

Slabs

- Statical Conditions
- Geometrical Conditions
- Constitutive Equations
- Yield Zones
- Upper Bound Solutions
- Lower Bound Solutions

Upper bound Solutions

- Assume yield lines
- Work equations
- Minimize the upper bound solutions

Axes of rotations
Lines of plastic hinges
Fan mechanisms
Corner levers

Lower Bound Solutions

$$\frac{\partial^2 m_x}{\partial x^2} - 2 \frac{\partial^2 m_{xy}}{\partial x \partial y} + \frac{\partial^2 m_y}{\partial y^2} = -p$$

$$m_x = a + bx + cx^2$$

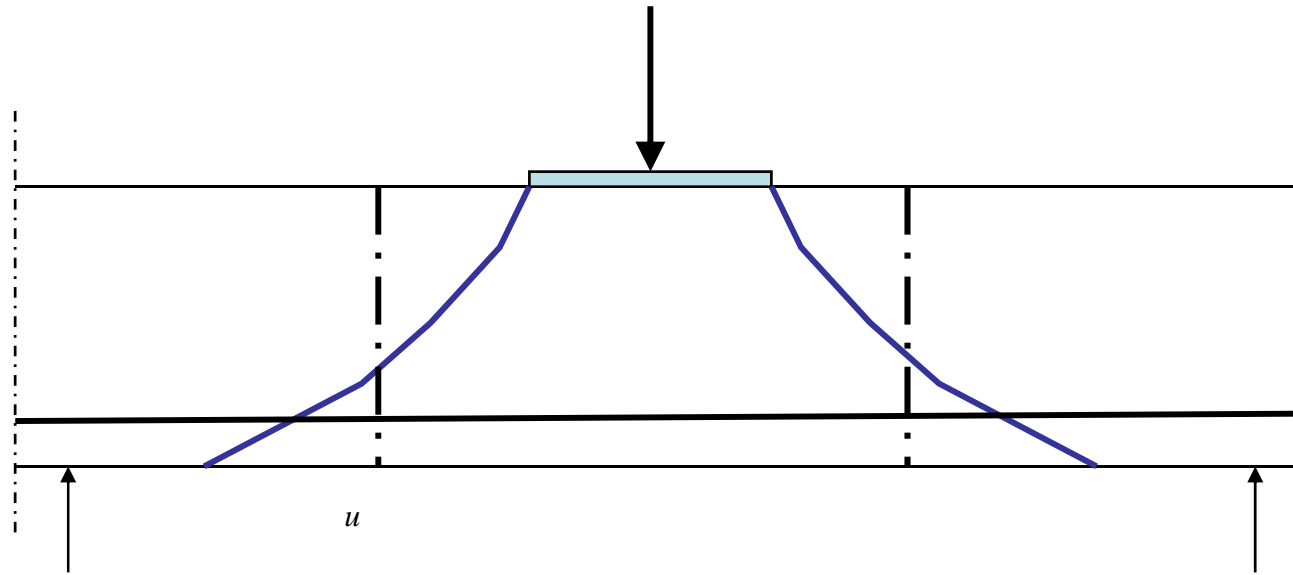
$$m_y = d + ey + fy^2$$

$$m_{xy} = g + hx + my + ixy$$

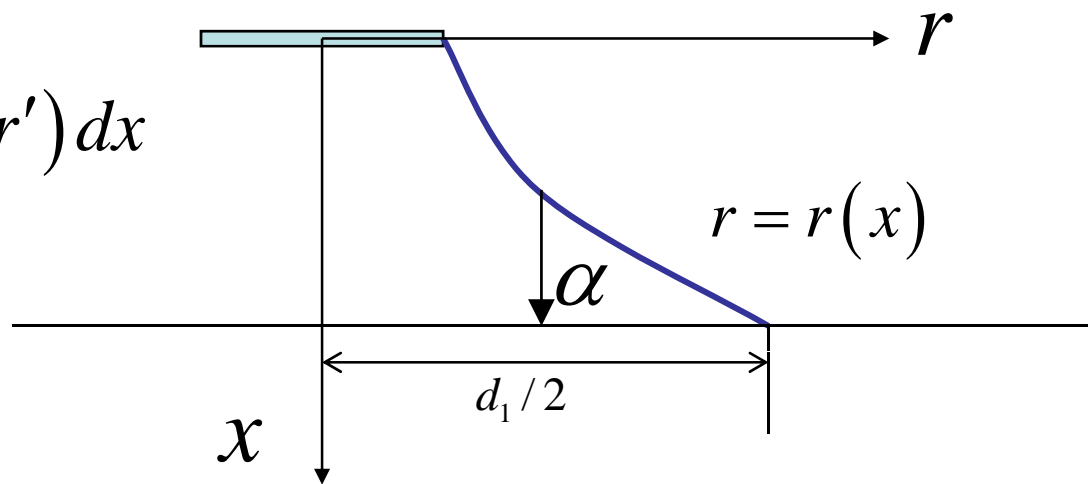
Punching Shear

- Upper Bound Solutions
- Practical Applications
- Eccentric Loading
- Effect of Counter-pressure
- Edge and Corner Loads

Upper Bound Solution



$$P = \pi f_c \int_0^h F(r, r') dx$$



Use of Euler Equation

- Minimization of functional

$$P = \pi f_c \int_0^h F(r, r') dx$$

- Complete solution

$$r = a \cosh \frac{x}{c} + b \sinh \frac{x}{c}$$

