Chapter I: Types of the Structures and Loads

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Objectives

I

- To introduce the basic types of structures
- To provide a brief explanation of the various types of loads that must be considered for an appropriate analysis and design.

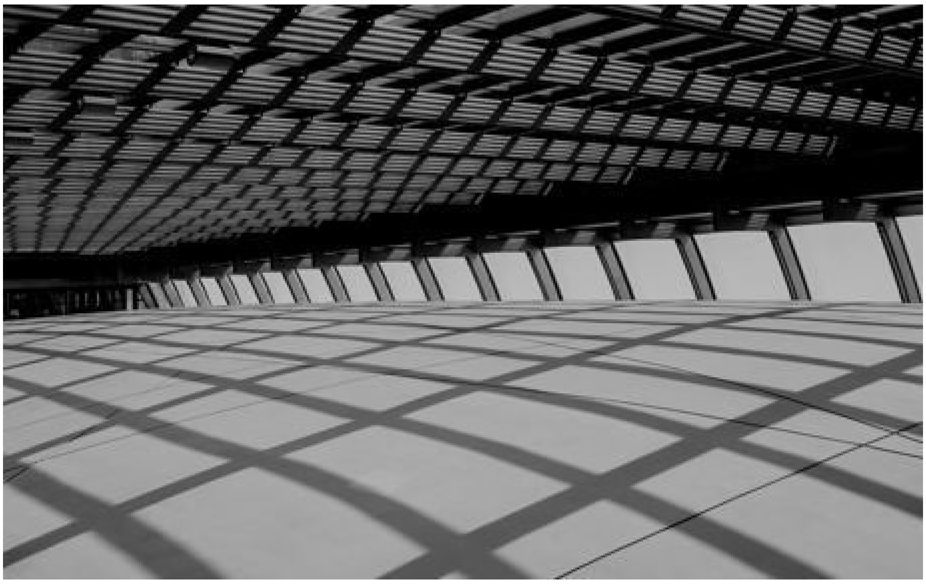
1. Introduction

II

A. 1.1. Definition

Definition

A **structure** refers to a system of connected parts used to support a load.

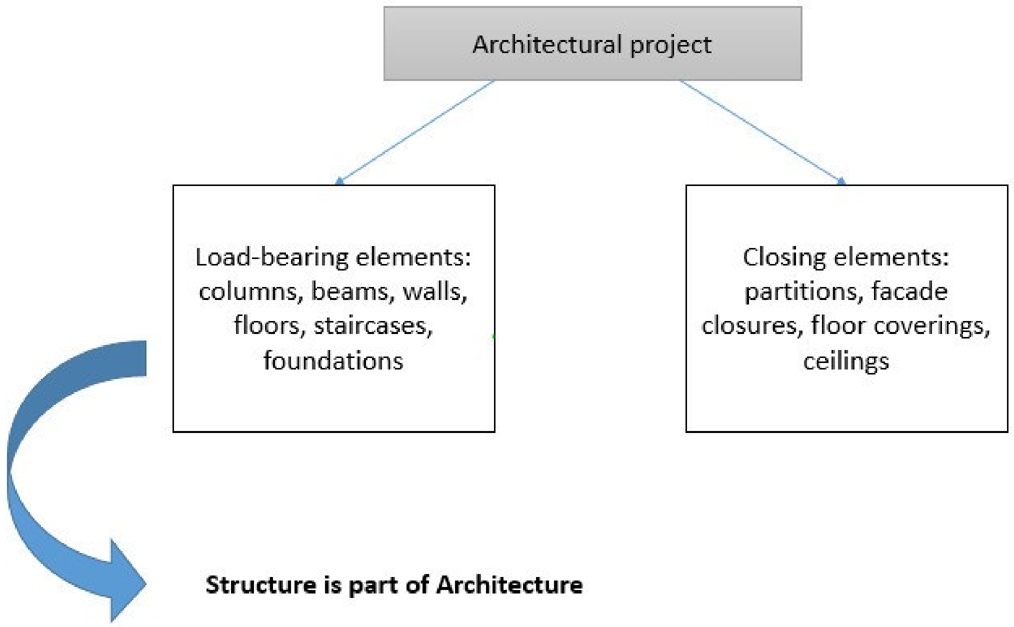


A well-designed structure must meet various requirements, here are some essential requirements that structures typically need to fulfill:

- **Structural Integrity**
- **Safety**
- **Compliance with Building Codes and Regulations**
- **Functional Requirements**
- **Durability**
- **Economic Viability**
- **Accessibility**
- **Architectural and Aesthetic Considerations**

