Building and Construction

Apply basic levelling procedures

Learner Guide

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Basic Levelling [1]

The setting out stage for building work is the most critical as any mistake in levelling or measuring made here will continue right throughout the structure and in some cases the error will increase as the structure progresses.

Therefore, it is essential that all levelling, setting out and measuring be accurate and consistent to avoid costly adjustments. This process begins with the formal and legal phase of application for the development and construction approval.

Levelling Terms and Symbols

The principle of levelling is based on the fact that water, once at rest, will find it's own level regardless of the type of container or the angle at which it may be held. Therefore, a level line may be described as, ' any parallel line to the surface of still water'. All levelling instruments are based on this principle.

TERMINOLOGY

Contour lines

These are imaginary level lines on a plan, which represent the rise and fall or humps and hollows of the earth's surface. These lines are like the water tide marks found on any beach, which are left in the sand when the tide goes out. When used on a site plan they give the designer information related to heights, which will enable drawings of a structure to be produced showing relative heights to ground level. Where these lines are close together on a plan it indicates a steep slope and when they are far apart it indicates a gentle slope. It also provides useful information for quantity surveyors, estimators, excavators and builders so they may calculate the amount of soil to be removed or the filling required to create a level area.

Each contour line is given a *reduced level* which relates to the job datum or bench mark.

[1] Source: Sydney Institute, as at http://mikestrade.sydneyinstitute.wikispaces.net/file/view/TAFE%20set%20out%20%26%20levelling.pdf/32334985/TAFE%20set%20out%20%26%20levelling.pdf, as on 16th June, 2014; National VET Content, as at https://nationalvetcontent.edu.au/alfresco/d/d/workspace/SpacesStore/29f0483b-55c3-49f7-a819-22b5f69e5abd/index.htm?guest=true, as on 17th June, 2014.

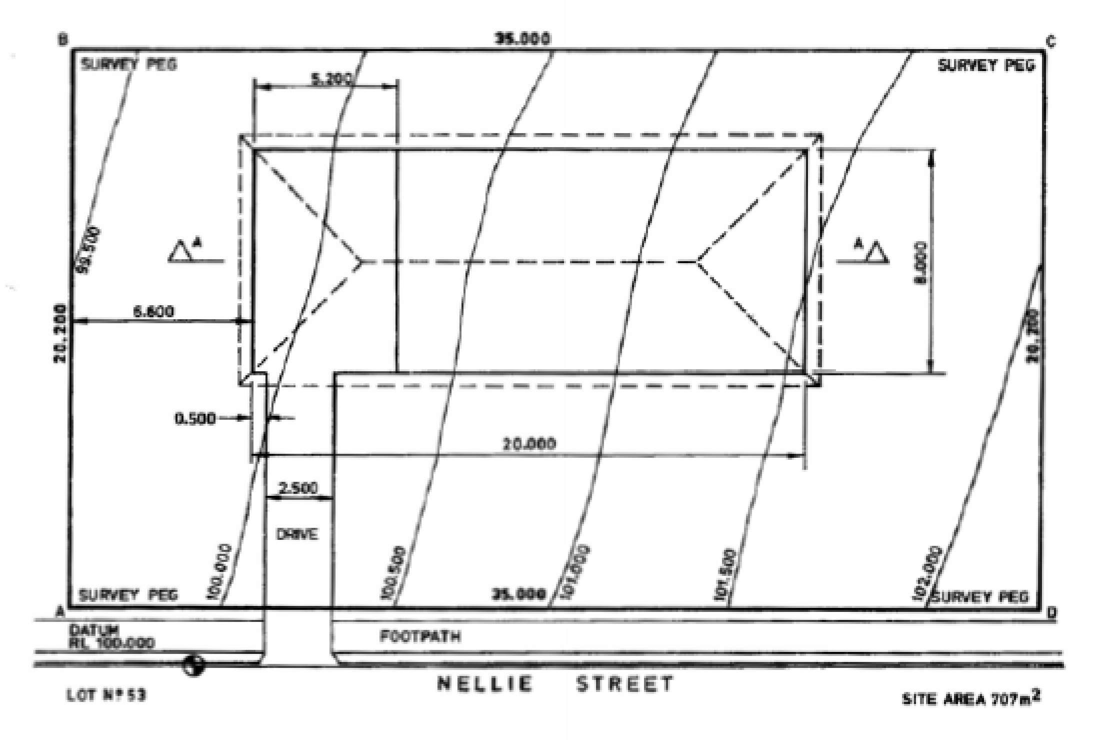


Fig.1 Contour site plan

Contour interval
This is the height difference between one contour line and the next contour line. Where the surface of the site has a gentle slope the contour lines are spaced far apart on plan but the contour intervals may only have a 100mm height difference, whereas to retain the same spacing of contour lines on plan for a steeply sloping site the contour intervals may be 1.000m or more.

Contour lines have a reduced level measurement shown on them, and the difference in height between adjacent contour lines becomes known as the *contour interval*.

Datum
This is any fixed reference point where the height or elevation of that point is known. A position on a job site may be selected as a fixed reference point and is given an assumed height, eg. 100.0m, and all heights for the construction will be referred to that point for the duration of the job. The nominated fixed point may be set on a permanent local structure, tree, fence post, etc., and is then referred to as *the job datum*. It is shown on plan in the form of a symbol, as shown below:

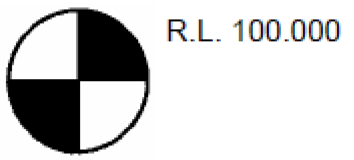


Fig. 2 Datum symbol

Bench mark
This is a fixed point of reference which has a known height or *elevation,* and is formally recorded for use by qualified Surveyors. There is usually a permanent mark either chiselled into a concrete kerb, a metal plug set in a path or kerb, lines and arrows carved into the face of a mature tree, marked with paint on the retaining walls at railway stations, a stamp or metal plug on the plinth of a building or monument, etc.

In Sydney all bench marks are given a height in relation to the average tide mark, which is set in a brass plate on the north wall of Fort Denison in Sydney harbour.

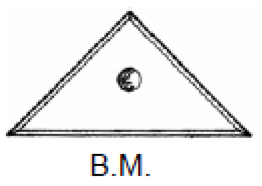


Fig. 3 Typical Bench mark symbol

Reduced Level (RL)
This is a term given to the height or elevation of a point above or below a known point, such as the given datum.

Example:
The assumed height of the Datum has an RL of 50.000m, and a point some distance away is set 1.000m above this datum then this point would have an RL of 51.000m. If a point on the other side of this datum was say 2.000m below, it would have an RL of 48.000m, and so on. The assumed height of the datum is always given as a large measurement so that points lower than the datum will not be recorded as a negative measurement.

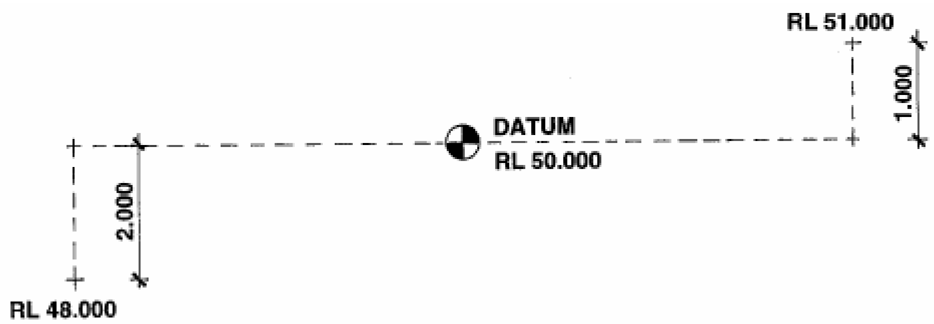


Fig. 4 Example of reduced levels

Site Setting Out
Once the Development Consent stage of the project is complete the actual establishment and setting out may commence.

Prior to any work starting, a careful check should be made to ensure the property is the correct one and it's boundaries are clearly defined, as follows;

Property Identification

The most essential requirement is that the property is the correct one. There have been many instances where a building has been erected on the wrong site, which tends to cause a legal nightmare.

The person most capable of identifying an allotment, i.e. building block, site or lot, is a *Registered Surveyor*. If a survey has been recently completed and the survey pegs are still in position, the services of a surveyor may not be necessary, as the property can be identified from a copy of the plan detailing the registered sub-division of the area.

Such plans show the *Lot* numbers and position of the allotment in relation to street corners or other features, from which they can be measured. They also show the dimensions of all the allotments in the subdivision.

The illustration below is an extract from a typical Registered Plan of an urban subdivision;
Example:

• Lot 110 on Breadsell St is a regular shaped block which has an area of 630m2 and measures 21m x 30m.

• Other allotments such as 175 and 181 have irregular boundaries, with the dimensions shown on each side or change in direction of a side.

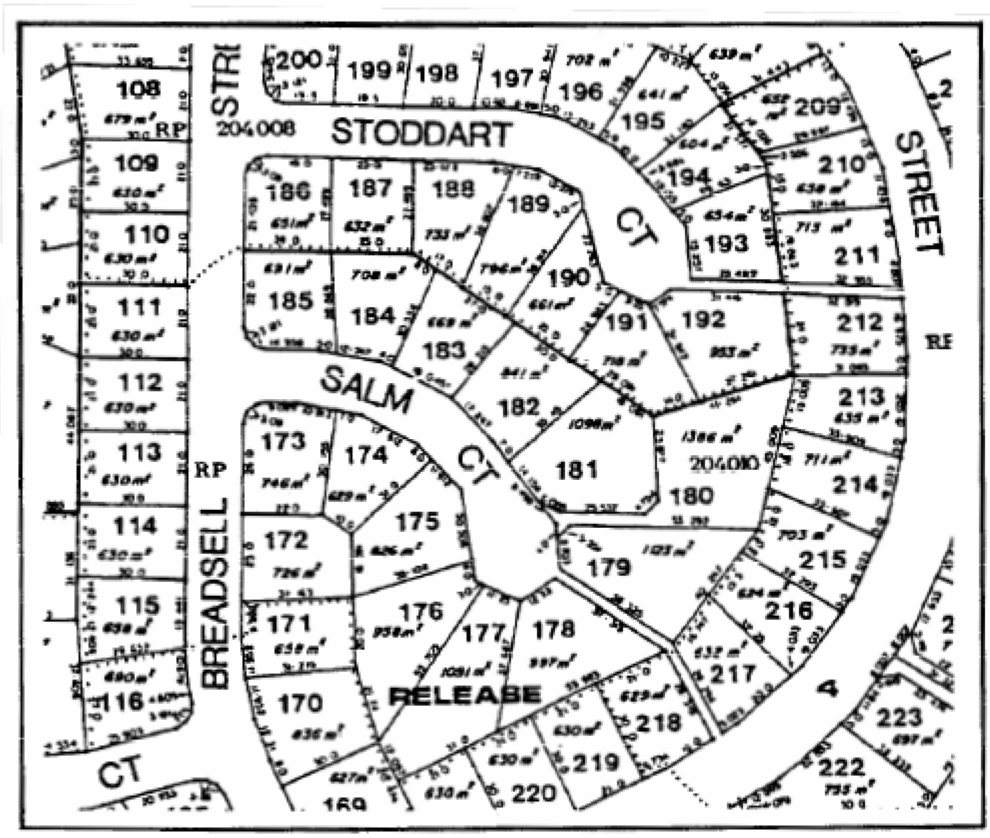


Fig. 5 Typical urban subdivision plan

Establishment of Boundaries

A builder or Surveyor must be absolutely certain the boundary dimensions are accurate and true to shape. This may be done by checking the actual site dimensions with those on a *'site plan'* accompanying the registered Certificate of Title.

When an allotment is surveyed it is pegged with 100x50 hardwood survey pegs, these are painted white and project 75mm above the ground, which mark the junctions of the boundaries.

Once these pegs are found, make certain that they are the correct pegs for the site. The pegs will originally have been numbered, but on some sites the correct pegs may be difficult to locate due to being covered with fill or being accidentally removed.

Once the pegs have been identified their positions should be checked, by measuring, in relation to the registered site plan. Unusually shaped blocks should be double checked for shape and size making sure all change in direction points are the correct ones for the block.

If pegs have been removed the only solution may be to have the site re-surveyed. Information regarding the site and the building can be found on the site plan of the working drawings.

Note: There is a penalty for unauthorised removal of survey pegs.

The illustration below indicates some of the information which could be found on the site plan of Lot 110 of the urban subdivision illustrated previously. The information found on the plan should be an exact reproduction of the site plan accompanying the registered Certificate of Title.

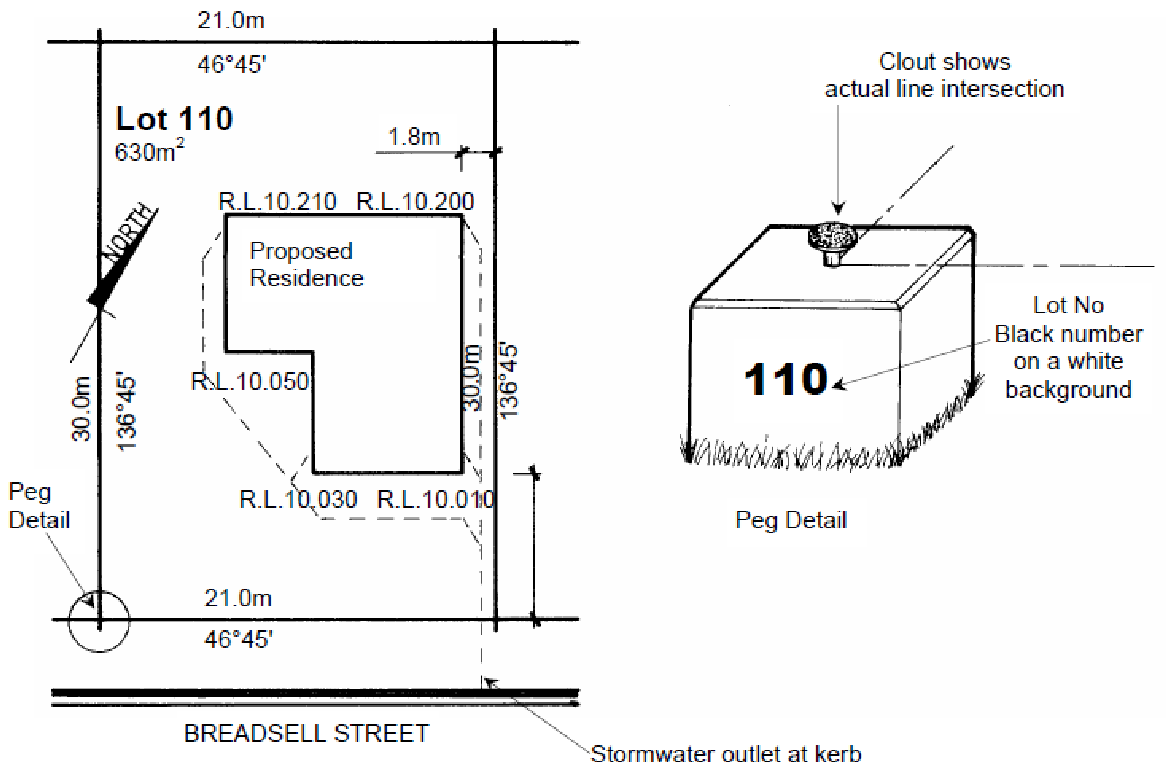


Fig 6 Site plan

Site Set Out Process

Creating Right Angles and Checking for Square

When setting out a building, it is usual to start with a square or relatively square corner. This may be achieved using any one of the several methods available but it should be remembered that this is only the starting corner and may not be completely accurate, therefore final checking for square is carried out over the whole set out shape. The most common method used to check for squaring is to measure the diagonals. When checking for square, both the diagonals in a quadrilateral shape will be exactly the same length provided the opposite sides are the same length and are parallel.

Note: Setting up of a smaller right angled starting corner may be by-passed if the full size shape is set out using the Pythagorean method, i.e. using the calculated full length hypotenuse to link the full length and width sides. Any of the following four methods may be used to create a right angle:

(1) Fixed Type Builders Square

STEP 1 Drive pegs on the base line at positions ‘A’ and ‘B’, then attach a taut line between them. This becomes the starting base line;

STEP 2 Drive a peg at position ‘C’ and place a nail in the top centre to coincide with the base line, and to provide a starting point for the right angle;

STEP 3 Place the outside edge of one arm of the square along the base line with the right angled corner directly over position 'C'.

Note: At least one arm of the square must be level for more accurate results.

STEP 4 Place pegs 'D' and 'E' so that when a line is stretched and fixed taut between them it will lie directly over the nail at position 'C' and in line with the outside edge of the second arm of the square.

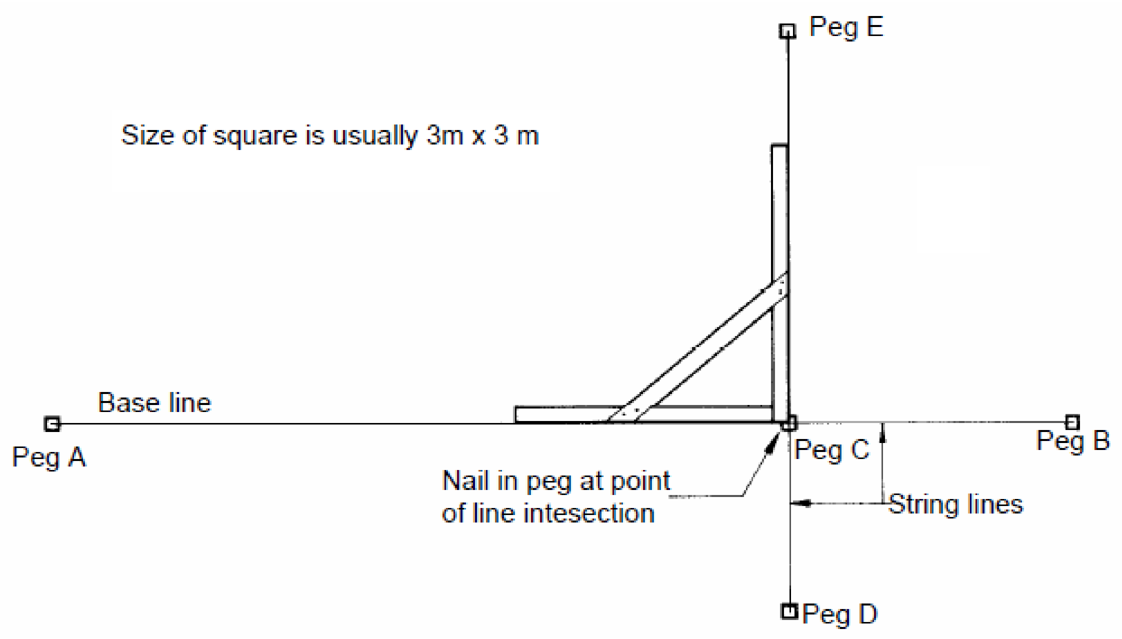


Fig. 7 Using a fixed type builders square

(2) Folding Type Builders Square

STEP 1 Drive pegs on the base line at positions 'A' and 'B', then attach a taut line between them. This becomes the starting base line;

STEP 2 Drive a peg at position 'C' and place a nail in the top centre to coincide with the base line, and to provide a starting point for the right angle;

STEP 3 Adjust the long arm of the square so that it is inclined at approximately 45° to the base line. Line up the hole at the end of the short arm over the nail in peg 'C' and then set a peg under the hole at the end of the long arm, position 'D', and fix a nail through the hole.

STEP 4 Place pegs at positions 'F' and 'G' so that when the line is taut between them it will lie directly over the nail at position 'C' and line up with the nail hole at position 'E'. The angle formed by the intersecting lines at position 'C' will be a right angle.

Note: In this case both arms of the square should be held in a level position or at least 'C' - 'D' or 'C' - 'E' should be level.

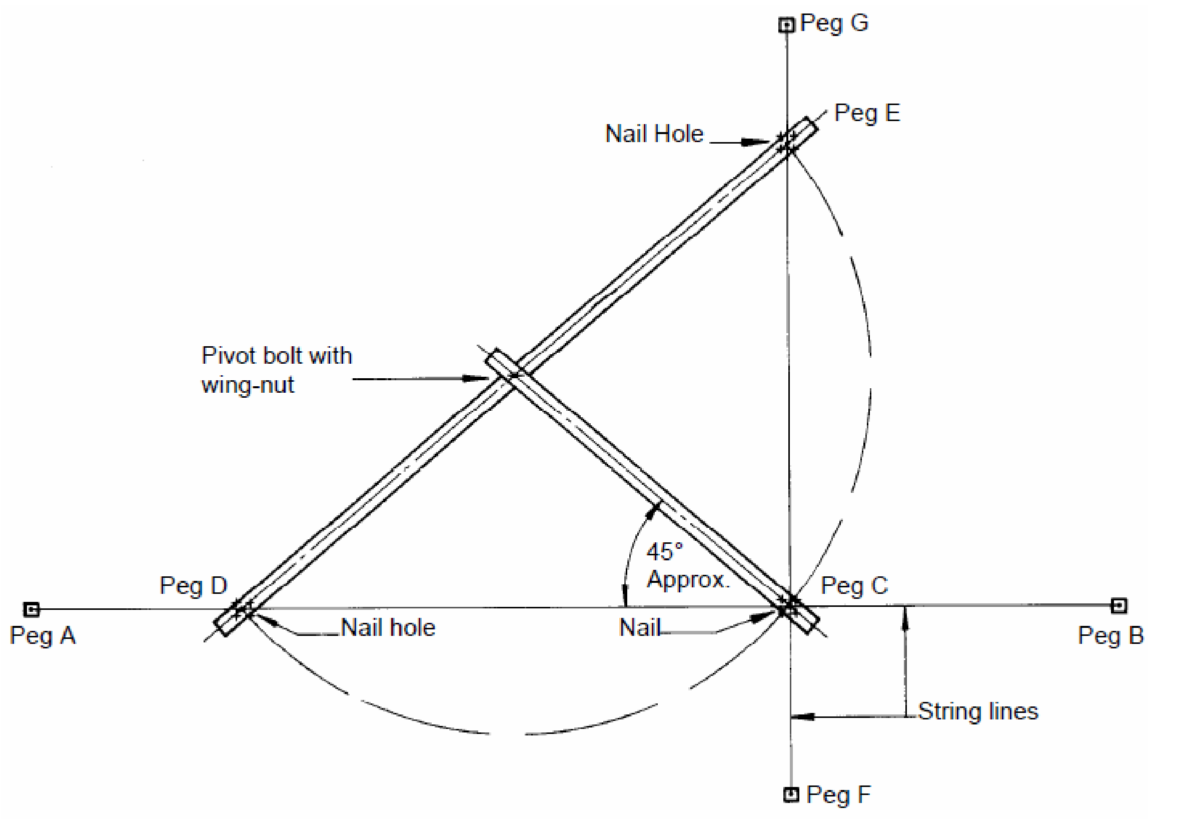


Fig. 8 Use of the folding type builders square

(3) Measuring Tape: 3-4-5 method
STEP 1 Set up a base line at the required position in from the boundary by attaching a taut level line between two pegs.

