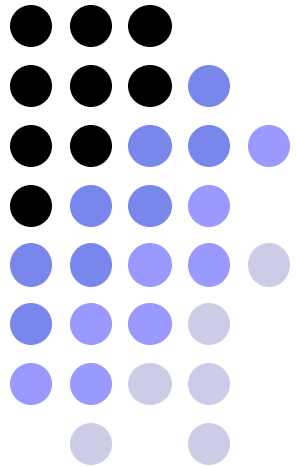
CONSTRUCTION METHODS AND MATERIALS

LECTURE 1



Roger J. Marino, PhD, PE

Welcome to the Course!

Purpose of the Course

- Although the course is titled “Construction Methods and Materials”, it is designed to give you an overview of the elements of construction, including:
- How is site suitability for development determined?
- How is a specific type of project selected for that site?
- How does one go about forecasting if a project will be profitable?
- What is the standard format used for building contracts?
- What types of building materials are commonly used in construction?
- What elements are typically included in construction drawings?

Guest Speakers

- Guest Lecturers will be utilized in the course to reinforce class material when possible.
- Each Guest Lecturer will have their own area of specialization.
- The Guest Lecture will conclude with a Question and Answer Session. In order to promote student interaction (and understanding of subject matter), students will be required to pre-submit at least three (3) questions for the Lecturer beforehand.
- Subsequent to the Guest Lecture, students will be required to submit a report/ reflection on that lecture.

Origin of Construction and Design (History – Before Engineers and Architects)

- Much has been written about the History of Construction.
- Essentially, due to crude hand tools and availability of materials, initial construction consisted of biologically-degradable materials such as wood branches and thatch
- Locally-resourced materials (such as stone, wood, adobe, brick) were later used following the advent of more sophisticated hand tools (with metals incorporated into the tools)

Origin of Construction and Design (History – Before Engineers and Architects)

- Initial understanding of material behavior was limited to the concepts of:

- "If you build it, and it does not fall down, build it like that the next time"

- "If it does fall down, make the structural members bigger the next time"

What are the Six Most Dangerous Words in the Construction Industry?

The Six Most Dangerous Words in the Construction Industry

"We've always done it that way"

Rear Admiral Grace Mary Hopper

The Six Most Dangerous Words in the Construction Industry

"We've always done it that way"

Be careful. This attitude may compromise safety on the jobsite. If you are on a construction site and something doesn't look right, feel free to question it. You may be protecting others.

Structural Member Design Consideration

In order to create a “competent design” of a structure, one must consider how the support members will behave under a load (how they will respond to the load).

Factors to be considered include:

- Deflection and bending stress (How far will the member bend and how much stress can it handle?)
- Shear (How much resistance will the member have in the horizontal and vertical directions?)
- Torsion (How much can it be twisted?

Much of this behavior is dependent upon the strength of the type of material used.

How is the Strength of Building Members Determined?

How is Strength of Building Members Determined?

Type of Materials

(Steel, Aluminum, Wood, Concrete, Composite)

How Do I Determine the Strength of Building Members?

Much testing has been done in laboratories to define material structural behavior. There are many references available.

We use these references as a starting point in design.

How is the Strength of Building Members Determined?

Size (Length, Diameter, Geometry/ Shape)

The Orientation of the member also affects its strength

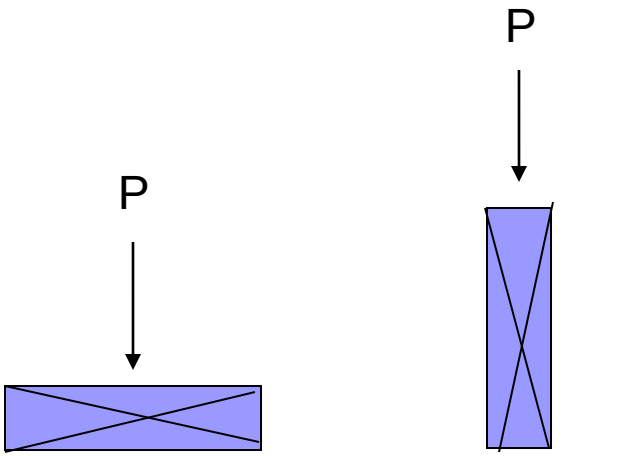


Figure A Figure B

If you want to confirm this, try laying a 2x10 board flat on top of two concrete block end supports (Figure A). Stand on the center of the board and feel it flex. Next, turn the board sideways (Figure B) and stand in the center. The board is much stiffer this way and does not flex as much. Same material, different strength.

