

BiCon 상부 구조계산서

교량영식	BiCon
교 량 명	용두천교
설계등급	1등급
거더전장	44.900 M
교량폭	24.470 M
거더높이	2.100 M

2013년 3월

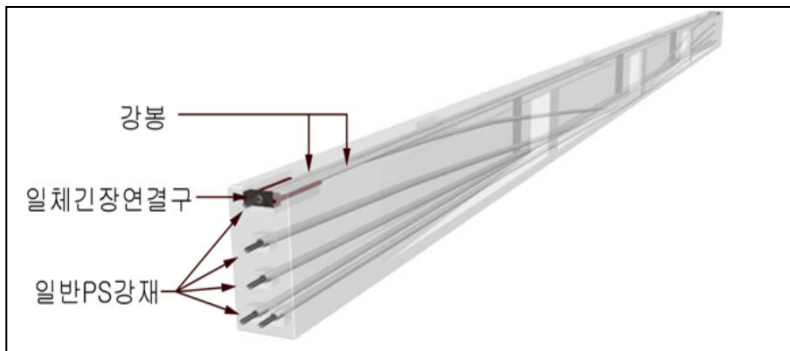
1. 설 계 개 요

1.1 공법개요

역T형의 고강도 콘크리트 단면 상연에 강봉을 삽입하여 PS강선 긴장시 발생하는 압축력을 강봉이 부담하고 콘크리트 단면에는 대편심 휨모멘트를 발생시킴으로써, 거더 상연응력의 과다 누적을 피하면서 저형고화할 수 있도록 개선된 프리스트레스트 콘크리트 공법이다.

1.2 단면구성

Bicon은 고강도 콘크리트를 주재료로 하여 강봉, 강선을 배치하여 효율적인 단면구성이 되도록 하였다. 상연에 발생하는 응력을 줄이기 위해 일체긴장연결구를 사용하여 강선 긴장시 강봉에 인장력이 도입되는 방식을 사용하여, 대편심 휨모멘트가 동시에 도입되도록 강봉 및 강선을 구성하였으며, 하연에 발생하는 응력은 일반 PS 강재를 사용하여 프리스트레스를 도입하여 저항하도록 단면을 구성하였다.



< Bicon 단면구성 >

1.3 설계법 및 사용 프로그램

(1) 적용설계법

- 거더 설계 : 허용응력 설계법
- 하중 횡분배 : Guyon-Massonnet Method

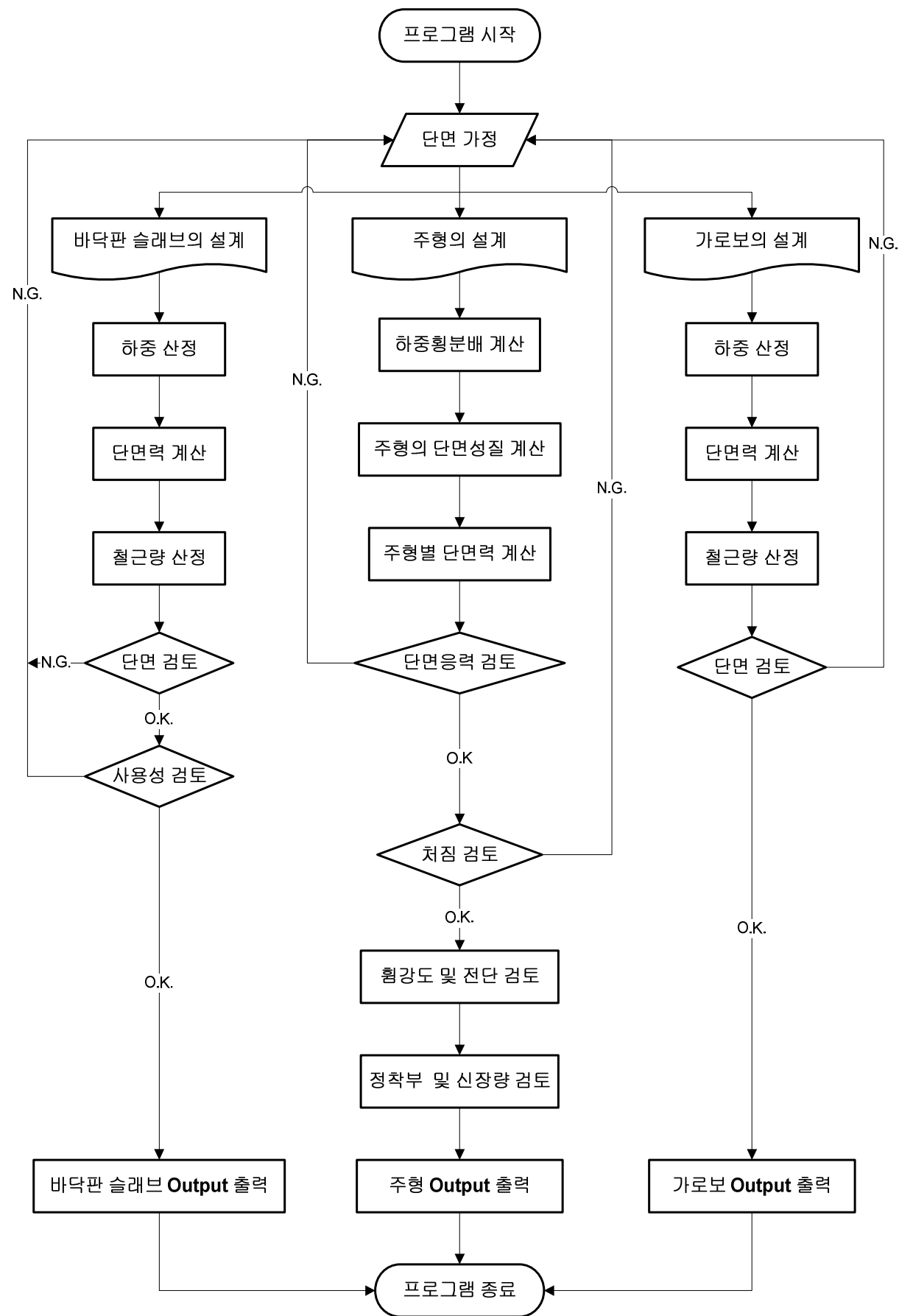
(2) 사용프로그램

- FEM 해석 : SAP2000 (Computers and Structures, Inc.)