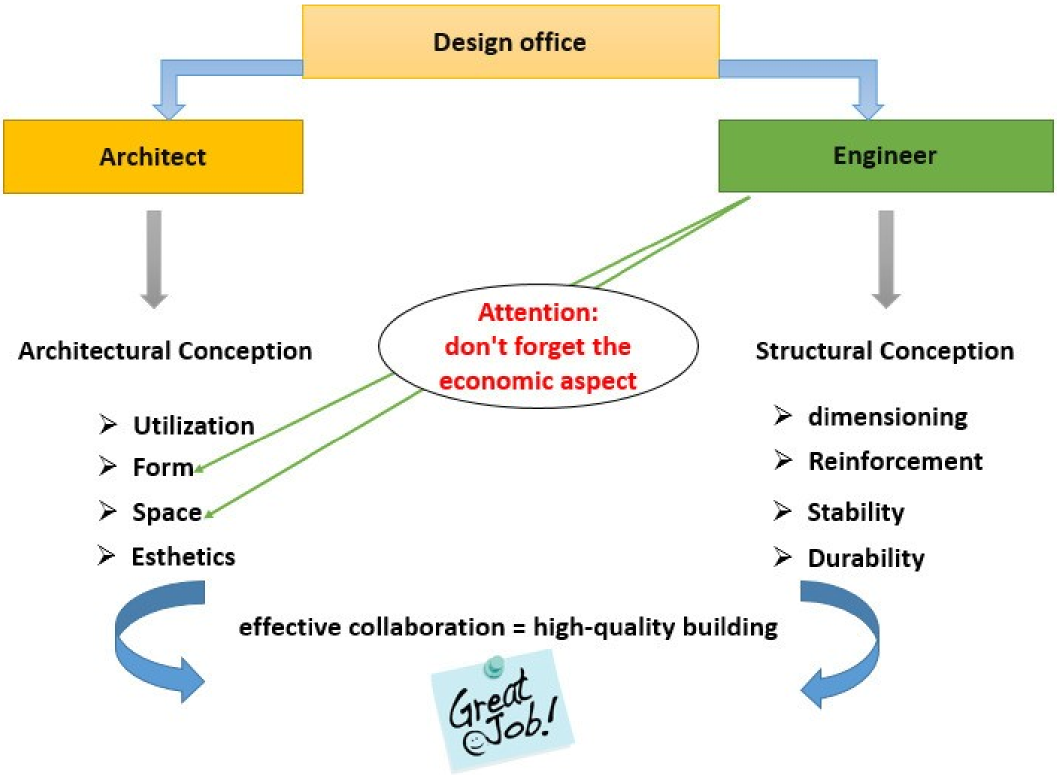
B. 1.2. What is the relationship between architecture and structure?

The relationship between architecture and structure:



C. 1.3. What is the relationship between an Architect and an Engineer?

The relationship between an Architect and an Engineer:


Design office
Architect
Engineer
Attention:
don't forget the
economic aspect
Architectural Conception
Utilization
Form
Space
Esthetics
Structural Conception
dimensioning
Reinforcement
Stability
Durability
effective collaboration = high-quality building
Great Job!

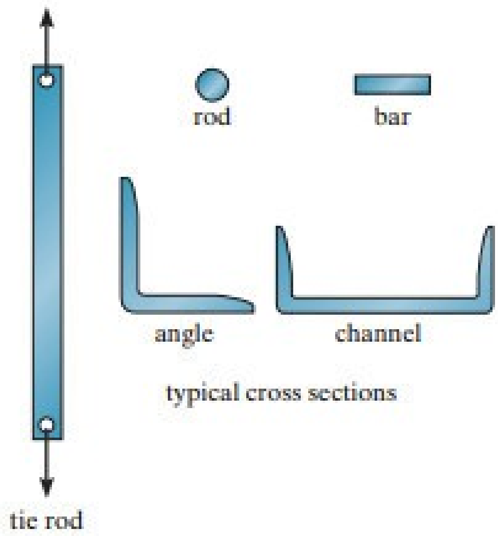
2. Types of Structures

III

A. 2.1. Structural elements

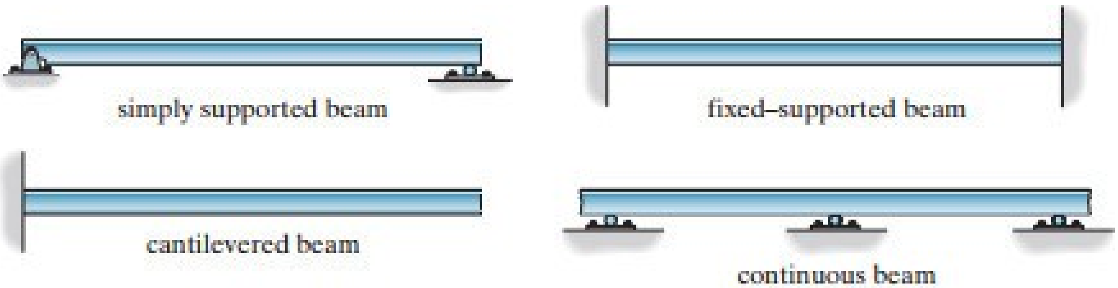
a. Tie rods

Structural members that are subjected to a tensile force are often referred to as tie rods or bracing struts. These members are rather slender, and are often chosen from rods, bars, angles, or channels.

