Determination of Site-Specific Loads for Residential Buildings in Coastal Areas

An Online Continuing Education Course for Engineers

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Determination of Site-Specific Loads for Residential Buildings in Coastal Areas

1 Introduction

This course provides the design professional and others with guidance on how to determine—by calculation or graphical interpretation—the magnitude of the loads placed on a building by a particular natural hazard event or a combination of events. The calculation methods presented in this course are intended to serve as the basis of a methodology for applying the calculated loads to the building during the design process.

NOTE

All coastal residential buildings should be designed and constructed to prevent flotation, collapse, or lateral movement due to the effects of wind and water loads acting simultaneously.

The flowchart in Figure 1 shows that the process for determining site-specific loads from natural hazards begins with **identifying the building codes** or **engineering standards** in place for the selected site. Be aware, however, that model building codes and other building standards may not provide load determination and design guidance for each of the hazards identified. In such instances, supplemental guidance should be sought.

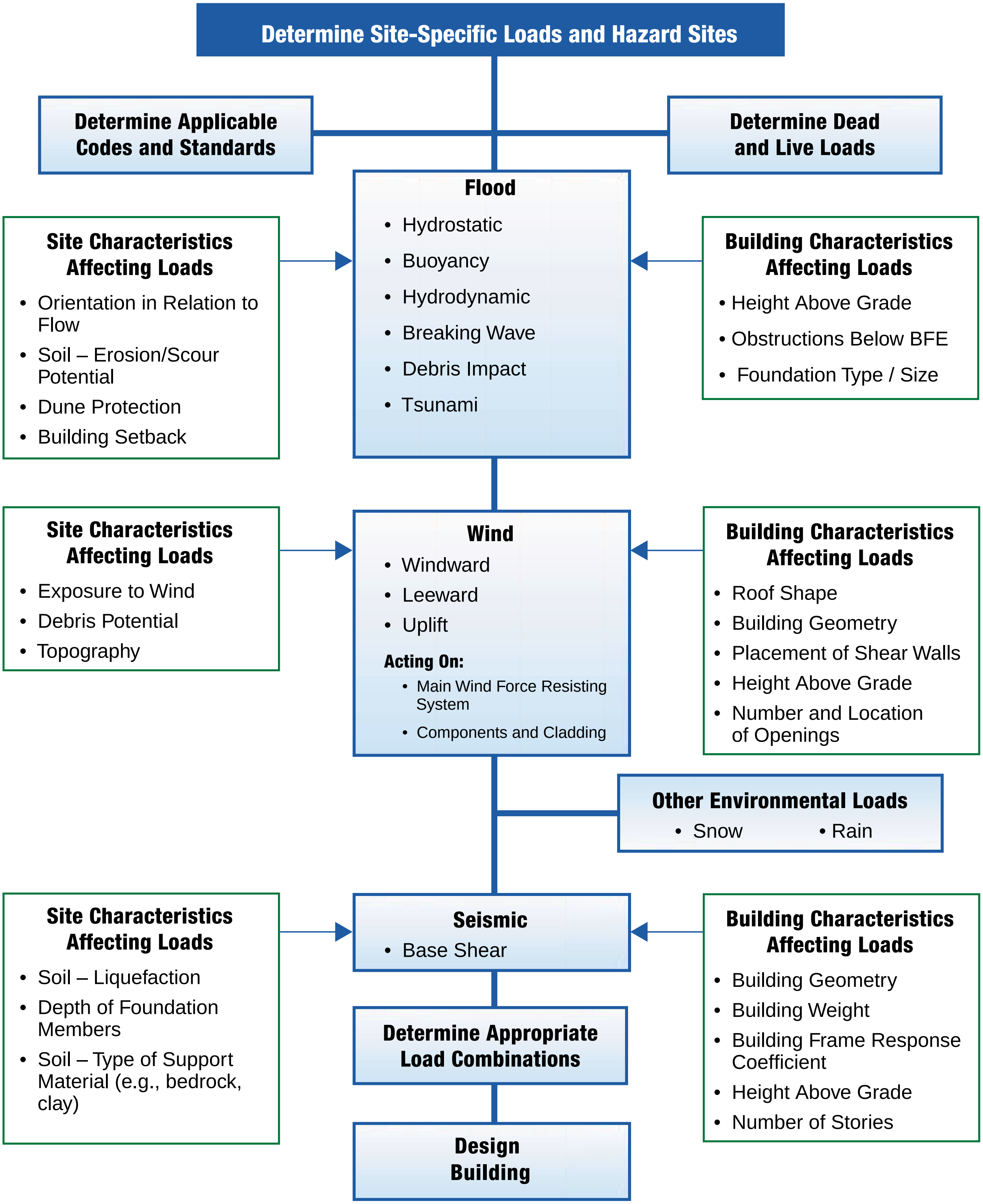
The procedure continues with the **calculation of the loads** imposed by each of the identified hazards. The final step is to determine the **load combinations** appropriate for the building site. It is possible that some loads will be highly correlated and can be assumed to occur simultaneously (such as during a hurricane, when high winds and flooding are closely related). Other loads, however, are weakly correlated, and their simultaneous occurrence is unlikely (e.g., seismic and flood loads).

