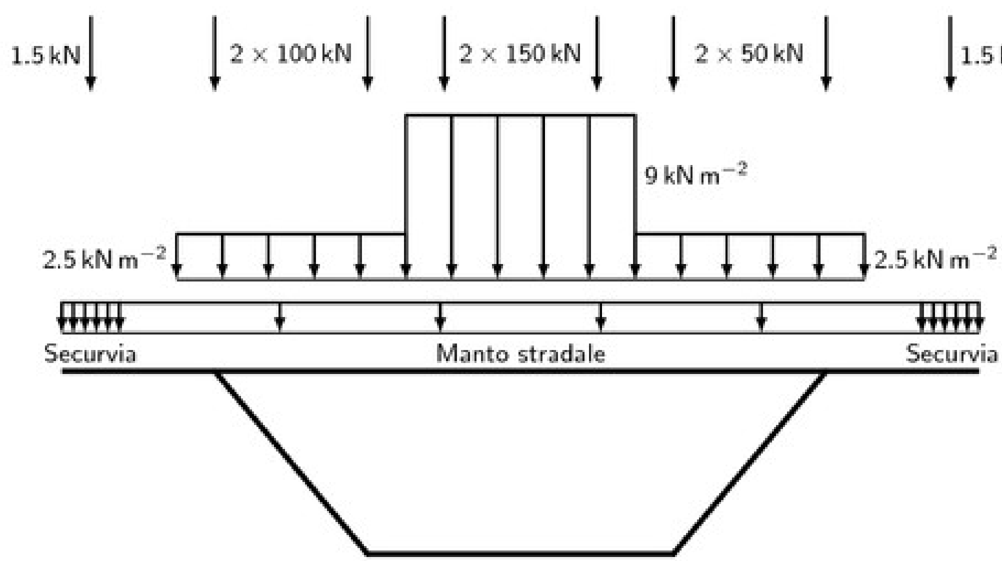
2024

LOADS

&

TYPES OF LOADS



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LOADS

&

TYPES OF LOADS

Introduction

The world of civil engineering is a fascinating dance between design, materials, and the invisible forces that act upon them. These forces, known as **loads**, are the primary consideration for any civil engineer, as they determine the strength, stability, and ultimately, the safety of a structure.

This discussion delves into the world of loads, exploring their various types and their profound impact on the design and construction of civil engineering marvels, from towering skyscrapers to sprawling bridges. We will explore the fundamental categories of loads, their characteristics, and how they are accounted for during the design process.

By understanding these invisible forces, we gain a deeper appreciation for the intricate calculations and meticulous planning that goes into every civil engineering project, ensuring that the structures we interact with every day can withstand the diverse challenges they face.

In engineering, **loads** refer to the **forces, deformations, or accelerations** that are applied to a structure or its elements. These loads can cause various effects on the structure, including:

- **Stress:** This is the internal force per unit area that arises due to the load.
- **Deformation:** This is the change in the shape or size of the structure under the load.
- **Displacement:** This is the movement of the structure or its elements due to the load.

Understanding and analyzing loads are crucial steps in various engineering disciplines, especially:

- **Structural engineering:** This field focuses on designing and building structures that can safely withstand various loads throughout their lifespan.
- **Mechanical engineering:** This field deals with the design, development, and operation of machines and systems, which often experience various loads during their function.
- **Aerospace engineering:** This field involves designing and building aircraft and spacecraft, which face unique loads due to factors like air pressure, thrust, and gravity during operation.

Here are some **common types of loads** encountered in engineering:

- **Dead loads:** These are static forces that are constant over time, such as the weight of the structure itself, furniture, or occupants.
- **Live loads:** These are variable or moving loads, such as the weight of people on a floor, snow accumulation on a roof, or wind pressure on a building.
- **Impact loads:** These are sudden and short-duration forces, such as the shock from an earthquake or the impact of a dropped object.
- **Environmental loads:** These are loads caused by natural phenomena, such as wind pressure, rain, snow, and ice.

By understanding the different types of loads and their effects on structures, engineers can design safe, efficient, and reliable structures for various purposes.

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load—forces or other actions that result from the weight of all building materials, occupants, and their possessions, environmental effects, differential movement, and restrained dimensional changes; permanent loads are those loads in which variations over time are rare or of small magnitude; all other loads are variable loads.

loads—A number of definitions for loads are given as the Code contains requirements that are to be met at various load levels. The terms “dead load” and “live load” refer to the unfactored, sometimes called “service” loads specified or defined by the general building code. Service loads (loads without load factors) are to be used where specified in this Code to proportion or investigate members for adequate serviceability. Loads used to proportion a member for adequate strength are defined as factored loads. Factored loads are service loads multiplied by the appropriate load factors for required strength except wind and earthquake which are already specified as strength loads in ASCE/SEI 7. The factored load terminology clarifies where the load factors are applied to a particular load, moment, or shear value as used in the Code provisions.

LOADS:Forces or other actions that result from the weight of all building materials, occupants and their possessions, environmental effects, differential movement, and restrained dimensional changes. Permanent loads are loads in which varia tions over time are rare or of small magnitude. All other loads are variable loads (see also nominal loads).

NOMINAL LOADS: The magnitudes of the loads specified in this standard for dead, live, soil, wind, tornado, snow, rain, f lood, and earthquake loads.

Symbols

The following symbols apply only to the provisions as indicated:

D=Dead load

F_x =Minimum design lateral force applied to level x of the structure and used for purposes of evaluating structural integrity in accordance

L=Live load

L_r =Roof live load

N =Notional load for structural integrity

R=Rain load

S =Snow load

W_x =Portion of the total dead load of the structure, D, located or assigned

to level x

1 – DEAD LOAD

In civil engineering, a **dead load** refers to the **permanent and static** weight or force acting on a structure. It remains **relatively constant** over time unless the structure itself undergoes modifications. Dead loads are crucial for engineers to consider when designing and building safe and stable structures.

Here are some key aspects of dead loads:

Examples of Dead Loads:

- **Structural elements:** The weight of the structure itself, including beams, columns, walls, slabs, foundations, and roofing materials.
- **Permanent fixtures:** Fixed features like stairs, railings, built-in furniture, and non-structural partitions.
- **Fixed building components:** Permanent building components like cladding, finishes, and plumbing systems.

Calculating Dead Loads:

Dead loads are typically calculated by multiplying the **volume** of each element by its **unit weight**. Unit weight refers to the weight of a material per unit volume and can be found from reference tables or material specifications.