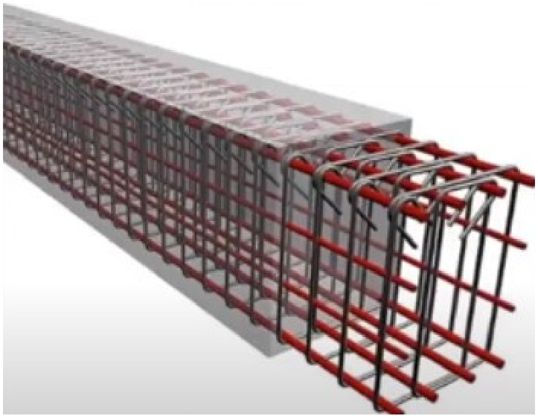


b. Beams

Are usually straight horizontal members used primarily to carry vertical loads. Quite often they are classified according to the way they are supported, as indicated in bellow figure.



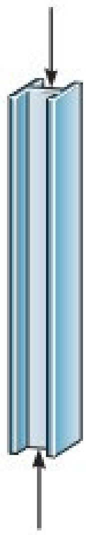
Beams are primarily designed to resist bending moment; however, if they are short and carry large loads, the internal shear force may become quite large and this force may govern their design.



Beams can be categorized according to materials which is used to made. Such as concrete beams, steel beams and timber beams.

c. Columns

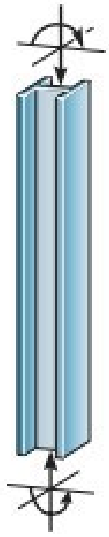
Members that are generally vertical and resist axial compressive loads are referred to as columns.



Tubes and wide flange cross sections are often used for metal columns, and circular and square cross sections with reinforcing rods are used for those made of

concrete.

Occasionally, columns are subjected to both an axial load and a bending moment as shown in the figure. These members are referred to as beam columns.



beam column

B. 2.2. Structural systems

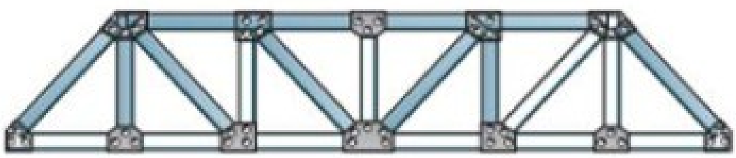
A combination of structural elements is referred to as a **structural system**.

a. Truss

Truss is a structure composed of members arranged in triangular patterns. Trusses are commonly used in the design of bridges, roofs, towers, and other structures due to their efficiency in distributing loads. The triangular arrangement of members provides inherent stability and strength.

There are various types of trusses based on their configuration and purpose, including:

Planar Trusses: All members and joints lie within a single plane.



Space Trusses: Members are located in three-dimensional space

b. Arch

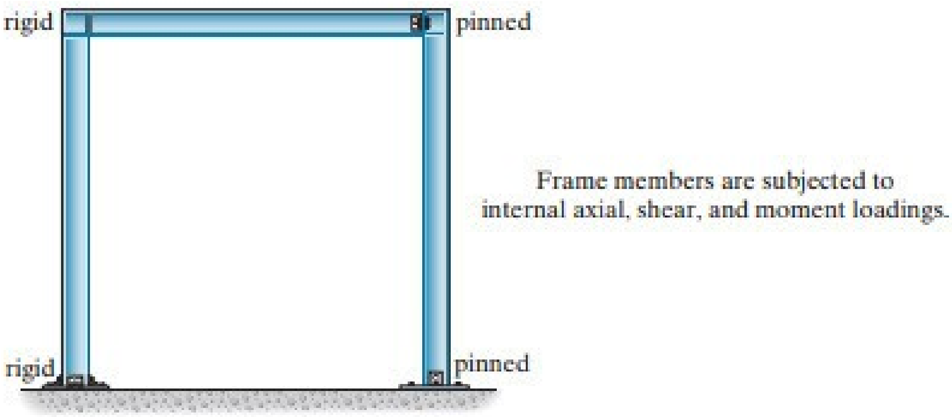
An arch is a curved structural element that spans an open space and supports loads primarily through axial compression. The curve of the arch distributes loads outward and downward to its supports (abutments or piers) in a manner that minimizes bending moments. Arches can be found in various architectural structures, such as bridges, buildings, and aqueducts.

c. Cable

A cable refers to a slender, flexible structural element capable of carrying tensile loads. Cables are commonly made of materials such as steel or other high-strength alloys. They are used in various structural systems to provide support and stability, particularly in applications where the primary loads are tension forces.

