

장암교

(Steel BOX GIRDER교, 40.0+4@50.0+40.0=280.0m)

1. 설 계 조 건

1) 교 량 제 원

- (1) 교 량 명 : 장암교
 (2) 교 량 형 식 : Steel Box Girder교
 (3) 교 량 연 장 : $40 + (4 \times 50) + 40 = 280\text{m}$
 (4) 교 량 폭 원 : $B = 19.500 \text{ m}$
 (5) 사 각(Skew) : 90.000°
 (6) Girder 제 원 : $B = 2.500 \text{ m}$ $H = 1.500 \text{ m}$
 (7) 교 량 등 급 : 1 등급 (DB-24 및 DL-24 적용)

(10) 사용재료 및 물리적 특성치

① 강 재

▪ 사 용 재 료

주 부 재	SWS50B
부 부 재	SWS41B
강재 탄성계수 (E_{st})	205,000 MPa
강재의 전단탄성계수 (G)	79,000 MPa

▪ 허용 응력 (MPa)

(☞ 도.설.해 3.3.2.1)

강 종		SS 400 SM 400 SMA400	SM 490	SM490Y SM 520 SMA490	SM 570 SMA570	HSB500	HSB600	HSB800
응력 종류, 판두께(mm)	40 이하	140	190	215	270	230	270	380
	축방향 인장응력 및 휨 인장응력	130	175 (190)	200 (215)	260 (270)			
	75 초과 100이하			195 (215)	250 (270)			

강 증 응력 종류, 판두께(mm)		SS 400 SM 400 SMA400	SM 490	SM490Y SM 520 SMA490	SM 570 SMA570	HSB500	HSB600	HSB800
㉠ 휨 압축응력	40 이하	140	190	215	270	230	270	380
	40 초과 75 이하	130	175 (190)	200 (215)	260 (270)			
	75 초과 100이하			195 (215)	250 (270)			
전단응력	40 이하	80	110	125	155	135	155	220
	40 초과 75 이하	75	100 (110)	115 (125)	150 (155)			
	75 초과 100이하			115 (125)	145 (155)			
지압응력 (감판과 감판 사이)	40 이하	210	285	325	405	345	405	570
	40 초과 75 이하	195	265 (285)	300 (325)	390 (405)			
	75 초과 100이하			295 (325)	375 (405)			

※ TMC 강재일 경우에는 ()안의 값을 적용한다.

압축플랜지가 콘크리트 바닥판 등에 직접 고정되어 있는 경우, 상자형 단면, π 형 단면과 같이
휨자굴이 일어나기 어려운 경우 휨 압축응력 적용

• 항복 응력 (MPa)

(도.설.해 3.2.5)

강 증 응력 종류, 판두께(mm)		SS 400 SM 400 SMA400	SM 490	SM490Y SM 520 SMA490	SM 570 SMA570	HSB500	HSB600	HSB800
기준 항복점	40 이하	235	315	355	450	380	450	690
	40 초과 75 이하	215	295 (315)	335 (355)	430 (450)			
	75 초과 100이하			325 (355)	420 (450)			

※ TMC 강재일 경우에는 ()안의 값을 적용하고, HSB 600인 경우에는 []안의 값을 적용한다.

▪ 국부좌굴을 고려하지 않는 허용 축방향 압축응력 (MPa)

(199 도, 설, 해 3.3.2.1)

강종 판두께 (mm)	SS 400 SM 400 SMA400	SM 490 [SM490C-TMC]	SM490Y SM 520 SMA490 [SM520C-TMC]	SM 570 SMA570 [SM570-TMC]
40 이하	$140 : \frac{l}{r} \leq 18.6$ $140 - 0.82 \left(\frac{l}{r} - 18.6 \right) :$ $18.6 < \frac{l}{r} \leq 92.8$ $\frac{1,200,000}{6,700 + \left(\frac{l}{r} \right)^2} : 92.8 < \frac{l}{r}$	$190 : \frac{l}{r} \leq 16.0$ $190 - 1.29 \left(\frac{l}{r} - 16.0 \right) :$ $16.0 < \frac{l}{r} \leq 80.1$ $\frac{1,200,000}{5,000 + \left(\frac{l}{r} \right)^2} : 80.1 < \frac{l}{r}$	$215 : \frac{l}{r} \leq 15.1$ $215 - 1.55 \left(\frac{l}{r} - 15.1 \right) :$ $15.1 < \frac{l}{r} \leq 75.5$ $\frac{1,200,000}{4,400 + \left(\frac{l}{r} \right)^2} : 75.5 < \frac{l}{r}$	$270 : \frac{l}{r} \leq 13.4$ $270 - 2.19 \left(\frac{l}{r} - 13.4 \right) :$ $13.4 < \frac{l}{r} \leq 67.1$ $\frac{1,200,000}{3,500 + \left(\frac{l}{r} \right)^2} : 67.1 < \frac{l}{r}$
40 초과 75 이하	$130 : \frac{l}{r} \leq 19.4$ $130 - 0.73 \left(\frac{l}{r} - 19.4 \right) :$ $19.4 < \frac{l}{r} \leq 97$	$175 : \frac{l}{r} \leq 16.6$ $175 - 1.15 \left(\frac{l}{r} - 16.6 \right) :$ $16.6 < \frac{l}{r} \leq 82.8$	$200 : \frac{l}{r} \leq 15.5$ $200 - 1.4 \left(\frac{l}{r} - 15.5 \right) :$ $15.5 < \frac{l}{r} \leq 77.7$ $\frac{1,200,000}{4,700 + \left(\frac{l}{r} \right)^2} : 77.7 < \frac{l}{r}$	$260 : \frac{l}{r} \leq 13.7$ $260 - 2.07 \left(\frac{l}{r} - 13.7 \right) :$ $13.7 < \frac{l}{r} \leq 68.6$ $\frac{1,200,000}{3,600 + \left(\frac{l}{r} \right)^2} : 68.6 < \frac{l}{r}$
75 초과 100 이하	$195 : \frac{l}{r} \leq 15.8$ $195 - 1.35 \left(\frac{l}{r} - 15.8 \right) :$ $15.8 < \frac{l}{r} \leq 78.9$ $\frac{1,200,000}{7,300 + \left(\frac{l}{r} \right)^2} : 78.9 < \frac{l}{r}$	$250 : \frac{l}{r} \leq 13.9$ $250 - 1.96 \left(\frac{l}{r} - 13.9 \right) :$ $13.9 < \frac{l}{r} \leq 69.4$ $\frac{1,200,000}{5,300 + \left(\frac{l}{r} \right)^2} : 69.4 < \frac{l}{r}$		
비고	l : 부재의 유효 좌굴길이 (mm) r : 부재 총단면의 단면 회전 반경 (mm)			

※ TMC 강재일 경우에는 일반강재에 40이하 값을 사용함

강종 판두께 (mm)	HSB500	HSB600	HSB800	비 고
80 이하	$230 : \frac{l}{r} \leq 14.6$ $230 - 1.72 \left(\frac{l}{r} - 14.6 \right) :$ $14.6 < \frac{l}{r} \leq 73.0$ $\frac{1,200,000}{4,100 + \left(\frac{l}{r} \right)^2} : 73.0 < \frac{l}{r}$	$270 : \frac{l}{r} \leq 13.4$ $270 - 2.19 \left(\frac{l}{r} - 13.4 \right) :$ $13.4 < \frac{l}{r} \leq 67.1$ $\frac{1,200,000}{3,500 + \left(\frac{l}{r} \right)^2} : 67.1 < \frac{l}{r}$	$380 : \frac{l}{r} \leq 18.0$ $380 - 4.18 \left(\frac{l}{r} - 18.0 \right) :$ $18.0 < \frac{l}{r} \leq 54.2$ $\frac{1,200,000}{2,300 + \left(\frac{l}{r} \right)^2} : 54.2 < \frac{l}{r}$	
80 초과 100 이하				
비고	l : 부재의 유효 좌굴길이 (mm) r : 부재 총단면의 단면 회전 반경 (mm)			

• a) 이외의 허용 휨 압축 응력 (MPa)

(附 도, 설, 해 3.3.2.1)

강 종		SS 400 SM 400 SMA400	SM 490 [SM490C-TMC]	SM490Y SM 520 SMA490 [SM520C-TMC]	SM 570 SMA570 SM570C-TMC]		
		판두께 (mm)					
$\frac{A_w}{A_c} \leq 2$	40 이하	$140 : \frac{l}{b} \leq 4.6$ $140 - 2.49(\frac{l}{b} - 4.6) :$ $4.6 < \frac{l}{b} \leq 30$	$190 : \frac{l}{b} \leq 4.0$ $190 - 3.91(\frac{l}{b} - 4.0) :$ $4.0 < \frac{l}{b} \leq 30$	$215 : \frac{l}{b} \leq 3.8$ $215 - 4.69(\frac{l}{b} - 3.8) :$ $3.8 < \frac{l}{b} \leq 27$	$270 : \frac{l}{b} \leq 3.4$ $270 - 6.64(\frac{l}{b} - 3.4) :$ $3.4 < \frac{l}{b} \leq 25$		
		40 초과 75 이하	$130 : \frac{l}{b} \leq 4.9$	$175 : \frac{l}{b} \leq 4.1$	$200 : \frac{l}{b} \leq 3.9$ $200 - 4.24(\frac{l}{b} - 3.9) :$ $3.9 < \frac{l}{b} \leq 27$	$260 : \frac{l}{b} \leq 3.4$ $260 - 6.25(\frac{l}{b} - 3.4) :$ $3.4 < \frac{l}{b} \leq 25$	
			75 초과 100 이하	$130 - 2.21(\frac{l}{b} - 4.9) :$ $4.9 < \frac{l}{b} \leq 30$	$175 - 3.48(\frac{l}{b} - 4.1) :$ $4.1 < \frac{l}{b} \leq 30$	$195 : \frac{l}{b} \leq 3.9$ $195 - 4.07(\frac{l}{b} - 3.9) :$ $3.9 < \frac{l}{b} \leq 27$	$250 : \frac{l}{b} \leq 3.5$ $250 - 5.94(\frac{l}{b} - 3.5) :$ $3.5 < \frac{l}{b} \leq 25$
	$\frac{A_w}{A_c} > 2$	40 이하	$140 : \frac{l}{b} \leq \frac{9.3}{K}$ $140 - 1.24(K\frac{l}{b} - 9.3) :$ $\frac{9.3}{K} < \frac{l}{b} \leq 30$	$190 : \frac{l}{b} \leq \frac{8.0}{K}$ $190 - 1.95(K\frac{l}{b} - 8.0) :$ $\frac{8.0}{K} < \frac{l}{b} \leq 30$	$215 : \frac{l}{b} \leq \frac{7.5}{K}$ $215 - 2.35(K\frac{l}{b} - 7.5) :$ $\frac{7.5}{K} < \frac{l}{b} \leq 27$	$270 : \frac{l}{b} \leq \frac{6.7}{K}$ $270 - 3.32(K\frac{l}{b} - 6.7) :$ $\frac{6.7}{K} < \frac{l}{b} \leq 25$	
			40 초과 75 이하	$130 : \frac{l}{b} \leq \frac{9.7}{K}$	$175 : \frac{l}{b} \leq \frac{8.3}{K}$	$200 : \frac{l}{b} \leq \frac{7.8}{K}$ $200 - 2.12(K\frac{l}{b} - 7.8) :$ $\frac{7.8}{K} < \frac{l}{b} \leq 27$	$260 : \frac{l}{b} \leq \frac{6.9}{K}$ $260 - 3.12(K\frac{l}{b} - 6.9) :$ $\frac{6.9}{K} < \frac{l}{b} \leq 25$
				75 초과 100 이하	$130 - 1.10(K\frac{l}{b} - 9.7) :$ $\frac{9.7}{K} < \frac{l}{b} \leq 30$	$175 - 1.74(K\frac{l}{b} - 8.3) :$ $\frac{8.3}{K} < \frac{l}{b} \leq 30$	$195 : \frac{l}{b} \leq \frac{7.9}{K}$ $195 - 2.04(K\frac{l}{b} - 7.9) :$ $\frac{7.9}{K} < \frac{l}{b} \leq 27$
비 고		A_w : 복부판의 총 단면적 (mm ²) A_c : 압축플랜지의 총단면적 (mm ²) l : 압축플랜지의 고정점간의 거리 (mm) b : 압축플랜지의 폭 (mm) $K : \sqrt{3 + \frac{A_s}{2A_c}}$					

※ TMC 강재일 경우에는 ()안의 값을 적용한다.

강 종		HSB500	HSB600	HSB800	비 고
판두께 (mm)					
$\frac{A_w}{A_c} \leq 2$	100 이하	$230 : \frac{l}{b} \leq 3.6$ $230 - 5.19(\frac{l}{b} - 3.6) :$ $3.6 < \frac{l}{b} \leq 27$	$270 : \frac{l}{b} \leq 3.4$ $270 - 6.64(\frac{l}{b} - 3.4) :$ $3.4 < \frac{l}{b} \leq 25$	$380 : \frac{l}{b} \leq 5.4$ $380 - 12.63(\frac{l}{b} - 5.4) :$ $5.4 < \frac{l}{b} \leq 19$	
$\frac{A_w}{A_c} > 2$	100 이하	$230 : \frac{l}{b} \leq \frac{7.3}{K}$ $230 - 2.60(K\frac{l}{b} - 7.3) :$ $\frac{7.3}{K} < \frac{l}{b} \leq 27$	$270 : \frac{l}{b} \leq \frac{6.7}{K}$ $270 - 3.32(K\frac{l}{b} - 6.7) :$ $\frac{6.7}{K} < \frac{l}{b} \leq 25$	$380 : \frac{l}{b} \leq \frac{10.8}{K}$ $380 - 6.13(K\frac{l}{b} - 10.8) :$ $\frac{10.8}{K} < \frac{l}{b} \leq 19$	
비 고		A_w : 복부판의 총 단면적 (mm^2) A_c : 압축플랜지의 총단면적 (mm^2) l : 압축플랜지의 고정점간의 거리 (mm) b : 압축플랜지의 폭 (mm) $K : \sqrt{3 + \frac{A_w}{2A_c}}$			

• 강재 주거더의 허용응력 증가율

(도.설.해 3.9.3.1)

하중의 조합			증 가 율 (%)	
			정의 휨모멘트를 받는 부분	부의 휨모멘트를 받는 부분
1	크리프의 영향과 건조수축의 영향을 제외한 주하중		0	0
2	주 하 중	압 축 연	15	0
		인 장 연	0	0
3	주하중 + 바닥판 콘크리트와 강재 주거더와의 온도차	압 축 연	30	15
		인 장 연	15	15
4	가설시 하중	압 축 연	25	25
		인 장 연	25	25

• 마찰 이음용 고장력 볼트 허용력 (kN) (1볼트 1마찰면 마다)

(도.설.해 3.3.2.3)

나사호칭	볼트의 등급	F 8 T	F 10 T	S 10 T	F 13 T	S 13 T
M 20		31	39	39	50	50
M 22		39	48	48	63	63
M 24		45	56	56	73	73
M 27		58	73	73	-	-
M 30		71	89	89	-	-

② 바닥판 콘크리트 (☞ 도.설.해 3.9.2.7, 도.설.해 3.9.2.8, 도.설.해 4.2.3, 도.설.해 4.6.3.3)

콘크리트 설계 기준강도 (f_{ck})	27.0	MPa
콘크리트 탄성계수 (E_c)	26,702	MPa
전단 탄성계수 (G_c)	11,444	MPa
탄성계수비 (n)	7	
바닥판 콘크리트와 강재 주거더와의 온도차	10	℃
바닥판 콘크리트와 강재의 선팅창계수 (α)	0.000012	
건조수축 계수 (ε_s)	0.000270	
CREEP 계수 (ϕ_2)	$\phi_2 = 2\phi_1$: 4	

③ 바닥판 철근

철근 설계 항복강도 (f_y)	400	MPa
철근 탄성계수 (E_s)	200,000	MPa
허용압축응력 (f_{ca})	180	MPa
허용인장응력 (f_{ta})	160	MPa

2) 하 중 조 건

(1) 고 정 하 중

(☞ 도.설.해 2.1.2)

- ① 철근 콘크리트 : 25.000 kN/m³
- ② 무근 콘크리트 : 23.500 kN/m³
- ③ 강 재 : 78.500 kN/m³
- ④ 포장 콘크리트 : 23.000 kN/m³

(2) 활 하 중

(☞ 도.설.해 2.1.3)

① 설계 차선수 산정

$$W_0 = 9.000 \text{ m}, N = 2 \text{ 차로}$$

$$W = 9.000 / 2 = 4.500 \text{ m} > 3.600 \text{ m}$$

∴ 설계 차로폭 3.600m마다 2차로 연속으로 재하 → 양방향 총 4차선

② 1등급 교량으로서 DB-24 및 DL-24 하중을 적용한다.

▪ DB-24 하중

- 전륜하중 : $P_f = 24.000$ kN
- 후륜하중 : $P_r = 96.000$ kN

▪ DL-24 하중

- 차로당 등분포 하중 : $W_l = 12.700$ kN/m
- 모멘트 계산시 집중하중 : $P_m = 108.000$ kN
- 전단력 계산시 집중하중 : $P_s = 156.000$ kN

③ 충격 계 수

$$1,6\text{경간 } i = 15 / (40 + L) = 0.188 < 0.300 \therefore i = 0.188$$

$$2-5\text{경간 } i = 15 / (40 + L) = 0.167 < 0.300 \therefore i = 0.167$$

(3) 콘크리트의 Creep와 건조수축의 영향

- 철근 콘크리트의 바닥판의 Creep와 건조수축의 영향에 대한 단면력을 검토한다.

(4) 지점침하에 의한 영향

- 각 지점에서 발생할 수 있는 부등침하의 발생을 가정하여 가장 불리한 단면력을 산정한다.

(5) 온도변화에 대한 영향

- 바닥판과 주형의 온도차 발생시 생기는 단면력 및 응력을 산정하고 이때의 온도 변화는 직선변화 한다고 가정한다.

3) 설 계 방 법

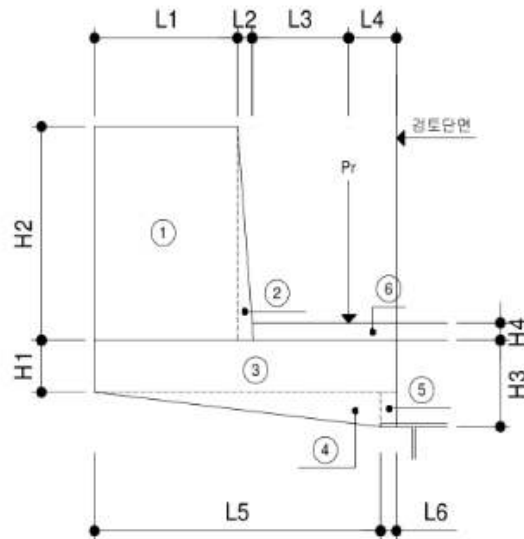
- (1) 바 닥 판 : 강도설계법
- (2) Steel Box Girder : 허용응력 설계법

4) 참 고 문 헌

- (1) 도로교 설계기준 (2010)
- (2) 콘크리트 구조기준(2012)
- (3) 도로설계 편람 (2008)
- (4) 도로설계 요령 (2009)
- (5) 강도로교 상세부 설계지침 (2006)

1. 바닥판설계

1-1. 캔틸레버부



콘크리트 단위중량	: 25.000 kN/m³	H1 =	0.150 m	L1 =	0.450 m
포장 단위중량	: 23.000 kN/m³	H2 =	0.618 m	L2 =	0.050 m
설계 속도	80.000 km/h	H3 =	0.250 m	L3 =	0.300 m
트럭의 1후륜하중 (Pr)	96.000 kN	H4 =	0.050 m	L4 =	0.150 m
곡선 반경(R)	∞ m	L5 =	0.900 m	L6 =	0.050 m

가) 고정하중

NO.	작용 하중 (kN)	거리 (m)	모멘트(kN · m)
1	$0.618 \times 0.45 \times 25 = 6.953$	0.725	5.041
2	$\frac{1}{2} \times 0.618 \times 0.05 \times 25 = 0.386$	0.483	0.187
3	$0.95 \times 0.15 \times 25 = 25.143$	0.475	11.943
4	$\frac{1}{2} \times 0.9 \times 0.1 \times 25 = 1.125$	0.350	0.394
5	$0.1 \times 0.05 \times 25 = 0.125$	0.025	0.003
6	$0.45 \times 0.05 \times 23 = 0.518$	0.225	0.116
TOTAL	34.249		17.683

$$\therefore M_d = 17.683 \text{ kN} \cdot \text{m}$$

나) 활하중 (DB-24 : $P_r = 96 \text{ kN}$)

윤하중 분포폭 (도.설 3.6.1.4)

$$E = 0.8 \cdot X + 1.14 = 0.8 \times 0.15 + 1.14 = 1.26 \text{ m} \quad \text{여기서, } X = 0.150 \text{ m}$$

충격계수 (도.설 2.1.4)

$$i = 15 / (40 + L) = 15 / (40 + 0.15) = 0.374 > 0.3 \quad \therefore i = 0.3$$

$$Ml+i = P_r / E \cdot X \cdot (1 + i) = (96 / 1.26) \times 0.15 \times (1 + 0.3) = 14.857 \text{ kN} \cdot \text{m/m}$$

다) 차량 충돌 하중 (도.설.해 2.4.3.5)

수평충돌력 H 는 노면상 1.0m 높이에 교축을 따라 1.0m마다 작용시

$$H = (V/60)^2 \times 7.5 + 2.5 = (80/60)^2 \times 7.5 + 2.5 = 15.833 \text{ kN/m} \quad h = 1.000 \text{ m}$$

$$Mco = 15.833 \times 1.000 = 15.833 \text{ kN} \cdot \text{m/m}$$

라) 풍하중

$$P_w = 3.0 \text{ kN/m}^2 \times 1.368 \text{ m} = 4.104 \text{ kN/m}$$

$$M_w = 4.104 \text{ kN/m} \times 0.859 \text{ m} = 3.525 \text{ kN} \cdot \text{m/m}$$

마) 하중 조합 (도.설 2.2.3.2)

계수 모멘트

$$\begin{aligned} \textcircled{1} \quad Mu1 &= 1.3 \quad Md + 2.15 \quad Ml+i \\ &= 1.3 \times 17.683 + 2.15 \times 14.857 &= 54.931 \text{ kN} \cdot \text{m/m} \end{aligned}$$

$$\begin{aligned} \textcircled{2} \quad Mu2 &= 1.3 \quad Md + 1.3 \quad Ml+i + 1.3 \quad Mco \\ &= 1.3 \times 17.683 + 1.3 \times 14.857 + 1.3 \times 15.833 &= 62.886 \text{ kN} \cdot \text{m/m} \end{aligned}$$

$$\begin{aligned} \textcircled{3} \quad Mu3 &= 1.3 \quad Md + 1.3 \quad Ml+i + 0.65 \quad Mw \\ &= 1.3 \times 17.683 + 1.3 \times 14.857 + 0.65 \times 3.525 &= 44.594 \text{ kN} \cdot \text{m/m} \end{aligned}$$

$$\begin{aligned} \textcircled{4} \quad Mu4 &= 1.2 \quad Md + 1.2 \quad Mw + 1.2 \quad Mco \\ &= 1.2 \times 17.683 + 1.2 \times 3.525 + 1.2 \times 15.833 &= 44.450 \text{ kN} \cdot \text{m/m} \end{aligned}$$

$$\begin{aligned} \textcircled{5} \quad Mu5 &= 1.3 \quad Md + 1.3 \quad Mw \\ &= 1.3 \times 17.683 + 1.3 \times 3.525 &= 27.571 \text{ kN} \cdot \text{m/m} \end{aligned}$$

사용 모멘트

$$\begin{aligned} M &= 1.0 \quad Md + 1.0 \quad Ml+i + 0.3 \quad Mw \\ &= 1.0 \times 17.683 + 1.0 \times 14.857 + 0.3 \times 3.525 &= 33.598 \text{ kN} \cdot \text{m/m} \end{aligned}$$

바) 바닥판의 최소 두께 ($X \leq 0.25$ 인 경우) (콘.설 3.6.1.5)

$$h_{min} = (280 \cdot L + 180) : \{(280 \times 0.15) + 180\} = 222.0 \text{ mm}$$

$$h_{use} = 250.0 \text{ mm} > 222.0 \text{ mm} \quad \text{O.K!!}$$

사) 단면검토

◀ 철근량 산정

① 캔틸레버부

[DESIGN CONDITION]

$$f_{ck} = 27 \text{ MPa} \quad f_y = 400 \text{ MPa}$$

$$M_u = 62.886 \text{ kN} \cdot \text{m}$$

$$b = 1000 \text{ mm} \quad h = 250.0 \text{ mm}$$

$$d' = 40 \text{ mm} \quad d = 210.0 \text{ mm}$$

$$\phi(\text{Bending}) = 0.85 \quad \beta_1 = 0.85$$

[Req'd d & As] (콘.설 6.3.2)

$$a = A_s \times f_y / (0.85 \times f_{ck} \times b) = 0.0174 A_s = 27.692 \text{ mm}$$

$$M_u = \phi \times A_s \times f_y \times (d - a/2) = -3.0 A_s^2 + 71400 A_s$$

$$= 62886000$$

$$\epsilon_t = 0.003 \times (H - a/\beta_1 - D_{c_min}) / (a/\beta_1) = 0.01634 > 0.004$$

O.K.!!

$$0.005 < \epsilon_t \quad \phi_f = 0.850$$

$$\therefore \text{Req'd } A_s = 915.5 \text{ mm}^2$$

$$\text{Min. } A_s = \text{Req'd } A_s \times 4/3 = 1220.7 \text{ mm}^2$$

$$\text{Min. } A_s = 0.002 \times b \times d = 420.0 \text{ mm}^2$$

$$\text{Min. } A_s = 1.4/f_y \times b \times d = 735.0 \text{ mm}^2$$

$$\text{Min. } A_s = 0.25 \sqrt{f_{ck}} / f_y \times b \times d = 682.0 \text{ mm}^2$$

$$\text{USE } H 16 @ 125 = 1588.8 \text{ mm}^2$$

$$A_{use} = 1588.8 \text{ mm}^2$$

O.K. !!

[RE-BAR RATIO CHECK]

$$P = A_s / (b \times d) = 0.00757 < P_{max} = 0.75 \times p_b = 0.0219 \quad \text{O.K.!!}$$

[DESIGN MOMENT CHECK]

$$\text{Max. } c = 0.75 \times 600 / (600 + f_y) \times i = 94.500 \text{ mm} > c = a/0.85 = 32.578 \text{ mm}$$

$$\text{Max. } a = 0.85 \times c = 80.325 \text{ mm} > a = f_y \times A_s / (0.85 \times f_{ck} \times b) = 27.692 \text{ mm}$$

$$j d = d - a/2 = 196.154 \text{ mm}$$

$$C = 0.85 \times f_{ck} \times a \times b = 635.520 \text{ kN} \quad T = f_y \times A_s = 635.520 \text{ kN}$$

$$\phi M_n = \phi f_y \times A_s \times j d = 105.961 \text{ kN} \cdot \text{m} > M_u = 62.886 \text{ kN} \cdot \text{m} \quad \text{O.K.}$$

아) 사용성(균열) 검토

$$M_{max} = 33.598 \text{ kN} \cdot \text{m/m}$$

$$\text{탄성계수비}(n) = 7$$

$$\text{철근비}(\rho) = A_s / b d = 1588.8 / 1000 \times 210 = 0.0076$$

$$\text{중립축}(k) = -np + \sqrt{\{(np)^2 + 2np\}} = -0.0532 + \sqrt{\{(0.0532)^2 + 2 \times 0.0532\}} = 0.277$$

$$\text{중립축 거리}(x) = k \times d = 0.277 \times 210 = 58.170 \text{ mm}$$

$$j = 1 - (k / 3) = 1 - (0.277) / 3 = 0.908$$

$$\begin{aligned} f_{smax} &= \frac{M_{max}}{\rho b j d^2} = \frac{33.598 \times 1000000}{0.0076 \times 1000 \times 0.908 \times 210^2} \\ &= 110.442 \text{ MPa} < 0.6 f_y = 240.000 \text{ MPa} \quad \text{O.K!!} \end{aligned}$$

$$\text{최소두께}(C_c) = d' - \text{철근직경} / 2 = 40 - 16 / 2 = 32.00 \text{ mm}$$

$$\text{인장연단폭}(S_1) = 375 (210 / f_s) - 2.5C_c = 375 (210 / 110.442) - 2.5 \times 32 = 611.794 \text{ mm}$$

$$\text{인장연단폭}(S_2) = 300 (210 / f_s) = 300 (210 / 110.442) = 570.435 \text{ mm}$$

$$\text{철근 소요중심간격}(S_a) = \text{Min} (S_1, S_2) = 570.435 \text{ mm}$$

$$\text{철근 평균간격 } S = 125.0 \text{ mm} \leq 570.435 \text{ mm} \quad \text{O.K!!}$$

1-2. 중앙부

가) 고정하중

$$\begin{aligned}
 \text{철근콘크리트 : } & 0.250 \text{ m} \times 25.000 \text{ kN/m}^3 = 6.250 \text{ kN/m}^2 \\
 \text{포장 : } & 0.050 \text{ m} \times 23.000 \text{ kN/m}^3 = 1.150 \text{ kN/m}^2 \\
 \hline
 W_d = & 7.400 \text{ kN/m}^2 \\
 \text{계산지간 } L = & 2.500 \text{ m} \quad \text{바닥판 지점의 수 } n = 4 \\
 M_d = (1/10) \cdot W_d \cdot L^2 = (1/10) \times 7.4 \times 2.5^2 & = 4.625 \text{ kN} \cdot \text{m}
 \end{aligned}$$

나) 활하중 (DB-24 : Pr = 96.0 kN)

충격계수 (☞ 도.설 2.1.4)

$$i = 15 / (40 + L) = 15 / (40 + 2.5) = 0.353 > 0.3 \quad \therefore i = 0.3$$

$$\begin{aligned}
 M_{I+i} &= ((L+0.6) / 9.6) \cdot Pr \cdot (1+i) = ((2.5+0.6) / 9.6) \times 96 \times (1+0.3) \\
 &= 40.300 \text{ kN} \cdot \text{m}
 \end{aligned}$$

연속바닥판이므로, (☞ 도.설 3.6.1.4)

$$M_{I+i} = 0.8 \times 40.3 = 32.240 \text{ kN} \cdot \text{m/m}$$

다) 하중 조합 (☞ 도.설 2.2.3.2)

① 계수 모멘트

$$\begin{aligned}
 M_{u1} &= 1.3 M_d + 2.15 M_{I+i} \\
 &= 1.3 \times 4.625 + 2.15 \times 32.24 = 75.329 \text{ kN} \cdot \text{m/m}
 \end{aligned}$$

① 사용 모멘트

$$\begin{aligned}
 M &= 1.0 M_d + 1.0 M_{I+i} \\
 &= 1.0 \times 4.625 + 1.0 \times 32.24 = 36.865 \text{ kN} \cdot \text{m/m}
 \end{aligned}$$

라) 바닥판의 최소 두께 (☞ 도.설 3.6.1.5)

$$h_{min} = (30 \cdot L + 130) = \{(30 \times 2.5) + 130\} = 205.0 \text{ mm}$$

$$h_{use} = 250.0 \text{ mm} > 220.0 \text{ mm} \quad \mathbf{O.K!!}$$

마) 단면검토

◀ 철근량 산정

① 캔틸레버부

[DESIGN CONDITION]

$$f_{ck} = 27 \text{ MPa} \quad f_y = 400 \text{ MPa}$$

$$M_u = 75.329 \text{ kN} \cdot \text{m}$$

$$b = 1000 \text{ mm} \quad h = 250 \text{ mm}$$

$$d' = 40 \text{ mm} \quad d = 210 \text{ mm}$$

$$\phi(\text{Bending}) = 0.85 \quad \beta_1 = 0.85$$

[Req'd d & As]

(콘.설 6.3.2)

$$\begin{aligned}
 a &= A_s \times f_y / (0.85 \times f_{ck} \times b) &= 0.0174 A_s &= 27.692 \text{ mm} \\
 M_u &= \Phi \times A_s \times f_y \times (d - a/2) &= -3.0 A_s^2 + 71400 A_s \\
 & &= 75329000 \\
 \epsilon_t &= 0.003 \times (H - a/\beta_1 - D_{c_min}) / (a/\beta_1) &= 0.01634 > 0.004 \\
 & & & \text{O.K.!!} \\
 0.005 &< \epsilon_t &\phi_f &= 0.850
 \end{aligned}$$

$$\begin{aligned}
 \therefore \text{Req'd } A_s &= 1105.8 \text{ mm}^2 \\
 \text{Min. } A_s &= \text{Req'd } A_s \times 4/3 &= 1474.4 \text{ mm}^2 \\
 \text{Min. } A_s &= 0.002 \times b \times d &= 420.0 \text{ mm}^2 \\
 \text{Min. } A_s &= 1.4/f_y \times b \times d &= 735.0 \text{ mm}^2 \\
 \text{Min. } A_s &= 0.25 \sqrt{f_{ck}} / f_y \times b \times d &= 682.0 \text{ mm}^2 \\
 \text{USE } H 16 @ 125 & &= 1588.8 \text{ mm}^2 \\
 A_{s\text{use}} &= 1588.8 \text{ mm}^2
 \end{aligned}$$

O.K. !!

[RE-BAR RATIO CHECK]

$$P = A_s / (b \times d) = 0.0076 < P_{\max} = 0.75 \times p_b = 0.0219 \quad \text{O.K.!!}$$

[DESIGN MOMENT CHECK]

$$\begin{aligned}
 \text{Max. } c &= 0.75 \times 600 / (600 + f_y) \times d = 94.500 \text{ mm} > c = a/0.85 = 32.578 \text{ mm} \\
 \text{Max. } a &= 0.85 \times c = 80.325 \text{ mm} > a = f_y \times A_s / (0.85 \times f_{ck} \times b) = 27.692 \text{ mm} \\
 j d &= d - a/2 = 196.154 \text{ mm} \\
 C &= 0.85 \times f_{ck} \times a \times b = 635.520 \text{ kN} \quad T = f_y \times A_s = 635.520 \text{ kN} \\
 \Phi M_n &= \Phi f_y \times A_s \times j d = 105.961 \text{ kN} \cdot \text{m} > M_u = 75.329 \text{ kN} \cdot \text{m} \quad \text{O.K.}
 \end{aligned}$$

아) 사용성(균열) 검토

$$M_{max} = 36.865 \text{ kN} \cdot \text{m/m}$$

$$\text{탄성계수비}(n) = E_s / E_c = 7$$

$$\text{철근비}(p) = A_s / b d = 1588.8 / 1000 \times 210 = 0.0076$$

$$\text{중립축}(k) = -np + \sqrt{\{(np)^2 + 2np\}} = -0.0532 + \sqrt{\{(0.0532)^2 + 2 \times 0.0532\}} = 0.277$$

$$\text{중립축 거리}(x) = k \times d = 0.277 \times 210 = 58.170 \text{ mm}$$

$$j = 1 - (k / 3) = 1 - (0.277 / 3) = 0.908$$

$$\begin{aligned} f_{smax} &= \frac{M_{max}}{pbjd^2} = \frac{36.865 \times 1000000}{0.0076 \times 1000 \times 0.908 \times 210^2} \\ &= 121.181 \text{ MPa} < 0.6 f_y = 240.000 \text{ MPa} \quad \mathbf{O.K!!} \end{aligned}$$

$$\text{최소두께}(C_c) = d' - \text{철근직경} / 2 = 40 - 16 / 2 = 32.00 \text{ mm}$$

$$\text{인장연단폭}(S1) = 375 (210 / f_s) - 2.5C_c = 375 (210 / 121.181) - 2.5 \times 32 = 548.604 \text{ mm}$$

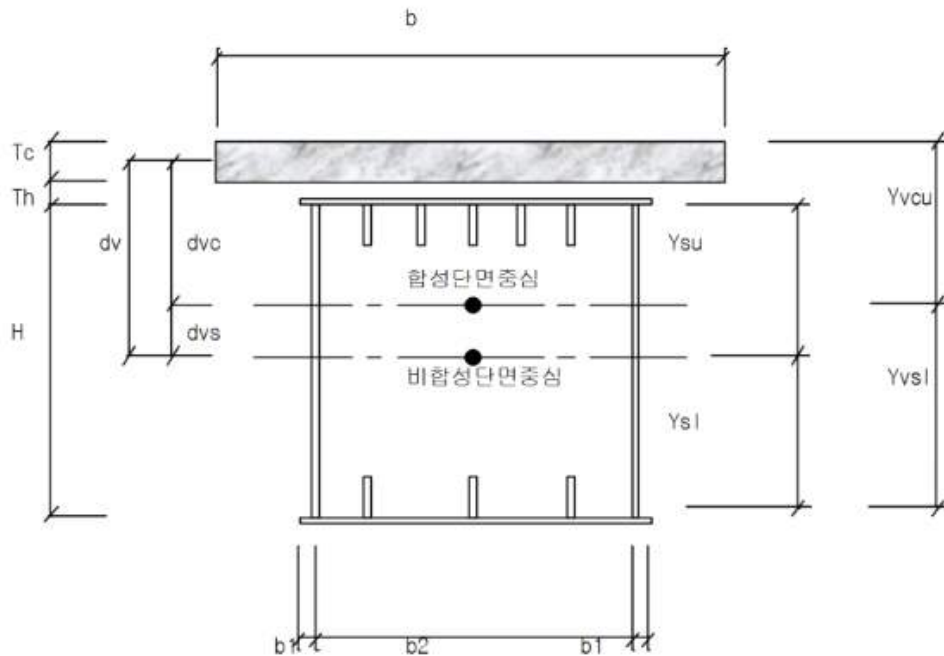
$$\text{인장연단폭}(S2) = 300 (210 / f_s) = 300 (210 / 121.181) = 519.883 \text{ mm}$$

$$\text{철근 소요중심간격}(S_a) = \text{Min} (S1, S2) = 519.883 \text{ mm}$$

$$\text{철근 평균간격 } S = 125.0 \text{ mm} \leq 519.883 \text{ mm} \quad \mathbf{O.K!!}$$

2. 단면상수 산정

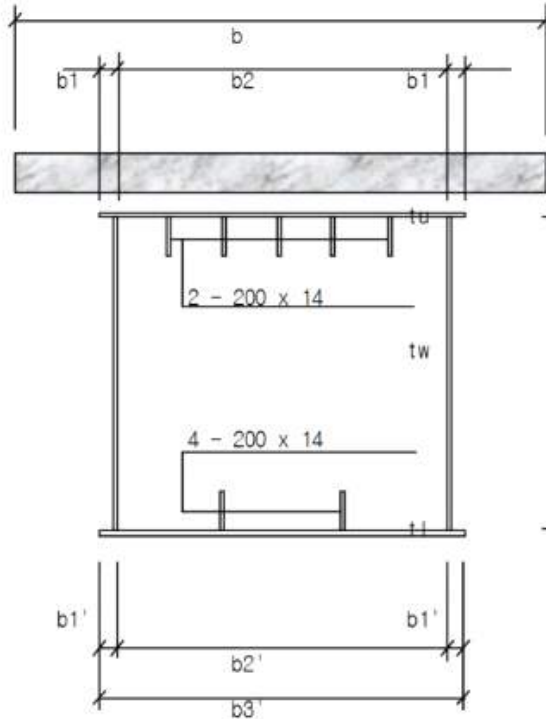
2-1. Steel Box 주형 단면상수 산정



주형의 탄성변형 및 부정정력을 계산하는 경우에는 정부모멘트에 관계없이 바닥판 콘크리트의 합성작용을 고려한다.

