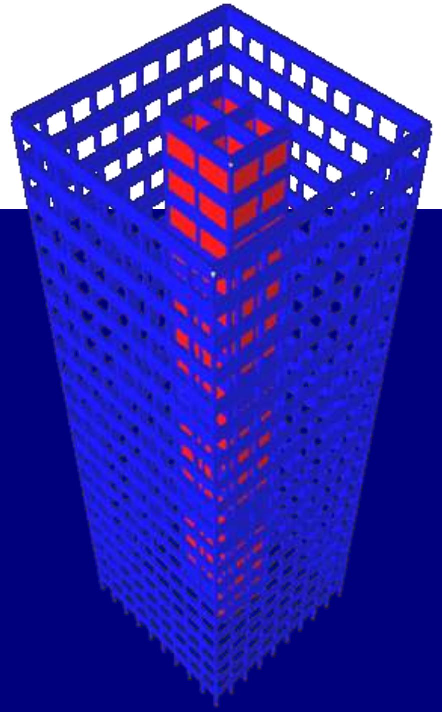
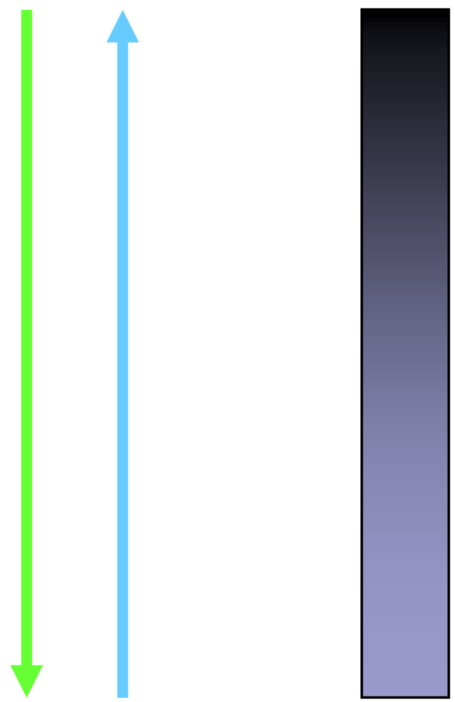


Dr.G.Kumaran, Professor, Structural Engg. Dept., Annamalai university

Building Structures Modeling and Analysis Concepts

Overall Design Process

- Conception
- **Modeling**
- **Analysis**
- **Design**
- Detailing
- Drafting
- Costing

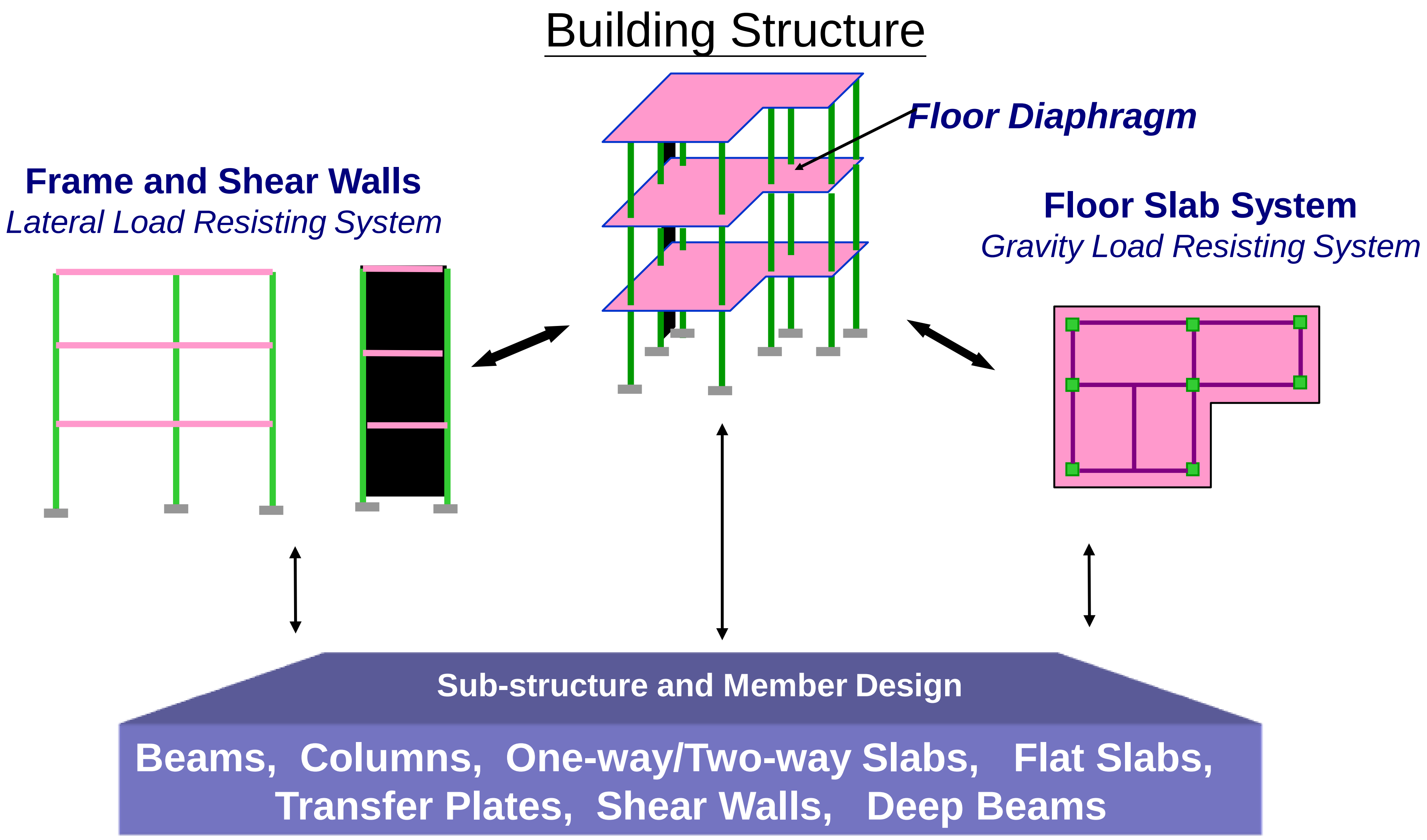


Integrated
Design
Process

Building Systems

- Building is an assemblage of various Systems
  - Basic Functional System
  - **Structural System**
  - Plumbing and Drainage System
  - Electrical, Electronic and Communication System
  - Security System
  - Other specialized systems

The Building Structural System - Physical



The Building Structural System - Conceptual

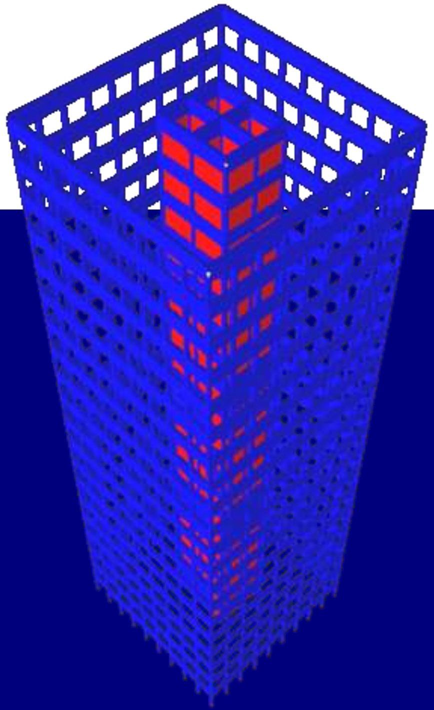
- **The Gravity Load Resisting System (GLRS)**
  - The structural system (beams, slab, girders, columns, etc) that act primarily to support the gravity or vertical loads
- **The Lateral Load Resisting System (LLRS)**
  - The structural system (columns - tubular structure, shear walls, bracing, etc) that primarily acts to resist the lateral loads
- **The Floor Diaphragm (FD)**
  - The structural system that transfers lateral loads to the lateral load resisting system and provides in-plane floor stiffness

Building Response

- **Objective: To determine the load path for gravity and lateral loads**

- **For Gravity Loads - How Gravity Loads are Distributed**
  - Analysis of Gravity Load Resisting System for:
    - Dead Load, Live Load, Cladding Loads, temperature, shrinkage, creep
  - Important Elements: Floor slabs, beams, columns, openings, Joists, etc.

- **For Lateral Loads – How Lateral Loads are Distributed**
  - Analysis of Lateral Load Resisting System for:
    - Wind Loads, Seismic Loads, Structural Un-symmetry
  - Important elements: Columns, shear walls, bracing , beams



Structural Response To Loads

Structural System

STRUCTURE

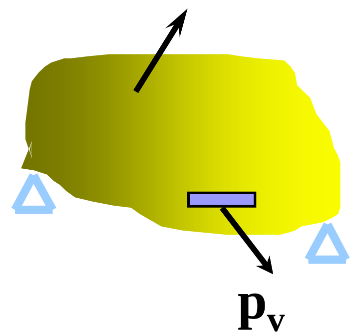
EXCITATION

Loads

Vibrations

Settlements

Thermal Changes



RESPONSES

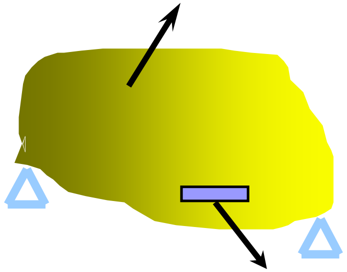
Displacements

Strains

Stress

Stress Resultants

Analysis of Structures



$$\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y} + \frac{\partial \sigma_{zz}}{\partial z} + p_{vx} = 0$$

Real Structure is governed by "Partial Differential Equations" of various order

Direct solution is only possible for:

- Simple geometry
- Simple Boundary
- Simple Loading.

The Need for Modeling

- **We would like to predict the structural response before the structure is being constructed**

- **Real structure are not available for analysis**

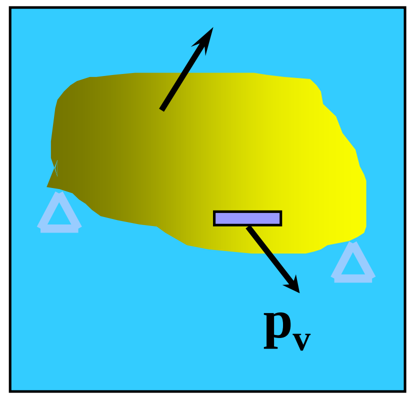
We therefore need tools to Model the Structure and to Analyze the Model

The Need for Structural Model

STRUCTURE

EXCITATION

Loads
Vibrations
Settlements
Thermal Changes



RESPONSES

Displacements
Strains
Stress
Stress Resultants

Structural Model

Finite Element Method: The Analysis Tool

- **Finite Element Analysis (FEA)**

  "A discretized solution to a continuum problem using FEM"

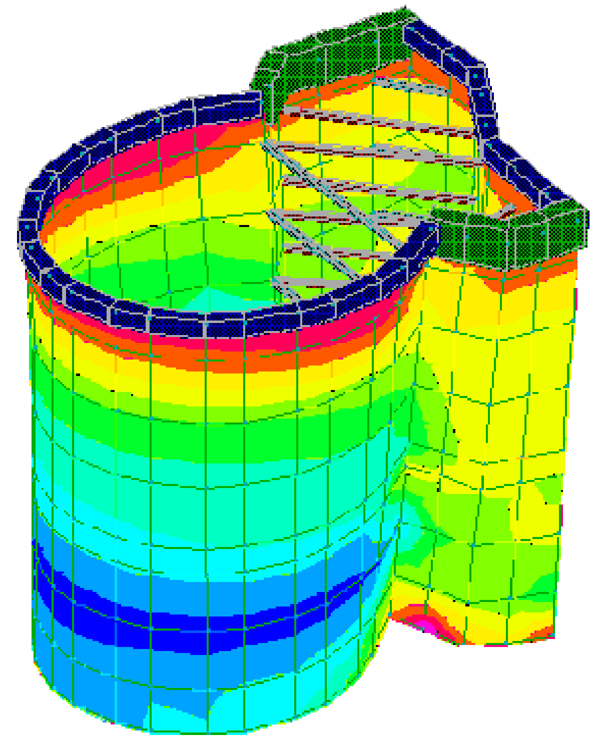
- **Finite Element Method (FEM)**

  "A *numerical procedure for solving (partial) differential equations associated with field problems, with an accuracy acceptable to engineers"*

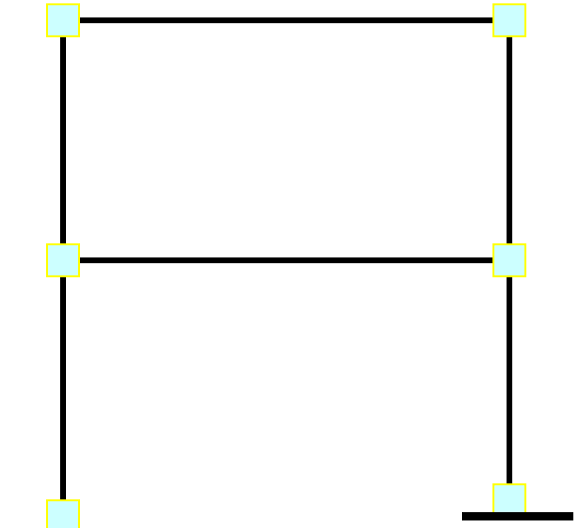
  Throughout the semester, you have already learnt the foundation of FEM:-

  - The matrix structural analysis technique

  - Different element types for FEM



Continuum to Discrete Model



3D-CONTINUM MODEL

(Governed by partial differential equations)

CONTINUOUS MODEL OF STRUCTURE

(Governed by either partial or total differential equations)

DISCRETE MODEL OF STRUCTURE

(Governed by algebraic equations)

Basic Steps in FEA

- Evaluate Real Structure
- Create Structural Model
- Discretize Model in FE
- Solve FE Model
- Interpret FEA Results
- Physical significance of Results

Engineer

Engineer + Software

Software

Discretization of Continuums

<u>General Solid</u>

↓

(Orthogonal dimensions)

↓

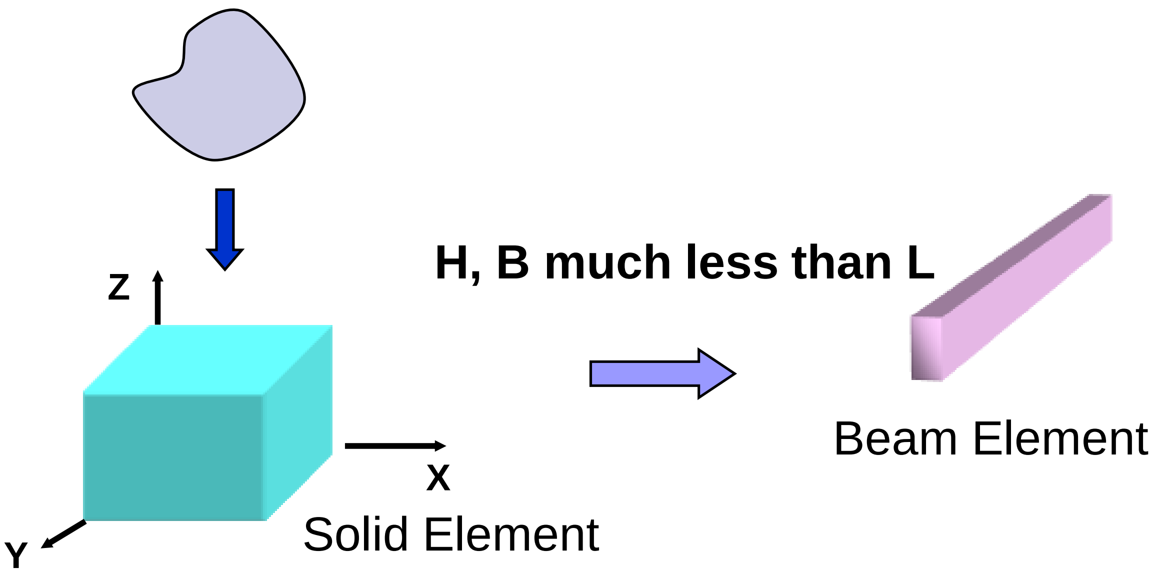
<u>Regular Solid</u>

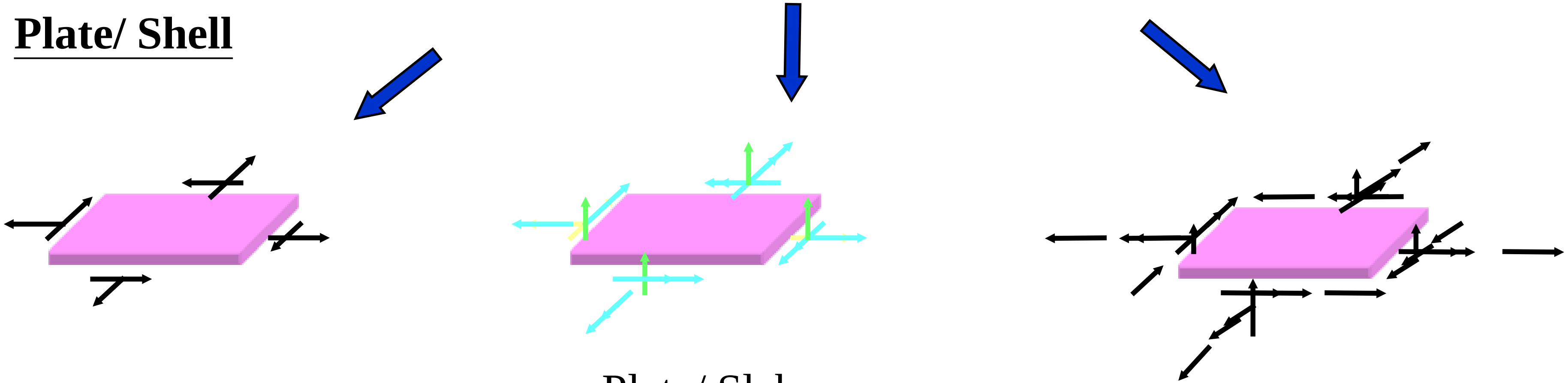
↓

(T small compared to Lengths)

↓

<u>Plate/ Shell</u>





Membrane/ Panel
<u>In-Plane, Only Axial</u>

Plate/ Slab
<u>Out of Plane, Only Bending</u>

Shell
<u>In-Plane and Bending</u>

Global Modeling of Structural Geometry

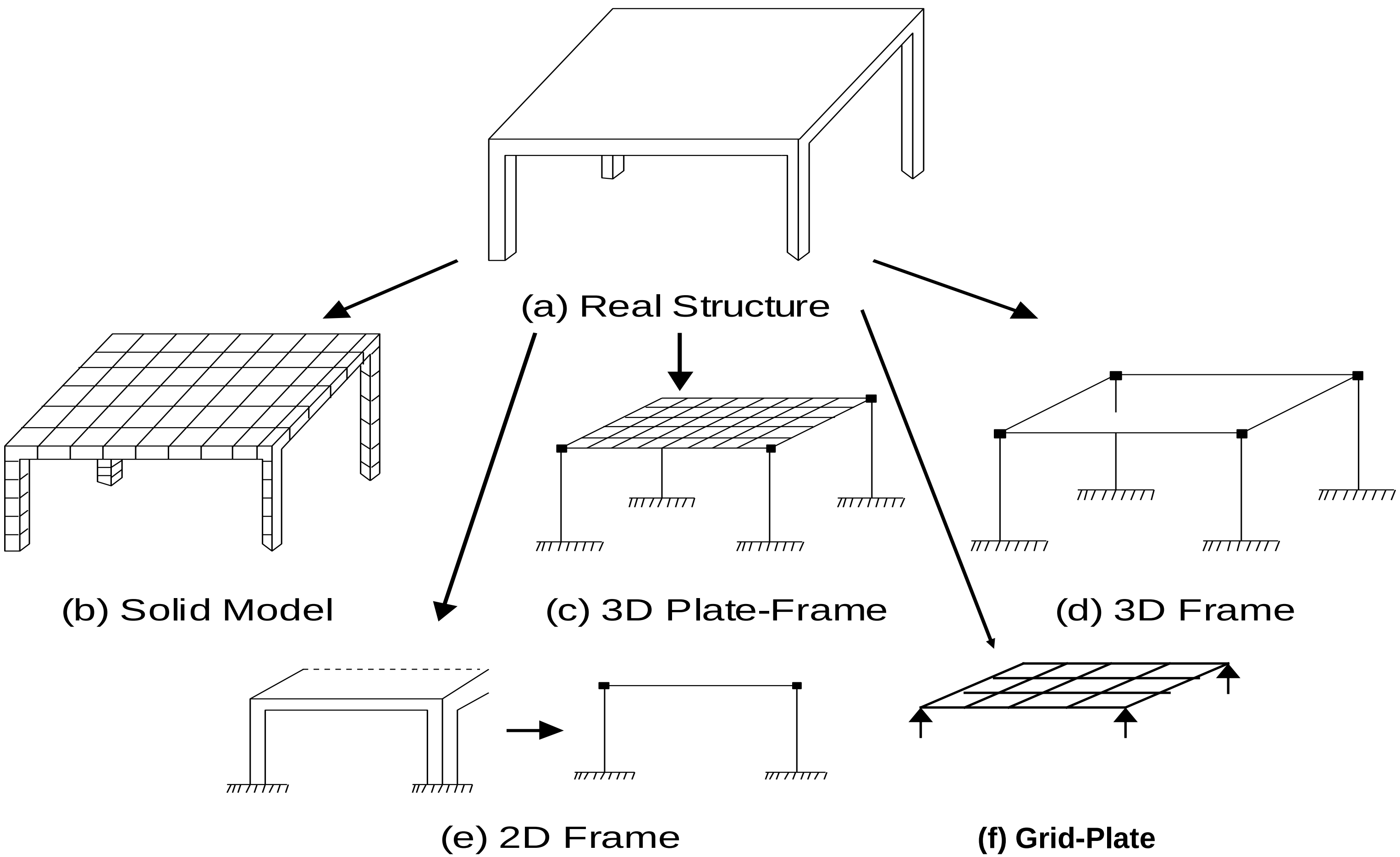
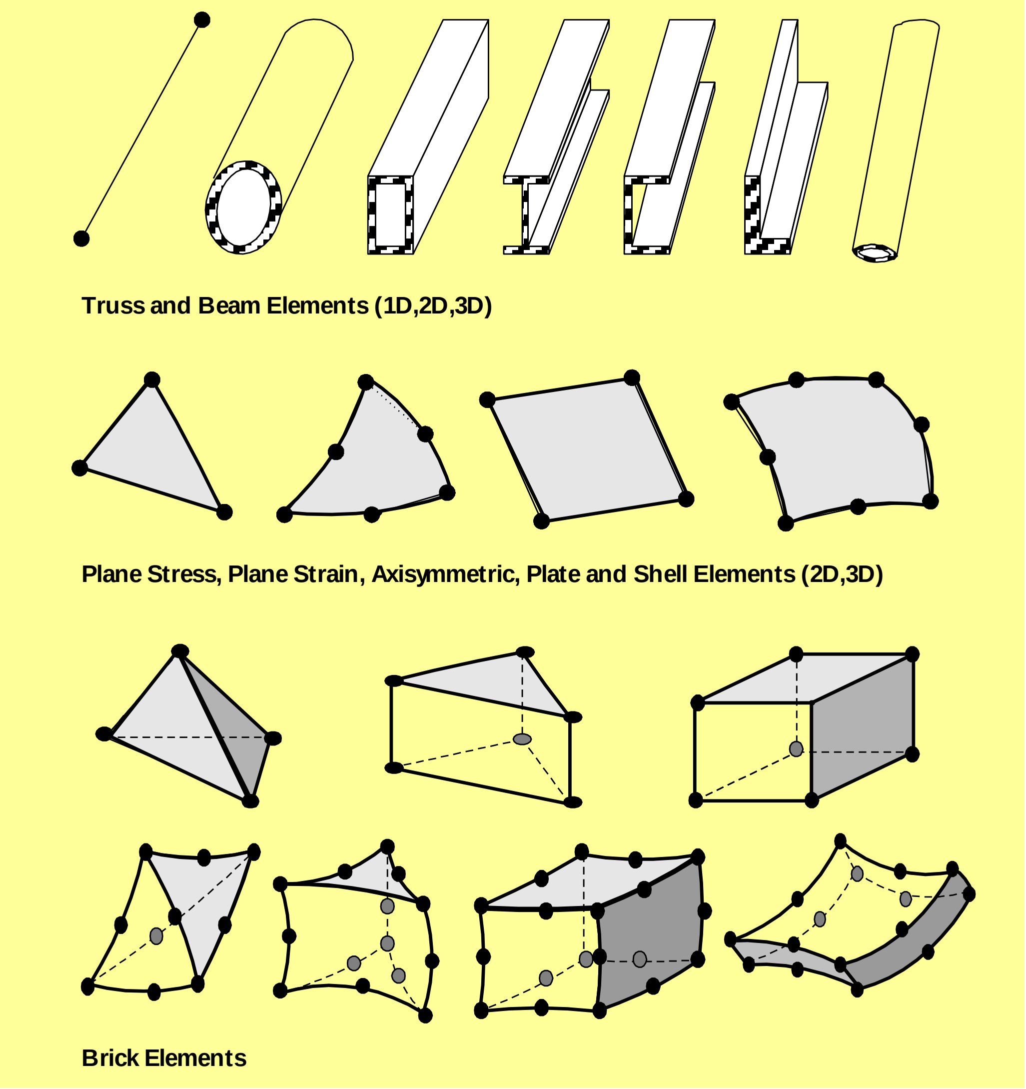


Fig. 1 Various Ways to Model a Real Struture

Dimensions of Elements

- **1 D Elements (Beam type)**
  - Can be used in 1D, 2D and 2D
  - 2-3 Nodes. A, I etc.
- **2 D Elements (Plate type)**
  - Can be used in 2D and 3D Model
  - 3-9 nodes. Thickness
- **3 D Elements (Brick type)**
  - Can be used in 3D Model
  - 6-20 Nodes.

