

STRUKTUR BAJA 11

MODUL 6

S e s i 2

Struktur Jembatan Komposit

Materi Pembelajaran :

WORKSHOP/PELATIHAN

Perhitungan Tegangan Elastis Pada Penampang Komposit

Tujuan Pembelajaran :

- *Mahasiswa mengetahui, memahami dan dapat melakukan pemeriksaan tegangan elastis pada penampang komposit.*

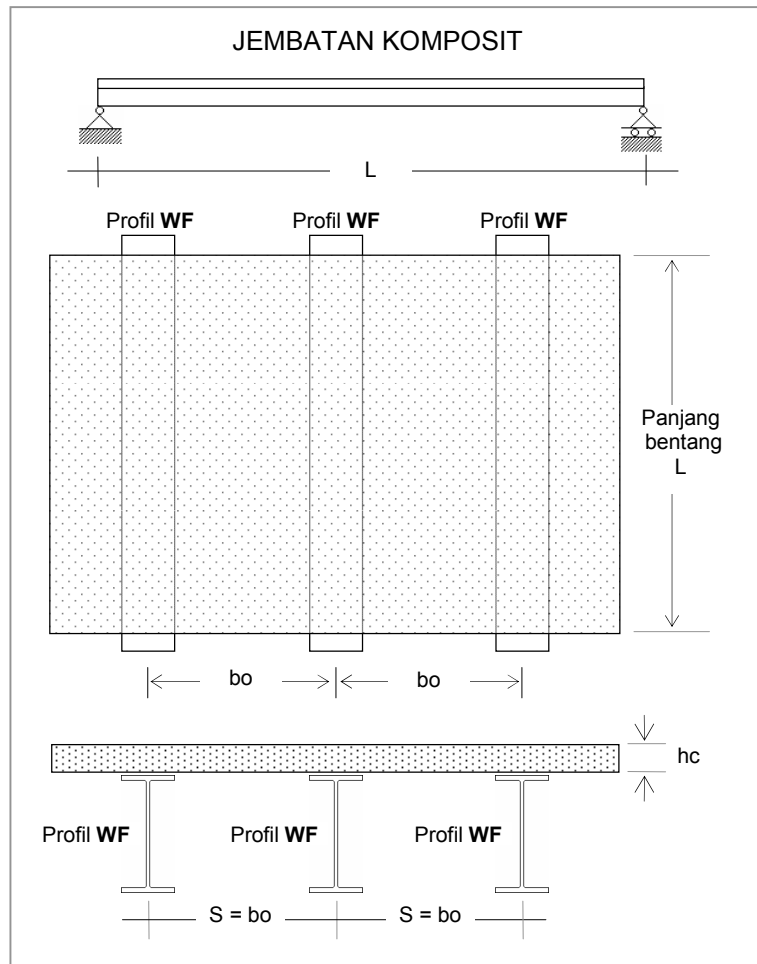
DAFTAR PUSTAKA

- a) Agus Setiawan, "Perencanaan Struktur Baja Dengan Metode LRFD (Berdasarkan SNI 03-1729-2002)", Penerbit AIRLANGGA, Jakarta, 2008.
- b) Charles G. Salmon, Jhon E. Johnson, "STRUKTUR BAJA, Design dan Perilaku", Jilid 2, Penerbit AIRLANGGA, Jakarta, 1996, atau,
- c) Charles G. Salmon, Jhon E. Johnson, *Steel Structures Design and Behavior*, 5th Edition, Pearson Education Inc., 2009
- d) RSNIT-03-2005, *Perencanaan Struktur Baja Untuk Jembatan*.
- e) Tabel Baja PT. GUNUNG GARUDA.

WORKSHOP/PELATIHAN

Perhitungan Tegangan Elastis Penampang Komposit

Sebuah jembatan komposit dengan perletakan sederhana dengan data-data terlampir pada tabel berikut. Hitung dan gambarkan tegangan yang terjadi pada penampang komposit akibat berat sendiri.



