GENERAL:

(1) This project will be carried out at Foreshore Park.

(2) Work in full parties.

(3) For your topographic map and calculation of volume of excavation for the 9 m $\times$ 18 m building foundation, you will need the elevations of grid line intersections at 3 m intervals on the building site and the elevations of points beyond the sides AD and BC (see Figure 1) for calculation of volume of side berms. Ends AB and CD will have vertical cuts.

EXERCISE:

The plan view and dimensions of the outsides of the perimeter walls of a proposed building, together with its relationship to a property line XY and a bench mark, to be given in the field, is shown in Figure 1.

(1) Each party is required to locate and stake out the corner points A, B, C and D of the building, to measure diagonals AC and BD, and to determine the errors in these diagonal distances. Chained or taped lengths are to be corrected for slope and temperature. The coefficient of expansion of the metric tapes is 1.10×10^{-5} per degree Celsius. The metric tapes were standardized in catenary and can be assumed to have negligible standardization errors at 20°C, under 70 N tension. The standard pulls or their equivalents in lbs. should be applied using tension grips so as to avoid the need to correct for pull. Given 1 lb. = 4.448 N.

(2) The volume in m^3 and the cost of excavation down to the 73.50 m level is to be found by determining the existing ground elevations at the intersections of grid lines spaced at 3 m intervals parallel and perpendicular to sides AD and BC, and wherever else deemed necessary beyond sides AD and BC in order to determine the volumes of the berms along these sides. End slopes of the excavation will be vertical, as indicated by sections a-a and b-b in Figure 1. Cost o excavation will be \$12.50 per m^3.

STAKING OUT A BUILDING:

(1) Most cities and towns have regulations requiring buildings to be set back given distances from streets and also specify distances between buildings or houses for appearance, fire protection and other purposes.

(2) Locate corners, A, B, C and D of the building on the lot assigned to your party by making appropriate measurements from given property line XY.

(3) Set the 4 corner stakes initially at their exact proper locations. These stakes serve as a visual check on the location, but, of course, are lost when excavation for the foundation begins, and are replaced by new stakes or reference marks offset at suitable distances away from the actual corners.

(4) Check the correctness of the 4 corner points by measuring both diagonals AC and BD. Record the lengths of these diagonals and the differences between them and the correct lengths to a suitable precision in your field book.

