Task 0: Static determincy

No.

Structure type

Static determinacy

Degree of freedom

1

Cable

Unstable

-1

2

Truss

statically determinate

3

3

Arch-cable

Unstable

1

4

Truss

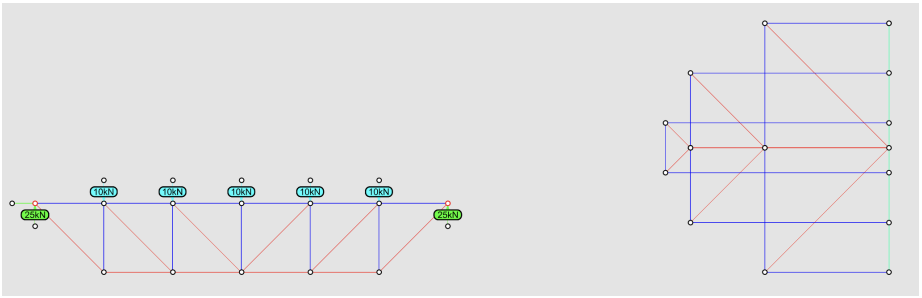
statically indeterminate

-

Arch-cable is only stable under specific loading. The shape of the arch-cable should be form found. As long as the loading changes, the arch-cable is no longer stable. Truss is composed of only triangles and it can take any loading conditions.

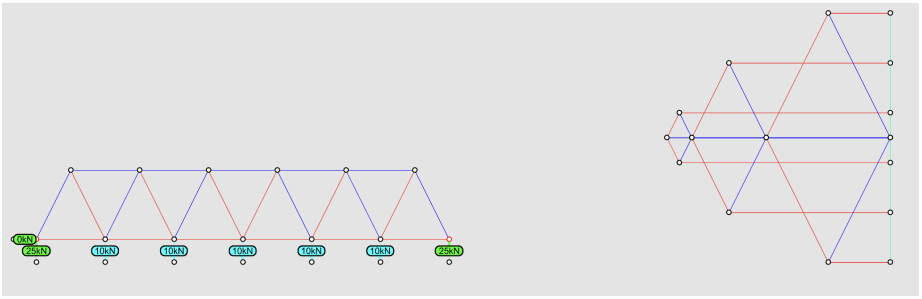
Task 1: Analysis of trusses

Truss 1:

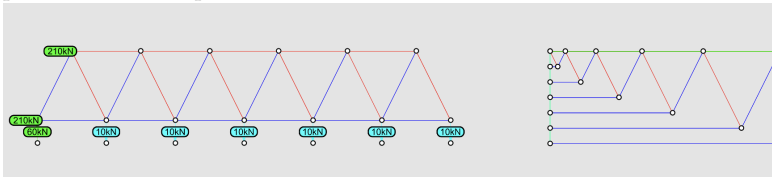


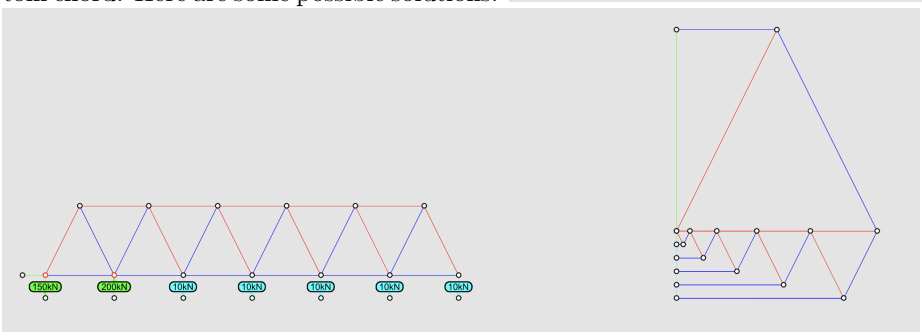
Compared with the truss in tutorial 2. Analysis of a truss, the members in tension are in compression; the members in compression are in tension. A truss under uniform loading behaves like a beam, the top is always in compression and the bottom is always in tension.

