MPSC 2024

Maharashtra Public Service Commission

Assistant Engineer Examination

Civil Engineering

Building Construction

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY PUBLICATIONS

Building Construction

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CHAPTER 01

Introduction

1.1 Introduction

The term building in Civil Engineering parlance is used to mean a structure having various components like foundations, walls, columns, floors, roofs, doors, windows ventilators, stairs, lifts, various type of surface finishes etc. As a Civil Engineer is mainly concerned with the construction of buildings, it is essential for him to acquire good knowledge of construction of various components of a building.

1.2 Type of Building

National building code of India (SP : 7-1970) defines the building as any structure for whatsoever purpose and of whatsoever materials constructed and every part there of whether used as human habitation or not and includes foundations, plinth, walls, floors, roofs, chimneys, plumbing and building services, fixed platforms, verandah, balcony cornice or projection, part of a building or any thing affixed there to or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures tents, shamianas and tarpaulin, shelters are not considered as a building.

As per national building code of India, buildings are classified into nine groups based on occupancy as follows:

Group A : Residential buildings
Group B : Educational buildings
Group C : Institutional buildings
Group D : Assembly buildings
Group E : Business buildings
Group F : Mercantile buildings
Group G : Industrial buildings
Group H : Storage buildings
Group I : Hazardous buildings

1.3 Structural System of Building

Building is an assemblage of two or more components which are interrelated and compatible. Each component is essential for the required performance of a building. Building components like walls, floors, roofs, windows and doors are interrelated and compatible with each other. The required performance of the building as a whole imposes restrictions on the components.

The simplest building system consists of only two components, floor and an enclosure. Floor is a flat horizontal surface, on which human- activities take place. An enclosure extends over and around the floor giving shelter to living being from weather.

A load bearing wall is one which rests on the foundation taken deep into the subsoil. It takes superimposed load. i.e. the load transmitted from slabs and beams. It transmits the load of the superstructure on the subsoil on which it rests. The entire wall should be taken deep into the ground where the enlarged footings provide enough stability for it. Also stress transmitted is considerably reduced because of increase in width of footings.

A partition wall is an internal screen wall which rests above the floor level; to create a room or enclosure. It may not be anchored deep into the soil and may; not take any load of superstructure.

According to structural system there are three types of buildings:

(1) Load bearing structure (2) Framed structure (3) Composite structure

Load bearing structure

The system of building comprising of slabs, beams and load bearing walls is known as a load bearing structure. Most of the residential buildings are small in size and are up to three storey are generally constructed as load bearing structures.

As shown in figure below loads from the slab roof or trusses and floors are transmitted through walls to the firm soil below the ground. In load bearing structures walls of the upper floors have less thickness than the walls of lower floors, so compared to upper floors, the carpet area at lower floors will be less. Such type of structures are most suited for buildings up to three storey and where hard strata of soil is available. Generally for individual residential bungalow, tenement, low rise flats, temples and rural buildings load bearing structure system is adopted.

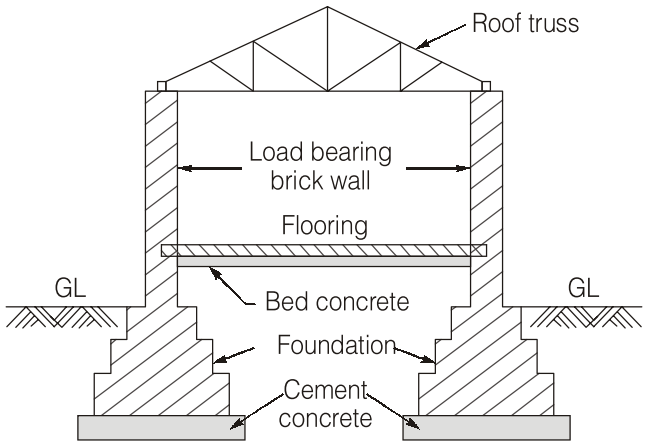

Fig. Load Bearing Structure

Framed Structure

It is a structure comprising of slabs resting on beams which are supported by a network of columns. As shown in figure below the live load from the slab is transferred to the cross beams, which in turn transfer it to main beams through rigid joints. Main beams rest over I columns and load from the beam is transferred I to the soil through columns and their footings.