DATA GEOMETRIS JEMBATAN

No. Stb.	L m	hc cm	S = bo cm
-1	12	20	110
0	10	20	100
1	11	20	105
2	13	20	115
3	14	20	120
4	15	20	125
5	16	20	130
6	17	20	135
7	18	20	140
8	19	20	145
9	20	20	150

DATA MATERIAL

BETON			BAJA BJ-41, $f_y = 250$ MPa., $E = 200.000$ MPa.				
No. Stb.	K kg/cm ²	Wc kN/m ³	PROFIL	hs cm	qs kN/m	As cm ²	Ios cm ⁴
-1	300	25.0	WF600.300.12.20	58.8	1.510	192.5	118000
0	250	23.0	WF400.400.13.21	40.0	1.720	218.7	66600
1	255	23.2	WF600.300.12.20	58.8	1.510	192.5	118000
2	260	23.4	WF600.300.12.20	58.8	1.510	192.5	118000
3	265	23.6	WF700.300.13.24	70.0	1.850	235.5	201000
4	270	23.8	WF700.300.13.24	70.0	1.850	235.5	201000
5	275	24.0	WF700.300.13.24	70.0	1.850	235.5	201000
6	280	24.2	WF700.300.13.24	70.0	1.850	235.5	201000
7	285	24.4	WF800.300.14.26	80.0	2.100	267.4	292000
8	290	24.6	WF800.300.14.26	80.0	2.100	267.4	292000
9	295	24.8	WF800.300.14.26	80.0	2.100	267.4	292000

Penyelesaian :

A). DATA - DATA**1. DATA GEOMETRIS JEMBATAN**

Tebal slab lantai jembatan $h_c = 20,0$ cm.

Jarak antara gelagar baja $S = b_o = 110,0$ cm.

Panjang bentang jembatan $L = 12,0$ m.

2. DATA MATERIAL**a. BETON**

Mutu beton, K-300 $= 300$ kg/cm²

Kuat tekan beton, $f_c' = 0,83 K/10 = 24,9$ MPa.

Modulus Elastis, $E_c = 4700 \sqrt{f_c'} = 23453$ MPa.

Berat beton bertulang, $W_c = 25$ kN/m³

b. BAJA

Mutu baja, BJ - 41

Tegangan leleh baja, $f_y = 250$ MPa.

Modulus elastis, $E_s = 200.000$ Mpa.

Profil WF 600.300.12.20

$I_o = 118000$ cm⁴.

$h_s = 58,8$ cm.

$A_s = 192,5$ cm².

$q_s = 151$ kg/m = 1,51 kN/m.

B). ANALISA STRUKTUR.**a. Berat Sendiri.**

- Pelat beton, $q_c = (1,10 \text{ m}) \cdot (0,20 \text{ m}) \cdot (25 \text{ kN/m}^3) = 5,500 \text{ kN/m'}$.

- Profil WF 600.300.12.20, $q_s = 1,510 \text{ kN/m'}$.
 $q = 7,010 \text{ kN/m'}$.

b. Momen lentur.

Momen maksimum terjadi di tengah bentang sebesar,

$M_{maks} = 1/8 q L^2 = 1/8 \cdot (7,010 \text{ kN/m'}) \cdot (12 \text{ m})^2$

$M_{maks} = 126,180 \text{ kN.m'}$.

C). GARIS NETRAL PENAMPANG KOMPOSIT.

