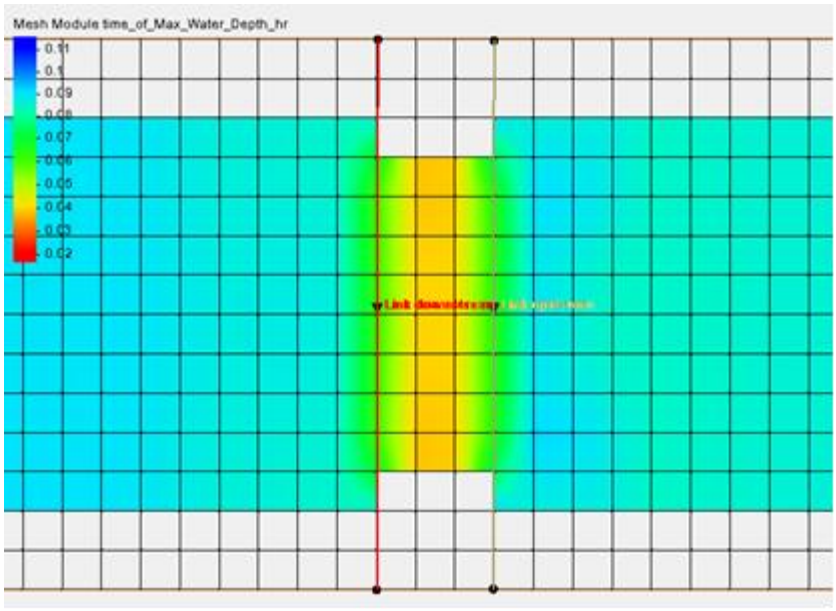
SMS 14.0 Tutorial

3D Structures (2 of 3) –
SRH-2D: Pressure Flow with 3D Structures

Using a 3D Structure to Model Pressure Flow with SRH-2D



Objectives

This tutorial shows how to simulate pressure flow in a Sedimentation and River Hydraulics – Two-Dimensional (SRH-2D) model using a 3D structure in the Surface-water Modeling System (SMS).

Prerequisite Tutorials

- Overview
- SRH-2D
- SRH-2D Simulations
- 3D Structures (1 of 3)

Required Components

- SMS Core
- SRH-2D Model & Interface

Time

- 10–20 minutes

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1 Introduction

The Sedimentation and River Hydraulics – Two-Dimensional (SRH-2D) model is a two-dimensional (2D) hydraulic, sediment, temperature, and vegetation model for river systems developed at the United States Bureau of Reclamation (USBR) and sponsored by the United States Federal Highway Administration (FHWA).

This tutorial shows how to simulate pressure flow in SRH-2D using a 3D structure. SRH-2D can simulate pressure flow using pressure zones defined in a boundary condition coverage (pressure structure) or using a 3D structure. The two methods cannot be combined in a single simulation.

This tutorial makes use of an idealized SRH-2D model. The idealized model is being used to speed up processing time. There is an existing simulation with two structures that model pressure zones under the structures. A second simulation will be run that simulates both pressure and overtopping. The overtopping will create “link-weir” boundary conditions associated with the 3D structures.

2 Opening the SMS Project

Begin by opening an existing SMS project that includes an SRH-2D simulation with its solution:

1. Open the SMS application.
2. Select *File* | **Open** to bring up the *Open* dialog.
3. Select “Project Files (*.sms)” from the *Files of type* drop-down.
4. Browse to the *data files* folder for this tutorial and select “start.sms”.
5. Click **Open** to open the file into SMS and exit the *Open* dialog.

The project contains an idealized mesh. Boundary condition arcs have already been created for the inlet and outlet conditions. A simulation has already been set up using this “ BC” coverage and the existing mesh and material coverage.

