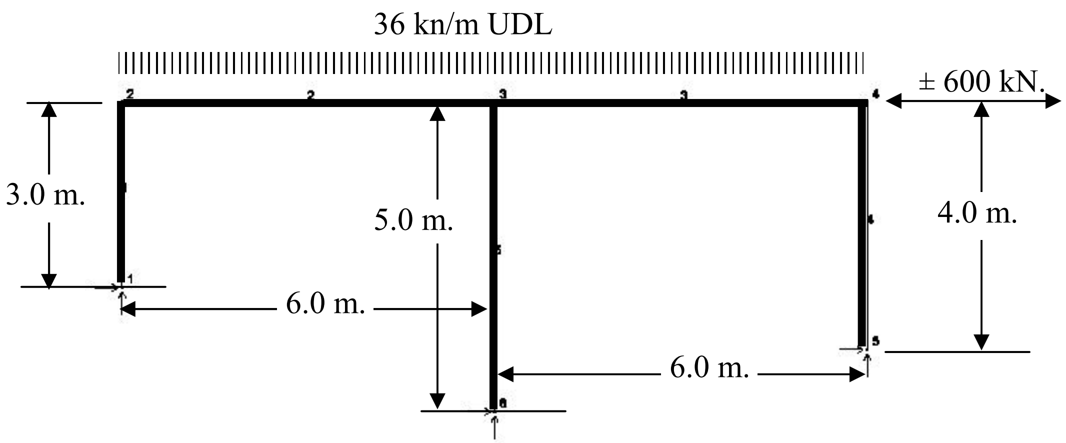
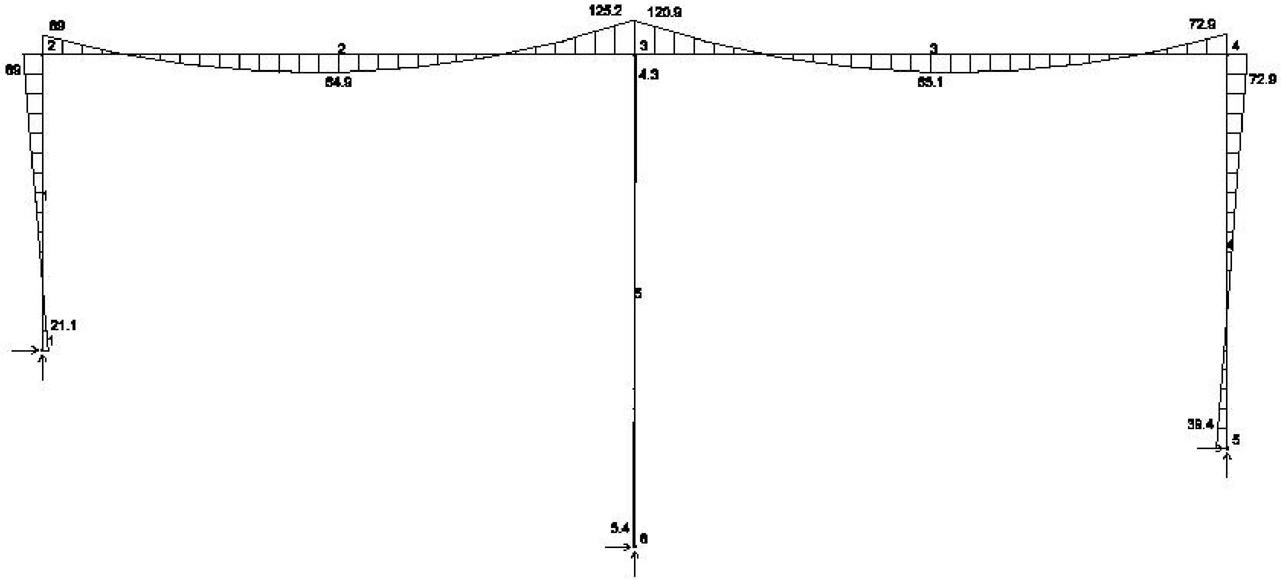
Tutorial No. 4: Moment Redistribution with Unequal Length Columns



Example:

The diagram on the left shows the example to be analyzed. The three columns are of unequal length. The loads are as shown. The beam is 800 mm deep by 400 mm wide and the columns are all 900 mm by 600 mm. The base of each column is considred fixed.



