The Institution of Structural Engineers

Possible solution to past AM examination question

Question 4 - April 2011

Viewing Tower

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Question 4. Viewing Tower

Client's Requirements

1. A viewing tower is required to overlook an exposed coastal site. The tower is to have an observation area located at a height of 12m, accessed by a spiral staircase. See figure Q4.
2. A roof is required over the observation area.
3. The sides of the observation area are to be constructed with the minimum of obstructions.
4. The staircase is to be provided with a weatherproof envelope to protect users.

Imposed Loading

5. Roof 0.75kN/m²
   Observation area floor 5.0kN/m²

Site Conditions

6. The site is level and open.
7. Basic wind speed 44m/s based on a 3 second gust; the equivalent mean hourly wind speed is 22m/s.
8. Ground conditions:
   Ground level – 3.0m Loose sand, N = 5
   Below 3.0m Chalk, allowable bearing pressure 100kN/m²
   No groundwater was encountered.

Omit From Consideration

9. Local design of the spiral staircase.

SECTION 1 (30 marks)

a. Prepare a design appraisal with appropriate sketches indicating a viable structural solution for the proposed scheme. Indicate clearly the functional framing, load transfer and stability aspects of the scheme. Justify the reasons for your solution. (20 marks)

b. Upon completion of the design the client asks whether the tower can be increased in height to 15m to the observation area. Describe the implications this will have on the original design. (10 marks)

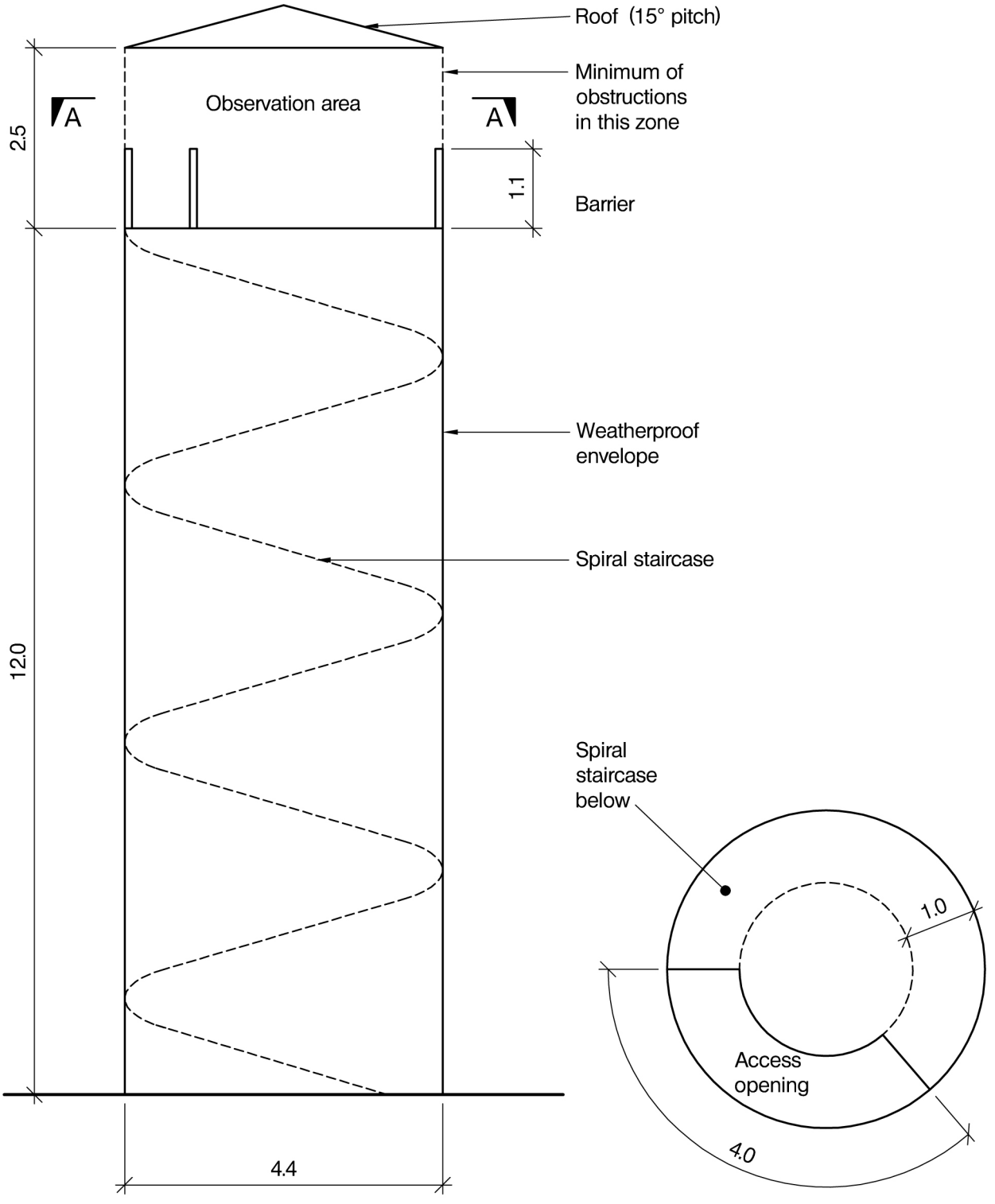
SECTION 2 (70 marks)

