JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem – III Year / V Semester (2020-21)
Subject –Structural Analysis-I
Unit – I
Presented by – Akhil Maheshwari *(Asst. Prof., Department of Civil Engineering)*

VISSION AND MISSION OF INSTITUTE

Vision

To become a renowned center of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission

M-1: Focus on evaluation of learning outcomes and motivate students to inculcate research Aptitude by project based learning.

M-2: Identify, based on informed perception of Indian, Regional and global needs, areas of focus and provide platform to gain knowledge and solutions.

M-3: Offer opportunities for interaction between academia and industry.

M-4: Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISSION AND MISSION OF DEPARTMENT

VISION

To become a role model in the field of Civil Engineering for the sustainable development of the society.

MISSION

To provide outcome base education.

To create a learning environment conducive for achieving academic excellence.

To prepare civil engineers for the society with high ethical values.

PROGRAMME OUTCOMES (PO)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering Fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outcomes (CO)

CO1. Students will be able to understand the Static and Kinematic Indeterminacy.

CO 2. Students will be able to understand the different types of Prop, Fixed and Continuous Beam.

CO 3. Students will be able to understand the Slope Deflection and Moment Distribution Method.

CO 4. Students will be able to understand Mechanical vibrations.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	1	-	-	1	1	1	2
CO2	3	3	3	2	2	1	-	-	2	1	1	2
CO3	3	3	3	2	2	1	-	-	1	1	2	2
CO4	3	2	2	2	3	2	-	-	2	1	3	3

Teaching Plan

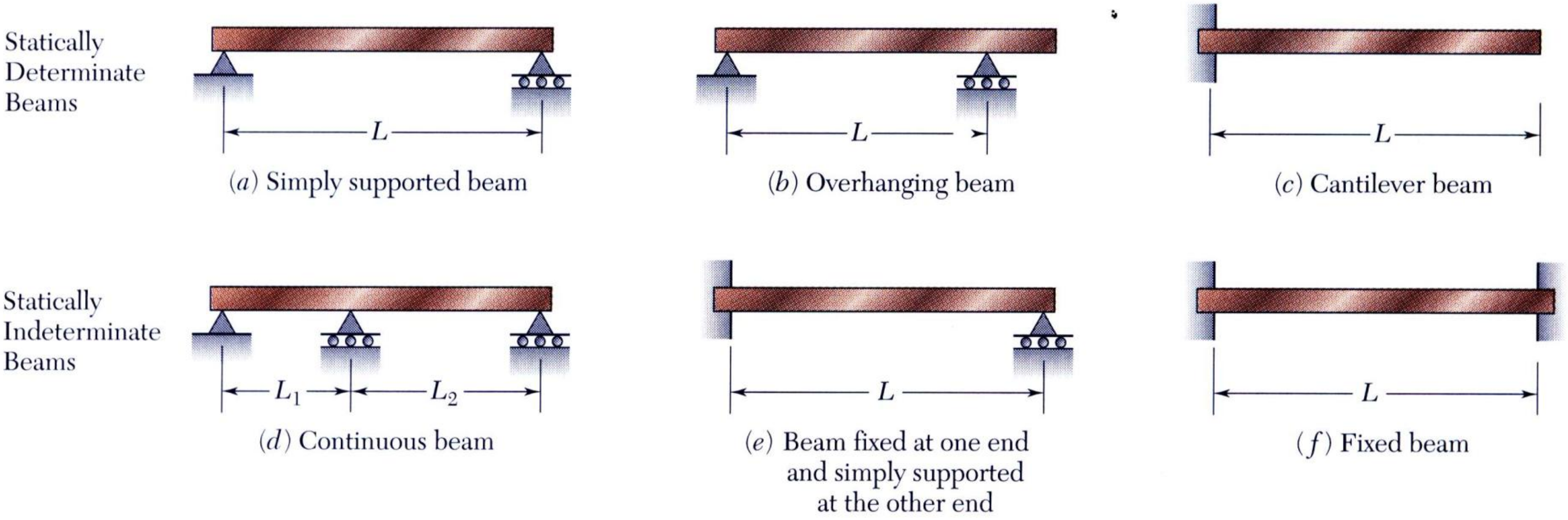
Lect No.	Unit Code	Topic Discription	Expexcted Month	Expected week	Plan of teaching
1	1.1	Introduction,Scope, and Coutcome of subject	July	1	PPT
2	2.1	Introduction to Indeterminate structures	July	1	PPT
3	2.2	Degrees of freedom per node		1	PPT
4	2.3	Static and Kinematic indeterminacy (i.e. for beams, frames & portal with & without sway etc.)		1	PPT
5	2.4	Releases in structures		1	PPT
6	2.5	Maxwell's reciprocal theorem and Betti's theorem.	August	1	PPT
7	2.6	Analysis of prop cantilever structures		1	PPT
8	2.7	Analysis of Indeterminate Structure (fixed and continues beams) using Area moment method		1	PPT
9	2.8	Conjugate beam method		1	PPT
10	2.9	Three moments Theorem.		1	PPT

Teaching Plan

Lect No.	Unit Code	Topic Discription	Expexcted Month	Expected week	Plan of teaching
11	3.1	Analysis of Statically Indeterminate Structures using Slope-deflection method	September	1	PPT
12	3.2	Moment-distribution method applied to continuous beams and portal frames with and without inclined members		1	PPT
13	4.1	Vibrations: Elementary concepts of structural vibration, Mathematical models, basic elements of vibratory system.		1	PPT
14	4.2	Degree of freedom. Equivalent Spring stiffness of springs in parallel and in series.		1	PPT
15	4.3	Simple Harmonic Motion: vector representation, characteristic, addition of harmonic motions, Angular oscillation.	October	1	PPT
16	4.4	Undamped free vibration of SDOF system: Newton's law of motion		1	PPT
17	4.5	D Almbert's principle, deriving equation of motions, solution of differential equation of motion, frequency & period of vibration, amplitude of motion; Introduction to damped and forced vibration.		1	PPT

Introduction

Classification of Beam Supports



(*a*) Simply supported beam

(*b*) Overhanging beam

(*c*) Cantilever beam

(*d*) Continuous beam

(*e*) Beam fixed at one end and simply supported at the other end

(*f*) Fixed beam

BENDING MOMENTS AND SHEARING FORCES IN BEAMS

BEAM

- A structural member which is long when compared with its lateral dimensions, subjected to transverse forces so applied as to induce bending of the member in an axial plane, is called a beam.