1.4 참고문헌

- 도로교 설계기준 (건설교통부), 2010.
- 도로교 설계 실무편람 (한국도로공사), 1996.
- 콘크리트 구조설계기준 (한국콘크리트학회), 2007.
- 횡분배 실용계산법 (원기술), 1998.
- Concrete Structures A. Ghali, R. Ravre and M. Elbadry
- Time Effects in Concrete Structure R.I.Gilbert, 1988.
- 콘크리트 구조물의 응력과 변형 이종득 역, 일광.
- 프리스트레스트 콘크리트 신현묵 저, 동명사

1.5 설계흐름도



2. 설 계 조 건

- 교 량 명 : 용두천교
- 교량형식 : Bicon 교
- 교량등급 : 1등급

2.1 기본제원

- (1) 슬래브 전장 : 45.000 m
- (2) 거 더 전 장 : 44.900 m
- (3) 설 계 지 간 : 44.000 m
- (4) 교 량 폭 원 : 24.470 m
- (5) 횡 단 면 도 : 슬래브 일반도 참조
- (6) 종 단 면 도 : 슬래브 일반도 참조

2.2 주요재료

2.2.1 바닥판

- (1) 콘크리트 $F_{cks} = 27 \text{ MPa}$
 $E_{cks} = 8,500 \times \sqrt{(f_{ck}+8)}^{1/3} = 27804 \text{ MPa}$
- (2) 철근(SD400) $F_{yb} = 400 \text{ MPa}$
 $E_{sb} = 2.0 \times 10^5 \text{ MPa}$

2.2.2 Bicon 거더

- (1) 콘크리트(사용 하중 시)
 - 설계기준강도 : $F_{ck} = 40 \text{ MPa}$
 - 탄성계수 : $E_{cks} = 8,500 \times \sqrt{(f_{ck}+8)}^{1/3} = 30891 \text{ MPa}$
- (2) 콘크리트(PS강재 긴장 시)
 - 설계기준강도 : $F_{ci} = 0.8 \times f_{ck} = 32 \text{ MPa}$
 - 탄성계수 : $E_{ci} = 8,500 \times \sqrt{(f_{ck}+8)}^{1/3} = 29070 \text{ MPa}$
- (3) 철근(SD300)
 - 항복강도 : $F_{by} = 300 \text{ MPa}$
 - 탄성계수 : $E_{bs} = 2.0 \times 10^5 \text{ MPa}$
- (4) PS 강연선(KS D 7002 SWPC 7B, 저릴렉세이션 강재)
 - 직경 : $D_{pt} = 15.2 \text{ mm}$
 - 단면적 : $A_{pt} = 138.7 \text{ mm}^2$
 - 극한강도 : $F_{put} = 1900 \text{ MPa}$
 - 항복강도 : $F_{pyt} = 1600 \text{ MPa}$
 - 탄성계수 : $E_{pt} = 2.0 \times 10^5 \text{ MPa}$
- (5) PS 강봉(KS D 3505, 저릴렉세이션 강재)
 - 직경 : $D_{pc} = 40 \text{ mm}$
 - 단면적 : $A_{pc} = 1257 \text{ mm}^2$
 - 극한강도 : $F_{puc} = 1050 \text{ MPa}$
 - 항복강도 : $F_{pyc} = 950 \text{ MPa}$
 - 탄성계수 : $E_{pc} = 2.00 \times 10^5 \text{ MPa}$

(6) 쉬스규격

구분	단위	강연선						강봉
PS강재 개수	개, mm	7	10	11	13	16	19	40
쉬스관 내경	mm	65	75	75	85	85	100	50
쉬스관 외경	mm	70	80	80	90	90	105	55
곡률마찰계수(μ)	/rad	0.25	0.25	0.25	0.25	0.25	0.25	-
파상마찰계수(κ)	/m	0.005	0.005	0.005	0.005	0.005	0.005	0.008

2.2.3 탄성계수비

- (1) 거더콘크리트와 PS 강봉의 탄성계수비(nc) = $E_{pc} / E_{ck} = 200000 / 30891 = 6.474$
- (2) 거더콘크리트와 PS 강연선의 탄성계수비(nt) = $E_{pt} / E_{ck} = 200000 / 30891 = 6.474$
- (3) 거더콘크리트와 바닥판콘크리트의 탄성계수비(ns) = $E_{cks} / E_{ck} = 27804 / 30891 = 0.900$

2.3 허용응력

2.3.1 바닥판 콘크리트

- 허용압축응력 : $0.4 \times f_{cks} = 10.8 \text{ MPa}$
- 허용인장응력 : $0.5 \sqrt{F_{ck}} = 2.60 \text{ MPa}$ (부착된 철근을 갖는 부재)

2.3.2 거더 콘크리트

(1) 크리프와 건조수축에 의한 손실이 일어나기 전의 일시적 응력

- 허용압축응력 : $0.60 \times f_{ci} = 19.2 \text{ MPa}$
- 허용인장응력 : $1.41 \text{ MPa} \quad 0.25 \times \sqrt{f_{ci}}$

(2) 모든 손실이 일어난 후 사용하중 상태에서의 응력

- 허용압축응력 : $0.45 \times f_{ck} = 18.0 \text{ MPa}$
- 허용인장응력 : $0.5 \times \sqrt{f_{ck}} = 3.16 \text{ MPa}$

(3) 균열응력 : $0.63 \times \sqrt{f_{ck}} = 3.98 \text{ MPa}$

(4) 정착부의 지압응력

- 긴장재 정착 직후 : $f_{cr} = 0.7 \times f_{ci} \times \sqrt{(A_b'/A_b - 0.2)} \leq 1.10 \times f_{ci}$
- 프리스트레스 손실 발생 후 : $f_{cr} = 0.5 \times f_{ck} \times \sqrt{(A_b'/A_b)} \leq 0.90 \times f_{ck}$

2.3.3 PS 강연선

- (1) 긴장시 최대응력 : $\text{MIN}(0.94 \times f_{pyt}, 0.8 \times f_{put}) = 1504 \text{ MPa}$
- (2) 정착 후 정착부에서의 허용응력 : $\text{MIN}(0.74 \times f_{put}, 0.82 \times f_{pyt}) = 1312 \text{ MPa}$
- (3) 사용하중 상태에서의 허용응력 : $\text{MIN}(0.74 \times f_{put}, 0.82 \times f_{pyt}) = 1312 \text{ MPa}$

2.3.4 PS 강봉

- (1) 긴장시 최대응력 : $\text{MIN}(0.94 \times f_{pyc}, 0.8 \times f_{puc}) = 840 \text{ MPa}$
- (2) 정착 후 정착부에서의 허용응력 : $\text{MIN}(0.74 \times f_{put}, 0.82 \times f_{pyt}) = 777 \text{ MPa}$
- (3) 사용하중 상태에서의 허용응력 : $\text{MIN}(0.74 \times f_{put}, 0.82 \times f_{pyt}) = 777 \text{ MPa}$

2.4 설계하중

2.4.1 고정하중(단위중량)

- (1) 철근콘크리트 : 25000 N/m^3
- (2) 프리스트레스 콘크리트 : 25000 N/m^3
- (3) PS강연선 : 11.01 N/m
- (4) PS강봉 : 102.1 N/m
- (5) 무근콘크리트 포장 : 23500 N/m^3