Properties of Materials

If a material is strong in one property, and weak in another, you can add a different material to the member to address the weakness

Example - iron “rebar” (reinforcing bar) added to concrete to improve tensile strength

Iron Rebar Placement

Discussion: considerations when designing and placing rebar?

Combination of Materials

- Two or more metals combined is called an “alloy”

- Two or more combined materials is called a “composite” or “amalgam”

Material Composition Example Exercise: "Metal" or "Composite" Fillings in a Tooth

Let's consider Materials Engineering in the design of a filling that a dentist installs in your tooth.

The material has been engineered to address specific concerns.

What Properties Must These Materials Have In Order for The Filling to Behave the Same as the Surrounding Tooth?

What Properties Must These Materials Have In Order for The Filling to Behave the Same as the Surrounding Tooth?

- Thermal expansion
- Thermal contraction
- Compressive strength (Hardness)
- Corrosion resistance
- Durability
- For composite filling –
  matching coloring, and not changing color over time, thermal insulator
- Adhesion

Can you use a material's weak property to your advantage?

Can you use a material's weak property to your advantage?

Answer: Yes.

Examples of planned failure or weak point in the system

- Fuses
- Shear pin in gear
- "Control Joint" in concrete

Concrete “Control Joints” in-class discussion – Why and how are they used?

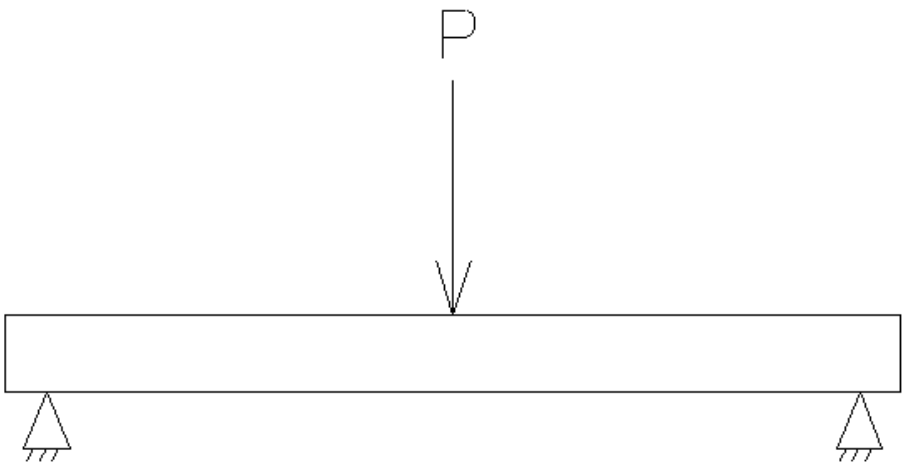
Two Types of Forces Considered in Structural Design

