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Rathkjen, Arne

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CONCENTRATED LOAD ON REINFORCED CONCRETE BEAM

A. Rathkjen
Department of Building Technology and Structural Engineering
Aalborg University

According to Danish Standard DS 411 the load carrying capacity of a reinforced concrete beam is determined using the extremum principles of the theory of plasticity. The model used is shown in figure 1.

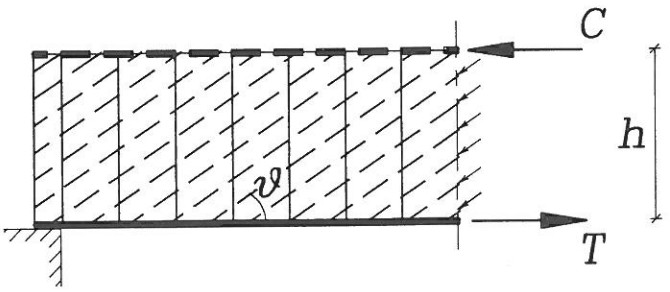

Figure 1

It is a kind of truss model that consists of two horizontal stringers and a zone between the two stringers in which the concrete is in uniaxial compression and the stirrups are in uniaxial tension.

In the concrete the stress components are

$$\sigma^c_{xx} = -\sigma^c \cos^2 \vartheta$$
$$\sigma^c_{yy} = -\sigma^c \sin^2 \vartheta$$
$$\sigma^c_{xy} = -\sigma^c \sin \vartheta \cos \vartheta$$

where σ^c is the uniaxial compressive stress, and ϑ is the angle between a horizontal x-axis and the direction of compression. In the vertical stirrups the stress is σ^s and the components are

$$\sigma^s_{xx} = 0$$
$$\sigma^s_{yy} = \sigma^s$$
$$\sigma^s_{xy} = 0$$

The total stress thus becomes

$$\sigma_{xx} = -\sigma^c \cos^2 \vartheta$$

$$\sigma_{yy} = -\sigma^c \sin^2 \vartheta + \varphi\sigma^s$$

$$\sigma_{xy} = -\sigma^c \sin\vartheta \cos\vartheta$$

where φ is the reinforcement ratio for the stirrups.

Using these assumptions one finds that the stresses σ^c and σ^s are determined from

$$\sigma^c bh \sin\vartheta \cos\nu = Q$$

$$\varphi\sigma^s bh \cot\vartheta = Q$$

where b is the width of the beam, h is the distance between the two horizontal stringers and Q is the shear force.

With these stresses, the stringerforces T and C in the horizontal stringers are found

$$T = M/h + \frac{1}{2}Q\cot\nu$$

$$C = M/h - \frac{1}{2}Q\cot\nu$$

where M is the moment. The variation of T and C is shown in figure 2. For more details see [1].