TYPES OF BEAMS

- Beams are usually described by the manner in which they are supported.
- For instance, a beam with a pin support at one end and a roller support at the other is called a **simply supported beam or a simple beam** (Figure 3.1a).
- A **cantilever beam** (Figure 3.1b) is one that is fixed at one end and is free at the other. The free end is free to translate and rotate unlike the fixed end that can do neither.

Types of Beams

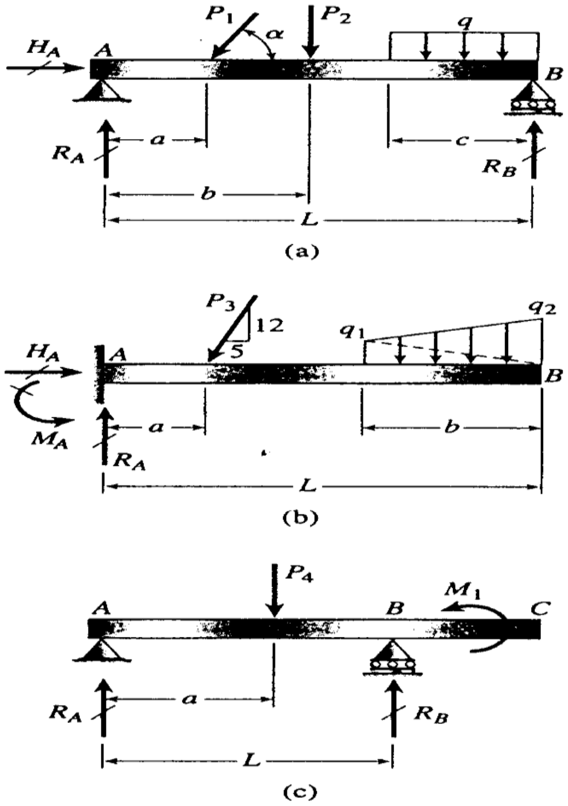
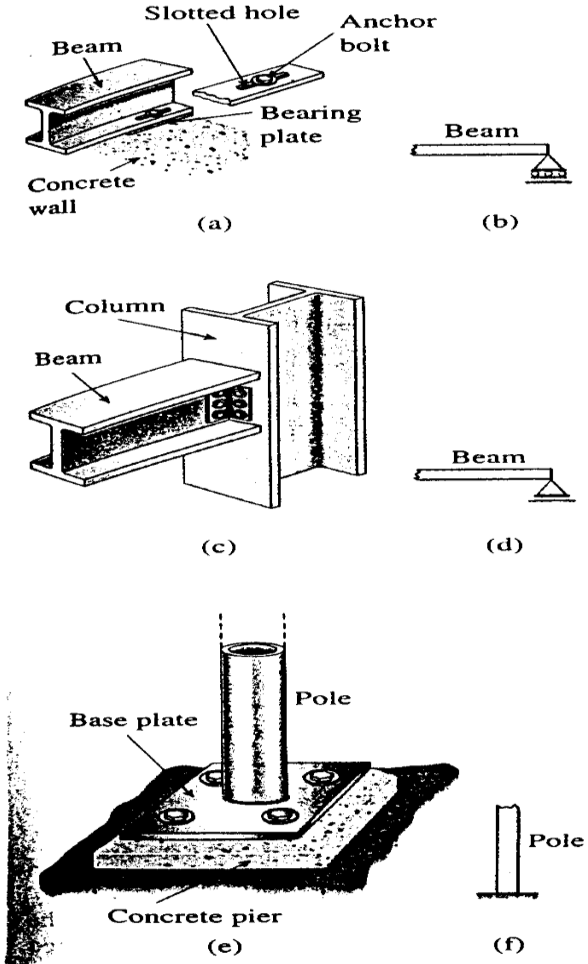


Fig. 3.1 Types of beams: (a) simple beam, (b) cantilever beam, and (c) beam with an overhang



Beam supported on a wall: (a) actual construction, and (b) representation as a roller support. Beam-to-column connection: (c) actual construction, and (d) representation as a pin support. Pole anchored to a

TYPES OF BEAMS

- The third example is a **beam with an overhang** .
- The beam is simply supported at points A and B but it also projects beyond the support at B.
- The overhanging segment is similar to a cantilever beam except that the beam axis may rotate at point B.

TYPES OF LOADS:

- A load can be classified as:
- **(i) Concentrated**: which is regarded as acting wholly at one. Examples are loads P, P_2, P_3 and P_4 .
- **(ii) Distributed Load**: A load that is spread along the axis of the beam, such as q. Distributed loads are measured by their intensity, which is expressed in force per unit distance e.g. kN/m.

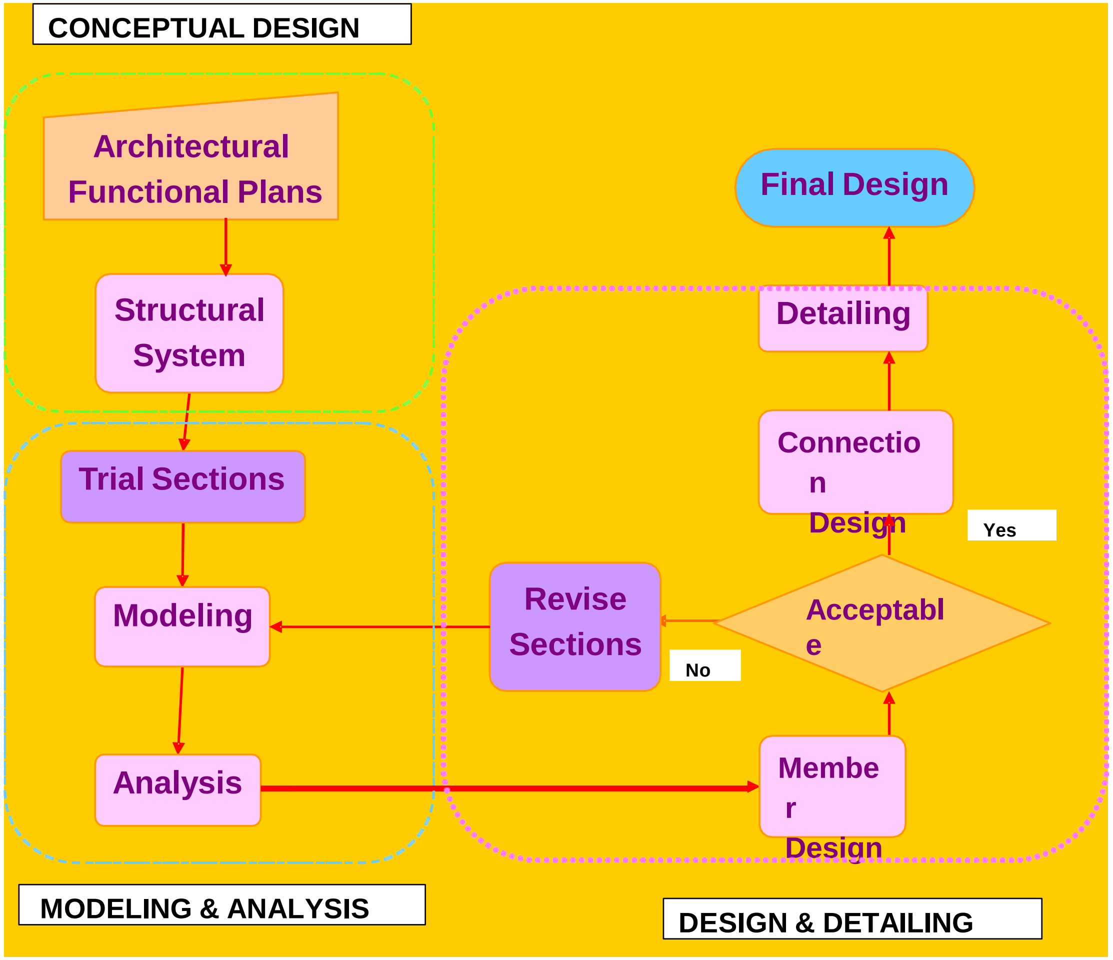
TYPES OF LOADS CONTD.