All the walls may or may not be a partition walls as none of them bear any load. All the walls rest on plinth beams and not provided with any footing or foundations. Generally all multistoried buildings or high-rise buildings are constructed as framed structure. As partition walls can be shifted easily anywhere on the floor, higher degree of flexibility is available while planning a framed structure.

All the above elements of the frame are constructed monolithically. Framed structure is subjected to a variety of external loads like compressive, tensile, torsion and shear along with moment. R.C.C. is the most suitable material to withstand all these loads. Bricks can withstand only compressive loads, so all framed structures are constructed with R.C.C.

In comparison with load bearing structures, more carpet area is available and lit is almost same for all the floors.

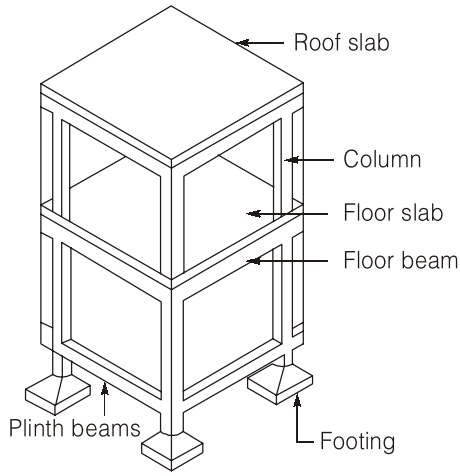

Fig. Framed Structure

Composite Structure

As shown in figure below some of the buildings are constructed with combination of both load bearing as well as framed structure. Such structure is (called composite structure. In this type of structure external walls are treated as load 'bearing walls and all intermediate supports are in the form of R.C.C. columns. Composite structures have advantages of both load bearing as well as framed structure. Composite structures are preferred for the buildings having large spans such as warehouses, workshops, halls, large factory sheds, etc.

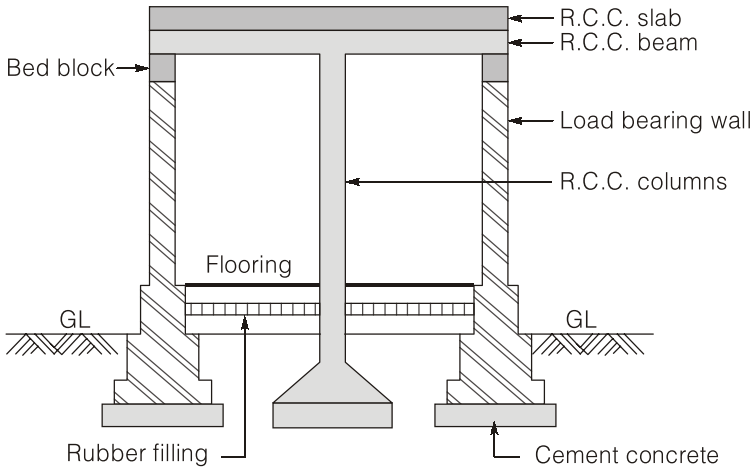

Fig. Composite Structure

1.3 Components of Buildings

A building has two basic parts: (i) Sub-structure or foundations (ii) Super structure

- Sub structure or foundation is the lower portion of the building, usually located below the ground level, which transmits the load of the superstructure to the supporting soil.
- A foundation is therefore that part of the structure which is in direct contact with the ground to which the loads are transmitted.
- Superstructure is that part of the structure which is above ground level and which serves the purpose of its intended use. A part of the superstructure, located between the ground and the floor level is known as plinth.
- Plinth is therefore defined as the portion of the structure between the surface of the surrounding ground and surface of the floor, immediately above the ground. The level of the floor is usually known as plinth level. The built up covered area measured at the floor level is known as plinth area.