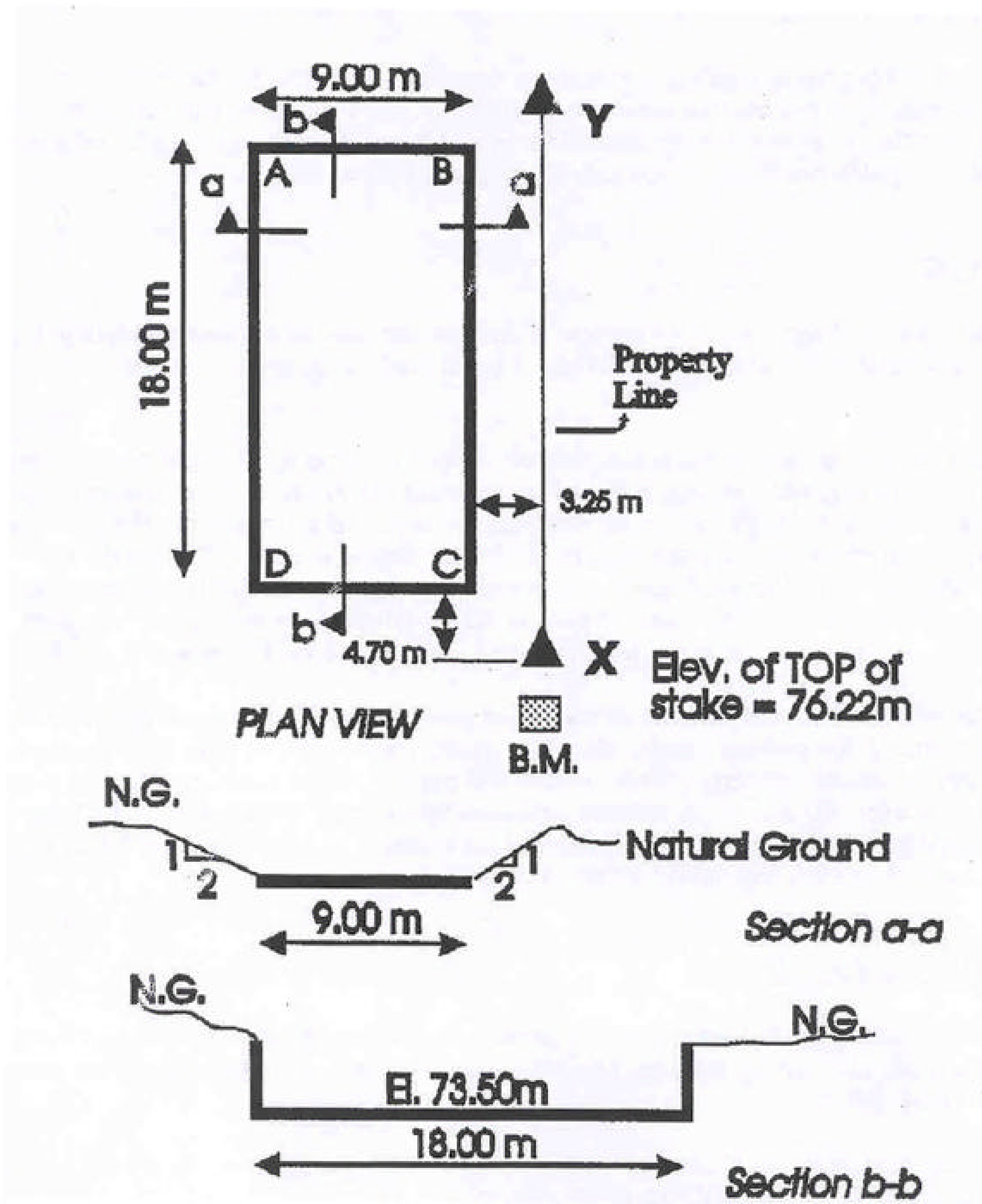


Figure 1

DETERMINING VOLUME AND COST OF EXCAVATION

Note: Before excavation begins, it is important that the general contractor for the building and the excavation sub-contractor should agree on the method to be used to calculate volumes of excavation. Failure to do this has, in the past, led to disputes and to costly court actions in some cases.

(1) Establish a set of grid lines spaced at 3 m intervals parallel and normal to the sides AD and BC of the foundation site.

(2) Determine the elevation of each grid intersection location with respect to the top of the given Bench Mark (BM) stake, whose given elevation is 76.22 m. Also obtain ground elevations beyond sides AD and BC on grid lines produced as you deem necessary to determine the volumes of the berms along these sides (see Section a-a, Fig. 1).

(3) Assuming linear elevation changes between grid intersection points, draw a contoured diagram of the foundation area ABCD and an appropriate distance beyond sides AD and BC. Draw contour lines at intervals of 0.5 m. Use a scale of 1/100 or 1 cm = 1 m.

(4) Draw a second diagram at the same scale showing grid lines, and at each grid intersection and intersections with sides, show the following:

H_A	H_P
H_C	H_F

where:
H_A = actual or existing ground elevation
H_P = planned excavation level
h_C = depth of cut at point
h_F = depth of fill at point

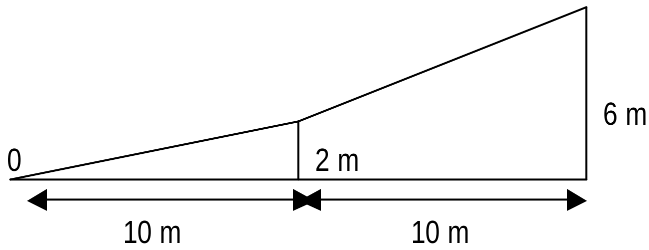
(see example below)

(5) Compute the volume and cost of excavation, including material to be removed to leave the berms, by the following two methods:

a) *Section Method*

Draw sections depicting the depths of excavation across the width of the building at each end and along each lateral grid line.

