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Studies and Investigation of Stresses in Thin Walled Members

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***Abstract*—Demand for "thin sections" is increasing due to economy. They are widely used in the construction industry because of their light weight and economy, particularly for long-span floors in industrial and public buildings and for storage structures for liquids and bulk materials, such as tanks, hoppers, silos etc. In case of thick walled members there is classical theory which explains the behavior of structural elements. But it is noted that classical theory does not hold good for thin walled members as the nature and magnitude of the stresses of these members differ from that of the thick walled members. Therefore a study is made to understand the behavior of the member when it is assumed as thin walled and its stress pattern is studied.. Here we have attempted to calculate longitudinal stresses caused due to bimoment only for Symmetrical Z-section and compare the percentage increase in the stresses in thin walled when compared to that of the thick walled for various height and thickness of flange and web.**

***Index Terms*— Flexural Twist(Tw), Bimoment(B).**

I. INTRODUCTION

The cross section of a thin walled beam is formed by using thin surface elements mainly plane elements – that are monolithically connected to one other at their common edges. They thus form beam-type oblong members, resulting in a huge saving in material compared with a corresponding solid cross-section of the same constructional height.

In thin walled members the dimension of length L is clearly larger than the maximum transverse dimension B, with a length/width ratio (L/B) Of more than 5 ie.,L/B>5, while the thickness t of the plane elements is thin enough that t/B <0.1

The main difference between the thin walled and the thick walled, and which causes the biggest difficulties in analyzing the thin walled member, lies in the way the torsion is taken up. Not only shear but also longitudinal normal stresses contribute a fact that is not foreseen in the so called 'Classical technical theory'.

The classical theory of thick-walled members with an arbitrary open cross section is based on the following

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assumptions

(a) The cross section is perfectly rigid in its own plane

(b) Shear strains in the middle surface can be neglected

(c) Normal's to the middle surface remain un-deformed and normal during deformation.

But this is not valid for thin walled members with an open cross-section because when is subjected to a torsional moment it presents a perceptible distortion in each cross-sectional plane. More specifically, the longitudinal fibres of the beam are deformed along their length so that no cross-section remains planar but undergoes warping and when warping is restrained there is a development of longitudinal stresses in the member, where this cannot be analyzed by the concept of thick walled theory.

II. OBJECTIVES AND SCOPE OF THE WORK.

The objective of this investigation is to study the behaviour of thin walled sections and to identify the thin walled sections.

The scope of investigation encompass the following

1. To identify the stresses caused due to compressive force.
2. To know the stress pattern of various open cross section and calculate their net stresses.
3. To know the ratio new stress obtained due to the effect of thin walled action to the old stress due to thick walled action when the member is assumed to act as thin walled member.
4. To identify which is the least and highly stressed member in the members selected for study.

III. DETAILS OF THE PROPOSED WORK

Parameters selected for Theoretical studies.

1. Breath of the member was assumed to be constant.
2. Area of the member was assumed to be constant.
3. Height of the member was varied.
4. Thickness of the flange and web members was varied.

IV. METHODOLOGY ADOPTED.

1. Selecting the sections whose shear centers are not at its intersections therefore there sectorial co-ordinates are not zero.
2. Calculating the stresses caused due to the effect of thin walled action for the selected sections and there percentage increase.

V. THEORETICAL INVESTIGATION

The concept of thin walled beam is based on the following assumptions

1. Thickness (t) to the maximum transverse dimension (B) should be less than 0.1. i.e, $t/B<0.1$.
2. Length (L) to the maximum transverse dimension (B) should be greater than 5 i.e, $L/B>5$.
3. Shear Centre should not be present at the intersection of their flanges.
4. Presence of two new forces "Flexural twist" (T_w) and "Bimoment"(B).

The concept of selecting the sections mainly depends on the concept of shear centre. Sections whose shear centre are at the intersection of their flanges cannot be considered as Thin walled because all their components pass through their shear center, the principal sectorial co-ordinates are equal to zero at each point of the cross section. Therefore, the sectorial moment of inertia is equal to zero and hence do not develop warping.

Here we have attempted to calculate longitudinal stresses caused due to bimoment only for Symmetrical I-section and compare the percentage increase in the stresses in thin walled when compared to that of the thick walled for various height and thickness of flange and

Calculation of the stresses for Symmetrical I-shaped beam.

Assumptions

1. Height of the member (h) = Two times the breath of the flange (b). i.e, $h=2b$

2. Thickness of the flange (tf) = Thickness of the web (tw). i.e, tf=tw=t
3. The concentrated load (F) acts at the centre of the web.
4. Positive sign indicates compression and Negative sign tension.