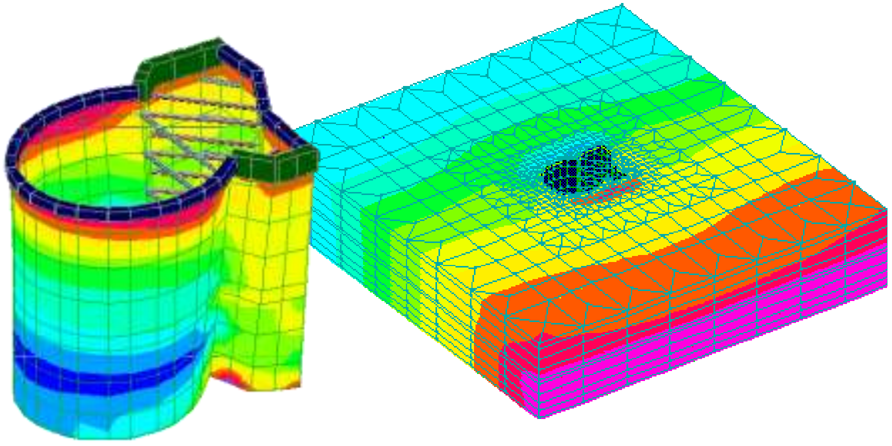


Soil-Structure Interaction

- **Simple Supports**
  - **Fix, Pin, Roller etc.**
  - **Support Settlement**

- **Elastic Supports**
  - **Spring to represent soil**
  - **Using Modulus of Sub-grade reaction**

- **Full Structure-Soil Model**
  - **Use 2D plane stress elements**
  - **Use 3D Solid Elements**

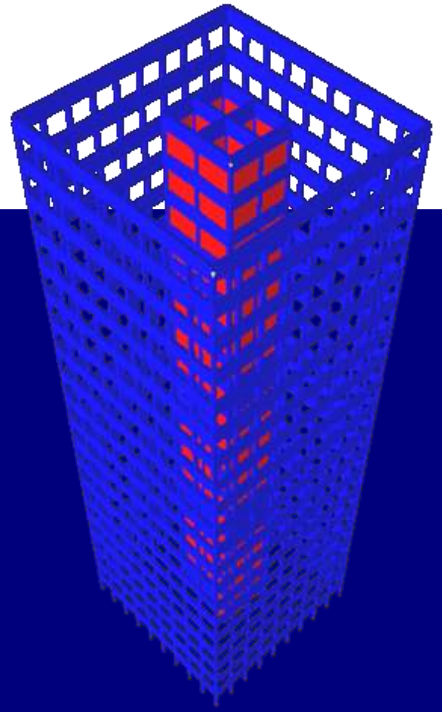


Connecting Different Types of Elements

	Truss	Frame	Membrane	Plate	Shell	Solid
Truss	OK	OK	Dz	OK	OK	OK
Frame	Rx, Ry, Rz	OK	Rx, Ry, Rz, Dz	Rx ? Dx, Dy	Rx ?	Rx, Ry, Rz
Membrane	OK	OK	OK	Dx, Dy	OK	OK
Plate	Rx, Rz	OK	Rx, Rz	OK	OK	Rx, Rz
Shell	Rx, Ry, Rz	OK	Rx, Ry, Rz, Dz	Dx, Dz	OK	Rx, Rz
Solid	OK	OK	Dz	Dx, Dz	OK	OK

Orphan Degrees Of Freedom:

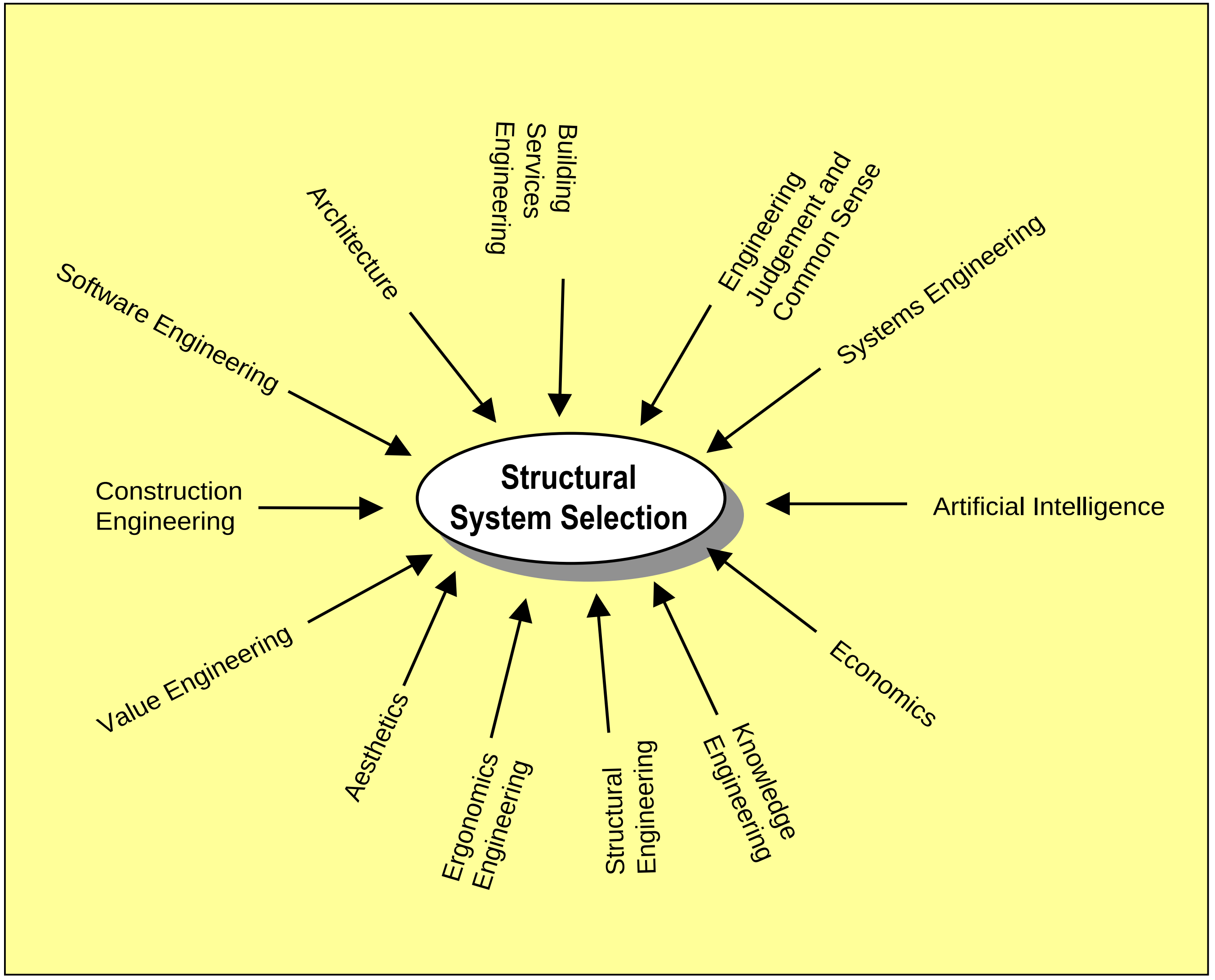
0	1	2	3	4



Selection Of Structural Systems

Knowledge Model for System Selection

- Architecture
- Building Services
- Construction Eng.
- Value Eng.
- Aesthetics
- Ergonomics Eng.
- Structural Eng.
- Knowledge Eng.
- Economics
- Artificial Intelligence
- System Eng.
- Common Sense



Selection of Structural System

Function has considerable effect on the selection of structural system

Based on Function/Occupancy of Tall Buildings:

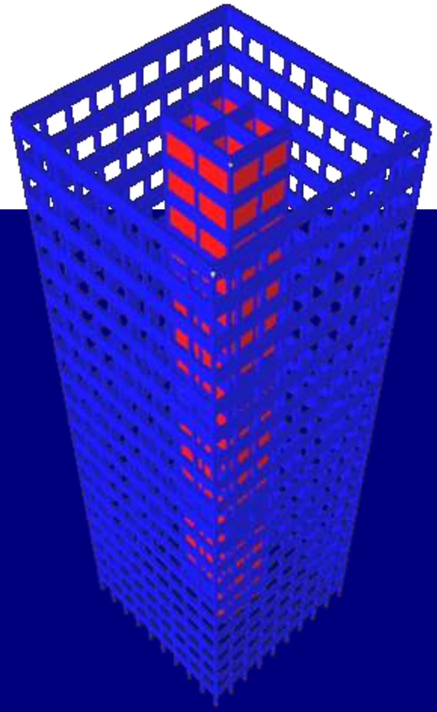
- **Residential Buildings**
  - Apartments
  - Hotels
  - Dormitories
- **Office and Commercial Buildings**
- **Mixed Occupancy – Commercial + Residential**
- **Industrial Buildings and Parking Garages**

Typical Characteristic of Residential Bldg

- **Known location of partitions and their load**
- **Column lines generally matches architectural layout**
- **Typical spans 15-22 ft**
- **Tall buildings economy in achieved using the thinnest slab**
- **One way pre-cast or flat slab – popular**
- **Lateral load resistance provided by frame or shear walls**
- **More or less fixed M/E system layouts**

Typical Characteristic of Commercial Bldg

- **Unknown location of partitions and their load**
- **Typical spans 20-35 ft**
- **Need for flexible M/E layouts**
- **Post-tension or ribbed and flat slab with drop panel – popular**
- **Ideal balance between vertical and lateral load resisting systems: sufficient shear walls to limit the resultant tension under gravity plus wind**
- **Lateral load resistance varies significantly**



Vertical Load Resisting Systems

Gravity Load Resisting Systems

Purpose

“ To Transfer Gravity Loads Applied at the Floor Levels down to the Foundation Level ”

- **Direct Path Systems**
  - Slab Supported on Load Bearing Walls
  - Slab Supported on Columns

- **Indirect Multi Path Systems**
  - Slab Supported on Beams
  - Beams Supported on Other Beams
  - Beams Supported on Walls or Columns

Vertical Load Resisting Systems

1. **Slabs supported on Long Rigid Supports**
   - Supported on stiff Beams or Walls
   - One-way and Two-way Slabs
   - Main consideration is flexural reinforcement

2. **Slab-System supported on Small Rigid Supports**
   - Supported on Columns directly
   - Flat Slab Floor systems
   - Main consideration is shear transfer, moment distribution in various parts, lateral load resistance

3. **Slabs supported on soil**
   - Slabs on Grade: Light, uniformly distributed loads
   - Footings, Mat etc. Heavy concentrated loads

Popular Gravity Load Resting Systems

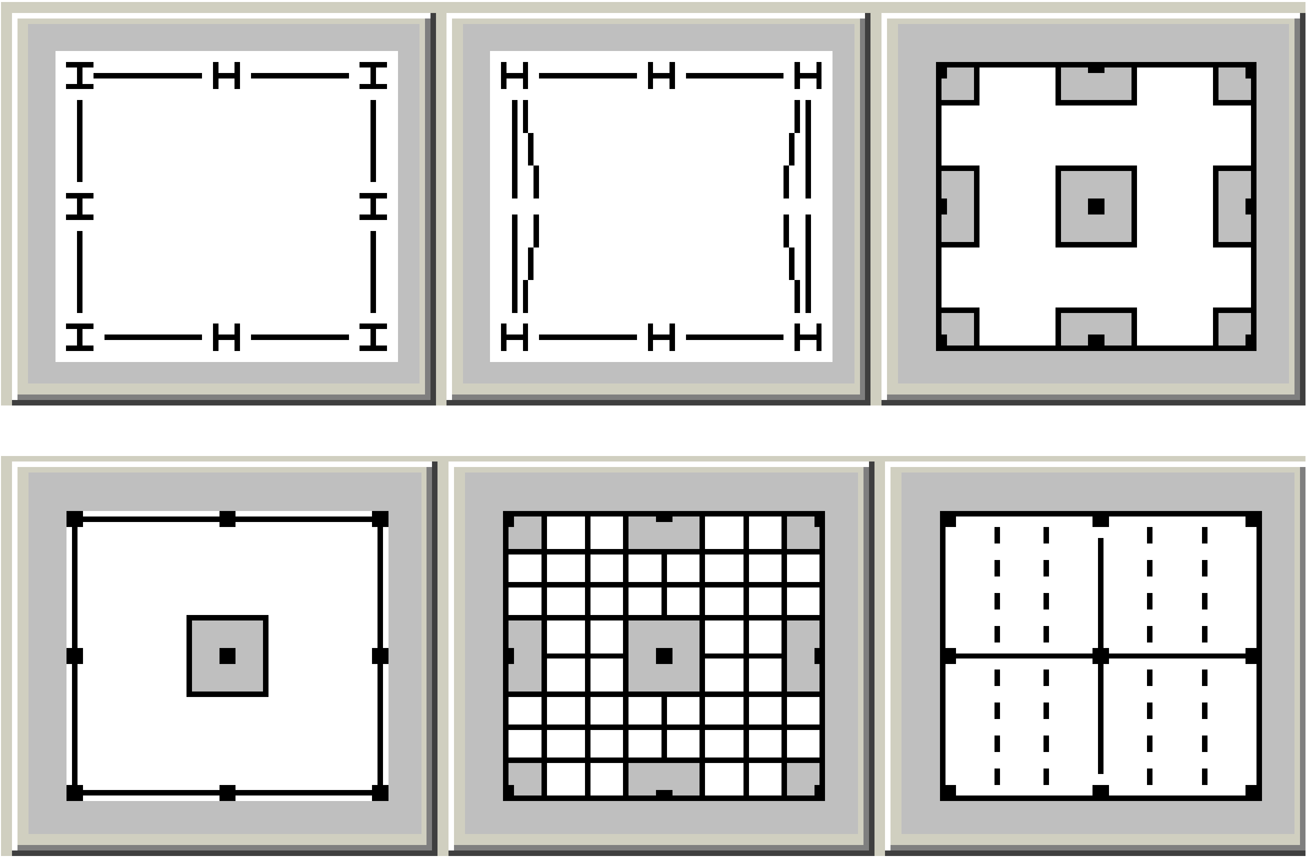
- **Direct Load Transfer Systems *(Single load transfer path)***
  - Flat Slab and Flat Plate
  - Beam-Slab
  - Waffle Slab
  - Wall Joist

- **Indirect Load Transfer System *(Multi step load transfer path)***
  - Beam, Slab
  - Girder, Beam, Slab
  - Girder, Joist

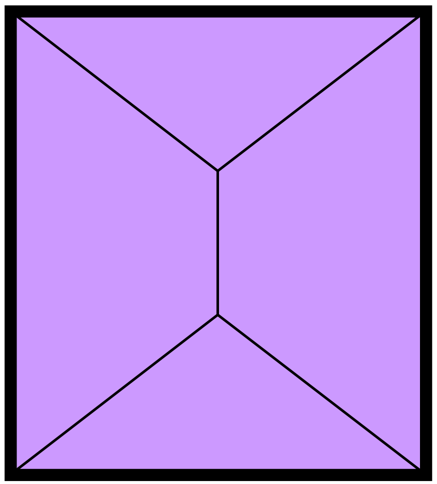
Conventional Approach

- **For Wall Supported Slabs**
  - Assume load transfer in One-Way or Two-Way manner
  - Uniform, Triangular or Trapezoidal Load on Walls
- **For Beam Supported Slabs**
  - Assume beams to support the slabs in similar ways as walls
  - Design slabs as edge supported on beams
  - Transfer load to beams and design beams for slab load
- **For Flat-Slabs or Columns Supported Slabs**
  - Assume load transfer in strips directly to columns

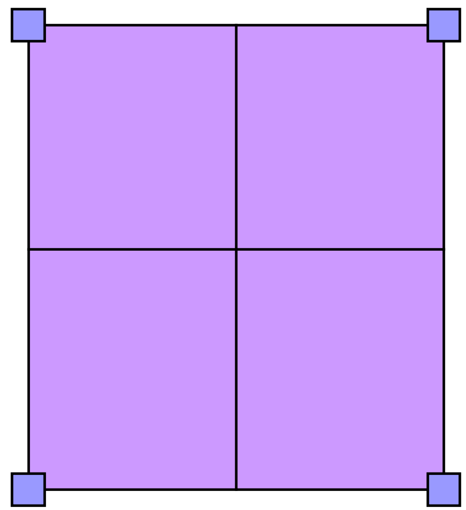
Popular Gravity Load Resting Systems



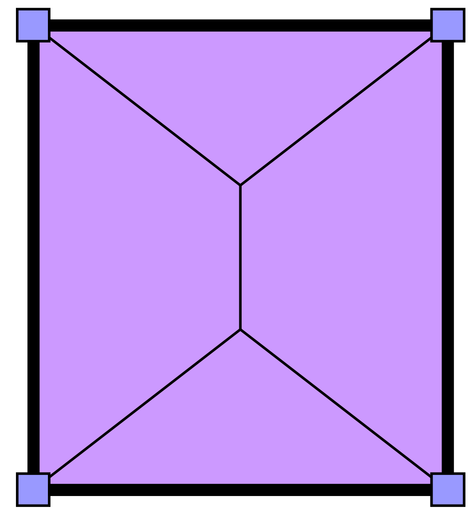
Gravity Load Transfer Paths



Single Path
Slab On Walls

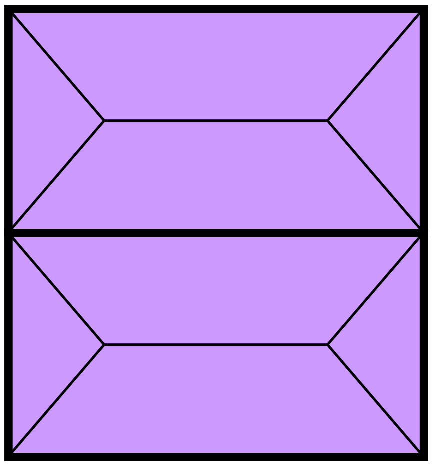


Single Path
Slab on Columns

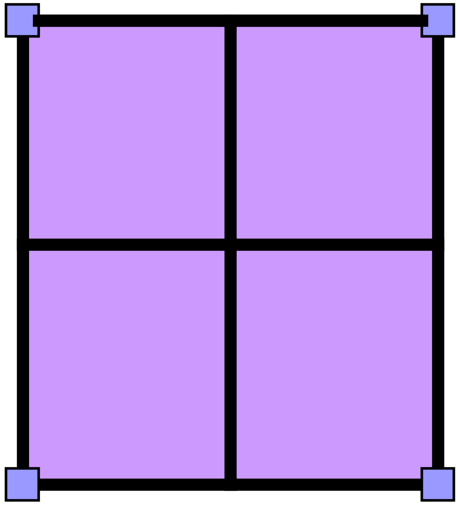


Dual Path
Slab On Beams,
Beams on Columns

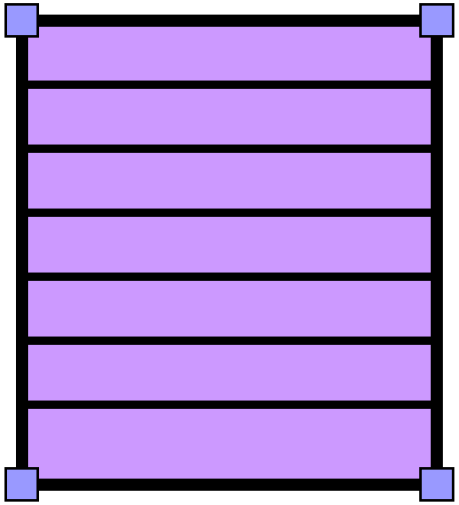
Gravity Load Transfer Paths



Mixed Path
Slab On Walls
Slab On Beams
Beams on Walls

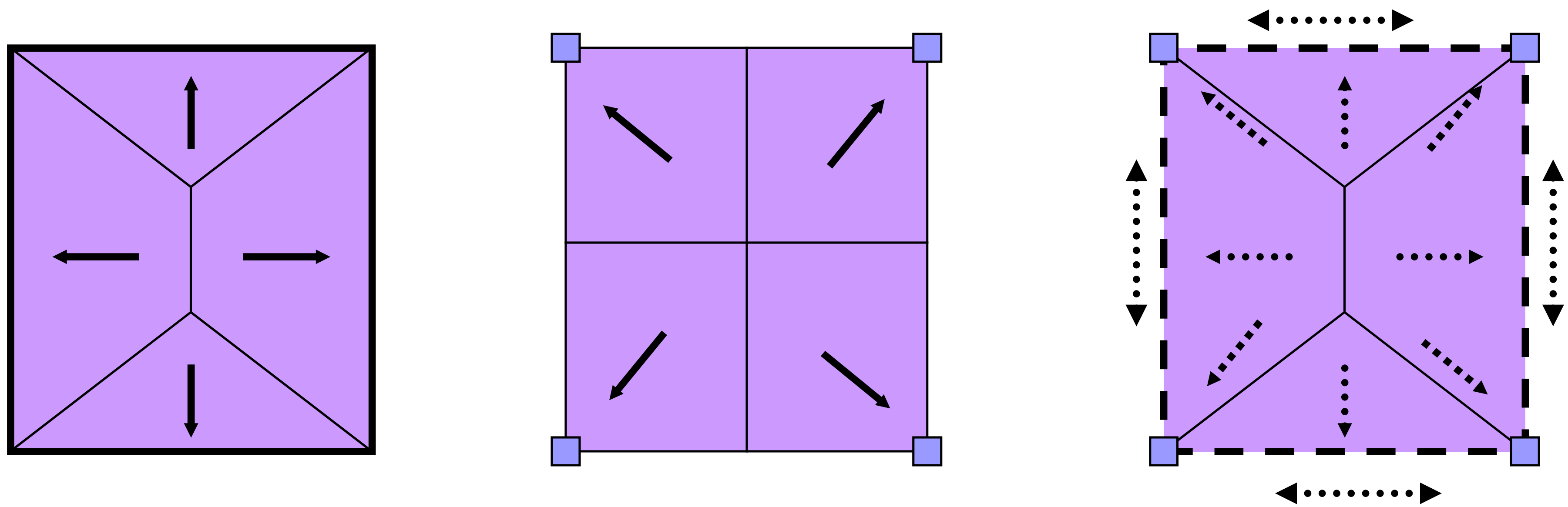


Complex Path
Slab on Beams
Slab on Walls
Beams on Beams
Beams on Columns



Three Step Path
Slab On Ribs
Ribs On Beams
Beams on Columns

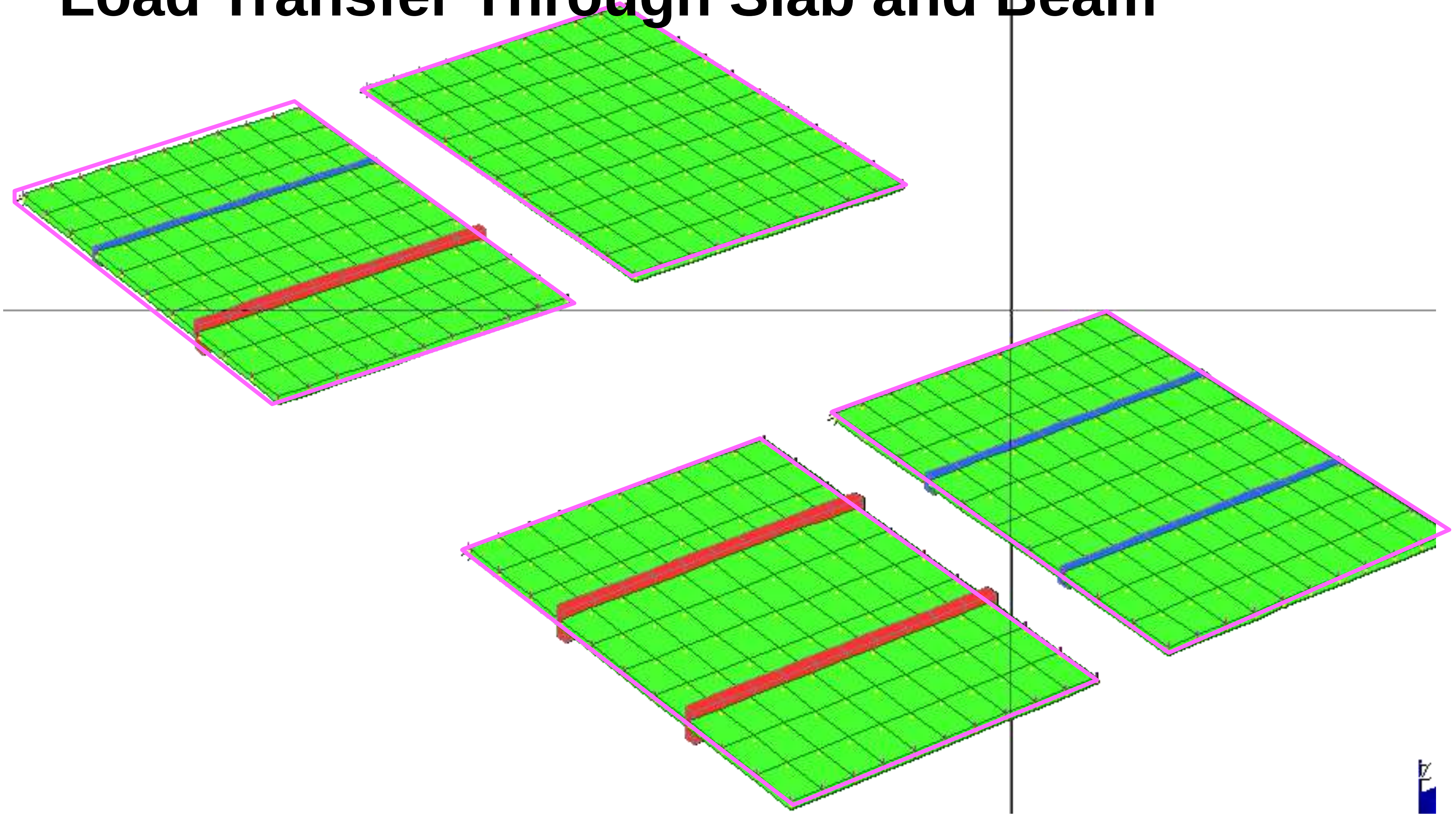
Simplified Load Transfer



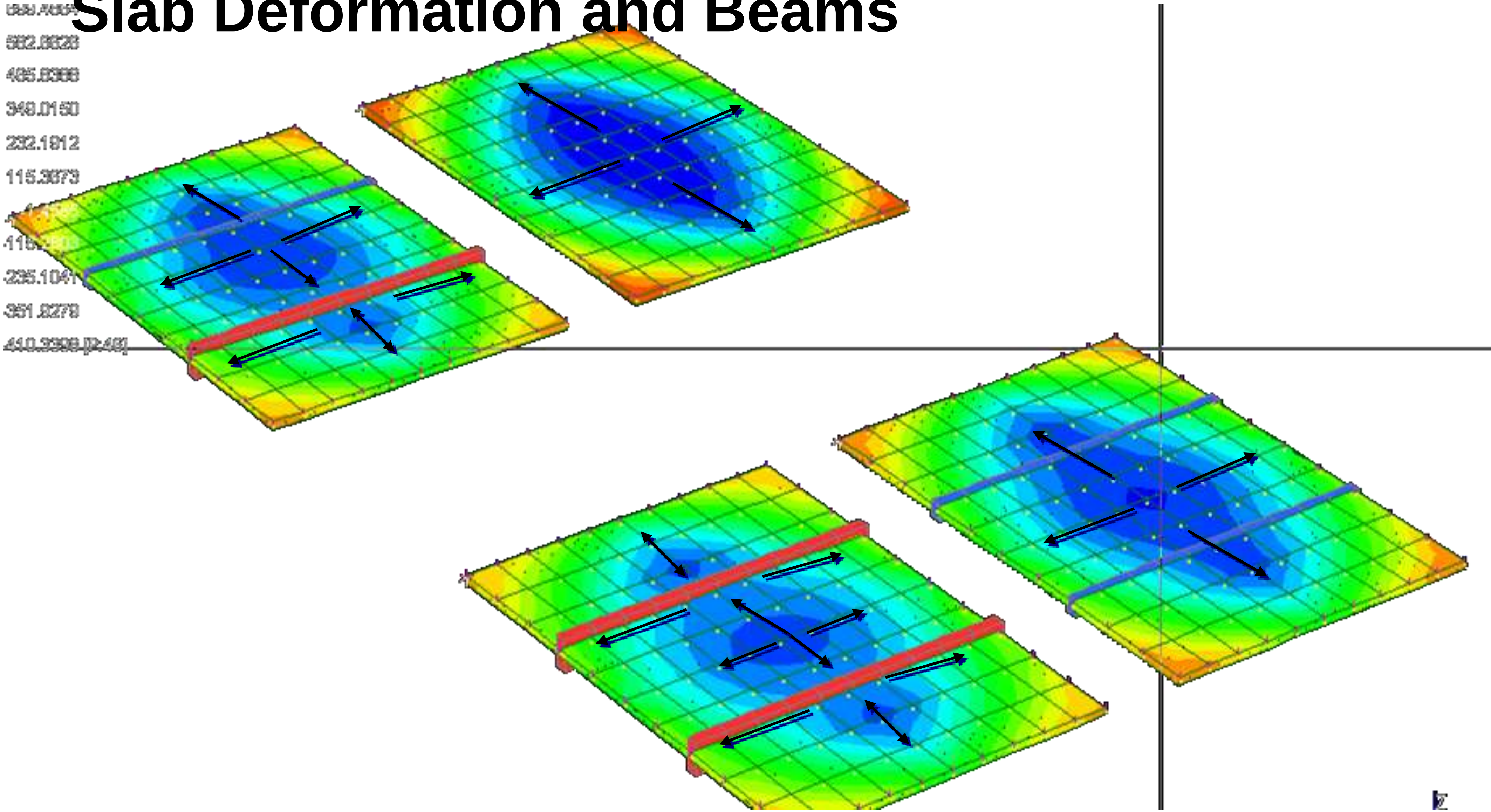
To Lines | To Points | To Lines and Points