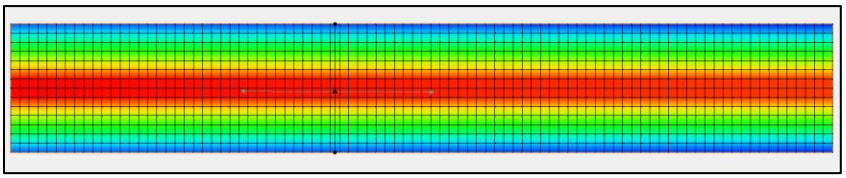

Figure 1 Initial project

This project includes two 3D structure coverages representing two separate bridges. For information on the process of defining 3D structures see the “3D Structures (1 of 3)” tutorial. For the purposes of this tutorial, these bridges provide ceiling elevations that will be used to compute pressure flow.

This approach to pressure flow simulation in SRH-2D does not represent weir flow over the top of a bridge. To simulate weir flow, a link boundary condition must be defined at the bridge location. This is demonstrated below.

3 Reviewing the 3D Structures

The ceiling elevation of the 3D structures in the project will be used to compute pressure flow. Review the 3D structures by doing the following:

1. In the Project Explorer, right-click on the "Bridge 1 – no overtop" coverage and select **Edit Structure** to open the *Structure Properties* dialog.

This dialog is used to define 3D structures (3D bridges and 3D culverts). This particular coverage is set to define a 3D bridge. Note that "Bridge" is selected in the drop-down box below the text *Structure type*. For 3D bridges, the first tab in the dialog is used to define the *Crest profile* for the bridge and the *Low chord upstream profile*. If the *Low chord downstream profile* is different from the upstream, then it can be specified as well.

2. Select the *Bridge Properties* tab.

This portion of the dialog is where the width of the bridge is specified as well as the ceiling roughness coefficient. The low chord profiles and the roughness coefficient are used to define the pressure ceiling file that is an input to SRH-2D. The last tab in the dialog is to specify overtopping parameters. This will be discussed later in the tutorial.

3. When done, click **OK** to close the *Structure Properties* dialog.
4. Review the second bridge by following steps 1–3 above for the "Bridge 2 – no overtop" coverage.

To visualize the bridges graphically, a 3D UGrid for each bridge has been added to the project. The UGrids are not necessary to compute pressure flow but have been included for the sake of illustration. To view the 3D bridges in the Graphics Window, complete the following:

5. In the Project Explorer, turn on the "UGrid Data" item.
6. Using the **Rotate** tool, rotate the Graphics Window to view the 3D bridges.
7. When done viewing the bridges, select the **Plan View** macro.
8. Turn off the "UGrid Data" object in the Project Explorer.

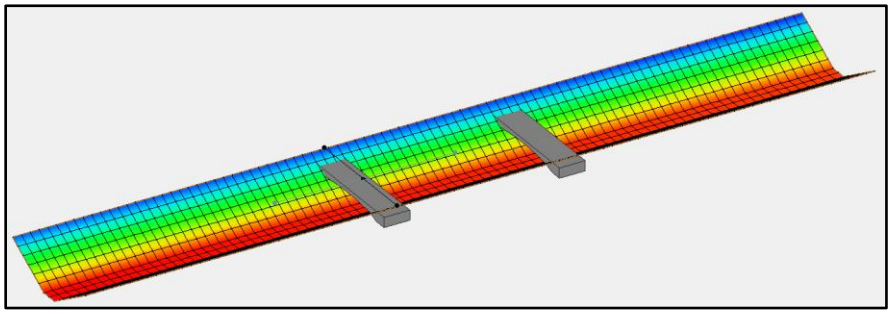

Figure 2 Viewing the 3D bridge UGrids

4 Linking the 3D Structure

After reviewing the 3D structures, the structures need to include overtopping parameters and be linked to the second simulation. Two different structure coverages are used in the "Overtop" simulation so the "No_Overtop" simulation will remain unchanged. To do this:

1. In the Project Explorer, right-click on the "Bridge 1 – overtop" coverage and select **Edit Structure** to open the *Structure Properties* dialog.
2. Select the *Overtopping* tab.
3. Turn on the *Model overtopping* option.

