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ANALYSIS AND DESIGN OF MULTISTORIED RESIDENTIAL BUILDING

PERIKALA SWATHI 1*, T PARIMALA 2*

1. *II.M.Tech , Dept of CIVIL, AM Reddy Memorial College of Engineering & Technology, Petlurivaripalem.*
2. *Asst .Prof, Dept. of CIVIL, AM Reddy Memorial College of Engineering & Technology, Petlurivaripalem.*

Abstract: Housing is an important indicator of the level of country's social progress. Besides food and clothing the man's basic need is shelter. Man requires shelter for protecting himself from natural calamities, wild animals and from other fellow beings. This history of making reveals that man has been moulding his environment consciously or un-consciously through the ages. From the caves his early adobe, down to the most sophisticated house of today, it is an absorbing and thought provoking study of man's progress and advances in various fields. The main advantage of multistoried buildings is that considerable amount of land can be saved there by reducing the overall cost of each independent flat. The various steps involved in the construction of an RCC Multistoried structures are discussed in the respective chapters. The planning has been done satisfying building Bye-lays.

Introduction: Due to migration of more and more people to urban areas in search of employment or other needs, multi-storey buildings have become essential to provide housing to even increasing population in cities. It is essential to finalize the program with reference to the people who will be using the building. Since the advent of RCC, the construction with monolithic joints between various members of a framed structure including slabs has been possible, bringing T beam concept into picture. The more or less rigid nature of the joints will reflect truly the assumptions of various methods of analysis. A structure is to be designed with economy and elegance. A durable structure serves the desired functions satisfactorily during its excepted life span.

Object and basic requirements of structural design:

- Safety
- Serviceability
- Durability
- Economy
- Aesthetic beauty
- Feasibility

- **Safety:** It is the prime requirement of structural design. A structure shall be so designed that it will not collapse during its expected life span. This is achieved by adequate strength and stability.
- **Serviceability:** A structure shall efficiently serve the intended function and also shall give a satisfactory performance through out the life span.
- **Durability:** A structure shall resist effectively environmental actions during its anticipated exposure conditions such as rain, climate variations in temperature and humidity chemical actions etc...
- **Economy:** The economy shall be of materials by optimum utilization or it may be the economy which includes cost of construction maintenance repairs etc.
- **Aesthetics Beauty:** The structure should give a pleasing appearance without affecting the economy to a greater extent.
- **Feasibility:** The structure has to be so designed that the proposed solution is feasible, practicable and acceptable.

STAGES IN PLANNING OF STRUCTURE: Once the plan of the structure is finalized for the particular type of occupancy design of structure involves the corresponding stages in the planning.

- Location of Beams.

- Column positioning.
- Orientation of columns
- Spanning of slabs.
- Layout and planning of stairs.
- Type of footings.

❖ **Location of Beams:**

Following are some of the guidelines for beams

Beams shall be normally provided under the walls or below a heavy concentric loads directly coming onto slabs. Since beams are primarily provided to support slabs, its spacing shall be decided by maximum spans of slabs

❖ **Column Positioning:**

The guiding principles which help in deciding the positioning of columns are;

Columns should preferably be located at or near the corners of building and at corners of rooms because basically the function of column is to support beams, but not to interfere with the movement of people in the various spaces. Large spans of beams should be avoided for economical reasons and from the considerations of controlling the deflection and cracking.

Large spacing of column not only increases the span and cost of beams but also the load on the column increases at each floor requiring costly foundations.

❖ **Orientation of Column:**

Normally columns provided in a building are rectangular with width of column not guidelines of orientation: When a column is rigidly connected to beams at rigid angles it is required to carry moments in addition to axial load. In such cases column should be so oriented that the depth of column is in the direction of long or spaces so as to get greater moments resting capacity is in the direction of longer moments of inertia. The projection of column outside the wall into a room should be avoided as it not only gives bad appearances but also obstructs the usage of corner creating problems in planning of the wall to avoid offsets.

❖ **Spanning of Slabs:**

This is decided by supporting beams. When the supports are only on opposite side or load distribution is only in one direction, then the slab acts as one-way supported slab.

However the two way action of slab depending not only on the provision of supports on all the four sides, but also on the aspect ratio, the effective spans in the two directions.

❖ **Layout of stairs:**

The type of stair, its layout is governed by the available size of staircases room and positions of beams and columns along the boundary of staircase, satisfying the maximum travel distance.

❖ **Types of Footings:**

Among various types of footings the suitable type of footing required for the structure shall be based on the applied loads, moments, forces and the induced reactions and safe bearing capacity of soil, e.g., if columns are very closely spaced and bearing capacity of soil is low raft foundation is used.

DESIGN METHODS.

Structural design for framed R.C.C structure can be done by three methods

- Working stress method.
- Ultimate load method.
- Limit state method.

