

Surveying Notes

When surveying, the position of existing features and ground detail are recorded and then plotted at a suitable scale either graphically or digitally.

Various pieces of equipment and different methodologies can be used to achieve this.

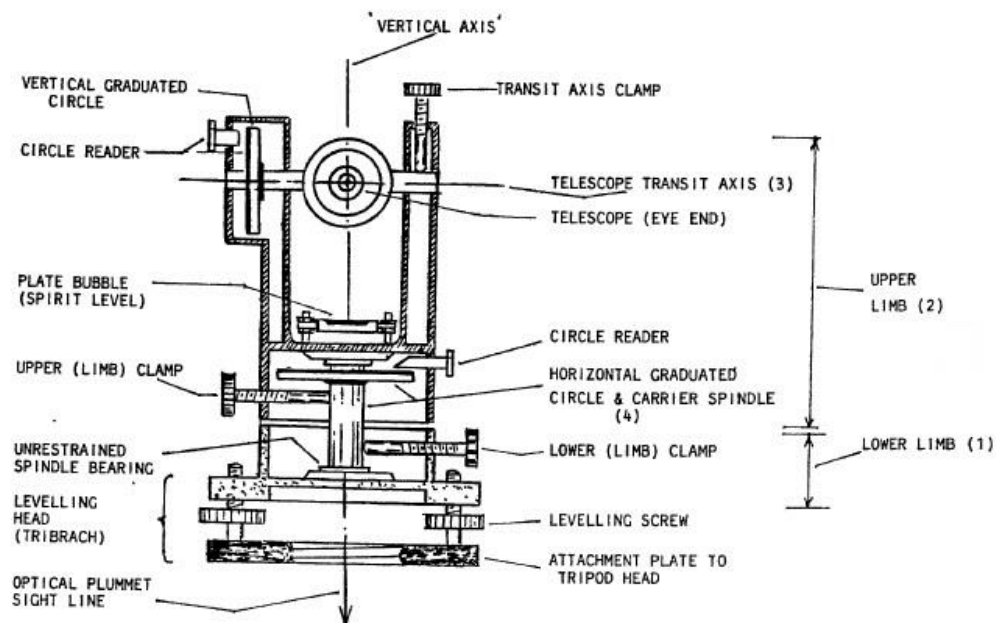
1. Using a tape measure or chain, to measure a centreline and then taking perpendicular measurements from the centreline to the features that need to be plotted.
2. Using a compass to take bearings from a point and a tape measure to measure the distances from that point to the features required.
3. Using a theodolite to measure the relative angles between points and a tape measure to take distances to these points.
4. Using a theodolite to measure the relative angles between points and using a levelling staff and a process known as tacheometry, where by the interval between the top horizontal and bottom horizontal cross hairs on the instrument is taken and that figure being multiplied by the instrument constant, which then provides the distance from the theodolite to the levelling staff.
Unfortunately modern theodolites do not always come with the 3 horizontal cross hairs, with most only having the one vertical and one horizontal and so you are unable to use tacheometry to obtain a distance.
5. Using a total station, which can measure the relative angles between points and using an EDM to measure the distance to the point, whether that is an infra-red beam sighting to a prism on a detail pole, or a laser beam directly sighting a point on a building. The total station not only takes the measurements, it also records the detail to its internal memory and can use the detail to calculate coordinates. The information can then be downloaded using the appropriate software to your computer, for further processing and production of drawings or spreadsheets.
6. Using a GNSS system, whether a smart rover or base station and rover to obtain the National Grid coordinates of points.
7. Laser scanner, to create point clouds of buildings and features that can be used to create 3D models or elevation drawings once the information has been processed.

8. Other items of equipment have already been discussed in the notes on survey equipment and new items of survey equipment are constantly coming to the market, by companies like Leica and Topcon.

