RIICCM208D
Carry Out Basic Levelling

Reference Material
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SECTION 1: PLAN AND PREPARE FOR OPERATIONS

Introduction

This section explains how to plan and prepare for levelling operations and provides general information about your roles and obligations while working on site. The section will detail the process of receiving work instructions and the procedures required for safe work. Included in this section are some basic concepts of civil construction, including the types of plans and drawings that you may use. You will also review the environmental protection requirements and the clean up provisions for your worksite.

On completion of this section, you will be able to:

• access and apply the relevant compliance documentation for levelling operations
• plan and prepare for work using information from the work instructions
• obtain and apply the safety requirements
• identify and implement the requirements of the traffic management plan
• identify the environmental protection requirements of the job
• clean up the site and dispose of, or recycle materials.

NOTE
This training resource is a guide only. Always follow site standard operating procedures when performing work.
1.1 General Obligations

You are obliged to act responsibly and perform work safely. You are also expected to take reasonable care to protect the health and safety of yourself and others by:

- reporting to a supervisor or safety representative any unsafe conditions, activities, dangerous occurrences or injuries
- using correct Personal Protective Equipment (PPE)
- using your work site's lock and tag system (if applicable)
- reporting damaged or defective equipment for repair
- not attempting any task unless you are qualified, authorised, competent and confident to perform the task in a safe manner.

1.2 Legislation and Site Policies

You must access and understand government legislation and site guidelines to perform your work within the regulations. Compliance documentation may include:

- legislative acts and regulations
- employment and workplace health and safety procedures
- organisational and site requirements and procedures
- manufacturer guidelines and specifications
- national standards
- codes of practice.

1.2.1 Comply with Legislation and Site Procedures

During your general and site specific inductions you would have been familiarised with organisational and site policies and procedures. These have been developed in accordance with legislation and are designed to ensure that work is undertaken safely.

Gather and read all relevant documents and procedures for the task that you are doing. Ensure that you understand the documents and how they apply to your work.

The general hierarchy of statutory and organisational compliance documentation is shown in the following table.
2.1.1 Equipment Inspections

Do not use any equipment that is in an unsafe condition. You should aim to improve the general appearance, mechanical standard and operating efficiency by:

- carrying out inspections and pre-start checks
- completing detailed and accurate defect reports
- ensuring that all servicing is carried out as scheduled
- using the equipment according to manufacturer instructions
- keeping the equipment clean (dirt can hide defects).

Regular inspections will identify defects at an early stage, before they become a significant problem that may cause injury and equipment or environmental damage. You should inspect the equipment before using it and again after use before storage.

Isolate any defective equipment and attach an Out of Service tag to the item. Report all damaged or defective equipment according to site procedures.

2.2 Measuring and Marking Tools

Measuring and marking tools commonly used during levelling operations include:

- steel tape measure
- cloth tape measure
- string line
- plumb bob
- chalk line.

2.2.1 Steel Tapes

The convenience and versatility of steel tapes make them the most widely used measuring tool on a construction site. Tapes are marked in either mm or fractions of cms. Because they can be stretched, steel tapes must be checked regularly against a measuring block to verify their accuracy. Dirt and moisture can also damage the face of the tape making it difficult to read. The steel end-hook must also be checked regularly for wear, as movement of up to 2 mm can occur.
Carry Out Basic Levelling

Steel tapes can be locked in position. This makes them particularly useful for measuring the depth of trenches while standing at ground level or for completing short measurements above head height.

The tape can be used for both internal and external measurements. When making an internal measurement ensure that the hook is butted against the internal corner. Care must be taken when measuring over long distances that the hook does not become dislodged and that the tape is kept tight. You may need a work colleague to hold the end of the tape in position while you take the readings.

2.2.2 Cloth Tapes

Cloth tapes are used for measuring large distances beyond the reach of a steel tape or where the measurement must be made in a single operation, as opposed to “stepping-out” the distance with a steel tape. Check that the tape is clean of dirt and moisture. Keep the tape as tight as possible when measuring as variations due to a bowing of the tape can be significant over large distances.

2.2.3 String Line

Use a string line to identify the shortest distance between two points and to provide a straight line. The string line enables construction work to take place on a horizontal plane and ensures that other work, such as masonry and carpentry, is vertical.
To use a string line accurately for construction, place two fixed floor joists at A and B. Place a 20 mm packer under the string line at each end. Use the third packer at C to check the height of the joists. The packers prevent the joists lifting the line by a small amount and creating a curve. In a long run of string, pack up the centre of the line in one or more places and sight along the line to ensure that the line is straight.