Drive pegs on the base line at positions 'A' and 'B', with peg 'A' being the intersection point for the right angle and peg 'B' being set '4 units' away, e.g. 4 metres or any measurement in multiples of 4 such as 4 x 300mm = 1.200m, 4 x500mm = 2.000m, etc.

Note: Ensure that the same base units are used for each of the 3-4-5 components when setting out the right angle;

STEP 2 Attach the end of a tape to peg 'A' and extend it to equal '3 units', e.g. 3 metres or any measurement in multiples of 3 such as 3 x 300mm = 0.900m, 3 x 500mm = 1.500m, etc. Also, attach the end of another tape to peg 'B' and extend it to equal '5 units', e.g. 5 metres or any measurement in multiples of 5 such as 5 x 300mm = 1.500m, 5 x 500mm = 2.500m, etc.;

STEP 3 Where the two tapes intersect will be the centre position for peg 'C'. Mark this point and drive in a nail. Attach a string line to point 'A' and pull it taut over peg 'C', extending it out for the total length of the side required. The angle formed between pegs 'B' - 'A' - 'C' will be 90°.

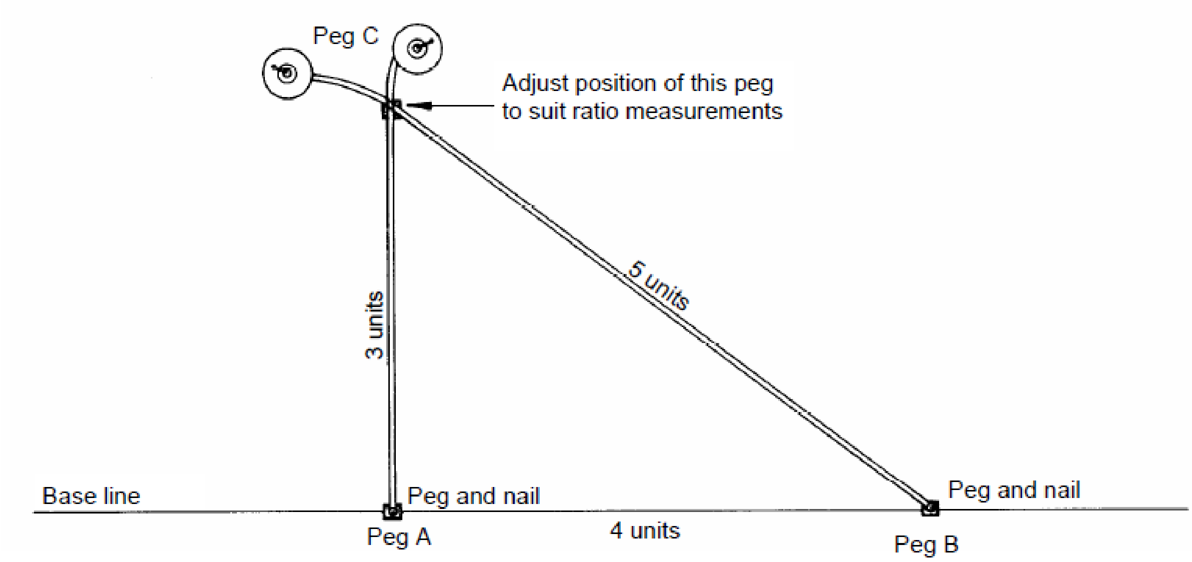


Fig. 9 Use of the 3-4-5 method

(4) Isosceles Triangle Method (Using tapes)

STEP 1 Set up a base line at the required position in from the boundary by attaching a taut level line between two pegs.

Drive a peg 'A' at the required intersection point for the right angle. Drive in two more pegs at position 'B' and 'C' an **equal** distance away from peg 'A'.
Drive a nail into each peg to allow a tape to be attached.

STEP 2 Attach a tape to peg 'B' and another tape to peg 'C'. Extend the tapes out to any length, providing they are the same.

Note: The longer the length, say around 5.0m, the greater the accuracy of the angle formed. Where the two tapes intersect will be the centre position for peg 'D'.
Attach a string line to point 'A' and pull it taut over peg 'D', extending it out for the total length of the side required. The angle formed between pegs 'B' - 'A' - 'D' or 'C' - 'A' - 'D' , will be 90°.

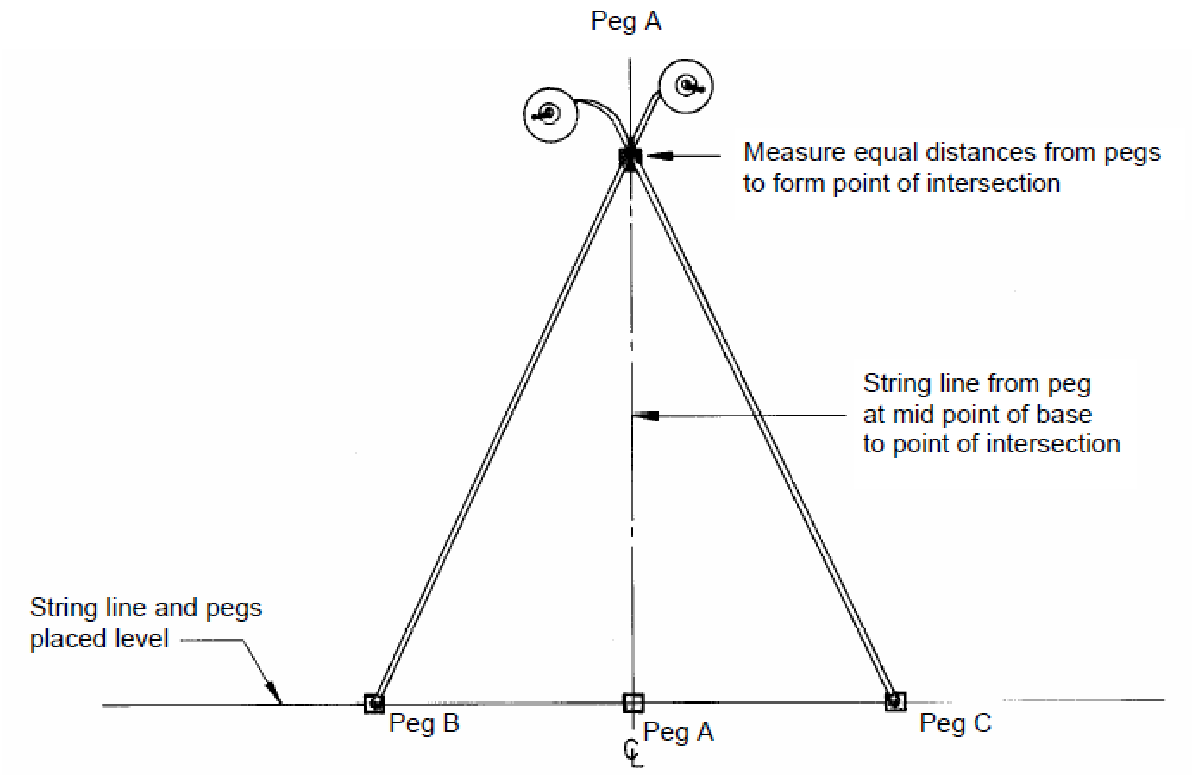


Fig 10 Use of the isosceles triangle method

Checking Diagonals
After the right angle is established, all other lines are produced parallel to the original lines. To check if the building is *square*, the diagonals are measured to ensure they are the same length.

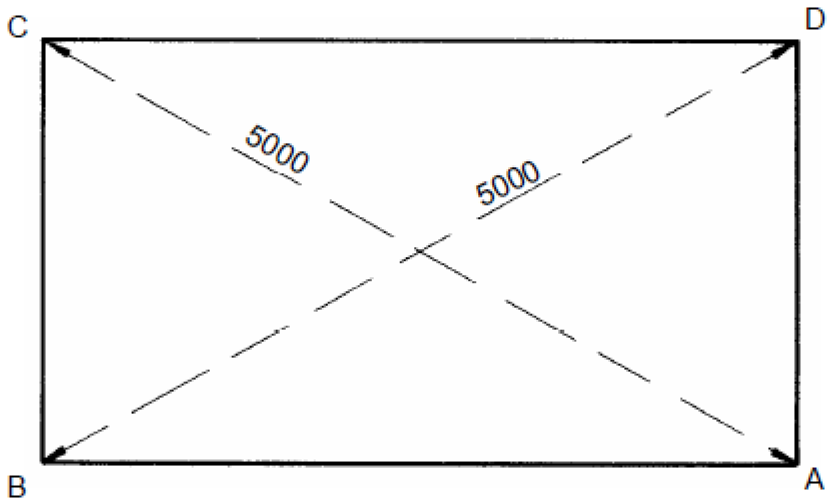


Fig. 11 Checking for square

If the diagonals are not equal, there is an error in either the original right angle or the measurements of the parallel sides.

Solution

- Check all measurements for error and adjust if required to the correct lengths, then re-check the diagonals; or
- Adjust the original corner for square, e.g. BD = 4900mm and AC = 5100mm in the diagram below, therefore there is 200mm difference in the length of the diagonals. To correct the error, move points A and D in an Easterly direction while maintaining the same distance between D and A. Both diagonals should be re-checked to make sure they are both exactly the same length.

Note: A rhomboid shape results when the diagonals are unequal

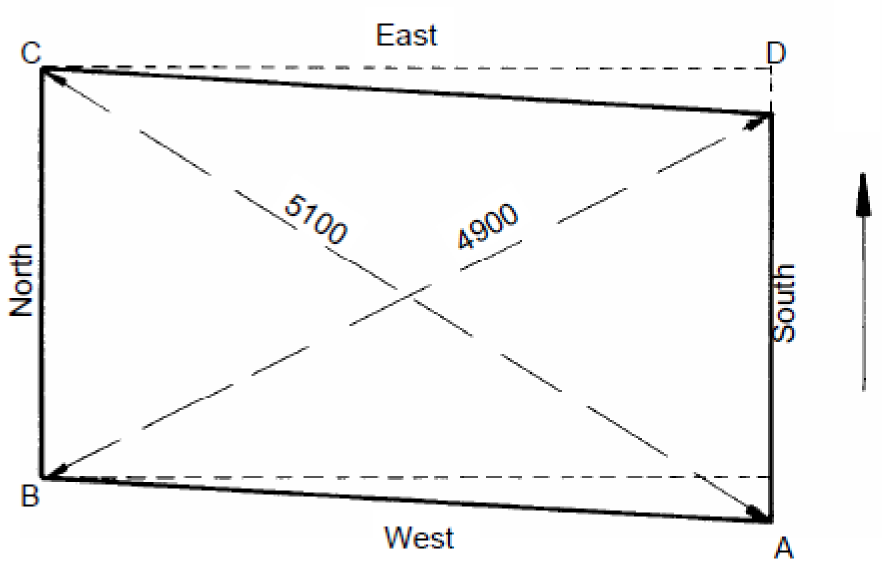


Fig. 12 Method of adjusting diagonals

Profiles

Timber profiles may be described as being temporary structures positioned to indicate the overall width and length of a building and used to show the width of footings, walls and provide an anchor point for string lines.

Common Profiles

There are two main methods of profile construction used, i.e. Saddle - which sits on top of the pegs, and Hurdle - which is fixed to the back of the pegs. The horizontal members of both should be placed as level as possible to allow for accurate set out and measurement transfer.

Both types are suitable for cottage construction but the Hurdle type is preferred for large commercial projects as the design of the profile allows for greater resistance to line strain over longer distances.

The position and height of the first profile placed will be determined by the slope of the site, i.e. the first profile is set as low as possible at the highest position of the setout. Tall profiles used on sloping sites may require additional bracing, to resist raking and bending under line strain. Continuous profiles are often used where many walls or services are required and their location is critical.

The profiles should be placed at least 1.0m away from the proposed excavation when manual excavation methods are used, e.g. pick and shovel, and at least 1.5m away when mechanical excavation methods are used, e.g. backhoe or trench excavator. This space allows for ease of access and the prevention of spoil falling back into the excavated area.

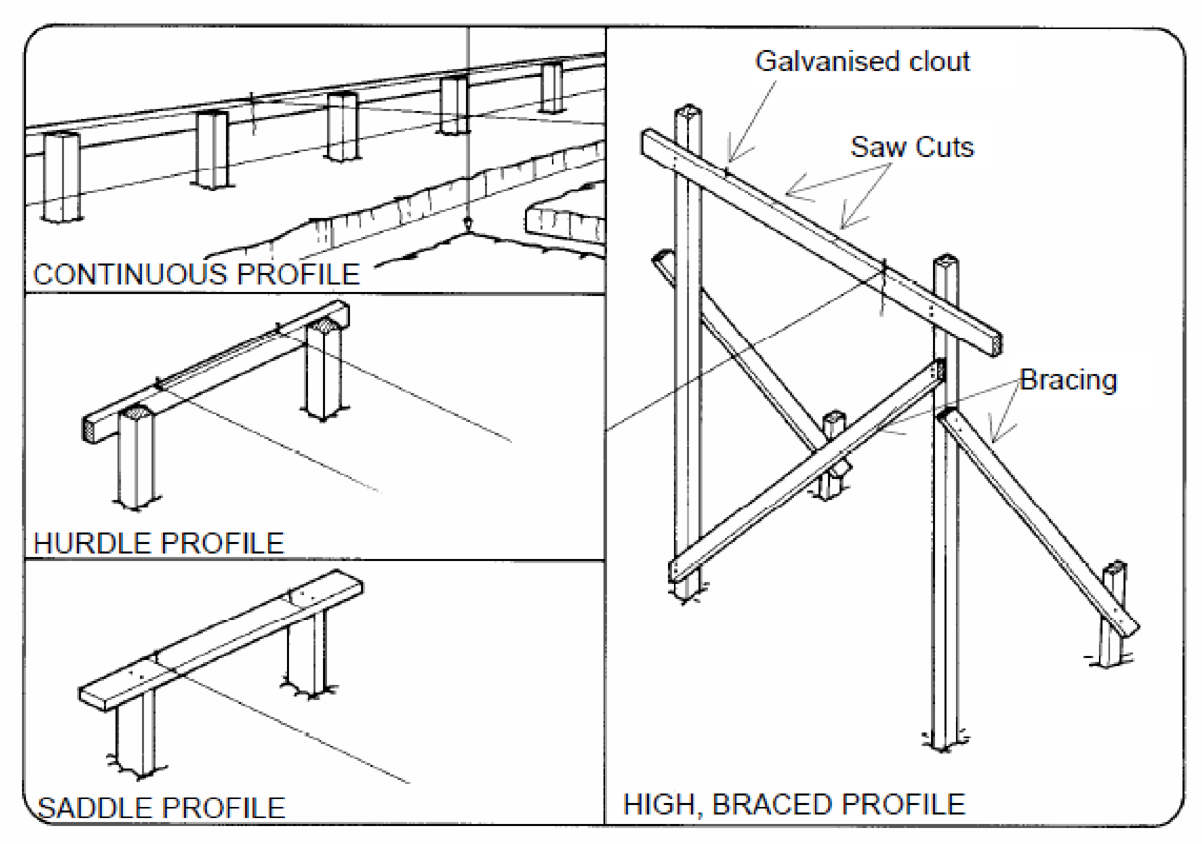


Fig. 13 Common profile structures

Information Contained on Profiles

The position and degree of information to be marked on the profile will vary, depending on the type of construction, e.g:

• The details marked on the profile boards for a timber framed construction, set on a slab-onground, will only require the outside or overall size of the slab, whereas;

• The details marked on the profile boards for a timber framed building on 230mm perimeter piers will indicate the outside line of the brick piers and the width of the blob footings;

• The details marked on the profile boards for a brick veneer building on a continuous strip footing will indicate the width of the footing and the outside face of the brickwork. The position of the outside face of the brick veneer building (i.e. the brickwork) in relation to the edge of the footing will be different to that of the timber framed building, and;

• The details marked on the profile boards for a cavity brick building on a continuous strip footing will indicate the width of footing and the outside face of the outer skin and the inside face of the inner skin. These details are shown below;

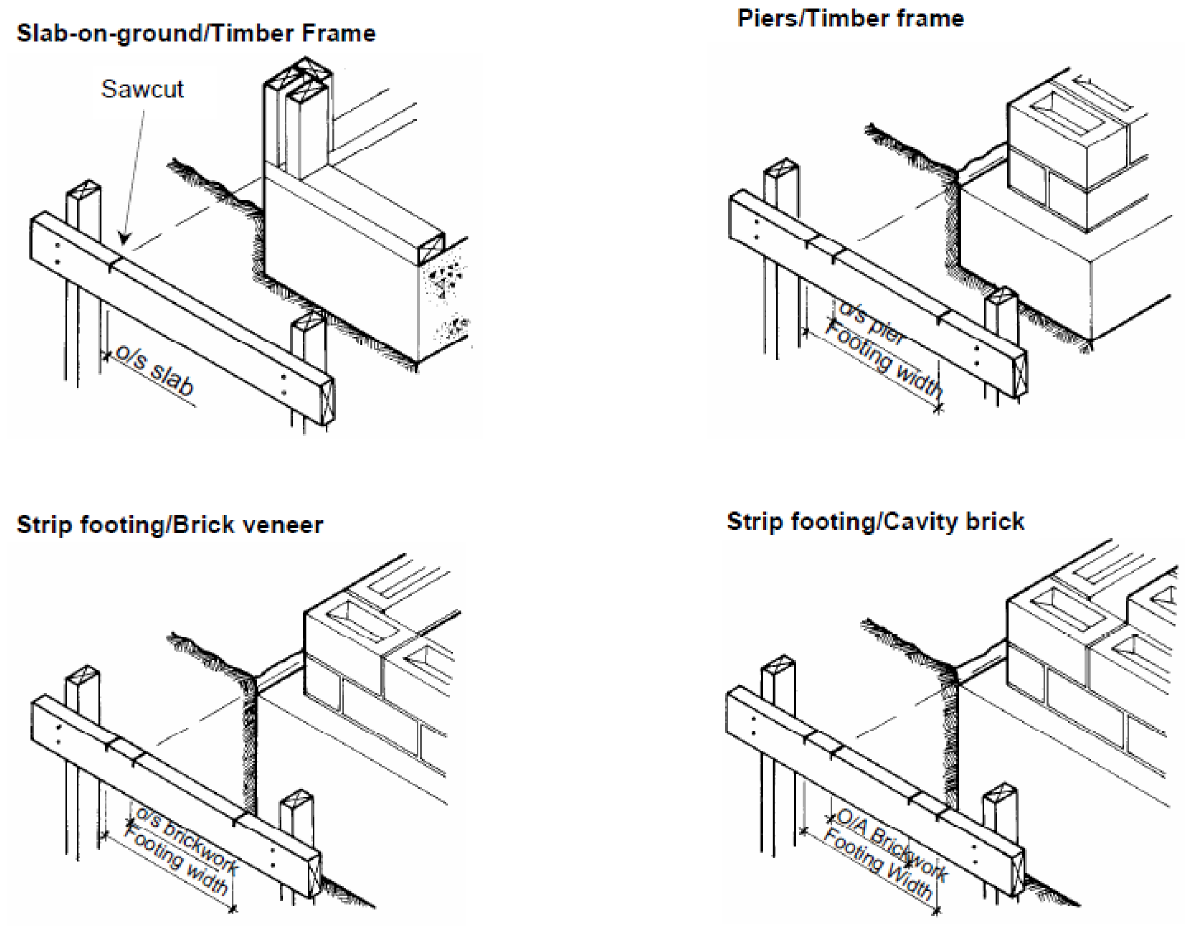


Fig. 14 Profile set out information

Levelling Instruments

TELESCOPIC DEVICES

The telescope consists of:

• A pair of *cross hairs*, thin black lines set at 90° to one another visible through the eyepiece, mounted in a ring or diaphragm near the rear of the telescope;

• *Stadia lines*, which are short cross hairs set above and below the main horizontal cross hair. They are used to calculate the distance of an object from the instrument by subtracting the reading of the bottom hair from the reading of the top hair, then multiplying the difference by 100.

