2016-08-04

Measuring Building Substructures: Solutions to 'First Year' Introductory Level Examination Questions

Tony Cunningham
Technological University Dublin, tony.cunningham@tudublin.ie

Follow this and additional works at: https://arrow.tudublin.ie/beschreoth

Part of the Architectural Engineering Commons, and the Construction Engineering Commons

Recommended Citation

This Other is brought to you for free and open access by the School of Surveying and Construction Management at ARROW@TU Dublin. It has been accepted for inclusion in Other Resources by an authorized administrator of ARROW@TU Dublin. For more information, please contact arrow.admin@tudublin.ie, aisling.coyne@tudublin.ie, gerard.connolly@tudublin.ie, vera.kilshaw@tudublin.ie.
MEASURING BUILDING SUBSTRUCTURES: -
SOLUTIONS TO ‘FIRST YEAR’ INTRODUCTORY LEVEL
EXAMINATION QUESTIONS

Tony Cunningham
School of Surveying and Construction Management
Dublin Institute of Technology

Introduction

The measurement of substructure works to simple domestic type buildings is a logical starting point for students to commence the process of taking-off building quantities. Substructure work is typically the first class of work to be explained in textbooks dealing with both construction technology and building measurement. However, substructure work is often one of the most challenging elements to measure. This element is unique, in that it contains both vertical (rising walls) and horizontal elements (ground floor slabs), and comprises work from a number of separate work sections and trades (e.g. excavation and earthworks, concrete work, brickwork and blockwork, waterproofing and occasionally aspects of woodwork, The element also contains works which are measured in linear metres (dpcs for example), square metres (e.g. blinding and powerfloating), and cubic metres (e.g. concrete foundations). Examiners may be of the view that if the candidate can demonstrate the ability to measure substructures that they should be able to successfully apply the principles of measurement to other areas of work. The task of measuring substructures is, as a result, a regular topic in first year building measurement and quantity surveying examinations.

In this paper, the author demonstrates the process of measuring basic substructure designs. The approach taken involves providing solutions to a sample of four Irish Department of Education Technological Certificate: Builders’ Quantities Intermediate Stage examinations. These three-hour-long State examinations, which ceased in 2007, required candidates to answer two compulsory measurement questions, one of which almost always involved a substructure. The measurement questions accounted for 80% of the marks, (40 marks each). Candidates were also required to answer two other short questions (10% each) relating to various theoretical aspects of quantity surveying practice. The marking scheme above, indicates that each of the measurement questions should take approximately 75 minutes to answer. Completing the questions within this time frame is both challenging and pressurised.
The Worked Examples

The worked examples are measured in accordance with the Irish Agreed Rules of Measurement (ARM4). Different rules may apply under other standard methods of measurement. Candidates taking these examinations were required to enter all dimensions on dimension sheets which were provided. Readers are therefore expected to be familiar with traditional ‘paper based’ taking-off procedures. These procedures are explained in the following papers An Introduction to Taking Off Building Quantities: an Irish Approach http://arrow.dit.ie/beschreoth/30, Measuring Building Perimeters and Centrelines - Worked Examples http://arrow.dit.ie/beschreoth/43, and Composing Descriptions for Bills of Quantities in Accordance with ARM4 – Worked Examples http://arrow.dit.ie/beschreoth/44.

The worked examples are presented in order of increasing difficulty as the plans become more complex. Explanatory notes on ARM4 rules are presented to support the first worked example. In the interest of brevity these notes are not repeated for the subsequent questions, but apply nonetheless.

1992 – A Plain Rectangular Building

The Question

Take off the quantities for the substructure to damp proof course level. (40 marks)
Measuring Substructure Work
Although this is a straight-forward substructure layout which would be suitable for a garage or similar non-habitable outbuilding, the task required the candidates to take off the complete substructure. Candidates were not required to square the dimensions. As the candidates were not permitted to use the ARM, they were expected to remember what items needed to be measured and the various measurement and coverage rules governing these. The candidates would also have been expected to make certain assumptions regarding whether particular works were necessary. For example stripping of topsoil has not been measured in this example on the assumption that it is not required to be preserved, this assumption avoids the need to measure the items relating to stripping, preserving and spreading the topsoil, thereby speeding up the take-off process. All such assumptions should, however, be checked with the architect and documented on a query sheet.