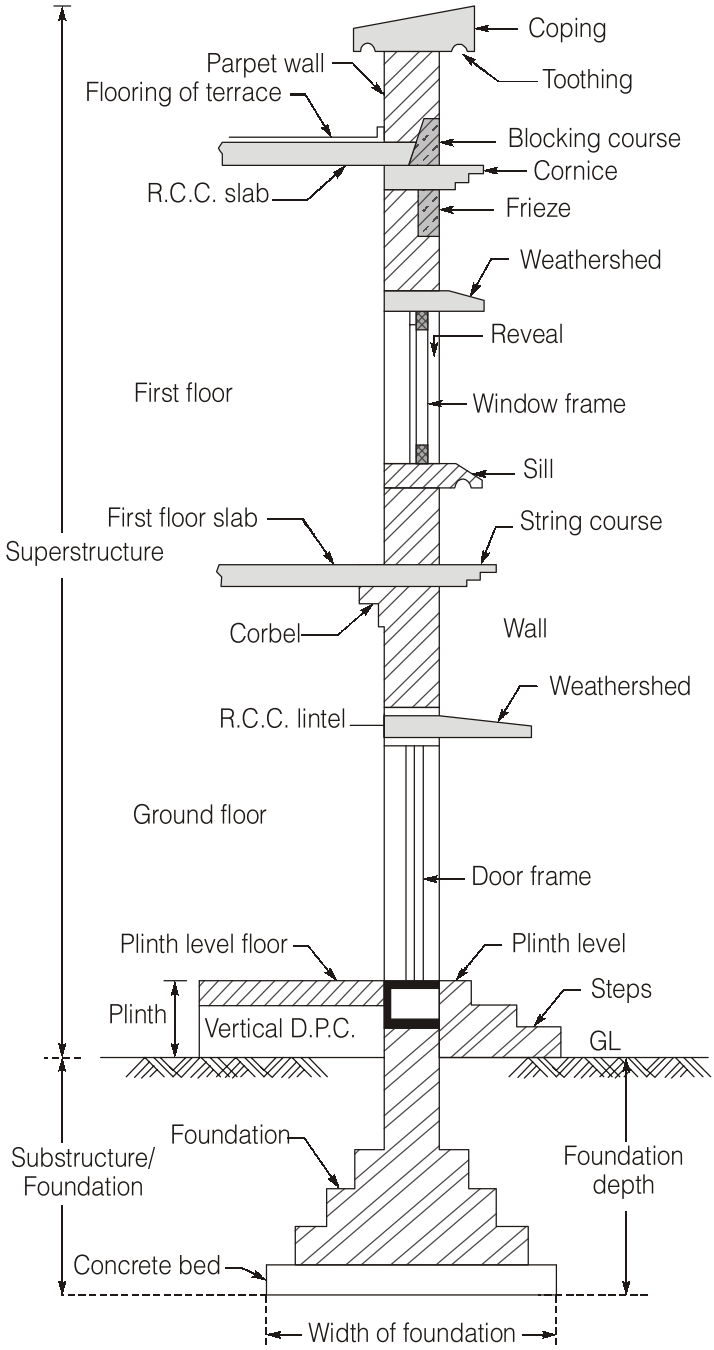

Fig. Components of a Building

A building has the following components:

1. Foundations
2. Masonry units: Walls and columns.
3. Floor structures
4. Roof structures
5. Doors, windows and other openings
6. Vertical transportation structures such as stairs, lifts, ramps etc.
7. Building finishes.

1.5 Principles of Site Selection

For good planning and designing of buildings, the site selection of the building is the most important. The following general principles should be kept in mind while selecting a site for a building:

(i) The purpose of the. building and extent of privacy is desired.

(ii) The site should be located in fully developed or fast developing locality.

(iii) The site should be located in such a way that community services like police and fire protection, clearing of waste .and street cleaning, utility services like water-supply, electricity, drainage, etc., amenities like school, hospital, market, cinema, bank, etc., shopping facilities and means of transport are also available within short distance.

(iv) Before selecting a site, one should study the bye-laws of the local authority, which before restrictions regarding proportions of plots to be built up, open spaces and margins to be left in front and sides, heights of buildings etc.

(v) Area of plot should be such that the building constructed on it meets the requirement of the owner, after following certain restrictions of local authority.

(vi) Shape of the plot should be irregular or not having any sharp corners.

(vii) The site -should be situated on an elevated place and also levelled with uniform slopes from one end to the other to provide good and quick drainage of rain water.

(viii) The soil of the site should be good enough with high safe bearing capacity to provide economical foundations.

1.6 Planning Regulations and Bye-Laws

A bye-law is a local law framed by a subordinate authority. The building codes or bye-laws are defined as the standards and specifications designed to great minimum-safeguards to the workers during construction; to the health and comfort of users; and to provide enough safety to the public is general.

Every locality has peculiarities of its own and with respect to its weather conditions, availability of materials and labour, other factors etc., it becomes economical to construct residential buildings and other structures in a definite planned way. Hence, every locality prepares or frames certain rules and regulations controlling the development of area under its command.