2.4.2 활하중

- (1) 적용하중 : 1등급
- (2) 충격계수

$$i = 15 / (40 + L) = 15 / (40 + 44) = 0.179 \leq 0.300$$

- (3) 군중하중 : 바닥판 설계 시 : 5000 N/m^2
거더 설계 시 : 3500 N/m^2

2.5 활하중에 대한 허용처짐

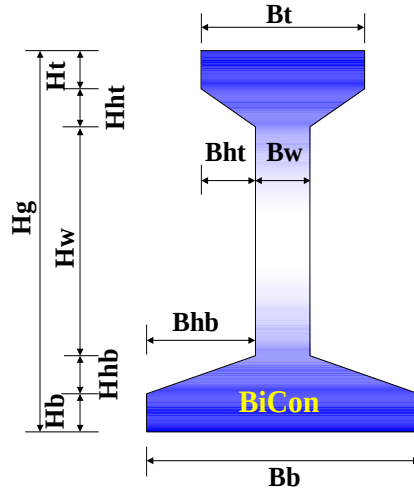
$$L / 800 = 0.0550 \text{ mm}$$

3. 단 면 가 정

3.1 단면제원

(1) 바닥판 두께(sh) : 240 mm

(2) 거더 단면



BiCon 단면제원

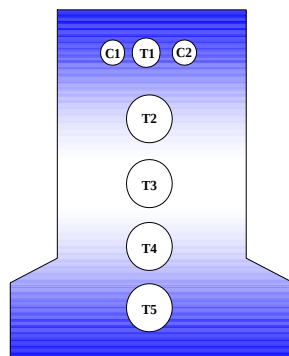
Hg	2100 mm
Ht	200 mm
Hb	300 mm
Hht	150 mm
Hhb	200 mm
Hw	1250 mm
Bt	800 mm
Bb	1100 mm
Bw	200 mm
Bht	300 mm
Bhb	450 mm

(3) 중간가로보수 : 1 EA

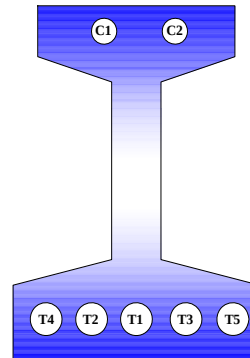
(4) 단부블록크기 : 600 mm

3.2 PS 강연선 및 PS강봉 배치

(1) 단면 배치



< 단 부 >



< 중 앙 부 >

단위 : mm

		PS 강봉		PS 강연선				
		C1	C2	T1	T2	T3	T4	T5
직경,가닥수		40mm	40mm	7EA	15EA	15EA	15EA	15EA
쉬스관외경		55mm	55mm	70mm	90mm	90mm	90mm	90mm
초기긴장력		-675kN	-675kN	1350kN	3060kN	3060kN	3060kN	3060kN
단부 좌표	Y	-105mm	105mm	0mm	0mm	0mm	0mm	0mm
	Z	1975mm	1975mm	1975mm	1600mm	1150mm	700mm	250mm
중앙부 좌 표	Y	-105mm	105mm	0mm	-150mm	150mm	-300mm	300mm
	Z	1975mm	1975mm	115mm	125mm	125mm	125mm	125mm

※ 좌표의 기준 원점은 거더의 하단 중심점.

4. 바닥판의 설계

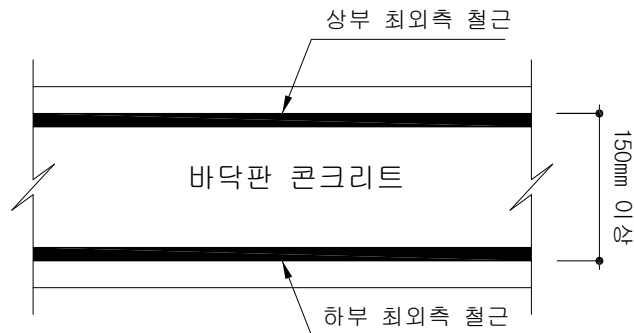
4.1 경험적 설계법에 의한 바닥판 슬래브계산

4.1.1 설계조건

- (1) 지지부재들이 3개이상의 강재 주거더 또는 콘크리트 지지보와 완전합성으로 거동하고 바닥판의 지간방향이 차량진행방향에 직각인 경우의 철근콘크리트 바닥판에만 적용할 수 있다.
- (2) 캔틸레버 바닥판에 적용할 수 없다.
- (3) 콘크리트가 현장타설되고 습윤양생되어야 한다.
- (4) 거더 플랜지부의 현치와 같이 국부적으로 두껍게한 곳을 제외한 상태에서 전체적으로 바닥판의 두께가 일정해야 한다.
- (5) 바닥판 두께에 대한 유효지간의 비가 6이상 15이하인 경우 적용한다.

$$6 \leq 1.950 \text{ m} / 0.240 \text{ m} = 8.125 \leq 15 \quad \text{-----} \quad \text{O.K}$$

- (6) 바닥판의 상부와 하부에 배근된 철근의 외측면 사이의 두께가 150mm이상인 경우 적용한다.



$$240 - (60 + 40) + (16/2 + 16/2) = 156 \text{ mm} \geq 150 \text{ mm} \quad \text{-----} \quad \text{O.K}$$

- (7) 유효지간이 표준차선평(3.6m) 이하인 경우 적용한다.

$$1.950 \text{ m} \leq 3.600 \text{ m} \quad \text{-----} \quad \text{O.K}$$

- (8) 바닥판의 흙집, 마모면, 보호피복 두께층을 제외한 바닥판의 최소두께가 240mm이상인 경우 적용한다.

- (9) 콘크리트의 28일 압축강도가 27MPa 이상인 경우 적용한다.

- (10) 캔틸레버부의 길이가 내측바닥판 두께의 5배 이상이거나, 캔틸레버부의 길이가 내측 바닥판 두께의 3배 이상이고 구조적으로 연속적인 콘크리트 방호책과 합성된 경우 적용한다

▶ 중분대 또는 방호벽, 보도 등이 있을 경우

$$1.366 \text{ m} \text{ (좌측캔틸레버 길이)} \geq 0.24 \times 3 = 0.720 \quad \text{-----} \quad \text{O.K}$$

$$1.239 \text{ m} \text{ (우측캔틸레버 길이)} \geq 0.24 \times 3 = 0.720 \quad \text{-----} \quad \text{O.K}$$

※ 경험적 설계법 적용구간

	캔틸레버구간	캔틸레버 인접 내측바닥판	중앙부 내측바닥판	비고
좌측	강도설계법	경험적 설계법 적용	경험적 설계법 적용	
우측	강도설계법	경험적 설계법 적용	경험적 설계법 적용	

4.1.2 철근 배근

(1) 지간방향 (주철근)

상부 최소철근량 : 콘크리트 바닥판 단면의 0.3%이상

하부 최소철근량 : 콘크리트 바닥판 단면의 0.4%이상

(2) 지간의 직각방향 (배력철근)

상부 최소철근량 : 콘크리트 바닥판 단면의 0.3%이상

하부 최소철근량 : 콘크리트 바닥판 단면의 0.3%이상

(3) 현장타설 되는 콘크리트 바닥판에는 4개층의 철근을 배근하되 콘크리트 피복두께 요구조건에 의해 허용되는 한도에서 바깥 표면에 가까이 배근하며, 유효지간방향으로 배근되는 철근을 가장 바깥쪽 층에 배근한다.