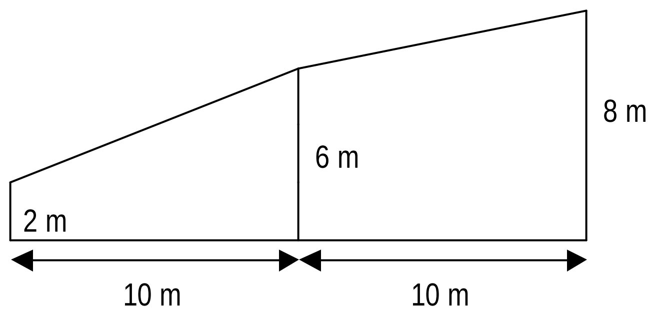
Example: The following example shows the calculation of the volume of excavation for the foundation of a 30 m long by 20 m wide building, grid lines being spaced at 10 m intervals. (N.B. This example does not include calculation of volumes of berms. It is left to the student to devise a proper method of calculating volumes where berms are involved.)



$$S_{1-1} = \left(\frac{2+0}{2} + \frac{2+6}{2} \right) 10 = 50\ m^2$$

$$S_{1-2} = \frac{50+110}{2} = 80\ m^2$$

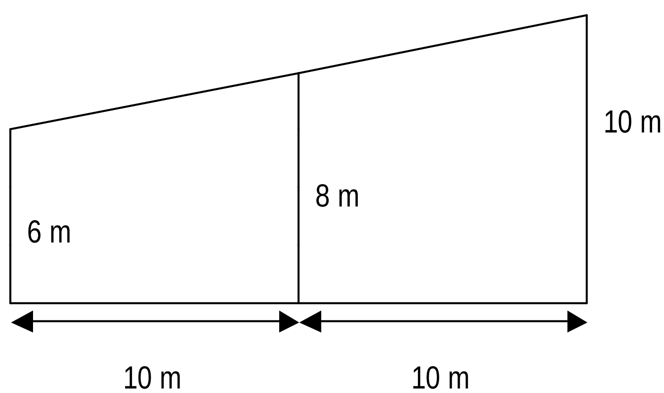
Section 1-1 (at south end)



$$\mathrm{S}_{2-2} = \left(\frac{2+6}{2} + \frac{6+8}{2} \right) 10 = 110\ \mathrm{m}^2$$

$$\mathrm{S}_{1-3} = \frac{110+160}{2} = 135\ \mathrm{m}^2$$

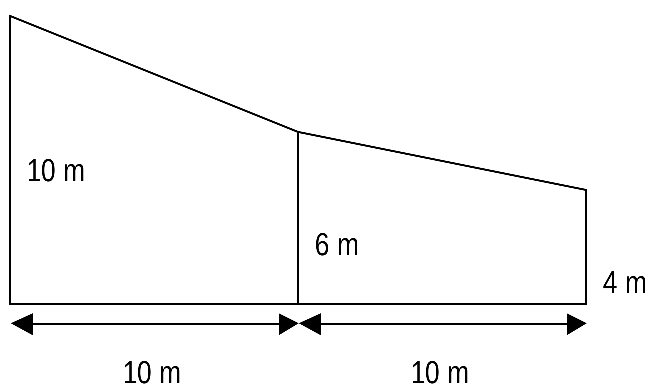
Section 2-2



$$\mathrm{S}_{3-3} = \left(\frac{6+8}{2} + \frac{8+10}{2} \right) 10 = 160\ \mathrm{m}^2$$

