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Measuring Building Perimeters and Centrelines - Worked Examples

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MEASURING BUILDING PERIMETERS AND CENTRELINES - WORKED EXAMPLES

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Introduction

One of the 'initiation rituals' suffered by generations of quantity surveying and construction management students, is the dark art of mastering the ability to calculate perimeters of awkwardly shaped building plans. This task is often made deliberately challenging by examiners and the task can often be daunting for fledgling, and indeed, more seasoned surveyors. The student is typically required to calculate a perimeter and adjust this to derive the centrelines of various elements in the associated construction details. In this paper, the author aims to explain these processes, comments on various worked examples from the literature, and provides a number of worked examples from past Department of Education *Builders' Quantities Intermediate Stage* examinations to demonstrate best practice in this area.

Quantity surveyors measure the perimeters of buildings and individual rooms as part of their routine practice. Building perimeter measurements are very useful in finding out the overall lengths of foundations, external walls, external wall finishes and associated items. Internally, perimeter measurements of individual rooms are needed to calculate the quantities of internal wall finishes such as plaster and paint as well as associated items such as skirting and coving.

Calculating Perimeters.

Rectangular buildings

Many buildings have a rectangular plan shape and the calculation of the perimeter of these buildings is relatively straight-forward. The perimeter is found by calculating:

Twice times the overall length plus twice times the overall width

The general arrangement drawings typically show overall plan dimensions. The quantity surveyor will *take these dimensions off the drawing* and use them to build up the overall perimeter. This process is usually carried out as a handwritten ‘waste calculations’ or ‘side casts’ on dimension paper[1]. The reader is referred to *An Introduction To Taking Off Building Quantities – An Irish Approach* which is available on-line at the Dublin Institute of Technology ‘Arrow’ website http://arrow.dit.ie/beschreoth/30/ which explains these terms and provides an introduction to the taking off process. It is important, particularly when sitting examinations, to show all the steps taken to calculate the various dimensions where these are not shown on the drawings. This calculation should not be done ‘in your head’ in the hope that the person reading the take off notes will be able to understand what you have done. One of the fundamental principles of taking off is to avoid mental arithmetic so that dimensions can checked to ensure that they are correct, and can also be traced back to the drawings.

Figure 1 below is taken from *Seeley and Winfield’s Building Quantities Explained Irish Edition* and shows the plan of a rectangular building.

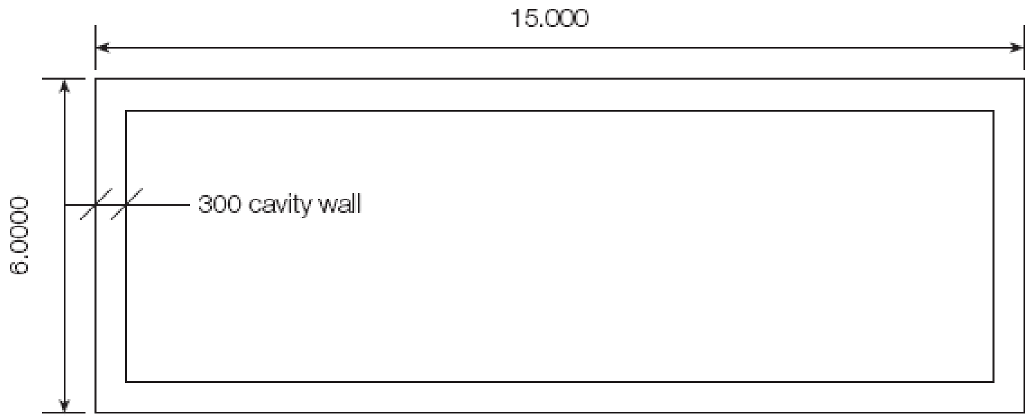

Fig 1 Plan of a rectangular building: Source: Hore, O’Kelly and Scully (2009 p.29)

The external perimeter, in this case, can be calculated in two ways. Firstly, by ‘squaring’ the dimensions – this process is shown on the left side of the dimension sheet, (Fig 2 below). Secondly, and more usually, by carrying out a ‘waste calculation’ – this process is shown on the right side of the dimension sheet which demonstrates two alternative methods of performing the waste calculation.

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[1] In current working practice these calculations are carried out by entering the multipliers and dimensions into formula cells within software packages.

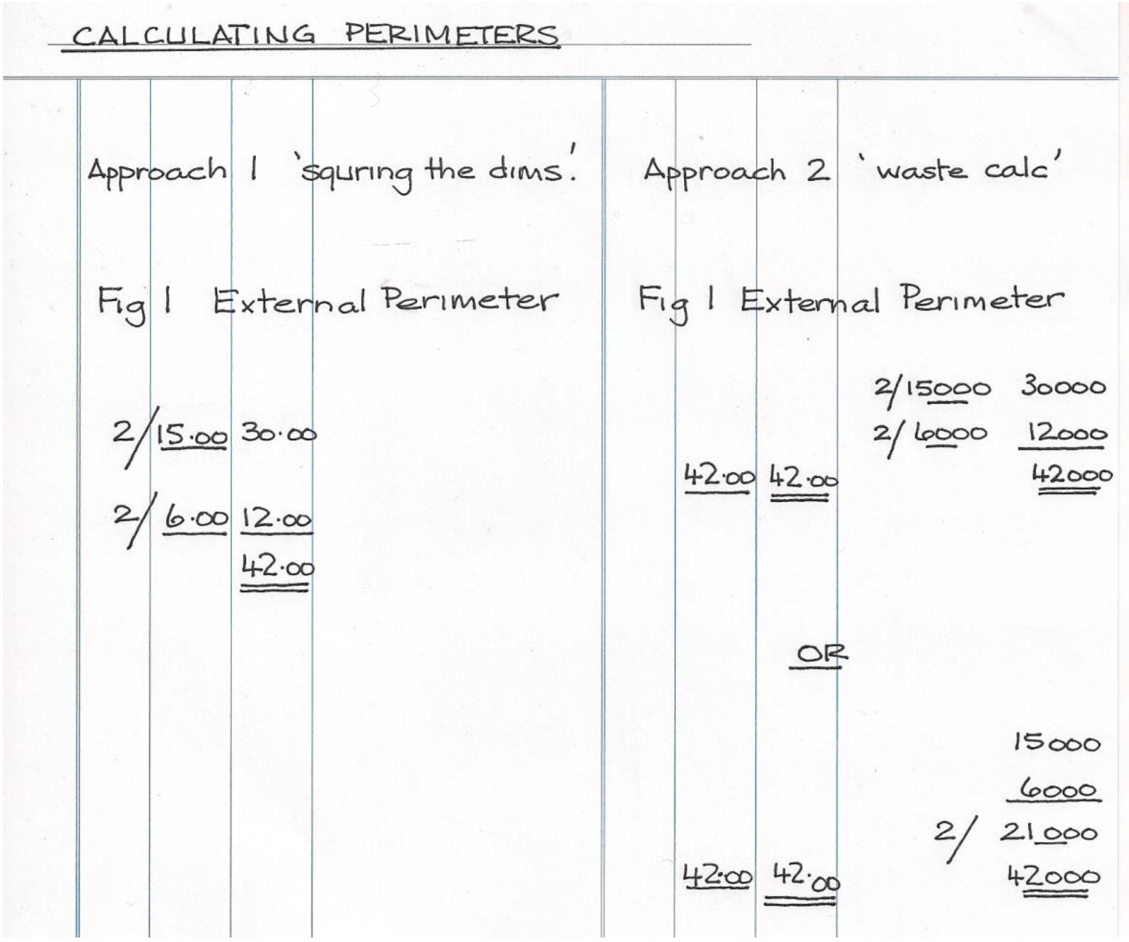


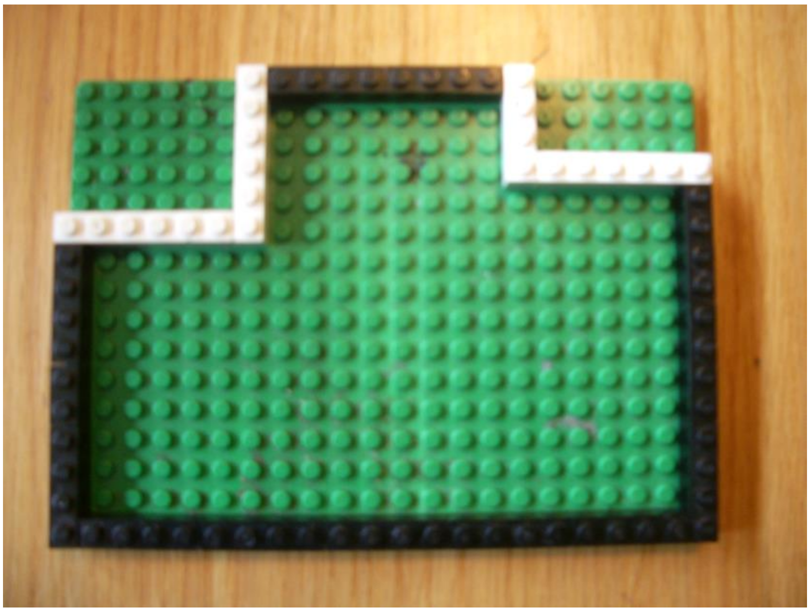
Fig 2 Calculating the external perimeter of a rectangular building

Buildings with set-back corners

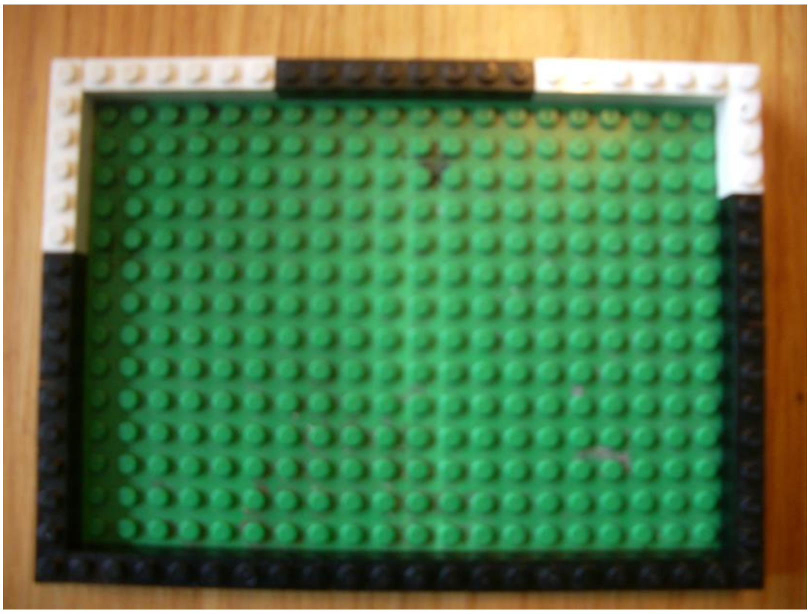
In many cases buildings are designed with set-back corners due to site restrictions and/or for aesthetic reasons. Buildings of this type may have 'L' or a 'T' or even an 'S' type plan shape. In such cases, the perimeter can be calculated as if it were a plain rectangular building, again using the formula.