4.1.3 사용철근량

(1) 바닥판 슬래브 단면 : $1000 \times 240 = 240000 \text{ mm}^2$

(2) 주철근

상부 철근량

$$A_{s_{req}} = 240000 \times 0.300\% = 720.000 \text{ mm}^2$$

$$A_{s_{use}} = \text{H 16} @ 200 = 993.000 \text{ mm}^2$$

$$\Sigma = 993.000 \text{ mm}^2 \quad (N = 5) \quad \text{-----} \quad \mathbf{0.K}$$

하부 철근량

$$A_{s_{req}} = 240000 \times 0.400\% = 960.000 \text{ mm}^2$$

$$A_{s_{use}} = \text{H 16} @ 200 = 993.000 \text{ mm}^2$$

$$\Sigma = 993.000 \text{ mm}^2 \quad (N = 5) \quad \text{-----} \quad \mathbf{0.K}$$

(3) 배력철근

상부 철근량

$$A_{s_{req}} = 240000 \times 0.300\% = 720.000 \text{ mm}^2$$

$$A_{s_{use}} = \text{H 16} @ 250 = 794.400 \text{ mm}^2$$

$$\Sigma = 794.400 \text{ mm}^2 \quad (N = 4) \quad \text{-----} \quad \mathbf{0.K}$$

하부 철근량

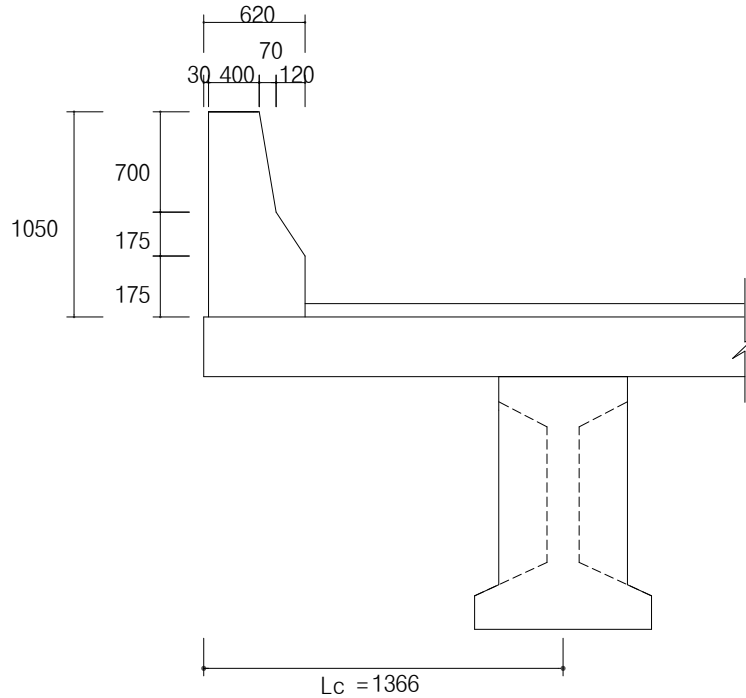
$$A_{s_{req}} = 240000 \times 0.300\% = 720.000 \text{ mm}^2$$

$$A_{s_{use}} = \text{H 16} @ 250 = 794.400 \text{ mm}^2$$

$$\Sigma = 794.400 \text{ mm}^2 \quad (N = 4) \quad \text{-----} \quad \mathbf{0.K}$$

4.2 캔틸레버 부(좌측)

4.2.1 단면치수



4.2.2 바닥판의 두께 검토

(1) 활하중에 대한 지간 (도로교설계기준, 2010, p.4-151)

$$L = 0.046 \text{ m}$$

(2) 최소두께 (도로교설계기준, 2010, P.4-153)

$$L \leq 0.25 \text{ m}$$

$$T_{min} = 280 \times L + 180 = 192.88 \text{ mm or } 220 \text{ mm}$$

(3) 두께검토

$$T_{can} = 240.000 \text{ mm} > T_{min} = 220.000 \text{ mm} \text{ ----- } \mathbf{O.K}$$

4.2.3 설계하중에 의한 단면력

(1) 고정하중에 의한 휨모멘트

구 분	면적 (m ²)	단위중량 (kN/m ³)	하중 (kN)	작용거리 (m)	휨모멘트 (kN · m)
방호벽	0.501	25.000	12.525	0.693	8.680
바닥판	0.232	25.000	5.800	0.483	2.801
포 장	0.017	23.500	0.407	0.173	0.070
방음판			2.000	0.736	1.472
합 계			20.732		13.023

(2) 활하중에 의한 휨모멘트(도로교설계기준, 2010, p.3-70) - 주철근이 차량진행방향과 직각인 경우

1) 활하중 : $P_r = 96 \text{ kN}$

2) 유효하중 분포폭

$$E = 1 \times X + 1.14 = 1.177 \text{ m}$$

여기서, X는 하중점에서 지지점까지의 거리(m)

3) 충격계수

$$i = 15 / (40 + L) = 0.375 > 0.300 \therefore i = 0.300$$

여기서, L은 캔틸레버부 지간(m)

4) 충격을 포함한 차량하중에 의한 휨모멘트

$$\begin{aligned} ML(i) &= (P_r / E) \cdot X \cdot (1 + i) \\ &= (96.000 / 1.177) \cdot 0.046 \cdot (1 + 0.300) = 4.878 \text{ kN} \cdot \text{m} \end{aligned}$$

(3) 충돌하중에 의한 휨모멘트

1) 작용위치 = 1.0 m

$$H = (V / 60)^2 \times 7500 + 2500 \text{ (N/m)}$$

$$(100 / 60)^2 \times 7500 + 2500 \text{ (N/m)} = 23.333 \text{ kN/m}$$

$$M_{co1} = 23.333 \times 1.0 = 23.333 \text{ kN} \cdot \text{m}$$

2) 작용높이 = 1.170 m (방호벽 상단)

$$H = 10.0 \text{ kN/m}$$

$$M_{co2} = 10.0 \times 1.170 = 11.700 \text{ kN} \cdot \text{m}$$

$$\therefore M_{co} = \max(M_{co1}, M_{co2}) = 23.333 \text{ kN} \cdot \text{m}$$

(4) 풍하중에 의한 휨모멘트 (도로교설계기준, 2010, p.2-12)

각 형 부 재	풍상측 부재(MPa)	재하위치(mm)	휨모멘트(kN · m)
활하중 재하시	0.0015	1500	6.863
활하중 비재하시	0.0030	1670	15.281

(5) 원심하중에 의한 휨모멘트

보의수	단일지간	복수지간
2	2°	3°
3 또는 4	3°	4°
5 이상	4°	5°

< 개단면 상부구조에서 곡률을 무시할 수 있는 한계 중심각 >

본 교량은 $R = \infty \text{m}$ 이며 중심각이 0.003°로서 직교로 설계한다.

