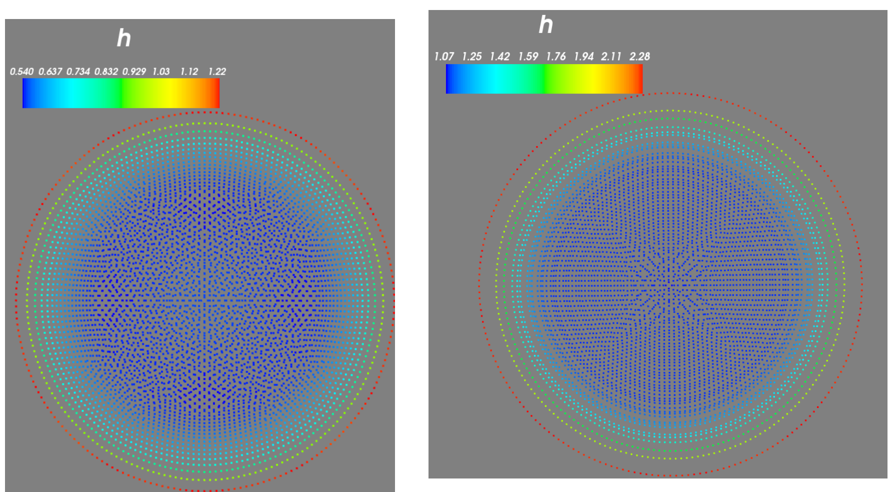
1 Cylindrical Dam Break Collapse using Newton-Raphson Variable-h SPH

1.1 Comparison with Vishnu's Simulation

- The Newton-Raphson Iterative procedure is implemented to find the smoothing length of each particle such that its neighbors are approximately constant.
- This is compared with Vishnu's simulation, wherein the smoothing length is initially doubled and recalculated from the summation density and volume of the particle.
- For the dam break shown in Fig. 1, the interior particles have retained more of their circular arrangement on using the variable-h SPH with Newton-Raphson iteration.
- For a final simulation time of 2s, the variable-h SPH using Newton-Raphson iteration took 2.5 hrs whereas the other took 0.8 hrs.



(a) Vishnu Simulation

(b) Variable-h SPH (Newton-Rapshon Iteration)

Figure 1: Top View of a Collapsing Water Column

1.2 Comparison with Rodriguez dam break example

- As shown in Fig. 2, an initially cylindrical dam of height 1m and dia 1m is made to collapse on a frictionless flat bed. Viscous effects of the fluid have not been considered.
- As shown in Fig. 3a, a perfectly flat cylindrical column height could not be maintained as first the summation density was calculated and then the height was computed based on below formula (Boundary particles having less density and hence less height compared to interior particles due to kernel truncation effect)

$$h_t = \rho * 1000 \tag{1}$$

- Comparing the simulation results (Fig. 3) with the Rodriguez example (Fig. 2) , it is observed that a good match is obtained for the fluid column height at various times.
- Comparing the simulation results (Fig. 5) with the Rodriguez example (Fig. 4) , it is observed that a good match is obtained for the fluid column width at various times.

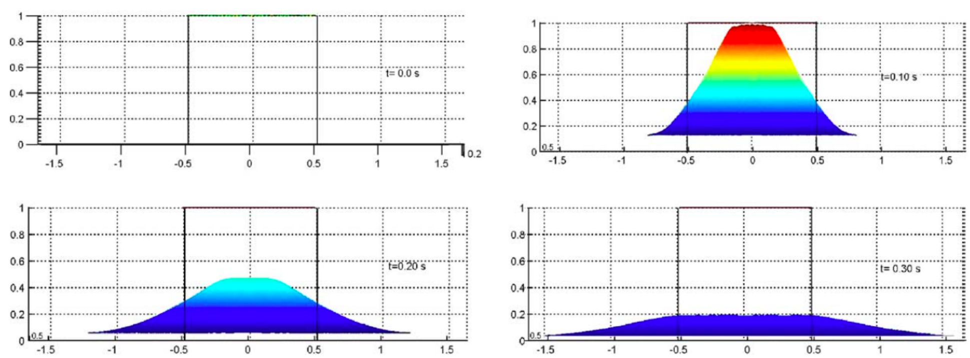
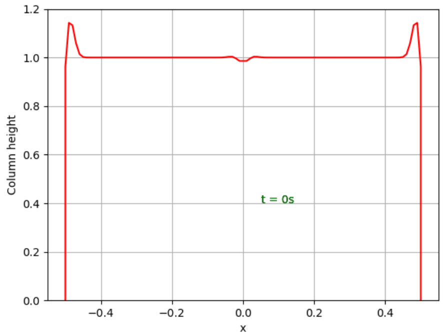
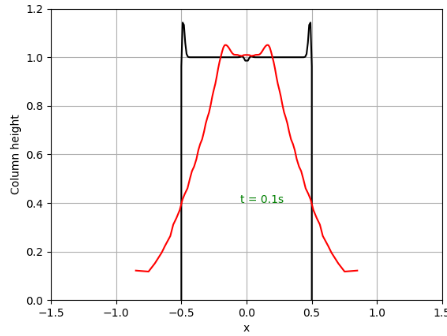


