C709 London 2007

Setting-out procedures for the modern built environment

B M Sadgrove MA CEng MICE

CIRIA sharing knowledge ■ building best practice

Classic House, 174-180 Old Street, London ECI V 9BP
TELEPHONE +44 (0)20 7549 3300 FAX +44 (0)20 7253 0523
EMAIL enquiries@ciria.org WEBSITE www.ciria.org

Sadgrove, B M
Danson, E (Revision and update)
More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here More about Ed Danson in here

Setting-out procedures for the modern built environment CIRIA C709, 2007

First published 1988. Reprinted 1988, 1989, 1990, 1993, 1996
Second edition 1997, Reprinted 2003, 2004, 2005.

Revised and updated as *Setting-out procedures for the modern built environment* 2007

ISBN 0-86017-709-2 978-0-86017-709-8

Classification	
Availability:	Unrestricted
Content:	Advice/guidance
Status:	Committee guided
User:	Site engineers

Acknowledgements

The revision and update of *Setting-out procedures* (C707) was carried out by Ed Danson of Swan Consultants, resulting in this new edition: *Setting-out procedures for the modern built environment* .

In preparing this revised and updated edition, the contributors included:

Steven Fox	*Edmund Nuttall Ltd*
Dr Gethin Roberts	*Department of Geomatics, Nottingham University*
Dr Paul Cruddace	*Geodetic Adviser, Ordnance Survey*
Edwin Danson	*Independent Consultant and editor*
Michael Sutton	*Environment Agency*
York Survey Supply Centre	*for the table on steel tape accuracy*
Mark Greaves,	*Geodetic Analyst, Ordnance Survey.*

CIRIA'S Research Manager for the project was Nick Bean.

Preface

Setting-out procedures for the modern built environment is an entirely revised and updated publication which includes modern instrumentation and techniques and describes recommendations for setting-out of building and civil engineering works. These are based on the practical experience of practising engineers and are applicable to most small to medium size construction contracts. On contracts involving high-rise structures or complex underground projects, state-of-the-art engineering design and concepts, unusual materials or robotic plant, the site engineer is encouraged to seek the advice and guidance of qualified and competent professionals.

Adoption of these procedures should reduce the incidence of errors, and the costs of putting them right. It is hoped that acceptance and use of these procedures will result in better communication and understanding between architects, consulting engineers, resident engineers and clerks of works, contractors' staff and foremen.

As in earlier editions, the epithet 'site engineer' is used throughout, but it is intended to apply to all site staff who are concerned with the process of construction setting-out. The old appellation 'chainman' has been updated to 'assistant'. It is assumed that these site staff will have a sound basic knowledge of surveying and are familiar with the more common instrumentation employed on construction sites and that the site engineer responsible for these activities is properly qualified and competent in setting-out works.

The site engineer is advised to report certain actions, errors and omissions. To whom the engineer should report is not generally stated, because the reporting procedure will vary from site to site. Where the term 'supervisory authority' is used, this means the architect, engineer or supervising officer or a nominated representative of one of these.

Specific recommendations for the desired accuracy of setting-out have been avoided – any references to figures or dimensions are recommendations only or are used for clarity. Site engineers should set out as accurately to the tolerances appropriate to the work, or specified for the construction, and choose instrumentation and techniques appropriate to meeting the criteria. If the instrumentation and resources provided to the site engineer are inadequate to meet the specification, then the site engineer must make this clear to the supervising authority in writing together with recommendations.

Visual and commonsense checks should always be applied. Although design details are normally not the contractor's responsibility, the site engineer is advised to check a number of such details, as best practice dictates, to smooth the running of the contract, minimise any consequential delay and encourage good relations.

The first edition of this publication superseded the CIRIA Manual of setting-out procedures and was based on the same material re-written with additions and rearranged in a format convenient for reference in the field. The second edition was updated in parallel with industry practice. This new version has been extensively revised and updated, particularly with the use of electronic instruments and computers.

