International Journal of Structural Civil Engineering and Management
Volume 1, Issue 02, 2025

Design of Commercial Reinforced Concrete Buildings

Mr. Mohdalaliyaf Abrar[*1], Mrs. Waseema Masoodhg[2]

Research Article
Received: 19-02-2025 Revised:22-03-2025 Accepted:05-04-2025 Published:15-04-2025

Abstract

The study and construction of structures that support or withstand loads are the focus of the civil engineering discipline of structural engineering. Large non-building constructions and building design are the most prevalent tasks for structural engineers. Structural engineers are required to make sure that their designs meet predetermined design requirements based on either serviceability and performance (e.g., building sway must not cause discomfort to the inhabitants) or safety (e.g., buildings must not collapse without appropriate notice). In order to prevent or lessen fatalities or injuries, structural engineers make sure that buildings and bridges are strong and stable enough to withstand all relevant structural loads, such as gravity, wind, snow, rain, seismic (earthquake), ground pressure, temperature, and traffic. Additionally, they create structures that are sufficiently rigid to prevent deflection or excessive vibration.
An analysis and design of a G+4 commercial building (hospital) have been attempted in this article. For analysis and structural design, we have chosen to use the Limit State Method. The design complies with IS 456-2000. We keep in mind that structural design should fulfil serviceability, which restricts deflection and cracking to an acceptable limit, as well as ultimate strength in flexure, shear, compression, tension, and torsion created under a certain system of loads.

Keywords: Structure Engineering, Serviceability,Commercial..

Introduction

The highest stress that a material can bear while being stretched or pulled before failing or breaking is known as ultimate tensile strength (UTS), also abbreviated as tensile strength (TS) or ultimate strength. Compressive strength and tensile strength are not the same, and their values might differ significantly. A brittle failure occurs when some materials shatter quickly without undergoing plastic deformation. Others, like the majority of metals, are more ductile and may undergo necking and mild plastic deformation prior to breaking. Typically, a tensile test is used to determine the UTS, and the engineering stress versus strain is recorded. The UTS is the highest point on the stress-strain curve (see point 1 on the engineering stress/strain diagrams below). Because it is an intense characteristic, the size of the test specimen has no bearing on its value. The specimen's preparation, the existence or absence of surface flaws, and the material's and test environment's temperature all affect it, though. Although they are crucial for brittle members, tensile strengths are rarely utilised in the design of ductile members. For common materials such alloys, composite materials, ceramics, plastics, and wood, they are tabulated. Stress, which is expressed as force per unit area, is the definition of tensile strength. It can be expressed simply as a force or as a force per unit width for certain non-homogeneous materials (or constructed components). The unit of measurement in the SI system is the Pascal (Pa) (or a multiple of it, frequently megapascals (MPa), using the mega- prefix); alternatively, newtons per square metre (N/m2) are equivalent to pascals. A popular unit of measurement for tensile strengths is kilo-pounds per square inch (ksi, or occasionally kpsi), which is equivalent to 1000 psi, or pounds-force per square inch (lbf/in² or psi).

Application Of Structure Designing

STRUCTURE DISIGNING:

Structural design for frame R.c.c structure can be done by three method

1. WORKING STRESS METHOD
2. ULTIMATE STRENGTH METHOD
3. LIMIT STATE METHOD

WORKING STRESS METHOD OF DESIGN:
It is the first R.C.C. structure technique. In order to provide a margin of safety, the structure element in this technique is designed such that the stress resulting from the action of service load as calculated in linear elastic theory using the modular ratio idea does not exceed a pre-design permissible stress, which is retained as a fraction of ultimate stress. This approach produces a heavy section since it does not fully utilise the material's strength. This approach does not adequately utilise the economic side.

ULTIMATE STRENGTH DESIGN METHOD:

The strength notion is the main foundation of this approach. By increasing the service load of a factor known as the load factor in order to provide the desired margin of safety, the structure element in this manner is proportionate to sustain the ultimate load. as the technique is based on the material's real stress-strain behaviour.