• An *eyepiece* which magnifies the cross hairs. The cross hairs must be focused according to the eyesight of the observer; and

• The *object lens* which forms an inverted image within the telescope.

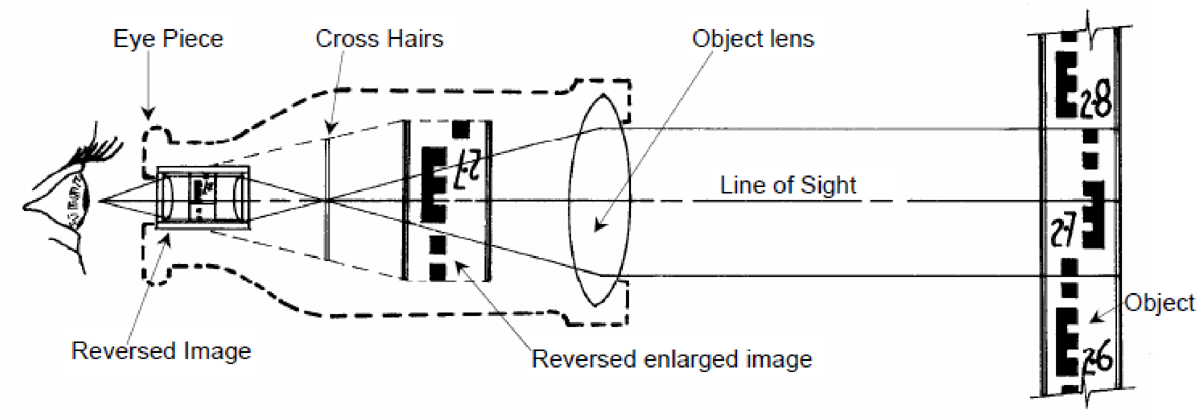


Fig. 15 Parts of the telescope

When a point is observed through the telescope, the line through the centre of the object and the intersection of the cross hairs is referred to as the 'line of sight' or the 'line of *collimation*'.

The Quickset (or Builder's) Level
This is a commonly used instrument due to it's simplicity and ease of use. It consists of a tripod with a 'ball and socket' head to allow the instrument to be moved in any direction to obtain a level base. When the central attaching screw is loosened the instrument is adjusted by moving it around on the pivot point until the circular or bull's-eye bubble is in the centre, then tighten the screw. There is also a 'tubular level bubble' on the telescope which must be adjusted using the tilting screw, each time the telescope is rotated horizontally for a new sighting.

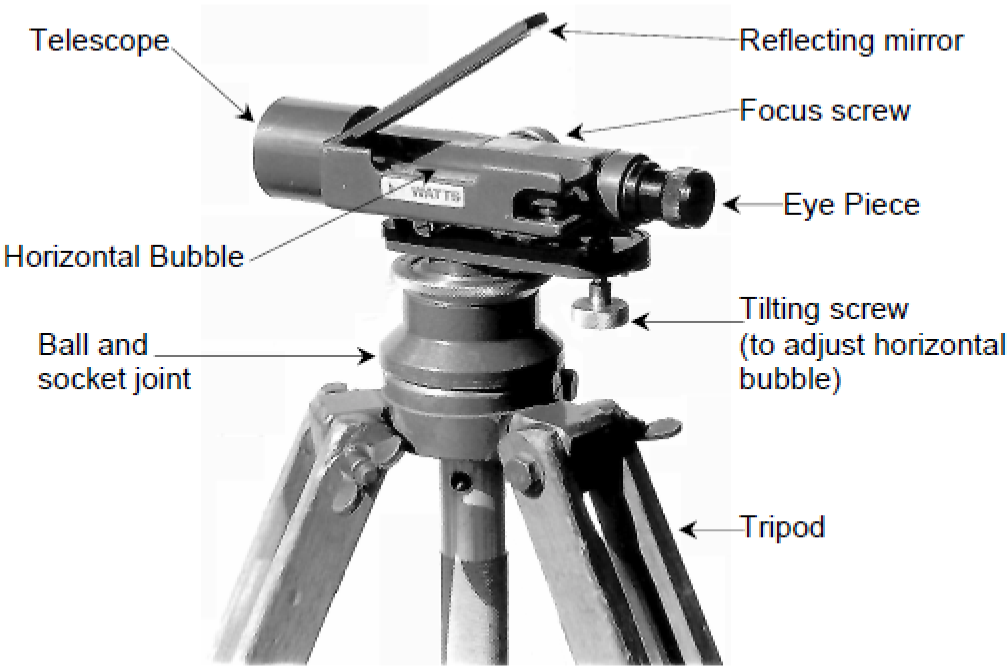


Fig. 16 Parts of the Quickset or Builder's level

The Tilting Level (or Three screw)
This level is similar to the Quickset except for the method of mounting on the tripod. In place of the ball and socket is a 'trivet stage', which consists of three foot screws. The 'bull's-eye' bubble is centred using these screws and the telescope's tubular bubble must also be adjusted each time a new sighting is taken.

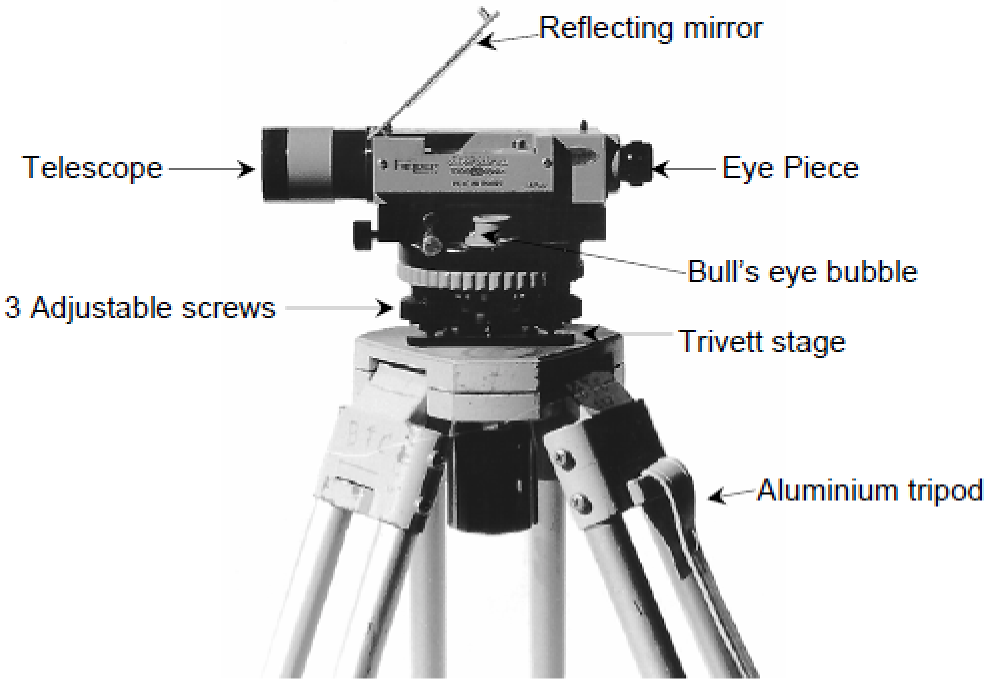


Fig. 17 Parts of the Tilting level

Method of Centring the Bubbles
Bull's-eye Bubble

STEP 1 Rotate the base until the bull's-eye bubble is between two of the base adjusting screws. This will leave the third screw directly opposite the bubble on the far side of the base.

STEP 2 Adjust the screws up or down on either side of the bull's-eye until the moving bubble is close to the middle of the bull's-eye. This may take two or three goes to get it close.

STEP 3 Using the third screw, opposite the bubble, adjust it up or down until the moving bubble is at rest in the centre of the bull's-eye, or at least within the centre ring. Allow the moving bubble to settle, for approx. 10 seconds, and providing it is still within the centre ring the base will now be set be set and the adjustment screws should not be altered or touched again, unless the instrument is moved or bumped.

Tubular Telescope Bubble

STEP 1 The tubular bubble is usually encased beside the telescope itself and may be easily viewed through an attached hinged mirror, if provided. Turn the telescope towards the object to be sighted and lock in position.

STEP 2 Adjust the telescope up or down using the tilting screw under the eye-piece. Allow the bubble to settle, for approx. 10 seconds, and carry out fine adjustment until the desired position between the marked lines is obtained. It will be necessary to adjust the telescope each time it is rotated to a new position to maintain the same line of sight or line of collimation.

The Split Bubble

STEP 1 The split bubble is usually encased beside the telescope and may be viewed through a separate eye-piece. Turn the telescope towards the object to be sighted and lock in position.

STEP 2 Adjust the tilting screw up or down to move the split image of the bubble. Carry out fine adjustment until the bubbles are completely aligned, as shown below.

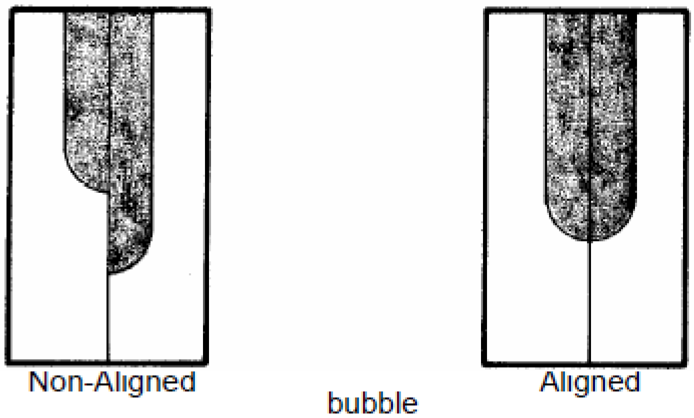


Fig. 18 Aligning the Split bubble

The Surveyor's Dumpy Level or Automatic level
The Dumpy level takes a little more time to set up as there is no 'tilting screw' for the telescope. However, once set up there is no need to worry about levelling the telescope each time it is rotated as it will remain level for all sightings automatically, unless it is moved or bumped.

Setting Up
STEP 1 If the instrument has a bull's-eye bubble, follow the procedure for the 'tilting level' to centre it. The next step is to level the instrument using the telescope bubble.

STEP 2 Rotate the instrument until the telescope is lined up parallel to two of the foot screws. Use these two screws to centre the telescope bubble, as shown below

Fig. 19 Method of first adjustment of the plate bubble

STEP 3 With the bubble now centred, rotate the telescope at 90° to the first position. The telescope should now line up with the third foot screw. Adjust this screw until the bubble is in the centre.

Note: When the telescope bubble is centred it may be noted that the bull's-eye bubble is now off centre. Ignore this as the bulls'-eye bubble only gives an approximation of level when first setting up.

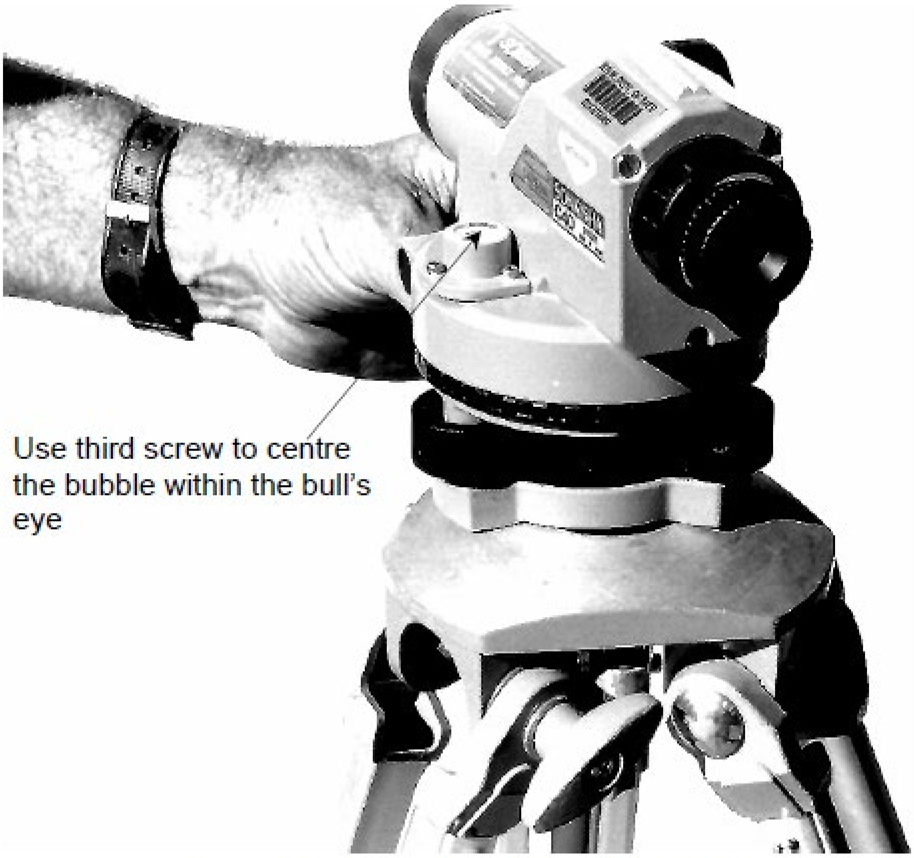


Fig. 20 Final centring of the plate bubble

The Laser Level
Laser levels are the most recent levelling instruments used on construction sites.

The Laser level consists of a laser beam projected by a rotating mirror in a horizontal plane, which is the transmitter, and a response device, which is the receiver. The laser instrument is set up on a tripod and may have a bull's-eye bubble to assist with levelling the base, but it does not have to be levelled accurately before use as the *gyroscopic* effect of the rotating mirrors will automatically level the instrument.

The receiver may be hand held, attached to a staff or placed against an object and is moved up or down until the laser beam is received. At this time a fast beeping tone will be heard when the beam is within the level range followed by a constant tone when the exact level point is obtained. The laser level is very accurate over long distances, including purpose made lasers for pipe laying, mining operations, preparation of site grades, ceiling grid installation, partition alignment for both plumb and for straight, setting up computer floors, general building site setting out and even the setting up of a square corner.

Danger - Laser Radiation : Avoid exposure to the beam, especially the eyes.

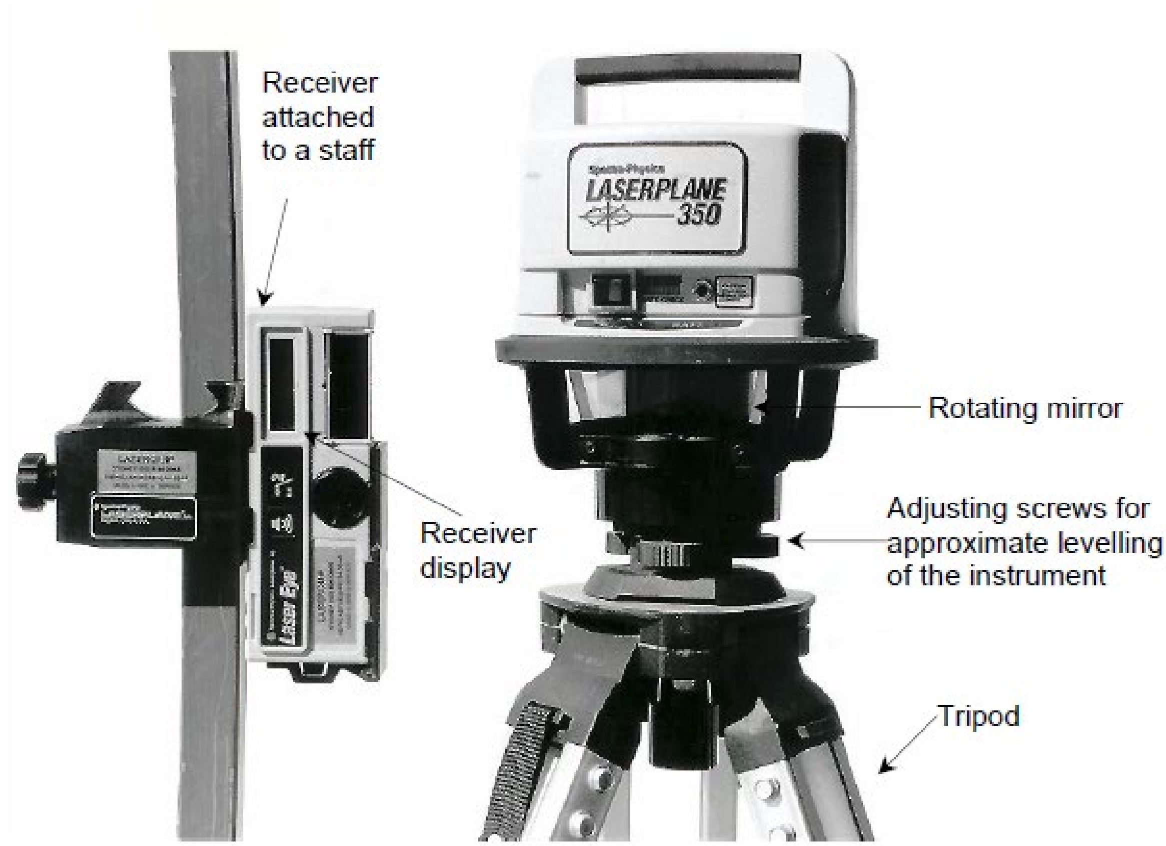


Fig. 21 Typical Laser level

Alternative Levelling Devices

There are other types of levelling devices which are used for more complicated tasks, such as the 'Transit level' and the 'Theodolite' which may be used for horizontal levelling, vertical plumbing, creating or checking angles including right angles, measuring the distance of an object, measuring the height of an object, etc.

The Staff

The staff is essentially a graduated measuring rod for reading heights at the point or station where the staff is held. When taking several readings, a greater reading would indicate a fall whereas a lesser reading would indicate a rise. Most staves are made as a telescopic unit which may be extended to 5m in height. Single staves may be made from seasoned timber but the majority of telescopic types are made from fibreglass or Aluminium with coloured markings to allow ease of reading.

It is important to hold the staff as plumb as possible, in both directions, when readings are taken so that accuracy is maintained. Some staves may even be fitted with a bubble for just this purpose.

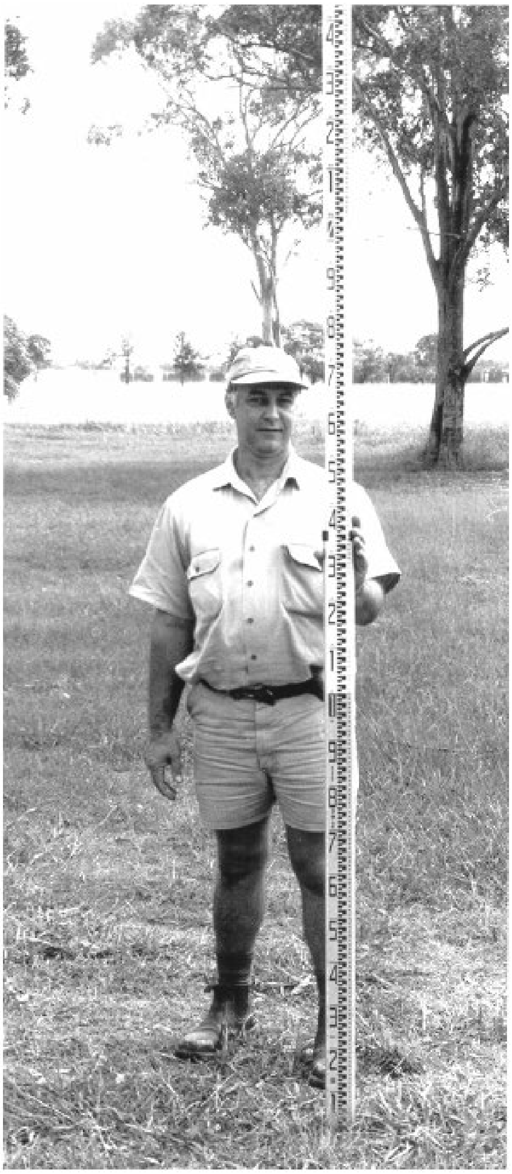


Fig. 22 Using a staff

Reading the Staff

Shown below are two common staff faces, one with a graduated face and the other with an 'E' pattern face.