$$\mathrm{S}_{3-4} = \frac{160+130}{2} = 145\ \mathrm{m}^2$$

Section 3-3



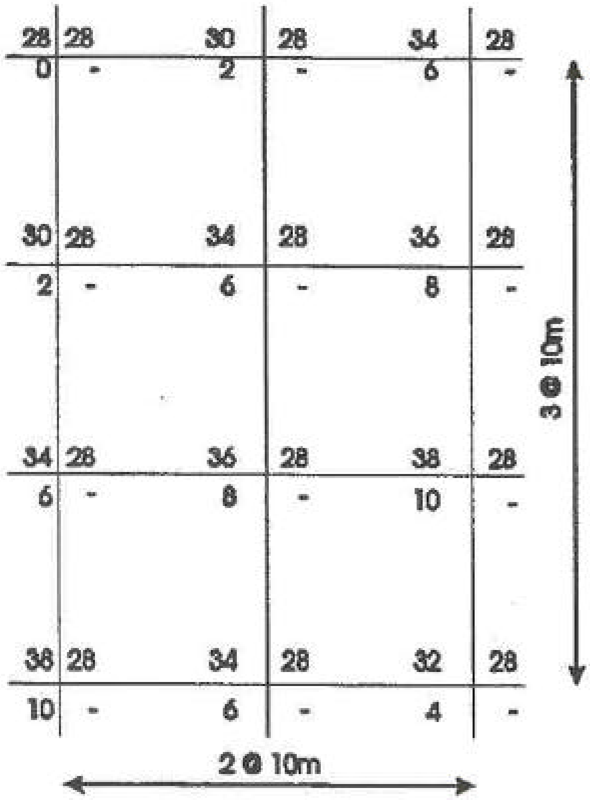
$$\mathrm{S}_{4-4} = \left(\frac{10+6}{2} + \frac{6+4}{2} \right) 10 = 130\ \mathrm{m}^2$$

Section 4-4 (at north end)

Total volume = 80(10) + 135(10) + 145(10) = 3600 m^3

Cost @ \$10.00 per m^3 = 3600(10) = \$36,000.

b) *Grid Square Method*



$$V_1 = \left(\frac{0+2+2+6}{4}\right)(10)(10) = 250\,\mathrm{m}^2$$

$$V_2 = \left(\frac{2+6+8+6}{4}\right)(10)(10) = 550\,\mathrm{m}^2$$

$$V_3 = \left(\frac{2+6+8+6}{4}\right)(10)(10) = 550\,\mathrm{m}^2$$

$$V_4 = \left(\frac{6+8+10+8}{4}\right)(10)(10) = 800\,\mathrm{m}^2$$

$$V_5 = \left(\frac{6+8+6+10}{4}\right)(10)(10) = 750\,\mathrm{m}^2$$

$$V_6 = \left(\frac{8+10+4+6}{4}\right)(10)(10) = 700\,\mathrm{m}^2$$

Total volume = 250 + 550 + 550 + 800 + 750 + 700 = 3600 m^3

Check section method (a)

Short way of calculating volume using Grid Square Method

Let,

n_1 = no. of corner points = 4 above
n_2 = no. of intermediate side points = 6 above
n_3 = no. of interior intersection points = 2 above

Now, total cut is:

Σh_c = 1(Σcorner cut depths) + 2(Σintermediate side point cuts)
+4(Σinterior intersection point cuts)