Lebar efektif (RSNI T-03-2005),

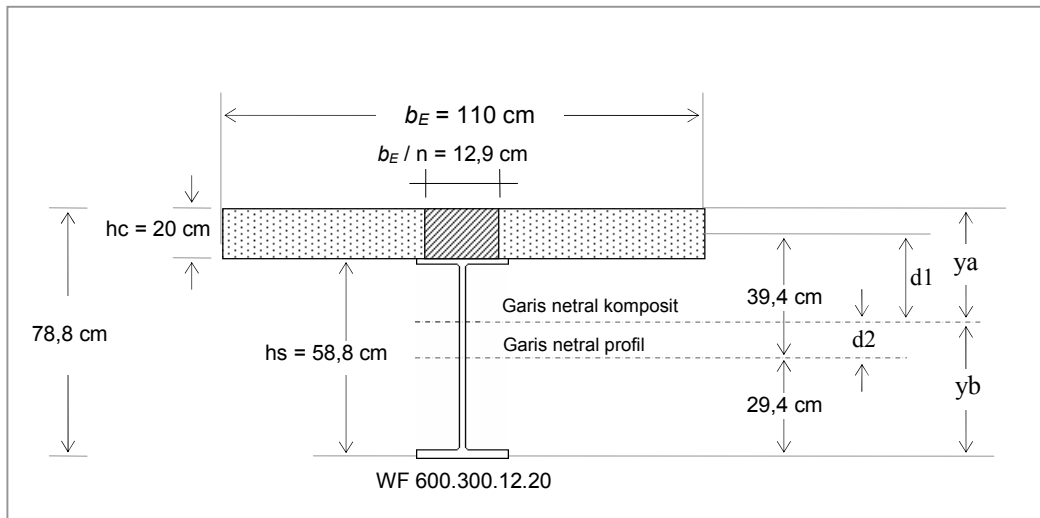
$$\begin{aligned} b_E &= L / 5 = 12 \text{ m} / 5 = 2,4 \text{ m} \\ b_E &= b_o = 1,10 \text{ m (menentukan).} \\ b_E &= 12 h_c = 12 \cdot (0,20 \text{ m}) = 2,40 \text{ m.} \end{aligned}$$

Modulus ratio,

$$n = E_s / E_c = (200.000 \text{ MPa}) / (23500 \text{ MPa}) = 8,5$$

Lebar equivalen baja,

$$b_E / n = 1,10 \text{ m} / 8,5 = 0,129 \text{ m} = 12,9 \text{ cm.}$$



Letak garis netral komposit.

Luas penampang baja equivalen,	$A_c = (12,9 \text{ cm}) \cdot (20 \text{ cm})$	$= 258 \text{ cm}^2$
Luas profil WF 600.300.12.20	A_s	$= 192,5 \text{ cm}^2$
Luas total,	A_{total}	$= 450,5 \text{ cm}^2$

- Statis momen ke sisi atas pelat beton,

$$\begin{aligned} A_{total} \cdot y_a &= A_c \cdot (h_c/2) + A_s \cdot (h_s/2 + h_c) \\ (450,5 \text{ cm}^2) \cdot y_a &= (258 \text{ cm}^2) \cdot (20 \text{ cm}/2) + (192,5 \text{ cm}^2) \cdot (58,8 \text{ cm}/2 + 20 \text{ cm}) \\ (450,5 \text{ cm}^2) \cdot y_a &= 2580,0 \text{ cm}^3 + 9509,5 \text{ cm}^3 = 12089,5 \text{ cm}^3 \\ y_a &= (12089,5 \text{ cm}^3) / (450,5 \text{ cm}^2) = 26,84 \text{ cm.} \end{aligned}$$

- Statis momen ke sisi bawah flens bawah profil,

$$\begin{aligned} A_{total} \cdot y_b &= A_c \cdot (h_s + h_c/2) + A_s \cdot (h_s/2) \\ (450,5 \text{ cm}^2) \cdot y_b &= (258 \text{ cm}^2) \cdot (58,8 \text{ cm} + 20 \text{ cm}/2) + (192,5 \text{ cm}^2) \cdot (58,8 \text{ cm}/2) \\ (450,5 \text{ cm}^2) \cdot y_b &= 17750,4 \text{ cm}^3 + 5659,5 \text{ cm}^3 = 23409,9 \text{ cm}^3 \\ y_b &= (23409,9 \text{ cm}^3) / (450,5 \text{ cm}^2) = 51,96 \text{ cm} \end{aligned}$$

- Kontrol,

$$\begin{aligned} y_a + y_b &= h_s + h_c \\ 26,84 \text{ cm} + 51,96 \text{ cm} &= 58,8 \text{ cm} + 20 \text{ cm} \\ 78,8 \text{ cm} &= 78,8 \text{ cm (memenuhi).} \end{aligned}$$

D). MOMEN INERTIA PENAMPANG KOMPOSIT.