LIMIT STATE DESIGN METHOD:

The concept and approach of the limit state technique of design has resulted from extended research work conducted over the past several years on many areas of the study in the actual behaviour of members and structure.
Idea
In accordance with clause 36.4.1 of IS-456-2000, the working load is multiplied by the partial factor of safety; additionally, the material strength is divided by the partial design factor in accordance with clause 36.4.1 of IS-456-2000; the partial safety factor is introduced to reduce the probability of failure to approximately zero. When a structure or a portion of a structure reaches a limit state, it is considered unfit for use. This can happen in a number of ways, and the goal of the limit state method of design is to provide an acceptable probability that the structure will not reach the limit state during its service life span. Limit states can be broadly classified into two main categories:

1) LIMIT STATE OF COLLAPSE: This is the point at which the structure is most likely to collapse. It has to do with the structure's strength and stability. This constraint in design ensures that the structure is secure from collapsing.
2) LIMIT STATE OF SERVICIABLITY: This refers to how well a structure performs under working load and is determined by factors that impact the structure's serviceability. This limit state is concerned with structural deflection and cracking. The structure must be designed to safely bear all loads that are anticipated to act on it during the course of its lifetime when using the limit state technique. The goal of design is to create a structure with acceptable target reliability that can be used for the duration of its life. Steel structures must be built and developed to meet design specifications for durability, strength, and stability.

BEAN BEND:

A beam experiences a slight curvature as it bends due to a bending force. The concrete receives tensile stress at the curvature's outer face and compressive stress at its inner face. A singly reinforced beam is one in which the tension steel reinforcement is intended to withstand the tension and the concrete element is solely strengthened close to the tensile face.
A doubly reinforced beam is one in which the concrete element is reinforced close to the compressive face in addition to the tensile reinforcement to enable the concrete withstand compression. Compression steel is the name given to the latter type of reinforcement. If the architect restricts the section's size, more reinforcement must be supplied when the concrete's compression zone is insufficient to withstand the compressive moment (positive moment).
When the tensile reinforcement's tension capacity is less than the concrete's and compression steel's combined compression capacity, the beam is said to be under-reinforced at the tensile face. The tension steel yields when the reinforced concrete part experiences an increased bending moment, but the concrete does not reach its ultimate failure condition. An "under-reinforced" concrete also fails in a ductile manner when the tension steel strains and yields, showing significant deformation and warning before to its final failure. In this instance, the design is determined by the steel's yield stress.

When the tension steel's tension capacity exceeds the concrete's and compression steel's combined compression capacity, the beam is said to be over-reinforced at the tensile face. Therefore, the "over-reinforced concrete" beam breaks by crushing the concrete in the compressive zone before the steel in the tension zone gives. Since the failure happens instantly, there is no warning.

The concrete will crush and the tensile steel will yield simultaneously in a balanced-reinforced beam when the compressive and tensile zones achieve yielding at the same applied stress. However, this design criteria is just as dangerous as over-reinforced concrete since the concrete crushes at the same moment as the tensile steel yields, providing very little notice of distress in tension failure. Moment-carrying steel-reinforced concrete components should typically be designed to be under-reinforced so that users of the structure will be alerted to an approaching collapse.
A material's typical strength is the strength at which fewer than 5% of the specimen exhibits reduced strength.
The strength of a material, including a material-safety factor, is known as the design strength or nominal strength. In permissible stress design, the safety factor's value typically falls between 0.75 and 0.85. The theoretical failure point with a specific probability is the ultimate limit state. It is mentioned under calculated resistances and factored loads. Structures made of reinforced concrete (RC) are often developed in accordance with guidelines or recommendations from codes like ACI-318, CEB, CP110, or similar ones. RC structural members are designed using WSD, USD, or LRFD techniques. Both linear and non-linear methods may be used for RC member analysis and design. Building regulations often recommend a linear method and, in certain situations, a non-linear approach for applying safety factors. to view an illustration of a non-linear computation.

SLAB DESIGN

Slab is a simple structural component that forms a building's roof and floors. Its thickness is very minor in relation to its other dimensions. These come in a variety of designs, including square, rectangle, triangle, and circular, and are mostly used to carry loads by flexure. They may be utilised as parking ramps for multistory buildings, tanks, etc. An inclined slab is referred to as a staring case.