Compressive Forces

Tensile Forces

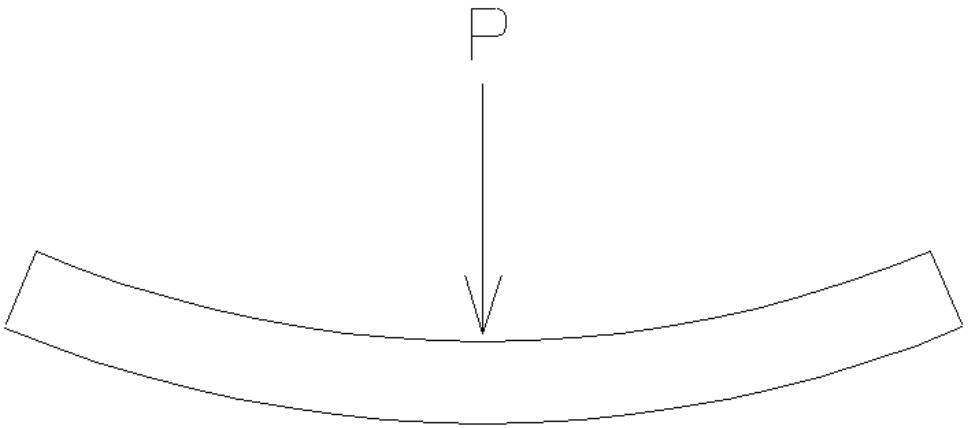
Considering a Beam's Flexural (Bending) Behavior

Apply a load, P



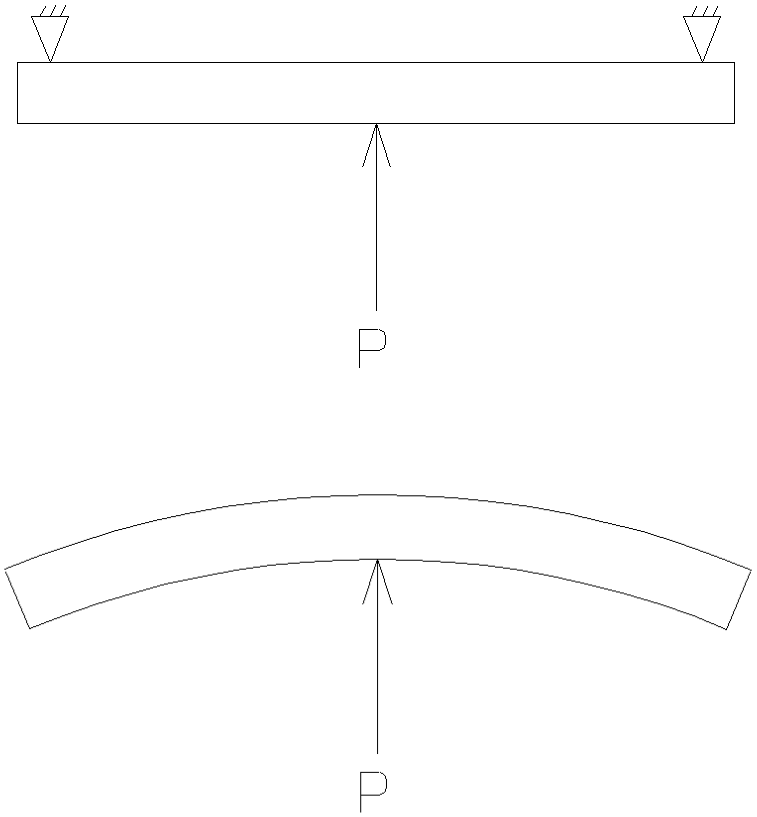
Considering a Beam's Flexural (Bending) Behavior

The beam deflects in the downward direction
(Positive Moment)