- b - 바닥판 콘크리트의 폭
- T_c - 바닥판 콘크리트의 두께
- T_h - 바닥판 콘크리트의 현치 높이
- N - 강재와 콘크리트의 탄성계수비 ($N = E_s / E_c$)
- A_c - 바닥판 콘크리트의 단면적
- A_v - 합성후 (강재+바닥판 콘크리트)의 환산단면적
- I_c - 바닥판 콘크리트의 단면2차모멘트
- d_v - 강재단면 도심에서 바닥판 도심까지의 거리
- d_{vc} - 합성단면 도심에서 바닥판 도심까지의 거리
- d_{vs} - 합성단면 도심에서 강재단면 도심까지의 거리 (합성전 및 합성후단면에서의 도심축 이동량)
- I_{33} - 합성전 강재단면의 3축방향(종방향) 단면2차모멘트
- I_{22} - 합성전 강재단면의 2축방향(횡방향) 단면2차모멘트
- I_{v33} - 합성후 강재단면의 3축방향(종방향) 단면2차모멘트
- I_{v22} - 합성후 강재단면의 2축방향(횡방향) 단면2차모멘트

- Section G1,3/1-1



b	=	6000.000	mm
b1	=	100.000	mm
b2	=	2500.000	mm
b3	=	2700.000	mm
b1'	=	100.000	mm
b2'	=	2500.000	mm
b3'	=	2700.000	mm
Tc	=	250.000	mm
Th	=	50.000	mm
H	=	3000.000	mm
n	=	8	

① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1510.00	81540000	123125400000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1400.00	7840000	10976000000	18666667
W E B	2 - 3000.0 X 14.0	84000				630000000000
LOWER RIB	4 - 200.0 X 14.0	11200	-1400.00	-15680000	21952000000	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1510.00	-81540000	123125400000	1800000
TOTAL		208800		-7840000	279178800000	630596000000

$$I_{s'} = \sum AsY^2 + \sum I_o$$

$$= 279178800000 + 630596000000 = 342238400000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -7840000 / 208800 = -37.55 \text{ mm}$$

$$I_{33} = I_{s'} - \sum As \times \delta s^2$$

$$= 342238400000 - 208800 \times (-37.548)^2 = 341944024521 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((3000 \times 14^3 / 12) + (3000 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 198335488000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 3000.000 + 20.000 / 2 + 20.000 / 2 = 3020.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 3020^2) / (2 \times 3020/14 + 2514/20 + 2514/20) \\
&= 337670203095 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

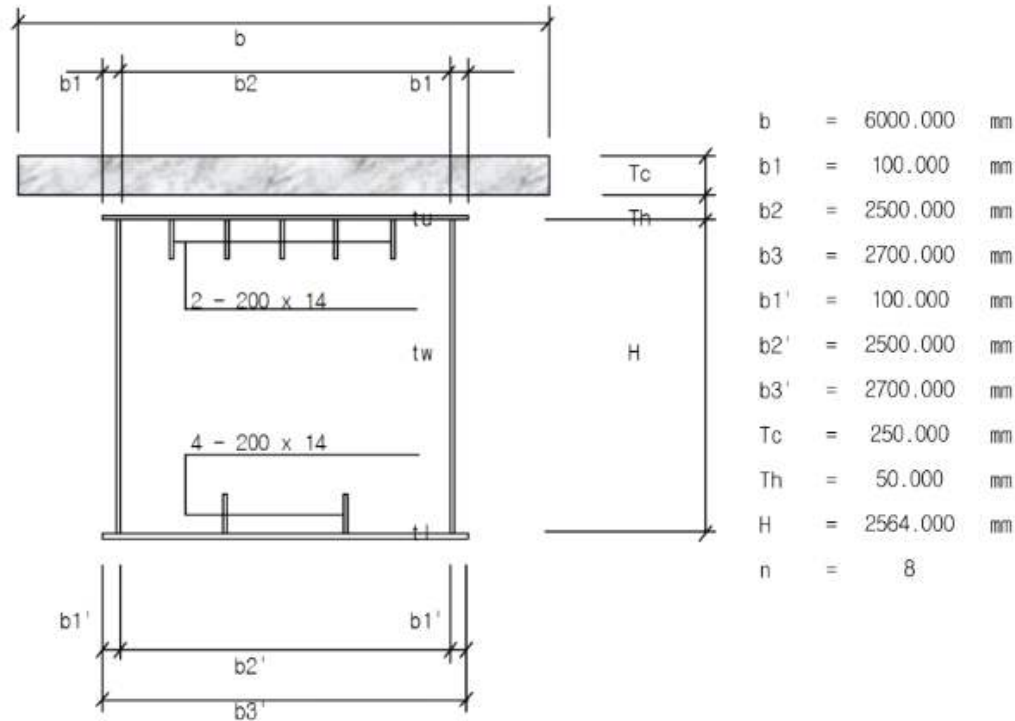
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 208800 + 1500000 / 8 = 396300 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 3000.000 / 2 - 37.548 + 50.000 + 250.000 / 2 = 1712.55 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1712.548 \times 208800 / 396300 = 902.30 \text{ mm} \\
dvs &= dv - dvc = 1712.548 - 902.296 = 810.25 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot dvs^2 + A_c / N \cdot dvc^2 \\
&= 341944024521 + 7812500000 / 8 + 208800 \times 810.25^2 \\
&\quad + 1500000 / 8 \times 902.296^2 = 632650372921 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 198335488000 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 760835488000 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 3020^2) / (2 \times 3020/14 + 2514/51.25 + 2514/20) \\
&= 380365591395 \text{ mm}^4
\end{aligned}$$

- Section G1,3/1-2



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1292.00	69768000	90140256000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1182.00	6619200	7823894400	18666667
W E B	2 - 2564.0 X 14.0	71792				39330625003
LOWER RIB	4 - 200.0 X 14.0	11200	-1182.00	-13238400	15647788800	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1292.00	-69768000	90140256000	1800000
TOTAL		196592		-6619200	203752195200	39390225003

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 203752195200 + 39390225003 = 243142420203 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -6619200 / 196592 = -33.67 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 243142420203 - 196592 \times (-33.670)^2 = 242919553511 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2564 \times 14^3 / 12) + (2564 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2$$

$$= 179046050411 \text{ mm}^4$$

- 비틀림 강성

$$I_{bk} = I_{22} + I_{33} / 2$$

$$= 179046050411 + 242919553511 / 2 = 2514.00 \text{ mm}^4$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2564.000 + 20.000 / 2 + 20.000 / 2 = 2584.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2584^2) / (2 \times 2584/14 + 2514/20 + 2514/20) \\
&= 272021841117 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

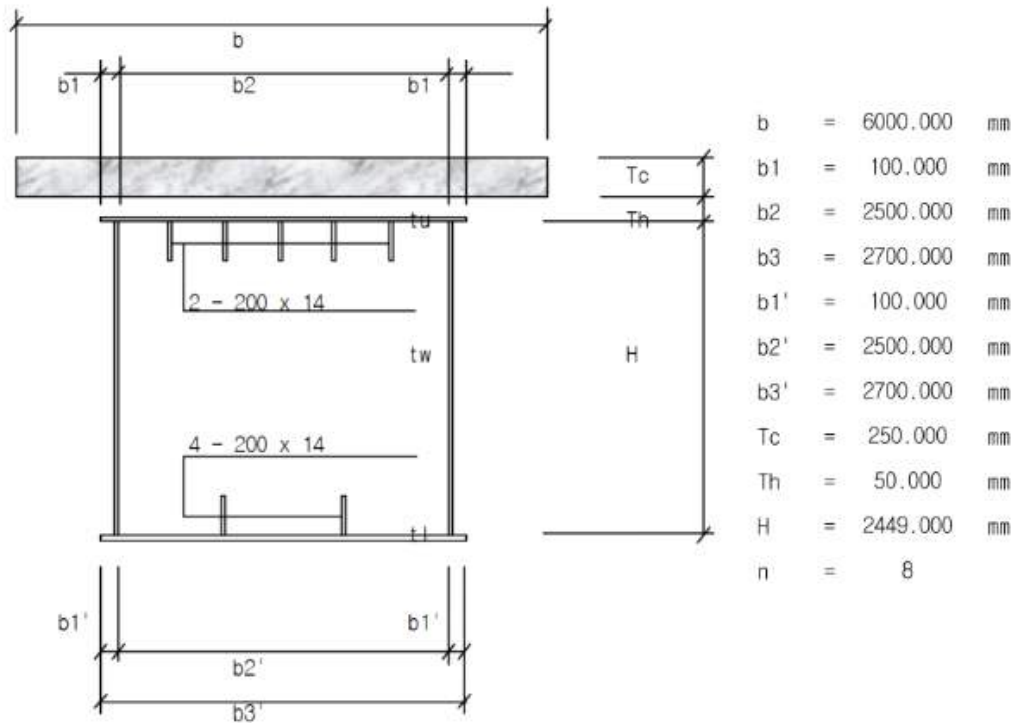
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 196592 + 1500000 / 8 = 384092 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2564.000 / 2 - -33.670 + 50.000 + 250.000 / 2 = 1490.67 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1490.670 \times 196592 / 384092 = 762.98 \text{ mm} \\
dvs &= dv - dvc = 1490.670 - 762.978 = 727.69 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 242919553511 + 7812500000 / 8 + 196592 \times 727.692^2 \\
&\quad + 1500000 / 8 \times 762.978^2 = 457148904129 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 179046050411 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 741546050411 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2584^2) / (2 \times 2584/14 + 2514/51.25 + 2514/20) \\
&= 310355381264 \text{ mm}^4
\end{aligned}$$

- Section G1,3/1-3



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1234.50	66663000	82295473500	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1124.50	6297200	7081201400	18666667
W E B	2 - 2449.0 X 14.0	68572				34272291314
LOWER RIB	4 - 200.0 X 14.0	11200	-1124.50	-12594400	14162402800	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1234.50	-66663000	82295473500	1800000
TOTAL		193372		-6297200	185834551200	34331891314

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 185834551200 + 34331891314 = 220166442514 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -6297200 / 193372 = -32.57 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 220166442514 - 193372 \times (-32.565)^2 = 219961372867 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2449 \times 14^3 / 12) + (2449 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 173958240037 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2449.000 + 20.000 / 2 + 20.000 / 2 = 2469.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2469^2) / (2 \times 2469/14 + 2514/20 + 2514/20) \\
&= 255101852344 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

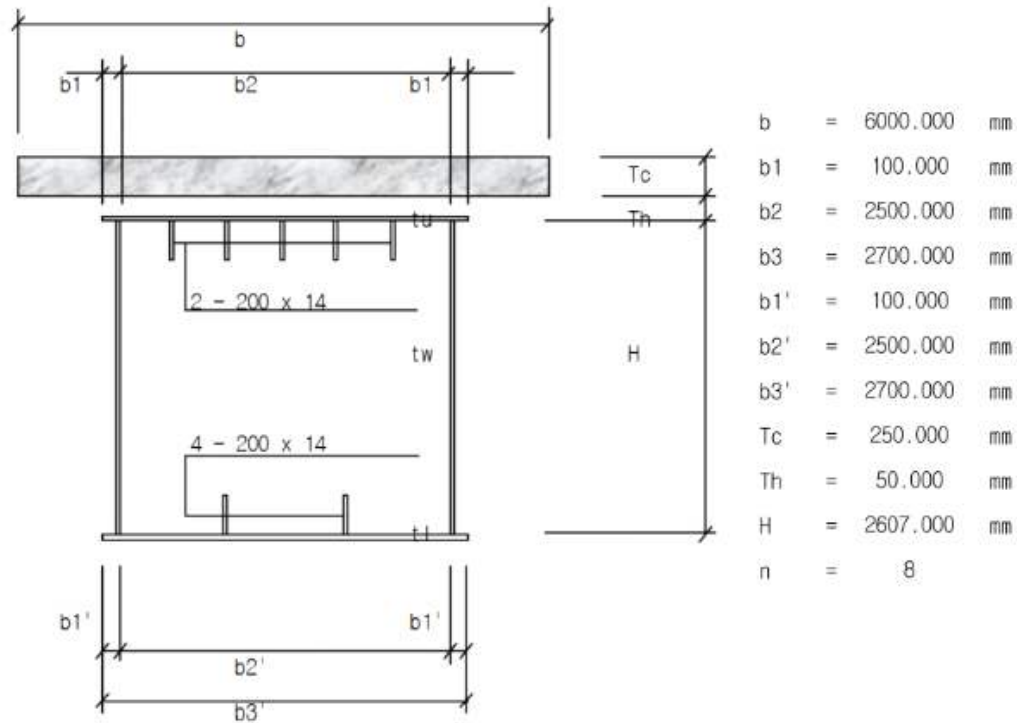
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 193372 + 1500000 / 8 = 380872 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2449.000 / 2 - 32.565 + 50.000 + 250.000 / 2 = 1432.07 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1432.065 \times 193372 / 380872 = 727.07 \text{ mm} \\
dvs &= dv - dvc = 1432.065 - 727.072 = 704.99 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot dvs^2 + A_c / N \cdot dvc^2 \\
&= 219961372867 + 7812500000 / 8 + 193372 \times 704.993^2 \\
&\quad + 1500000 / 8 \times 727.072^2 = 416165620122 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 173958240037 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 736458240037 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2469^2) / (2 \times 2469/14 + 2514/51.25 + 2514/20) \\
&= 292170690168 \text{ mm}^4
\end{aligned}$$

- Section G1,3/1-4



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1313.50	70929000	93165241500	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1203.50	6739600	8111108600	18666667
W E B	2 - 2607.0 X 14.0	72996				41342799267
LOWER RIB	4 - 200.0 X 14.0	11200	-1203.50	-13479200	16222217200	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1313.50	-70929000	93165241500	1800000
TOTAL		197796		-6739600	210663808800	41402399267

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 210663808800 + 41402399267 = 252066208067 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -6739600 / 197796 = -34.07 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 252066208067 - 197796 \times (-34.07)^2 = 251836566375 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times tl / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2607 \times 14^3 / 12) + (2607 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 180948449072 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2607.000 + 20.000 / 2 + 20.000 / 2 = 2627.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2627^2) / (2 \times 2627/14 + 2514/20 + 2514/20) \\
&= 278394652420 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 197796 + 1500000 / 8 = 385296 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2607.000 / 2 - 34.073 + 50.000 + 250.000 / 2 = 1512.57 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1512.573 \times 197796 / 385296 = 776.50 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 1512.573 - 776.496 = 736.08 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 251836566375 + 7812500000 / 8 + 197796 \times 736.077^2 \\
&\quad + 1500000 / 8 \times 776.496^2 = 473033375821 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 180948449072 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 743448449072 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2627^2) / (2 \times 2627/14 + 2514/51.25 + 2514/20) \\
&= 317188114571 \text{ mm}^4
\end{aligned}$$

Technical drawing of a reinforced concrete slab and its supporting frame. The drawing includes a plan view of the slab, a cross-section of the slab, and a plan view of the supporting frame.

Plan View of Slab: Shows dimensions b (total width), b_1 (width of the column strip), and b_2 (width of the middle strip).

Cross-section of Slab: Shows dimensions t_w (slab thickness), t_u (top reinforcement), and t_i (bottom reinforcement). The reinforcement is labeled as $2 - 200 \times 14$ and $4 - 200 \times 14$.

Plan View of Supporting Frame: Shows dimensions b_1' , b_2' , and b_3' .

b	=	6000.000	mm
b1	=	100.000	mm
b2	=	2500.000	mm
b3	=	2700.000	mm
b1'	=	100.000	mm
b2'	=	2500.000	mm
b3'	=	2700.000	mm
Tc	=	250.000	mm
Th	=	50.000	mm
H	=	2449.000	mm
n	=	8	

구분	규격				As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1	-	2700.0	X 20.0	54000	1234.50	66663000	82295473500	1800000
UPPER RIB	2	-	200.0	X 14.0	5600	1124.50	6297200	7081201400	18666667
W E B	2	-	2449.0	X 12.0	58776				29376249698
LOWER RIB	4	-	200.0	X 14.0	11200	-1124.50	-12594400	14162402800	37333333
LOWER FL.	1	-	2700.0	X 16.0	43200	-1232.50	-53244000	65623230000	921600
TOTAL					172776		7121800	169162307700	29434971298

$$\begin{aligned}
 I_{22} &= (b3^3 \times t_u / 12) + (b3^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((2449 \times 12^3 / 12) \\
 &\quad + (2449 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 151770961248 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2449.000 + 20.000 / 2 + 16.000 / 2 = 2467.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2467^2) / (2 \times 2467/12 + 2512/20 + 2512/16) \\
&= 221423713949 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 172776 + 1500000 / 8 = 360276 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2449.000 / 2 - 41.220 + 50.000 + 250.000 / 2 = 1358.28 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1358.280 \times 172776 / 360276 = 651.38 \text{ mm} \\
dvs &= dv - dvc = 1358.280 - 651.385 = 706.90 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 198303719503 + 7812500000 / 8 + 172776 \times 706.896^2 \\
&\quad + 1500000 / 8 \times 651.385^2 = 385173283873 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 151770961248 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 714270961248 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2467^2) / (2 \times 2467/12 + 2512/51.25 + 2512/16) \\
&= 248899945194 \text{ mm}^4
\end{aligned}$$

b	=	6000.000	mm
b1	=	100.000	mm
b2	=	2500.000	mm
b3	=	2700.000	mm
b1'	=	100.000	mm
b2'	=	2500.000	mm
b3'	=	2700.000	mm
Tc	=	250.000	mm
Th	=	50.000	mm
H	=	2406.000	mm
n	=	8	

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1213.00	65502000	79453926000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1103.00	6176800	6813010400	18666667
W E B	2 - 2406.0 X 12.0	57744				27855878832
LOWER RIB	4 - 200.0 X 14.0	11200	-1103.00	-12353600	13626020800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1211.00	-52315200	63353707200	921600
TOTAL		171744		7010000	163246664400	27914600432

$$\begin{aligned}
 I_{22} &= (b3^3 \times t_u / 12) + (b3^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((2406 \times 12^3 / 12) \\
 &\quad + (2406 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 150142931712 \text{ mm}^4
 \end{aligned}$$

- 비틀림 감성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500,000 + 12,000 / 2 \times 2 = 2512,00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2406.000 + 20.000 / 2 + 16.000 / 2 = 2424.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2424^2) / (2 \times 2424/12 + 2512/20 + 2512/16) \\
&= 216003452792 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

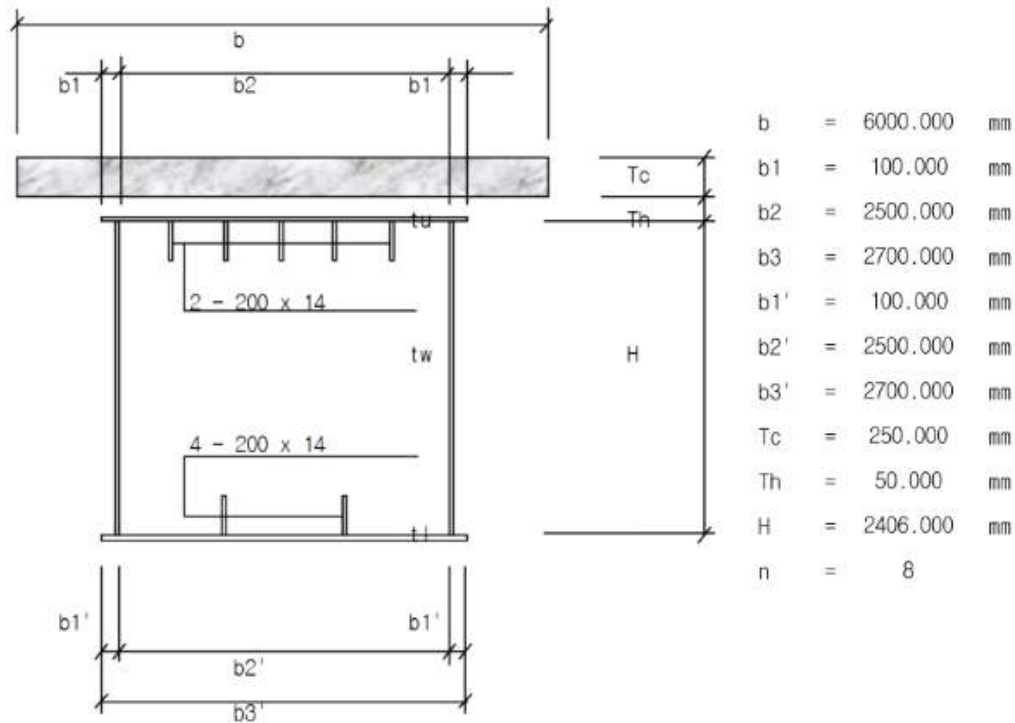
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 171744 + 1500000 / 8 = 359244 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2406.000 / 2 - 40.817 + 50.000 + 250.000 / 2 = 1337.18 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1337.183 \times 171744 / 359244 = 639.27 \text{ mm} \\
dvs &= dv - dvc = 1337.183 - 639.268 = 697.92 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 190875140717 + 7812500000 / 8 + 171744 \times 697.915^2 \\
&\quad + 1500000 / 8 \times 639.268^2 = 352130214033 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 150142931712 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 712642931712 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2424^2) / (2 \times 2424/12 + 2512/51.25 + 2512/16) \\
&= 243121988204 \text{ mm}^4
\end{aligned}$$

- Section G1,3/3-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	1211.00	52315200	63353707200	921600
UPPER RIB	2 - 200.0 X 14.0	5600	1103.00	6176800	6813010400	18666667
W E B	2 - 2406.0 X 12.0	57744				27855878832
LOWER RIB	4 - 200.0 X 14.0	11200	-1103.00	-12353600	13626020800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1211.00	-52315200	63353707200	921600
TOTAL		160944		-6176800	147146445600	27913722032

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 147146445600 + 27913722032 = 175060167632 \text{ mm}^4$$

$$\delta s = \frac{\sum AsY}{\sum As}$$

$$= \frac{-6176800}{160944} = -38.38 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 175060167632 - 160944 \times (-38.379)^2 = 174823110903 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((2406 \times 12^3 / 12) + (2406 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 143581931712 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2406.000 + 16.000 / 2 + 16.000 / 2 = 2422.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2422^2) / (2 \times 2422/12 + 2512/16 + 2512/16) \\
&= 206312130550 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

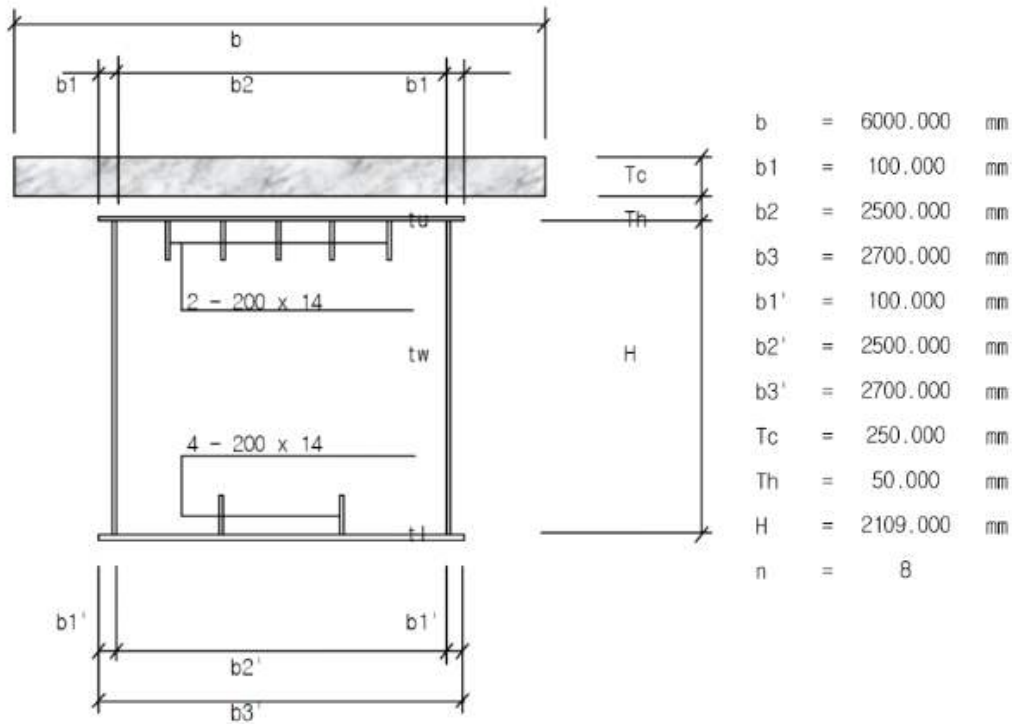
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 160944 + 1500000 / 8 = 348444 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 781250000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2406.000 / 2 - 38.379 + 50.000 + 250.000 / 2 = 1416.38 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1416.379 \times 160944 / 348444 = 654.22 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1416.379 - 654.216 = 762.16 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 174823110903 + 781250000 / 8 + 160944 \times 762.163^2 \\
&\quad + 1500000 / 8 \times 654.216^2 = 349540452422 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 143581931712 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 706081931712 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2422^2) / (2 \times 2422/12 + 2512/47.25 + 2512/16) \\
&= 241212018167 \quad \text{mm}^4
\end{aligned}$$

- Section G1.3/3-2



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	1062.50	45900000	48768750000	921600
UPPER RIB	2 - 200.0 X 14.0	5600	954.50	5345200	5101993400	18666667
W E B	2 - 2109.0 X 12.0	50616				18761162058
LOWER RIB	4 - 200.0 X 14.0	11200	-954.50	-10690400	10203986800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1062.50	-45900000	48768750000	921600
TOTAL		153816		-5345200	112843480200	18819005258

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 112843480200 + 18819005258 = 131662485458 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -5345200 / 153816 = -34.75 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 131662485458 - 153816 \times (-34.75)^2 = 131476736491 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((2109 \times 12^3 / 12) + (2109 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 132337169568 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
 Hk &= H + t_u / 2 + t_l / 2 \\
 &= 2109.000 + 16.000 / 2 + 16.000 / 2 = 2125.00 \text{ mm} \\
 K &= (4 \times b k^2 \times Hk^2) / (2 \times Hk / t_w + b k / t_u + b k / t_l) \\
 &= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/16 + 2512/16) \\
 &= 170581655276 \text{ mm}^4
 \end{aligned}$$

② 합성후 단면

$$\begin{aligned}
 A_c &= b \times T_c \\
 &= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
 A_v &= \sum A_s + A_c/N \\
 &= 153816 + 1500000 / 8 = 341316 \text{ mm}^2 \\
 I_c &= b \times T_c^3 / 12 \\
 &= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
 dv &= H / 2 - \delta s + T_h + T_c / 2 \\
 &= 2109.000 / 2 - -34.751 + 50.000 + 250.000 / 2 = 1264.25 \text{ mm} \\
 dvc &= dv \cdot \sum A_s / A_v \\
 &= 1264.251 \times 153816 / 341316 = 569.74 \text{ mm} \\
 dvs &= dv - dvc = 1264.251 - 569.742 = 694.51 \text{ mm} \\
 I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
 &= 131476736491 + 7812500000 / 8 + 153816 \times 694.509^2 \\
 &\quad + 1500000 / 8 \times 569.742^2 = 267508863487 \text{ mm}^4 \\
 I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
 &= 132337169568 + 6000.000^3 \\
 &\quad \times 250.000 / 12 / 8 = 694837169568 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
 t_{cu} &= t_u + T_c / N \\
 &= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
 K &= (4 \times b k^2 \times Hk^2) / (2 \times Hk / t_w + b k / t_{cu} + b k / t_l) \\
 &= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/47.25 + 2512/16) \\
 &= 201968417557 \text{ mm}^4
 \end{aligned}$$

Technical drawing of a bridge structure showing dimensions and material specifications. The drawing includes a plan view (top) and a side elevation view (bottom). The plan view shows a rectangular bridge deck with a total width b , divided into three sections: b_1 (left), b_2 (middle), and b_1 (right). The side elevation view shows the bridge structure with a total height H , divided into three sections: T_c (top), T_h (middle), and H (bottom). The side view also shows the bridge deck with a total width b , divided into three sections: b_1 (left), b_2 (middle), and b_1 (right). The side view also shows the bridge structure with a total height H , divided into three sections: T_c (top), T_h (middle), and H (bottom). The side view also shows the bridge structure with a total height H , divided into three sections: T_c (top), T_h (middle), and H (bottom).

b	$=$	6000.000	mm
b_1	$=$	100.000	mm
b_2	$=$	2500.000	mm
b_3	$=$	2700.000	mm
b_1'	$=$	100.000	mm
b_2'	$=$	2500.000	mm
b_3'	$=$	2700.000	mm
T_c	$=$	250.000	mm
T_h	$=$	50.000	mm
H	$=$	2109.000	mm
n	$=$	8	

구분	규격				As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1	-	2700.0	X 16.0	43200	1062.50	45900000	48768750000	921600
UPPER RIB	4	-	200.0	X 14.0	11200	954.50	10690400	10203986800	37333333
W E B	2	-	2109.0	X 12.0	50616				18761162058
LOWER RIB	4	-	200.0	X 14.0	11200	-954.50	-10690400	10203986800	37333333
LOWER FL.	1	-	2700.0	X 16.0	43200	-1062.50	-45900000	48768750000	921600
TOTAL					159416		0	117945473600	18837671925

$$\begin{aligned}
 I_{22} &= (b_3^3 \times t_u / 12) + (b_3^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((2109 \times 12^3 / 12) \\
 &\quad + (2109 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 132337169568 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2109.000 + 16.000 / 2 + 16.000 / 2 = 2125.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/16 + 2512/16) \\
&= 170581655276 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

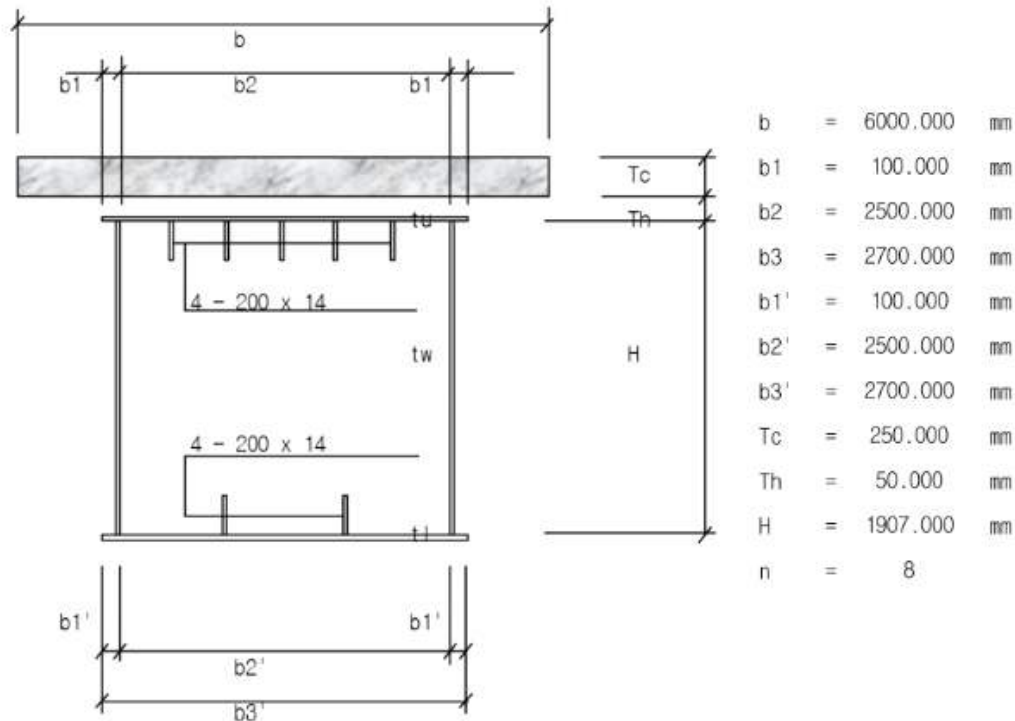
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 159416 + 1500000 / 8 = 346916 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2109.000 / 2 - 0.000 + 50.000 + 250.000 / 2 = 1229.50 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1229.500 \times 159416 / 346916 = 564.98 \text{ mm} \\
dvs &= dv - dvc = 1229.500 - 564.984 = 664.52 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot dvs^2 + A_c / N \cdot dvc^2 \\
&= 136783145525 + 7812500000 / 8 + 159416 \times 664.516^2 \\
&\quad + 1500000 / 8 \times 564.984^2 = 268006164249 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 132337169568 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 694837169568 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/47.25 + 2512/16) \\
&= 201968417557 \text{ mm}^4
\end{aligned}$$

- Section G1.3/4-2



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	961.50	41536800	39937633200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	853.50	9559200	8158777200	37333333
W E B	2 - 1907.0 X 12.0	45768				13870179286
LOWER RIB	4 - 200.0 X 14.0	11200	-853.50	-9559200	8158777200	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-961.50	-41536800	39937633200	921600
TOTAL		154568		0	96192820800	13946689153

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 96192820800 + 13946689153 = 110139509953 \text{ mm}^4$$

$$\delta s = \frac{\sum AsY}{\sum As}$$

$$= \frac{0}{154568} = 0.00 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 110139509953 - 154568 \times 0.00^2 = 110139509953 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times tl / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1907 \times 12^3 / 12) + (1907 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 124689216864 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1907.000 + 16.000 / 2 + 16.000 / 2 = 1923.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/16 + 2512/16) \\
&= 147104583084 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

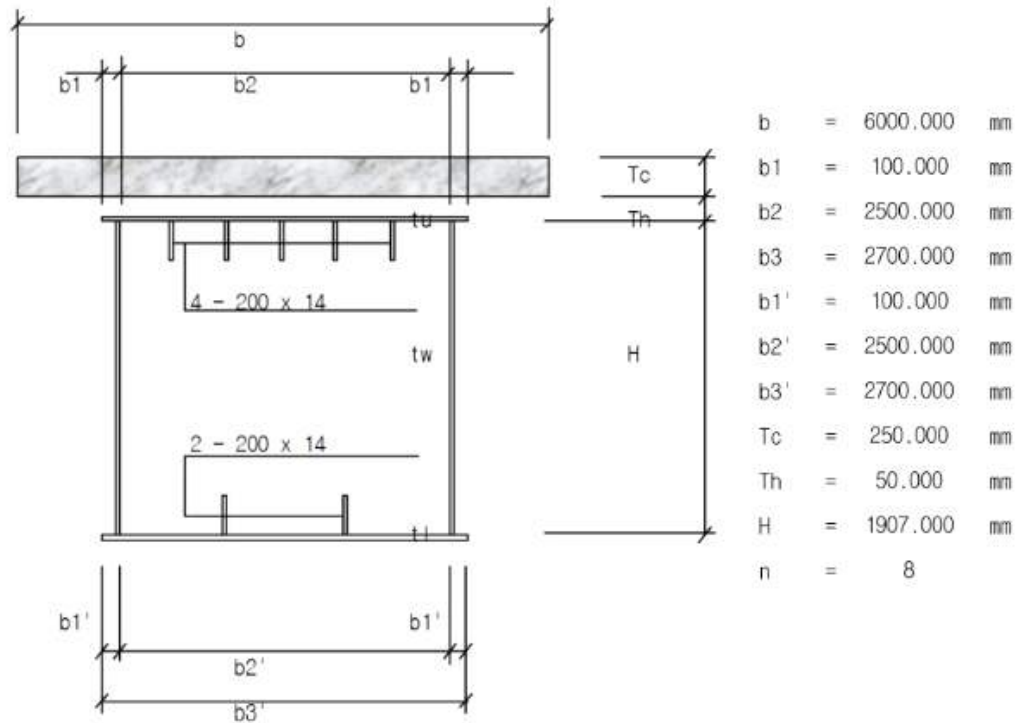
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 154568 + 1500000 / 8 = 342068 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1907.000 / 2 - 0.000 + 50.000 + 250.000 / 2 = 1128.50 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1128.500 \times 154568 / 342068 = 509.93 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 1128.500 - 509.928 = 618.57 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 110139509953 + 7812500000 / 8 + 154568 \times 618.572^2 \\
&\quad + 1500000 / 8 \times 509.928^2 = 219013611168 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 124689216864 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 687189216864 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/47.25 + 2512/16) \\
&= 175888800153 \text{ mm}^4
\end{aligned}$$

- Section G1.3/5-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	961.50	41536800	39937633200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	853.50	9559200	8158777200	37333333
W E B	2 - 1907.0 X 12.0	45768				13870179286
LOWER RIB	2 - 200.0 X 14.0	5600	-853.50	-4779600	4079388600	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-961.50	-41536800	39937633200	921600
TOTAL		148968		4779600	92113432200	13928022486

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 92113432200 + 13928022486 = 106041454686 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 4779600 / 148968 = 32.08 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 106041454686 - 148968 \times 32.08^2 = 105888102448 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1907 \times 12^3 / 12) + (1907 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 124689216864 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1907.000 + 16.000 / 2 + 16.000 / 2 = 1923.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/16 + 2512/16) \\
&= 147104583084 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

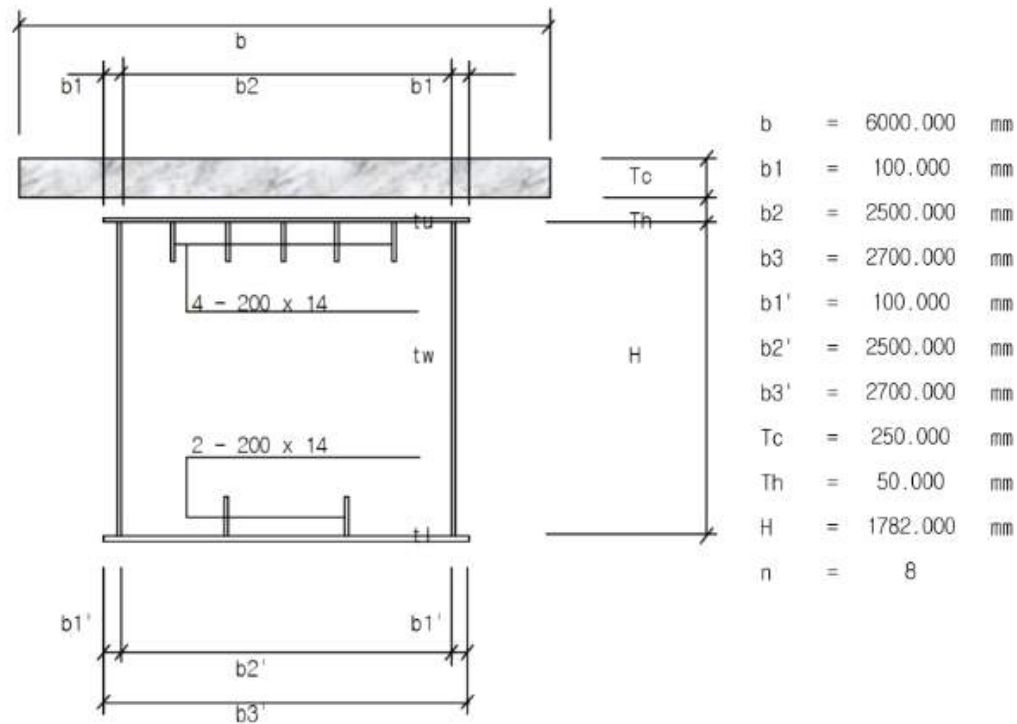
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 148968 + 1500000 / 8 = 336468 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1907.000 / 2 - 32.085 + 50.000 + 250.000 / 2 = 1096.42 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1096.415 \times 148968 / 336468 = 485.43 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1096.415 - 485.427 = 610.99 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 105888102448 + 7812500000 / 8 + 148968 \times 610.988^2 \\
&\quad + 1500000 / 8 \times 485.427^2 = 206657792320 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 124689216864 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 687189216864 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/47.25 + 2512/16) \\
&= 175888800153 \quad \text{mm}^4
\end{aligned}$$

- Section G1,3/5-2



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	899.00	38836800	34914283200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	791.00	8859200	7007627200	37333333
W E B	2 - 1782.0 X 12.0	42768				11317567536
LOWER RIB	2 - 200.0 X 14.0	5600	-791.00	-4429600	3503813600	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-899.00	-38836800	34914283200	921600
TOTAL		145968		4429600	80340007200	11375410736

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 80340007200 + 11375410736 = 91715417936 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 4429600 / 145968 = 30.35 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 91715417936 - 145968 \times 30.346^2 = 91580995623 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1782 \times 12^3 / 12) + (1782 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 119956572864 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1782.000 + 16.000 / 2 + 16.000 / 2 = 1798.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1798^2) / (2 \times 1798/12 + 2512/16 + 2512/16) \\
&= 132967683414 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

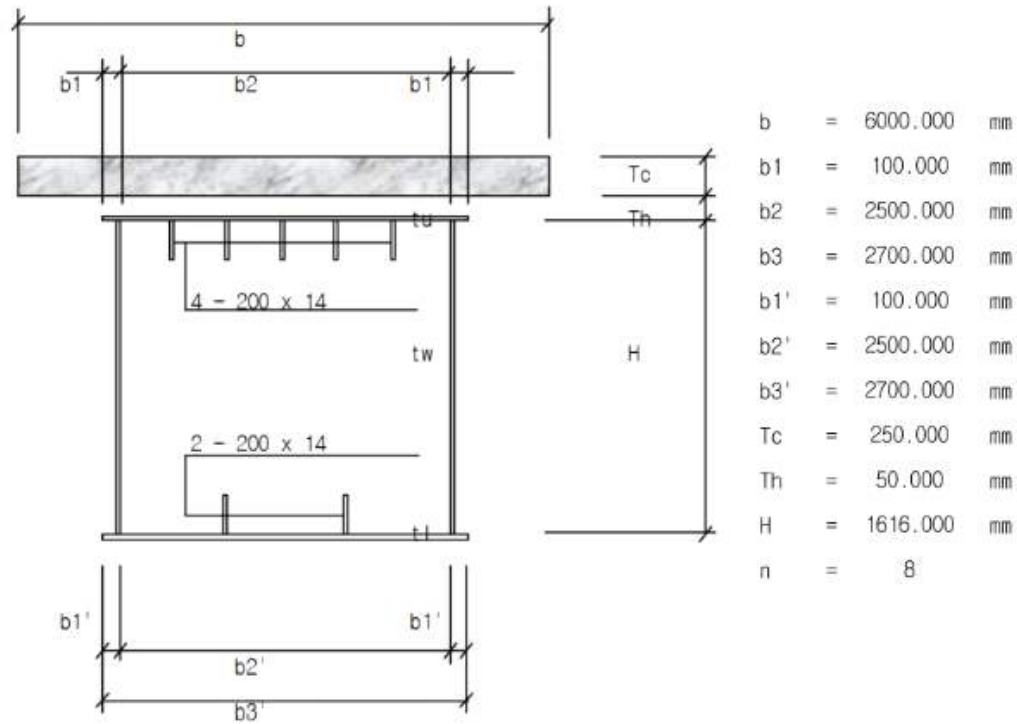
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 145968 + 1500000 / 8 = 333468 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 781250000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1782.000 / 2 - 30.346 + 50.000 + 250.000 / 2 = 1035.65 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1035.654 \times 145968 / 333468 = 453.33 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 1035.654 - 453.334 = 582.32 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 91580995623 + 781250000 / 8 + 145968 \times 582.320^2 \\
&\quad + 1500000 / 8 \times 453.334^2 = 180588190591 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119956572864 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 682456572864 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1798^2) / (2 \times 1798/12 + 2512/47.25 + 2512/16) \\
&= 160048888784 \text{ mm}^4
\end{aligned}$$

- Section G1,3/5-3



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	816.00	35251200	28764979200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	708.00	7929600	5614156800	37333333
W E B	2 - 1616.0 X 12.0	38784				8440225792
LOWER RIB	2 - 200.0 X 14.0	5600	-708.00	-3964800	2807078400	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-816.00	-35251200	28764979200	921600
TOTAL		141984		3964800	65951193600	8498068992

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 65951193600 + 8498068992 = 74449262592 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3964800 / 141984 = 27.92 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 74449262592 - 141984 \times 27.92^2 = 74338548434 \text{ mm}^4$$

$$I_{22} = (b3^3 \times t_u / 12) + (b3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1616 \times 12^3 / 12) + (1616 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 113671621632 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1616.000 + 16.000 / 2 + 16.000 / 2 = 1632.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1632^2) / (2 \times 1632/12 + 2512/16 + 2512/16) \\
&= 114720743843 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

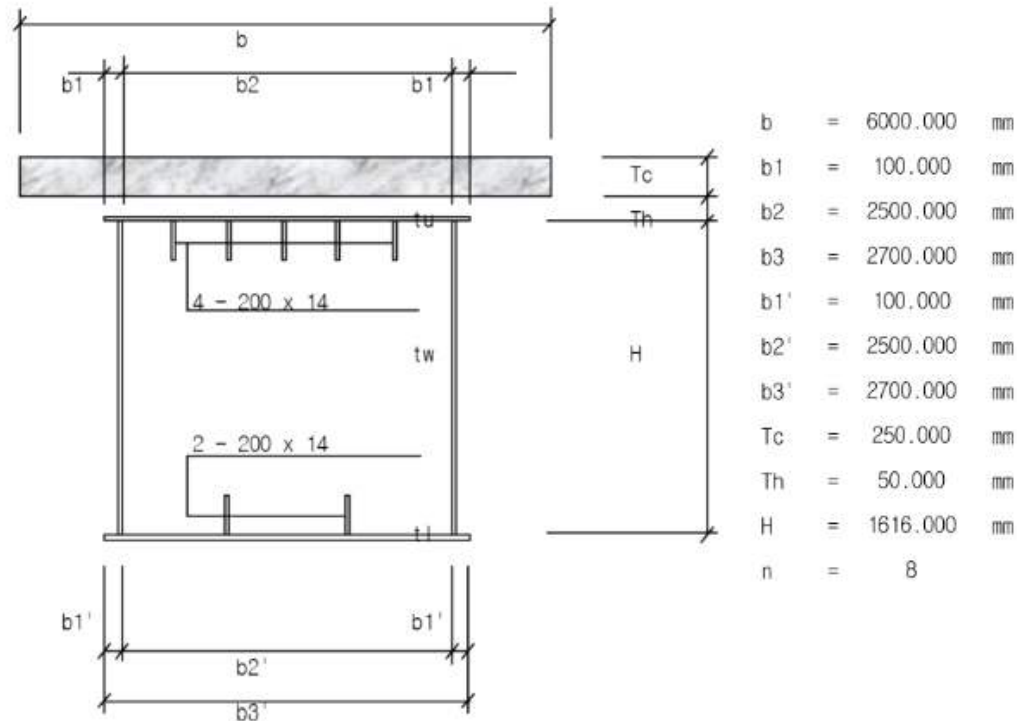
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 141984 + 1500000 / 8 = 329484 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1616.000 / 2 - 27.924 + 50.000 + 250.000 / 2 = 955.08 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 955.076 \times 141984 / 329484 = 411.57 \text{ mm} \\
dvs &= dv - dvc = 955.076 - 411.569 = 543.51 \text{ mm} \\
Iv33 &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 74338548434 + 7812500000 / 8 + 141984 \times 543.507^2 \\
&\quad + 1500000 / 8 \times 411.569^2 = 149017567692 \text{ mm}^4 \\
Iv22 &= I_{22} + b^3 \times T_c / 12 / N \\
&= 113671621632 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 676171621632 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1632^2) / (2 \times 1632/12 + 2512/47.25 + 2512/16) \\
&= 139426321628 \text{ mm}^4
\end{aligned}$$

- Section G1,3/6-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	818.00	44172000	36132696000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	708.00	7929600	5614156800	37333333
W E B	2 - 1616.0 X 12.0	38784				8440225792
LOWER RIB	2 - 200.0 X 14.0	5600	-708.00	-3964800	2807078400	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-816.00	-35251200	28764979200	921600
TOTAL		152784		12885600	73318910400	8498947392

$$\begin{aligned}
 I_s' &= \sum AsY^2 + \sum I_o \\
 &= 73318910400 + 8498947392 = 81817857792 \text{ mm}^4 \\
 \delta s &= \sum AsY / \sum As \\
 &= 12885600 / 152784 = 84.34 \text{ mm} \\
 I_{33} &= I_s' - \sum As \times \delta s^2 \\
 &= 81817857792 - 152784 \times 84.339^2 = 80731103372 \text{ mm}^4 \\
 I_{22} &= (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((1616 \times 12^3 / 12) + (1616 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 \\
 &= 120232621632 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

$$\begin{aligned}
 b_k &= b_2 + t_w / 2 \times 2 \\
 &= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1616.000 + 20.000 / 2 + 16.000 / 2 = 1634.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1634^2) / (2 \times 1634/12 + 2512/20 + 2512/16) \\
&= 121440222251 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 152784 + 1500000 / 8 = 340284 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 781250000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1616.000 / 2 - 84.339 + 50.000 + 250.000 / 2 = 898.66 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 898.661 \times 152784 / 340284 = 403.49 \text{ mm} \\
dvs &= dv - dvc = 898.661 - 403.490 = 495.17 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 80731103372 + 781250000 / 8 + 152784 \times 495.172^2 \\
&\quad + 1500000 / 8 \times 403.490^2 = 149695267807 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 120232621632 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 682732621632 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1634^2) / (2 \times 1634/12 + 2512/51.25 + 2512/16) \\
&= 140883273090 \text{ mm}^4
\end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 16.000 / 2 = 1626.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1626^2) / (2 \times 1626/12 + 2512/20 + 2512/16) \\
&= 120543629177 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 152592 + 1500000 / 8 = 340092 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1608.000 / 2 - 84.015 + 50.000 + 250.000 / 2 = 894.99 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 894.985 \times 152592 / 340092 = 401.56 \text{ mm} \\
dvs &= dv - dvc = 894.985 - 401.561 = 493.42 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 79887339742 + 7812500000 / 8 + 152592 \times 493.424^2 \\
&\quad + 1500000 / 8 \times 401.561^2 = 148249679448 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119929732416 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 682429732416 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1626^2) / (2 \times 1626/12 + 2512/51.25 + 2512/16) \\
&= 139897077229 \text{ mm}^4
\end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 22.000 / 2 = 1629.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1629^2) / (2 \times 1629/12 + 2512/20 + 2512/22) \\
&= 131002951709 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