This will allow overtopping for the structure to be included in the simulation run. When this coverage is included in a simulation an SRH "Link weir" boundary condition will be defined at the upstream and downstream faces of the bridge. The elevation of the weir comes from the average elevation of the *Crest profile*. The *Weir length* and the *Weir type* must be specified. In this case the weir type will be left at the default: "Paved". The weir length is defaulted to the length of the arc in the coverage. The weir length refers to the length of the bridge over which water can overtop the bridge. When a 3D bridge is defined it often intersects the embankment, so this length is usually shorter than the length of the bridge arc in the coverage.

4. For the *Weir Length*, enter a value of "186.0".
5. Click **OK** to close the *Structure Properties* dialog.

Now add the structure to the simulation.

6. Right-click on the "Bridge 1 – overtop" coverage and select the *Apply To* | **SRH-2D Simulations** → **Overtop** command.
7. Repeat steps 1–6 using "Bridge 2 – overtop".

5 Saving and Running SRH-2D

Before running the model, it needs to be configured. Then, the project should be saved with a new name. To do this:

1. Right-click on the "Overtop" simulation and select **Model Control…** to open the *SHR2D Model Control* Dialog.
2. In *Initial Conditions*, select *Initial Water Surface Elevation*.
3. Enter "351.0" in the *Initial Water Surface Elevation* and choose *Feet*.
4. Select *File* | **Save As** to bring up the *Save As* dialog.
5. For the *File name* enter "structure.sms" and click **Save** to close the *Save As* dialog.

The project is now ready to run.

6. Right-click on the "Overtop" simulation and choose **Save Project, Simulation and Run**.
7. This brings up the *Simulation Run Queue* dialog.

As SRH-2D is running, feel free to review the plots from the simulation by selecting the SRH-2D process and stepping through the tabs for the plots.

8. Once SRH-2D is finished, click **Load Solution** to import the solution datasets.

9. Click **Close** to exit the *Simulation Run Queue* dialog.

Several solution dataset will appear in the Project Explorer.

6 Viewing the Results

Now to review the results of the model run:

1. Select the "Water_Elev+Pressure_ft" dataset under the "Overtop" solution to make it active.

Notice how the water constricts around the first bridge (Figure 3).

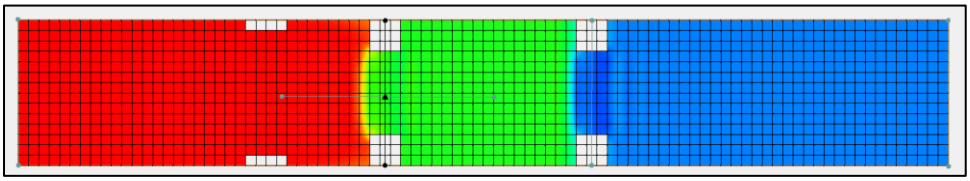

Figure 3 The "Water_Elev+Pressure_ft" dataset

2. Select the "Water_Elev+Pressure_ft" dataset under the "No_Overtop" solution to make it active.

Notice the difference in the contours for the simulation that has no overtopping. (Figure 4).

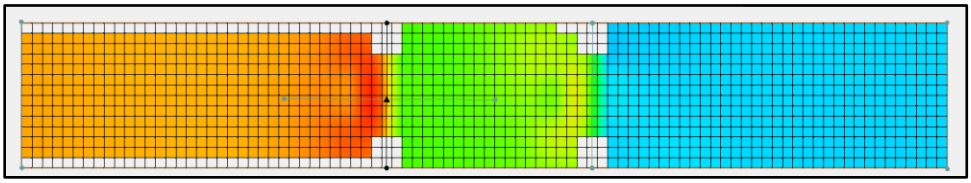

Figure 4 The "Water_Elev+Pressure_ft" dataset for "No_Overtop"

Compare other datasets in the solutions by selecting them and visualizing the contours.

6.1 Viewing the 3D Structure Summary

The 3D structures can be used to view a plot of the simulation run at the structure location. These plots show the flow that overtops the structure as well as the upstream, downstream, and crest elevation.

