Dipstick Elevation Studies

1. <u>Why do it?</u>

The Dipstick® will enable you to collect elevation data that is much more precise than that available from a Rod and Level. If you need to know exactly how a surface looks in 3-D, or if you need very precise elevations of points on the surface, you can make a 3-D elevation study on your own. Some examples of reasons for doing an elevation study include:

- checking drainage patterns, such as checking for "birdbaths" where water might collect on a nominally flat surface;
- determining exact elevations of critical locations such as mounting pads for a machine that must be mounted exactly level;
- determining exact elevations for a system that interfaces with the surface;
- checking the results of corrective grinding, and other reasons.

2. <u>What Do You Need?</u>

To make an **<u>Elevation Study of a surface</u>**, all you will need for a basic study is your Dipstick®. This will allow you to graph lines (one at a time or many at once) and calculate elevations of each of the points on any of the lines.

To make a **<u>3-D plot of a surface</u>**, you will also need a 3-D plotting or graphing software program such as Microsoft Excel® or Perspective Jr.®, or a specialized graphing program like Harvard Graphics®. These programs take the data and present it as a 3-D plot. What you need to do to make this work will be explained below.

3. <u>Marking the surface</u>

Starting at a convenient point at one end of a measurement line, mark this starting point with chalk, crayon, or a dot of paint. Mark the other end too. Paint is much better than chalk or crayon, because when you get the results calculated and graphed, you will be able to go right to the key spots on the surface. Mark the measurement lines with a chalk line or similar method. We like to spray paint clear lacquer over the chalk line so it will last, but a temporary method is OK, so long as you can find these lines later from the paint spots at the ends.

4. <u>Dirt or Grit on the Surface</u>

If the surface is excessively dirty, have it swept to remove the dirt/grit that you would otherwise walk over. (A light coat of dust is OK, but not piles of dirt or grit.) This can be important, depending on the desired accuracy of the result, because the Dipstick® can measure to .001 inch, or 1/10 mm. The cleaner the floor, the better your data will be. When you compute the Surface Roughness Bias from the data you collect, check to ensure that it is less than .004"/step. Anything more indicates a problem.

5. Three Ways to Collect Data

You should collect the data in closed loops; in any of these three methods:

- An "out-and-back" line
- A "Comb" pattern, or
- A series of "boxes," either overlapping, or tied together by one or more "base" lines.