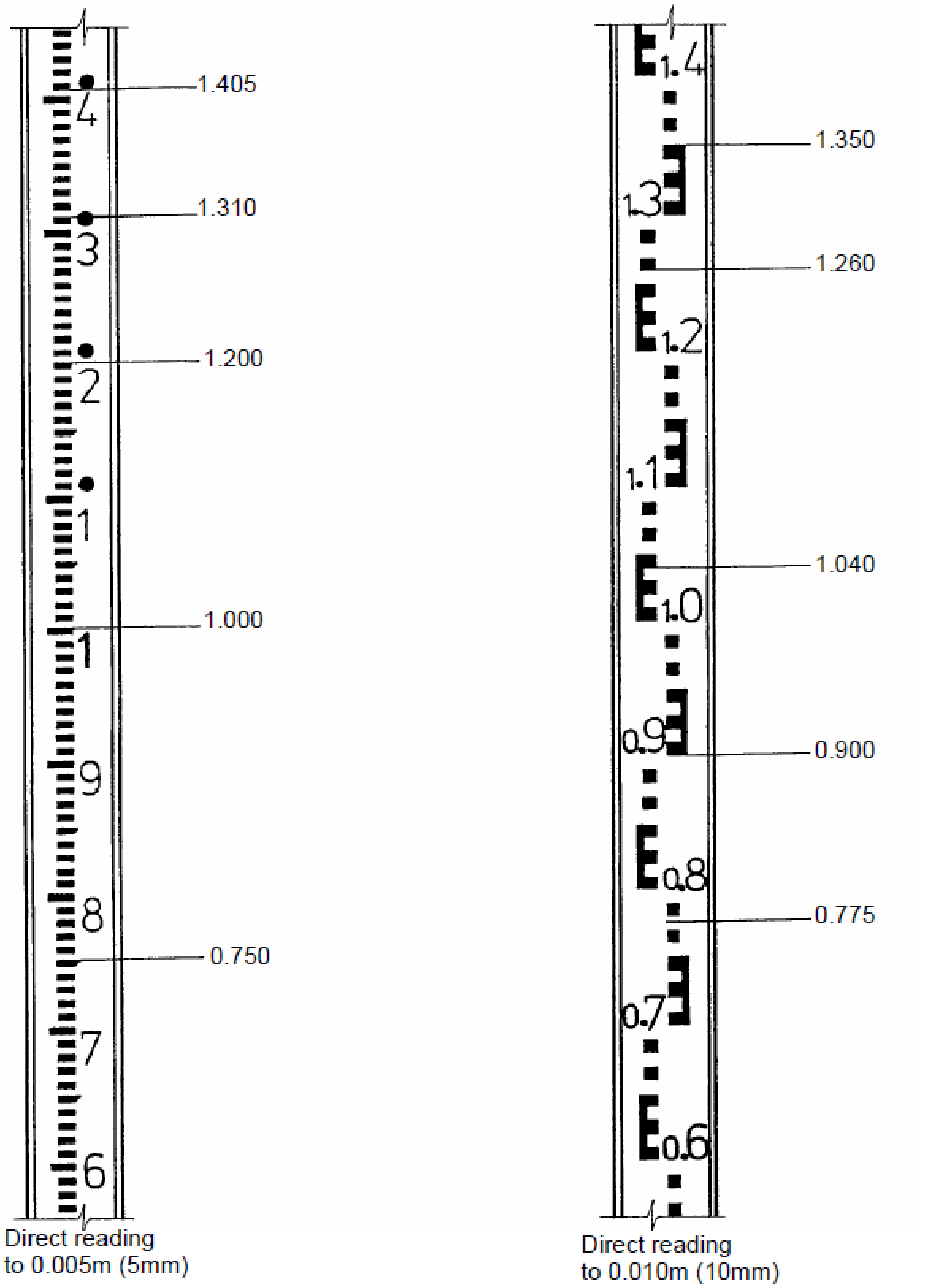


Fig. 23 Reading common staves

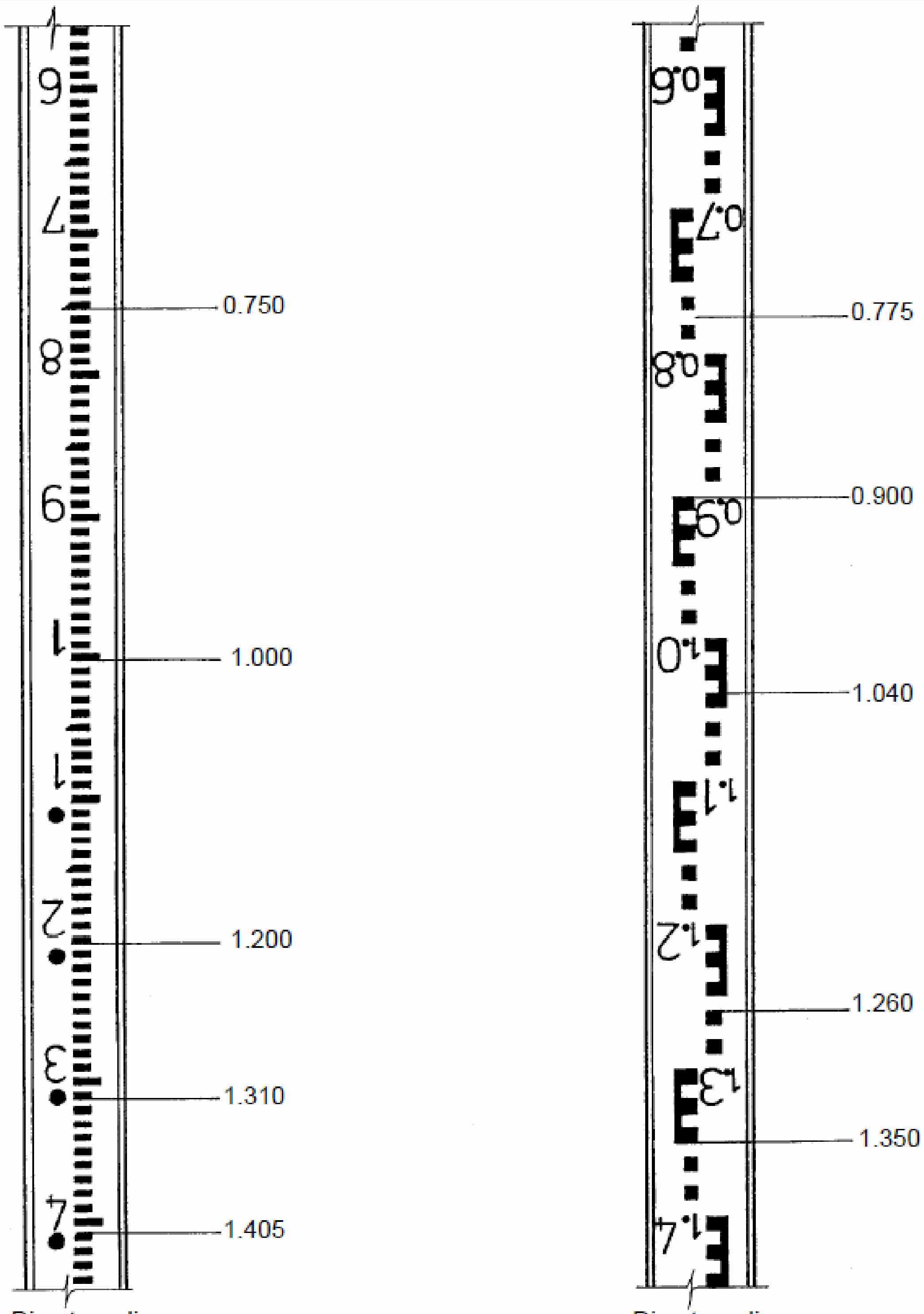


Fig. 24 Direct reading to 0.005m (5mm) Alternative reading method Direct reading to 0.010m (10mm)

Note: Details show reading positions as viewed through an older type of levelling instrument, which shows the image in the inverted position.

Sights and Recording Information

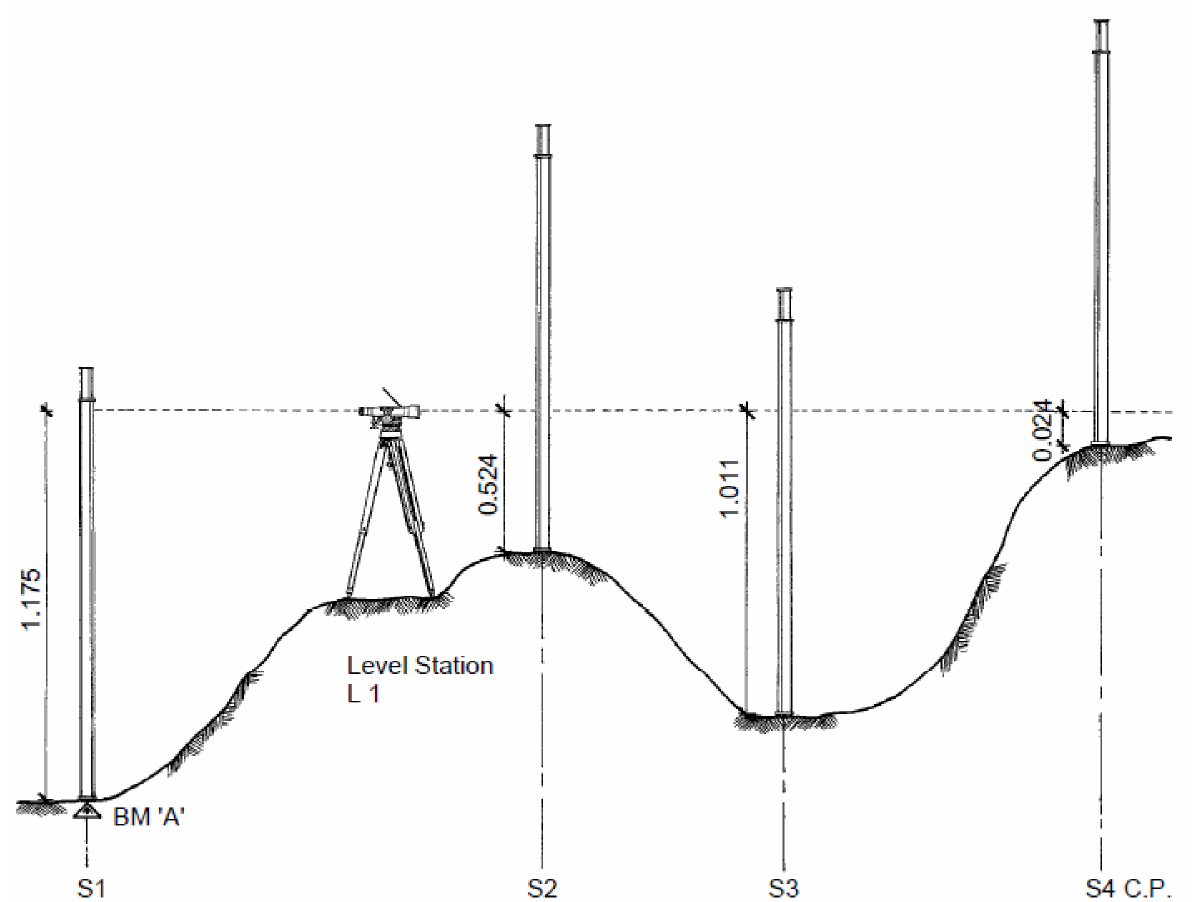
Line of Collimation

This is the line of sight taken through the eyepiece, centre of the cross hairs of the telescope and the centre of the object being viewed. It is important to note that the instrument should be set at a height to suit the viewer so it is not necessary to bend or stretch to take a reading as this may lead to 'an error of *parallax*' occurring, which means looking through the eyepiece at an angle above or below the cross hairs resulting in an incorrect reading.

This imaginary line remains straight and level in all directions as the telescope is rotated to provide a constant common line from which to measure so an accurate picture of the surface being surveyed can be created. In other words, the surface is measured in relation to the height of the instrument, from the centre of the telescope.

Once the reduced level of the datum or bench mark is known, all other sights may also be given a reduced level which is either above or below the datum or bench mark. This information can be used to create a contour map of the site or area being surveyed so builders and designers can use it to determine falls, cut and fill requirements, structural design requirements, etc.

Fig 25 Method of reading and recording rises and falls



Booking of Levels

To record a *Traverse,* a straight line survey, or a *Closed Traverse*, a survey around a site, the readings need to be logged onto a table or 'Level Book' so the rises, falls, reduced levels and distances may be calculated. This information will be useful when setting out the site to identify areas to be excavated or filled, heights of floors, drainage, etc.

Level Book Terminology
Backsight

This is the first sight taken and recorded after the levelling instrument is set up. It is usually taken from the Datum or Bench mark or Job Datum to establish a starting point and show the height of the instrument in relation to that point.

Intermediate Sight
These are all the sights taken at nominated positions, known as stations, to enable a running calculation of rises and falls, which are used to determine the Reduced levels.

Foresight
This is the last sight taken before the instrument is moved to another location or when a traverse is complete.

Change Station
This is a point at which two readings are taken because the instrument has to be moved due to not being able to see the next intermediate sight from that set up position. The first sight taken at a change point will be recorded as a *Foresight* , because it is the last sight taken before the instrument is moved, and the second sight taken will be recorded as a *Backsight*, because it is the first sight taken once the instrument is set up again. This procedure allows the traverse to continue which in turn allows the Reduced levels to continue in sequence, giving the impression that there was no obstacle or disruption in the levelling process.

Rise
This is a measurement calculated by subtracting the last two sights from one another, i.e. an intermediate sight from the backsight or an intermediate sight from an intermediate sight or a foresight from an intermediate sight, etc. If the height or elevation of the second sight is less than the first sight, then the difference in measurement will be recorded as a 'rise'.

Fall
Same method of calculation as for the rise, but if the height or elevation of the second sight is greater than the first sight, then the difference will be recorded as a 'fall'.

Reduced Level
These are the finished calculated heights or elevations in relation to the original reduced level, which was recorded as the identified Datum or Bench Mark. To calculate these levels it is necessary to add the rises and subtract the falls.

Remarks
These are comments made relating to the start and finish of the traverse or to indicate a change in station, intermediate sight, special landmark, etc.

Example of a Level Book page;

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks

Method of Booking Levels
The following example outlines the sequence required to book levels, calculate the rise and fall, calculate the reduced levels and identify where the levels were taken.

Example 1:
A traverse or straight line survey is to be taken, at 5.0m intervals through the centre of a large residential block which is to be subdivided. There are two existing buildings on the block which will obscure the view of some points from the first set up position, therefore a change station is required.

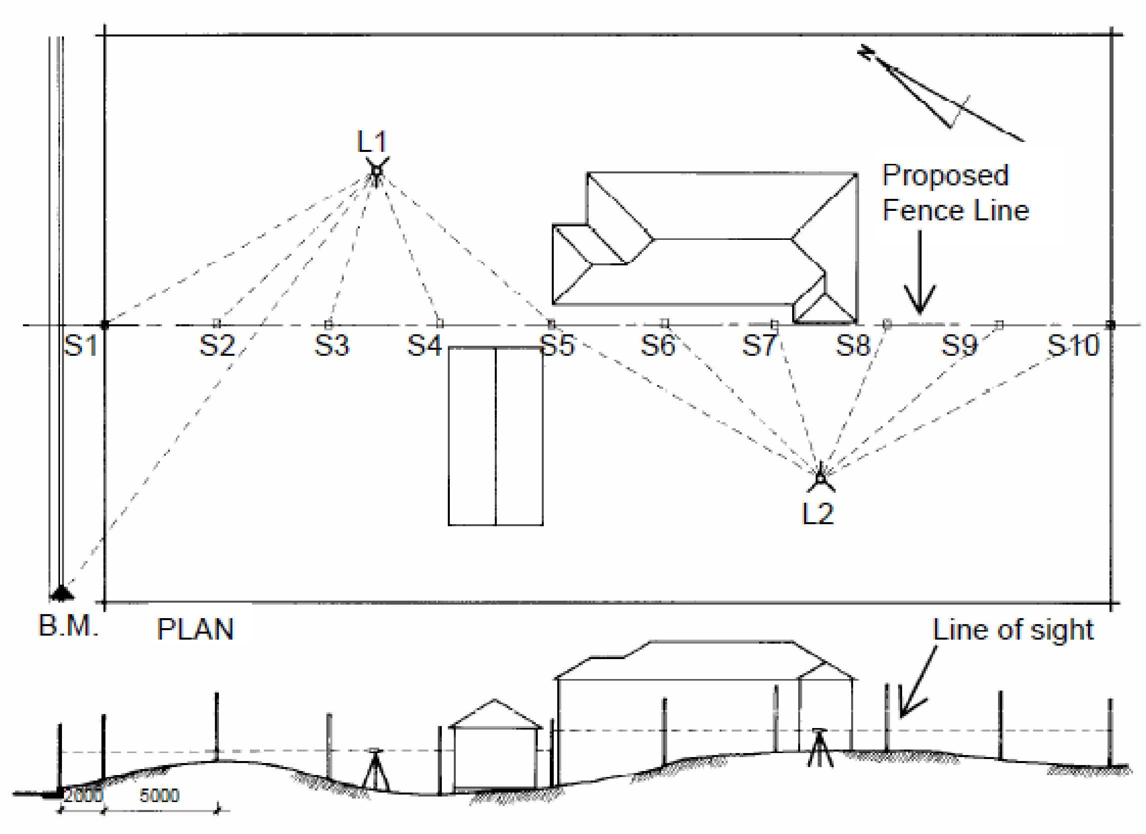


Fig. 26 Plan and section of block to be subdivided

STEP 1 The first set up position of the level should be where the greatest number of stations and the datum or bench mark can be seen. This will avoid unnecessary moving of the instrument. This position is identified as ‘L1’. The reading taken here back to the identified bench mark on the kerb and gutter, at the north/east corner of the block, is 1.575m. This is the relative height of the instrument above the bench mark and as it is the first sight taken it will booked as a *Backsight.* The actual Reduced Level of the Bench Mark is also recorded.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
5	1.57				47.195	0.000	B.M. & L1 (start)

STEP 2 Book all the intermediate sights before the instrument has to be moved. Include the progressive distance, starting at 2.0m from the Bench Mark.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250					2.000	Station 1
	0.850					7.000	Station 2
	1.330					12.000	Station 3
	1.580					17.000	Station 4

STEP 3 The next station, i.e. S5, will be when the instrument has to be moved as the station after it, i.e. S6, cannot be seen from position L1. This will be the last sight taken from L1, therefore the sight will be recorded as a *Foresight* **Note:** When relocating the instrument it must be in a position where S5 can be seen so a backsight may be taken from the new position.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250					2.000	Station 1
	0.850					7.000	Station 2
	1.330					12.000	Station 3
	1.580					17.000	Station 4
		1.450				22.000	Change Station 5

STEP 4 The instrument has been relocated to position L2, therefore the first sight taken after setting up will be back to S5 and will be booked as a *Backsight.*

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250					2.000	Station 1
	0.850					7.000	Station 2
	1.330					12.000	Station 3
	1.580					17.000	Station 4
		1.450				22.000	Change Station 5
2.550						(no change)	L2 & Change St. 5

STEP 5 Book all other intermediate stations through to S9.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250					2.000	Station 1
	0.850					7.000	Station 2
	1.330					12.000	Station 3
	1.580					17.000	Station 4
		1.450				22.000	Change Station
2.550						(no change)	L2 & Change St. 5
	1.980					27.000	Station 6
	1.760					32.000	Station 7
	1.710					37.000	Station 8
	1.840					42.000	Station 9

STEP 6 The final sight, at S10, is also the last sight before the instrument is moved, therefore it will be booked as a *Foresight*. It should also be noted in the remarks column that this is the end of the traverse.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250					2.000	Station 1
	0.850					7.000	Station 2
	1.330					12.000	Station 3
	1.580					17.000	Station 4
		1.450				22.000	Change Station 5
2.550						(no change)	L2 & Change St. 5
	1.980					27.000	Station 6
	1.760					32.000	Station 7
	1.710					37.000	Station 8
	1.840					42.000	Station 9
		1.920				47.000	Station 10 (end)

STEP 7 The next step is to determine the rises and falls and book them in the appropriate column. When a sight has a lesser elevation than the previous sight, it will be classified as a ‘Rise’. When a sight has a greater elevation than the previous sight, it will be classified as a ‘Fall’.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduce d Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250		0.325			2.000	Station 1
	0.850		0.400			7.000	Station 2
	1.330			0.480		12.000	Station 3
	1.580			0.250		17.000	Station 4
		1.450	0.130			22.000	Change Station 5
2.550						(no change)	L2 & Change St. 5
	1.980		0.570			27.000	Station 6
	1.760		0.220			32.000	Station 7
	1.710		0.050			37.000	Station 8
	1.840			0.130		42.000	Station 9
		1.920		0.080		47.000	Station 10 (end)

STEP 8 The Reduced Levels are now calculated by 'adding the rises' and 'subtracting the falls'. Each measurement is either added or subtracted from the previous Reduced Level total.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250		0.325		+47.520	2.000	Station 1
	0.850		0.400		+47.920	7.000	Station 2
	1.330			0.480	-47.440	12.000	Station 3
	1.580			0.250	-47.190	17.000	Station 4
		1.450	0.130		+47.320	22.000	Change Station 5
2.550					47.320	(no change)	L2 & Change St. 5
	1.980		0.570		+47.890	27.000	Station 6
	1.760		0.220		+48.110	32.000	Station 7
	1.710		0.050		+48.160	37.000	Station 8
	1.840			0.130	-48.030	42.000	Station 9
		1.920		0.080		47.000	Station 10 (end)

STEP 9 To ensure the sights have been placed in the correct columns and the rises and falls are in the correct columns, a check is made in three areas;
1. Add the backsights together, then add the foresights together and find the difference between them;
2. Add the rises together, then add the falls together and find the difference between them.
3. Subtract the first reduced level from the last reduced level and find the difference between them.
If all three differences are the same, then the book is said to be balanced.

Backsight	Intermediate Sight	Foresight	Rise	Fall	Reduced Levels	Distance	Remarks
1.575					47.195	0.000	B.M. & L1 (start)
	1.250		0.325		47.520	2.000	Station 1
	0.850		0.400		47.920	7.000	Station 2
	1.330			0.480	47.440	12.000	Station 3
	1.580			0.250	47.190	17.000	Station 4
		1.450	0.130		47.320	22.000	Change Station 5
2.550					47.320	(no change)	L2 & Change St. 5
	1.980		0.570		47.890	27.000	Station 6
	1.760		0.220		48.110	32.000	Station 7
	1.710		0.050		48.160	37.000	Station 8
	1.840			0.130	48.030	42.000	Station 9
		1.920		0.080	47.950	47.000	Station 10 (end)
4.125		**3.370**	**1.695**	**0.940**			

Check: Backsights/Foresights : *4.125* - *3.370* = *0.755*

Rise/Falls : *1.695* - *0.940* = *0.755*

Reduced Levels : *47.950* - *47.195* = *0.755*

Contours

Contour lines provide Builders, Architects, Landscapers, etc. with information which assists with design, costing, drainage, cut and fill requirements. These lines are imaginary and when shown on a site plan may appear to resemble the tide water marks on the sand at the beach. In fact they are very similar as they provide a clear picture of the rise and fall of land by intersection of the surface in a level plane. They are usually best shown on plan and appear in many situations such as road maps, large land maps, building development plans, geotechnical surveys, etc and are given a height, which is relative to a known point, called a Reduced Level.