Twice times the overall length plus twice times the overall width

The two photographs below illustrate why this is possible. Photograph 1 shows an inverted 'T' shaped plan with two set-back corners along its 'top side'. Note that the 'white blocks' can be moved out to square off the shape, the result of which is shown in Photograph 2.



Photograph 1 The perimeter of a building with offset corners …



Photograh 2 …Is the same as the perimeter of a rectangular building.

Figure 3 below (Hore *et al*. 2009) shows a typical example of this arrangement. They explain that ‘in this case the internal and external angles, E and D, at the set-back cancel each other out, and the total length is the same as if there had been no recess and the building was of plain rectangular outline (ABCG), as shown by the broken lines.’

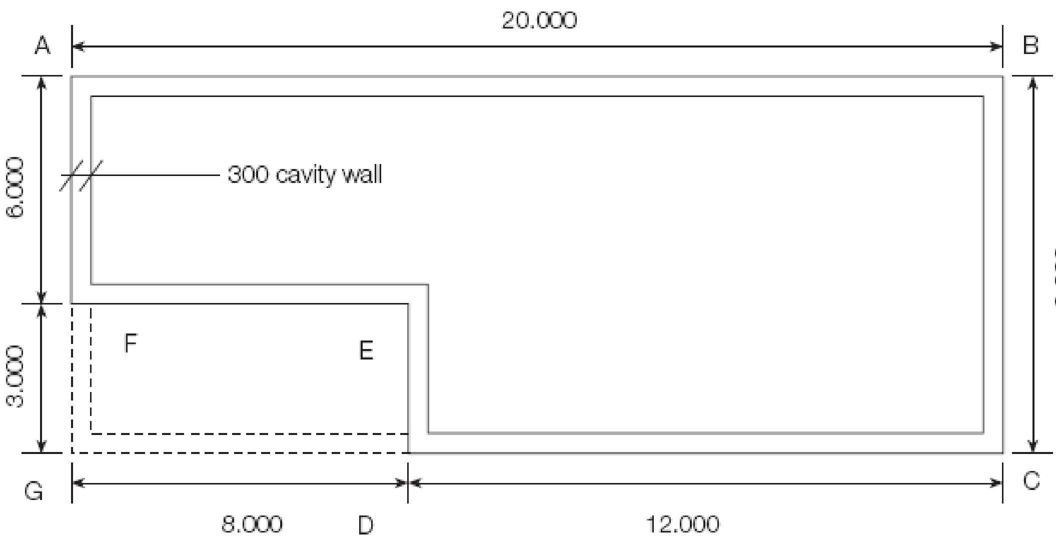


Figure 3 A Building with a set-back corner. (Source: Hore et al. 2009)

The method of calculating the external perimeter for Figure 3 is demonstrated as waste calculations in Figure 4 below.

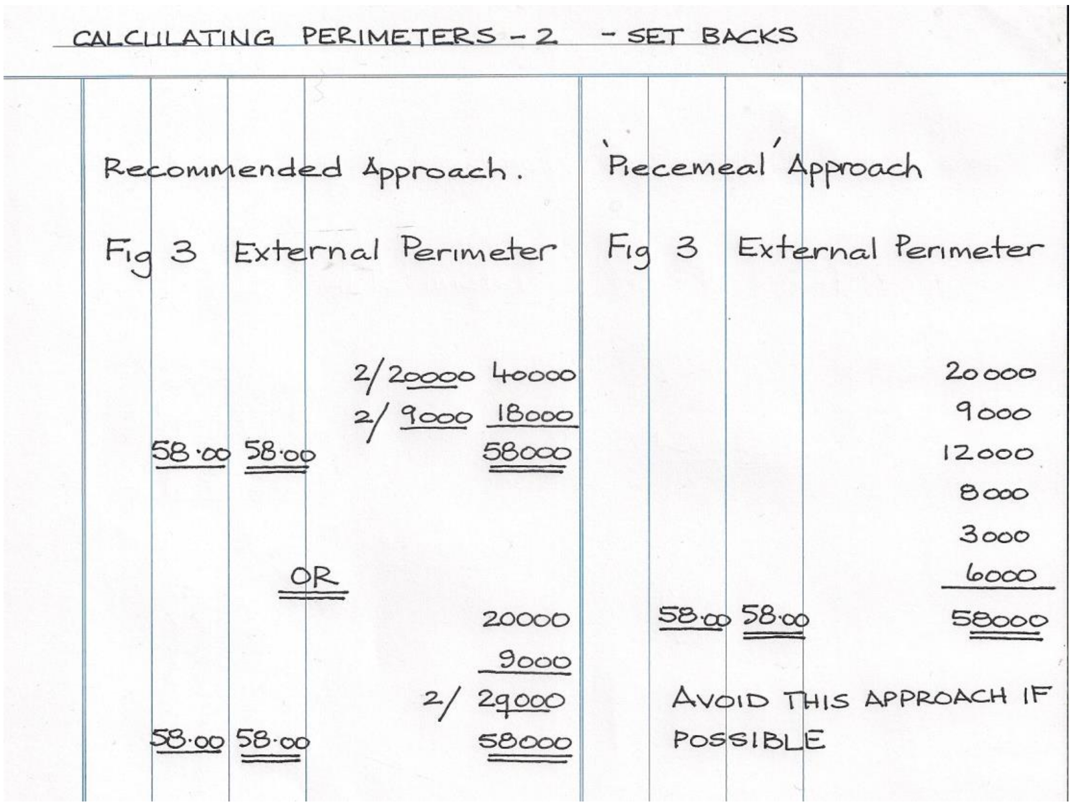


Fig 4 Calculating the external perimeter of a building with set-back corners.

The recommended approach is shown on the left hand side of the sheet and involves using the '*overall'* dimensions. A second 'piecemeal' calculation, found by totalling the individual dimensions around the perimeter of the building, is shown on the right hand side of the sheet– this approach should be avoided if possible. The 'piecemeal' approach involves taking off and processing **six** dimensions instead of the **two** used in the 'overall' approach. It is therefore easier to make mistakes by leaving out dimensions, or misaligning figures, and/or incorrectly totalling a string of dimensions when using this (piecemeal) approach.

Figure 5 below shows various plan shapes, all of which have the same perimeter. This indicates that:

A perimeter is not affected by a set-back corner

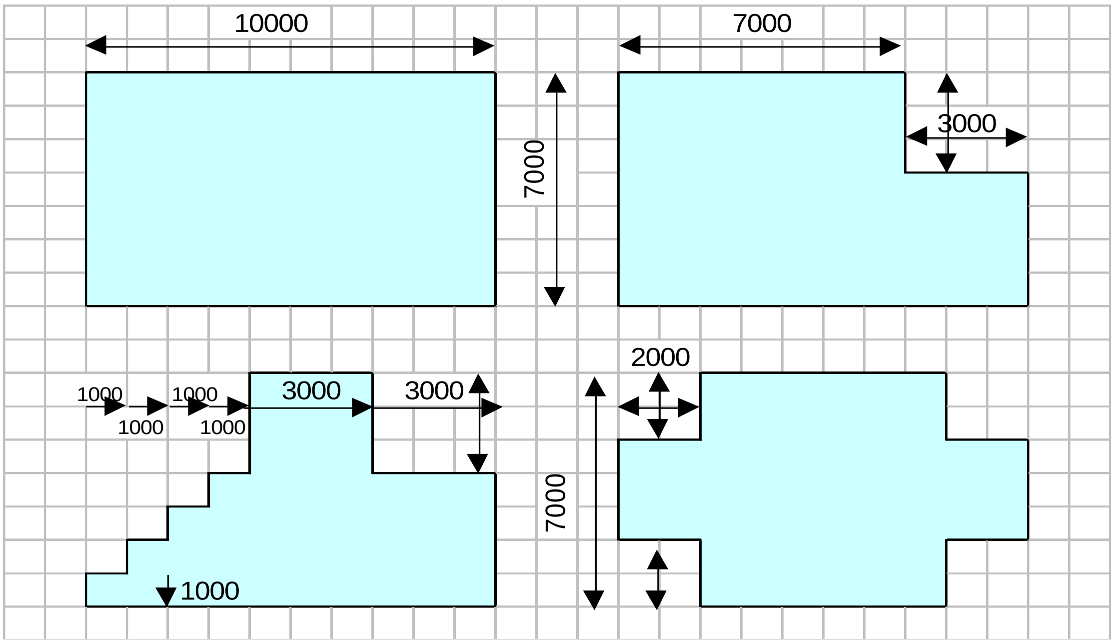


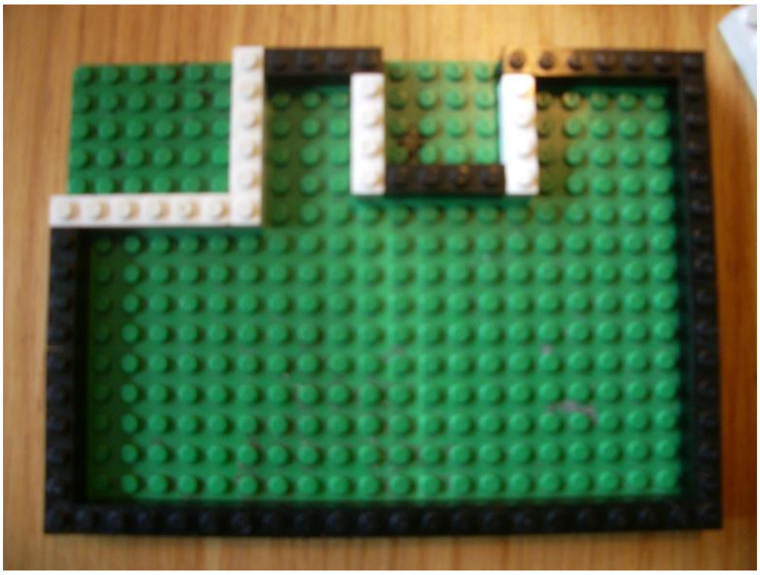
Figure 5 Plan shapes with identical perimeters.