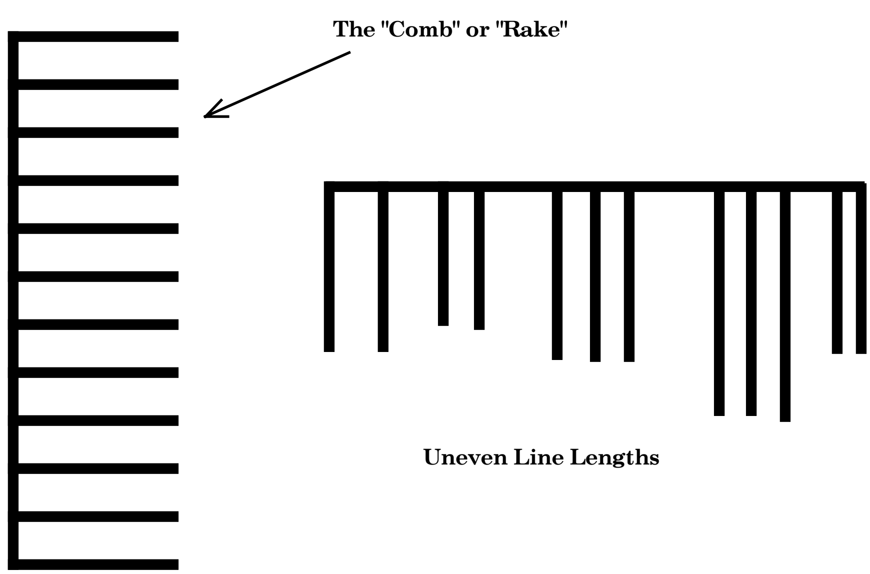
a. "Out-and-Back" lines

This is the simplest method, and is often very satisfactory to achieve the desired result. Here's an example showing how this technique might be used: One major aircraft manufacturer measures the deflection of runway and taxiway pavement by starting from a point that is sufficiently remote from the aircraft that it is assumed to be unaffected by the presence or absence of the aircraft. Using a starting point elevation of 0.0, they walk a line from that point to a point right next to one of the wheels, and reverse direction on the same line, returning back to the starting point. Then they remove the aircraft and collect another set of data in the identical location. The only difference is that in the second Run, the aircraft has been removed. After computing the Bias for each of the two Runs, the runs are segmented to retain the first half of each run. These profiles then represent the elevations of the profile between the starting point and the aircraft's wheel location, before and after removing the aircraft. The two segmented Runs are then selected and the menu item CALCULATE/DIFFERENCE is used. This creates a profile that represents the precise deflection of the pavement due to the weight of the aircraft.

b. The "Rake" or "Comb" pattern

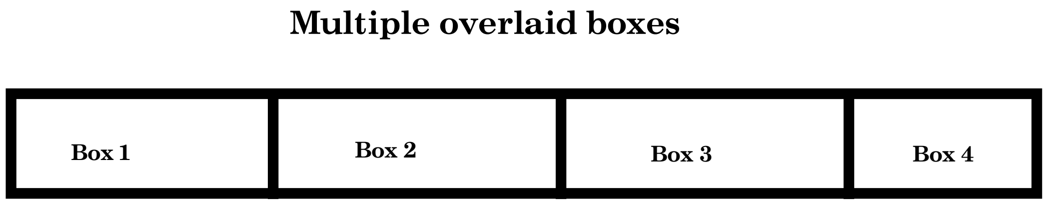
We call it the "Rake" or "Comb" method because the layout pattern looks like the tines of a garden rake, or the teeth of a comb. There is a "Base" line, which is typically the longest line, and there are the "tines" or "Teeth" lines, which all start from the base line. If the tines are short, you won't have to measure the tines "out and back". The base line should ***always*** be measured "out and back."

Although the teeth or tine lines do not have to be parallel or the same length, we recommend that you make the pattern symmetric, even, and parallel, unless you have a reason for not doing so. Collecting the data in even, regular patterns will make it ***much*** easier to make 3-D graphs.

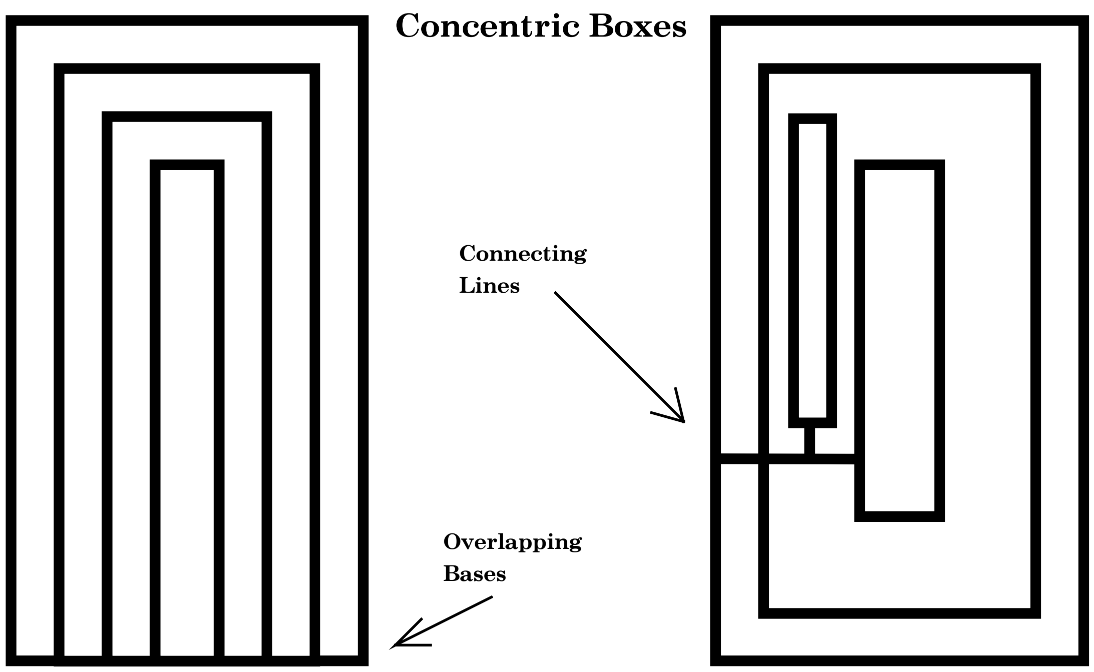


c. The "Box" method

Boxes are quite a bit more efficient than the "Rake" or "Comb" in terms of data collection and analysis time, particularly if you need to cover a large area without collecting data at every point.