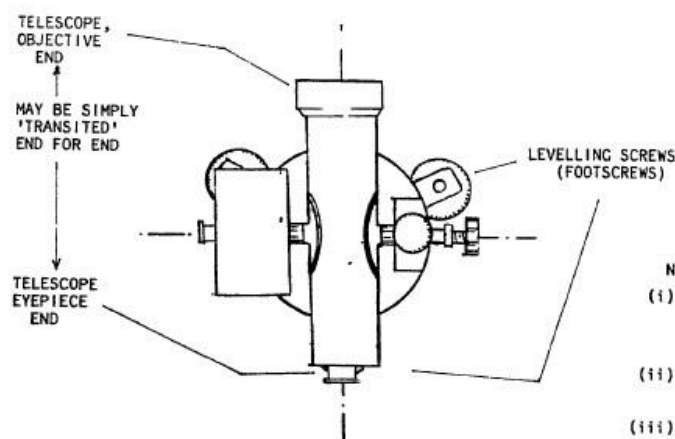
Surveying principles

As discussed the theodolite is used to measure relative angles between points and below is a simplified detail drawing, of the working structure.

SIMPLIFIED FUNCTIONAL SKETCH OF 'THEODOLITE'/'OPTICAL TRANSIT' WITH DOUBLE CENTRES



SECTION THROUGH INSTRUMENT FROM OBSERVER'S POSITION ('FACE' OR 'CIRCLE' LEFT)



PLAN VIEW OF INSTRUMENT

- NOTES:
- (i) ASSEMBLIES MARKED (1), (2), (3) and (4), THOUGH COUPLED, MAY BE ROTATED INDEPENDENTLY.
 - (ii) CLAMPS ARE PROVIDED WITH FINE (SLOW) ADJUSTMENT
 - (iii) CIRCLE READERS ON ACTUAL INSTRUMENTS OPERATE VIA COMPLEX OPTICAL PATHWAYS TO DISPLAYS NEAR EYEPIECE.

When using a Total Station the angles and distances measured are of only partial use, the information must now be converted into grid coordinates, whether that be, National Grid coordinates, pseudo National Grid coordinates or local grid coordinates.

The pseudo National Grid would be based on one GPS established survey /setting out station, with its true National Grid coordinates, the remainder of the survey being rotated about this point relative to Grid North, with no Local Scale Factor (LSF) or Mean Sea Level (MSL) corrections applied.

Most surveys undertaken for a project are normally carried out, based on these pseudo National Grid coordinates, allowing the designers, architects etc. to avoid applying Local Scale Factors (LSF) and Mean Sea Level (MSL) corrections to their design drawings.

Note: Local Scale Factors and Mean Sea Level corrections are applied because the surface of the Earth is curved and the only way a basic projection can be produced is to apply these factors.

Note: A Map projection is the way in which the curved surface of the Earth is represented on a flat plane surface.

Note: The Ordnance Survey use the Transverse Mercator Projection as the basis of the National Grid of Great Britain

Note: When using the GPS Smart rover adjustments are made within the on board software to convert the World Geodetic System (WGS 84) latitude and longitude to the latest National Grid transformation and also adjusts elevations to Ordnance Datum Newlyn.

As can be seen, to tie your survey into the National Grid we require GPS coordinates, however in the past surveys were tied in with the use of Trig pillars, these are the pillars you may have seen on the tops of mountains and the agents acting on behalf on the Ordnance Survey would provide the National Grid coordinates of these pillars to the public for a fee.

Another way to tie your survey into the National Grid, is to overlay your digital drawing onto the digital Ordnance survey (OS) mapping of an area and tie in as a best fit. The digital OS mapping can be purchased for a fee from Promap and other agents acting on behalf of the Ordnance Survey.

Converting your angles and distances to grid coordinates

All coordinate systems are relative to an origin point 0,0 and orientated to the North (Y axis) and East (X axis), likewise so is the National Grid and pseudo National Grid.

Consider the cardinal points and bearings of a compass. North is 0 degrees, East 90 degrees, South 180 degrees and West 270 degrees.