Truss 2:

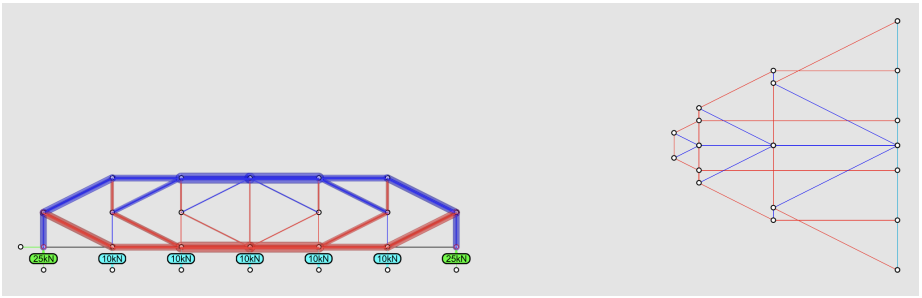


A cantilever truss will have tension in the top chord and compression in the bottom chord. Here are some possible solutions.

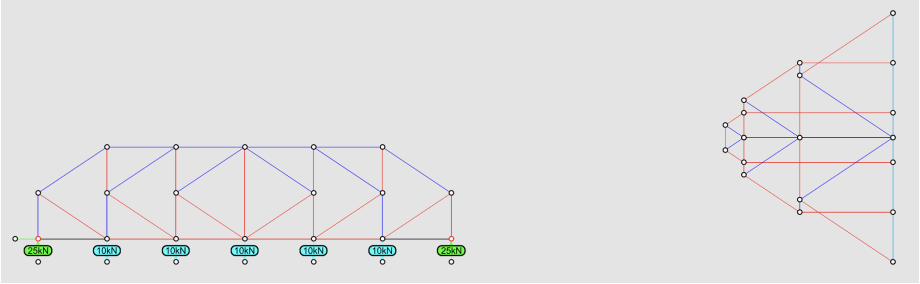




Truss 3:



The largest forces in the top chord and the bottom chord are located in the middle of the span. The force magnitude is 40 kN. The largest forces in the diagonals are near the supports. The force magnitude is 28 kN.



The forces in the members can be reduced by increasing the height of the truss,

Task 2: Cantilever arch-cable structure

The cantilever arch-cable structure can be constructed in the following steps:

Part 1: 1. Find the intersection point of the reaction force and the load on the most right location. Draw a curve, and find the intersection between the curve and the external loads loads. Redraw the curve as segments.

Figure 1: Fig-1-3

2. Conmpute the form diagram. Assign one force, and compute the force diagram. The external loads are not constant.

1. Assign default constraint. Assign target edge magnituede 10kN to the external loads.

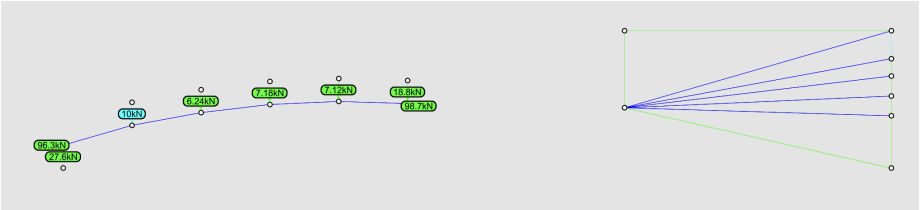


Figure 2: Fig-1-3

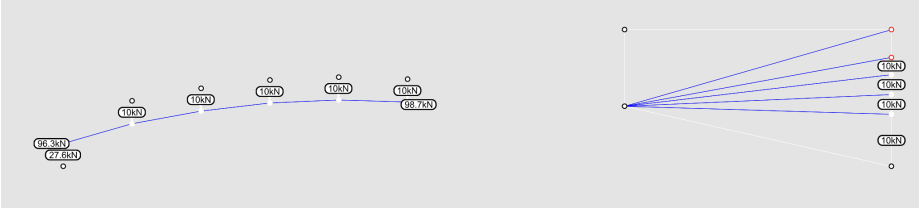


Figure 3: Fig-1-3

1. Update the diagrams. Note that if your horizontal reaction force is very large, sometimes the solver cannot converge perfectly. The tolerance difference is accepted for this exercise.