Buildings with recesses

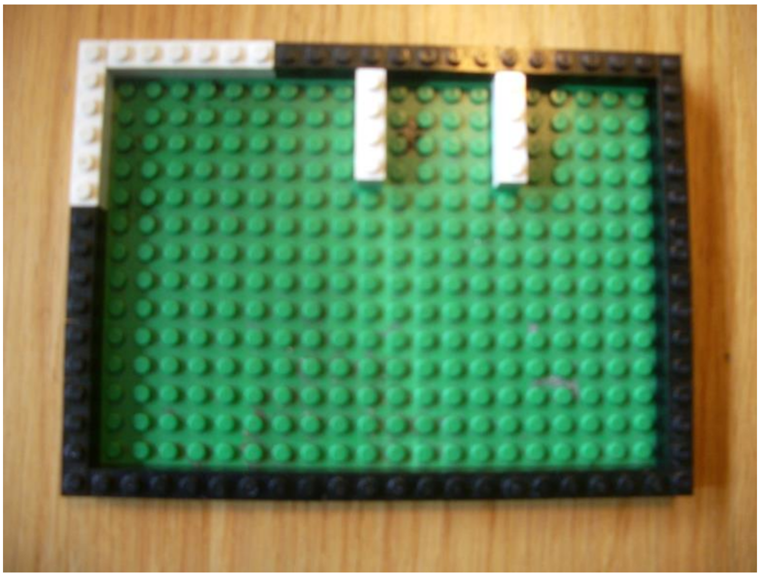
In some cases buildings are designed with recesses or 'bights' and may have 'U' type plan shape. In these cases, the perimeter must take account of the depth of the recess and can be expressed using the formula.

Twice times the overall length plus twice times the overall width plus twice times the overall depth of projections

The photographs below illustrate this principle. Photograph 3 shows a plan shape with a set-back corner and a recess along its 'top side'. When the plan is 'squared off' the two legs of the recess are left 'hanging' as shown in Photograph 4, and must be added to perimeter of the squared off shape.



Photograph 3 The perimeter of a building with recesses …



Photograph 4 …Must take account of the additional depths of any recesses

Figure 6 below (Hore *et al*. 2009) shows a typical example of this arrangement. They explain that 'in this case twice the depth of the recess, that is, BC + ED, will have to be added to the lengths of the sides of the enclosing rectangle, AFGH. The internal and external angles, at C, D, B and E, cancel each other out and the length of CD is equal to BE, thus requiring no further adjustment to the length of the external wall.'

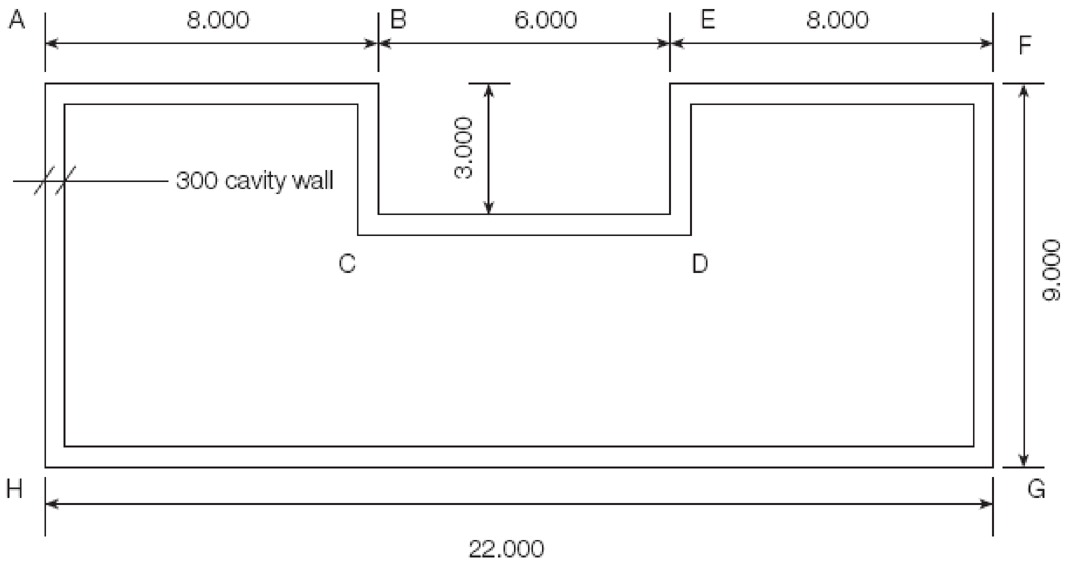


Fig 6 A building with a recess

In this case the external perimeter is calculated as follows:

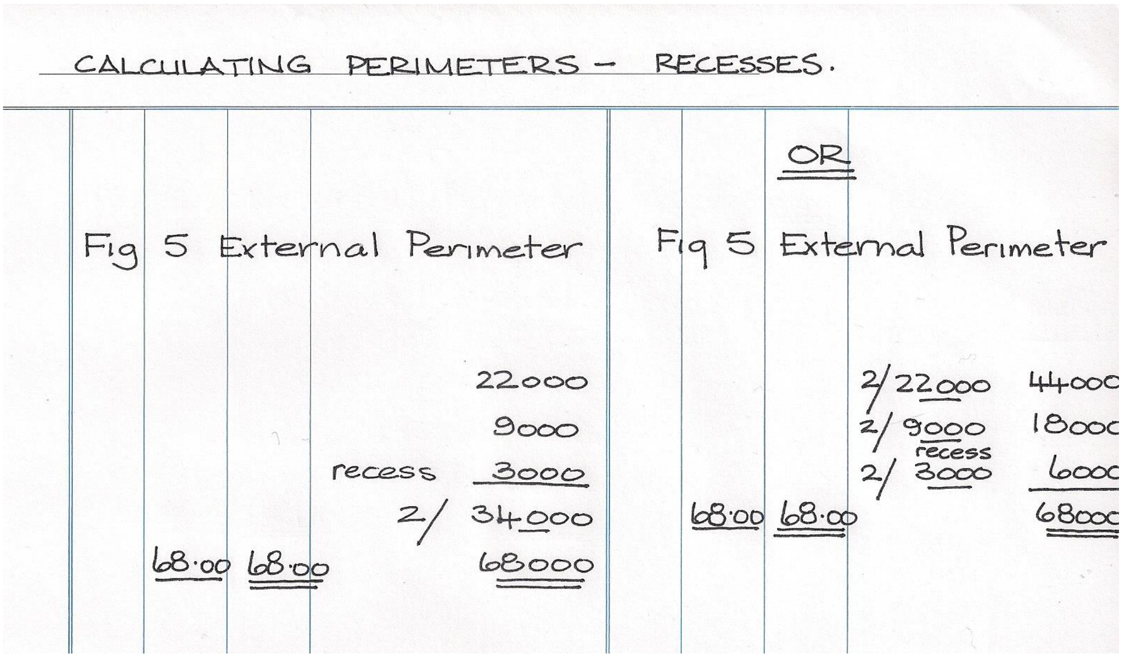
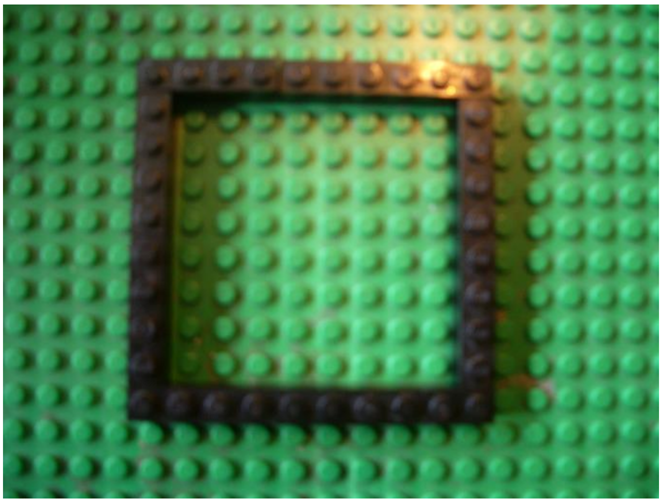


Fig 7 Calculating the external perimeter of a building with a recess.

In summary a perimeter can be stated as 2 x (l+w+p) where l equals the overall length, w equals the overall width, p equals the overall projection into the building.

Adjusting Perimeters and Calculating Centre Lines

The outside perimeter of the Lego block in Photograph 5 below, measures 10 blocks long by 10 blocks wide. How many ‘blocks’ were needed to construct this perimeter ‘wall’?



Photograph 5 – A 10x10 Lego construction

A first guess might have been 40 but the correct answer is, in fact, 36. This is because a wall’s true length is measured on its ***centreline***. The term ‘centreline’ is the most widely known term for an item’s mean (average) length. The ability to adjust a perimeter to calculate a centreline is an important technique, and is used to establish the quantities of trenches, foundations, and various elements of the external wall construction.

The majority of ‘regular’ buildings (i.e. those where the angles are at 90° to each other) are enclosed by walls which return to their original starting point – see Fig 8 below. In these cases the centreline of various elements of the construction details may be found using a technique known as the ‘girthing formula’ which is usually expressed as:

Four times, twice times, the distance moved

The ‘four’ in the formula relates to the fact that in ‘regular’ buildings there are always four more external angles than internal angles, this can be checked in Fig 8 below. This occurs because an external angle cancels out an internal one.

