PRIMARY STRESS ALLOCATION, LOADS AND DESIGN APPROACH

Loads

Primary – hull girder stresses

$$\sigma = \frac{M_y}{I}$$

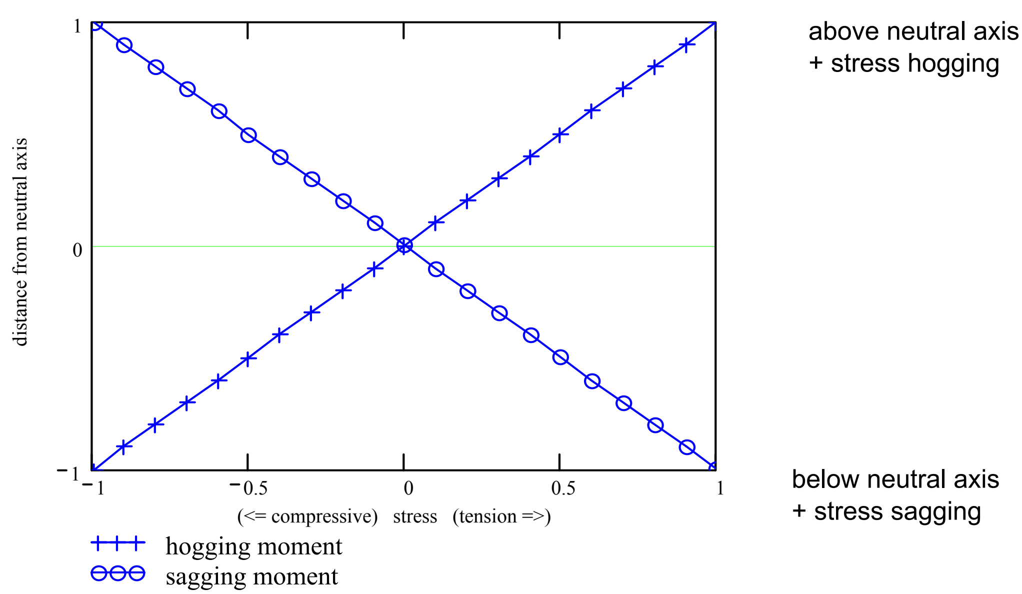
Secondary/Tertiary

Other

Primary – Hull Girder

Hogging/Sagging

σ_{DSM} σ_{DHM}



Treat "corners" of the plot i.e.

σ at deck (D), hogging(H), maximum(M); σ_{DHM}

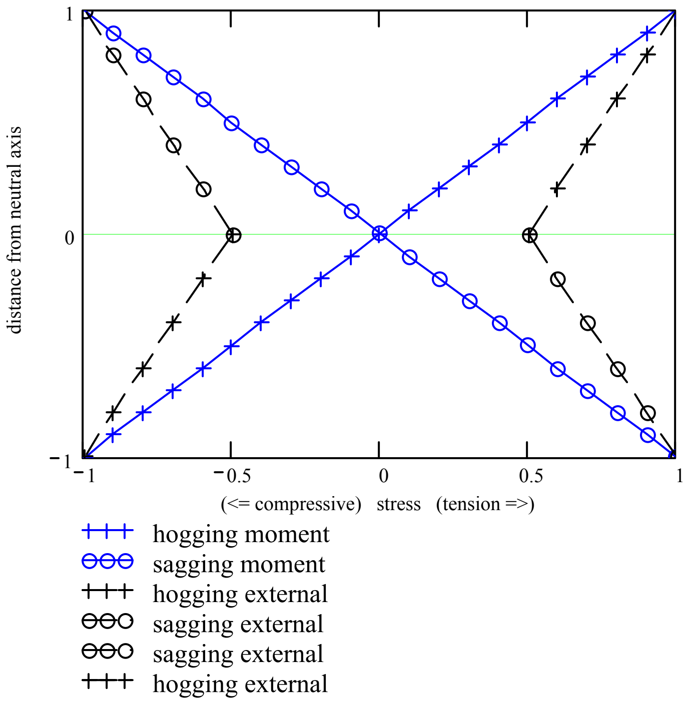
σ at deck (D), sagging(S), maximum(M); σ_{DSM}

and at keel (K); σ_{KHM}, σ_{KSM}

For first approximation treat internal and external and external structure differently:

Internal – linear through 0, 0

External – Design Philosophy governs at least to start



first set tension at neutral axis at half the maximum in tension and compression ;

$$\sigma_{TNA} \equiv \frac{1}{2} \max \begin{Bmatrix} |\sigma_{DHM}| \\ |\sigma_{KSM}| \end{Bmatrix}$$

$$\sigma_{CNA} \equiv \frac{1}{2} \max \begin{Bmatrix} |\sigma_{DSM}| \\ |\sigma_{KHM}| \end{Bmatrix}$$

Then linear

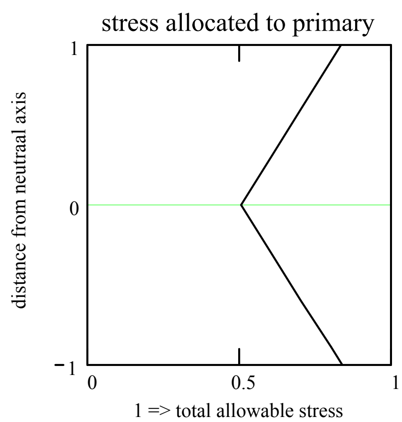
Design Philosophy further allocates a fraction of allowable stress to primary

MS	8.5	TSI	19.04 KSI
HTS	9.5	TSI	21.28 KSI
HY-80	10.5	TSI	23.52 KSI
HY-100	11.5	TSI	25.76 KSI

And applies margin of

1 TSI combatant

0.5 TSI auxiliary and patrol craft



If required, bending moments could be estimated as follows:

With sufficient knowledge of the design, a bending moment can be calculated (static or stochastic etc.) Frequently to get started on the design spiral an initial estimate of the structural weight and scantlings is desired. Estimates can be used for a first estimate. One such approximation derived from a curve fit of 13 destroyer and frigate hulls (used by Asset) is as follows:

$$M_{bH} = -0.000457 * L^{2.5} * B \quad \text{longtons*feet}$$

$$M_{bS} = 0.000381 * L^{2.5} * B \quad \text{longtons*feet}$$

where:

L = length between perpendiculars

B = maximum beam at design waterline

When process starts may not be sufficiently confident to calculate I_{yy} so we cannot estimate σ

Set $\sigma_{DHM} = \sigma_{KSM} = \sigma_{\text{allow primary max}}$

Use linear relations for interior and exterior – with

$y_{NA} = y_D/2$

then when first estimate of scantlings are complete, calculate neutral axis, moment of inertia and bending moment and repeat the process

Review

handout material properties

plate catalog

stiffener catalog

acronym PSF

Maestro description

Loads table

Loads sketch SNAME

Material properties

Note 1: allowable working stress

Steel $\sigma_{AWS} = \frac{1}{2}\left(\frac{\sigma_u}{2.15} + \frac{\sigma_y}{1.25}\right)$ ex $MS = \frac{\sigma_y}{1.25}$

actual close for MS

Note 2: maximum allowable working stress; 13.122 will use σ_y factored by

$\gamma_S = 1.25$ for serviceability

$\gamma_C = 1.5$ for collapse

Plate/stiffeners – use for future problem sets

Partial Safety Factors

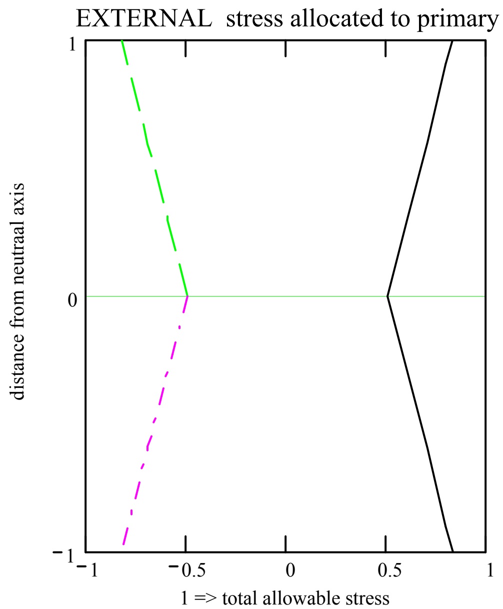
Tabular form – separate by origin and serviceability vs collapse