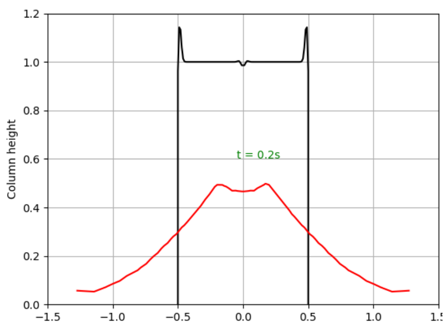
Figure 2: Collapse of cylindrical water column (Reproduced from Rodriguez et al)



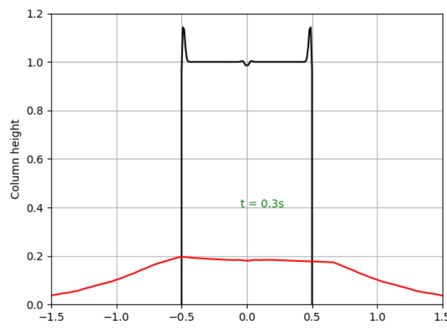
(a) t = 0 s



(b) t = 0.1 s



(c) t = 0.2 s



(d) t = 0.3 s

Figure 3: Side View of a Collapsing Water Column

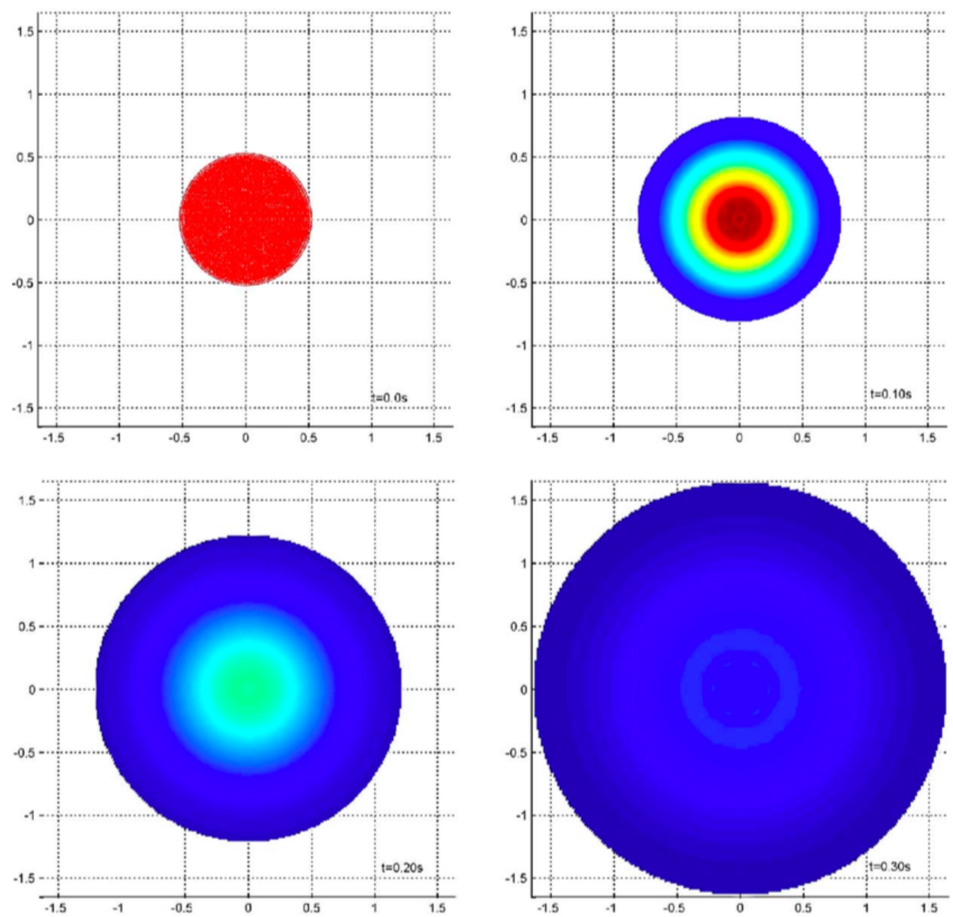
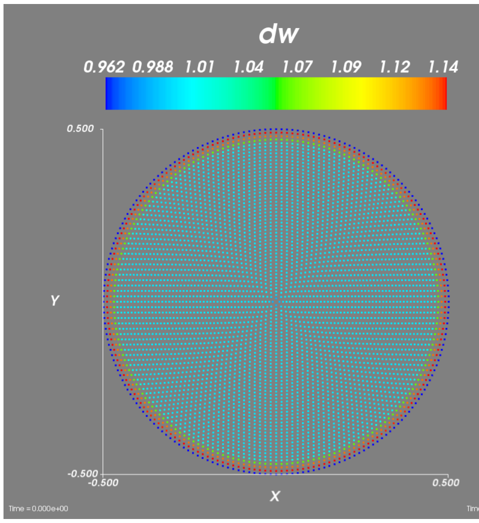
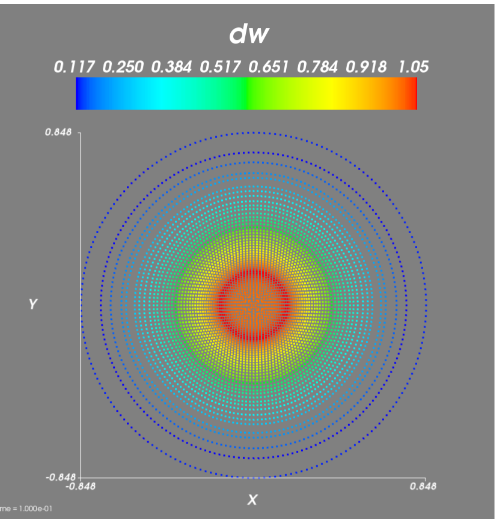