Contents

Glossary

Assistant	Assistant to setting-out (site) engineer (in the past aka chainman)
Azimuth	Angle measured from True North
Bearing	Angle measured from Grid North
Benchmark	A height reference point or mark of known level
Boning (-in)	Sighting over profiles at travellers and establishing formation depths etc.
Boning rod	Upright and rail forming a tee, 1 to 1.5 m high. Used when boning between two other boning rods of equal height
Borrow pit	Pit supplying soil for construction of a road or other foundation
Chainage	Distance along a line from an origin or datum point (formerly measured in chains, hence chainage)
Chord points	Points on a curve defining a chord
Collimation, line of	Optical axis of a telescope: also the line of sight through an instrument when set horizontal
Crossfall	Gradient on cross-section of road to shed water to one or both sides
Datum Level	Horizontal plane of assumed (or actual) level from which other levels are determined
Datum	Horizontal, vertical or 3-dimensional coordinate reference definition
Deflection angle	Angle between the tangent and a chord at a point on a curve
Falsework	Temporary structure needed to construct permanent works
Forkhead	Scaffolding component supporting falsework beam
Formation level	Excavation level (height) on which permanent works constructed
Formwork	Forms used to constrain fluid concrete to a desired shape
Galileo	Developing European GNSS
GLONASS	Global'naya Navigatsionnaya Sputnikovaya Sistema (Russian GNSS)
GNSS	Global Navigation Satellite Systems (the generic term for satellite navigation systems, includes GPS, GLONASS and Galileo)
GPS	Global Positioning System (US GNSS)
Ground distance	True (actual) horizontal distance over the ground; the physical measurement of this distance. (*See* also Projection distance)
HSE	Health, Safety and the Environment – a priority for all site engineers
Intersection point	Intersection of tangents from tangent points
Invert	Lowest internal level, at a given cross-section, of a pipe, channel or tunnel
Kicker	Concrete ‘step’ used to locate vertical forms
MOSS	Proprietary software for modelling three-dimensional surfaces
Partial coordinates	Coordinates of a point relative to another on the same grid. They are the algebraic differences between the eastings and northings
PPE	Personal Protective Equipment
ppm	Parts per million

Profile	A site marker delineating the shape/level etc of a construction element at that location
Projection distance	Distance *calculated* between coordinated points on a geodetic, eg National Grid projection. (See also Ground distance)
Shoulder	Unpaved width at edge of road section
Sight rail	Horizontal or sloping rail of profile
Soffit	Lower surface of slab, bridge or similar structure
Summit	A high point on a road surface
Tangent point	Point defining start or finish of a curve
Temporary works	Temporary construction needed to construct permanent works
Total coordinates	Coordinates of a point referenced by eastings and northings relative to the origin of a grid
Total station	A combined distance and angle (electronic) measuring survey instrument
Trammel Traveller	Rod used in describing arcs about a fixed centre for curved walls etc
Trench sheet	Steel sheet used in supporting trench sides
Tribrach	The three-armed support frame on which an instrument is mounted
Valley	A low point on a road surface
Whole Circle Bearing	Angle measured clockwise from *grid* North

Health, safety and the environment

Health and safety aspects

Health and safety of all those involved in construction work is a key consideration in the planning and management of site activities, including setting-out. Regulations which affect the planning and management of site work are constantly under review by government and other regulatory bodies and it is imperative that the setting out engineer is familiar with those regulations in force and relevant to his/her work.

Statistics indicate that those working on construction sites are most at risk during the first two weeks of their time on any new or unfamiliar site. Many of the hazards found on construction sites are explained in CIRIA's site guide SP130 Site Safety.

In an effort to improve safety, all personnel working on UK construction sites are now required to undertake formal site safety briefings and carry the Construction Skills Certification Scheme (CSCS), card details of which can be found at: <www.cscs.uk.com>. The card lists the holder's qualifications and are valid for either three or five years. It also shows they have health and safety awareness as all cardholders have to pass the appropriate CITB-ConstructionSkills Health and Safety Test. Not having a CSCS card may affect your ability to work on certain sites.

Some typical hazards include:

- falls from heights or into excavations – edges should be protected with parapets or guard rails; use safety harness where appropriate
- falling objects – wear safety helmet at all times; consider brimless helmet to avoid knocking instrument when taking readings
- rough ground and nails projecting from discarded timbers – wear approved safety footwear
- unsupported vertical excavations – do not enter trenches until supports have been installed
- confined spaces – ventilate to avoid poisonous gases or wear breathing apparatus
- working over or near water – wear approved lifejacket
- moving plant, lorries – wear high visibility jacket
- ladders damaged or not correctly fixed at top – see CIRIA publication SP121
- shot-fired nails – operator must be checked as competent – use protective glasses
- compressed air working in tunnels – conform to CIRIA Report 44, *see* Bibliography
- lasers – avoid looking into beams and take measures to prevent others from doing so.

In addition, general precautions can help prevent accidents:

- be aware of any existing site specific Health and Safety Statement
- be aware of any existing site-specific Risk Assessments
- if one doesn't exist, establish an emergency plan – any vital contacts, nearest hospital A&E, etc
- ensure a properly equipped first aid kit is easily accessed
- ensure telephone contact is available, landline or mobile
- never cut corners on safety
- take immediate action to correct and report unsafe practices
- be aware of your surroundings and those of the assistant
- bring any health and safety considerations to the attention of anyone you bring to the site, contractors, consultants, etc
- be aware of actions that could affect other site workers, general public, etc
- keep aware of current and potentially changing weather conditions
- wear approved and suitable personal protective equipment (PPE) including UV protection
- do not run
- understand any COSHH assessments relating to chemicals you use – paint, sprays, etc

- never work alone:
  - in confined spaces
  - over or near water
  - on live electrical equipment
  - in derelict or dangerous buildings
- if possible avoid working alone:
  - on live roads
  - on roofs
  - in empty buildings
  - near demolition work
- whenever working alone:
  - use or establish a lone worker procedure
  - ensure a responsible contact is aware of your location, contact details and duration of stay
- never cut corners on safety
- take immediate action to correct or report unsafe practices.