Slab can be simply supported or continuous across one or more supports, and it can be supported by walls or beams. When a slab's length to width ratio is greater than two and the majority of the loads are supported by a short span, it is referred to as a one-way slab; when the ratio is less than two, it is referred to as a two-way slab, which is further divided into resistance and simple support slabs.

Reinforced cement concrete slabs range in thickness from 75 to 300 mm. They are first planned like beams, with the width of the slab being measured in units based on the unit system. Therefore, it is presumed that the entire slab is made up of strips of unit-width compression reinforced concrete, which is only utilised in rare circumstances. Because a slab's shear stress is so minimal, shear reinforcement is seldom used. If necessary, it is better to deepen the slab to lessen the tension before adding reinforced concrete. In a slab, temperature-reinforced concrete is positioned at a right angle to the primary longitudinal reinforcement. The slab's design is entirely compliant with IS-456-2000; M-20 and FE415 steel are utilised in both the design and implementation phases. With a 20mm Clare cover, the slab's entire depth is resistible to 150mm. Temperature-reinforced concrete is made of mild steel bars, whereas the primary reinforced concrete is made of tor steel bars. The maximum bending moment of all the span's moments determines the section's overall depth.

COLUMN DESIGN

A column is a vertical element supporting a compressive load whose effective length is more than three times its least lateral dimension. Columns move the weight from the slab or beams to the foundation or footing. The column's form can often be square, rectangular, or round. Because concrete is robust under compression, longitudinal steel bars are inserted into the column to either decrease its size or enhance its tension and load bearing capability. A column is a compressive member which is used primarily of support axial compressive load and with a height of at least three time its least lateral dimension.
A reinforcement concrete column is said to be subjected to axiually loaded when the line of the resultant thrust of load support by the column is coincided upon the architecture requirement and the load to be supported. R.c.c column may be cast in various shape such as square, rectangle, hexagonal and circular etc.
The longitudinal bars are held in position by transferring reinforcement or lateral binder. The binder prevent displacement of the longitudinal bars during concreting operation and also check the

tendency of their bulking outward under load.

TYPES OF COLUMN

Based on types of reinforcement: depending up on the reinforcement used reinforced column are classified into

(a) Tied column: a column is referred to as tied when its primary longitudinal bars fall inside closely spaced lateral tiles.
(b) Spiral column: a column is referred to be a spiral column when its primary longitudinal bars are encased in spiral reinforcement that is continually wrapped and tightly spaced.
(c) Composite column: a composite column is one that has longitudinal reinforcement in the form of a structural steel section or pipe, either with or without longitudinal bars.

2. Based on loading type: Columns can be categorised into the following kinds based on loading type:
(a) Axially laden column: a column is said to be axially loaded when the center of gravity of its cross section and the line of action of the resulting compressive force coincide.
(b) Eccentrically loaded columns (uniaxial or biaxial): an eccentrically loaded column is one in which the center of gravity of the column's cross section does not align with the line of action of the resulting compressive force. The design of eccentrically loaded columns must account for both bending moments and combined axial force.
3. Based on slenderness ratio: The columns are categorised as follows based on the slenderness ratio, which is the ratio of the column's effective length to its least lateral dimension:
(a) Short column: a column is classified as short if its effective length divided by its least lateral dimension is less than 12. Crushing causes a short column to fail (pure compression failure).
(b) Long column: a column is said to as long if its effective length divided by its least lateral dimension is greater than 12. A lengthy column buckles or bends.

EFFECTIVE DURATION:

The distance between the bulking column's point of contract flexure is known as the effective length of the column. As stated in IS-456-2000's appendix D, the code provides an effective length value for typical use under idealised conditions. Depending on the kind of load, a column can be categorised using the following
1. A column loaded axially.
2. Axial load and uniaxial bending are applied to a column.
3. A column may experience bi-axial bending and axial stress.

AXIAL FORCE

A load on a column is referred to be an axial load if it is imposed via the cross-sectional center of gravity. • A force is applied parallel to the shaft's centerline. • A force exerted just in one direction straight on the axis direction is known as a uniaxial force. Compression or tension forces applied to a member are known as axial forces. Concentric loading occurs when the axial force passes through the member's center. Eccentric loading occurs when the force does not act through the centroid. Because the load is far from the centroid, eccentric loading causes a moment on the beam.