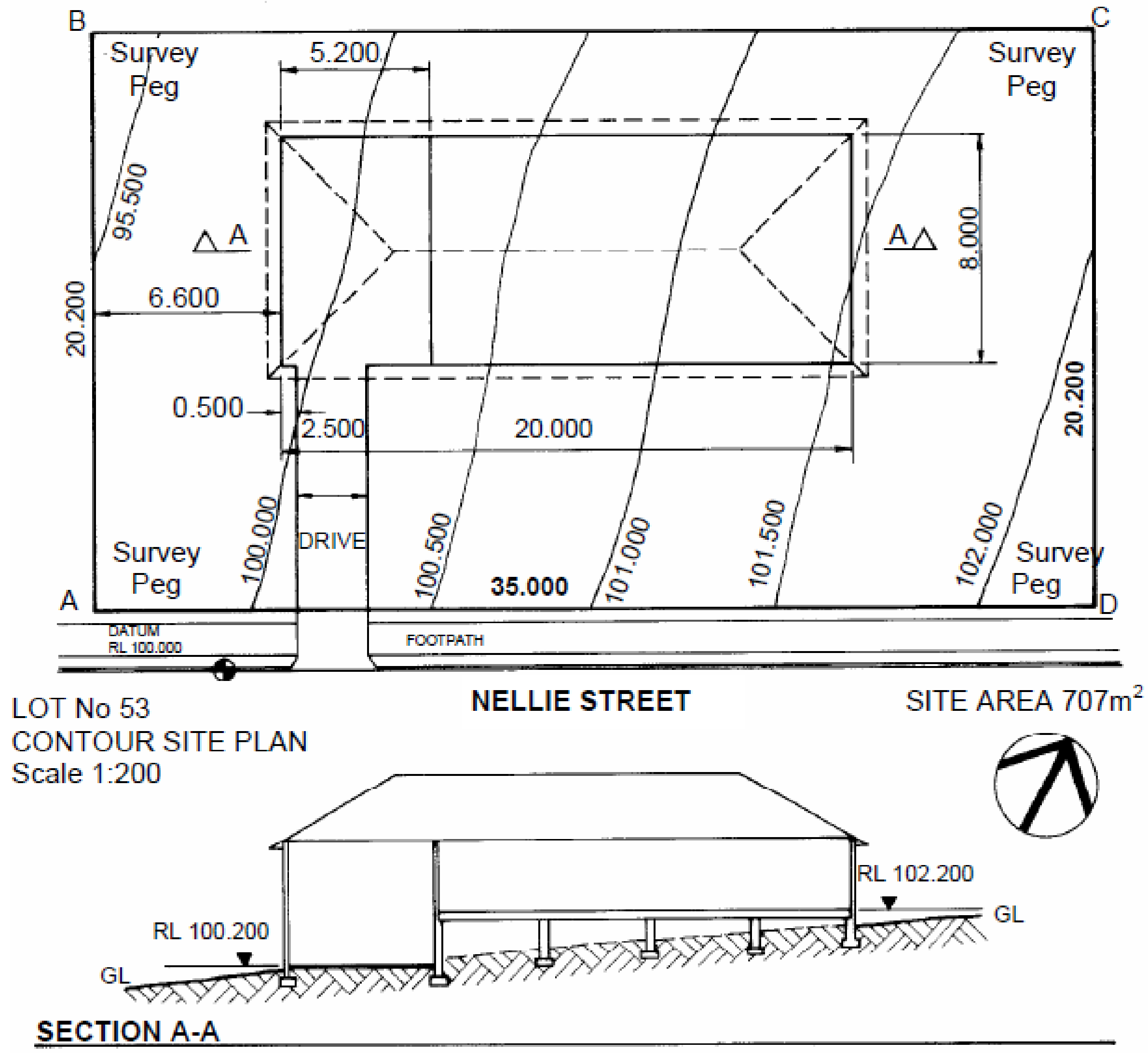


Fig 27 Contour site plan and section

Reduced Level

The known point, referred to as the datum or bench mark, is also given a reduced level and all the contours are shown on plan either above or below this point.

Note: The datum or bench mark is never given as zero as there may be falls on the site which would result in a negative measurement being shown.

As contour lines have reduced levels it is easy to determine the difference in height from one corner of the building to the other. In the plan above, it is also possible to calculate the depth of the excavation in each corner of the garage or the height from floor level to ground level at a number of points in the building.

Contour Plans

A contour plan is made of the site before the building is designed, using the information from the 'Level Book'. The site is usually set out to a grid with a grid spacing to suit the slope of the site, i.e. smaller grids for steep or *undulating* sites, to record the most information for establishing changes in elevation, and larger grids for relatively level sites as less detail is required.

The average gently sloping building block may be set out to 5.0m grid spacings, which is determined prior to booking levels, and the calculated reduced levels may then be plotted to the intersection points on a grid plan.

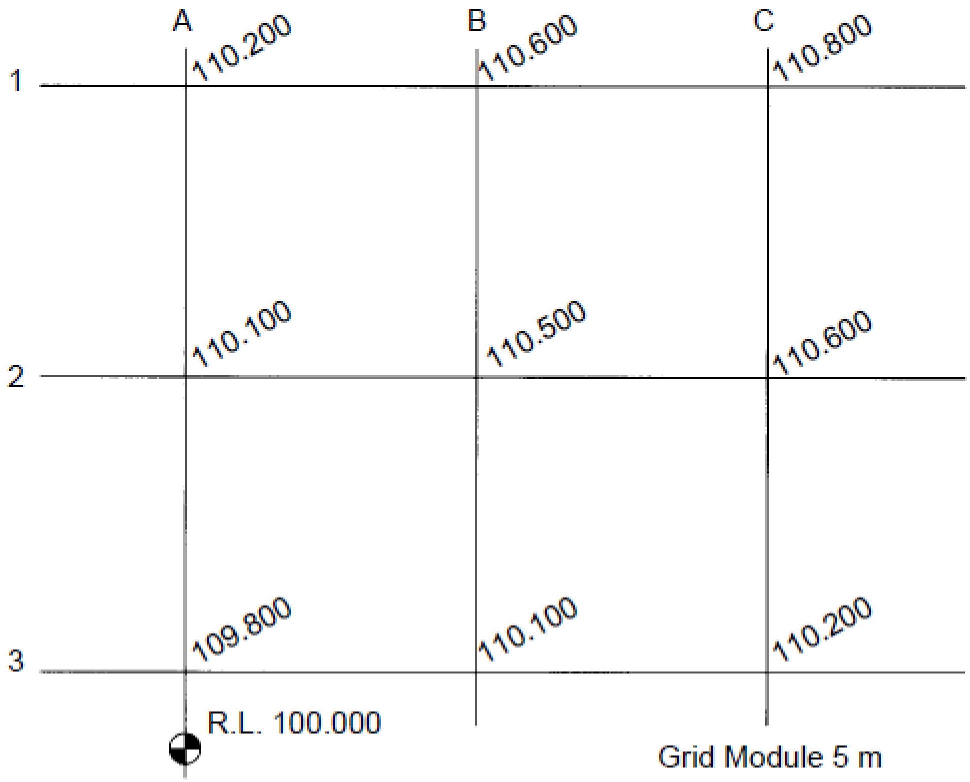


Fig. 28 Sample part grid plan

Contour Intervals

This is the vertical height or elevation between adjacent contour lines. On steeply sloping sites the contour interval may be greater, e.g. 1.0m intervals, than that required for gently Sloping sites, e.g. 50, 100 or 200mm intervals, depending on the accuracy required.

1. Start from the highest point on the grid and select two adjacent grid points, e.g. C1 and B1, on the grid plan. Subtract one reduced level from the other, i.e. 110.800 - 110.600 = 200mm;

2. Divide the difference between the reduced levels by the nominated contour interval, e.g. 100mm, which would equal 200 ¸ 100 = 2 divisions;
3. Mark the 2 equal spacings on the grid plan line between C and B;
4. Repeat the process between grid points C1 and C2;
5. Identify the position of the contours with the same contour interval and join them with a line, which should be curved in the direction of highest to lowest position. The degree of curve may be determined by selecting the diagonally opposite grid points which have the

highest and lowest reduced levels. Subtract one from the other and divide them into the same contour interval spacings, then join all the like points.

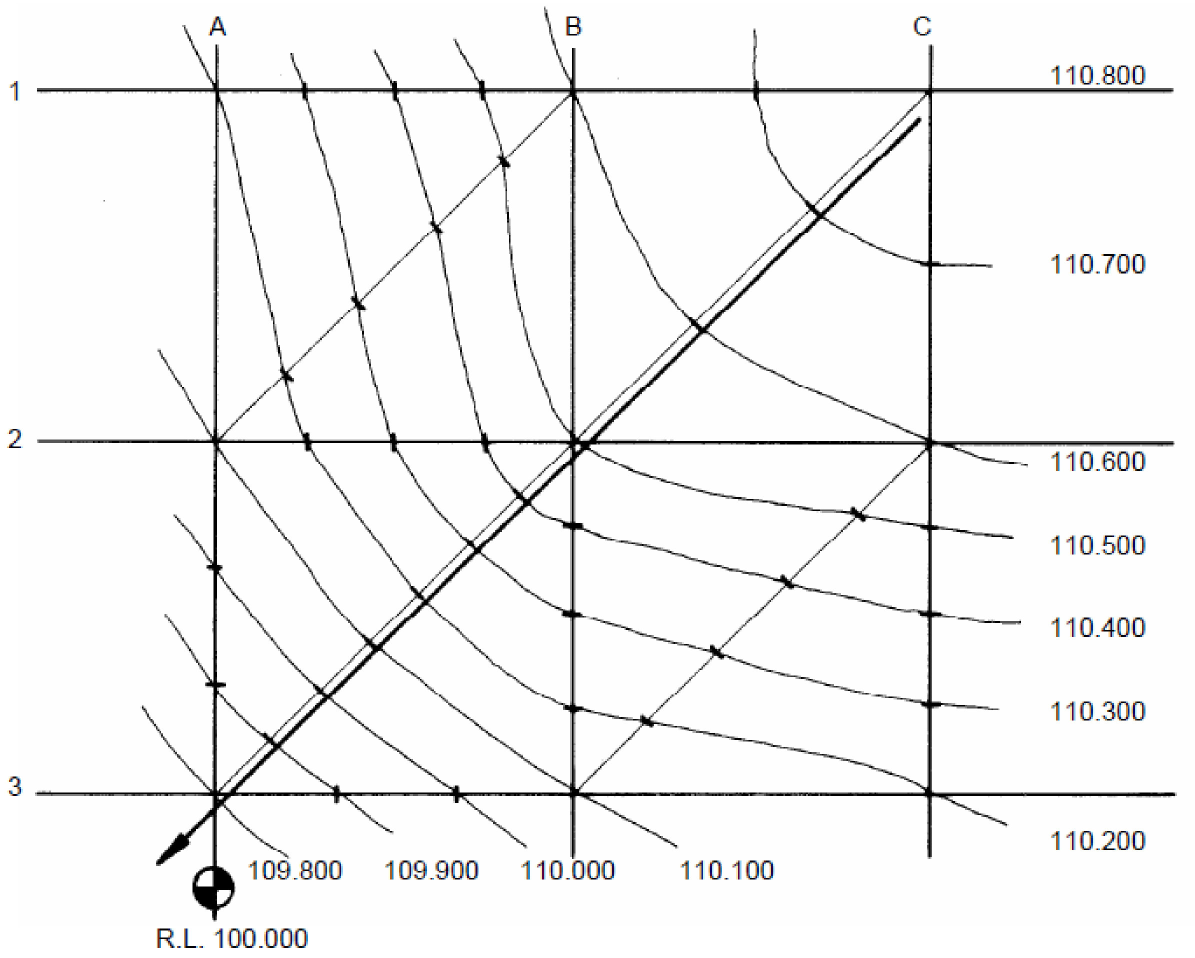


Fig. 29 Method of dividing contour grids

Note: Where the contour lines are shown as a circle on plan it would indicate the peak of a hill or the depression of a hole.

6. Repeat the process between all other adjacent grid intersections until a completed contour map is revealed;
7. Indicate the flow of water on the grid with an arrow, starting at the highest point to the lowest point.

Setting Out 'T' or 'L' Shaped Buildingss (Slab-on-Ground)

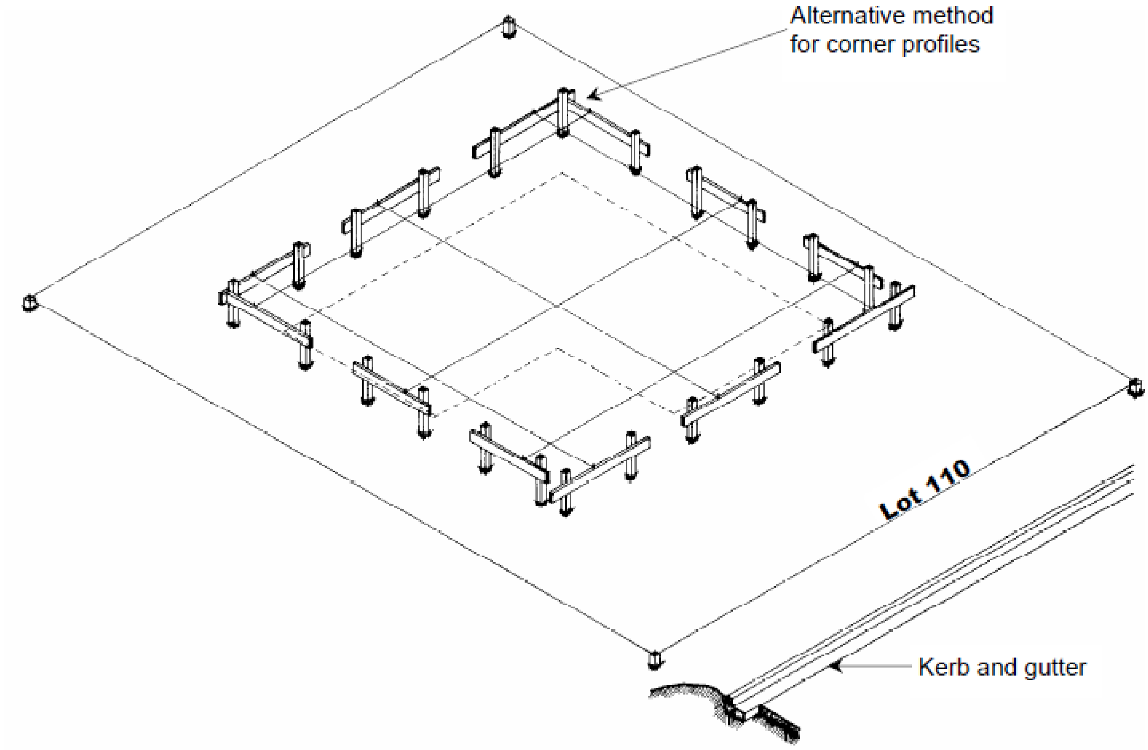
Summary of Site Set-Out Procedures

STEP 1 Establish the correct building block and size.
STEP 2 Establish the appropriate boundary lines
STEP 3 Establish the position of Peg A.
STEP 4 Establish the position of Peg B.
STEP 5 Establish the position of Peg C using the Pythagorean formula for right angled triangles: *Formula : a2 + b2 = c2*
STEP 6 Establish the position of Peg D.

Note: Pegs A, B, C, and D should be established so that their tops are level with each other.

STEP 7 Place profiles 1 to 8 in position.
STEP 8 Transfer string lines to profiles.
STEP 9 Check for square and adjust if necessary.
STEP 10 Place additional profiles required for offsets in the building outline to form the 'T' or 'L' shape.
STEP 11 Mark the position and attach string lines for the offsets in the building outline.

Fig. 30 Site plan showing completed set out



Detailed Set Out Procedure

Prior to any set out taking place, Steps 1 and 2 outlined previously must be established.

STEP 3 Position Peg A the correct distance from the front and side boundaries, using measurements obtained from the site plan. Drive a clout partly into the top of the peg to mark the exact position.

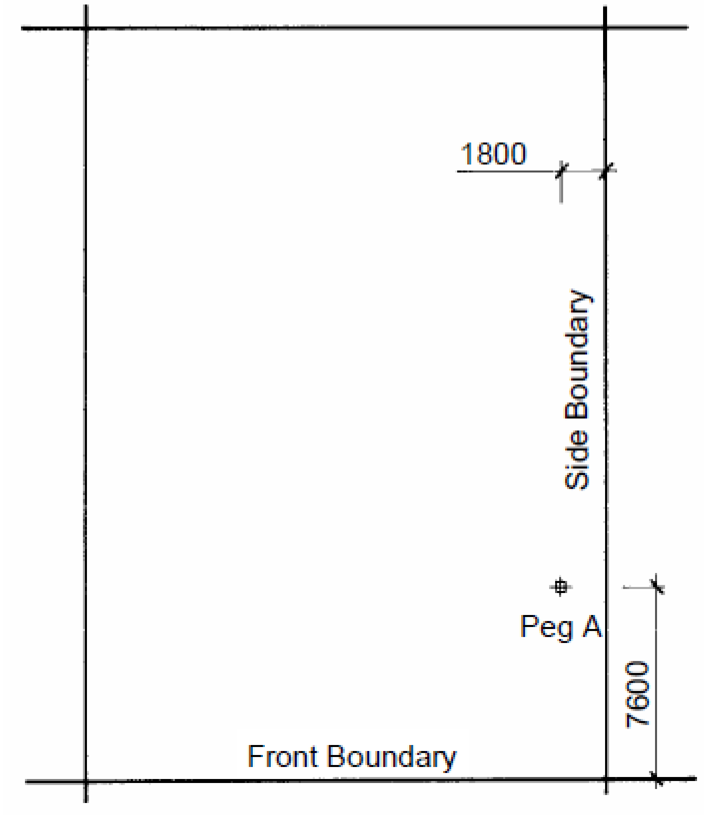


Fig. 31 Positioning peg A

STEP 4 Position Peg B the correct distances from Peg A and the side boundary with measurements taken from the site and floor plans.

Drive a clout partly into the top of the peg to mark the exact position.

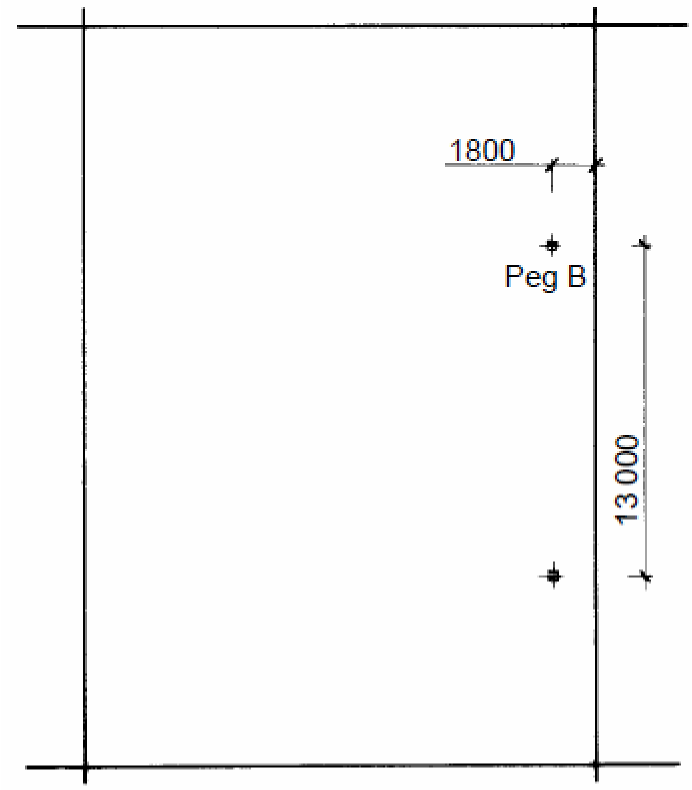


Fig. 32 Positioning peg B

STEP 5 Position Peg C the correct distance from A and B using the Pythagorean formula to calculate a full length diagonal measurement from B to C.

