

Chapter 15

Civil Engineering Standard

Method of Measurement

15.1 Canal aqueduct

An aqueduct is required to enable a canal to be carried over a new road which is to be constructed beneath. The abutment walls of the aqueduct, and the adjacent wing walls, require the installation of 30 nr ground anchors. The work involves drilling into ground which includes some rock.

15.1.1 Construction method

The aqueduct is to be constructed using ‘top-down’ construction in the following (simplified) sequence:

- Stank-off existing canal during autumn–spring possession period.
- Remove section of existing canal.
- Install two rows of secant piles to form the abutment walls to carry the aqueduct over a new road to be constructed below.
- Construct capping beams.
- Install ground anchors.
- Construct reinforced concrete aqueduct.
- Commission canal and open to traffic.
- Excavate beneath aqueduct and construct new road.
- Face up secant pile walls with brickwork.

This is illustrated in Figure 15.1.

15.2 Ground anchors

Figure 15.2 shows a typical cross section at an anchor point where the Commencing Surface is below the Original Surface.

For simplicity, the anchors are assumed to be 100 mm diameter and 15 m long. The length drilled into rock at each anchor is 3 m.

15.2.1 Commencing surface

It can be seen from Figure 15.1(a) and (d) that the Commencing Surface for the ground anchor work is at an indeterminate level, below the deck of the new aqueduct. This is the level at which there is a



(a)



(b)



(c)



(d)

Figure 15.1 Construction details. (a) Stanking to existing canal and ground anchor locations, (b) Access to bridge deck, (c) Bridge deck construction and (d) Abutment wall and ground anchors.

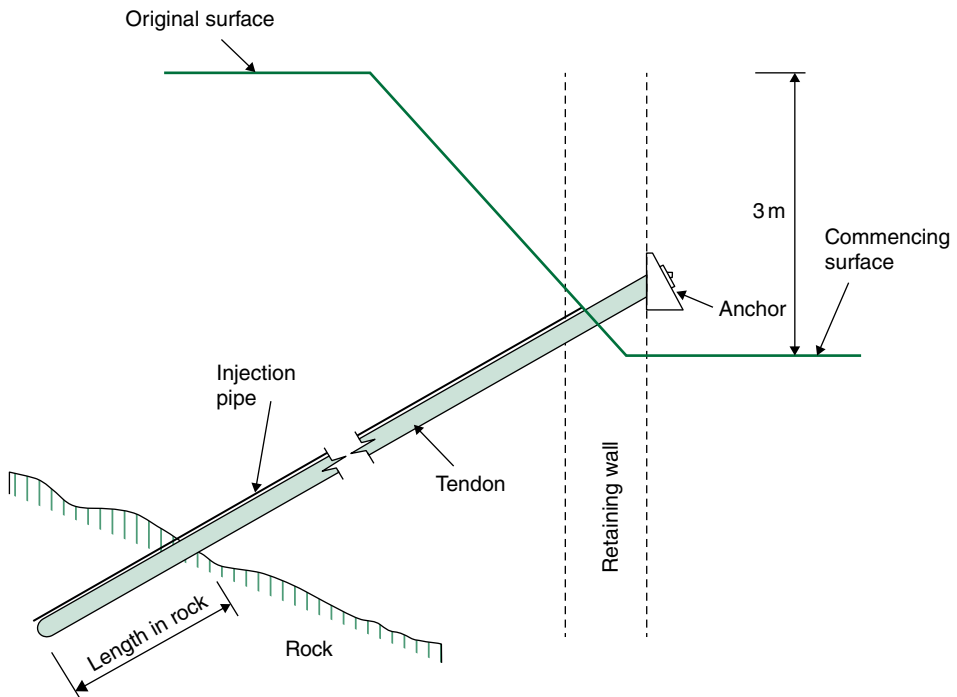


Figure 15.2 Typical cross section at anchor position.

hardstanding for the falsework which supports the deck construction, but it is not formation level for the road which has yet to be excavated.

Clearly, the Original Surface is not the Commencing Surface for the ground anchors, and so in accordance with Measurement Rule M1, a Commencing Surface needs to be chosen for use when preparing the bill of quantities.

In making the decision, the bill compiler needs to ask:

- Is the 'top-down' method of construction the only method that could be adopted?
- Is the 'top-down' method expressly required in the tender documents or is this a contractor choice?
- In any event, should the Commencing Surface be related to:
 - A depth/level below the Original Surface?
 - The underside of the aqueduct deck?
 - The pile capping beam (which is the bearing for the ends of the aqueduct)?
 - Somewhere else?