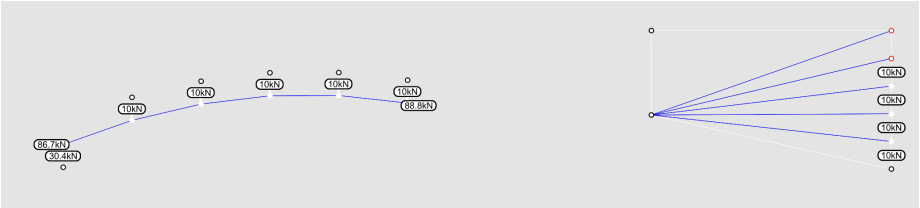


Figure 4: Fig-1-3

5. Use the form-found arch to construct the input lines for the arch-cable. The upper chord needs to be segments. The top support should be drawn as one horizontal reaction force and one vertical reaction force.

1. Compute the form and force diagram.

Part 2: Adding diagonals can help the arch-cable to resist non-uniform loadings.

Part 3: For the arch-cable in tutorial 4. The rise of the arch changes to achieve constant force in the upper chord(Fig-3-1). Similarly, to allow constant force in the lower chord, the rise of the bottom chord needs to move. Thus, we need to unfix the bottom support and add a line constraint to the support so that it remains on the vertical cliff.