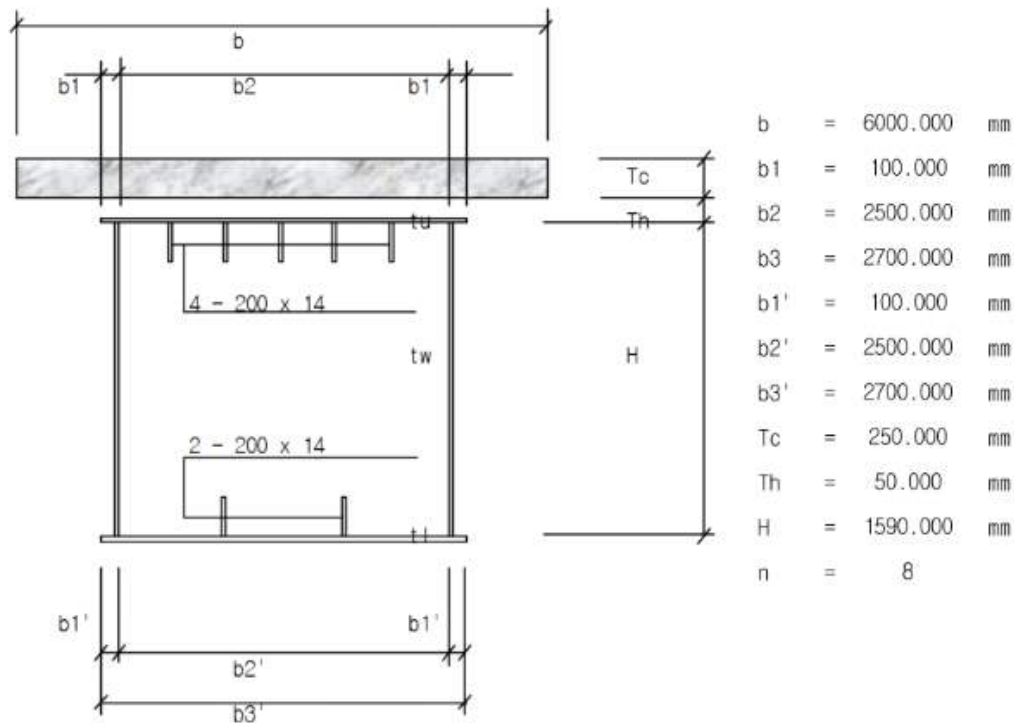
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 168792 + 1500000 / 8 = 356292 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1608.000 / 2 - -3.037 + 50.000 + 250.000 / 2 = 982.04 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 982.037 \times 168792 / 356292 = 465.24 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 982.037 - 465.236 = 516.80 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 91935632322 + 7812500000 / 8 + 168792 \times 516.801^2 \\
&\quad + 1500000 / 8 \times 465.236^2 = 178577043163 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 129771232416 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 692271232416 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1629^2) / (2 \times 1629/12 + 2512/51.25 + 2512/22) \\
&= 154083215951 \quad \text{mm}^4
\end{aligned}$$

- Section G1,3/7-2



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	805.00	43470000	34993350000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	695.00	7784000	5409880000	37333333
W E B	2 - 1590.0 X 12.0	38160				8039358000
LOWER RIB	2 - 200.0 X 14.0	5600	-695.00	-3892000	2704940000	18666667
LOWER FL.	1 - 2700.0 X 22.0	59400	-806.00	-47876400	38588378400	2395800
TOTAL		168360		-514400	81696548400	8099553800

$$I_{s'} = \sum AsY^2 + \sum I_o$$

$$= 81696548400 + 8099553800 = 89796102200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -514400 / 168360 = -3.06 \text{ mm}$$

$$I_{33} = I_{s'} - \sum As \times \delta s^2$$

$$= 89796102200 - 168360 \times (-3.055)^2 = 89794530524 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 22 / 12) + ((1590 \times 12^3 / 12) + (1590 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 129089731680 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
 H_k &= H + t_u / 2 + t_l / 2 \\
 &= 1590.000 + 20.000 / 2 + 22.000 / 2 = 1611.00 \text{ mm} \\
 K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
 &= (4 \times 2512^2 \times 1611^2) / (2 \times 1611/12 + 2512/20 + 2512/22) \\
 &= 128880071255 \text{ mm}^4
 \end{aligned}$$

② 합성후 단면

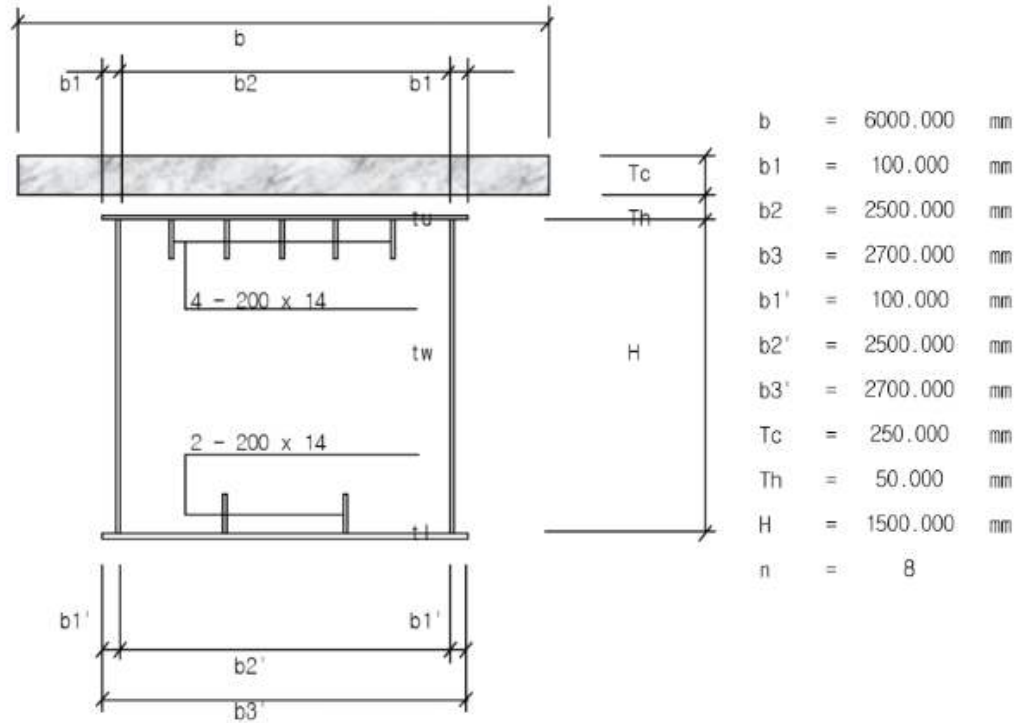
$$\begin{aligned}
 A_c &= b \times T_c \\
 &= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
 A_v &= \sum A_s + A_c/N \\
 &= 168360 + 1500000 / 8 = 355860 \text{ mm}^2 \\
 I_c &= b \times T_c^3 / 12 \\
 &= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
 dv &= H / 2 - \delta s + T_h + T_c / 2 \\
 &= 1590.000 / 2 - -3.055 + 50.000 + 250.000 / 2 = 973.06 \text{ mm} \\
 dvc &= dv \cdot \sum A_s / A_v \\
 &= 973.055 \times 168360 / 355860 = 460.36 \text{ mm} \\
 dvs &= dv - dvc = 973.055 - 460.360 = 512.70 \text{ mm} \\
 Iv33 &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
 &= 89794530524 + 7812500000 / 8 + 168360 \times 512.696^2 \\
 &\quad + 1500000 / 8 \times 460.360^2 = 174762742659 \text{ mm}^4 \\
 Iv22 &= I_{22} + b^3 \times T_c / 12 / N \\
 &= 129089731680 + 6000.000^3 \\
 &\quad \times 250.000 / 12 / 8 = 691589731680 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
 t_{cu} &= t_u + T_c / N \\
 &= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
 K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
 &= (4 \times 2512^2 \times 1611^2) / (2 \times 1611/12 + 2512/51.25 + 2512/22) \\
 &= 151744116941 \text{ mm}^4
 \end{aligned}$$

- Section G1.3/7-3



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 22.0	59400	-761.00	-45203400	34399787400	2395800
TOTAL		166200		-523400	72688187400	6810195800

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 72688187400 + 6810195800 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -523400 / 166200 = -3.15 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 22 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 125682228000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 22.000 / 2 = 1521.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1521^2) / (2 \times 1521/12 + 2512/20 + 2512/22) \\
&= 118375705793 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

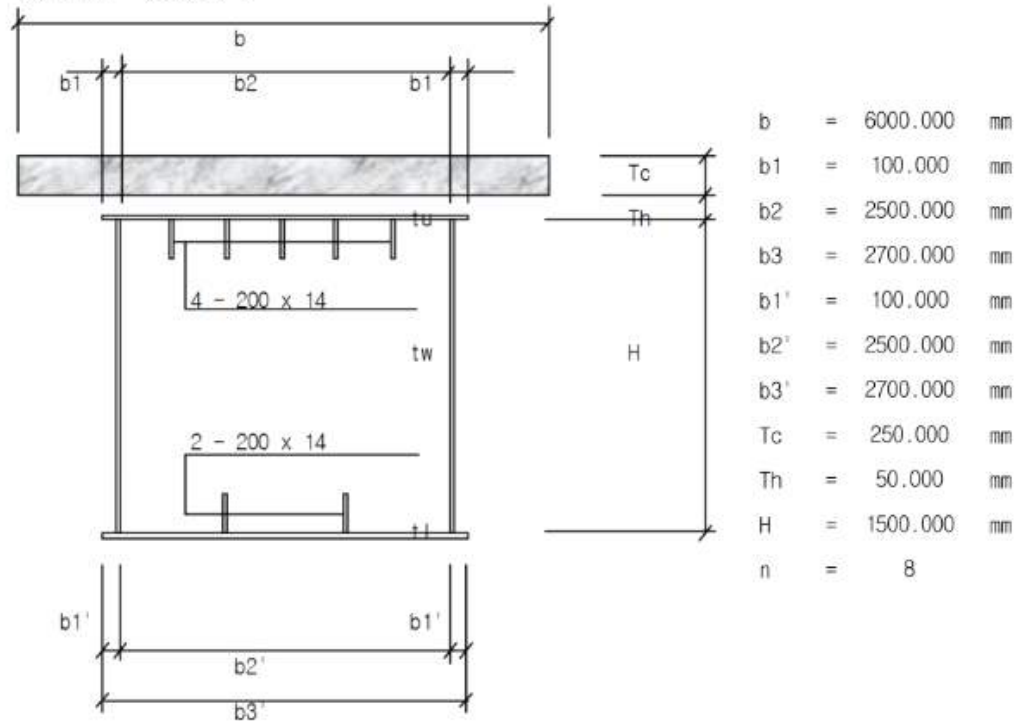
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 166200 + 1500000 / 8 = 353700 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 3.149 + 50.000 + 250.000 / 2 = 928.15 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 928.149 \times 166200 / 353700 = 436.13 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 928.149 - 436.128 = 492.02 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 79496734899 + 7812500000 / 8 + 166200 \times 492.021^2 \\
&\quad + 1500000 / 8 \times 436.128^2 = 156371735324 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 125682228000 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 688182228000 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1521^2) / (2 \times 1521/12 + 2512/51.25 + 2512/22) \\
&= 140132182685 \text{ mm}^4
\end{aligned}$$

- Section G1,3/8-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-760.00	-41040000	31190400000	1800000
TOTAL		160800		3640000	69478800000	6809600000

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 69478800000 + 6809600000 = 76288400000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3640000 / 160800 = 22.64 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 76288400000 - 160800 \times 22.637^2 = 7620601990 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 122401728000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 20.000 / 2 = 1520.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1520^2) / (2 \times 1520/12 + 2512/20 + 2512/20) \\
&= 115583694748 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

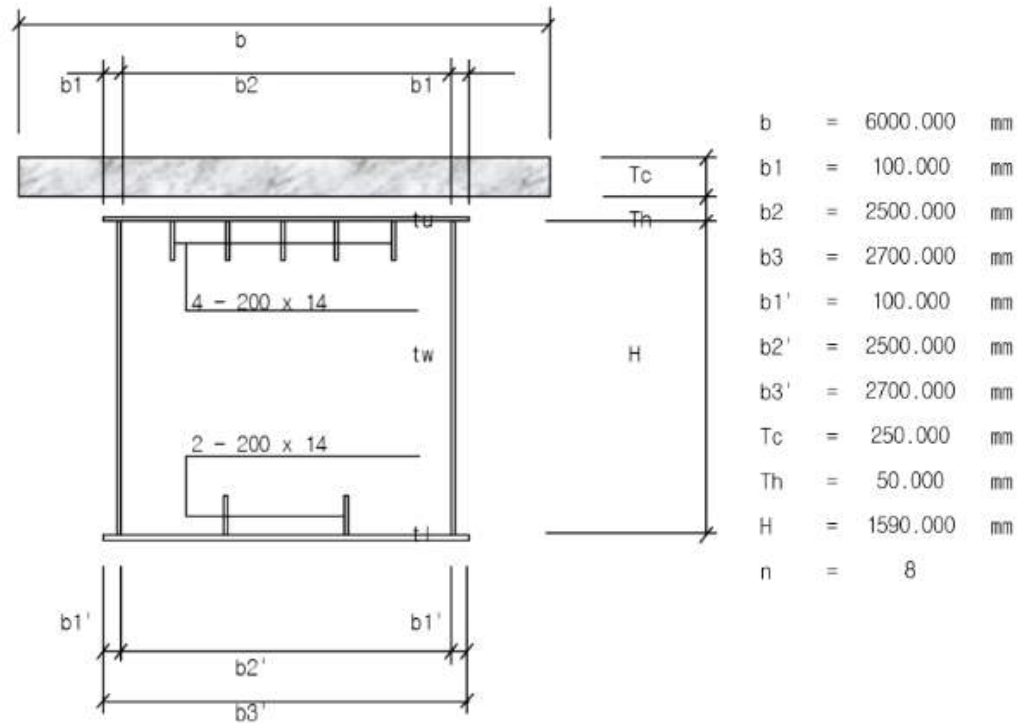
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 160800 + 1500000 / 8 = 348300 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 22.637 + 50.000 + 250.000 / 2 = 902.36 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 902.363 \times 160800 / 348300 = 416.59 \text{ mm} \\
dvs &= dv - dvc = 902.363 - 416.595 = 485.77 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 76206001990 + 7812500000 / 8 + 160800 \times 485.768^2 \\
&\quad + 1500000 / 8 \times 416.595^2 = 147667544039 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 122401728000 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 684901728000 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1520^2) / (2 \times 1520/12 + 2512/51.25 + 2512/20) \\
&= 136268498093 \text{ mm}^4
\end{aligned}$$

- Section G1.3/8-2



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	805.00	43470000	34993350000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	695.00	7784000	5409880000	37333333
W E B	2 - 1590.0 X 12.0	38160				8039358000
LOWER RIB	2 - 200.0 X 14.0	5600	-695.00	-3892000	2704940000	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-805.00	-43470000	34993350000	1800000
TOTAL		162960		3892000	78101520000	8098958000

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 78101520000 + 8098958000 = 86200478000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3892000 / 162960 = 23.88 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 86200478000 - 162960 \times 23.88^2 = 86107524735 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1590 \times 12^3 / 12) + (1590 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 125809231680 \text{ mm}^4$$

- 비틀림 감성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1590.000 + 20.000 / 2 + 20.000 / 2 = 1610.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1610^2) / (2 \times 1610/12 + 2512/20 + 2512/20) \\
&= 125932433690 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

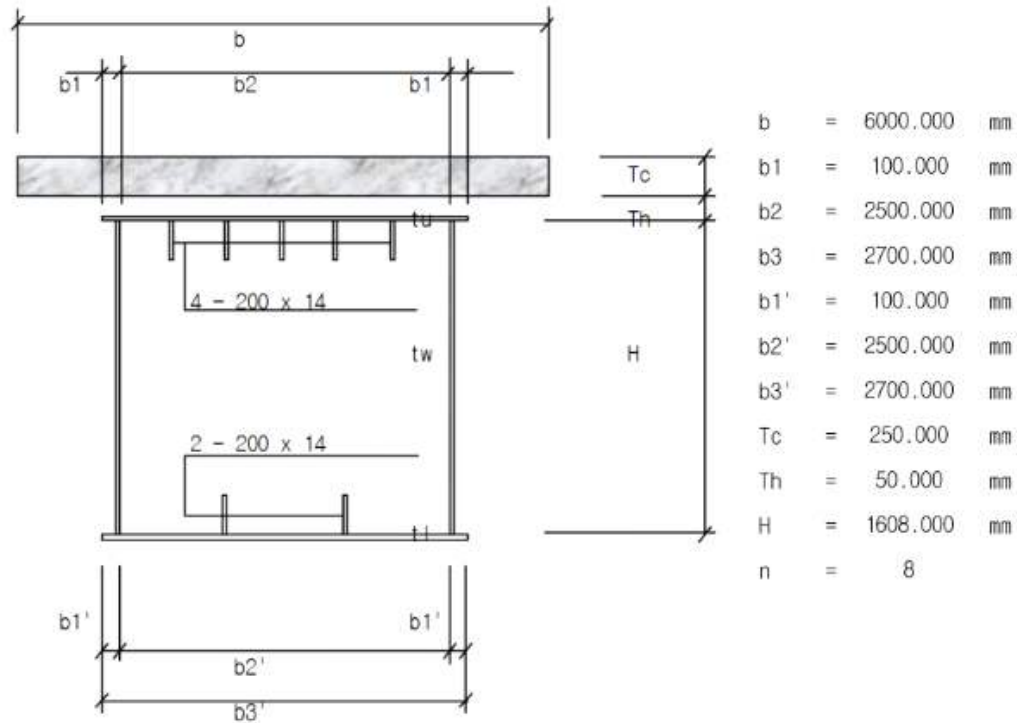
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 162960 + 1500000 / 8 = 350460 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1590.000 / 2 - 23.883 + 50.000 + 250.000 / 2 = 946.12 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 946.117 \times 162960 / 350460 = 439.93 \text{ mm} \\
dvs &= dv - dvc = 946.117 - 439.934 = 506.18 \text{ mm} \\
Iv33 &= I33 + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 86107524735 + 7812500000 / 8 + 162960 \times 506.183^2 \\
&\quad + 1500000 / 8 \times 439.934^2 = 165126982964 \text{ mm}^4 \\
Iv22 &= I22 + b^3 \times T_c / 12 / N \\
&= 125809231680 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 688309231680 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1610^2) / (2 \times 1610/12 + 2512/51.25 + 2512/20) \\
&= 147706055458 \text{ mm}^4
\end{aligned}$$

- Section G1,3/8-3



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	814.00	43956000	35780184000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	704.00	7884800	5550899200	37333333
W E B	2 - 1608.0 X 12.0	38592				8315495424
LOWER RIB	2 - 200.0 X 14.0	5600	-704.00	-3942400	2775449600	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-814.00	-43956000	35780184000	1800000
TOTAL		163392		3942400	79886716800	8375095424

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 79886716800 + 8375095424 = 88261812224 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3942400 / 163392 = 24.13 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 88261812224 - 163392 \times 24.128^2 = 88166688119 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1608 \times 12^3 / 12) + (1608 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 126490732416 \text{ mm}^4$$

- 비틀림 감성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 20.000 / 2 = 1628.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1628^2) / (2 \times 1628 / 12 + 2512 / 20 + 2512 / 20) \\
&= 128024787155 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

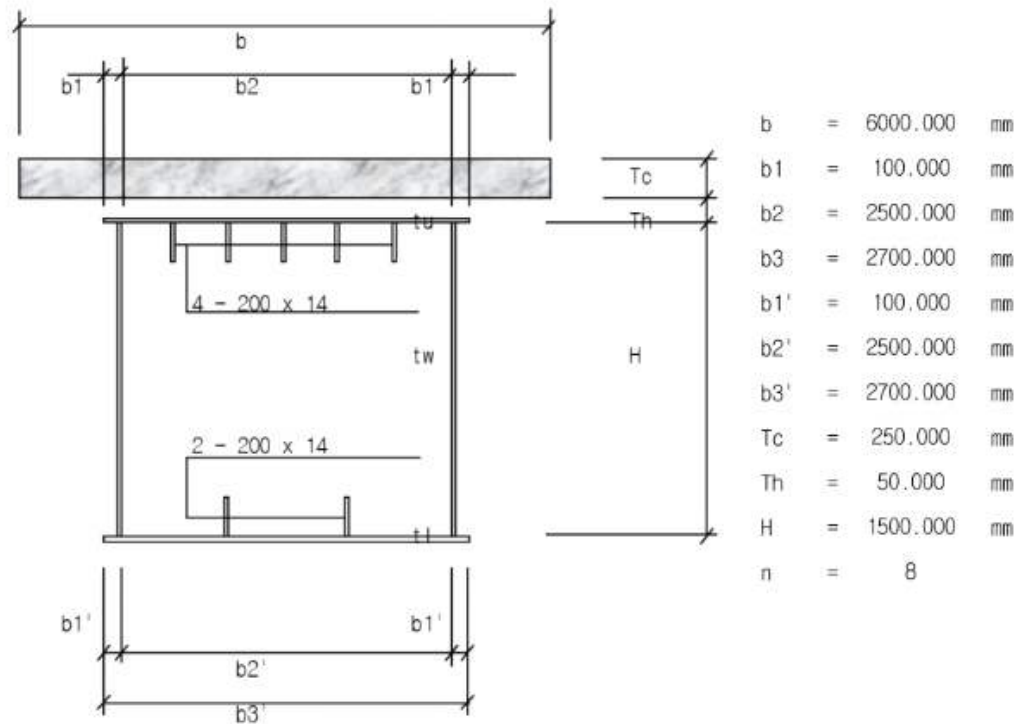
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 163392 + 1500000 / 8 = 350892 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1608.000 / 2 - 24.128 + 50.000 + 250.000 / 2 = 954.87 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 954.872 \times 163392 / 350892 = 444.63 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 954.872 - 444.634 = 510.24 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 88166688119 + 7812500000 / 8 + 163392 \times 510.238^2 \\
&\quad + 1500000 / 8 \times 444.634^2 = 168749741065 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 126490732416 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 688990732416 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1628^2) / (2 \times 1628 / 12 + 2512 / 51.25 + 2512 / 20) \\
&= 150011265124 \text{ mm}^4
\end{aligned}$$

- Section G1.3/9



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 18.0	48600	-759.00	-36887400	27997536600	1312200
TOTAL		155400		7792600	66285936600	6809112200

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 66285936600 + 6809112200 = 73095048800 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 7792600 / 155400 = 50.15 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 73095048800 - 155400 \times 50.145^2 = 72704285513 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 18 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 119121228000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 18.000 / 2 = 1519.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1519^2) / (2 \times 1519/12 + 2512/20 + 2512/18) \\
&= 112360840772 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

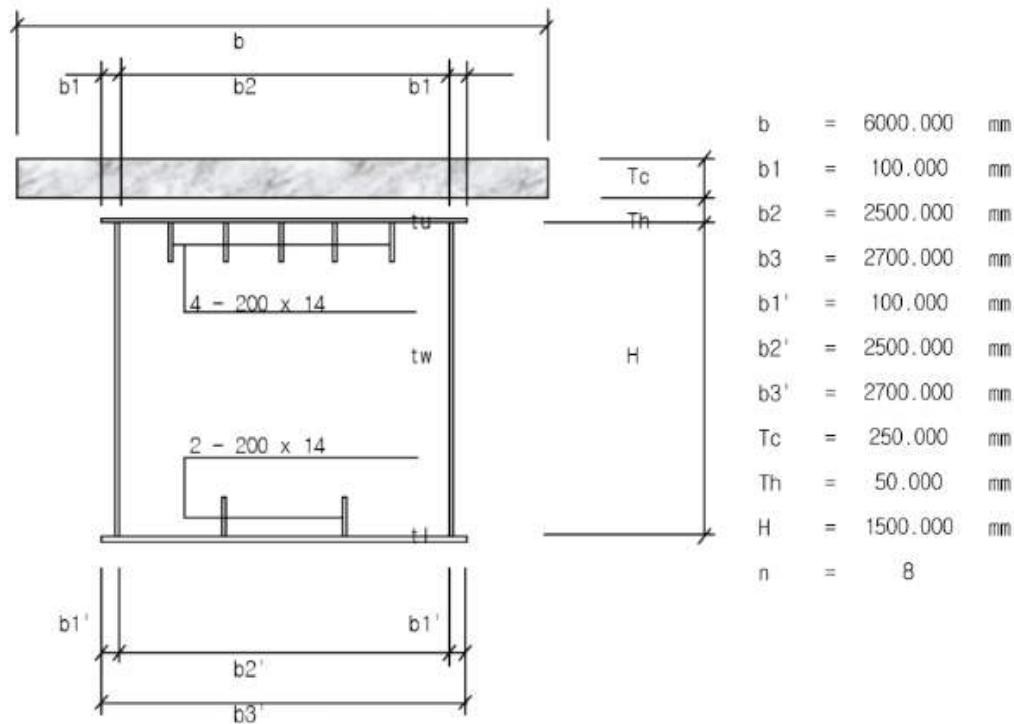
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 155400 + 1500000 / 8 = 342900 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 50.145 + 50.000 + 250.000 / 2 = 874.85 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 874.855 \times 155400 / 342900 = 396.48 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 874.855 - 396.478 = 478.38 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 72704285513 + 7812500000 / 8 + 155400 \times 478.376^2 \\
&\quad + 1500000 / 8 \times 396.478^2 = 138717253463 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119121228000 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 681621228000 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1519^2) / (2 \times 1519/12 + 2512/51.25 + 2512/18) \\
&= 131841207815 \text{ mm}^4
\end{aligned}$$

- Section G1,3/10



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	758.00	32745600	24821164800	921600
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 18.0	48600	-759.00	-36887400	27997536600	1312200
TOTAL		144600		-501800	59916701400	6808233800

$$I_{s'} = \sum AsY^2 + \sum I_o$$

$$= 59916701400 + 6808233800 = 66724935200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -501800 / 144600 = -3.47 \text{ mm}$$

$$I_{33} = I_{s'} - \sum As \times \delta s^2$$

$$= 66724935200 - 144600 \times (-3.47)^2 = 66723193822 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times tl / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 18 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 112560228000 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 16.000 / 2 + 18.000 / 2 = 1517.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1517^2) / (2 \times 1517/12 + 2512/16 + 2512/18) \\
&= 105728130068 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

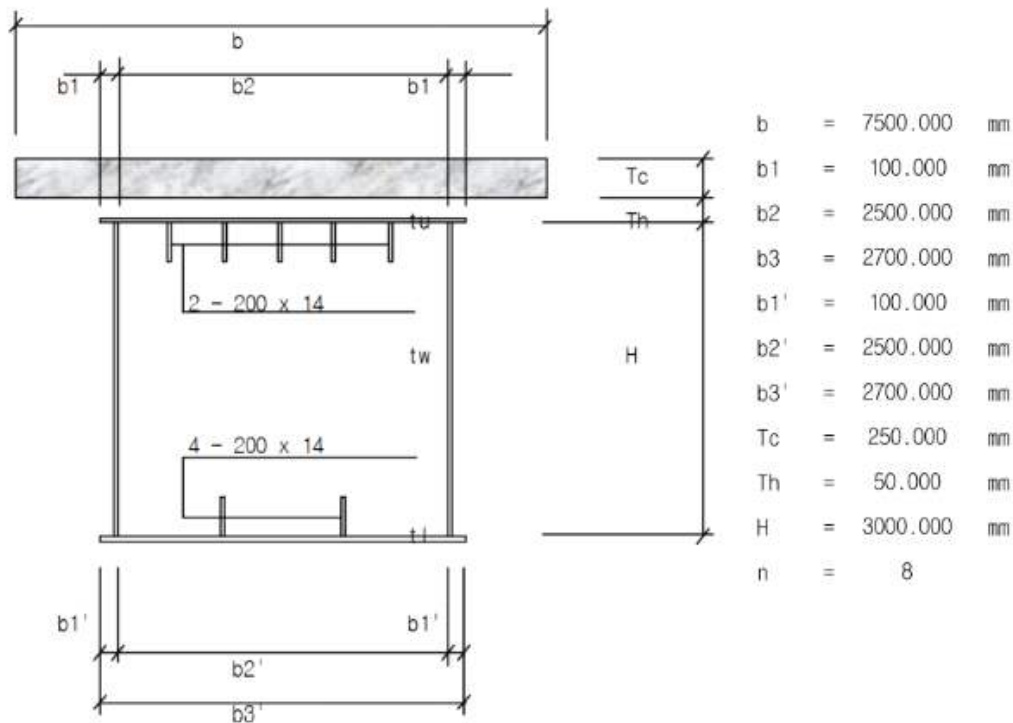
$$\begin{aligned}
A_c &= b \times T_c \\
&= 6000.000 \times 250.000 = 1500000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 144600 + 1500000 / 8 = 332100 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 6000.000 \times 250.000^3 / 12 = 7812500000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1500.000 / 2 - -3.470 + 50.000 + 250.000 / 2 = 928.47 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 928.470 \times 144600 / 332100 = 404.27 \text{ mm} \\
dvs &= dv - dvc = 928.470 - 404.266 = 524.20 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 66723193822 + 7812500000 / 8 + 144600 \times 524.204^2 \\
&\quad + 1500000 / 8 \times 404.266^2 = 138077718369 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 112560228000 + 6000.000^3 \\
&\quad \times 250.000 / 12 / 8 = 675060228000 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1517^2) / (2 \times 1517/12 + 2512/47.25 + 2512/18) \\
&= 130368040679 \text{ mm}^4
\end{aligned}$$

- Section G2/1-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1510.00	81540000	123125400000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1400.00	7840000	10976000000	18666667
W E B	2 - 3000.0 X 14.0	84000				63000000000
LOWER RIB	4 - 200.0 X 14.0	11200	-1400.00	-15680000	21952000000	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1510.00	-81540000	123125400000	1800000
TOTAL		208800		-7840000	279178800000	63059600000

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 279178800000 + 63059600000 = 342238400000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -7840000 / 208800 = -37.55 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 342238400000 - 208800 \times (-37.548)^2 = 341944024521 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((3000 \times 14^3 / 12) + (3000 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 198335488000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 3000.000 + 20.000 / 2 + 20.000 / 2 = 3020.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 3020^2) / (2 \times 3020/14 + 2514/20 + 2514/20) \\
&= 337670203095 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

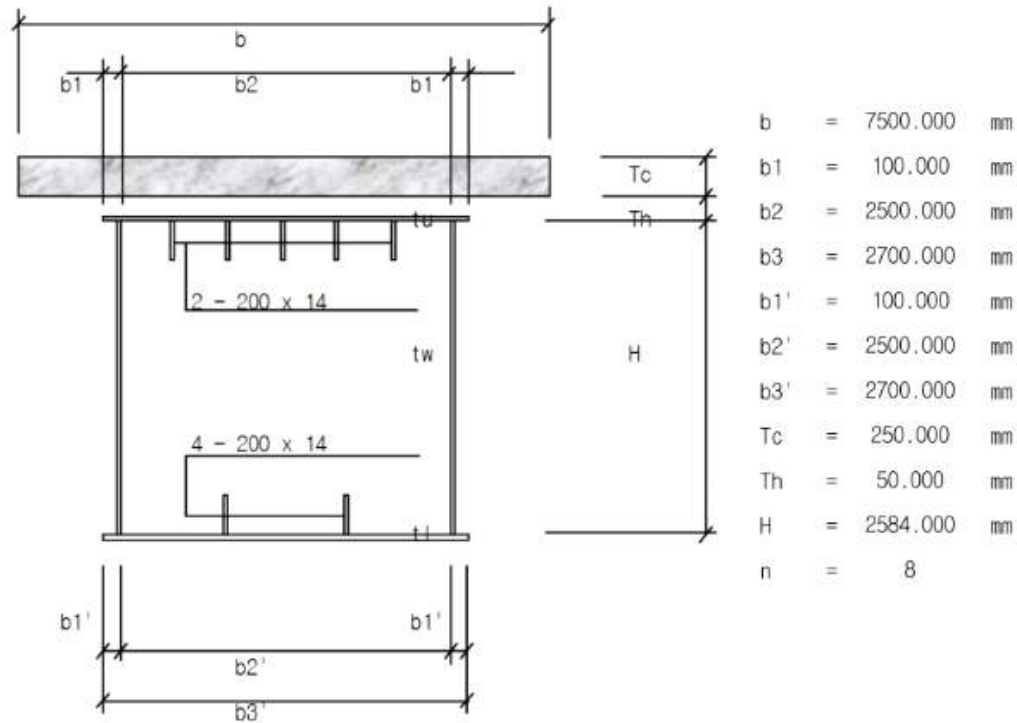
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 208800 + 1875000 / 8 = 443175 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 3000.000 / 2 - 37.548 + 50.000 + 250.000 / 2 = 1712.55 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1712.548 \times 208800 / 443175 = 806.86 \text{ mm} \\
dvs &= dv - dvc = 1712.548 - 806.860 = 905.69 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 341944024521 + 9765625000 / 8 + 208800 \times 905.688^2 \\
&\quad + 1875000 / 8 \times 806.860^2 = 667020749963 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 198335488000 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1296968300500 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 3020^2) / (2 \times 3020/14 + 2514/51.25 + 2514/20) \\
&= 380365591395 \text{ mm}^4
\end{aligned}$$

- Section G2/1-2



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1302.00	70308000	91541016000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1192.00	6675200	7956838400	18666667
W E B	2 - 2584.0 X 14.0	72352				40258196309
LOWER RIB	4 - 200.0 X 14.0	11200	-1192.00	-13350400	15913676800	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1302.00	-70308000	91541016000	1800000
TOTAL		197152		-6675200	206952547200	40317796309

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 206952547200 + 40317796309 = 247270343509 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -6675200 / 197152 = -33.86 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 247270343509 - 197152 \times (-33.86)^2 = 247044333654 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2584 \times 14^3 / 12) + (2584 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 179930886997 \text{ mm}^4$$

- 비틀림 감성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2584.000 + 20.000 / 2 + 20.000 / 2 = 2604.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2604^2) / (2 \times 2604/14 + 2514/20 + 2514/20) \\
&= 274982907667 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

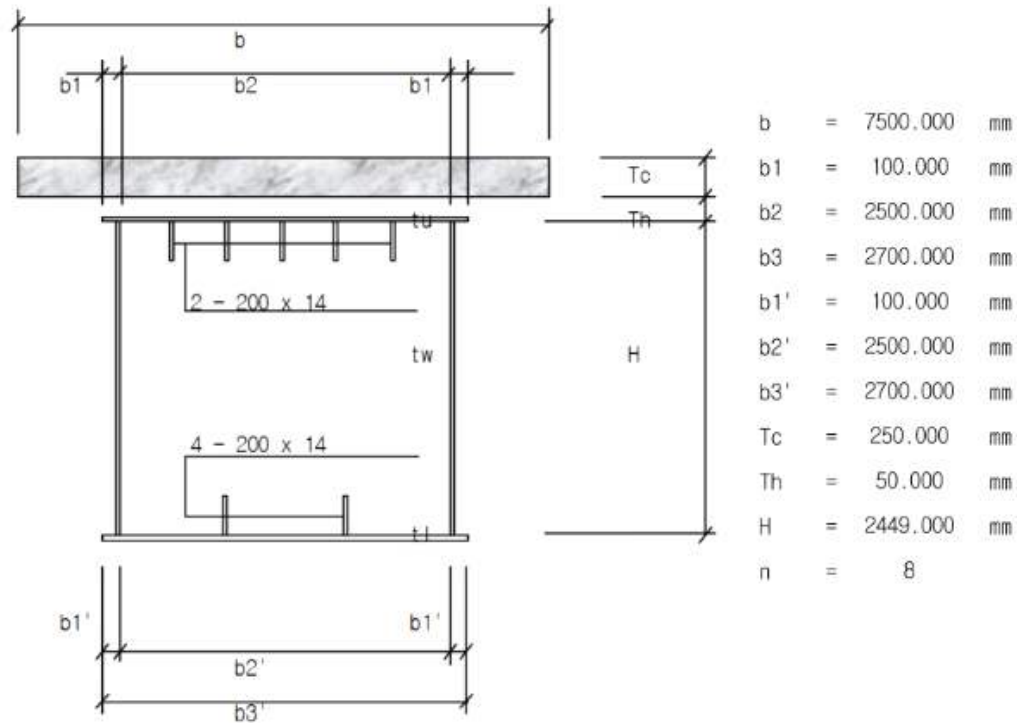
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 197152 + 1875000 / 8 = 431527 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2584.000 / 2 - 33.858 + 50.000 + 250.000 / 2 = 1500.86 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1500.858 \times 197152 / 431527 = 685.70 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 1500.858 - 685.698 = 815.16 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 247044333654 + 9765625000 / 8 + 197152 \times 815.160^2 \\
&\quad + 1875000 / 8 \times 685.698^2 = 489468638239 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 179930886997 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1278563699497 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2604^2) / (2 \times 2604/14 + 2514/51.25 + 2514/20) \\
&= 313531225559 \text{ mm}^4
\end{aligned}$$

- Section G2/1-3



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1234.50	66663000	82295473500	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1124.50	6297200	7081201400	18666667
W E B	2 - 2449.0 X 14.0	68572				34272291314
LOWER RIB	4 - 200.0 X 14.0	11200	-1124.50	-12594400	14162402800	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1234.50	-66663000	82295473500	1800000
TOTAL		193372		-6297200	185834551200	34331891314

$$\begin{aligned}
 I_s' &= \sum AsY^2 + \sum Io \\
 &= 185834551200 + 34331891314 = 220166442514 \text{ mm}^4
 \end{aligned}$$

$$\begin{aligned}
 \delta s &= \sum AsY / \sum As \\
 &= -6297200 / 193372 = -32.57 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 I_{33} &= I_s' - \sum As \times \delta s^2 \\
 &= 220166442514 - 193372 \times (-32.565)^2 = 219961372867 \text{ mm}^4
 \end{aligned}$$

$$\begin{aligned}
 I_{22} &= (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2449 \times 14^3 / 12) \\
 &\quad + (2449 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 173958240037 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

$$\begin{aligned}
 bk &= b_2 + t_w / 2 \times 2 \\
 &= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2449.000 + 20.000 / 2 + 20.000 / 2 = 2469.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2469^2) / (2 \times 2469/14 + 2514/20 + 2514/20) \\
&= 255101852344 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

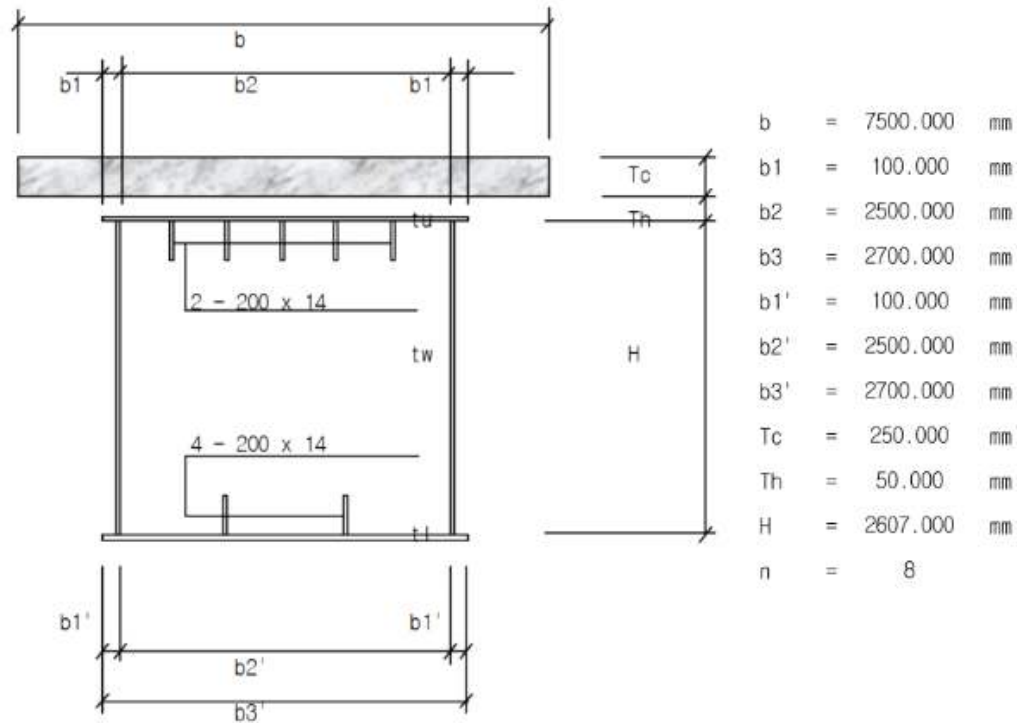
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 193372 + 1875000 / 8 = 427747 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2449.000 / 2 - 32.565 + 50.000 + 250.000 / 2 = 1432.07 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1432.065 \times 193372 / 427747 = 647.40 \text{ mm} \\
dvs &= dv - dvc = 1432.065 - 647.395 = 784.67 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 219961372867 + 9765625000 / 8 + 193372 \times 784.670^2 \\
&\quad + 1875000 / 8 \times 647.395^2 = 438473952815 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 173958240037 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1272591052537 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2469^2) / (2 \times 2469/14 + 2514/51.25 + 2514/20) \\
&= 292170690168 \text{ mm}^4
\end{aligned}$$

- Section G2/1-4



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1313.50	70929000	93165241500	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1203.50	6739600	8111108600	18666667
W E B	2 - 2607.0 X 14.0	72996				41342799267
LOWER RIB	4 - 200.0 X 14.0	11200	-1203.50	-13479200	16222217200	37333333
LOWER FL.	1 - 2700.0 X 20.0	54000	-1313.50	-70929000	93165241500	1800000
TOTAL		197796		-6739600	210663808800	41402399267

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 210663808800 + 41402399267 = 252066208067 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -6739600 / 197796 = -34.07 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 252066208067 - 197796 \times (-34.07)^2 = 251836566375 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((2607 \times 14^3 / 12) + (2607 \times 14 \times (2500 / 2 + 14 / 2)^2)) \times 2 = 180948449072 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 14.000 / 2 \times 2 = 2514.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2607.000 + 20.000 / 2 + 20.000 / 2 = 2627.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2514^2 \times 2627^2) / (2 \times 2627/14 + 2514/20 + 2514/20) \\
&= 278394652420 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

