Yield Line Theory

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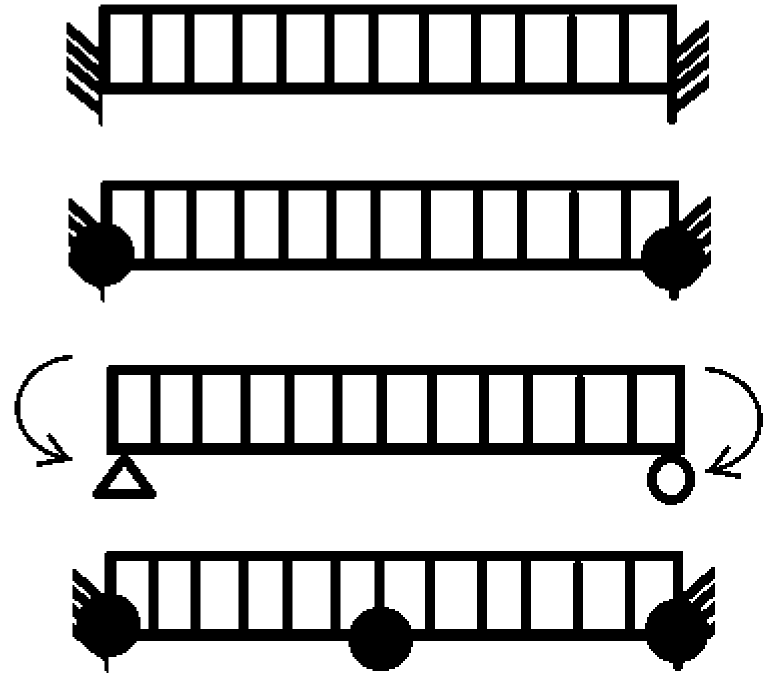
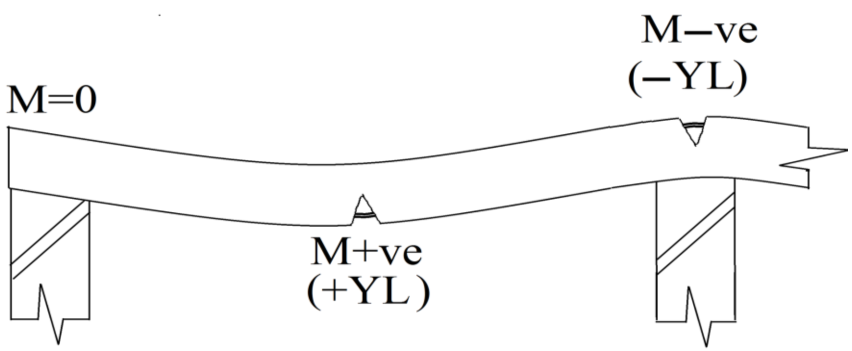
For a **statically indeterminate** structure (beam, slab, or a frame), failure will not occur when the **ultimate moment capacity at just one critical section** is reached (Elastic Analysis). It fails (mechanism) when **more critical sections** appear (plastic Analysis).

