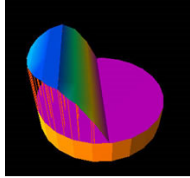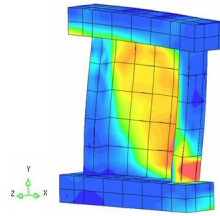## Reinforced Concrete Beams

Mathematical modeling of reinforced concrete is essential to civil engineering.



Concrete as a material

Concrete in a structure

## Reinforced Concrete Beams

Mathematical modeling of reinforced concrete is essential to civil engineering.



Stress distribution in a reinforced concrete beam

## Reinforced Concrete Beams

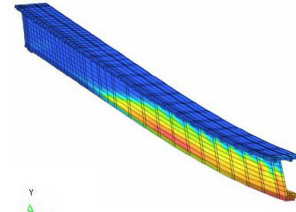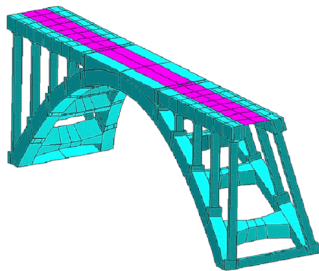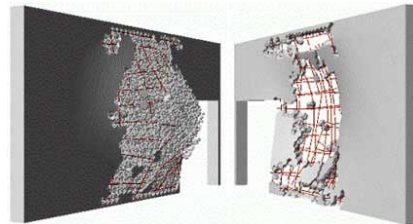Mathematical modeling of reinforced concrete is essential to civil engineering.



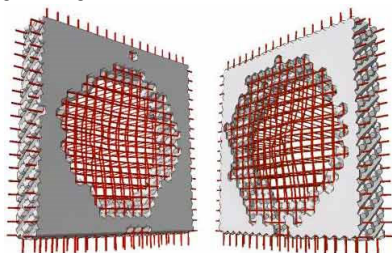Geometric model a reinforced concrete bridge

## Reinforced Concrete Beams

Mathematical modeling of reinforced concrete is essential to civil engineering.



Blast failure of a reinforced concrete wall

## Reinforced Concrete Beams

Mathematical modeling of reinforced concrete is essential to civil engineering.



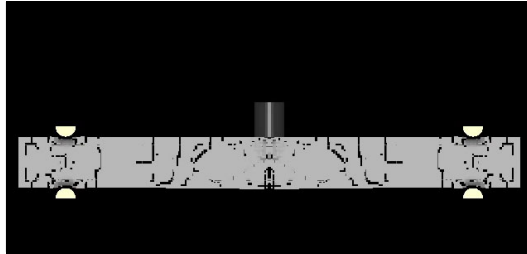Blast failure of a reinforced concrete wall

## Reinforced Concrete Beams

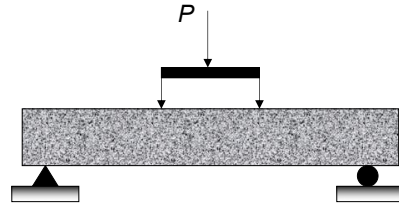Mathematical model for failure in an unreinforced concrete beam.

## Reinforced Concrete Beams

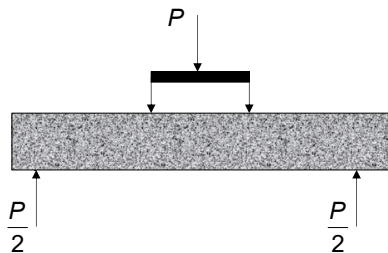Mathematical model for failure in a reinforced concrete beam



## Reinforced Concrete Beams

In the reinforced concrete beam project, there are three different failure modes we need to investigate
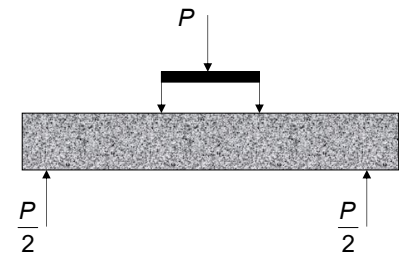


## Reinforced Concrete Beams

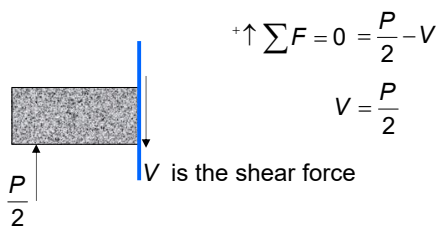First, let's consider the loading of the beam.