For the solution recommended in Section 1(a):

c. Prepare sufficient design calculations to establish the form and size of all principal structural elements including the foundations. (30 marks)

d. Prepare general arrangement plans, sections and elevations to show the dimensions, layout and disposition of the structural elements for estimating purposes. Prepare clearly annotated sketches to illustrate details of:
   (i) The formation of the opening in the floor of the observation area.
   (ii) The connection of the barrier with the supporting structure. (30 marks)

e. Prepare a detailed method statement for the safe construction of the tower. (10 marks)



ELEVATION

PLAN A-A

NOTE: All dimensions are in metres

FIGURE Q4

Viewing Tower

The brief and appraisal of the issues

Initially this looks a rather daunting question with the brief relating to a circular observation tower. However, it is actually a relatively straightforward vertical cantilever with an observation platform on top. There is solid ground at 3m. Therefore the question divides into three elements: the observation area, the tower and the soil/foundation.

Development of a structural scheme to satisfy the brief

The tower

The first issue to deal with is how the circular form will be achieved. It is possible that this could be formed from a circular membrane, similar to a tower or chimney, but of course this would be difficult to analyse and design under exam conditions. It would be far simpler to create a structure with straight elements to support the observation platform and allow the cladding to create the final curved form.

There are three options available:

- to build a lattice structure around the circumference comprising columns and diagonal bracing, see Figure 1a and Figure 2
- to build a similar arrangement but inside the spiral staircase (this has the advantage of avoiding complications relating to the circular weatherproof envelope but has the disadvantage of being a more slender cantilever, see Figure 1b
- to stabilise the tower with a series of braced cantilevers running diagonally across the inner circular space, see Figure 1c.

Observation area

The design of the observation area allows some imagination, particularly in relation to the requirement for minimal obstruction in the circumference that forms the viewing area. It is absolutely crucial that you observe this requirement which can be dealt with by providing light columns to carry the weight of the roof and provide stability, see Figure 3a. However it is possible, with a little imagination, to provide a completely free observation area, at the expense of a less robust structural arrangement, by running

internal columns from the top of the tower to the observation area's roof and cantilevering the roof. See Figure 3b. Although the question only requires you to provide one proposal, a design appraisal could explore different options and demonstrates to the examiners that you can see different ways of satisfying the brief, and assessing the pros and cons of each.

Ground conditions and foundations

The ground conditions comprise of loose sand from ground level to 3m which would not be capable of supporting the tower. At 3m there is chalk with an allowable ground bearing pressure of 100kN/m^2. A circular foundation on the chalk would provide an appropriate solution.