Transfer of Area Load

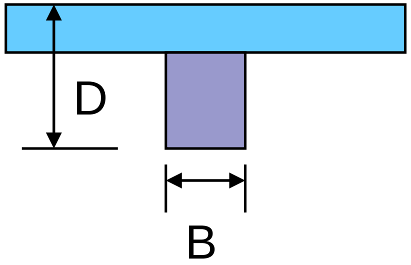
Load Transfer Through Slab and Beam

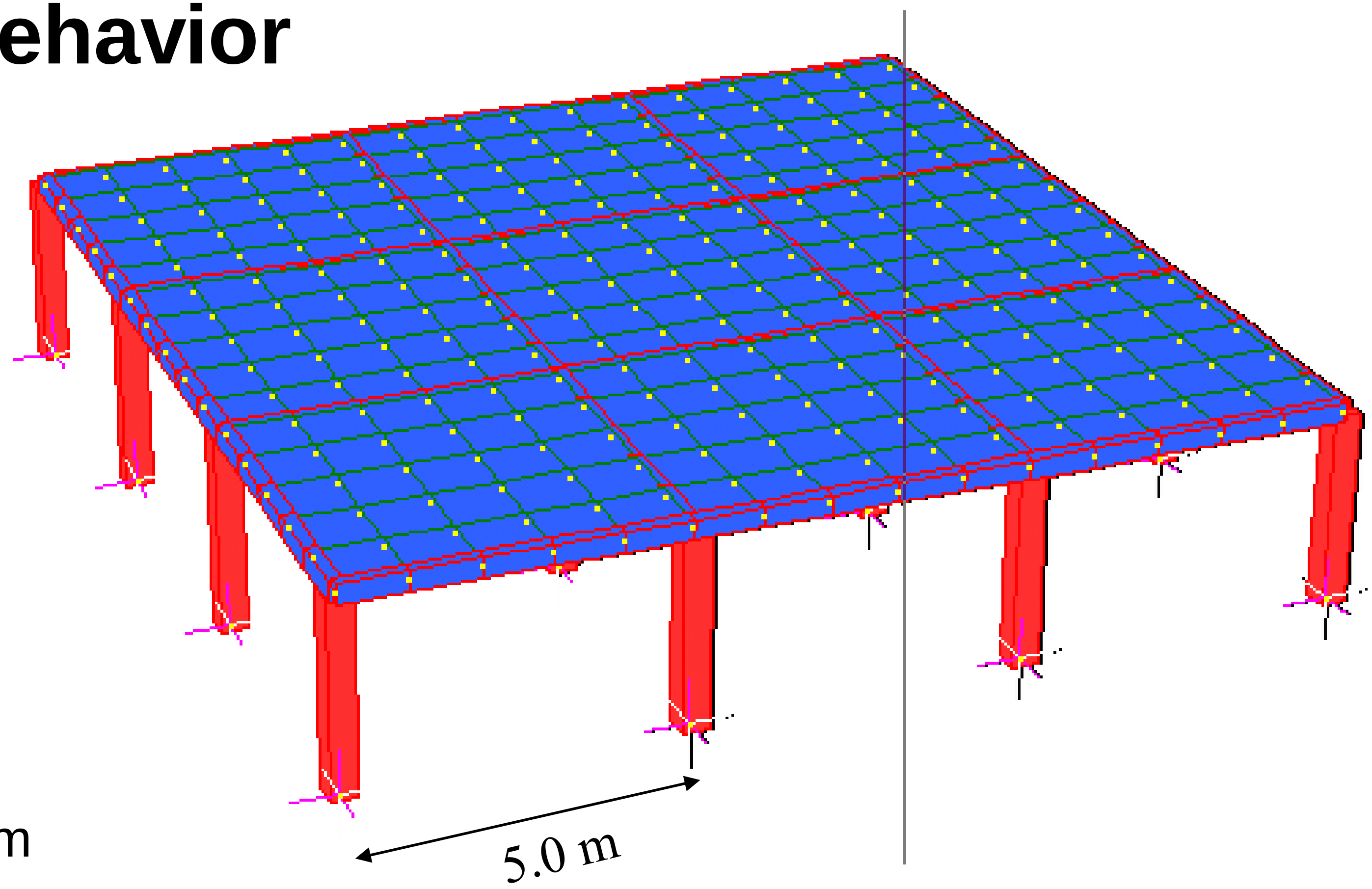


Slab Deformation and Beams



Slab System Behavior



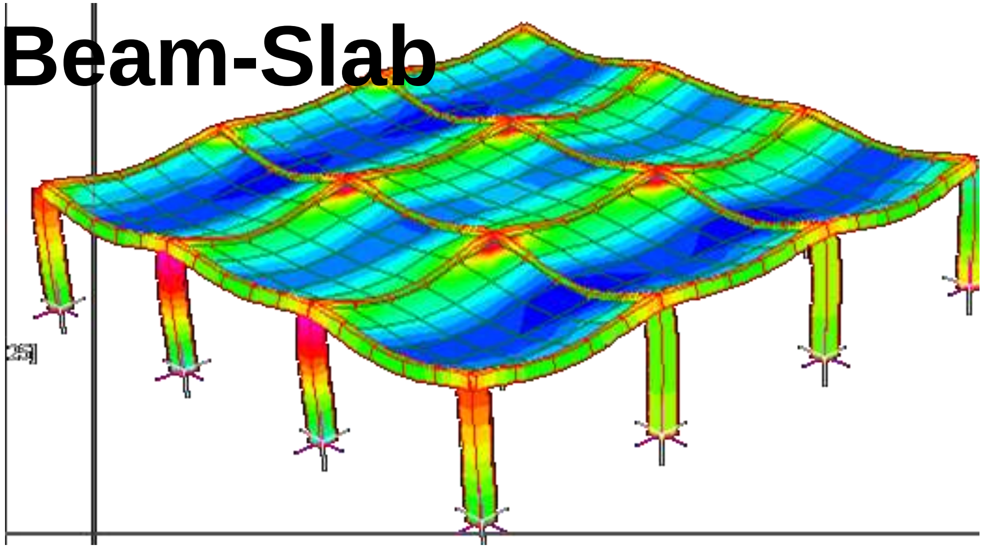


Slab T = 200 mm
Beam Width, B = 300 mm
Beam Depth, D

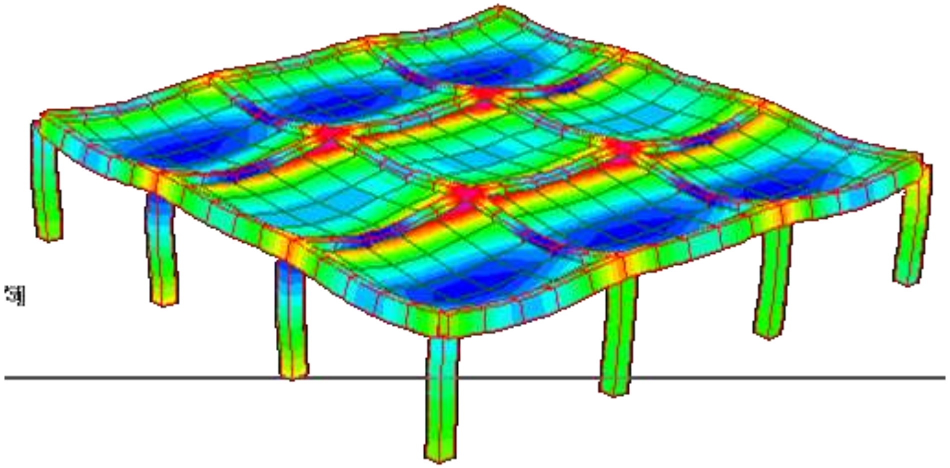
a) 300 mm
b) 500 mm
c) 1000 mm

Moment Distribution in Beam-Slab

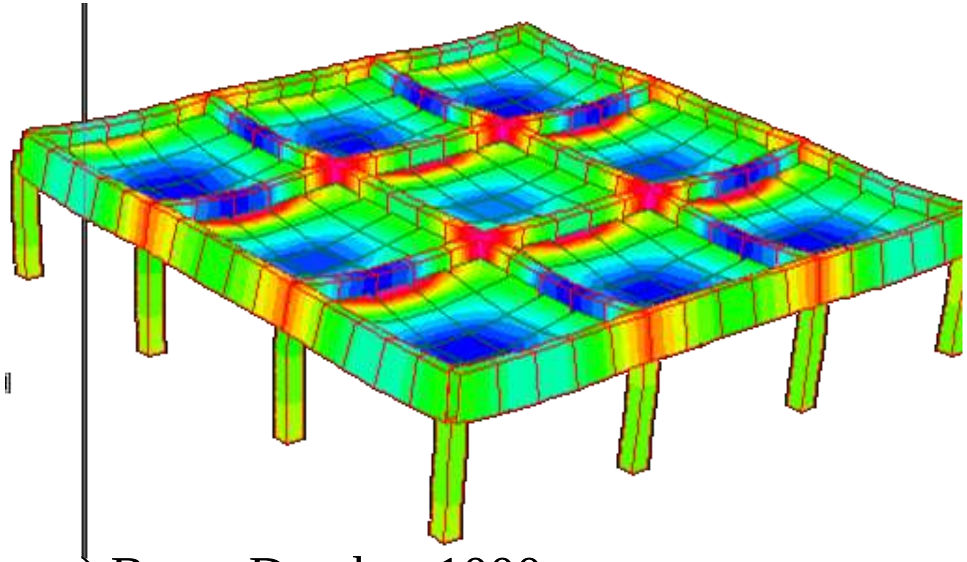
Effect of Beam Size on Moment Distribution



a) Beam Depth = 300 mm



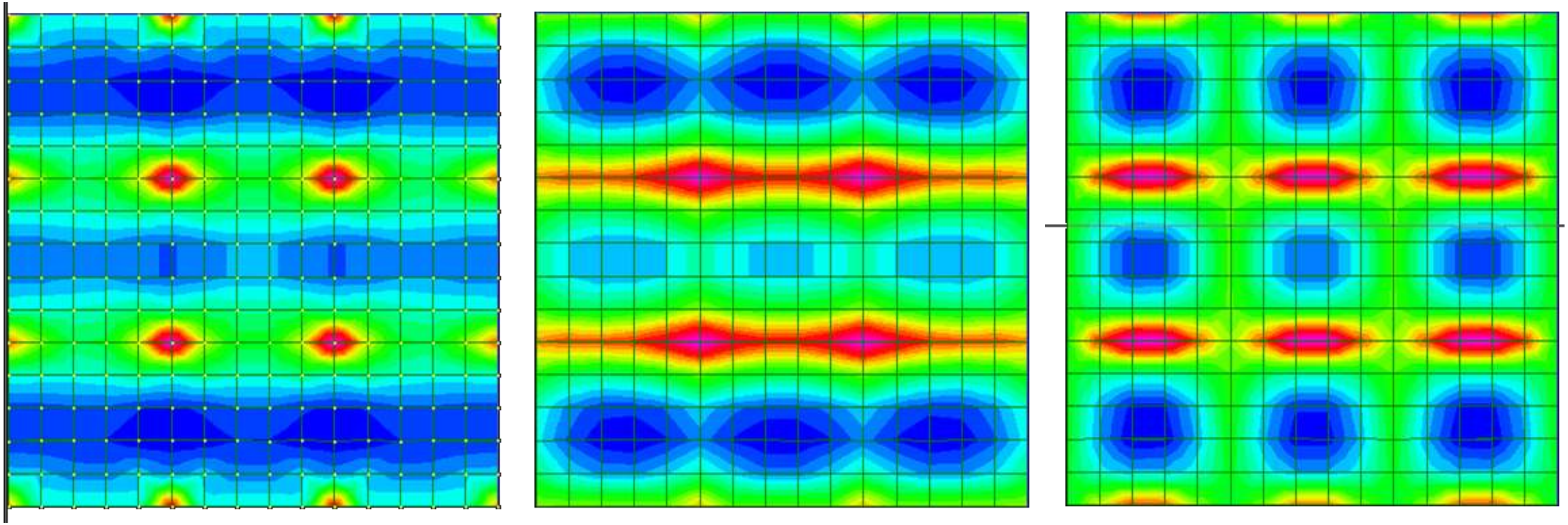
b) Beam Depth = 500 mm



c) Beam Depth = 1000 mm

Moment Distribution in Beam-Slab

Effect of Beam Size on Moment Distribution



a) Beam Depth = 300 mm

b) Beam Depth = 500 mm

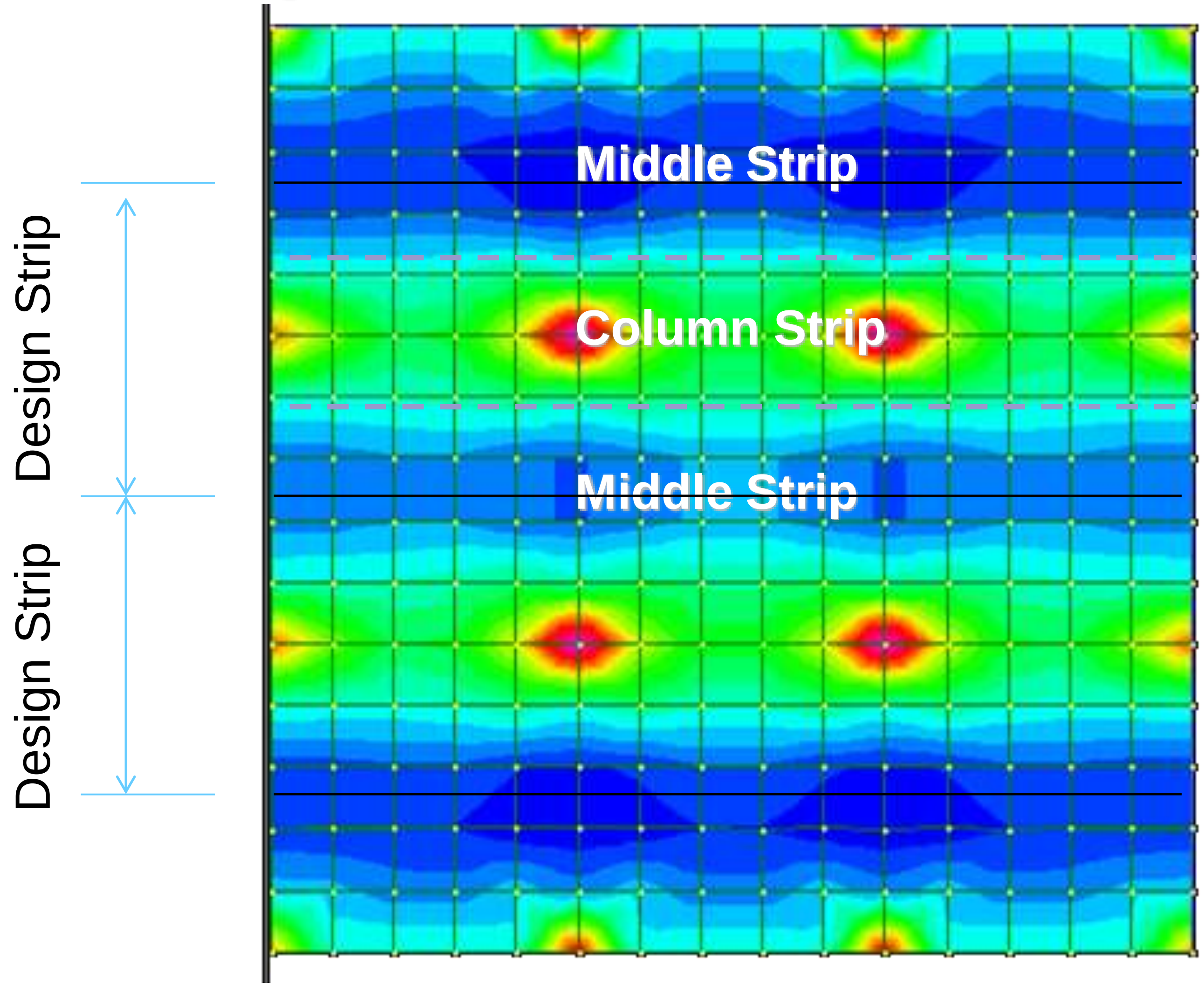
c) Beam Depth = 1000 mm

Modeling for Gravity Loads

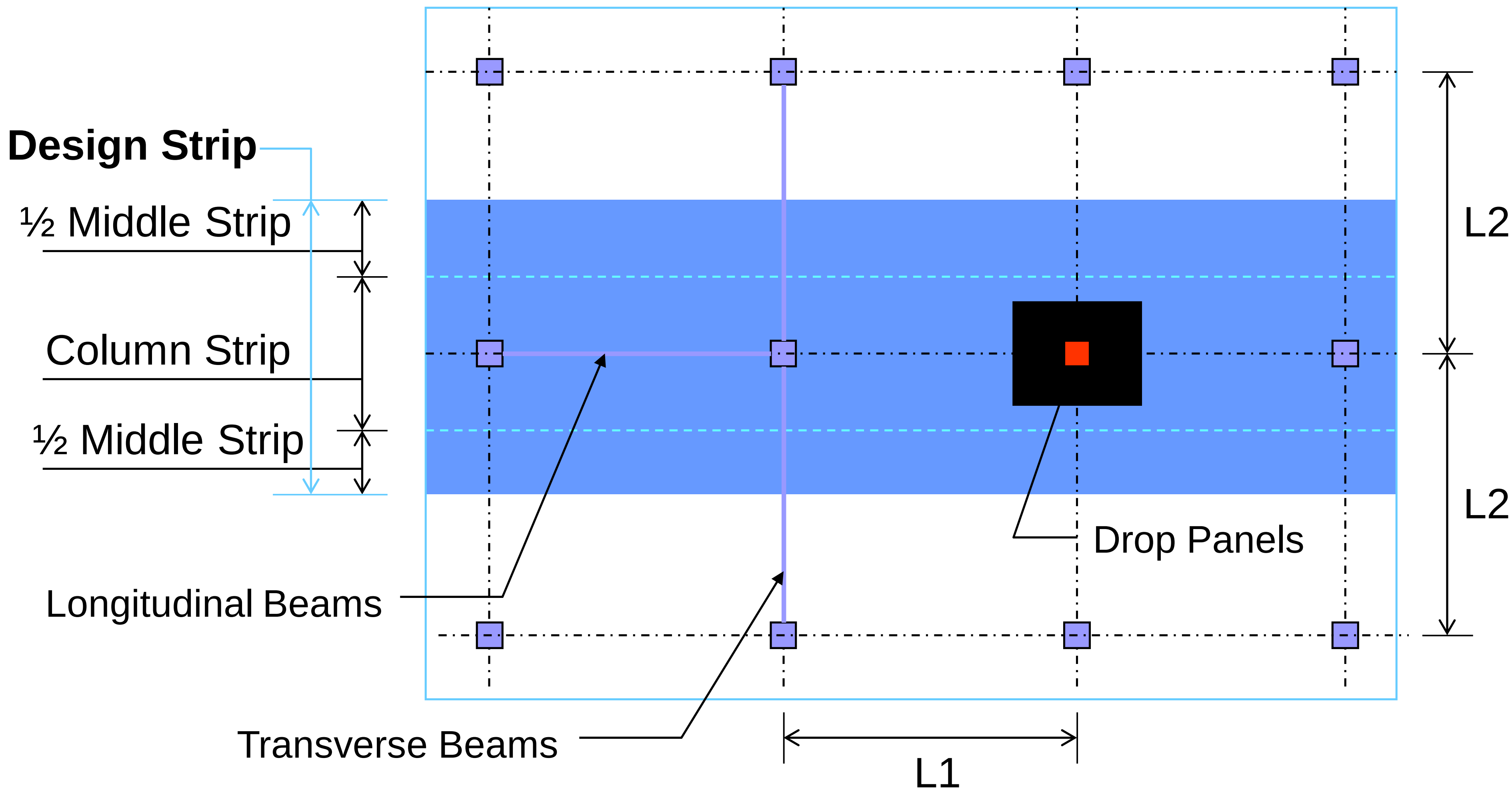
- **Must be carried out for several load cases/ patterns**
- **Does not change much for different floors**

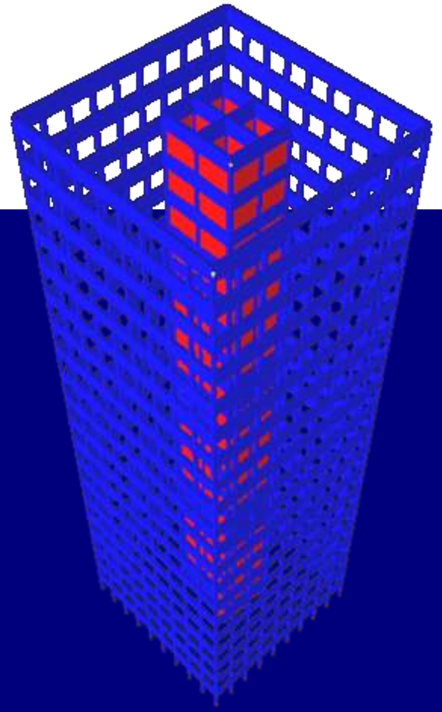
1. Use "Direct Design" Methods
   - Model, analyze and design "Floor by Floor, Without columns"
   - Slab analysis and design by using Coefficients
   - Beam analysis as continuous beams
2. Use Sub-Frame Concept
   - Model slab/ beam for in-plane loads
   - Model, analyze and design "Floor by Floor, With columns"
3. Use Grid, Plate Model for the Floor
   - Model slab and beams for out-of plane loads
   - Analyze un-symmetrical loads, geometry, openings etc.
4. Use full 3D Modeling

The Design Strip Concept



Using Equivalent Frame Method – Design Strip





Lateral Load Resisting Systems

Lateral Load Bearing Systems

Purpose

“ To Transfer Lateral Loads Applied at any location in the structure down to the Foundation Level”

- **Single System**
  - Moment Resisting Frames
  - Braced Frames
  - Shear Walls
  - Tubular Systems
  - Outrigger System

- **Dual System**
  - Shear Wall + Frames
  - Tube + Frame + Shear Wall

Lateral Load

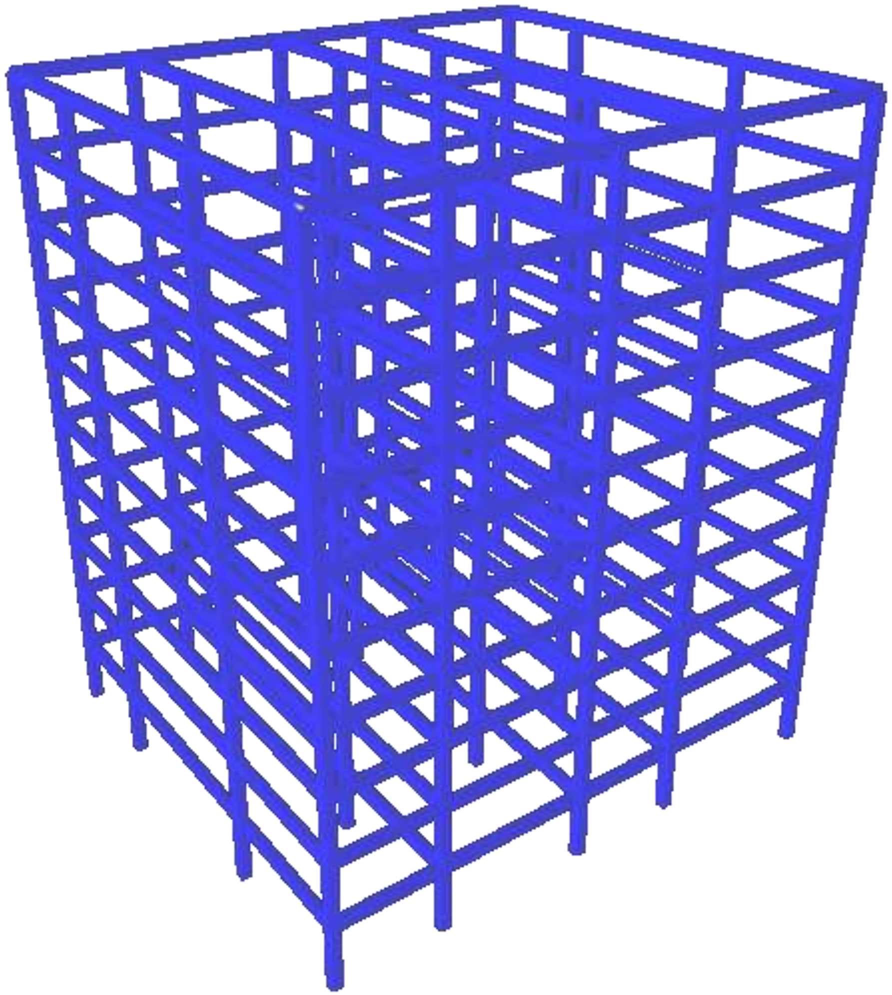
- **Primary Lateral Loads**
  - Load generated by Wind Pressure
  - Load generated due to Seismic Excitation

- **Other Lateral Loads**
  - Load generated due to horizontal component of Gravity Loads in Inclined Systems and in Un-symmetrical structures
  - Load due to lateral soil pressure, liquid and material retention