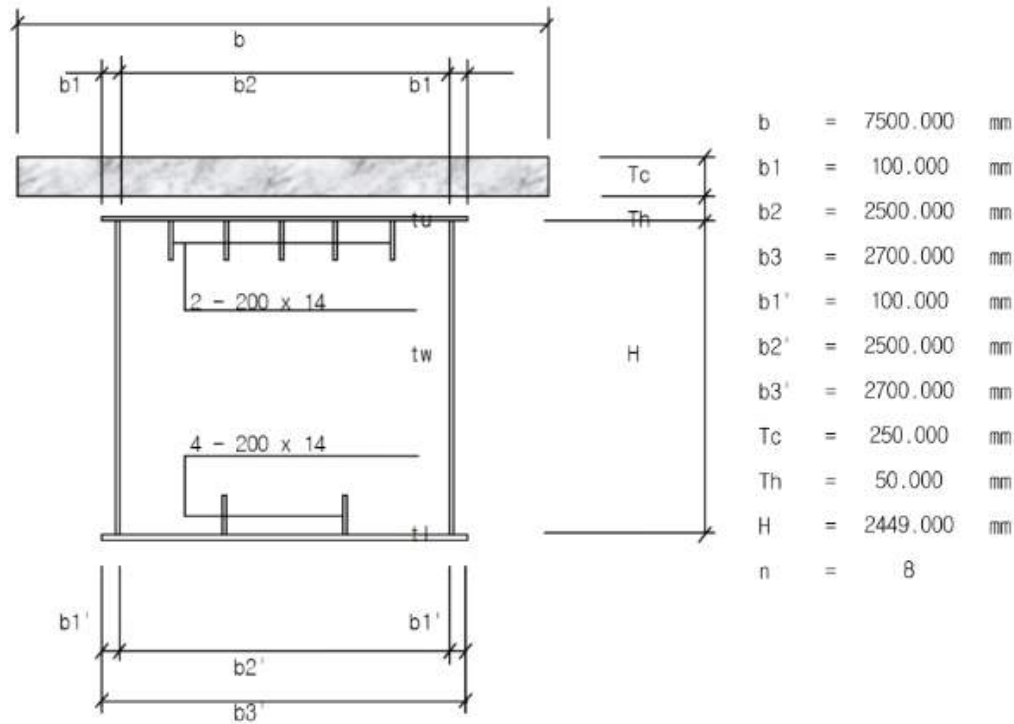
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 197796 + 1875000 / 8 = 432171 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2607.000 / 2 - 34.073 + 50.000 + 250.000 / 2 = 1512.57 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1512.573 \times 197796 / 432171 = 692.27 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1512.573 - 692.275 = 820.30 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 251836566375 + 9765625000 / 8 + 197796 \times 820.299^2 \\
&\quad + 1875000 / 8 \times 692.275^2 = 498475114136 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 180948449072 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1279581261572 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2514^2 \times 2627^2) / (2 \times 2627/14 + 2514/51.25 + 2514/20) \\
&= 317188114571 \quad \text{mm}^4
\end{aligned}$$

- Section G2/2-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1234.50	66663000	82295473500	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1124.50	6297200	7081201400	18666667
W E B	2 - 2449.0 X 12.0	58776				29376249698
LOWER RIB	4 - 200.0 X 14.0	11200	-1124.50	-12594400	14162402800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1232.50	-53244000	65623230000	921600
TOTAL		172776		7121800	169162307700	29434971298

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 169162307700 + 29434971298 = 198597278998 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 7121800 / 172776 = 41.22 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 198597278998 - 172776 \times 41.22^2 = 198303719503 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times tl / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((2449 \times 12^3 / 12) + (2449 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 151770961248 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
 H_k &= H + t_u / 2 + t_l / 2 \\
 &= 2449.000 + 20.000 / 2 + 16.000 / 2 = 2467.00 \quad \text{mm} \\
 K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
 &= (4 \times 2512^2 \times 2467^2) / (2 \times 2467/12 + 2512/20 + 2512/16) \\
 &= 221423713949 \quad \text{mm}^4
 \end{aligned}$$

② 합성후 단면

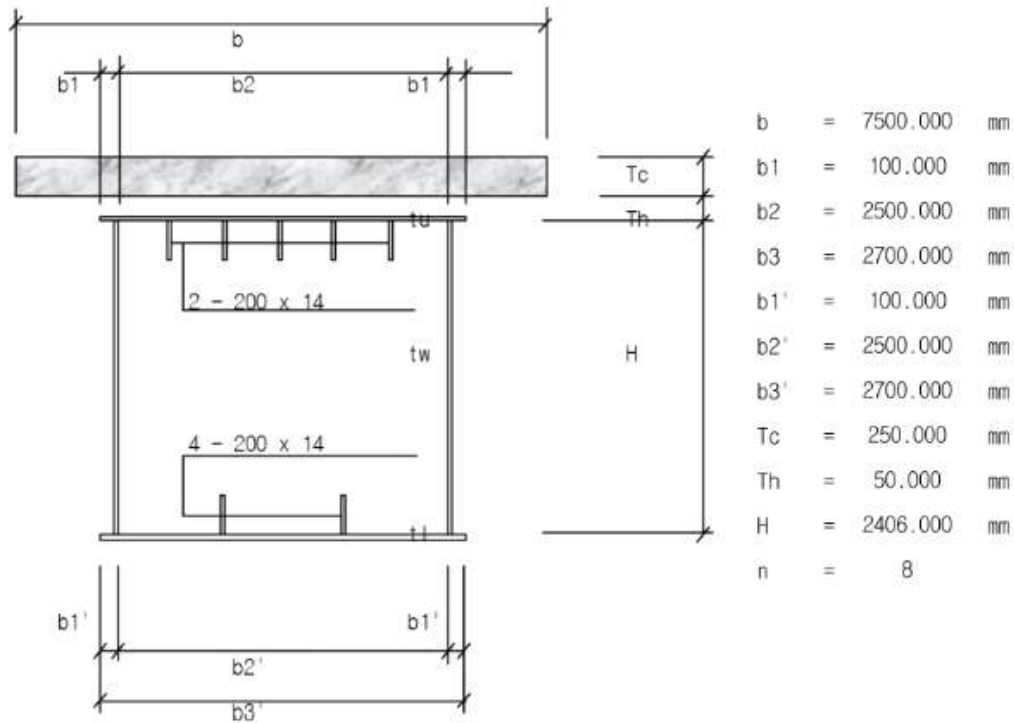
$$\begin{aligned}
 A_c &= b \times T_c \\
 &= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
 A_v &= \sum A_s + A_c/N \\
 &= 172776 + 1875000 / 8 = 407151 \quad \text{mm}^2 \\
 I_c &= b \times T_c^3 / 12 \\
 &= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
 dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
 &= 2449.000 / 2 - 41.220 + 50.000 + 250.000 / 2 = 1358.28 \quad \text{mm} \\
 dvc &= dv \cdot \sum A_s / A_v \\
 &= 1358.280 \times 172776 / 407151 = 576.39 \quad \text{mm} \\
 dvs &= dv - dvc = 1358.280 - 576.391 = 781.89 \quad \text{mm} \\
 I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
 &= 198303719503 + 9765625000 / 8 + 172776 \times 781.889^2 \\
 &\quad + 1875000 / 8 \times 576.391^2 = 383016748392 \quad \text{mm}^4 \\
 I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
 &= 151770961248 + 7500.000^3 \\
 &\quad \times 250.000 / 12 / 8 = 1250403773748 \quad \text{mm}^4
 \end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
 t_{cu} &= t_u + T_c / N \\
 &= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
 K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
 &= (4 \times 2512^2 \times 2467^2) / (2 \times 2467/12 + 2512/51.25 + 2512/16) \\
 &= 248899945194 \quad \text{mm}^4
 \end{aligned}$$

- Section G2/2-2



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	1213.00	65502000	79453926000	1800000
UPPER RIB	2 - 200.0 X 14.0	5600	1103.00	6176800	6813010400	18666667
W E B	2 - 2406.0 X 12.0	57744				27855878832
LOWER RIB	4 - 200.0 X 14.0	11200	-1103.00	-12353600	13626020800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1211.00	-52315200	63353707200	921600
TOTAL		171744		7010000	163246664400	27914600432

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 163246664400 + 27914600432 = 191161264832 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 7010000 / 171744 = 40.82 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 191161264832 - 171744 \times 40.817^2 = 190875140717 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((2406 \times 12^3 / 12) + (2406 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 150142931712 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2406.000 + 20.000 / 2 + 16.000 / 2 = 2424.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2424^2) / (2 \times 2424/12 + 2512/20 + 2512/16) \\
&= 216003452792 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

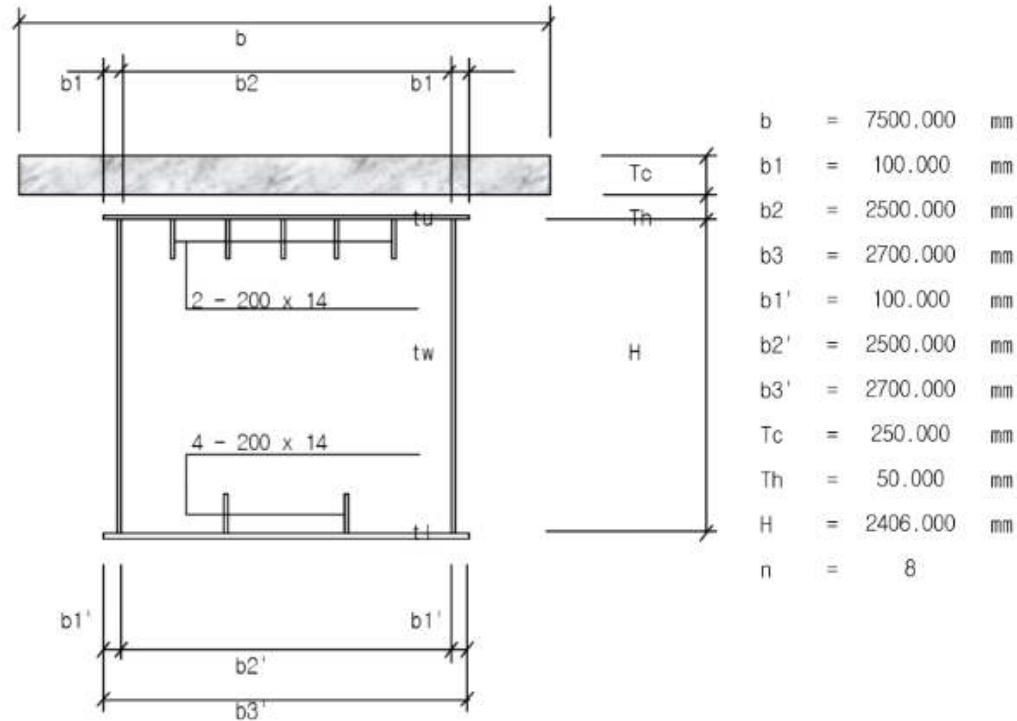
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 171744 + 1875000 / 8 = 406119 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2406.000 / 2 - 40.817 + 50.000 + 250.000 / 2 = 1337.18 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1337.183 \times 171744 / 406119 = 565.48 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1337.183 - 565.483 = 771.70 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 190875140717 + 9765625000 / 8 + 171744 \times 771.701^2 \\
&\quad + 1875000 / 8 \times 565.483^2 = 369319432678 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 150142931712 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1248775744212 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2424^2) / (2 \times 2424/12 + 2512/51.25 + 2512/16) \\
&= 243121988204 \quad \text{mm}^4
\end{aligned}$$

- Section G2/3-1



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	1211.00	52315200	63353707200	921600
UPPER RIB	2 - 200.0 X 14.0	5600	1103.00	6176800	6813010400	18666667
W E B	2 - 2406.0 X 12.0	57744				27855878832
LOWER RIB	4 - 200.0 X 14.0	11200	-1103.00	-12353600	13626020800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1211.00	-52315200	63353707200	921600
TOTAL		160944		-6176800	147146445600	27913722032

$$\begin{aligned}
 I_s' &= \sum AsY^2 + \sum I_o \\
 &= 147146445600 + 27913722032 = 175060167632 \text{ mm}^4
 \end{aligned}$$

$$\begin{aligned}
 \delta s &= \sum AsY / \sum As \\
 &= -6176800 / 160944 = -38.38 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 I_{33} &= I_s' - \sum As \times \delta s^2 \\
 &= 175060167632 - 160944 \times (-38.379)^2 = 174823110903 \text{ mm}^4
 \end{aligned}$$

$$\begin{aligned}
 I_{22} &= (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2 \\
 &= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((2406 \times 12^3 / 12) \\
 &\quad + (2406 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 143581931712 \text{ mm}^4
 \end{aligned}$$

- 비틀림 강성

$$\begin{aligned}
 b_k &= b_2 + t_w / 2 \times 2 \\
 &= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2406.000 + 16.000 / 2 + 16.000 / 2 = 2422.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2422^2) / (2 \times 2422/12 + 2512/16 + 2512/16) \\
&= 206312130550 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 160944 + 1875000 / 8 = 395319 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2406.000 / 2 - 38.379 + 50.000 + 250.000 / 2 = 1416.38 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1416.379 \times 160944 / 395319 = 576.64 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1416.379 - 576.642 = 839.74 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 174823110903 + 9765625000 / 8 + 160944 \times 839.736^2 \\
&\quad + 1875000 / 8 \times 576.642^2 = 367468119477 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 143581931712 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1242214744212 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2422^2) / (2 \times 2422/12 + 2512/47.25 + 2512/16) \\
&= 241212018167 \quad \text{mm}^4
\end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2109.000 + 16.000 / 2 + 16.000 / 2 = 2125.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/16 + 2512/16) \\
&= 170581655276 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

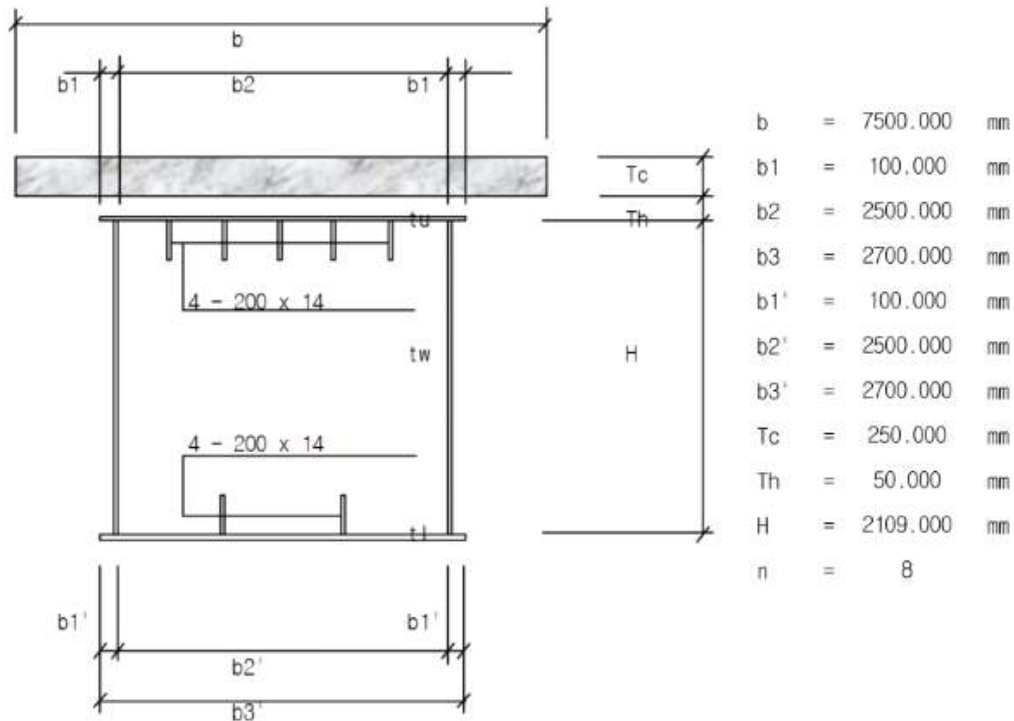
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 153816 + 1875000 / 8 = 388191 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 2109.000 / 2 - 34.751 + 50.000 + 250.000 / 2 = 1264.25 \quad \text{mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1264.251 \times 153816 / 388191 = 500.94 \quad \text{mm} \\
dvs &= dv - dvc = 1264.251 - 500.944 = 763.31 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot dvs^2 + A_c / N \cdot dvc^2 \\
&= 131476736491 + 9765625000 / 8 + 153816 \times 763.307^2 \\
&\quad + 1875000 / 8 \times 500.944^2 = 281131538589 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 132337169568 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1230969982068 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/47.25 + 2512/16) \\
&= 201968417557 \quad \text{mm}^4
\end{aligned}$$

- Section G2/4-1



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	1062.50	45900000	48768750000	921600
UPPER RIB	4 - 200.0 X 14.0	11200	954.50	10690400	10203986800	37333333
W E B	2 - 2109.0 X 12.0	50616				18761162058
LOWER RIB	4 - 200.0 X 14.0	11200	-954.50	-10690400	10203986800	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-1062.50	-45900000	48768750000	921600
TOTAL		159416		0	117945473600	18837671925

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 117945473600 + 18837671925 = 136783145525 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 0 / 159416 = 0.00 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 136783145525 - 159416 \times 0.00^2 = 136783145525 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times ti / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((2109 \times 12^3 / 12) + (2109 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 132337169568 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 2109.000 + 16.000 / 2 + 16.000 / 2 = 2125.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/16 + 2512/16) \\
&= 170581655276 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

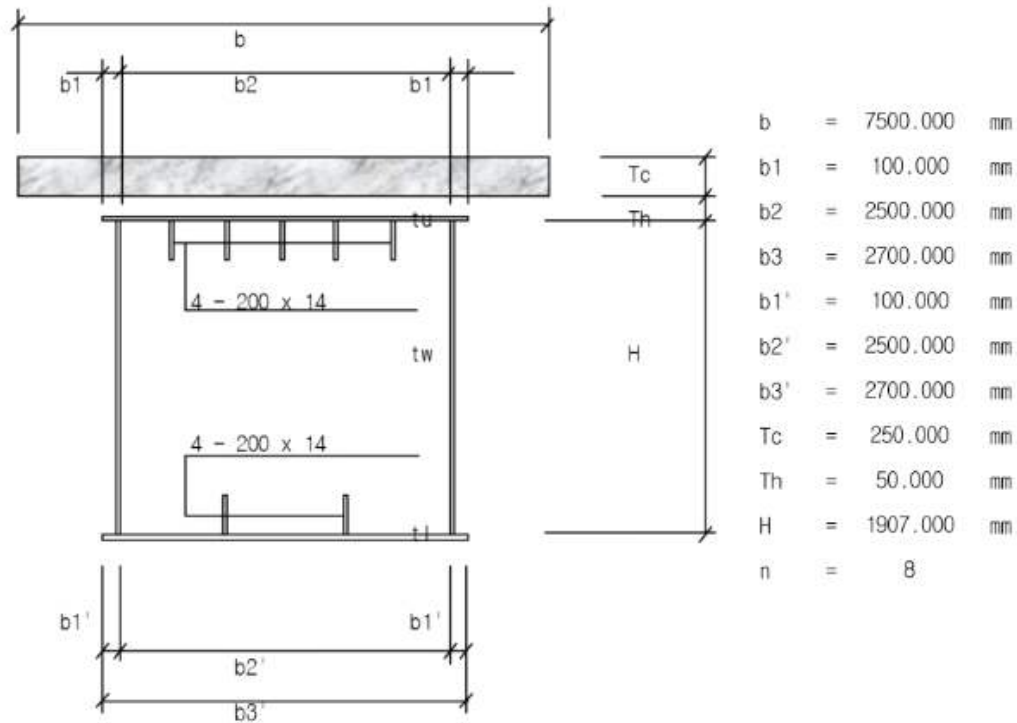
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 159416 + 1875000 / 8 = 393791 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 2109.000 / 2 - 0.000 + 50.000 + 250.000 / 2 = 1229.50 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1229.500 \times 159416 / 393791 = 497.73 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1229.500 - 497.731 = 731.77 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 136783145525 + 9765625000 / 8 + 159416 \times 731.769^2 \\
&\quad + 1875000 / 8 \times 497.731^2 = 281432023772 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 132337169568 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1230969982068 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 2125^2) / (2 \times 2125/12 + 2512/47.25 + 2512/16) \\
&= 201968417557 \quad \text{mm}^4
\end{aligned}$$

- Section G2/4-2



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	961.50	41536800	39937633200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	853.50	9559200	8158777200	37333333
W E B	2 - 1907.0 X 12.0	45768				13870179286
LOWER RIB	4 - 200.0 X 14.0	11200	-853.50	-9559200	8158777200	37333333
LOWER FL.	1 - 2700.0 X 16.0	43200	-961.50	-41536800	39937633200	921600
TOTAL		154568		0	96192820800	13946689153

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 96192820800 + 13946689153 = 110139509953 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 0 / 154568 = 0.00 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 110139509953 - 154568 \times 0.00^2 = 110139509953 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1907 \times 12^3 / 12) + (1907 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 124689216864 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1907.000 + 16.000 / 2 + 16.000 / 2 = 1923.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/16 + 2512/16) \\
&= 147104583084 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

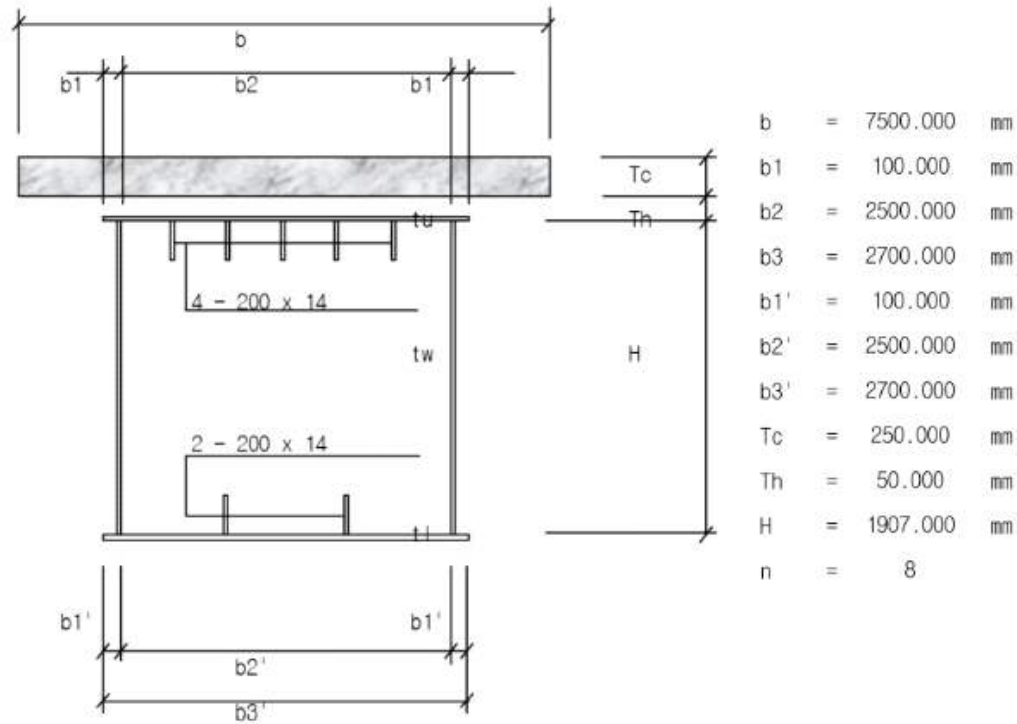
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 154568 + 1875000 / 8 = 388943 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1907.000 / 2 - 0.000 + 50.000 + 250.000 / 2 = 1128.50 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1128.500 \times 154568 / 388943 = 448.47 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 1128.500 - 448.472 = 680.03 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 110139509953 + 9765625000 / 8 + 154568 \times 680.028^2 \\
&\quad + 1875000 / 8 \times 448.472^2 = 229977514563 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 124689216864 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1223322029364 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/47.25 + 2512/16) \\
&= 175888800153 \text{ mm}^4
\end{aligned}$$

- Section G2/5-1



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	961.50	41536800	39937633200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	853.50	9559200	8158777200	37333333
W E B	2 - 1907.0 X 12.0	45768				13870179286
LOWER RIB	2 - 200.0 X 14.0	5600	-853.50	-4779600	4079388600	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-961.50	-41536800	39937633200	921600
TOTAL		148968		4779600	92113432200	13928022486

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 92113432200 + 13928022486 = 106041454686 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 4779600 / 148968 = 32.08 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 106041454686 - 148968 \times 32.085^2 = 105888102448 \text{ mm}^4$$

$$I_{22} = (b3^3 \times t_u / 12) + (b3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1907 \times 12^3 / 12) + (1907 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 124689216864 \text{ mm}^4$$

- 비틀림 감성

$$b_k = b2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1907.000 + 16.000 / 2 + 16.000 / 2 = 1923.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/16 + 2512/16) \\
&= 147104583084 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

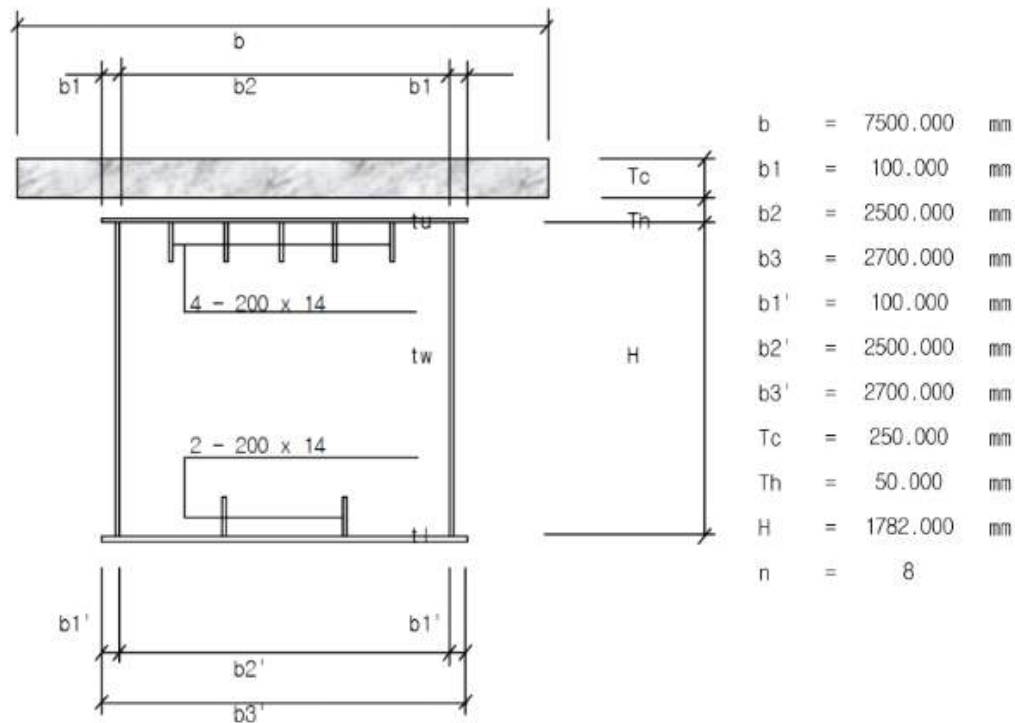
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 148968 + 1875000 / 8 = 383343 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1907.000 / 2 - 32.085 + 50.000 + 250.000 / 2 = 1096.42 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 1096.415 \times 148968 / 383343 = 426.07 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 1096.415 - 426.070 = 670.35 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 105888102448 + 9765625000 / 8 + 148968 \times 670.346^2 \\
&\quad + 1875000 / 8 \times 426.070^2 = 216596894506 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 124689216864 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1223322029364 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1923^2) / (2 \times 1923/12 + 2512/47.25 + 2512/16) \\
&= 175888800153 \quad \text{mm}^4
\end{aligned}$$

- Section G2/5-2



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	899.00	38836800	34914283200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	791.00	8859200	7007627200	37333333
W E B	2 - 1782.0 X 12.0	42768				11317567536
LOWER RIB	2 - 200.0 X 14.0	5600	-791.00	-4429600	3503813600	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-899.00	-38836800	34914283200	921600
TOTAL		145968		4429600	80340007200	11375410736

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 80340007200 + 11375410736 = 91715417936 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 4429600 / 145968 = 30.35 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 91715417936 - 145968 \times 30.346^2 = 91580995623 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1782 \times 12^3 / 12) + (1782 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 119956572864 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1782.000 + 16.000 / 2 + 16.000 / 2 = 1798.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1798^2) / (2 \times 1798/12 + 2512/16 + 2512/16) \\
&= 132967683414 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

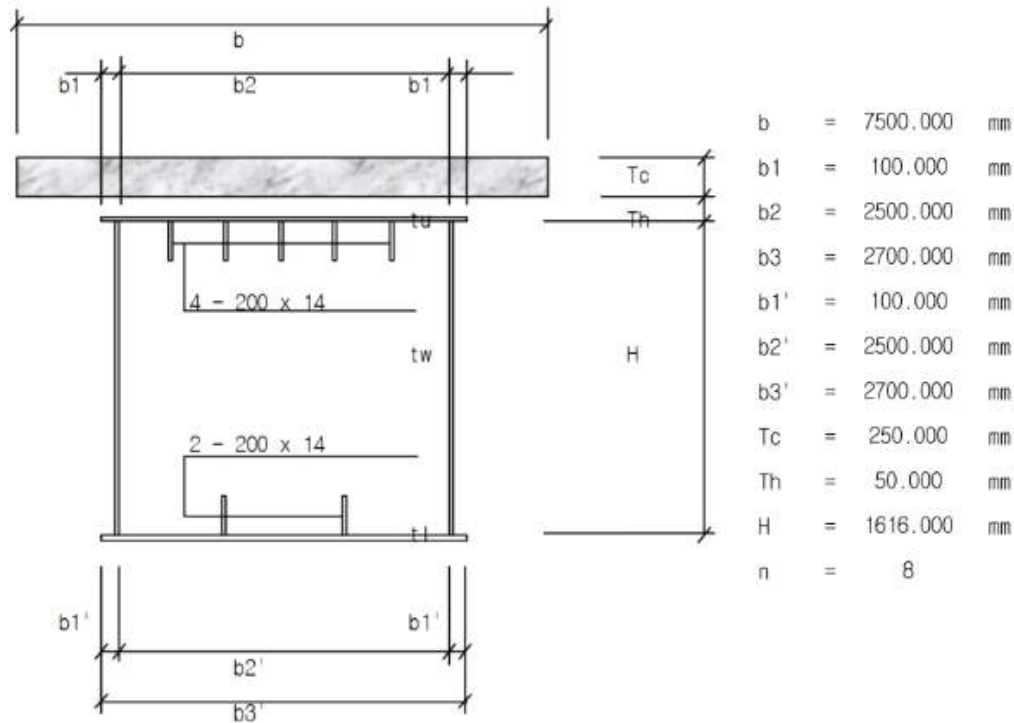
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 145968 + 1875000 / 8 = 380343 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1782.000 / 2 - 30.346 + 50.000 + 250.000 / 2 = 1035.65 \quad \text{mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 1035.654 \times 145968 / 380343 = 397.46 \quad \text{mm} \\
dvs &= dv - dvc = 1035.654 - 397.463 = 638.19 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 91580995623 + 9765625000 / 8 + 145968 \times 638.191^2 \\
&\quad + 1875000 / 8 \times 397.463^2 = 189278428133 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119956572864 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1218589385364 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1798^2) / (2 \times 1798/12 + 2512/47.25 + 2512/16) \\
&= 160048888784 \quad \text{mm}^4
\end{aligned}$$

- Section G2/5-3



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	816.00	35251200	28764979200	921600
UPPER RIB	4 - 200.0 X 14.0	11200	708.00	7929600	5614156800	37333333
W E B	2 - 1616.0 X 12.0	38784				8440225792
LOWER RIB	2 - 200.0 X 14.0	5600	-708.00	-3964800	2807078400	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-816.00	-35251200	28764979200	921600
TOTAL		141984		3964800	65951193600	8498068992

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 65951193600 + 8498068992 = 74449262592 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3964800 / 141984 = 27.92 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 74449262592 - 141984 \times 27.92^2 = 74338548434 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times t1 / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 16 / 12) + ((1616 \times 12^3 / 12) + (1616 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 113671621632 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1616.000 + 16.000 / 2 + 16.000 / 2 = 1632.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1632^2) / (2 \times 1632/12 + 2512/16 + 2512/16) \\
&= 114720743843 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

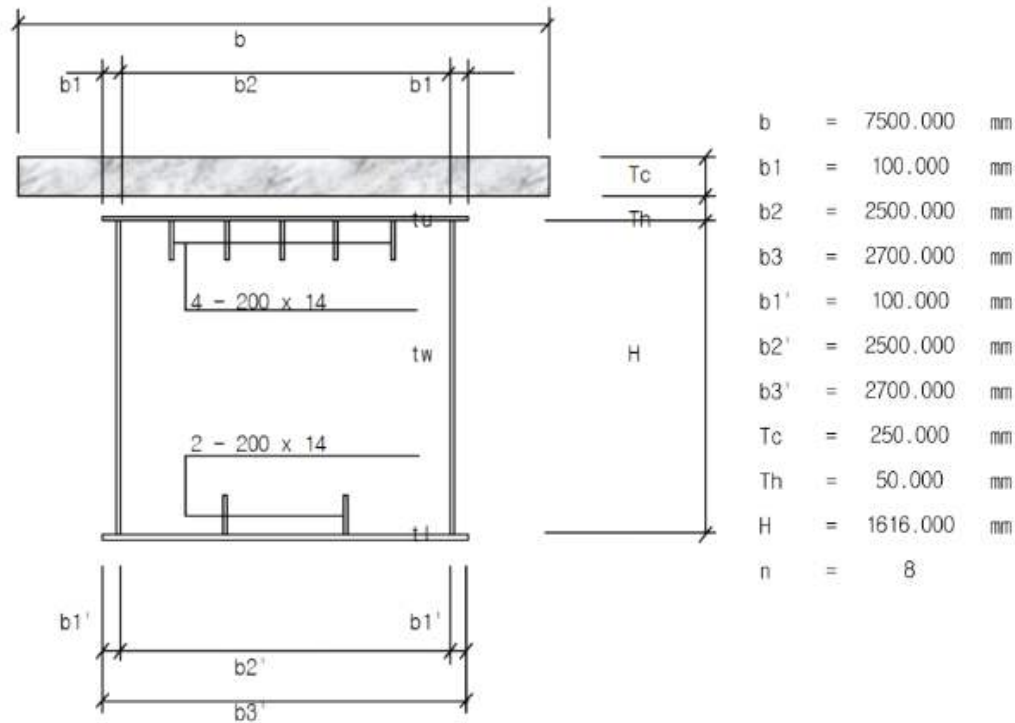
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 141984 + 1875000 / 8 = 376359 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1616.000 / 2 - 27.924 + 50.000 + 250.000 / 2 = 955.08 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 955.076 \times 141984 / 376359 = 360.31 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 955.076 - 360.309 = 594.77 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 74338548434 + 9765625000 / 8 + 141984 \times 594.767^2 \\
&\quad + 1875000 / 8 \times 360.309^2 = 156212896957 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 113671621632 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1212304434132 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1632^2) / (2 \times 1632/12 + 2512/47.25 + 2512/16) \\
&= 139426321628 \text{ mm}^4
\end{aligned}$$

- Section G2/6-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	818.00	44172000	36132696000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	708.00	7929600	5614156800	37333333
W E B	2 - 1616.0 X 12.0	38784				8440225792
LOWER RIB	2 - 200.0 X 14.0	5600	-708.00	-3964800	2807078400	18666667
LOWER FL.	1 - 2700.0 X 16.0	43200	-816.00	-35251200	28764979200	921600
TOTAL		152784		12885600	73318910400	8498947392

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 73318910400 + 8498947392 = 81817857792 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 12885600 / 152784 = 84.34 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 81817857792 - 152784 \times 84.339^2 = 80731103372 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 16 / 12) + ((1616 \times 12^3 / 12) + (1616 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 120232621632 \text{ mm}^4$$

- 비틀림 감성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1616.000 + 20.000 / 2 + 16.000 / 2 = 1634.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1634^2) / (2 \times 1634/12 + 2512/20 + 2512/16) \\
&= 121440222251 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 152784 + 1875000 / 8 = 387159 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1616.000 / 2 - 84.339 + 50.000 + 250.000 / 2 = 898.66 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 898.661 \times 152784 / 387159 = 354.64 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 898.661 - 354.637 = 544.02 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 80731103372 + 9765625000 / 8 + 152784 \times 544.024^2 \\
&\quad + 1875000 / 8 \times 354.637^2 = 156646870853 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 120232621632 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1218865434132 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1634^2) / (2 \times 1634/12 + 2512/51.25 + 2512/16) \\
&= 140883273090 \quad \text{mm}^4
\end{aligned}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 16.000 / 2 = 1626.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1626^2) / (2 \times 1626/12 + 2512/20 + 2512/16) \\
&= 120543629177 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

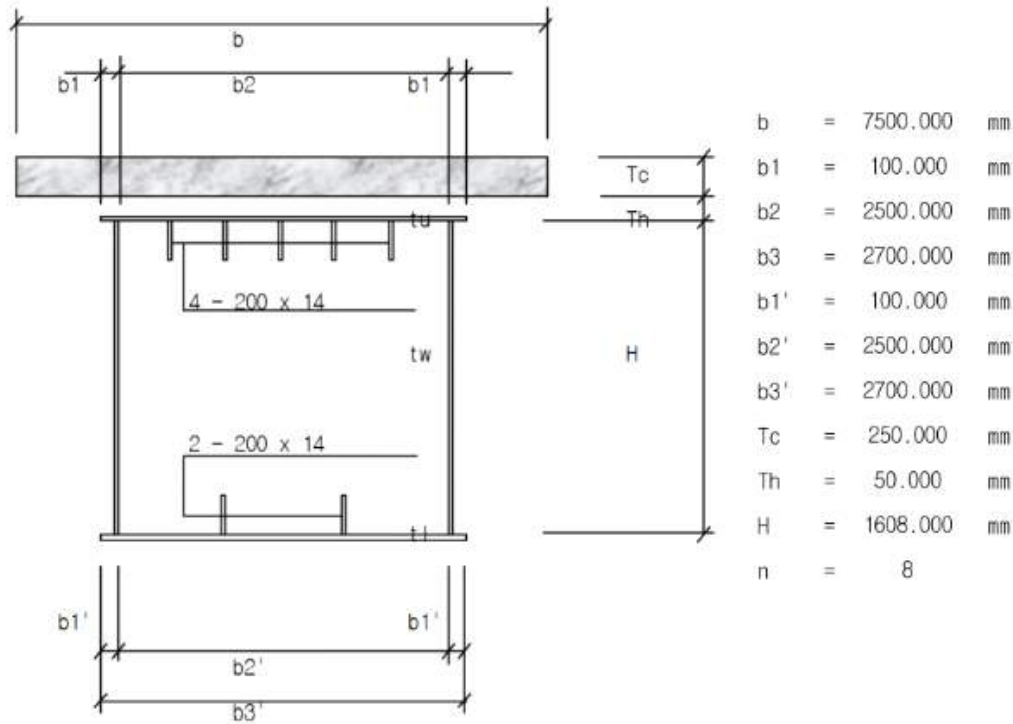
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 152592 + 1875000 / 8 = 386967 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1608.000 / 2 - 84.015 + 50.000 + 250.000 / 2 = 894.99 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 894.985 \times 152592 / 386967 = 352.92 \text{ mm} \\
dvs &= dv - dvc = 894.985 - 352.918 = 542.07 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 79887339742 + 9765625000 / 8 + 152592 \times 542.067^2 \\
&\quad + 1875000 / 8 \times 352.918^2 = 155136848106 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119929732416 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1218562544916 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1626^2) / (2 \times 1626/12 + 2512/51.25 + 2512/16) \\
&= 139897077229 \text{ mm}^4
\end{aligned}$$

- Section G2/7-1



① 합성전 단면

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	814.00	43956000	35780184000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	704.00	7884800	5550899200	37333333
W E B	2 - 1608.0 X 12.0	38592				8315495424
LOWER RIB	2 - 200.0 X 14.0	5600	-704.00	-3942400	2775449600	18666667
LOWER FL.	1 - 2700.0 X 22.0	59400	-815.00	-48411000	39454965000	2395800
TOTAL		168792		-512600	83561497800	8375691224

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 83561497800 + 8375691224 = 91937189024 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -512600 / 168792 = -3.04 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 91937189024 - 168792 \times (-3.037)^2 = 91935632322 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 22 / 12) + ((1608 \times 12^3 / 12) + (1608 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 129771232416 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 22.000 / 2 = 1629.00 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1629^2) / (2 \times 1629/12 + 2512/20 + 2512/22) \\
&= 131002951709 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

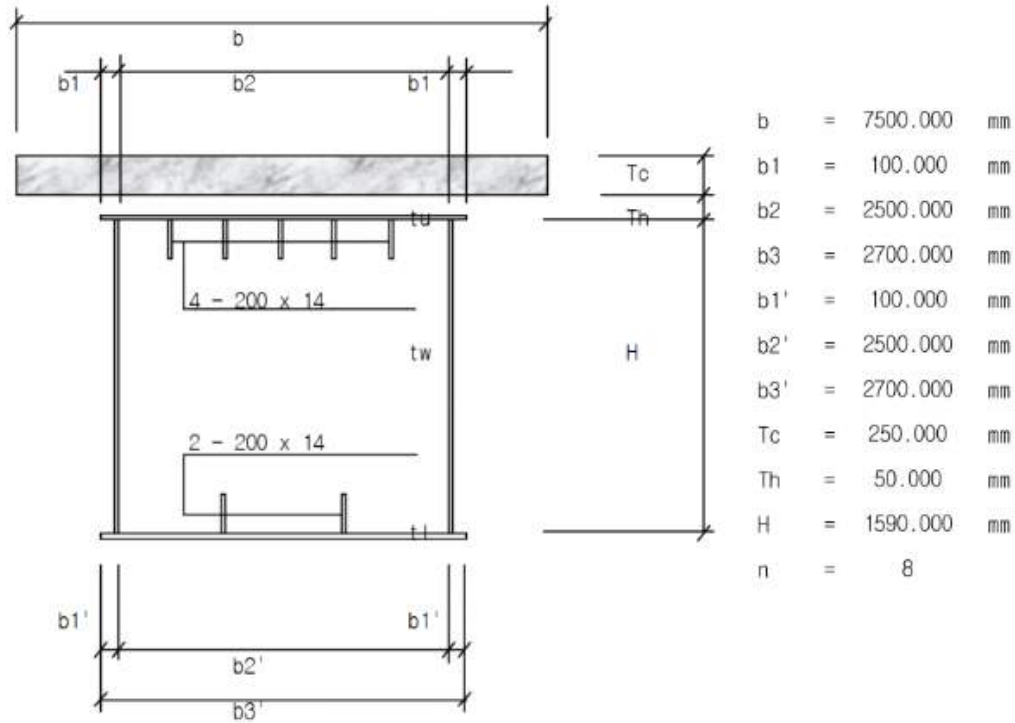
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 168792 + 1875000 / 8 = 403167 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
dv &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1608.000 / 2 - 3.037 + 50.000 + 250.000 / 2 = 982.04 \text{ mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 982.037 \times 168792 / 403167 = 411.14 \text{ mm} \\
dvs &= dv - dvc = 982.037 - 411.145 = 570.89 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 91935632322 + 9765625000 / 8 + 168792 \times 570.89^2 \\
&\quad + 1875000 / 8 \times 411.145^2 = 187787406893 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 129771232416 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1228404044916 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1629^2) / (2 \times 1629/12 + 2512/51.25 + 2512/22) \\
&= 154083215951 \text{ mm}^4
\end{aligned}$$

- Section G2/7-2



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	805.00	43470000	34993350000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	695.00	7784000	5409880000	37333333
W E B	2 - 1590.0 X 12.0	38160				8039358000
LOWER RIB	2 - 200.0 X 14.0	5600	-695.00	-3892000	2704940000	18666667
LOWER FL.	1 - 2700.0 X 22.0	59400	-806.00	-47876400	38588378400	2395800
TOTAL		168360		-514400	81696548400	8099553800

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 81696548400 + 8099553800 = 89796102200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -514400 / 168360 = -3.06 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 89796102200 - 168360 \times (-3.055)^2 = 89794530524 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 22 / 12) + ((1590 \times 12^3 / 12) + (1590 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 129089731680 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1590.000 + 20.000 / 2 + 22.000 / 2 = 1611.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1611^2) / (2 \times 1611/12 + 2512/20 + 2512/22) \\
&= 128880071255 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