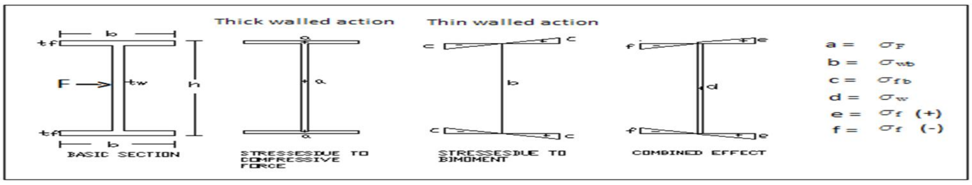

Figure 1. Stress pattern for both thick walled and thin walled behaviour of member.

Solution:-
The area of the cross section of this beam is equal to
A=(ht) + (2bt) = 4bt
The sectorial co ordinate of the web is
$w_{(w)} = 0$
At the tip of each flange we have
$w_{(f)} = (h/2)*(b/2) = 0.5b^2$
Sectorial moment of inertia
$Iw = Iyy*(h/2)^2 = 0.17tb^3$
Where- $Iyy = (2\ t_f\, b^3)/12$
The bimoment caused by an axial force f is given by
$B = (-)\ F\ w_f = (-)\ 0.5b^2F$
The stresses caused by this bimoment are
At the web
$s_{wb} = B\ (w_w / I_w) = 0$ (compression)
At the tip of the Flange
$s_{fb} = (-)B\ (w_w / I_w) = (-)\ 1.5\ F/bt$ (tension)
The compressive stresses due to axial force 'F' are constant over the whole cross-section and their value is,
$s_F = F/A = 0.25\ F/bt$
Therefore resultant net stresses are,
At the Web
$s_w = s_{wB} + s_f = 0.25\ F/bt$ (compression)
At the tip of each flange
$s_f = s_{fB} + s_f = (-)1.25\ F/bt$ (tension)
We see from the above results that "local" stresses does not vary at web where it is in compression but at the average stress, but at the tip of the flange the stresses vary at about 5times in tension.
Where, a = stresses due to thick walled action in the entire member ; d = net stresses due to combined action in web
e/e' = net stresses due to combined action in flange in compression; f/f' = net stresses due to combined action in flange in tension
The section selected for analysis randomly
Selected section has the following dimensions.

1. Height= h=100mm
2. Width = b=50mm
3. Thickness of web = t_w=4mm
4. Thickness of flange = t_f=6.4mm

Here area and breadth of the member are taken constant
Table III. Stresses for section both for thick

VI. RESULTS

From the theoretical investigations we have identified the maximum and minimum stressed dimension of the member.

TABLE: I. SPECIFIC CASES FOR Z-SECTION

Case no	Height (h)	Thickness(t)
1	1b	$t_w = t_f/2 = t/2$
2	1b	$t_w = t_f = t$
3	1b	$t_w = 2t_f = 2t$
4	2b	$t_w = t_f/2 = t/2$
5	2b	$t_w = t_f = t$
6	2b	$t_w = 2t_f = 2t$
7	5b	$t_w = t_f/2 = t/2$
8	5b	$t_w = t_f = t$
9	5b	$t_w = 2t_f = 2t$
10	7b	$t_w = t_f/2 = t/2$
11	7b	$t_w = t_f = t$
12	7b	$t_w = 2t_f = 2t$