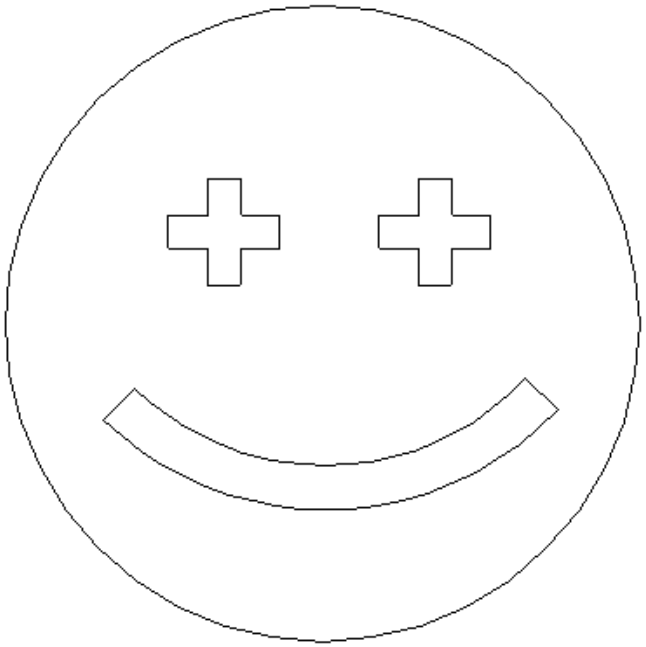
Considering a Beam's Behavior

Negative Moment

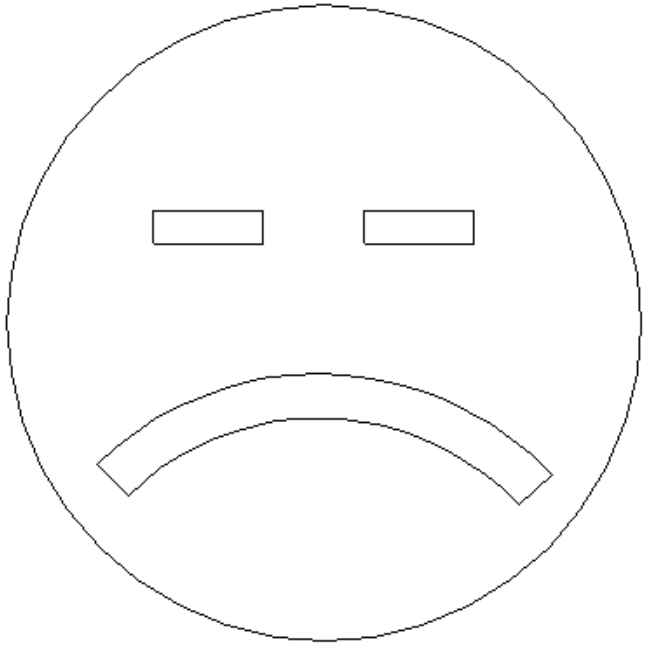


Considering a Beam's Flexural (Bending) Behavior

(corny, but useful mnemonic)



Positive Moment



Negative Moment

We Design So the Sum of All Forces Acting on the Structure Equals Zero

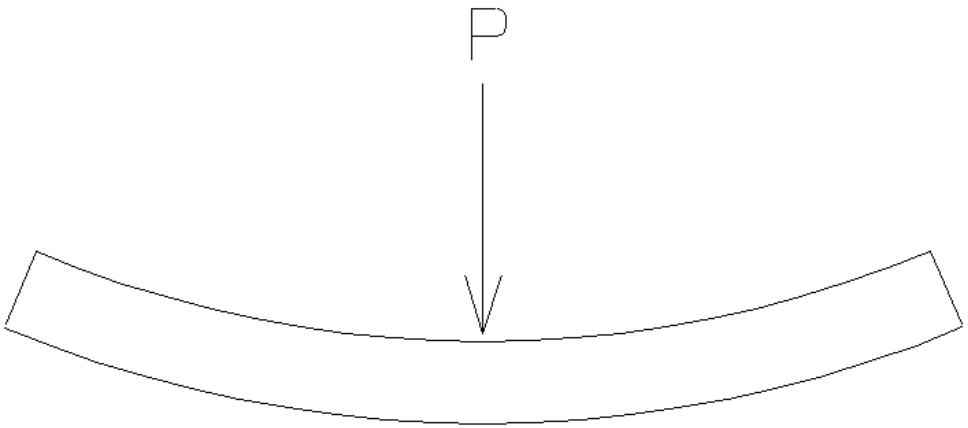
(so the structure is in static equilibrium and does not move)

Objects are considered to be in “Static Equilibrium” when:

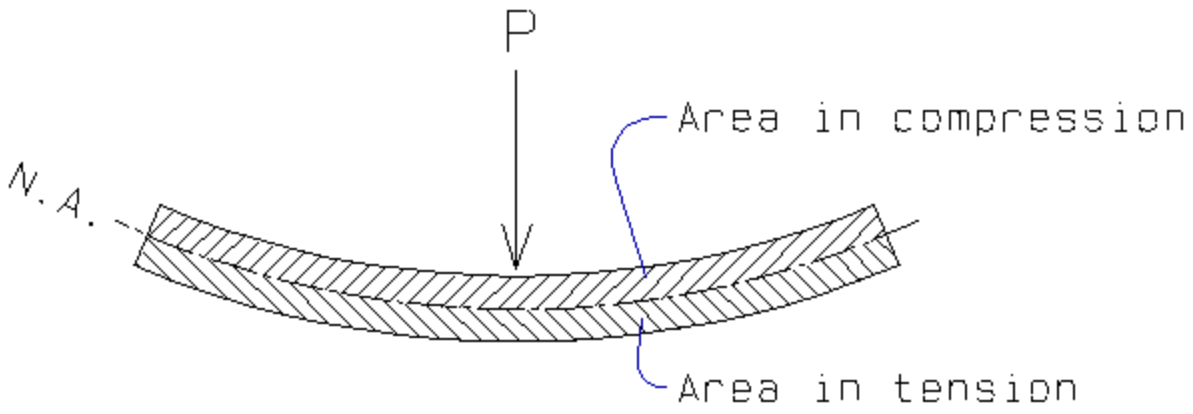
All forces acting on the object are in balance, and therefore the object does not “translate” (move in a linear direction) or “rotate” (turn around a fixed point)

Example - Concrete Beam Behavior

(Good in compression, weak in tension)



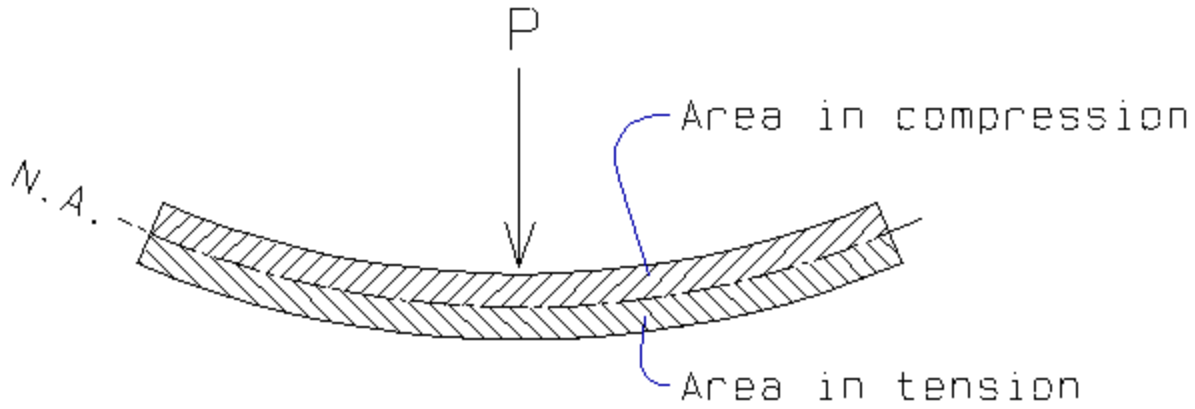
Example - Concrete Beam Behavior (Cont.)



(N.A. = Neutral Axis which is defined as the location where the beam is neither in compression nor in tension)

Considering this, where would you install the rebar?

Example - Concrete Beam Behavior (Cont.)



