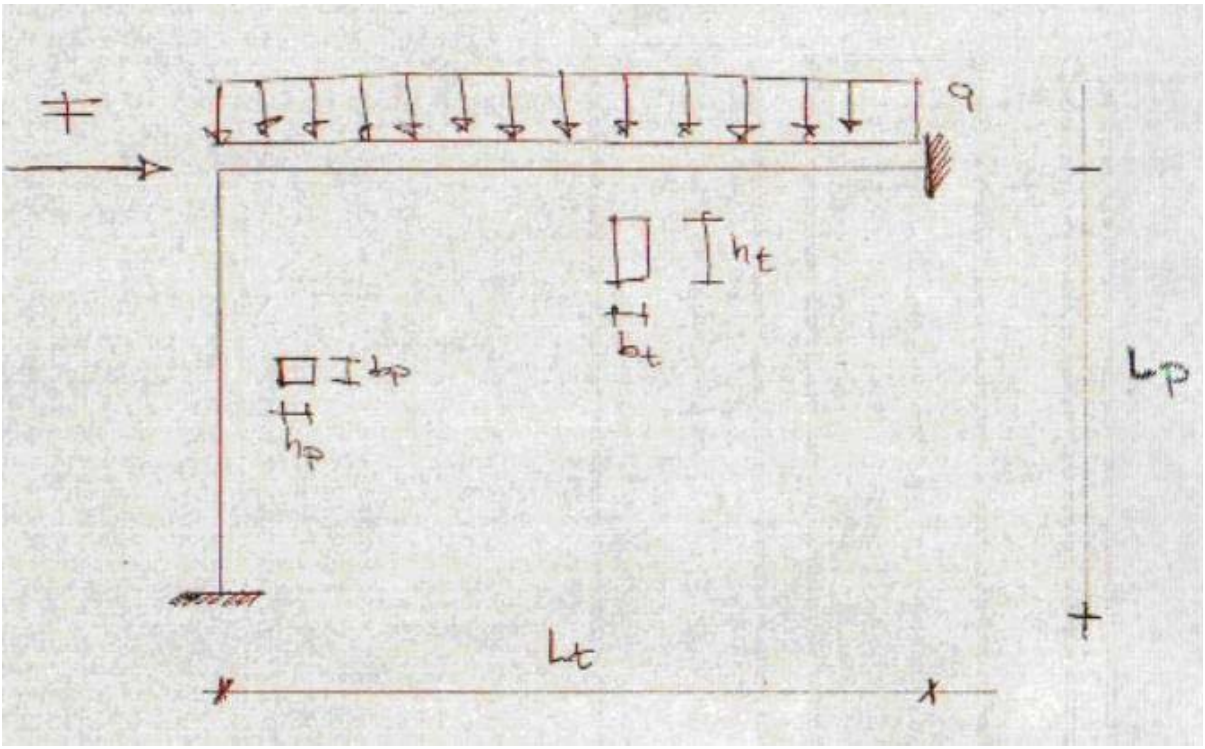
Applicazione del metodo di soluzione matriciale dei telai piani



à Dati

ü Grandezze geometriche

ü Pilastro

```
bp = 300;
hp = 300;
Lp = 3000;
```

ü Trave

```
bt = 300;
ht = 500;
Lt = 5000;
```

ü Carichi

ü Forza concentrata

```
F = 10000;
```

ü Carico distribuito

```
q = 50;
```

ü Materiali

```
fck = 20;
Ec = N@9500 Hfck + 8L ^ H1 ê 3LD
```

```
28847.6
```

à Caratteristiche delle sezioni

ü Pilastro

```
EAp = Ec bp hp;
EIp = Ec bp hp^3 ê 12;
```

ü Trave

```
EAt = Ec bt ht;
EIt = Ec bt ht^3 ê 12;
```

à Matrici di rigidezza locali

ü Espressione generale

```
K@EA_, EI_, L_D :=
 88EA ê L, 0, 0, -EA ê L, 0, 0<, 80, 12 EI ê L^3, 6 EI ê L^2, 0, -12 EI ê L^3, 6 EI ê L^2<,
  80, 6 EI ê L^2, 4 EI ê L, 0, -6 EI ê L^2, 2 EI ê L<, 8-EA ê L, 0, 0, EA ê L, 0, 0<,
  80, -12 EI ê L^3, -6 EI ê L^2, 0, 12 EI ê L^3, -6 EI ê L^2<,
  80, 6 EI ê L^2, 2 EI ê L, 0, -6 EI ê L^2, 4 EI ê L<<
```

```
MatrixForm@K@EA, EI, LDD
```