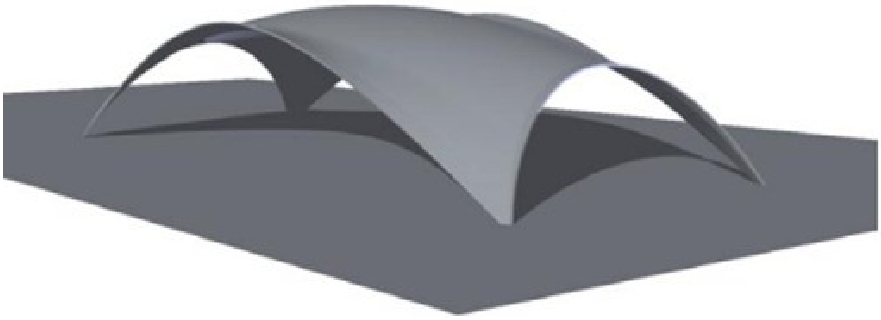
d. Frame

Frames are often used in buildings and are composed of beams and columns that are either pin or fixed connected.



e. Surface structure

A surface structure is made of a material having a very small thickness compared to its other dimensions. Sometimes this material is very flexible and can take the form of a tent or air-inflated structure. In either case the material acts as a membrane that is subjected to pure tension. Surface structures may also be made of rigid material such as reinforced concrete. As such they may be shaped as folded plates, cylinders, or hyperbolic paraboloids, and in any of these forms, they are referred to as thin plates or shells.



3. Loads

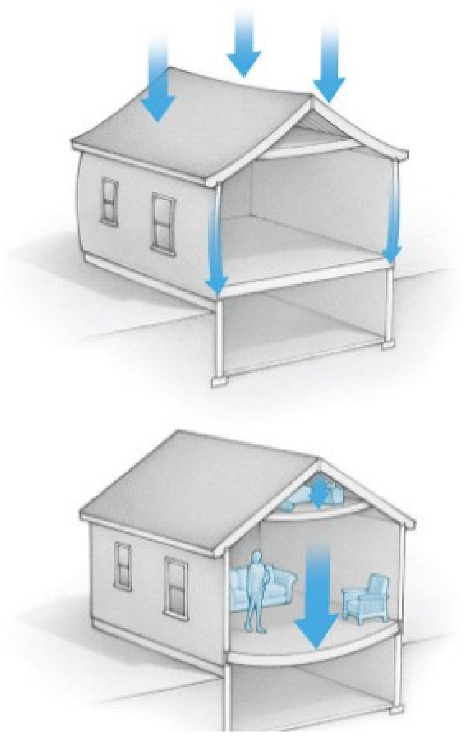
IV

A. 3.1. Definition

Definition

Once the dimensional requirements for a structure have been defined, it becomes necessary to determine the loads the structure must support.

Often, it is the anticipation of the various loads that will be imposed on the structure that provides the basic type of structure that will be chosen for design.

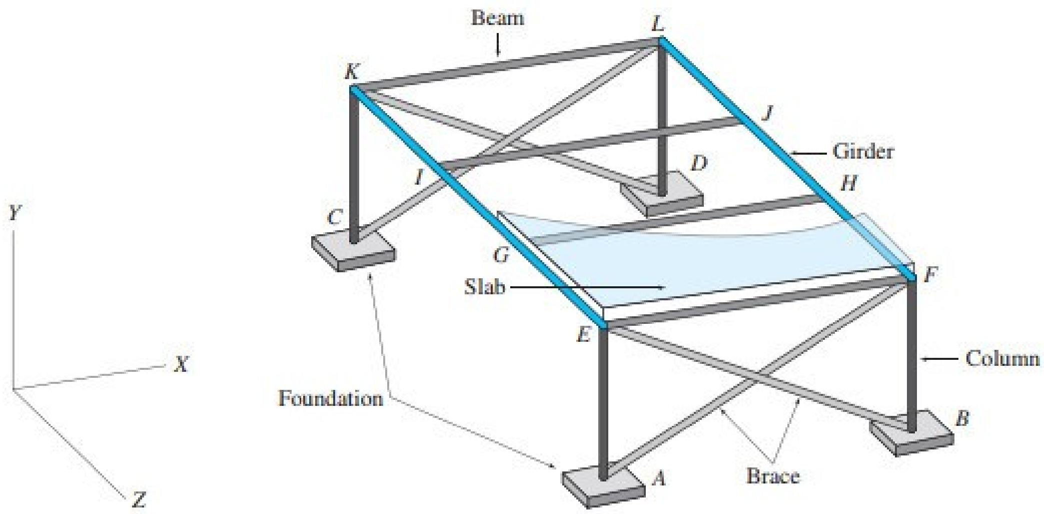


The design loading for a structure is often specified in codes (see table 1)

Table 1. Codes
American Society of Civil Engineers (ASCE 7) - "Minimum Design Loads and Associated Criteria for Buildings and Other Structures"
Eurocode 1 - "Actions on Structures"
British Standards (BS) - BS EN 1991 - "Eurocode 1: Actions on Structures"