2.2.4 **Plumb Bob**

A plumb bob consists of a weight suspended from a string line to obtain a straight, vertical line. In ancient times, the weight was made of lead, which in Latin was the word plumbum. The Latin word has provided us with the term plumb today. Although other metals are used now, when a line is vertical, it is still said to be plumb.

A simple plumb bob may be made using a weighted string attached to a piece of timber about 1200 mm length. To use the plumb bob, tilt the timber slowly towards you until the bob swings free. When the bob stops moving, tilt the timber backwards until the bob rests against the timber. The plumb line marks the vertical.

An alternative use for a plumb bob is to suspend a plumb line from a fixed point and compare the bottom of the string line with the building line being constructed or prop being fixed. Use the fine point of the plumb bob to mark the point directly below the upper level to transfer a point or edge vertically.
3.1 Levelling Methods

Levelling is a procedure that measures the different heights between two or more points on the earth’s surface. The purposes for levelling include:

- determining heights or contours on a plan
- surveying an area for road, building or other civil construction projects
- obtaining data for road cross-sections or volumes of earthworks
- ensuring an area is either level or at the required inclination for construction work.

Levelling is performed either by indirect or direct levelling methods.

3.1.1 Indirect Levelling

Indirect levelling measures vertical distances by calculation or other indirect means. One process involves measuring the vertical angles and horizontal distances to compute the difference in elevation using trigonometry. Another method, known as barometrical levelling, uses the difference in air pressure to determine the differences in elevation. This is the principle used in aircraft altimeters to indicate height above the ground. Indirect levelling is beyond the scope of this training material.

3.1.2 Direct Levelling

Direct levelling, also called differential levelling, measures the vertical distance or difference in elevation between two points using optical or laser levelling instruments. This method uses the measured vertical distance to carry elevation from a known to an unknown point and is the most precise method to determine elevation. Direct levelling is the method that will be explained in this training material.
Fly Levelling

When direct levelling is specified for lower accuracy surveys, it is sometimes referred to as spirit or fly levelling. This process is used to repeat original levels to ensure that there are no mistakes. Fly levelling uses a shorter route and a smaller number of observation points than the original survey.

Reciprocal Levelling

Reciprocal levelling is used when a long sight across a wide river, ravine or similar obstacle is required. This method requires several readings from both sides of the obstacle to balance the results. The readings should be averaged to obtain the most accurate reading. For greatest accuracy, the readings should be taken either simultaneously or with the minimum time lapse between them.

Profile Levelling

The elevations obtained by the differential levelling process can be plotted along a line or onto a graph to determine the final grade or alignment of a road, rail line or sewer. Profiles are also used to compute volumes of earthworks or show the centre of a road.

3.2 Basic Levelling Concepts

Levelling seeks to find a horizontal line in preparation for civil construction projects, including building, road construction, formwork, drainage and other earthwork. Using special instruments, levelling obtains measurements of the differences in elevation of objects that are not vertically above each other. Before performing levelling operations you should understand the basic levelling concepts and some of the terminology that is used.
3.9 Rise and Fall Levelling Method

The first method of levelling is the rise and fall method. In the example below, the task is to survey a line of points S1 to S10 along a proposed fence line running between two buildings. The bench mark (BM) is at the corner of the plan, offset from the proposed fence. The recommended set up points are shown as L1, L2, and L3. The diagram shows the area both in plan and profile. The profile view indicates the approximate elevations along the proposed fence line.

**NOTE**
The values you will obtain will be different from this example. This example is provided only as an illustration of the method.
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**Step 1.**

After setting up the instrument at the first setup point (L1), read the level at the bench mark (BM). In the example below, this is 1.575. Record this on the booking sheet as a backsight (BS). Note this as a BM in the remarks column. Also record the known BM elevation, shown below as 47.195.

<table>
<thead>
<tr>
<th>Booking Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location:</strong></td>
</tr>
<tr>
<td><strong>Observer:</strong></td>
</tr>
<tr>
<td><strong>Job No:</strong></td>
</tr>
<tr>
<td><strong>Instrument No:</strong></td>
</tr>
<tr>
<td>BS</td>
</tr>
<tr>
<td>1.575</td>
</tr>
</tbody>
</table>

**Step 2.**

If you are required to measure the distance using the levelling instrument, read the top and bottom stadia lines. Record the values in the respective columns. Subtract the bottom value from the top value and move the decimal point over two places (multiply by 100) to determine the distance in metres. Record the value in the distance column.