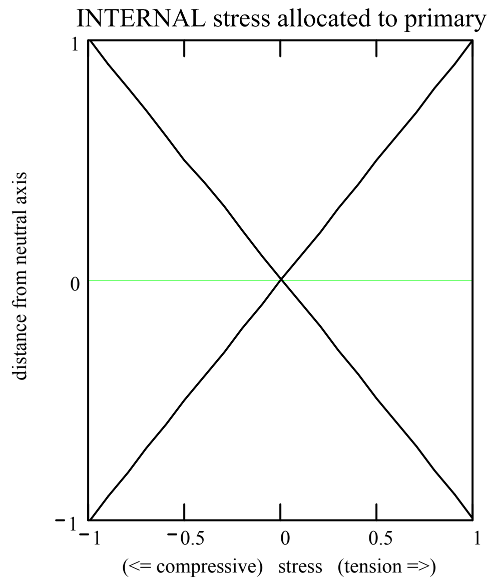
note yield $\neq$ collapse

Next page defines words

Outlines where we're going

Design Practice





$$\sigma_{TNA} \equiv \frac{1}{2}\max\begin{Bmatrix} |\sigma_{DHM}| \\ |\sigma_{KSM}| \end{Bmatrix}$$

$\sigma_{TNA} = 0$

$$\sigma_{CNA} \equiv \frac{1}{2}\max\begin{Bmatrix} |\sigma_{DSM}| \\ |\sigma_{KHM}| \end{Bmatrix} \quad \text{(use – sign for compression)}$$

$\sigma_{CNA} = 0$

1st Iteration

$y_{NA} = y_D/2$ ref. keel

$\sigma_{DHM} = \sigma_{KSM} =$ Max Primary Stress (+ => tension)

$\sigma_{DSM} = \sigma_{KHM} = -$ Max Primary Stress (- => compression)

Relationship (y) is linear

Not necessary but typically expressed such that y (ref keel) to mid ht of panel

treat above and below NA separately

Below Neutral axis EXTERNAL:

$\sigma_T(y) = \sigma_{TNA} + (\sigma_{KSM} - \sigma_{TNA})*(y_{NA}-y)/y_{NA}$

$\sigma_C(y) = \sigma_{CNA} + (\sigma_{KHM} - \sigma_{CNA})*(y_{NA}-y)/y_{NA}$

Above Neutral axis EXTERNAL:

$\sigma_T(y) = \sigma_{TNA} + (\sigma_{DHM} - \sigma_{TNA})*(y-y_{NA})/y_{NA}$

$\sigma_C(y) = \sigma_{CNA} + (\sigma_{DSM} - \sigma_{CNA})*(y-y_{NA})/y_{NA}$

INTERNAL: above with $\sigma_{TNA} = \sigma_{CNA} = 0$

Then: Maximum Stress = $\sigma_{MAX}(y) = MAX\{\sigma_T(y), -\sigma_C(y)\}$

Have talked about mechanism for hull girder shear and bending

wt – buoyancy distribution in still water or wave induced

Will now consider relationships as they relate to other than primary bending effects

Secondary loads:

Many ways to classify, we will use

Sea & Weather and	**Individual**
wave *	live
green sea	dead
heel *	damage (* heel)
slap	

We will **ignore**: e.g. pitch *

blast missile on deck > acceleration *

underwater on hull _ pressure

slamming

ice, snow, wind

equipment weight *

* Maestro includes explicitly

others are input as pressures on strake

13.122 Design Loads (all expressed in ht of sea water pressure (feet))

Weather (choose largest – where applicable)