= 1(0+6+4+10) + 2(2+8+10+6+6+2) + 4(6+8) = 144 m

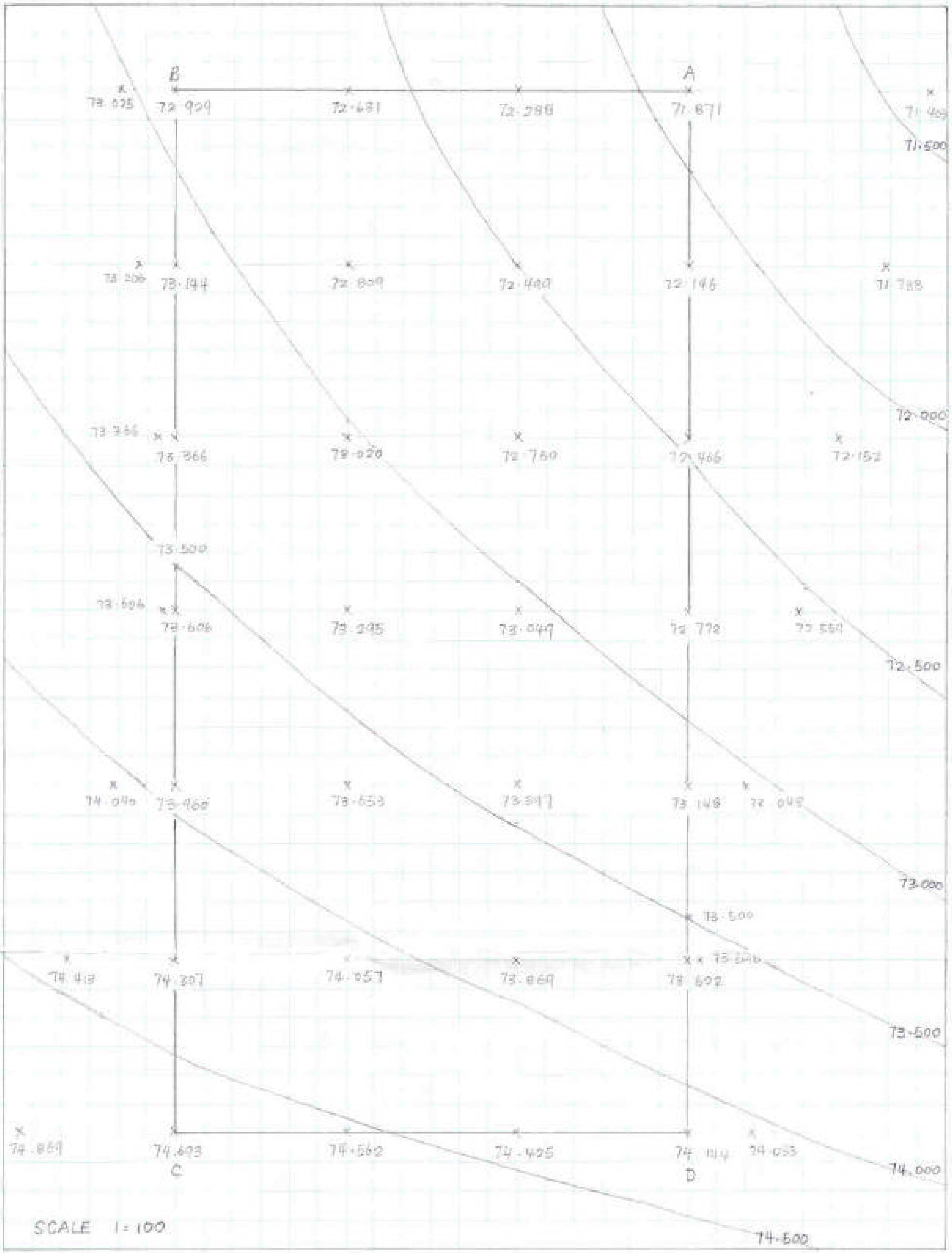
Average cut:

$$H_c = \frac{\Sigma h_c}{1(n_1) + 2(n_2) + 4(n_3)} = \frac{144}{1(4) + 2(6) + 4(2)} = \frac{144}{24} = 6.0\ \text{m}$$