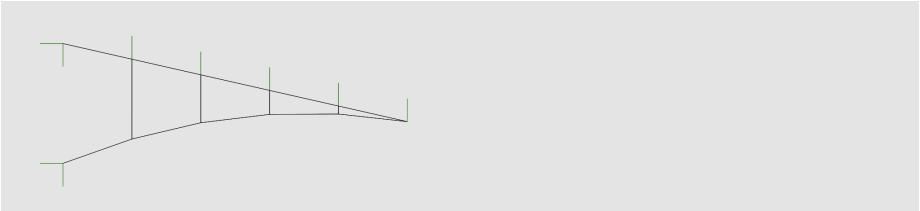


Figure 5: Fig-1-3

Figure 6: Fig-1-3

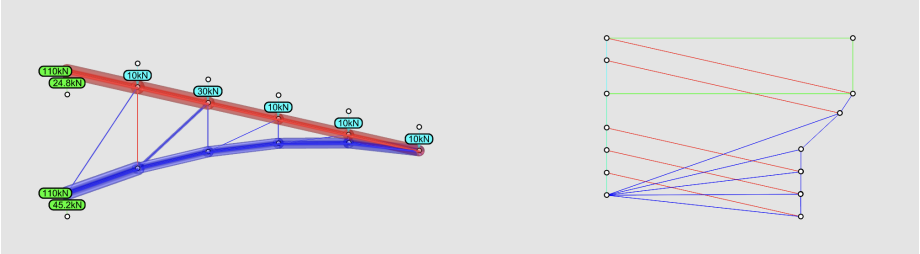


Figure 7: Fig-1-3

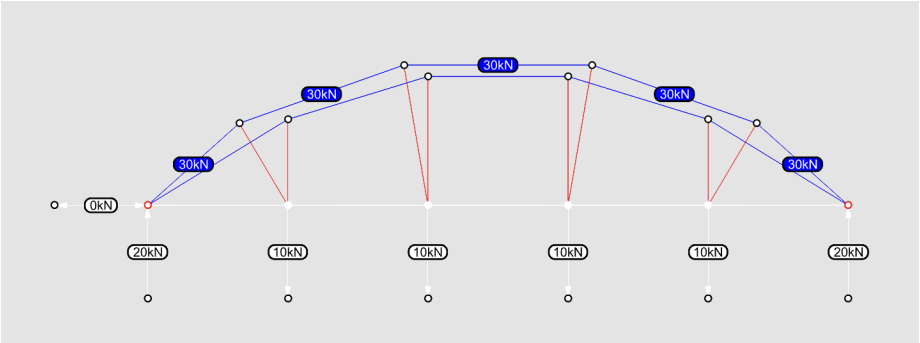


Figure 8: Fig-1-3

1. We can use edge inspector to find a reasonable edge magnitude to assign to the bottom chord.

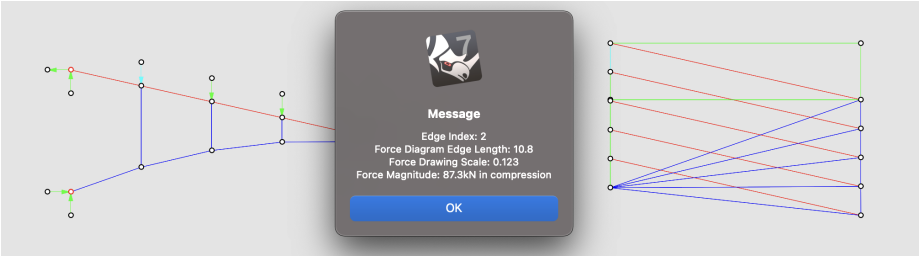


Figure 9: Fig-1-3

2. Now assign the constraints.

   A. Fix the top support on the cliff.

   B. Add default constraint, this will:

   - fix orientation of reactional forces and external loads
   - vertices where external loads are applied remain on the line of action of the load
   - fixed support remain in place

   C. The bottom support is not fixed but should remain on the vertical cliff. Use vertex constraint, select the support, and keep it in y-direction.

   D. Assign a target constant force in the bottom chord.

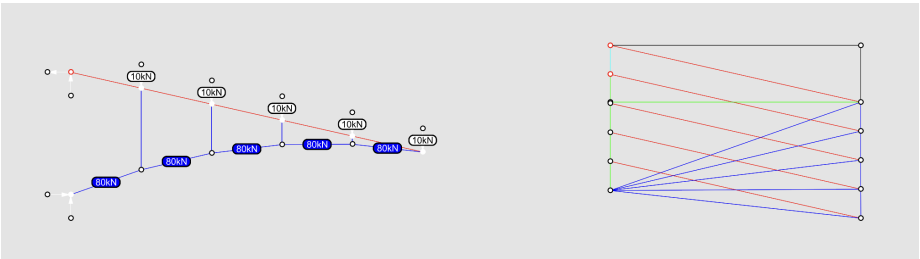


Figure 10: Fig-1-3

1. Update both diagrams.

Task 3: Design your bridge

Part 1:

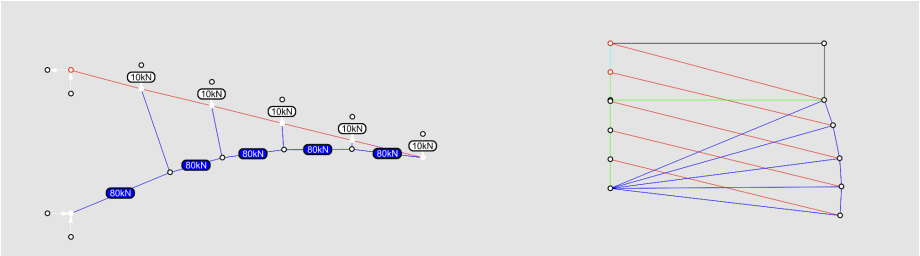
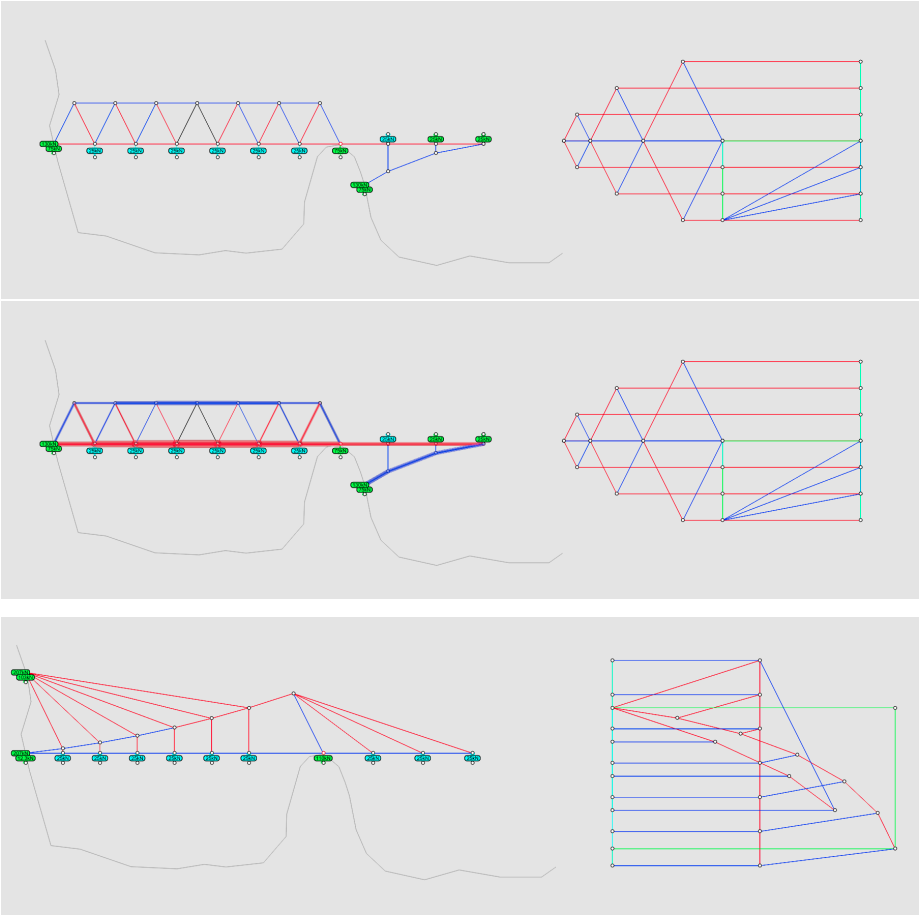
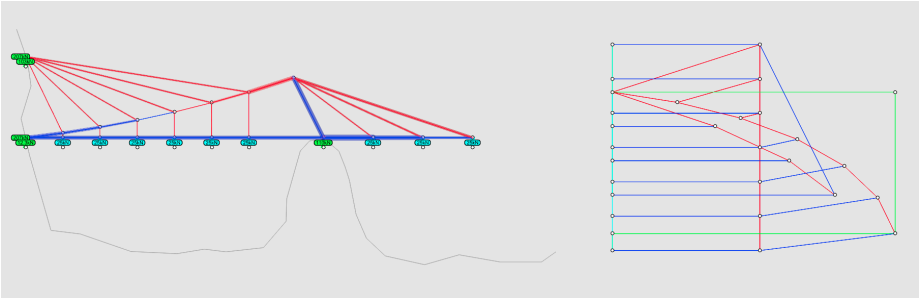
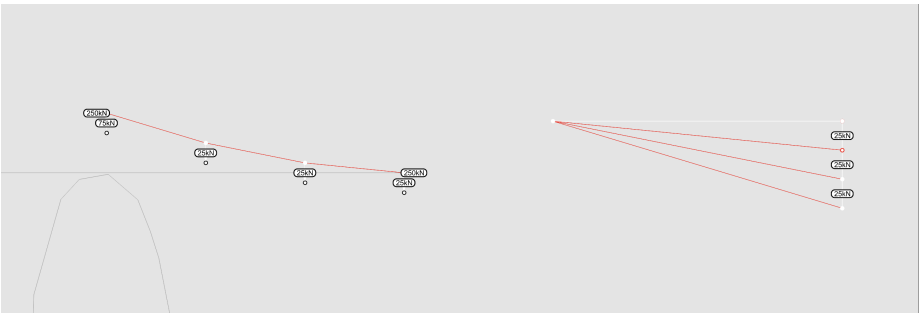