- A uniformly distributed load, or uniform load has constant intensity, q per unit distance.
- A linearly varying load has an intensity which changes with distance.
- **(iii) Couple:** This is illustrated by the couple of moment M acting on the overhanging beam.

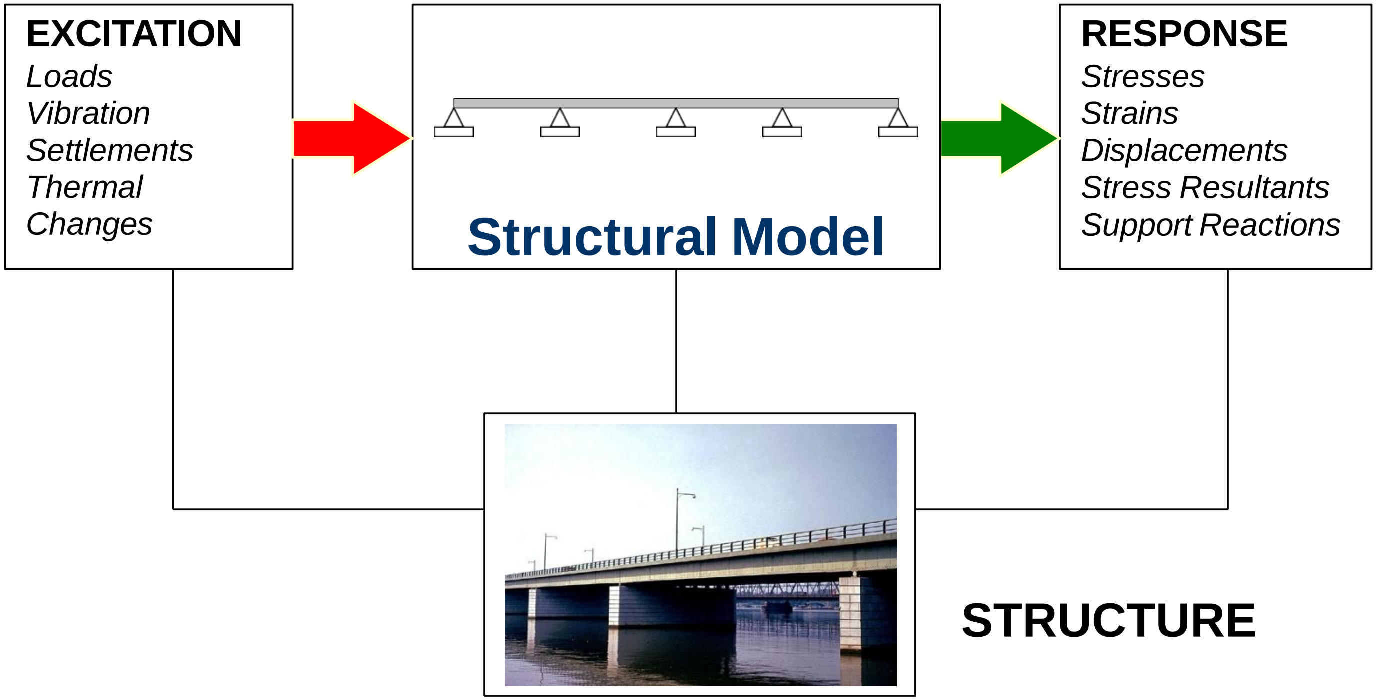
SHEAR FORCES AND BENDING MOMENTS

- When a beam is loaded by forces or couples, stresses and strains are created throughout the interior of the beam.
- To determine these stresses and strains, the internal forces and internal couples that act on the cross sections of the beam must be found.

Structural Analysis is an integral part of a structural engineering Project



Structures can not be analyzed.
They can only be load-tested.
We analyze the “model” of a structure.