❖ **Working Stress Method: (IS 456-2000)**

This method is developed for purely elastic materials. It assumes that the structure is made up concrete and steel both obey hook's law. The margin of safety is provided for the available stress.

❖ **Ultimate load method:**

This method is based on the strength capacity of member just before collapse stage.

The safety has been specified with respect to the behavior at the ultimate stage of member are proportioned.

❖ **Limit state method. : (IS 456-2000)**

This method is used in design of reinforced and pre stressed concrete structures.

The acceptable limit for the safety and serviceability requirements before failure occurs is called a limit state method.

a. Limit state of collapse.

b. Limit state of serviceability.

During planning and construction of any buildings certain restrictions are laid down by municipal bodies, urban development authorities and other government departments as town planning trusts related to clear open space to be left round the building, permissible constructions areas etc. Hence, the proposed plans of buildings are to be prepared according to these bye-laws which are checked and approved by the above authorities.
Frames are structures, which consists of individual members namely beams (horizontal members) and columns (vertical members), which are connected by rigid joints. Frames are designed by number of stories (single or multi-storied) and bays (single or multi-bay frames). Frames which may be indeterminate externally or combination of both external and internal indeterminacy.

METHOD OF ANALYSIS:
Any indeterminacy structure can be analyzed by the following methods:-
1) Slope deflection method
2) Moment distribution method
3) Kani's method (or) Rotation contribution method
4) Column analogy method
5) Strain energy method
6) Matrix method
7) Finite element method

Among all the above-mentioned methods, moments distribution, slope deflection and Kani's method is usually adopted in analyzing the structure.

Slope deflection method
The slope deflection method is developed by Axel Bendixen in 1914 and was later presented in greater detail by G.A.Maney of university of Minnesota in 1915.
This method can be used to analyze statically indeterminate structures, composed of moments resisting members such as continuous beams and frames. The popularity of the method is lost to some extent by the advent of relaxation is generally reduced by the introduction of the displacement method of matrix analysis. This method through not preferred by the engineers, is considered useful for the understanding of the relationship that exists between displacement of joints and the forces t the forces at the ends of member.

Moment distribution method
Professor Hardy Cross first introduced this method in 1930; the moment distribution method could be used for the analysis of all types of statically indeterminate beams or frames (rigid frames). In this method all the members of a structure, are first assumed to be fixed in a position and direction, and fixed end moments due to external loads are obtained. Now all the hinged joints are released by applying an equal and opposite moments and there effects are evaluated on the opposite joints. The unbalanced moments at a joint in distributed in the two spans in the ratio of their distribution factors.

Kani's method
Gasper kani developed this method. This methods is an excellent extension of the slope deflection method it has the simplicity of moment distribution method.
The kani's method is similar to the moment distribution method in both these method Gauss-Seidel iteration method to solve the slope deflection equations. However the difference between the Kani's method and moment distribution method is that Kani's method iterates the members end moments they rather than iterating their increments. Kani's method essentially consists of single, sample numerical operation performed repeatedly at the joints of the structure.

SLAB DESIGNING
INTRODUCTION: Slabs are plane structural members whose thickness is quite small as compares to its other dimensions. Slabs of thin structural members used as coverings for roof and floors. They generally carry uniformly distributed loads primarily by flexure. The common shapes of slabs are square, rectangular, triangular and circular.

On the basis of the direction of transfer of the load, slabs are classified into two types:

- One way slabs.
- Two way slabs.

ONE WAY SLABS: when the load on the slab is transferred along only one direction then the slabs is called one way slab. In general when the aspect **(L_y / L_x) is greater than 2**, then the load on slab is made to transfer along only the short span by stiffening the slab along short span is called main steel. A minimum reinforcement is provided along the direction perpendicular to the main steel reinforcement also, in order to keep the main steel bars in portion and prevent the temperature and shrinkage stresses. This reinforcement is called secondary reinforcement small part of the load will be transferred along the long span, to the beams supporting short edges.
In practice some situations arise, especially in case of balconies where the total load on slab shall have to be necessarily transferred only along span and no load is transferred along short span, even when the aspect ration L_y / L_x is greater than two (but not greater than around 2.5) this can be made possible by arranging main steel reinforcement along only long span and secondary steel along short span.

TWO WAY SLABS: when the load on the slabs is transferred along both directions then the slabs are two way slabs. In two way slabs the slab is stiffened along both the directions by providing main steel reinforcement along both the directions by providing main steel reinforcement along both the directions the arrangements of steel reinforcement in slabs.
In general slabs are designed as two way slabs when the aspect ratio **L_y /L_x < 2**.
It is a fact that the design of slabs would be economical when the slab panels are arranged in such a manner, where L_y /L_x<2. In other words the two way slabs are always economical than one way slabs. The maximum bending moment coefficients are taken in accordance with IS: 456-2000, table 26 and 27.