Sample Lateral Load Resistance Systems

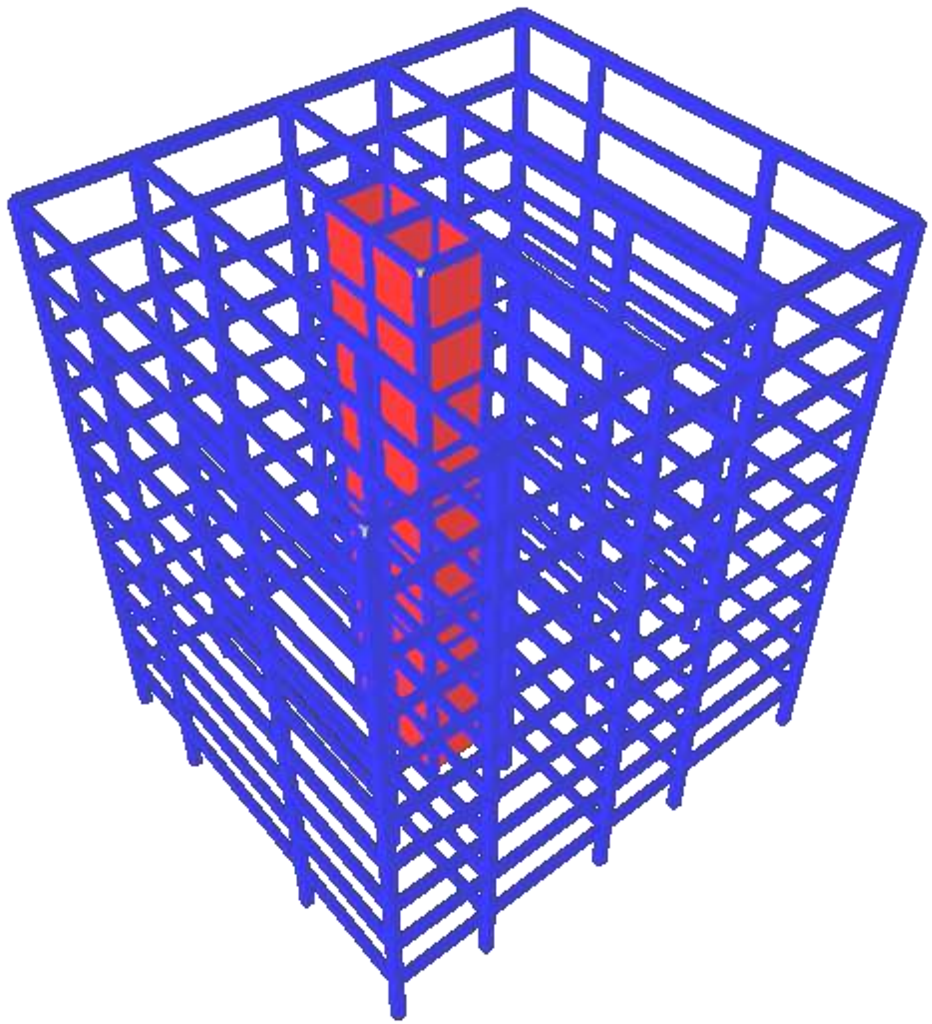
- **Bearing wall system**
  - Light frames with shear panels
  - Load bearing shear walls
- **Fully Braced System (FBS)**
  - Shear Walls (SW)
  - Diagonal Bracing (DB)
- **Moment Resisting Frames (MRF)**
  - Special Moment-Resisting Frames (SMRF)
  - Concrete Intermediate Moment-Resisting Frame (IMRF)
  - Ordinary Moment-Resisting Frame (OMRF)
- **Dual Systems (DS)**
  - Shear Walls + Frames (SWF)
  - Ordinary Braced Frame (OBF)
  - Special Braced Frame (SBF)

Moment Resisting Frame



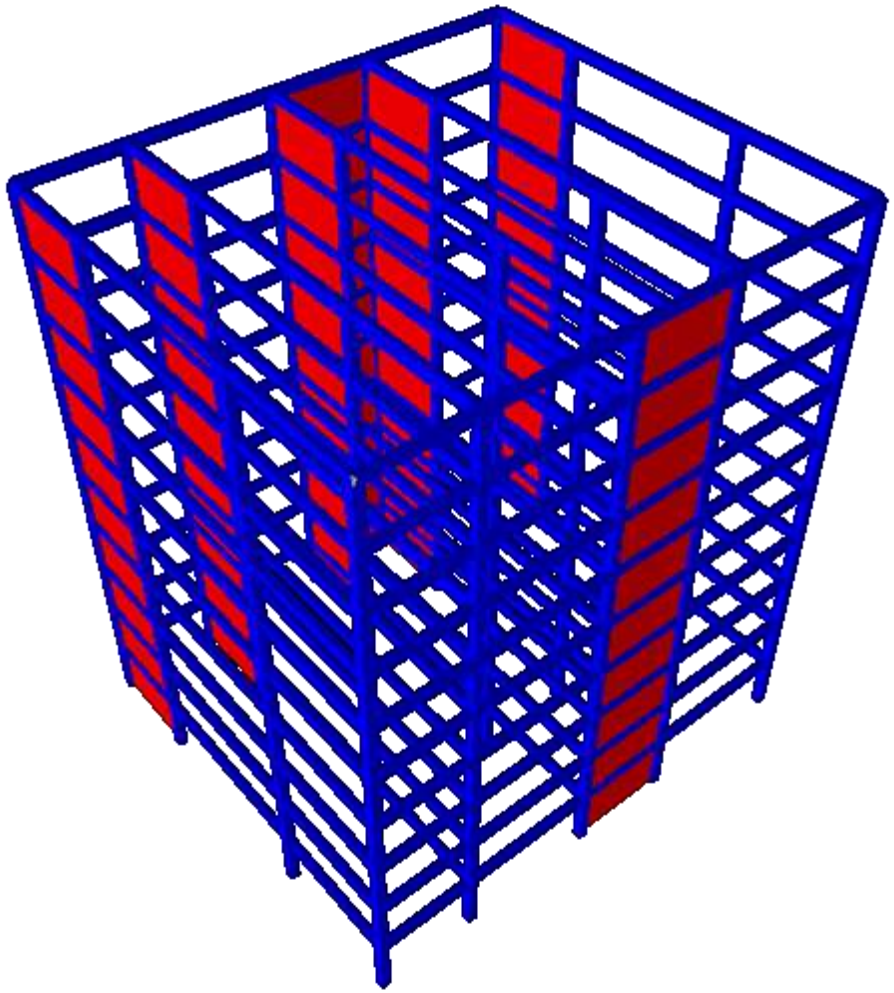
- The Load is transferred by shear in columns, that produces moment in columns and in beams
- The Beam-Column connection is crucial for the system to work
- The moments and shear from later loads must be added to those from gravity loads

Shear Wall and Frame



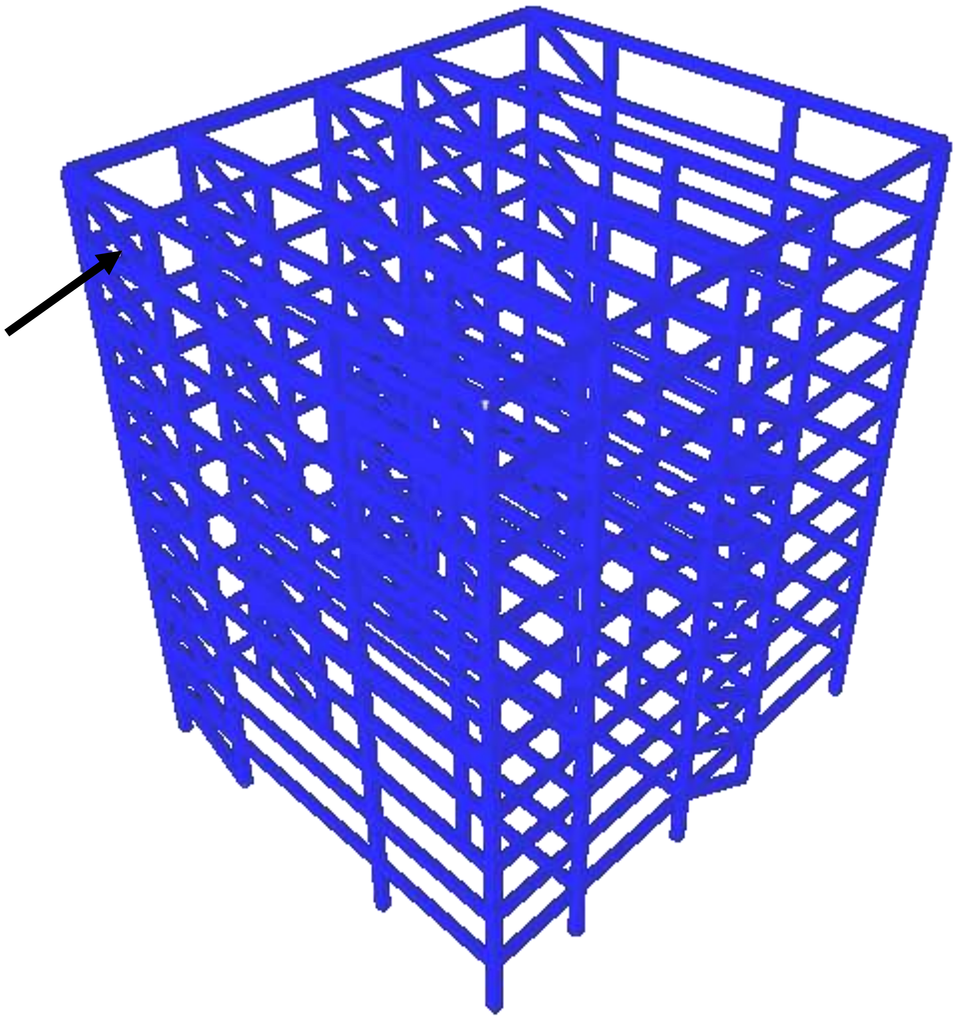
- The lateral loads is primarily resisted by the shear in the walls, in turn producing bending moment
- The openings in wall become areas of high stress concentration and need to be handled carefully
- Partial loads is resisted by the frames
- Traditionally 75/25 distribution haws been used

Shear Wall - Frame



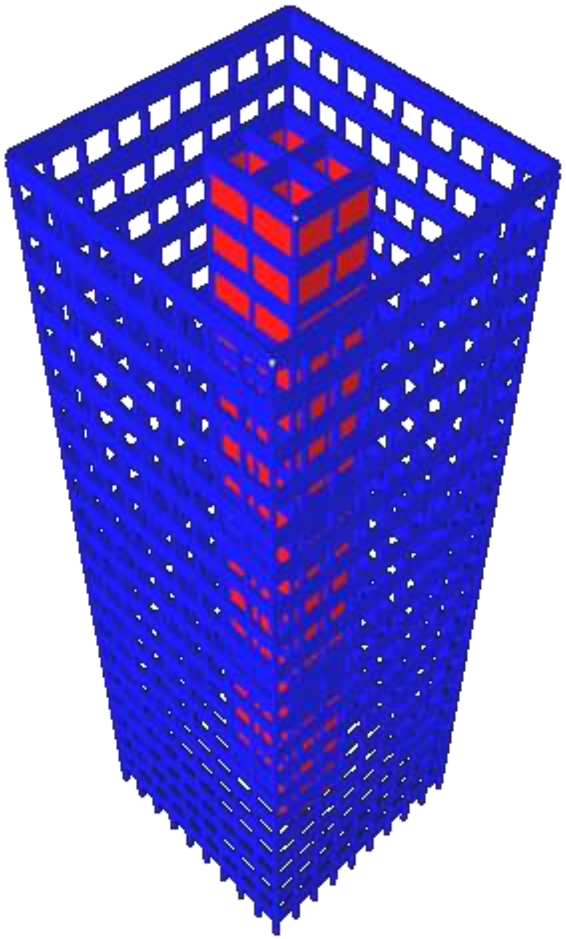
- The Walls are part of the frame and act together with the frame members
- The lateral loads is primarily resisted by the shear in the walls, in turn producing bending moment.
- Partial loads is resisted by the frame members in moment and shear

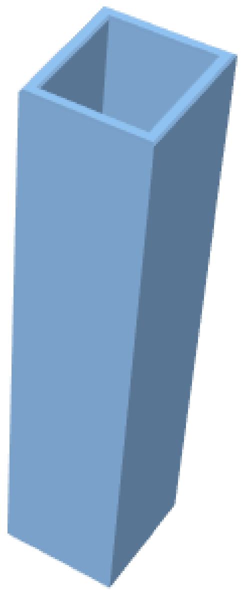
Braced Frame



- The lateral loads is primarily resisted by the Axial Force in the braces, columns and beams in the braced zone.
- The frame away from the braced zone does not have significant moments
- Bracing does not have to be provided in every bay, but should be provided in every story

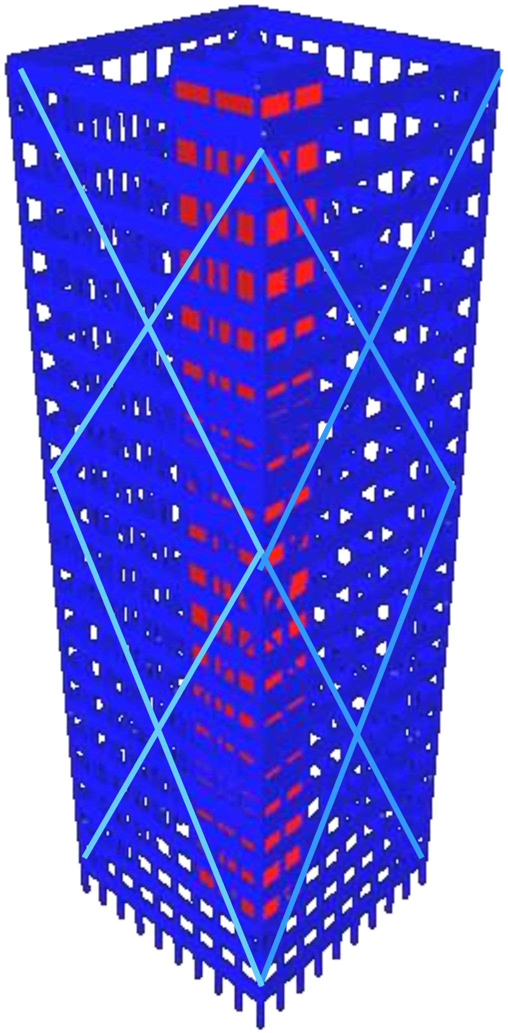
Tubular Structure



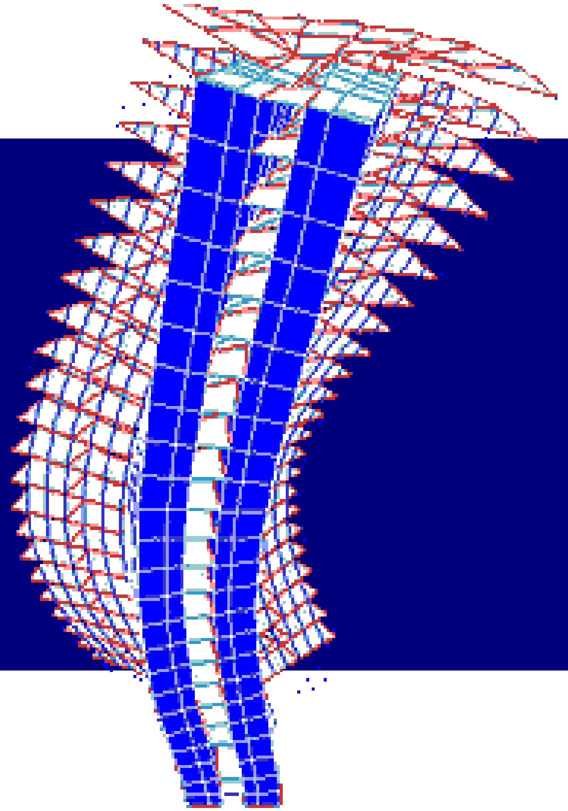


- The system is formed by using closely spaced columns and deep spandrel beams
- The lateral loads is primarily resisted by the entire building acting as a big cantilever with a tubular/ box cross-section
- There is a “shear lag” problem between opposite faces of the tube due to in-efficiency of column beam connection
- The height to width ratio should be more than 5

Braced Tube Systems



- Diagonal Braces are added to the basic tubular structure
- This modification of the Tubular System reduces shear lag between opposite faces



Modeling of Lateral Load Resisting Systems

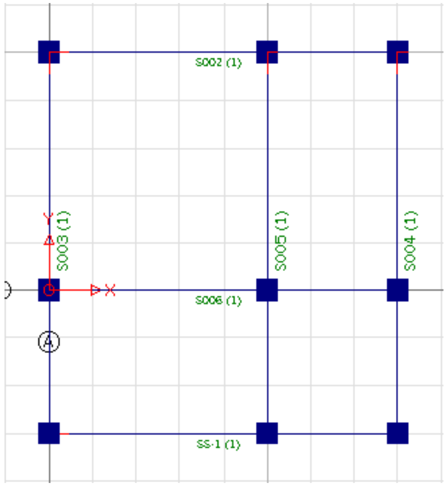
Modeling for Lateral Loads

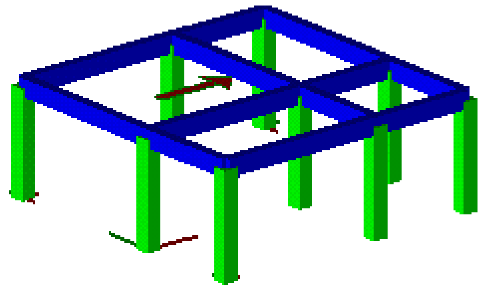
1. **2D Frame Models**
   - Convert building in to several 2D frames in each direction
   - Suitable for symmetrical loads and geometry
2. **3D Frame Model**
   - Make a 3D frame model of entire building structure
   - Can be “open floor” model or “braced floor” model
3. **Full 3D Finite Element Model**
   - A full 3D Finite Element Model using plate and beam elements
4. **Rigid Diaphragm Model**
   - A special model suitable for buildings that uses the concept of Rigid Floor Diaphragm

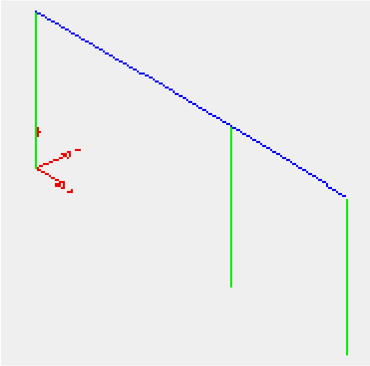
Modeling as 2D Frame

- **Convert 3D Building to an assemblage of 2D Frames**
  - Using Independent Frames
  - Using Linked Frames
  - Using Sub-Structuring Concept
- **Advantages**
  - Easier to model, analyze and interpret
  - Fairly accurate for Gravity Load Analysis
- **Main Problems:**
  - Center of Stiffness and Center of Forces my not coincide
  - Difficult to consider building torsional effects
  - Several Frames may need to be modeled in each direction
  - Difficult to model non-rectangular framing system

Create a Simple 2D Model



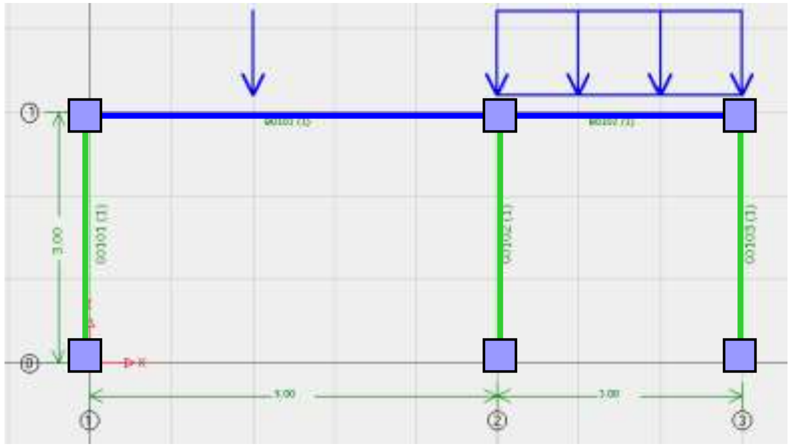


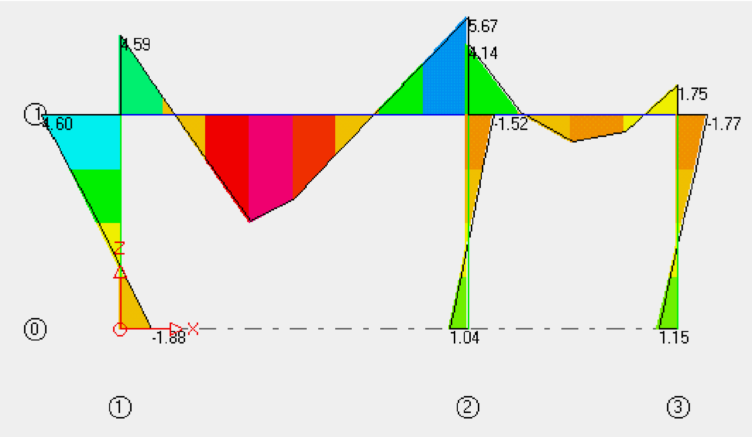


1. Consider the Structure Plan and 3D View

2. Select and isolate Typical 2D Structure

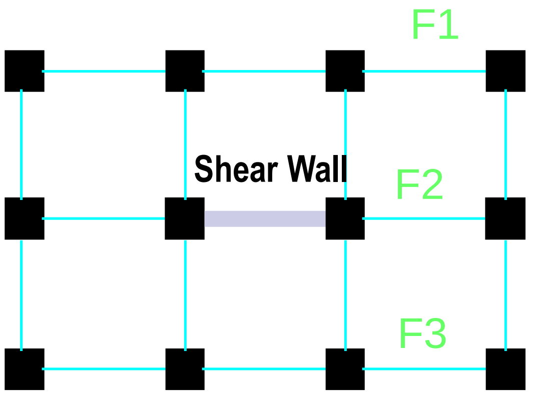
3. Discretize the Model, apply loads



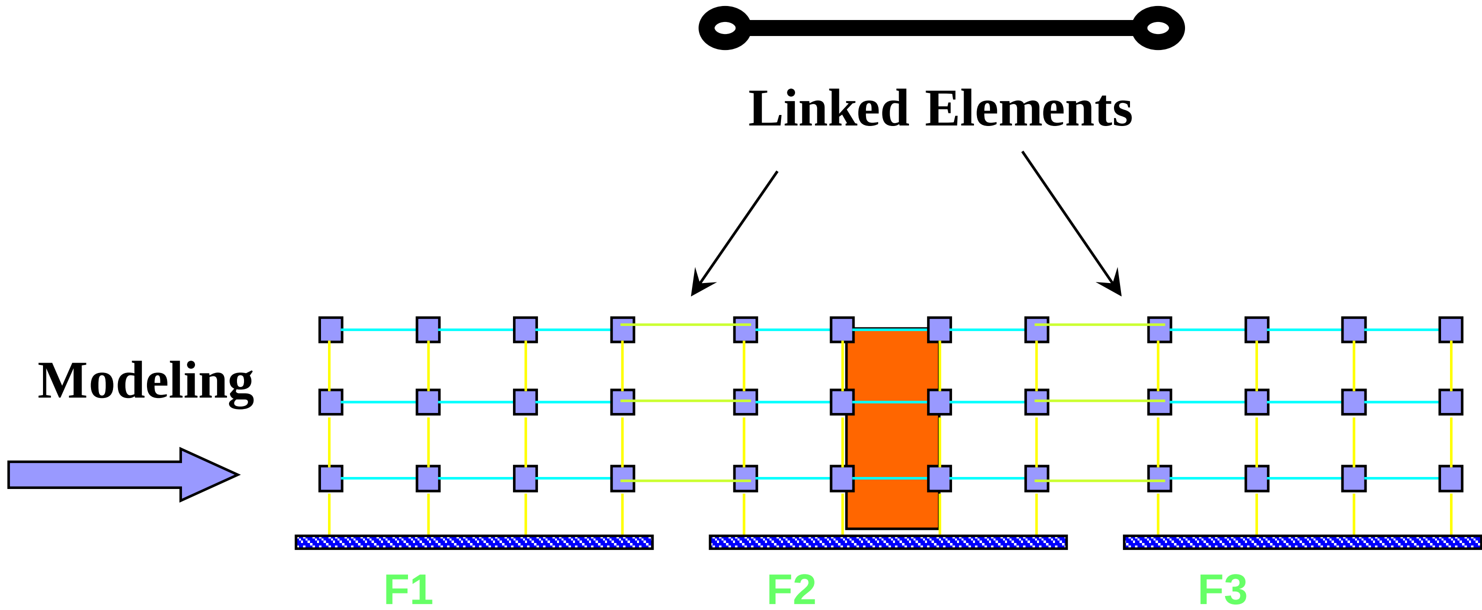


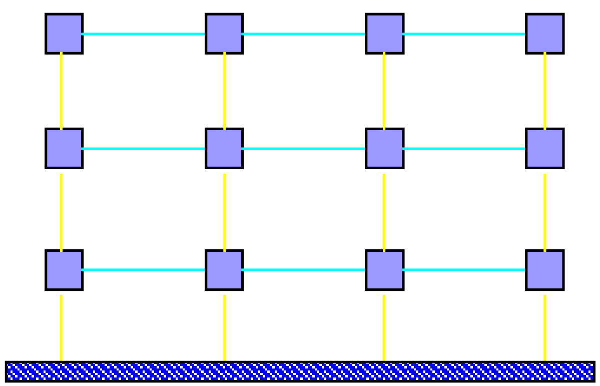
4. Obtain results

Using Linked Frames



Plan





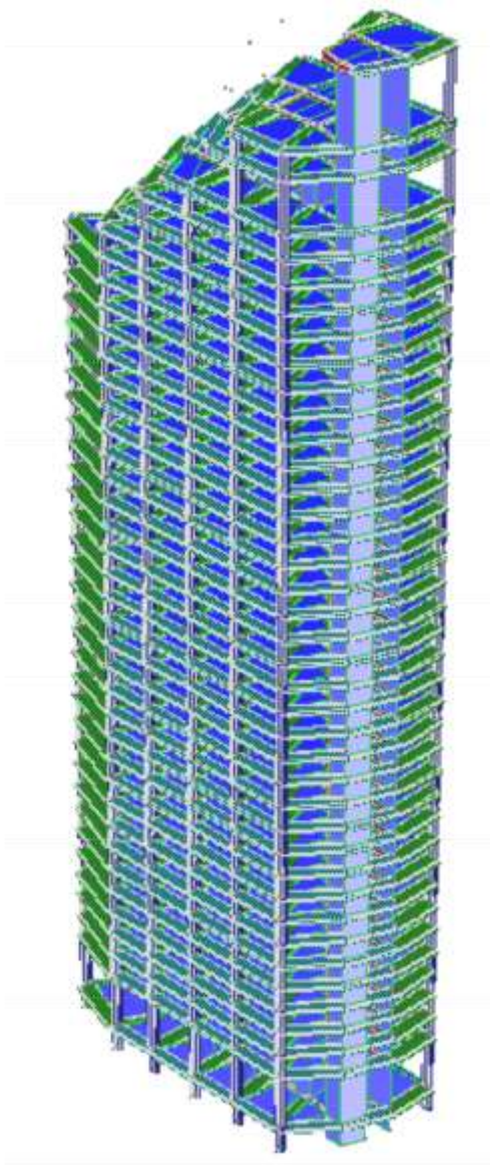
Typical Frame Elevation

Link Element can allow only to **transmit the shear and axial force from one end to other end**. It has moment discontinuity at both ends

Link Element act as a member which links the forces of one frame to another frame, representing the effect of Rigid Floor.