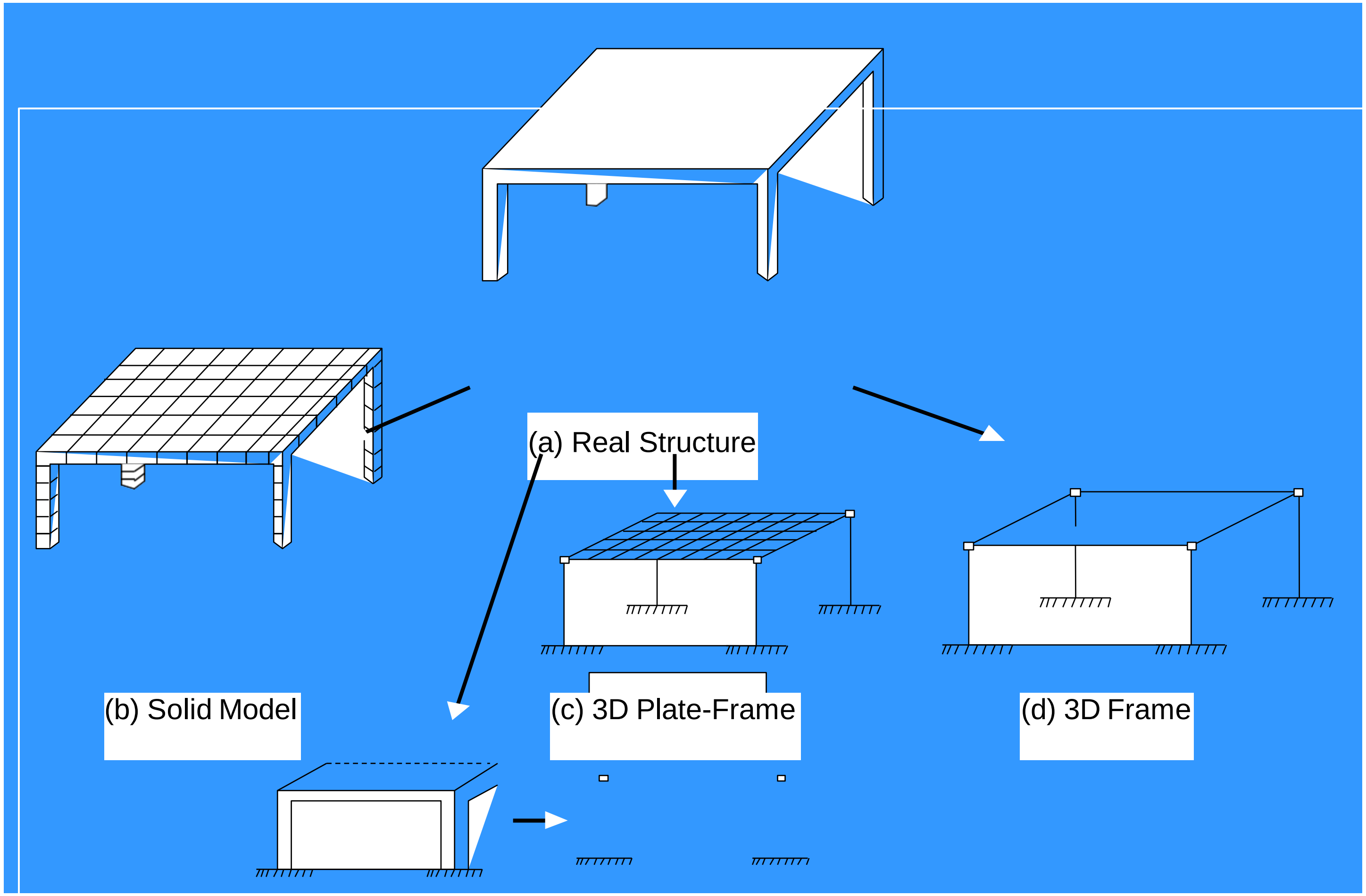


EXCITATION
Loads
Vibration
Settlements
Thermal Changes

Structural Model

RESPONSE
Stresses
Strains
Displacements
Stress Resultants
Support Reactions

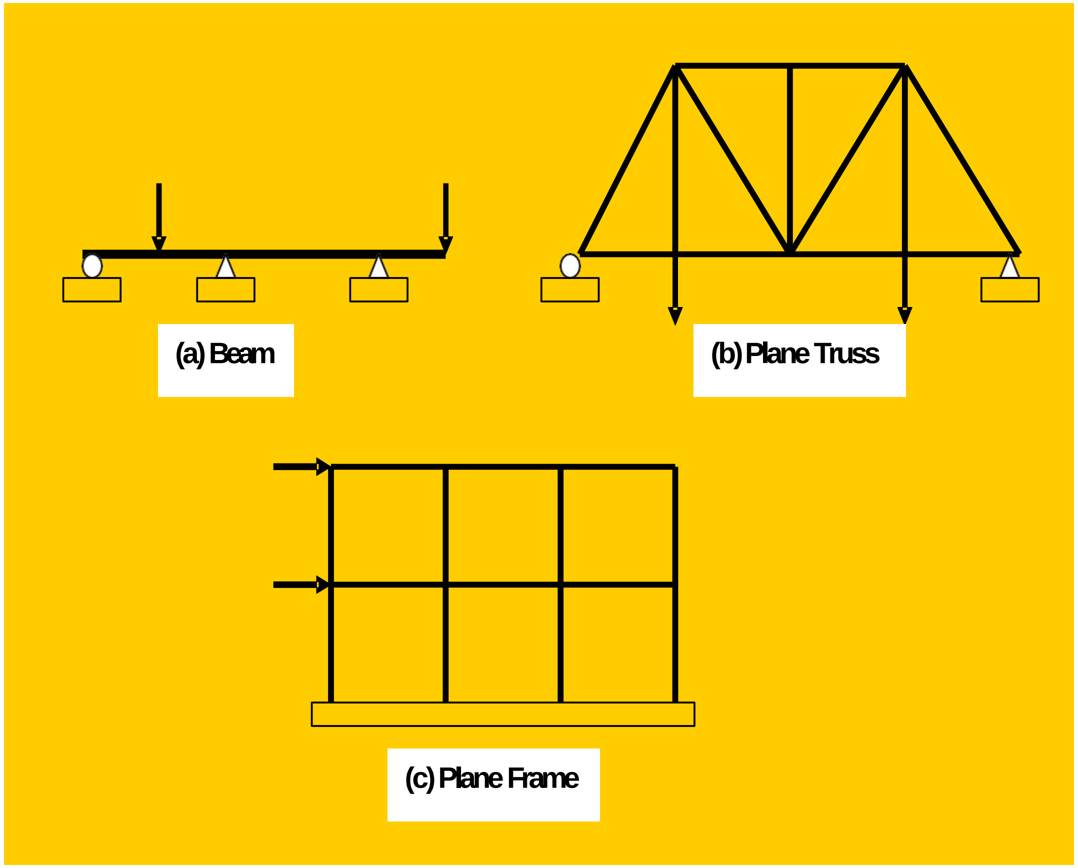
STRUCTURE



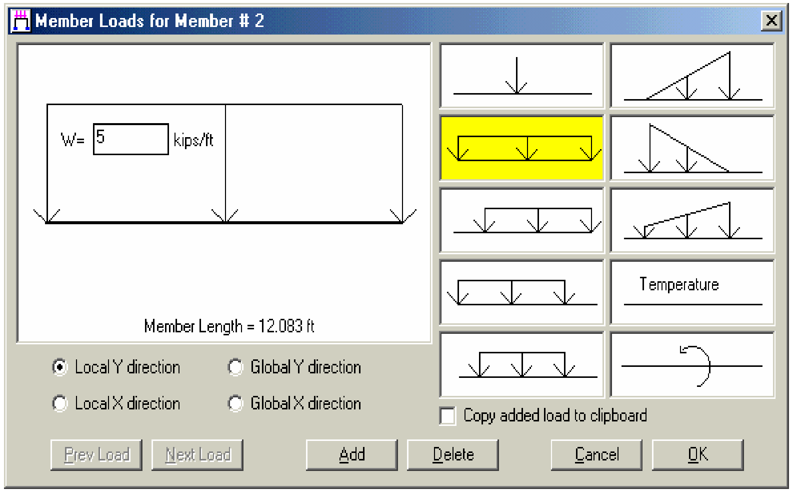
(e) 2D Frame

“It is imperative that the model represents the real structure with an appropriate likeness to capture the desired response. “

2D Models of Structures



Modeling Loads & Supports



Member Loads for Member # 2

W= 5 kips/ft

Member Length = 12.083 ft

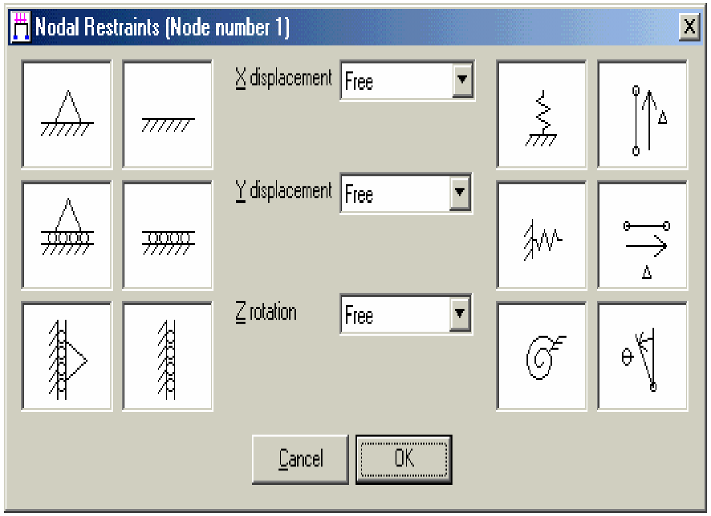
● Local Y direction ○ Global Y direction

○ Local X direction ○ Global X direction