DESIGN OF BEAMS

TYPE OF BEAMS:

- Singly reinforced beams
- Doubly reinforced beams
- Flange beams

- **SINGLY REINFORCED BEAMS:**

In singly reinforced simply supported beams, reinforcement steel bars are placed near the bottom of the beams where they are most effective in resisting the tensile bending stresses. In singly reinforced cantilevers beams reinforcement bars are placed near the top of the beam.

- **DOUBLY REINFORCED BEAMS:**

A double reinforced beam is reinforced both in compression and tension regions. The section of beams may be a rectangle, T or L section.
The necessity of using in the compression zone arises to two main reasons as follows:
1. When the depth of the beam is restricted the strength available from a singly reinforced beams in adequate.
2. At support of continuous beam where bending moment changes sign.

- **FLANGE BEAMS:**

If the beams and slab are acts monolithically, some portion of the slab on either side of beam along its length also bends with the beams. At continuous supports the portion is reversed. The slab in tension is a part supports the portion is reversed. The slab in tension is part of it have cracked in tension; the beams is equivalent to rectangle at the supports.

DESIGN OF COLUMN

General

Column or strut is a compression member, the effective length of which exceeds three times the least lateral dimensions. Column is defined as a structural member subjected to compressive forces in a direction similar to its longitudinal axis. When the compression members are over loaded then their failure may take place in direct compression, excessive bonding combined with twisting. The failure of

column depends upon their slenderness ratio.

TYPES OF COLUMN:

- **SHORT COLUMNS**

The compressive member are considered as short when both slenderness **i.e**., l_{ex} / D and l_{ey} are < 12 l_{ex} and l_{ey} – effective lengths w.r.t major and minor axes respectively.
B - Width of the member
D – Depth w.r.t major axes

- **Long Columns**

The compressive members are considered as long when both slenderness ratios i.e, l_{ex} / D and l_{ey} are > 12 Columns may be square, rectangle or polygonal in cross – section.
Effective length of column depends upon end restraint conditions.

IS CODE RECOMMENDATIONS

1. The percentage of longitudinal steel should not be less than 0.8, not more than 6% of gross sectional area of column.
2. The minimum number of longitudinal bars provided in a column shall be 4 in a rectangular column and 6 in a circular column.
3. The bars shall not be less than 12mm in diameter.
4. The spacing of longitudinal bars measured along the periphery of the column shall not be exceed 30 cm.
5. The pitch of the transverse reinforcement shall not be more than the least of the following.

a) The least lateral dimension of the member.
b) 16 times the smallest diameter of the longitudinal bar.
c) 300mm diameter of tie shall not be less than $1/4^{th}$ of the diameter of the longitudinal bar and in no case less than 5mm,

6. Unsupported length of column is taken as per clause 24.1.3(b) and effective Length is taken from table 24 of IS: 456:2000.
7. Columns are to be checked in limit state method using chart given in specification IS: 456:2000 under clause 38.5 considering axial load and uni-axial bending,
8. The cover to the longitudinal reinforcement bar in a column shall not less than diameter of such bar in case of column of minimum dimension of 20mm or under where reinforcing bars doesn't exceed 12mm cover of 25mm may be used.

DESIGN OF FOOTINGS

General

Footings or foundation is defined as the part of subtractive which transmits the load from superstructure to surrounding soil stratum safely. Foundations are classified as two types:

- Shallow foundation
- Deep foundation

- **SHALLOW FOUNDATION:**

The depth of the foundation is less than or equal to the width of the foundation is said to be shallow foundation

- **DEEP FOUNDATION:**

If the depth of the foundation is greater than the width of the foundation then the foundation is said to be deep foundation. Design of footing mainly depends on the safe bearing capacity of the soil on which the footing rests and the load coming from superstructure.

FOOTINGS MAY BE ISOLATED, COMBINED:

Isolated or independent footing are footing that supports the individual columns. They distribute and separate the load over a sufficiently large area of soil stratum to minimum the bearing pressure. Isolated footing may be square, rectangle or circular. In general, it is assumed that the soil behaves elastically i.e. The strain in the soil is proportional to applied stress and strain distribution in the soil immediately under the base of the footings in linear, stress distribution is different for different soils. For analysis purpose, a footing can be compressed with a rigid body in equilibrium subjected to loads. Like others structural member a footing is designed to resist shear forces and bending moment. In design, the critical section for one-way shear (beam

shear) is at a distance equal to the effective depth, d from the face of the column footing. The critical section for two-way shear or slab type shear shall be at a distance d/2 from the periphery of the column perpendicular to the plane slab. The critical section for bending moment is at the face of the column. Generally the footing is sensitive to punching shear.

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