Preliminaries 2

Buit 5110

CONSTRUCTION LEVELLING

Contents

Automatic level.

The automatic level uses a prism that is hung in a variety of ways but can always assume a vertical axis from its point of suspension. The prism and sighting mechanism are arranged so that when the pendulum is vertical, the instrument is automatically levelled. The pendulum is unlocked when the instrument is within 5^0 of the horizontal. (See Sokkia product sheet)

Setting up the tripod

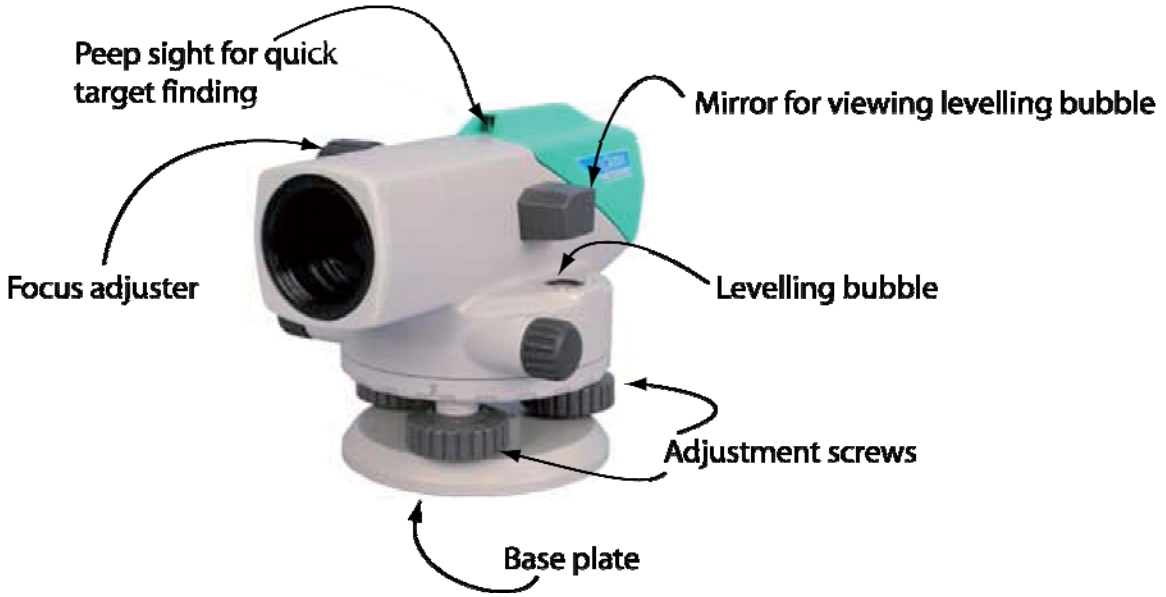
1. Push two legs of the tripod firmly into the ground.
2. Get tripod head approximately level and push third leg into the ground. Do not set the tripod too low!
3. If the tripod is set on a steep slope, *two of the legs* must be secured in the ground roughly at the same height on the downhill side of the instrument.
4. The *remaining leg* is secured to the uphill side. Adjust the *remaining leg* to level the tripod head by sliding leg adjustment.

Levelling a 3 screw instrument

1. Attach the levelling instrument firmly to the tripod head. If the setting up bubble is circular, the bubble must be in the centre of the ring.

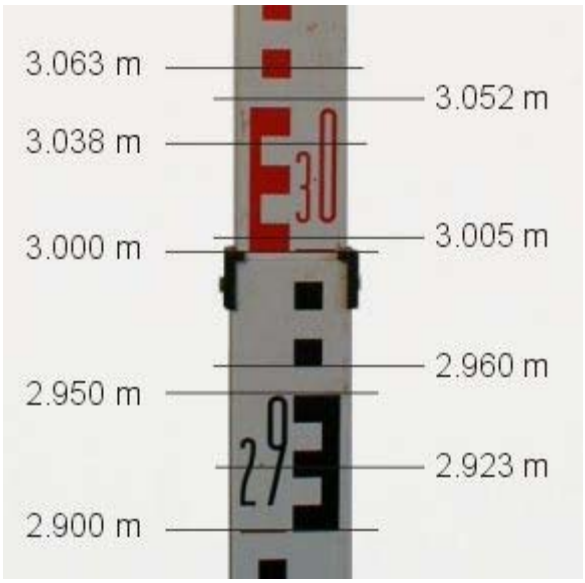
2. Move the bubble towards the centre direction by using screws 1 and 2 to level the bubble.

