

## Levelling and how heights are defined

In surveying, three basic quantities are measured heights, angles and distances - levelling is the name given to one of the methods available for determining heights. When levelling, it is possible to measure heights within a few millimetres and this order of precision is more than adequate for height measurement on the majority of civil engineering projects. As well as levelling, it is worth noting that heights can also be measured by using total stations, handheld laser distance meters and GNSS receivers these are described in subsequent chapters of the book. In comparison to these, levelling offers a versatile yet simple, accurate and inexpensive field procedure for measuring heights and this is the reason for its continued use on construction sites in competition with other methods.

All methods of height measurement determine the heights of points above (or below) an agreed datum. On site or in the office, surveyors, builders and engineers all use, on a daily basis, horizontal and vertical datum's as references for all types of measurement including levelling. The direction of gravity along the plumb-line defines the vertical at P and a horizontal line is a line taken at right angles to this. Any horizontal line can be chosen as a datum and the height of a point is obtained by measuring along a vertical above or below the chosen horizontal line. On most survey and construction sites, a permanent feature of some sort is usually chosen as a datum for levelling and this is given an arbitrary height to suit site conditions. The horizontal line or surface passing through this feature, with its assigned height, then becomes the levelling datum. Although it may seem logical to assign a height of 0 m to such a datum, a value often used is 100 m and this is chosen to avoid any negative heights occurring as these can lead to mistakes if the minus sign is accidentally omitted. The heights of points relative to a datum are known as *reduced levels* (RLs).

Any permanent reference point which has an arbitrary height assigned to it or has had its height accurately determined by levelling is known as a *bench mark*. For most surveys and construction work, it is usual to establish the heights of several bench marks throughout a site and if these have heights based on an arbitrary datum, they are known as *Temporary Bench Marks* (TBMs).

The definition of a levelling datum given above is a horizontal or level line or surface that is always at right angles to the direction of gravity. As might be expected, the direction of gravity is generally towards the centre of the Earth and over large areas, because the Earth is curved, a level surface will become curved.

If heights are to be based on the same datum for the whole of a large area such as the UK, a curved level surface of zero height has to be defined. For mainland Great Britain, this has been established by the Ordnance Survey and is known as the *Ordnance Datum Newlyn* (ODN) vertical coordinate system. This corresponds to the mean sea level measured at Newlyn, Cornwall and heights which refer to this particular level surface as zero height are known as ODN heights, but are often called heights above mean sea level. Mean sea level (MSL) is represented by a surface known as the *Geoid* which is the level surface to which all height measurements are referenced, whether these are national or local.