CESMM4 Section 1 Paragraph 1.10 defines *Commencing Surface* as *the surface of the ground before any work covered by [an] item has been carried out*.

In this particular example, the Commencing Surface has been chosen as the reduced level below the Original Surface. A strict interpretation could conclude that the inclined surface is where the ground anchor work commences (see Figure 15.2) but it is difficult to describe where work commences on a slope. Measurement Rule M1 comes to the rescue to some extent by stating that whichever Commencing Surface is adopted for preparing the bill of quantities, this will be adopted for the admeasurement of the completed work.

It would be easy to conjecture that the Commencing Surface could be shown on a drawing but in practice, where ground anchors are to be installed in disparate locations, this might prove to be more difficult than imagined.

Figure 15.3 illustrates the ground anchor installation process for the aqueduct project.

15.2.2 Measurement

The completed bill of quantities items for the Stage 1 Earthworks are illustrated in Table 15.1, where it will be noted that the Excavated Surface is 3m below existing towpath level.

The Excavated Surface for the Stage 1 Earthworks is the Commencing Surface for the ground anchor installation as illustrated in Table 15.2, which shows the completed bill of quantities items for the ground anchor work.

The principal dimension sheets for the earthworks and ground anchors are given in Table 15.3.

NB: Some technical details have been omitted from the item descriptions for clarity.



Figure 15.3 Ground anchor installation. (a) Drilling (Class C 2 3 3), (b) Pressure test, (c) Tendons, (d) Taping injection pipe to tendon, (e) Tendon strands, (f) Cement and grout pump and (g) Anchor head.

Table 15.1 Bill of quantities – Earthworks.

CLASS E: EARTHWORKS			
<u>Excavation for foundations</u>			
Material other than topsoil, rock or artificial hard material			
maximum depth : 2-5 m			
E	Stage 1 excavation; Excavated surface 3m below existing towpath	818	m3
<u>Excavation ancillaries</u>			
Disposal of excavated material			
F	material other than topsoil, rock or artificial hard material	819	m3

Table 15.2 Bill of quantities – Anchors.

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				£	p
<u>CLASS C: GEOTECHNICAL AND OTHER SPECIALIST PROCESSES</u>					
<u>Drilling for grout holes through material other than rock or artificial hard material</u>					
Horizontally or downwards at an angle less than 45 degrees to the horizontal					
in holes of depth : 10-20 m					
A	100 mm diameter	360	m		
<u>Drilling for grout holes through rock or artificial hard material</u>					
Horizontally or downwards at an angle less than 45 degrees to the horizontal					
in holes of depth : 10-20 m					
B	100 mm diameter	90	m		
<u>Driving injection pipes for grout holes diameter 100 mm</u>					
Horizontally or downwards at an angle less than 45 degrees to the horizontal					
C	in holes of depth : 10-20 m	450	m		
<u>Grout holes materials and injection</u>					
Number of holes					
D	cement and sand	30	nr		
Single water pressure tests					
E	cement and sand	30	nr		
Materials					
F	cement	0.57	t		
G	sand	3.71	t		

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Injection					
A	number of injections	30	nr		
B	cement and sand filler grout	7.42	t		
<u>Ground reinforcement</u>					
Number in material which includes rock or artificial hard material to a [stated] maximum depth					
C	permanent with double corrosion protection	30	nr		
Total length of tendons which includes rock or artificial hard material					
D	permanent with double corrosion protection	30	m		

Table 15.3 Principal Dim Sheets.

<p>CLASS E: EARTHWORKS Excavation for foundations Material other than topsoil, rock or artificial hard material maximum depth : 2-5 m Stage 1 excavation; Excavated surface 3m below existing towpath</p>			
		Unit: m3	Sort: Sheet: 1
Item Code:			
	22.000 16.000 3.000 ===== (22.000) 9.000 1.200 =====	1056.000 (237.600) ----- 818.400 =====	existing canal basin

<p>CLASS C: GEOTECHNICAL AND OTHER SPECIALIST PROCESSES Drilling for grout holes through material other than rock or artificial hard material Horizontally or downwards at an angle less than 45 degrees to the horizontal in holes of depth : 10-20 m 100 mm diameter</p>			
		Unit: m	Sort: NA Sheet: 3
Item Code:			
30/	12.000 =====	360.000 ----- 360.000 =====	
<p>Drilling for grout holes through rock or artificial hard material in holes of depth : 10-20 m 100 mm diameter</p>			
		Unit: m	Sort: Sheet: 4
Item Code:			
30/	3.000 =====	90.000 ----- 90.000 =====	