## Reinforced Concrete Beams

The purpose of RC is to reinforce areas in concrete that are weak in tension.



## Reinforced Concrete Beams

Let's look at the internal forces acting on the beam and locate the tension zones.

$$^{+}\uparrow \sum F = 0 = \frac{P}{2} - V$$

$$V = \frac{P}{2}$$

$V$ is the shear force

## Reinforced Concrete Beams

The shear between the applied load and the support is constant $V = P/2$.

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## Reinforced Concrete Beams

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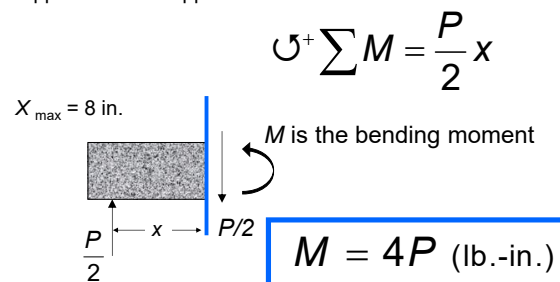$\frac{P}{2}$    P/2
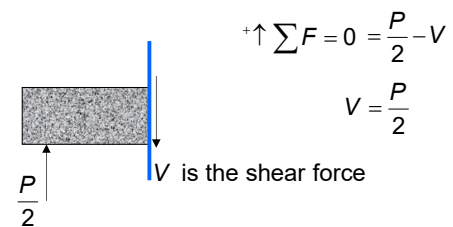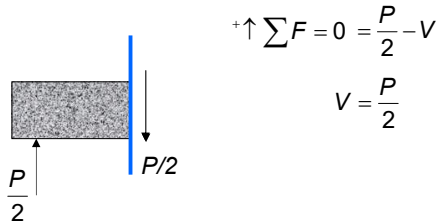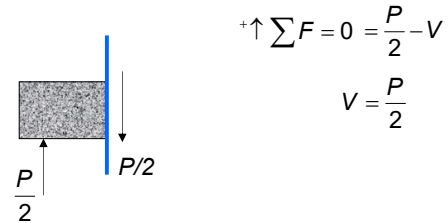
## Reinforced Concrete Beams

The shear between the applied load and the support is constant $V = P/2$.

The shear force $V = P/2$ is constant between the applied load and the support.
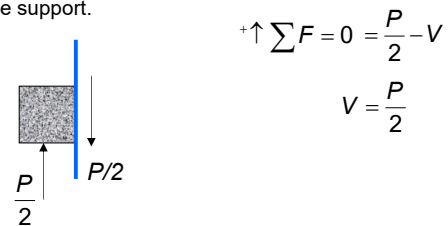
$$^+\uparrow\sum F = 0 = \frac{P}{2} - V$$

$$V = \frac{P}{2}$$

$\frac{P}{2}$    P/2

## Reinforced Concrete Beams

Let's look at the internal moment at the section between the supports and the applied load

$$\circlearrowleft^+\sum M = \frac{P}{2}x$$

$X_{max} = 8$ in.

$M$ is the bending moment

$\frac{P}{2}$ — $x$ — P/2

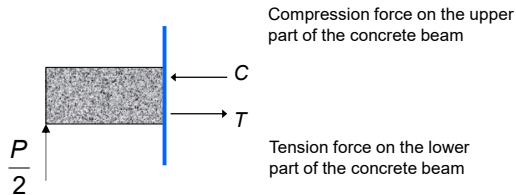$$\boxed{M = 4P \text{ (lb.-in.)}}$$

## Reinforced Concrete Beams

➤ Let's look at the internal moment at the section between the supports and applied load

➤ The bending moment is the internal reaction to forces that cause a beam to bend.