☐ Copy added load to clipboard

- Dead Load
- Live Load
- Wind Load
- Seismic Load
- Impact
- Temperature

- Roller
- Pinned
- Fixed
- Spring
- Settlements



Nodal Restraints (Node number 1)

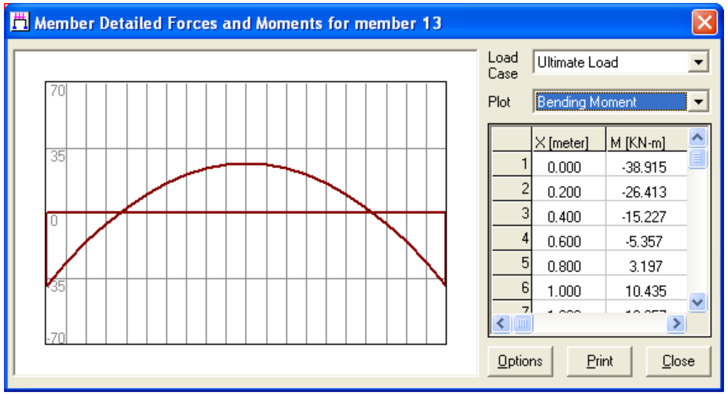
X displacement: Free

Y displacement: Free

Z rotation: Free

Structural Analysis Output

- Displacements
- Axial Forces
- Shear Forces
- Bending Moments
- Stresses

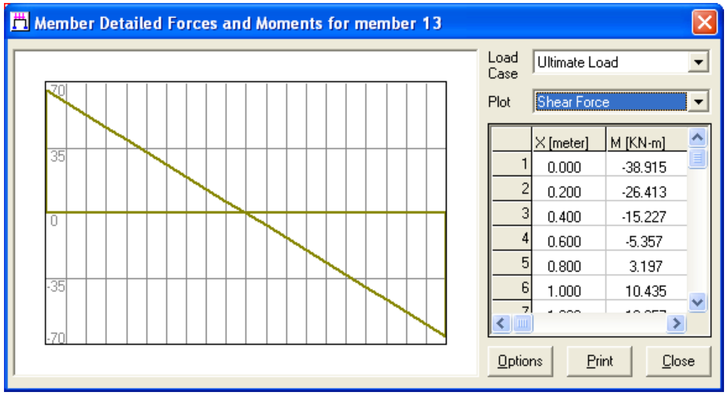


Member Detailed Forces and Moments for member 13

Load Case: Ultimate Load

Plot: Bending Moment

	X [meter]	M [KN-m]
1	0.000	-38.915
2	0.200	-26.413
3	0.400	-15.227
4	0.600	-5.357
5	0.800	3.197
6	1.000	10.435
7		