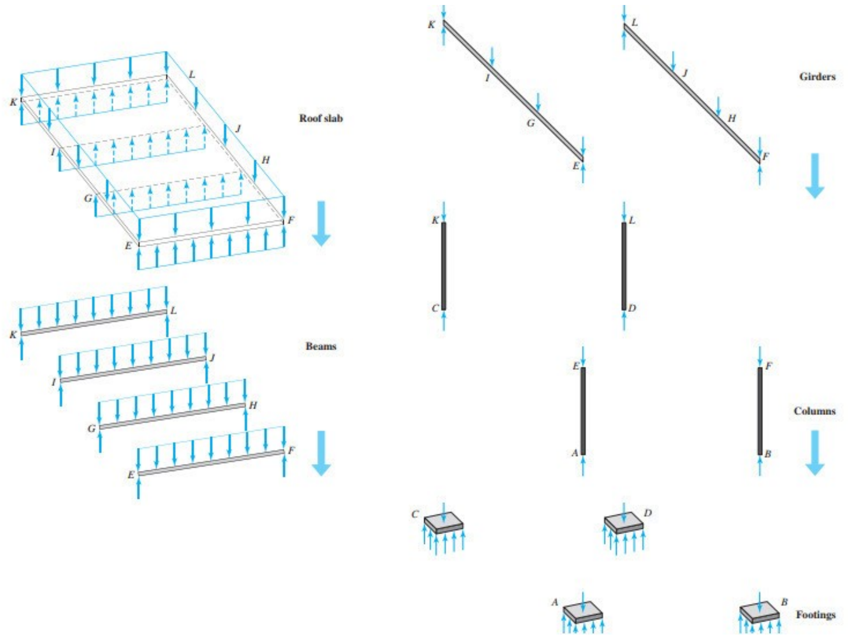
B. 3.2. Structural system for transmitting loads

An example of the load-carring system of a single-story building is shown in the bellow figure.



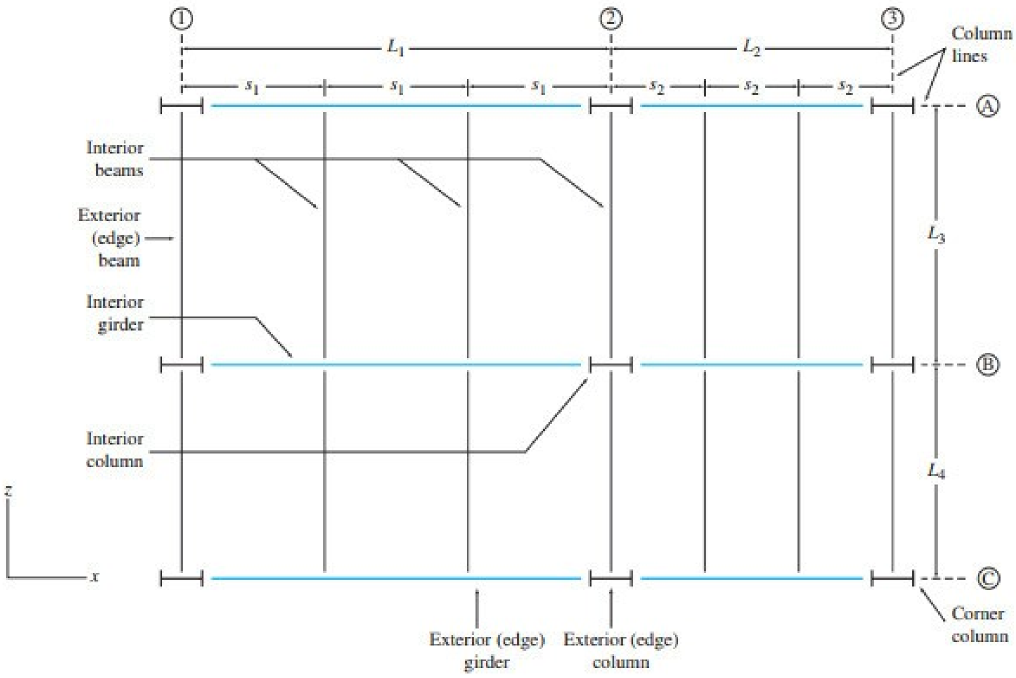
(a) Structural System for a Single-Story Building