(5) 휨모멘트 종합

하중 구분			휨모멘트	비 고
1	고정하중	Md	13.023	
2	활하중	MI	4.878	
3	풍하중	Mw	6.863	활하중 재하시
			15.281	활하중 비재하시
4	원심하중	Mc _f	0.000	
5	충돌하중	Mco	23.333	

(6) 하중조합

① 계수하중 - 단면 검토시

Load Case	고정하중	활 하 중	풍하중	원심하중	충돌하중	비 고
Case 1	1.30	2.15		1.30		
Case 2	1.30		1.30			
Case 3	1.30	1.30	0.65	1.30		
Case 4	1.30	1.30		1.30		
Case 5	1.25	1.25	0.625	1.25		
Case 6	1.30	1.30		1.30	1.30	
Case 7	1.20		1.20		1.20	

② 사용하중 - 사용성 검토시

Load Case	고정하중	활 하 중	풍하중	원심하중	충돌하중	비 고
Case 1	1.00	1.00		1.00		
Case 2	1.00		1.00			
Case 3	1.00	1.00	1.00	1.00		
Case 4	1.00	1.00		1.00		
Case 5	1.00	1.00	1.000	1.00		
Case 6	1.00	1.00		1.00	1.00	
Case 7	1.00		1.00		1.00	

③ 하중조합 결과

Load Case	계 수 하 중 M (kN · m)	사 용 하 중 M (kN · m)	비 고
Case 1	27.418	17.901	
Case 2	36.795	28.304	
Case 3	27.732	24.764	
Case 4	23.272	17.901	
Case 5	26.666	24.764	
Case 6	53.605	41.234	
Case 7	61.964	51.637	

④ 적용하중

구 분	M (kN · m)	비 고
계 수 하 중	61.964	
사 용 하 중	51.637	

4.2.4 철근량 산정

(1) 설계조건

- 1) 설계휨모멘트 : $M_u = 61963800.0 \text{ (N} \cdot \text{mm)}$
 2) 단면치수 : $H = 240.00 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 : $d = 180.00 \text{ (mm)}$, $d' = 60.0 \text{ (mm)}$
 3) 재료의 성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400 \text{ MPa}$
 4) 강도감소계수 : $\phi_f = 0.85$, $k_1 = 0.85$

* 강도감소계수(ϕ) 산정

$$T = A_s \times f_y = 1626.500 \times 400.000 = 650600.000$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 1000.000 = 22950.000 \times a$$

$$T = C \text{ 이므로, } a = 28.349 \text{ mm , } c = 28.349 / \beta_1$$

$$= 28.349 / 0.85 = 24.096 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 400.000 / 200000.000 = 0.002$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (180.000 - 24.096) / 24.096$$

$$= 0.0194$$

$\epsilon_t \geq 0.005$ 이므로 인장지배단면이며, $\phi_f = 0.85$ 를 적용한다.

(2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s \text{ (mm}^2\text{)}$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a / 2)$$

$$-2.963 A_s^2 + 61200 A_s - 61963800.0 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 1067.670 \text{ (mm}^2\text{)}$$

$$\text{단면철근비 : } P = A_s / (b \times d) = 0.0059$$

$$\text{최대철근비 : } P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck} / f_y) \times (600 / (600 + f_y)) = 0.0209$$

$$\text{최소철근비 : } P_{\min} = 1.4 / f_y = 0.0035$$

$$\textcircled{1} A_s(\text{req}) = 1067.670$$

$$\textcircled{2} A_s(\text{min}) = 630.000$$

$$\textcircled{3} 4/3 \times A_s = 1423.560$$

$\therefore A_s = 1067.67 \text{ mm}^2$ 이상 사용

(3) 사용 철근량

$$\textcircled{1} \text{ H 16 @ 200 } = 993.000$$

$$\textcircled{2} \text{ H 13 @ 200 } = 633.500$$

$$\Sigma = 1626.500 \text{ mm}^2 \quad (N = 10) \quad \text{----- 0.K}$$

(4) 설계휨강도

$$\phi_f \cdot M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 91.703 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 28.349 \text{ mm}$$

$$\therefore \phi_f \cdot M_n = 91.703 \text{ kN} \cdot \text{m} > M_u = 61.964 \text{ kN} \cdot \text{m} \quad \text{----- 0.K}$$

4.2.5 사용성 검토

(1) 처짐 검토 (콘크리트구조설계기준 · 해설, 2007, p.75)

1) 처짐검토를 필요로 하지 않는 최소두께 (켄틸레버)

$$T_{min} = L / 10 = 0.966 \times 1000 / 10 = 96.6 \text{ mm}$$

$$T_{can} (240\text{mm}) > T_{min} (96.6\text{mm}) \text{ ----- 처짐검토 불필요}$$

(2) 균열 검토 (콘크리트구조설계기준 · 해설, 2007, p.495)

1) 사용하중에 대한 철근의 인장응력 최대값

M_{max} : 사용하중하에서 최대하중을 유발하는 하중조합 사용(도로교설계기준, 2010, p.4-96)

$$M_{max} = M_{net} = 51.637 \text{ kN} \cdot \text{m}$$

$$n = E_s / E_c = 8$$

$$p_{use} = A_{s_use} / b \cdot d = 0.00904$$

$$k = -n \cdot p + \sqrt{\{(n \cdot p)^2 + 2 \cdot n \cdot p\}} = 0.315$$

$$j = 1 - (k / 3) = 0.895$$

$$F_{smax} = M_{max} / (p \cdot j \cdot b \cdot d^2) = 196.979 \text{ MPa}$$

$$F_{smax} (=196.979 \text{ MPa}) < 0.6F_y (=240 \text{ MPa}) \text{ ----- 0.K}$$

2) 철근의 최대 중심간격

$$C_c = d' - H_n / 2 = 60.00 - 116 / 2 = 52.00 \text{ mm}$$

여기서 C_c : 인장철근이나 긴장재의 표면과 콘크리트 표면사이의 두께(mm)

$$S_{min} : 375 \times (210 / F_{smax}) - 2.5 C_c$$

$$= 375 \times (210 / 196.98) - 2.5 \times 52.00 = 269.789 \text{ mm}$$

$$300 \times (210 / F_{smax}) = 300 \times (210 / 196.98) = 319.831 \text{ mm}$$

S_a 는 작은 값인 269.789 mm 를 적용

$$S = 100 \text{ mm} \leq S_a (= 269.789 \text{ mm}) \text{ ----- 0.K}$$

(3) 피로 검토 (콘크리트구조설계기준 · 해설, 2007, p.82)

▶ SD40 이형철근의 경우 피로를 고려하지 않아도 되는 응력 범위 : 150 MPa

$$M_I = 4.878 \text{ kN} \cdot \text{m}$$

$$f_y = M_I / (p \cdot j \cdot b \cdot d^2) = 18.609 \text{ MPa} < 150 \text{ MPa} \text{ ----- 검토 불필요}$$

4.2.6 배력철근량 산정 (도로교설계기준, 2010, p.4-160 ; 콘크리트구조설계기준 해설 2007, p.109)

(1) 주철근에 대한 백분율로 산정한 배력철근량

(주철근이 차량진행방향에 직각인 경우)

$$\min (120/\sqrt{L}, 67\%) = 67 \%$$

$$Ar_{req} = As \times 0.67 = 715.339 \text{ mm}^2$$

(2) 온도 및 건조수축에 대한 철근량

$$At_{req} = 0.002 \times b \times d = 360.000 \text{ mm}^2$$

(3) 사용 배력철근량

$$\max (Ar_{req}, At_{req}) = 715.339 \text{ mm}^2$$

$$H \text{ 16 @ 250 } = 794.400 \text{ mm}^2 > 715.339 \text{ mm}^2 \text{ ----- 0.K}$$

4.2.7 캔틸레버 단부검토

(1) 단면치수

1) 휨모멘트 종합

하중 구분			휨모멘트	비 고
1	고정하중	Md	13.023	
2	활하중	MI	4.878	
3	충돌하중	Mco	23.333	
4	풍하중	Mw	6.863	

2) 하중조합

Load Case	고정하중	활 하 중	충돌하중	풍 하 중	하중조합	비 고
Case 1	1.3	4.30			37.907	
Case 2	1.3		1.3		47.263	
Case 3	1.3	2.6		0.65	34.074	
Case 4	1.3	2.6	1.3		59.946	
Case 5	1.2		1.2	1.2	51.862	
적 용					59.946	