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6	1.000	10.435
7		

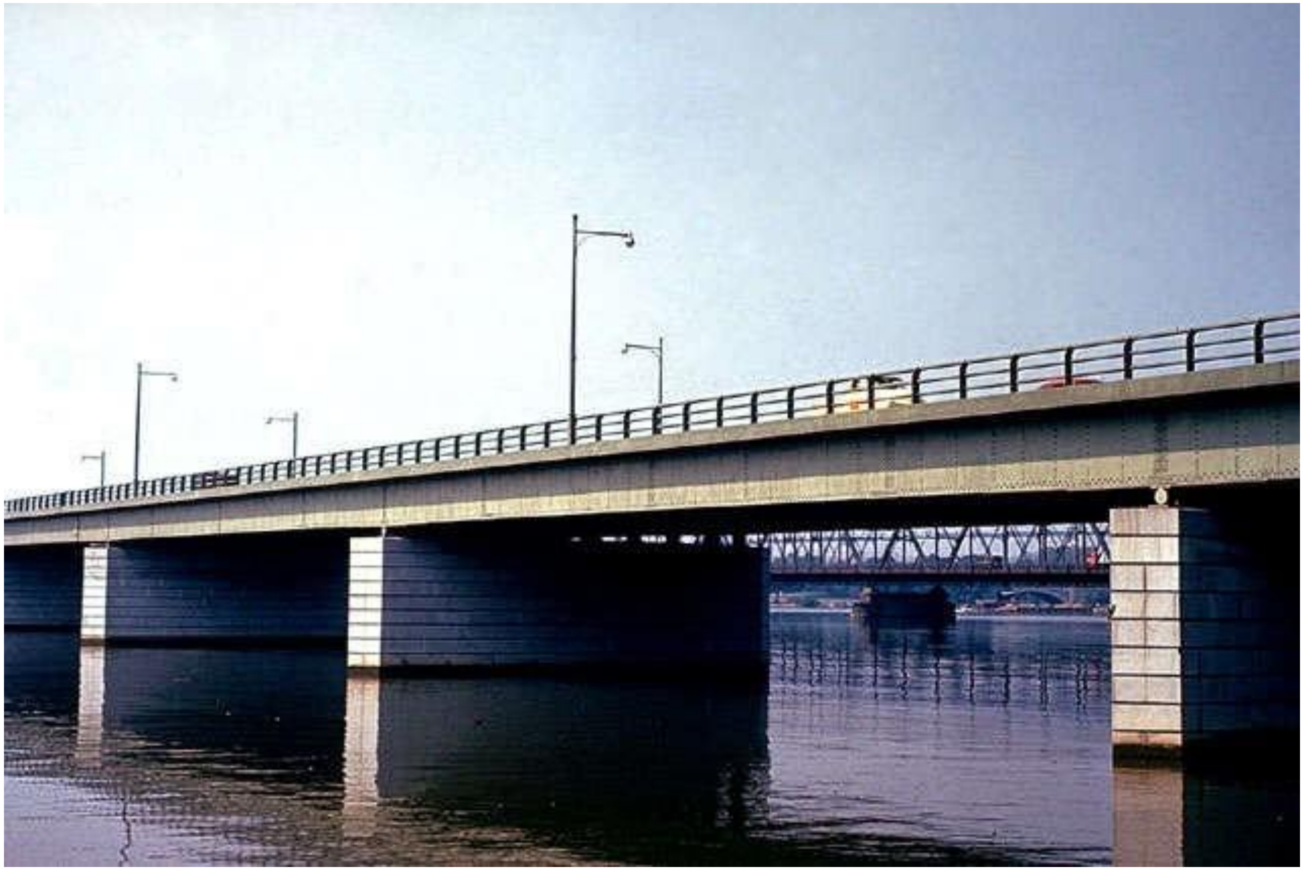
BEAMS are usually horizontal members, primarily designed to resist bending moment.

COLUMNS are generally vertical and resist axial compressive loads.

Stonehenge, England. One of the earliest examples of beam and column construction, it was built in approximately 2000 B.C. The picture shows part of a 30-meter circle of 30 upright stones, each weighing approximately 25 tons, capped by a continuous ring of 30 lintel stones, each weighing about 7 tons. The stones were brought 30 km from the quarry. Transport and construction procedures are still a matter of conjecture.

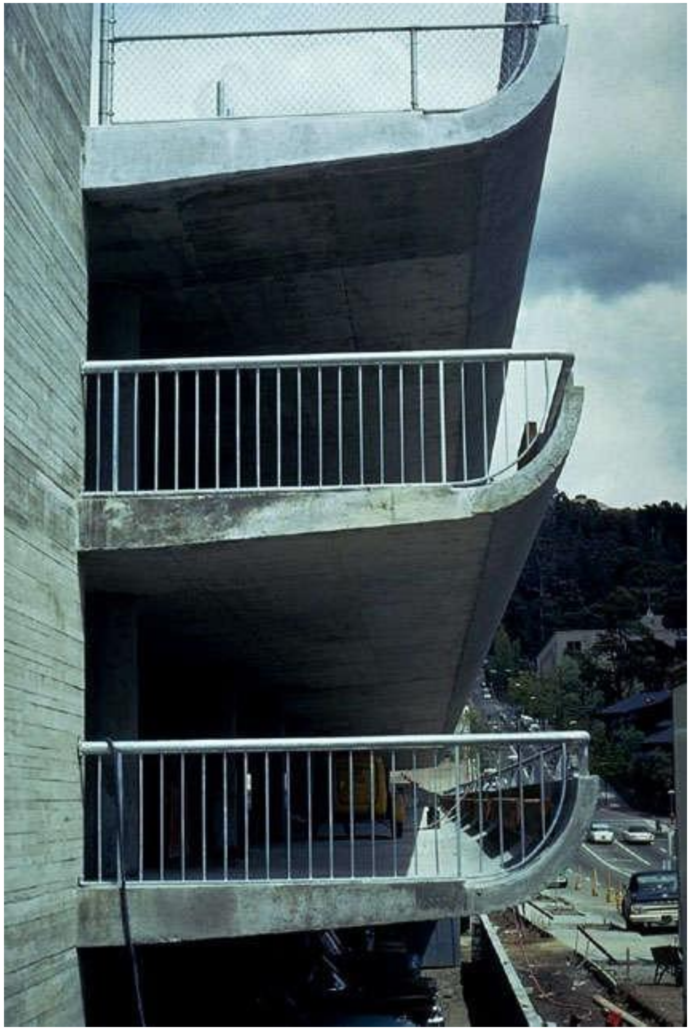
Temple of Olympian Zeus. Completed by the Roman Emperor Hadrian (AD 76-138) 700 years after the first columns were raised. Columns are 6 ft. 4 in. diameter, 56 ft. high, 18 ft. centers. Architrave beam span is obviously limited by the self-weight and tensile strength of the stone. (Athens, Greece)

Continuous Beam



14th Street Bridge over the Potomac River. Continuous riveted steel girders. Note the absence of internal hinges and the resulting internal self-straining forces in the girders if one of the supports should settle. (Washington, D.C.)