Importance of Dead Loads:

- **Structural design:** Dead loads form the **base** for all other load calculations in structural design. They are crucial for determining the overall **strength and stability** requirements of a structure.
- **Foundation design:** Dead loads are critical for designing the **foundations** of a structure, which need to be able to safely support the entire weight of the building.
- **Member sizing:** Knowing the dead load helps engineers determine the **appropriate size** for structural members like beams

and columns to ensure they can handle the weight without excessive deflection or failure.

By understanding and accounting for dead loads accurately, civil engineers can design and build structures that are **safe, efficient, and durable** throughout their lifespan.

Dead load, also known as permanent or static load, refers to the weight of the structural components and other permanent elements of a building or structure that remain constant over time. These loads are typically self-weight and do not change significantly during the lifespan of the structure. Dead loads are an essential consideration in structural engineering and construction as they affect the design, stability, and safety of a structure.

Various types of dead loads can be categorized based on the nature and characteristics of the components they represent. Here are some examples:

1. Structural Dead Load: This type of dead load includes the weight of the structural elements of a building, such as columns, beams, slabs, walls, and the materials used to construct them. These loads are inherent to the structure and are always present. For instance, in a reinforced concrete building, the structural dead load includes the weight of the concrete and the reinforcing steel.
2. Partition Load: Partition walls are non-load-bearing walls that are used to divide the internal space of a building. Although they do not contribute significantly to the overall structural strength, they still add to the dead load of the structure. The weight of partition walls, along with any finishes applied to them, is considered a partition load.
3. Floor Finish Load: Floor finishes include materials like tiles, carpet, linoleum, or hardwood that are applied to the floor surface for functional or aesthetic purposes. The weight of these finishes contributes to the dead load of the floor system. For example, in a commercial building, the dead load would include the weight of the floor tiles or carpeting.
4. Built-in Services Load: Built-in services refer to permanent fixtures within a structure, such as HVAC (heating, ventilation, and air conditioning) systems, electrical conduits, plumbing pipes, ductwork, and fire suppression systems. These systems have their own weight and

contribute to the dead load. The weight of these components is accounted for in the design and construction of the structure.

5. Equipment Load: In certain structures, heavy equipment or machinery may be permanently installed. Examples include industrial equipment, generators, or large storage systems. The weight of such equipment is considered a dead load and must be factored into the design to ensure the structure can safely support it.

It's important to note that the specific dead loads in a structure may vary depending on the type of building, its purpose, and local building codes. Engineers and architects carefully calculate and consider these dead loads during the design phase to ensure the structural integrity and safety of the building throughout its lifespan.

DEAD LOADS

Definition Dead loads consist of 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 the weight of fixed service equipment, including cranes and material handling systems.

load, dead—

(a) the weights of the members, supported structure, and permanent attachments or accessories that are likely to be present on a structure in service; or

(b) loads meeting specific criteria found in the general building code; without load factors.

load, factored—load, multiplied by appropriate load factors.

load, self-weight dead—weight of the structural system, including the weight of any bonded concrete topping.

load, service—all loads, static or transitory, imposed on a structure or element thereof, during the operation of a facility, without load factors.

load, superimposed dead—dead loads other than the self-weight that are present or are considered in the design.

load effect —forces and deformations produced in structural members by applied loads or restrained volume changes.

load effect —Stresses and strains are directly related to forces and deformations and are considered as load effects.

load path—sequence of members and connections designed to transfer the factored loads and forces in such combinations as are stipulated in this Code, from the point of application or origination through the structure to the final support location or the foundation.

Loads shall include self-weight; applied loads; and effects of prestressing, earthquakes, restraint of volume change, and differential settlement.

Loads and Seismic Design Categories (SDCs) shall be in accordance with the general building code, or determined by the building official.

DEAD LOADS consist of the weight of all materials and fixed equipment incorporated into the building or other structure.

General. Dead loads are those loads defined in Chapter 2 of this code. Dead loads shall be considered to be permanent loads.

Weights of materials of construction. For purposes of design, the actual weights of materials of construction shall be used. In the absence of definite information, values used shall be subject to the approval of the building official.

Weight of fixed service equipment. In determining dead loads for purposes of design, the weight of fixed service equipment, including the maximum weight of the contents of fixed service equipment, shall be included. The components of fixed service equipment that are variable, such as liquid contents and movable trays, shall not be used to counteract forces causing overturning, sliding, and uplift conditions in accordance with Section 1.3.6 of ASCE 7.

Exceptions:

1. Where force effects are the result of the presence of the variable components, the components are permitted to be used to counter those load effects. In such cases, the structure shall be designed for force effects with the variable components present and with them absent.

2. For the calculation of seismic force effects, the components of fixed service equipment that are variable, such as liquid contents and movable trays, need not exceed those expected during normal operation.

Photovoltaic panel systems. The weight of photo voltaic panel systems, their support system, and ballast shall be considered as dead load.

Vegetative and landscaped roofs. The weight of all landscaping and hardscaping materials for vegetative and landscaped roofs shall be considered as dead load. The weight shall be computed considering both fully saturated soil and drainage layer materials and fully dry soil and drain age layer materials to determine the most severe load effects on the structure.

DEAD LOADS

General. Dead loads shall be as defined in Section 1602 and this section. 1606.2 Partition Loads. Floors in office buildings and other buildings where partition locations are subject to change shall be designed to support, in addition to all other loads, a uniformly distributed dead load equal to 20 pounds per square foot (psf) (0.96 kN/m2) of floor area.

EXCEPTION: Access floor systems shall be designed to support, in addition to all other loads, a uniformly distributed dead load not less than 10 psf (0.48 kN/m2) of floor area.

2 – LIVE LOAD

In civil engineering, **live load (LL)** refers to the **variable and temporary loads** acting on a structure due to **occupancy, use, or moveable elements**. Unlike dead loads, which are constant, live loads can **change in magnitude and location** over time and are often unpredictable.

Here are some key characteristics and examples of live loads:

- **Variable:** Live loads can **vary significantly** depending on the **intended use** of the structure and the **occupancy level**.
- **Examples:**
    - **Residential buildings:** Weight of people, furniture, appliances.
    - **Office buildings:** Weight of people, furniture, office equipment.
    - **Warehouses:** Weight of stored goods, material handling equipment.
    - **Roofs:** Weight of snow, ice, rain, and people performing maintenance.
    - **Bridges:** Weight of vehicles, pedestrians, and wind pressure.

Determining live loads for design purposes involves consulting **building codes and design standards** that specify minimum live load values for different types of structures and occupancies. These values are based on **engineering experience and statistical data** to account for typical usage scenarios and ensure safety.

Importance of live load:

- **Structural design:** Live loads are crucial for designing the **flexibility and strength** of a structure. They influence the design of beams, floors, and other elements to ensure they can handle the **anticipated** live loads without excessive deflection or failure.