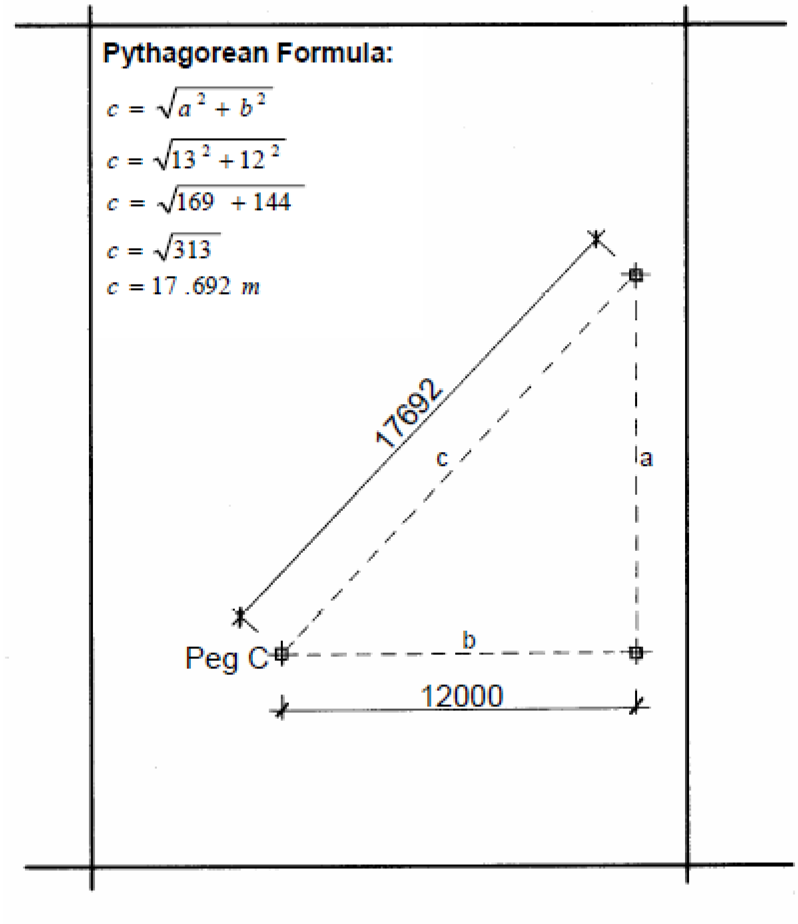


Fig. 33 Positioning Peg C

STEP 6 Using parallel measurements taken from the plan, position Peg D the correct distance from B and C.

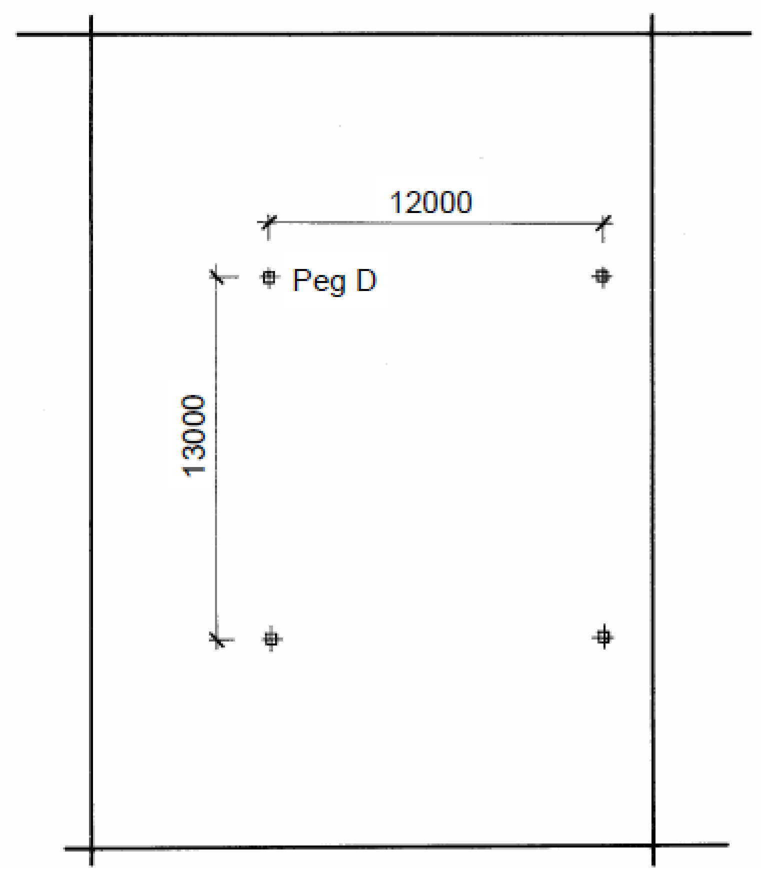


Fig. 34 Positioning Peg D

STEP 7 Erect the profile boards at a convenient distance (e.g. one metre to allow for excavation work) from the pegs, keeping them parallel to the pegs.

Establish a profile close to the ground at the highest point of the set-out, which is assumed to be at Peg A. Use any of the basic telescopic or laser levelling instruments to transfer a height measurement from this profile to all other profiles, to maintain a constant height.

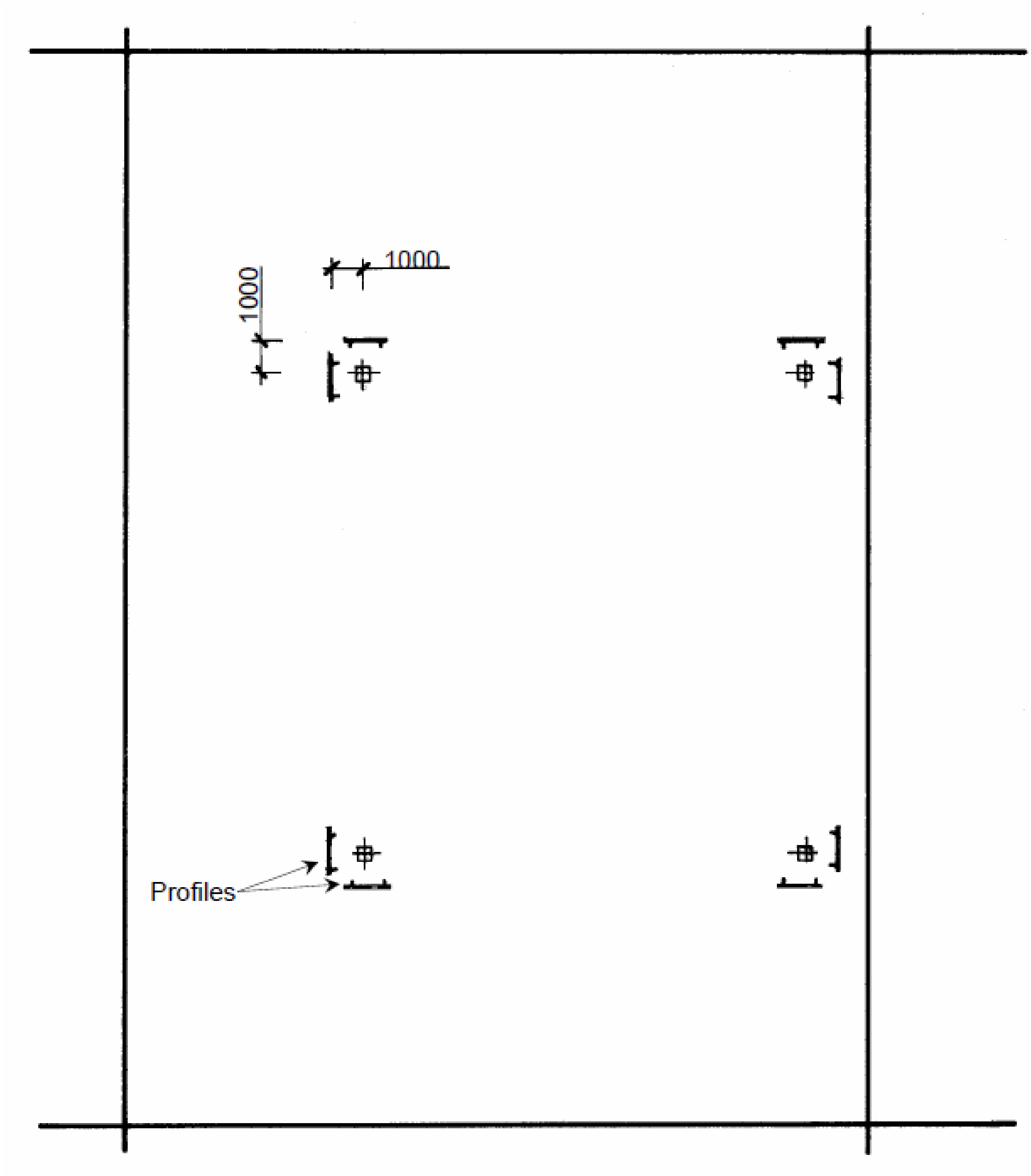


Fig. 35 Erect profile boards

STEP 8 Position string lines between profile boards.
Start procedure by pulling a line, attached to the nail in Peg A, exactly plumb over the nail in Peg B. Use a spirit level to plumb the position up to the profile. Mark the position on profile number 4, release the string line then partly drive a nail at this mark.

Attach a line to the nail on profile 4 and pull it back plumb over the nail in Peg A and mark the position on profile 1. Partly drive a nail at this mark and tie off line.

Carry out the same procedure between pegs A and C, using profiles 2 and 7.

Note: These two first lines will form a right angle.
Position marks on all other profiles by measuring the correct parallel distances from the marks on the profiles 1,2,4, and 7, and position the remaining string lines.

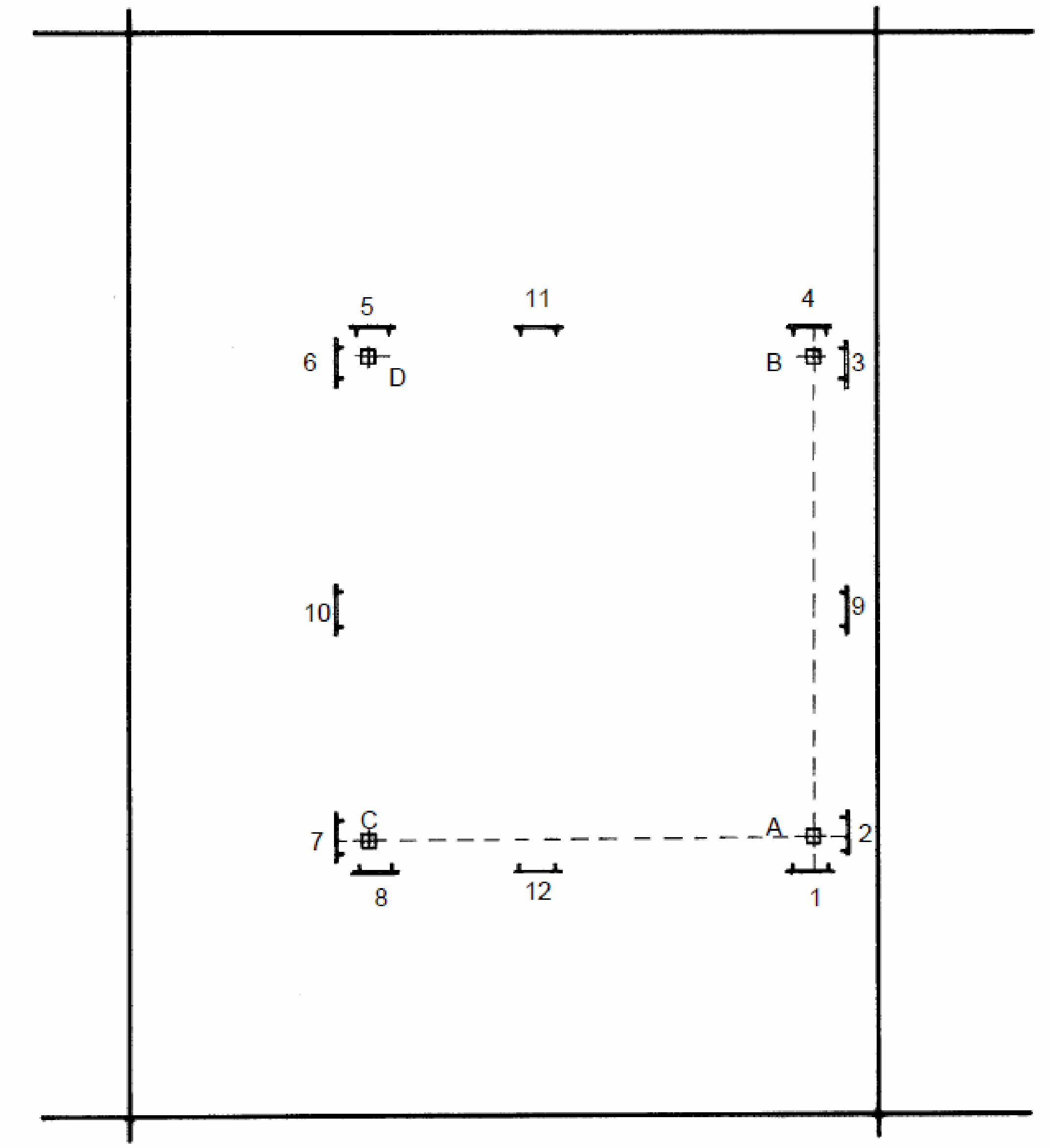


Fig. 36

Setting out positions on profiles

STEP 9 Measure the diagonals to check for square. If the difference between the length of each diagonal is more than 10mm, it will be necessary to adjust some of the nails on the profiles.

Check the diagonal measurement on a calculator to give you some indication of where the error might have occurred.

Note: DO NOT move line A-B. If adjustments need to made for square use lines A-C and B-D, making sure to move them both the same amount. When adjusting line A-C, ensure the adjustment is away from the front so the 'Building Alignment' is not encroached upon. The building alignment is set by Council which is a minimum distance from the street alignment to the closest face of the structure and must not be reduced by any amount, unless Council gives permission.

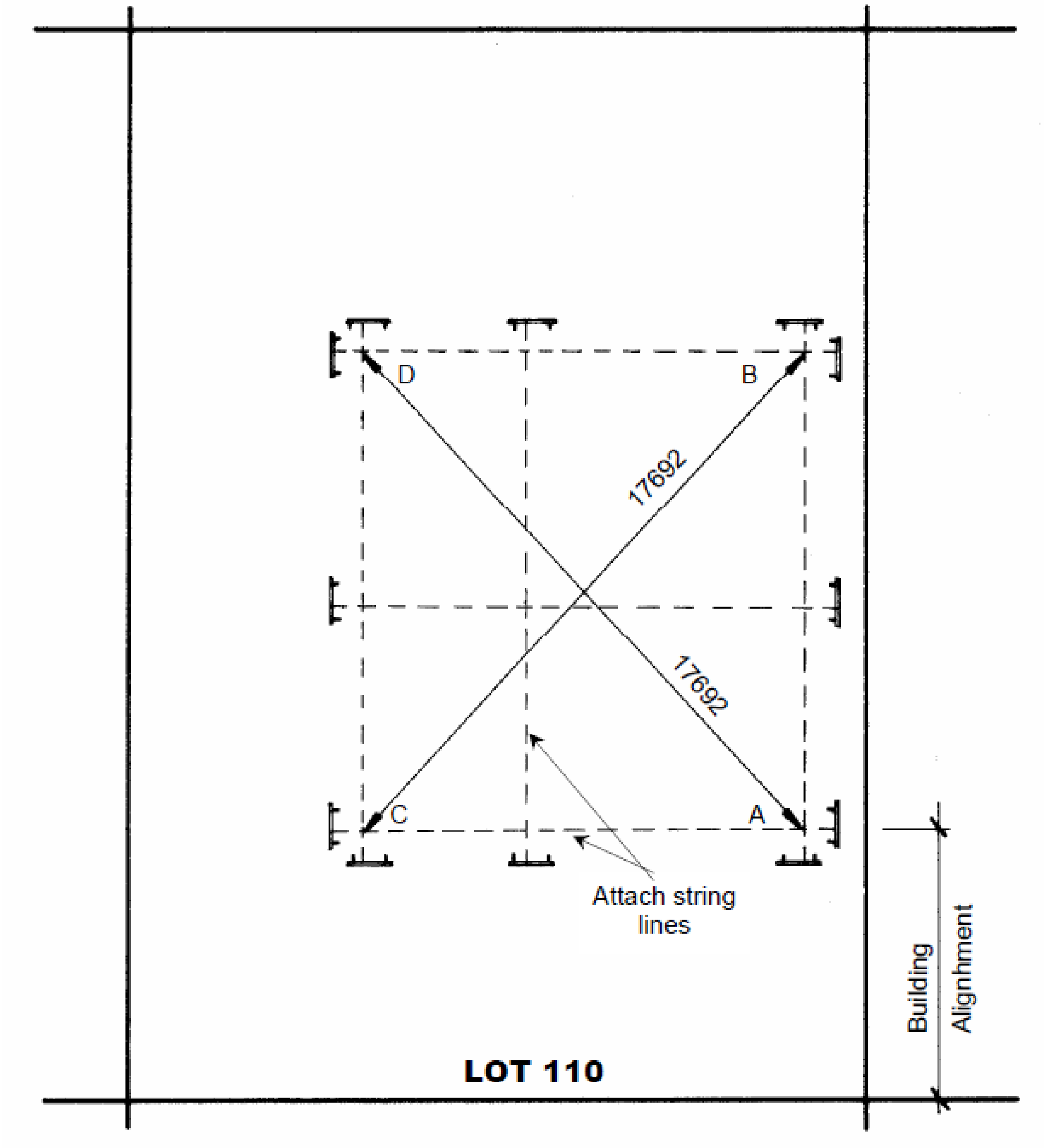


Fig. 37

Completed set out ready for excavation

Site and Building Calculations

Surface Area of Irregular Shapes

Basic irregular shapes and the relevant formulae are dealt with in 'Basic Building and Construction Skills' in the section of 'Measurement, calculations and quantities. Also, the basic calculation of volume related to various materials is addressed.

This section will deal with the calculation of larger areas, including floor areas in 'square metres' and building sites in 'square metres' and 'Hectares'. Floor and site areas are calculated to allow Builders, designers, landscapers, floor finishers, etc. to estimate quantities and costs of materials required and the areas may also be applied to other calculations to find volumes.

These include carpets, parquetry flooring, tongue and grooved flooring, turf for landscaping, topsoil, filling, etc.

Terms and Areas

The measurement system used in Australia is the 'metric' system, based on the universal measurement system introduced in 1960 known as the *System International d'Unites* or SI units of measurement. However, some Builders and many Real Estate agents still use some of the old terms from the superseded measurement system, known as the 'Imperial' system. Commonly
used measurements are :

Current SI Area Units of Measure

The correct terminology used for surface area is:
- Square metre = 1.0 x 1.0 or 1000mm x 1000mm = 1.0m²
- Hectare = 100.0 x 100.0m = 10000m²
- *'Square'* - this an area measurement commonly used to state the area of the floor in a cottage, i.e. 1 square = 10 feet x 10 feet = 100sq.ft. or 3.048m x 3.048m = 9.290m².
- *Chain* - this is a unit of length used to describe long boundaries. It's length is equal to 22 yards (the length of a standard cricket pitch) or 20.1m.
- *Acre* - this is a unit of surface measurement used to describe the area of large tracts of land.
It is approximately equal to 4,000m² or 2.5 acres to a Hectare.

Areas of Irregular Shaped Building Sites

The following examples describe the method used to calculate the surface area of irregular shaped sites;
Example 1:
Calculate the surface area of the irregular shaped block of land so turf may be priced and ordered:

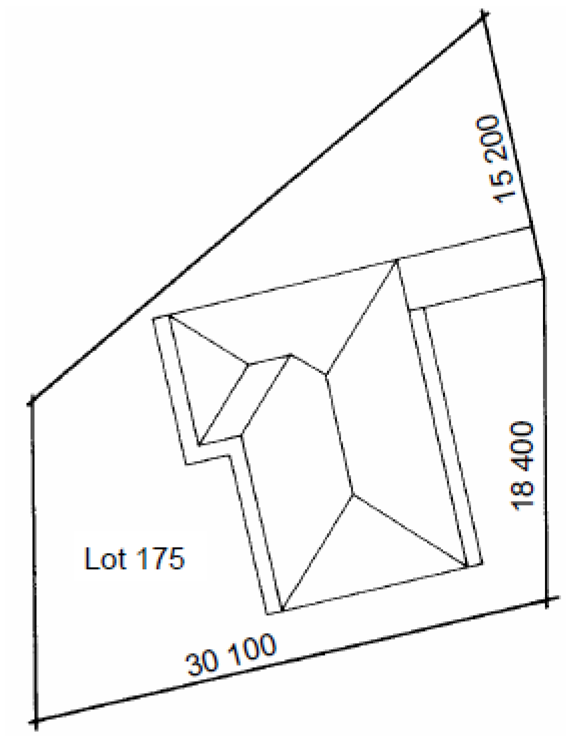


Fig. 38 Irregular shaped allotment

STEP 1 Divide the whole block into shapes which are easily calculated. Apply the appropriate formula for area to each shape, calculate the area of each shape and add the totals together as follows:

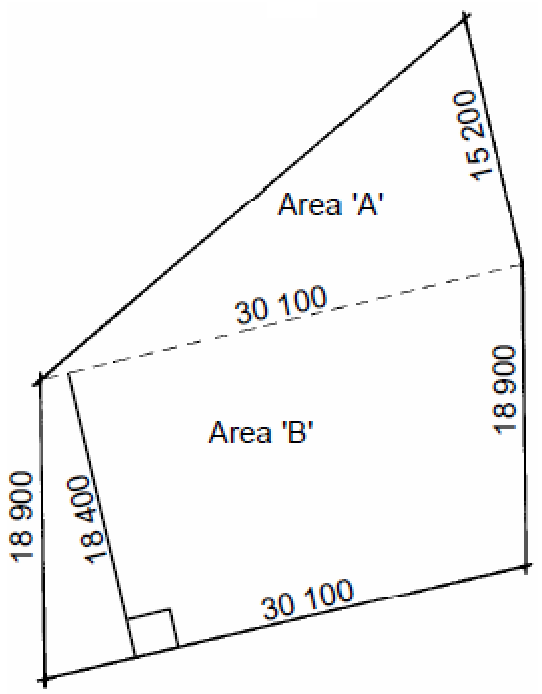
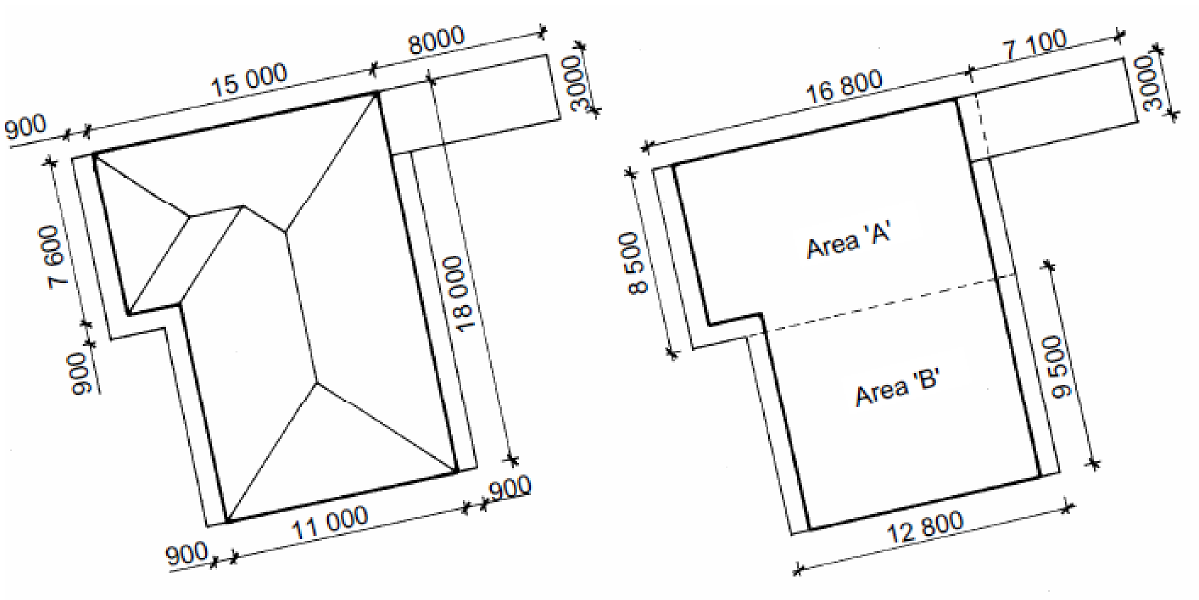


Fig. 39 Method of dividing up the shape

Area 'A'	= ½ base x height	
	$= \frac{30.100}{2} \times 15.200$	
	= 15.050 x 15.200 = **228.760m²**	
Area 'B'	= length x width	
	= 30.100 x 18.400 = **553.840m²**	
Add A + B	= 228.760 + 553.840 = **782.600m²**	

STEP 2 The cottage and paved areas will not have turf, therefore this total area must be deducted from the area of the block. It will be necessary to divide the cottage/ paths and drive into separate areas as follows;

Fig. 40 Method of dividing up a regular shape



Therefore, the total area to be turfed is, say **497m² or 0.050 Hectares**

Area 'A'	=	Length x width
	=	16.800 x 8.500 = **142.800m²**
Area 'B'	=	12.800 x 9.500 = **121.600m²**
Area 'C'	=	7.100 x 3.000 = **21.300m²**
Add A+B+C		= 142.800 + 121.600 + 21.300 = **285.700m²**
deduct		782.600 - 285.700 = **496.900m²**

Example 2:

The floors of the bedrooms, hall and lounge/dining in the cottage shown below require a variety of new floor coverings. The total square metres of floor area are also required so the correct size compressor unit can be purchased for a new ducted air-conditioning system.