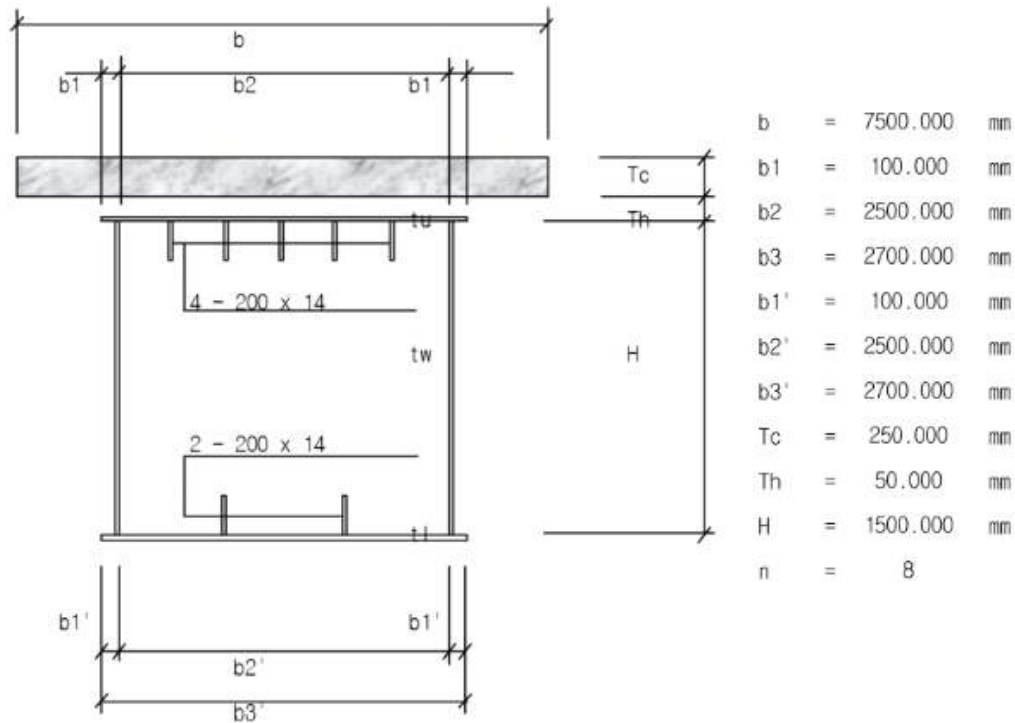
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 168360 + 1875000 / 8 = 402735 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
dv &= H / 2 - \delta s + T_h + T_c / 2 \\
&= 1590.000 / 2 - -3.055 + 50.000 + 250.000 / 2 = 973.06 \quad \text{mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 973.055 \times 168360 / 402735 = 406.78 \quad \text{mm} \\
dvs &= dv - dvc = 973.055 - 406.778 = 566.28 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot dvs^2 + A_c / N \cdot dvc^2 \\
&= 89794530524 + 9765625000 / 8 + 168360 \times 566.278^2 \\
&\quad + 1875000 / 8 \times 406.778^2 = 183784885030 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 129089731680 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1227722544180 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1611^2) / (2 \times 1611/12 + 2512/51.25 + 2512/22) \\
&= 151744116941 \quad \text{mm}^4
\end{aligned}$$

- Section G2/7-3



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 22.0	59400	-761.00	-45203400	34399787400	2395800
TOTAL		166200		-523400	72688187400	6810195800

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 72688187400 + 6810195800 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -523400 / 166200 = -3.15 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times t1 / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 22 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 125682228000 \text{ mm}^4$$

- 비틀림 강성

$$bk = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 22.000 / 2 = 1521.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1521^2) / (2 \times 1521/12 + 2512/20 + 2512/22) \\
&= 118375705793 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

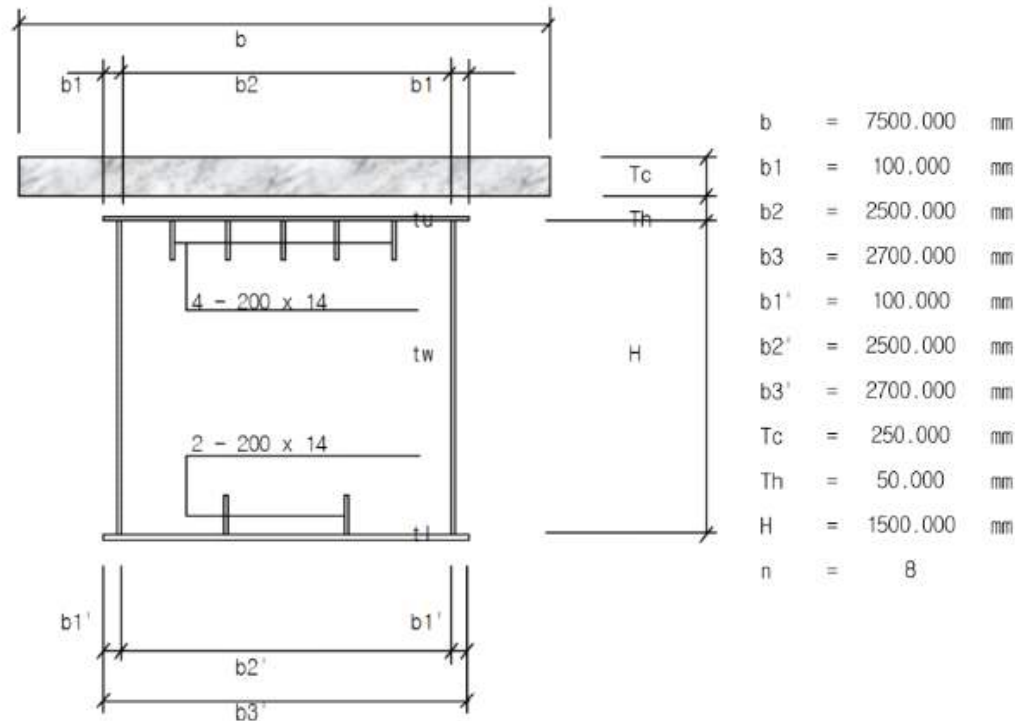
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 166200 + 1875000 / 8 = 400575 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1500.000 / 2 - -3.149 + 50.000 + 250.000 / 2 = 928.15 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 928.149 \times 166200 / 400575 = 385.09 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 928.149 - 385.092 = 543.06 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 79496734899 + 9765625000 / 8 + 166200 \times 543.057^2 \\
&\quad + 1875000 / 8 \times 385.092^2 = 164488509278 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 125682228000 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1224315040500 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1521^2) / (2 \times 1521/12 + 2512/51.25 + 2512/22) \\
&= 140132182685 \quad \text{mm}^4
\end{aligned}$$

- Section G2/8-1



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-760.00	-41040000	31190400000	1800000
TOTAL		160800		3640000	69478800000	6809600000

$$I_{s'} = \sum AsY^2 + \sum I_o$$

$$= 69478800000 + 6809600000 = 76288400000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3640000 / 160800 = 22.64 \text{ mm}$$

$$I_{33} = I_{s'} - \sum As \times \delta s^2$$

$$= 76288400000 - 160800 \times 22.637^2 = 76206001990 \text{ mm}^4$$

$$I_{22} = (b3^3 \times tu / 12) + (b3'^3 \times tl / 12) + ((H \times tw^3 / 12) + (H \times tw \times (b2 / 2 + tw / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 122401728000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b2 + tw / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 20.000 / 2 = 1520.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1520^2) / (2 \times 1520/12 + 2512/20 + 2512/20) \\
&= 115583694748 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

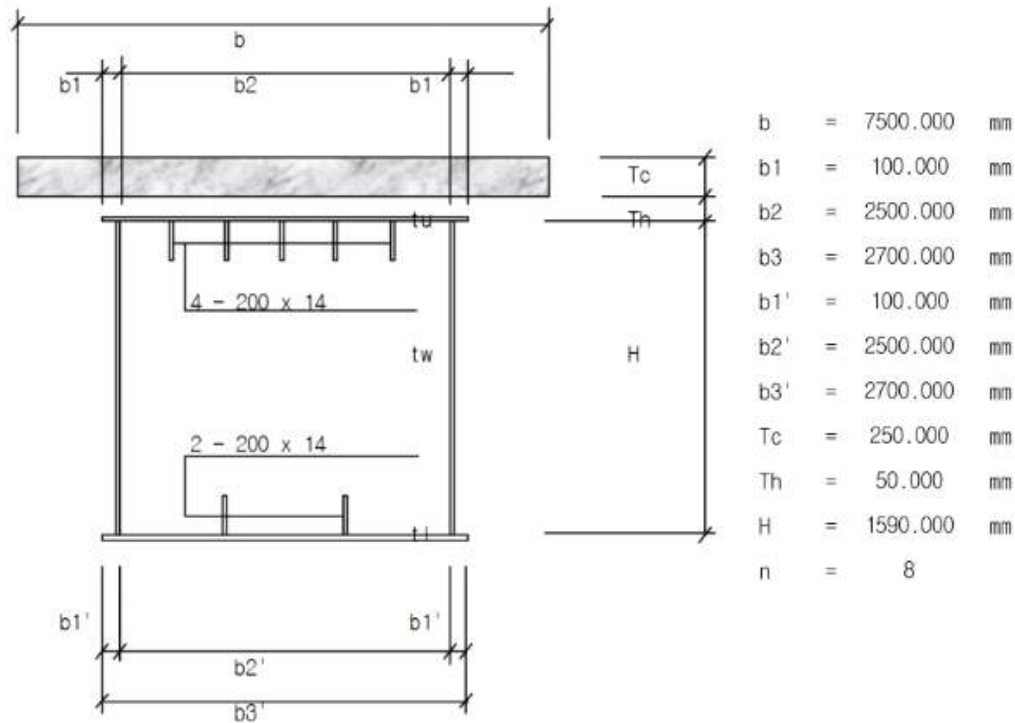
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 160800 + 1875000 / 8 = 395175 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 22.637 + 50.000 + 250.000 / 2 = 902.36 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 902.363 \times 160800 / 395175 = 367.18 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 902.363 - 367.179 = 535.18 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 76206001990 + 9765625000 / 8 + 160800 \times 535.184^2 \\
&\quad + 1875000 / 8 \times 367.179^2 = 155081916024 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 122401728000 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1221034540500 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

★ 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1520^2) / (2 \times 1520/12 + 2512/51.25 + 2512/20) \\
&= 136268498093 \quad \text{mm}^4
\end{aligned}$$

- Section G2/8-2



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	805.00	43470000	34993350000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	695.00	7784000	5409880000	37333333
W E B	2 - 1590.0 X 12.0	38160				8039358000
LOWER RIB	2 - 200.0 X 14.0	5600	-695.00	-3892000	2704940000	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-805.00	-43470000	34993350000	1800000
TOTAL		162960		3892000	78101520000	8098958000

$$I_s' = \sum AsY^2 + \sum Io$$

$$= 78101520000 + 8098958000 = 86200478000 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3892000 / 162960 = 23.88 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 86200478000 - 162960 \times 23.88^2 = 86107524735 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1590 \times 12^3 / 12) + (1590 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 125809231680 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1590.000 + 20.000 / 2 + 20.000 / 2 = 1610.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1610^2) / (2 \times 1610/12 + 2512/20 + 2512/20) \\
&= 125932433690 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

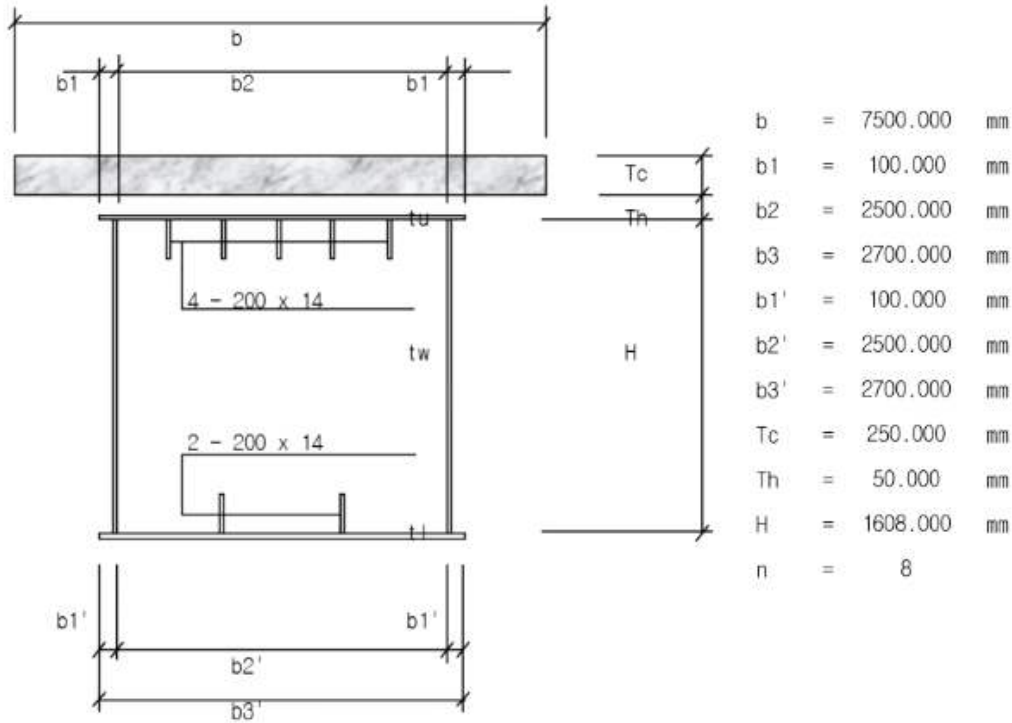
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 162960 + 1875000 / 8 = 397335 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1590.000 / 2 - 23.883 + 50.000 + 250.000 / 2 = 946.12 \quad \text{mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 946.117 \times 162960 / 397335 = 388.03 \quad \text{mm} \\
d_{vs} &= d_v - d_{vc} = 946.117 - 388.033 = 558.08 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 86107524735 + 9765625000 / 8 + 162960 \times 558.084^2 \\
&\quad + 1875000 / 8 \times 388.033^2 = 173373105725 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 125809231680 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1224442044180 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1610^2) / (2 \times 1610/12 + 2512/51.25 + 2512/20) \\
&= 147706055458 \quad \text{mm}^4
\end{aligned}$$

- Section G2/8-3



① 합성전 단면

구 분	구 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	814.00	43956000	35780184000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	704.00	7884800	5550899200	37333333
W E B	2 - 1608.0 X 12.0	38592				8315495424
LOWER RIB	2 - 200.0 X 14.0	5600	-704.00	-3942400	2775449600	18666667
LOWER FL.	1 - 2700.0 X 20.0	54000	-814.00	-43956000	35780184000	1800000
TOTAL		163392		3942400	79886716800	8375095424

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 79886716800 + 8375095424 = 88261812224 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 3942400 / 163392 = 24.13 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 88261812224 - 163392 \times 24.128^2 = 88166688119 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 20 / 12) + ((1608 \times 12^3 / 12) + (1608 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 126490732416 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1608.000 + 20.000 / 2 + 20.000 / 2 = 1628.00 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1628^2) / (2 \times 1628/12 + 2512/20 + 2512/20) \\
&= 128024787155 \quad \text{mm}^4
\end{aligned}$$

② 합성후 단면

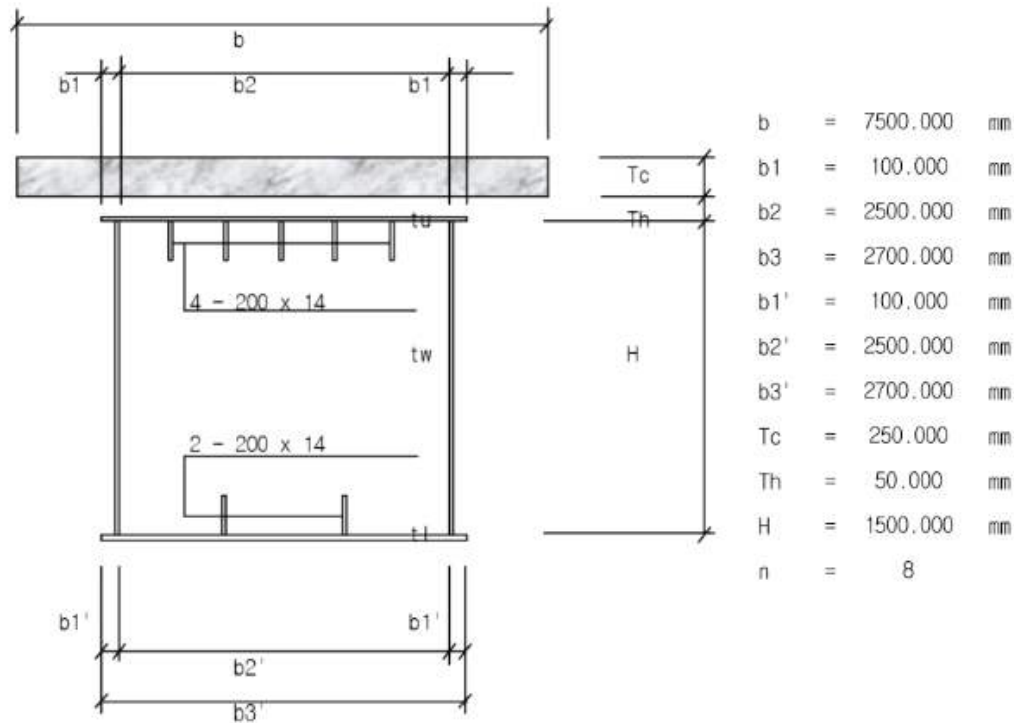
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \quad \text{mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 163392 + 1875000 / 8 = 397767 \quad \text{mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \quad \text{mm}^4 \\
dv &= H / 2 - \delta s + Th + T_c / 2 \\
&= 1608.000 / 2 - 24.128 + 50.000 + 250.000 / 2 = 954.87 \quad \text{mm} \\
dvc &= dv \cdot \sum A_s / A_v \\
&= 954.872 \times 163392 / 397767 = 392.24 \quad \text{mm} \\
dvs &= dv - dvc = 954.872 - 392.236 = 562.64 \quad \text{mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot dvs^2 + A_c/N \cdot dvc^2 \\
&= 88166688119 + 9765625000 / 8 + 163392 \times 562.636^2 \\
&\quad + 1875000 / 8 \times 392.236^2 = 177168933723 \quad \text{mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 126490732416 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1225123544916 \quad \text{mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \quad \text{mm} \\
K &= (4 \times b k^2 \times H_k^2) / (2 \times H_k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1628^2) / (2 \times 1628/12 + 2512/51.25 + 2512/20) \\
&= 150011265124 \quad \text{mm}^4
\end{aligned}$$

- Section G2/9



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 20.0	54000	760.00	41040000	31190400000	1800000
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 18.0	48600	-759.00	-36887400	27997536600	1312200
TOTAL		155400		7792600	66285936600	6809112200

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 66285936600 + 6809112200 = 73095048800 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= 7792600 / 155400 = 50.15 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 73095048800 - 155400 \times 50.145^2 = 72704285513 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 20 / 12) + (2700^3 \times 18 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2$$

$$= 119121228000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
H_k &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 20.000 / 2 + 18.000 / 2 = 1519.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1519^2) / (2 \times 1519/12 + 2512/20 + 2512/18) \\
&= 112360840772 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

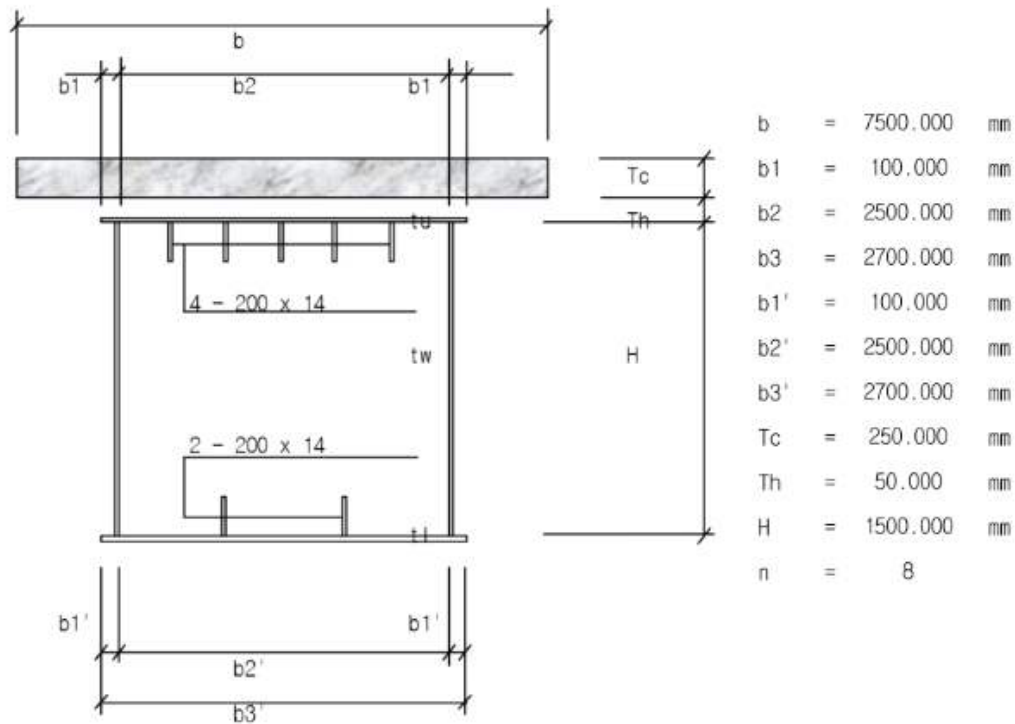
$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c / N \\
&= 155400 + 1875000 / 8 = 389775 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 50.145 + 50.000 + 250.000 / 2 = 874.85 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 874.855 \times 155400 / 389775 = 348.80 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 874.855 - 348.797 = 526.06 \text{ mm} \\
I_{v33} &= I_{33} + I_c / N + \sum A_s \cdot d_{vs}^2 + A_c / N \cdot d_{vc}^2 \\
&= 72704285513 + 9765625000 / 8 + 155400 \times 526.057^2 \\
&\quad + 1875000 / 8 \times 348.797^2 = 145443760458 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 119121228000 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1217754040500 \text{ mm}^4
\end{aligned}$$

- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 20.000 + 250.000 / 8 = 51.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1519^2) / (2 \times 1519/12 + 2512/51.25 + 2512/18) \\
&= 131841207815 \text{ mm}^4
\end{aligned}$$

- Section G2/10



① 합성전 단면

구분	규격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	1 - 2700.0 X 16.0	43200	758.00	32745600	24821164800	921600
UPPER RIB	4 - 200.0 X 14.0	11200	650.00	7280000	4732000000	37333333
W E B	2 - 1500.0 X 12.0	36000				6750000000
LOWER RIB	2 - 200.0 X 14.0	5600	-650.00	-3640000	2366000000	18666667
LOWER FL.	1 - 2700.0 X 18.0	48600	-759.00	-36887400	27997536600	1312200
TOTAL		144600		-501800	59916701400	6808233800

$$I_s' = \sum AsY^2 + \sum I_o$$

$$= 59916701400 + 6808233800 = 66724935200 \text{ mm}^4$$

$$\delta s = \sum AsY / \sum As$$

$$= -501800 / 144600 = -3.47 \text{ mm}$$

$$I_{33} = I_s' - \sum As \times \delta s^2$$

$$= 66724935200 - 144600 \times (-3.47)^2 = 66723193822 \text{ mm}^4$$

$$I_{22} = (b_3^3 \times t_u / 12) + (b_3'^3 \times t_l / 12) + ((H \times t_w^3 / 12) + (H \times t_w \times (b_2 / 2 + t_w / 2)^2)) \times 2$$

$$= (2700^3 \times 16 / 12) + (2700^3 \times 18 / 12) + ((1500 \times 12^3 / 12) + (1500 \times 12 \times (2500 / 2 + 12 / 2)^2)) \times 2 = 112560228000 \text{ mm}^4$$

- 비틀림 강성

$$b_k = b_2 + t_w / 2 \times 2$$

$$= 2500.000 + 12.000 / 2 \times 2 = 2512.00 \text{ mm}$$

$$\begin{aligned}
Hk &= H + t_u / 2 + t_l / 2 \\
&= 1500.000 + 16.000 / 2 + 18.000 / 2 = 1517.00 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_u + b k / t_l) \\
&= (4 \times 2512^2 \times 1517^2) / (2 \times 1517/12 + 2512/16 + 2512/18) \\
&= 105728130068 \text{ mm}^4
\end{aligned}$$

② 합성후 단면

$$\begin{aligned}
A_c &= b \times T_c \\
&= 7500.000 \times 250.000 = 1875000 \text{ mm}^2 \\
A_v &= \sum A_s + A_c/N \\
&= 144600 + 1875000 / 8 = 378975 \text{ mm}^2 \\
I_c &= b \times T_c^3 / 12 \\
&= 7500.000 \times 250.000^3 / 12 = 9765625000 \text{ mm}^4 \\
d_v &= H / 2 - \delta_s + T_h + T_c / 2 \\
&= 1500.000 / 2 - 3.470 + 50.000 + 250.000 / 2 = 928.47 \text{ mm} \\
d_{vc} &= d_v \cdot \sum A_s / A_v \\
&= 928.470 \times 144600 / 378975 = 354.26 \text{ mm} \\
d_{vs} &= d_v - d_{vc} = 928.470 - 354.263 = 574.21 \text{ mm} \\
I_{v33} &= I_{33} + I_c/N + \sum A_s \cdot d_{vs}^2 + A_c/N \cdot d_{vc}^2 \\
&= 66723193822 + 9765625000 / 8 + 144600 \times 574.207^2 \\
&\quad + 1875000 / 8 \times 354.263^2 = 145035133822 \text{ mm}^4 \\
I_{v22} &= I_{22} + b^3 \times T_c / 12 / N \\
&= 112560228000 + 7500.000^3 \\
&\quad \times 250.000 / 12 / 8 = 1211193040500 \text{ mm}^4
\end{aligned}$$

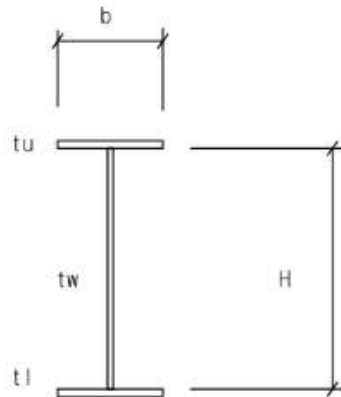
- 비틀림 강성

* 합성단면의 K값 산정시 CON'C SLAB의 두께를 강재로 환산하여 적용한다.

$$\begin{aligned}
t_{cu} &= t_u + T_c / N \\
&= 16.000 + 250.000 / 8 = 47.25 \text{ mm} \\
K &= (4 \times b k^2 \times H k^2) / (2 \times H k / t_w + b k / t_{cu} + b k / t_l) \\
&= (4 \times 2512^2 \times 1517^2) / (2 \times 1517/12 + 2512/47.25 + 2512/18) \\
&= 130368040679 \text{ mm}^4
\end{aligned}$$

2-2. 가로보 및 세로보 단면상수 산정

- 가로보 Section 1 : 일반 및 교각



$$b_u = 300.00 \text{ mm}$$

$$b_l = 300.00 \text{ mm}$$

$$H = 1200.00 \text{ mm}$$

$$t_u = 12.00 \text{ mm}$$

$$t_w = 9.00 \text{ mm}$$

$$t_l = 12.00 \text{ mm}$$

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	300.00 X 12.00	3600.0	606.00	2181600	1322049600	43200
W E B	1200.00 X 9.00	10800.0				12960000000
LOWER FL.	300.00 X 12.00	3600.0	-606.00	-2181600	1322049600	43200
TOTAL		18000.0		0	2644099200	1296086400

$$I_{33} = \sum AsY^2 + \sum I_o$$

$$= 2644099200 + 1296086400 = 3940185600 \text{ mm}^4$$

$$I_{22} = (b_u^3 \times t_u / 12) + (b_l^3 \times t_l / 12) + (H \times t_w^3 / 12)$$

$$= (300^3 \times 12 / 12) + (300^3 \times 12 / 12) + (1200 \times 9^3 / 12)$$

$$= 54072900 \text{ mm}^4$$

모델링시의 가로보 강성보정은 $I' = I \times (L' / L)^3$ 에 의한다.

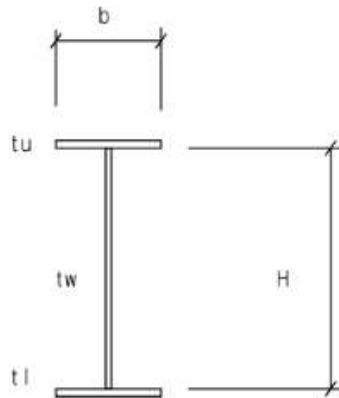
여기서, L, l : 실제 가로보의 길이 및 강성 L', l' : 모델링시 가로보의 길이 및 보정강성

- 비틀림 강성

$$K = \sum (b \times t^3) / 3$$

$$= (300 \times 12^3 + 300 \times 12^3 + 1200 \times 9^3) / 3 = 637200 \text{ mm}^4$$

- 가로보 Section 2 : 교대



$$b_u = 300.00 \text{ mm}$$

$$b_l = 300.00 \text{ mm}$$

$$H = 1000.00 \text{ mm}$$

$$t_u = 12.00 \text{ mm}$$

$$t_w = 9.00 \text{ mm}$$

$$t_l = 12.00 \text{ mm}$$

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	300.00 X 12.00	3600.0	506.00	1821600	921729600	43200
W E B	1000.00 X 9.00	9000.0				750000000
LOWER FL.	300.00 X 12.00	3600.0	-506.00	-1821600	921729600	43200
TOTAL		16200.0		0	1843459200	750086400

$$I_{33} = \sum AsY^2 + \sum I_o$$

$$= 1843459200 + 750086400 = 2593545600 \text{ mm}^4$$

$$I_{22} = (b_u^3 \times t_u / 12) + (b_l^3 \times t_l / 12) + (H \times t_w^3 / 12)$$

$$= (300^3 \times 12 / 12) + (300^3 \times 12 / 12) + (1000 \times 9^3 / 12)$$

$$= 54060750 \text{ mm}^4$$

모델링시의 가로보 강성보정은 $I' = I \times (L' / L)^3$ 에 의한다.

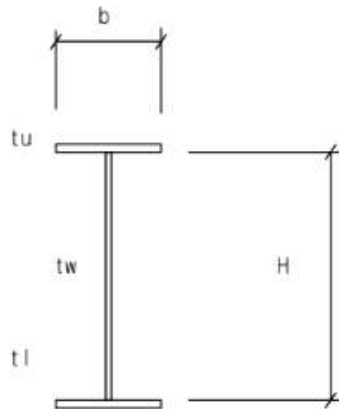
여기서, L, I : 실제 가로보의 길이 및 강성 L', I' : 모델링시 가로보의 길이 및 보정강성

- 비틀림 강성

$$K = \sum (b \times t^3) / 3$$

$$= (300 \times 12^3 + 300 \times 12^3 + 1000 \times 9^3) / 3 = 588600 \text{ mm}^4$$

- 세로보 Section 1



$$\begin{aligned} b_u &= 300.00 \text{ mm} \\ b_l &= 300.00 \text{ mm} \\ H &= 800.00 \text{ mm} \\ t_u &= 12.00 \text{ mm} \\ t_w &= 9.00 \text{ mm} \\ t_l &= 12.00 \text{ mm} \end{aligned}$$

구 분	규 격	As(mm ²)	Y(mm)	AsY(mm ³)	AsY ² (mm ⁴)	Io(mm ⁴)
UPPER FL.	300.00 X 12.00	3600.0	406.00	1461600	593409600	43200
W E B	800.00 X 9.00	7200.0				384000000
LOWER FL.	300.00 X 12.00	3600.0	-406.00	-1461600	593409600	43200
TOTAL		14400.0		0	1186819200	384086400

$$\begin{aligned} I_{33} &= \sum AsY^2 + \sum I_o \\ &= 1186819200 + 384086400 = 1570905600 \text{ mm}^4 \\ I_{22} &= (b_u^3 \times t_u / 12) + (b_l^3 \times t_l / 12) + (H \times t_w^3 / 12) \\ &= (300^3 \times 12 / 12) + (300^3 \times 12 / 12) + (800 \times 9^3 / 12) \\ &= 54048600 \text{ mm}^4 \end{aligned}$$

모델링시의 가로보 강성보정은 $I' = I \times (L' / L)^3$ 에 의한다.

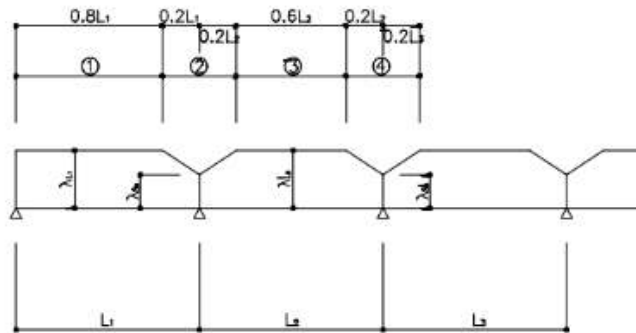
여기서, L, l : 실제 가로보의 길이 및 강성 L', l' : 모델링시 가로보의 길이 및 보정강성

- 비틀림 강성

$$\begin{aligned} K &= \sum (b \times t^3) / 3 \\ &= (300 \times 12^3 + 300 \times 12^3 + 800 \times 9^3) / 3 = 540000 \text{ mm}^4 \end{aligned}$$

3. 플랜지 및 슬래브 유효폭

3-1. 플랜지 유효폭 (☞ 도.설 3.8.3.4)



상부 : 복부간격 $2b = 2.500$ m, 플랜지돌출폭 $be = 0.100$ m

하부 : 복부간격 $2b = 2.500$ m, 플랜지돌출폭 $be = 0.100$ m

$L1,6 = 40.000$ m

$L2-5 = 50.000$ m

1. 제 1, 6 경간 정모멘트부

$$l = 0.8 \times L1 = 0.8 \times 40 = 32.000 \text{ m}$$

· 상부

$$b/l = 1.25 / 32 = 0.039$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda L1 = b = 1.25 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda L1 + be) = 2.700 \text{ m}$$

· 하부

$$b/l = 1.25 / 32 = 0.039$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda L1 = b = 1.25 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda L1 + be) = 2.700 \text{ m}$$

2. 제 1, 6 경간 부모멘트부

$$l = 0.2 \times (L1 + L2) = 0.2 \times (40 + 50) = 18.000 \text{ m}$$

· 상부

$$b/l = 1.25 / 18 = 0.069$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda S1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.074 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda S1 + be) = 2.349 \text{ m}$$

· 하 부

$$b/l = 1.25 / 18 = 0.069$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda S1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.074 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda S1 + b_e) = 2.349 \text{ m}$$

3. 제 2~5 경간 정모멘트부

$$l = 0.6 \times L2 = 0.6 \times 50 = 30.000 \text{ m}$$

· 상 부

$$b/l = 1.25 / 30 = 0.042$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda L2 = b = 1.25 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda L2 + b_e) = 2.700 \text{ m}$$

· 하 부

$$b/l = 1.25 / 30 = 0.042$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda L2 = b = 1.25 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda L2 + b_e) = 2.700 \text{ m}$$

4. 제 2~5 경간 부모멘트부

$$l = 0.2 \times (L2 + L2) = 0.2 \times (50 + 50) = 20.000 \text{ m}$$

· 상 부

$$b/l = 1.25 / 20 = 0.063$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda S1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 0 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda S1 + b_e) = 2.394 \text{ m}$$

· 하 부

$$b/l = 1.25 / 20 = 0.063$$

여기서, $0.02 < b/l < 0.30$ 이므로

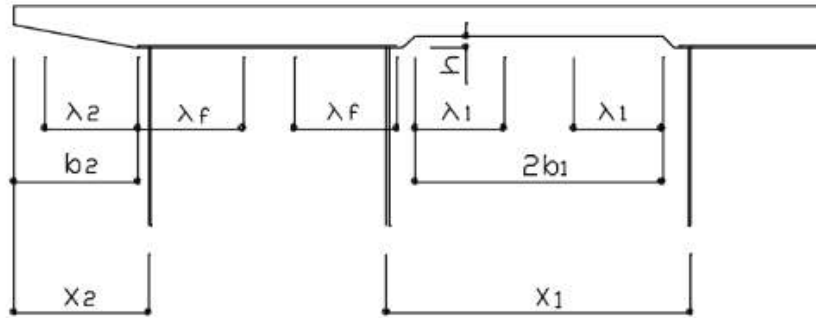
$$\lambda S1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 0 \text{ m}$$

$$\therefore \text{플랜지 유효폭 } B = 2 \times (\lambda S1 + b_e) = 2.394 \text{ m}$$

3-2. 슬래브 유효폭 (도.설 3.8.3.4)

플랜지 상단 부분에서의 바닥판에 대한 전단 지면도 상판내의 전단지면과 같은 정도가 되는 것으로 간주 한다

1) GIRDER - 1, 3



$X_1 = 5.000$: 인접한 GIRDER의 복부사이의 간격

$X_2 = 1.000$: 외측 GIRDER 복부에서 캔틸레버 끝단까지의 거리

$h = 0.100$: 현치 높이

$b_e = 0.100$: 플랜지의 돌출폭

$$2b_1 = X_1 - 2(b_e + h) = 5 - 2 \times (0.1 + 0.1) = 4.600 \text{ m}$$

$$b_2 = X_2 - b_e = 1 - 0.1 = 0.900 \text{ m}$$

1. 제 1.6 경간 정모멘트부

$$l = 0.8 \times L_1 = 0.8 \times 40 = 32.000 \text{ m}$$

$$b_1 / l = 2.3 / 32 = 0.072$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda_1 = \{1.1 - 2(b/l)\} \cdot b = 2.199 \text{ m}$$

$$b_2 / l = 0.9 / 32 = 0.028$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda_2 = b = 0.9 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda_1 + \lambda_2 + h = 5.899 \text{ m}$$

2. 제 1.6 경간 부모멘트부

$$l = 0.2 \times (L_1 + L_2) = 0.2 \times (40 + 50) = 18.000 \text{ m}$$

$$b_1 / l = 2.3 / 18 = 0.128$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda_1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.667 \text{ m}$$

$$b_2 / l = 0.9 / 18 = 0.050$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda_2 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 0.82 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda_1 + \lambda_2 + h = 4.936 \text{ m}$$

3. 제 2~5 경간 정모멘트부

$$l = 0.6 \times L2 = 0.6 \times 50 = 30.000 \text{ m}$$

$$b1 / l = 2.3 / 30 = 0.077$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda 1 = \{1.1 - 2(b/l)\} \cdot b = 2.177 \text{ m}$$

$$b2 / l = 0.9 / 30 = 0.030$$

여기서, $b/l \leq 0.05$ 이므로

$$\lambda 2 = b = 0.9 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda 1 + \lambda 2 + h = 5.877 \text{ m}$$

4. 제 2~5 경간 부모멘트부

$$l = 0.2 \times (L2 + L2) = 0.2 \times (50 + 50) = 20.000 \text{ m}$$

$$b1 / l = 2.3 / 20 = 0.115$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda 1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.728 \text{ m}$$

$$b2 / l = 0.9 / 20 = 0.045$$

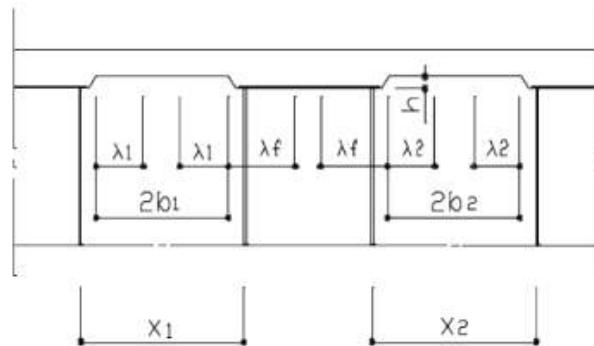
여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda 2 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 0.833 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda 1 + \lambda 2 + h = 5.055 \text{ m}$$

2) GIRDER - 2



X1 = 5.000 : GIRDER 1, 2 의 복부사이의 간격

X2 = 5.000 : GIRDER 2, 3 의 북부사이의 거리

$h = 0.100$: 현치 높이

be = 0.100 : 플랜지의 돌출폭

$$2b_1 = X_1 - 2(b_e + h) = 5 - 2 \times (0.1 + 0.1) = 4.600 \text{ m}$$

$$2b_2 = X_2 - 2(b_e + h) = 5 - 2 \times (0.1 + 0.1) = 4.600 \text{ m}$$

1. 제 1.6 경간 정모멘트부

$$I = 0.8 \times L1 = 0.8 \times \lambda S1 = 32,000 \text{ m}$$

$$b1 / 1 = 2.3 / 32 = 0.072$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda_1 = \{1,1 - 2(b/l)\} \cdot b = 2,199 \text{ m}$$

$$b_2 / 1 = 2.3 / 32 = 0.072$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda_2 = \{1.1 - 2(b/l)\} \cdot b = 2.199 \text{ m}$$

슬래프 유효폭

$$B = \text{플랜지 유효폭} + \lambda_1 + \lambda_2 + h = 7.198 \text{ m}$$

2. 제 1.6 경간 부모멘트부

$$I = 0.2 \times (L1 + L2) = 0.2 \times (\lambda S1 +) = 18.000 \text{ m}$$

$$b1 / 1 = 2.3 / 18 = 0.128$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda_1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.667 \text{ m}$$

$$b_2 / 1 = 4.6 / 18 = 0.256$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda_2 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 2.466 \text{ m}$$

슬래브 유효폭

$$B = \text{플래지 유효폭} + \lambda_1 + \lambda_2 + b = 6.582 \text{ m}$$

3. 제 2~5 경간 정모멘트부

$$l = 0.6 \times L2 = 0.6 \times 50 = 30.000 \text{ m}$$

$$b1 / l = 2.3 / 30 = 0.077$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda 1 = \{1.1 - 2(b/l)\} \cdot b = 2.177 \text{ m}$$

$$b2 / l = 2.3 / 30 = 0.077$$

여기서, $0.05 < b/l < 0.30$ 이므로

$$\lambda 2 = \{1.1 - 2(b/l)\} \cdot b = 2.177 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda 1 + \lambda 2 + h = 7.154 \text{ m}$$

4. 제 2~5 경간 부모멘트부

$$l = 0.2 \times (L1 + L2) = 0.2 \times (40 + 50) = 20.000 \text{ m}$$

$$b1 / l = 2.3 / 20 = 0.115$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda 1 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 1.728 \text{ m}$$

$$b2 / l = 4.6 / 20 = 0.230$$

여기서, $0.02 < b/l < 0.30$ 이므로

$$\lambda 2 = \{1.06 - 3.2(b/l) + 4.5(b/l)^2\} \cdot b = 2.585 \text{ m}$$

슬래브 유효폭

$$B = \text{플랜지 유효폭} + \lambda 1 + \lambda 2 + h = 6.807 \text{ m}$$

4. 부재력 요약

[5경간 정모멘트부]

[BENDING MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	3,433.653	771.033	3,200.439	447.853	-0.057
G2	3,781.417	858.218	3,662.035	469.039	-0.073
G3	3,433.653	771.032	3,200.439	447.853	-0.057

[SHEAR FORCE]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	242.346	54.011	316.261	54.610	
G2	273.605	66.018	306.853	57.164	
G3	242.346	54.011	316.261	54.610	

[TORSION MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	14.699	5.291	616.548	0.086	
G2	0.000	0.000	696.739	0.000	
G3	14.431	5.102	616.107	0.088	

[6경간 정모멘트부]

[BENDING MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	3,157.537	708.667	3,204.695	876.022	0.148
G2	3,600.139	808.272	3,899.185	918.607	0.284
G3	3,157.537	708.667	3,204.695	876.022	0.148

[SHEAR FORCE]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	709.991	169.032	398.047	32.537	
G2	792.971	189.898	567.960	34.415	
G3	709.991	169.032	398.047	32.537	

[TORSION MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	54.612	16.665	690.923	0.266	
G2	0.000	0.000	646.961	0.000	
G3	-40.464	-14.445	692.623	0.266	

[P6 부모멘트부]

[BENDING MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	-13,037.081	-2,905.336	-4,999.156	-876.022	-0.358
G2	-14,913.289	-3,473.081	-7,757.560	-918.607	-0.373
G3	-13,037.081	-2,905.336	-4,999.156	-876.022	-0.358

[SHEAR FORCE]

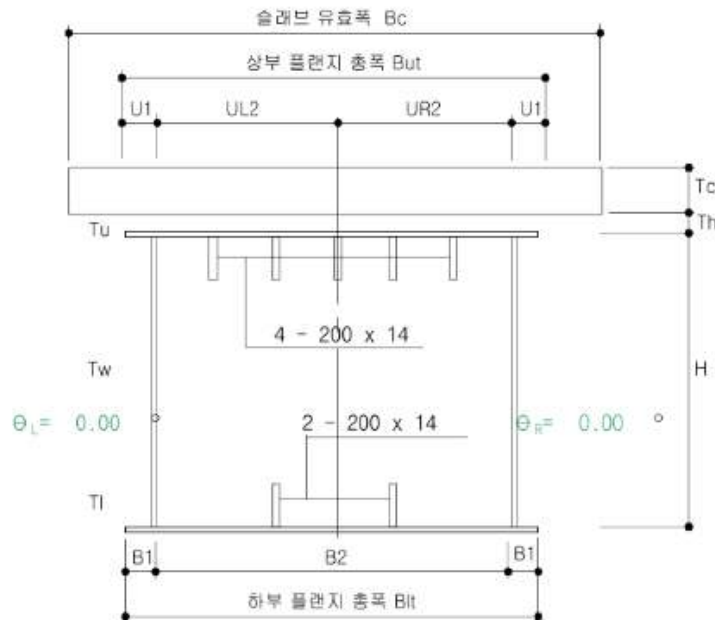
거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	-1,297.035	-284.713	-698.166	-54.797	
G2	-1,525.658	-358.202	-1,078.705	-57.915	
G3	-1,297.035	-284.713	-698.166	-54.797	