- **Building codes:** Building codes establish **minimum live load requirements** for various types of structures, ensuring a **consistent level of safety** across different projects.
- **Safety considerations:** By considering live loads, engineers can design structures that can safely **accommodate the intended use** and avoid overloading or collapse.

Understanding and incorporating live loads is an essential step in ensuring the **safety, functionality, and efficient design of structures** in civil engineering.

LIVE LOADS

General. Live loads are those loads defined in Chapter 2 of this code.

Loads not specified. For occupancies or uses not designated in Section 1607, the live load shall be determined in accordance with a method approved by the building official.

Uniform live loads. The live loads used in the design of buildings and other structures shall be the maximum loads expected by the intended use or occupancy but shall not be less than the minimum uniformly distributed live loads.

Concentrated live loads. Floors, roofs and other similar surfaces shall be designed to support the uniformly distributed live loads prescribed in Section 1607.3 or the concentrated live loads, given in Table 1607.1, whichever produces the greater load effects. Unless otherwise specified, the indicated concentration shall be assumed to be uniformly distributed over an area of 21/2 feet by 21/2 feet (762 mm by 762 mm) and shall be located so as to produce the maximum load effects in the structural members.

Partition loads. In office buildings and in other buildings where partition locations are subject to change, provisions for partition weight shall be made, whether or not partitions are shown on the construction documents, unless the specified live load is 80 psf (3.83 kN/m2) or greater. The partition load shall be not less than a uniformly distributed live load of 15 psf (0.72 kN/m2).

1607.6 Helipads. Helipads shall be designed for the following live loads:

1. A uniform live load, L, as specified in Items 1.1 and 1.2. This load shall not be reduced.

1.1. 40 psf (1.92 kN/m2) where the design basis helicopter has a maximum take-off weight of 3,000 pounds (13.35 kN) or less.

1.2. 60 psf (2.87 kN/m2) where the design basis helicopter has a maximum take-off weight greater than 3,000 pounds (13.35 kN).

2. A single concentrated live load, L, of 3,000 pounds (13.35 kN) applied over an area of 4.5 inches by 4.5 inches (114 mm by 114 mm) and located so as to produce the maximum load effects on the structural elements under consideration. The concentrated load is not required to act concurrently with other uniform or concentrated live loads.

3. Two single concentrated live loads, L, 8 feet (2438 mm) apart applied on the landing pad (representing the helicopter's two main landing gear, whether skid type or wheeled type), each having a magnitude of 0.75 times the maximum take-off weight of the helicopter, and located so as to produce the maximum load effects on the structural elements under consideration. The concentrated loads shall be applied over an area of 8 inches by 8 inches (203 mm by 203 mm) and are not required to act concurrently with other uniform or concentrated live loads.

Landing areas designed for a design basis helicopter with maximum take-off weight of 3,000 pounds (13.35 kN) shall be identified with a 3,000-pound (13.34 kN) weight limitation. The landing area weight limitation shall be indicated by the numeral "3" (kips) located in the bottom right corner of the landing area as viewed from the primary approach path. The indication for the landing area weight limitation shall be a minimum 5 feet (1524 mm) in height.

Passenger vehicle garages. Floors in garages or portions of a building used for the storage of motor vehicles shall be designed for the uniformly distributed live loads indicated in Table 1607.1 or the following concentrated load:

1. For garages restricted to passenger vehicles accommodating not more than nine passengers, 3,000 pounds (13.35 kN) acting on an area of 4.5 inches by 4.5 inches (114 mm by 114 mm).

2. For mechanical parking structures without slab or deck that are used for storing passenger vehicles only, 2,250 pounds (10 kN) per wheel.

1607.8 Heavy vehicle loads. Floors and other surfaces that are intended to support vehicle loads greater than a 10,000 pound (4536 kg) gross vehicle weight rating shall comply with Sections 1607.8.1 through 1607.8.5.

Loads. Where any structure does not restrict access for vehicles that exceed a 10,000-pound (4536 kg) gross vehicle weight rating, those portions of the structure subject to such loads shall be designed using the vehicular live loads, including consideration of impact and fatigue, in accordance with the codes and specifications required by the jurisdiction having authority for the design and construction of the roadways and bridges in the same location of the structure.

Fire truck and emergency vehicles. Where a structure or portions of a structure are accessed and loaded by fire department access vehicles and other simi lar emergency vehicles, the structure shall be designed for the greater of the following loads:

1. The actual operational loads, including outrigger reactions and contact areas of the vehicles as stip ulated and approved by the building official.

2. The live loading specified in Section 1607.8.1.

LIVE LOADS are those loads produced by the use and occupancy of the building or other structure and do not include dead load, construction load, or environmental loads such as wind load, snow load, rain load, earthquake load or flood load.

LIVE LOADS

General. Live loads shall be the maximum loads expected by the intended use or occupancy but in no case shall be less than the loads required by this section.

LIVE LOAD: A load produced by the use and occupancy of the building or other structure that does not include construction or environmental loads, such as wind load, snow load, rain load, earthquake load, flood load, or dead load.

ROOF LIVE LOAD: A load on a roof produced (1) during maintenance by workers, equipment, and materials, and (2) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related. An occupancy-related live load on a roof such as rooftop assembly areas, rooftop decks, and vegetative or landscaped roofs with occupiable areas, is considered to be a live load rather than a roof live load.

load, live—

(a) load that is not permanently applied to a structure, but is likely to occur during the service life of the structure (excluding environmental loads); or

(b) loads meeting specific criteria found in the general building code; without load factors.

load, roof live—a load on a roof produced:

(a) during maintenance by workers, equipment, and materials, and

(b) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related; or loads meeting specific criteria found in the general building code; without load factors.

3 – FLOOD LOAD

In civil engineering, **flood load (FL)** refers to the **hydrodynamic and hydrostatic forces** exerted on a structure due to **flooding**. These forces can be significant and pose a threat to the safety and stability of structures located in floodplains or near bodies of water.

Here are some key characteristics of flood loads:

- **Transient:** Flood loads are **temporary and dynamic**, occurring only during flooding events and varying depending on the flood's characteristics (e.g., water depth, velocity, debris). They differ from dead and live loads, which are constant or variable but not transient.
- **Components:** Flood loads can be categorized into two main components:
    - **Hydrodynamic forces:** These are the **drag and uplift forces** exerted by flowing water on the structure. The magnitude is influenced by the water velocity, depth, and the shape of the structure.
    - **Hydrostatic pressure:** This is the **static pressure** exerted by the water on the submerged surfaces of the structure. The magnitude increases proportionally with the water depth.