Step 1.) Redistribute Vertical Moments:

The diagram at the left shows the vertical load moments. The beam moments from the far left are:

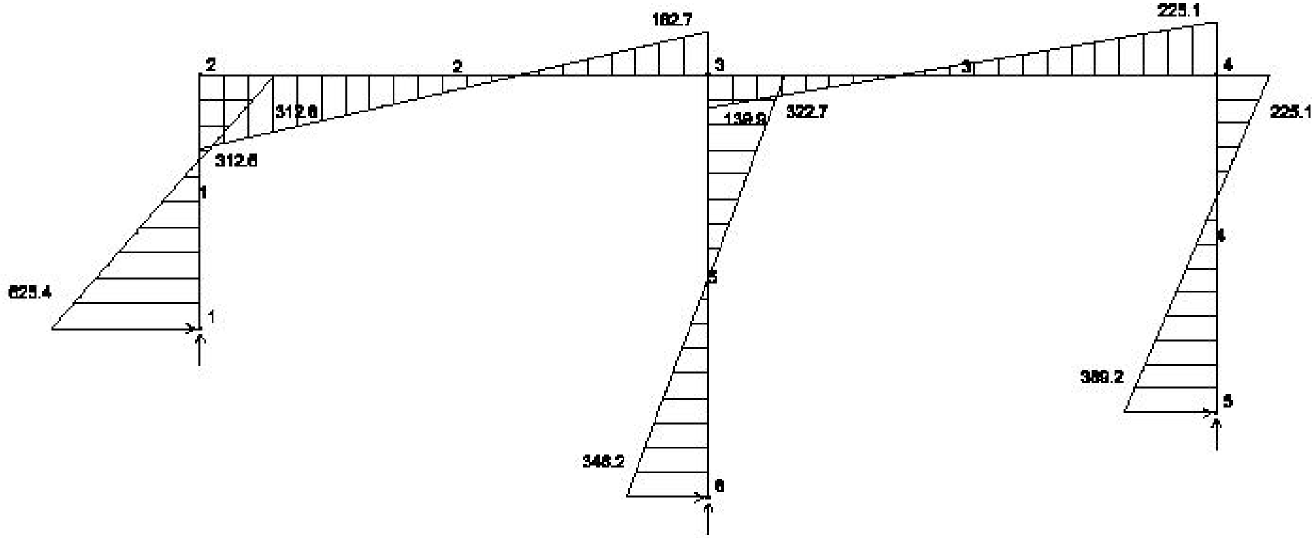
-69.0 +64.9 -125.2 -120.9 +65.1 -72.9

Average the negative moments:

-97.0 -97.0 -97.0 -97.0

Average the positive moments:

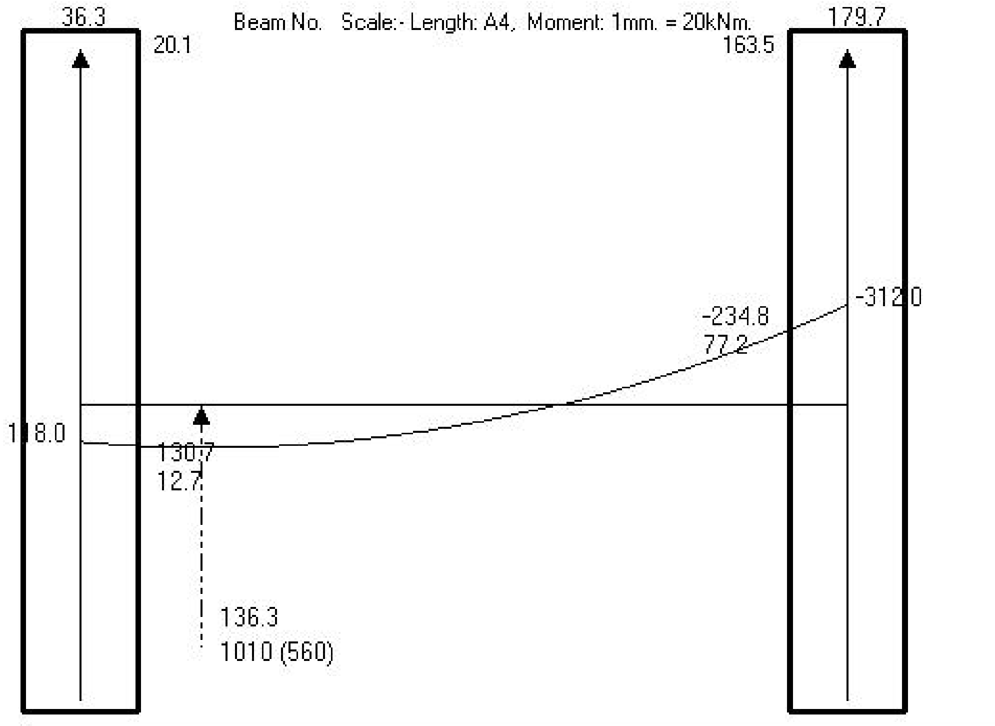
+65.0 +65.0



Step 2.) Redistribute seismic moments:

The diagram on the left shows the elastic analysis of the seismic moments. The moments from the far left are:
+312.6 -182.7 +139.9 -225.1

Average the negative moments:
-203.9 -203.9
Average the positive moments:
+226.25 +226.25
Average positive and negative moments
+215 -215 +215 -215
Combine these seismic moments with the averaged vertical load moments from Step 1.) in the Plotter.