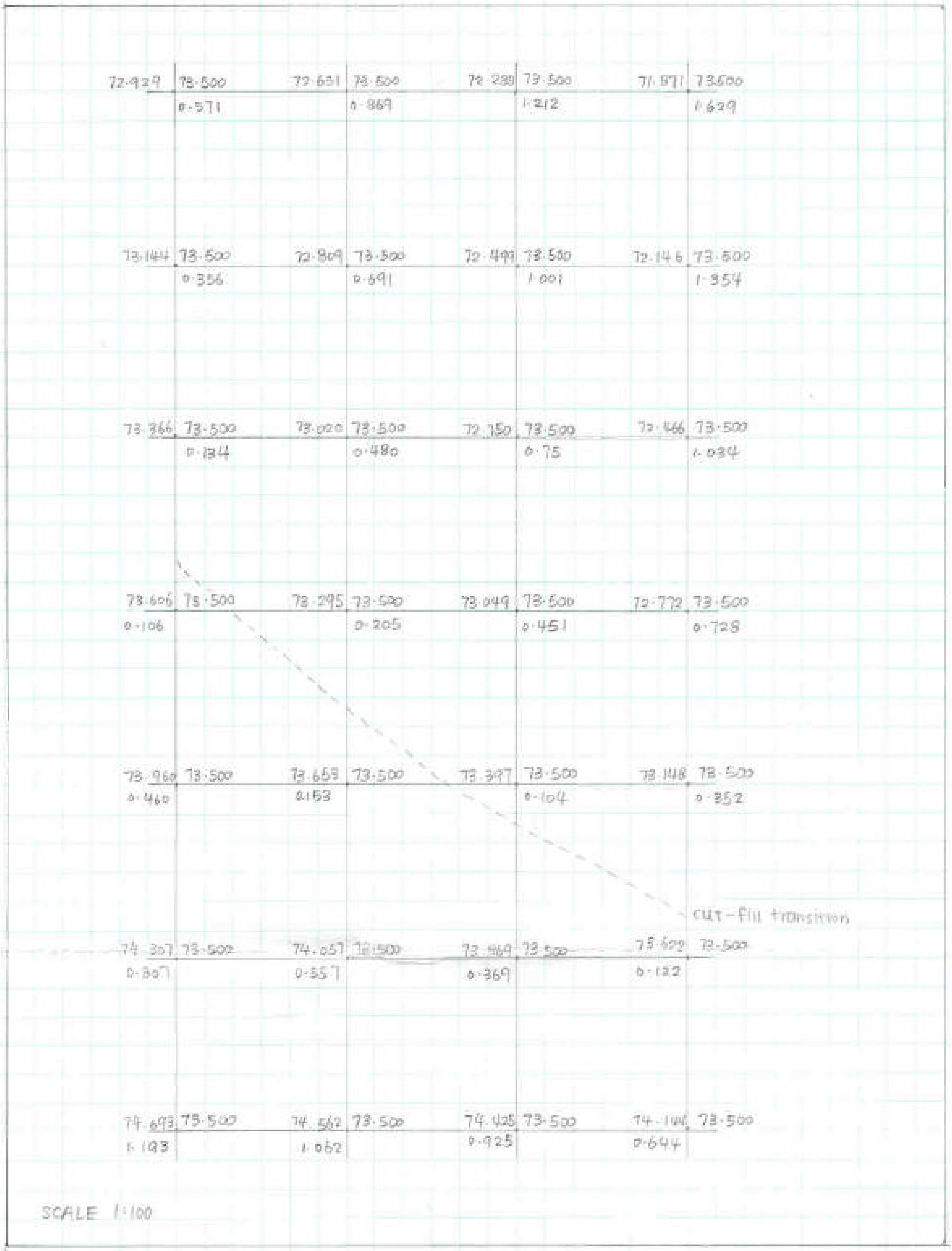
Total volume = Area $\times$ Average cut = 30(20)(6) = 3600 m^3

Cost at \$10.00 per m^3 = (3600)(10) = \$36,000. Check method (a).

(c) The excavated material, whose volume is 12% greater than its volume in place, weighs about 21 kN per cubic metre. The combined cost of loading it onto a truck and hauling it to a dumping site 3.55 km away is agreed upon to be \$0.10 per kN-kilometre. Compute the cost of loading and hauling away the excavated material, and find the total cost of excavating and disposing of the material.