In this instance it would be prudent to compile a ‘to-take’ list of the items to be measured. This will help to organise an effective take-off approach and reduce the risk of accidentally leaving out items to be measured. A to-take list showing ARM4 references and units of measurement to answer this question would include:

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>ARM Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce level excavation; - <em>assumed there is no requirement to preserve any topsoil.</em></td>
<td>m$^3$</td>
<td>D22.3.7.4.</td>
</tr>
<tr>
<td>Trench excavation</td>
<td>m$^3$</td>
<td>D22.3.9.</td>
</tr>
<tr>
<td>Disposal of surface water</td>
<td>item</td>
<td>D24.3.8.10.</td>
</tr>
<tr>
<td>Disposal of surplus excavated material</td>
<td>m$^3$</td>
<td>D24.3.10.</td>
</tr>
<tr>
<td>Backfilling trenches with excavated material</td>
<td>m$^3$</td>
<td>D24.4.11.16.</td>
</tr>
<tr>
<td>Backfilling to make up levels</td>
<td>m$^3$</td>
<td>D24.4.12.16.</td>
</tr>
<tr>
<td>Hardcore beds</td>
<td>m$^3$</td>
<td>D24.4.12.16.</td>
</tr>
<tr>
<td>Blinding hardcore beds</td>
<td>m$^2$</td>
<td>D24.5.13.</td>
</tr>
<tr>
<td>Concrete strip foundations</td>
<td>m$^3$</td>
<td>F36.4.0.0.2.</td>
</tr>
<tr>
<td>Concrete ground floor slabs</td>
<td>m$^3$</td>
<td>F36.9.1.</td>
</tr>
<tr>
<td>Powerfloating floor slab</td>
<td>m$^2$</td>
<td>F38.2.6.</td>
</tr>
<tr>
<td>Rising Walls</td>
<td>m$^2$</td>
<td>G48.2.1</td>
</tr>
<tr>
<td>Labours on brickwork</td>
<td>item</td>
<td>G48.7.2</td>
</tr>
<tr>
<td>DPC</td>
<td>m</td>
<td>G52.3.5.2.3.</td>
</tr>
<tr>
<td>DPM horizontal</td>
<td>m$^2$</td>
<td>I66.2.1.1.</td>
</tr>
<tr>
<td>DPM perimeter kerb</td>
<td>m</td>
<td>I66.10.5.</td>
</tr>
</tbody>
</table>
Reduce level excavation is measured in m³ classifying the depth as ≤ 2.00m or exceeding 2.00m in 2m increments. Reduce levels refers to the excavation required to reach the formation level i.e. the bottom of the hardcore bed - which is 150mm below ground level. The measurements are taken to the footprint of the building which extends to the outer edge of the foundations. This requires the width of the rising walls (215mm) plus the projection of the ‘toe’ of the foundation (155mm) to be added at both ends (2/) to the (internal) dimensions shown on the plan.

Trench excavation is also measured in m³ classifying the depth as ≤ 2.00m or exceeding 2.00m in 2m increments. The trench is measured along its centreline, and its depth is calculated from formation
level (600-150mm) to base of the concrete foundation. Note that the standard formula for adjusting perimeters, **four times twice the distance moved**, can be simplified when moving to the centreline of a work item to four times the item’s width/thickness, - the twice and half the thickness cancel each other out! Note also that where the dimensions relate to the inside of a building (as here) the centreline adjustments is **added** to the internal perimeter length.

**Disposal of surface water:** an item is taken to allow the contractor the opportunity of removing rainwater on the site and in the excavations.

**Disposal of surplus excavated material:** material removed from site is measured in m$^3$. The location of the tip is usually at the Contractor’s discretion. There are a number of approaches that may be used to measure ‘cartaway’. As the trenches are backfilled on both sides of the rising walls it seems that measuring the volume of earth displaced by the foundations, rising walls and hardcore bed is the most straightforward method of calculating this quantity. Note the re-use of the trench centreline
measurement in calculating the foundations and rising wall. An alternative approach is to add up all the excavation and deduct any backfilling. Note, no allowance is made for bulking of the excavated material when measuring this class of work.

**Backfilling** is measured in m³ stating whether it exceeds or does not exceed 250mm thick. Details of treatment of the fill such as compacting in 225mm thick layers must be given in the description. Excavated material is commonly used to backfill voids left by excavation operations. In trenches this occurs between the rising wall and the trench side above the top of the foundation. In this case the
both sides of the trench are backfilled –therefore the width of the fill is obtained by subtracting the rising wall’s thickness from the trench width.