3. Move the third screw to centralise the bubble. Once the bubble is centralised, check to ensure the instrument is levelled by rotating the instrument at $360^{0.}$ If the bubble remains within the circle the instrument is correctly set.
(*Note*: not necessary for automatic levels)



Levelling Staff

Standard staffs are 3 metres, 4 metres, or 5 metres long, they fold or telescope down to about1200 mm, have a reading face at least 38 mm wide. The staff is graduated in 10mm increments with alternating black and red figures per metre on a white staff. Reading the staff to the graduation will give ***0.01m accuracy.*** If three decimal places of accuracy are needed, it has to be estimated.



Taking a reading

The method of taking readings differs slightly with the type of instrument being used; however the instrument must be set up level.
The staff holder must hold the staff on the mark or peg. Ensure the staff is plumb and facing the instrument.
Ensure the staff is visible for the instrument to focus on. If the *parallax* has been eliminated, the black hair line will be sharply outlined against the staff. To remove the parallax you will need to focus the cross hairs separately. This is done by having the background out of focus and then focusing the cross hairs against the out of focus background.

Levelling and Booking

Levelling Terms

Datum

An arbitrary horizontal line or plane to which levels are referred. Usually taken as 10.00 or 100.00. *(On most commercial jobs, the mean sea level is the reference point.)*

Temporary Bench mark

A levelling reference point established in a position adjacent to or on the site to provide a convenient reference to the datum. *This may in fact be the datum*.

Bench mark

Established by Lands and Survey Department, Councils, Registered Surveyors, Engineers. These are recorded at certain points as *Above Mean Sea Level* (AMSL).

Reduced level

Levels expressed in terms of the datum, may be indicated by

(a) Spot levels on the plan e.g. 103.420, 96.820,
(b) Vertical section,
(c) Contour lines.

To avoid negative reduced levels, the datum will have to be set well below the lowest level being worked on.

Line of collimation

Horizontal line of sight through the telescope of the instrument

Station point

Position of the instrument when taking spot levels.

Back sight (BS)

The first sight taken after the instrument is set up or moved and re-setup.

Fore sight (FS)

The last sight taken before the instrument is moved.

Intermediate sight (IS)

Any sight between fore sight and back sight.

Change station

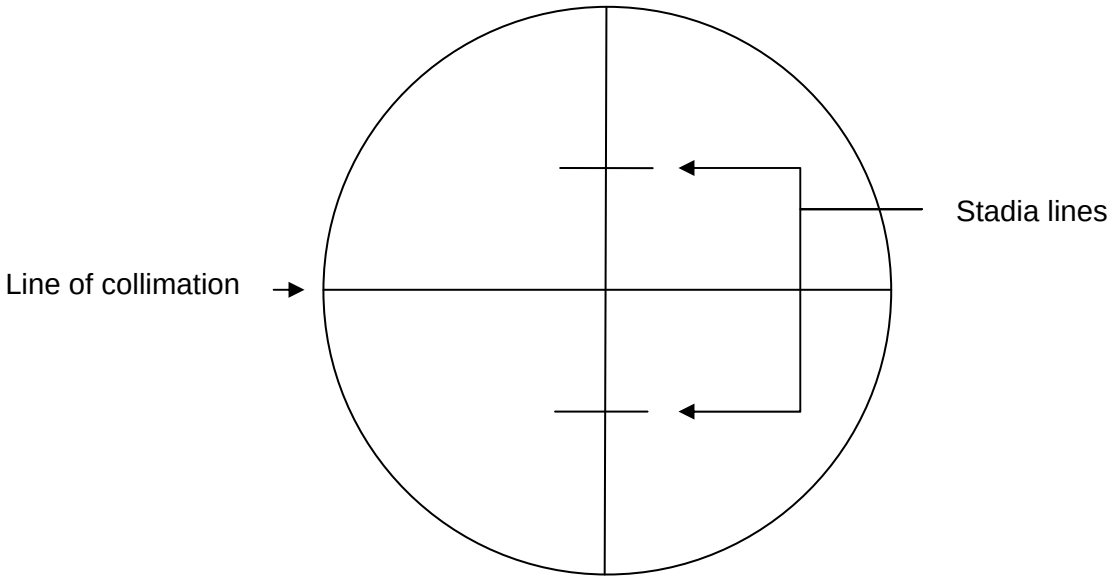
Change point of the instrument, the point at which the fore sight of one collimation line is linked to the back sight of the next collimation line.

