either striking or resting against a building, structure, or parts thereof, and (3) extreme impact loads, which result from very large objects, such as boats, barges, or collapsed buildings, striking the building, structure, or component under consideration. Design for extreme impact loads is not practical for most buildings and structures. However, in cases where there is a high probability that a Category III or IV structure (see Table 1-1) will be exposed to extreme impact loads during the design flood, and where the resulting damages will be very severe, consideration of extreme impact loads may be justified. Unlike extreme impact loads, design for special and normal impact loads is practical for most buildings and structures.

The recommended method for calculating normal impact loads has been modified beginning with ASCE 7-02. Previous editions of ASCE 7 used a procedure contained in U.S. Army Corps of Engineers (1995) (the procedure, which had been unchanged since at least 1972, relied on an impulse-momentum approach with a 1,000 lb (4.5 kN) object striking the structure at the velocity of the floodwater and coming to rest in 1.0 s). Work (Kriebel et al. 2000 and Haehnel and Daly 2001) has been conducted to evaluate this procedure, through a literature review and laboratory tests. The literature review considered riverine and coastal debris, ice floes and impacts, ship berthing and impact forces, and various methods for calculating debris loads (e.g., impulse-momentum, work-energy). The laboratory tests included log sizes ranging from 380 lb (1.7 kN) to 730 lb (3.3 kN) traveling at up to 4 ft/s (1.2 m/s).

Kriebel et al. 2000 and Haehnel and Daly 2001 conclude: (1) an impulse-momentum approach is appropriate; (2) the 1,000 lb (4.5 kN) object is reasonable, although geographic and local conditions may affect the debris object size and weight; (3) the 1.0-s impact duration is not supported by the literature or by laboratory tests—a duration of impact of 0.03 s should be used instead; (4) a half-sine curve represents the applied load and resulting displacement well; and (5) setting the debris velocity equivalent to the flood velocity is reasonable for all but the largest objects in shallow water or obstructed conditions.

Given the short-duration, impulsive loads generated by flood-borne debris, a dynamic analysis of the affected building or structure may be appropriate. In some cases (e.g., when the natural period of the building is much greater than 0.03 s), design professionals may wish to treat the impact load as a static load applied to the building or structure (this approach is similar to that used by some following the procedure contained in Section C5.3.3.5 of ASCE 7-98).

In either type of analysis—dynamic or static—Eq. C5-3 provides a rational approach for calculating the magnitude of the impact load.

$$F = \frac{\pi W V_b C_I C_O C_D C_B R_{max}}{2g\Delta t} \qquad \text{(C5-3)}$$

where

F = impact force, in lb (N)
W = debris weight in lb (N)
V_b = velocity of object (assume equal to velocity of water, V) in ft/s (m/s)
g = acceleration due to gravity, = 32.2 ft/s^2 (9.81 m/s^2)
Δt = impact duration (time to reduce object velocity to zero), in s
C_I = importance coefficient (see Table C5-1)
C_O = orientation coefficient, = 0.8
C_D = depth coefficient (see Table C5-2, Fig. C5-1)
C_B = blockage coefficient (see Table C5-3, Fig. C5-2)
$R_{\max}$ = maximum response ratio for impulsive load (see Table C5-4)

The form of Eq. C5-3 and the parameters and coefficients are discussed in the following text:

Basic Equation. The equation is similar to the equation used in ASCE 7-98, except for the π/2 factor (which results from the half-sine form of the applied impulse load) and the coefficients C_I, C_O, C_D, C_B, and

Table C5-1 Values of Importance Coefficient, C_I

Risk Category	C_I
I	0.6
II	1.0
III	1.2
IV	1.3

Table C5-2 Values of Depth Coefficient, C_D

Building Location in Flood Hazard Zone and Water Depth	C_D
Floodway or V-Zone	1.0
A-Zone, stillwater depth > 5 ft	1.0
A-Zone, stillwater depth = 4 ft	0.75
A-Zone, stillwater depth = 3 ft	0.5
A-Zone, stillwater depth = 2 ft	0.25
Any flood zone, stillwater depth < 1 ft	0.0