Methods of Analysis in Yield Line Theory

1.Method of Segmental Equilibrium

2.Method of Virtual Work





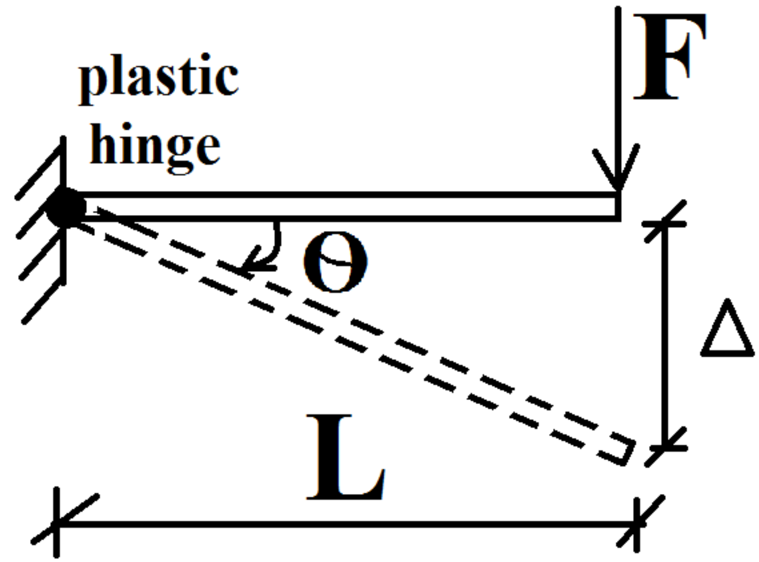
It is **upper bound approach- kinematics method**, **limit design approach**. Limit analysis is applicable to RC slabs because rc slabs have small ρ, which means the section is ductile. Yield line theory takes into consideration the **flexural strength** only, i.e., **shear and torsion** are not included here. In yield theory, only **plastic deformations** are taken into consideration. The **elastic deformations** are neglected. It is applicable for uniform thickness and homogeneous slabs…

Isotropically reinforced slabs are reinforced identically in orthogonal directions, i.e., orthogonal moments are equal. Opposite is **orthotropically reinforced**, i.e., orthogonally anisotropic.

At the collapse stage, the steel reinforcement will be fully yielded along the yield lines.

Virtual Work concept

External work=Internal work



$$We = \sum F.\Delta \qquad \&$$

$$Wi = \sum M.\theta$$

We=Wi

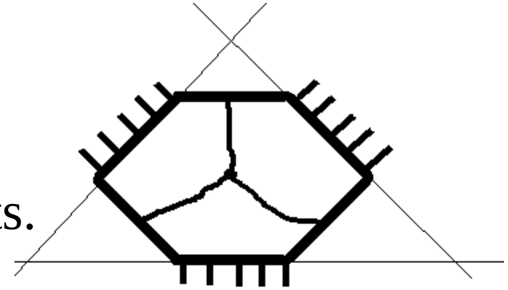
$$\sum F.\Delta = \sum M.\theta$$

$$F.\Delta = M.\frac{\Delta}{L} \qquad \therefore M = F.L$$

General notes about yield lines

1-Yield lines are generally straight.

2-Axes of rotations lie –generally – along lines of supports.



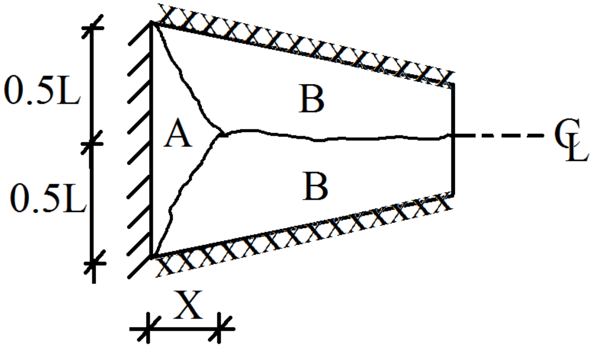
3-Generally, axes of rotations pass over any column.

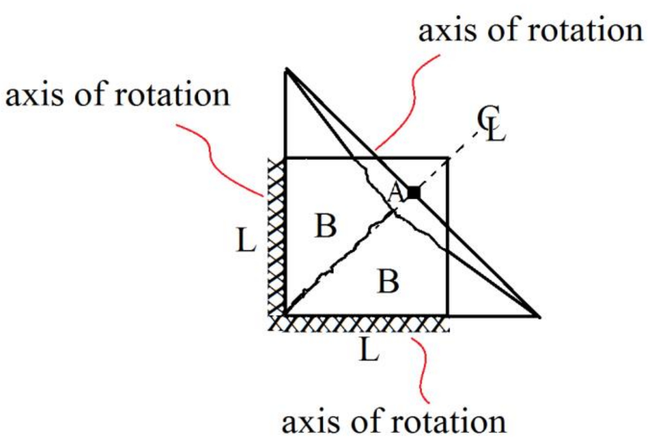
4-Yield lines pass through the intersection of the axes of rotation of the adjacent slab segments.