Full 3D Finite Element Model

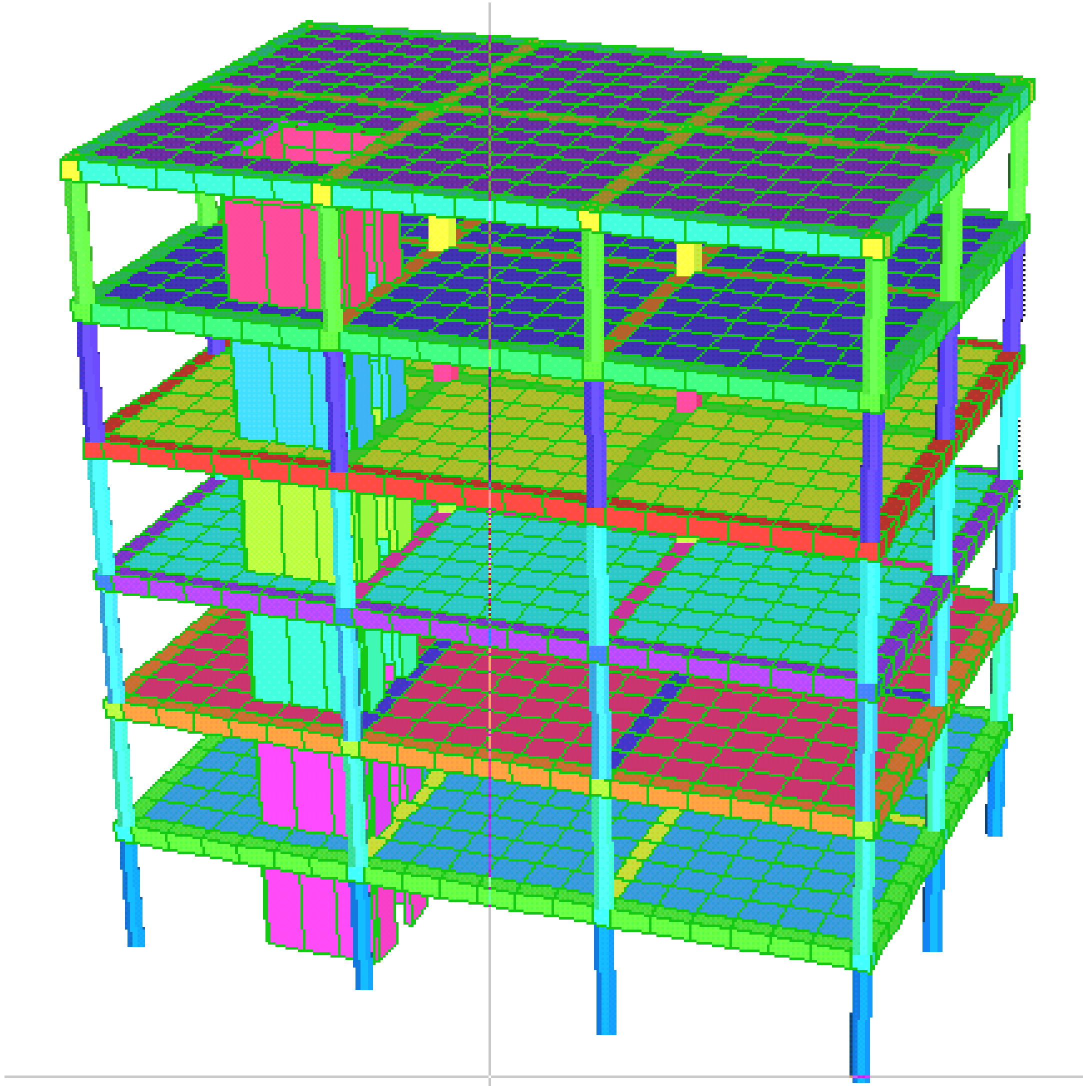
- The columns and beams are modeled by using beam elements
- The slabs and shear walls are modeled by using shell elements
  - Enough elements in each slab panel must be used if gravity loads are applied to the slabs
  - If the model is only for lateral analysis, one element per slab panel may be sufficient to model the in-plane stiffness
  - Shear walls may be modeled by plate or panel or plane stress element. The out of plane bending is not significant



Full 3D Finite Element Model

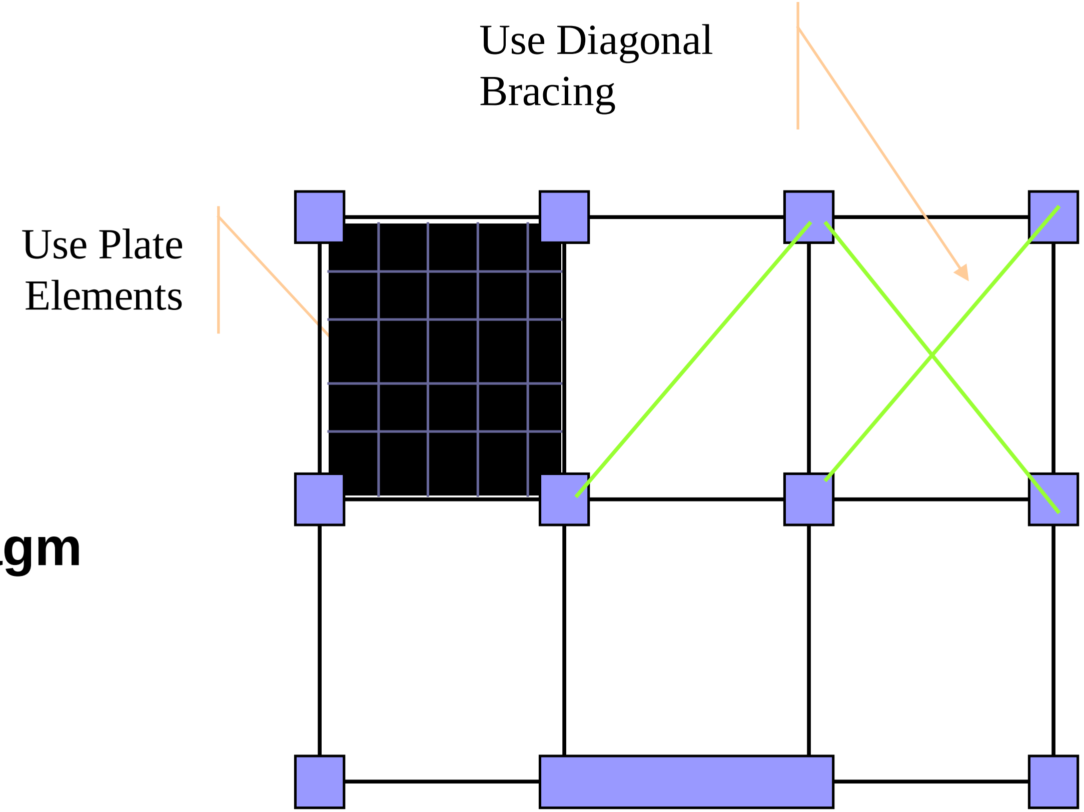
Example:

- Uses more than 4000 beam and plate elements
- Suitable for analysis for gravity and lateral loads
- Results can be used for design of columns and beams
- Slab reinforcement difficult to determine from plate results



Modeling of Floor Diaphragm

- **Use Plate Elements**
  - Panels, Plane Stress
- **Use Diagonals**
  - In 3D Frame Models
- **Use Conceptual Rigid Diaphragm**
  - Link Frames in 2D
  - Master DOF in 3D
  - Use Approximately



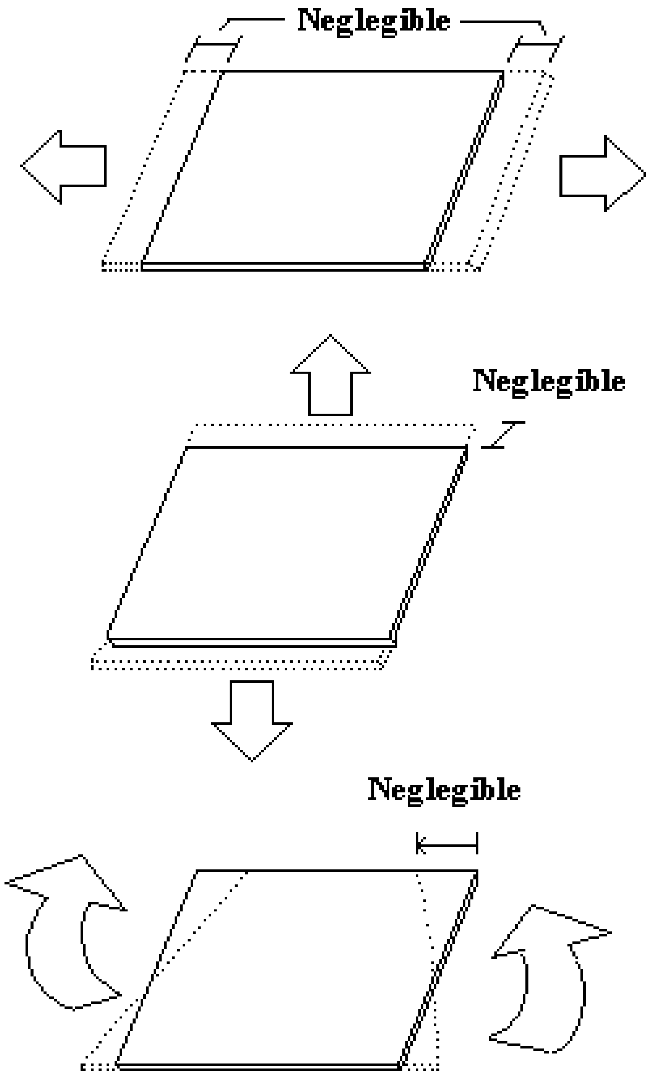
The Rigid Floor Diaphragm

- **Combines the simplicity and advantages of the 2D Frame models with the accuracy of the 3D models**

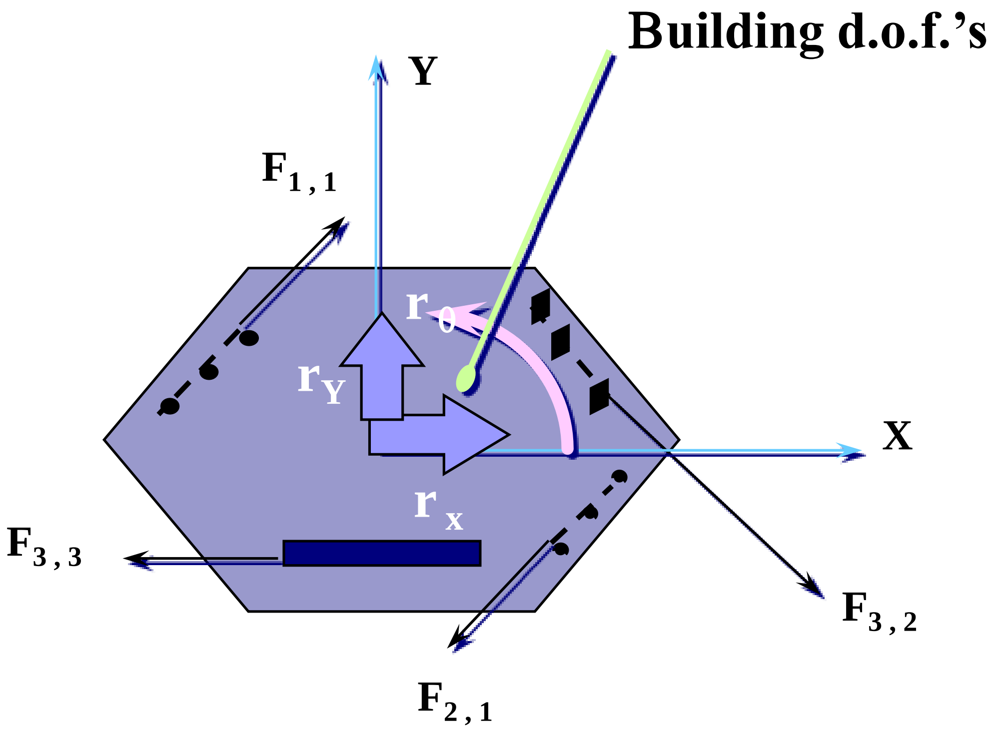
- **Basic Concept:**
  - The building structure is represented by vertical units (2D Frames, 3D Frames and Shear Walls), connected by the invisible rigid diaphragm
  - The lateral movement of all vertical units are connected to three master degree of freedom
  - This takes into account the building rotation and its effect on the vertical units.
  - The modeling and analysis is greatly simplified and made efficient

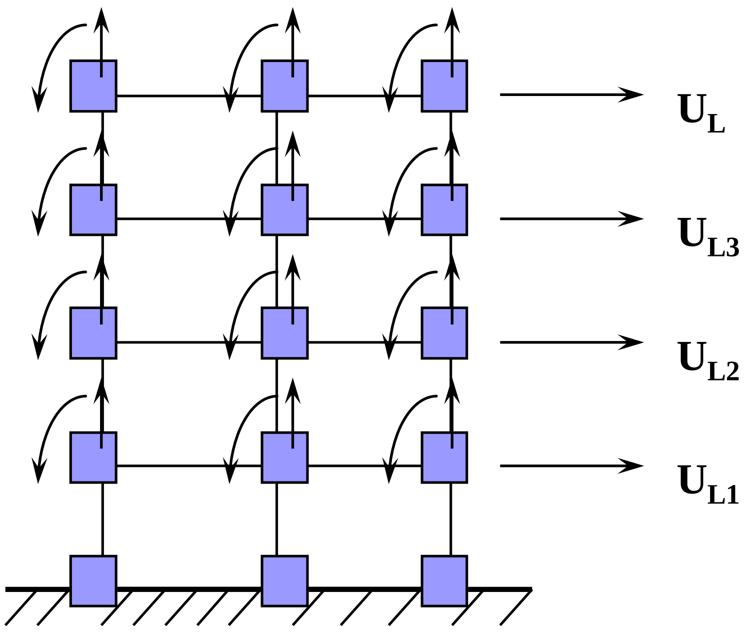
Rigid Floor Diaphragm Concept

- Modeled as Rigid Horizontal Plane of infinite in-plane stiffness (in X-Y plane)
- Assumed to have a hinge connection with frame member or shear wall, so flexural influence of all floors to lateral stiff ness is neglected
- All column lines of all frames at particular level can not deform independent of each other
- The floor levels of all frames must be at the same elevation and base line, but they need not have same number of stories



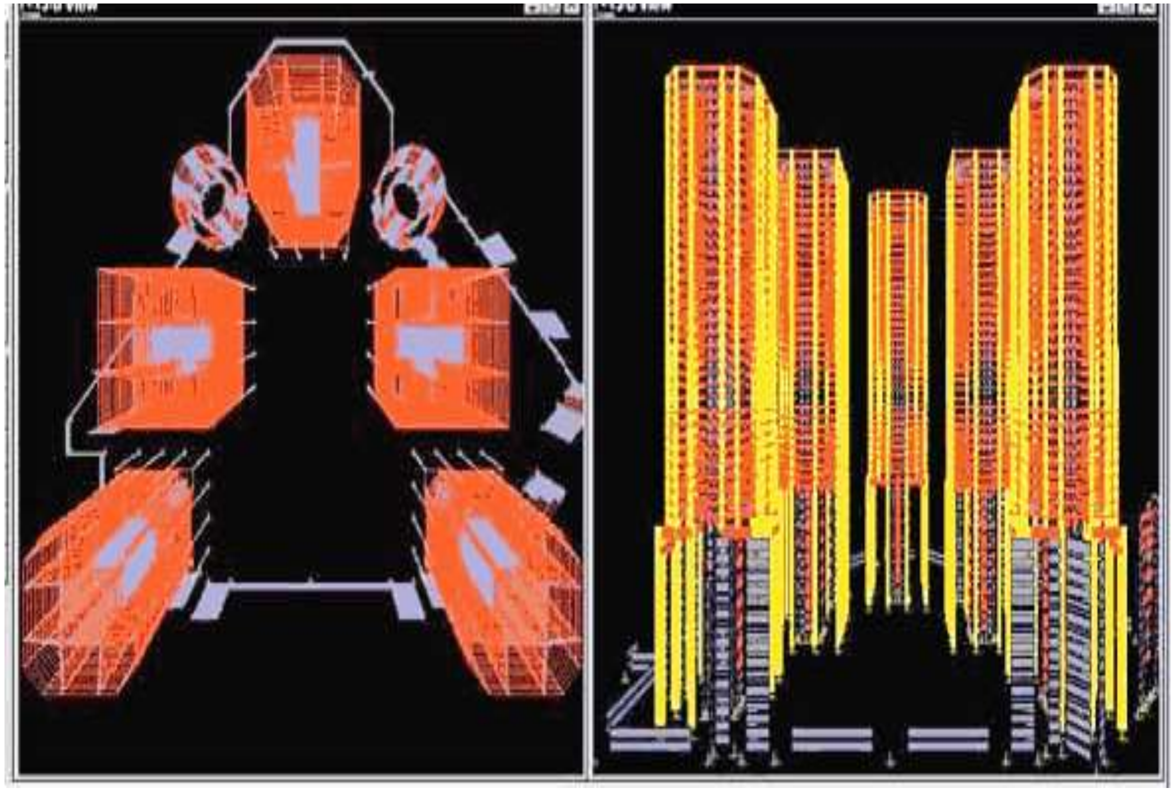
How RFD Concept Works

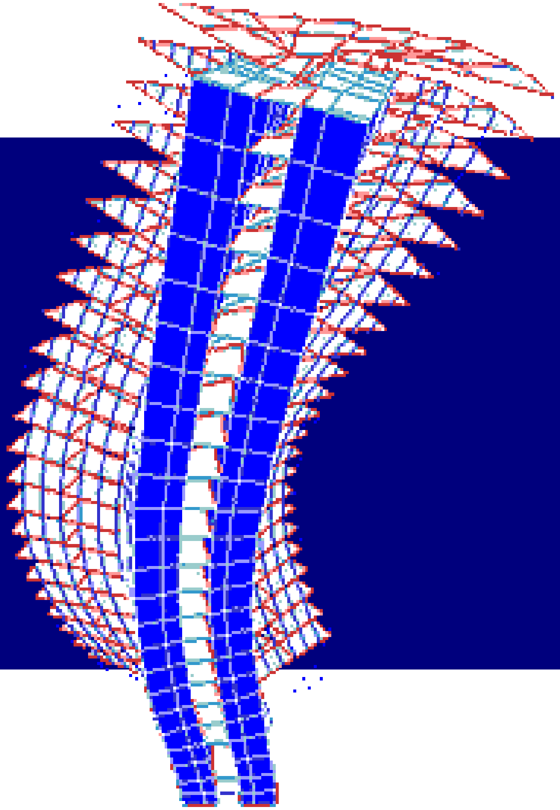




Local Frame DOF

When Single Rigid Floor Cannot be Used

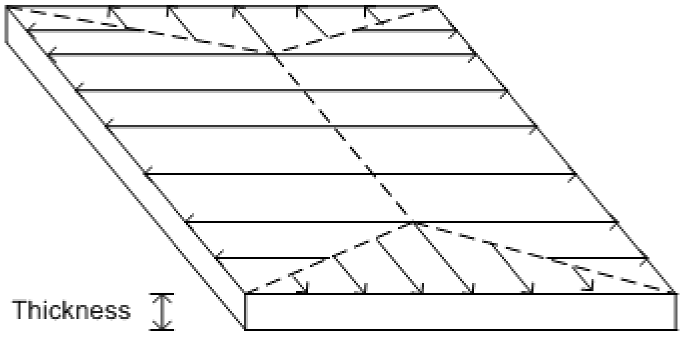




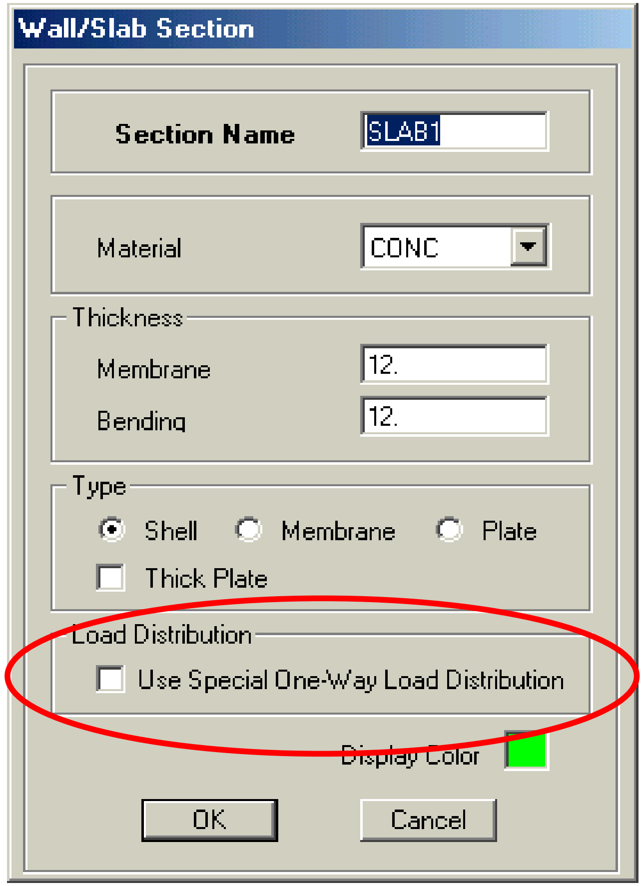
Modeling of
Vertical Load Resisting Systems

Area Objects: Slab

- By default uses two-way load transfer mechanism
- Simple RC solid slab
- Can also be used to model one way slabs

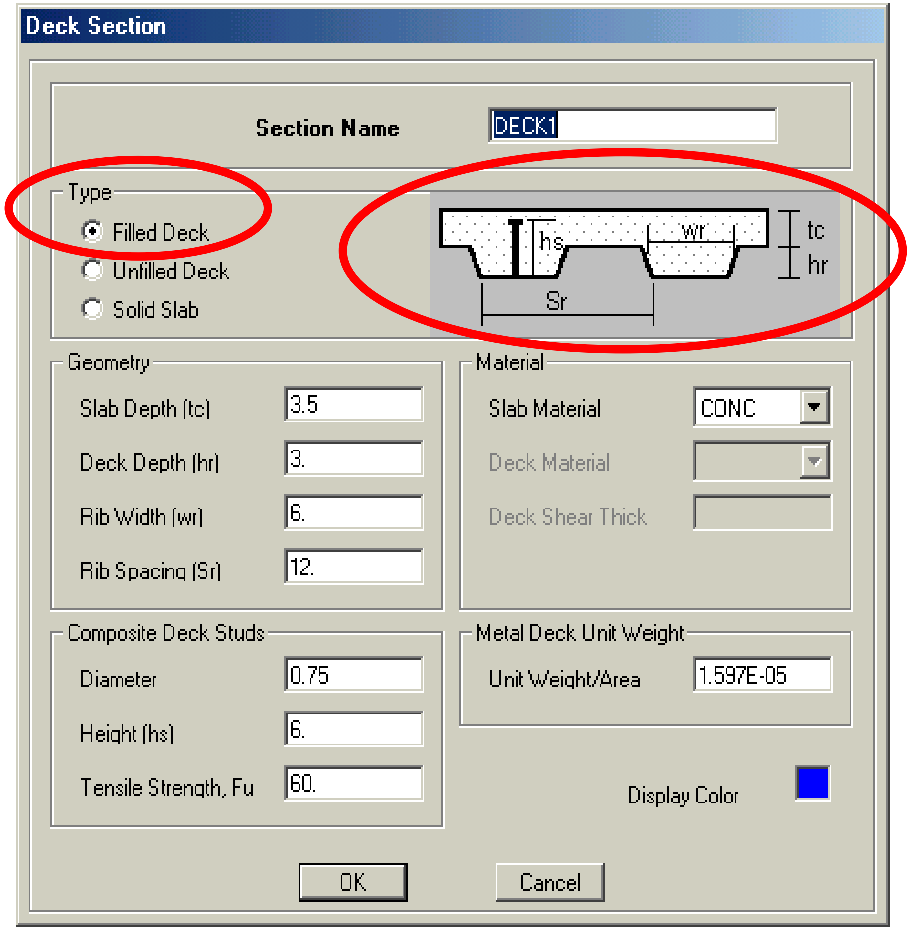


Slab



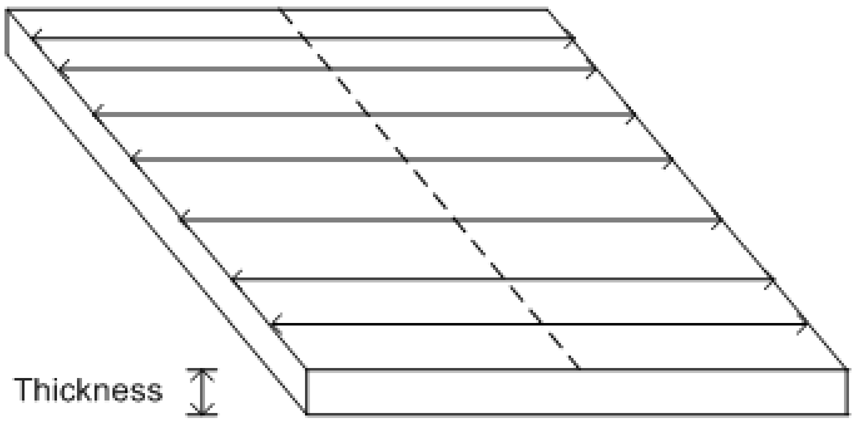
Area Objects: Deck

- ➢Use one-way load transfer mechanism
- ➢Metallic Composite Slabs
- ➢Includes shear studs
- ➢Generally used in association with composite beams
- ➢Deck slabs may be
  - o Filled Deck
  - o Unfilled Deck
  - o Solid Slab Deck

