

Survey Basics

Laying out Trenches and Levelling

Guide 10



BAJR Practical Guide Series
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Survey Basics – Laying out a trench and Levelling.



Introduction

One of the first tasks when preparing a site for excavation is laying out of the trenches in the locations decided previously. A rectangular or square trench has become the standard within the archaeological discipline and it is very easy to achieve a perfect trench with right angled corners every time.

This knowledge is of course transferable to other aspects of survey, and therefore should be seen as a basic skill that must be understood and mastered.

Along with this, it is certain that use of a dumpy level will be another core skill that is required by all archaeologists. This guide will provide you with both these skills.

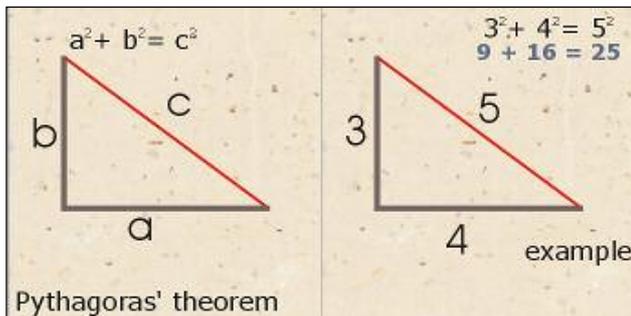
Setting out a Trench

Start with your fixed point, a single peg that is to be the corner of your grid which the trench will lie inside.



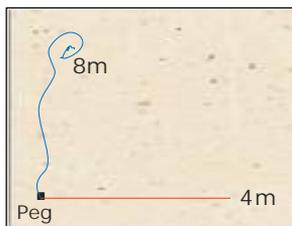
Now attach two tapes to the nail on the top of the peg (or survey arrow).

This is where Pythagoras' theorem comes in – in geometry, $a^2 + b^2 = c^2$



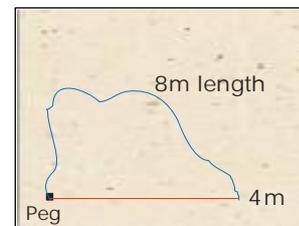
Other useful diagonals are listed below, but you can now find the diagonal of any right angled triangle by using this method. You will also be able to 'offset' from a baseline tape using this method to arrive at a right angle

Based on simple geometry, a right angle can be created by making the tapes work together as a triangle with sides of exactly 3, 4 and 5 metres.

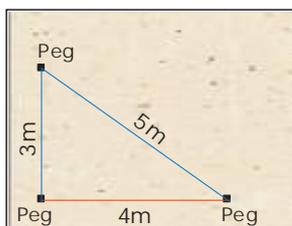


Step 1

Pull one tape tight and hold at 4m, then with the other tape, play out 8m of tape **Step 1** (the sum of the two remaining sides) and then hold the 8m mark over the other tape at 4m. **Step 2**

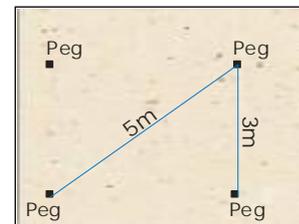


Step 2



Step 3

Now hold the long (8m length) tape at 3m and pull taught until both sides are tight - **Step 3**. You now have your third peg, and if you repeat this on the other side, you will now have four pegs which are all at right angles. **Step 4**



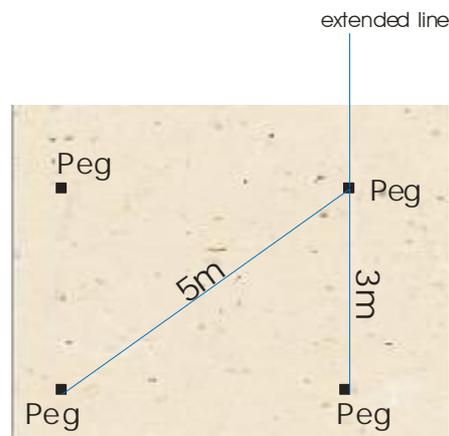
Step 4

When the long side (the hypotenuse) is **5** (for example), **3** and **4** (in this case) will be the lengths of the two shorter sides and therefore you have therefore created a right angle. Vertical heights, such as slopes, can be measured using tapes and measuring rods in a step-like fashion.