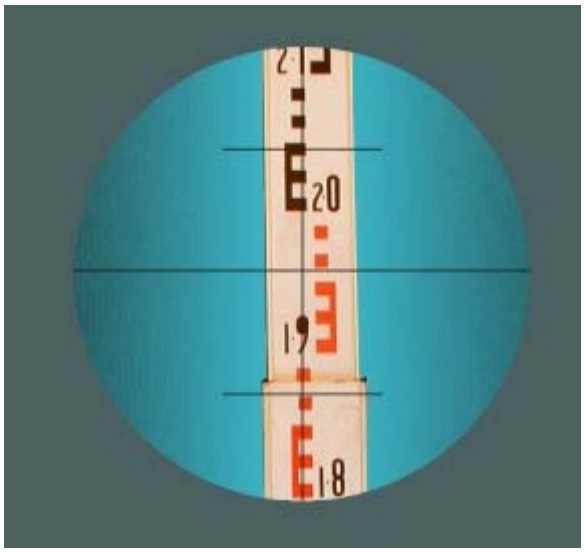
Stadia lines

Two short level lines equal distance above and below the levelling line in the telescope. The distance between the stadias is read off the staff. Distance between stadia lines multiplied by 100 = distance from instrument to staff.

Note.	**The degree of accuracy for stadia is 100 mm in 30 metres**

STADIA LINES (view through telescope)





EXAMPLE

Stadia lines read	***2.043(top)***
and	***1.872(bottom)***
Difference	***=.171***
	171 x 100= 17100mm or 17.1m

Taking Spot Levels - Rise and Fall Method

This method of taking levels is more suited for taking levels around a proposed building to calculate excavations

1. Set up the instrument in a position where most spots can be seen.
2. Ensure instrument is levelled accurately.
3. Focus the cross hairs in the telescope (at start of levelling only).
4. Focus the telescope until staff readings are clear.
5. Read, record, and check the readings required (Level, or stadia and level). Do not hold the instrument while taking the readings.
6. Signal staff holder to move to next spot and repeat steps 4, 5, and 6. Ensure that staff is held plumb while taking the readings.

Booking and reducing the readings

Rise and Fall method.

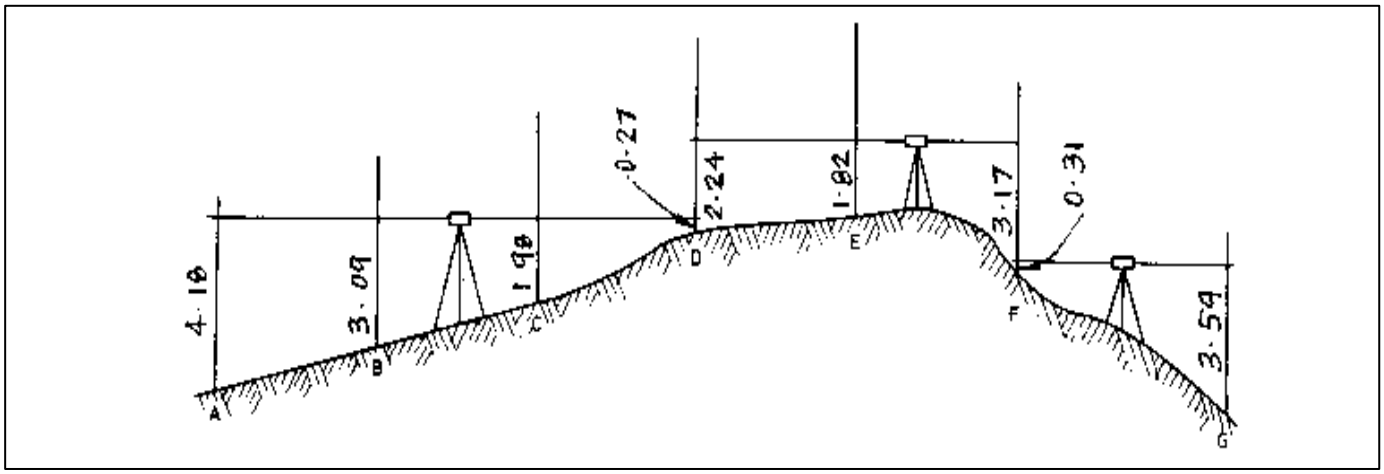
- Rule up a ***level sheet*** as shown.