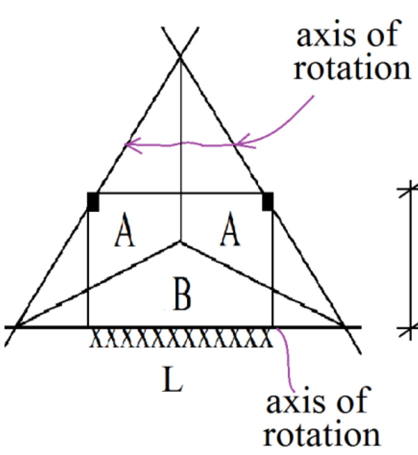
5-Yield lines pass through the intersection of adjacent slab segments.

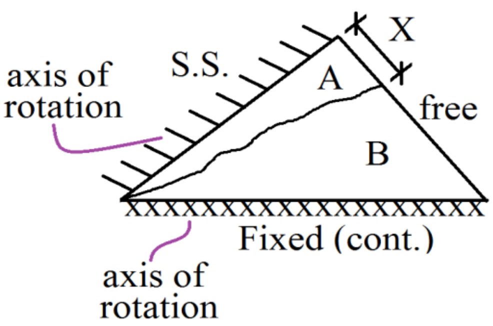
6- Any symmetry is reflected on the yield lines.

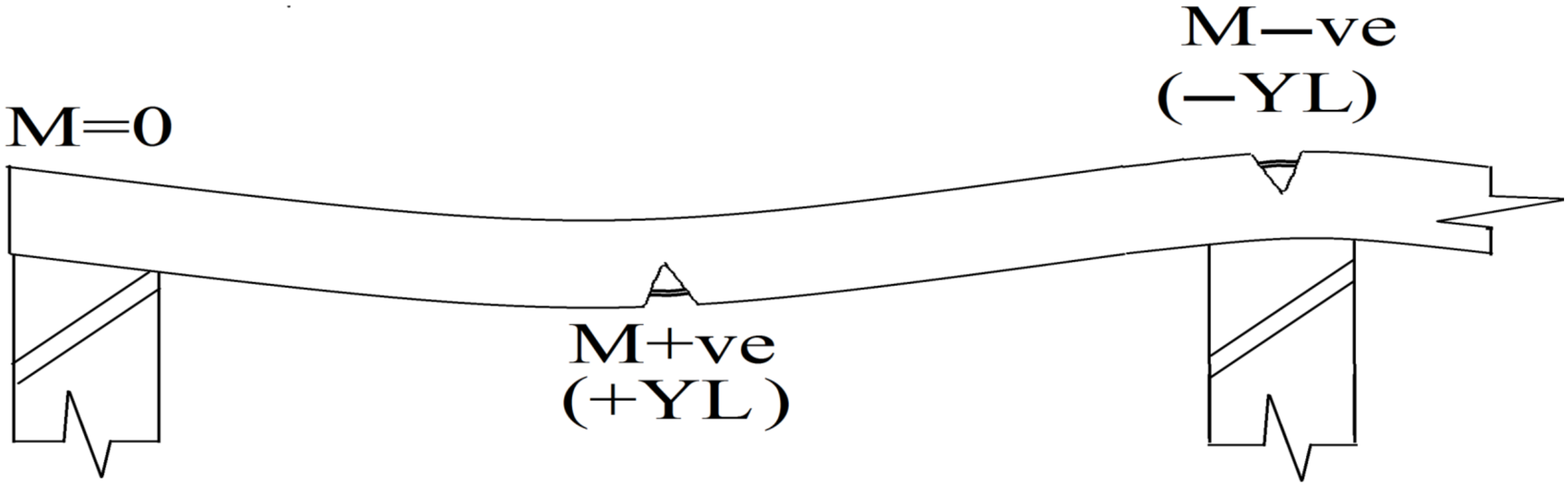
7-At yield line, reinforcing bars reach yield.