The load combinations used in this course are those recommended in ASCE 7-05. All of the calculations, analyses, and load combinations presented in this course are based on **Allowable Stress Design** (ASD). The use of factored loads and Strength Design methods will require the designer to modify the approaches presented in this course to accommodate ultimate strength concepts.

NOTE

Throughout this course, the recommendations of the engineering standards ASCE 7-05, *Minimum Design Loads for Buildings and Other Structures* will be followed unless otherwise noted. ASCE 7-05 includes procedures for calculating dead and live loads; loads due to soil pressure, fluids, wind, snow, atmospheric ice, and earthquake; and load combinations.

Figure 1 Load determination flowchart.



2 Dead Loads

The first step in determining the loads placed on a building is to determine the weight of the building and its appurtenances (i.e., dead load). The definition of dead load in ASCE 7-05 is "…the weight of all materials of construction incorporated into the building, including but not limited to walls, floors, roofs, ceilings, stairways, built-in partitions, finishes, cladding, and other similarly incorporated architectural and structural items, and fixed service equipment." The sum of the dead loads of all the individual components will equal the unoccupied weight of the building.

The total weight of a building is usually determined by multiplying the unit weight of the various building materials—expressed in pounds (lb) per unit area—by the surface area of those materials. This approach requires that the designer develop a complete list of all of the materials and determine their representative unit weights. Minimum design dead loads are included in ASCE 7-05, *Commentary*. Additional information about material weights can be found in *Architectural Graphic Standards* (Ramsey and Sleeper 1996) and numerous other texts. A simpler, alternative technique is to determine the surface area of building elements such as exterior walls, floors, and roofs and then develop an average unit weight for each. The total weight is equal to the unit weight of the element multiplied by the area of the element.

Determining dead loads is important for several reasons:

- Foundation size (e.g., footing width, pile embedment depth, number of piles) depends partly on dead load.
- Dead load counterbalances uplift forces due to buoyancy and wind.
- Dead load counterbalances wind and earthquake overturning moments.
- Dead load changes the response of the building to both seismic forces and impact forces generated by floating objects.

3 Live Loads

ASCE 7-05 defines live loads as "… those loads produced by the use and occupancy of the building … and do not include construction or environmental loads such as wind load, snow load, rain load, earthquake load, flood load, or dead load." The flood, wind, and earthquake loads referred to here are the natural hazard loads discussed in detail later in this course. For residential one- and two-family buildings, the uniformly distributed live load for habitable areas (except sleeping and attic areas) recommended by ASCE 7-05 is 40 lb/ft^2. For balconies and decks on one- and two-family buildings not exceeding 100 ft^2, the recommended uniformly distributed live load is 60 lb/ft^2. ASCE 7-05 contains no requirements for supporting a concentrated load in a residential building.

4 Concept of Tributary or Effective Area and Application of Loads to a Building

All loads (e.g., dead, live, snow, flood, wind, seismic) affect a building by acting on some area of the building and being transferred to the structural member(s) that supports that area. Loads are usually applied to a “tributary” area, or the smallest area of the building supported by a structural member. Seismic loads, however, are usually distributed through larger building areas such as an entire roof or floor area. For example, when taken as part of the structural frame, a roof truss spaced 24 inches on center (o.c.) and spanning 30 feet has a tributary area of 2 feet x 30 feet or 60 ft^2. In this example, one half of the applied load is carried on each supporting wall. Figure 2 illustrates tributary areas for roof loads, lateral wall loads, and column or pile loads. The concept of loads being carried by a tributary area is important to the concept of “continuous load path."

ASCE 7-05 uses effective wind area to define the area of a building component or cladding element that will be affected by wind. Component and cladding elements include items such fasteners, panels, studs, trusses, and window and door mullions. The effective wind area may be the same as the tributary area defined above or, for areas supported by long, slender members (e.g., studs, trusses), may be taken to be at least one third the length of the area (span of the member). Thus, effective area is used only in the determination of the gust coefficient GC_p.

5 Snow Loads

Snow loads are applied as a vertical load on the roof or other flat, exposed surfaces such as porches or decks. Recommended ground snow loads are normally specified by the local building code or building official; however, ASCE 7-05 includes a map of the United States with recommended snow loads that can be used in the absence of local snow load information. The weight of snow is added to the building weight when the seismic force is determined. The *International Building Code* 2000, hereafter referred to as the IBC contains information about how to apply snow loads for this purpose.

CROSS-REFERENCE

See ASCE 7-05 and Section 8.2 of this course for additional information regarding effective wind area.

Figure 2 Examples of tributary areas for different structural members.