Factors affecting flood loads:

- **Flood characteristics:** Water depth, velocity, and debris content significantly influence the magnitude and distribution of flood loads.
- **Structure geometry:** The shape, size, and orientation of the structure relative to the flow can significantly impact the forces experienced.
- **Foundation type:** The type of foundation (e.g., shallow, deep) can influence the stability and resistance of the structure to flood loads.

Importance of flood load:

- **Structural design:** Flood loads are critical for designing structures located in flood-prone areas. Ignoring them can lead to structural failures, posing safety hazards and causing significant damage.
- **Floodplain management:** Understanding flood loads is crucial for **floodplain management** practices, such as establishing setbacks, designing flood protection measures, and raising structures above flood levels.
- **Building codes:** Some building codes may have specific provisions for flood loads, requiring engineers to consider them in their designs for structures located in designated flood zones.

By incorporating flood load analysis into the design process, civil engineers can ensure that structures in flood-prone areas are **resilient, safe, and can withstand potential flooding events with minimal damage.**

FLOOD LOADS

DEFINITIONS The following definitions apply to the provisions of this chapter:

APPROVED:Acceptable to the Authority Having Jurisdiction.

BASE FLOOD: The flood having a 1% chance of being equaled or exceeded in any given year.

BASE FLOOD ELEVATION (BFE): The elevation of f looding, including wave height, having a 1% chance of being equaled or exceeded in any given year.

BREAK A WAY WALL : Any type of wall subject to flooding that is not required to provide structural support to a building or other structure and that is designed and constructed such that, under base flood or lesser flood conditions, it will collapse in such a way that (1) it allows the free passage of floodwaters, and (2) it does not damage the structure or supporting foundation system.

COASTAL A-ZONE: An area within a special flood hazard area, landward of a V-Zone or landward of an open coast without mapped V-Zones. To be classified as a Coastal A-Zone, the principal source of flooding must be astronomical tides, storm surges, seiches, or tsunamis, not riverine flooding, and the potential for breaking wave heights greater than or equal to 1.5 ft (0.46 m) must exist during the base flood.

COASTAL HIGH HAZARD AREA (V-ZONE): An area within a special flood hazard area, extending from offshore to the inland limit of a primary frontal dune along an open coast, and any other area that is subject to high-velocity wave action from storms or seismic sources. This area is designated on flood insurance rate maps (FIRMs) as V, VE, VO, or V1-30.

4 – SNOW LOAD

In civil engineering, **snow load (SL)** refers to the **weight of accumulated snow** acting on the **roof and other horizontal surfaces** of a structure. Snow load is a crucial consideration for ensuring the **structural integrity and safety** of buildings, especially in regions with significant snowfall.

Here's a breakdown of the key aspects of snow load:

Components:

- **Water weight:** The primary contributor to snow load is the **weight of the water** contained within the snowpack. As snow accumulates, the water content increases, leading to a **higher load** on the structure.
- **Snow density:** The density of snow varies depending on factors like temperature, wind, and the age of the snowpack. **Denser snow** will exert a **greater weight** compared to lighter, freshly fallen snow.

Factors influencing snow load:

- **Ground snow load:** This refers to the **maximum amount of snow expected to accumulate** on the ground in a given region over a specific period. It is typically determined by historical data and weather records.
- **Roof slope:** The **angle of the roof** plays a significant role in snow accumulation. Steeper roofs are less likely to retain snow due to **sliding and melting**, while flat roofs require careful consideration of snow load.
- **Drifting:** Wind can cause **snow to accumulate unevenly** on different parts of the roof, leading to **concentrated loads** in specific areas.

- **Rain-on-snow:** Rainfall on top of existing snow can create a **heavy, water-saturated layer** that significantly increases the load on the roof.

Importance of considering snow load:

- **Structural design:** Snow load is crucial for **designing the roof structure**, including beams, trusses, and support columns. Understanding the expected snow load allows engineers to ensure the roof can **safely support the weight** without collapsing or exceeding its capacity.
- **Building codes:** Most **building codes** in regions with snowfall specify **minimum snow load requirements** for structures. These requirements ensure that buildings can withstand the expected snow burden and maintain their safety.
- **Roof maintenance:** Knowing the snow load helps in determining the **maintenance needs** for roofs. Regular snow removal may be necessary in areas with high snow accumulation to prevent overloading and potential damage.

By considering and incorporating snow loads into the design process, civil engineers can help **ensure the safety and functionality** of structures in snowy regions. This prevents roof failures, minimizes maintenance needs, and contributes to **building resilient infrastructure** that can withstand the winter elements.

SNOW LOADS

General. Design snow loads shall be determined in accordance with Chapter 7 of ASCE 7, but the design roof load shall be not less than that determined .

Ground snow loads. The ground snow loads to be used in determining the design snow loads for roofs shall be determined in accordance with ASCE 7 or Figures 1608.2(1) and 1608.2(2) for the contiguous United States and Table 1608.2 for Alaska. Site-specific case studies shall be made in areas designated “CS” in Figures 1608.2(1) and 1608.2(2). Ground snow loads for sites at elevations above the limits indicated in Figures 1608.2(1) and 1608.2(2) and for all sites within the CS areas shall be approved. Ground snow load determination for such sites shall be based on an extreme value statistical analysis of data available in the vicinity of the site using a value with a 2-percent annual probability of being exceeded (50-year mean recurrence interval). Snow loads are zero for Hawaii, except in mountainous regions as approved by the building official.

1608.3 Ponding instability. Susceptible bays of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7.

Snow loads shall be determined in accordance with Chapter 16, Division II.

SNOW LOADS

Buildings and other structures and all portions thereof that are subject to snow loading shall be designed to resist the snow loads, as determined by the building official, in accordance with the load combinations set forth in Section 1612.2 or 1612.3.

Potential unbalanced accumulation of snow at valleys, parapets, roof structures and offsets in roofs of uneven configuration shall be considered.

ASCE DESIGN GROUND SNOW LOAD GEODATABASE: The ASCE database (version 2022-1.0) of geocoded values of risk-targeted design ground snow load values.

DRIFT : Theaccumulation of wind-driven snow that results in a local surcharge load on the roof structure at locations such as a parapet or roof step.

FLAT ROOF SNOW LOAD: Uniform load for flat roofs.

FREEZER BUILDINGS: Buildings in which the inside temperature is kept at or below freezing. Buildings with an air space between the roof insulation layer above and a ceiling of the freezer area below are not considered freezer buildings.

GROUND SNOW LOAD: The site-specific weight of the accumulated snow at the ground level used to develop roof snow loads on the structure.

MINIMUM SNOW LOAD : Snow load on low sloped roofs, including the roof snow load immediately after a single snow storm without wind. PONDING: Refer to definitions in Chapter 8, “Rain Loads.”

