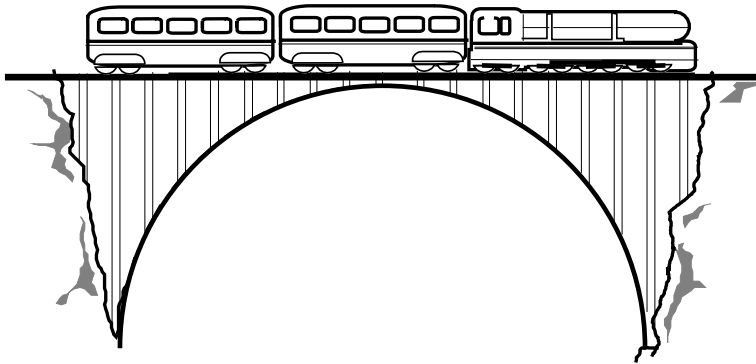


MEASURING DEFLECTION OF BEAMS

If you apply a force to a structure, it bends - in other words, each point in the structure is deflected. You can measure the 'bending' of a structure by applying a force at a point and measuring the resulting deflection of some other point.

In maintaining railway bridges, Railtrack guarantees that structures will not bend more than 0.2% of their length when trains travel over them.



In most large structures like railway bridges and in small ones such as bookshelves, beams are used to support loads. When a beam is loaded, it is subject to both tensile and compressive forces. An imaginary line running through the beam's centre is called the neutral axis because in theory it is neither stretched nor compressed.

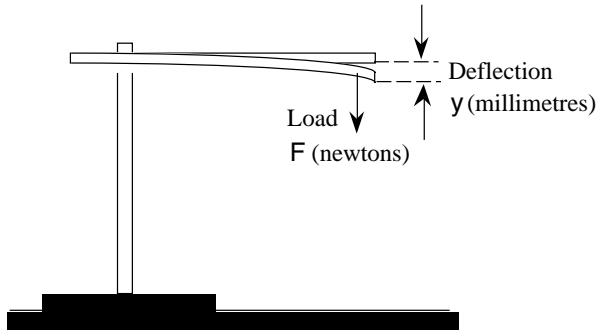
An ideal beam is one that supports a load without deflection. In practice, all beams deflect to some extent, and it is the designer's job to reduce this as far as possible. In a reinforced concrete beam, steel rods at the bottom of the beam provide tensile strength where it is most needed.

INVESTIGATING BENDING

1. Clamp a beam (metre ruler) at a set point and note how the deflection varies with the load applied.

Change the point at which the rule is clamped and note how the deflection varies with the load applied.

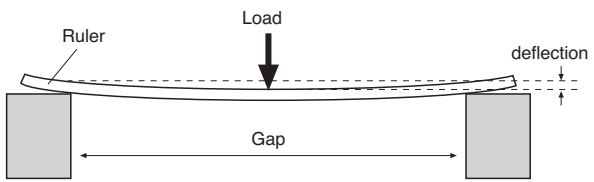
Change the beam material and repeat the above two investigations.



2. Place a beam (metre ruler) between two supports and note how the deflection varies when the load is applied at the centre.

Change the distance between the supports and note how the deflection varies.

Change the beam material and repeat the above two investigations.



PRACTICAL HINTS

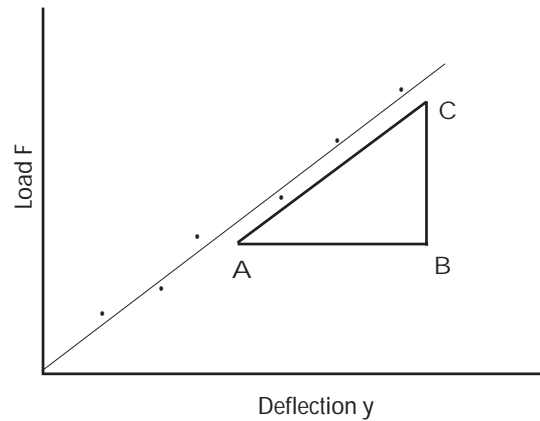
- Collect about ten sets of data.
- Use a wide range of loads.

Make a note of the data you collect in a table. The results of your investigation can be shown on a graph.