[TORSION MOMENT]

거더 번호	합성전 고정하중	합성후 고정하중	활하중	지점침하	비 고
G1	-14.969	-5.833	-836.825	-0.113	
G2	0.000	0.000	-1,127.273	0.000	
G3	-19.641	-7.387	-843.096	-0.113	

5-1. 5경간 최대 정모멘트 단면검토(G1)

주부재사용강종 = SWS50B


$$H = 1.500 \text{ m}$$
$$B_c = 5.877 \text{ m}$$
$$UL2 = 1.250, \quad UR2 = 1.250 \text{ m}$$
$$B2 = 2.500 \text{ m}$$
$$B_{ut} = 2.700 \quad , \quad B_{lt} = 2.700 \quad m$$

상하 플랜지 유효폭

Bue= 2.700 , Ble= 2.700 m

$$T_c = 0.250 \text{ m}$$
$$Th = 0.000 \text{ m}$$
$$T_U = 0.020 \text{ m}$$
$$Tl = 0.022 \text{ m}$$
$$T_W = 0.012 \text{ m}$$
$$U1 = 0.100 \text{ m}$$
$$B1 = 0,100 \text{ m}$$

RIB 200 x 14 mm, 200 x 14 mm

구 분	단 위	입력 DATA
Es : 강의 탄성계수	MPa	205000
Ec : 콘크리트의 탄성계수	MPa	26702
ϵ_s : 바닥판 콘크리트의 건조수축에 의한 최종수축률		0.00027
α : 강재 및 콘크리트의 선팽창계수		0.000012
ϕ_2 : 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
Ms : 합성전 고정하중에 의한 모멘트	kN · m	3433.653
Msc : 합성후 고정하중에 의한 모멘트	kN · m	771.033
Mv : 활하중+지점침하에 의한 모멘트	kN · m	3648.292
Ss : 합성전 고정하중에 의한 전단력	kN	242.346
Ssc : 합성후 고정하중에 의한 전단력	kN	54.011
Sv : 활하중+지점침하에 의한 전단력	kN	370.871
Mst : 합성전 고정하중에 의한 비틀림모멘트	kN · m	14.699
Msct : 합성후 고정하중에 의한 비틀림모멘트	kN · m	5.291
Mvt : 활하중+지점침하에 의한 비틀림모멘트	kN · m	616.634

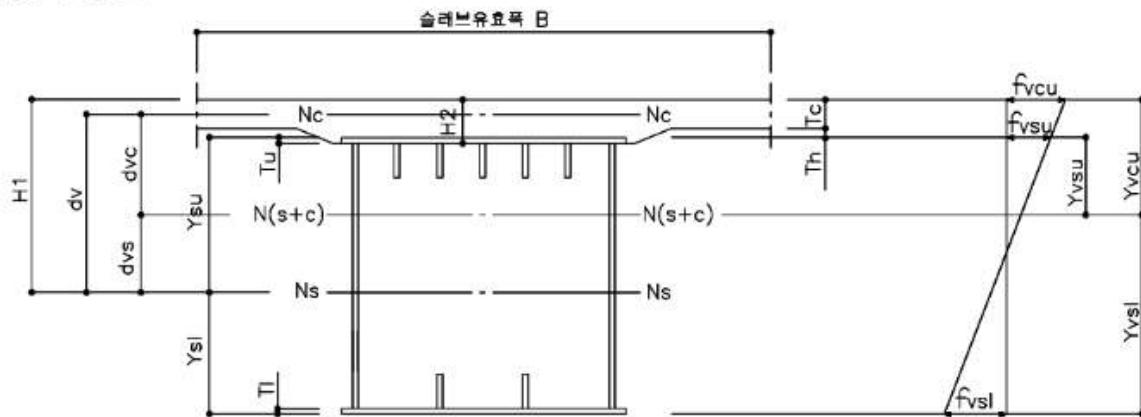
< 참고 > 합성전 고정하중 : 강재자중 + 콘크리트바닥판자중
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y2(mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
1 - R_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	22.0	59400	-761.0	-45203400	34399787400	2395800
강단면 합계			166200		-523400	72688187400	6810195800
1 - RC SLAB	5877.0	250.0	1469250	875.0	1285593750	1124894531250	7652343750

* $A_s = 166200 \text{ mm}^2$, $A_c = 1469250 \text{ mm}^2$

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 72688187400 + 6810195800.0 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = -523400 / 166200 = -3.149 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - (-3.149) = 773.149 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 773.149 - 1542.000 = -768.851 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + Tu/2 + Tl/2) = 3820752.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 33.394 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -33.208 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot Tw) = 6.892 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 349856.3 \text{ mm}^2$$

$$I_{c/n} = 956542969 \text{ mm}^4$$

$$dv = Y_{su} - T_u + T_h + T_c/2 = 878.1 \text{ mm}$$

$$dvc = dv \cdot A_s / (A_{c/n} + A_s) = 417.2 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 461.0 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 542.2 \text{ mm} \\
Yvcl &= Yvcu - Tc = 292.2 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 312.2 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1229.8 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 147732929295 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860002.0 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.354 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.191 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.629 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -6.419 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 1.557 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.674 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 0.902 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 7.709 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -30.371 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 16.958 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 258028.1 \text{ mm}^2 & \# 2차 부정정력으로 인한 영향 고려 \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 565.6 \text{ mm} & K = -0.057 \\
ds1 &= dv - dc1 = 312.5 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 690.6 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 440.6 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 460.6 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1081.4 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 125586713537 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 399863 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 399863 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 226174356 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.354 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.191 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.261 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.097 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.502 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.661 \text{ MPa}
\end{aligned}$$

(5) 건조 수축

$$n_2 = n \cdot (1 + \phi_2 / 2) = 8 \times (1 + 4.0 / 2) = 24$$

$$A_{v2} = A_s + A_c/n_2 = 227418.750 \text{ mm}^2$$

$$d_{c2} = d_v \cdot A_s / (A_c/n_2 + A_s) = 641.8 \text{ mm}$$

$$d_{s2} = d_v - d_{c2} = 236.4 \text{ mm}$$

$$Y_{v2cu} = d_{c2} + T_c/2 = 766.8 \text{ mm}$$

$$Y_{v2cl} = Y_{v2cu} - T_c = 516.8 \text{ mm}$$

$$Y_{v2su} = Y_{v2cu} - H_2 + T_u = 536.8 \text{ mm}$$

$$Y_{v2sl} = Y_{v2su} - (H + T_u + T_l) = -1005.2 \text{ mm}$$

$$I_{v2} = I_s + I_c/n_2 + A_s \cdot d_{s2}^2 + A_c/n_2 \cdot d_{c2}^2 = 114316118900.5 \text{ mm}^4$$

$$P_2 = E_s \cdot \epsilon_s \cdot A_c/n_2 = 3388458 \text{ N}$$

$$M_{v2} = P_2 \cdot d_{c2} = 2174578816 \text{ N} \cdot \text{mm}$$

$$E_{c2} = E_s \cdot /n_2 = 8542 \text{ MPa}$$

$$f_{vcu2} = 1/n_2 \cdot (P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2cu}/I_{v2}) - E_{c2} \cdot \epsilon_s = -1.720 \text{ MPa}$$

$$f_{vcl2} = 1/n_2 \cdot (P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2cl}/I_{v2}) - E_{c2} \cdot \epsilon_s = -1.709 \text{ MPa}$$

$$f_{vsu2} = P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2su}/I_{v2} = 14.318 \text{ MPa}$$

$$f_{vsl2} = P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2sl}/I_{v2} = 15.990 \text{ MPa}$$

(6) 온도 차

$$\epsilon_t = \alpha \cdot t = 0.000012 \times 10 = 0.00012$$

$$P_1 = E_s \cdot \epsilon_t \cdot A_c/n = 4517944 \text{ N}$$

$$M_{vt} = P_1 \cdot d_{vc} = 1884735978 \text{ N} \cdot \text{mm}$$

$$f_{cut} = 1/n \cdot (P_1/A_v + k \cdot M_{vt} \cdot Y_{vcu}/I_v) - E_c \cdot \epsilon_t = -1.639 \text{ MPa}$$

$$f_{clt} = 1/n \cdot (P_1/A_v + k \cdot M_{vt} \cdot Y_{vcl}/I_v) - E_c \cdot \epsilon_t = -1.617 \text{ MPa}$$

$$f_{sut} = P_1/A_v + k \cdot M_{vt} \cdot Y_{vsu}/I_v = 12.687 \text{ MPa}$$

$$f_{slt} = P_1/A_v + k \cdot M_{vt} \cdot Y_{vsl}/I_v = 13.808 \text{ MPa}$$

(7) 전단 및 비틀림

$$u = (S_s + S_{sc} + S_v)/A_w + M_{st}/(2 F T_w) + (M_{sct} + M_{vt})/(2 F_v T_w) = 25.408 \text{ MPa} < u_a = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (☞ 도.설 3.4.2.1)

$$i = 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0$$

$$= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

★ 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

★ 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1,000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1,000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 \left(\frac{b}{(t_u \cdot i \cdot n) - 24} \right) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1,000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220,000 \times \left\{ (t_u \cdot i \cdot n) / b \right\} = 352.000 \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

★ 철근콘크리트의 허용응력 (☞ 도.설 3.9.3)

$$f_{ca} = 0.4 \text{ } f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \text{ } f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	33.394	-33.208	186.100	190.000
1+2+3	2.027	1.092	10.800	10.800	42.732	-69.998	186.100	190.000
1+2+3+4	1.766	0.996	10.800	10.800	44.235	-68.337	214.015	190.000
1+2+3+4+5	0.046	-0.713	10.800	1.890	58.552	-52.348	214.015	190.000
1+2+3+4+5+6	-1.593	-2.329	2.174	2.174	71.239	-38.540	241.930	218.500
1+2+3+4+5-6	1.685	0.904	12.420	12.420	45.866	-66.156	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 합증 (☞ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (☞ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{71.239}{241.930} \right)^2 + \left(\frac{25.408}{110.000} \right)^2 \\ &= 0.087 + 0.053 = 0.140 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-69.998}{190.000} \right)^2 + \left(\frac{25.408}{110.000} \right)^2 \\ &= 0.136 + 0.053 = 0.189 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.} \quad (\text{합성형 스테드 설치})$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(fca/fc)} = \sqrt{(190/33.394)} = 2.385 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = bc / (219 \times 1.200) = 2.4 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(fca/fc)} = \sqrt{(190/71.239)} = 1.633 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.354 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.027 - 0.354 = 1.674 \text{ MPa}$$

$$\Sigma f = 1.3 \times 0.354 + 2.15 \times 1.674 + (-0.261) + (-1.72) + (1.639)$$

$$= 3.716 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times 0.354 + 2.15 \times 1.674 + (1.639)$$

$$= 5.697 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시})$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 33.394 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.629 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 42.732 - 33.394 - 1.629 = 7.709 \text{ MPa}$$

$$\Sigma f = 1.3 \times (33.394 + 1.629) + 2.15 \times 7.709 + (1.502) + (14.318) + (12.687)$$

$$= 90.612 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times (33.394 + 1.629) + 2.15 \times 7.709 + (12.687)$$

$$= 74.792 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시})$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -33.208 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -6.419 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -69.998 - -33.208 - -6.419 = -30.371 \text{ MPa}$$

$$\Sigma f = 1.3 \times \{-33.208 + -6.419\} + 2.15 \times -30.371 + (1.661) + (15.99) + (-13.808)$$

$$= -112.971 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times \{-33.208 + -6.419\} + 2.15 \times -30.371 + (-13.808)$$

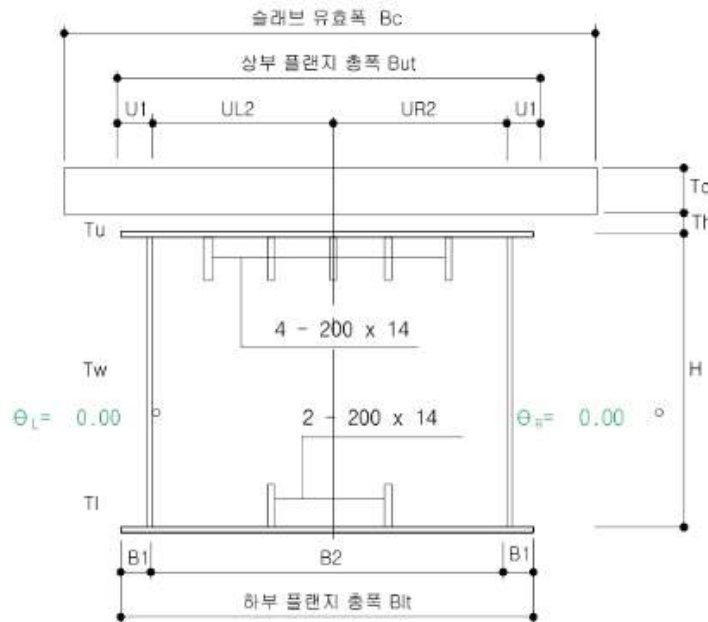
$$= -130.621 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시})$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	3.716	16.200	0.K!!!	4.35
	크리프, 건조수축제외시	5.697	16.200	0.K!!!	2.84
상부플랜지	크리프, 건조수축 포함시	90.612	315.000	0.K!!!	3.47
	크리프, 건조수축제외시	74.792	315.000	0.K!!!	4.21
하부플랜지	크리프, 건조수축 포함시	-112.971	315.000	0.K!!!	2.78
	크리프, 건조수축제외시	-130.621	315.000	0.K!!!	2.41

5-2. 6경간 최대 정모멘트 단면검토(G1)

1) 단면가정 및 설계조건



주부재사용강종 = SWS50B

H = 1.500 m
 Bc = 5.899 m
 UL2= 1.250 , UR2= 1.250 m
 B2 = 2.500 m
 But= 2.700 , Bit= 2.700 m
 상하 플랜지 유효폭
 Bue= 2.700 , Ble= 2.700 m
 Tc = 0.250 m
 Th = 0.000 m
 Tu = 0.020 m
 Tl = 0.022 m
 Tw = 0.012 m
 U1 = 0.100 m
 B1 = 0.100 m
 RIB 200 x 14 mm , 200 x 14 mm

구 분	단 위	입력 DATA
Es : 강 의 탄성계수	MPa	205000
Ec : 콘크리트의 탄성계수	MPa	26702
εs: 바닥판 콘크리트의 건조수축에 의한 최종수축율		0.00027
α : 강재 및 콘크리트의 선팅창계수		0.000012
φ2: 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
Ms : 합성전 고정하중에 의한 모멘트	kN · m	3157.537
Msc : 합성후 고정하중에 의한 모멘트	kN · m	708.667
Mv : 활하중+지정침하에 의한 모멘트	kN · m	4080.717
Ss : 합성전 고정하중에 의한 전단력	kN	709.991
Ssc : 합성후 고정하중에 의한 전단력	kN	160.032
Sv : 활하중+지정침하에 의한 전단력	kN	430.584
Mst : 합성전 고정하중에 의한 비틀림모멘트	kN · m	54.812
Mscst : 합성후 고정하중에 의한 비틀림모멘트	kN · m	16.665
Mvt : 활하중+지정침하에 의한 비틀림모멘트	kN · m	691.189

< 참고 > 합성전 고정하중 : 강재자중 + 바닥판콘크리트자중

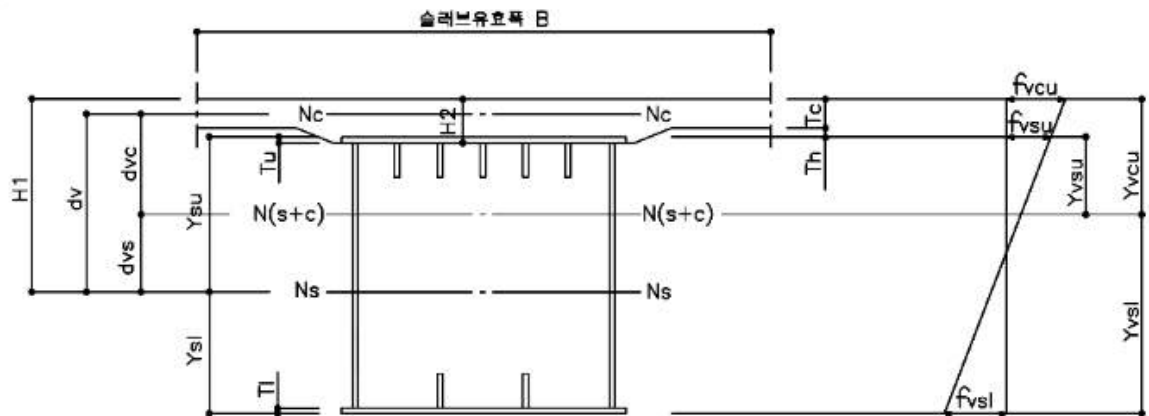
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y ² (mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
1 - R_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	22.0	59400	-761.0	-45203400	34399787400	2395800
강단면 합계			166200		-523400	72688187400	6810195800
1 - RC SLAB	5899.0	250.0	1474750	875.0	1290406250	1129105468750	7680989583

* $A_s = 166200 \text{ mm}^2$, $A_c = 1474750 \text{ mm}^2$

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 72688187400 + 6810195800.0 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = -523400 / 166200 = -3.149 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - (-3.149) = 773.149 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 773.149 - 1542.000 = -768.851 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + T_u/2 + T_l/2) = 3820752.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 30.709 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -30.538 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot T_w) = 20.320 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 350543.8 \text{ mm}^2$$

$$I_{c/n} = 960123698 \text{ mm}^4$$

$$dv = Y_{su} - T_u + T_h + T_c/2 = 878.1 \text{ mm}$$

$$dvc = dv \cdot A_s / (A_{c/n} + A_s) = 416.3 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 461.8 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 541.3 \text{ mm} \\
Yvcl &= Yvcu - Tc = 291.3 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 311.3 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1230.7 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 147855919699 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860002.0 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.324 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.175 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.492 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -5.898 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 4.625 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.868 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 1.005 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 8.593 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -33.965 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 19.422 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 258371.9 \text{ mm}^2 & \# \text{ 2차 부정정력으로 인한 영향 고려} \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 564.9 \text{ mm} & K = 0.148 \\
ds1 &= dv - dc1 = 313.3 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 689.9 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 439.9 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 459.9 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1082.1 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 125698335954 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 367865 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 367865 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 207798841 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.324 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.175 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.225 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.079 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.536 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.159 \text{ MPa}
\end{aligned}$$

(5) 건조 수축

$$n_2 = n \cdot (1 + \phi_2 / 2) = 8 \times (1 + 4.0 / 2) = 24$$

$$A_{v2} = A_s + A_c/n_2 = 227647.917 \text{ mm}^2$$

$$d_{c2} = d_v \cdot A_s / (A_c/n_2 + A_s) = 641.1 \text{ mm}$$

$$d_{s2} = d_v - d_{c2} = 237.0 \text{ mm}$$

$$Y_{v2cu} = d_{c2} + T_c/2 = 766.1 \text{ mm}$$

$$Y_{v2cl} = Y_{v2cu} - T_c = 516.1 \text{ mm}$$

$$Y_{v2su} = Y_{v2cu} - H_2 + T_u = 536.1 \text{ mm}$$

$$Y_{v2sl} = Y_{v2su} - (H + T_u + T_l) = -1005.9 \text{ mm}$$

$$I_{v2} = I_s + I_c/n_2 + A_s \cdot d_{s2}^2 + A_c/n_2 \cdot d_{c2}^2 = 114411601291.5 \text{ mm}^4$$

$$P_2 = E_s \cdot \epsilon_s \cdot A_c/n_2 = 3401142 \text{ N}$$

$$M_{v2} = P_2 \cdot d_{c2} = 2180521868 \text{ N} \cdot \text{mm}$$

$$E_{c2} = E_s \cdot /n_2 = 8542 \text{ MPa}$$

$$f_{vcu2} = 1/n_2 \cdot (P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2cu}/I_{v2}) - E_{c2} \cdot \epsilon_s = -1.594 \text{ MPa}$$

$$f_{vcl2} = 1/n_2 \cdot (P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2cl}/I_{v2}) - E_{c2} \cdot \epsilon_s = -1.623 \text{ MPa}$$

$$f_{vsu2} = P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2su}/I_{v2} = 16.453 \text{ MPa}$$

$$f_{vsl2} = P_2/A_{v2} + k \cdot M_{v2} \cdot Y_{v2sl}/I_{v2} = 12.103 \text{ MPa}$$

(6) 온도 차

$$\epsilon_t = \alpha \cdot t = 0.000012 \times 10 = 0.00012$$

$$P_1 = E_s \cdot \epsilon_t \cdot A_c/n = 4534856 \text{ N}$$

$$M_{v1} = P_1 \cdot d_{vc} = 1888081057 \text{ N} \cdot \text{mm}$$

$$f_{cut1} = 1/n \cdot (P_1/A_v + k \cdot M_{v1} \cdot Y_{vcu}/I_v) - E_c \cdot \epsilon_t = -1.459 \text{ MPa}$$

$$f_{clt1} = 1/n \cdot (P_1/A_v + k \cdot M_{v1} \cdot Y_{vcl}/I_v) - E_c \cdot \epsilon_t = -1.518 \text{ MPa}$$

$$f_{sut1} = P_1/A_v + k \cdot M_{v1} \cdot Y_{vsu}/I_v = 13.525 \text{ MPa}$$

$$f_{slt1} = P_1/A_v + k \cdot M_{v1} \cdot Y_{vsl}/I_v = 10.611 \text{ MPa}$$

(7) 전단 및 비틀림

$$u = (S_s + S_{sc} + S_v)/A_w + M_{st}/(2 F_{Tw}) + (M_{sct} + M_{vt})/(2 F_vTw) = 44.367 \text{ MPa} < u_a = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (도.설 3.4.2.1)

$$i = 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0$$

$$= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

★ 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

★ 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 \left(\frac{b}{(t_u \cdot i \cdot n) - 24} \right) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220000 \times \left\{ (t_u \cdot i \cdot n) / b \right\} = 352.000 \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

★ 철근콘크리트의 허용응력 (☞ 도.설 3.9.3)

$$f_{ca} = 0.4 \quad f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \quad f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	30.709	-30.538	186.100	190.000
1+2+3	2.192	1.180	10.800	10.800	40.794	-70.402	186.100	190.000
1+2+3+4	1.967	1.101	10.800	10.800	42.330	-69.243	214.015	190.000
1+2+3+4+5	0.373	-0.522	10.800	1.890	58.783	-57.139	214.015	190.000
1+2+3+4+5+6	-1.086	-2.041	2.174	2.174	72.308	-46.529	241.930	218.500
1+2+3+4+5-6	1.833	0.996	12.420	12.420	45.258	-67.750	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 활용 (☞ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (☞ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{72.308}{241.930} \right)^2 + \left(\frac{44.367}{110.000} \right)^2 \\ &= 0.089 + 0.163 = 0.252 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-70.402}{190.000} \right)^2 + \left(\frac{44.367}{110.000} \right)^2 \\ &= 0.137 + 0.163 = 0.300 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K. (합성형 스티드 설치)}$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190/30.709)} = 2.487 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b_c / (219 \times 1.200) = 2.4 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190/72.308)} = 1.621 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.324 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.192 - 0.324 = 1.868 \text{ MPa}$$

$$\Sigma f = 1.3 \times 0.324 + 2.15 \times 1.868 + (-0.225) + (-1.594) + (1.459) \\ = 4.078 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times 0.324 + 2.15 \times 1.868 + (1.459) \\ = 5.896 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 30.709 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.492 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 40.794 - 30.709 - 1.492 = 8.593 \text{ MPa}$$

$$\Sigma f = 1.3 \times (30.709 + 1.492) + 2.15 \times 8.593 + (1.536) + (16.453) + (13.525) \\ = 91.850 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (30.709 + 1.492) + 2.15 \times 8.593 + (13.525) \\ = 73.861 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -30.538 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -5.898 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -70.402 - (-30.538) - (-5.898) = -33.965 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-30.538 + -5.898) + 2.15 \times -33.965 + (1.159) + (12.103) + (-10.611) \\ = -117.741 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (-30.538 + -5.898) + 2.15 \times -33.965 + (-10.611) \\ = -131.003 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

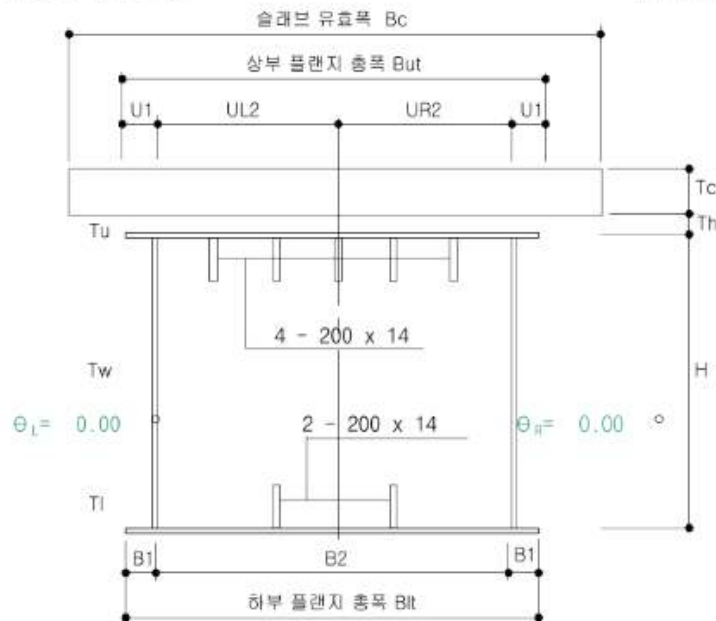
- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	4.078	16.200	0.K!!!	3.97
	크리프, 건조수축제외시	5.896	16.200	0.K!!!	2.74
상부플랜지	크리프, 건조수축 포함시	91.850	315.000	0.K!!!	3.42
	크리프, 건조수축제외시	73.861	315.000	0.K!!!	4.26
하부플랜지	크리프, 건조수축 포함시	-117.741	315.000	0.K!!!	2.67
	크리프, 건조수축제외시	-131.003	315.000	0.K!!!	2.40

5-3. 5경간 최대 정모멘트 단면검토(G2)

1) 단면가정 및 설계조건

주부재사용강종 = SWIS50B



H = 1.500 m
Bc = 7.154 m
UL2= 1.250 , UR2= 1.250 m
B2 = 2.500 m
But= 2.700 , Bit= 2.700 m
상하 플랜지 유효폭
Bue= 2.700 , Bie= 2.700 m
Tc = 0.250 m
Th = 0.000 m
Tu = 0.020 m
Tl = 0.022 m
Tw = 0.012 m
U1 = 0.100 m
B1 = 0.100 m

RIB 200 x 14 mm, 200 x 14 mm

구 분	단 위	입력 DATA
E_s : 강의 탄성계수	MPa	205000
E_c : 콘크리트의 탄성계수	MPa	26702
ϵ_s : 바닥판 콘크리트의 건조수축에 의한 최종수축률		0.00027
α : 강재 및 콘크리트의 선팽창계수		0.000012
ϕ_2 : 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	$^{\circ}\text{C}$	10
M_s : 합성전 고정하중에 의한 모멘트	$\text{kN} \cdot \text{m}$	3781.417
M_{sc} : 합성후 고정하중에 의한 모멘트	$\text{kN} \cdot \text{m}$	868.218
M_v : 활하중+지정침하에 의한 모멘트	$\text{kN} \cdot \text{m}$	4331.067
S_s : 합성전 고정하중에 의한 전단력	kN	273.605
S_{sc} : 합성후 고정하중에 의한 전단력	kN	66.018
S_v : 활하중+지정침하에 의한 전단력	kN	564.017
M_{st} : 합성전 고정하중에 의한 비틀림모멘트	$\text{kN} \cdot \text{m}$	0.000
M_{sct} : 합성후 고정하중에 의한 비틀림모멘트	$\text{kN} \cdot \text{m}$	0.000
M_{vt} : 활하중+지정침하에 의한 비틀림모멘트	$\text{kN} \cdot \text{m}$	696.739

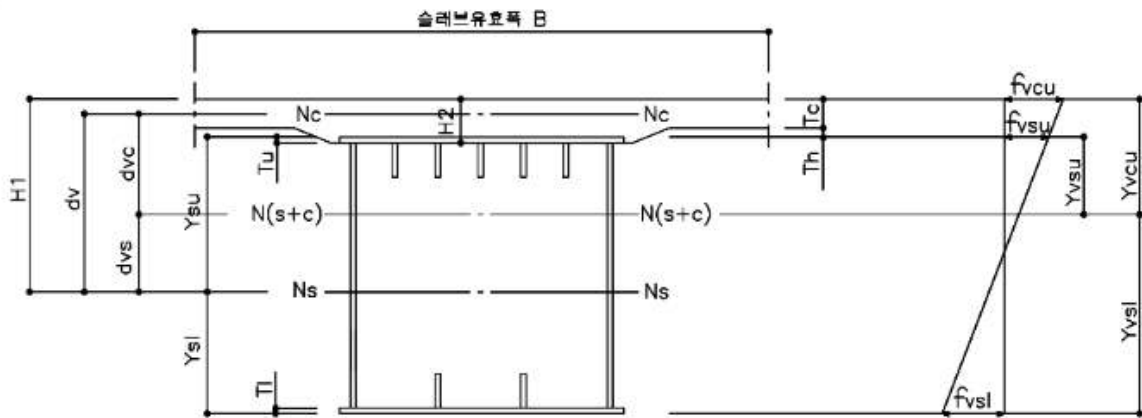
< 참고 > 합성전 고정하중 : 강재자중 + 콘크리트바닥판자중
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y ² (mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
1 - R_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	22.0	59400	-761.0	-45203400	34399787400	2395800
강단면 합계			166200		-523400	72688187400	6810195800
1 - RC SLAB	7154.0	250.0	1788500	875.0	1564937500	1369320312500	9315104167

* As = 166200 mm² , Ac = 1788500 mm²

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 72688187400 + 6810195800.0 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = -523400 / 166200 = -3.149 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - (-3.149) = 773.149 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 773.149 - 1542.000 = -768.851 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + T_u/2 + T_l/2) = 3820752.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 36.776 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -36.572 \text{ MPa}$$

$$v = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot T_w) = 7.600 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 389762.5 \text{ mm}^2$$

$$I_c/n = 1164388021 \text{ mm}^4$$

$$dv = Y_{su} - T_u + T_h + T_c/2 = 878.1 \text{ mm}$$

$$dvc = dv \cdot A_s / (A_c/n + A_s) = 374.5 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 503.7 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 499.5 \text{ mm} \\
Yvcl &= Yvcu - Tc = 249.5 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 269.5 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1272.5 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 154174531887 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860002.0 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.352 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.176 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.517 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -7.166 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 1.834 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.754 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 0.876 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 7.570 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -35.748 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 23.188 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 277981.3 \text{ mm}^2 & \# 2\text{차 부정정력으로 인한 영향 고려} \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 525.0 \text{ mm} & K = -0.073 \\
ds1 &= dv - dc1 = 353.1 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 650.0 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 400.0 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 420.0 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1122.0 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 131616163997 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 471427 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 471427 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 247513120 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.352 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.176 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.251 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.073 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.638 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.850 \text{ MPa}
\end{aligned}$$

(5) 건 조 수 축

$$\begin{aligned}
 n2 &= n \cdot (1 + \phi 2 / 2) = 8 \times (1 + 4.0 / 2) = 24 \\
 Av2 &= As + Ac/n2 = 240720.833 \text{ mm}^2 \\
 dc2 &= dv \cdot As / (Ac/n2 + As) = 606.3 \text{ mm} \\
 ds2 &= dv - dc2 = 271.9 \text{ mm} \\
 Yv2cu &= dc2 + Tc/2 = 731.3 \text{ mm} \\
 Yv2cl &= Yv2cu - Tc = 481.3 \text{ mm} \\
 Yv2su &= Yv2cu - H2 + Tu = 501.3 \text{ mm} \\
 Yv2sl &= Yv2su - (H + Tu + Tl) = -1040.7 \text{ mm} \\
 Iv2 &= Is + Ic/n2 + As \cdot ds2^2 + Ac/n2 \cdot dc2^2 = 119561211408.4 \text{ mm}^4 \\
 P2 &= Es \cdot \epsilon s \cdot Ac/n2 = 4124728 \text{ N} \\
 Mv2 &= P2 \cdot dc2 = 2500811674 \text{ N} \cdot \text{mm} \\
 Ec2 &= Es \cdot /n2 = 8542 \text{ MPa} \\
 fvcu2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cu/Iv2) - Ec2 \cdot \epsilon s = -1.639 \text{ MPa} \\
 fvcl2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cl/Iv2) - Ec2 \cdot \epsilon s = -1.623 \text{ MPa} \\
 fvsu2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2su/Iv2 = 16.369 \text{ MPa} \\
 fvsl2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2sl/Iv2 = 18.724 \text{ MPa}
 \end{aligned}$$

(6) 온 도 차

$$\begin{aligned}
 \epsilon t &= \alpha \cdot t = 0.000012 \times 10 = 0.00012 \\
 P1 &= Es \cdot \epsilon t \cdot Ac/n = 5499638 \text{ N} \\
 Mvt &= P1 \cdot dvc = 2059365110 \text{ N} \cdot \text{mm} \\
 fcut &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcu/Iv) - Ec \cdot \epsilon t = -1.501 \text{ MPa} \\
 fcit &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcl/Iv) - Ec \cdot \epsilon t = -1.471 \text{ MPa} \\
 fsut &= P1/Av + k \cdot Mvt \cdot Yvsu/Iv = 13.847 \text{ MPa} \\
 fsit &= P1/Av + k \cdot Mvt \cdot Yvsl/Iv = 15.351 \text{ MPa}
 \end{aligned}$$

(7) 전 단 및 비틀림

$$u = (Ss+Ssc+sv)/Aw + Mst/(2 F Tw) + (Msct+Mvt)/(2 FvTw) = 32.622 \text{ MPa} < ua = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (19 도.설 3.4.2.1)

$$\begin{aligned}
 i &= 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0 \\
 &= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000
 \end{aligned}$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

* 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

* 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 (b / (t_u \cdot i \cdot n) - 24) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220000 \times \{ (t_u \cdot i \cdot n) / b - 352.000 \} \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

* 철근콘크리트의 허용응력 (☞ 도.설 3.9.3)

$$f_{ca} = 0.4 \text{ } f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \text{ } f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	36.776	-36.572	186.100	190.000
1+2+3	2.105	1.052	10.800	10.800	45.863	-79.486	186.100	190.000
1+2+3+4	1.854	0.979	10.800	10.800	47.502	-77.636	214.015	190.000
1+2+3+4+5	0.215	-0.644	10.800	1.890	63.871	-58.913	214.015	190.000
1+2+3+4+5+6	-1.286	-2.115	2.174	2.174	77.718	-43.561	241.930	218.500
1+2+3+4+5-6	1.717	0.826	12.420	12.420	50.023	-74.264	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 합증 (☞ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (☞ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{77.718}{241.930} \right)^2 + \left(\frac{32.622}{110.000} \right)^2 \\ &= 0.103 + 0.088 = 0.191 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-79.486}{190.000} \right)^2 + \left(\frac{32.622}{110.000} \right)^2 \\ &= 0.175 + 0.088 = 0.263 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K. (합성형 스티드 설치)}$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190/36.776)} = 2.273 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = bc / (219 \times 1.200) = 2.1 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190/77.718)} = 1.564 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.352 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.105 - 0.352 = 1.754 \text{ MPa}$$

$$\Sigma f = 1.3 \times 0.352 + 2.15 \times 1.754 + (-0.251) + (-1.639) + (1.501)$$

$$= 3.839 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times 0.352 + 2.15 \times 1.754 + (1.501)$$

$$= 5.729 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 36.776 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.517 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 45.863 - 36.776 - 1.517 = 7.570 \text{ MPa}$$

$$\Sigma f = 1.3 \times (36.776 + 1.517) + 2.15 \times 7.57 + (1.638) + (16.369) + (13.847)$$

$$= 97.912 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (36.776 + 1.517) + 2.15 \times 7.57 + (13.847)$$

$$= 79.904 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -36.572 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -7.166 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -79.486 - -36.572 - -7.166 = -35.748 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-36.572 + -7.166) + 2.15 \times -35.748 + (1.85) + (18.724) + (-15.351)$$

$$= -128.495 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (-36.572 + -7.166) + 2.15 \times -35.748 + (-15.351)$$

$$= -149.069 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

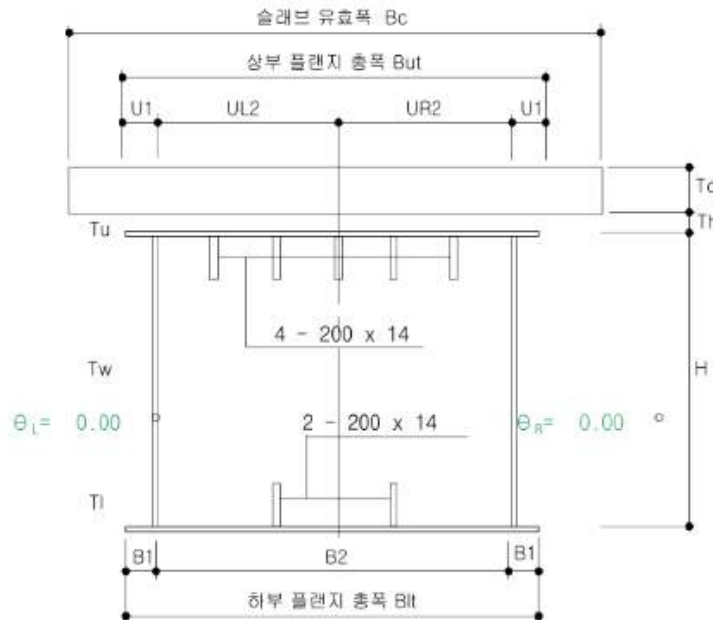
- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	3.839	16.200	0.K!!!	4.21
	크리프, 건조수축제외시	5.729	16.200	0.K!!!	2.82
상부플랜지	크리프, 건조수축 포함시	97.912	315.000	0.K!!!	3.21
	크리프, 건조수축제외시	79.904	315.000	0.K!!!	3.94
하부플랜지	크리프, 건조수축 포함시	-128.495	315.000	0.K!!!	2.45
	크리프, 건조수축제외시	-149.069	315.000	0.K!!!	2.11

5-4. 6경간 최대 정모멘트 단면검토(G2)

1) 단면가정 및 설계조건

주부재사용강종 = SWS50B



H = 1.500 m
Bc = 7.198 m
UL2= 1.250 , UR2= 1.250 m
B2 = 2.500 m
But= 2.700 , Bit= 2.700 m
상하 플랜지 유효폭
Bue= 2.700 , Ble= 2.700 m
Tc = 0.250 m
Th = 0.000 m
Tu = 0.020 m
Tl = 0.022 m
Tw = 0.012 m
U1 = 0.100 m
B1 = 0.100 m

RIB 200 x 14 mm, 200 x 14 mm

구 분	단 위	입력 DATA
E_s : 강의 탄성계수	MPa	205000
E_c : 콘크리트의 탄성계수	MPa	26702
ϵ_s : 바닥판 콘크리트의 건조수축에 의한 최종수축율		0.00027
α : 강재 및 콘크리트의 선형창계수		0.000012
ϕ_2 : 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
M_s : 합성전 고정하중에 의한 모멘트	kN · m	3500.139
M_{sc} : 합성후 고정하중에 의한 모멘트	kN · m	808.272
M_v : 활하중+지점침하에 의한 모멘트	kN · m	4817.792
S_s : 합성전 고정하중에 의한 전단력	kN	782.971
S_{sc} : 합성후 고정하중에 의한 전단력	kN	180.888
S_v : 활하중+지점침하에 의한 전단력	kN	602.375
M_{st} : 합성전 고정하중에 의한 비틀림모멘트	kN · m	0.000
M_{sct} : 합성후 고정하중에 의한 비틀림모멘트	kN · m	0.000
M_{vt} : 활하중+지점침하에 의한 비틀림모멘트	kN · m	846.961

< 참고 > 합성전 고정하중 : 강재자중 + 바닥판콘크리트자중

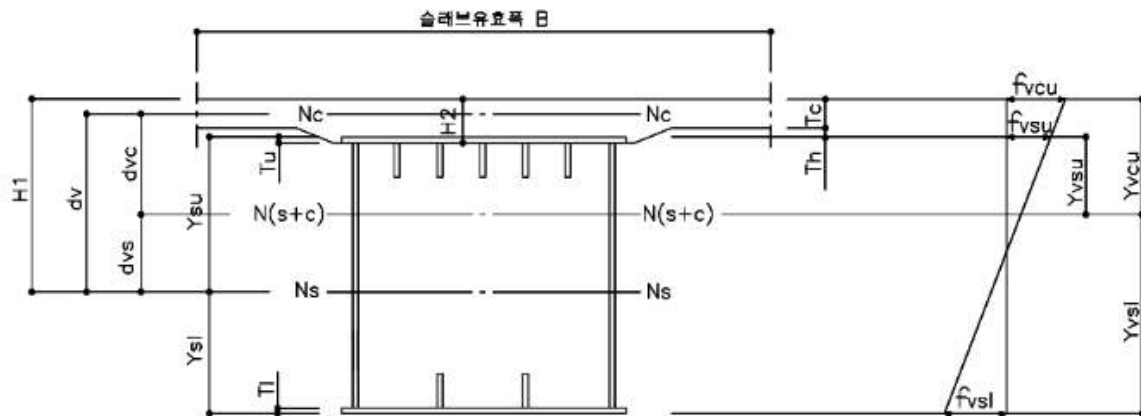
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y ² (mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
1 - R_WEB	12.0	1500.0	18000	0.0	0	0	3375000000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	22.0	59400	-761.0	-45203400	34399787400	2395800
강단면 합계			166200		-523400	72688187400	6810195800
1 - RC SLAB	7198.0	250.0	1799500	875.0	1574562500	1377742187500	9372395833

* As = 166200 mm² , Ac = 1799500 mm²

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 72688187400 + 6810195800.0 = 79498383200 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = -523400 / 166200 = -3.149 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 79498383200 - 166200 \times (-3.149)^2 = 79496734899 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - (-3.149) = 773.149 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 773.149 - 1542.000 = -768.851 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + T_u/2 + T_l/2) = 3820752.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 34.041 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -33.852 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot T_w) = 21.749 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 391137.5 \text{ mm}^2$$

$$I_c/n = 1171549479 \text{ mm}^4$$

$$d_v = Y_{su} - T_u + T_h + T_c/2 = 878.1 \text{ mm}$$

$$d_{vc} = d_v \cdot A_s / (A_c/n + A_s) = 373.1 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 505.0 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 498.1 \text{ mm} \\
Yvcl &= Yvcu - Tc = 248.1 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 268.1 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1273.9 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 154373813030 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860002.0 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.326 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.162 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.404 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -6.670 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 5.025 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.943 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 0.968 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 8.368 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -39.755 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 25.875 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 278668.8 \text{ mm}^2 & \# \text{ 2차 부정정력으로 인한 영향 고려} \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 523.7 \text{ mm} & K = 0.284 \\
ds1 &= dv - dc1 = 354.4 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 648.7 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 398.7 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 418.7 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1123.3 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 131808790776 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 439456 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 439456 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 230158341 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.326 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.162 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.207 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.051 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.785 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.020 \text{ MPa}
\end{aligned}$$

