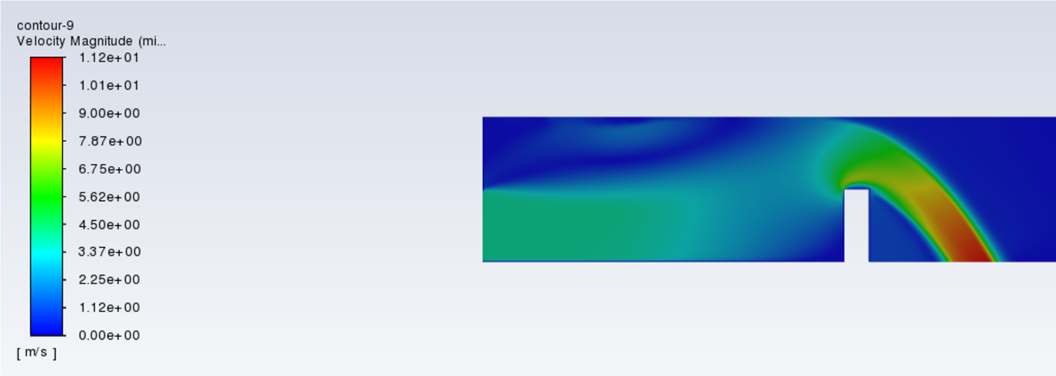


Figure 3.2 A: Velocity profile diagram under turbulent conditions with height of stream over weir = 0 m

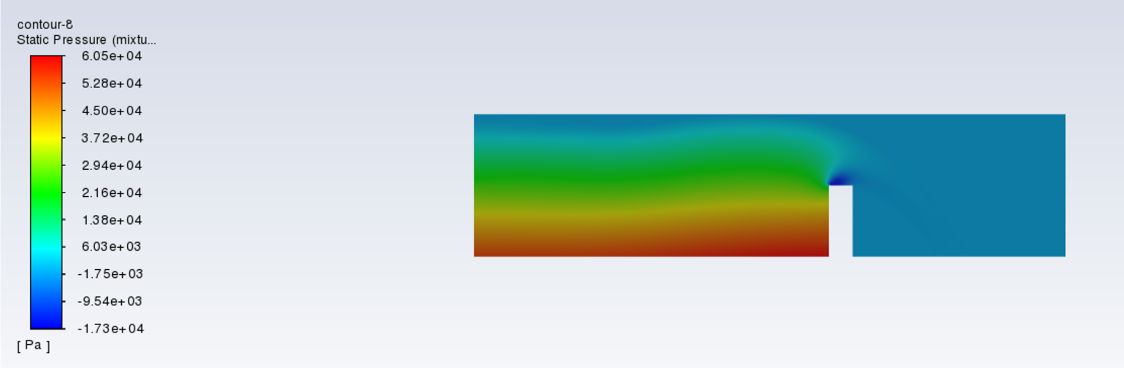


Figure 3.2 B: Pressure field diagram under turbulent conditions with height of stream over weir = 0 m

1.3.2 Case 2: $H = 0.5\ m$

Laminar flow $(v = 0.005\ m/s)$

Figure 4.1 A: Velocity profile diagram under laminar conditions with height of stream over weir = 0.5 m