UNIAXIAL BENDING AND AXIAL LOAD

The part that is exposed to uniaxial bending and axial force must be designed using • In axial compression, the maximum compression strain in concrete is lak as 0.02. • When there is no tension on the section, the maximum compressive strain in concrete at the highly compressed extreme fibre is subjected to axial compression, and the strain at the least compressed extreme fibre is 0.0035 minus 0.75 time.

BI AXIAL BENDING AND AXIALLY LOADED

A member's resistance to axial force and biaxial bending must be determined using the assumptions outlined in 38.1 and 38.2, with neutral axes selected to fulfil the equilibrium of load and moment about two axes. Alternatively, the following equation might be used to create such a member. MUX,MUY = Design load-related moment about the X and Y axes MUXB,MUB = MAXIMUM UNI AXIAL MOMENY CAPACITY FOR A PU AXIAL LOAD

BENDING ABOUT X AND Y AXIS RESPECTIVELY AND RELATED TO PU/PUZ
PUZ=0.45FCKAC+0.75FYASC
PU/PUZ=0.2-0.8, THE VALUE OF AN VARIES FROM 1-2

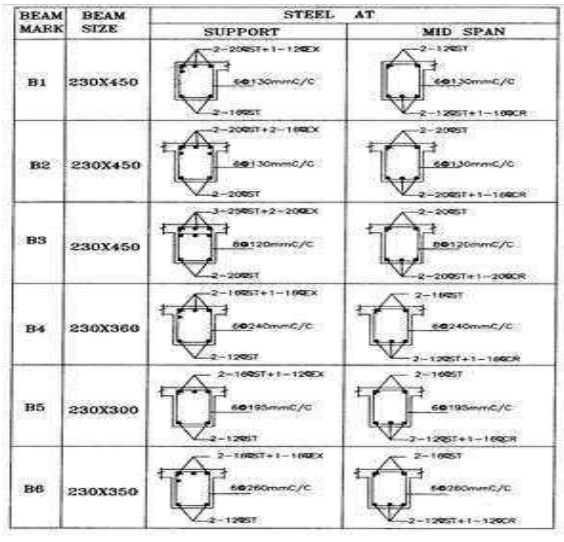
1. FOR VALUES UNDER 0.2=1
2. COLUMN POSITIONS FOR VALUE GREATER THAN 0.8=2 • Column placement

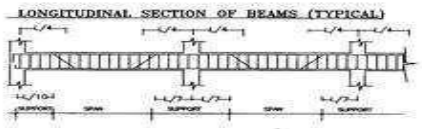
Some criteria and concepts for column placement are shown below.

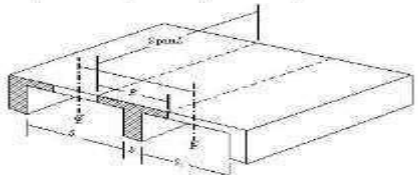
1. Because columns are used to support beams, which are often positioned beneath walls to support them, they should ideally be situated at or close to the building's corner and at the junction of the walls. The columns that are close to the property border may be exempt from the aforementioned consideration since it is difficult to provide footing for them.

The spacing between two columns is controlled by restrictions on the spans of supported beams because the column spacing is next to the span of the beams when the center-to-center distance between the junction of the walls is wide or when there are no cross walls. As the beam's breadth increases, so does the necessary depth and, consequently, its own weight. On the other hand, a column's increased length results in a small increase in the overall load. As a result, columns are often less expensive per unit than beams. Large beam spans should thus be avoided for financial reasons.

FIG 2- Slab-beam floor system.







Conclusion

The design specifications for concrete floor systems with nonprestressed reinforcement in accordance with ACI 318-05 are concluded in the aforementioned publication. It is crucial to remember that the reinforcing bars must be appropriately produced in line with the necessary flexure and shear reinforcement. Additionally, the standards for structural integrity must be met.

Reference

[1] ACI 318-05 Code and Analysis;
[2] "The Design of Concrete Floor Systems," D. Fanella, I. Alsamsam, PCA Professional Development Series, 2005.