Figure 11: Fig-1-3

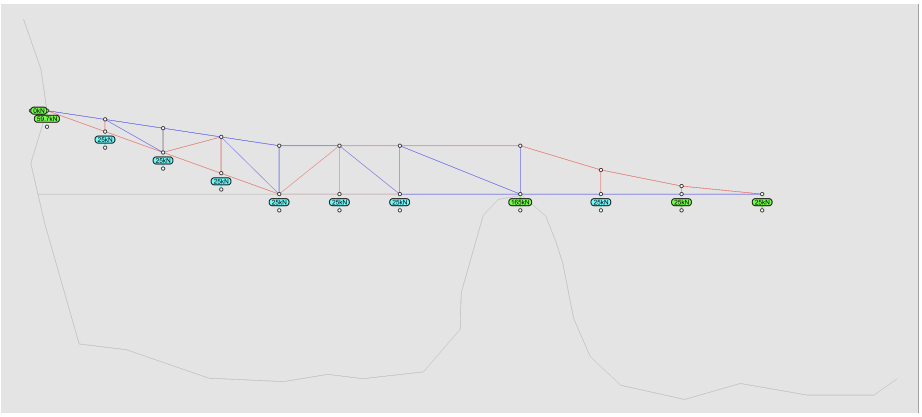


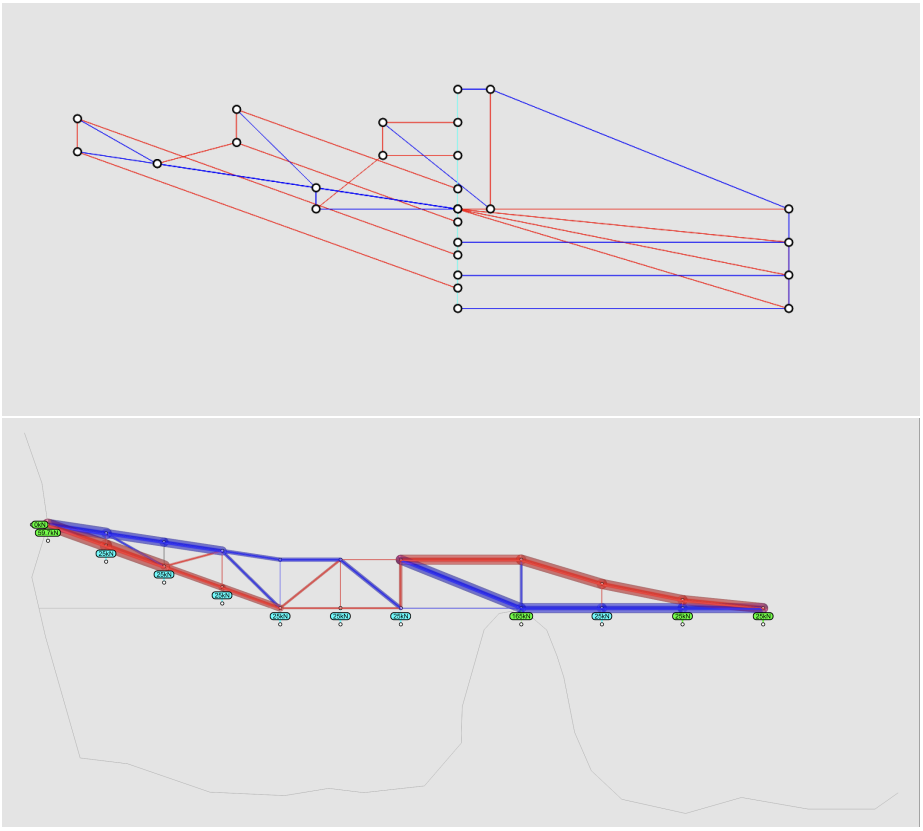


Part 2: Solution I: This solution is a combination of a truss and an arch-cable - Step 1: Form find the arch. Here we will construct a cantilever arch-cable.



- Step 2: Since a truss can take any forces. Simply draw the truss based on the form-found arch-cable.





Solution II: This is solution is composed of two cantilevering arch-cables. - Step 1: Solve the left side of the arch-cable. You can refer to the solution of Task 2.

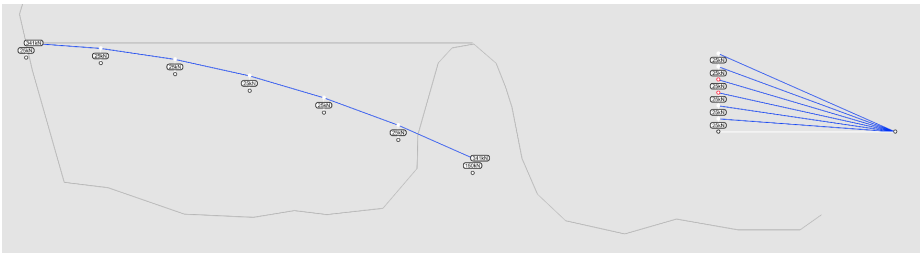


Figure 12: Fig-1-3

- Step 2: Solve the right part. The left part and right part should have the same horizontal force. Allow the left extreme support to move vertically so that the rise of the arch can change, and the horizontal force can be modified. Set the target force of the two horizontal forces to the horizontal force in the left part. Here is the form found arch of the right part.