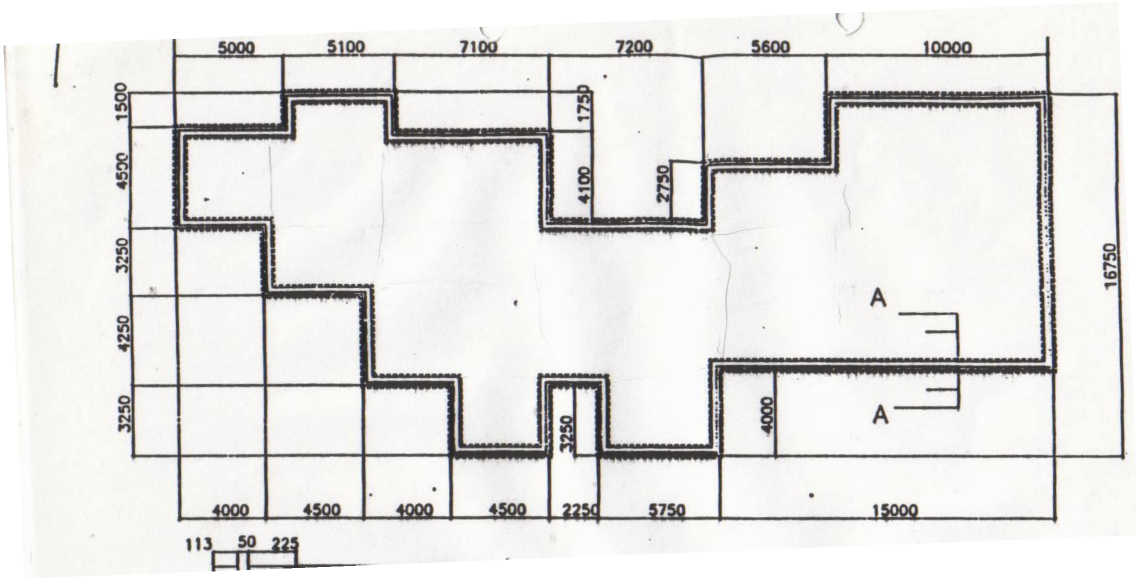


Fig 8 A 'Regular' Building with multiple set backs an recesses …has 4 more external angles than internal angles.

The 'twice times the distance moved' component of the formula occurs because an adjustment must be made to the two sides of the external angle. This is shown in Fig 9 below. The figure shows that the external perimeter is being tightened on both sides of the wall to move to its centre point at 'O'. – this is '*the distance moved*' component of the formula.

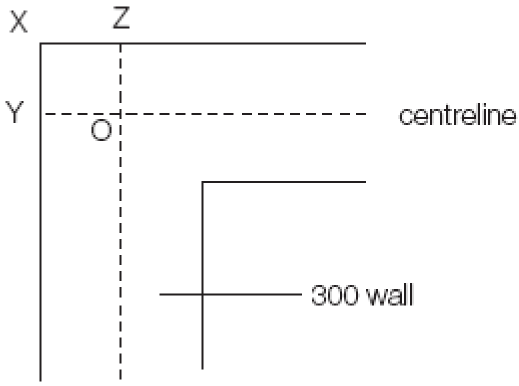


Fig 9 Adjusting a perimeter at an external angle to calculate a centreline measurement (Hore et al 2009)

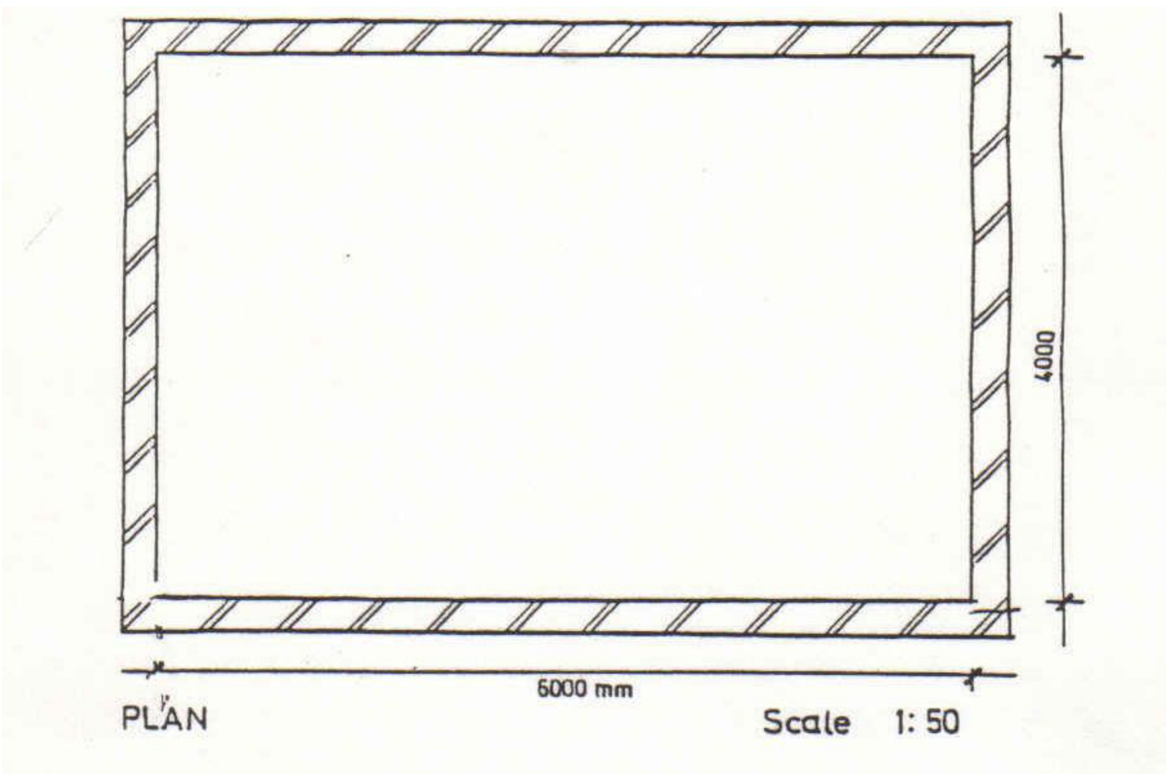
Hore *et al*. (2009) explain the process as follows: where 'the external dimensions have been supplied and these have to be adjusted to give the girth on the centreline through the intersection point O. The procedure is made clearer if the centrelines are extended past O to meet the outer wall faces at Y and Z. It is then apparent that the lengths to be deducted are XY and XZ, which are equal to OZ and OY, respectively. These are equivalent to half the thickness of the wall in each case and so together are equal to the full thickness of the wall'.

The Worked Examples

The following worked examples are taken from the *Builders' Quantities Intermediate Stage* examinations from the Department of Education's *Technological Certificate* examinations. These examinations were generally taken by candidates on completion of one year of quantity surveying studies. The worked examples focus on the measurement of the concrete foundations and *particular* aspects of the rising wall construction. In all cases, a perimeter must be established as the first step in calculating the centreline of the foundations and walls. It will be seen that plans become increasingly complex as the study progresses, culminating in two particularly demanding examples involving 45° angles.

1991 – A Rectangular Building

This is a straight-forward substructure layout from which the concrete foundations and the concrete brick rising wall have been selected to demonstrate the technique of adjusting a perimeter to find the centreline of two items. Note, that the dimensions relate to the internal size of the building. This indicates that the centreline adjustments will be **added** to the internal perimeter length.



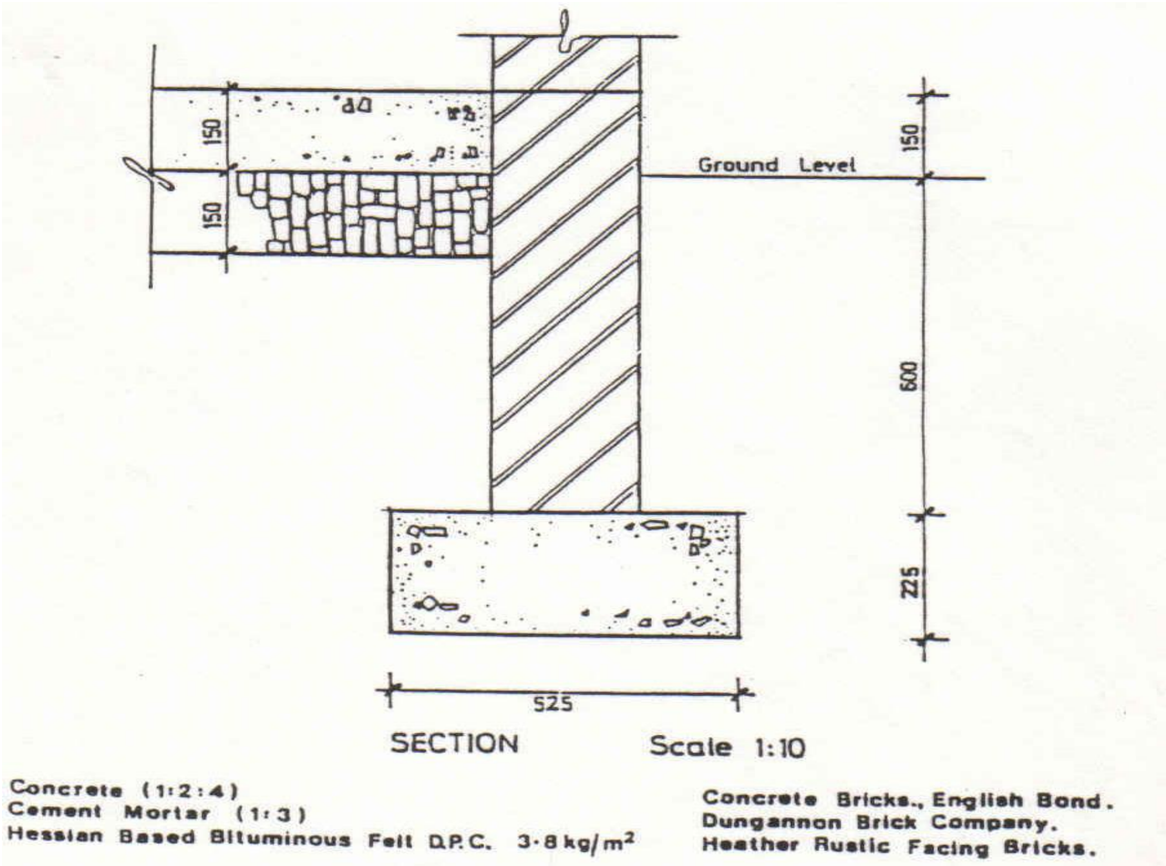


Figure 10 Department of Education 1991 *Builders' Quantities* examination.