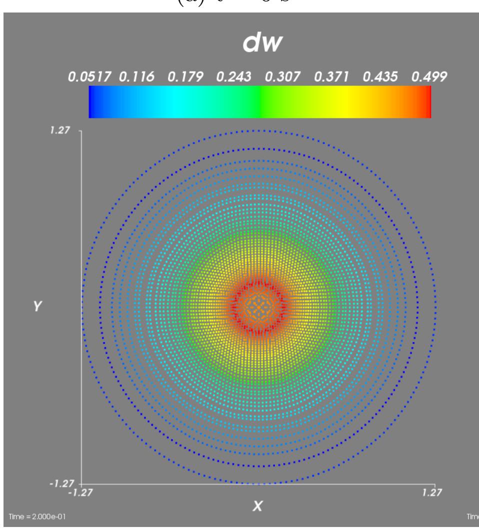
Figure 4: Top View of collapse of a cylindrical water column (Reproduced from Rodriguez et al)



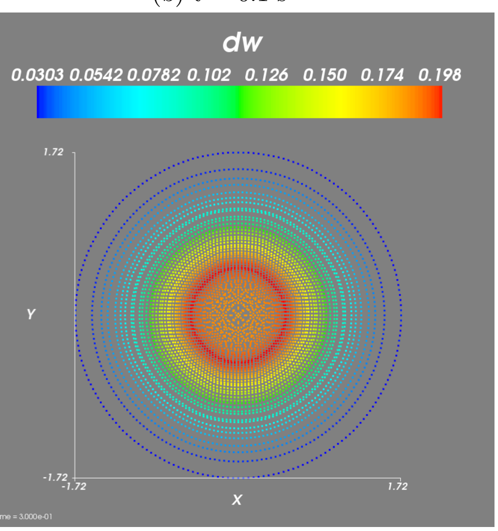
(a) t = 0 s



(b) t = 0.1 s



(c) t = 0.2 s

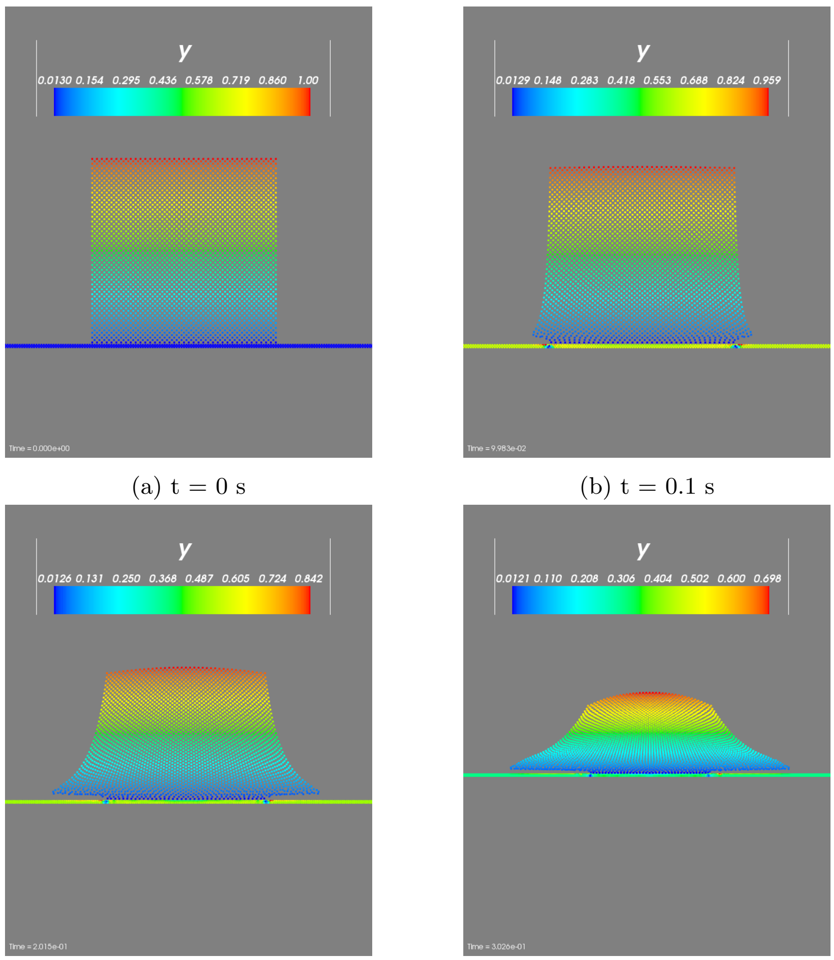


(d) t = 0.3 s

Figure 5: Top View of a Collapsing Water Column (The color represents height of column in m)

1.3 Comparison with dam break collapse using Weakly Compressible Scheme

- Due to the presence of viscosity when using the WC scheme, the dam breaks much slowly than the above simulation