Perhitungan momen inertia komposit (I), terhadap garis netral komposit adalah sebagai berikut,

a. Penampang baja equivalen.

Luas penampang baja equivalen,

$$A_c = 258,0 \text{ cm}^2.$$

Momen inertia terhadap diri sendiri,

$$I_{oc} = 1/12 \cdot (12,9 \text{ cm}) \cdot (20 \text{ cm})^3 = 8600,0 \text{ cm}^4.$$

Letak pusat berat penampang baja equivalen terhadap garis netral komposit,

$$d_1 = y_a - (h_c/2) = (26,84 \text{ cm}) - (20 \text{ cm}/2) = 16,84 \text{ cm}.$$

Momen inertia penampang baja equivalen terhadap garis netral komposit ,

$$I_c = I_{oc} + A_c \cdot d_1^2 = 8600,0 \text{ cm}^4 + (258,0 \text{ cm}^2) \cdot (16,84 \text{ cm})^2 = 81765,1 \text{ cm}^4.$$

b. Profil WF 600.300.12.20.

Luas profil WF,

$$A_s = 192,5 \text{ cm}^2.$$

Momen inertia terhadap diri sendiri,

$$I_{os} = 118000 \text{ cm}^4.$$

Letak pusat berat profil WF terhadap garis netral komposit,

$$d_2 = y_b - (h_s/2) = (51,96 \text{ cm}) - (58,8 \text{ cm}/2) = 22,56 \text{ cm}.$$

Momen inertia profil WF terhadap garis netral komposit ,

$$I_s = I_{os} + A \cdot d_2^2 = 118000 \text{ cm}^4 + (192,5 \text{ cm}^2) \cdot (22,56 \text{ cm})^2 = 215973,6 \text{ cm}^4.$$

c. Momen inertia penampang komposit.

$$I = I_c + I_s = 81765,1 \text{ cm}^4 + 215973,6 \text{ cm}^4 = 297738,7 \text{ cm}^4.$$

E). TEGANGAN LENTUR PADA PENAMPANG KOMPOSIT.

Pada tepi atas pelat beton,

$$f_{ca} = \frac{M \cdot y_a}{n \cdot I} = \frac{(126,180 \times 10^6 \text{ N.mm}) \times (268,4 \text{ mm})}{(8,5) \cdot (297738,7 \times 10^4 \text{ mm}^4)} = 1,3 \text{ MPa (tekan)}.$$