Additional filling is required **to make up levels** on the outside of the wall between the top of the trench and ground level (see the red box on the thumbnail sketch above). Note how the internal perimeter is adjusted to move to the centreline of this filling. The distance moved is 215 (Wall) plus 78mm (half the ‘toe’ projection) and is adjusted for each corner (4/2/293mm)

**Hardcore** a 150mm hardcore bed is required below the ground floor slab and is classified as making up levels and is measured in m³ stating the average thickness as exceeding or not exceeding 250mm thick. Hardcore descriptions must specify the kind and quality of the materials and any treatments such as compacting. The measurements are taken within the walls producing a value which is often referred to as the ‘gross internal floor area’

**Surface treatments** including blinding filling with sand is measured in m². Note that blinding sloping surfaces are measured separately.

**Concrete Work** is measured in accordance with section F of ARM, and is measured in cubic metres. Concrete particulars state the kind and quality of materials; any performance or mix details and any
testing requirements. In this question the concrete mix proportions are specified. Concrete is typically billed in order of increasing concrete strengths.

Concrete foundations must state if they are poured on or against earth or unblinded hardcore as in these instances a large proportion of the fill will seep into the surrounding ground strata. The estimator
will need to take this into consideration when pricing this class of work. Note the work is measured on the centreline of the trench.

**Concrete ground floor slabs** are described as beds and classified as either not exceeding, or exceeding, 150mm thick.

**Surface Treatments** such as power floating is measured in m².

```
1992 - Q1 P/LO.

**BRICKWORK AND BLOCKWORK**

Concrete bricks; Dungannon Brick Company; 'Heather'
Rustic Facing bricks;
22.215 x 102.5 x 65 mm;
English bond in cement mortar (1:3)
Walls in trenches
215 mm thick.

---

Hessian based bituminous felt damp proof course
3.8 kg/m²; 150 mm laps
Damp proof course
n ≥ 250 mm wide;
horizontal

---

20.86
---

600
150
750
---

Labours on brickwork

---

Item

---

Item
```
Brick rising walls are measured in accordance with Section G of ARM in m². In answering this question candidates should have provided the following particulars in their brickwork descriptions: the kind, quality and size of the bricks; the type of bond; and the composition and mix of mortar. As the work is covered up there are no surface finish or pointing requirements. The work is classified as walls in trenches stating the thickness (215mm). The walls are measured on the centreline of the trench. An Item is taken for labours on brickwork which includes various tasks such as cutting, forming angles and ends, raking out joints and building in ends.

Damp proof courses not exceeding 225mm wide are measured in linear metres; where these exceed 225mm they are measured in m² with laps stated in the description.

Damp proof membrane is measured in m² in accordance with the Roofing Cladding and Waterproofing (Section I) of ARM, within the Waterproof and Gas Proof Non-metal Flexible Sheet Covering sub-section. The information to be provided in damp proofing coverings states: the kind, quality and thickness of the materials; the number of layers and extent of laps; the nature of the base.
on which the material is applied, and any underlay and insulation. Damp proofing is categorised as (1) horizontal, (2) sloping 15-45 degrees, (3) sloping over 45 degrees – stating the slope, and (4) vertical. Membranes are further categorised as either exceeding or not exceeding 300mm wide, identifying whether the work is curved. A cautious approach has been taken in measuring the perimeter upstand and lap under the damp proof course as a separate kerb. Kerbs are described in detail stating the girth in stages of 150mm. Many surveyors, however, take the view that the upstand is not a separate activity from the general damp proofing and include it with the horizontal damp proofing activity.

2001 A ‘T’ Shaped Building

The Question

Measure only the following items below DPC level shown in Figure 1 and calculate the net quantities in the units indicated.

- a. Excavate topsoil average 150mm deep. Squ.m.
- b. Excavate foundation trenches Cu.m.
- c. Excavate to reduced level Cu.m.
- d. Disposal of excavated material off site Cu.m.
- e. Concrete in foundations Cu.m.
- f. 100mm thick concrete blockwork in skins of hollow wall Sq.m.
- g. 100mm wide DPC M

General Commentary

This question involves taking off and squaring seven items in the substructure, (the previous worked example contained 16 items). The question mainly focuses on the candidates’ ability to calculate quantities derived from perimeter and centreline calculations. Candidates should use the overall building dimensions (9000 and 5300) to calculate the external perimeter. Submissions using the less efficient ‘around the house’ approach i.e. totalling the eight dimensions on the drawing would probably be marked down. The ‘overall’ approach also demonstrates the candidates’ understanding that the clipped corners can be ignored when measuring perimeters. Note, however, that the figures used to calculate the overall width of the building (5300) must be shown as a side cast (1700 + 3600).