<table>
<thead>
<tr>
<th>Booking Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location:</strong></td>
</tr>
<tr>
<td><strong>Observer:</strong></td>
</tr>
<tr>
<td><strong>Job No:</strong></td>
</tr>
<tr>
<td><strong>Instrument No:</strong></td>
</tr>
<tr>
<td>BS</td>
</tr>
<tr>
<td>1.575</td>
</tr>
</tbody>
</table>

1.597 | 1.553 | 44.000 |
3.12 Levelling Using Boning Rods

Boning rods are “T”-shaped measuring devices, usually in a set of three, one of which is adjustable. Sets must be of equal length, but any objects of equal length can be used, for example, three pick handles or three sticks each marked at an equal distance from one end.

3.12.1 Boning

Boning is the process of sighting between two fixed profiles or rods and lining a third marker or rod to establish points on a grade between the fixed profiles. Boning is a reasonably accurate method of setting out a straight grade in roadworks and trench lines. A person with normal sight can readily establish intermediate points where the rods or fixed profiles are up to 80 metres apart. One advantage of the system is that it is independent of any horizontal measurement and is self checking.

NOTE
Ensure that the rods are plumb.

3.12.2 Application

Boning rods are commonly used in areas to:

- identify horizontal alignment
- indicate areas of cut and fill in earthworks
- maintain level floors for culverts
- control contours on road cross sections
- maintain gradients on roadwork.
## Terms and Acronyms

The following are terms commonly used on some sites. Space is provided over the page for you to add terms and acronyms common to your site.

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td><strong>Job Safety Analysis (JSA)</strong></td>
<td>A risk management process that focuses on job tasks to identify potential hazards, assess risks and determine suitable controls to manage risks.</td>
</tr>
<tr>
<td></td>
<td>A JSA:</td>
</tr>
<tr>
<td></td>
<td>• must be completed before a high risk task commences</td>
</tr>
<tr>
<td></td>
<td>• is a written record that could be used in a court of law if a serious incident occurs in the workplace</td>
</tr>
<tr>
<td></td>
<td>• must be signed off by all parties who have responsibility for the work to be performed under the JSA.</td>
</tr>
<tr>
<td></td>
<td>Also called a Job Step Analysis (JSA), Job Safety and Environment Analysis (JSEA) or Job Hazard Analysis (JHA).</td>
</tr>
<tr>
<td><strong>Permits</strong></td>
<td>Permits are required for certain jobs that have high risk potential. Some permits used on work sites include Hot Work Permit, Permit to Dig/Penetrate, Confined Space and Work at Heights Permits.</td>
</tr>
<tr>
<td><strong>Site Procedures</strong></td>
<td>Site procedures are documented ways of working to achieve an acceptable level of risk. A procedure can be a Standard Work Procedure (SWP), Safe Work Instruction (SWI) or Standard Operating Procedure (SOP). Procedures are a legal requirement and outline the workplace method and processes for carrying out tasks safely and in an environmentally sustainable way. Procedures are developed after consultation with workers and are monitored and amended as required. Procedures contain detailed information such as:</td>
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<td>• a description of the task</td>
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<td>• a list of tools and equipment required</td>
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<td>• information on identified hazards associated with the task</td>
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<td>• risk controls, including training requirements</td>
</tr>
<tr>
<td></td>
<td>• sequential steps to perform the task safely and efficiently</td>
</tr>
<tr>
<td></td>
<td>• references to applicable workplace health and safety acts, regulations and policies.</td>
</tr>
<tr>
<td><strong>Safe Work Method Statement (SWMS)</strong></td>
<td>A SWMS documents a process for identifying and controlling health and safety hazards and risks. A SWMS must be prepared for all high-risk activities and contains detailed information such as:</td>
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<tr>
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<td>• the type of high risk work to be performed</td>
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<td>• associated hazards and risks</td>
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<td></td>
<td>• risk management controls to be put in place</td>
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<tr>
<td></td>
<td>• how the risk controls will be implemented, monitored and reviewed.</td>
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</table>
**Supporting Document Register**

Use this register to note the location of important supporting documentation such as your site operating and safety procedures, work instructions, relevant standards, equipment manuals and safety alerts/bulletins.

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Description</th>
<th>Location/How to Access Document</th>
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