Cantilever Beam



U.C. parking structure 'A'. The variable depth cantilever slab supports its own weight, automobile loading, and also any impact due to an automobile hitting the timber wall guard. (University of California, Berkeley)

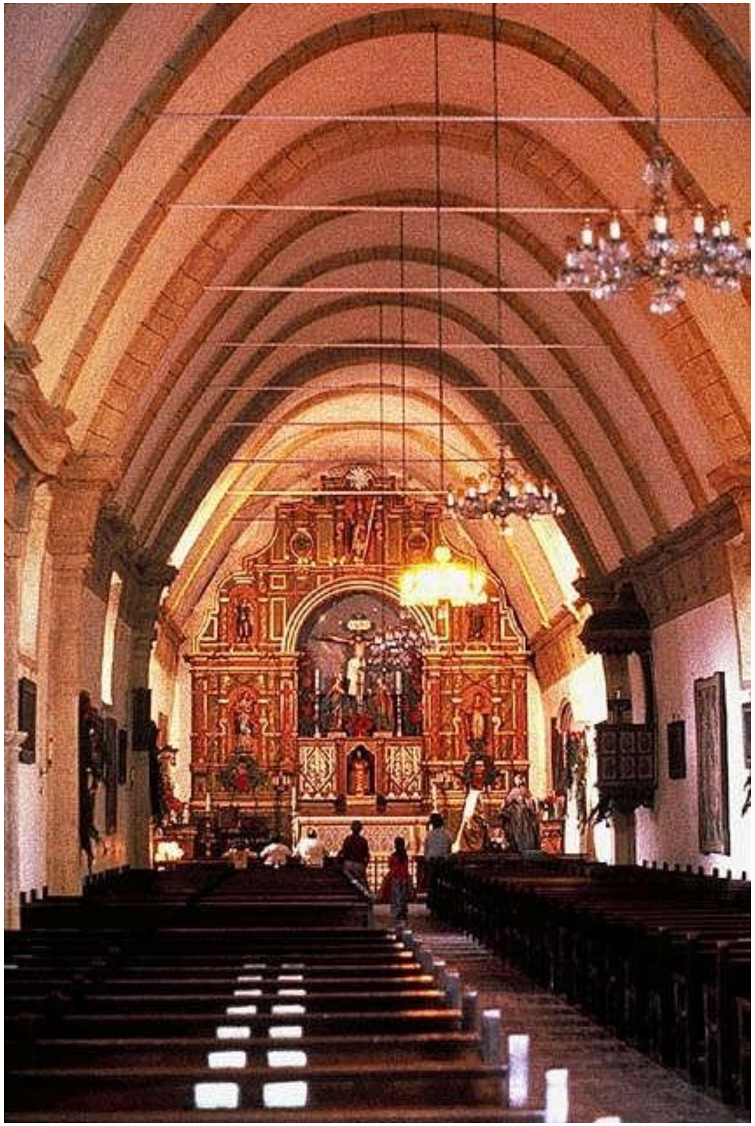
TRUSSES consist of slender elements which resist axial tensile or compressive forces.

Detail of pin-jointed truss connection, approach span to San Francisco-Oakland Bay Bridge. Pin joints are used in older bridges or situations where rotation has to be allowed for due to settlement, or for construction purposes. (San Francisco Bay Area)

Single-story building. In a strongly seismic area, buildings have to resist horizontal inertial forces caused by the horizontal components of earthquake ground motions. This building has simple X-bracing in both directions. (Larkspur, California)

Truss members as Bracing on Buildings

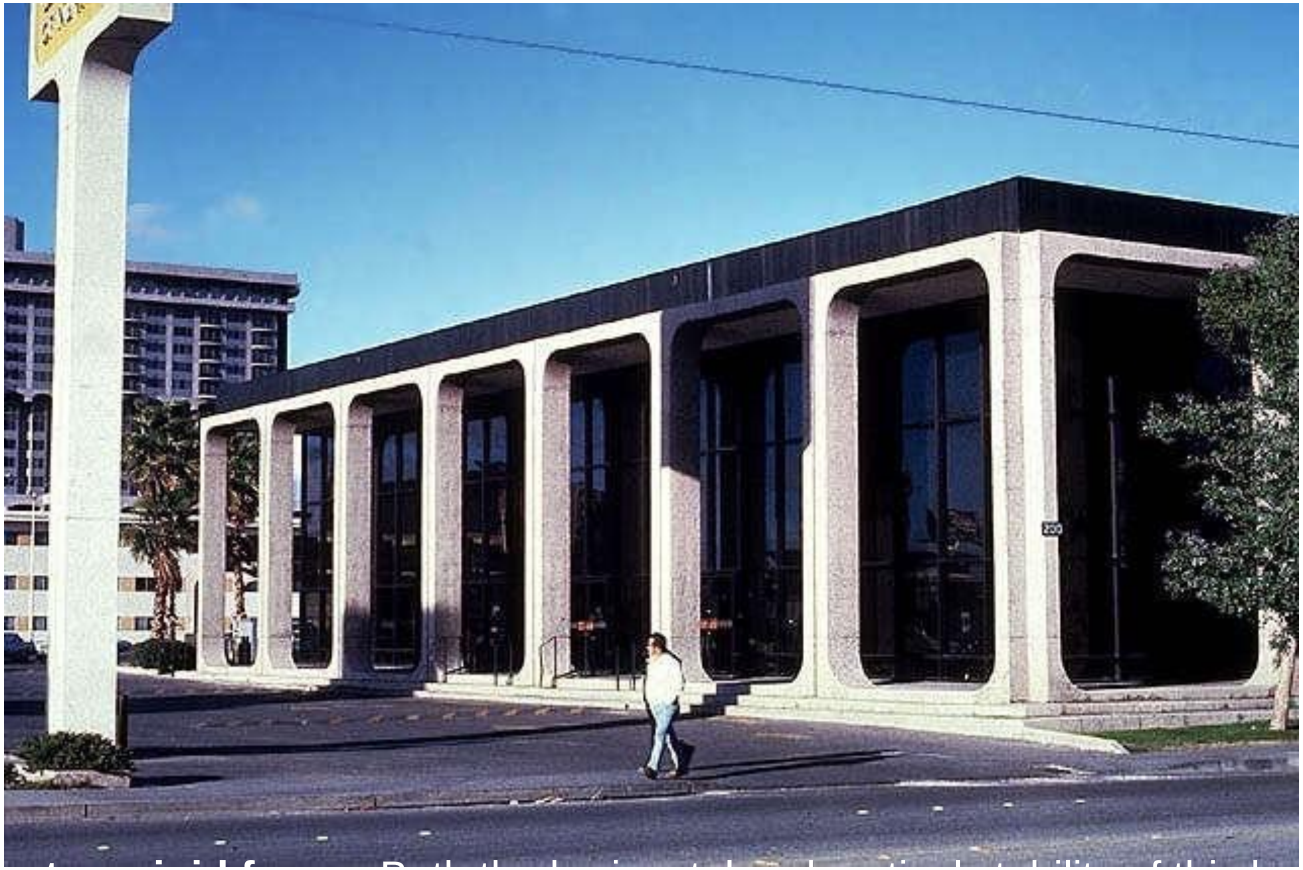
ARCHES support their loads in compression



Interior of Carmel Mission. Built in 1793 it is an interesting design in that the walls curve inward towards the top, and the roof consists of a series of inverted catenary arches built of native sandstone quarried from the nearby Santa Lucia Mountains. (Carmel, California)

CABLES support their loads in tension

FRAMES are often used in buildings and are composed of beams and columns that are either pin or fixed connected.