The bedrooms are to be carpeted, the hall and alcove area will have a *parquetry* covering and the lounge/dining will have ceramic tiles laid.

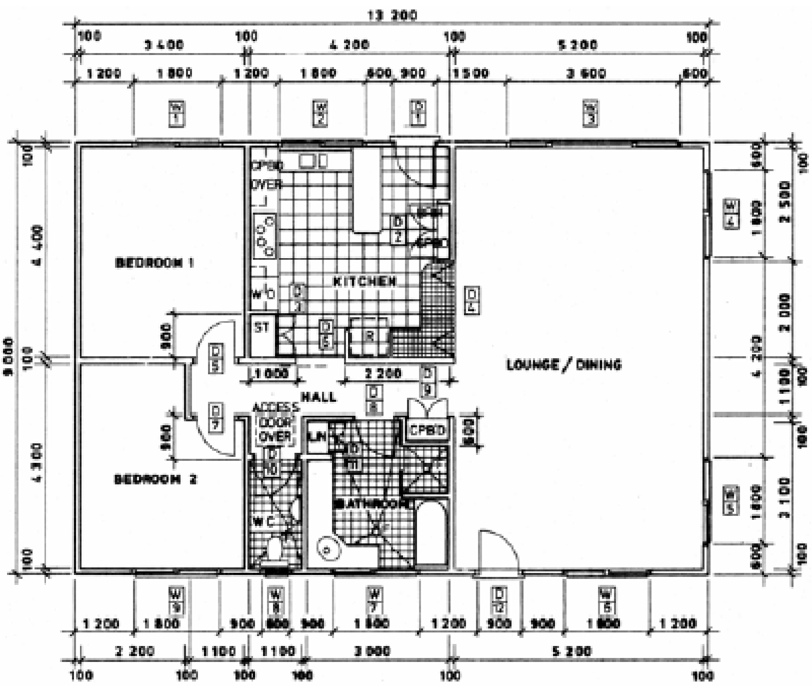


Fig. 41 Floor plan

Therefore, the total floor area of these rooms is, say **82m^2** (or around **9 squares**)

Bedroom 1 = Length x width
= 4.400 x 3.400 = 14.960m^2

Bedroom 2 = 4.300 x 3.400 = 14.620m^2
deduction = 1.100 x 1.100 = 1.210m^2
= 14.620 - 1.210 = 13.410m^2
Therefore, the total floor area to be carpeted will be: 14.960 + 13.410 = **28.370m^2**

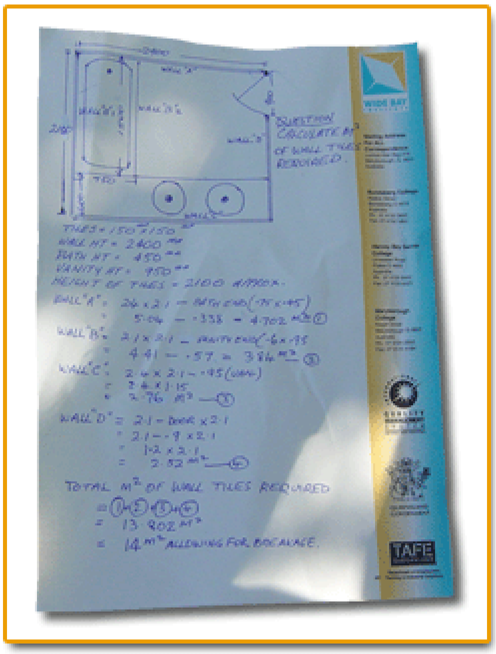
Hall = 5.500 x 1.100 = 6.050m^2
Alcove = 1.100 x 0.900 = 0.990m^2
Therefore, the total floor area to be covered with parquetry will be:
6.050 + 0.990 = **7.040m^2**

Lounge/ Dining = 8.800 x 5.200 = 45.760m^2
Therefore, the total floor area to be covered with ceramic tiles will be:
= **45.760m^2**

The total floor area of these rooms:
= 28.370 + 7.040 + 45.760
= **81.170m^2**

Levelling a Site Process Summary

Plans are an important part of planning the job. You can't do a job right if you're building without a plan. Reading and following the plans for the job will mean everyone involved knows exactly what they are doing and what the result will be.



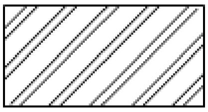
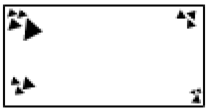
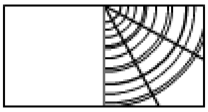
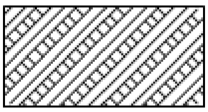
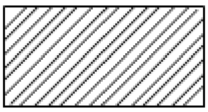
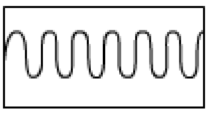
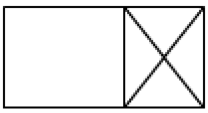
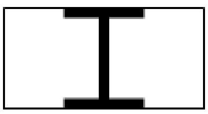
A set of working drawings usually includes:

1. a site plan
2. a floor plan
3. elevations
4. sections
5. details
6. specifications, including:
   - title panel
   - legend
   - notes
   - notations.

There may also be a separate set of general specifications and a schedule of finishes.

Symbols for materials usually show you the cross-section view, not the way the material looks on the outside.

Examples of symbols on a plan
Below are some examples of material symbols.

Symbol	**Explanation**
	Brickwork
	Cement render
	Concrete
	Dressed timber
	Earth
	Earth fill
	Insulation
	Sawn timber
	Structural steel

In addition, colour is used mostly to identify extensions to existing buildings. It is an important part of identifying the standardised symbol.

Scale can best be described as looking at the same object from different distances.

If you are standing close enough to an item to touch it, it would be full size - or a scale of 1:1 (one to one).

As you move further away the item looks smaller, yet the proportions remain the same.

It would be difficult to draw buildings full size. Most building and construction drawings use a reduction scale. This is drawn smaller than actual size.

Building scales most commonly used for details include:

- 1:1 = full scale
- 1:2 = two times smaller
- 1:5 = five times smaller
- 1:10 = ten times smaller
- 1:50 = fifty times smaller

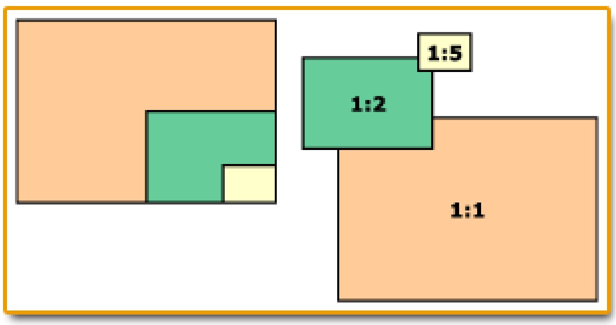
For plans and elevations, including site plans:

- 1:100 = 100 times smaller
- 1:200 = 200 times smaller
- 1:500 = 500 times smaller

The actual unit of measurement is indicated on the drawings. You can use a scale rule to work out approximate measurements only. This might be useful for estimating materials.

Which box is the smallest, yellow, green, or orange?

They're all the same size, just drawn to different scales!



Isometric drawings are not generally used as part of working drawings, but are very useful to help explain the real life construction. It is sometimes difficult to imagine what a new building will look like before it is built. That is why we use construction drawings. Because we live in a three-dimensional world we need to view or look at a building from at least three different positions to get an idea of what the building will look like when it is finished.

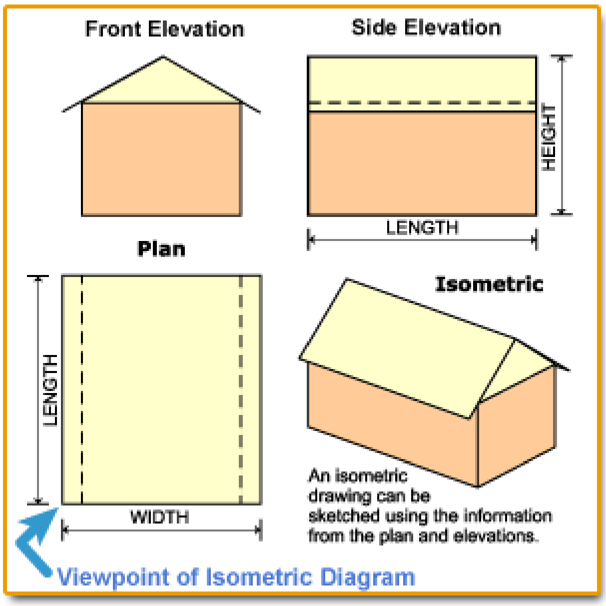
The most common views for building and construction drawings are:

- from the top
- from the side
- from the front.

These views give the dimensions and properties of a building but only from one direction at a time. To get a better picture of the finished building an isometric drawing can be used.

These views give the dimensions and properties of a building but only from one direction at a time.

To get a better picture of the finished building an isometric drawing can be used.



Before you start marking out your building site according to your plans, you will need to find out how level the site really is. You will need to set a horizontal line that is truly level, which you can use as a reference for all your measurements. From this line you can find the 'reduced levels', or how much the ground slopes away from the highest point.

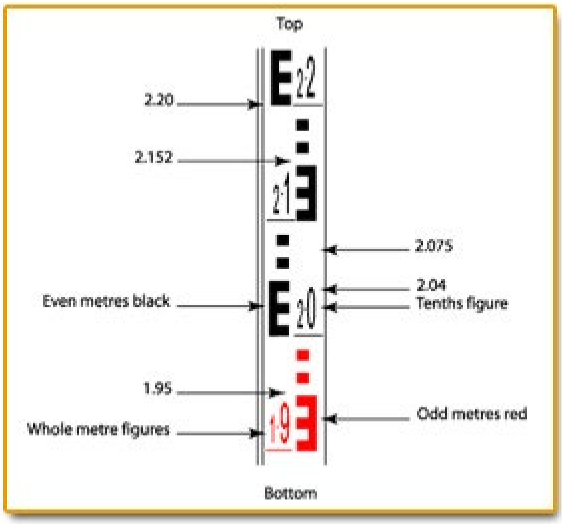
To find these levels, you will need levelling equipment including a levelling instrument, tripod, measuring staff and a record sheet.

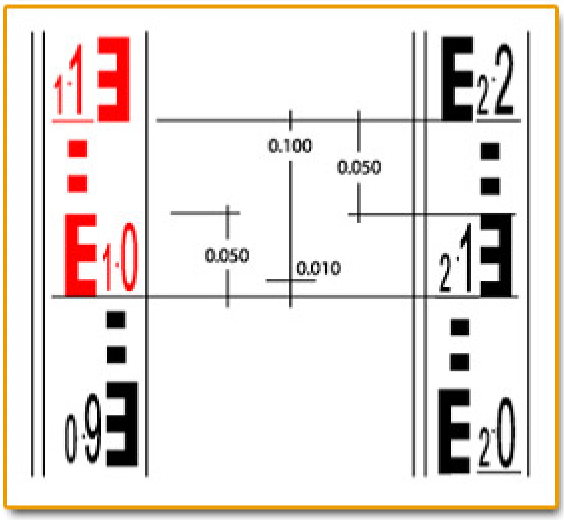
There are several types of surveying staff (rod) but the most common type used in the building industry is the metric 'E'.

A staff can be made of wood, fibreglass, metal, or a combination of these materials. They usually consist of three or four telescopic leaves and are either three, four or five metres long when extended.

Make sure the leaves are locked when the staff is extended. On either the side or the base is a locking device, which holds the telescope leaves accurately in position. The staff cannot be collapsed without disengaging this locking device.

Reading the staff





You read the staff by looking through the telescope of the levelling instrument at the staff. Focus the cross hairs on the staff and take the reading on the horizontal hair. The staff is marked in metre sections. Even numbered metres are colored black while odd numbered metres are red.

The metres are written as the smaller figure and the tenths of metres are the larger figure.

The 'E' covers 50 mm.

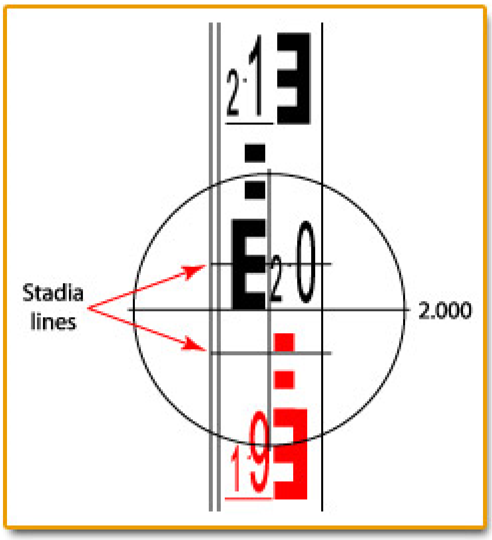
The staff is divided into 0.1 m (or 100 mm) sections from the bottom of one E to the bottom of the next E. These measurements are shown as the larger figure.

The staff is also divided into 10 mm divisions and 50 mm divisions as shown.

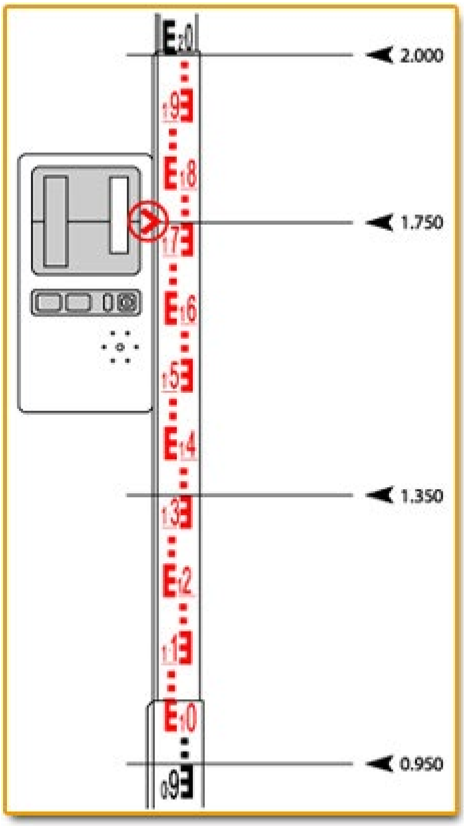
Readings less than 10 mm must be estimated which means the accuracy using a staff is limited.

Check your view

You've had a look at the staff, but it can be a bit tricky reading through the telescope of the levelling instrument. Sometimes the staff is used upside down. Remember to take the reading from the centre cross hairs and not the stadia lines. They are used to measure distance.



Readings using a receiver or sensor



An electronic sensor or signal detector (receiver) is used with a laser level to take readings. The receiver is attached to a levelling staff. When the laser beam points to the receiver it beeps. The display indicates to the user whether or not a signal is above or below the signal line.

On specially designed surveying staves, you can read from a dial on the staff.

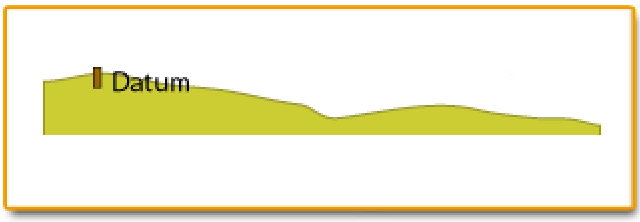
The laser receiver is attached to the staff via a locking screw. The receiver is moved up or down, depending on which direction the digital arrows point on the receiver's screen. The receiver gives off an intermittent beep. When the screen displays a flat line and the sound becomes one continuous beep, the receiver is level with the laser, and a reading can be taken where the line points to on the surveying staff.

Step 1: Mark the datum

The 'datum' is the height you will use as your reference line for all other levels. Sometimes you may use a height taken from a surveyor's mark, or you may choose your own.

Make sure your datum is higher than the highest level of the ground, plus the thickness the slab is to be. This will make it easier to find the reduced levels.

If you are not using a surveyor's peg for datum, put a peg in the ground to mark this point, and drive it down until its top is level with the surface of the ground.



Step 2: Find the highest point
Set up your levelling instrument on stable ground roughly in the middle of the site, at a comfortable height so that you can look through the eyepiece without bending over or stretching up.

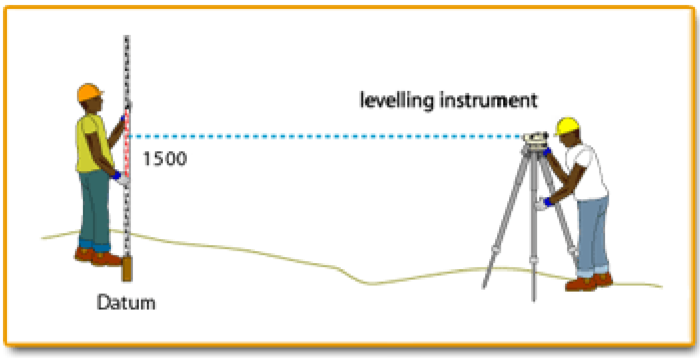
- Make sure you adjust your instrument for parallax.
- Ask your workmate to hold the measuring staff upright on the top of the datum peg.
- Look through the eyepiece of your levelling instrument at the staff and read the mark that appears in the centre of your view. This is the datum height you will use as your reference line.
- Note the reading on the staff on your record sheet.

Step 3: Highest point example
In this example, we will set the datum height at 1500 mm from the ground at the datum point.

This height will be used as a reference point for other height measures taken on this day.

Record sheet

Datum	Point A	Point B	Point C	Point D
1500				



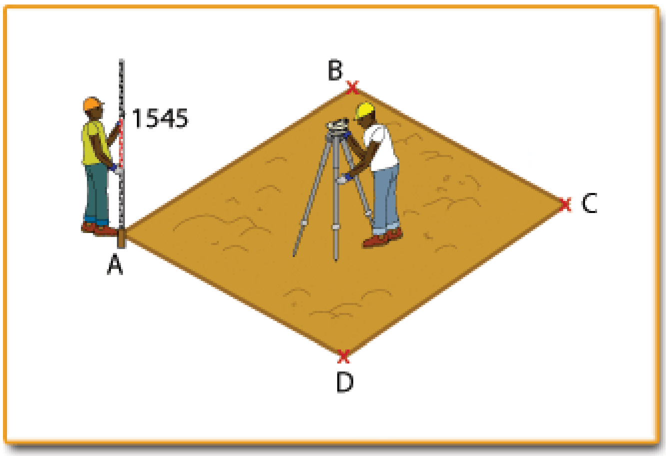
Step 4: Find the height of point A

- Ask your workmate to hold the measuring staff upright on the ground at a corner of where your slab is to go. This will be point A.
- Be careful not to upset the level of your levelling instrument, but turn it to read the mark on the staff at this level.
- Record the reading on your record sheet.
- Note the reading on the staff on your record sheet.