The question also examines the candidates’ ability to calculate quantities relating to plan areas (parts a and c: topsoil strip and reduce level dig). These require candidates to measure the area of the topsoil stating its average thickness. This value can be labelled (TOT A) and repeated to calculate the volume of the reduce level dig, - note this technique (CUBE X). The topsoil is measured to the footprint of the building which extends to outer edge of the projecting ‘toe’ of the foundation. The approach taken
below is to measure overall and then adjust for the complications, (i.e. deduct for the two set-back ‘clipped’ corners at the top of the plan). The figured dimensions of the clipped corners are used, without adjustment, when deducting these the areas.

With regard to part (f) and (g), although the detail indicates brickwork, the question requests candidates to measure 100mm blockwork and this has been demonstrated here. A query sheet would confirm this discrepancy between the drawing and the bill of quantities. As the two skins of the cavity wall are positioned an equal distance on either side of the centreline of the foundation, the centreline can be twiced (this establishes the length of the dpcs) and multiplied by the height of the rising walls to produce the blockwork quantity. Note that the coverage rules of ARM4 state that the term ‘walls’ includes skins of hollow walls.
Excavation and Earthwork

Excavation

- Topsoil for preservation average depth 150 mm
- Reduce levels; depth ≤ 2.00 m.

\[
\begin{align*}
\text{Topsoil} & \quad 51 \text{ m}^2 \\
\text{Toe of found} & \quad 255 \\
\text{Spread} & \quad 495 \\
\text{Width} & \quad 248 \\
\text{Cubex} & \quad 0.08 \\
\text{Cube x} & \quad 4.12 \\
\text{Length} & \quad 3600 \\
\text{Spread} & \quad 2/248 \\
\text{Topsoil} & \quad 150 \\
\text{Insul} & \quad 25 \\
\text{Hardcore} & \quad 225 \\
\text{Insul} & \quad 25 \\
\text{Hardcore} & \quad 225 \\
\text{Topsoil} & \quad 75 \\
\text{Trench excav.} & \quad \text{measured before}
\end{align*}
\]

- Trench excav.

Total:

- 51.45

\[
\begin{align*}
\text{Total} & \quad 51.45
\end{align*}
\]
**Measuring Substructure Work**

<table>
<thead>
<tr>
<th>Foundation Trenches; depth ≤ 2.00 m</th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 m³</td>
<td>Excavated Material; off site</td>
</tr>
<tr>
<td>length 9000</td>
<td>12 m³</td>
</tr>
<tr>
<td>width 5300</td>
<td></td>
</tr>
<tr>
<td>Ext Perim 28600</td>
<td></td>
</tr>
<tr>
<td>2/14 300</td>
<td></td>
</tr>
<tr>
<td>&amp; Adj - 4/255 - 1026</td>
<td></td>
</tr>
<tr>
<td>&amp; 27580</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>height 675</td>
<td></td>
</tr>
<tr>
<td>+ Found + 225</td>
<td></td>
</tr>
<tr>
<td>- Tot Reduce low - 225</td>
<td></td>
</tr>
<tr>
<td>depth 675</td>
<td></td>
</tr>
<tr>
<td>27.58</td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>0.63 14.07</td>
<td></td>
</tr>
</tbody>
</table>

| Conc Found. & as across           | Cavity Wall |
| 4.76                               | 675         |
| 0.23                               |            |
| 27.58                              | Red1 - 225  |
| 0.45                               | 450         |
| 3.23                               |            |
| 12.11                              | Backfill above trench on outer face of wall. |
|                                    |            |
| Ddt                                |            |
|                                    |            |
| Ext Perim 28600                    | 29.592     |
| 0.25                               |            |
| 0.08 0.59                          |            |
|                                    |            |
|                                    | Ext Perim 28600 |
|                                    | 29.592     |
|                                    |            |
|                                    |            |
### Concrete Work