For covering a large area, you can collect the data in concentric boxes. The boxes may be any convenient distance from each other, but you will need to link each of the boxes with a line, in order to get the relative elevations of the several boxes right.



Decide whether you will use the "Rake/Comb" method, or the "Box" method before laying out the measurement lines. We prefer the "box" method.

6. Designating Run Names

Designate the runs with names that you can remember, that will mean something to you later. There is nothing worse than labeling all runs numerically from 1 to whatever, with no correlation to the run location on the surface.

Name the area covered by each comb and use the same name for the comb. You might have a comb in bay 18, so call the base line 18B. (B for "base") You could number the teeth from N to S, so you have runs labeled 18B, 18-1, 18-2, 18-3, etc. If some of the combs are aligned N-S and some are E-W, designate the base line 18BNS, or 18BEW. You don't have to carry the NS or EW designations on to the teeth, because you know they are perpendicular to the base line. The important thing is to give each line a meaningful name that will help you remember where it was taken from. If you use boxes, name each box in a way you'll be able to remember later.

Each box will be broken into its 4 constituent lines later. The Dipstick® software will automatically name each of these 4 lines with the name of the box and a suffix.

7. Collecting Data

a. Combs

Start the Dipstick® with the rear foot on the paint mark and collect data along the base line. Using a keel or chalk, mark a circle around the foot when you get to any point from which you want to run a "tooth" later. Do not move the Dipstick® off the base line or turn it off; simply draw a circle where you want to start a "tooth". Mark the step number on the surface next to the circle. You will come back to this location later to start your "tooth" runs. When you get to the end of the base line, collect the last reading, then rotate the Dipstick® in a complete circle, setting it back where it was so it can collect another reading. Now continue back along the base line until you get back to the start point. (The details of how to do this are covered in the Hardware Manual under "Bias Run".) Assign a start point elevation of 0 (zero) to the Base Line.

Now collect all the "tooth" runs, starting at the locations where you circled the foot.

b. Boxes

Start the Dipstick® with the rear foot on the paint mark at one corner of the end box, and collect data along a line. For example, if your lines run from West to East as shown in the example above, start at the lower left (Southwest) corner of the Western box, and measure along the South (right) line, going from West to East. (Whichever way you do it is OK, but always start at the outside corner of the outside box, collecting data in the same direction, i.e., going East.)

After you have taken a certain number of steps, say 50, stop and mark a circle around the front foot. Don't stop the run on the pocket computer, just stop rotating the Dipstick® for a moment while you mark the surface. Now turn the Dipstick® so you march *across* to the opposite line , stopping when the front foot is on the left (North) line at a point just opposite where you stopped a moment ago. It is important that this point be exactly across from the 50th step, because these are the two points you are going to compare. Mark a circle on the floor around your front foot again. It doesn't matter if the front foot is the switch end or the battery end, so long as it's the front foot. Then turn West and march back on the North line until you are at the end of the line opposite where you started at the beginning. Stop and mark this point by circling around the front foot. Finally, turn South and march back across to where you started from.

It is imperative that you end up with one end of the Dipstick® exactly on top of the paint spot where you started. Terminate the collection of data at this point.

Record the locations of the turning points and the end point on the run **Notes** by step number, i.e.: 50, 56, 106, 112. In this example, let's assume the box is 6 steps wide. You start at the paint mark, and the 50th reading is taken with the battery end of the Dipstick® over the first turning point. The second turning point is 6 steps later, at 56, and the last turning point is at 106, across from the starting point. The run is ended with the battery end of the Dipstick® forward, with the foot right over the paint mark, at step # 112. You will need these turning points for the analysis later.