Environmental aspects

The construction and demolition industry has consistently had a poor record regarding pollution of land and watercourses and the consequent damage to wildlife and natural habitats. The site engineer has a role to play in improving the environment by leadership and example.

Identify if the site owner/operator, etc has an environmental and/or sustainability statement. Actively consider requiring or writing one; the paragraphs in this section would provide the essential content, however site-specific considerations also need to be taken into consideration.

By your actions, positively avoid causing unnecessary damage or harm to the environment and adopt an awareness of environmental matters to minimise the effects of our activities. Where possible, adopt best practice regarding all UK, EU and international legislative and regulatory requirements and agreements.

Where practicable, review activities and operations to identify environmental aspects and prioritise action to address them. Take a lead in raising awareness of environmental matters among employees, contractors, clients, suppliers, visitors, etc.

Where you have the influence, you should encourage minimising energy and resource consumption by promoting effective and efficient measures consistent with best practice. By influencing suppliers and contractors you should ensure that services and goods procured support national environmental policy.

Where possible influence and minimise the use of toxic materials and waste generated to prevent pollution. Dispose or recycle any waste in a responsible and appropriate manner. Ensure good management practices by reviewing them regularly, to verify their effectiveness in achieving environmental gains.

Surveying and setting-out instruments

Type	Remarks
Theodolite	Optical/manual (analogue) instrument for the measurement of angles only
Total Station	Most common electronic instrument used on site for the measurement of both angles and distances. Measurement information displayed digitally can be stored in a data logger. The Total Station includes a built-in computer that provides the site engineer with a number of features that typically include: ● input of ambient metrological conditions ● observed positions as Cartesian coordinates or bearing and distances ● distances corrected for slope ● setting-out mode either using either coordinates, offsets or bearing and distances Reflectorless Total Stations do not need a prism reflector set at the target. Robotic Total Stations do not need an operator at the instrument.
Gyroscopic theodolite	For measuring and setting-out angles relative to True North – especially useful when working underground.
GPS	Generic term for a range of positioning and setting-out solutions using the US DoD's NavStar Global Positioning System (GPS) satellites. For the site engineer, the use of GPS for control is the most relevant application and is discussed in the section Global Positioning System (GPS). Many GPS systems now also incorporate the GLONASS satellite navigation system. It should also be noted that GPS aided/robotic systems are becoming increasingly common for the automatic control of earth moving machinery. This aspect is outside the scope of this book.
Optical level	Optical/manual instrument only. Suitable for most site applications.
Automatic level	Similar to the optical level in principle but susceptible to vibration.
Digital level	Used with a 'bar-coded' staff for precise levelling.
Precise level	Also known as a geodetic level. Only for very high accuracy control and requires a competent specialist operator.
Optical plumb	Optical/manual instrument only. Average of four readings should be taken with instrument turned horizontally 90º between readings. For automatic version, normally two readings separated by 180º are sufficient.
Lasers	Alignment – used to define a line/direction Rotating (horizontal) – defines a horizontal plane Rotating (general) – defines any set plane. Pipe – defines line and grade.
Optical square	For setting-out right angles over short distances only.

Table 1 *Example of common surveying and setting out instrumentation*

Surveying instruments

It is assumed the site engineer is familiar with the use of the more common instruments used in setting-out works.

A sample of the more frequently encountered instruments is listed in *Table 1 Surveying instruments* although the list changes frequently as new and innovative instruments come onto the market.

Although setting-out is greatly facilitated by modern instrumentation, their potential high accuracy should not be taken for granted and they must always be checked before use. Furthermore, accurate setting-out of works can still be achieved with less sophisticated instruments although the task may take longer. The choice of which instruments to use depends upon many factors including:

- size of the site
- complexity of the work
- precision/accuracy demanded
- economics: the time a task requires may be a dominating factor.

The manufacturer's instructions must be studied and followed. Inexperienced site engineers should take every opportunity to work with more experienced engineers.

See also Appendix B: Care and checking of equipment.

Setting-out techniques

Horizontal

Total stations and GPS receivers are both commonly used for setting-out, and often combined. The coordinates of points for setting-out can be uploaded directly from the design software into the equipment and then software tools are displayed, which allow the surveyor to locate the points to be set out. Total Station/GPS equipment has become very sophisticated, and can provide the engineer with useful information, but there is still need to have a full understanding of the keyboard operation and the correction factors and errors associated with the instruments.