Concrete: type A as specification

Foundations
- poured on or against earth or unblinded hardcore
  - \(5 \text{ m}^3\)

\[
\begin{array}{c}
27.58 \quad £ \text{ as before} \\
0.75 \\
0.23 \quad 4.76
\end{array}
\]

### Brickwork and Blockwork

Blockwork: as specified; solid; 440 x 215 x 100 mm; stretcher bond; in cement mortar (1:3)

Walls in trenches
- 100 mm thick
  - \(460 \text{ m}^2\)

\[
\begin{array}{c}
2/27.58 \\
0.83 \quad 45.78
\end{array}
\]

\[
\begin{array}{c}
+ 150 \\
825 \quad £ \text{ as before}
\end{array}
\]

### Damp Proof Course

Damp proof course as specified; 150 mm laps
- \(55 \text{ m}\)

\[
2/27.58 \quad 55.16 \quad £ \text{ as before}
\]
2000 A building with set-back corners and a recessed ‘bight’

The Question

Measure only the following items below DPC level shown in Figure 1 and calculate the net quantities in the units indicated.

i. Excavate topsoil average 150mm deep. Sq.m.
ii. Excavate to reduced level Cu.m.
iii. Excavate foundation trenches starting at reduced level Cu.m.
iv. Disposal of excavated material off site Cu.m.
v. Concrete in foundations Cu.m.
vi. 200mm thick concrete blockwork in rising walls Sq.m.
vii. 50 thick sand blinding Sq.m.

General Commentary

This question again involves measuring seven items, but there is a greater emphasis here in calculating quantities relating to areas on the plan.

Candidates were required to measure areas based on the ‘footprint’ (parts i and ii) and the ‘gross internal floor area’ of the building (part vii). The presence of clipped corners and a recess or ‘bight’ results in a plan shape that is quite complicated. In dealing with this layout, it is advisable to measure overall in the first instance and then adjust for the various complications, - an approach that has been described as a ‘golden’ rule of measurement.

Dealing with ‘clipped’ corners is relatively straight forward. The plan dimensions for the adjustment of the set-back are constant. Therefore, in moving outwards they can be applied to the topsoil, and moving inwards they apply to the floor slab.

Adjustments for recesses or ‘bights’, on the other hand, are variable in their width but constant in their depth. So, when moving outwards to adjust for the topsoil the width of the bight tightens by the ‘toe’ of the foundation on either side (2/175). Similarly, when adjusting for floor slab, the width of the bight expands to include the width of the wall on both sides (2/400). Note the adjustment for the depth of the bight remains constant in both cases (1500mm).

In calculating the perimeter of the building and associated girthings, candidates must have taken account of the depth of the bight. The perimeter formula here is expressed as twice times the sum of the overall length, width and projections. Again, the figures used to calculate the overall length, width and the set-back to the top right side of the building must be shown as side casts.
Note how the external perimeter is adjusted when calculating the volume of the backfill on the inside and outside of the rising walls in the trench and the area of the 200mm blockwork (part vi), which is adjusted using the formula four times twice times the distance moved.
Note that process of checking the squaring by somebody else is demonstrated in this example.
<table>
<thead>
<tr>
<th></th>
<th>Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>foundation trenches; depth ≤ 2.00m</td>
<td>excavated material; off site</td>
</tr>
<tr>
<td></td>
<td>7 cu.m.</td>
</tr>
<tr>
<td>7500</td>
<td>10 cu.m.</td>
</tr>
<tr>
<td>6000</td>
<td></td>
</tr>
<tr>
<td>bright 1500</td>
<td></td>
</tr>
<tr>
<td>2/1500</td>
<td></td>
</tr>
<tr>
<td>EXT PERIM 30000</td>
<td></td>
</tr>
<tr>
<td>- 4/400</td>
<td></td>
</tr>
<tr>
<td>- 1600</td>
<td></td>
</tr>
<tr>
<td>28400</td>
<td></td>
</tr>
<tr>
<td>topsoil 150</td>
<td></td>
</tr>
<tr>
<td>on drag. 200</td>
<td></td>
</tr>
<tr>
<td>found 250</td>
<td></td>
</tr>
<tr>
<td>- red lev. 250</td>
<td></td>
</tr>
<tr>
<td>350</td>
<td></td>
</tr>
<tr>
<td>7.46 /3.84 m³</td>
<td></td>
</tr>
<tr>
<td>28.40 /0.75</td>
<td></td>
</tr>
<tr>
<td>0.35 /7.46</td>
<td></td>
</tr>
</tbody>
</table>