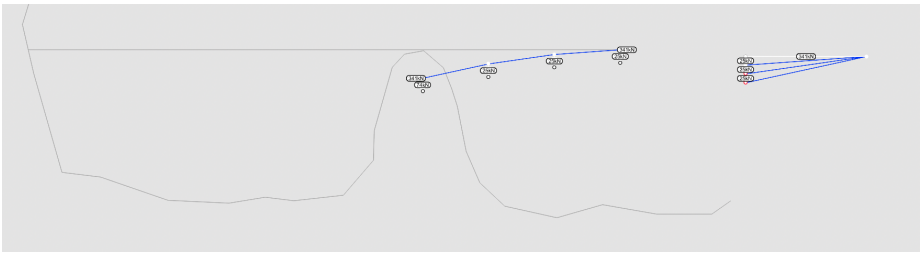
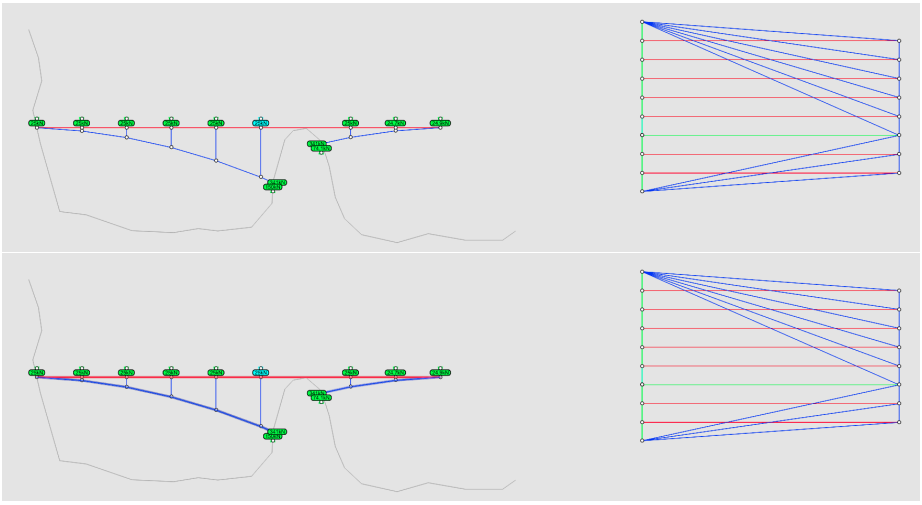


Figure 13: Fig-1-3

- Step 3: Add upper chord and the vertical struts. Verify the design. Note that decimal difference can happen, which can be ignored.



Solution III: This solution follows similar steps as solution II. Firstly solve the cantilevering part on the right. Secondly solve the arch on the left and make sure that the horizontal reaction force on the left and right are the same.

- Step 1
- Step 2
- Step 3

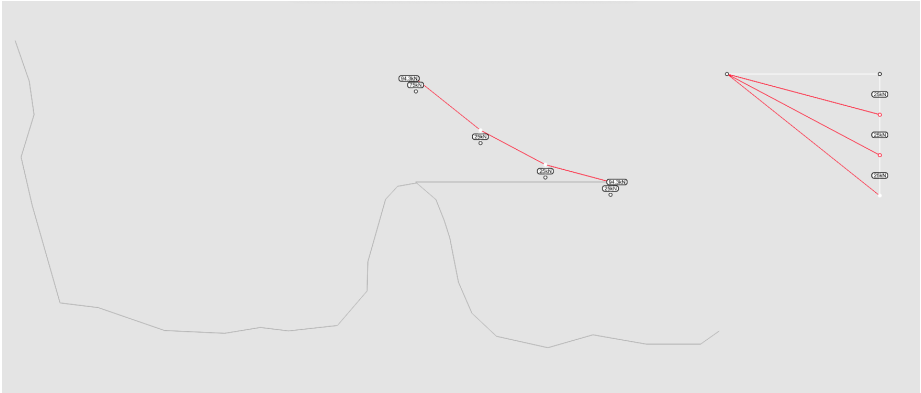


Figure 14: Fig-1-3

Figure 15: Fig-1-3