BS	IS	FS	Rise	Fall	RL	Dist	Remarks

- Record BS, IS, FS, readings in the correct columns as you take the readings.
- When readings are complete, calculate rises & falls
- Calculate reduced levels.
- Check your calculations.
- **Example shown over the page**

EXAMPLE

The sketch below shows the spot levels taken on a sloping site.



BS	IS	FS	Rise	Fall	RL	Distance	Remarks
4.180					**100.000**		A
	3.090		1.090		101.090		B
	1.980		1.110		102.200		C
2.240		0.270	1.710		103.910		D Ch.St
	1.820		0.420		104.330		E
0.310		3.170		1.350	102.980		F Ch.St
		3.590		3.280	**99.700**		G
6.73		**7.03**	**4.33**	**4.63**			

Foresight minus Backsight			**Fall minus rise**		**First RL minus last RL**		
		7.03		**4.63**	**100.00**		
6.73			**4.33**		**99.700**		
0.300			**0.300**		**0.300**	**All these answers should be the same**	

To calculate the rise or fall

Subtract the **second** reading from the first reading.

If the answer is **positive**, there is a **rise**.

If the answer is ***negative*** (-), there is a ***fall.***

A to B: 4.180- 3.090 = 1.090**(rise)**

B to C3: .090- 1.980= 1.110**(rise)**

C to D: 1 .980- 0.270=1.710 **(rise)**

D to E: 2.240- 1.820= 0.420 **(rise)**

E to F: 1.820- 3.170=- 1.350 ***(fall)***

F to G: 0.310- 3.590=- 3.280 ***(fall)***

Calculate the reduced level (RL) by adding rises and deducting falls from the previous RL reading.

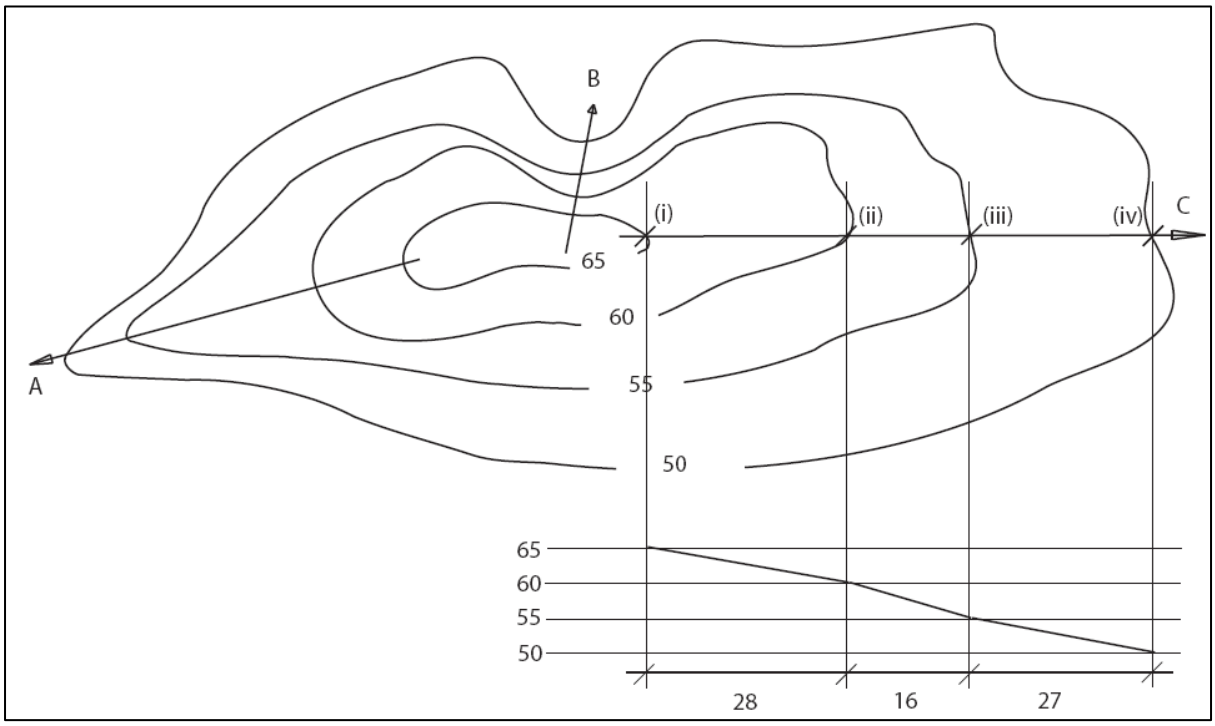
To check on rise and fall method

a. Add back sights, add fore sights.
    - Take total of fore sights from total of back sights (or vice versa).
b. Add rises, add falls.
    - Take total of rises from total of falls (or vice versa).
c. Subtract last reduced level reading from first reduced level reading (or vice versa).