$$\begin{pmatrix} \frac{EA}{L} & 0 & 0 & -\frac{EA}{L} & 0 & 0 \\ 0 & \frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} & 0 & -\frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{4\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{2\,EI}{L} \\ -\frac{EA}{L} & 0 & 0 & \frac{EA}{L} & 0 & 0 \\ 0 & -\frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} & 0 & \frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{2\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{4\,EI}{L} \end{pmatrix}$$

ü Matrice di rigidezza del pilastro

```
KP = K@EAp, EIp, LpD;
```

ü Matrice di rigidezza della trave

```
KT = K@EAt, EIt, LtD;
```

ü Vettore delle azioni di incastro perfetto sulla trave

```
Q0T = 80, q Lt ê 2, q Lt^2 ê 12, 0, q Lt ê 2, -q Lt^2 ê 12<
```

$$\left\{0,\ 125000,\ \frac{312500000}{3},\ 0,\ 125000,\ -\frac{312500000}{3}\right\}$$

à Matrice di rigidezza globale

```
KGlob = Table@Table@0, 8j, 1, 9<D, 8i, 1, 9<D;
s = 8u1, v1, fi1, u2, v2, fi2, u3, v3, fi3<;
FGlob = Table@0, 8i, 1, 9<D;
F0Glob = Table@0, 8i, 1, 9<D;
```

à Matrici di rotazione

ü Espressione generale

```
T@Alpha_D :=
 88Cos@AlphaD, Sin@AlphaD, 0, 0, 0, 0<, 8-Sin@AlphaD, Cos@AlphaD, 0, 0, 0, 0<,
  80, 0, 1, 0, 0, 0<, 80, 0, 0, Cos@AlphaD, Sin@AlphaD, 0<,
  80, 0, 0, -Sin@AlphaD, Cos@AlphaD, 0<, 80, 0, 0, 0, 0, 1<<
```

ü Espressione pilastro

```
TP = T@Pi ê 2D;
MatrixForm@TPD
```

$$\begin{pmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

ü Espressione trave

```
TT = T@0D;
MatrixForm@TTD
```

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

à Rotazione ed assemblaggio

ü Rotazione e assemblaggio matrice pilastro

```
KP = Transpose@TPD.KP.TP;
MatrixForm@KPD
```

$$\begin{pmatrix} 8654.28 & 0. & -1.29814\times10^{7} & -8654.28 & 0. & -1.29814\times10^{7} \\ 0. & 865428. & 0. & 0. & -865428. & 0. \\ -1.29814\times10^{7} & 0. & 2.59628\times10^{10} & 1.29814\times10^{7} & 0. & 1.29814\times10^{10} \\ -8654.28 & 0. & 1.29814\times10^{7} & 8654.28 & 0. & 1.29814\times10^{7} \\ 0. & -865428. & 0. & 0. & 865428. & 0. \\ -1.29814\times10^{7} & 0. & 1.29814\times10^{10} & 1.29814\times10^{7} & 0. & 2.59628\times10^{10} \end{pmatrix}$$

```
For@i = 1, i <= 6,
  For@j = 1, j <= 6, KGlob@@i, jDD = KGlob@@i, jDD + KP@@i, jDD; j++D; i++D;
MatrixForm@
 KGlobD
```

$$\begin{pmatrix} 8654.28 & 0. & -1.29814\times10^{7} & -8654.28 & 0. & -1.29814\times10^{7} & 0 & 0 & 0 \\ 0. & 865428. & 0. & 0. & -865428. & 0. & 0 & 0 & 0 \\ -1.29814\times10^{7} & 0. & 2.59628\times10^{10} & 1.29814\times10^{7} & 0. & 1.29814\times10^{10} & 0 & 0 & 0 \\ -8654.28 & 0. & 1.29814\times10^{7} & 8654.28 & 0. & 1.29814\times10^{7} & 0 & 0 & 0 \\ 0. & -865428. & 0. & 0. & 865428. & 0. & 0 & 0 & 0 \\ -1.29814\times10^{7} & 0. & 1.29814\times10^{10} & 1.29814\times10^{7} & 0. & 2.59628\times10^{10} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