(N.A. = Neutral Axis which is defined as the location where the beam is neither in compression nor in tension)

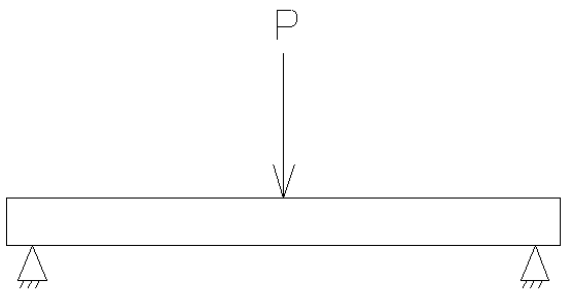
Considering this, where would you install the rebar?

Answer: Within the “Area in Tension”. Preferably as close to the bottom of the beam as possible (while complying with code location requirements for the distance of the rebar from the outside edge of the beam)

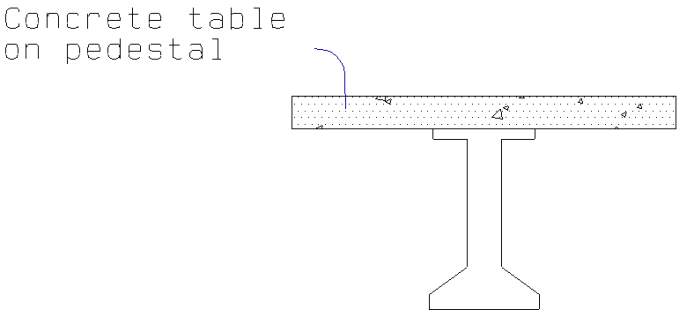
Exercise

Determine where you would put additional rebar for each condition in order to increase the tensile property of the member.

(Hint: Think about which way the member is bending)



Simply Supported Beam with a point load

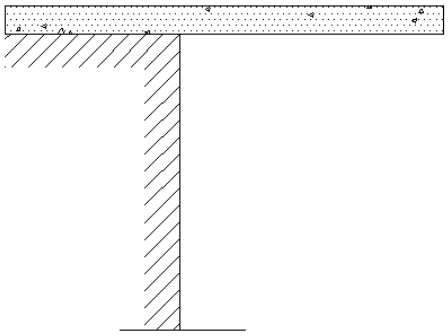


Concrete table

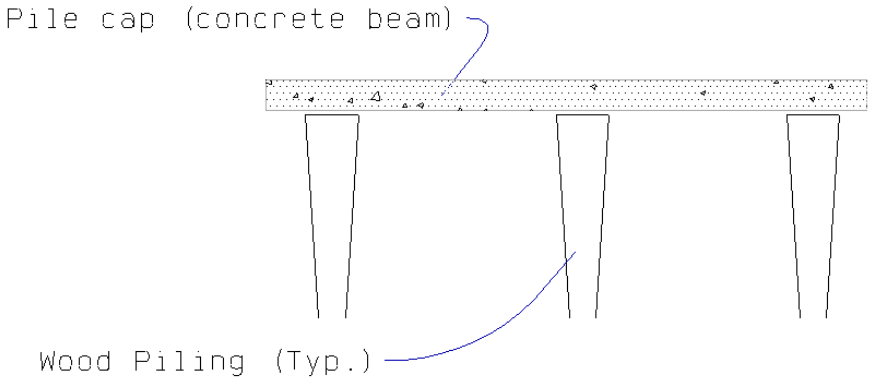
Exercise (con't.)

Determine where you would put additional rebar for each condition in order to increase the tensile property of the member.

(Hint: Think about which way the member is bending)



Building with cantilevered concrete roof (overhang).



Pile cap footing for residence.

Residential Structures are:

Overdesigned for strength

Controlled by deflection (comfort)

Commercial Structures are also designed for comfort

Commercial Structures are also designed for comfort

Ex. The World Trade Center was limited to a 6’ sway at the top so office inhabitants felt safe and would not experience motion sickness

Intro to “Master Format”

- Master Format is a construction industry standard that breaks down the elements of the project into: .

- Contract requirements

- Contract specifications

Facets of the project are divided into separate Divisions (ex. concrete, fire suppression, plumbing, electrical) and then into further subdivisions of each.

Class discussion:

Why do we need Standardization? How does standardization benefit the construction industry?