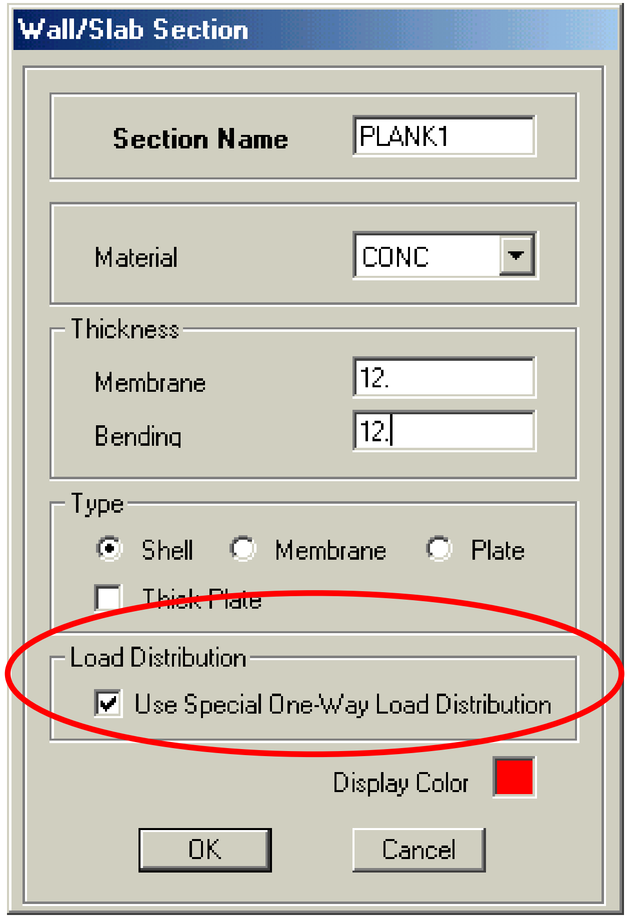


Area Objects: Plank

- ➢By default use one-way load transfer mechanism
- ➢Generally used to model pre-cast slabs
- ➢Can also be simple RC solid slab



Plank



Automatic Floor Meshing

First step to Auto Load Transfer

Basic Floor Modeling Object

- **Points**
  - Columns
  - Load Points
  - Boundary Point
- **Lines**
  - Beams
- **Areas**
  - Deck: Represents a Steel Metal Deck, One way Load Transfer
  - Plank : Represents clearly one-way slab portion
  - Slab: Represents one-way or two-way slab portion
  - Opening: Represents Openings in Floor

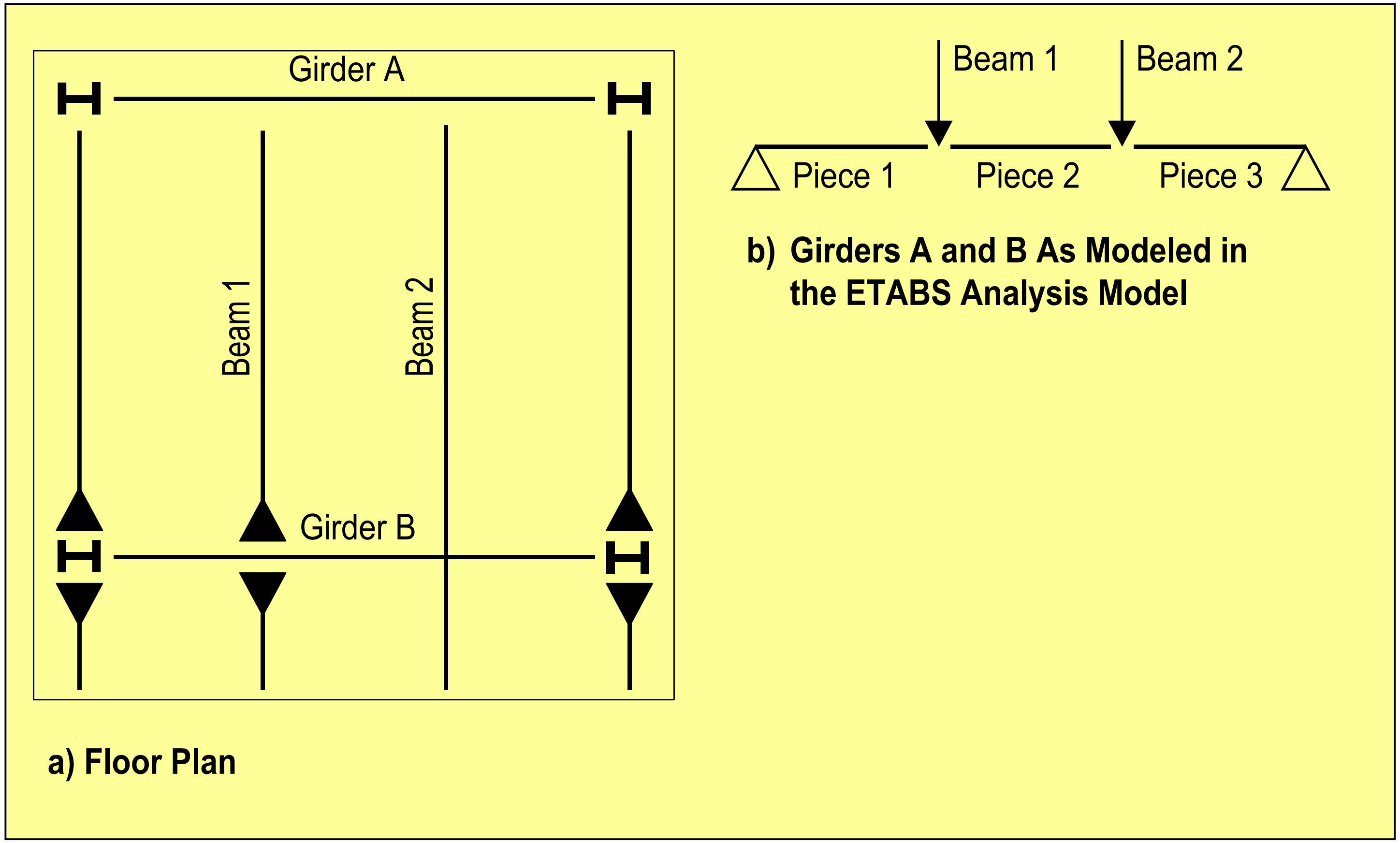
Basic Floor Modeling Object

- ETABS automatically meshes all line objects with frame section properties into the analysis model
- ETABS meshes all floor type (horizontal) area objects (deck or slab) into the analysis model
- Meshing does not change the number of objects in the model
- To mesh line objects with section properties use Edit menu > Divide Lines
- To mesh area objects with section properties use Edit menu > Mesh Areas

Automatic Meshing

- **Automatic Meshing of Line Objects**
  - Frame elements are meshed at locations where other frame elements attach to or cross them and at locations where point objects lie on them.
  - Line objects assigned link properties are never automatically meshed into the analysis model by ETABS
  - ETABS automatically meshes (divides) the braces at the point where they cross in the analysis model
  - No end releases are introduced.

Automatic Meshing of Line Objects

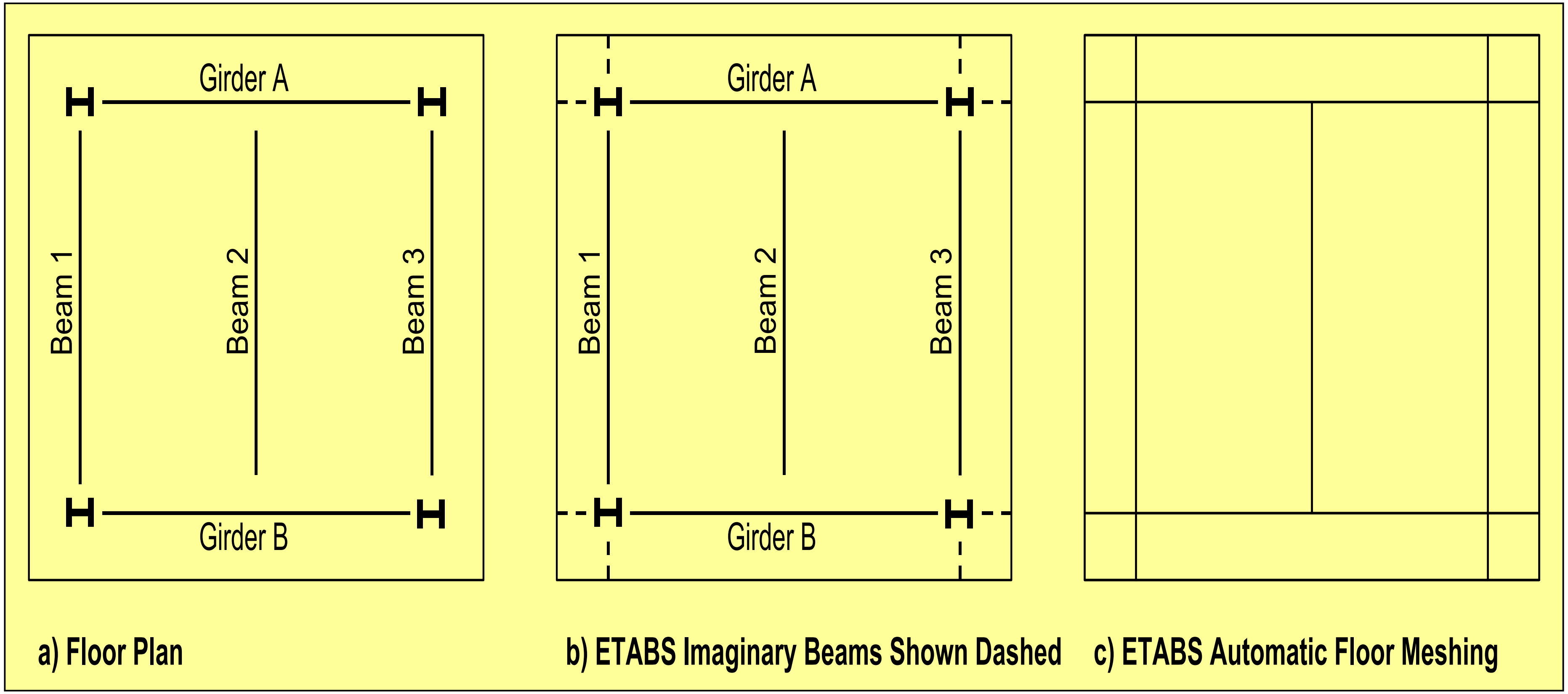


Example showing how beams are automatically divided (meshed) where they support other beams for the ETABS analysis model

Automatic Meshing of Area Objects

- ETABS automatically meshes a floor-type area object up into four-sided (quadrilateral) elements
- Each side of each element of the mesh has a beam (Real or Imaginary) or wall running along it
- ETABS treats a wall like two columns and a beam where the columns are located at the ends of the wall and the beam connects the columns.
- Each column is assumed to have four beams connecting to it
- The floor is broken up at all walls and all real and imaginary beams to create a mesh of four-sided elements

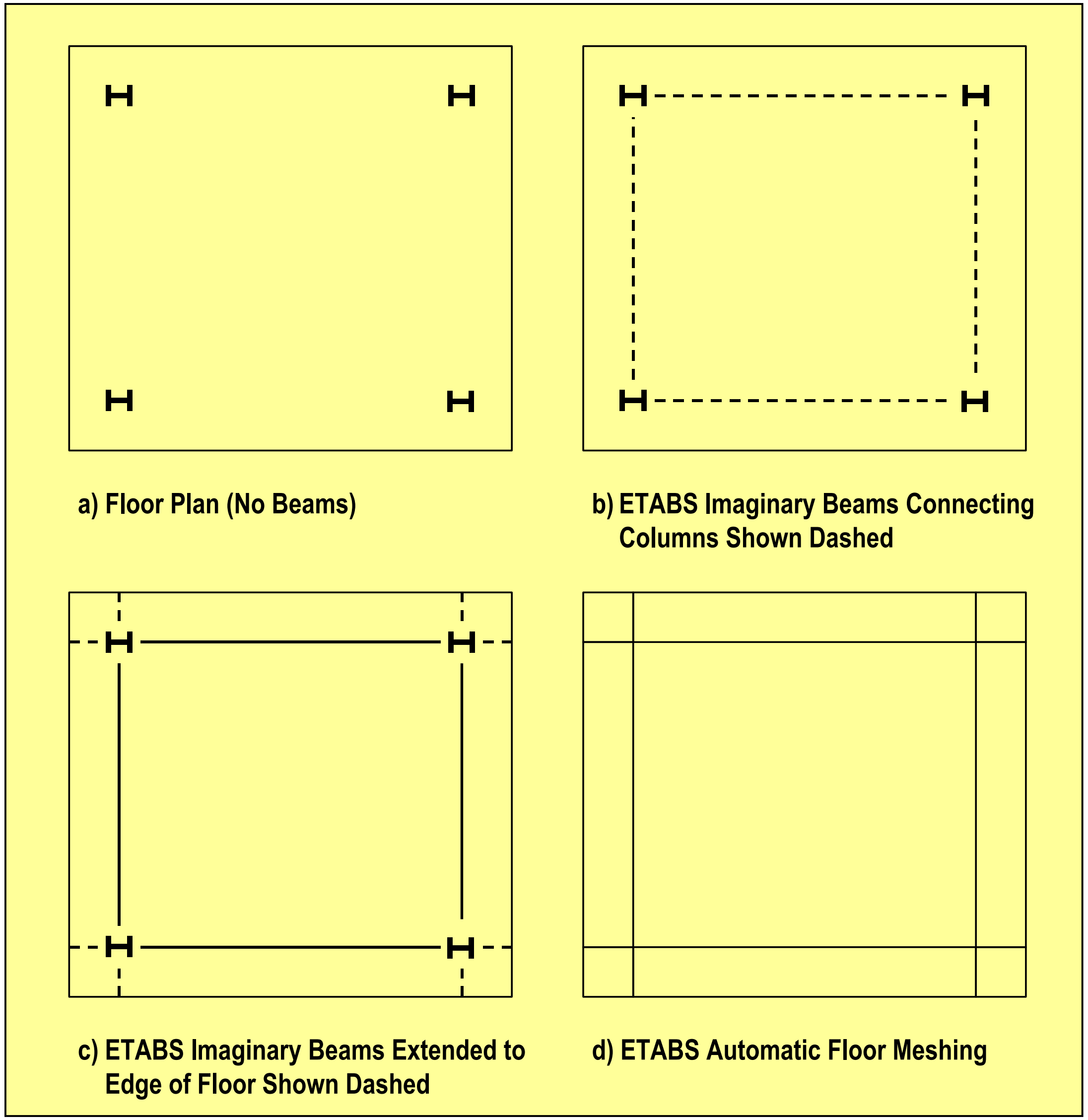
Automatic Meshing of Area Objects



Example of ETABS automatically generated mesh for floor-type area objects

Automatic Meshing of Area Objects

Example of ETABS automatically generated mesh for floor-type area objects



Automatic Meshing of Area Objects

- For floors that are automatically meshed by ETABS it is recommended that model beams (or at least null-type line objects) are connecting columns rather than no beams (or line objects)

- This makes the automatic meshing for the analysis model cleaner, faster and more predictable

- Including beams and/or null-type line objects between all columns in your model makes automatic floor meshing more predictable

Automatic Transformation and Transfer of Floor Loads to Appropriate Elements

(Using the Auto Meshed Geometry)

Load Transformation

The main issue:

How point loads, line loads and area loads that lie on an area object in your object-based ETABS model are represented in the analysis model

There are four distinct types of load transformation in ETABS for out-of-plane load transformation for floor-type area objects

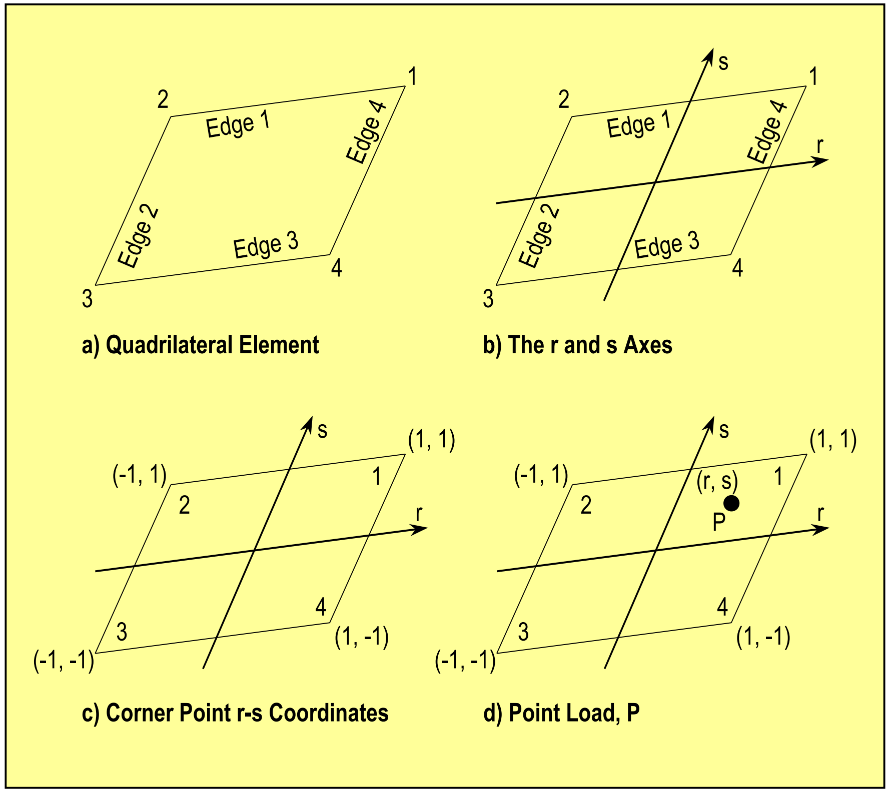
- With deck section properties
- With slab section properties that have membrane behavior only
- All other types of area objects
- In-plane load transformation for all types of area objects

Load Transformation

Area Objects

- Load transformation occurs after any automatic meshing into the analysis model
- ETABS normalizes the coordinates of the four corner points of the area object
- The normalization is the key assumption in this method
- It is a perfectly valid assumption if the quadrilateral is a square, rectangular or a parallelogram

•



Example of transfer of out-of-plane loads for other area objects

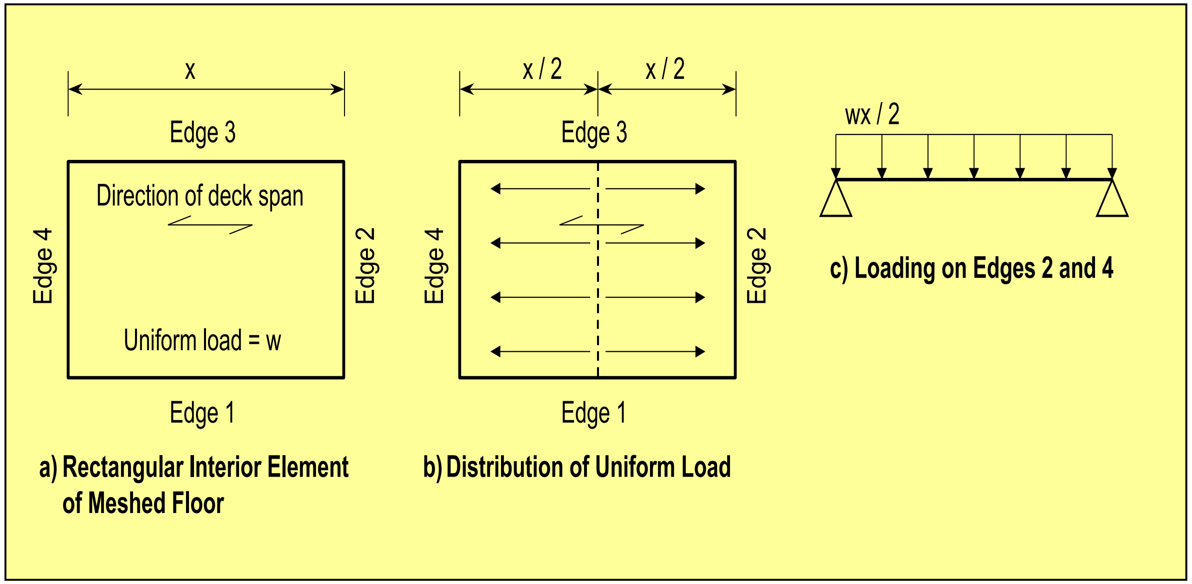
Load Transformation

- The load distribution for deck sections is one way, in contrast to slab sections which are assumed to span in two directions
- ETABS first automatically meshes the deck into quadrilateral elements
- Once the meshing is complete ETABS determines the meshed shell elements that have real beams along them and those that have imaginary beams
- It also determines which edges of the meshed shell elements are also edges of the deck.

Load Transformation

Rectangular Interior Meshed Element with Uniform Load

If the supporting member at the end point of an imaginary beam is itself imaginary, then the load from the imaginary beam tributary to that end point is lost, that is, it is ignored by ETABS



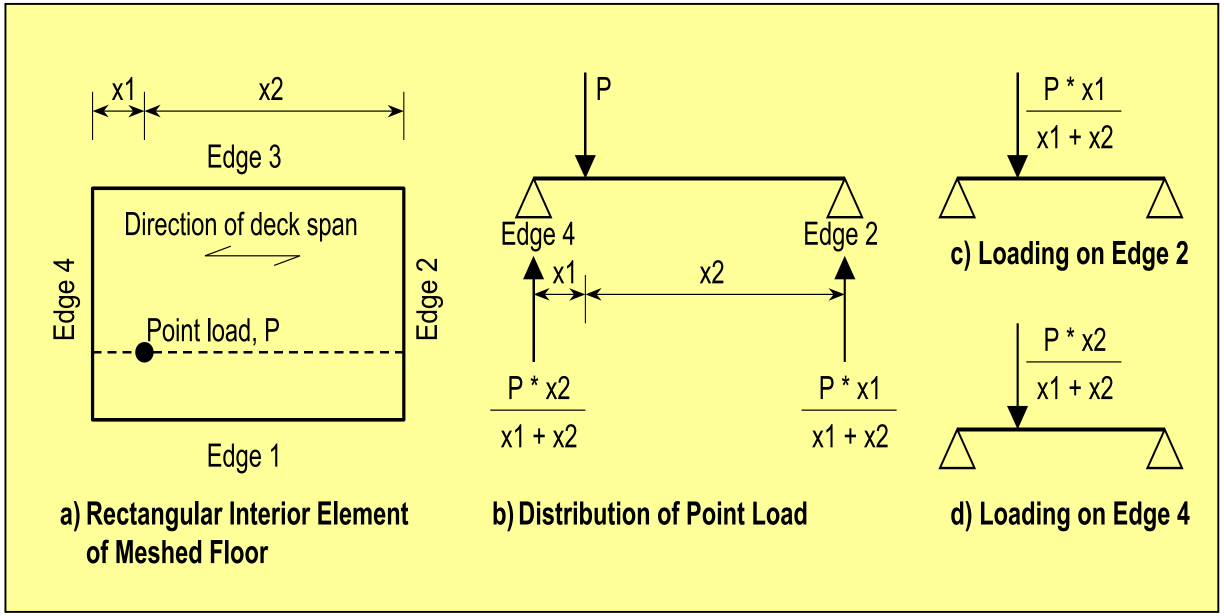
Example of rectangular interior meshed element with a uniform load

Load Transformation

Rectangular Interior Meshed Element with Point Load

- **ETABS distributes the point load to the appropriate edge beams (based on the direction of the deck span)**
- **If the beams along edges are real beams ETABS transfers the load onto adjacent beams**

If the supporting member at the end point of an imaginary beam is itself imaginary, then the load from the imaginary beam tributary to that end point is lost, that is, it is ignored by ETABS



Load Transformation

Rectangular Interior Meshed Element with Line Load

- **A line load is transformed in a similar fashion to that for a point load using a numerical integration technique**

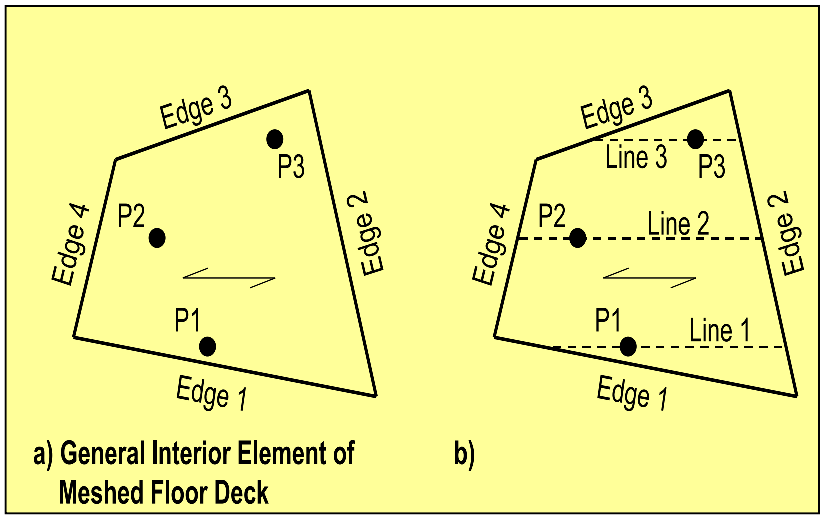
- **The line load is discredited as a series of point loads which are transformed to surrounding beams**

- **The series of point loads is then converted back to a line load on the surrounding beams**

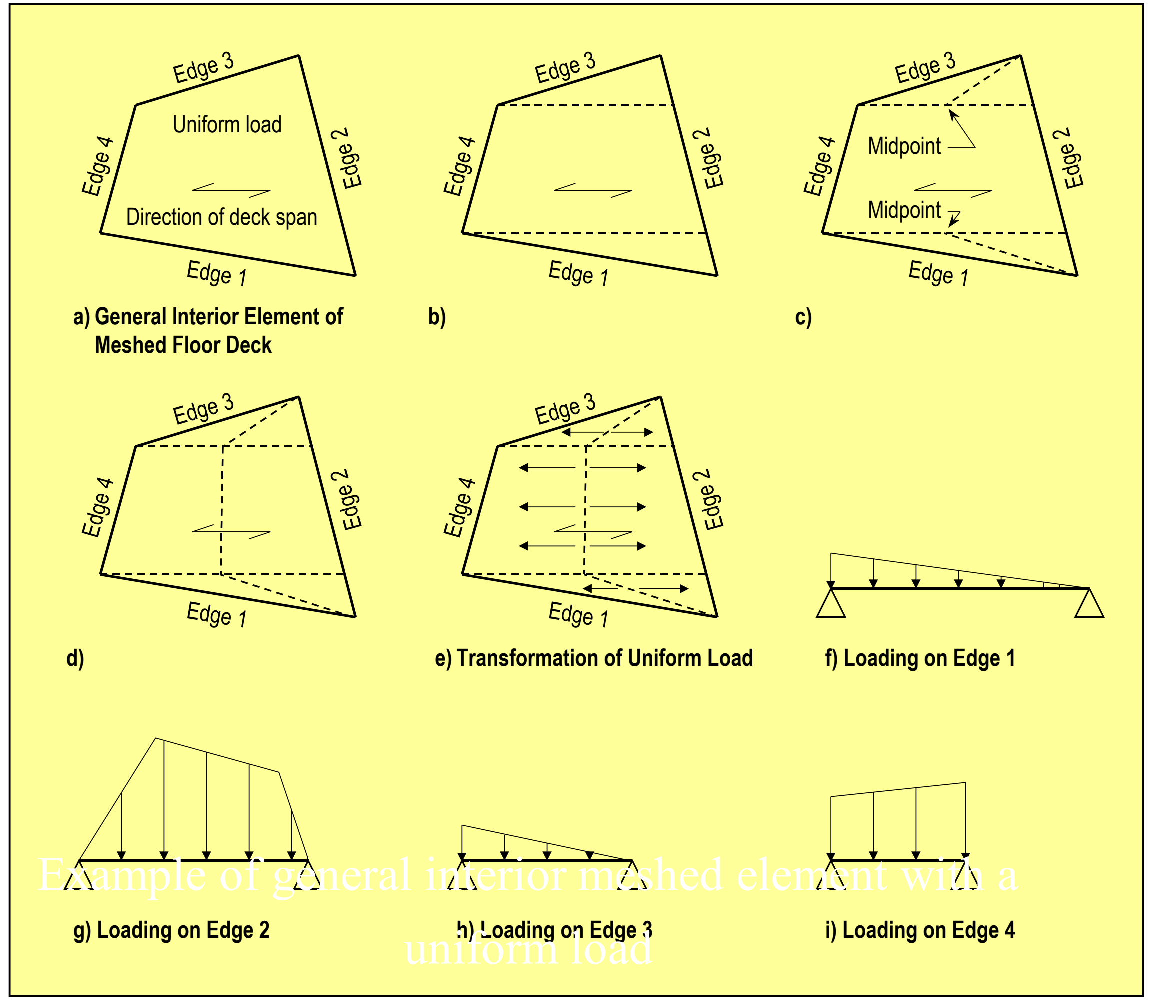
- **An area load that does not cover the entire element is also transformed in a similar fashion to that for a point load using a numerical integration technique.**