Client change

The scenario presented in section 1b relates to the client enquiring about the implications of increasing the height of the tower by 3m prior to any construction taking place. The design of the observation platform would remain unchanged, and the increased height would not present any fundamental changes to the design philosophy. It would however increase the overall slenderness of the tower, marginally increase the axial load due to self-weight and increase the moment induced by wind loads, further increasing axial loads in the columns, forces in the bracing and overturning moments on the foundation. All these forces should be readily accommodated in a straightforward redesign which will result in slightly larger sections in the tower, and a larger foundation.

Summary

This is a relatively straightforward question, however the circular nature of the tower could well be off-putting. This illustrates the importance of perusing each of the questions and keeping an open mind until each has been assessed. However it is fully acknowledged that reading and understanding more than one question at the start of the examination is time-consuming.

Once the decision has been taken to attempt this question, it breaks down to three relatively straightforward elements with some scope for different structural options, but remains manageable in both scale, and the volume of calculations and drawings required.

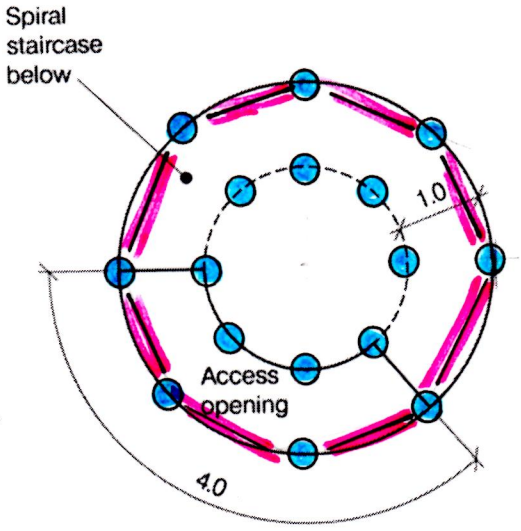


FIGURE 1a.

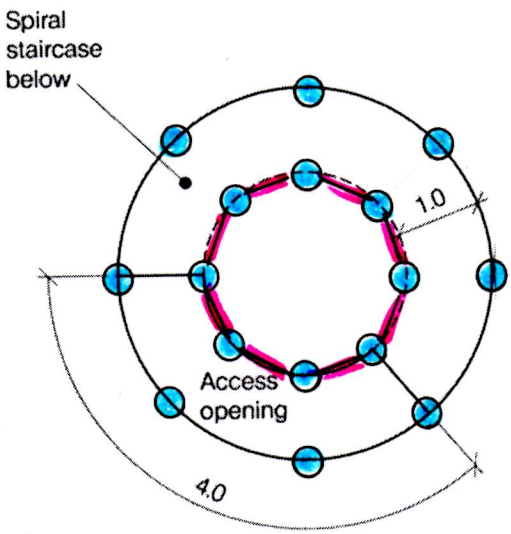


FIGURE 1b.