TABLE II. STRESSES FOR SECTION BOTH FOR THICK AND THIN WALLED ACTION

slno	H	t	A	$\omega_{(w)}$	$\omega_{(f)}$	I_w	B	b	c	a	d	e	f	g	h	i
	*b		*bt	* b^2 (+)	*bt (+)	* b^5t (+)	*F (-)	* $\frac{F}{bt}$ (+)	* $\frac{F}{bt}$ (-)	* $\frac{F}{bt}$ (+)	* $\frac{F}{bt}$ (+)	* $\frac{F}{bt}$ (+)	* $\frac{F}{bt}$ (-)	(+)	(+)	(-)
1	1	tw=tf/2=t/2	2.5	0	0.3	0.08	0.25	0	0.75	0.40	0.40	0.35	0.35	1	0.88	0.88
2	1	tw=tf=t	3.0	0	0.3	0.08	0.25	0	0.75	0.33	0.33	0.42	0.42	1	1.27	1.27
3	1	tw=2tf=2t	4.0	0	0.3	0.08	0.25	0	0.75	0.25	0.25	0.50	0.50	1	2.00	2.00
4	2	tw=tf/2=t/2	3.0	0	0.5	0.17	0.5	0	1.50	0.33	0.33	1.17	1.17	1	3.55	3.55
5	2	tw=tf=t	4.0	0	0.5	0.17	0.5	0	1.50	0.25	0.25	1.25	1.25	1	5.00	5.00
6	2	tw=2tf=2t	6.0	0	0.5	0.17	0.5	0	1.50	0.17	0.17	1.33	1.33	1	7.82	7.82
7	5	tw=tf/2=t/2	4.5	0	1.3	1.04	1.25	0	1.50	0.22	0.22	1.28	1.28	1	5.82	5.82
8	5	tw=tf=t	7.0	0	1.3	1.04	1.25	0	1.50	0.14	0.14	1.36	1.36	1	9.71	9.71
9	5	tw=2tf=2t	12.0	0	1.3	1.04	1.25	0	1.50	0.08	0.08	1.42	1.42	1	17.75	17.75
10	7	tw=tf/2=t/2	5.5	0	1.8	2.04	1.75	0	1.50	0.18	0.18	1.32	1.32	1	7.33	7.33
11	7	tw=tf=t	9.0	0	1.8	2.04	1.75	0	1.50	0.11	0.11	1.40	1.40	1	12.00	12.00
12	7	tw=2tf=2t	16.0	0	1.8	2.04	1.75	0	1.50	0.06	0.06	1.44	1.44	1	24.00	24.00

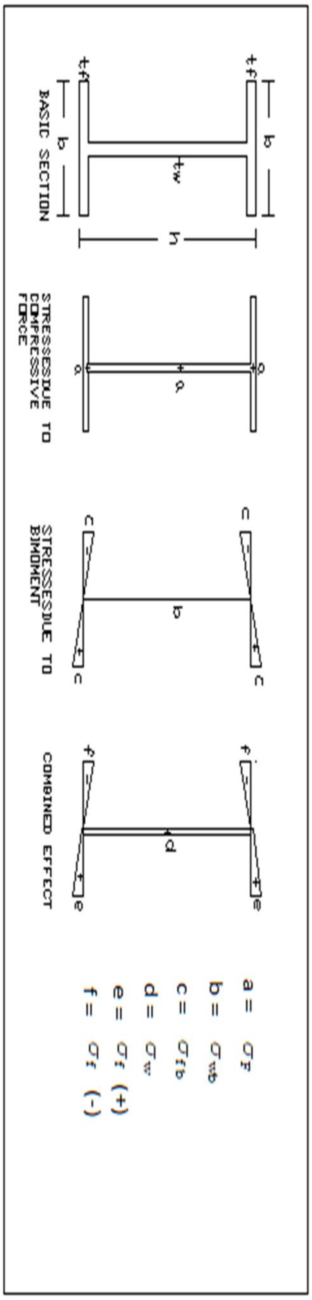

Figure.2. Stresses in the member

Maximum Stress

<u>Case 12:</u>

a. h = 7times b = 350mm
b. $t_w = 2t_f$, ie., t_f = 1.3mm, t_w =2.6mm
c. stresses due to thick walled action in the entire member = 1.0 N/mm^2
d. net stresses due to combined action in web = 1.0 N/mm^2
e. net stresses due to combined action in flange in compression = 22.1 N/mm^2
f. net stresses due to combined action in flange in tension = (-) 22.1 N/mm^2

