EXTRACTION OF FORCES IN BEAMS USING FLOOR PRO

WITH PARTICULAR REFERECE TO TORSION

This Technical Note explains how to obtain the values of computed forces in beams, when using the Floor Pro computer program. It covers both beams that are on their own (stand alone), and beams that are part of a floor system.

The first step in obtaining the computed actions in a beam is to make a cut (design section) at the location, where you want to know the values. Once a design section is made, the program calculates the resultant of all the forces that pass through the cut, and expresses them in six components acting at the centroid of the design section. The six components consist of three forces and three moments. The moment component normal to the face of the cut is reported as "torsion."

The important consideration in making a design section is to ensure that the section crosses the centerline of the beam(s), whose forces you want to capture. The following two examples illustrate the procedure.

STAND ALONE BEAMS

Figure 1 shows the plan of a cantilever beam that is subjected to a torque of 100 k-ft at its free end. At the other end, the beam is connected to a column that is fixed at its bottom end. The beam is 30 ft long and has a rectangular cross-section (2 ft by 4 ft).

FIGURE 1 PLAN OF CANTILEVER BEAM SUBJECTED
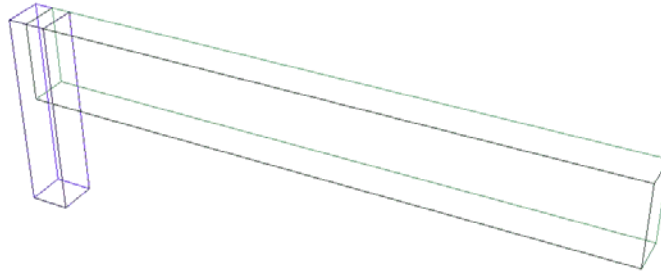TO TORSION AT FREE END

Figure 2 shows a 3D view of the beam

FIGURE 2 3D VIEW OF BEAM WITH APPLIED TORSION AT FREE END

Evidently, the value of the torsion along the entire length of the cantilever beam is constant at 100 k-ft. To illustrate the process, five design sections (beam cuts) are made. These are marked 1 through 5 and are shown in Fig. 1. The values for four of the six actions calculated by the program for each of these design sections are listed in Table 1.

Note in Table 1 that the value of torsion for design section 1 is zero, since the section does not cross the centerline of the beam. To include the beam, the section must intersect the beam's centerline.

Design section 2 is only slightly longer that section 1, but since it crosses the beam's centerline, it captures the entire torsion in the beam. The torsion reported in the table for this section is essentially 100 k-ft.

TABLE 1 VALUE OF COMPLUTED ACTIONS AT DESIGN SECTIONS

Design section	Moment	Shear	Axial	Torsion
	k-ft	k	k	k-ft
Design Section 1	0.000	0.000	0.000	0.000
Design Section 2	0.000	0.000	0.000	-99.998
Design Section 3	-0.126	0.000	0.000	-99.998
Design Section 4	70.618	0.000	-0.000	-70.801
Design Section 5	0.000	0.000	0.000	-99.998

Design section 3 covers the entire beam. Again, it captures the entire torsion. In connection with the three design sections 1 through 3, note that for this stand alone beam, the central criterion is whether the section crosses the beam's centerline or not. The length of the design section is not critical.

Section 4 is at 45 degrees to the axis of the beam. The applied torsion at the beam end translates to 100*cos(45) = 70.7 k-ft of torsion, along with a bending moment of the same value, as reported in the table.

Finally, a short design section (5) that intersects the beam centerline reports the entire torsion in the beam.

FLANGED BEAMS

Figure 3 shows a flanged beam. The flange represents the slab of a floor system. The beam is free at one end, where it is subjected to a torque of 100 k-ft. The value of torsion along the entire length of the structure remains unchanged. At the free end the torque is entirely resisted by the beam, but it diffuses partly into the flange with distance from the free end.