Theodolite and tape is still a common method for setting-out. Care must be taken to apply corrections to all taped distances, however short. For accuracy, it is essential to check any angle or distance that has been set out. This can be done by setting up the instrument at key positions and observing all related points and comparing these angles with angles calculated from construction drawing dimensions. This will locate any errors and confirm that the specification has been met.

A Total Station can be used to set out many points from one station, working on a coordinate system or by bearings and distances. This method speeds up the setting-out process while maintaining a high order of accuracy. Total Station technology is continually advancing and these instruments provide the site engineer with useful information. Manufacturer's instructions must be studied carefully to understand the keyboard operation, the capabilities (and limitations) of the instrument, the application of correction factors and to reduce the potential for inadvertent error.

The cost of renting Total Stations has decreased greatly since their introduction, as has the cost of the instruments themselves.

The choice of traditional or modern systems comes down to the following:

Theodolite and tape

- low cost equipment
- simple to use
- requires two people – operator and assistant
- slow operations compared to Total Station
- excellent for small, simple sites.

Total Station

- reasonably inexpensive to hire
- requires familiarisation with the functions and operation of the instrument
- efficient setting-out of multiple points
- excellent for larger scale/more complex sites
- requires a battery recharging supply.

Versions available include:

  - reflectorless (doing away with need for a pole mounted prism)
  - robotic (one-man operation).

Equipment suppliers should be consulted for a more detailed analysis of the benefits of the two methods. Whichever type of instrument is used, daily checks should be made to ensure that the instruments are working properly, and all setting-out points must be cross-checked and the results recorded to show that the specifications have been met.

Vertical

Optical tilting or automatic levels are adequate for most setting-out purposes and site control where sight lines can be kept reasonably short. For more advanced applications, a precision level is required for example when:

- establishing primary benchmarks for an extensive site or long overland site, eg railway or road
- monitoring movement of structures
- track laying to high tolerances.

The digital version of the precise level has further advantages:

- speed of setting up
- immediate calculation of reduced levels
- storage of information in data logger
- automatic compensation.

Setting-out control

Setting-out control is normally divided into three Orders:

1. **Primary or First Order**: the network of control points coordinated in three dimensions to provide an overall fixed reference framework for the works
2. **Secondary or Second Order**: local control points for construction or baselines established for setting-out the infrastructure
3. **Tertiary or Third Order**: points set out at the actual positions for construction or at suitable offset positions.

Each level of control is verified and agreed before proceeding to the next. Points at any level are established and checked from points of a higher order.

Refer also to BS5964/ISO 4463 – 1979, – Setting out and measurement of buildings.

Precision naturally decreases with each order therefore, to maintain the accuracy of the actual setting-out point demanded in the specification, the precision of the preceding orders must be higher. For example, if the required accuracy of a (tertiary) point within the framework of the site reference system were 2 cm, then the accuracy of the secondary control station that it was set out from would have to be better than 1 cm.

Accuracy

The final accuracy required for the setting out of works will be determined by the specification. Greater accuracy and care may be necessary in parts of the work in order to achieve this, eg for a fit between one part and the next. The need for economy in construction can also be a factor in deciding the extent of the setting-out, but the site engineer is cautioned that a parsimonious approach will inevitably lead to poor work, unnecessary time delays and increased costs due to remediation.

Linear measurements

Conventional steel tapes

The precision achievable with slope correction and the appropriate tension applied (if known) is circa. 0.01–0.05% of distance measured, eg 1 to 5 mm over 10 m.

York Survey Supply Centre, provides the following useful table on its website www.YorkSurvey.co.uk

Accuracy & Tolerances
The tape blade length accuracy is given by the formula:

ECI ± [0.1 mm+(L×0.1 mm)])

ECII ± [0.3 mm+(L×0.2 mm)]) where L = Length rounded up to the next whole metre above.

ECIII ± [0.6 mm+(L×0.4 mm)])

The tolerance applies at the temperature and tension printed on the blade. If no temperature or tension is specified then the tolerance applies at a temperature of 20°C and zero tension.

Tolerances for typical blade lengths are:

Length	ECI	ECII	ECIII
	±mm	±mm	±mm
1 m	0.2	0.5	1
2 m	0.3	0.7	1.4
3 m	0.4	0.9	1.8
3.5 m	0.5	-	2
5 m	0.6	1.3	2.6
6 m	0.7	1.5	3
8 m	0.9	1.9	3.8
10 m	1.1	2.3	4.6
15 m	1.6	3.3	6.6
20 m	2.1	4.3	8.6
25 m	2.6	5.3	10.6
30 m	3.1	6.3	12.6
50 m	5.1	10.3	20.6
100 m	10.1	20.3	40.6

Specialist tapes

The use of a certified and calibrated steel bands with all corrections applied (tension, temperature, slope {and catenary}) can provide accuracy of a much higher order, circa. 0.002%, but requires expert operation.

Total Station

Distance accuracy depends on the quality of the instrument but typical values are 1 mm ±5 ppm
eg 1 mm for the shortest distance, ranging up to 1.5–2 mm over 100 m.