COLUMN

BRACING

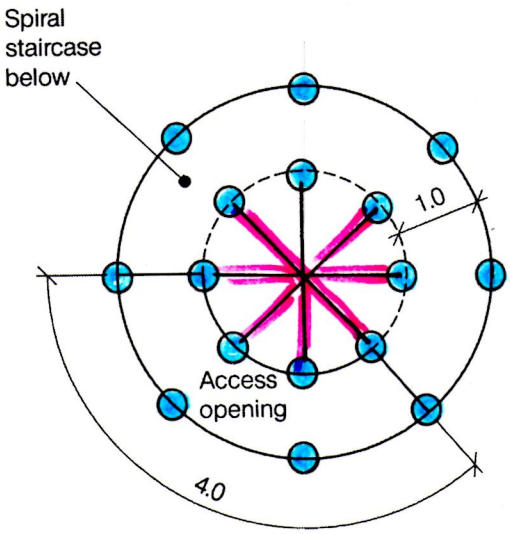
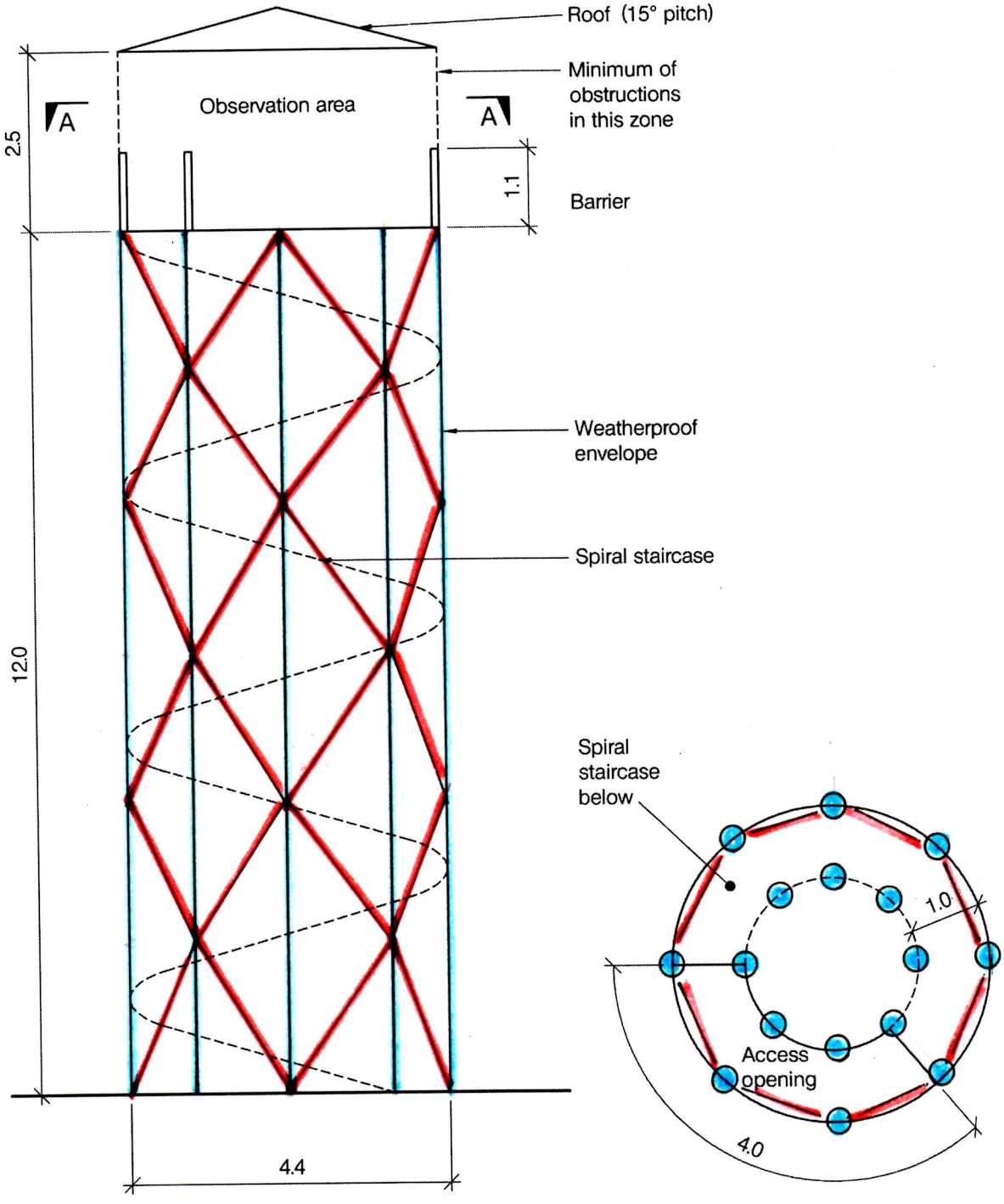


FIGURE 1c.