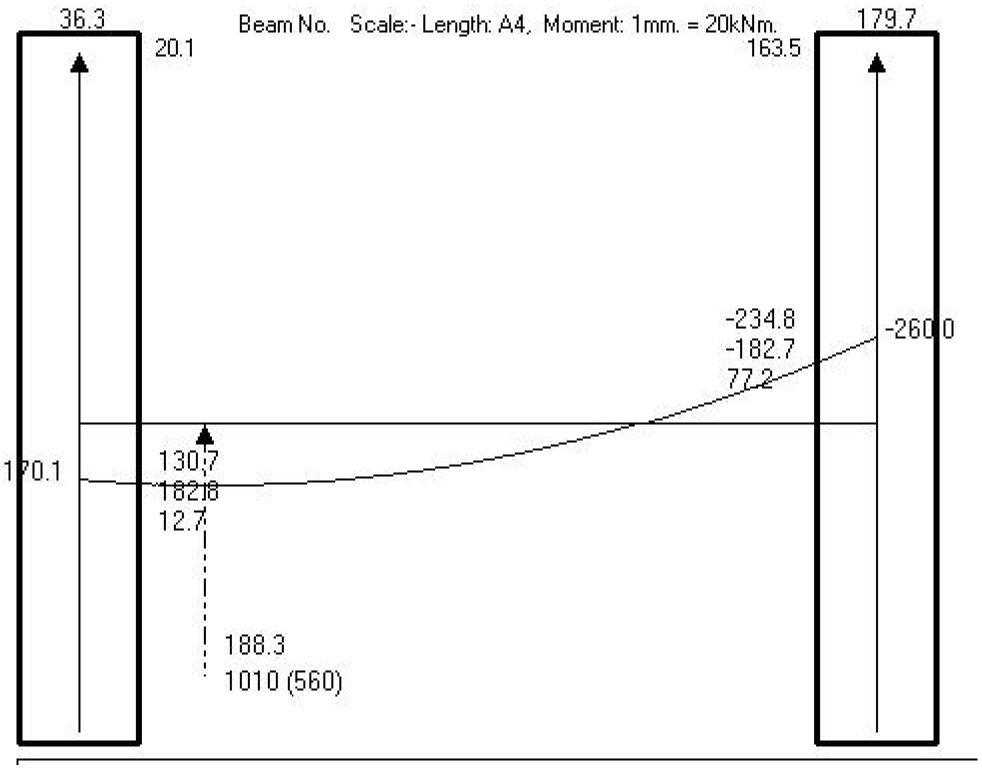


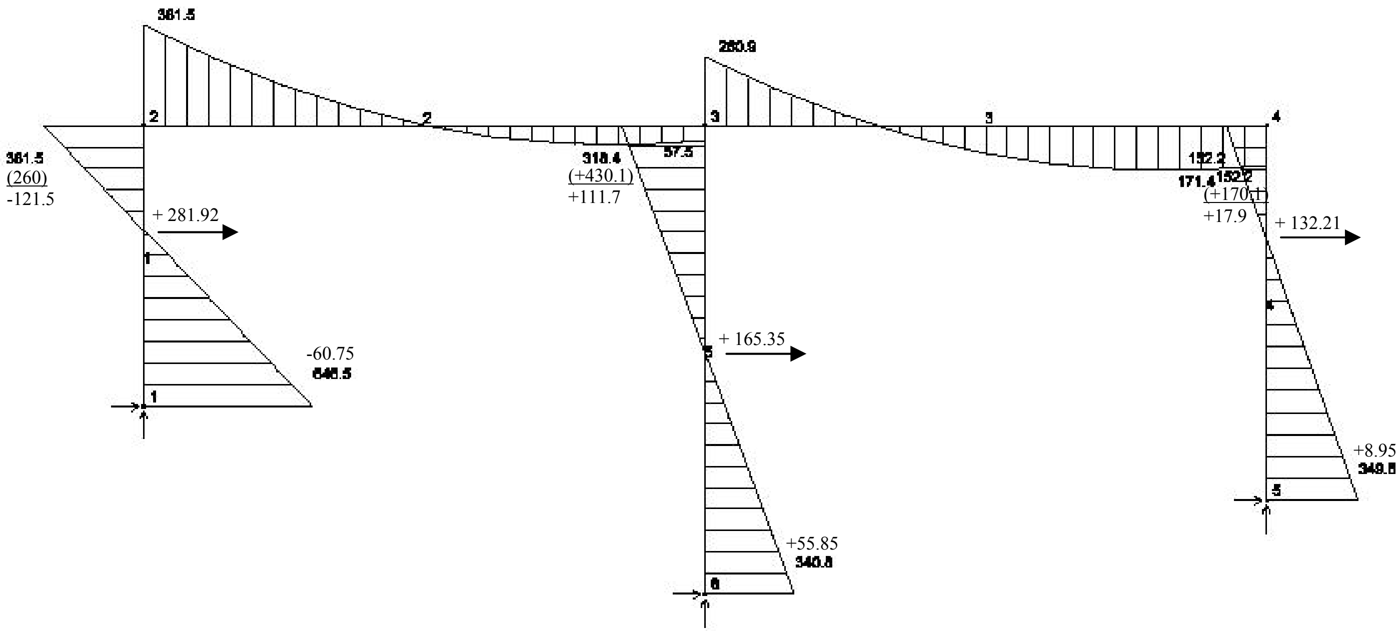
Step 3.) Combine moments in span:

The combining of the moments as above produces the moments at left in the Plotter. These can now be redistributed within the span. The amount of this redistribution is obtained by summing the face moments algebraically and dividing the answer by -2.

-234.8 + 130.7 = -104.1 / -2 = +52.05

This figure is now inserted into the “Redistribution Moment at Face” box under the “Moments” tab. This produces the moments in Step 4.) when Draw Beam is clicked under the “Plot Control” tab.