(5) 건 조 수 축

$$\begin{aligned}
 n2 &= n \cdot (1 + \phi^2 / 2) = 8 \times (1 + 4.0 / 2) = 24 \\
 Av2 &= As + Ac/n2 = 241179.167 \text{ mm}^2 \\
 dc2 &= dv \cdot As / (Ac/n2 + As) = 605.1 \text{ mm} \\
 ds2 &= dv - dc2 = 273.0 \text{ mm} \\
 Yv2cu &= dc2 + Tc/2 = 730.1 \text{ mm} \\
 Yv2cl &= Yv2cu - Tc = 480.1 \text{ mm} \\
 Yv2su &= Yv2cu - H2 + Tu = 500.1 \text{ mm} \\
 Yv2sl &= Yv2su - (H + Tu + Tl) = -1041.9 \text{ mm} \\
 Iv2 &= Is + Ic/n2 + As \cdot ds2^2 + Ac/n2 \cdot dc2^2 = 119731760091.8 \text{ mm}^4 \\
 P2 &= Es \cdot \epsilon_s \cdot Ac/n2 = 4150097 \text{ N} \\
 Mv2 &= P2 \cdot dc2 = 2511410944 \text{ N} \cdot \text{mm} \\
 Ec2 &= Es \cdot /n2 = 8542 \text{ MPa} \\
 fvcu2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cu/Iv2) - Ec2 \cdot \epsilon_s = -1.408 \text{ MPa} \\
 fvc12 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cl/Iv2) - Ec2 \cdot \epsilon_s = -1.470 \text{ MPa} \\
 fvsu2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2su/Iv2 = 20.187 \text{ MPa} \\
 fvs12 &= P2/Av2 + k \cdot Mv2 \cdot Yv2sl/Iv2 = 11.001 \text{ MPa}
 \end{aligned}$$

(6) 온 도 차

$$\begin{aligned}
 \epsilon_t &= \alpha \cdot t = 0.000012 \times 10 = 0.00012 \\
 P1 &= Es \cdot \epsilon_t \cdot Ac/n = 5533463 \text{ N} \\
 Mvt &= P1 \cdot dvc = 2064747048 \text{ N} \cdot \text{mm} \\
 fcut &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcu/Iv) - Ec \cdot \epsilon_t = -1.199 \text{ MPa} \\
 fclt &= 1/n \cdot (P1/Av + K \cdot Mvt \cdot Yvcl/Iv) - Ec \cdot \epsilon_t = -1.318 \text{ MPa} \\
 fsut &= P1/Av + K \cdot Mvt \cdot Yvsu/Iv = 15.166 \text{ MPa} \\
 fs1t &= P1/Av + K \cdot Mvt \cdot Yvsl/Iv = 9.308 \text{ MPa}
 \end{aligned}$$

(7) 전 단 및 비틀림

$$u = (Ss+Ssc+Sv)/Aw + Mst/(2 F Tw) + (Msct+Mvt)/(2 FvTw) = 52.649 \text{ MPa} < u_a = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (☞ 도.설 3.4.2.1)

$$\begin{aligned}
 i &= 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0 \\
 &= 0.650 \times (0.0 / 5)^2 + 0.130 \times (0.0 / 5) + 1.0 = 1.000
 \end{aligned}$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

★ 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

★ 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 \left(\frac{b}{(t_u \cdot i \cdot n) - 24} \right) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220000 \times \left\{ (t_u \cdot i \cdot n) / b \right\} = 352.000 \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

★ 철근콘크리트의 허용응력 (☞ 도.설 3.9.3)

$$f_{ca} = 0.4 \text{ } f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \text{ } f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	34.041	-33.852	186.100	190.000
1+2+3	2.269	1.130	10.800	10.800	43.813	-80.277	186.100	190.000
1+2+3+4	2.062	1.079	10.800	10.800	45.598	-79.257	214.015	190.000
1+2+3+4+5	0.654	-0.391	10.800	1.890	65.784	-68.256	214.015	190.000
1+2+3+4+5+6	-0.545	-1.709	2.174	2.174	80.950	-58.947	241.930	218.500
1+2+3+4+5-6	1.853	0.927	12.420	12.420	50.619	-77.564	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 할증 (☞ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (☞ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{80.950}{241.930} \right)^2 + \left(\frac{52.649}{110.000} \right)^2 \\ &= 0.112 + 0.229 = 0.341 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-80.277}{190.000} \right)^2 + \left(\frac{52.649}{110.000} \right)^2 \\ &= 0.179 + 0.229 = 0.408 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot j \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K. (합성형 스티드 설치)}$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 22 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/34.041)} = 2.363 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = bc / (219 \times 1.200) = 2.0 \text{ mm} \leq t = 12 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/80.95)} = 1.532 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.326 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.269 - 0.326 = 1.943 \text{ MPa}$$

$$\Sigma f = 1.3 \times 0.326 + 2.15 \times 1.943 + (-0.207) + (-1.408) + (1.199) = 4.186 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times 0.326 + 2.15 \times 1.943 + (1.199) = 5.801 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 34.041 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.404 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 43.813 - 34.041 - 1.404 = 8.368 \text{ MPa}$$

$$\Sigma f = 1.3 \times (34.041 + 1.404) + 2.15 \times 8.368 + (1.785) + (20.187) + (15.166) = 101.207 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (34.041 + 1.404) + 2.15 \times 8.368 + (15.166) = 79.235 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -33.852 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -6.670 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -80.277 - -33.852 - -6.67 = -39.755 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-33.852 + -6.67) + 2.15 \times -39.755 + (1.02) + (11.001) + (-9.308) = -135.439 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

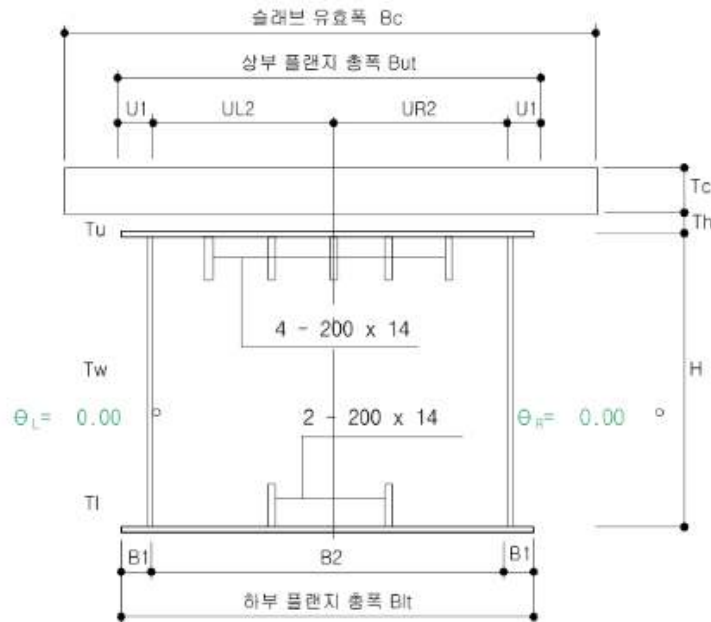
$$\Sigma f = 1.3 \times (-33.852 + -6.67) + 2.15 \times -39.755 + (-9.308) = -147.460 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	4.186	16.200	0.K!!!	3.87
	크리프, 건조수축제외시	5.801	16.200	0.K!!!	2.79
상부플랜지	크리프, 건조수축 포함시	101.207	315.000	0.K!!!	3.11
	크리프, 건조수축제외시	79.235	315.000	0.K!!!	3.97
하부플랜지	크리프, 건조수축 포함시	-135.439	315.000	0.K!!!	2.32
	크리프, 건조수축제외시	-147.460	315.000	0.K!!!	2.13

5-5. 5경간 최대 정모멘트 단면검토(G3)

1) 단면가정 및 설계조건



주부재사용강종 = SWS50B

H = 1.500 m
 Bc = 5.877 m
 UL2= 1.250 , UR2= 1.250 m
 B2 = 2.500 m
 But= 2.700 , Blt= 2.700 m
 상하 플랜지 유효폭
 Bue= 2.700 , Ble= 2.700 m
 Tc = 0.250 m
 Th = 0.000 m
 Tu = 0.020 m
 Tl = 0.020 m
 Tw = 0.014 m
 U1 = 0.100 m
 B1 = 0.100 m
 RIB 200 x 14 mm , 200 x 14 mm

구 분	단 위	입력 DATA
Es : 강 의 탄성계수	MPa	205000
Ec : 콘크리트의 탄성계수	MPa	26702
εs : 바닥판 콘크리트의 건조수축에 의한 최종수축율		0.00027
α : 강재 및 콘크리트의 선형창계수		0.000012
φ2: 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
Ms : 합성전 고정하중에 의한 모멘트	kN · m	3433.653
Msc : 합성후 고정하중에 의한 모멘트	kN · m	771.033
Mv : 활하중+지점침하에 의한 모멘트	kN · m	3648.292
Ss : 합성전 고정하중에 의한 전단력	kN	242.346
Ssc : 합성후 고정하중에 의한 전단력	kN	54.011
Sv : 활하중+지점침하에 의한 전단력	kN	370.871
Mst : 합성전 고정하중에 의한 비틀림모멘트	kN · m	14.431
Mscst : 합성후 고정하중에 의한 비틀림모멘트	kN · m	5.192
Mvst : 활하중+지점침하에 의한 비틀림모멘트	kN · m	616.193

< 참고 > 합성전 고정하중 : 강재자중 + 바닥판콘크리트자중

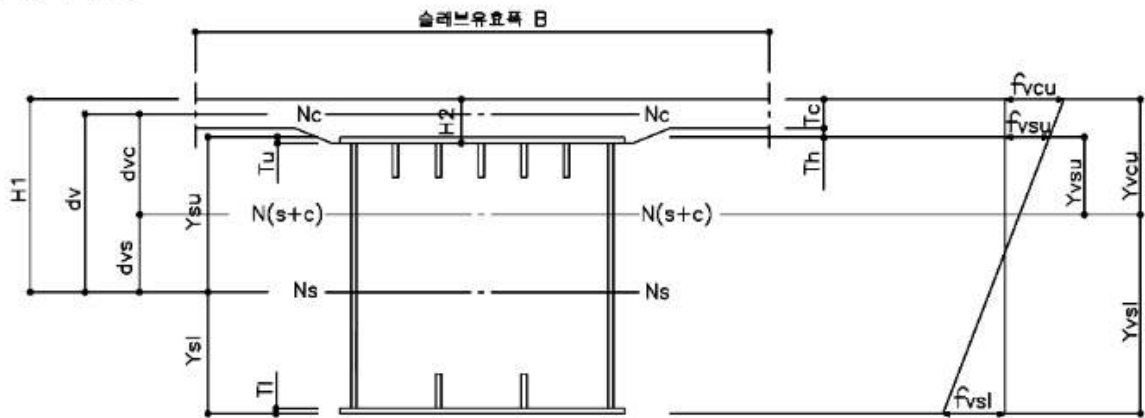
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y2(mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	14.0	1500.0	21000	0.0	0	0	3937500000
1 - R_WEB	14.0	1500.0	21000	0.0	0	0	3937500000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	20.0	54000	-760.0	-41040000	31190400000	1800000
강단면 합계			166800		3640000	69478800000	7934600000
1 - RC SLAB	5877.0	250.0	1469250	875.0	1285593750	1124894531250	7652343750

$$* A_s = 166800 \text{ mm}^2, A_c = 1469250 \text{ mm}^2$$

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 69478800000 + 7934600000.0 = 77413400000 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = 3640000 / 166800 = 21.823 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 77413400000 - 166800 \times 21.823^2 = 77333965947 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - 21.823 = 748.177 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 748.177 - 1540.000 = -791.823 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + T_u/2 + T_l/2) = 3821280.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 33.219 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -35.157 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot T_w) = 5.905 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 350456.3 \text{ mm}^2$$

$$I_c/n = 956542969 \text{ mm}^4$$

$$dv = Y_{su} - T_u + T_h + T_c/2 = 853.2 \text{ mm}$$

$$dvc = dv \cdot A_s / (A_c/n + A_s) = 406.1 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 447.1 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 531.1 \text{ mm} \\
Yvcl &= Yvcu - Tc = 281.1 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 301.1 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1238.9 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 141918277644 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860561.3 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.361 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.191 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.636 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -6.731 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 1.334 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.707 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 0.903 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 7.740 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -31.849 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 14.531 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 258628.1 \text{ mm}^2 & \# 2차 부정정력으로 인한 영향 고려 \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 550.2 \text{ mm} & K = -0.057 \\
ds1 &= dv - dc1 = 302.9 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 675.2 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 425.2 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 445.2 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1094.8 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 120921913195 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 405174 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 405174 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 222946995 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.361 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.191 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.267 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.096 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.520 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.682 \text{ MPa}
\end{aligned}$$

(5) 건 조 수 축

$$\begin{aligned}
 n2 &= n \cdot (1 + \phi 2 / 2) = 8 \times (1 + 4.0 / 2) = 24 \\
 Av2 &= As + Ac/n2 = 228018.750 \text{ mm}^2 \\
 dc2 &= dv \cdot As / (Ac/n2 + As) = 624.1 \text{ mm} \\
 ds2 &= dv - dc2 = 229.1 \text{ mm} \\
 Yv2cu &= dc2 + Tc/2 = 749.1 \text{ mm} \\
 Yv2cl &= Yv2cu - Tc = 499.1 \text{ mm} \\
 Yv2su &= Yv2cu - H2 + Tu = 519.1 \text{ mm} \\
 Yv2sl &= Yv2su - (H + Tu + Tl) = -1020.9 \text{ mm} \\
 Iv2 &= Is + Ic/n2 + As \cdot ds2^2 + Ac/n2 \cdot dc2^2 = 110250643422.8 \text{ mm}^4 \\
 P2 &= Es \cdot \epsilon s \cdot Ac/n2 = 3388458 \text{ N} \\
 Mv2 &= P2 \cdot dc2 = 2114788504 \text{ N} \cdot \text{mm} \\
 Ec2 &= Es \cdot /n2 = 8542 \text{ MPa} \\
 fvcu2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cu/Iv2) - Ec2 \cdot \epsilon s = -1.721 \text{ MPa} \\
 fvcl2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cl/Iv2) - Ec2 \cdot \epsilon s = -1.710 \text{ MPa} \\
 fvsu2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2su/Iv2 = 14.293 \text{ MPa} \\
 fvsl2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2sl/Iv2 = 15.977 \text{ MPa}
 \end{aligned}$$

(6) 온 도 차

$$\begin{aligned}
 \epsilon t &= \alpha \cdot t = 0.000012 \times 10 = 0.00012 \\
 P1 &= Es \cdot \epsilon t \cdot Ac/n = 4517944 \text{ N} \\
 Mvt &= P1 \cdot dvc = 1834604391 \text{ N} \cdot \text{mm} \\
 fcut &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcu/Iv) - Ec \cdot \epsilon t = -1.642 \text{ MPa} \\
 fclt &= 1/n \cdot (P1/Av + K \cdot Mvt \cdot Yvcl/Iv) - Ec \cdot \epsilon t = -1.619 \text{ MPa} \\
 fsut &= P1/Av + K \cdot Mvt \cdot Yvsu/Iv = 12.670 \text{ MPa} \\
 fslt &= P1/Av + K \cdot Mvt \cdot Yvsl/Iv = 13.805 \text{ MPa}
 \end{aligned}$$

(7) 전 단 및 비틀림

$$u = (Ss+Ssc+sv)/Aw + Mst/(2 F Tw) + (Msct+Mvt)/(2 FvTw) = 21.770 \text{ MPa} < u_a = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (☞ 도.설 3.4.2.1)

$$\begin{aligned}
 i &= 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0 \\
 &= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000
 \end{aligned}$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

★ 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

★ 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 \left(\frac{b}{(t_u \cdot i \cdot n) - 24} \right) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220000 \times \left\{ (t_u \cdot i \cdot n) / b \right\} = 352.000 \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

★ 철근콘크리트의 허용응력 (≡ 도.설 3.9.3)

$$f_{ca} = 0.4 \quad f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \quad f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	33.219	-35.157	186.100	190.000
1+2+3	2.067	1.094	10.800	10.800	42.595	-73.737	186.100	190.000
1+2+3+4	1.800	0.998	10.800	10.800	44.114	-72.056	214.015	190.000
1+2+3+4+5	0.079	-0.711	10.800	1.890	58.407	-56.079	214.015	190.000
1+2+3+4+5+6	-1.563	-2.330	2.174	2.174	71.077	-42.275	241.930	218.500
1+2+3+4+5-6	1.720	0.907	12.420	12.420	45.738	-69.884	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 참조 (≡ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (≡ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{71.077}{241.930} \right)^2 + \left(\frac{21.770}{110.000} \right)^2 \\ &= 0.086 + 0.039 = 0.125 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-73.737}{190.000} \right)^2 + \left(\frac{21.770}{110.000} \right)^2 \\ &= 0.151 + 0.039 = 0.190 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.} \quad (\text{합성형 스티드 설치})$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 14 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/33.219)} = 2.392 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b_c / (219 \times 1.200) = 2.3 \text{ mm} \leq t = 14 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/71.077)} = 1.635 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
+ (크리프응력 변화량) + (건조수축응력변화량) + (온도차응력변화량)의 조합 중에서
가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.361 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.067 - 0.361 = 1.707 \text{ MPa}$$

$$\begin{aligned} \Sigma f &= 1.3 \times 0.361 + 2.15 \times 1.707 + (-0.267) + (-1.721) + (1.642) \\ &= 3.791 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시}) \end{aligned}$$

$$\begin{aligned} \Sigma f &= 1.3 \times 0.361 + 2.15 \times 1.707 + (1.642) \\ &= 5.780 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시}) \end{aligned}$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 33.219 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.636 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 42.595 - 33.219 - 1.636 = 7.740 \text{ MPa}$$

$$\begin{aligned} \Sigma f &= 1.3 \times (33.219 + 1.636) + 2.15 \times 7.74 + (1.52) + (14.293) + (12.67) \\ &= 90.434 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시}) \end{aligned}$$

$$\begin{aligned} \Sigma f &= 1.3 \times (33.219 + 1.636) + 2.15 \times 7.74 + (12.67) \\ &= 74.622 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시}) \end{aligned}$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -35.157 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -6.731 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -73.737 - (-35.157) - (-6.731) = -31.849 \text{ MPa}$$

$$\begin{aligned} \Sigma f &= 1.3 \times (-35.157 + -6.731) + 2.15 \times -31.849 + (1.682) + (15.977) + (-13.805) \\ &= -119.077 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 포함시}) \end{aligned}$$

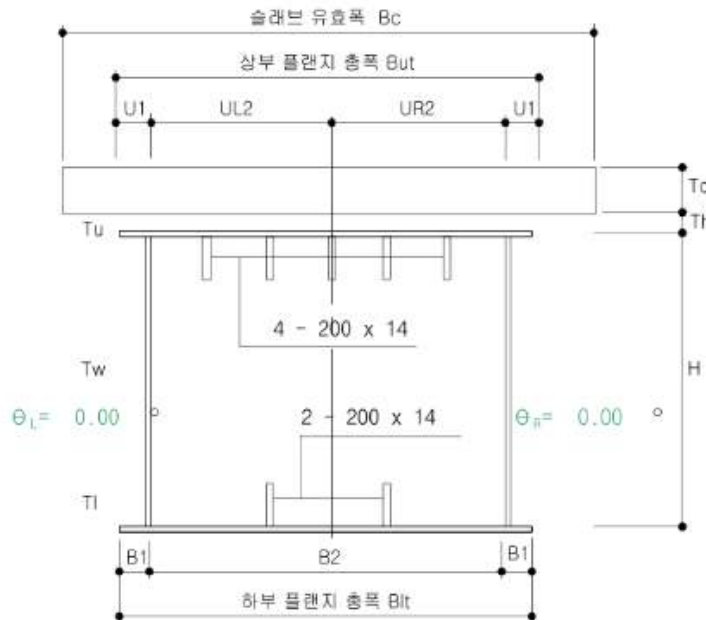
$$\begin{aligned} \Sigma f &= 1.3 \times (-35.157 + -6.731) + 2.15 \times -31.849 + (-13.805) \\ &= -136.735 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K.} \quad (\text{크리프, 건조수축 제외시}) \end{aligned}$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	3.791	16.200	0.K!!!	4.27
	크리프, 건조수축제외시	5.780	16.200	0.K!!!	2.80
상부플랜지	크리프, 건조수축 포함시	90.434	315.000	0.K!!!	3.48
	크리프, 건조수축제외시	74.622	315.000	0.K!!!	4.22
하부플랜지	크리프, 건조수축 포함시	-119.077	315.000	0.K!!!	2.64
	크리프, 건조수축제외시	-136.735	315.000	0.K!!!	2.30

5-6. 6경간 최대 정모멘트 단면검토(G3)

1) 단면가정 및 설계조건



주부재사용강종 = SWS50B

H = 1.500 m

Bc = 5.899 m

UL2= 1.250 , UR2= 1.250 m

B2 = 2.500 m

But= 2.700 , Blt= 2.700 m

상하 플랜지 유효폭

Bue= 2.700 , Ble= 2.700 m

Tc = 0.250 m

Th = 0.000 m

Tu = 0.020 m

Tl = 0.020 m

Tw = 0.014 m

U1 = 0.100 m

B1 = 0.100 m

RIB 200 x 14 mm , 200 x 14 mm

구 분	단 위	입력 DATA
Es : 강의 탄성계수	MPa	205000
Ec : 콘크리트의 탄성계수	MPa	26702
εs : 바닥판 콘크리트의 건조수축에 의한 최종수축율		0.00027
α : 강재 및 콘크리트의 선팽창계수		0.000012
φ2: 건조수축에 의한 크리이프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
Ms : 합성전 고정하중에 의한 모멘트	kN · m	3157.537
Msc : 합성후 고정하중에 의한 모멘트	kN · m	708.667
Mv : 활하중+지정침하에 의한 모멘트	kN · m	4080.717
Ss : 합성전 고정하중에 의한 전단력	kN	709.991
Ssc : 합성후 고정하중에 의한 전단력	kN	160.032
Sv : 활하중+지정침하에 의한 전단력	kN	430.584
Mst : 합성전 고정하중에 의한 비틀림모멘트	kN · m	-40.464
Msc : 합성후 고정하중에 의한 비틀림모멘트	kN · m	-14.445
Mvt : 활하중+지정침하에 의한 비틀림모멘트	kN · m	663.089

< 참고 > 합성전 고정하중 : 강재자중 + 바닥판콘크리트자중

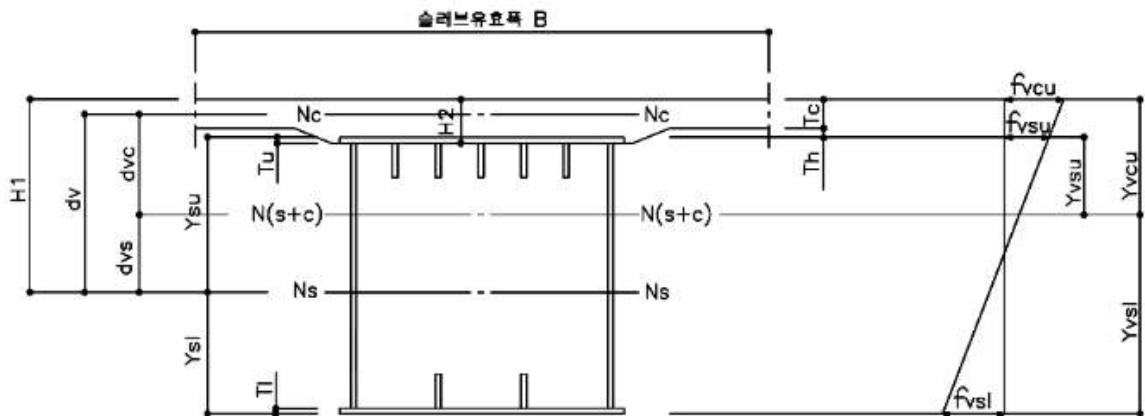
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y ² (mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2700.0	20.0	54000	760.0	41040000	31190400000	1800000
4 - UPPER RIB	14.0	200.0	11200	650.0	7280000	4732000000	37333333.33
1 - L_WEB	14.0	1500.0	21000	0.0	0	0	3937500000
1 - R_WEB	14.0	1500.0	21000	0.0	0	0	3937500000
2 - LOWER RIB	14.0	200.0	5600	-650.0	-3640000	2366000000	18666666.67
1 - LOWER FLANGE	2700.0	20.0	54000	-760.0	-41040000	31190400000	1800000
강단면 합계			166800		3640000	69478800000	7934600000
1 - RC SLAB	5899.0	250.0	1474750	875.0	1290406250	1129105468750	7680989583

* As = 166800 mm² , Ac = 1474750 mm²

2) 응 력 검 토



(1) 합 성 전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 69478800000 + 7934600000.0 = 77413400000 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = 3640000 / 166800 = 21.823 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 77413400000 - 166800 \times 21.823^2 = 77333965947 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 1500.0 / 2 + 20.0 - 21.823 = 748.177 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 748.177 - 1540.000 = -791.823 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + T_u/2 + T_l/2) = 3821280.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = 30.548 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = -32.330 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot Tw) = 17.283 \text{ MPa}$$

(2) 합 성 후

$$A_v = A_s + A_c/n = 351143.8 \text{ mm}^2$$

$$I_c/n = 960123698 \text{ mm}^4$$

$$dv = Y_{su} - T_u + T_h + T_c/2 = 853.2 \text{ mm}$$

$$dvc = dv \cdot A_s / (A_c/n + A_s) = 405.3 \text{ mm}$$

$$\begin{aligned}
dvs &= dv - dvc = 447.9 \text{ mm} \\
Yvcu &= dvc + Tc/2 = 530.3 \text{ mm} \\
Yvcl &= Yvcu - Tc = 280.3 \text{ mm} \\
Yvsu &= Yvcu - H2 + Tu = 300.3 \text{ mm} \\
Yvsl &= Yvsu - (H + Tu + Tl) = -1239.7 \text{ mm} \\
Iv &= Is + Ic/n + As \cdot dvs^2 + Ac/n \cdot dvc^2 = 142035000617 \text{ mm}^4 \\
Fv &= b \cdot hv = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + (Tu + Tc/n)/2 + Tl/2) = 3860561.3 \text{ mm}^2 \\
fvcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.331 \text{ MPa} \\
fvcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.175 \text{ MPa} \\
fvsu &= Msc \cdot Yvsu / Iv = 1.498 \text{ MPa} \\
fvsl &= Msc \cdot Yvsl / Iv = -6.185 \text{ MPa} \\
u &= Ssc / A(Web) + Msct / (2 \cdot Fv \cdot Tw) = 3.944 \text{ MPa}
\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}
fvcu &= Mv \cdot Yvcu / (n \cdot Iv) = 1.904 \text{ MPa} \\
fvcl &= Mv \cdot Yvcl / (n \cdot Iv) = 1.007 \text{ MPa} \\
fvsu &= Mv \cdot Yvsu / Iv = 8.627 \text{ MPa} \\
fvsl &= Mv \cdot Yvsl / Iv = -35.618 \text{ MPa} \\
u &= Sv / A(Web) + Mvt / (2 \cdot Fv \cdot Tw) = 16.386 \text{ MPa}
\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}
n1 &= n \cdot (1 + \phi 1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\
Av1 &= As + Ac/n1 = 258971.9 \text{ mm}^2 & \# 2\text{차 부정정력으로 인한 영향 고려} \\
dc1 &= dv \cdot As / (Ac/n1 + As) = 549.5 \text{ mm} & K = 0.148 \\
ds1 &= dv - dc1 = 303.7 \text{ mm} \\
Yv1cu &= dc1 + Tc/2 = 674.5 \text{ mm} \\
Yv1cl &= Yv1cu - Tc = 424.5 \text{ mm} \\
Yv1su &= Yv1cu - H2 + Tu = 444.5 \text{ mm} \\
Yv1sl &= Yv1su - (H + Tu + Tl) = -1095.5 \text{ mm} \\
Iv1 &= Is + Ic/n1 + As \cdot ds1^2 + Ac/n1 \cdot dc1^2 = 121027644153 \text{ mm}^4 \\
Nc &= Msc \cdot dvc \cdot Ac / (n \cdot Iv) = 372757 \text{ N} \\
P\phi &= Nc \cdot 2 \cdot \phi 1 / (2 + \phi 1) = 372757 \text{ N} \\
M\phi &= P\phi \cdot dc1 = 204837065 \text{ N} \cdot \text{mm} \\
Ec1 &= Ec / (1 + \phi 1 / 2) = 13351 \text{ MPa} \\
fcu &= Msc \cdot Yvcu / (n \cdot Iv) = 0.331 \text{ MPa} \\
fcl &= Msc \cdot Yvcl / (n \cdot Iv) = 0.175 \text{ MPa} \\
fvcu1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cu / Iv1) - Ec1 \cdot fcu \cdot \phi 1 / Ec = -0.230 \text{ MPa} \\
fvcl1 &= 1/n1 \cdot (P\phi / Av1 + k \cdot M\phi \cdot Yv1cl / Iv1) - Ec1 \cdot fcl \cdot \phi 1 / Ec = -0.078 \text{ MPa} \\
fvsu1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1su / Iv1 = 1.551 \text{ MPa} \\
fvsl1 &= P\phi / Av1 + k \cdot M\phi \cdot Yv1sl / Iv1 = 1.165 \text{ MPa}
\end{aligned}$$

(5) 건조수축

$$\begin{aligned}
 n2 &= n \cdot (1 + \phi 2 / 2) = 8 \times (1 + 4.0 / 2) = 24 \\
 Av2 &= As + Ac/n2 = 228247.917 \text{ mm}^2 \\
 dc2 &= dv \cdot As / (Ac/n2 + As) = 623.5 \text{ mm} \\
 ds2 &= dv - dc2 = 229.7 \text{ mm} \\
 Yv2cu &= dc2 + Tc/2 = 748.5 \text{ mm} \\
 Yv2cl &= Yv2cu - Tc = 498.5 \text{ mm} \\
 Yv2su &= Yv2cu - H2 + Tu = 518.5 \text{ mm} \\
 Yv2sl &= Yv2su - (H + Tu + Tl) = -1021.5 \text{ mm} \\
 Iv2 &= Is + Ic/n2 + As \cdot ds2^2 + Ac/n2 \cdot dc2^2 = 110341012365.5 \text{ mm}^4 \\
 P2 &= Es \cdot \epsilon s \cdot Ac/n2 = 3401142 \text{ N} \\
 Mv2 &= P2 \cdot dc2 = 2120573768 \text{ N} \cdot \text{mm} \\
 Ec2 &= Es / n2 = 8542 \text{ MPa} \\
 fvcu2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cu/Iv2) - Ec2 \cdot \epsilon s = -1.597 \text{ MPa} \\
 fvcl2 &= 1/n2 \cdot (P2/Av2 + k \cdot Mv2 \cdot Yv2cl/Iv2) - Ec2 \cdot \epsilon s = -1.626 \text{ MPa} \\
 fvsu2 &= P2/Av2 + k \cdot Mv2 \cdot Yv2su/Iv2 = 16.376 \text{ MPa} \\
 fvs12 &= P2/Av2 + k \cdot Mv2 \cdot Yv2sl/Iv2 = 11.996 \text{ MPa}
 \end{aligned}$$

(6) 온도차

$$\begin{aligned}
 \epsilon t &= \alpha \cdot t = 0.000012 \times 10 = 0.00012 \\
 P1 &= Es \cdot \epsilon t \cdot Ac/n = 4534856 \text{ N} \\
 Mvt &= P1 \cdot dvc = 1837866666 \text{ N} \cdot \text{mm} \\
 fcut &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcu/Iv) - Ec \cdot \epsilon t = -1.463 \text{ MPa} \\
 fc1t &= 1/n \cdot (P1/Av + k \cdot Mvt \cdot Yvcl/Iv) - Ec \cdot \epsilon t = -1.523 \text{ MPa} \\
 fsut &= P1/Av + k \cdot Mvt \cdot Yvsu/Iv = 13.490 \text{ MPa} \\
 fs1t &= P1/Av + k \cdot Mvt \cdot Yvs1/Iv = 10.540 \text{ MPa}
 \end{aligned}$$

(7) 전단 및 비틀림

$$u = (Ss + Ssc + Sv) / Aw + Mst / (2 F Tw) + (Msct + Mvt) / (2 Fv Tw) = 36.589 \text{ MPa} < u_a = 110 \text{ MPa} \quad \text{O.K.}$$

(8) 조합응력의 검토 (☞ 도.설 3.4.2.1)

$$\begin{aligned}
 i &= 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0 \\
 &= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000
 \end{aligned}$$

$$\therefore \phi = (f_1 - f_2) / f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

★ 인장 (하부)플랜지의 허용응력 (SWS50B 사용)

$$f_{ta} = 190.0 \text{ MPa}$$

★ 압축 (상부)플랜지의 허용응력 (SWS50B 사용)

$$t_u \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.8 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190.0 \text{ MPa}$$

$$\frac{b}{24 \cdot i \cdot n} > t_u \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = 10.2 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 190 - 3.9 \left(\frac{b}{(t_u \cdot i \cdot n) - 24} \right) = 186.1$$

$$\frac{b}{49 \cdot i \cdot n} > t_u \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.3 \text{ mm}$$

$$\text{인 경우 : } f_{ca} = 220000 \times \left\{ (t_u \cdot i \cdot n) / b \right\} = 352.000 \text{ MPa}$$

$$\text{사용 } t_u = 20.0 \text{ mm}$$

$$\text{따라서, } f_{ca} = 186.100 \text{ MPa}$$

★ 철근콘크리트의 허용응력 (≪ 도.설 3.9.3)

$$f_{ca} = 0.4 \text{ } f_{ck} = 10.800 \text{ MPa}$$

$$(f_{ck} = 27 \text{ MPa 사용})$$

$$f_{ta} = 0.07 \text{ } f_{ck} = 1.890 \text{ MPa}$$

하중조합	CONCRETE				STEEL			
	작용응력 (MPa)		허용응력 (MPa)		작용응력 (MPa)		허용응력 (MPa)	
	상 연	하 연	상 연	하 연	상 연	하 연	상 연	하 연
1			10.800	10.800	30.548	-32.330	186.100	190.000
1+2+3	2.235	1.181	10.800	10.800	40.673	-74.133	186.100	190.000
1+2+3+4	2.005	1.103	10.800	10.800	42.224	-72.968	214.015	190.000
1+2+3+4+5	0.408	-0.523	10.800	1.890	58.600	-60.973	214.015	190.000
1+2+3+4+5+6	-1.055	-2.046	2.174	2.174	72.089	-50.432	241.930	218.500
1+2+3+4+5-6	1.871	1.000	12.420	12.420	45.110	-71.513	241.930	218.500

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 합증 (≪ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (≪ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{72.089}{241.930} \right)^2 + \left(\frac{36.589}{110.000} \right)^2 \\ &= 0.089 + 0.111 = 0.199 < 1.2 \quad \text{O.K.} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-74.133}{190.000} \right)^2 + \left(\frac{36.589}{110.000} \right)^2 \\ &= 0.152 + 0.111 = 0.263 < 1.2 \quad \text{O.K.} \end{aligned}$$

(10) 판의 최소두께 검토

압축(상부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K. (합성형 스타드 설치)}$$

인장(하부)플랜지 (☞ 도.설.기 3.8.3.1 및 3.8.3.2)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

$$t_{min} = b / (80 \cdot n) = 2500 / (80 \times 3) = 10.4 \text{ mm} \leq t = 20 \text{ mm} \quad \text{O.K.}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 5.7 \text{ mm} \leq t = 14 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/30.548)} = 2.494 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b_c / (219 \times 1.200) = 2.3 \text{ mm} \leq t = 14 \text{ mm} \quad \text{O.K.}$$

$$\text{여기서, } \sqrt{(f_{ca}/f_c)} = \sqrt{(190/72.089)} = 1.623 > 1.2 \Rightarrow 1.200$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 바닥판 콘크리트

$$\text{합성후 사하중 응력} = \{ M_{sc} / (n \cdot I_v) \} \times Y_{vcu} = 0.331 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 2.235 - 0.331 = 1.904 \text{ MPa}$$

$$\Sigma f = 1.3 \times 0.331 + 2.15 \times 1.904 + (-0.23) + (-1.597) + (1.463) \\ = 4.160 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times 0.331 + 2.15 \times 1.904 + (1.463) \\ = 5.987 \text{ MPa} < (3/5) f_{ck} = 16.2 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = 30.548 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsu} = 1.498 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 40.673 - 30.548 - 1.498 = 8.627 \text{ MPa}$$

$$\Sigma f = 1.3 \times (30.548 + 1.498) + 2.15 \times 8.627 + (1.551) + (16.376) + (13.49) \\ = 91.624 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (30.548 + 1.498) + 2.15 \times 8.627 + (13.49) \\ = 73.698 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = -32.330 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_v \times Y_{vsl} = -6.185 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -74.133 - -32.33 - -6.185 = -35.618 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-32.33 + -6.185) + 2.15 \times -35.618 + (1.165) + (11.996) + (-10.54) \\ = -124.028 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 포함시)}$$

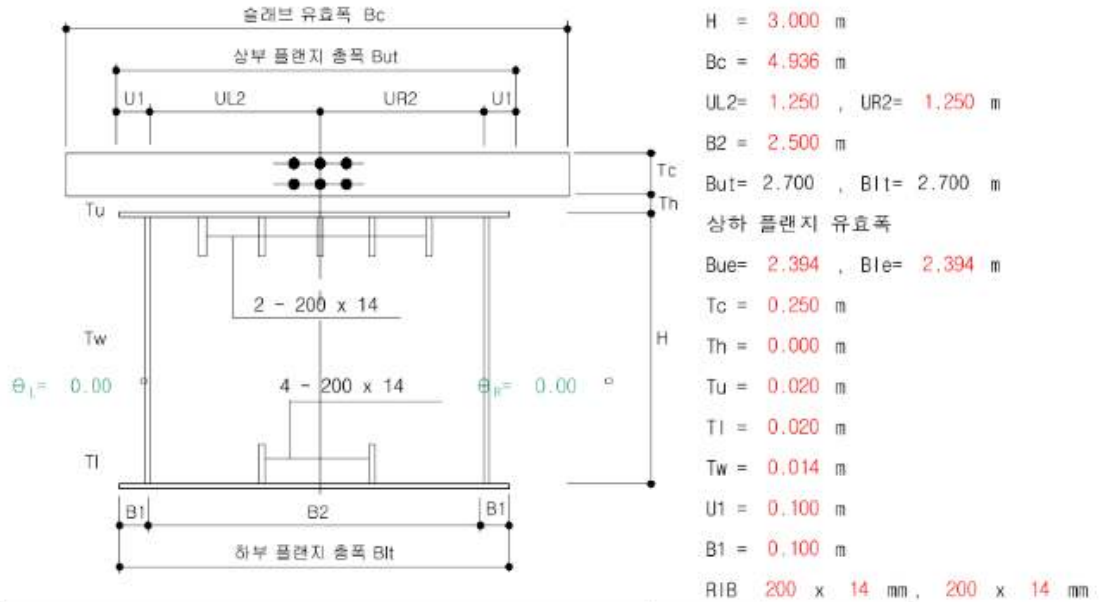
$$\Sigma f = 1.3 \times (-32.33 + -6.185) + 2.15 \times -35.618 + (-10.54) \\ = -137.189 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{O.K. (크리프, 건조수축 제외시)}$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	4.160	16.200	0.K!!!	3.89
	크리프, 건조수축제외시	5.987	16.200	0.K!!!	2.70
상부플랜지	크리프, 건조수축 포함시	91.624	315.000	0.K!!!	3.43
	크리프, 건조수축제외시	73.698	315.000	0.K!!!	4.27
하부플랜지	크리프, 건조수축 포함시	-124.028	315.000	0.K!!!	2.53
	크리프, 건조수축제외시	-137.189	315.000	0.K!!!	2.29

5-7. P1 최대 부모멘트 단면검토(G1)

1) 단면가정 및 설계조건



구분	단위	입력 DATA
Es : 강역 탄성계수	MPa	205000
Ec : 콘크리트의 탄성계수	MPa	26702
es: 바닥판 콘크리트의 건조수축에 의한 최종수축률		0.00027
α : 강재 및 콘크리트의 선팅계수		0.000012
$\phi 2$: 건조수축에 의한 크리프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
Ms : 합성전 고정하중에 의한 모멘트	kN · m	-13037.081
Msc : 합성후 고정하중에 의한 모멘트	kN · m	-2905.336
Mv : (활하중 + 지정침하)에 의한 모멘트	kN · m	-5835.180
Ss : 합성전 고정하중에 의한 전단력	kN	-1297.035
Ssc : 합성후 고정하중에 의한 전단력	kN	-284.713
Sv : (활하중 + 지정침하)에 의한 전단력	kN	-652.963
Mst : 합성전 고정하중에 의한 비틀림모멘트	kN · m	-14.969
Msc1 : 합성후 고정하중에 의한 비틀림모멘트	kN · m	-5.833
Mvt : (활하중 + 지정침하)에 의한 비틀림모멘트	kN · m	-836.938
tcl, tcl : 교축방향 철근의 피복두께	mm	40, 40

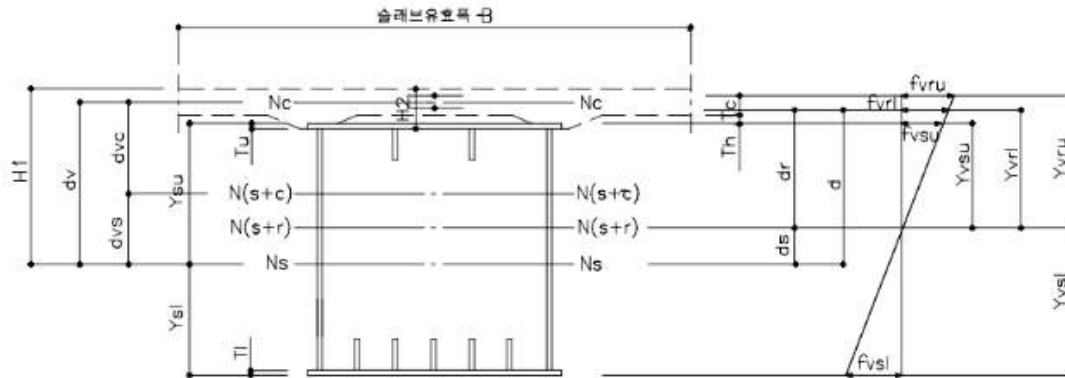
< 참고 > 합성전 고정하중 : 강재자중 + 콘크리트바닥판자중
합성후 고정하중 : 방호벽 + PAVEMENT 자중

단면제원

단면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y ² (mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2394.0	20.0	47880	1510.00	72298800	109171188000	1596000
2 - UPPER RIB	14.0	200.0	5600	1400.00	7840000	10976000000	18666667
1 - L_WEB	14.0	3000.0	42000	0.00	0	0	31500000000
1 - R_WEB	14.0	3000.0	42000	0.00	0	0	31500000000
4 - LOWER RIB	14.0	200.0	11200	-1400.00	-15680000	21952000000	37333333
1 - LOWER FLANGE	2394.0	20.0	47880	-1510.00	-72298800	109171188000	1596000
강단면 합계			196560		-7840000	251270376000	63059192000
UPPER RE-BAR	-	-	4269.90	1710.00	7301529	12485614590	-
LOWER RE-BAR	-	-	6255.90	1540.00	9634086	14836492440	-
RE-BAR 합계			10526		16935615	27322107030	-
1 - RC SLAB	4936.0	250.0	1234000	1625.00	2005250000	3258531250000	6427083333

* $A_s = 196560 \text{ mm}^2$, $A_c = 1234000 \text{ mm}^2$, $A_r = 10526 \text{ mm}^2$