Answers from (a) (b) and (c) should be equal.

Contour Plans

Establishing contours is most suited for an overview of the whole site for things such as the overland flow of water or gradients of proposed driveways



Gradient formula

Gradient = AB = vertical interval
BC horizontal equivalent

e.g. The gradient of the slope between (i) and (ii)

5 = 1 Therefore for every 5.600mtrs there is a 1mtr rise.
28 5.6

Reading Contours

As above the contours shown describe the form of the land

- Direction A would be a descending ridge with steep sides
- Direction B would be a steep descending gulley
- Direction C is a gradual descent with a rounded surface

The graduations above are in 5 meter stages. This would be impractical for gentle slope, such as a residential section. On gentle sloped site it would be more practical to have the intervals at 0.500m intervals

Method of Contouring

Using the Grid Method

Calculate where a 0.500 interval is between 55.604 and 55.434 by subtracting one from the other 55.604 - 55.434 = 170.

Divide the grid into 17 parts (scaled = 10mm rises). Therefore 55.434 + 7 parts will be where 55.500approx crosses the line.

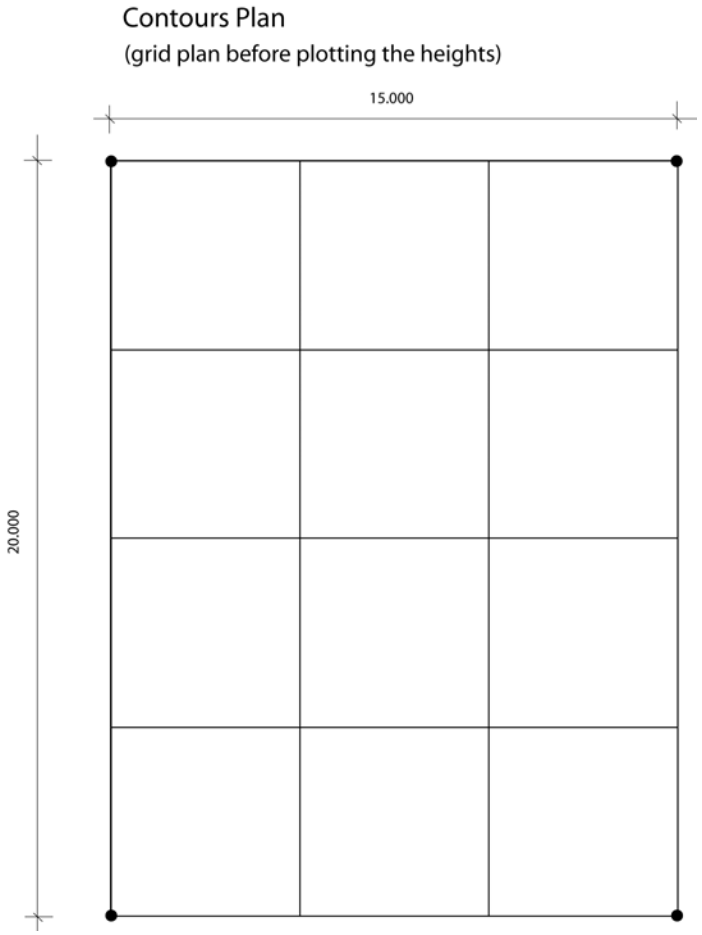
Formula for dividing between two grid points.

Establish the graduations. The graduations could be .250 or .500m for small sites like residential properties and small lifestyle blocks, 1-10m for larger areas or very steep sites.