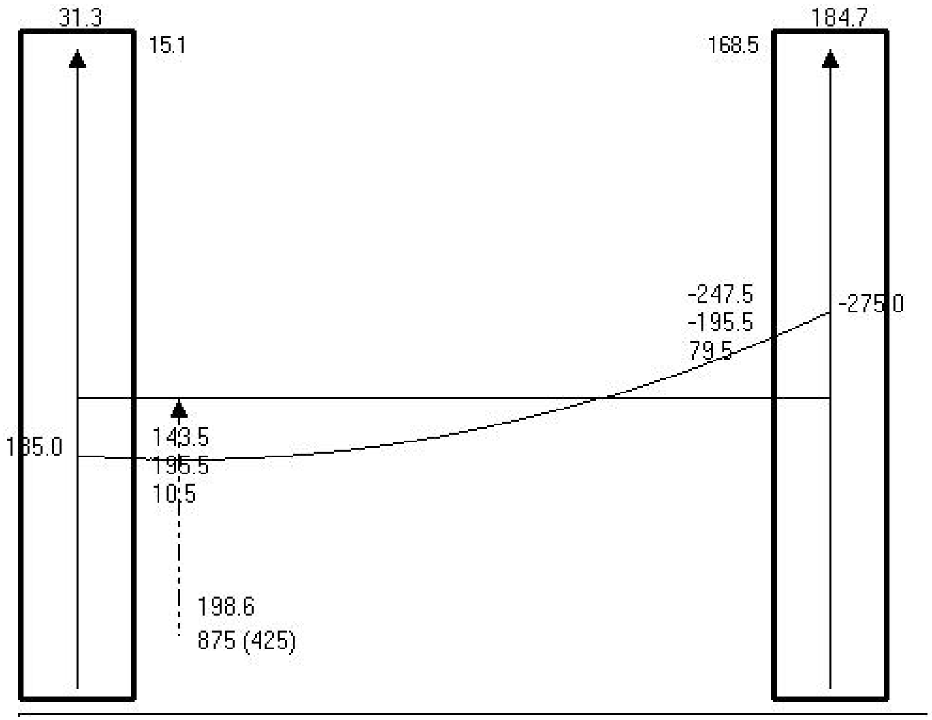


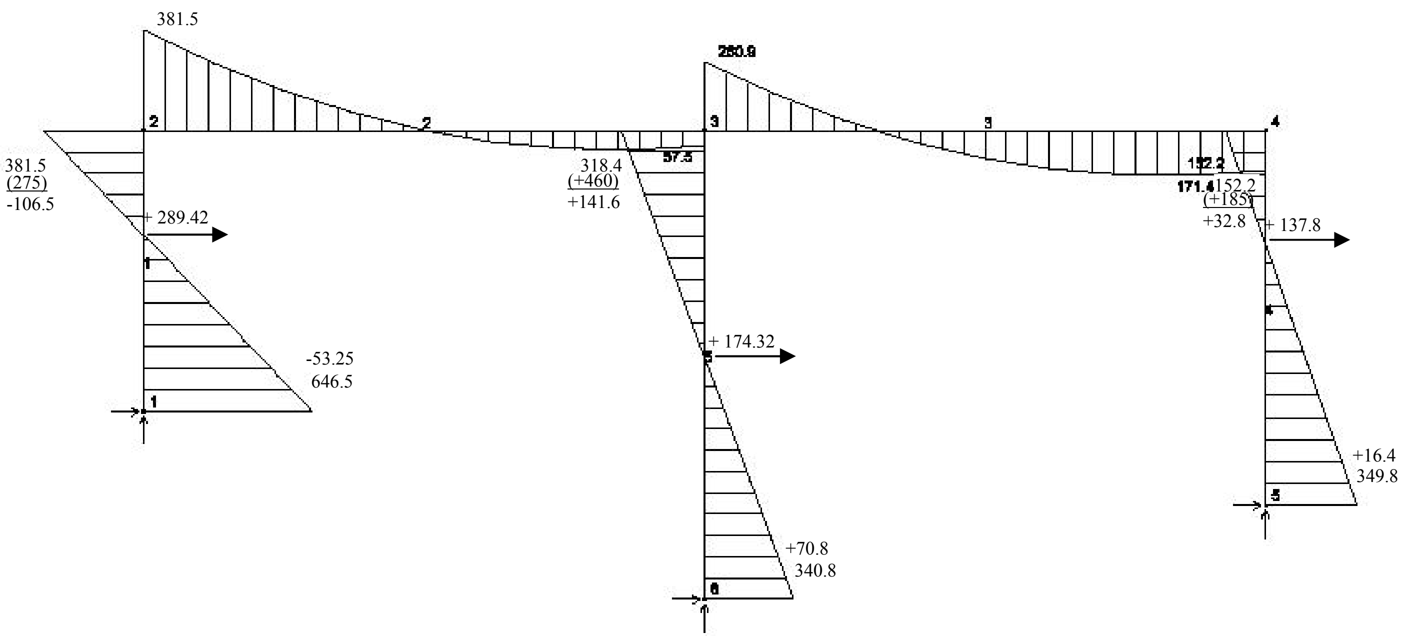
Step 4.) Redistribute in the span:

The face moments are now the same size for positive and negative at 182.7 kNm. The centre line moments are +170.1 and -260 kNm. These centre line moments must now be inserted over the combined moments from our Steps 1 and 2. and the change in column moments calculated and from these the seismic shear recalculated as shown in Step 5.)