**2000 Q1 P2.**
Surface Treatment.

blinding with sand
50 mm thick

√

22 Sq.m

CONCRETE WORK

Concrete; Type A as described (1:3:6)

Foundations

poured on or against earth or unblinded hardcore

5' Cum

6000
- walls 2/400 800
5206

6.70

5.20 34.84

√

Data

Clipped corners

4.50

1.00 4.50

3.00

1.50 4.50

'Bight'

2000

+ walls 2/400 + 800

2800

2.80

1.50 4.20

13.20

21.64
BRICKWORK AND BLOCKWORK

Concrete blockwork; solid; type A as described; stretcher bond; in cement mortar (1:3)

Walls in trenches

200 mm thick

\[
\begin{align*}
\text{Ext Perim} & \quad 30000 \checkmark \\
\text{outer leaf} & \quad 100 \\
\text{cavity} & \quad 100 \\
\frac{1}{2} \text{inner leaf} & \quad 100 \\
- 4/2/300 & \quad 2400 \checkmark \\
& \quad 27600 \checkmark \\
\text{Height} & \quad \\
\text{trench} & \quad 100 \\
\text{hadcore} & \quad 250 \\
\text{Sand} & \quad 50 \\
\text{Slab} & \quad 100 \checkmark \\
\text{Total} & \quad 0.50 \checkmark \\
\text{Total} & \quad 13.80 \checkmark \\
\text{Total} & \quad 500 \checkmark 
\end{align*}
\]
2007 A Building with Internal Walls

The Question

Measure the following items below DPC level shown in Figure 1 and calculate the net quantities in the units indicated.

a) Excavate topsoil average 150mm deep.  
   b) Excavate foundation trenches starting from stripped level  
   c) Concrete to foundation trenches  
   d) Concrete to floor slab  
   e) 100mm thick brickwork internal walls  
   f) 100mm thick brickwork external leaf of cavity wall  
   g) 150 mm thick blockwork internal leaf of cavity wall

General Commentary

This question involves measuring the seven items above. The layout contains a clipped corner, a bight, and foundations to both external and internal walls.

The additional issues involved in this layout requires candidates to measure foundations to partition walls and to deal with the effects of angles and intersections on the internal foundations and also with junctions between the internal and external foundations. In addition, works relating to the ground floor slab must take account of the rising walls which penetrate the various constituents of the floor structure.

It may be noted that when measuring the partitions that the lengths of the foundation trenches do not equal the lengths of the walls. This is due to the trenches overlapping each other at the various junctions. On external foundations, the extent of the projecting ‘toe’ is subtracted from the adjoining internal foundation trench. Where internal partitions intersect, the width of the intersecting foundation is deducted. Note also, that in measuring the partitions, it is possible to envision a simplified layout by realigning the partitions running top to bottom on the plan to form a continuous ‘crosswall’ (see item b).

With regard to the two 100mm brickwork items (items e and f), these would normally be aggregated and measured together. The question, however, requires the two to be measured separately and this instruction has been followed here.
Fig. 1

Plan

Section A–A

Foundations at levels shown throughout
### Excavation and Earthworks

**Excavation**

- Topsoil for preservation average 150 mm deep.

<table>
<thead>
<tr>
<th>Area</th>
<th>Sq.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

- Foundation trenches: starting from stripped level; depth not exceeding 2.00 m

<table>
<thead>
<tr>
<th>Cu.m</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

**Details**

- Length: 11,250
- Bight: 8,000
- Ext. Perim: 4,150

**Cavity**

- Ext. Leaf: 100
- Int. Leaf: 150

**Width**

- 125
- 100
- 50

**Depth**

- 300
- 475
- 225

**Excavation Details**

<table>
<thead>
<tr>
<th>Area</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.50</td>
<td>11,500</td>
</tr>
<tr>
<td>8.25</td>
<td>8,250</td>
</tr>
<tr>
<td>2.50</td>
<td>250</td>
</tr>
<tr>
<td>3.00</td>
<td>3,000</td>
</tr>
<tr>
<td>8.00</td>
<td>8,000</td>
</tr>
<tr>
<td>1.00</td>
<td>1,000</td>
</tr>
<tr>
<td>4.00</td>
<td>4,000</td>
</tr>
<tr>
<td>5.00</td>
<td>5,000</td>
</tr>
<tr>
<td>6.00</td>
<td>6,000</td>
</tr>
<tr>
<td>7.00</td>
<td>7,000</td>
</tr>
</tbody>
</table>