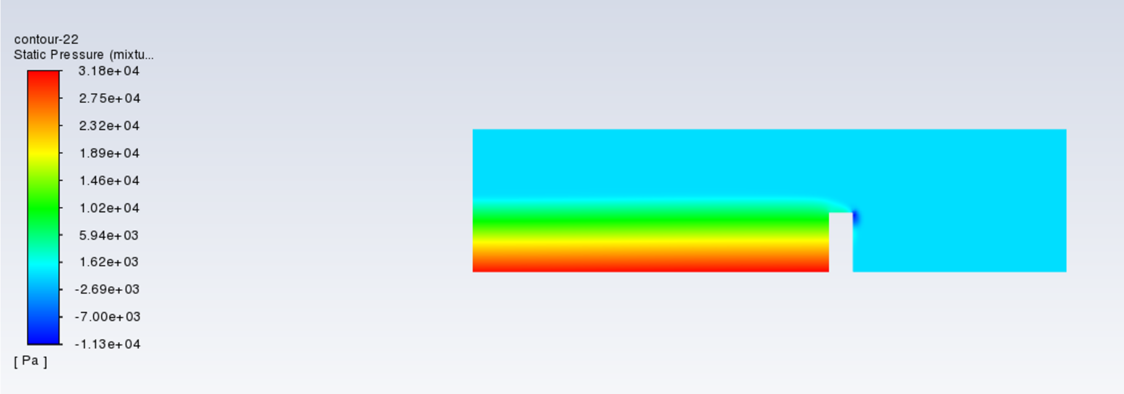
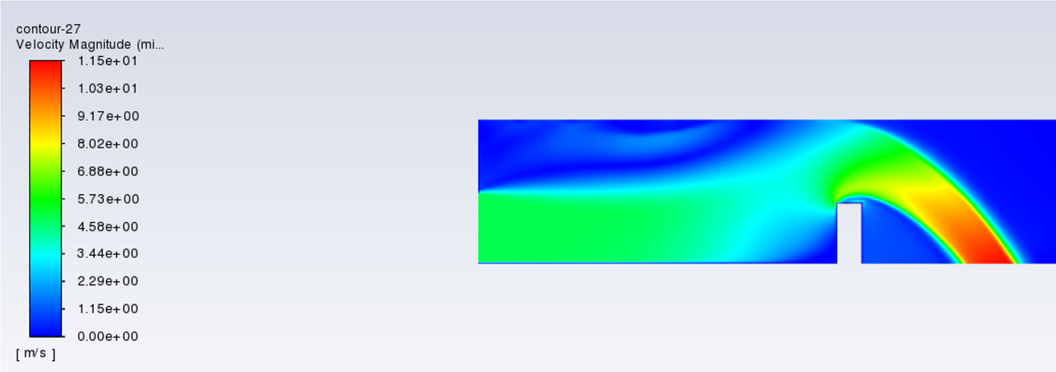


Figure 4.1 B: Pressure field diagram under laminar conditions with height of stream over weir = 0.5 m



Turbulent flow $(v = 5\ m/s)$

Figure 4.2 A: Velocity profile diagram under turbulent conditions with height of stream over weir = 0.5 m

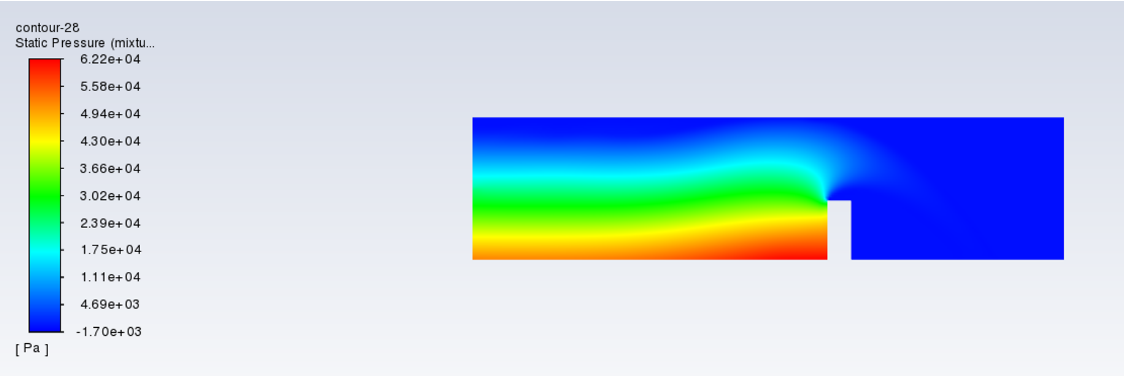


Figure 4.2 B: Pressure field diagram under turbulent conditions with height of stream over weir = 0.5 m

1.3.3 Case 3: $H = 1\ m$

Laminar flow $(v = 0.005\ m/s)$

Figure 5.1 A: Velocity profile diagram under laminar conditions with height of stream over weir = 1 m

