DESIGN OF MEMBERS CONSISTING OF BEAMS AND SLABS

This narrative explains why the values obtained for design sections from the ADAPT-Builder Platform programs, in particular, FLOOR-Pro differ from the other commercially available programs, and further, why contrary to other commercially available programs, the results from the Builder Platform are correct. The discrepancy generally observed by the users of the software relates to floor systems that include both beams and slabs, or feature changes in slab elevation, such as steps.

In short, in the Builder Platform the programs recognize the continuity between the members that are cast monolithically, and are intended to jointly resist the applied loads. This feature is not accommodated in simplified formulation used in most commercially available programs. The following explains the concept details.

CONCEPT

Refer to Fig. 1-a. It illustrates two members (such as beams or slab regions) that are placed over one another and subjected to an applied load. If at interface the two members are not bonded together, each would act independently from the other in resisting the load, There will be slippage at the interface (Fig. 1-b). For the configuration shown in the figure, each member resists the load through bending (part ii of the same figure) developing high bending stresses. For the configuration shown, axial load in each member will be zero.

Figure 1-c shows the same two members, but in this instance they are bonded together at the interface. The two members will act compositely and resist the applied load jointly. The distribution of bending stress through the depth of the composite member will be continuous (part i of the figure). If viewed independently, the distribution of each layer consists of an axial force and bending (part ii). For each of the members, when viewed in isolation, the Builder programs report the distribution of stress shown in part (ii) of the figure. Generally, the axial forces shown are the principal means for developing the moment necessary to resist the applied load. Most other commercially available programs report a high bending stress and zero axial force (part b-ii).

BEAM AND SLAB FLOOR SYSTEMS

The common scenario encountered in practice is illustrated in Fig. 2, where beams and slabs are intended to act together. In this case, the entire flanged beam resists the applied loads. The distribution of stress in the slab will consist of bending stresses and axial compression as illustrated in (ii). Likewise, the distribution of stress in the stem will consist of bending part (iv) and axial force (iii).

If a you cut a design section that includes only the beam with or without a small portion of the flange, the forces reported by the Builder Playroom programs will show a net tension in addition to bending. Similarly a design section that includes only part of the slab, will show a net compression in addition to the bending. In practice, there will be a given width for a design section that includes both the flange and the beam stem, and for which the net axial force is zero. This design section represents the "effective width" of the flange acting with the stem.

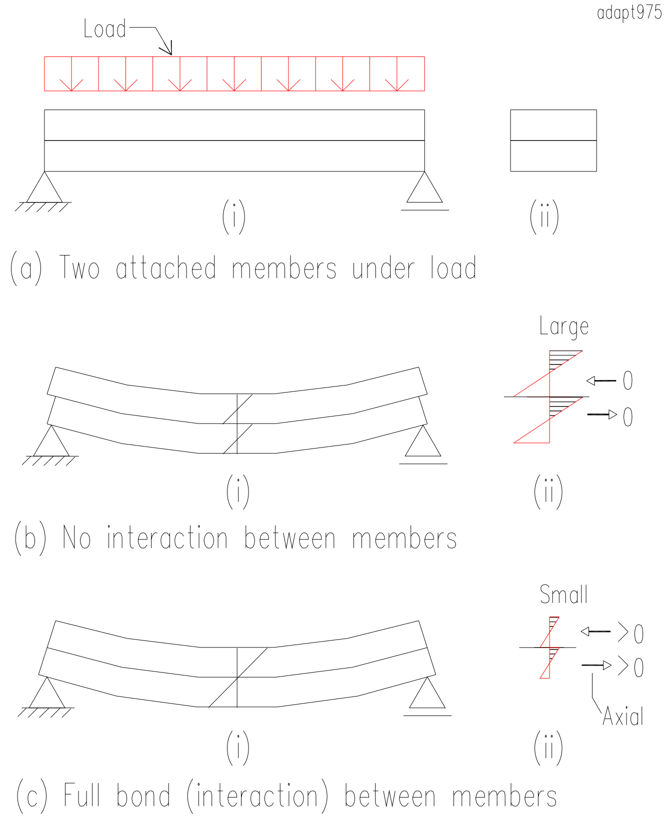

FIGURE 1 ATTACHED MEMBERS UNDER LOAD

It is important to recognize that, since the effective width of slab that acts with a beam stem is not known a-priori, it is impractical to expect designers to select the length of their design sections to match the effective width. To overcome this, the formulation developed for the determination of the strength reinforcement in the Builder Platform is such that, regardless of the width of a design section, be it limited to the stem of the beam or extend an arbitrary length over the slab, the program reports the correct same amount of reinforcement that associates with the effective width, and is needed for the safe design of the structure. In other words, it is not necessary for a user to be concerned about the width of the flange. This is further described in the Technical Note 228.

Essentially all other commercially available programs internally model the beam and slab as shown in Fig. 3. A separation between the slab and the beam allows each to displace independently from the other. When under pure bending, no axial force develops in either the beam or the slab. The elevation of the beam with respect to the slab becomes immaterial. Upturned and downturned beams exhibit the same response.

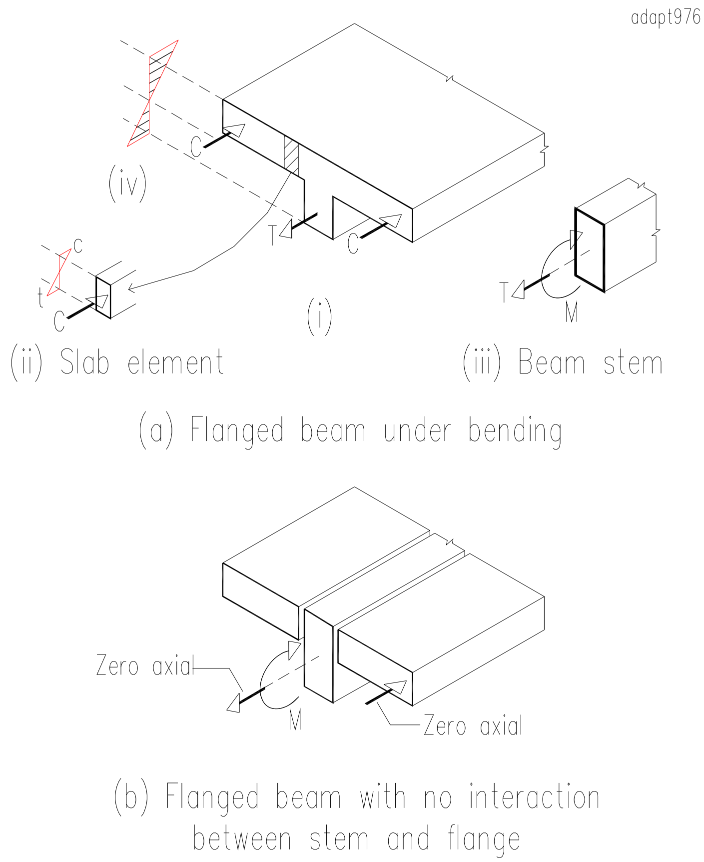

FIGURE 2 FLANGED BEAM WITH NO INTERACTION BETWEEN STEM AND FLANGE