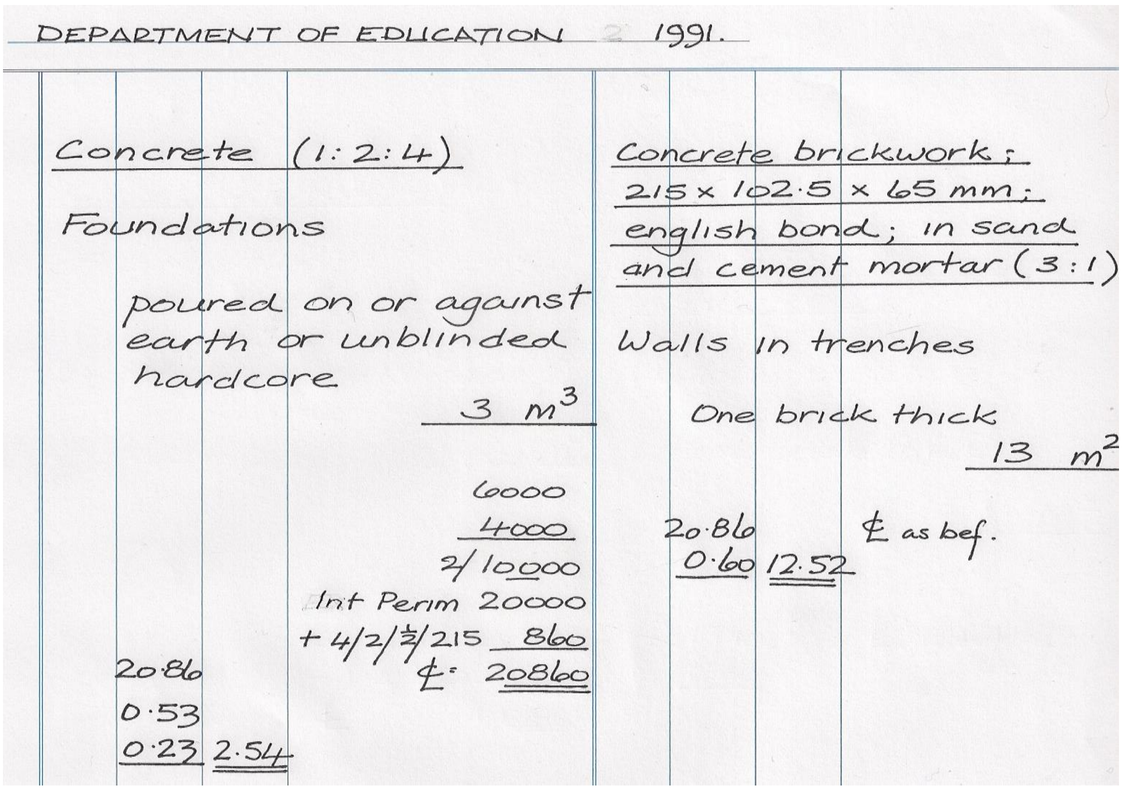


Fig 11 1991 Solutions - concrete foundation and brick rising walls below ground level.

Note that the internal perimeter (20,000) and the centreline (₵) (20,860) calculations have both been labelled for further use. The centreline of the rising wall is the same as that of the concrete foundation and therefore does not need to be recalculated.

2001 A 'T' Shaped Building

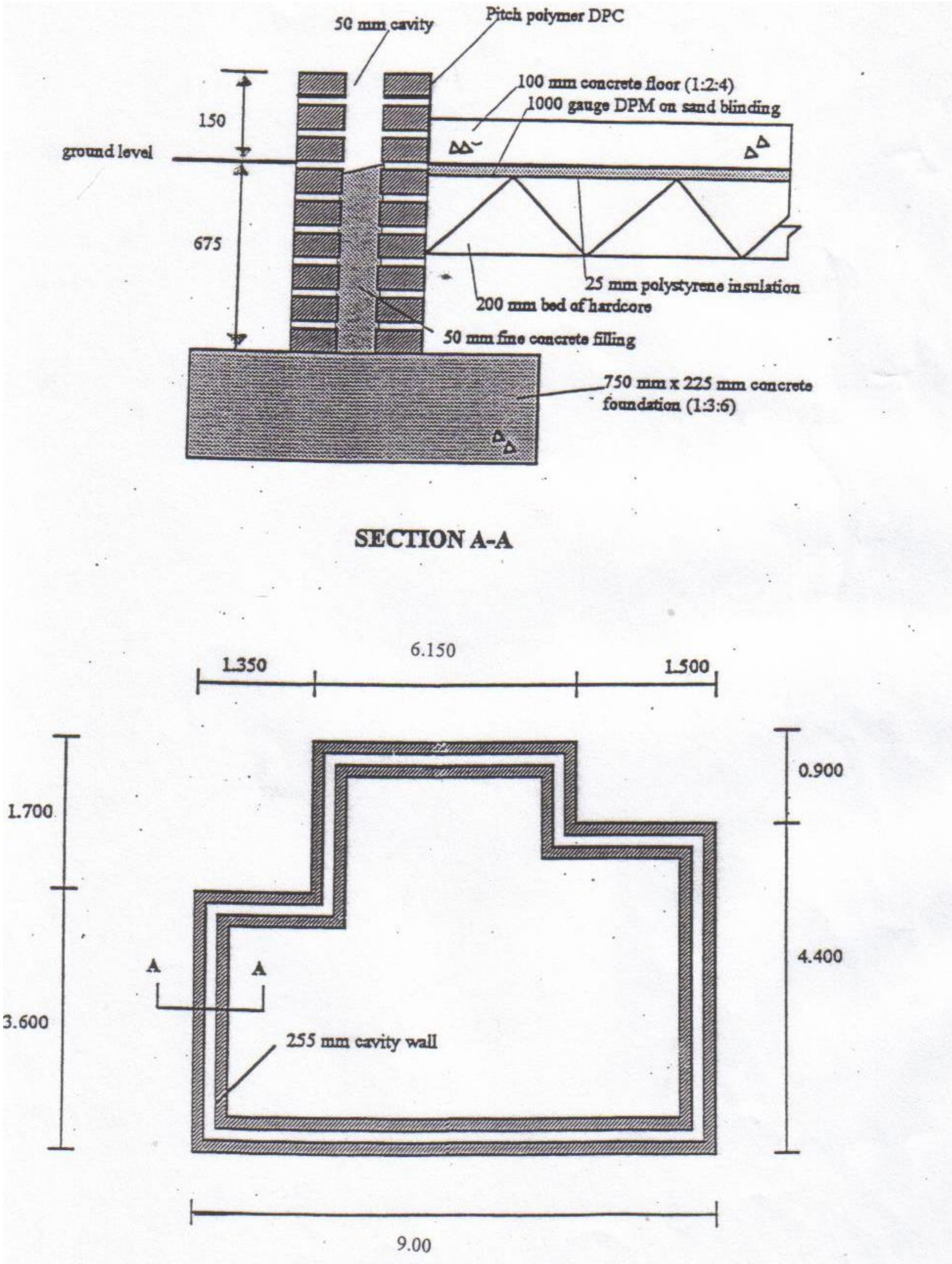
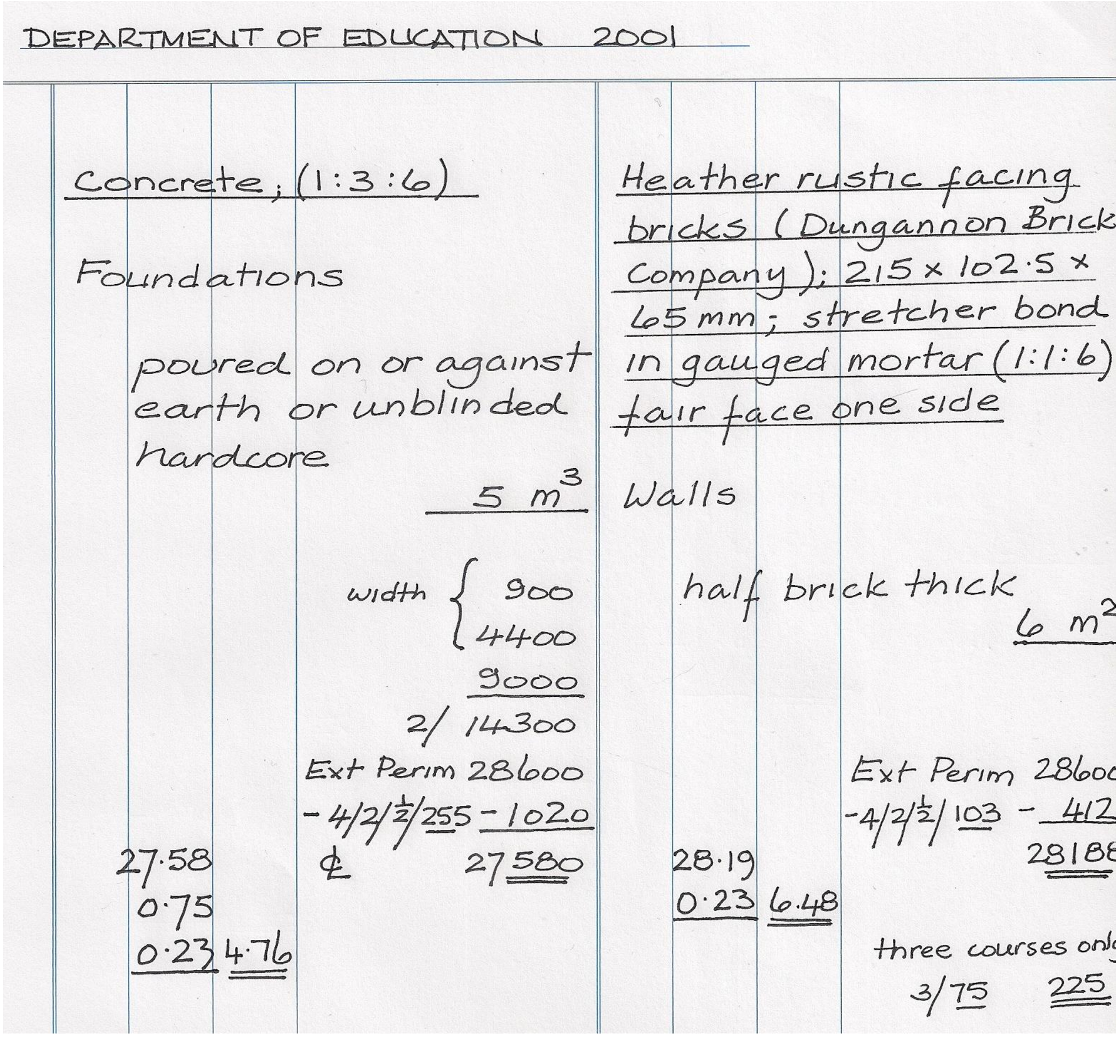


Figure 12 Department of Education 2001 *Builders' Quantities* examination.