**Clipped Corners**

<table>
<thead>
<tr>
<th>Area</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.468</td>
<td></td>
</tr>
</tbody>
</table>

**Bight**

- 250

**Toe**

- 2,250

**Continued over**
CONCRETE WORK

Concrete: Type A as specification

Foundations
poured on or against earth or unblinded hardcore

6 Cum

Int Trenches

<table>
<thead>
<tr>
<th>Width</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.53</td>
<td>150</td>
</tr>
<tr>
<td>0.40</td>
<td>100</td>
</tr>
<tr>
<td>0.35</td>
<td>400</td>
</tr>
</tbody>
</table>

Total Width: 20.31
### Concrete: Type B as specification

<table>
<thead>
<tr>
<th>Beds</th>
<th>≤ 150 mm thick</th>
<th>9 Cum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>11.250</td>
</tr>
<tr>
<td></td>
<td>-Walls 2/300 - 600</td>
<td>10.650</td>
</tr>
<tr>
<td>10.65</td>
<td></td>
<td>8000</td>
</tr>
<tr>
<td>7.40</td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>0.15</td>
<td>11.82</td>
<td>7400</td>
</tr>
<tr>
<td>2.50</td>
<td></td>
<td>1.13</td>
</tr>
<tr>
<td>3.00</td>
<td></td>
<td>1.13</td>
</tr>
<tr>
<td>8.00</td>
<td></td>
<td>1.13</td>
</tr>
<tr>
<td>1.00</td>
<td></td>
<td>1.13</td>
</tr>
<tr>
<td>0.15</td>
<td>1.20</td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>Bight</td>
<td>2500</td>
</tr>
<tr>
<td>1.50</td>
<td>Walls</td>
<td>600</td>
</tr>
<tr>
<td>0.15</td>
<td>0.70</td>
<td>3100</td>
</tr>
<tr>
<td>11.15</td>
<td>Internal Walls</td>
<td>6250</td>
</tr>
<tr>
<td>0.10</td>
<td></td>
<td>7000</td>
</tr>
<tr>
<td>0.15</td>
<td>0.17</td>
<td>1500</td>
</tr>
<tr>
<td>3.20</td>
<td>Bight</td>
<td>600</td>
</tr>
<tr>
<td>8.62</td>
<td></td>
<td>11150</td>
</tr>
</tbody>
</table>

### Brickwork and Blockwork

<table>
<thead>
<tr>
<th>Brickwork: Type A as specification; 215x103x65 mm; stretcher bond in cement mortar (1:3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walls</td>
</tr>
<tr>
<td>100 mm thick</td>
</tr>
<tr>
<td>5 Sq.m</td>
</tr>
<tr>
<td>11.15</td>
</tr>
<tr>
<td>Int. walls only as last)</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>150</td>
</tr>
<tr>
<td>450</td>
</tr>
</tbody>
</table>
100 mm thick

38 Sq.m

External Walls only

EXT PERIM 41500
- 4/100 - 400
- % of brick 41100

41100

475
300
150

0.93 38.22

925

Walls

150 mm thick

37 Sq.m

EXT PERIM 41500

brick 100
Cavity 50
½ block 75

-4/2/225 -1800

-4/2/225 - 1800

D block 39700

39700

0.93 36.92 Ht as brick.
In Summary

Measuring substructures is a frequent examination topic on first year quantity surveying programmes. These examinations remain, to a great extent, paper based and require the candidates to demonstrate sound measurement procedure in describing and quantifying work. In this paper the Author presents solutions to a sample of four State examinations. The intention is to demonstrate how descriptions, dimensions and the supporting ‘waste calculations’ and annotations may be set out. It is acknowledged that there are many ways to arrive at a quantity, but examiners must be able to follow the candidates thought process without undue difficulty. Demonstrating a clear and effective approach is the key to obtaining high marks. Sound practice holds that all steps in performing calculations should be clearly recorded, and that mental arithmetic should be avoided. Candidates should also avoid presenting cramped / sloppy work.

The substructure examination questions selected here show the importance of the ability to measure and adjust surface areas and perimeters accurately and effectively. This skill is acquired through practice. It is hoped that the worked examples presented here will help students to develop these skills and develop their ability to apply the principles to other situations.

Further Reading