ü Rotazione e assemblaggio matrice trave

```
KT = Transpose@TTD.KT.TT;
MatrixForm@KTD
```

$$\begin{pmatrix} 865428. & 0. & 0. & -865428. & 0. & 0. \\ 0. & 8654.28 & 2.16357\times10^{7} & 0. & -8654.28 & 2.16357\times10^{7} \\ 0. & 2.16357\times10^{7} & 7.2119\times10^{10} & 0. & -2.16357\times10^{7} & 3.60595\times10^{10} \\ -865428. & 0. & 0. & 865428. & 0. & 0. \\ 0. & -8654.28 & -2.16357\times10^{7} & 0. & 8654.28 & -2.16357\times10^{7} \\ 0. & 2.16357\times10^{7} & 3.60595\times10^{10} & 0. & -2.16357\times10^{7} & 7.2119\times10^{10} \end{pmatrix}$$

```
For@i = 1, i <= 6,
 For@j = 1, j <= 6, KGlob@@i + 3, j + 3DD = KGlob@@i + 3, j + 3DD + KT@@i, jDD; j++D; i++D
MatrixForm@KGlobD
```

$$\begin{pmatrix} 8654.28 & 0. & -1.29814\times10^{7} & -8654.28 & 0. & -1.29814\times10^{7} & 0 \\ 0. & 865428. & 0. & 0. & -865428. & 0. & 0 \\ -1.29814\times10^{7} & 0. & 2.59628\times10^{10} & 1.29814\times10^{7} & 0. & 1.29814\times10^{10} & 0 \\ -8654.28 & 0. & 1.29814\times10^{7} & 874082. & 0. & 1.29814\times10^{7} & -865428. \\ 0. & -865428. & 0. & 0. & 874082. & 2.16357\times10^{7} & 0. \\ -1.29814\times10^{7} & 0. & 1.29814\times10^{10} & 1.29814\times10^{7} & 2.16357\times10^{7} & 9.80818\times10^{10} & 0. \\ 0 & 0 & 0 & -865428. & 0. & 0. & 865428. \\ 0 & 0 & 0 & 0. & -8654.28 & -2.16357\times10^{7} & 0. \\ 0 & 0 & 0 & 0. & 2.16357\times10^{7} & 3.60595\times10^{10} & 0. \end{pmatrix}$$

ü Rotazione e assemblaggio vettore azioni sulla trave

```
For@i = 1, i <= 6, F0Glob@@i + 3DD = F0Glob@@i + 3DD + Q0T@@iDD; i++D
```

```
F0Glob
```

$$\{0, 0, 0, 0, 125000, \frac{312500000}{3}, 0, 125000, -\frac{312500000}{3}\} =$$

ü Vettore delle azioni esterne

```
FGlob@@4DD = F;
FGlob
```

```
80, 0, 0, 10000, 0, 0, 0, 0, 0<
```

à Imposizione delle condizioni al contorno

```
For@i = 1, i ≤ 9, For@j = 1, j ≤ 9, If@i ≤ 3 »» i > 6 »» j ≤ 3 »» j > 6,
   If@i « j, KGlob@@i, jDD = 1, KGlob@@i, jDD = 0DD; j++D; i++D
```

```
MatrixForm@KGlobD
```

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 874082. & 0. & 1.29814\times10^{7} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0. & 874082. & 2.16357\times10^{7} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.29814\times10^{7} & 2.16357\times10^{7} & 9.80818\times10^{10} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

```
For@i = 7, i ≤ 9, F0Glob@@iDD = 0; i++D;
F0Glob
FGlob
```