(2) 철근량 산정

1) 설계조건

- ① 설계휨모멘트 : $M_u = 59946416.6 \text{ (N} \cdot \text{mm)}$
② 단면치수 : $H = 240.00 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 : $d = 180.00 \text{ (mm)}$, $d' = 60.0 \text{ (mm)}$
③ 재료의성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400 \text{ MPa}$
④ 강도감소계수 : $\phi_f = 0.85$, $k_1 = 0.85$

* 강도감소계수(ϕ) 산정

$$T = A_s \times f_y = 2425.500 \times 400.000 = 970200.000$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 1000.000 = 22950.000 \times a$$

$$T = C \text{ 이므로, } a = 42.275 \text{ mm} , c = 42.275 / \beta_1$$

$$= 42.275 / 0.85 = 35.933 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 400.000 / 200000.000 = 0.002$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (180.000 - 35.933) / 35.933 \\ = 0.0120$$

$\epsilon_t \geq 0.005$ 이므로 인장지배단면이며, $\phi_f = 0.85$ 를 적용한다.

2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a / 2)$$

$$-2.963 A_s^2 + 61200 A_s - 59946416.6 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 1030.978 \text{ (mm}^2\text{)}$$

$$\text{단면철근비 : } P = A_s / (b \times d) = 0.0057$$

$$\text{최대철근비 : } P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck} / f_y) \times (600 / (600 + f_y)) = 0.0209$$

$$\text{최소철근비 : } P_{\min} = 1.4 / f_y = 0.0035$$

① $A_s(\text{req})$	=	1030.978	} $\therefore A_s = 2135.34 \text{ mm}^2$ 이상 사용
② $A_s(\text{min})$	=	630.000	
③ $4/3 \times A_s$	=	1374.637	
④ 일반캔틸레버부 필요철근의 2배	=	2135.340	

3) 사용 철근량

$$\textcircled{1} \text{ H 16 @ 200} = 993.000$$

$$\textcircled{2} \text{ H 19 @ 200} = 1432.500$$

$$\Sigma = 2425.500 \text{ mm}^2 \quad (N = 10) \quad \text{----- 0.K}$$

4) 설계휨강도

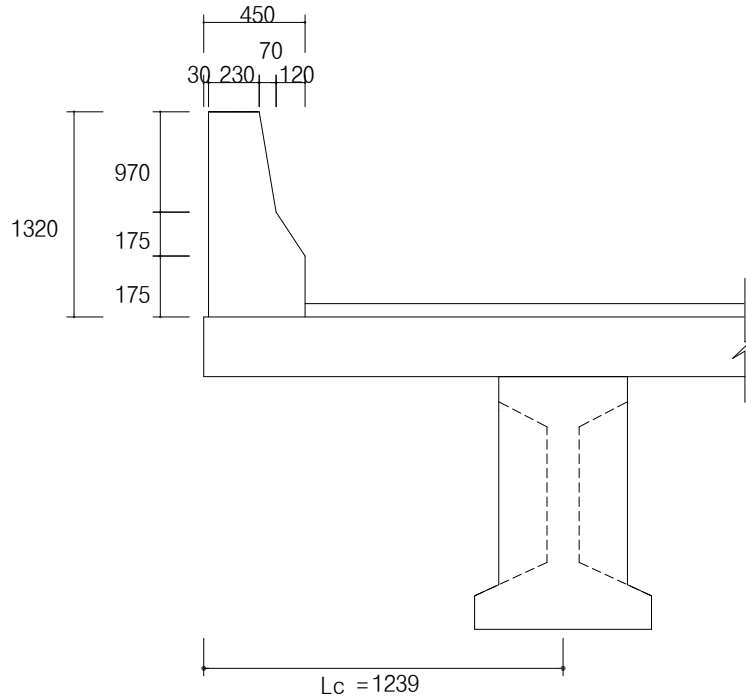
$$\phi_f \cdot M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 131.009 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 42.275 \text{ mm}$$

$$\therefore \phi_f \cdot M_n = 131.009 \text{ kN} \cdot \text{m} > M_u = 59.946 \text{ kN} \cdot \text{m} \quad \text{----- 0.K}$$

4.3 캔틸레버 부(우측)

4.3.1 단면치수



4.3.2 바닥판의 두께 검토

(1) 활하중에 대한 지간 (도로교설계기준, 2010, p.4-151)

$$L = 0.089 \text{ m}$$

(2) 최소두께 (도로교설계기준, 2010, P.4-153)

$$L \leq 0.25 \text{ m}$$

$$T_{min} = 280 \times L + 180 = 204.92 \text{ mm or } 220 \text{ mm}$$

(3) 두께검토

$$T_{can} = 240.000 \text{ mm} > T_{min} = 220.000 \text{ mm} \text{ ----- } \mathbf{O.K}$$

4.3.3 설계하중에 의한 단면력

(1) 고정하중에 의한 휨모멘트

구 분	면적 (m ²)	단위중량 (kN/m ³)	하중 (kN)	작용거리 (m)	휨모멘트 (kN · m)
방호벽	0.394	25.000	9.850	0.654	6.442
바닥판	0.201	25.000	5.025	0.420	2.108
포 장	0.019	23.500	0.457	0.195	0.089
방음판			0.000	0.694	0.000
합 계			15.332		8.639

(2) 활하중에 의한 휨모멘트(도로교설계기준, 2010, p.3-70) - 주철근이 차량진행방향과 직각인 경우

1) 활하중 : $P_r = 96 \text{ kN}$

2) 유효하중 분포폭

$$E = 1 \times X + 1.14 = 1.211 \text{ m}$$

여기서, X는 하중점에서 지지점까지의 거리(m)

3) 충격계수

$$i = 15 / (40 + L) = 0.374 > 0.300 \therefore i = 0.300$$

여기서, L은 캔틸레버부 지간(m)

4) 충격을 포함한 차량하중에 의한 휨모멘트

$$\begin{aligned} ML(i) &= (P_r / E) \cdot X \cdot (1 + i) \\ &= (96.000 / 1.211) \cdot 0.089 \cdot (1 + 0.300) = 9.170 \text{ kN} \cdot \text{m} \end{aligned}$$

(3) 충돌하중에 의한 휨모멘트

1) 작용위치 = 1.0 m

$$H = (V / 60)^2 \times 7500 + 2500 \text{ (N/m)}$$

$$(100 / 60)^2 \times 7500 + 2500 \text{ (N/m)} = 23.333 \text{ kN/m}$$

$$M_{co1} = 23.333 \times 1.0 = 23.333 \text{ kN} \cdot \text{m}$$

2) 작용높이 = 1.170 m (방호벽 상단)

$$H = 10.0 \text{ kN/m}$$

$$M_{co2} = 10.0 \times 1.170 = 11.700 \text{ kN} \cdot \text{m}$$

$$\therefore M_{co} = \max(M_{co1}, M_{co2}) = 23.333 \text{ kN} \cdot \text{m}$$

(4) 풍하중에 의한 휨모멘트 (도로교설계기준, 2010, p.2-12)

각 형 부 재	풍상측 부재(MPa)	재하위치(mm)	휨모멘트(kN · m)
활하중 재하시	0.0015	1500	2.970
활하중 비재하시	0.0030	805	3.188

(5) 원심하중에 의한 휨모멘트

보의수	단일지간	복수지간
2	2°	3°
3 또는 4	3°	4°
5 이상	4°	5°

< 개단면 상부구조에서 곡률을 무시할 수 있는 한계 중심각 >

본 교량은 $R = \infty \text{m}$ 이며 중심각이 0.003°로서 직교로 설계한다.