An order prescribed is known as the regulation, while the law of a local authority-is known as bye-law. Bye-law is supplementary law or regulation.

Following are the three main objects of framing bye-laws:

(i) It becomes easier to pre-plan the building activities and provisions of bye-laws give <guide lines to the designing architect or engineer.

(ii) The building bye-laws prevent haphazard development without any resemblance to the development of the area as a whole.

(iii) The provisions of the building bye-laws usually afford safety to the human beings who work and live in them against fire,noise, health hazard and structural failure.

The bye-laws and regulations govern the following building aspects:

1. Set-back or building line.
2. Floor space index or built-up area.
3. Open space requirements around the building.
4. Size of rooms.

5. Height of rooms and buildings.
6. Lighting and ventilation of rooms.
7. Water supply and sanitary provisions.
8. Structural design or sizes and sections.

1. **Set-back or building line:** A set back may be defined as frontage margin or open space in front of the abutting street or road. The land contained in set-back belongs to the owner of the property. It is also referred to as a building line and is laid down in each case parallel to the plot boundaries by the local authority, beyond which nothing can be constructed towards the plot boundaries. Certain buildings like cinema, business centres, factories, etc. which attract large number of vehicles, should be set-back a further distance apart from the building line. This line after this extra margin is called control line.

   The fixation of building line depends upon the site of the proposed building, keeping in view' the present width and future widening requirements.

   Following are the advantages of the building line or set-backs are as follows:

   (i) If absolutely necessary, part of the set-backs may be acquired for the purpose of widening the road.

   (ii) If the set-back is uniform, the buildings are constructed in one line parallel to the axis of road, resulting in improvement of road.

   (iii) The-provisions of the set-backs results into better conditions of air, light and ventilation of the buildings.

   (iv) The set-backs at street corners improve visibility and impart safety to the traffic.

   (v) The space of set-backs can be conveniently used as a parking place or for developing as garden.

   (vi) They are necessary for the protection of the buildings from street nuisance.

   (vii) They reduce the danger of fire by increasing the distance between opposite buildings.

2. **Floor space index or built-up area:** The built up area or covered area equals to the plot area minus the area due for open spaces. The ratio of the total floor area inclusive of all the floors to the area of the plot on which building stands is known as the floor space index (F.S.I.) or floor area ratio (F.A.R.). The value (of F.S.I. or F.A.R. is determined by local authority and it may be different for different areas and for different buildings of the town. Floor area means built up area excluding area of walls.

   The F.S.I, controls the development activity on the plot of land and consequently. It can be used as a measure to check density of population. For instance, if the plot area is 600 m^2 and if permissible F.S.I, is 0.80, the maximum built-up area' which can be put up on the plot is 480 m^2.

   Following are the limitations of built-up area mentioned in National Building Code:

No.	Plot Area	Maximum permissible built-up area
1.	Less than 200 m^2	60% with two-storeyed structure
2.	From 200 m^2 to 500 m^2	50% of the plot area
3.	From 500 m^2 to 1000 m^2	40% of the plot area
4.	More 1000 m^2	33.33% of the plot area

3. **Open space requirements around the buildings:** The sufficient open a spaces, inside and around the building should be left to meet with the requirements of lighting and ventilation. In case of buildings abutting streets, in front, the open! spaces to the rear or sides of the building should be

provided to serve the purpose! of future widening of such streets. All such open spaces weather interior or exterior;] should be kept free from any erection thereon and shall be kept open to the sky and no cornice, roof, or weather shed more than 0.75 m in width shall project over such open space. Following are the requirements of open space for varying heights of building as per National Building Code:

No.	Height of building	Open space requirement
1.	Less than 10 m	(a) Front open space width: (i) For building with front street - minimum 3 m (ii) For building with streets on two or more sides – average 3 m and in no case less than 1.8 m (b) Rear margin: – average 3 m and in no case less than 1.8 m (c) Side margin: – minimum 3 m for every detached and semi-attached building (d) Distance from centre line of any street: – In no case less than 7.5 m or as determined by local authority
2.	From 10 m to 25 m	Requirements as per above item no. 1 is increased at the rate of 1 m for every 3 m or fraction thereof.
3.	From 25 m to 30 m	Minimum 10 m.
4.	Above 30 m	Minimum 10 m increased by at the rate of 1 m for every 5 m or fraction thereof subject to maximum 16 m.

If any human-habitation is not receiving air and light from front or rear, shall abut on interior open space having width not less than 3 m.