Load Transformation

General Interior Meshed Element



Example of general interior meshed element with a point load

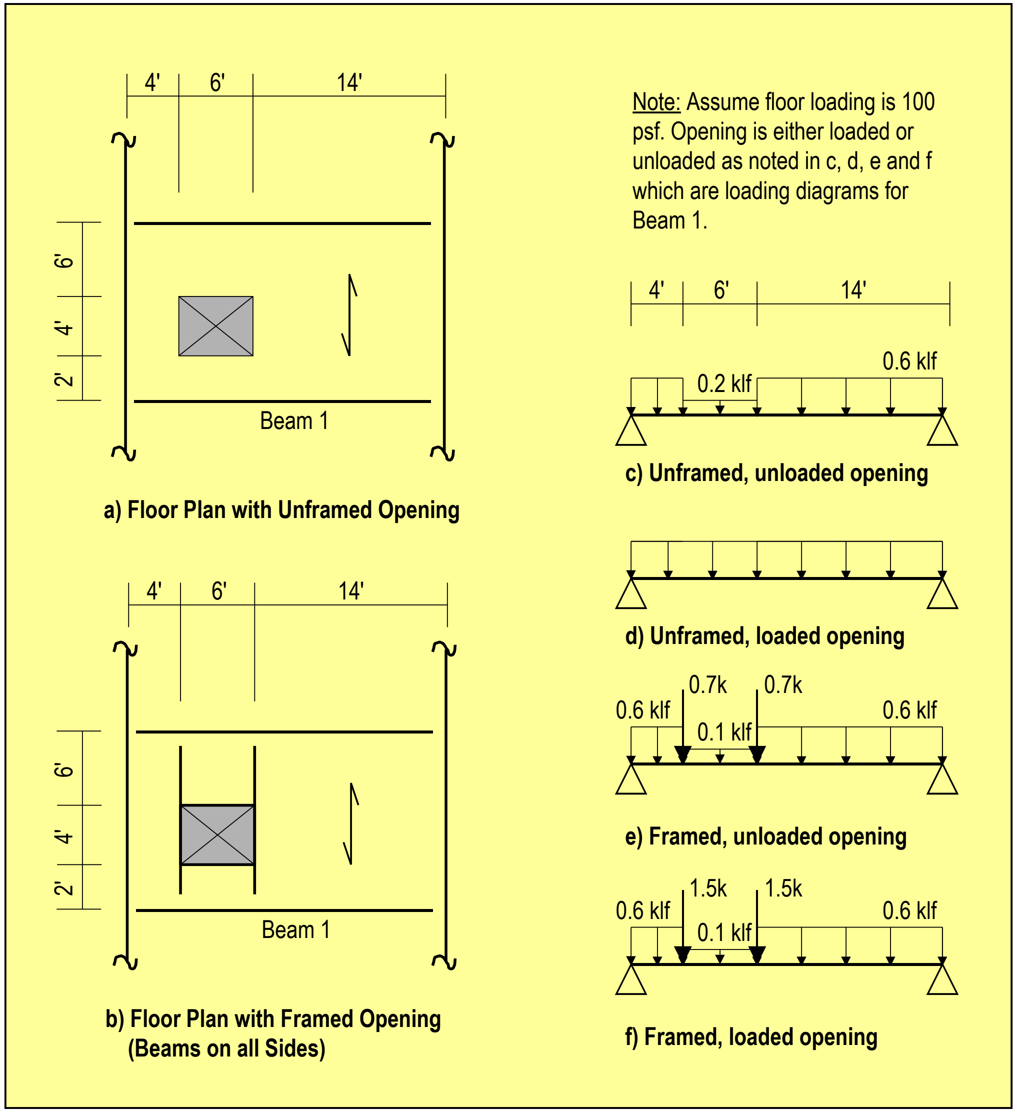


Example of general interior meshed element with a uniform load

Load Transformation

Effect of Deck Openings

Example of effect of openings on distribution of load over deck sections

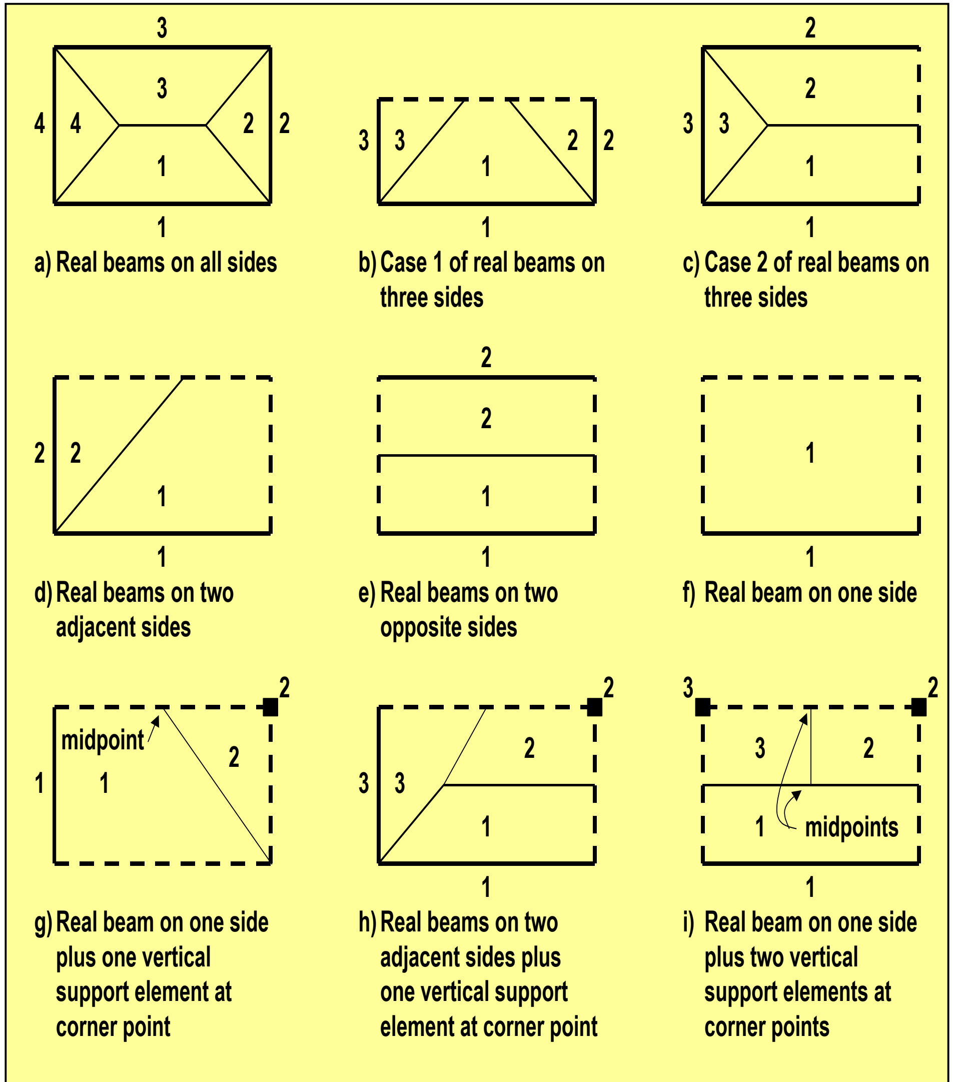


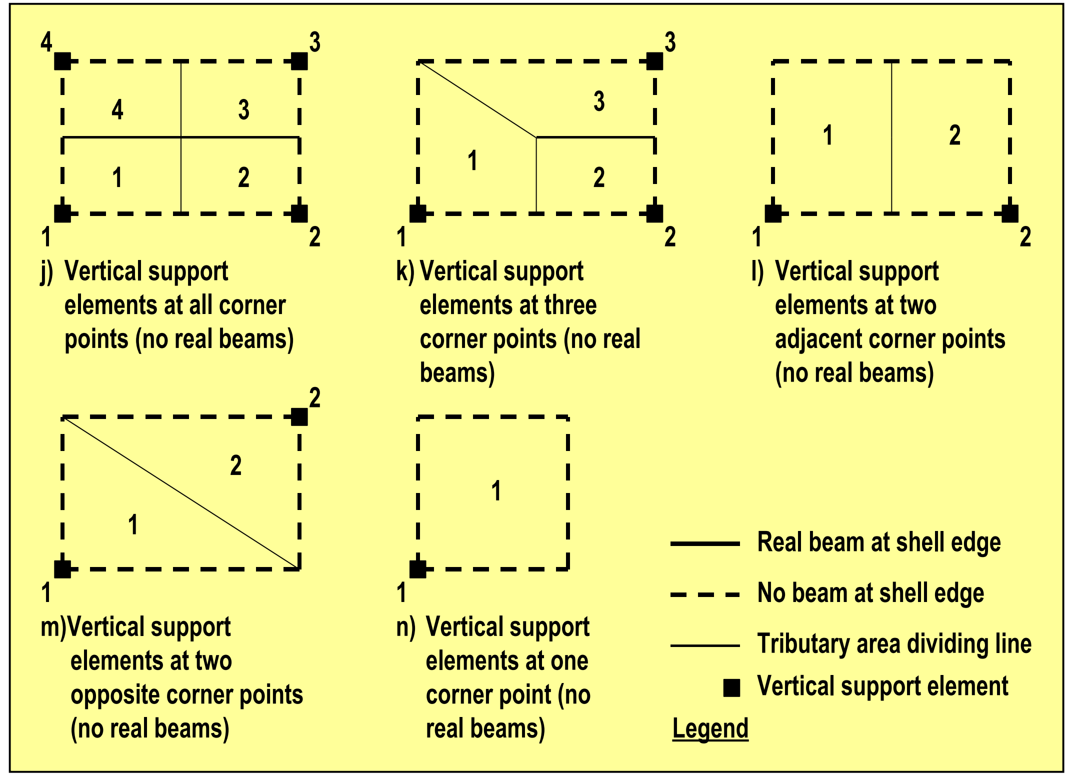
Load Transformation

Vertical Load Transformation for Floors with Membrane Slab Properties

- Only applies to floor-type area objects with slab section properties that have membrane behavior only
- The load distribution for membrane slab sections is two way
- The actual distribution of loads on these elements is quite complex
- ETABS uses the concept of tributary loads as a simplifying assumption for transforming the loads

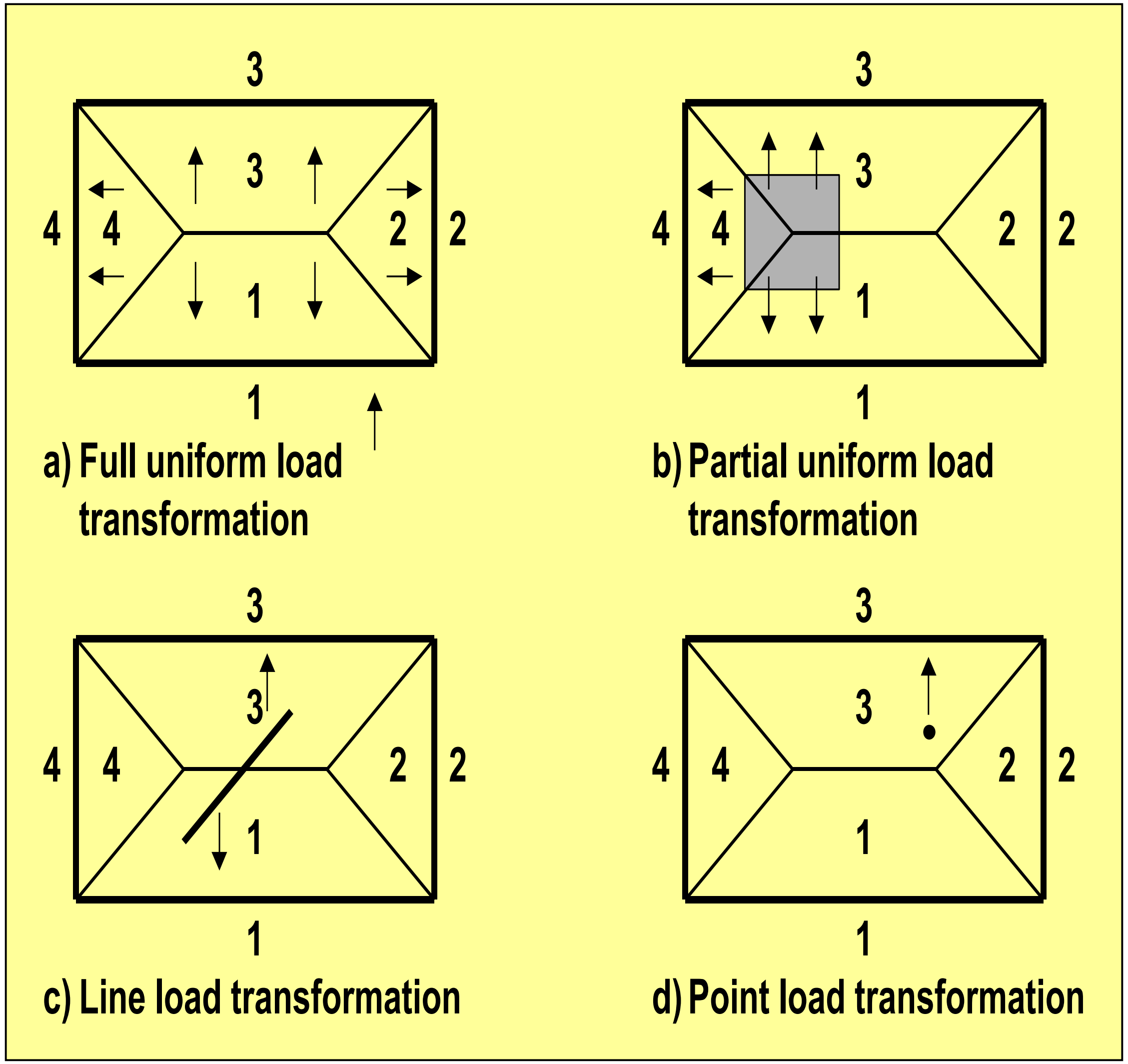
Floors with Membrane Slab Properties



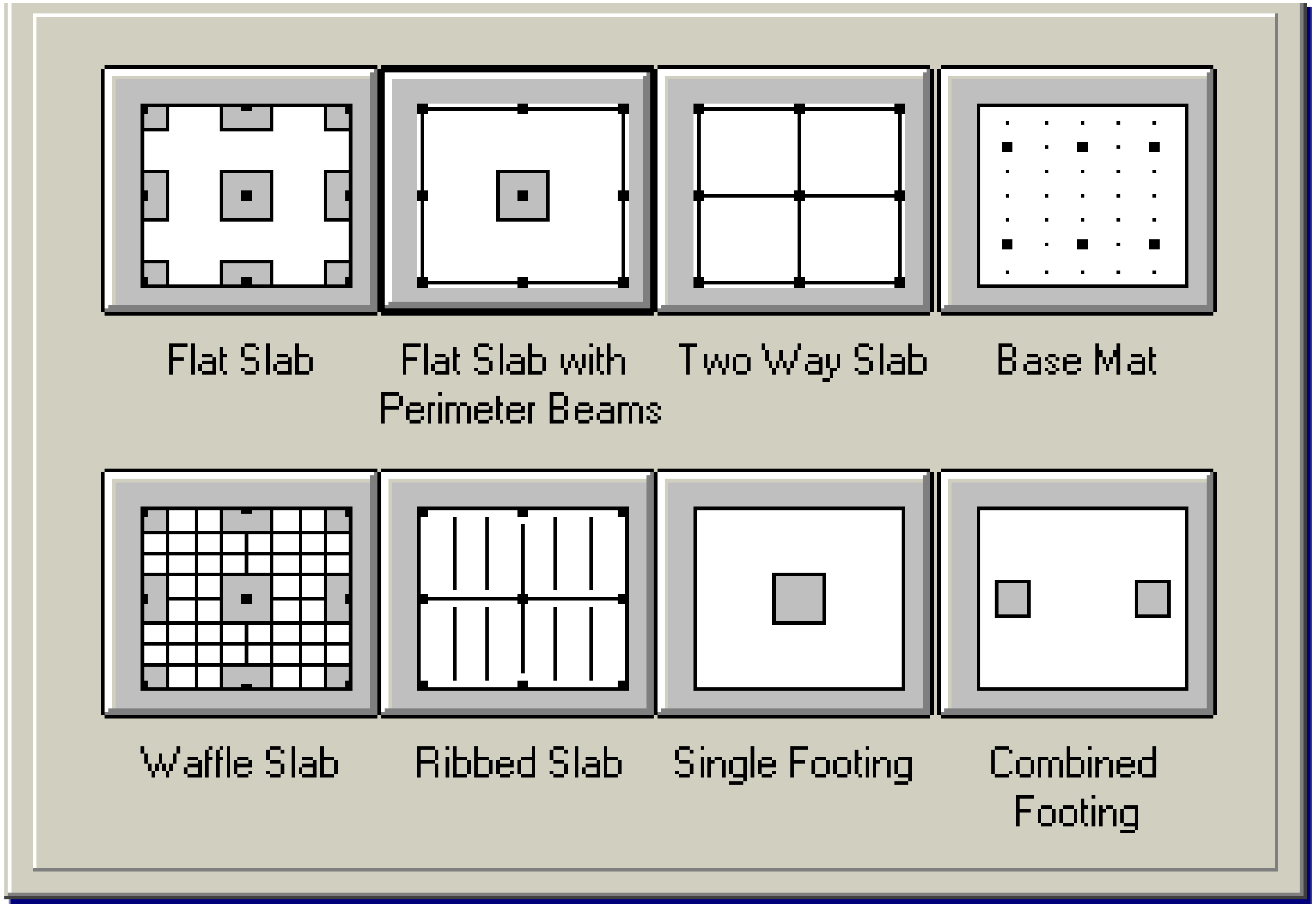


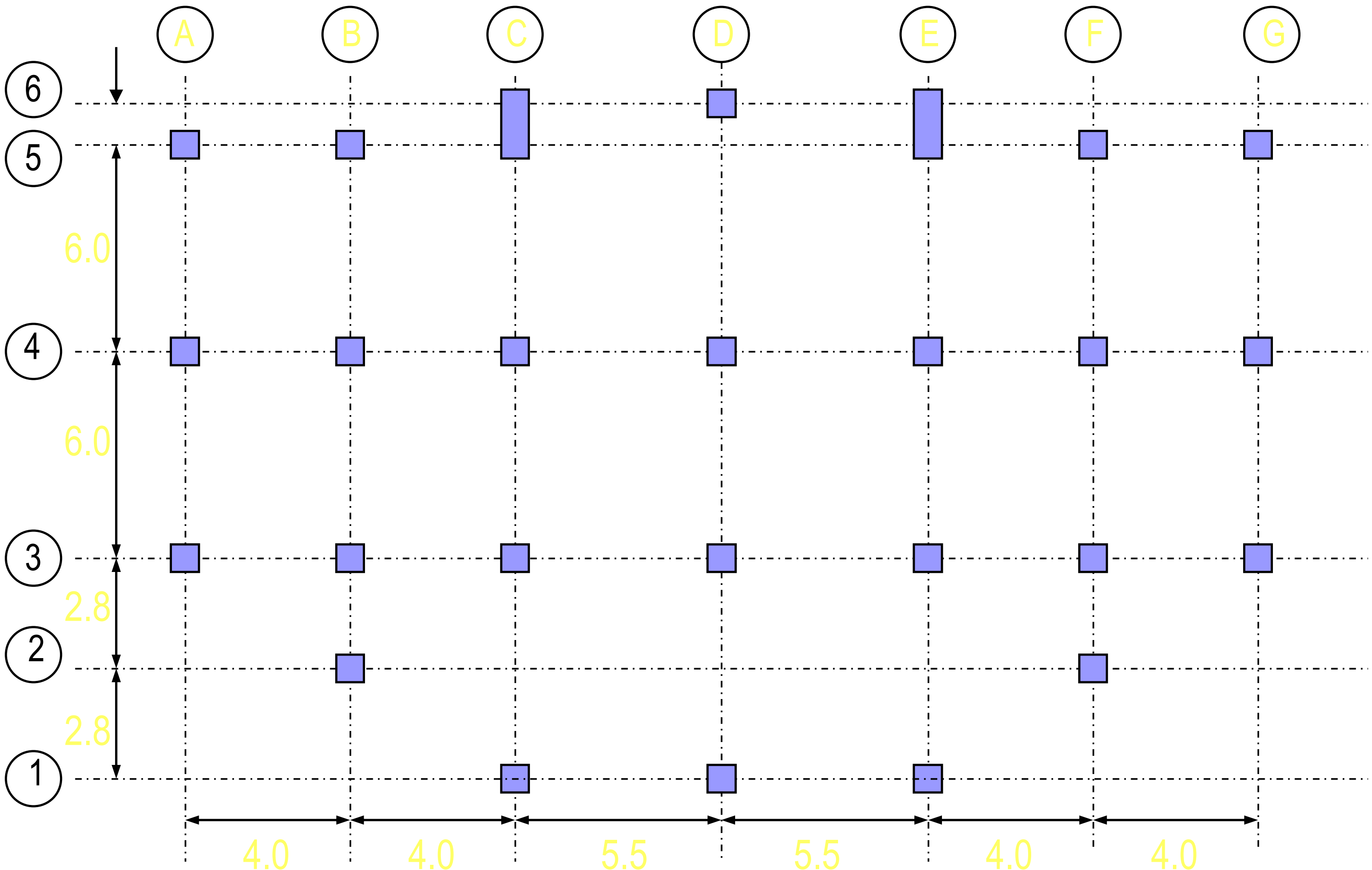
Tributary areas for various conditions of a membrane slab

Floors with Membrane Slab Properties

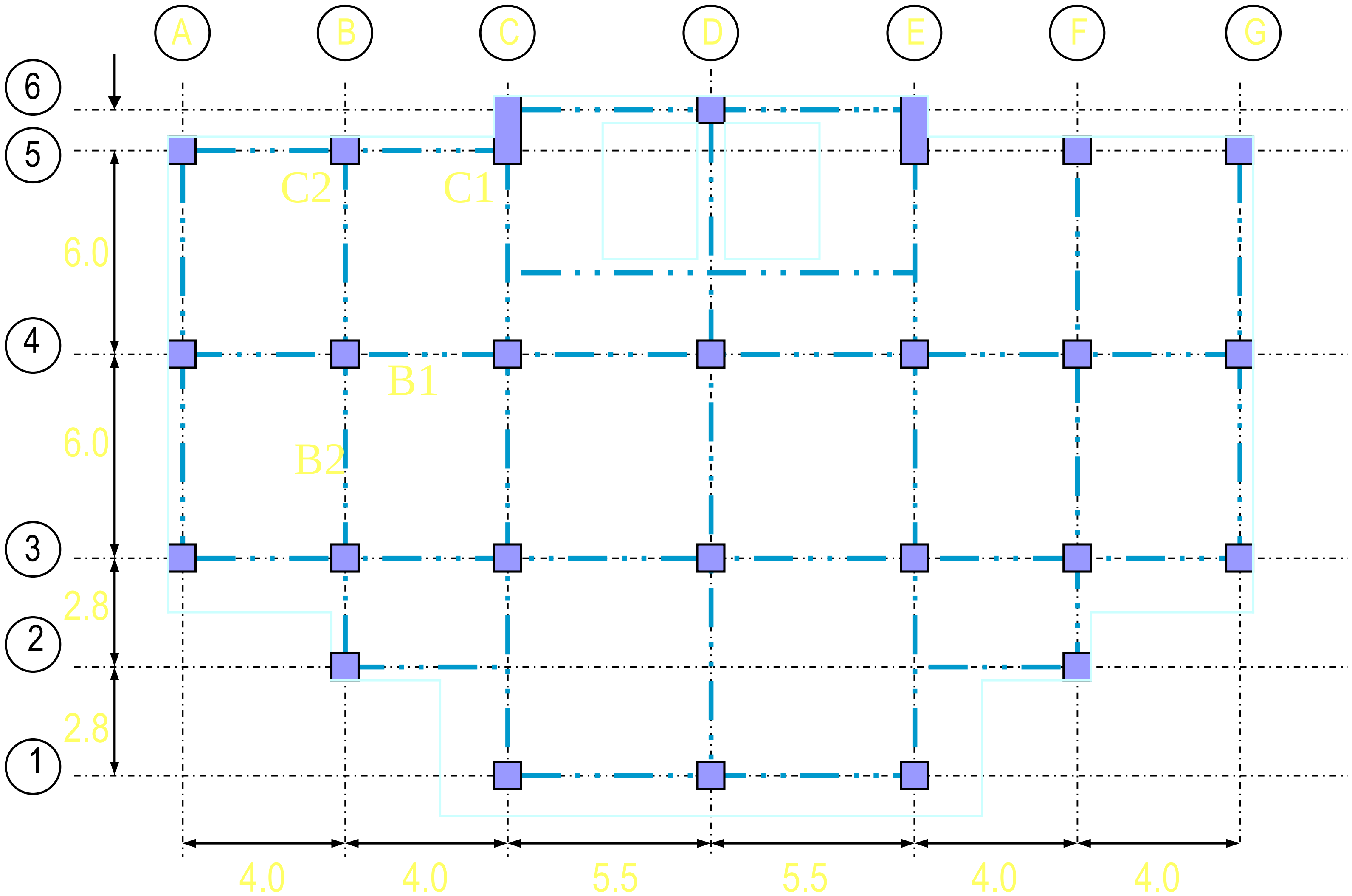


Example of load distribution on a membrane slab


Flat Slab
Flat Slab with Perimeter Beams
Two Way Slab
Base Mat
Waffle Slab
Ribbed Slab
Single Footing
Combined Footing