(5) 휨모멘트 종합

하중 구분			휨모멘트	비 고
1	고정하중	Md	8.639	
2	활하중	MI	9.170	
3	풍하중	Mw	2.970	활하중 재하시
			3.188	활하중 비재하시
4	원심하중	Mc _f	0.000	
5	충돌하중	Mco	23.333	

(6) 하중조합

① 계수하중 - 단면 검토시

Load Case	고정하중	활 하 중	풍하중	원심하중	충돌하중	비 고
Case 1	1.30	2.15		1.30		
Case 2	1.30		1.30			
Case 3	1.30	1.30	0.65	1.30		
Case 4	1.30	1.30		1.30		
Case 5	1.25	1.25	0.625	1.25		
Case 6	1.30	1.30		1.30	1.30	
Case 7	1.20		1.20		1.20	

② 사용하중 - 사용성 검토시

Load Case	고정하중	활 하 중	풍하중	원심하중	충돌하중	비 고
Case 1	1.00	1.00		1.00		
Case 2	1.00		1.00			
Case 3	1.00	1.00	1.00	1.00		
Case 4	1.00	1.00		1.00		
Case 5	1.00	1.00	1.000	1.00		
Case 6	1.00	1.00		1.00	1.00	
Case 7	1.00		1.00		1.00	

③ 하중조합 결과

Load Case	계 수 하 중 M (kN · m)	사 용 하 중 M (kN · m)	비 고
Case 1	30.947	17.809	
Case 2	15.375	11.827	
Case 3	25.083	20.779	
Case 4	23.152	17.809	
Case 5	24.118	20.779	
Case 6	53.485	41.142	
Case 7	42.192	35.160	

④ 적용하중

구 분	M (kN · m)	비 고
계 수 하 중	53.485	
사 용 하 중	41.142	

4.3.4 철근량 산정

(1) 설계조건

- 1) 설계휨모멘트 : $M_u = 53485132.4 \text{ (N} \cdot \text{mm)}$
 2) 단면치수 : $H = 240.00 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 : $d = 180.00 \text{ (mm)}$, $d' = 60.0 \text{ (mm)}$
 3) 재료의 성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400 \text{ MPa}$
 4) 강도감소계수 : $\phi_f = 0.85$, $k_1 = 0.85$

* 강도감소계수(ϕ) 산정

$$T = A_s \times f_y = 1626.500 \times 400.000 = 650600.000$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 1000.000 = 22950.000 \times a$$

$$T = C \text{ 이므로, } a = 28.349 \text{ mm , } c = 28.349 / \beta_1$$

$$= 28.349 / 0.85 = 24.096 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 400.000 / 200000.000 = 0.002$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (180.000 - 24.096) / 24.096 = 0.0194$$

$\epsilon_t \geq 0.005$ 이므로 인장지배단면이며, $\phi_f = 0.85$ 를 적용한다.

(2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s \text{ (mm}^2\text{)}$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a / 2)$$

$$-2.963 A_s^2 + 61200 A_s - 53485132.4 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 914.423 \text{ (mm}^2\text{)}$$

$$\text{단면철근비 : } P = A_s / (b \times d) = 0.0051$$

$$\text{최대철근비 : } P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck} / f_y) \times (600 / (600 + f_y)) = 0.0209$$

$$\text{최소철근비 : } P_{\min} = 1.4 / f_y = 0.0035$$

$$\text{① } A_s(\text{req}) = 914.423$$

$$\text{② } A_s(\text{min}) = 630.000$$

$$\text{③ } 4/3 \times A_s = 1219.231$$

$\therefore A_s = 914.423 \text{ mm}^2$ 이상 사용

(3) 사용 철근량

$$\text{① H 16 @ 200} = 993.000$$

$$\text{② H 13 @ 200} = 633.500$$

$$\Sigma = 1626.500 \text{ mm}^2 \quad (N = 10) \quad \text{----- 0.K}$$

(4) 설계휨강도

$$\phi_f \cdot M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 91.703 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 28.349 \text{ mm}$$

$$\therefore \phi_f \cdot M_n = 91.703 \text{ kN} \cdot \text{m} > M_u = 53.485 \text{ kN} \cdot \text{m} \quad \text{----- 0.K}$$

4.3.5 사용성 검토

(1) 처짐 검토 (콘크리트구조설계기준 · 해설, 2007, p.75)

1) 처짐검토를 필요로 하지 않는 최소두께 (켄틸레버)

$$T_{min} = L / 10 = 0.839 \times 1000 / 10 = 83.9 \text{ mm}$$

$$T_{can} (240\text{mm}) > T_{min} (83.9\text{mm}) \text{ ----- 처짐검토 불필요}$$

(2) 균열 검토 (콘크리트구조설계기준 · 해설, 2007, p.495)

1) 사용하중에 대한 철근의 인장응력 최대값

M_{max} : 사용하중하에서 최대하중을 유발하는 하중조합 사용(도로교설계기준, 2010, p.4-96)

$$M_{max} = M_{net} = 41.142 \text{ kN} \cdot \text{m}$$

$$n = E_s / E_c = 8$$

$$p_{use} = A_s_{use} / b \cdot d = 0.00904$$

$$k = -n \cdot p + \sqrt{\{(n \cdot p)^2 + 2 \cdot n \cdot p\}} = 0.315$$

$$j = 1 - (k / 3) = 0.895$$

$$F_{smax} = M_{max} / (p \cdot j \cdot b \cdot d^2) = 156.947 \text{ MPa}$$

$$F_{smax} (=156.947 \text{ MPa}) < 0.6F_y (=240 \text{ MPa}) \text{ ----- 0.K}$$

2) 철근의 최대 중심간격

$$C_c = d' - H_n / 2 = 60.00 - 16 / 2 = 52.00 \text{ mm}$$

여기서 C_c : 인장철근이나 긴장재의 표면과 콘크리트 표면사이의 두께(mm)

$$S_{min} : 375 \times (210 / F_{smax}) - 2.5 C_c$$

$$= 375 \times (210 / 156.95) - 2.5 \times 52.00 = 371.762 \text{ mm}$$

$$300 \times (210 / F_{smax}) = 300 \times (210 / 156.95) = 401.409 \text{ mm}$$

S_a 는 작은 값인 371.762 mm 를 적용

$$S = 100 \text{ mm} \leq S_a (= 371.762 \text{ mm}) \text{ ----- 0.K}$$

(3) 피로 검토 (콘크리트구조설계기준 · 해설, 2007, p.82)

▶ SD40 이형철근의 경우 피로를 고려하지 않아도 되는 응력 범위 : 150 MPa

$$M_I = 9.170 \text{ kN} \cdot \text{m}$$

$$f_y = M_I / (p \cdot j \cdot b \cdot d^2) = 34.983 \text{ MPa} < 150 \text{ MPa} \text{ ----- 검토 불필요}$$