Go to the spot on the South line where the circle is on the floor at the 50th step. (The first turning point from the first box) Start a second box here, again going East along the South line for 50 steps. Mark the turning location, turn North, and march to the North line. Finish this box just like the first box. Point # 106 of the second box should be right on top of point # 56 from the first box, and point # 112 (the end point) from the second box should be right on top of point # 50 from the first box, which is at the same point as the start point of the second box. Record the locations of the turning points and the end point on the run **Notes** by step number, i.e.: 50, 56, 106, 112.

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8. General Info on Collecting Data

Here's how to make the short transverse legs land exactly on top of the other wheelpath: When you have the 50th point marked, (the circle around the foot at the 50th step) leave the Dipstick® there and go across and mark the desired location directly opposite. Draw a 12 inch (300mm) circle around this point on the floor. Now go back and continue taking data towards this point. At the point where you would step across the 12 inch (300mm) circle, ***don't step over the circle,*** but ***put the foot down exactly on the circle.*** ***(Anywhere on the circle)*** This will require that you "step off" at a slight angle. Your next step will put you exactly on the desired spot at the center of the circle. You may also have to do this to get exactly back on to the starting point. (At reading # 112)

9. Processing the Data

a. Combs

Download the data to a PC. Calculate the Data Collection Bias from the Base Line, and apply this Bias to all runs. If your "Teeth" runs are long, you may want to calculate the Bias on each run independently and apply that Bias to the run it was collected on. If the "Teeth" runs are short, You won't need to calculate the Bias on anything other than the Base line.

After processing the data, you will need to find the elevations of each of the points where you started the "teeth" from the Base Line, then edit the "teeth" runs to include the correct start point elevation for each of the runs.

You have referred the start point elevations of each "tooth" run to the corresponding elevation at the same point on the "Base" line. The elevations of this Base line are all referred to its start point, which you set at 0 (zero). Therefore, the elevations of any and all points on any of the lines are referenced to each other, and are measured relative to the zero elevation of the start point of the Base line. If you now want to know what the difference in elevation is between any pair of points on any line, all you need to do is subtract the elevation of one from the other. It is just as if you now have a great many bench marks located 12 inches (300 mm) apart.

b. Boxes

After collecting the data, download it to a PC, and unbox the boxes following the procedure described in the hardware manual**.** (EDIT/UNBOX)

The start point elevation of the second box should not be zero, but should be whatever is computed for the end point elevation of the first leg of the first box. (The elevation of the 50th point in the example) Similarly, the start point elevation of the third box will be the elevation of the end point of the first leg of the second box, and so on.

You have referred the start point elevations of each leg of each box to the corresponding elevation at the same point on the previous box. The elevations of this Base line are all referred to its start point, which you set at 0 (zero). Therefore, the elevations of any and all points on any of the lines are referenced to each other, and are measured relative to the zero elevation of the start point of the first leg of the first box. If you now want to know what the difference in elevation is between any pair of points on any line, all you need to do is subtract the elevation of one from the other. Once again, it is just as if you now have a great many bench marks located 12 inches (300 mm) apart.

10. Making a 3-D Graph

To make a 3-D graph, you will need to load the data into a spreadsheet or specialized graphing program. You will first need to transform the run data from the Dipstick® format into ASCII format. Your Face Co. Dipstick® software will do this for you. You will need to do this for every run.

After doing that, open your spreadsheet program and import (load) the ASCII elevation data files you just produced. Copy each file to the same spreadsheet, and align the data in the same pattern as it was in on the surface when you collected it. In other words, if the data was collected in a "Comb", then the data must be placed in the spreadsheet in a "Comb" pattern, with blank fields in the spaces between the "Teeth".

Depending upon the spreadsheet you use, you may have to input zeros into all the blank fields. There must not be any text in the data. For a better-looking plot, you may wish to average the data between columns to fill blank spaces. While this is not strictly correct, in many cases it may be approximately correct, and it may produce a more viewable picture that still represents the surface quite well. (Sometimes the 3-D picture is difficult to discern if there are many empty cells in the data that produce the picture.)

Finally, make the graph or 3-D plot following the instructions for the spreadsheet or graphing software.