Pada tepi bawah pelat beton,

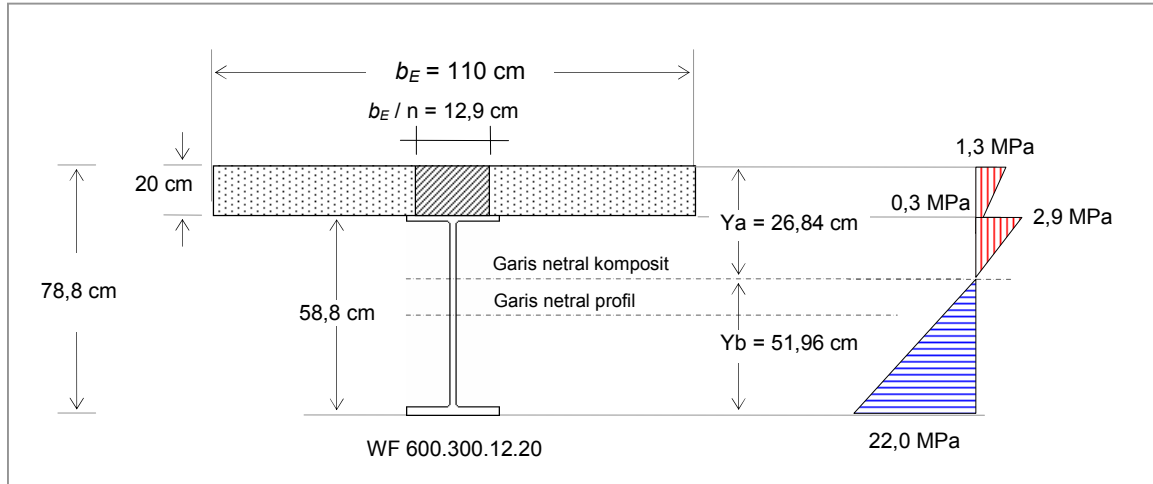
$$\begin{aligned} f_{cb} &= \frac{M \cdot (y_a - 200 \text{ mm})}{n \cdot I} = \frac{(126,180 \times 10^6 \text{ N.mm}) \times (268,4 \text{ mm} - 200 \text{ mm})}{(8,5) \cdot (297738,7 \times 10^4 \text{ mm}^4)} \\ &= 0,3 \text{ MPa (tekan)}. \end{aligned}$$

Pada tepi atas flens atas profil WF,

$$\begin{aligned} f_{sa} &= \frac{M \cdot (y_a - 200 \text{ mm})}{I} = \frac{(126,180 \times 10^6 \text{ N.mm}) \times (268,4 \text{ mm} - 200 \text{ mm})}{(297738,7 \times 10^4 \text{ mm}^4)} \\ &= 2,9 \text{ Mpa (tekan)}. \end{aligned}$$

Pada tepi bawah flens bawah profil WF,

$$f_{sa} = \frac{M \cdot (y_b)}{I} = \frac{(126,180 \times 10^6 \text{ N.mm}) \times (519,6 \text{ mm})}{(297738,7 \times 10^4 \text{ mm}^4)} = 22,0 \text{ Mpa (tarik)}.$$



Gambar 14 : Diagram tegangan penampang komposit akibat berat sendiri.

Kunci Jawaban

No. Stb.	f'_c Mpa.	E_c Mpa.	f_y Mpa.	E_s Mpa.	q_c kN/m'	q kN/m'	M kN.m'
-1	24.9	23453	250	200000	5.500	7.010	126.180
0	20.8	21435	250	200000	4.600	6.320	79.000
1	21.2	21640	250	200000	4.872	6.382	96.528
2	21.6	21844	250	200000	5.382	6.892	145.594
3	22.0	22045	250	200000	5.664	7.514	184.093
4	22.4	22244	250	200000	5.950	7.800	219.375
5	22.8	22442	250	200000	6.240	8.090	258.880
6	23.2	22638	250	200000	6.534	8.384	302.872
7	23.7	22881	250	200000	6.832	8.932	361.746
8	24.1	23073	250	200000	7.134	9.234	416.684
9	24.5	23264	250	200000	7.440	9.540	477.000

No. Stb.	$b_E = L/5$ cm	$b_E = b_o$ cm	$b_E = 12 \cdot h_c$ cm	n	b_E / n cm
-1	240	110	240	8.5	12.9
0	200	100	240	9.3	10.8
1	220	105	240	9.2	11.4
2	260	115	240	9.2	12.5
3	280	120	240	9.1	13.2
4	300	125	240	9.0	13.9
5	320	130	240	8.9	14.6
6	340	135	240	8.8	15.3
7	360	140	240	8.7	16.1
8	380	145	240	8.7	16.7
9	400	150	240	8.6	17.4