The most useful angles to know are:

1m x 1m square	1.414m Diagonal
2m x 2m square	2.83m Diagonal
5m x 5m square	7.07m Diagonal
10m x 10m square	14.14m Diagonal
3m x 4m square	5m Diagonal

Remember that you can always extend a line, so although you might use a 3x4m triangle to create a right angle, the lines can extend beyond this.



Result.... A nice clean, right-angled trench!

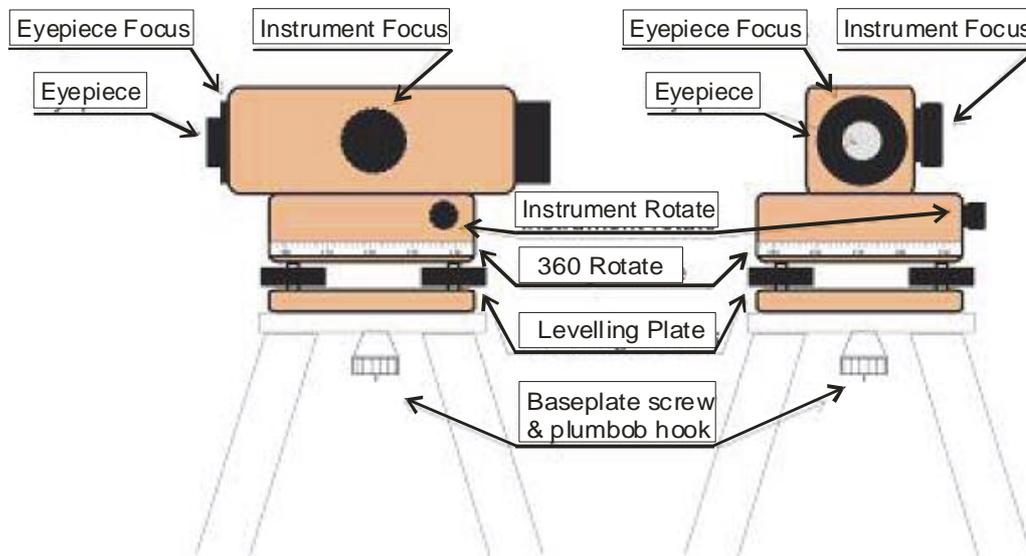
Levelling

The other basic skill, is easy to learn, and once again it is simple geometry.



First find or establish your datum (a fixed point of a known height that all other measurements are taken from.) This can be an Ordnance bench mark, such as the one on the left. Or a temporary datum that you assign an arbitrary height number to – though this should be tied into the OS datum as soon as possible. This is just one of the measures that keeps us all consistent and having to recalculate all your levels, when you have a real height value is not a pleasant task. Most maps will show you the location of Bench Marks... establish them as early as possible as this will save having to redo all your level calculations.

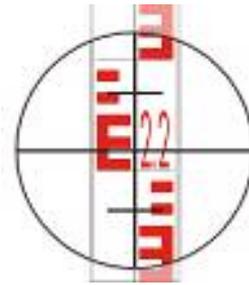
Now set up your dumpy level. It will probably be like the one pictured, and has an eyepiece, bulls-eye spirit level and 3 levelling screws as well as a focus for the telescope lens – quite often the base has a 360 degree compass, for laying out, however as you now know how to create perfect right angles, this is not usually needed.



Start by attaching the dumpy level to the legs and tighten the baseplate screw. Next turn the dumpy so it is parallel with two of the levelling screws. Turn BOTH screws either away from each other or towards each other simultaneously until the bubble in the spirit level is centralised. Now turn the dumpy 90 degrees so the level now points towards the levelling screw that has not been touched and then use this to complete the bubble levelling by putting the bubble in the middle of the bulls-eye.

This should now result in the dumpy being perfectly level, which is very important, before you start to take spot heights.