Absolute and relative accuracy

Absolute accuracy refers to the precision of individual points within a control framework. For example, a point located by a differentially corrected GNSS receiver within, say, the Ordnance Survey National Grid, may be ±2 cm. This does not mean that, relatively, all such points are within ±2 cm of each other.

Relative accuracy refers to the precision of measurements of one or more points to each other. In the above example, the relative distance between the two GNSS points, while precise in absolute terms, could range from 0 cm to 4 cm, ie ±2 cm + ±2 cm. The distinction is particularly important when setting out using GNSS systems but equally applies to other instruments.

Levels

Optical level:	(builder's type) ±5 mm over 30–50 m
	(engineer's type) ± 2mm over 30–50 m

Digital/precise levels can be read to 0.1 mm with precision in the order of twice this.

A run of levels should open and close on different TBMs to eliminate the common error of using an incorrect starting level. For tertiary points, the level run should close better than $1.5 \times \sqrt{2n}$ mm where n is the number of set-ups. Example: a level run of nine set-ups $= 1.5 \times 9 = 1.5 \times 3 = 4.5$ mm maximum misclosure.

Horizontal angles

20" theodolite: ± 20" or 10 mm in 100 m
5" theodolite: ± 5" or 2.5 mm in 100 m

These estimates assume the average of observations on each face with readings in opposite quadrants of the circle. If the difference is twice the nominal accuracy of the instrument, the observations should be repeated. If the error remains, then the instrument needs checking.

Total Station (typical): <3" or <2 mm/100 m

Typically, Total Stations are self-calibrating (see manufacturer's instructions) and do not require readings on opposite faces. However, the prudent engineer will check this first.

Vertical alignment

Plumb-bob in still conditions:

- Freely suspended: ±5 mm in 5 m (maximum recommended distance)
- Oil damped: ±5 mm in 10 m (maximum recommended distance)

Optical plummet: (properly adjusted and operated) ±5 mm in 100 m
Laser plummet: (properly adjusted and calibrated) ±4–8 mm in 100 m.

Note: The nominal accuracy of an instrument, or the precision with which it can be read, is not the same as the accuracy of the actual measurement which is affected by corrections factors and others including, for example, rounding errors or operators personal judgement.

Checks: physical and calculation

The site engineer must acquire or develop methods of checking and cross-checking all setting-out operations until they become second nature. For particularly critical setting-out, seek an independent check by someone else. Where this is not practicable self-checking is essential.

When principal lines and levels have been set out, the contractor should advise the supervising authority. The relevant person may arrange an independent check of these lines and levels, but the site engineer should not count on this. The responsibility for the setting-out will remain with the contractor.

Physical checks

Where possible, make physical checks:

- check visually that lines and levels tie in with existing features
- check distances to nearest metre by rough taping or pacing
- check levels by 'eyeing-in' on known levels
- check that supposed right angles look to be correct
- check that falls are in the right direction
- check verticality approximately with spirit level.

Calculation checks

Calculations must always be checked. Most site engineers use calculators or PCs and tend to rely on them implicitly. It is, however, all too easy to input the wrong figures or press the wrong function button or apply the wrong sign. Therefore a check or independent calculation is imperative. Where possible, data for check calculations should be input in a different order to minimise the risk of mis-keying an incorrect value twice. For example, if adding a column of figures, input from the top for the first total and then from the bottom as a check.

Conversions from degrees, minutes and seconds to decimal degrees are helpful for various computations but must be carefully executed. The formula is degrees + minutes/60 + seconds/3600.

Date .... Levels taken for ....

From .... To ....

Back-sight	*Inter-sight*	*Fore-sight*	*Rise*	*Fall*	*Reduced level*	*Distance*	*Remarks*

LEVEL BOOK HEADINGS - 'RISE-AND-FALL'

Back-sight	*Inter-sight*	*Fore-sight*	*Height of collimation*	*Reduced level*	*Distance*	*Remarks*

LEVEL BOOK HEADINGS - 'HEIGHT OF COLLIMATION'

BLOGGS CONTRACTORS LTD No. 00001
Old Wharf
Newtown

SITE INFORMATION SHEET

Copies to:
Date ....
Contract ....
Compiled by ....

.. General Foreman
.. Ganger
.. Site Office (Engs)
.. Site Office (Q.S.)
.. Resident Engineer

SITE INFORMATION SHEET

Recording and informing

Keeping records

Good records are essential for:

- accurate construction
- dissemination of setting-out information
- accurate measurement of completed work
- resolving disputes with supervising authority.