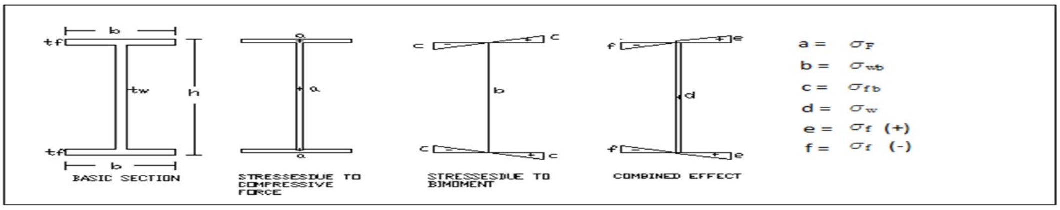

Figure.3. Stresses in the member and thin walled action

TABLE III. STRESSES FOR SECTION BOTH FOR THICK

sl no	h	t_f	t_w	A	$\omega_{(w)}$	$\omega_{(f)}$	I_w	B	b	c	a	d	e	f	g	h	i
	mm	mm	mm	mm^2	mm^2	mm^2	mm^6	Nmm^2	$\frac{N}{mm^2}$	$\frac{N}{mm^2}$	$\frac{N}{mm^2}$	$\frac{N}{mm^2}$	$\frac{N}{mm^2}$	$\frac{N}{mm^2}$			
					(-)10^3	(+)10^3	(+)10^8	(-)10^6	(+)	(-)	(+)	(+)	(+)	(-)	(+)	(+)	(-)
1	50	8.2	4.10	1021	0	0.6	0.3	0.6	0	1.8	1.0	1.0	0.8	0.8	1	0.88	0.88
2	50	6.8	6.80	1021	0	0.6	0.3	0.6	0	2.2	1.0	1.0	1.2	1.2	1	1.27	1.27
3	50	5.1	10.20	1021	0	0.6	0.2	0.6	0	2.9	1.0	1.0	1.9	1.9	1	2.00	2.00
4	100	6.8	3.40	1021	0	1.3	0.6	1.3	0	4.4	1.0	1.0	3.4	3.4	1	3.55	3.55
5	100	5.1	5.10	1021	0	1.3	0.4	1.3	0	5.9	1.0	1.0	4.9	4.9	1	5.00	5.00
6	100	3.4	6.80	1021	0	1.3	0.3	1.3	0	8.8	1.0	1.0	7.8	7.8	1	7.82	7.82
7	250	4.5	2.25	1021	0	3.1	2.3	3.1	0	6.7	1.0	1.0	5.7	5.7	1	5.82	5.82
8	250	2.9	2.9	1021	0	3.1	1.5	3.1	0	10.3	1.0	1.0	9.4	9.4	1	9.71	9.71
9	250	1.7	3.4	1021	0	3.1	0.9	3.1	0	17.7	1.0	1.0	16.7	16.7	1	17.75	17.75
10	350	3.7	1.9	1021	0	4.4	3.8	4.4	0	8.1	1.0	1.0	7.1	7.1	1	7.33	7.33
11	350	2.3	2.3	1021	0	4.4	2.4	4.4	0	13.3	1.0	1.0	12.3	12.3	1	12.00	12.00
12	350	1.3	2.6	1021	0	4.4	1.3	4.4	0	23.1	1.0	1.0	22.1	22.1	1	24.00	24.00

Minimum Stress

Case 01:

g. h = 1times b = 50mm
h. $t_w = t_f /2$, ie., $t_f = 8.2$mm, t_w =4.1mm
i. stresses due to thick walled action in the entire member = 1.0 N/mm^2
j. net stresses due to combined action in web = 1.0 N/mm^2
k. net stresses due to combined action in flange in compression = 0.8 N/mm^2
l. net stresses due to combined action in flange in tension = (-) 0.8 N/mm^2

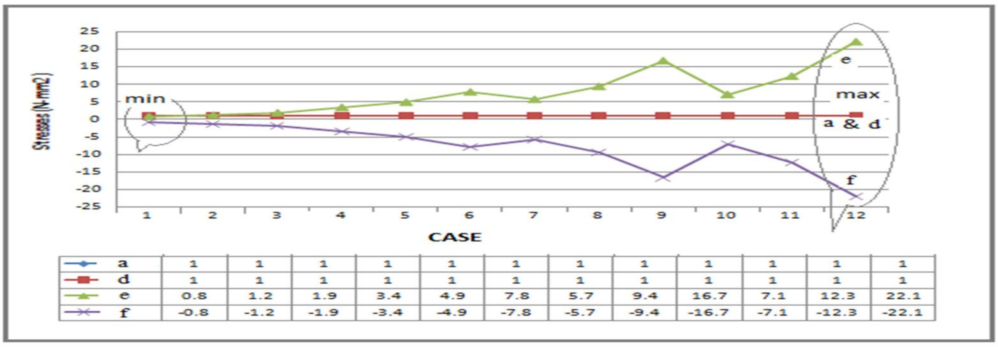

Figure.4. Comparision between thick walled and thin walled action of Symmetrical I-Shaped member

VII. CONCLUSIONS

In case of Symmetrical I-section as height of the member is increased the stress of the member is increased under thin walled action, when the thickness of the flange is half of the thickness of the web. Therefore the maximum stress is found in the member whose height is equal to 7times breath of the flange and thickness of flange is equal to half of thickness of web.

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