ELEVATION

PLAN A-A

FIGURE 2 - OPTION (a)

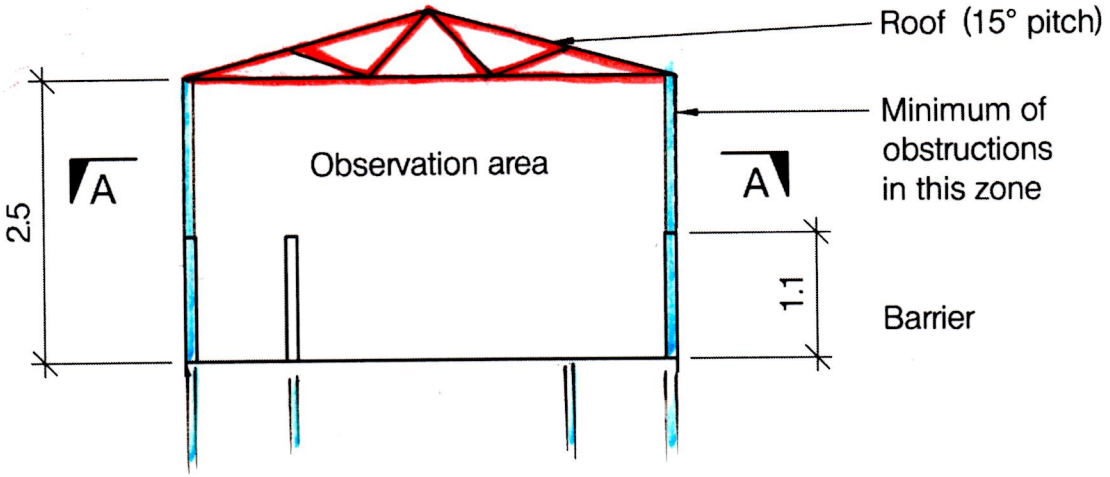


FIGURE 3a

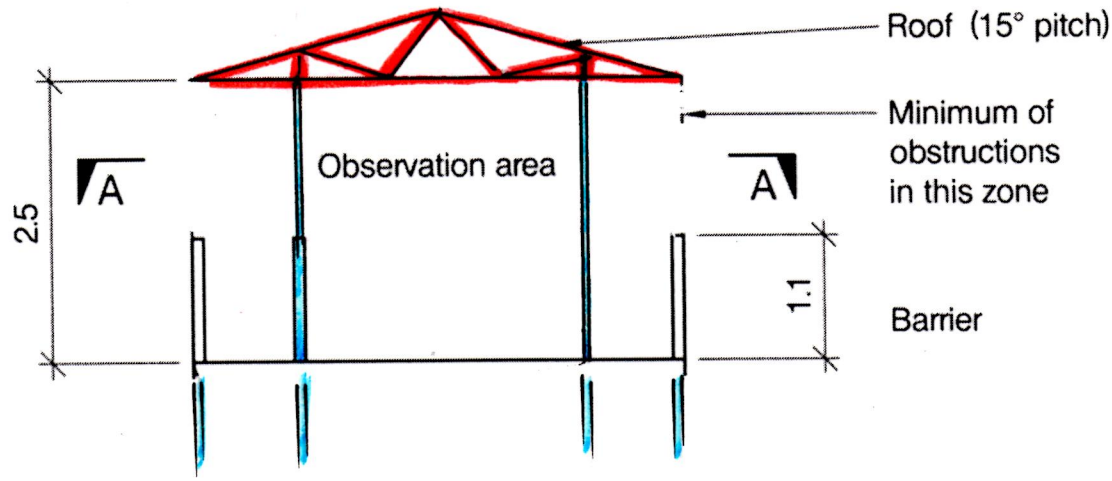


FIGURE 3b.