result. Once the dissipative friction term is added to the SWE-SPH model, I will compare it with the WC scheme.



(a) t = 0 s

(b) t = 0.1 s

(c) t = 0.2 s

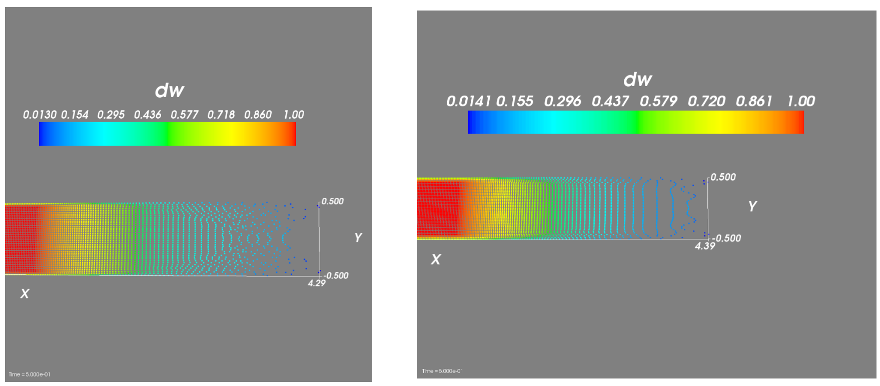
(d) t = 0.3 s

Figure 6: Side View of a Collapsing Water Column using Weakly Compressible Scheme

2 Rectangular Dam Break Collapse using Newton-Raphson Variable-h SPH

A rectangular dam of height 1m, width 1m and length 4m is made to collapse on a horizontal surface. The following are the results obtained on comparsion with the analytical solution (Ritters Solution).