(b) Vertical (Gravity) Load Path



C. 3.3. Floor systems and tributary areas

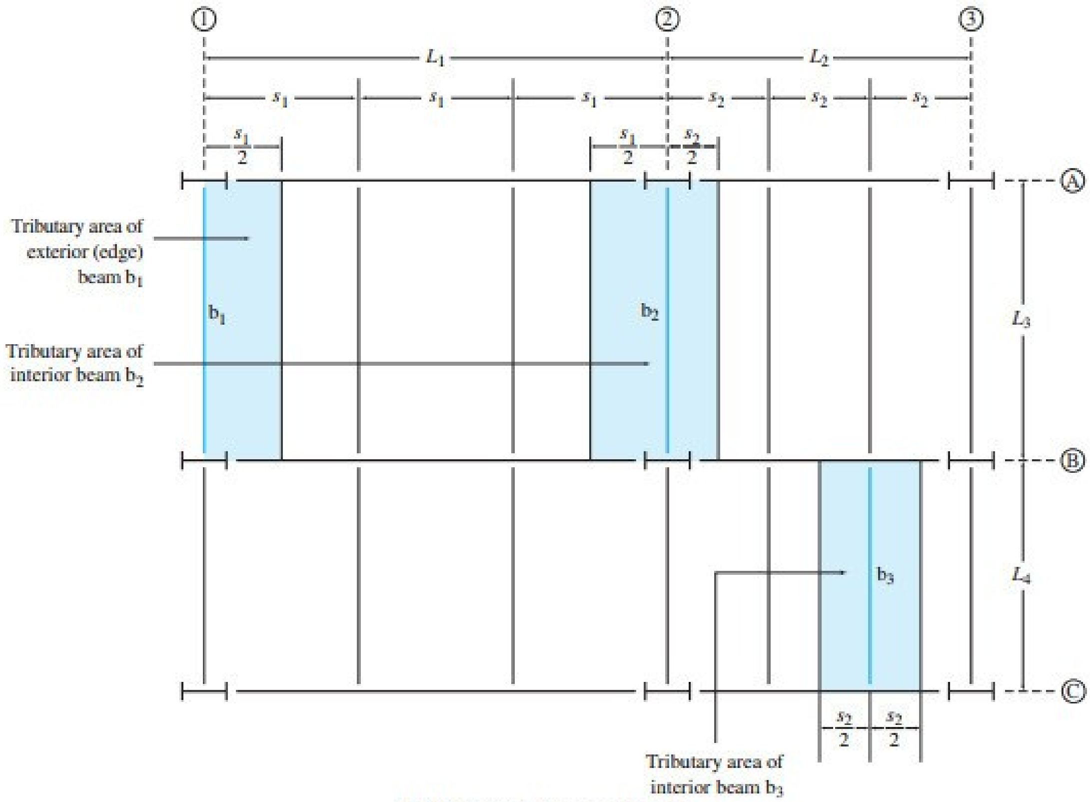
The following figure shows the top view or the framing plan of typical floor system.



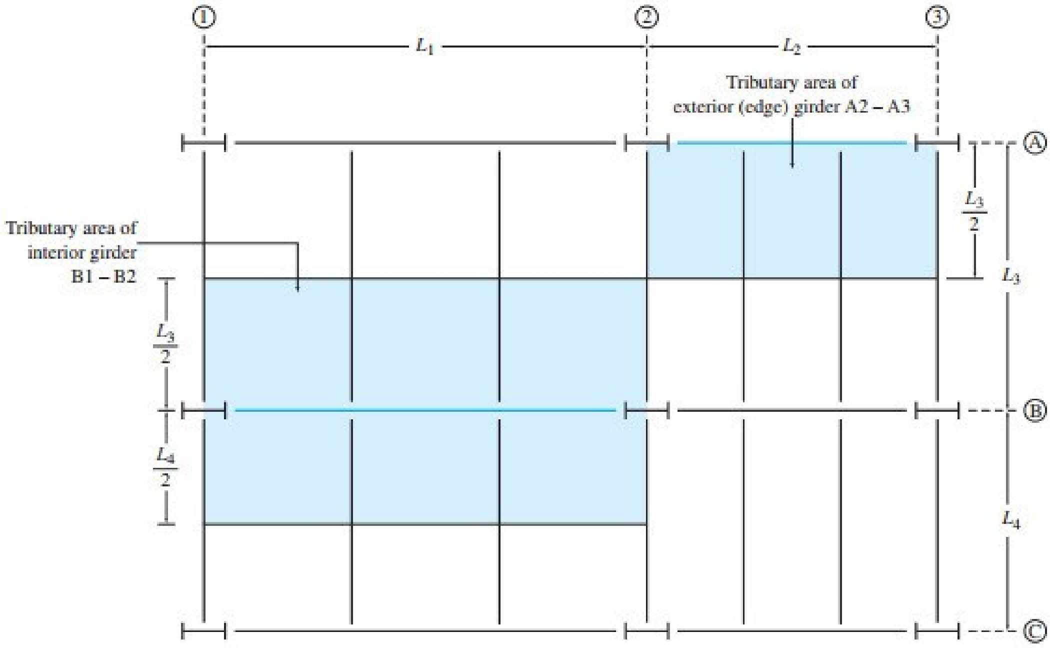
(a) A Typical Floor Framing Plan

The portion of the slab area whose load is carried by a practicular member is called the **tributary area** of the member.

