Solving Truss Equations Purely by Computer (continued 4)

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ii. Cycle through the bars and put in cosines and sines of bar angles

Cycling through the bars. If we look at the whole $[A]$ matrix we see that the information about bar 7, say, only occurs in column 7 of $[A]$; column 7 of $[A]$ consists of the terms that multiply T_7. Furthermore, information about bar 7 only shows up in the rows corresponding to the x and y force balance for the the joints at its two ends; that's 4 places in total.

- Bar 7 pulls on its base joint `B(7, 2)` in the x direction. Because we write 2 equations for each joint this equation corresponds to row `2*B(7, 2)-1`. Thus we can make the assignment

  `A(  (2*B(7, 2)-1), 7  )  =   C(7)`

- Bar 7 pulls on its base joint in the y direction. This equation corresponds to the next row `2 * B(7, 2)` Thus we can make the assignment

  `A( (2*B(7, 2) ~~+1~~), 7 )  =   S(7)`

- Bar 7 pulls in the opposite direction on its tip joint `B(7, 3)` so

  `A( 2*B(7, 3) -1),    7 )  =  -C(7)`

- and

  `A( (2*B(7, 3) ~~+1)~~, 7 )  =  -S(7)`

One needs to cycle through all the bars③ and make these 4 assignments, 7 was just used as an example. In a package that deals well with matrices all four assignments associated with one bar could be in a single line of code.

m — joint #

$$J = \begin{bmatrix} 1 & 3 & \vdots \\ 2 & \vdots & \vdots \\ 3 & \vdots & 10 \\ 4 & \vdots & \vdots \\ \vdots & 8 & 6 \\ 6 & 3 & \vdots \\ \vdots & \vdots & 2 \\ 13 & 1 & 6 \end{bmatrix}$$

X & Y coordinates

$$B = \begin{bmatrix} 1 & 2 & 13 \\ 2 & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots \\ 11 & 7 & 6 \\ \vdots & \vdots & \vdots \\ 23 & \vdots & \vdots \end{bmatrix}$$

bar #   base and tip joint #'s

iii. Cycle through the reaction forces to find the right-most columns of [A]

Cycling through the reactions to fill in the right-most columns of $[A]$. The unknown reaction components have much the same role as do the bar tensions. But they act on only one joint. Thus each reaction component only affects 2 rows of $[A]$, the x and y components of that joint equation.

For reaction 3, say, the relevant joint is `R(3, 2)` and thus the relevant rows are `2*R(3, 2)-1` and `2*R(3, 2)`. The relevant column is $n_{bars}+3$.

- for the x component of reaction 3 — joint at which reaction force is applied

  `A( (2*R(3, 2)-1), (nbars+3) )   =  R(3,3)`

- for the y component of reaction 3

  `A((2*R(3, 2)    ), (nbars+3) )   =  R(3,4)`

$$[R] = \begin{bmatrix} 1 & 2 & 1 & 0 \\ 2 & 2 & 0 & 1 \\ 3 & 13 & 1 & 0 \end{bmatrix}$$

Most often, for trusses that are rigid even when floating, one only has three such reaction components to cycle through.

iv. Find the load vector [L]

The load vector $[L]$ The load vector is just made up of the forces applied to the joints. For load 2, for example, applied at joint `F(2,1)`, the two relevant rows of $[L]$ are `2*F(2,1)` and `2*F(2,1)+1` at which act the x, and y components of the force `F(6,2)` and `F(6,3)`, respectively. Thus, for load 6, we have

```
L( 2*F(2,1)-1 )   =   -F(2,2)
L( 2*F(2,1)~~+1~~ )   =   -F(2,3)
```

Recall that the minus sign follows from moving the applied load to the right side of the equation. This pair of commands needs to be applied to each line of the $[F]$ matrix.

$$F = \begin{bmatrix} 4 & 100 & 0 \\ 1 & 0 & -50 \\ \vdots & & \\ 12 & 200 & 75 \end{bmatrix}$$

joint #   (x & y comps. of applied load

...and from all this, Solution!

`Solve {A T = L} for T`

...which in matlab is done with the command "\" and looks like this: T = A\L