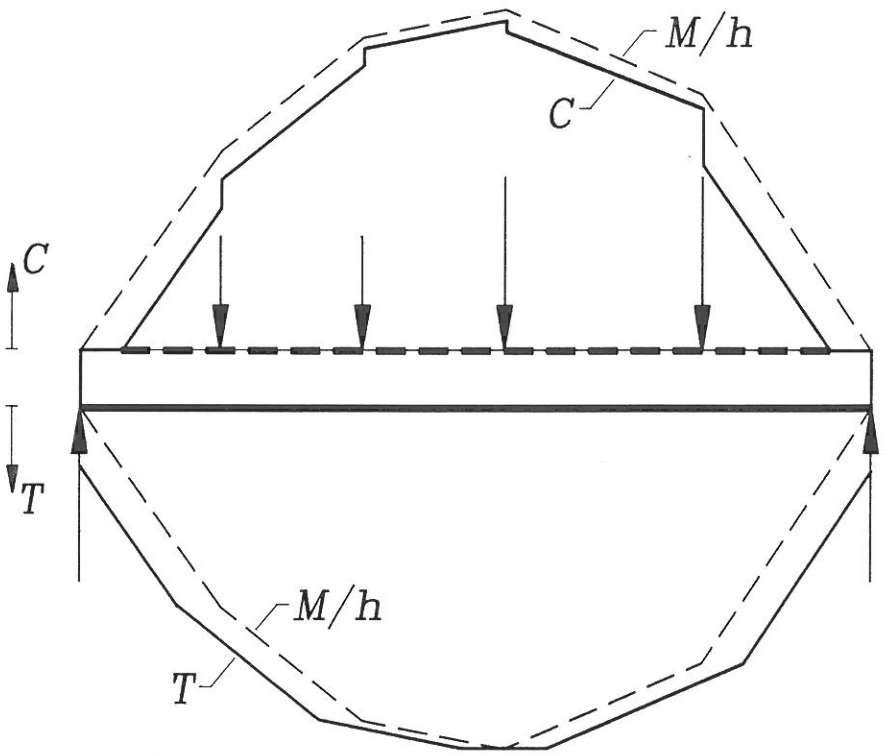

Figure 2

In a beam loaded with concentrated loads, the shear force is constant between any two loads and also the stresses σ^c and σ^s are constant. One question in this connection is: How do the stresses σ^c and σ^s change from values corresponding to one value of the shear force $Q = Q_1$ to another $Q = Q_2 = Q_1 - P$.

An answer to that question is found in assuming the existence of an inclined stringer under the concentrated load as shown in figure 3. The force in this stringer varies

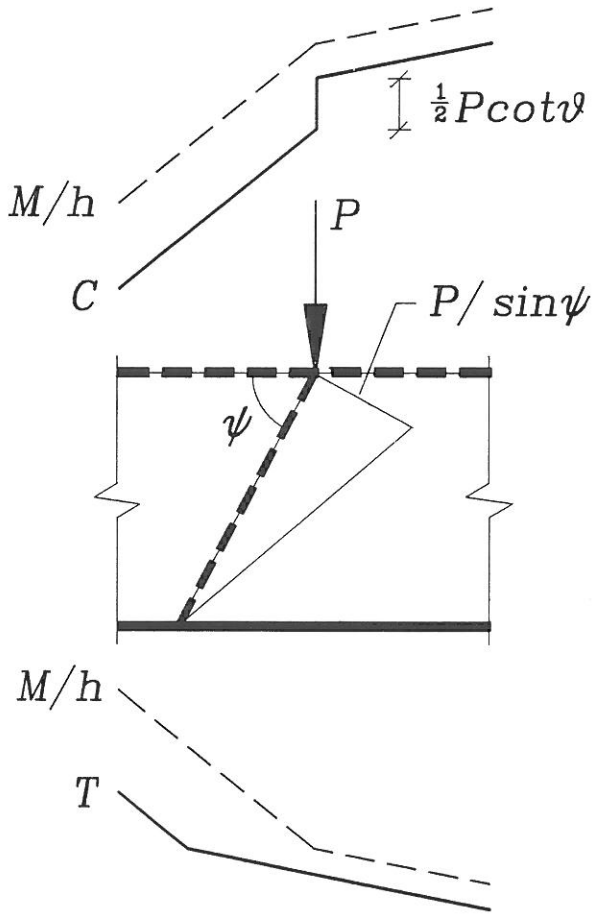

Figure 3

linearly from $P/\sin\psi$ to 0, where the inclination ψ is determined from

$$\cot\psi = \frac{1}{2}\cot\vartheta$$

The complete stringer system for a simply supported beam is shown in figure 4.

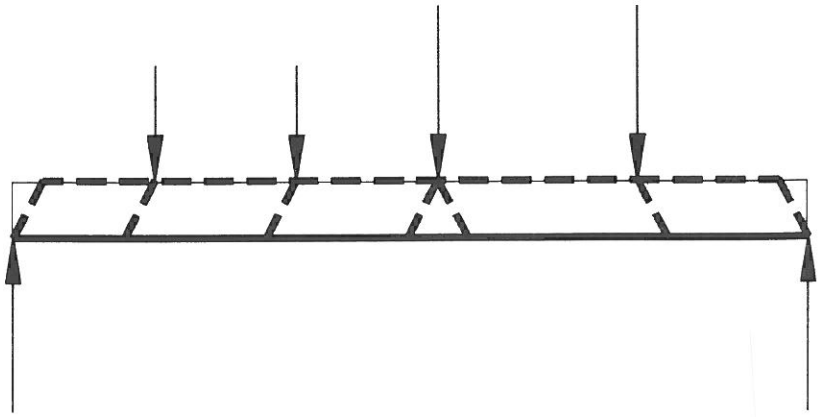

Figure 4

[1] Nielsen, M.P.: Limit Analysis and Concrete Plasticity, Englewood Cliffs, Prentice-Hall, Inc. 1984.