A total station is set up at over a survey station A, the coordinates of which are 100E, 100N (all figures are in metres) and is then sighted on to station B the coordinates of which are 100E, 110N, since the eastings are the same, point B must be due North of point A and the bearing of A to B is 0 degrees and distance is 10metres.

Let us now consider some new terms:

1. Whole Circle Bearing (WCB): This is the angle turned about a point from North in a clockwise direction; therefore the WCB of a point sighted due East would be 90 degrees.

Note: Another term for Whole Circle Bearing is Azimuth.

2. Partial Eastings and Partial Northings: These are the distances due North and due East from a coordinated point located anywhere within grid, relative to the origin point.

Note: Where the direction is towards the North and East they are both positive and where the direction is to the South and West they are both negative.

Taking the previous example:

A total station is set up at over a survey station A, the coordinates of which are 100E, 100N (all figures are in metres) and is then sighted on to station B the coordinates of which are 100E, 110N, therefore the partial eastings and northings from station A to station B are: partial easting 0m and partial northing is +10m and from station B to station A are: partial easting 0m and partial northing is -10m

We can then use the partial eastings and partial northings to calculate the distances between points and their Whole Circle Bearings.

Example 2

A total station is again set up at over a survey station A, the coordinates of which are 100E, 100N (all figures are in metres) and is then sighted on to station C the coordinates of which are 110E and 110N.

1. Calculate the WCB for A to C
2. Calculate the distance A To C

First we have to calculate the differences between the coordinated of the 2 survey stations, to establish our partial eastings and northings.

	Eastings	Northings
C	110.000	110.00
A	100.000	100.00
Partial easting	+10	Partial northing +10

We now have the two sides of a right angle triangle, so by using Pythagoras theorem and basic trigonometry: $S/OH = C/AH = T/OA$ we can calculate the distance between the points and their Whole Circle Bearing.

Answers:

Distance: 14.142m

Whole Circle Bearing: 45 Degrees

Alternatively we can use the polar rectangular function on our calculator.

Pol (partial northing , partial easting)

$r = \text{distance}$

Degrees = WCB

Where you have the WCB and distance between points, you can use the Rec function.

Rec (distance , WCB)

$X = \text{partial northing}$

$Y = \text{partial easting}$

Once you have calculated the partial eastings and partial northings between two survey stations, you can add them to the coordinates of the known station and calculate the coordinates of the station sighted to. (always remember to check if they are positive or negative and use the right sign)

Establishing the National Grid co-ordinates of control stations, using a GNSS system.

To establish the co-ordinates of the control station, the base station would have been set up over the point and left to record data from the satellites for a minimum of 4 hours (observation period), the longer it is left the more accurate the final solution. Once the data on the base station has been downloaded and using the appropriate software such as Topcon tools the data can be part processed, however to complete the processing the correction data (RINEX data) for the period of observation must be downloaded from the Ordnance Survey website and used in the final element of processing, once this operation has been completed you will have the corrected National Grid co-ordinates of your control station.

When requesting the RINEX data, input the approximate co-ordinates for the control station, this will allow you to choose the nearest 10 Ordnance survey active stations to your project for correction data and then select the time interval from the hour before to the hour after the period of observation.

It is important to keep your processing software up to date, to ensure the correct antenna information for the Ordnance Survey stations is used. (They do change them resulting in different offset data)

See the Ordnance Survey website for more information.

GNSS Smart Rovers

When using a smart rover the correction data is provided by the Ordnance survey over the mobile network (annual subscription is required for the Ordnance Survey licence in order to receive corrections), for this reason the device must also be fitted with a roaming sim card (another annual subscription required).

The GNSS Smart Rover is a cheaper option to the base and rover in that you only need one antenna and can also be a more secure option in that you do not require someone to stand guard next to the base station when working away from a main site.

Today most areas are covered by at least one mobile provider, allowing you to undertake surveys pretty much anywhere in the UK, however it is best to check coverage before working in an unfamiliar area.

Where you do not have mobile network coverage you will have to revert to a base and rover, whether as discussed earlier or by using another rover used as a relay station and relaying the correction data via the radio link to your survey area.