

Shear lag

ref: Hughes 3.8

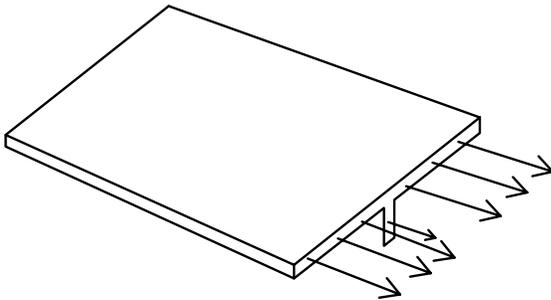
we have assumed "plane sections remain plane" during our bending analysis

? how valid is this assumption

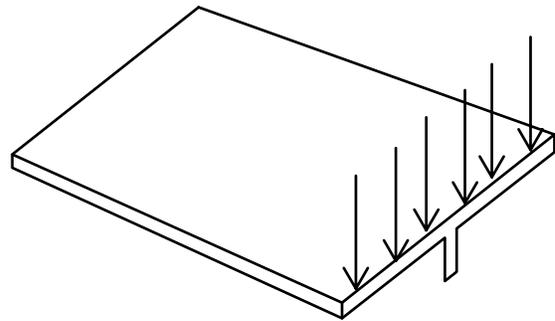
? are there situations where this is not the case

consider a wide flange "T" beam in bending due to two load scenarios

load is axial stress distributed proportional to distance from an (neutral) axis



load imposed by vertical shear force



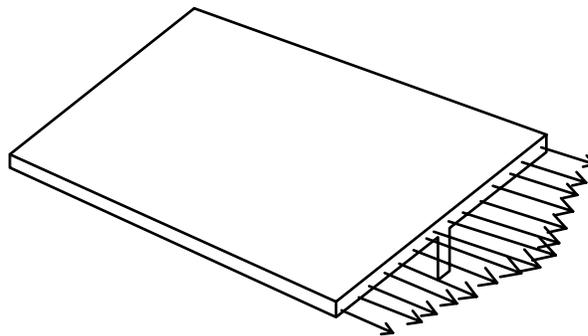
in the second case the axial stress is transmitted to the outer fibers of the flange by shear if the stress were transmitted without deformation (strain) there would be no difference but that is not the case. There will be less stress at the ends of the flange and more at the web.

The relationships used to this point can be considered an average stress (equilibrium still holds) and the stress at the web will be higher than this average.

that is

$$\sigma_x = \frac{-M_z y}{I}$$

is (the correct) average stress from bending even though it has a distribution below



Suppose we want our analysis to determine this maximum stress:

to account for "shear lag" let us model the flange width as having an "effective breadth" b_e that retains the property of calculating this max stress

we can define this "effective breadth" as the plate width "which, when used in calculating the moment of inertia of the section, will give the correct maximum stress σ_{\max} at the junction of web and flange, using simple beam theory". ref: Hughes pg 122

that is: we use a breadth b_e ($< b$) than results in a higher stress in the flange σ_{\max}

from equilibrium: (assuming plate flange of constant thickness t)

$$b_e \cdot \sigma_{\max} \cdot t = t \int_0^b \sigma_x dz \quad \text{or} \quad b_e \cdot \sigma_{\max} = \int_0^b \sigma_x dz$$

and

$$b_e = \frac{\int_0^b \sigma_x dz}{\sigma_{\max}}$$

see figure 3.36 in text derived from Schade "The Effective Breadth Concept in Ship Structure Design": *trans. SNAME* 61

two points to note:

the most important parameter determining effective breadth is L_0 the distance between zero bending moments

for short beams ($L_0 \sim b$) subject to uniform load $b_e \sim L_0/3$