CONTOURED DIAGRAM OF FOUNDATION ABCD



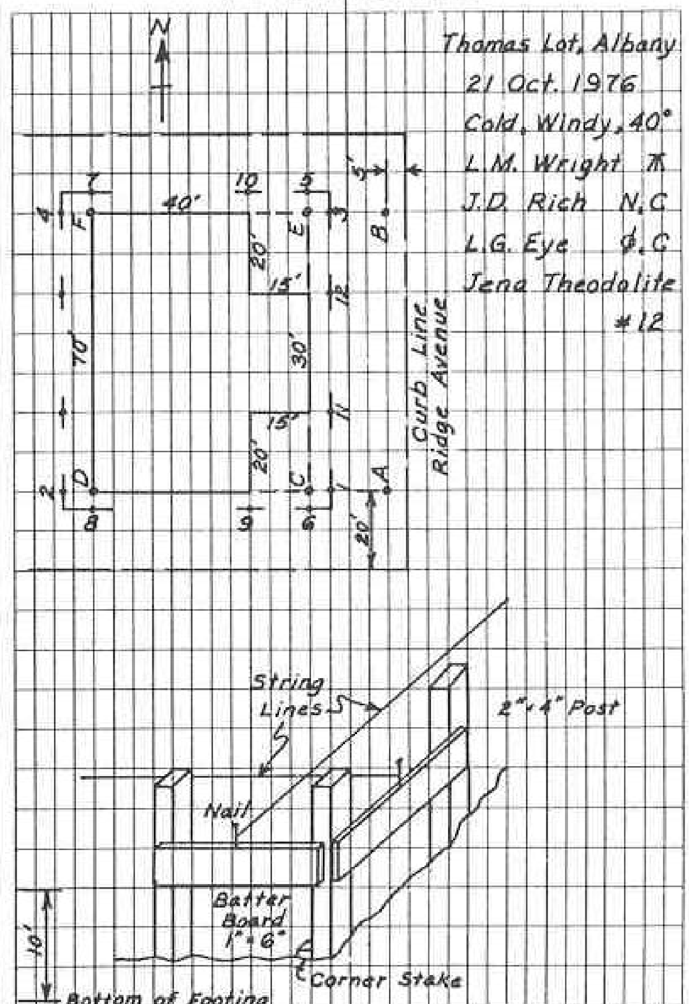
GRID SQUARE DIAGRAM

STAKING OUT

Steps	
1	Set hubs A and B 5′ inside curb line, hub A 20′ from South property line, hub B 70.00′ from A.
2	Set ⊼ at hub A. BS on hub B. Turn 90° ∡. Set batter board nails 1 and 2, stakes C and D.
3	Set ⊼ at hub B. BS on hub A. Turn 90° ∡. Set batter board nails 3 and 4, stakes E and F.
4	Measure diagonals CF and DE. Adjust error if small, restake if large.
5	Set ⊼ at C. BS on E. Set batter board nail 5. Plunge and set nail 6.
6	Set ⊼ at D. BS on F. Set nail 7. Plunge and set nail 8.
7	Set batter board nails 9, 10, 11, and 12 by measurements from established pts.

Plate

A BUILDING



A-11

JDRich

BORROW-PIT LEVELING

Point	+ Sight	HI	− Sight	Elev.	Cut
BM Road	4.22	364.70		360.48	
A,0			5.2	359.5	1.5
B,0			5.4	359.3	1.3
C,0			5.7	359.0	1.0
D,0			5.9	358.8	0.8
E,0			6.2	358.5	0.5
A,1			4.7	360.0	2.0
B,1			4.8	359.9	1.9
C,1			5.2	359.5	1.5
D,1			5.5	359.2	1.2
E,1			5.8	358.9	0.9
A,2			4.2	360.5	2.5
B,2			4.7	360.0	2.0
C,2			4.8	359.9	1.9
D,2			5.0	359.7	1.7
A,3			3.8	360.9	2.9
B,3			4.0	360.7	2.7
C,3			4.6	360.1	2.1
D,3			4.6	360.1	2.1
A,4			3.4	361.3	3.3
B,4			3.7	361.0	3.0
C,4			4.2	360.5	2.5
BM Road	4.23				

Plate

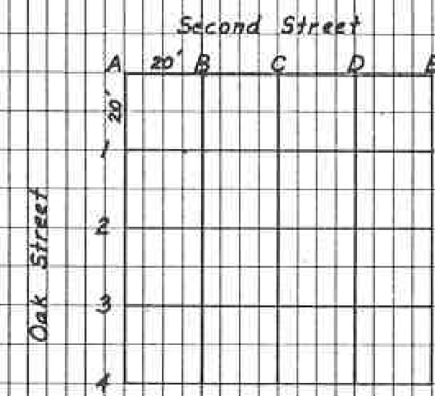
SECOND & OAK STREETS

Xn

BM Road - Description p. A-5

Madison, Wis.
Cool, Cloudy, 60°
D.A. Tyler N
B.K. Harris ϕ
E.A. Custer
Kern Level # 4
11 Oct. 1976

1.5
2.6
2.0
1.6
0.5
4.0
7.6
6.0
3.6
0.9
5.0
8.0
7.6
3.4
5.8
10.8
6.3
2.1
3.3
6.0
2.5



Grade elevation 358.0

Volume = area of base × $\frac{h_1+h_2+h_3+h_4}{4}$

91.1 / 4

$22.8 \times \frac{400}{27} = 337$ cu yd

A-6

D. Tyler