DEPARTMENT OF EDUCATION 2001

Concrete; (1:3:6)

Foundations

poured on or against earth or unblinded hardcore

5 m³

width { 900 / 4400

9000

2/ 14300

Ext Perim 28600

– 4/2/½/255 – 1020

℄ 27580

27.58
0.75
0.23 | 4.76

Heather rustic facing bricks (Dungannon Brick Company); 215 x 102.5 x 65 mm; stretcher bond in gauged mortar (1:1:6) fair face one side

Walls

half brick thick

6 m²

Ext Perim 28600

– 4/2/½/103 – 412

28188

28.19
0.23 | 6.48

three courses only

3/75 225

Fig 13 2001 Solutions - concrete foundation and fair faced brick walls.

Note that the ‘width’ of the building has been calculated from the string of dimensions on the right hand side of the plan shape (900 + 4400). The external perimeter has been adjusted by subtracting *four times twice times half* the thickness of the cavity wall (255mm) to arrive at the centreline of the concrete foundation – this is because the centre of the cavity wall is located on the centre of the concrete foundation.

Three courses of facing bricks have been specified on the outer leaf of the cavity wall. These have been measured by reusing the previously established external perimeter and adjusting it by subtracting *four times twice times half the thickness of the brick* (½/103mm). Note also that the height of the brickwork has been separately calculated (3/75mm).

2000 A Building with Set-backs and a Recess

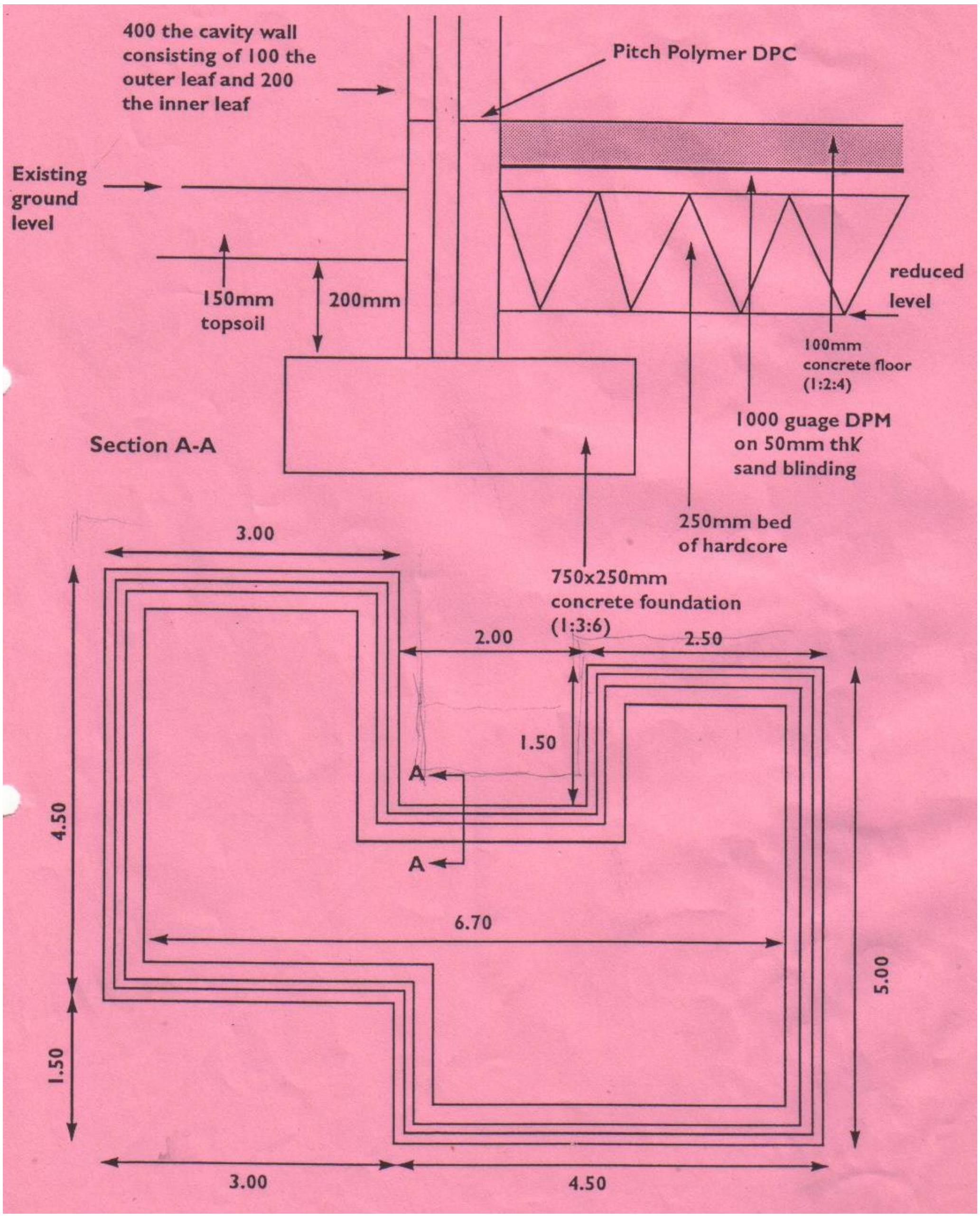
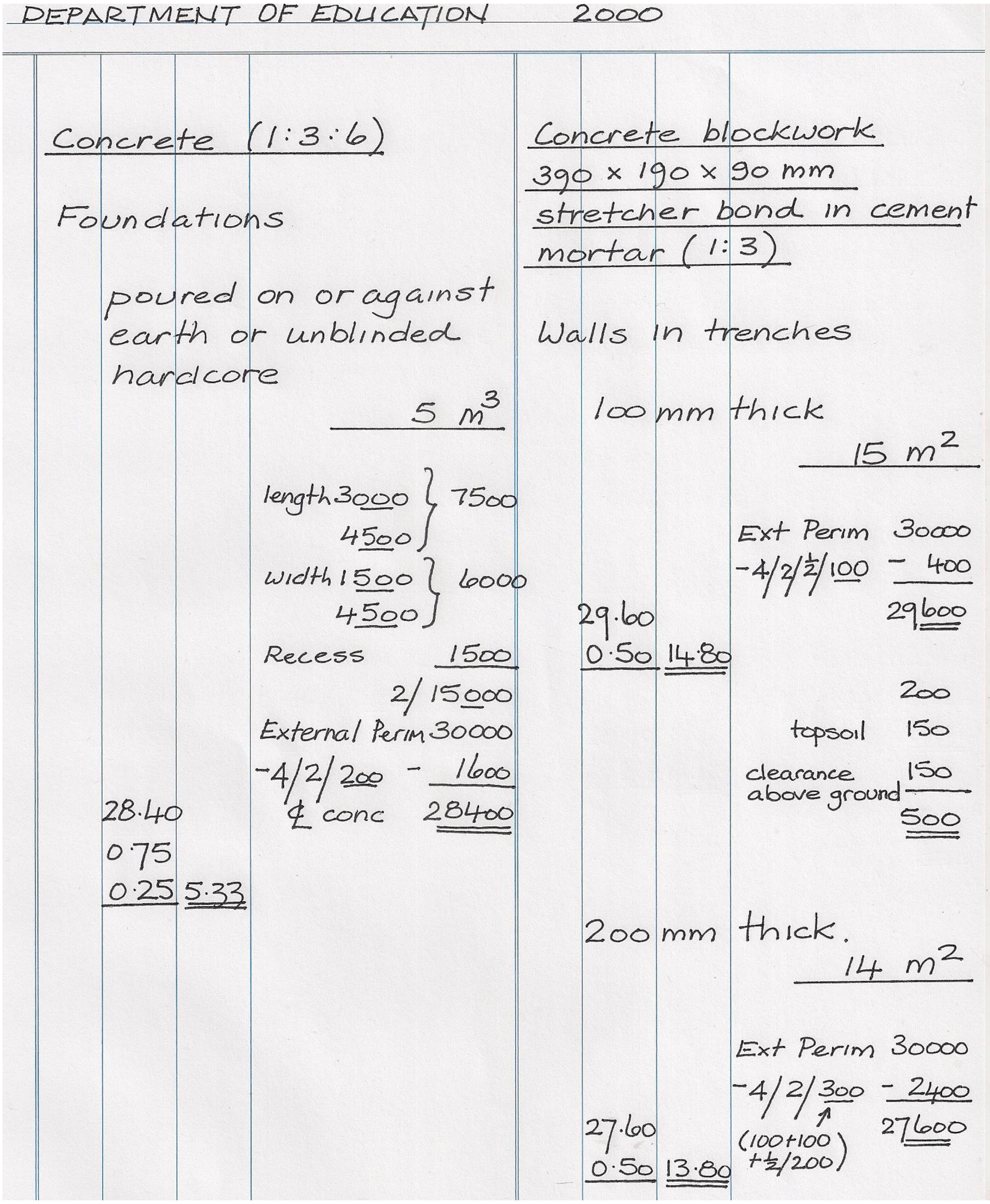


Figure 14 Department of Education 2000 *Builders' Quantities* examination.