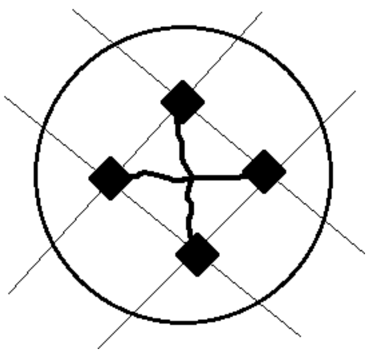


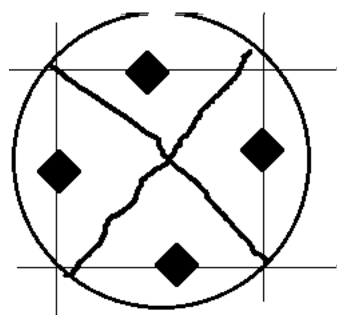


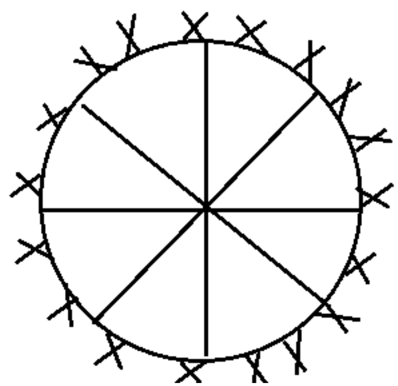


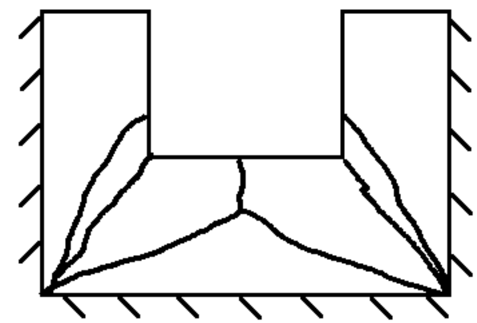


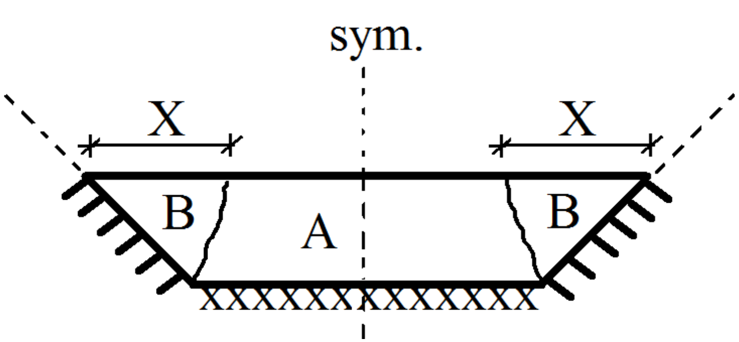


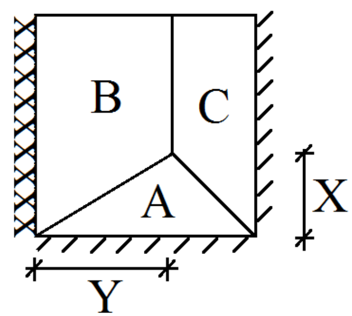


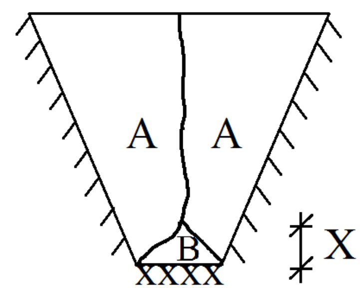












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$$We = \sum A.\Delta.w$$

$$Wi = \sum((M_{-ve} * L_1 * \theta) + (M_{+ve} * L_2 * \theta))$$

A=area of one divided slab segment

Δ=central def. of the load resultant for the divided slab segment ($\frac{1}{2}$for rectangular segments and $\frac{1}{3}$ for triangle segments, ..etc.)

w= distributed load

M-ve= negative moment at the fixed (continuous) support

L_1=actual length of the negative moment support

θ= rotation of the segment, i.e., $\theta = \frac{\Delta_1}{a}$

Δ1=max deflection of the normal line to the support

a= the length of the normal line to the support

L_2= the projection of the +YL