(4.5 kN). In alluvial fan areas, nonwoody debris (stones and boulders) may present a much greater debris hazard. Debris weights in coastal areas generally fall into three classes: in the Pacific Northwest, a 4,000 lb (18.0 kN) debris weight due to large trees and logs can be considered typical; in other coastal areas where piers and large pilings are available locally, debris weights may range from 1,000 lb (4.5 kN) to 2,000 lb (9.0 kN); and in other coastal areas where large logs and pilings are not expected, debris will likely be derived from failed decks, steps, and building components and will likely average less than 500 lb (2.3 kN) in weight.

Debris Velocity. The velocity with which a piece of debris strikes a building or structure will depend upon the nature of the debris and the velocity of the floodwaters. Small pieces of floating debris, which are unlikely to cause damage to buildings or other structures, will typically travel at the velocity of the floodwaters, in both riverine and coastal flood situations. However, large debris, such as trees, logs, pier pilings, and other large debris capable of causing damage, will likely travel at something less than the velocity of the floodwaters. This reduced velocity of large debris objects is due in large part to debris dragging along the bottom and/or being slowed by prior collisions. Large riverine debris traveling along the floodway (the deepest part of the channel that conducts the majority of the flood flow) is most likely to travel at speeds approaching that of the floodwaters. Large riverine debris traveling in the floodplain (the shallower area outside the floodway) is more likely to be traveling at speeds less than that of the floodwaters, for those reasons stated in the preceding text. Large coastal debris is also likely to be traveling at speeds less than that of the floodwaters. Eq. C5-2 should be used with the debris velocity equal to the flow velocity because the equation allows for reductions in debris velocities through application of a depth coefficient, C_D, and an upstream blockage coefficient, C_B.

Duration of Impact. A detailed review of the available literature (Kriebel et al. 2000), supplemented by laboratory testing, concluded the previously suggested 1.0 s duration of impact is much too long and is not realistic. Laboratory tests showed that measured impact durations (from initial impact to time of maximum force Δt) varied from 0.01 s to 0.05 s (Kriebel et al. 2000). Results for one test, for example, produced a maximum impact load of 8,300 lb (37,000 N) for a log weighing 730 lb (3,250 N), moving at 4 ft/s, and impacting with a duration of 0.016 s. Over all the test conditions, the impact duration averaged about 0.026 s. The recommended value for use in Eq. C5-3 is therefore 0.03 s.

Coefficients C_I, C_O, C_D, and C_B. The coefficients are based in part on the results of laboratory testing and in part on engineering judgment. The values of the coefficients should be considered interim, until more experience is gained with them.

The *importance coefficient,* C_I, is generally used to adjust design loads for the structure category and hazard to human life following ASCE 7-98 convention in Table 1-1. Recommended values given in Table C5-1 are based on a probability distribution of impact loads obtained from laboratory tests in Haehnel and Daly (2001).

The *Orientation Coefficient,* C_O, is used to reduce the load calculated by Eq. C5-3 for impacts that are oblique, not head-on. During laboratory tests (Haehnel and Daly 2001) it was observed that, while some debris impacts occurred as direct or head-on impacts that produced maximum impact loads, most impacts occurred as eccentric or oblique impacts with reduced values of the impact force. Based on these measurements, an orientation coefficient of $C_O = 0.8$ has been adopted to reflect the general load reduction observed due to oblique impacts.

The *depth coefficient,* C_D, is used to account for reduced debris velocity in shallow water due to debris dragging along the bottom. Recommended values of this coefficient are based on typical diameters of logs and trees, or on the anticipated diameter of the root mass from drifting trees that are likely to be encountered in a flood hazard zone. Kriebel et al. (2000) suggests that trees with typical root mass diameters will drag the bottom in depths of less than 5 ft, while most logs of concern will drag the bottom in depths of less than 1 ft. The recommended values for the depth coefficient are given in Table C5-2 and Fig. C5-1. No test data are available to fully validate the recommended values of this coefficient. When better data are available, designers should use them in lieu of the values contained in Table C5-2 and Fig. C5-1.

The *blockage coefficient,* C_B, is used to account for the reductions in debris velocities expected due to screening and sheltering provided by trees or other structures within about 10 log-lengths (300 ft) upstream from the building or structure of interest. Kriebel et al. (2000) quotes other studies in which dense trees have been shown to act as a screen to remove debris and shelter downstream structures. The effectiveness of the screening depends primarily on the spacing of the upstream obstructions relative to the design log length of interest. For a 1,000 lb log, having a length of about 30 ft, it is therefore assumed