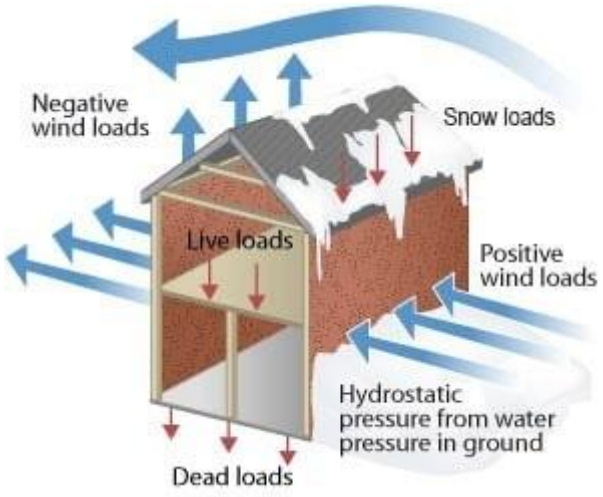
UNIT-2 DESIGN LOADS

The types of loads acting on structures for buildings and other structures can be broadly classified as vertical loads, horizontal loads and longitudinal loads. The vertical loads consist of dead load, live load and impact load.

The horizontal loads comprises of wind load and earthquake load. The longitudinal loads i.e. tractive and braking forces are considered in special case of design of bridges, gantry girders etc..




# Types of Loads on Structures and Buildings

In a construction of building two major factors considered are safety and economy. If the loads are adjudged and taken higher then economy is affected. If economy is considered and loads are taken lesser then the safety is compromised.

So the estimation of various loads acting is to calculated precisely. **Indian standard code IS: 875–1987** and **American Standard Code ASCE 7:**

**Minimum Design Loads for Buildings and Other Structures** specifies various design loads for buildings and structures.

**Types of loads acting on a structure are:**

1. Dead loads
2. Imposed loads
3. Wind loads
4. Snow loads
5. Earthquake loads
6. Special loads

# 1. Dead Loads (DL)

The first vertical load that is considered is dead load. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials. It majorly consists of the weight of roofs, beams, walls and column etc. which are otherwise the permanent parts of the building.

The calculation of dead loads of each structure are calculated by the volume of each section and multiplied with the unit weight. Unit weights of some of the common materials are presented in table below.

| Sl. No | Material | Weight |
|---|---|---|
| 1 | Brick Masonry | 18.8 $kN/m^3$ |

| | | |
|---|---|---|
| 2 | Stone Masonry | 20.4-26.5 kN/$m^3$ |
| 3 | Plain Cement Concrete | 24 kN/$m^3$ |
| 4 | Reinforced Cement Concrete | 24 kN/$m^3$ |
| 5 | Timber | 5-8 kN/$m^3$ |

**Read:** **Unit Weight / Density of Different Construction Materials**

## 2. Imposed Loads or Live Loads (IL or LL)

The second vertical load that is considered in design of a structure is imposed loads or live loads. Live loads are either movable or moving loads with out any acceleration or impact. These loads are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc..

Live loads keeps on changing from time to time. These loads are to be suitably assumed by the designer. It is one of the major load in the design. The minimum values of live loads to be assumed are given in IS 875 (part 2)–1987. It depends upon the intended use of the building.

**The code gives the values of live loads for the following occupancy classification:**

- Residential buildings–dwelling houses, hotels, hostels, boiler rooms and plant rooms, garages

- Educational buildings
- Institutional buildings
- Assembly buildings
- Business and office buildings
- Mercantile buildings
- Industrial buildings, and
- Storage rooms.

The code gives uniformly distributed load as well as concentrated loads. The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads whichever produce greater stresses in the part under consideration. Since it is unlikely that any one particular time all floors will not be simultaneously carrying maximum loading, the code permits some reduction in imposed loads in designing columns, load bearing walls, piers supports and foundations.

Some of the important values are presented in table below which are the minimum values and wherever necessary more than these values are to be assumed.

| Sl. No. | Occupancy | UDL Load | Concentrated |
|---|---|---|---|
| 1. | Bath rooms and toilets in all types of building | 2 kN/m² | 1.8 kN |
| 2. | Living and bed rooms | 2 kN/m² | 1.8 kN |
| 3. | Office rooms in | | |
| | (*i*) Hostels, hotels, hospitals and business building with separate store | 2.5 kN/m² | 2.7 kN |
| | (*ii*) In assembly buildings | 3 kN/m² | 4.5 kN |
| 4. | Kitchens in (*i*) Dwelling houses | 2 kN/m² | 1.8 kN |
| | (*ii*) Hostels, hotels and hospitals | 3 kN/m² | 4.5 kN |
| 5. | Banking halls, class rooms, x-ray rooms, operation rooms | 3 kN/m² | 4.5 kN |
| 6. | Dining rooms in (*i*) educational buildings, institutional and mercantine buildings | 3 kN/m² | 2.7 kN |
| | (*ii*) hostels and hotels | 4 kN/m² | 2.7 kN |
| 7. | Corridors, passages, stair cases in | | |
| | (*i*) Dwelling houses, hostels and hotels | 3 kN/m² | 4.5 kN |
| | (*ii*) Educational institutional and assembly buildings | 4 kN/m² | 4.5 kN |
| | (*iii*) Marcantine buildings | 5 kN/m² | 4.5 kN |
| 8. | Reading rooms in libraries | | |
| | (*i*) With separate storage | 3 kN/m² | 4.5 kN |
| | (*ii*) Without separate storage | 4 kN/m² | 4.5 kN |
| 9. | Assembly areas in assembly buildings | | |
| | (*i*) With fixed seats | 5 kN/m² | .. |
| | (*ii*) Without fixed seats | 5 kN/m² | 3.6 kN |
| 10. | Store rooms in educational buildings | 5 kN/m² | 4.5 kN |
| 11. | Store room in libraries | 6 kN/m² for a height of 2.24 + 2 kN/m² for every 1 m additional height | 4.5 kN |