The worked solution for the concrete foundation and the rising walls is presented in Fig 15 below. Note that the length and width of the building has been calculated from the string of dimensions on the bottom and the left hand string of dimensions on the plan. Note also, the addition of the 1500mm recess into the building. The measurement of the concrete foundation requires the external perimeter to be adjusted to the centreline of the strip foundation, this is located 200mm from the outside face of the outer leaf of the wall. The required adjustment, therefore, is to subtract *four times twice times 200mm* from the external perimeter.

The measurement of the 100mm outer leaf and 200mm inner leaf of the rising walls requires the external perimeter to be adjusted by 50mm (half of 100mm) and 300mm (100 + 100 + half of 200mm) respectively. Note also the build up of the common height of the two separate leafs.



DEPARTMENT OF EDUCATION 2000

Concrete (1:3:6)

Foundations

poured on or against earth or unblinded hardcore

5 m3

length 3000 / 4500 } 7500

width 1500 / 4500 } 6000

Recess 1500

2/ 15000

External Perim 30000

-4/2/200 - 1600

℄ conc 28400

28.40
0.75
0.25 5.33

Concrete blockwork 390 x 190 x 90 mm stretcher bond in cement mortar (1:3)

Walls in trenches

100 mm thick

15 m2

Ext Perim 30000

-4/2/½/100 - 400

29600

29.60
0.50 14.80

200
topsoil 150
clearance above ground 150
500

200 mm thick.

14 m2

Ext Perim 30000

-4/2/300 - 2400

(100+100 +½/200)

27600

27.60
0.50 13.80

Fig 15 2000 Solutions - concrete foundation and rising walls.

2005 A Building with a Bay Window

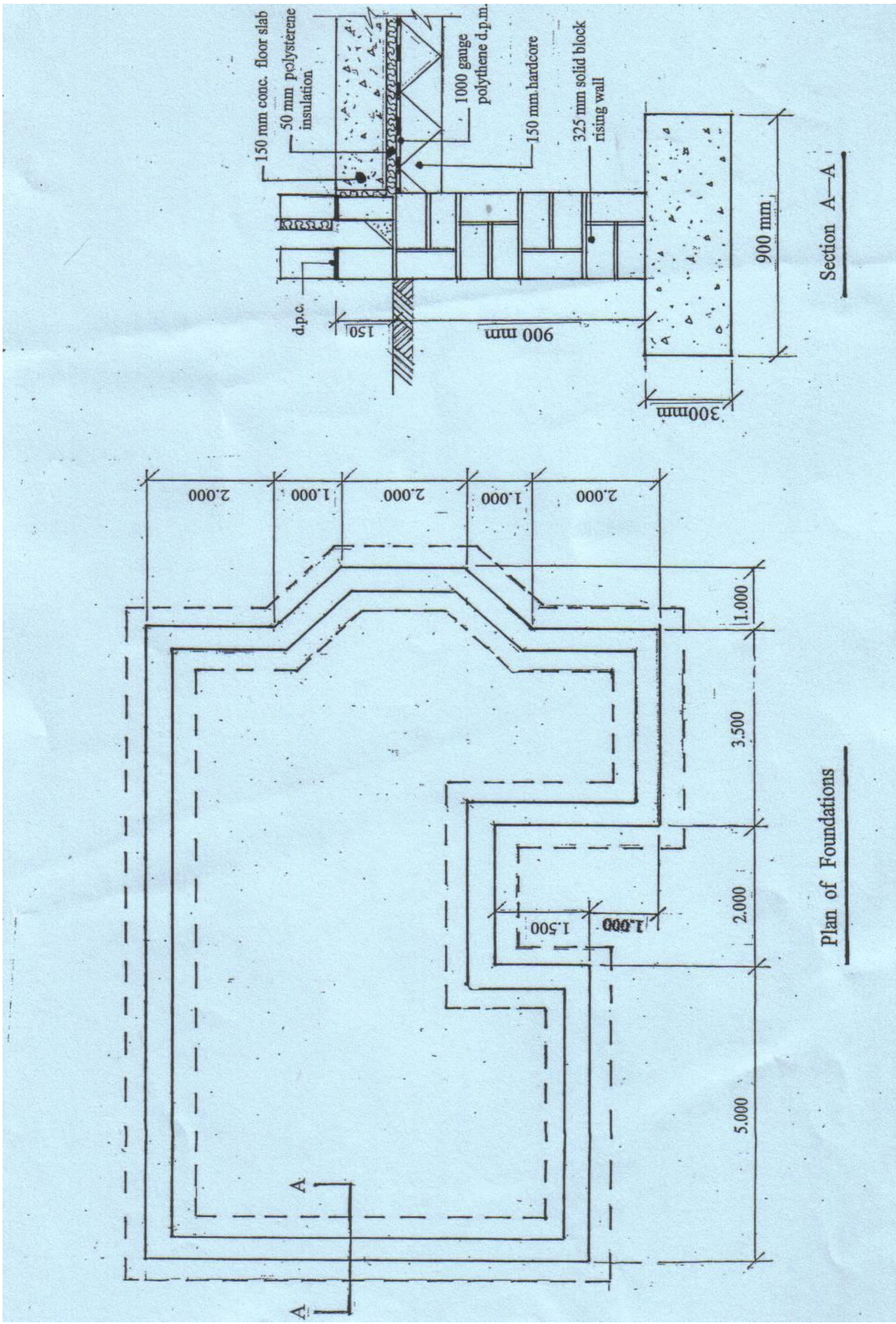
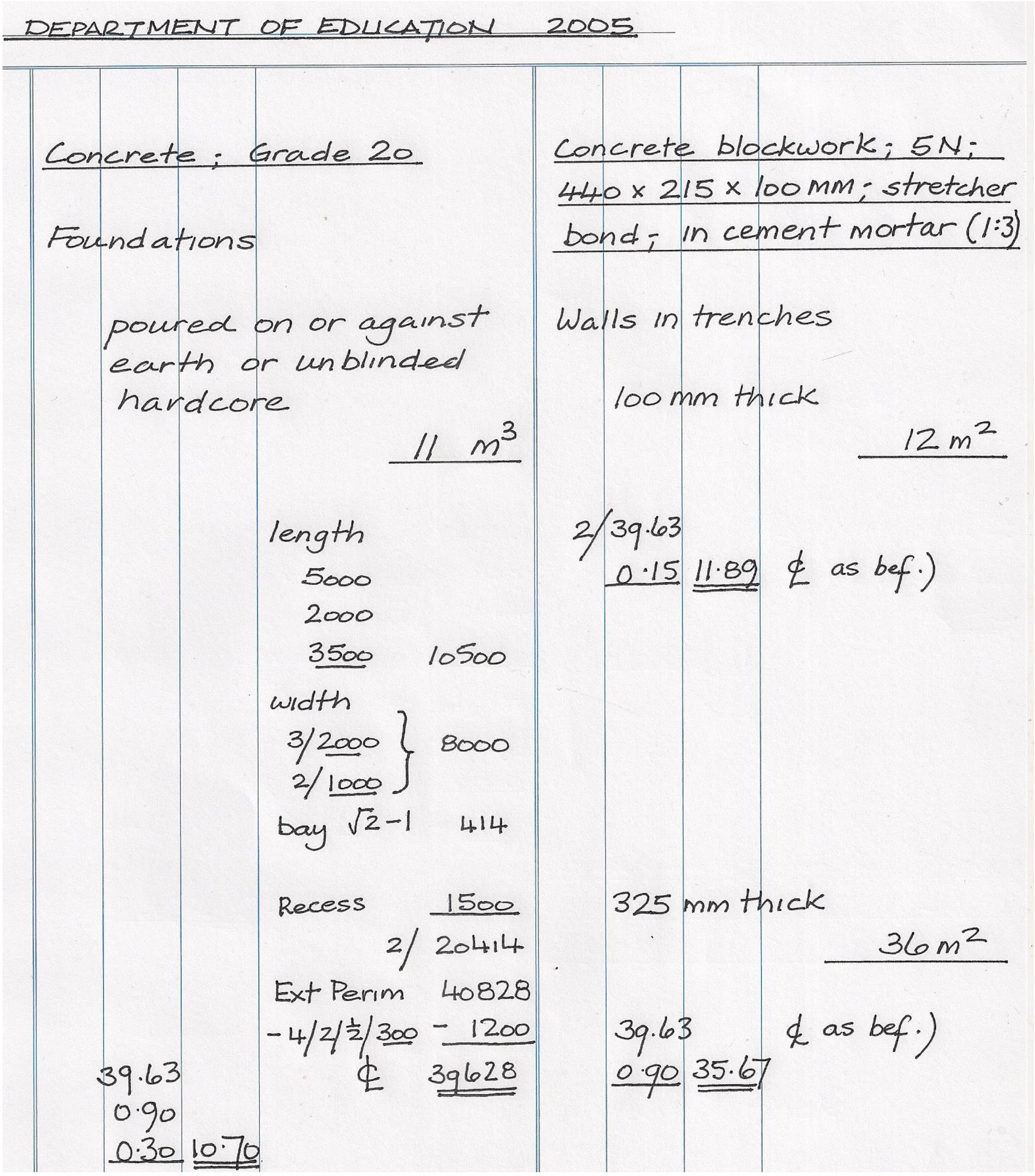


Figure 16 Department of Education 2005 *Builders' Quantities* examination.

This question introduces the further complication of dealing with a pair of 45° angles *within* one of the dimensions. The necessary adjustment is to add the *additional* length of the 'hypotenuse' of the angle. In this case it is a 45° angle whose hypotenuse is √2 or 1.414. The *additional length, therefore, is 414mm and is added immediately below the width of the building*. Note also how the recess or the 'bight' has been handled. The centreline has been copied and reused to measure the 325 solid wall and the two 100mm skins of the cavity wall.



DEPARTMENT OF EDUCATION 2005

Concrete ; Grade 20

Foundations

poured on or against earth or unblinded hardcore

11 m^3

length
5000
2000
3500 10500
width
3/2000 } 8000
2/1000
bay √2−1 414

Recess 1500
2/ 20414
Ext Perim 40828
−4/2/½/300 − 1200
℄ 39628

39.63
0.90
0.30 10.70

Concrete blockwork; 5N; 440 x 215 x 100 mm; stretcher bond; in cement mortar (1:3)

Walls in trenches

100 mm thick

12 m^2

2/39.63
0.15 11.89 (℄ as bef.)