PONDING INSTABILITY :Refer to definitions in Chapter 8, “Rain Loads.”

R-VALUE: A measure of the resistance to heat flow through a roof component or assembly per unit area.

SLIPPERY SURFACE: Membranes with a smooth surface, for example, glass, metal, or rubber. Membranes with an embedded aggregate or mineral granule surface are not considered a slippery surface.

SLOPED ROOF SNOW LOAD : Uniform load on horizontal projection of a sloped roof, also known as the balanced load. VENTILATED ROOF: Roof that allows exterior air to naturally circulate between the roof surface above and the insulation layer below. The exterior air commonly flows from the eave to the ridge.

5 – RAIN LOAD

Rain load in civil engineering refers to the weight of rainwater that a roof structure needs to be designed to withstand. This is an important consideration as accumulated water can exert significant pressure and potentially lead to structural failure if not properly accounted for.

Here's a breakdown of the key aspects of rain load:

Understanding the source:

- Rain load arises from the scenario where the primary drainage system of a roof, like gutters and downspouts, becomes clogged or fails to function effectively. This leads to water accumulating on the roof surface.

Components of rain load:

- The total rain load is typically considered to be a combination of two components:
    - **Static head:** This is the weight of the water itself, calculated based on the depth of water accumulation on the roof.
    - **Hydraulic head:** This accounts for the additional pressure exerted by the water flowing towards the secondary drainage system (overflow outlets, scuppers, etc.) if the primary system is blocked.

Design considerations:

- Building codes and standards, like the International Building Code (IBC) and ASCE/SEI 7 (Minimum Design Loads and Associated Criteria for Buildings and Other Structures), provide guidelines for calculating and incorporating rain loads into structural design.
- These guidelines consider factors like:
    - Rainfall intensity in the specific location
    - Roof geometry and slope
    - Drainage area contributing to each secondary outlet

    - Capacity and type of secondary drainage system

Importance of rain load:

- Accounting for rain load is crucial for ensuring the safety and structural integrity of roofs.
- Neglecting it can lead to:
    - Roof deflection or sagging
    - Structural damage to beams, columns, and walls supporting the roof
    - Potential collapse in extreme cases

By understanding and incorporating rain load into the design process, civil engineers can ensure that buildings are built to withstand the potential weight of accumulated rainwater on their roofs.

RAIN LOADS

Design rain loads. Each portion of a roof shall be designed to sustain the load of rainwater as per the requirements of Chapter 8 of ASCE 7. The design rainfall shall be based on the 100-year 15-minute duration event, or on other rainfall rates determined from approved local weather data. Alternatively, a design rainfall of twice the 100-year hourly rainfall rate indicated in Figures 1611.1(1) through 1611.1(5) shall be permitted.

(Equation 16-19)

$R = 5.2(ds + dh)$

For SI: $R = 0.0098(ds + dh)$

where:

dh = Additional depth of water on the undeflected roof above the inlet of secondary drainage system at its design flow (in other words, the hydraulic head), in inches (mm).

ds = Depth of water on the undeflected roof up to the inlet of secondary drainage system when the primary drainage system is blocked (in other words, the static head), in inches (mm).

R = Rain load on the undeflected roof, in psf (kN/m2). Where the phrase "undeflected roof" is used, deflections from loads (including dead loads) shall not be considered when determining the amount of rain on the roof.

Ponding instability. Susceptible bays of roofs shall be evaluated for ponding instability in accordance with Chapters 7 and 8 of ASCE 7.

Controlled drainage. Roofs equipped with hardware to control the rate of drainage shall be equipped with a secondary drainage system at a higher elevation that limits accumulation of water on the roof above that elevation. Such roofs shall be designed to sustain the load of rainwater that will accumulate on them to the elevation of the secondary drainage system plus the uniform load caused by water that rises above the inlet of the secondary drainage system at its design flow determined from Section 1611.1. Such roofs shall be checked for ponding instability in accordance with Section 1611.2.

RAIN LOADS

BAY:Aportion ofthe roof bounded by adjacent column lines or structural walls.

CONTROLLED FLOW ROOF DRAIN: A roof drain designed to intentionally regulate the rate of drainage.

PONDING: The accumulation of water caused by the deflection of the roof structure, resulting in added load.

PONDING INSTABILITY: Member instability caused by progressive deflection because of ponding on roofs.

PRIMARY DRAINAGE SYSTEM: Roof drainage system through which water is normally conveyed off the roof.

SECONDARY DRAINAGE SYSTEM FOR STRUCTURAL LOADING (SDSL): Roof drainage system through which water is drained from the roof when the drainage systems listed in Section 8.2 (a) through (d) are blocked or not working.

SECONDARY MEMBER: For the purposes of Section 8.3, structural members not having direct attachment to the columns.

Symbols

d_h =Hydraulic head equal to the depth of water on the unde f lected roof above the inlet of the secondary drainage system for structural loading (SDSL) required to achieve the design f low, in. (mm)

d_s =Static head equal to the depth of water on the undeflected roof up to the inlet of the secondary drainage system for structural loading (SDSL), in. (mm)

d_p =Ponding head equal to the depth of water due to deflections of the roof subjected to unfactored rain load and unfactored dead load in. (mm)

L_s =Span of secondary members, in. (mm)

S =Spacing of secondary members, in. (mm)

R=Rain load, lb⁄ft2 (kN⁄m2)

6 – ICE LOAD
ATMOSPHERIC ICING

Ice loads, also known as **atmospheric icing loads**, are the weight of ice that accumulates on a structure due to freezing rain, freezing fog, or sleet. These loads are often overlooked in structural engineering but can be critical for specific structures, especially those that are:

- **Lightweight:** Transmission lines, power lines, communication towers, and some roof structures are particularly vulnerable to the added weight of ice as they are typically designed to handle lighter loads.
- **Large surface area:** Signs, billboards, and even some roofs with large, flat areas can experience significant ice accumulation, leading to increased stress on the structure.

Here's a closer look at ice loads:

Formation:

- Ice forms on exposed surfaces when freezing rain, freezing fog, or sleet comes into contact with the structure and freezes.

Impact:

- The weight of the ice can increase the stress on the structural members, potentially leading to:
    - Bending and deformation of beams and columns.
    - Buckling of members, especially those with slender profiles.
    - Failure of connections and joints.

Design considerations:

- Similar to rain loads, ice loads are determined based on:
    - **Local historical data or building codes:** This helps establish the design ice thickness, which is the predicted

maximum ice accumulation for a specific location and return period (e.g., 50-year ice storm).

    - **Surface geometry:** The shape and slope of the structure influence ice accumulation, with horizontal or low-sloped surfaces being more prone to accumulating thicker ice.