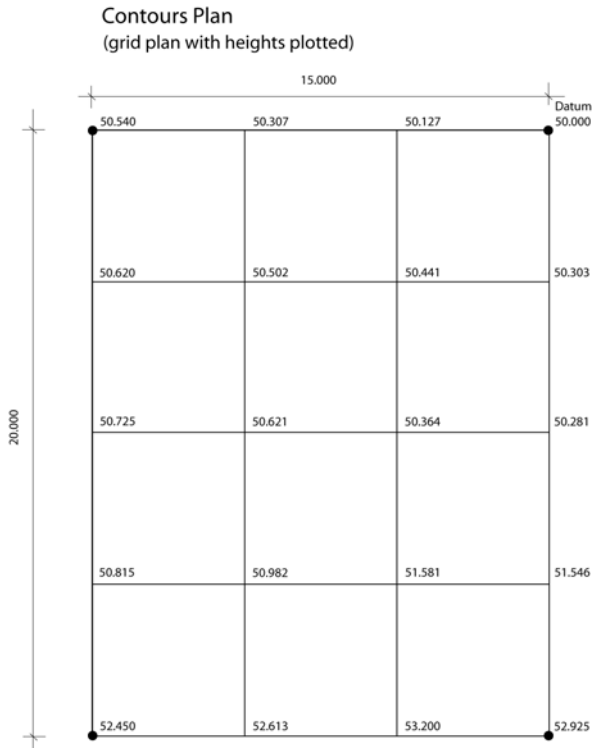
From the reduced levels establish where the graduations will land. On the grid you have the reduced levels recorded and where one of the RL's is greater than the graduation means there will be a contour line or lines plotted between them.

Below is an example:

Firstly grid the section as below



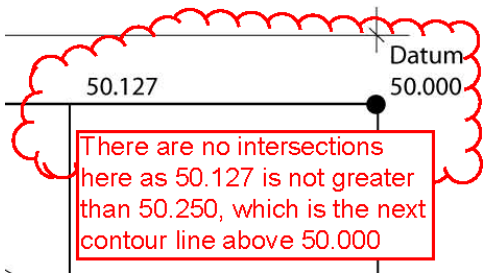
Secondly, once you have shot the heights, record them on the grid references as below

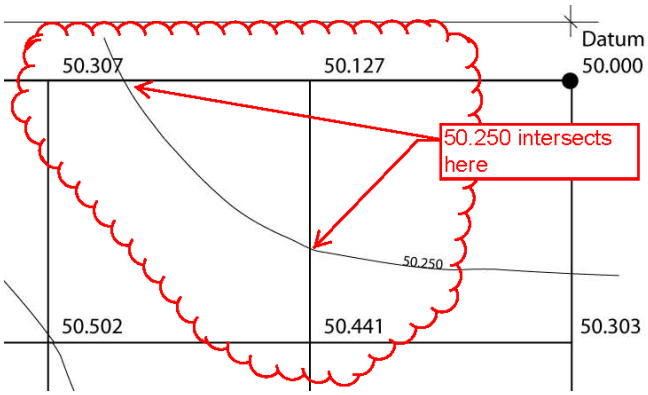


Thirdly, start to plot the contour lines between the gridlines.

Where to put contour lines?

Let's say the contour lines are at 0.250 intervals. This means the contours will be at …50.000, 50.250, 50.500, 50.750, 51.000… etc. Take note that they could also be below 50.000, like 49.500 or 48.750. Knowing this now look at the measurements and assess where a contour line will be as in the diagram below.