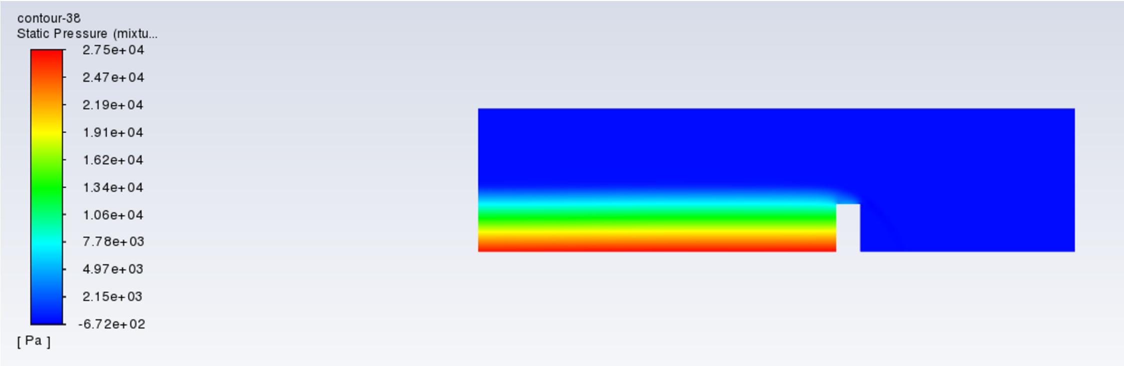
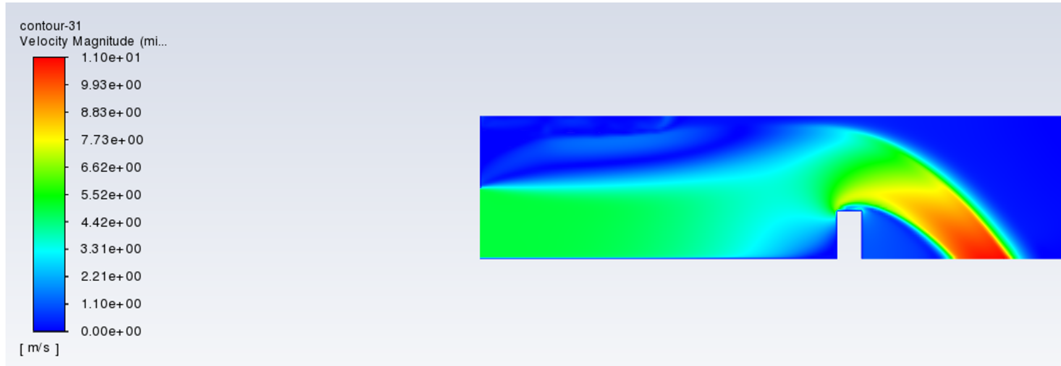


Figure 5.1 B: Pressure field diagram under laminar conditions with height of stream over weir = 1 m



Turbulent flow $(v = 5\,m/s)$

Figure 5.2 A: Velocity profile diagram under turbulent conditions with height of stream over weir = 1 *m*

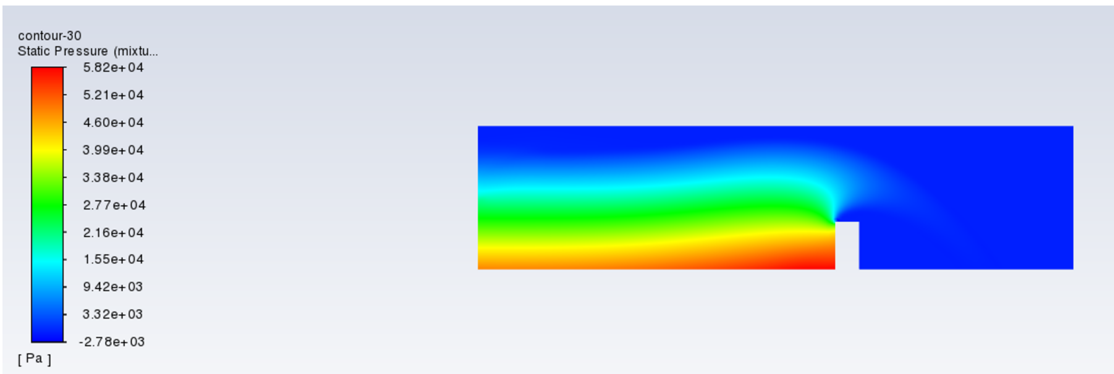


Figure 5.2 B: Pressure field diagram under turbulent conditions with height of stream over weir = 1 *m*

1.4 Conclusion

Weirs are mainly used to control the flow rates of rivers during periods of high discharge. Sluice gates (or in some cases the height of the weir crest) can be altered to increase or decrease the volume of water flowing downstream. As the height of the weir decreases, distance covered by the fluid over the flat surface also decreases. Thus, for the optimum outflow conditions the height of weir should be as close to the height of stream.

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