- **Standards and regulations:** Building codes like the International Building Code (IBC) and design standards like ASCE 7 (Minimum Design Loads for Buildings and Other Structures) provide guidelines for calculating and applying ice loads in structural design.

Importance:

- Ignoring ice loads during design can lead to catastrophic failures, particularly for structures sensitive to additional weight.
- Proper consideration of ice loads ensures the safety and functionality of structures in regions prone to freezing precipitation, preventing potential damage and economic losses.

GENERAL

Atmospheric ice loads caused by freezing rain, snow, and in-cloud icing shall be considered in the design of ice-sensitive structures. In areas where records or experience indicate that snow or in-cloud icing produces larger loads than freezing rain, site-specific studies shall be used. Structural loads caused by hoarfrost are not a design consideration. Roof snow loads are covered in Chapter 7.

ATMOSPHERIC ICE LOADS

General. Ice-sensitive structures shall be designed for atmospheric ice loads in accordance with Chapter 10 of ASCE 7.

7 – SEISMIC LOAD

Seismic load, in civil engineering, refers to the **forces exerted on a structure** during an earthquake. These forces, caused by the **ground shaking** from the earthquake, can be significant and pose a major threat to the stability and safety of buildings and other structures.

Here's a breakdown of the key points about seismic loads:

Origin:

- **Ground motion** caused by the movement of tectonic plates during an earthquake.
- This movement translates into **vibrations and accelerations** that are transmitted to the foundation of the structure.

Types of seismic load:

- **Inertial forces:** These are the most significant seismic loads and act horizontally on the structure, causing it to **sway** back and forth. They are proportional to the **mass** of the structure and the **acceleration** of the ground motion.
- **Vertical seismic loads:** These act **upwards** and **downwards** due to the vertical component of ground motion, but they are typically much smaller than the inertial forces.

Design considerations:

- **Seismic hazard analysis:** This involves studying the historical earthquake activity in the region and estimating the **ground motion** parameters for future earthquakes.
- **Building codes and standards:** These regulations, like ASCE 7 in the US, provide guidelines for calculating seismic loads based on the **location**, **soil type**, **occupancy**, and **structural characteristics**.
- **Structural design:** Structures in earthquake-prone zones are designed to **resist and absorb** seismic loads. This often involves

using **lateral load-resisting systems** like shear walls, braced frames, and moment-resisting frames.

Importance:

- Accurately calculating and accounting for seismic loads is crucial for ensuring the **safety and performance** of structures during earthquakes.
- Proper consideration of seismic loads helps to:
  - **Minimize the risk of structural collapse or damage** during an earthquake.
  - **Protect life and property** by ensuring the safety of building occupants and minimizing infrastructure damage.
  - **Improve the resilience** of structures, allowing them to withstand an earthquake and continue to function afterwards.

Seismic loads are a critical aspect of civil engineering in earthquake-prone regions, and understanding them is essential for designing safe and reliable structures.

EARTHQUAKE LOADS

Scope. Every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with Chapters 11, 12, 13, 15, 17 and 18 of ASCE 7, as applicable. The seismic design category for a structure is permitted to be determined in accordance with Section 1613 or ASCE 7.

Exceptions:

1. Detached one- and two-family dwellings, assigned to Seismic Design Category A, B or C, or located where the mapped short-period spectral response acceleration, SS , is less than 0.4 g.

2. The seismic force-resisting system of wood-frame buildings that conform to the provisions of Section 2308 are not required to be analyzed as specified in this section.

3. Agricultural storage structures intended only for incidental human occupancy.

4. Structures that require special consideration of their response characteristics and environment that are not addressed by this code or ASCE 7 and for which other regulations provide seismic criteria, such as vehicular bridges, electrical transmission towers, hydraulic structures, buried utility lines and their appurtenances and nuclear reactors.

5. References within ASCE 7 to Chapter 14 shall not apply, except as specifically required herein.

Seismic ground motion values. Seismic ground motion values shall be determined in accordance with this section.

Mapped acceleration parameters. The parameters SS and S1 shall be determined from the 0.2 and 1 second spectral response accelerations shown on Figures 1613.2.1(1) through 1613.2.1(10). Where S1 is less than or equal to 0.04 and SS is less than or equal to 0.15, the structure is permitted to be assigned Seismic Design Cate gory A.

Site class definitions. Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E or F in accordance with Chapter 20 of ASCE 7.

Where the soil properties are not known in sufficient detail to determine the site class, Site Class D, subjected to the requirements of Section 1613.2.3, shall be used unless the building official or geotechnical data deter mines that Site Class E or F soils are present at the site.

Where site investigations that are performed in accordance with Chapter 20 of ASCE 7 reveal rock conditions consistent with Site Class B, but site-specific velocity measurements are not made, the site coefficients Fa and Fv shall be taken at unity (1.0).

Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. The maximum considered earthquake spec tral response acceleration for short periods, SMS , and at 1 second period, SM1 , adjusted for site class effects shall be determined by Equations 16-20 and 16-21, respectively:

SMS = Fa SS

SM1 = Fv S1

(Equation 16-20)

(Equation 16-21) but SMS shall not be taken less than SM1 except when determining the seismic design category in accordance with Section 1613.2.5.

where:

Fa = Site coefficient defined in Table 1613.2.3(1).

Fv = Site coefficient defined in Table 1613.2.3(2).

SS = The mapped spectral accelerations for short periods as determined in Section 1613.2.1.

S1 = The mapped spectral accelerations for a 1-second period .

Where Site Class D is selected as the default site class per Section 1613.2.2, the value of Fa shall be not less than 1.2. Where the simplified design procedure of ASCE 7 Section 12.14 is used, the value of Fa shall be determined in accordance with ASCE 7 Section 12.14.8.1, and the values of Fv , SMS and SM1 need not be determined.

Design spectral response acceleration parameters. Five-percent damped design spectral response acceleration at short periods, SDS , and at 1-second period, SD1 , shall be determined from Equations 16-22 and Equation 16-23, respectively:

SDS = 2 3---SMS

(Equation 16-22)

SD1 = 2 3---SM1

(Equation 16-23)

where:

SMS = The maximum considered earthquake spectral response accelerations for short period as determined in Section 1613.2.3.

SM1 = The maximum considered earthquake spectral response accelerations for 1-second period as determined in Section 1613.2.3.