325 mm thick

36 m^2

39.63 (℄ as bef.)
0.90 35.67

Fig 17 2005 Solutions - concrete foundation and rising walls.

2006 A Building with a 'Proud' End.

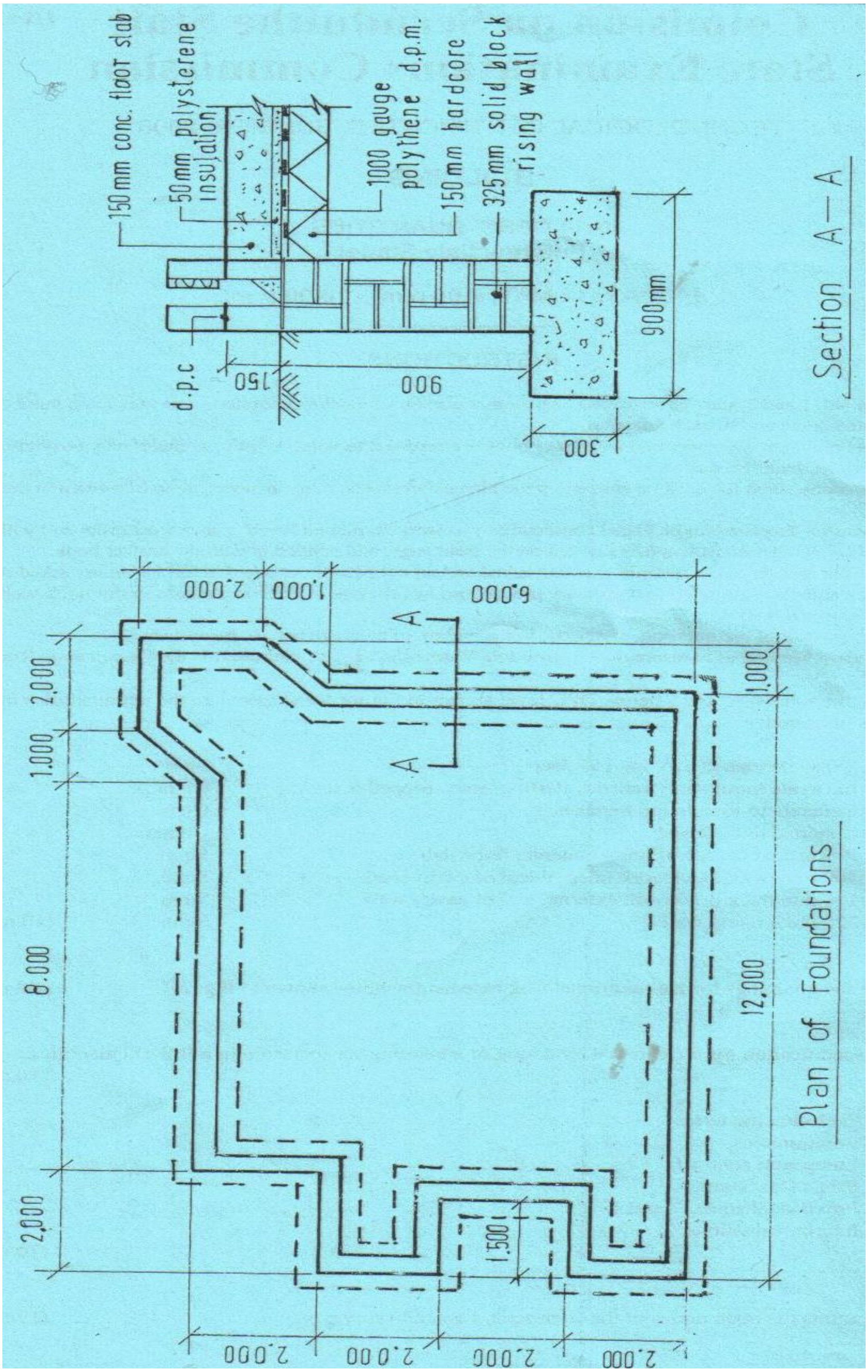
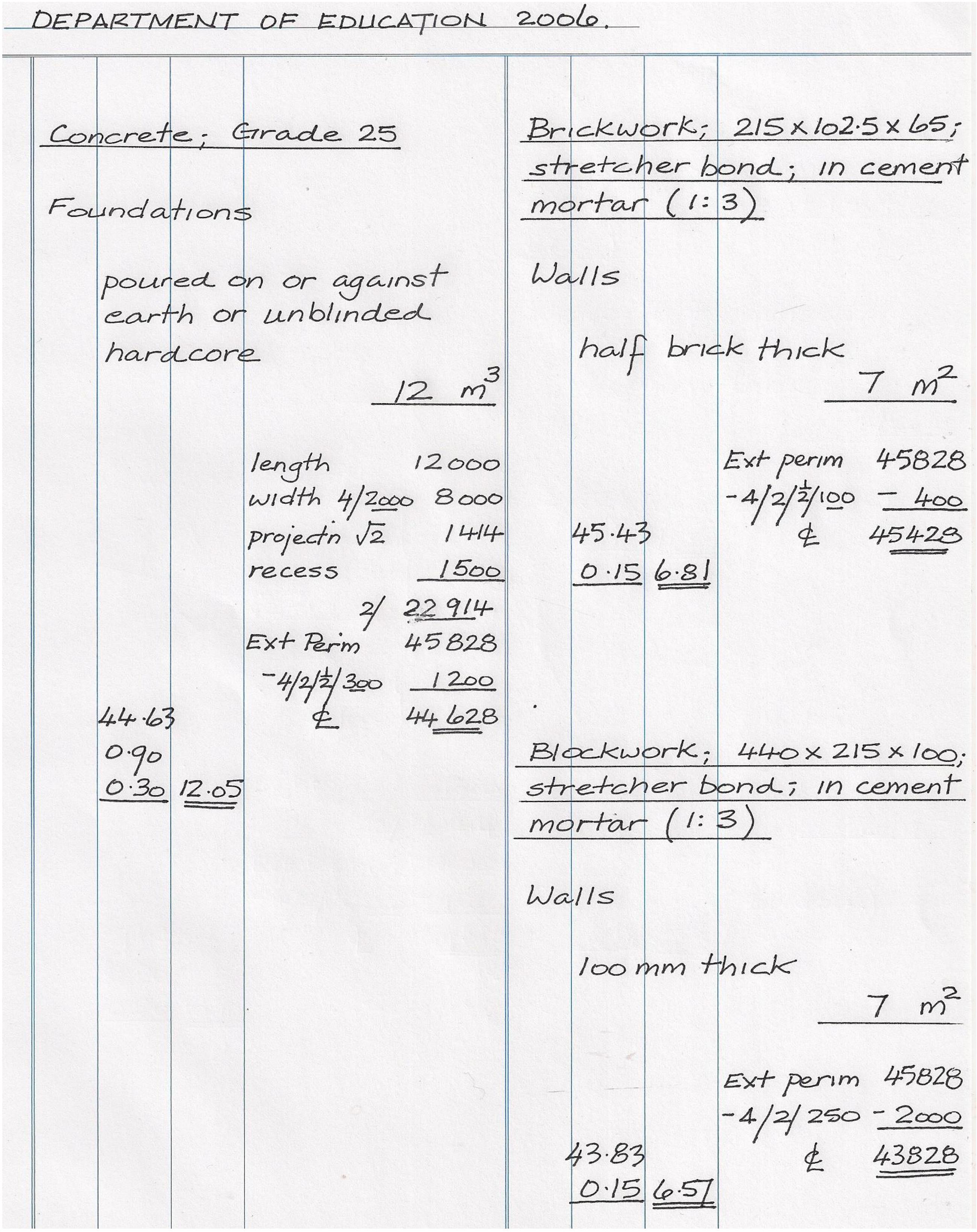


Figure 18 Department of Education 2006 *Builders' Quantities* examination.


DEPARTMENT OF EDUCATION 2006.

Concrete; Grade 25

Foundations

poured on or against earth or unblinded hardcore

12 m^3

length 12000
width 4/2000 8000
projectn √2 1414
recess 1500
2/ 22914
Ext Perim 45828
−4/2/½/300 1200
℄ 44628

44.63
0.90
0.30 12.05

Brickwork; 215 x 102.5 x 65; stretcher bond; in cement mortar (1:3)

Walls

half brick thick

7 m^2

Ext perim 45828
−4/2/½/100 − 400
℄ 45428

45.43
0.15 6.81

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

Walls

100 mm thick

7 m^2

Ext perim 45828
−4/2/250 − 2000
℄ 43828

43.83
0.15 6.57

Fig 19 2006 Solutions - concrete foundation and cavity walls above ground to dpc level.

This examination question differs from the previous example in that the 45° occurs at the *corner* of the building. In this case the *entire* length of the hypotenuse of the angle forms the projection. In this example the two leafs of the cavity wall above ground and below dpc level (150mm) have been taken for demonstration purposes to comprise of a brick outer leaf and a block inner leaf. The distance moved from the external perimeter to the centreline of the respective leafs is 50mm and 250mm.

In Summary

Quantity surveyors are expected to be able to calculate perimeters and centrelines accurately. Perimeters are typically found by *doubling* the totals of the overall length, overall width, and the total of any projections/recesses on the plan. Setback corners may be disregarded in this process, but recesses must be taken into account. Centrelines of the various construction elements may be found by adjusting the perimeter using the formula *four times twice times the distance moved*. Where an external perimeter has been calculated, the resulting adjustment will be *deducted from* the perimeter length. Where an internal perimeter has been calculated, the resulting adjustment will be *added to* the perimeter length. Best practice suggests that all steps in performing the calculations should be clearly recorded, and the most obvious/simple approach is usually the best approach.

The above examples show various approaches to calculating perimeters and centrelines, - these are not exhaustive. With increasing practice in, and familiarity with the technique, quantity surveyors, in time, develop their own individual approach to carrying out these calculations.

References

Hore, A.V. O'Kelly, M. and Scully, R. eds. (2009) *Seeley and Winfield's Building Quantities Explained Irish Edition.* Palgrave McMillan, Basingstoke, Hampshire.