Records to be maintained during the job and retained until all contractual obligations are fulfilled include:

- all drawings issued by the supervising authority
- site instructions issued by the supervising authority
- coordinates of main setting-out points
- locations and levels of relevant benchmarks and original ground levels
- records of located/relocated underground and over-ground utility services
- digital photographs/sketches of obstructions not shown on original drawings
- classes of subsoil encountered and obstacles to excavation
- printouts and calculations of the setting-out
- all field books and original observations
- computer files
- copies of Site Information Sheets received and issued
- CAD/hardcopy scale drawings of as-built works.

It is prudent to duplicate key records, especially those relating to measurement, and to store these records and any computer back-up files separately off site.

Field documents

Site engineers should be supplied with:

- level books ruled for ‘rise and fall’ or ‘height of collimation’
- observation/record books for use with theodolites, Total Stations or other site instrumentation
- pads of Site Information Sheets, preferably sequentially numbered
- pads of sewer information sheets.

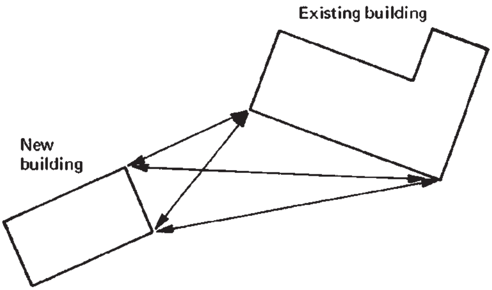
Site Information Sheets

The site engineer should use Site Information Sheets to confirm and supplement oral information/instructions given to foremen and gangers etc. Use sketches to clarify the information as appropriate. Typical details to be included:

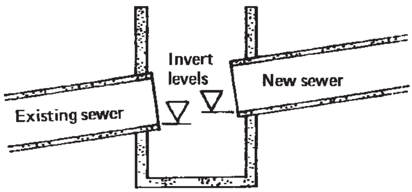
- essential dimensions
- offset distances from line pegs
- levels of offset level pegs
- levels of profiles and length of travellers
- spoil heaps, borrow pits and haul roads.

Quality assurance

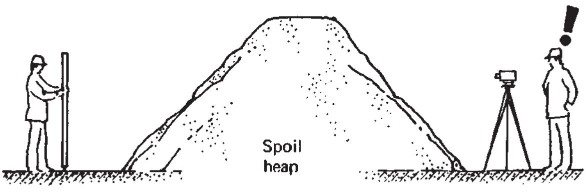
Construction sites have quality systems in place that may be independently audited in accordance with the Quality Assurance procedures or by the supervising authority or end customer. These procedures will establish the types of information and details that need to be recorded from any setting-out. They may be company standards or tailored to the needs of a specific site.



Check that location of the works is adequately shown on the drawings



Check that existing and new levels are compatible



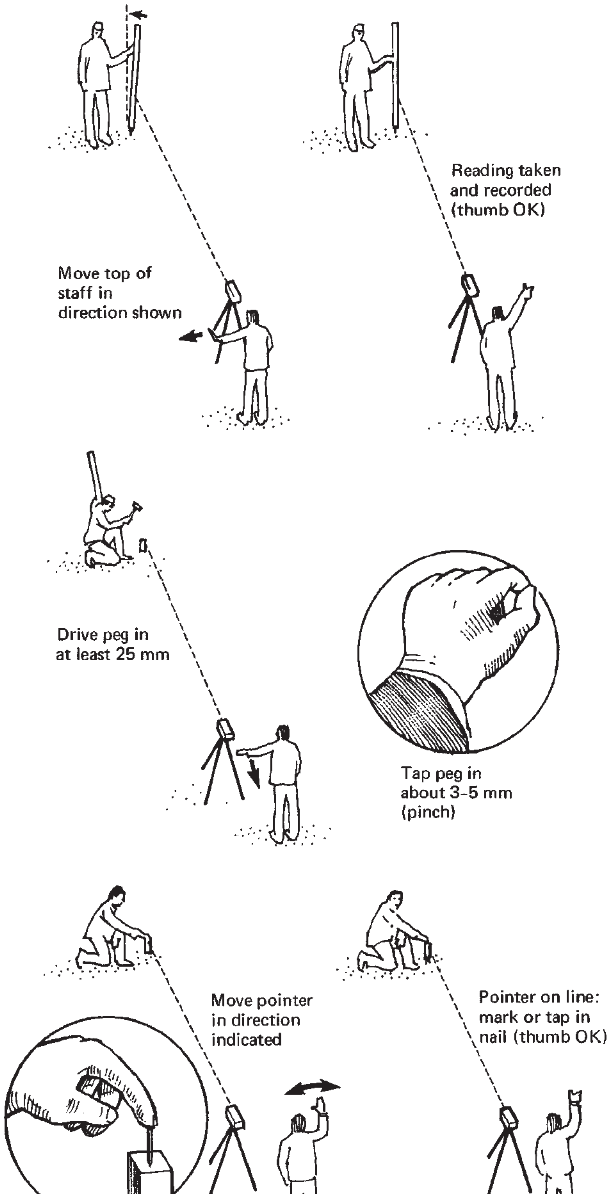
Temporary features can obstruct setting-out!