Determination of seismic design category. Structures classified as Risk Category I, II or III that are located where the mapped spectral response acceleration parameter at 1-second period, S1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Structures classified as Risk Category IV that are located where the mapped spectral response acceleration parameter at 1-second period, S1 , is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. Other structures shall be assigned to a seismic design category based on their risk category and the design spectral response acceleration parameters, SDS and SD1 , determined in accordance with Section 1613.2.4 or the site-specific procedures of ASCE 7. Each building and structure shall be assigned to the more severe seismic design category in accordance with Table 1613.2.5(1) or 1613.2.5(2), irrespective of the fundamental period of vibration of the structure, T.

Alternative seismic design category determination. Where S1 is less than 0.75, the seismic design category is permitted to be determined from Table 1613.2.5(1) alone where all of the following apply:

1. In each of the two orthogonal directions, the approximate fundamental period of the structure, Ta , in each of the two orthogonal directions determined in accordance with Section 12.8.2.1 of ASCE 7, is less than 0.8 Ts determined in accordance with Section 11.8.6 of ASCE 7.

2. In each of the two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than Ts .

3. Equation 12.8-2 of ASCE 7 is used to determine the seismic response coefficient, Cs .

4. The diaphragms are rigid or are permitted to be idealized as rigid in accordance with Section 12.3.1 of ASCE 7 or, for diaphragms permitted to be idealized as flexible in accordance with Section 12.3.1 of ASCE 7, the distances between vertical elements of the seismic force resisting system do not exceed 40 feet (12 192 mm).

Simplified design procedure. Where the alternate simplified design procedure of ASCE 7 is used, the seismic design category shall be determined in accordance with ASCE 7.

SEISMIC DESIGN CRITERIA

The following definitions apply only to the seismic provisions of Chapters 11 through 22 of this standard.

ACTIVE FAULT: A fault determined to be active by the Authority Having Jurisdiction from properly substantiated data (e.g., most recent mapping of active faults by the US Geological Survey).

ADDITION: An increase in building area, aggregate floor area, height, or number of stories of a structure.

ALTERATION: Any construction or renovation to an existing structure other than an addition.

APPENDAGE: An architectural component such as a canopy, marquee, ornamental balcony, or statuary.

APPROVAL: The written acceptance by the Authority Having Jurisdiction of documentation that establishes the qualification of a material, system, component, procedure, or person to fulfill the requirements of this standard for the intended use.

ATTACHMENTS: Means by which nonstructural compo nents or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

BASE: The level at which the horizontal seismic ground motions are considered to be imparted to the structure.

BASESHEAR: Total design lateral force or shear at the base.

BOUNDARY ELEMENTS: Portions along wall and diaphragm edges for transferring or resisting forces. Boundary elements include chords and collectors at diaphragm and shear wall perimeters, edges of openings, discontinuities, and reentrant corners.

BUILDING: Any structure whose intended use includes shelter of human occupants.

CANTILEVERED COLUMN SYSTEM: A seismic force-resisting system in which lateral forces are resisted entirely by columns acting as cantilevers from the base.

CHARACTERISTIC EARTHQUAKE: An earthquake assessed for an active fault having a magnitude equal to the best estimate of the maximum magnitude capable of occurring on the fault but not less than the largest magnitude that has occurred historically on the fault.

COLLECTOR (DRAG STRUT, TIE, DIAPHRAGM STRUT): A diaphragm or shear wall boundary element parallel to the applied load that collects and transfers diaphragm shear forces to the vertical elements of the seismic force-resisting system or distributes forces within the diaphragm or shear wall.

COMPONENT: A part of an architectural, electrical, or mechanical system.

Component, Flexible: Nonstructural component that has a fundamental period greater than 0.06 s.

Component, Nonstructural: A part of an architectural, mechanical, or electrical system within or without a building or nonbuilding structure.

Component, Rigid: Nonstructural component that has a fundamental period less than or equal to 0.06 s.

Component, Rugged: A nonstructural component that has been shown to consistently function after design earthquake level or greater seismic events (based on past earthquake experience data or past seismic testing) when adequately anchored or supported. The classification of a nonstructural component as rugged shall be based on a comparison of the specific component with components of similar strength and stiffness. Common examples of rugged components are AC motors, compressors, and base-mounted horizontal pumps.

CONCRETE:

Plain Concrete: Concrete that is either unreinforced or contains less reinforcement than the minimum amount specified in ACI 318 for reinforced concrete.

Reinforced Concrete: Prestressed or non prestressed concrete reinforced with no less reinforcement than the minimum amount required by ACI 318 and designed on the assumption that the two materials act together in resisting forces.

CONSTRUCTION DOCUMENTS: The written, graphic, electronic, and pictorial documents describing the design, locations, and physical characteristics of the project required to verify compliance with this standard.

COUPLING BEAM : A beam that is used to connect adjacent concrete wall elements to make them act together as a unit to resist lateral loads.

8 – WIND LOAD

In civil engineering, **wind load** refers to the **pressure or force exerted by wind** on a structure. It's a crucial consideration during the design phase to ensure the **stability and safety** of buildings and other structures, especially in regions prone to strong winds.

Here's a breakdown of the key aspects of wind load:

Origin:

- Wind creates pressure as it flows around and over a structure. This pressure difference between the windward (facing the wind) and leeward (downwind) sides translates to a force acting on the structure.

Types of wind load:

- Wind load can manifest in different ways, each requiring specific design considerations:
    - **Uplift load:** This occurs on roofs and other horizontal surfaces where the wind pressure acting upwards can try to lift the structure.
    - **Shear load:** This is a horizontal force acting on the sides of a structure, pushing it in a direction parallel to the wind flow.
    - **Overturning moment:** The wind pressure can also create a twisting force that can cause the structure to overturn, particularly for tall and slender structures.

Design considerations:

- To account for wind loads, engineers consider various factors during the design process:
    - **Wind speed:** This is typically based on historical data and building codes, considering factors like **maximum wind**

gusts and **recurrence intervals** (e.g., 50-year return period).
  - **Structure size and shape:** Larger and more complex shapes generally experience higher wind loads.
  - **Local topography:** Surrounding terrain features can influence wind behavior and needs to be factored in.
  - **Building codes and standards:** Local regulations like the International Building Code (IBC) and design standards like ASCE 7 (Minimum Design Loads for Buildings and Other Structures) provide guidelines for calculating and applying wind loads in structural design.

Importance:

- Ignoring wind loads during design can lead to:
  - **Structural failures:** This can range from minor damage to complete collapse, especially during severe wind events.
  - **Safety hazards:** Wind-related failures can cause injuries or fatalities.
  - **Economic losses:** Damaged structures and infrastructure require repairs or replacement, resulting in significant financial implications.

By incorporating wind loads into the design process, civil engineers can create **wind-resistant structures** that can withstand the forces of wind and ensure the safety and functionality of buildings and infrastructure.