How to calculate the position of the contour line

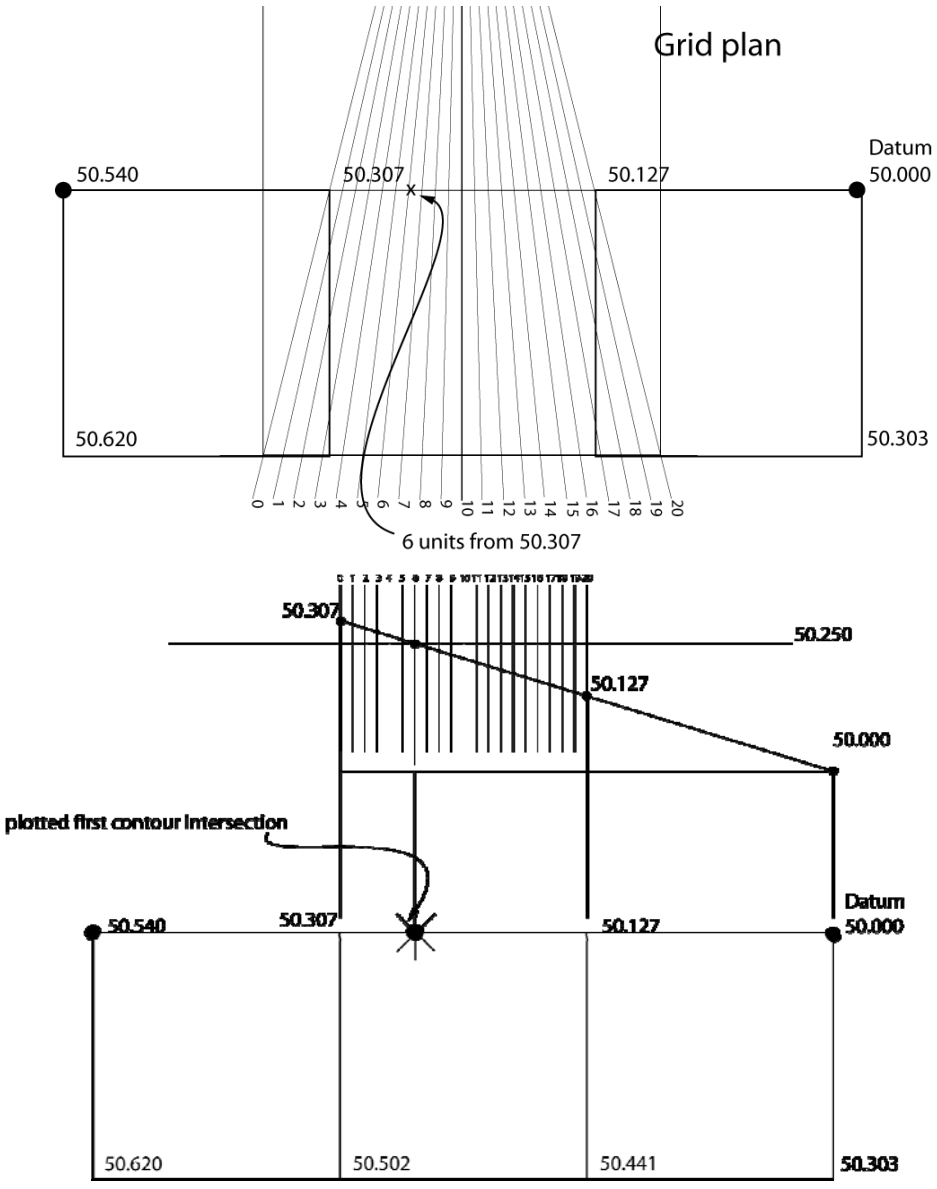
Take the two levels where you know a contour line is going to intersect and subtract one from the other

- 50.307 – 50.127 = 180
- Divide 180 by 20 (We use 20 because the graphic divider has 20 parts)
  = 9
  Therefore each of the 20 parts represents 9mm

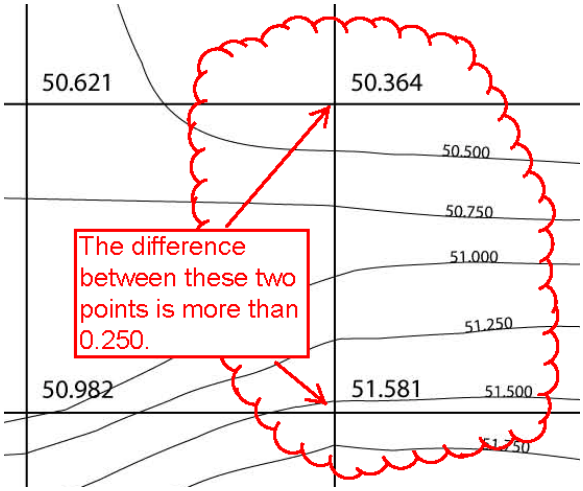
Now we can find the location of the 50.250 contour line
Take the higher level and subtract 50.250

- 50.307 – 50.250 = 57mm
- Divide 57 by 9
  = 6.3 (round down or up)
  Therefore, come down 6 units from 50.307 and this is where 50.250 intersects

Elevation and plan view of contour line



What to do if more than one contour line is between the plotted levels on the grid?



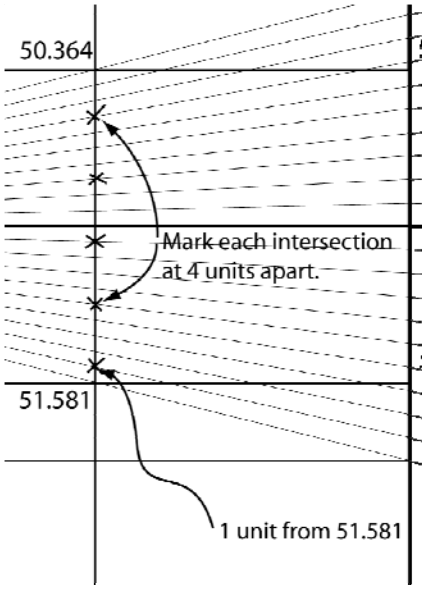
Find the difference between 50.364 and 51.581