Initial actions

Before starting to set out the works, the following actions need to be taken:

1. Review and become familiar with the drawings and check that:
   - the drawings are the latest issues
   - all essential dimensions are given (do not scale) and that intermediate dimensions agree with overall dimensions
   - the location of the works, in relation to permanent or temporary reference points, is adequately shown on the drawings
   - the level heights of the works, in relation to permanent features or temporary benchmarks, is shown
   - critical dimensions between related components are clearly indicated.
2. Walk over the site checking that:
   - boundaries are well defined and are as shown on the drawings
   - all permanent and temporary reference points and benchmarks are as shown on the drawings
   - all visible permanent features are correctly indicated on the drawings
   - any permanent or temporary features do not interfere with the setting-out or construction of the works
   - there is no evidence of hidden features that might affect the setting-out or construction of the works – (also check the contract documents for any warnings or cautions).
3. Report any discrepancies found from the above checks in writing and keep a copy. It may take some time to rectify discrepancies.
4. Confirm any oral instructions in writing.
5. Set up a system of recording and communicating information.
6. Set up the CAD/computer-aided construction system. Check the files for function.
7. Begin to train the setting-out team (if necessary).
8. Set up and/or prove setting-out stations.
9. Set up and/or prove site benchmarks.
10. Record and agree existing site levels and features.
11. Check that the works will tie in with any existing works.
12. Plan the sequence of setting-out and how dimensions will be controlled.
13. Make sure you are able and equipped to perform the work, for example are the instruments adequate, in good working order and fully adjusted? Is your assistant properly trained? Are you properly trained? Have you sufficient resources?
14. Do your thinking in the office before getting to the site.

Note: Report immediately any errors in setting-out as soon as they are discovered. Early action to correct errors will minimise costs. Never conceal your errors or your doubts.


Move top of staff in direction shown
Reading taken and recorded (thumb OK)
Drive peg in at least 25 mm
Tap peg in about 3-5 mm (pinch)
Move pointer in direction indicated
Pointer on line: mark or tap in nail (thumb OK)

Instructing the site assistant

A good assistant is an essential member of the setting-out team, contributing considerably towards the speed and accuracy of the setting-out work. The site engineer frequently has only the services of an inexperienced person and it is good investment to devote time to training the person before attempting any critical setting-out.

On small sites, the amount of setting-out may not justify a full-time assistant and the site engineer has to ‘borrow’ someone. In this case, try to use the same person each time.

Check on the experience of the assistant. Where necessary, explain the basic principles of setting-out, stressing the importance of accuracy and the role of the assistant in achieving accuracy and speed of setting-out.

Topics that may need to be covered include:

- safety aspects
- what the various instruments are for
- constructing and protecting setting-out stations
- measuring with tapes
- constructing and checking temporary benchmarks (TBMs)
- use of level staff and setting a peg to level
- setting up and using profiles
- using plumb-bob or optical plumbing instrument
- care of equipment
- maintaining stocks of pegs, nails, paint and other stores.

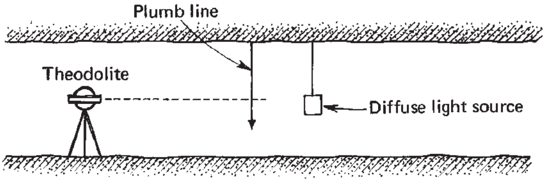
Signals and signs

The page opposite illustrates some of the common signals used to communicate information between site engineer and assistant. Mobile phones or low wattage radios can also be used subject to site conditions and restrictions.

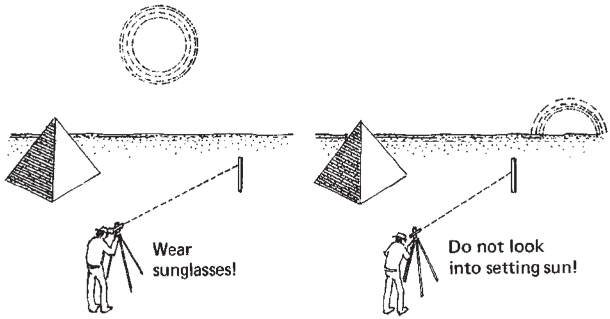
Responsibility for the assistant

The site engineer has a responsibility under health and safety legislation to take reasonable care for the health and safety of those affected by his/her actions, including any assistants. Ensure that the assistant is aware of the potential hazards of the site and is using the correct personal protective equipment and clothing.

