7-2-2 Zero-force Members

It is often the case that certain members of a given truss carry no load. Zero-force members in a truss usually arise in one of two general ways. The first is:

> When only two members form a noncollinear truss joint and no external load or support reaction is applied to the joint, then the members must be zero-force members.

The truss of Fig. 7-17*a* is an example of this condition. The free-body diagram of pin C is drawn in Fig. 7-17*b*. The equations of equilibrium for this joint

$$+\rightarrow \Sigma F = -T_{BC} - T_{CD}\cos 30° = 0$$
$$+\uparrow \Sigma F = -T_{CD}\sin 30° = 0$$

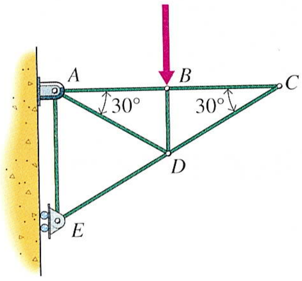
are trivially solved to get

$$T_{CD} = 0 \qquad \text{and} \qquad T_{BC} = 0$$

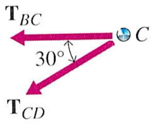
That is, for this particular truss and for this particular loading, the two members *BC* and *CD* could be removed without affecting the solution or even (in this particular case) the stability of the truss.

The second way in which zero-force members normally arise in a truss is:

> When three members form a truss joint for which two of the members are collinear and the third forms an angle with the first two, then the noncollinear member is a zero-force member provided no external force or support reaction is applied to that joint. The two collinear members carry equal loads (either both tension or both compression).



(*a*)



(*b*)

Fig. 7-17

Such a condition arises, for example, when the load of Fig. 7-17*a* is moved from pin *B* to pin C as in Fig. 7-18*a*. The free-body diagram of pin *B* is drawn in Fig. 7-18*b*. The equations of equilibrium for this joint are

$$+\rightarrow \Sigma F = -T_{AB} + T_{BC} = 0$$
$$+\uparrow \Sigma F = -T_{BD} = 0$$

Thus, since joint *B* is now unloaded, the force in member *BD* vanishes and the forces in members *AB* and *BC* are equal in magnitude—either both tension (both positive) or both compression (both negative).

Once it is known that *BD* is a zero-force member, the same reasoning can then be used to show that member *AD* carries no load. The free-body diagram of pin *D* is drawn in Fig. 7-18*c*. In order to simplify the calculations, coordinate axes are chosen along and normal to the collinear members *CD* and *DE*. The equations of equilibrium are then

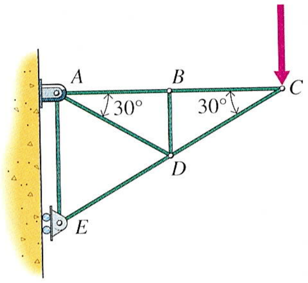
$$+\nearrow \Sigma F_x = -T_{DE} - T_{AD}\cos 60° + T_{BD}\cos 60° + T_{CD} = 0$$
$$+\nwarrow \Sigma F_y = T_{AD}\sin 60° + T_{BD}\sin 60° = 0$$

But since $T_{BD} = 0$ (*BD* is already known to be a zero-force member), then

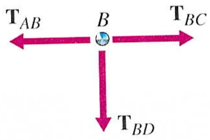
$$T_{AD} = 0 \qquad \text{and} \qquad T_{DE} = T_{CD}$$

Thus, for the loading of Fig. 7-18*a*, both members *AD* and *BD* are zero-force members.

These zero-force members cannot simply be removed from the truss and discarded, however. They are needed to guarantee the stabil-



(*a*)



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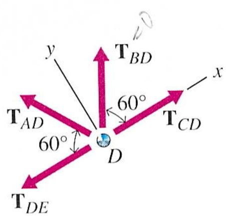
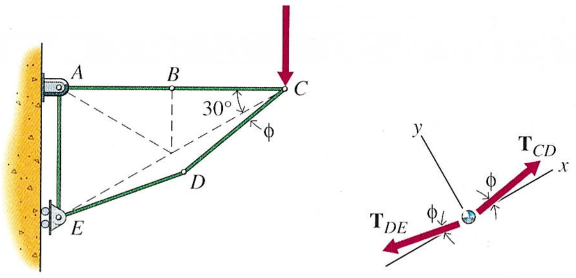


(*c*)

Fig. 7-18



(a) (b)

Fig. 7-19

ity of the truss. If members AD and BD were removed, there would be nothing to prevent some small disturbance from moving pin D slightly out of alignment as in Fig. 7-19*a*. Then the free-body diagram of pin D would look like Fig. 7-19*b*. Again choosing axes along and normal to the line CE gives the equilibrium equations

$$+\nearrow \Sigma F_x = -T_{DE}\cos\phi + T_{CD}\cos\phi = 0$$
$$+\nwarrow \Sigma F_y = T_{DE}\sin\phi + T_{CD}\sin\phi = 0$$

The first of these equations requires that $T_{CD} = T_{DE}$, whereas the second requires that $T_{CD} = -T_{DE}$. The only way both of these equations can be satisfied is if both forces equal zero. But equilibrium of pin C requires that T_{CD} not be zero. What has happened, of course, is that the truss is no longer in static equilibrium. Pin D will continue to buckle outward and the truss will collapse.

A seemingly trivial solution to the stability problem would be to replace the two members CD and DE with a single member CE and to replace the two members AB and BC with a single member AC. Though this solution would satisfy the statics part of the problem, it would not take care of the tendency for long slender members to buckle when subjected to large compressive loads. Therefore, long members such as member CE of Fig. 7-18 are usually replaced by a pair of shorter members and the midjoint braced if analysis of the truss indicates that the member is likely to be in compression for some expected loading. Long members such as member AC of Fig. 7-17 must also be replaced by a pair of shorter members and the midjoint braced if it is ever desired to load the truss at some point along the long member.

Thus one must not be too quick to discard truss members just because they carry no load for a given configuration. These members are often needed to carry part of the load when the applied loading changes, and they are almost always needed to guarantee the stability of the truss.

Although recognizing these and other special joint-loading conditions can simplify the analysis of a truss, such recognition is not required to solve the truss. If one does not recognize that a member is a zero-force member, drawing the free-body diagram and writing the equilibrium equations will immediately show that it is a zero-force member. Also, these shortcuts should be applied with care. If there is any doubt about whether or not a member is a zero-force member, the prudent choice is to draw the free-body diagram and solve for the member force.