4. **Size of rooms:** Considering the point of health and ventilation, National Building Code has fixed certain minimum areas or sizes for individual rooms and apartments which are tabulated below:

No.	Type of room	Minimum Area
1.	One habitable room	9.5 m^2, minimum width 2.4 m
2.	Two habitable rooms	Minimum area of one room 9.5 m^2 and of other 7.5 m^2 with minimum width 2.4 m.
3.	Kitchen only	4.5 m^2, minimum width 1.8 m
4.	Kitchen with store room	5.5 m^2 minimum width of kitchen 1.8 m
5.	Kitchen cum dining room	9.5 m^2, minimum width 2.4 m
6.	Bath room	1.8 m^2 or minimum size 1.5 m x 1.2 m
7.	Water closet (w.c)	1.1 m^2 (Floor area)
8.	Bath - W.C. combined	2.8 m^2 (Floor area) minimum width 1.2 m
9.	Mezzanine floor (living room)	9.5 m^2 (Not more than 1/3rd of the plinth area of the building.)

5. **Height of rooms and buildings:** General criteria to decide the height of the building as per N.B.C. is 1.5 times the width of the street to which the building abuts on its front side. If street width is above 8 m or equal to 12 m, the height of the building should not be more than 12 m and in case of more than 12 m wide street, the height of the building should not be more than street width and in no case more than 24 m.

6. **Lighting and ventilation of rooms:** For sufficient lighting and ventilation in the rooms of building, openings like windows, ventilators or direct opening to external air should be provided.
   The area of such openings excluding area of doors should be minimum $1/10^{th}$ of the floor area for dry and hot climate and minimum $1/6^{th}$ of the area for wet hot climate. The aggregate area of doors and windows shall not be less than $1/7^{th}$ of the floor area of room.
7. **Water supply and sanitary positions:** Certain minimum requirements for water supply and sanitary conveniences like water tap, sink, nahni trap, water closets, urinals, wash basins, etc. shall be provided as per N.B.C. for different types of buildings.
8. **Structural design or sizes and sections:** Each structure should be designed for safe loads, earthquake resistance, bearing capacities, etc. as per the; latest relevant I.S. codes and N.B.C. Each component of the building should be designed with its specific requirements. Some general thumb-rules for structural design are as follows:
   (i) Depth of foundation: 0.75 m to 1.0 m - for single storeyed building below ground level. 1.0 m to 1.3 m below G.L. for two storeyed building.
   (ii) Width of foundation of wall: Double the thickness of wall just above the plinth and then add 30 cm to it will give the width of the foundation.
   (iii) Concrete in foundation of wall: It should be nearly equal to $5/6^{th}$ of the thickness of wall above the plinth. The design of all other structural components is out of the scope of this book.

1.7 Orientation

The setting of plan of the building on its site with reference to the directions is known as orientation and it plays a great role in increasing its utility from the l view point of climate considerations. However, an orientation of the building may either be dictated by the prevailing circumstances or it may be decided by choice. In the former case, the plan is provided with elements which would make the orientation as comfortable as possible. In the latter case, maximum advantage is taken of the choice granted in the orientation of the building.

Following are some of the suggestions for good orientation of the buildings in a tropical climate:

1. **Cross ventilation:** Sufficient number of windows and ventilators at suitable level from the floor should be provided to cause movement of air for developing comfortable conditions inside the building. If this is not possible as in the case of the public buildings, resort should be taken to artificial ventilation.
2. **Damp-proof course:** It is desirable to provide damp-proof course at suitable level to keep away walls from damp. In a similar way, the overhanging of roofs on south and west sides will help in protecting the walls from the rain.
3. **Placing of walls:** The long walls of the building should be placed towards north and south. The short walls on the other hand should be placed towards east and west. Such a placing of walls would result in exposing less area of wall to the sun rays and it will assist in maintaining comfortable temperature inside the building.'
4. **Projections:** If projections in the form of balconies, verandahs weather-sheds, etc. are provided on east and west sides, the adjoining rooms remain comparatively cool.
5. **Roof:** It is evident that roof of a building is exposed to the maximum amount for sun and rain. Hence, it is necessary to exercise great care in deciding the type of roof and its method of construction. R.C.C. flat roofs should be provided [with water-proofing treatment and pitched roofs should contain valley gutters, overhang' eaves, etc. for draining rain water.