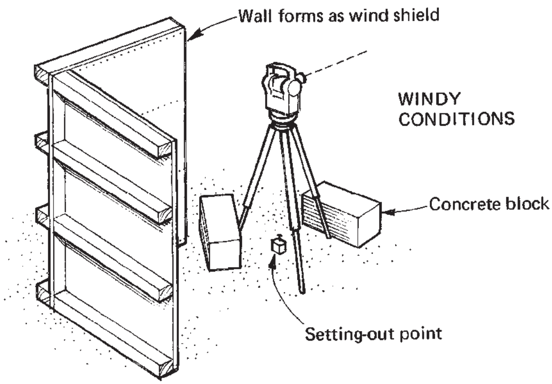
Assistants have been seriously injured and even killed by passing plant and traffic. Before signalling the assistant to move, check that it is safe to do so.



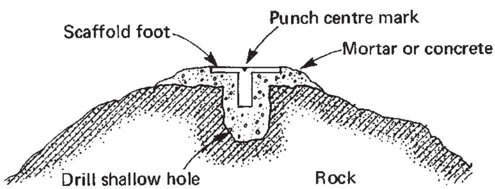
ILLUMINATING AIMING POINT



WORKING IN STRONG SUN



WINDY CONDITIONS



SETTING-OUT STATION ON ROCK

Difficult ambient conditions

Poor light

- use surveying instrument with integral lighting system to illuminate scales and cross-hairs. In the absence of a lighting kit, a pen light suffused by tissue paper will suffice. A little light aimed towards the object lens (not directly) will aid in illuminating cross hairs
- use diffuse light source to illuminate staff or aiming point (for example, place source behind plumb line, etc)
- GPS systems are normally equipped with illuminated displays and can be used in poor lighting conditions.

Strong sun

- shade instrument to avoid bubble disturbance – this is less of a problem with automatic self-collimating instruments
- wear good quality sunglasses in strong sunlight or use a light filter over the eyepiece
- to avoid heat shimmer, set out when sun is low but never look directly at the sun through the telescope.

Cold weather

- wear warm wind-proof and waterproof clothing
- wear mittens for ease of adjusting instruments.

Windy conditions

- ensure feet of tripod are suitably weighted down
- in extreme conditions, shield instrument.

Salt spray or dust

- meticulously clean instruments each day
- clean lenses with recommended tissue or brush only
- check for bearing wear on instruments frequently.

Noisy conditions

- carry out all preliminary calculations in site office to avoid being confused by noise
- brief assistant fully before going into a noisy area
- subject to need to hear alarms, wear ear defenders.

Vibration

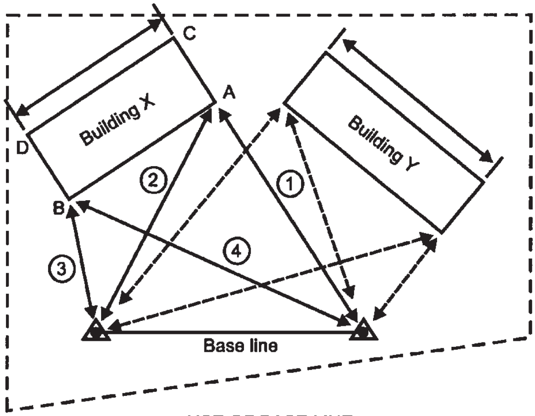
- position instruments as far from vibration sources as is practicable
- set out before operations start or during meal breaks
- ensure readings are consistent before accepting them.

Soft ground

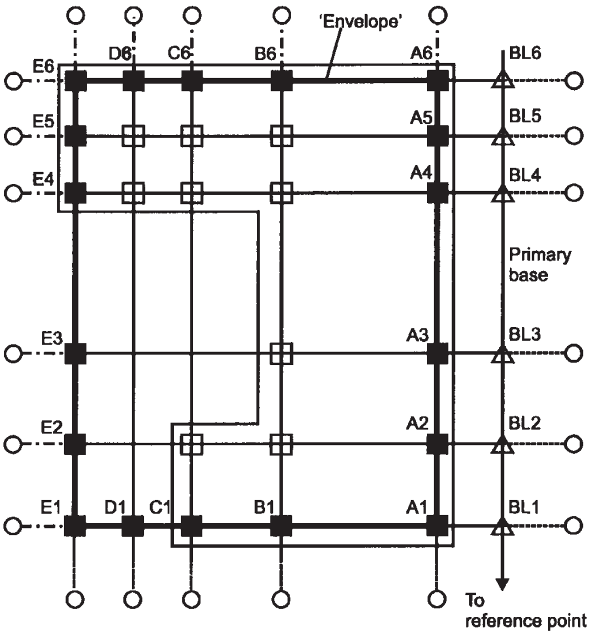
- for setting-out stations or benchmarks use existing features/works wherever possible, construct mass concrete block or install pile
- use offsets liberally – be resigned to resetting pegs frequently
- check pegs from offsets, do not assume they are correct or remain undisturbed
- avoid moving around tripod more than necessary.

Rock/hard ground

- use rock drill to make hole for level peg or steel pin
- for setting-out stations, use scaffold foot as shown in diagram.



USE OF BASE LINE



USE OF GRID LINES