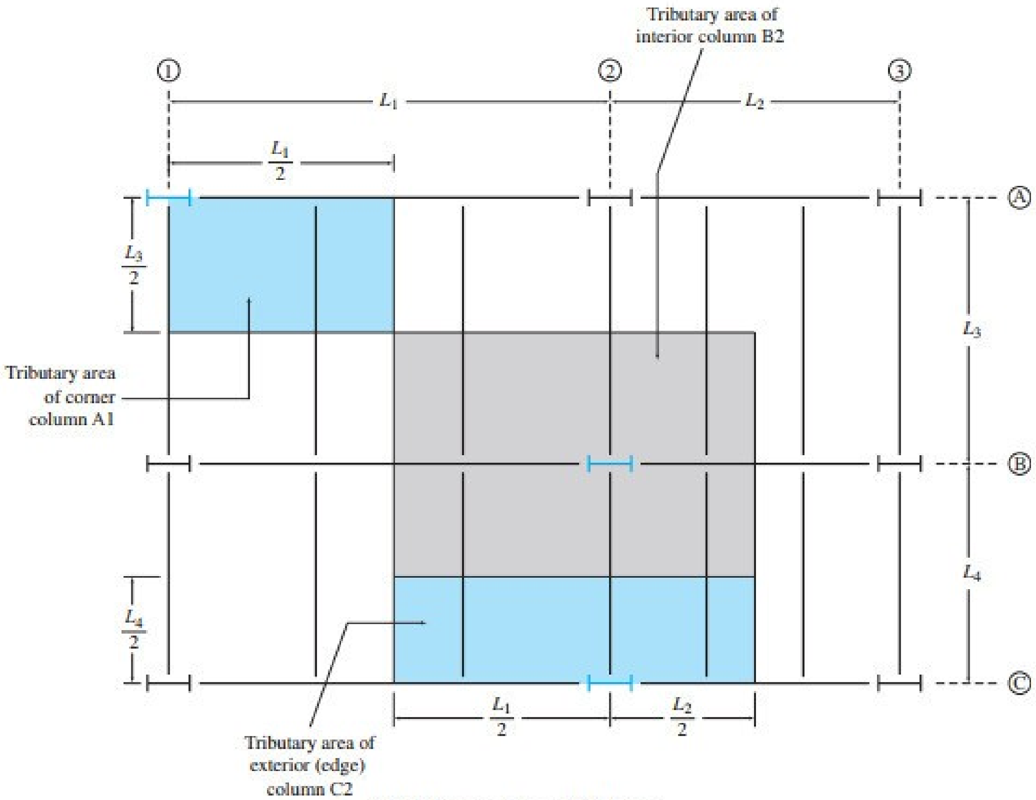
For the floor system with **one-way slabs (L/S > 2)**:



(b) Tributary Areas of Beams

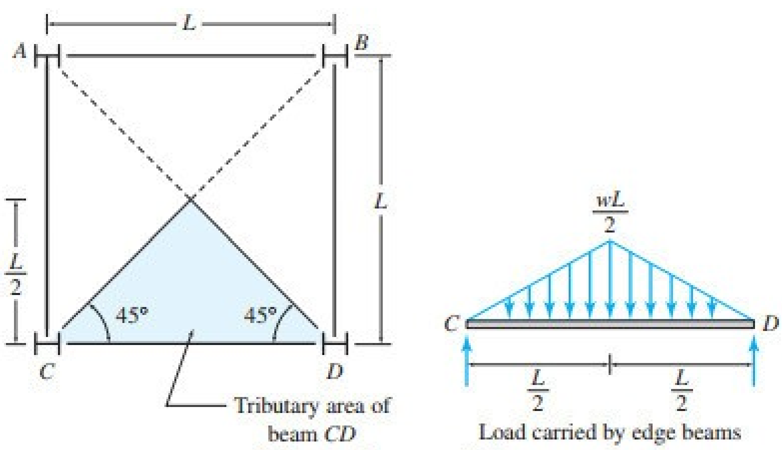


(c) Tributary Areas of Girders

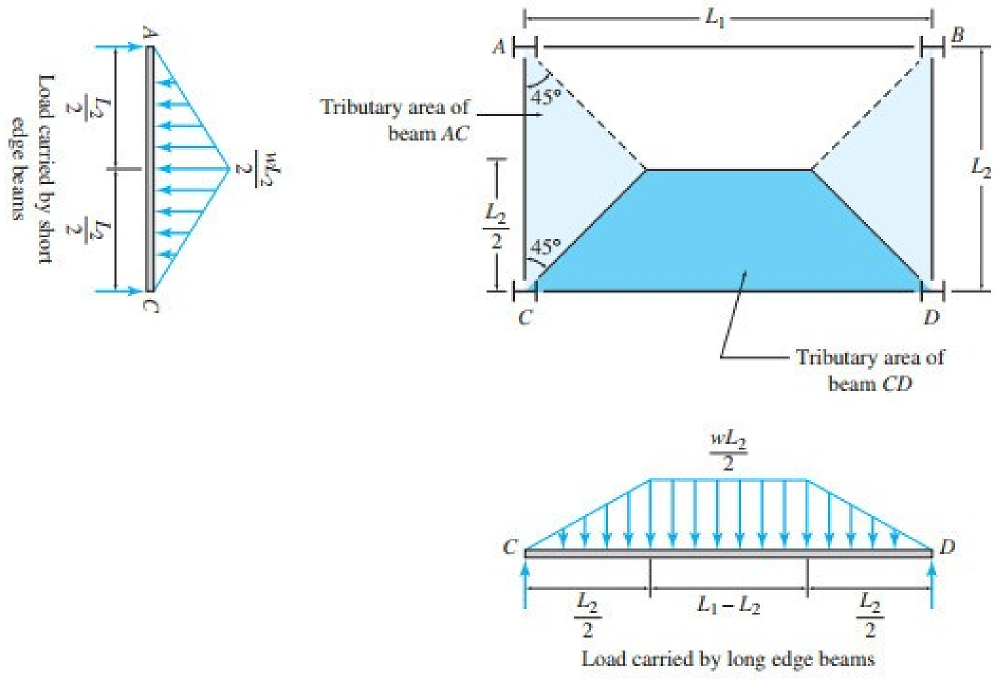


(d) Tributary Areas of Columns

For floor system with **two-way slabs (L/S ≤ 2)**:



(a) Square Two-way Slabs



(b) Rectangular Two-way Slabs

D. 3.4. Types of loads

a. Dead loads

Consist of the weights of the various structural members and the weights of any objects that are permanently attached to the structure.

If the materials and sizes of the various components of the structure are known, then their weights can be found from tables that list their densities.

TABLE 1.2 Minimum Densities for Design Loads from Materials*	kN/m^3
Aluminum	27
Concrete, cinder	17.0
Concrete, stone	22.6
Clay, dry	9.9
Clay, damp	17.3
Sand and gravel, dry, loose	15.7
Sand and gravel, wet	18.9
Masonry, lightweight concrete	16.5
Masonry, normal weight units	21.2
Plywood	5.7
Steel, cold-drawn	77.3
Wood, Douglas Fir	5.3
Wood, Southern Pine	5.8
Wood, spruce	4.5

*Minimum Densities for Design Loads from Materials. Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-16. Copies of this standard may be purchased from ASCE at www.asce.org/publications.

TABLE 1.3 Minimum Design Dead Loads*	
Walls	kN/m^2
102 mm clay brick	1.87
203 mm clay brick	3.78
305 mm clay brick	5.51
Frame Partitions and Walls	
Exterior stud walls with brick veneer	2.30
Windows, glass, frame and sash	0.38
Wood studs 51 × 102 mm, unplastered	0.19
Wood studs 51 × 102 mm, plastered one side	0.57
Wood studs 51 × 102 mm, plastered two sides	0.96
Floor Fill	
Cinder concrete, per mm	0.017
Lightweight concrete, plain, per mm	0.015
Stone concrete, per mm	0.023
Ceilings	
Acoustical fiberboard	0.05
Plaster on tile or concrete	0.24
Suspended metal lath and gypsum plaster	0.48
Asphalt shingles	0.10
Fiberboard, 13 mm	0.04

*Minimum Design Dead Loads. Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-16, American Society of Civil Engineers.

b. Live loads

can vary both in their magnitude and location. They may be caused by the weights of objects temporarily placed on a structure.

The following are important examples of live loads that must be considered when designing a structure:

- Building Loads: The floors of buildings are assumed to be subjected to uniform live loads, which depend on the purpose for which the building is designed. A representative sample of such minimum live loadings, taken from the ASCE 7-16 Standard, is shown in Table 1.4.

TABLE 1.4 Minimum Live Loads*

Occupancy or Use	Live Load kN/m^2	Occupancy or Use	Live Load kN/m^2
Assembly areas and theaters		Residential	
Fixed seats	2.87	Dwellings (one- and two-family)	1.92
Movable seats	4.79	Hotels and multifamily houses	
Garages (passenger cars only)	1.92	Private rooms and corridors	1.92
Office buildings		Public rooms and corridors	4.79
Lobbies	4.79	Schools	
Offices	2.40	Classrooms	1.92
Storage warehouse		First-floor corridors	4.79
Light	6.00	Corridors above first floor	3.83
Heavy	11.97		

*Minimum Live Loads. Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-16, American Society of Civil Engineers.

c. Environmental loads

Environmental loads include wind, rain, and snow, and seismic loads.

E. 3.5. Load combinations

The combined load effect, sometimes called the required factored strength, represents the minimum strength for which members need to be designed. Considering the load effect produced by the dead load D, live load L, roof live load Lr, wind load W, earthquake load E, rain load R, and snow load S, the ASCE 7 standard requires that the following load combinations be considered:

- 1.2 D + 1.6 L

The following load combinations according to EC 1:

- 1.35 D + 1.5 L

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V

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