PREDICTING DEFLECTION

- Plot load against deflection
- Measure gradient $\frac{AB}{BC}$

$y = kF \quad k = \frac{y}{F} = \frac{AB}{BC}$
--



So the relation between load (F) and deflection (y) is given by:

$$y = \frac{AB}{BC} F$$

(note that AB is measured on the horizontal scale and BC on the vertical scale)

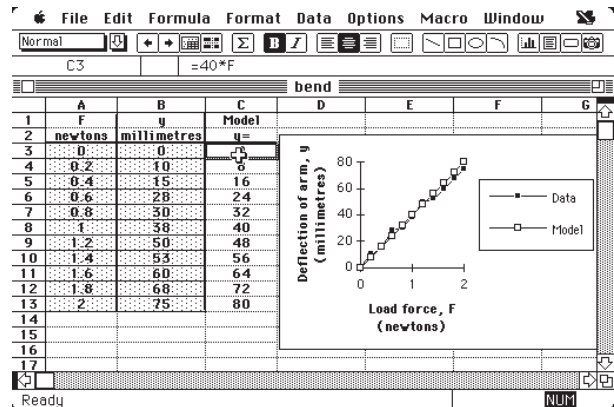
TECHNOLOGY STUDY FILE 5

USING A SPREADSHEET TO PREDICT DEFLECTION

Enter your data into a spreadsheet file. If you need help, use the following instructions:

- Enter your data for F into column A.
- Enter your data for y into column B.
- Enter a formula into column C such as $y=40 \cdot F$.

Your spreadsheet will look something like this:



INVESTIGATING THE MODEL FOR RIGIDITY

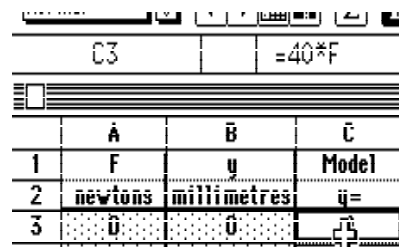
The column headed 'Model' calculates some results as you enter your data. The spreadsheet is trying to predict y when you know F. How good is the spreadsheet at predicting? The graph will help you answer this question. One line joins the data pairs (F,y). The other shows the points predicted. If the spreadsheet works, the points and lines will lie close together.

Try and alter the model so that it closely predicts y when you know F. If you can do this without help go on and make your structure. If you need help, use the instructions below.

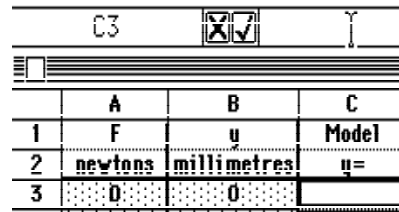
You

The computer

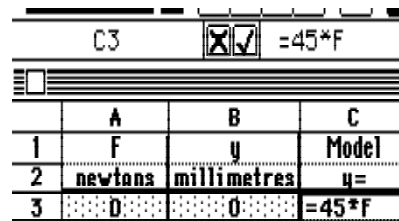
Click on cell C3



Delete the formula in the input strip by pressing the <delete> key.



Type in a new model.
Try ' $=45 \cdot F$ '



Press <return>

C4		=40*F
	A	B
3	0	0
4	0.2	10
5	0.4	15

The old model remains in cells C4-C13. The predictions do not change

Copy your model into all of column C

Click on cell C3. Keep the mouse button pressed down and drag down so that cells C3 to C13 are highlighted.

C3		=45*F
	A	B
3	0	0
4	0.2	10
5	0.4	15
6	0.6	28
7	0.8	30
8	1	38
9	1.2	50
10	1.4	53
11	1.6	60
12	1.8	68
13	2	75

Click on Edit on the menu bar. Select Fill Down from the Edit menu.

Try altering your model in column C so your predictions are as close as possible to the data in column B. Use your graph to help you.

	A	B
3	0	0
4	0.2	10
5	0.4	15
6	0.6	28
7	0.8	30
8	1	38
9	1.2	50
10	1.4	53
11	1.6	60
12	1.8	68
13	2	75

New predictions appear in cells C3 to C13

DRAWING CONCLUSIONS ABOUT RIGIDITY

Use your model to help you predict deflections for other loads.

- What will y be if F is 5 newtons?
- What will F be if y is 10 millimetres?
- Test your predictions in practice.

For a given load, your formula predicts the deflection of the structure. Therefore, if you know the maximum load to be applied, you can work out the maximum deflection.

Alternatively, if you know the maximum acceptable deflection for the structure, you can work out the maximum load which is acceptable.

Further investigations show how the bending may be reduced by using extra ties or struts or using more rigid members.