Column Layout Plan



C1= 0.3 x 0.8

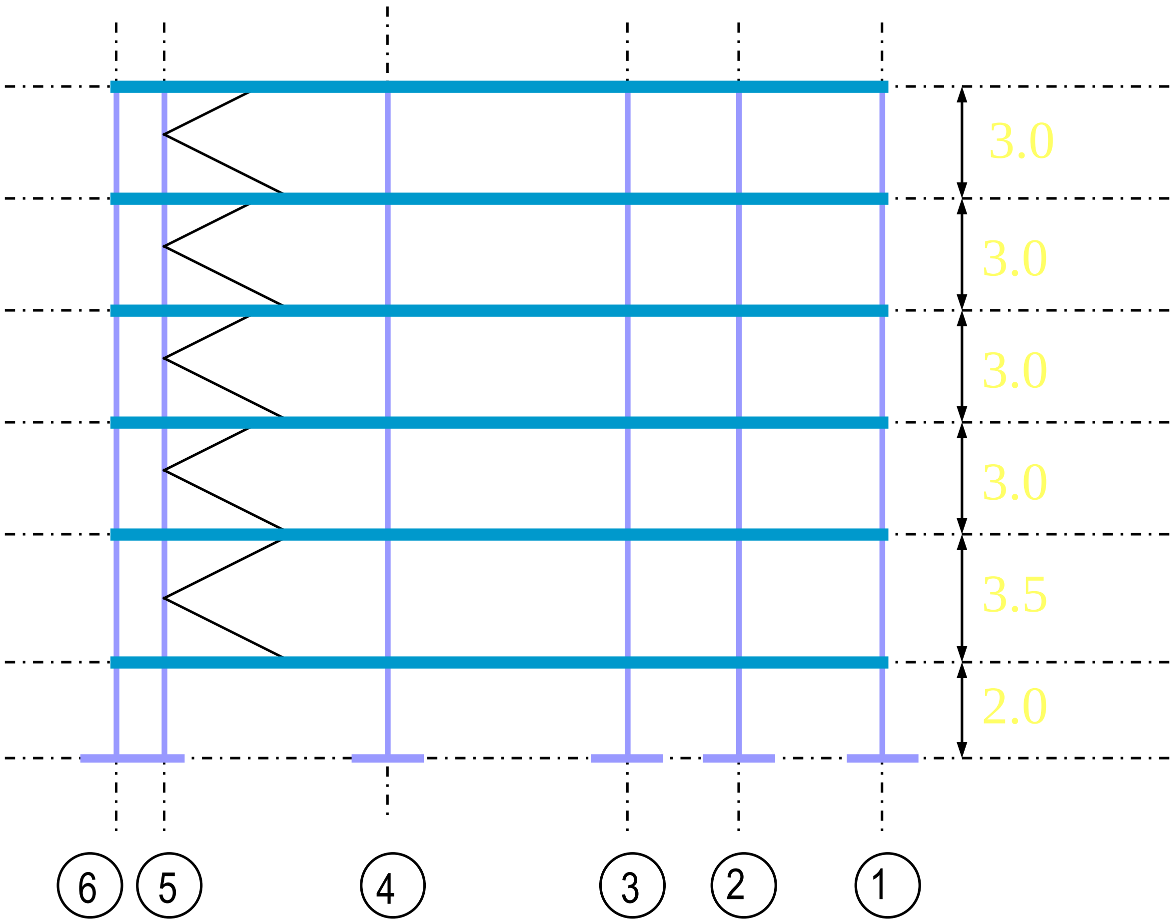
C2 = 0.3 x 0.4

B1 = 0.25 x 0.4

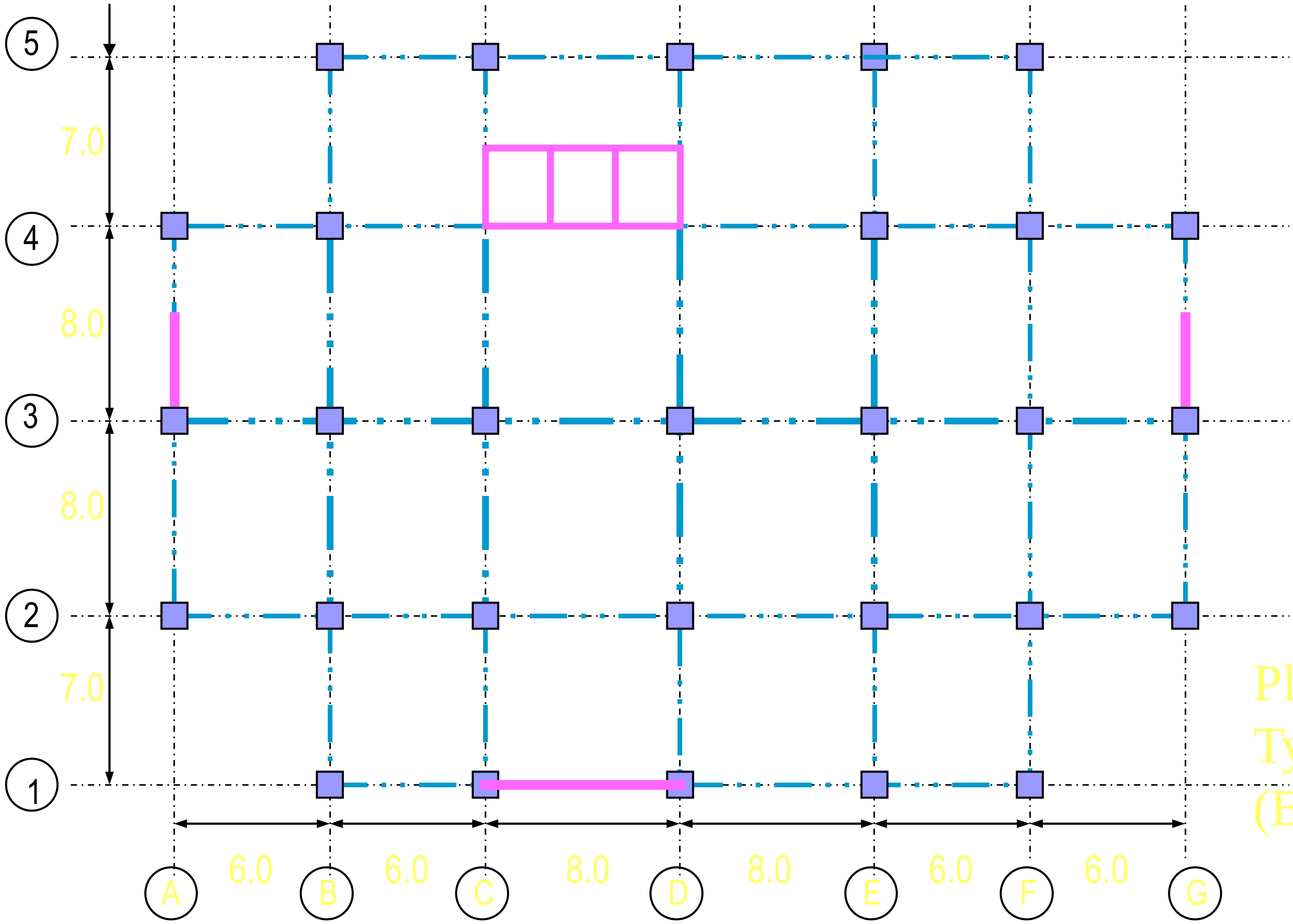
B2 = 0.25 x 0.5

S1 = 0.15

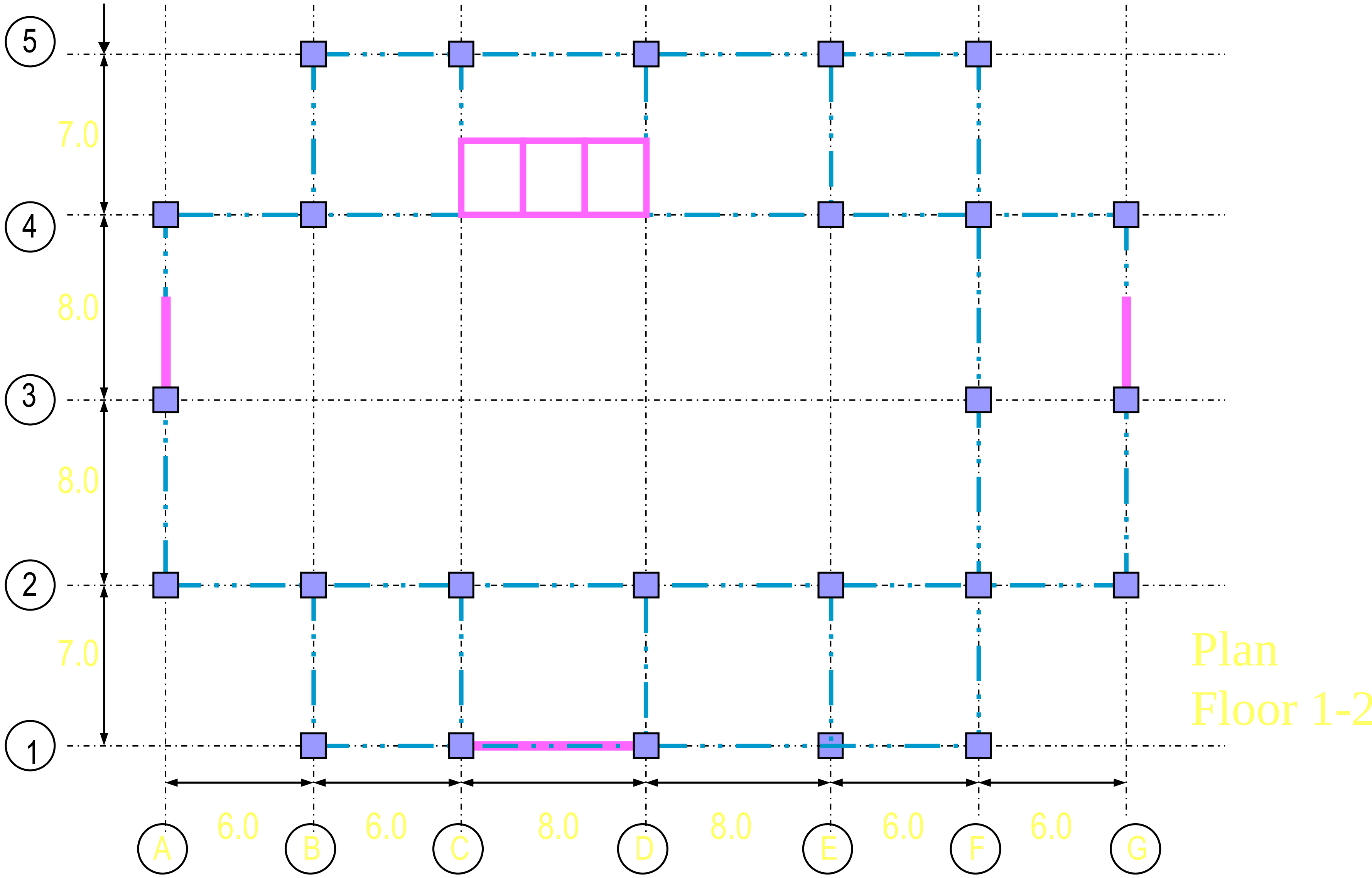
Slab and Beam Layout



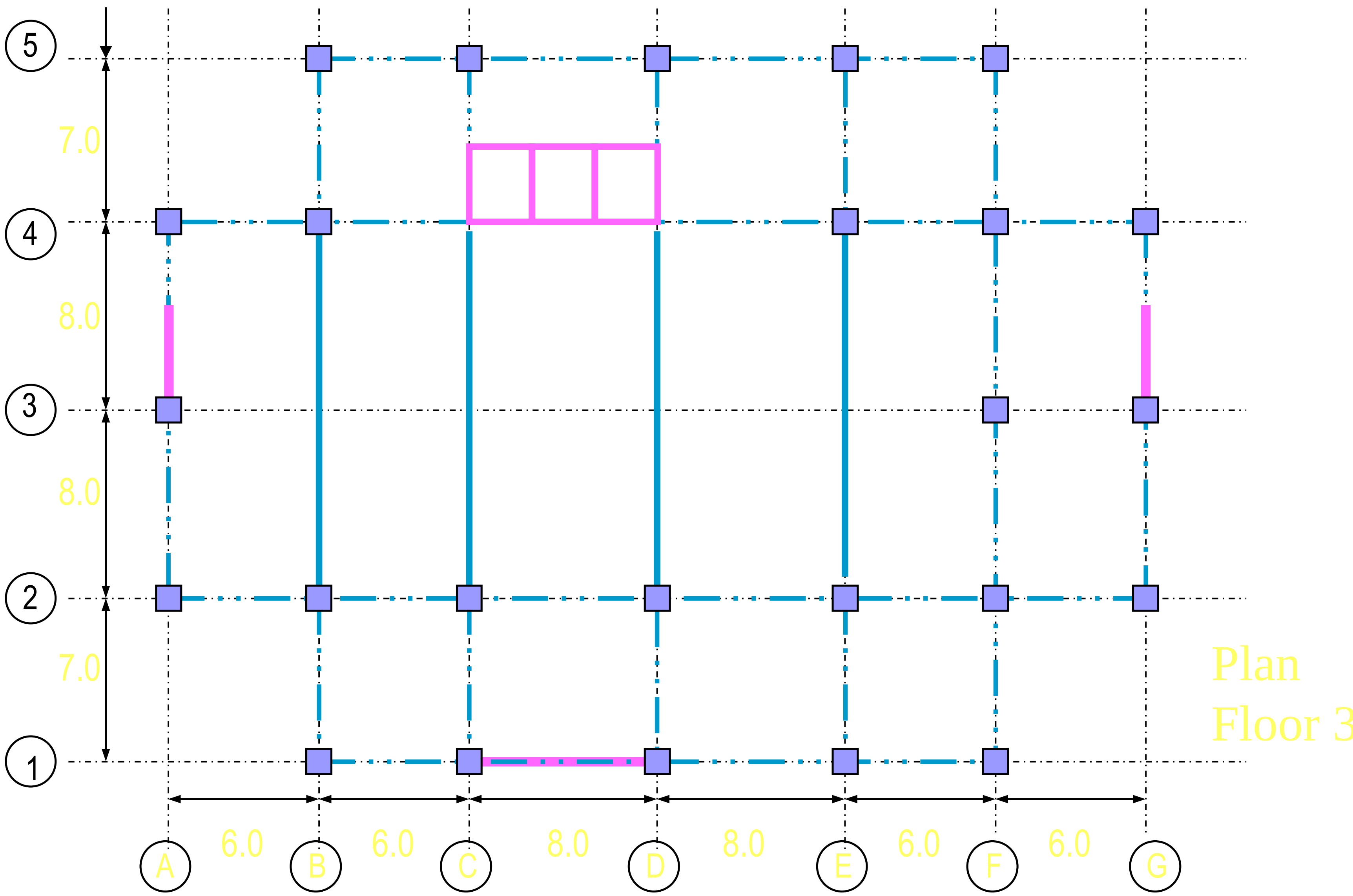
Section



Plan
Typical Floor
(B1, B2, 4-35)



5
4
3
2
1
7.0
8.0
8.0
7.0
A
B
C
D
E
F
G
6.0
6.0
8.0
8.0
6.0
6.0
Plan
Floor 1-2


5
4
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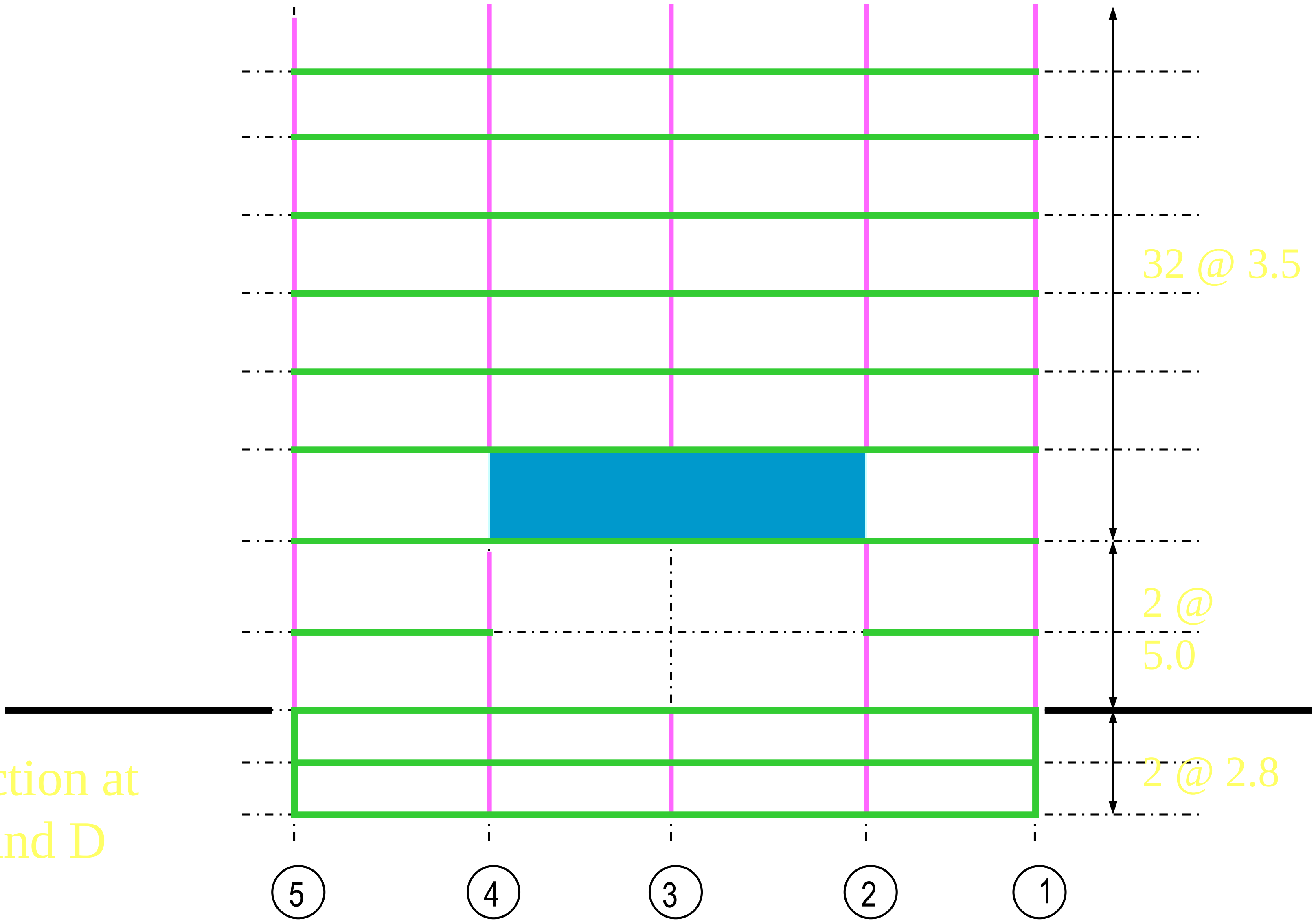
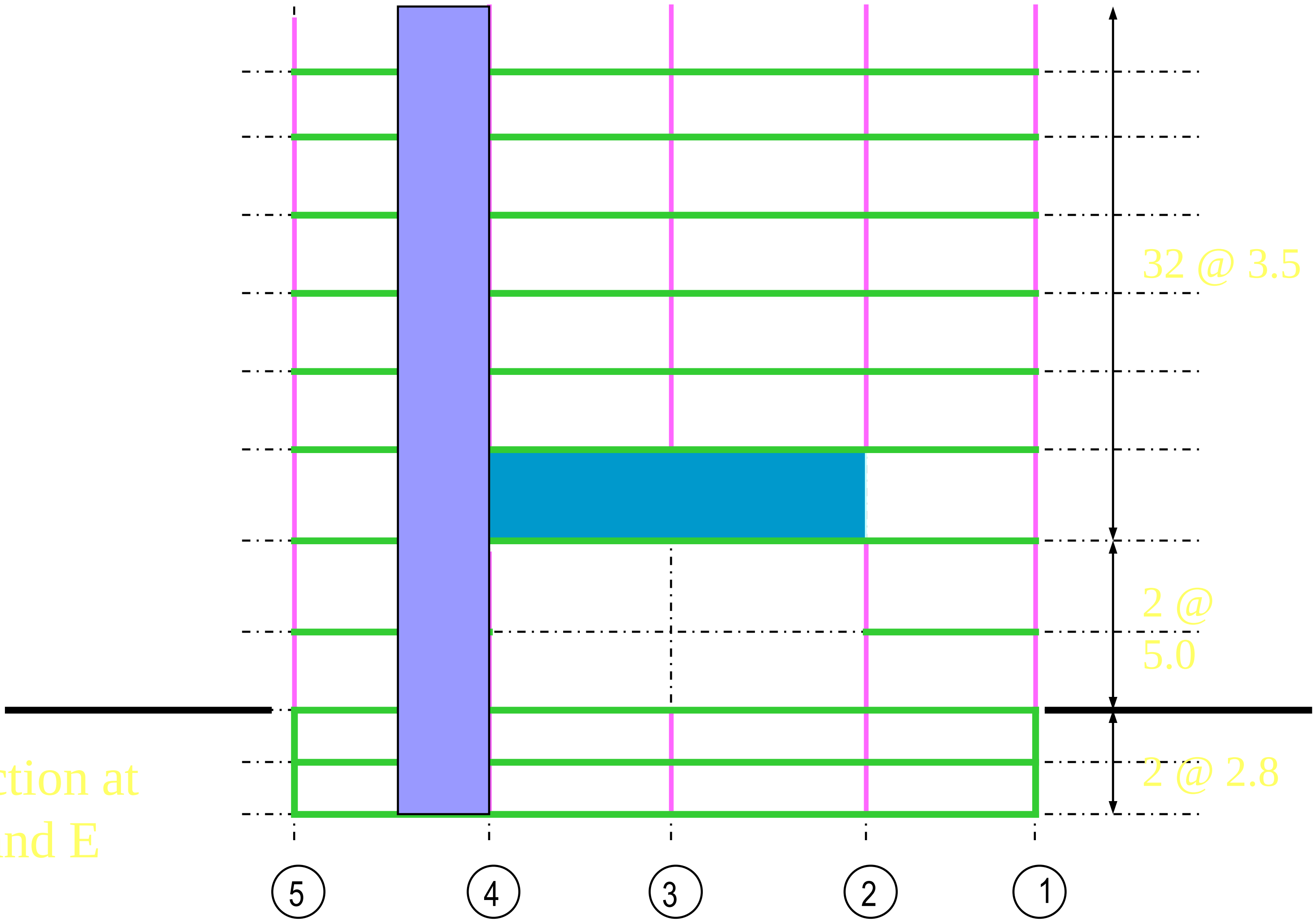
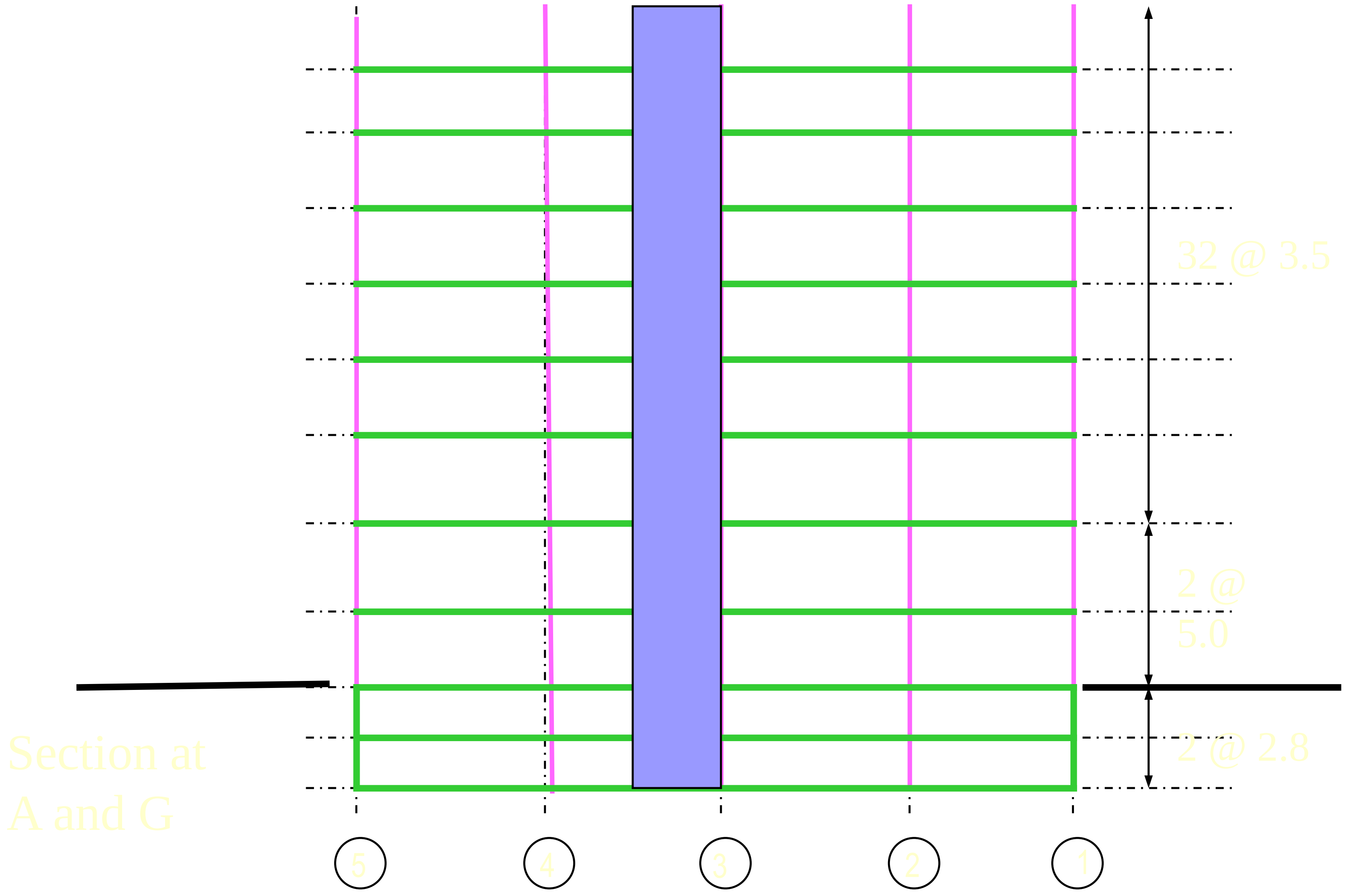
E
F
G
6.0
6.0
8.0
8.0
6.0
6.0
Plan
Floor 3



Section at C and D



Section at B and E


32 @ 3.5
2 @
5.0
2 @ 2.8
Section at
A and G
5
4
3
2
1