➤ Bending moment can also be referred to as torque
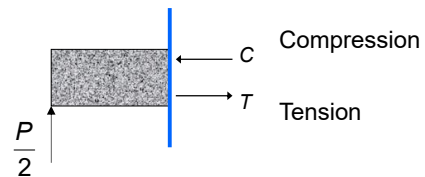
## Reinforced Concrete Beams

The top of the beam is in compression, and the bottom of the beam is in tension.

Compression force on the upper part of the concrete beam

$C$

$T$

$\dfrac{P}{2}$

Tension force on the lower part of the concrete beam
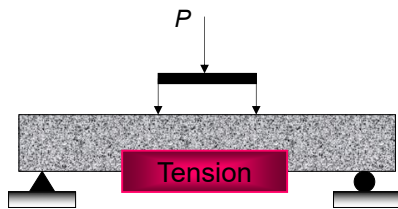
## Reinforced Concrete Beams

To model the behavior of a reinforced concrete beam, we will need to understand three distinct regions in the beam.

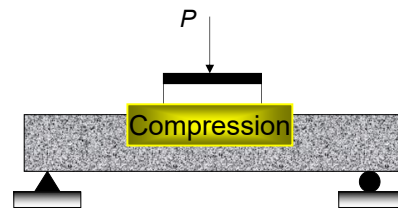Two are illustrated below; the third is called shear.

$C$    Compression
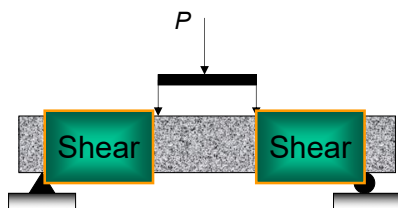
$T$    Tension

$\dfrac{P}{2}$

## Reinforced Concrete Beams

We need models to help us with compression, tension, and shear failures in concrete.

$P$

Tension

## Reinforced Concrete Beams

We need models to help us with compression, tension, and shear failures in concrete.

$P$

Compression

## Reinforced Concrete Beams

We need models to help us with compression, tension, and shear failures in concrete.

$P$

Shear          Shear

## Reinforced Concrete Beams

We need models to help us with compression, tension, and shear failures in concrete.

$P$

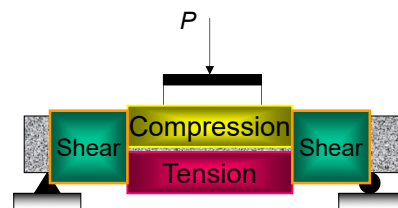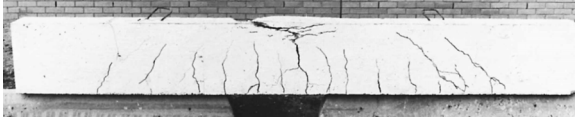Shear   Compression   Shear
Tension

## Reinforced Concrete Beams

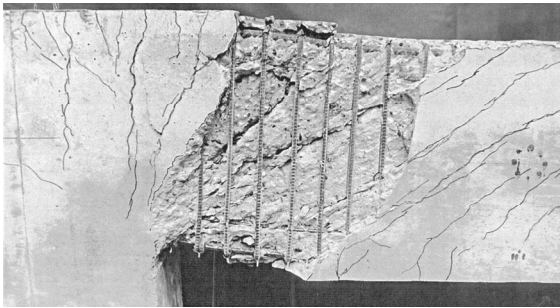Compression and tension failures in a reinforced concrete beam



## Reinforced Concrete Beams

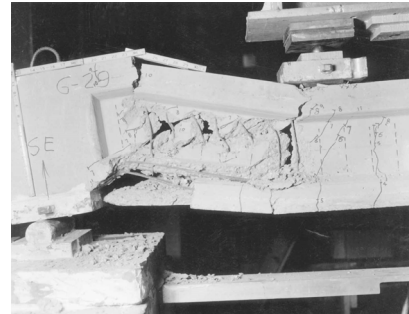Compression and tension failures in a reinforced concrete beam



## Reinforced Concrete Beams

Shear failure in a reinforced concrete beam



## Reinforced Concrete Beams

Shear failure in a reinforced concrete beam



## Reinforced Concrete Beams

Questions?