- = 1217
- Divide the answer by 20(We use 20 because the graphic divider has 20 parts)
- = 60.85
  Therefore each of the 20 parts represents 60.85mm

Now we can find the location of the 51.500 contour line

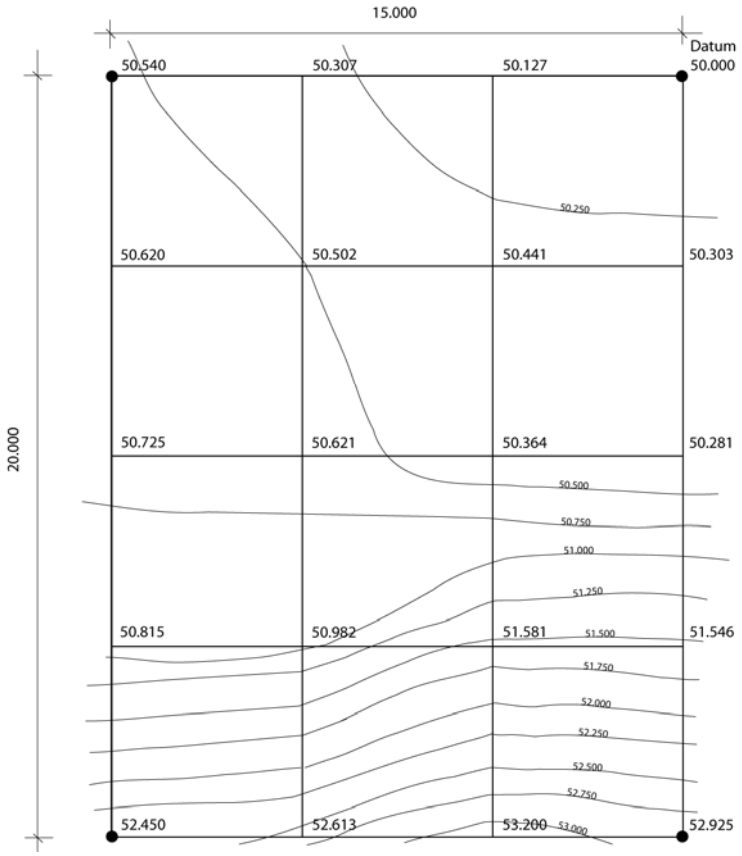
Take the higher level and subtract 51.500

- 51.581 – 51.500 = 81
- Divide 81 by 60.85
  = 1.33 (round up or down)
  Therefore, come down 1 unit from 51.581 and this is where 51.500 intersects
- Then divide 250 by 60.85
  = 4.1 (round up or down)
  Therefore mark every 4 units along for the 250 interval

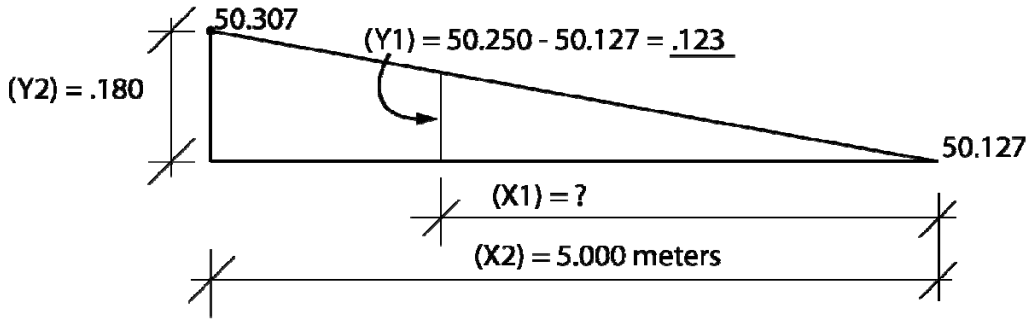


The finished contour plan

Contours Plan
(grid plan with heights plotted and contour lines drawn at 0.250 intervals)



Mathematical Interpolation technique of plotting contour lines



$$\frac{X1 = Y1}{X2 = Y2}$$

$$\text{therefore } X1 = \frac{Y1 \times X2}{Y2}$$

$$= \frac{.123 \times 5.000}{.180}$$

$$= 3.417$$