At the fixed end, the structure is supported by a wall (Fig. 4). The dimensions are: beam section 24x48 inch, beam length 30 ft; slab thickness 8 inch.
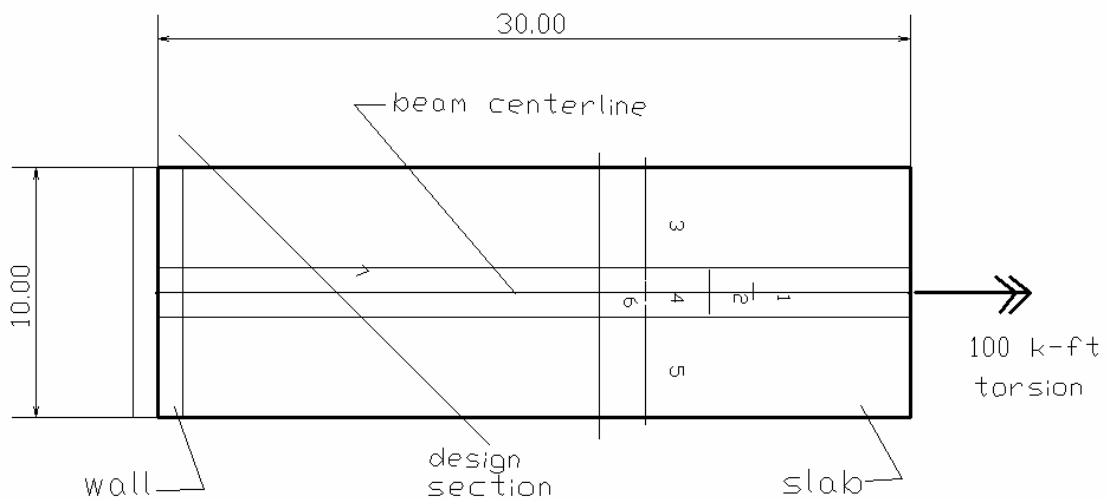

FIGURE 3 PLAN OF FLANGED CANTILEVER BEAM SUBJECTED
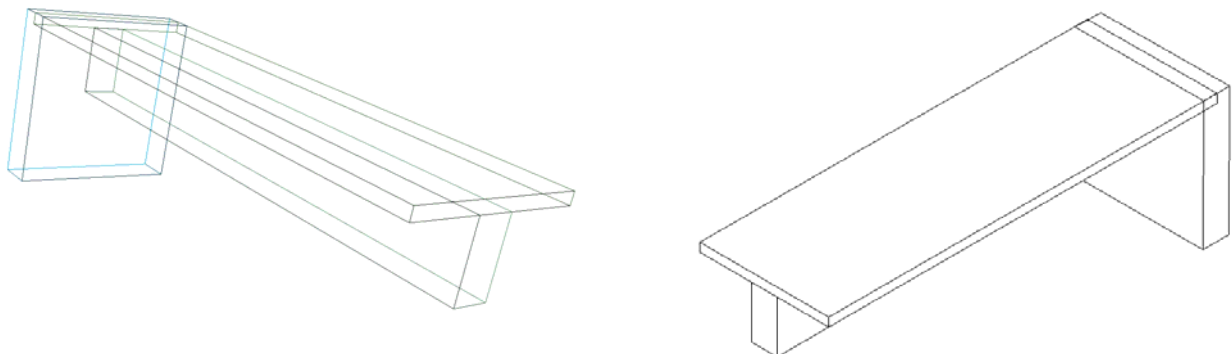TO A TORSION AT FREE END

FIGURE 4   3D VIEW OF THE FLANGED BEAM WITH APPLIED TORQUE
AT THE FREE END

Seven design sections are made to illustrate the concept. These are marked 1 through 7 in Fig. 1. The computed values reported by the program are listed in Table 2.

Unlike the stand alone beam of the previous example, in this case with distance from the free end, the torsion in the beam drops. This is observed in the values reported in Table 2 for sections 1, and 4 as 90.249, 89.249 k-ft. Section 2 is wider that 1 and captures some of the torsion in the flange.

Sections 3 and 5 report the amount of torsion diffused into the flanges. Note that the sum of the entire torsion across the flanged beam balances the torque applied at the member's end.

Section 3	4.908
Section 4	89.249
Section 5	4.901
Total	99.058

The above agrees with the value reported for section 6 as 99.283 that is equivalent to the sum of the sections 3, 4 and 5.

Section 7 is at 45 degrees to the axis of the member. The components of the torsion are reported as:

Bending   100 * cos (45) = 70.7 (reported 70.179 in the table)
Torsion   100* cos (45) = 70.7 (reported 70.222 in the table)

TABLE 2 VALUE OF COMPLUTED ACTIONS AT DESIGN SECTIONS

Design section	Moment	Shear	Axial	Torsion
	k-ft	k	k	k-ft
Design Section 1	0.053	-0.005	-0.036	-90.249
Design Section 2	0.038	-0.003	-0.025	-89.900
Design Section 3	0.397	-0.048	-0.566	-4.908
Design Section 4	0.018	-0.002	-0.013	-89.249
Design Section 5	-0.393	0.049	0.579	-4.901
Design Section 6	0.000	-0.000	-0.000	-99.283
Design Section 7	70.179	-0.000	0.316	-70.222