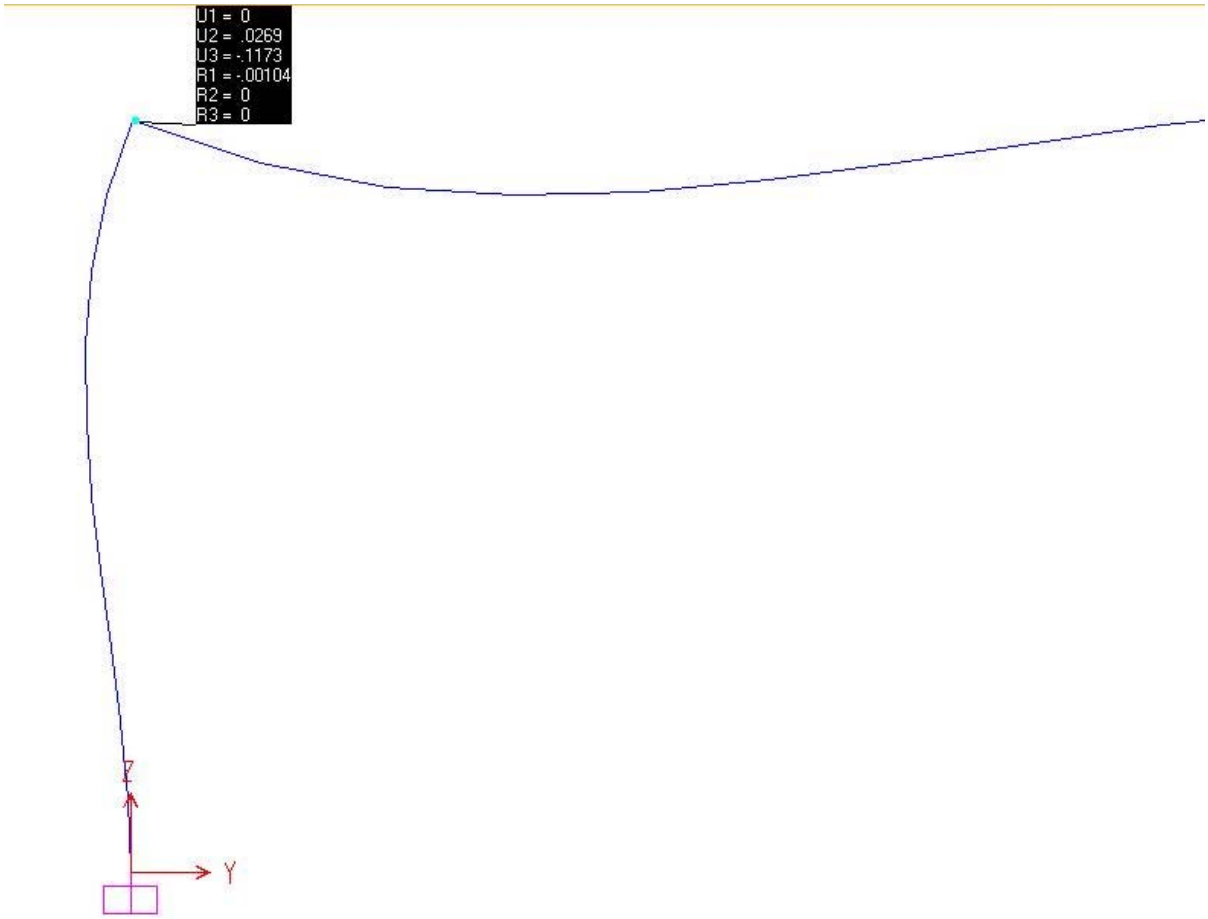
$$\{0, 0, 0, 0, 125000, \frac{312500000}{3}, 0, 0, 0\}$$

```
80, 0, 0, 10000, 0, 0, 0, 0, 0<
```

à Soluzione del sistema

```
Sol = Solve@KGlob.s « FGlob − F0Glob, sD êê Flatten;
sSol = s ê. Sol
```

```
80., 0., 0., 0.0268821, −0.117271, −0.00103973, 0., 0., 0.<
```



à Post-Processing: Calcolo delle forze nodali sulle aste

ü Trave

```
st = Table@sSol@@iDD, 8i, 4, 9<D
```

```
80.0268821, −0.117271, −0.00103973, 0., 0., 0.<
```

```
FT = KT.st + Q0T
```

```
823264.5, 101490., 2.66453×10^7, −23264.5, 148510., −1.44196×10^8<
```

ü Pilastro

```
sp = Table@sSol@@iDD, 8i, 1, 6<D;
```

FP = KP.sp

$$\{13264.5,\ 101490.,\ -1.31482\times10^{7},\ -13264.5,\ -101490.,\ -2.66453\times10^{7}\}$$