However in a multistoried buildings chances of full imposed loads acting simultaneously on all floors is very rare. Hence the code makes provision for reduction of loads in designing columns, load bearing walls, their supports and foundations as shown in table below.

| **Number of floors (including the roof) to be carried by member under consideration** | **Reduction in Total Distributed Imposed Loads in %** |
|---|---|
| 1 | 0 |
| 2 | 10 |
| 3 | 20 |

| | |
|---|---|
| 4 | 30 |
| 5-10 | 40 |
| Over 10 | 50 |

## 3. Wind loads

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in structural design especially when the heath of the building exceeds two times the dimensions transverse to the exposed wind surface.

For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered.

The horizontal forces exerted by the components of winds is to be kept in mind while designing is the building. The calculation of wind loads depends on the two factors, namely velocity of wind and size of the building. Complete details of calculating wind load on structures are given below (by the IS-875 (Part 3) - 1987).

Using colour code, basic wind pressure '$V_b$' is shown in a map of India. Designer can pick up the value of $V_b$ depending upon the locality of the building.

To get the design wind velocity $V_z$ the following expression shall be used:

$$\mathbf{V_z = k_1 k_2 . k_3 V_b}$$

Where $k_1$ = Risk coefficient

$k_2$ = Coefficient based on terrain, height and structure size.

$k_3$ = Topography factor

The design wind pressure is given by

$$\mathbf{p_z = 0.6\ V^2_z}$$

where $p_z$ is in $N/m^2$ at height Z and $V_z$ is in m/sec. Up to a height of 30 m, the wind pressure is considered to act uniformly. Above 30 m height, the wind pressure increases.

## 4. Snow Loads (SL)

Snow loads constitute to the vertical loads in the building. But these types of loads are considered only in the snow fall places. The IS 875 (part 4) – 1987 deals with snow loads on roofs of the building.

The minimum snow load on a roof area or any other area above ground which is subjected to snow accumulation is obtained by the expression

$$S = \mu S_0$$

Where S = Design snow load on plan area of roof.

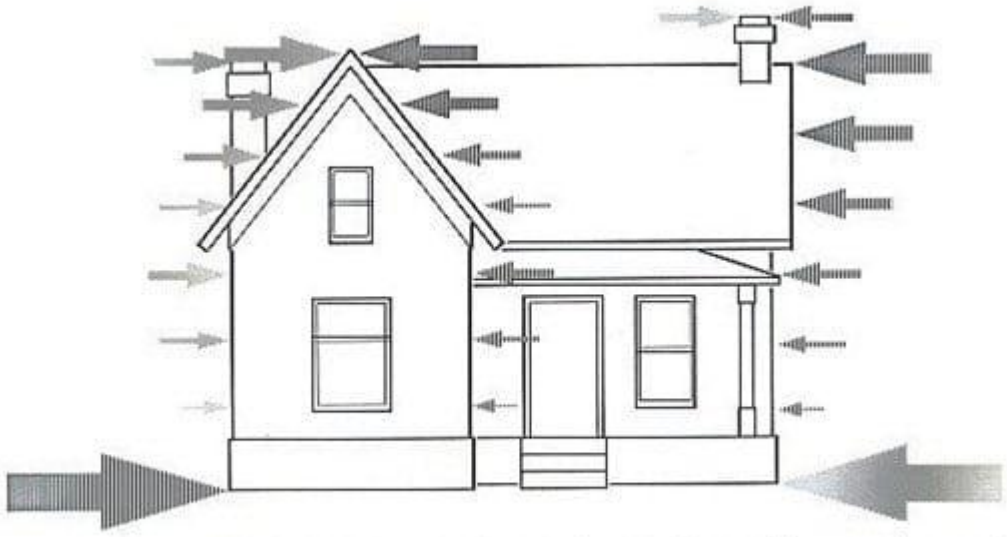
$\mu$ = Shape coefficient, and

$S_0$ = Ground snow load.

## 5. Earthquake Loads (EL)

Earthquake forces constitute to both vertical and horizontal forces on the building. The total vibration caused by earthquake may be resolved into three mutually perpendicular directions, usually taken as vertical and two horizontal directions.

The movement in vertical direction do not cause forces in superstructure to any significant extent. But the horizontal movement of the building at the time of earthquake is to be considered while designing.



Horizontal earthquake forces (back-and-forth shaking) create 'whipping' forces in all parts of a building. These forces must transfer between parts of the building to the foundation.

The response of the structure to the ground vibration is a function of the nature of foundation soil, size and mode of construction and the duration and intensity of ground motion. IS 1893– 2014 gives the details of such calculations for structures standing on soils which will not considerably settle or slide appreciably due to earthquake.

The seismic accelerations for the design may be arrived at from seismic coefficient, which is defined as the ratio of acceleration due to earthquake and acceleration due to gravity. For monolithic reinforced concrete structures located in the seismic zone 2, and 3 without more than 5 stories high and importance factor less than 1, the seismic forces are not critical.

## 6. Other Loads and Effects acting on Structures

As per the clause 19.6 of IS 456 – 2000, in addition to above load discussed, account shall be taken of the following forces and effects if they are liable to affect materially the safety and serviceability of the structure:

(a) Foundation movement (See IS 1904)

(b) Elastic axial shortening

(c) Soil and fluid pressure (See IS 875, Part 5)

(d) Vibration

(e) Fatigue

(f) Impact (See IS 875, Part 5)

(g) Erection loads (See IS 875, Part 2) and

(h) Stress concentration effect due to point load and the like.