1. In the Project Explorer, right-click on the "Bridge 1 - overtop" coverage and select **3D Structure Summary** to open the *3D Structure Summary* dialog. The first tab in the dialog shows the plots.
2. Under *Plots*, turn on *WSE_up,* and *WSE_down*.

Review the plots created at the structure location. The plots should appear similar to Figure 5. The flow under the bridge as well as the overtopping flow can be viewed by turning on the *Q-Structure(cfs)* and *Q-Overtopping(cfs)* items, respectively.

Note, there are no structure plots for the "Bridge 1 – no overtop" or "Bridge 2 – no overtop" coverages because they do not use the overtopping option.

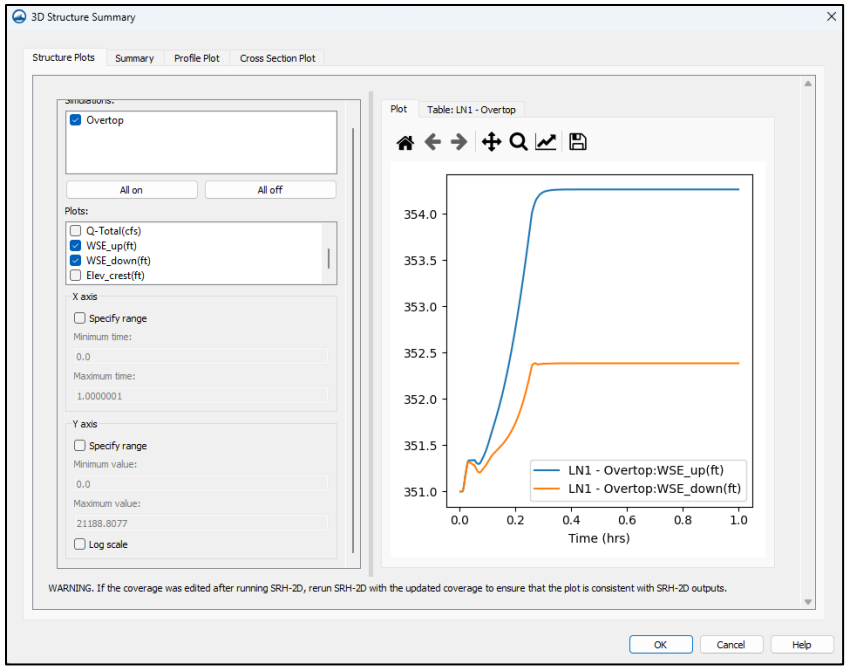

Figure 5 SRH-2D structure solution plots

3. Select the *Summary* tab.

This tab provides a summary of the flows and elevations at the 3D Structure for the selected time value. There are also tabs for creating a profile plot and a cross-section plot at the 3D Structure.

4. Select the *Profile Plot* tab.
5. Click **Select Coverage** to open the *Select Profile Line Coverage* dialog.
6. Select the “Profile” coverage and click **OK** to close the *Select Profile Line Coverage* dialog.
7. Under *Simulations*, turn on the *Overtop* item.

A profile plot is now displayed with the ground surface, water surface elevation and the 3D structure as intersected by the arc in the “Profile” coverage.

8. Select the *Cross Section Plot* tab.
9. Under *Simulations* turn on the *Overtop* item.

A cross-section plot is now displayed with the ground surface, water elevation surface and 3D Structure as intersected by the center line of the 3D structure.

Note, if the 3D structure is included in multiple simulations, then those simulations will be available and can be compared in the plot. Additionally, the output time can also be selected to update the plots.

10. When done, click **OK** to exit the *3D Structure Summary* dialog.

7 Conclusion

This concludes the “SRH-2D Pressure Flow with 3D Structures” tutorial. If desired, experiment with different options in this project. Some options could include:

- Adjust the Manning’s N value for the underside of the bridge.
- Change the elevation of the weir simulated by the link by changing the crest profile for the structure.