2.1 Comparison with Vishnu's Simulation



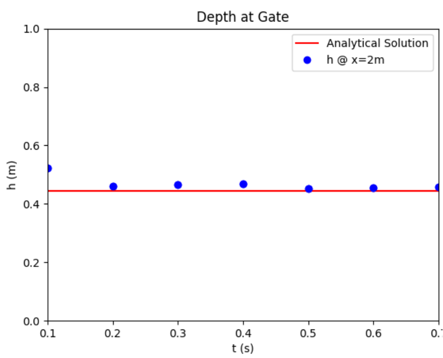
(a) Vishnu Simulation (b) SWE-SPH Newton-Raphson Iteration

Figure 7: Collapse of rectangluar dam at t = 0.5s

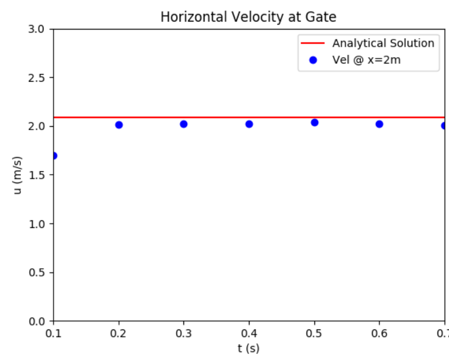
2.2 Comparison with Analytical Solution

The velocity and height of the dam at the gate is found to be constant till the backward travelling wave reaches the position x = 0.

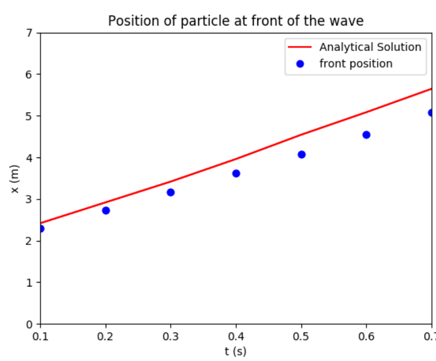
The height of the dam at the gate is given by $\frac{4}{9}h_o$
The velocity of the dam at the gate is given by $\frac{2}{3}\sqrt{gh_o}$



(a)



(b)



(c)

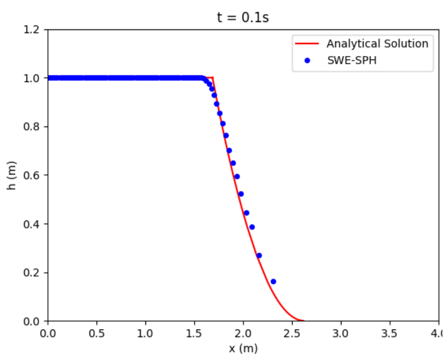
Figure 8: Comparsion of depth and velocity at the gate with Analytical Solution

The analytical expression for the profile of the dam is given by

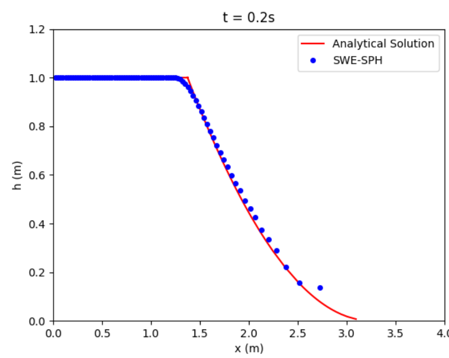
$$x = t[2\sqrt{(gh_o)} - 3\sqrt{(gh)}] \tag{2}$$

where,

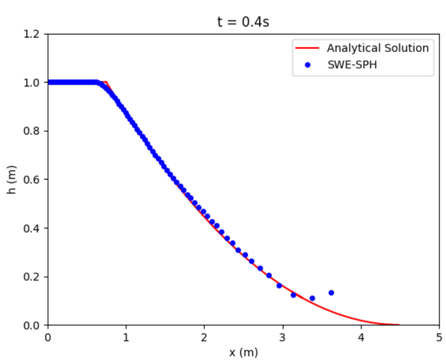
$$\begin{aligned} x &- \text{Distance measured from the dam gate} \\ h &- \text{Height of the dam after time t} \\ h_0 &- \text{Initial height of dam} \\ g &- \text{Acceleration due to gravity} \end{aligned}$$



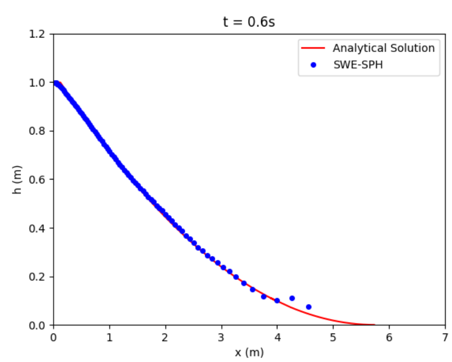
(a) t = 0.1 s



(b) t = 0.2 s



(c) t = 0.4 s



(d) t = 0.6 s

Figure 9: Dam break profile at various times