Multistory Building: First City National Bank Building, Houston, Texas. Concrete covered steel frame multi-story building. 3 bays x 9 bays in plan. (Houston, Texas)

Space Truss Frame

Expo 86, Vancouver, Canada. Plaza of the Nations. Triangulated truss canopy covering the stage area of the large open-air amphitheater. The part of the truss system to the right of the two support columns is cantilevered. The part to the left is supported on the back wall. (Vancouver, British Columbia)

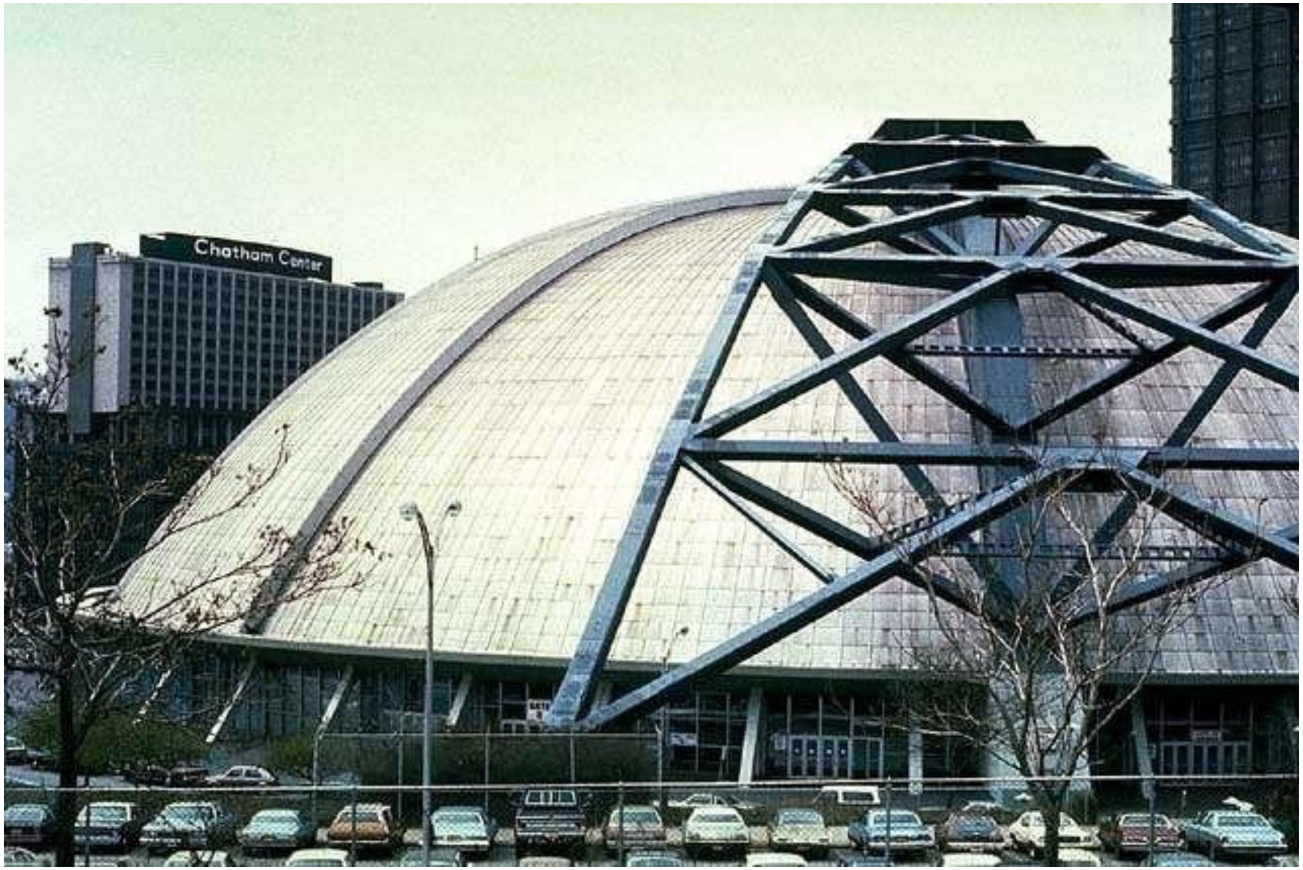
Plane Grid

Dallas Airport Terminal Building. The ceiling structure in this building is a modern example of a horizontal beam grid. The columns are at every other beam intersection point in both directions. (Dallas, Texas)

Cantilevered shell. The concrete edge beam tapers from minimum at the unsupported end to maximum at the support point. (San Francisco Bay Area)

SURFACE STRUCTURES, commonly referred to as thin plates or shells, are made from material having very small thickness compared to the other dimensions.

Public Auditorium. Designed to serve both as a convention hall and as an open-air amphitheater seating 13,600, the building has a retractable dome consisting of radial steel ribs sheathed in stainless steel. The dome has a diameter of 417 ft. and a rise of 109 ft. (Pittsburgh, Pennsylvania)



FIXED-PINNED COLUMNS: Dorothy Chandler Pavilion, Los Angeles Cultural Center. The outside of this building consists of a continuous reinforced concrete frame, the bottom of which can be seen in this slide, and consists of tapered columns pinned at the base. As the top of the column is built into a stiff horizontal beam, the columns are effectively fixed at the top and pinned at the base. (Los Angeles, California)

Support Connections

PIN or HINGED SUPPORT: Main River Bridge. Detail of the end bearing. This rolling expansion bearing consists of a hinge on top of a pedestal whose base rests on a series of rollers. This type of bearing is not uncommon where reactions are large. (Frankfurt, Germany)

LECTURE CONTENTS WITH A BLEND OF NPTEL CONTENTS

https://nptel.ac.in/courses/105/101/105101085/

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Thank you!