In this example, the height of point A is 1545. This means that it is 45 mm lower than the datum point.

Record sheet

Datum	Point A	Point B	Point C	Point D
1500	1545			



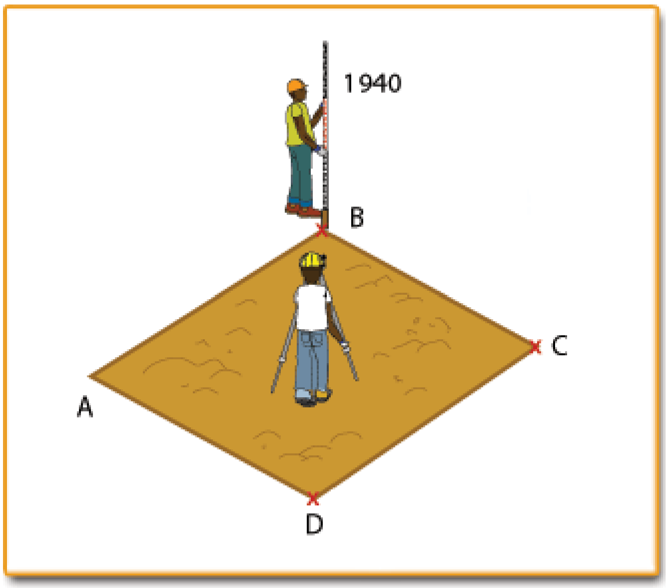
Step 5: Find the height of point B

- Ask your workmate to hold the staff upright on the ground at the next corner of where your slab is to go. This will be point B.
- Be careful not to upset the level of your levelling instrument, but turn it to read the mark on the staff at this level.
- Record the reading on your record sheet.

In this example, the height of point B is 1940. This means that it is 440 mm lower than the datum point.

Record sheet

Datum	Point A	Point B	Point C	Point D
1500	1545	1940		



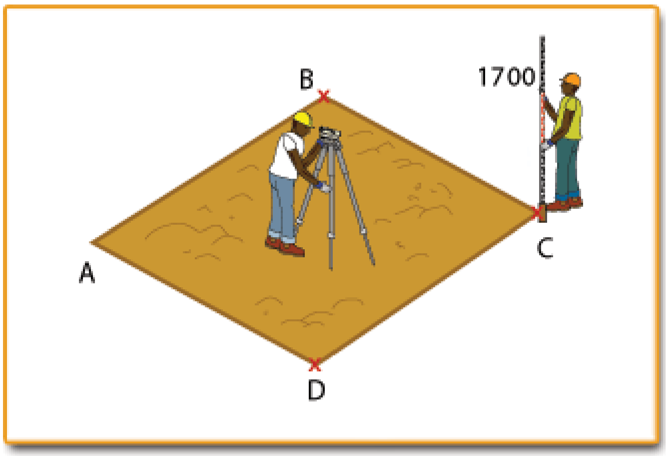
Step 6: Find the height of point C

- Repeat the procedure to find the height of point C.
- Record the reading on your record sheet.

In this example, the height of point C is 1700. This means that it is 200 mm lower than the datum point.

Record sheet

Datum	Point A	Point B	Point C	Point D
1500	1545	1940	1700	



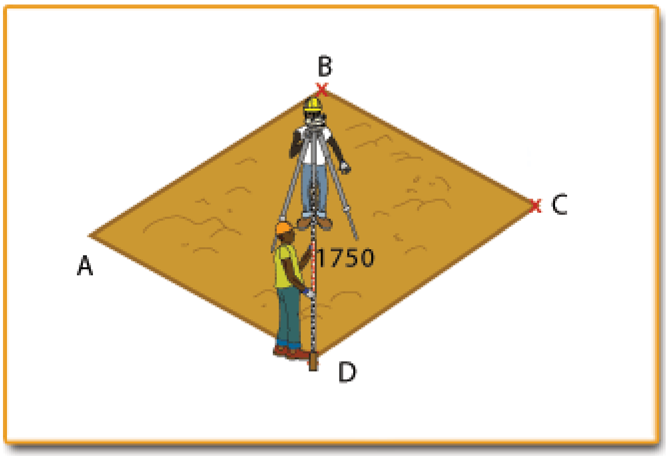
Step 7: Find the height of point D

- Repeat the procedure to find the height of point D.
- Record the reading on your record sheet.

In this example, the height of point D is 1750. This means that it is 250 mm lower than the datum point.

Record sheet

Datum	Point A	Point B	Point C	Point D
1500	1545	1940	1700	1750



Once you have found the levels of these points, you will have an idea of how much earth you will have to excavate to make a level site for your slab. You will also know how much deeper to dig some post holes than others.

Find the slab height

Many of the measurements on the plan for the cookhouse building are taken from the top of the slab. It will be useful to mark the height of the top of the slab with pegs at different points of the building site. These pegs can then be used as a guide for the height of the formwork, the depth of the trenches, and the depth of the holes for the posts.

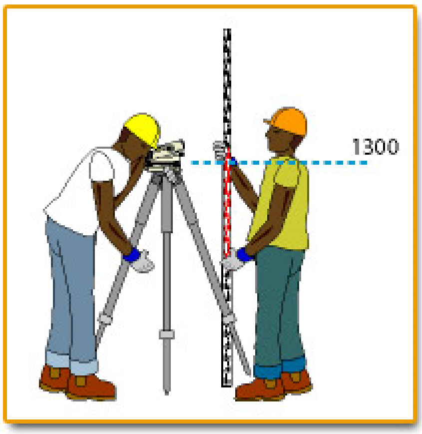
This task should be done after you have found the reduced levels on your site and excavated to make it level.

Step 1: Marking the datum
First, you should read your plans to find out how deep your slab is to be, and where it is to go on your site.

The next step is to mark a datum somewhere on the slab site.

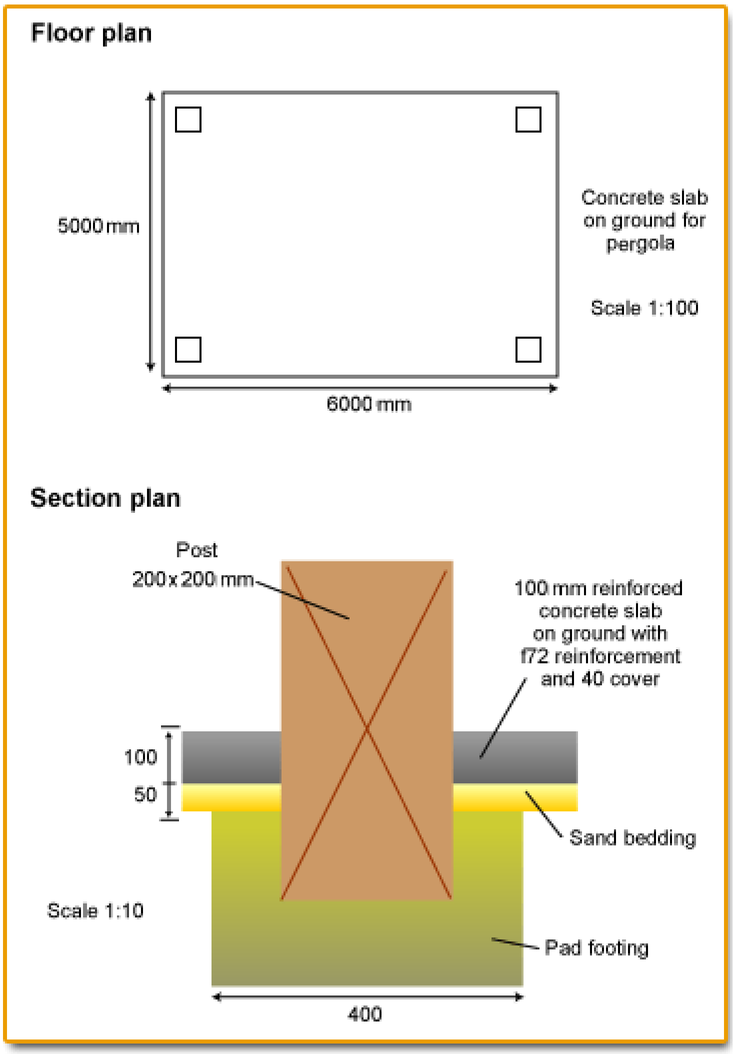
Set up your levelling instrument near the middle of the site and ask your workmate to hold the staff on the ground at the datum point, so you can make a datum height. Do this the same way as you made the datum in the task 'Find reduced levels'.

We will use the datum of 1300 mm for this task.



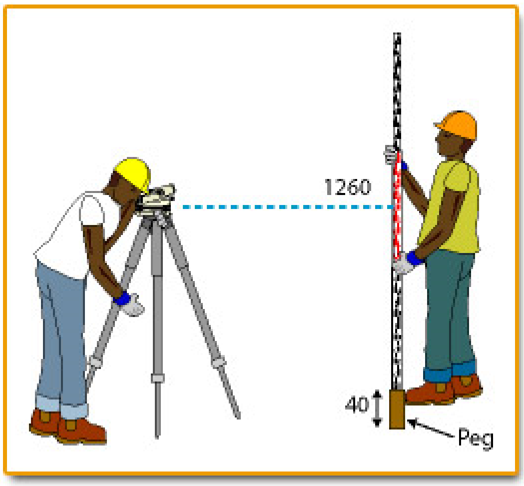
Step 2: Checking plans
You can use the datum to find out the slab height at different points around the building site.

Plans for a slab will show the length, width and shape of the slab. They will also show the depth of the slab and the amount of cover over the reinforcement that is needed.



Step 3: Finding heights
The first height we will find will be at a corner of the slab that we will call point A.

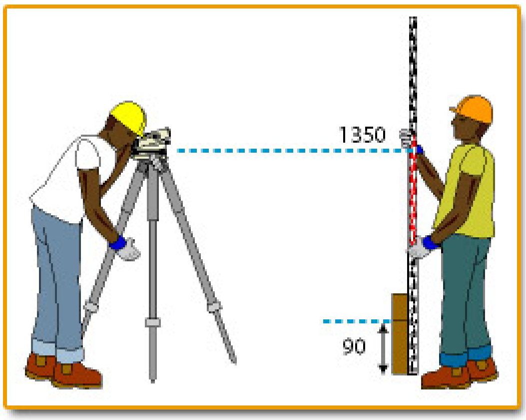
- Ask your workmate to hold the measuring staff at the first place. Mark the height at 'Point A'.
- Drive a peg into the ground at this point, leaving its top a reasonable height above ground for the moment.
- Ask your workmate to hold the staff on top of the peg while you look at it through the levelling instrument. Make sure you adjust the instrument for parallax.
- As the datum is 1300, the height you see on the measuring staff needs to be 40 mm below 1300 for the top of the peg to be the correct height.
- Drive the peg into the ground until the measuring staff reads 1260 mm.



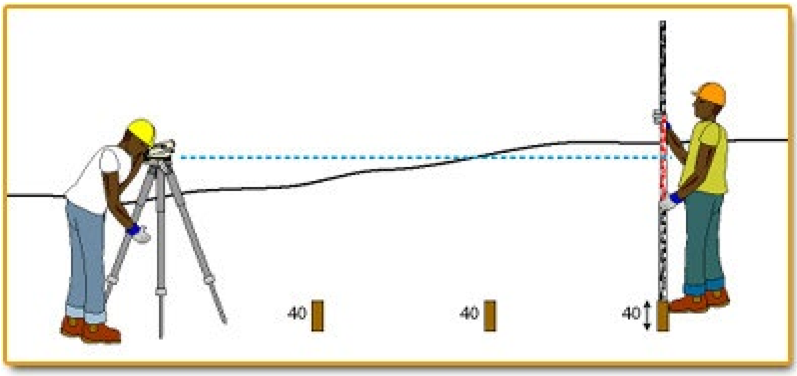
Step 4: Marking the peg
You can also place the staff on the ground next to the peg and mark the peg at 1260 mm **below the datum**.

For example, if the height on the staff is showing 1350 mm, mark the peg at 1350 - 1260 = 90 mm from the ground. In this case, the ground at the peg is lower than the ground at datum. The ground will have to be built up for correct slab placement according to the plans.

You can cut off the peg to the correct height if you wish, or mark the peg at slab height with a nail.

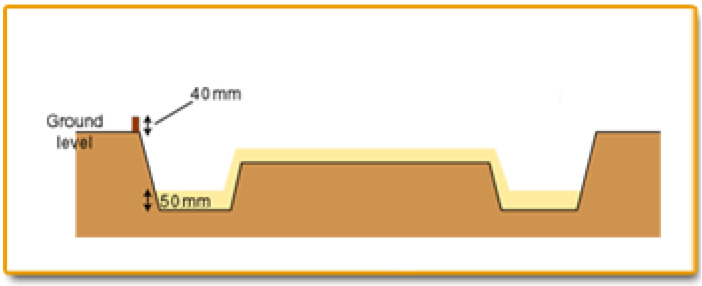


Repeat these steps at different points over the building site where it will be useful to know the slab height, such as at each corner and at mid-points where there are distances of more than a few metres.

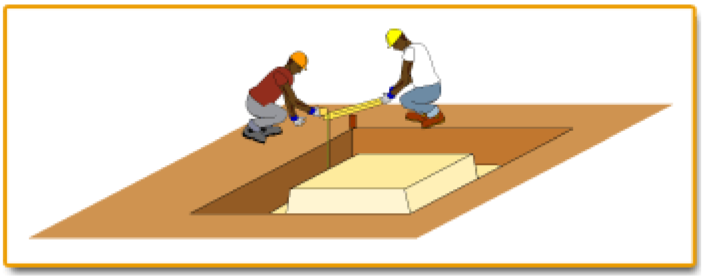


Use boning rods
When digging the trenches for the slab area for the cookhouse you will need to dig down to a depth of 350 mm below the height of the slab. To make sure the trench is level from one end to the other you can use boning rods.

Step 1: Marking trench depth

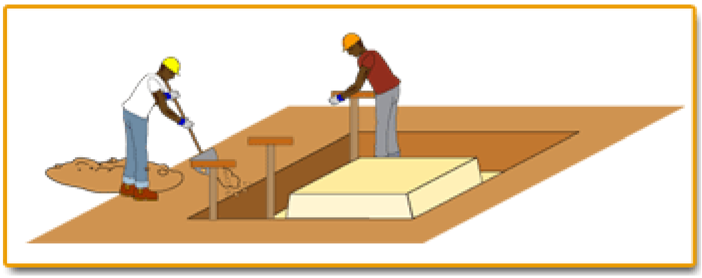


- Measure down from the peg height you marked in 'Finding the slab height' as your reference point. You will need to allow 300 mm for the trench and 50 mm for the sand bedding, making a total of 350 mm from the top of the peg.
- Place a spirit level on the peg and against the tape measure (or folding rule), and dig out or fill in the trench until the 350 mm marker is level with the top of the peg.
- Repeat this at each corner of the trench.



Step 2: Levelling the trenches
Fix boning rods at each end of the trench where the required depth of 350 mm has been marked.

Place the third boning rod about a metre from one end. Sight over the boning rods. Add or remove dirt from the trench until the third boning rod is level with the first two.



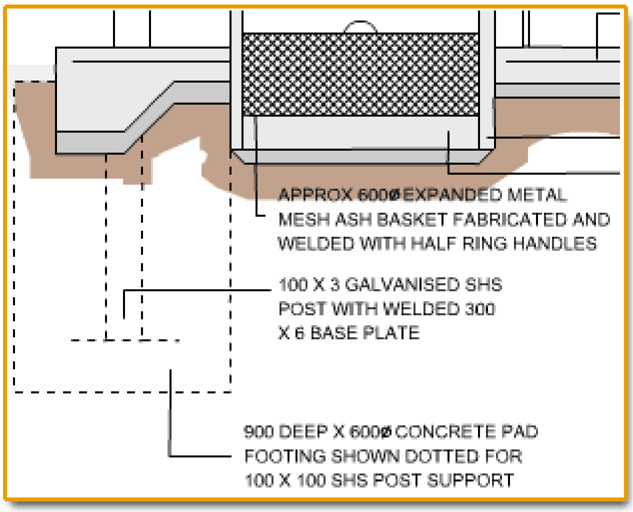
Repeat this process with the third boning rod for the length of the trench. Then dig out the areas in between the boning rods to make a smooth base between them.

Transfer heights

When pouring a slab you will often need to place posts into the slab. This would be the case for pergolas, carports or other similar structures. These posts will need to be placed in the ground before the slab is poured. The posts will have to be placed at a particular depth as worked out by an engineer so that they are placed on what is known as 'stable ground'. The plans will give details of the required depth. The posts may be placed on a pad footing or beam footing.

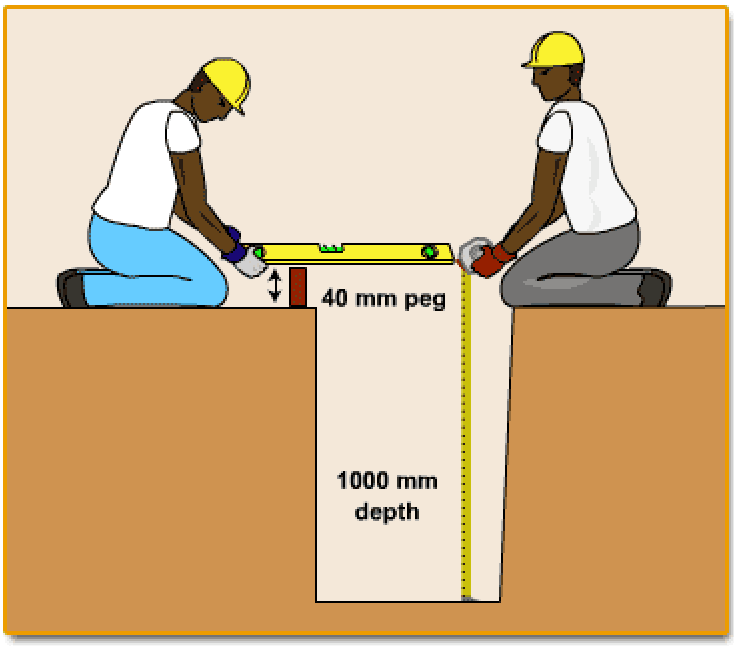
The depth of the post will need to be marked in relation to the other heights on the building site. The following screen will show how this is done in relation to the cookhouse plans.

Step 1: Reading the plans
The plans for the building show that a concrete pad footing should be placed below the post to a depth of 900 mm. As the slab is 100 mm deep, the bottom of the footing should be 1000 mm below slab height. We will assume that you have already dug the holes to nearly this depth.



Step 2: Marking the footing depth for a post
To mark the depth of this footing do the following:

- Use the height of a peg that you should have placed near the footing in 'Finding the slab height' as your reference point.
- Use a tape measure (or folding rule) to measure down 1000 mm into the hole you have dug.
- Place one end of a spirit level on the peg and the other on the 1000 mm marker on your tape measure or rule. Make sure you keep the tape or rule upright in the hole, and that you check that the bubble in the spirit level is in the centre when you are checking the depth.
- Keep removing soil from the hole until the spirit level shows that the 1000 mm marker and peg are level - the hole is therefore 1000 mm deep. Be careful not to dig the hole too deep.

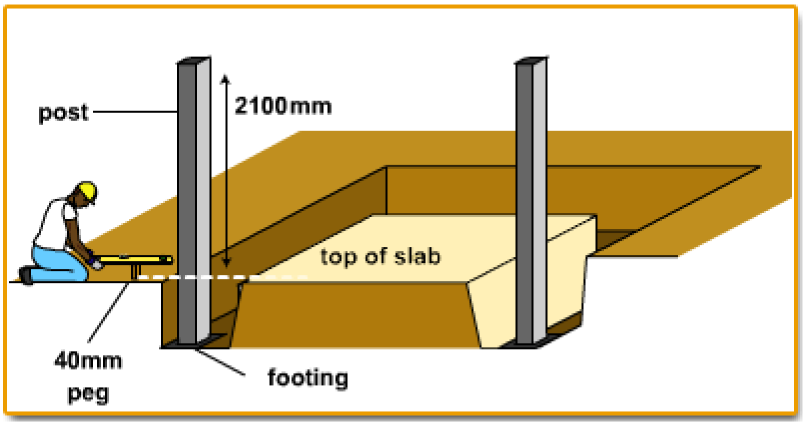


Step 3: Checking post placement
After the concrete pad footing has been poured in the hole, the posts will need to be placed on top of the pad. You will need to check that they are at the right height.

The steel posts will have been manufactured according to the design specifications. While the post is flat on the ground, mark a line at the level where it should meet the slab, which is 2100 mm from the top of the post.

Then place the post in the hole on top of the concrete pad footing.

Use a spirit level to check that the line you have marked on the post is level with the height of the pegs you marked in 'Find the slab height'.



Clean up

When you have finished levelling the site, it is important to pack away and store all tools and equipment safely. Always follow the manufacturer's instructions.

Some general rules you should follow include:

- store the equipment where it is dry. If the equipment becomes wet it will be damaged
- clean the tools after you have used them by removing dust and dirt with a soft cloth
- some of the levelling equipment is heavy so be careful not to drop it
- if you find that your levelling devices don't work, report the fault to your supervisor immediately
- store levelling equipment in the container provided by the manufacturer
- clean up any other tools and equipment you may have on site.