Step 5.) Calculate column shears:

The changed top moments in each column is inserted in brackets at the top of each column. Beneath it is the difference or change in moment caused in the column by the redistribution. For instance in the first column on the left the top moment was 381.5 kNm. This now becomes 260 kNm, a change of -121 kNm which carries over to the base as -60.75 kNm because the base is fully fixed. The total of the column moments is now summed:
381.5 – 121.5 + 646.5 – 60.75 = 845.75 kNm.
This sum is now divided by the column height to obtain the shear resisted by this column:
845.74 / 3.0 = 281.92 kN. This is repeated for all the columns and the shears recorded by each column. These are now summed to obtain the total shear of the frame of:
281.92 + 165.35 + 132.21 = 579.48 kN. This is less than the 600 kN seismic shear which the frame actually resists. This will be balanced in the next step.





Step 6.) Increase the beam moments:
The seismic moments in the beam must be increased to the point where the shear balances out to 600 kN. You would expect this to be in direct ratio so that if you multiply the existing seismic moments of ±215 kN by 600 / 579.48 or ±222.6 you would expect the shears to balance out to 600 kN. Unfortunately it does not work this way as about 50% of the increase is lost in the redistribution. As a start therefore we will double the increase to ± 230 kN and calculate the shear with this. The combination in the Plotter is shown on the left. This has seismic moments of ± 230 kNm with the same vertical moments as before of:
-97 +65 -97. The same redistribution in the span of 52.05 kNm is used. The new face moments are ± 195.5 kNm and are the moments to transfer into Beamdes for the beam design..

Step 7.) Balance the frame shear:
The changes to the original combined moments due to the new moments from Steps 5&6.) are shown on the left. The new centre line moments of – 275 KNm and + 185 kNm are given in brackets and the change from the original given below them with 50% carried over to the base. The new column shears are worked out and again for the left column is: **381.5 – 106.5 + 646.5 – 53.25 = 868.25** this divided by 3 gives a column shear of **289.42 kN.** This calculation is repeated for each column and sums to **289.42 + 174.32 + 137.8 = 601.54 ≈ 600 kN** and is accurate enough.

The 7 steps set out above have gone from the graphical print out of the applied loads and detailed the process of redistribution with unequal column length. The essential difference between the redistribution of moments in frames of equal column length and that of unequal column lengths is that you can no longer work only with the moments. You must also balance the shears in the columns to equal those applied to the frame. This in turn readjusts the seismic moments in the beams. In Step 6.) we found the new column shear and ratioed up the seismic moments in the beam from ± 215 to ± 222.6 and then we arbitrarily doubled up on this change to ± 230 kNm. It is found that this often works to arrive at the correct final frame shear, but sometimes it does not. In those cases you have to repeat the cycles adjusting up or down to arrive at the correct frame shear value.

8.) Check the amount of the redistribution:

The last check we have to make is to find out the percentage of the redistribution where this has occurred. This only applies where moments have been reduced and in this case only applies to the far left beam and column moments. No reduction must exceed 30%. In Step 7.) the top column and end beam moments is given as 381.5 kNm. This is reduced by -106.5 kNm down to 275 kNm. This is a reduction of 27.9% and is therefore O.K but this figure must be given in BeamDes when this moment is calculated. The percentage showing as transferred is only the redistribution within the span and so this must be changed. The only other moment reduction occurs at the base of this column and here the moment of 646.5 kNm is reduced by -53.25 kNm. This is 8.2%.

The left-right distribution in the Plotter shown in Step 6.) and the right-left distribution must be saved with the correct Beam No in the file name. When BeamDes is opened the “Load from Plotter” function is used to transfer these results into the Moment Envelope.