equally among the plates. The solids slide down the plates into a collection hopper. Further thickening of the solids occurs in the hopper due to compression in the quiescent zone made possible by feeding the plates from the side rather than from the bottom. Plate packs can also be retrofitted into existing clarifiers to improve performance.

Cocurrent Settling. In cocurrent settling, the solids suspension is introduced above the inclined surfaces and the flow is down through the tubes or plates (see Fig. 5–26*b*). The time for a particle to settle the vertical distance between two surfaces is the same as for countercurrent settling. The length of surface needed, L_p, however, has to be based on downward and not upward liquid flow, as follows:

$$L_p = w\frac{(v_\theta - v\sin\theta)}{v\cos\theta} \tag{5–37}$$

Consequently, the condition for removal of particles is given by

$$v \geq \frac{v_\theta w}{L_p\cos\theta - w\sin\theta} \tag{5–38}$$

Cross-Flow Settling. In cross-flow settling, the liquid flow is horizontal and does not interact with the vertical settling velocity (see Fig. 5–26*c*). The length of the surface L_p is determined by

$$L_p = \frac{wv_\theta}{v\cos\theta} \tag{5–39}$$

and

$$v \geq \frac{v_\theta w}{L_p\cos\theta} \tag{5–40}$$

Hindered (Zone) Settling

In systems that contain a high concentration of suspended solids, both hindered or zone settling and compression settling usually occur in addition to discrete (free) and flocculent settling. The settling phenomenon that occurs when a concentrated suspension, initially of uniform concentration throughout, is placed in a graduated cylinder, is illustrated on Fig. 5–28. Because of the high concentration of particles, the liquid tends to move up through the interstices of the contacting particles. As a result, the contacting particles tend to settle as a zone or "blanket," maintaining the same relative position with respect to each other. The phenomenon is known as hindered settling. As the particles settle, a relatively clear layer of water is produced above the particles in the settling region. The scattered, relatively light particles remaining usually settle as discrete or flocculent particles, as discussed previously. In most cases, an identifiable interface develops between the upper region and the hindered settling region on Fig. 5–28. The rate of settling in the hindered settling region is a function of the concentration of solids and their characteristics.

As settling continues, a compressed layer of particles begins to form on the bottom of the cylinder in the compression settling region. The particles apparently form a struc-