2) 응력검토



(1) 합성전

$$I_s' = A_s \cdot Y^2 + \sum I_s = 251270376000 + 63059192000 = 314329568000 \text{ mm}^4$$

$$\delta s = \sum (A \cdot Y) / A_s = -7840000 / 196560 = -39.886 \text{ mm}$$

$$I_s = I_s' - A_s \cdot \delta s^2 = 314329568000 - 196560 \times (-39.886)^2 = 314016861447 \text{ mm}^4$$

$$Y_{su} = H/2 + T_u - \delta s = 3000.0 / 2 + 20.0 - (-39.886) = 1559.886 \text{ mm}$$

$$Y_{sl} = Y_{su} - (H + T_u + T_l) = 1559.886 - 3040.000 = -1480.114 \text{ mm}$$

$$F = b \cdot h = ((UL2 + UR2 + B2) / 2 + Tw) \cdot (H + T_u/2 + T_l/2) = 7592280.0 \text{ mm}^2$$

$$f_{su} = M_s \cdot Y_{su} / I_s = -64.762 \text{ MPa}$$

$$f_{sl} = M_s \cdot Y_{sl} / I_s = 61.450 \text{ MPa}$$

$$u = S_s / A(\text{Web}) + M_{st} / (2 \cdot F \cdot Tw) = 15.511 \text{ MPa}$$

(2) 합 성 후

$$\begin{aligned}A_v &= A_s + A_r = 207086 \text{ mm}^2 \\d &= Y_{su} - T_u + T_h + t_{cl} + (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1648.848 \text{ mm} \\d_r &= d \cdot A_s / (A_s + A_r) = 1565.040 \text{ mm} \\d_s &= d - d_r = 83.808 \text{ mm} \\Y_{vru} &= d_r + (T_c - t_{cu} - t_{cl}) \cdot A_{rl}/A_r = 1666.078 \text{ mm} \\Y_{vrl} &= d_r - (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1496.078 \text{ mm} \\Y_{vsu} &= Y_{vrl} - t_{cl} - T_h + T_u = 1476.078 \text{ mm} \\Y_{vsl} &= Y_{vsu} - (H + T_u + T_l) = -1563.922 \text{ mm} \\I_{rv} &= I_s + A_s \cdot d_s^2 + A_r \cdot d_r^2 = 341178836183 \text{ mm}^4 \\F_v &= b \cdot h_v = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + (T_u + T_c/n)/2 + T_l/2) = 7631561.3 \text{ mm}^2 \\f_{vru} &= M_{sc} \cdot Y_{vru}/I_{rv} = -14.188 \text{ MPa} \\f_{vrl} &= M_{sc} \cdot Y_{vrl}/I_{rv} = -12.740 \text{ MPa} \\f_{vsu} &= M_{sc} \cdot Y_{vsu}/I_{rv} = -12.570 \text{ MPa} \\f_{vsl} &= M_{sc} \cdot Y_{vsl}/I_{rv} = 13.318 \text{ MPa} \\u &= S_{sc} / A(\text{Web}) + M_{sct} / (2 \cdot F_v \cdot T_w) = 3.417 \text{ MPa}\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}f_{vru} &= M_v \cdot Y_{vru}/I_{rv} = -28.495 \text{ MPa} \\f_{vrl} &= M_v \cdot Y_{vrl}/I_{rv} = -25.587 \text{ MPa} \\f_{vsu} &= M_v \cdot Y_{vsu}/I_{rv} = -25.245 \text{ MPa} \\f_{vsl} &= M_v \cdot Y_{vsl}/I_{rv} = 26.748 \text{ MPa} \\u &= S_v / A(\text{Web}) + M_{vt} / (2 \cdot F_v \cdot T_w) = 11.690 \text{ MPa}\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}A_{vc} &= A_s + A_c/n = 350810.000 \text{ mm}^2 \\d_v &= Y_{su} - T_u + T_h + T_c/2 = 1664.886 \text{ mm} \\d_{vc} &= d_v \cdot A_s / (A_c/n + A_s) = 932.841 \text{ mm} \\d_{vs} &= d_v - d_{vc} = 732.045 \text{ mm} \\n_1 &= n \cdot (1 + \phi_1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\A_{v1} &= A_s + A_c/n_1 = 273685.000 \text{ mm}^2 & \# \text{ 2차 부정정력으로 인한 영향 고려} \\d_{c1} &= d_v \cdot A_s / (A_c/n_1 + A_s) = 1195.718 \text{ mm} & K = -0.358 \\d_{s1} &= d_v - d_{c1} = 469.168 \text{ mm} \\I_{cv} &= I_s + I_c/n + A_s \cdot d_{vs}^2 + A_c/n \cdot d_{vc}^2 = 554381940653.3 \text{ mm}^4 \\N_c &= M_{sc} \cdot d_{vc} \cdot A_c / (n \cdot I_{cv}) = -754085 \text{ N} \\P\phi &= N_c \cdot 2 \cdot \phi_1 / (2 + \phi_1) = -754085 \text{ N} \\M\phi &= P\phi \cdot d_{c1} = -901672479 \text{ N} \cdot \text{mm} \\E_{c1} &= E_c / (1 + \phi_1 / 2) = 13351 \text{ MPa} \\f_{vru1} &= P\phi / A_v + k \cdot M\phi \cdot Y_{vru}/I_{rv} = -2.065 \text{ MPa} \\f_{vrl1} &= P\phi / A_v + k \cdot M\phi \cdot Y_{vrl}/I_{rv} = -2.226 \text{ MPa} \\f_{vsu1} &= P\phi / A_v + k \cdot M\phi \cdot Y_{vsu} / I_{rv} = -2.245 \text{ MPa} \\f_{vsl1} &= P\phi / A_v + k \cdot M\phi \cdot Y_{vsl} / I_{rv} = -5.121 \text{ MPa}\end{aligned}$$

(5) 건조수축

$$n2 = n \cdot (1 + \phi2 / 2) = 8 \times (1 + 4.0 / 2) = 24$$

$$Av2 = As + Ac/n2 = 247976.667 \text{ mm}^2$$

$$dc2 = dv \cdot As / (Ac/n2 + As) = 1319.681 \text{ mm}$$

$$ds2 = dv - dc2 = 345.205 \text{ mm}$$

$$P2 = Es \cdot \epsilon s \cdot Ac/n2 = 2845913 \text{ N}$$

$$Mv2 = P2 \cdot dc2 = 375569559 \text{ N} \cdot \text{mm}$$

$$fvru2 = P2/Av + K \cdot Mv2 \cdot Yvru/lrv = 7.177 \text{ MPa}$$

$$fvrl2 = P2/Av + K \cdot Mv2 \cdot Yvrl/lrv = 7.847 \text{ MPa}$$

$$fvru2 = P2/Av + K \cdot Mv2 \cdot Yvsu/lrv = 7.926 \text{ MPa}$$

$$fvsl2 = P2/Av + K \cdot Mv2 \cdot Yvsl/lrv = 19.906 \text{ MPa}$$

(6) 온도차

$$\epsilon t = \alpha \cdot t = 0.000012 \times 10 = 0.00012$$

$$P1 = Es \cdot \epsilon t \cdot Ac/n = 3794550 \text{ N}$$

$$Mvt = P1 \cdot dvc = 3539712344 \text{ N} \cdot \text{mm}$$

$$Ert = Es \cdot \epsilon t = 24.600 \text{ MPa}$$

$$frut = P1/Av + K \cdot Mvt \cdot Yvru/lrv - Es \cdot \epsilon t = -12.465 \text{ MPa}$$

$$frlt = P1/Av + K \cdot Mvt \cdot Yvrl/lrv - Es \cdot \epsilon t = -11.833 \text{ MPa}$$

$$fsut = P1/Av + K \cdot Mvt \cdot Yvsu/lrv = 12.641 \text{ MPa}$$

$$fslt = P1/Av + K \cdot Mvt \cdot Yvsl/lrv = 24.132 \text{ MPa}$$

(7) 전단 및 비틀림

$$u = (Ss+Ssc+Sv)/Aw + (Mst/(2 \cdot F \cdot Tw) + (Msct+Mvt)/(2 \cdot Fv \cdot Tw)) = 30.618 \text{ MPa} < ua = 110 \text{ MPa} \quad \text{O.K!!!}$$

(8) 조합응력의 검토 (도.설 3.4.2.1)

$$i = 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0$$

$$= 0.650 \times (0.0 / 5)^2 + 0.130 \times (0.0 / 5) + 1.0 = 1.000$$

$$\therefore \phi = (f_1 - f_2)/f_1 \leq 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

* 인장 (상부)플랜지의 허용응력 (SWS50B 사용)

$$fta = 190.0 \text{ MPa}$$

• 압축 (하부)플랜지의 허용응력 (SWS50B 사용)

$$t_l \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.833 \text{ mm}$$

인 경우 : $f_{ca} = 190.0 \text{ MPa}$

$$\frac{b}{24 \cdot i \cdot n} > t_l \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = \text{##### mm}$$

인 경우 : $f_{ca} = 190 - 3.9 (b / (t_l \cdot i \cdot n) - 24) = 186.100$

$$\frac{b}{49 \cdot i \cdot n} > t_l \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.250 \text{ mm}$$

인 경우 : $f_{ca} = 220000 \times \{ (t_l \cdot i \cdot n) / b \} = 352.000 \text{ MPa}$

사용 $t_l = 20.0 \text{ mm}$

따라서, $f_{ca} = 186.100 \text{ MPa}$

• RE-BAR의 허용응력 (≡ 도.설 2.2.2.4, 3.6.1.7)

$f_{ta} = 160.000 \text{ MPa}$ $f_{ca} = 180.000 \text{ MPa}$ (SD400 사용)

하중조합	RE-BAR			STEEL			
	작용응력(MPa)		허용응력	작용응력(MPa)		허용응력(MPa)	
	상 연	하 연	(MPa)	상 연	하 연	상 연	하 연
1			160.000	-64.762	61.450	190.000	186.100
1+2+3	-42.683	-38.327	160.000	-102.577	101.516	190.000	186.100
1+2+3+4	-44.748	-40.553	160.000	-104.822	96.394	190.000	186.100
1+2+3+4+5	-37.571	-32.706	160.000	-96.896	116.300	190.000	186.100
1+2+3+4+5+6	-50.035	-44.540	184.000	-84.055	140.433	218.500	214.015
1+2+3+4+5-6	-25.106	-20.873	184.000	-109.737	92.168	218.500	214.015

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음. 허용응력의 참조 (≡ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (≡ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-104.822}{190.000} \right)^2 + \left(\frac{30.618}{110.000} \right)^2 \\ &= 0.304 + 0.077 = 0.382 < 1.2 \quad \text{O.K!!!} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{140.433}{214.015} \right)^2 + \left(\frac{30.618}{110.000} \right)^2 \\ &= 0.431 + 0.077 = 0.508 < 1.2 \quad \text{O.K!!!} \end{aligned}$$

(10) 판의 최소두께 검토

인장(상부)플랜지 (☞ 도.설.기 3.8.3.1)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K.} \quad (\text{합성형 스티드 설치})$$

압축(하부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 11.4 \text{ mm} \leq t = 14 \text{ mm} \quad \mathbf{0.K!!!}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190.0 / 61.450)} = 1.758 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b / (219 \times 1.163) = 11.8 \text{ mm} \leq t = 14 \text{ mm} \quad \mathbf{0.K!!!}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190.0 / 140.433)} = 1.163 < 1.2 \Rightarrow 1.163$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력변화량}) + (\text{온도차응력변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 상부바닥판 REBAR

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{rvu} = -14.188 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -42.683 - -14.188 = -28.495 \text{ MPa}$$

$$\Sigma f = 1.3 \times -14.188 + 2.15 \times -28.495 + (-2.065) + (7.177) + (-12.465)$$

$$= -87.061 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times -14.188 + 2.15 \times -28.495 + (-12.465)$$

$$= -92.173 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = -64.762 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsu} = -12.570 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -102.577 - -64.762 - -12.57 = -25.245 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-64.762 + -12.57) + 2.15 \times -25.245 + (-2.245) + (7.926) + (-12.841)$$

$$= -161.969 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times (-64.762 + -12.57) + 2.15 \times -25.245 + (-12.841)$$

$$= -167.650 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = 61.450 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsl} = 13.318 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 101.516 - 61.45 - 13.318 = 26.748 \text{ MPa}$$

$$\Sigma f = 1.3 \times (61.45 + 13.318) + 2.15 \times 26.748 + (-5.121) + (19.906) + (24.132)$$

$$= 193.623 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times (61.45 + 13.318) + 2.15 \times 26.748 + (24.132)$$

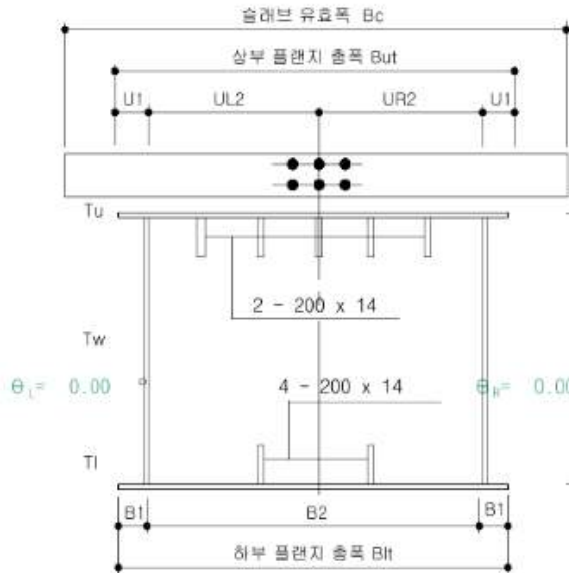
$$= 178.838 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	-87.061	400.000	0.K!!!	4.59
	크리프, 건조수축제외시	-92.173	400.000	0.K!!!	4.33
상부플랜지	크리프, 건조수축 포함시	-161.969	315.000	0.K!!!	1.94
	크리프, 건조수축제외시	-167.650	315.000	0.K!!!	1.87
하부플랜지	크리프, 건조수축 포함시	193.623	315.000	0.K!!!	1.62
	크리프, 건조수축제외시	178.838	315.000	0.K!!!	1.76

5-8. P1 최대 부모멘트 단면검토(G2)

1) 단면가정 및 설계조건



주부재사용강종 = SWS50B

H = 3.000 m
Bc = 6.582 m
UL2= 1.250 , UR2= 1.250 m
B2 = 2.500 m
But = 2.700 , BIt= 2.700 m
삼하 플랜지 유효폭
Bue = 2.394 , Ble= 2.394 m
Tc = 0.250 m
Th = 0.000 m
Tu = 0.020 m
Tl = 0.020 m
Tw = 0.014 m
U1 = 0.100 m
B1 = 0.100 m
RIB 200 x 14 mm , 200 x 14 mm

구 분	단 위	입력 DATA
E_s : 강의 탄성계수	MPa	205000
E_c : 콘크리트의 탄성계수	MPa	26702
ε_s : 바닥판 콘크리트의 건조수축에 의한 최종수축율		0.00027
α : 강재 및 콘크리트의 선팽창계수		0.000012
ϕ_2 : 건조수축에 의한 크리프계수		4
n : 강과 콘크리트의 탄성계수비		8
t : 강과 콘크리트의 온도차	℃	10
M_s : 합성전 고정하중에 의한 모멘트	kN · m	-14913.289
M_{sc} : 합성후 고정하중에 의한 모멘트	kN · m	-3473.081
M_v : (활하중 + 지정침하)에 의한 모멘트	kN · m	-8676.167
S_s : 합성전 고정하중에 의한 전단력	kN	-1525.858
S_{sc} : 합성후 고정하중에 의한 전단력	kN	-358.202
S_v : (활하중 + 지정침하)에 의한 전단력	kN	-1136.620
M_{st} : 합성전 고정하중에 의한 비틀림모멘트	kN · m	0.000
M_{sct} : 합성후 고정하중에 의한 비틀림모멘트	kN · m	0.000
M_{vt} : (활하중 + 지정침하)에 의한 비틀림모멘트	kN · m	-1127.273
t_{cu}, t_{cl} : 교축방향 철근의 피복두께	mm	40 , 40

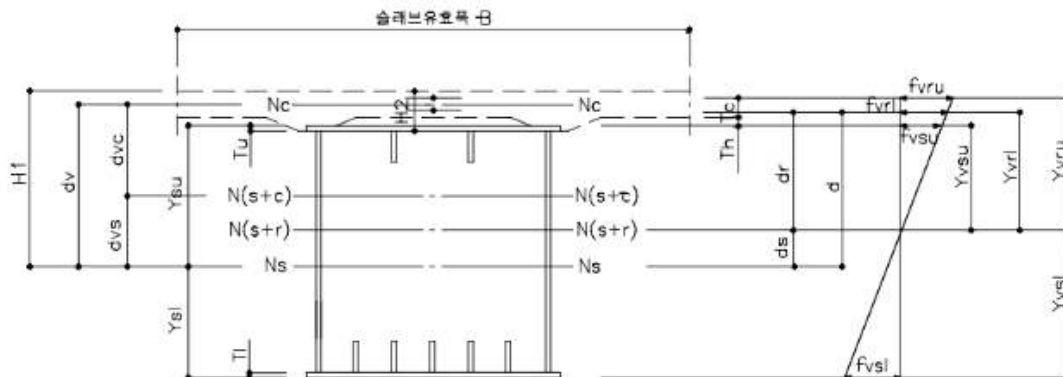
< 참고 > 합성전 고정하중 : 강재자중 + 콘크리트바닥판자중
합성후 고정하중 : 방호벽 + PAVEMENT자중

단 면 제 원

단 면	B(mm)	H(mm)	A(mm ²)	Y(mm)	A*Y(mm ³)	A*Y2(mm ⁴)	Ix(mm ⁴)
1 - UPPER FLANGE	2394.0	20.0	47880	1510.00	72298800	109171188000	1596000
2 - UPPER RIB	14.0	200.0	5600	1400.00	7840000	109760000000	18666667
1 - L_WEB	14.0	3000.0	42000	0.00	0	0	31500000000
1 - R_WEB	14.						

$$\star A_s = 196560 \text{ mm}^2, A_c = 1645500 \text{ mm}^2, A_r = 10526 \text{ mm}^2$$

2) 00 55 55 55



(1) 합성 전

$$\begin{aligned} I_s' &= A_s \cdot Y^2 + \sum I_s = 251270376000 + 63059192000 = 314329568000 \text{ mm}^4 \\ \delta_s &= \sum (A \cdot Y) / A_s = -7840000 / 196560 = -39.886 \text{ mm} \\ I_s &= I_s' - A_s \cdot \delta_s^2 = 314329568000 - 196560 \times -39.886^2 = 314016861447 \text{ mm}^4 \\ Y_{su} &= H/2 + T_u - \delta_s = 3000.0 / 2 + 20.0 - -39.886 = 1559.886 \text{ mm} \\ Y_{sl} &= Y_{su} - (H + T_u + T_l) = 1559.886 - 3040.000 = -1480.114 \text{ mm} \\ F &= b \cdot h = ((U_L2 + U_R2 + B2) / 2 + T_w) \cdot (H + T_u/2 + T_l/$$

(2) 합 성 후

$$\begin{aligned}A_v &= A_s + A_r = 207086 \text{ mm}^2 \\d &= Y_{su} - T_u + T_h + t_{cl} + (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1648.848 \text{ mm} \\d_r &= d \cdot A_s / (A_s + A_r) = 1565.040 \text{ mm} \\d_s &= d - d_r = 83.808 \text{ mm} \\Y_{vu} &= d_r + (T_c - t_{cu} - t_{cl}) \cdot A_{rl}/A_r = 1666.078 \text{ mm} \\Y_{vl} &= d_r - (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1496.078 \text{ mm} \\Y_{vsu} &= Y_{vl} - t_{cl} - T_h + T_u = 1476.078 \text{ mm} \\Y_{vsl} &= Y_{vsu} - (H + T_u + T_l) = -1563.922 \text{ mm} \\I_{rv} &= I_s + A_s \cdot d_s^2 + A_r \cdot d_r^2 = 341178836183 \text{ mm}^4 \\F_v &= b \cdot h_v = ((UL2 + UR2 + B2) / 2 + T_w) \cdot (H + (T_u + T_c/n)/2 + T_l/2) = 7631561.3 \text{ mm}^2 \\f_{vru} &= M_{sc} \cdot Y_{vu}/I_{rv} = -16.960 \text{ MPa} \\f_{vrl} &= M_{sc} \cdot Y_{vl}/I_{rv} = -15.230 \text{ MPa} \\f_{vsu} &= M_{sc} \cdot Y_{vsu}/I_{rv} = -15.026 \text{ MPa} \\f_{vsl} &= M_{sc} \cdot Y_{vsl}/I_{rv} = 15.920 \text{ MPa} \\u &= S_{sc} / A(\text{Web}) + M_{sct} / (2 \cdot F_v \cdot T_w) = 4.264 \text{ MPa}\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}f_{vru} &= M_v \cdot Y_{vu}/I_{rv} = -42.368 \text{ MPa} \\f_{vrl} &= M_v \cdot Y_{vl}/I_{rv} = -38.045 \text{ MPa} \\f_{vsu} &= M_v \cdot Y_{vsu}/I_{rv} = -37.537 \text{ MPa} \\f_{vsl} &= M_v \cdot Y_{vsl}/I_{rv} = 39.770 \text{ MPa} \\u &= S_v / A(\text{Web}) + M_{vt} / (2 \cdot F_v \cdot T_w) = 18.807 \text{ MPa}\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}A_{vc} &= A_s + A_c/n = 402247.500 \text{ mm}^2 \\d_v &= Y_{su} - T_u + T_h + T_c/2 = 1664.886 \text{ mm} \\d_{vc} &= d_v \cdot A_s / (A_c/n + A_s) = 813.554 \text{ mm} \\d_{vs} &= d_v - d_{vc} = 851.332 \text{ mm} \\n_1 &= n \cdot (1 + \phi_1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\A_{v1} &= A_s + A_c/n_1 = 299403.750 \text{ mm}^2 & \# \text{ 2차 부정정력으로 인한 영향 고려} \\d_{c1} &= d_v \cdot A_s / (A_c/n_1 + A_s) = 1093.006 \text{ mm} & K = -0.373 \\d_{s1} &= d_v - d_{c1} = 571.880 \text{ mm} \\I_{cv} &= I_s + I_c/n + A_s \cdot d_{vs}^2 + A_c/n \cdot d_{vc}^2 = 593686611503.2 \text{ mm}^4 \\N_c &= M_{sc} \cdot d_{vc} \cdot A_c / (n \cdot I_{cv}) = -978930 \text{ N} \\P_\phi &= N_c \cdot 2 \cdot \phi_1 / (2 + \phi_1) = -978930 \text{ N} \\M_\phi &= P_\phi \cdot d_{c1} = -1069976595 \text{ N} \cdot \text{mm} \\E_{c1} &= E_c / (1 + \phi_1 / 2) = 13351 \text{ MPa} \\f_{vru1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vu}/I_{rv} = -2.778 \text{ MPa} \\f_{vrl1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vl}/I_{rv} = -2.977 \text{ MPa} \\f_{vsu1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vsu} / I_{rv} = -3.000 \text{ MPa} \\f_{vsl1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vsl} / I_{rv} = -6.557 \text{ MPa}\end{aligned}$$

(5) 건조수축

$$n2 = n \cdot \{ 1 + \phi 2 / 2 \} = 8 \times \{ 1 + 4.0 / 2 \} = 24$$

$$Av2 = As + Ac/n2 = 265122.500 \text{ mm}^2$$

$$dc2 = dv \cdot As / (Ac/n2 + As) = 1234.335 \text{ mm}$$

$$ds2 = dv - dc2 = 430.551 \text{ mm}$$

$$P2 = Es \cdot \epsilon s \cdot Ac/n2 = 3794934 \text{ N}$$

$$Mv2 = P2 \cdot dc2 = 4684220593 \text{ N} \cdot \text{mm}$$

$$fvru2 = P2/Av + K \cdot Mv2 \cdot Yvru/lrv = 9.793 \text{ MPa}$$

$$fvrl2 = P2/Av + K \cdot Mv2 \cdot Yvrl/lrv = 10.664 \text{ MPa}$$

$$fv su2 = P2/Av + K \cdot Mv2 \cdot Yvsu/lrv = 10.766 \text{ MPa}$$

$$fv sl2 = P2/Av + K \cdot Mv2 \cdot Yvsl/lrv = 26.334 \text{ MPa}$$

(6) 온도차

$$\epsilon t = \alpha \cdot t = 0.000012 \times 10 = 0.00012$$

$$P1 = Es \cdot \epsilon t \cdot Ac/n = 5059913 \text{ N}$$

$$Mvt = P1 \cdot dvc = 4116511266 \text{ N} \cdot \text{mm}$$

$$Ert = Es \cdot \epsilon t = 24.600 \text{ MPa}$$

$$frut = P1/Av + K \cdot Mvt \cdot Yvru/lrv - Es \cdot \epsilon t = -7.664 \text{ MPa}$$

$$frlt = P1/Av + K \cdot Mvt \cdot Yvrl/lrv - Es \cdot \epsilon t = -6.899 \text{ MPa}$$

$$fsut = P1/Av + K \cdot Mvt \cdot Yvsu/lrv = 17.791 \text{ MPa}$$

$$fslt = P1/Av + K \cdot Mvt \cdot Yvsl/lrv = 31.472 \text{ MPa}$$

(7) 전단 및 비틀림

$$u = (Ss+Ssc+Sv)/Aw + (Mst/(2 \cdot F \cdot Tw) + (Msct+Mvt)/(2 \cdot Fv \cdot Tw)) = 41.234 \text{ MPa} < ua = 110 \text{ MPa} \quad 0.K!!!$$

(8) 조합응력의 검토 (도.설 3.4.2.1)

$$i = 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0$$

$$= 0.650 \times (0.0/5)^2 + 0.130 \times (0.0/5) + 1.0 = 1.000$$

$$\therefore \phi = (f_1 - f_2)/f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Panel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

* 인장 (상부)플랜지의 허용응력 (SWS50B 사용)

$$fta = 190.0 \text{ MPa}$$

★ 압축 (하부)플랜지의 허용응력 (SWS50B 사용)

$$t_l \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.833 \text{ mm}$$

인 경우 : $f_{ca} = 190.0 \text{ MPa}$

$$\frac{b}{24 \cdot i \cdot n} > t_l \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = \text{##### mm}$$

인 경우 : $f_{ca} = 190 - 3.9 (b / (t_l \cdot i \cdot n) - 24) = 186.100$

$$\frac{b}{49 \cdot i \cdot n} > t_l \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.250 \text{ mm}$$

인 경우 : $f_{ca} = 220000 \times \{ (t_l \cdot i \cdot n) / b = 352.000 \text{ MPa}$

사용 $t_l = 20.0 \text{ mm}$

따라서, $f_{ca} = 186.100 \text{ MPa}$

★ RE-BAR의 허용응력 (도.설 2.2.2.4, 3.6.1.7)

$f_{ta} = 160.000 \text{ MPa}$ $f_{ca} = 180.000 \text{ MPa}$ (SD400 사용)

하중조합	RE-BAR			STEEL			
	작용응력(MPa)		허용응력 (MPa)	작용응력(MPa)		허용응력(MPa)	
	상 연	하 연		상 연	하 연	상 연	하 연
1			160.000	-74.082	70.294	190.000	186.100
1+2+3	-59.328	-53.275	160.000	-126.645	125.984	190.000	186.100
1+2+3+4	-62.107	-56.252	160.000	-129.645	119.428	190.000	186.100
1+2+3+4+5	-52.313	-45.588	160.000	-118.879	145.762	190.000	186.100
1+2+3+4+5+6	-59.978	-52.487	184.000	-101.088	177.234	218.500	214.015
1+2+3+4+5-6	-44.649	-38.689	184.000	-136.670	114.290	218.500	214.015

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음. 허용응력의 참조 (도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-129.645}{190.000} \right)^2 + \left(\frac{41.234}{110.000} \right)^2 \\ &= 0.466 + 0.141 = 0.606 < 1.2 \quad \text{O.K!!!!} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{177.234}{214.015} \right)^2 + \left(\frac{41.234}{110.000} \right)^2 \\ &= 0.686 + 0.141 = 0.826 < 1.2 \quad \text{O.K!!!!} \end{aligned}$$

(10) 판의 최소두께 검토

인장(상부)플랜지 (☞ 도.설.기 3.8.3.1)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K.} \quad (\text{합성형 스테드 설치})$$

압축(하부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \mathbf{0.K!!!}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 11.4 \text{ mm} \leq t = 14 \text{ mm} \quad \mathbf{0.K!!!}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190.0 / 70.294)} = 1.644 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b / (219 \times 1.035) = 13.2 \text{ mm} \leq t = 14 \text{ mm} \quad \mathbf{0.K!!!}$$

$$\text{여기서, } \sqrt{f_{ca}/f_c} = \sqrt{(190.0 / 177.234)} = 1.035 < 1.2 \Rightarrow 1.035$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
+ (크리프응력 변화량) + (건조수축응력변화량) + (온도차응력변화량)의 조합 중에서
가장 불리한 하중 조합에 대하여 검토

① 상부바닥판 REBAR

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vru} = -16.960 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -59.328 - -16.96 = -42.368 \text{ MPa}$$

$$\Sigma f = 1.3 \times -16.96 + 2.15 \times -42.368 + (-2.778) + (9.793) + (-7.664)$$

$$= -113.789 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times -16.96 + 2.15 \times -42.368 + (-7.664)$$

$$= -120.804 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

② 강재주형 상판

$$\text{합성전 사하중 응력} = -74.082 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsu} = -15.026 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -126.645 - -74.082 - -15.026 = -37.537 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-74.082 + -15.026) + 2.15 \times -37.537 + (-3) + (10.766) + (-17.791)$$

$$= -206.569 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times (-74.082 + -15.026) + 2.15 \times -37.537 + (-17.791)$$

$$= -214.335 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

③ 강재주형 하판

$$\text{합성전 사하중 응력} = 70.294 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsl} = 15.920 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 125.984 - 70.294 - 15.92 = 39.770 \text{ MPa}$$

$$\Sigma f = 1.3 \times (70.294 + 15.92) + 2.15 \times 39.77 + (-6.557) + (26.334) + (31.472)$$

$$= 248.834 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 포함시})$$

$$\Sigma f = 1.3 \times (70.294 + 15.92) + 2.15 \times 39.77 + (31.472)$$

$$= 229.056 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \mathbf{0.K!!!} \quad (\text{크리프, 건조수축 제외시})$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	-113.789	400.000	0.K!!!	3.51
	크리프, 건조수축제외시	-120.804	400.000	0.K!!!	3.31
상부플랜지	크리프, 건조수축 포함시	-206.569	315.000	0.K!!!	1.52
	크리프, 건조수축제외시	-214.335	315.000	0.K!!!	1.46
하부플랜지	크리프, 건조수축 포함시	248.834	315.000	0.K!!!	1.26
	크리프, 건조수축제외시	229.056	315.000	0.K!!!	1.37

< 참고 > 합성전 고정하중 : 강재자중 + 콘크리트바닥판지중
합성후 고정하중 : 방호벽 + PAVEMENT자중

(2) 합 성 후

$$\begin{aligned}A_v &= A_s + A_r = 207086 \text{ mm}^2 \\d &= Y_{su} - T_u + T_h + t_{cl} + (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1640.829 \text{ mm} \\d_r &= d \cdot A_s / (A_s + A_r) = 1557.429 \text{ mm} \\d_s &= d - d_r = 83.400 \text{ mm} \\Y_{vu} &= d_r + (T_c - t_{cu} - t_{cl}) \cdot A_{rl}/A_r = 1666.486 \text{ mm} \\Y_{vl} &= d_r - (T_c - t_{cu} - t_{cl}) \cdot A_{ru}/A_r = 1496.486 \text{ mm} \\Y_{vu} &= Y_{vl} - t_{cl} - T_h + T_u = 1476.486 \text{ mm} \\Y_{vl} &= Y_{vu} - (H + T_u + T_l) = -1563.514 \text{ mm} \\I_{rv} &= I_s + A_s \cdot d_s^2 + A_r \cdot d_r^2 = 340915284160 \text{ mm}^4 \\F_v &= b \cdot h_v = ((U_L2 + U_R2 + B2) / 2 + T_w) \cdot (H + (T_u + T_c/n)/2 + T_l/2) = 7631561.3 \text{ mm}^2 \\f_{vru} &= M_{sc} \cdot Y_{vu}/I_{rv} = -14.202 \text{ MPa} \\f_{vrl} &= M_{sc} \cdot Y_{vl}/I_{rv} = -12.753 \text{ MPa} \\f_{vsu} &= M_{sc} \cdot Y_{vu}/I_{rv} = -12.583 \text{ MPa} \\f_{vsl} &= M_{sc} \cdot Y_{vl}/I_{rv} = 13.325 \text{ MPa} \\u &= S_{sc} / A(\text{Web}) + M_{sct} / (2 \cdot F_v \cdot T_w) = 3.424 \text{ MPa}\end{aligned}$$

(3) 활 하 중

$$\begin{aligned}f_{vru} &= M_v \cdot Y_{vu}/I_{rv} = -28.524 \text{ MPa} \\f_{vrl} &= M_v \cdot Y_{vl}/I_{rv} = -25.614 \text{ MPa} \\f_{vsu} &= M_v \cdot Y_{vu}/I_{rv} = -25.272 \text{ MPa} \\f_{vsl} &= M_v \cdot Y_{vl}/I_{rv} = 26.761 \text{ MPa} \\u &= S_v / A(\text{Web}) + M_{vt} / (2 \cdot F_v \cdot T_w) = 11.719 \text{ MPa}\end{aligned}$$

(4) 크 리 이 프

$$\begin{aligned}A_{vc} &= A_s + A_c/n = 350810.000 \text{ mm}^2 \\d_v &= Y_{su} - T_u + T_h + T_c/2 = 1664.886 \text{ mm} \\d_{vc} &= d_v \cdot A_s / (A_c/n + A_s) = 932.841 \text{ mm} \\d_{vs} &= d_v - d_{vc} = 732.045 \text{ mm} \\n_1 &= n \cdot (1 + \phi_1 / 2) = 8 \times (1 + 2.0 / 2) = 16 \\A_{v1} &= A_s + A_c/n_1 = 273685.000 \text{ mm}^2 & \# 2\text{차 부정정력으로 인한 영향 고려} \\d_{c1} &= d_v \cdot A_s / (A_c/n_1 + A_s) = 1195.718 \text{ mm} & K = -0.358 \\d_{s1} &= d_v - d_{c1} = 469.168 \text{ mm} \\I_{cv} &= I_s + I_c/n + A_s \cdot d_{vs}^2 + A_c/n \cdot d_{vc}^2 = 554381940653.3 \text{ mm}^4 \\N_c &= M_{sc} \cdot d_{vc} \cdot A_c / (n \cdot I_{cv}) = -754085 \text{ N} \\P_\phi &= N_c \cdot 2 \cdot \phi_1 / (2 + \phi_1) = -754085 \text{ N} \\M_\phi &= P_\phi \cdot d_{c1} = -901672479 \text{ N} \cdot \text{mm} \\E_{c1} &= E_c / (1 + \phi_1 / 2) = 13351 \text{ MPa} \\f_{vru1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vu}/I_{rv} = -2.063 \text{ MPa} \\f_{vrl1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vl}/I_{rv} = -2.224 \text{ MPa} \\f_{vsu1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vu} / I_{rv} = -2.243 \text{ MPa} \\f_{vsl1} &= P_\phi / A_v + k \cdot M_\phi \cdot Y_{vl} / I_{rv} = -5.122 \text{ MPa}\end{aligned}$$

(5) 건조수축

$$n2 = n \cdot (1 + \phi2 / 2) = 8 \times (1 + 4.0 / 2) = 24$$

$$Av2 = As + Ac/n2 = 247976.667 \text{ mm}^2$$

$$dc2 = dv \cdot As / (Ac/n2 + As) = 1319.681 \text{ mm}$$

$$ds2 = dv - dc2 = 345.205 \text{ mm}$$

$$P2 = Es \cdot \epsilon s \cdot Ac/n2 = 2845913 \text{ N}$$

$$Mv2 = P2 \cdot dc2 = 3755695559 \text{ N} \cdot \text{mm}$$

$$fvru2 = P2/Av + K \cdot Mv2 \cdot Yvru/lrv = 7.170 \text{ MPa}$$

$$fvrl2 = P2/Av + K \cdot Mv2 \cdot Yvrl/lrv = 7.841 \text{ MPa}$$

$$fvsu2 = P2/Av + K \cdot Mv2 \cdot Yvsu/lrv = 7.920 \text{ MPa}$$

$$fvsl2 = P2/Av + K \cdot Mv2 \cdot Yvsl/lrv = 19.909 \text{ MPa}$$

(6) 온도차

$$\epsilon t = \alpha \cdot t = 0.000012 \times 10 = 0.00012$$

$$P1 = Es \cdot \epsilon t \cdot Ac/n = 3794550 \text{ N}$$

$$Mvt = P1 \cdot dvc = 3539712344 \text{ N} \cdot \text{mm}$$

$$Ert = Es \cdot \epsilon t = 24.600 \text{ MPa}$$

$$frut = P1/Av + K \cdot Mvt \cdot Yvru/lrv - Es \cdot \epsilon t = -12.471 \text{ MPa}$$

$$frlt = P1/Av + K \cdot Mvt \cdot Yvrl/lrv - Es \cdot \epsilon t = -11.839 \text{ MPa}$$

$$fsut = P1/Av + K \cdot Mvt \cdot Yvsu/lrv = 12.835 \text{ MPa}$$

$$fslt = P1/Av + K \cdot Mvt \cdot Yvsl/lrv = 24.135 \text{ MPa}$$

(7) 전단 및 비틀림

$$u = (Ss+Ssc+Sv)/Aw + (Mst/(2 \cdot F \cdot Tw) + (Msc+Mvt)/(2 \cdot Fv \cdot Tw)) = 30.677 \text{ MPa} < ua = 110 \text{ MPa} \quad 0.K!!!$$

(8) 조합응력의 검토 (도.설 3.4.2.1)

$$i = 0.65(\phi/n)^2 + 0.13(\phi/n) + 1.0$$

$$= 0.650 \times (0.0 / 5)^2 + 0.130 \times (0.0 / 5) + 1.0 = 1.000$$

$$\therefore \phi = (f_1 - f_2) / f_1 \approx 0$$

여기서, n : 종리브에 의해서 구분되는 Pannel의 수

i : 응력구배계수 ϕ : 응력구배

f_1, f_2 : 보강된 판의 양면의 응력

(단, $f_1 \geq f_2$ 이며 압축응력을 정(+)으로 한다.)

* 인장 (상부)플랜지의 허용응력 (SWS508 사용)

$$fta = 190.0 \text{ MPa}$$

★ 압축 (하부)플랜지의 허용응력 (SWS50B 사용)

$$t_l \geq \frac{b}{24 \cdot i \cdot n} = \frac{2500}{24 \times 1.000 \times 5} = 20.833 \text{ mm}$$

만 경우 : $f_{ca} = 190.0 \text{ MPa}$

$$\frac{b}{24 \cdot i \cdot n} > t_l \geq \frac{b}{49 \cdot i \cdot n} = \frac{2500}{49 \times 1.000 \times 5} = \text{##### mm}$$

만 경우 : $f_{ca} = 190 - 3.9 (b / (t_l \cdot i \cdot n) - 24) = 186.100$

$$\frac{b}{49 \cdot i \cdot n} > t_l \geq \frac{b}{80 \cdot i \cdot n} = \frac{2500}{80 \times 1.000 \times 5} = 6.250 \text{ mm}$$

만 경우 : $f_{ca} = 220000 \times (t_l \cdot i \cdot n) / b = 352.000 \text{ MPa}$

사용 $t_l = 20.0 \text{ mm}$

따라서, $f_{ca} = 186.100 \text{ MPa}$

★ RE-BAR의 허용응력 (≡ 도.설 2.2.2.4, 3.6.1.7)

$f_{ta} = 160.000 \text{ MPa}$ $f_{ca} = 180.000 \text{ MPa}$ (S0400 사용)

하중조합	RE-BAR			STEEL			
	작용응력(MPa)		허용응력	작용응력(MPa)		허용응력(MPa)	
	상 연	하 연		상 연	하 연	상 연	하 연
1			160.000	-64.762	61.450	190.000	186.100
1+2+3	-42.726	-38.367	160.000	-102.617	101.536	190.000	186.100
1+2+3+4	-44.789	-40.592	160.000	-104.860	96.414	190.000	186.100
1+2+3+4+5	-37.619	-32.751	160.000	-96.941	116.323	190.000	186.100
1+2+3+4+5+6	-50.090	-44.590	184.000	-84.105	140.459	218.500	214.015
1+2+3+4+5-6	-25.148	-20.912	184.000	-109.776	92.188	218.500	214.015

주) 압축응력을 정(+), 인장응력을 부(-)로 하였음.

허용응력의 참조 (≡ 도.설 3.9.3.1 참조)

(9) 합성응력의 검토 (≡ 도.설 3.8.2.4)

(상 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{-104.860}{190.000} \right)^2 + \left(\frac{30.677}{110.000} \right)^2 \\ &= 0.305 + 0.078 = 0.382 < 1.2 \quad \mathbf{0.K!!!} \end{aligned}$$

(하 연)

$$\begin{aligned} \left(\frac{f}{f_a} \right)^2 + \left(\frac{u}{u_a} \right)^2 &= \left(\frac{140.459}{214.015} \right)^2 + \left(\frac{30.677}{110.000} \right)^2 \\ &= 0.431 + 0.078 = 0.509 < 1.2 \quad \mathbf{0.K!!!} \end{aligned}$$

(10) 판의 최소두께 검토

인장(상부)플랜지 (☞ 도.설.기 3.8.3.1)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{0.K!!!}$$

$$t_{min} = 10 \text{ mm} \leq t = 20 \text{ mm} \quad \text{0.K. (합성형 스티드 설치)}$$

압축(하부)플랜지 (☞ 도.설.기 3.4.2.2, 3.4.2.3 및 3.9.6)

$$t_{min} = \text{자유돌출폭} / 16 = 100 / 16 = 6.3 \text{ mm} \leq t = 20 \text{ mm} \quad \text{0.K!!!}$$

$$t_{min} = b / (49 \cdot i \cdot n) = 2500 / (49 \times 1.00 \times 5) = 10.2 \text{ mm} \leq t = 20 \text{ mm} \quad \text{0.K!!!}$$

복부판 수평보강재 사용단수 1 단 (☞ 도.설.기 3.8.4)

$$\text{합성전 } t_{min} = b / (219 \times 1.200) = 11.4 \text{ mm} \leq t = 14 \text{ mm} \quad \text{0.K!!!}$$

$$\text{여기서, } \sqrt{(fca/fc)} = \sqrt{(190.0 / 61.450)} = 1.758 > 1.2 \Rightarrow 1.200$$

$$\text{합성후 } t_{min} = b / (219 \times 1.163) = 11.8 \text{ mm} \leq t = 14 \text{ mm} \quad \text{0.K!!!}$$

$$\text{여기서, } \sqrt{(fca/fc)} = \sqrt{(190.0 / 140.459)} = 1.163 < 1.2 \Rightarrow 1.163$$

(11) 항복에 대한 안전도 검사 (☞ 도.설.해(2003) 3.9.3.2)

$\Sigma f = 1.3 \times (\text{합성전 사하중 응력} + \text{합성후 사하중}) + 2.15 \times \text{활하중에 의한 응력(충격포함)}$
 $+ (\text{크리프응력 변화량}) + (\text{건조수축응력 변화량}) + (\text{온도차응력 변화량})$ 의 조합 중에서
 가장 불리한 하중 조합에 대하여 검토

① 상부바닥판 REBAR

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vru} = -14.202 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -42.726 - -14.202 = -28.524 \text{ MPa}$$

$$\Sigma f = 1.3 \times -14.202 + 2.15 \times -28.524 + (-2.063) + (7.17) + (-12.471)$$

$$= -87.153 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times -14.202 + 2.15 \times -28.524 + (-12.471)$$

$$= -92.260 \text{ MPa} < f_y = 400.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 제외시)}$$

② 감재주형 상판

$$\text{합성전 사하중 응력} = -64.762 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsu} = -12.583 \text{ MPa}$$

$$\text{합성후 활하중 응력} = -102.617 - -64.762 - -12.583 = -25.272 \text{ MPa}$$

$$\Sigma f = 1.3 \times (-64.762 + -12.583) + 2.15 \times -25.272 + (-2.243) + (7.92) + (-12.835)$$

$$= -162.042 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (-64.762 + -12.583) + 2.15 \times -25.272 + (-12.835)$$

$$= -167.718 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 제외시)}$$

③ 감재주형 하판

$$\text{합성전 사하중 응력} = 61.450 \text{ MPa}$$

$$\text{합성후 사하중 응력} = M_{sc} / I_{rv} \times Y_{vsl} = 13.325 \text{ MPa}$$

$$\text{합성후 활하중 응력} = 101.536 - 61.45 - 13.325 = 26.762 \text{ MPa}$$

$$\Sigma f = 1.3 \times (61.45 + 13.325) + 2.15 \times 26.762 + (-5.122) + (19.909) + (24.135)$$

$$= 193.667 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 포함시)}$$

$$\Sigma f = 1.3 \times (61.45 + 13.325) + 2.15 \times 26.762 + (24.135)$$

$$= 178.880 \text{ MPa} < f_y = 315.0 \text{ MPa} \quad \text{0.K!!! (크리프, 건조수축 제외시)}$$

- 항복에 대한 안전도 검사 결과 집계

구분		작용응력	항복응력	검토결과	
바닥판 콘크리트	크리프, 건조수축 포함시	-87.153	400.000	0.K!!!	4.58
	크리프, 건조수축제외시	-92.260	400.000	0.K!!!	4.33
상부플랜지	크리프, 건조수축 포함시	-162.042	315.000	0.K!!!	1.94
	크리프, 건조수축제외시	-167.718	315.000	0.K!!!	1.87
하부플랜지	크리프, 건조수축 포함시	193.667	315.000	0.K!!!	1.62
	크리프, 건조수축제외시	178.880	315.000	0.K!!!	1.76