Applications. Buildings, structures and parts thereof shall be designed to withstand the minimum wind loads prescribed herein. Decreases in wind loads shall not be made for the effect of shielding by other structures.

Exposure categories. An exposure category shall be determined in accordance with the following:

Exposure B. For buildings with a mean roof height of less than or equal to 30 feet (9144 mm), Exposure B shall apply where the ground surface roughness, as defined by Surface Roughness B, prevails in the upwind direction for a distance of not less than 1,500 feet (457 m). For buildings with a mean roof height greater than 30 feet (9144 mm), Exposure B shall apply where Surface Roughness B prevails in the upwind direction for a distance of not less than 2,600 feet (792 m) or 20 times the height of the building, whichever is greater.

Exposure C. Exposure C shall apply for all cases where Exposure B or D does not apply.

Exposure D. Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance of not less than 5,000 feet (1524 m) or 20 times the height of the building, whichever is greater. Exposure D shall apply where the ground surface roughness immediately upwind of the site is B or C, and the site is within a distance of 600 feet (183 m) or 20 times the building height, whichever is greater, from an Exposure D condition as defined in the previous sentence.

WIND LOADS Wind loads shall be determined in accordance with Chapter 16, Division III.

PROCEDURES

Scope Buildings and other structures, including the main wind force resisting system (MWFRS) and all components and cladding (C&C) thereof, shall be designed and constructed to resist the wind loads determined in accordance with Chapters 26 through 31.

Risk Category III and IV buildings and other structures, including the MWFRS and all C&C thereof, shall also be designed and constructed to resist tornado loads determined in accordance with Chapter 32, as applicable.

The provisions of this chapter define basic wind parameters for use with other provisions contained in this standard.

ASCE WIND DESIGN GEODATABASE: The ASCE da tabase (version 2022-1.0) of geocoded wind speed design data.

ATTACHED CANOPY: A horizontal (maximum slope of 2%) patio cover attached to the building wall at any height; it is different from an overhang, which is an extension of the roof surface.

BASIC WIND SPEED, V: Three-second gust speed at 33 ft (10 m) above the ground in Exposure C (see Section 26.7.3) as determined in accordance with Section 26.5.1.

BUILDING, ELEVATED: A building supported on struc tural elements where wind can pass beneath the building.

BUILDING, ENCLOSED: A building that has the total area of openings in each wall that receives positive external pressure less than or equal to 4 ft2 (0.37 m2) or 1% of the area of that wall, whichever is smaller. This condition is expressed for each wall by the following equation:

Ao < 0.01Ag or4ft2 ð0.37m2Þ; whichever is smaller;

where Ao and Ag are as defined for Open Buildings.

BUILDING,LOW-RISE: An enclosed, partially enclosed, or partially open building that complies with the following conditions:

9 – SOIL LOAD

&

HYDROSTATIC PRESSURE

Lateral pressures. Foundation walls and retaining walls shall be designed to resist lateral soil loads from adjacent soil. Soil loads specified in Table 1610.1 shall be used as the minimum design lateral soil loads unless determined otherwise by a geotechnical investigation in accordance with Section 1803. Foundation walls and other walls in which horizontal movement is restricted at the top shall be designed for at-rest pressure. Retaining walls free to move and rotate at the top shall be permitted to be designed for active pressure. Lateral pressure from surcharge loads shall be added to the lateral soil load. Lateral pressure shall be increased if expansive soils are present at the site. Foundation walls shall be designed to support the weight of the full hydrostatic pressure of undrained backfill unless a drainage system is installed in accordance with Sections 1805.4.2 and 1805.4.3.

Exception: Foundation walls extending not more than 8 feet (2438 mm) below grade and laterally supported at the top by flexible diaphragms shall be permitted to be designed for active pressure.

Uplift loads on floor and foundations. Basement floors, slabs on ground, foundations, and similar approximately horizontal elements below grade shall be designed to resist uplift loads where applicable. The upward pressure of water shall be taken as the full hydrostatic pressure applied over the entire area. The hydrostatic load shall be measured from the underside of the element being evaluated. The design for upward loads caused by expansive soils shall comply with Section 1808.6.

10 – TSUNAMI LOADS

General. The design and construction of Risk Category III and IV buildings and structures located in the Tsunami Design Zones defined in the Tsunami Design Geodatabase shall be in accordance with Chapter 6 of ASCE 7, except as modified by this code.

11 – OTHER MINIMUM LOADS

General. In addition to the other design loads specified in this chapter, structures shall be designed to resist the loads specified in this section and the special loads set forth in Table 16-B.

Other Loads. Buildings and other structures and portions thereof shall be designed to resist all loads due to applicable fluid pressures, F, lateral soil pressures, H, ponding loads, P, and self-straining forces, T. See Section 1611.7 for ponding loads for roofs.

Impact Loads. Impact loads shall be included in the design of any structure where impact loads occur.

You can find common values of it in structural codes (usually expressed either concentrated or a planar load). Also, depending on the code you're using, there are additional standards to be observed. Some of these include live load reduction, instructions for roof loads, and distribution of loads.

References

- 2021 International Building Code | Chapter 2 Section 202: Formal Definition of Live Loads | Chapter 16 Section 1607: Live Loads
- American Society of Civil Engineers (ASCE) Standard 7-22 | *Minimum Design Loads for Buildings and Other Structures*: Chapter 4: Live Loads
- Eurocode (EN) 1991-1-1:2002 | *Actions on Structures*: Section 6: Imposed Loads on Buildings
- Japan Society of Civil Engineers | *Standard Specifications and Guidelines* | *Standard Specifications for Concrete Structures 2007 "Design"*: General Requirements 6.4.3 | *Standard Specifications for Steel and Composite Structures (First Edition, 2009): Volume III Design*: 2.4.5For certain structures like bridges, moving loads such as vehicles and railcars are the primary design loads for these structures. An example is the *design truck* which varies depending on the code.

- AASHTO Standard Specifications for Highway Bridges | Section 3 – Loads, Part A – Types of Loads | 3.7. Highway Loads
- AREMA Manual for Railway Engineering | Cooper E-Series Steam Locomotive
- Eurocode (EN) 1991-2: 2003 | Section 4: Road Traffic Actions and Other Actions Specifically for Load Bridges
- Japan Road Association | Specifications for Highway Bridges Part 1: Common | Chapter 2: Loads, 2.2.2 Live Load

- Connor, J. J., & Faraji, S. (2012). *Fundamentals of Structural Engineering*. Springer, Cham.
- Kassimali, A. (2010). *Structural Analysis*. Cengage Learning.
- ACI_318M_19_Building_Code_Requirements SI (International System of Units)
- UBC Uniform Building Code volume 2 – 1997
- Iraqi Seismic Code 2017