No. Stb.	Ac cm ²	yc cm	As cm ²	ys cm	Atotal cm ²	ΣAy cm ³	ya cm
-1	258.0	10	192.5	49.4	450.5	12089.500	26.84
0	216.0	10	218.7	40.0	434.7	10908.000	25.09
1	228.0	10	192.5	49.4	420.5	11789.500	28.04
2	250.0	10	192.5	49.4	442.5	12009.500	27.14
3	264.0	10	235.5	55.0	499.5	15592.500	31.22
4	278.0	10	235.5	55.0	513.5	15732.500	30.64
5	292.0	10	235.5	55.0	527.5	15872.500	30.09
6	306.0	10	235.5	55.0	541.5	16012.500	29.57
7	322.0	10	267.4	60.0	589.4	19264.000	32.68
8	334.0	10	267.4	60.0	601.4	19384.000	32.23
9	348.0	10	267.4	60.0	615.4	19524.000	31.73

No. Stb.	Ac cm ²	yc cm	As cm ²	ys cm	Atotal cm ²	ΣAy cm ³	yb cm
-1	258.0	68.8	192.5	29.4	450.5	23409.900	51.96
0	216.0	50.0	218.7	20.0	434.7	15174.000	34.91
1	228.0	68.8	192.5	29.4	420.5	21345.900	50.76
2	250.0	68.8	192.5	29.4	442.5	22859.500	51.66
3	264.0	80.0	235.5	35.0	499.5	29362.500	58.78
4	278.0	80.0	235.5	35.0	513.5	30482.500	59.36
5	292.0	80.0	235.5	35.0	527.5	31602.500	59.91
6	306.0	80.0	235.5	35.0	541.5	32722.500	60.43
7	322.0	90.0	267.4	40.0	589.4	39676.000	67.32
8	334.0	90.0	267.4	40.0	601.4	40756.000	67.77
9	348.0	90.0	267.4	40.0	615.4	42016.000	68.27

No. Stb.	ya + yb cm	hc + hs cm	Ioc cm ⁴	d ₁ cm	Ic cm ⁴	Ios cm ⁴	d ₂ cm	Is cm ⁴
-1	78.80	78.80	8600.0	16.84	81765.1	118000	22.56	215973.6
0	60.00	60.00	7200.0	15.09	56384.9	66600	14.91	115218.8
1	78.80	78.80	7600.0	18.04	81800.7	118000	21.36	205828.0
2	78.80	78.80	8333.3	17.14	81778.2	118000	22.26	213385.2
3	90.00	90.00	8800.0	21.22	127676.1	201000	23.78	334172.5
4	90.00	90.00	9266.7	20.64	127697.4	201000	24.36	340748.0
5	90.00	90.00	9733.3	20.09	127586.9	201000	24.91	347129.7
6	90.00	90.00	10200.0	19.57	127393.4	201000	25.43	353294.3
7	100.00	100.00	10733.3	22.68	176364.4	292000	27.32	491582.7
8	100.00	100.00	11133.3	22.23	176187.0	292000	27.77	498211.6
9	100.00	100.00	11600.0	21.73	175923.1	292000	28.27	505704.2

No. Stb.	I cm ⁴	<i>f</i> ca Mpa.	<i>f</i> cb Mpa.	<i>f</i> sa Mpa.	<i>f</i> sb Mpa.
-1	297738.7	1.3	0.3	2.9	22.0
0	171603.7	1.2	0.3	2.3	16.1
1	287628.7	1.0	0.3	2.7	17.0
2	295163.4	1.5	0.4	3.5	25.5
3	461848.6	1.4	0.5	4.5	23.4
4	468445.4	1.6	0.6	5.0	27.8
5	474716.6	1.8	0.6	5.5	32.7
6	480687.7	2.1	0.7	6.0	38.1
7	667947.1	2.0	0.8	6.9	36.5
8	674398.6	2.3	0.9	7.6	41.9
9	681627.3	2.6	1.0	8.2	47.8