Take the staff and place on the temporary bench mark or bench mark and rotate the dumpy, focus the crosshairs using the eyepiece focus (*you will only have to do this once to suit your eyes*), and then focus the instrument on the staff. You read off where the two large cross hairs meet. So in this example your reading would be 2.22 or two metres twenty two centimetres. (*there are never many reasons to take it to the nearest millimetre unless you are doing accurate **Stadia Tacheometry** – see next section*)



Each 'block' represents one centimetre
 Each E represents 5 centimetres
 Each 10 centimetre section alternates back and forth and finally, on some staffs the colour alternates between black and red for each metre.

Now its time to take your initial reading. (for this example we will assume your temporary benchmark is set at 123.45 metres above ordnance datum .. **maOD**)

TBM = 123.45
 Backsight (**BS**) = 2.22 (*the reading you have just taken*)
 Instrument Height (**IH**) = 125.67 (*add the TBM to the BS*)

Now you can start to take readings for your site. Mark the location of your levels on the plan (or section string line) and the prepare to take the Foresight (FS) levels. Repeat the process of placing the staff on the ground where you have marked the locations on the plan....read off the height reading and then move onto the next..... your notebook should look something like this :

<i>TBM - 123.45</i>	
<i>BS -</i>	<i>2.22</i>
<i>IH -</i>	<i>125.67</i>
<i>1 -</i>	<i>1.67</i>
<i>2 -</i>	<i>1.15</i>
<i>3 -</i>	<i>1.26</i>
<i>4 -</i>	<i>1.28</i>

Now you have the readings, all you have to do is '**reduce**' the levels. What you are doing is finding out the height of the ground at the base of the staff – in other words, as you know the height of the dumpy level all you have to do is **subtract** the staff reading to find out the actual height of the level on the ground. So in this case your finished levels notebook will look like this.

<i>TBM - 123.45</i>		
<i>BS -</i>	<i>2.22</i>	
<i>IH -</i>	<i>125.67</i>	
<i>Reduced</i>		
<i>1 -</i>	<i>1.67</i>	<i>124.00</i>
<i>2 -</i>	<i>1.15</i>	<i>124.52</i>
<i>3 -</i>	<i>1.26</i>	<i>124.41</i>
<i>4 -</i>	<i>1.28</i>	<i>124.39</i>

A useful trick is to either look for similar levels and use them or watch for this pattern:

In the previous example, you had already calculated that
 $125.67 - 1.26 = 124.41$

so when you see an FS reading of 1.28 it is 2 cm higher than 1.26 and therefore the reduced reading is 2 cm lower than the previous reading and would equal 124.39.

Using this method you can save a lot of time in calculating... the simple rule is

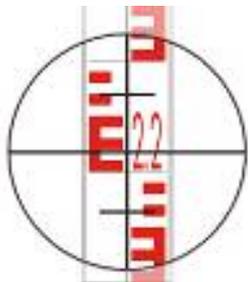
X cm up on the Foresight reading = **X** cm down on the reduced level
OR
X cm down on the Foresight reading = **X** cm up on the reduced level

Remember to check regularly though as mistakes can be made.

A final reminder is to reduce your levels on site and never wait till afterwards. Reducing 50 levels on site each time you draw a plan is nothing compared to trying to reduce thousands once back in the office !

Stadia Tacheometry

This information may be of use to you and may lead you on to understanding more about geometry and surveying. Although it is properly used with a theodolite, the dumpy level also has stadia cross hairs. These are the two short cross hairs above and below the main cross.



Very simply, the distance between the two is multiplied by 100 to give you the distance from where you are to where the staff is. So once again, in this example (*and here we will use the millimetres*) the lower cross hair is at 2.163 and the upper is at 2.218 so difference is 0.055 metres.

This is multiplied by 100 and the final distance is :-

5.50metres

It really is that easy.

It is important for you to understand the basic principles of survey and even more important if you are to use sophisticated Total Stations and Electronic Distance Measurers (EDMs) – only by understanding the underlying concept will you understand what you are trying to achieve with the digital version.

This book – if you can find it is to be recommended:

Surveying for Archaeologists F. Bettess - **Paperback** 145 pages (August 1998)

Check the **BAJR** bookshop for available copies.