Wave

$H_{wv} = y_{DWL} + 0.55\sqrt{L} - y$

Notes: only + H_{wv}

ignoring phase

ignoring adjustment of y_{DWL} due to dynamic effects

"Smith" effect

wave dynamics > exponential pressure

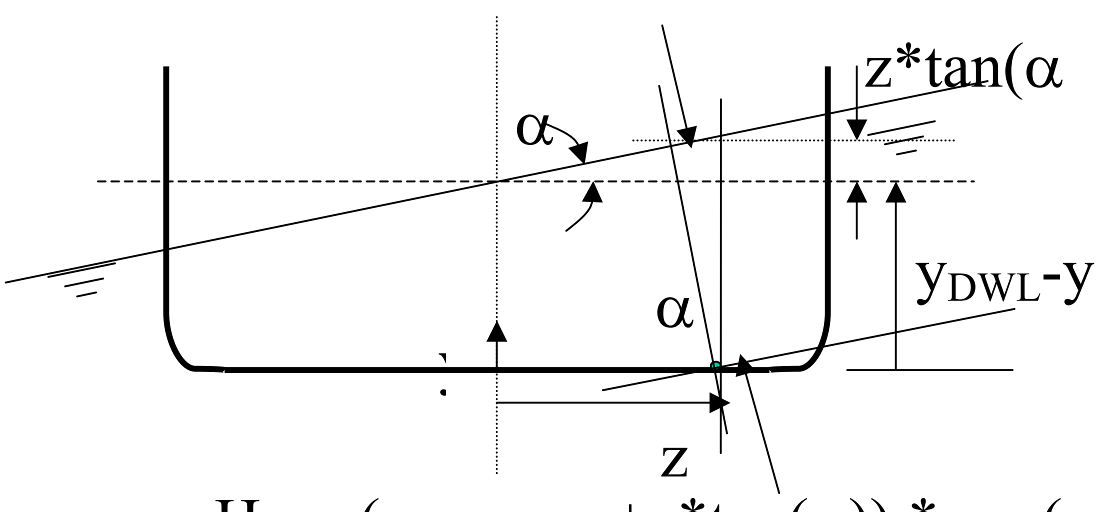
decay with depth

Maestro includes to a degree

Heel

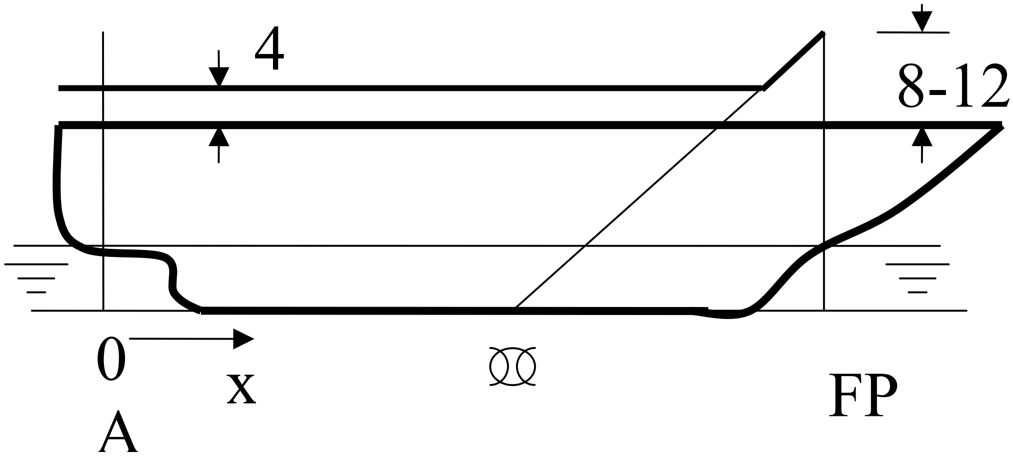
$H_H = (y_{DWL} - y + z*\tan(\alpha)) * \cos(\alpha)$

Set $\alpha = 30°$ for design



$$H_H = (y_{DWL} - y + z*\tan(\alpha)) * \cos(\alpha)$$

Green seas (applicable to Weather Deck WD)



≡ 8 to 12 submerged at FP linearly decreasing to constant 4' over weather deck => 13.122 use 8 ft

$$H_{GS} = \max\begin{bmatrix} y_o - y + 4\text{ft} \\ 2\left(\frac{\mathrm{y_o}+8}{L}\right)\left(x-\frac{L}{2}\right)-y \end{bmatrix}$$

Wave Slap

Design value 500 psf > converted to height in feet => 500/64 lbs/ft^3 = 7.82 feet

Completes weather and sea

$$H_{SW} = \max\left[H_{WV}, H_H, H_{WS}\right]$$

Independent

Live Load varies from 75 psf for living space Mezzanine Deck and up

100 psf living space below Mezzanine Deck

150 psf offices and control spaces below Mezzanine Deck

to 300 psf for storerooms/magazine

Use 150 psf => H_{LL} = 150/64 lbs/ft^3 = 2.37 feet

Damage (Internal structure horizontal and vertical)

Flooding occurs to margin line might be worsened with heel

Design approach (decks only)

Compare flooded pressure with heel = 30° Margin line at deck to that panel being flooded without heel

Margin line at deck $(y_D - y)$

as with heel y_{DWL} replaced by y_D Set $\alpha = 30°$

$$H_{DAM} = \mathrm{MAX}\{(y_D + z*\tan(\alpha) - y) * \cos(\alpha),\ (y_D - y)\}$$

Dead load

Weight of fixed structure

1” thick 1 ft^2 plate weighs ~ 40 lbs

Design: Use approximately 2.5 times plate thickness

$H_{DL} = 40 * 2.5 /64 *t = 1.72 * t$ in feet

Where t = plate thickness in inches

One other criteria: maximum stiffener spacing

maximum $b = \frac{B}{N+1}$ (breadth of plate)

$$23 \le b \le 28$$

b = stiffener spacing

N = number of stiffeners

Review

Look at Handout

Sea/Weather check applicability

use largest

Independent apply as appropriate