4.3.6 배력철근량 산정 (도로교설계기준, 2010, p.4-160 ; 콘크리트구조설계기준 해설 2007, p.109)

(1) 주철근에 대한 백분율로 산정한 배력철근량

(주철근이 차량진행방향에 직각인 경우)

$$\min (120/\sqrt{L}, 67\%) = 67 \%$$

$$Ar_{req} = As \times 0.67 = 612.663 \text{ mm}^2$$

(2) 온도 및 건조수축에 대한 철근량

$$At_{req} = 0.002 \times b \times d = 360.000 \text{ mm}^2$$

(3) 사용 배력철근량

$$\max (Ar_{req}, At_{req}) = 612.663 \text{ mm}^2$$

$$H 16 @ 250 = 794.400 \text{ mm}^2 > 612.663 \text{ mm}^2 \text{ ----- } 0.K$$

4.3.7 캔틸레버 단부검토

(1) 단면치수

1) 휨모멘트 종합

하중 구분			휨모멘트	비 고
1	고정하중	Md	8.639	
2	활하중	MI	9.170	
3	충돌하중	Mco	23.333	
4	풍하중	Mw	2.970	

2) 하중조합

Load Case	고정하중	활 하 중	충돌하중	풍 하 중	하중조합	비 고
Case 1	1.3	4.30			50.663	
Case 2	1.3		1.3		41.564	
Case 3	1.3	2.6		0.65	37.004	
Case 4	1.3	2.6	1.3		65.407	
Case 5	1.2		1.2	1.2	41.930	
적 용					65.407	

(2) 철근량 산정

1) 설계조건

- ① 설계휨모멘트 : $M_u = 65406664.7 \text{ (N} \cdot \text{mm)}$
 ② 단면치수 : $H = 240.00 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 : $d = 180.00 \text{ (mm)}$, $d' = 60.0 \text{ (mm)}$
 ③ 재료의 성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400 \text{ MPa}$
 ④ 강도감소계수 : $\phi_f = 0.85$, $k_1 = 0.85$

* 강도감소계수(ϕ) 산정

$$T = A_s \times f_y = 1986.000 \times 400.000 = 794400.000$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 1000.000 = 22950.000 \times a$$

$$T = C \text{ 이므로, } a = 34.614 \text{ mm , } c = 34.614 / \beta_1$$

$$= 34.614 / 0.85 = 29.422 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 400.000 / 200000.000 = 0.002$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (180.000 - 29.422) / 29.422$$

$$= 0.0154$$

$\epsilon_t \geq 0.005$ 이므로 인장지배단면이며, $\phi_f = 0.85$ 를 적용한다.

2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a / 2)$$

$$-2.963 A_s^2 + 61200 A_s - 65406664.7 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 1130.626 \text{ (mm}^2\text{)}$$

$$\text{단면철근비 : } P = A_s / (b \times d) = 0.0063$$

$$\text{최대철근비 : } P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck} / f_y) \times (600 / (600 + f_y)) = 0.0209$$

$$\text{최소철근비 : } P_{\min} = 1.4 / f_y = 0.0035$$

$$\text{① } A_s(\text{req}) = 1130.626$$

$$\text{② } A_s(\text{min}) = 630.000$$

$$\text{③ } 4/3 \times A_s = 1507.501$$

$$\text{④ 일반캔틸레버부 필요철근의 2배} = 1828.846$$

$\therefore A_s = 1828.846 \text{ mm}^2$ 이상 사용

3) 사용 철근량

$$\text{① H 16 @ 200} = 993.000$$

$$\text{② H 16 @ 200} = 993.000$$

$$\Sigma = 1986.000 \text{ mm}^2 \quad (N = 10) \quad \text{----- 0.K}$$

4) 설계휨강도

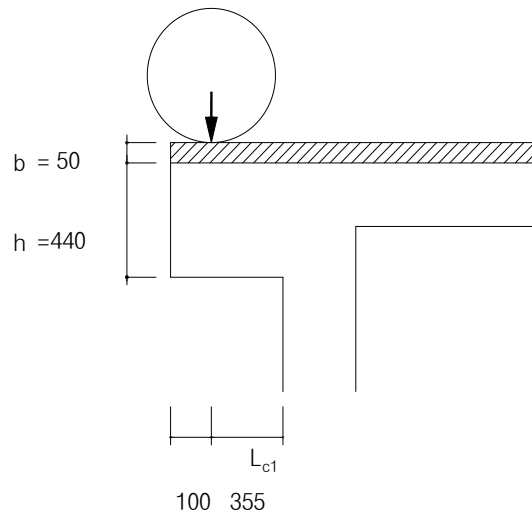
$$\phi_f \cdot M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 109.857 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 34.614 \text{ mm}$$

$$\therefore \phi_f \cdot M_n = 109.857 \text{ kN} \cdot \text{m} > M_u = 65.407 \text{ kN} \cdot \text{m} \quad \text{----- 0.K}$$

4.4. 슬래브 단부 설계

4.4.1 단면치수



4.4.2 설계하중에 의한 단면력

(1) 고정하중에 의한 단면력

$$H_s = 0.440 + 0.050 = 0.490 \text{ m}$$

$$L_c = 0.1 + 0.355 = 0.455 \text{ m}$$

$$W_d = 0.490 \times 25 = 12.250 \text{ kN/m}^2$$

$$M_D = W_d \times L_c^2 / 2 = 1.268 \text{ kN} \cdot \text{m/m}$$

(2) 활하중에 의한 휨모멘트

$$i = 15 / (40 + L_{c1}) = 0.038 \leq 0.300 \therefore i = 0.038$$

$$P_r = 96 \text{ kN}$$

$$E = 0.35 \times 0.355 + 0.98 = 1.104 \text{ m}$$

$$W_L(1+i) = 124.800 \text{ kN}$$

$$M_L(1+i) = W \times L (1 + i) \times H_1 / E = 40.121 \text{ kN} \cdot \text{m}$$

(3) 하중조합

1) 계수하중(Factored Load (도로교설계기준, 2010, p.2-25))

$$M_u = 1.3 M_D + 2.15 M_L(1+i) = 87.909 \text{ kN} \cdot \text{m}$$

4.4.3 철근량 산정

(1) 설계조건

- 1) 설계힘모멘트 : $M_u = 87909337.6 \text{ (N} \cdot \text{mm)}$
 2) 단면치수 : $H = 440.00 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 : $d = 248.00 \text{ (mm)}$, $d' = 192.0 \text{ (mm)}$
 3) 재료의 성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400.0 \text{ MPa}$
 4) 강도감소계수 : $\phi_f = 0.85$, $k_1 = 0.85$

* 강도감소계수(ϕ) 산정

$$T = A_s \times f_y = 1301.200 \times 400.000 = 520480.000$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 1000.000 = 22950.000 \times a$$

$$T = C \text{ 이므로, } a = 22.679 \text{ mm, } c = 22.679 / \beta_1$$

$$= 22.679 / 0.85 = 19.277 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 400.000 / 200000.000 = 0.002$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (248.000 - 19.277) / 19.277$$

$$= 0.0356$$

$$\epsilon_t \geq 0.005 \text{ 이므로 인장지배단면이며, } \phi_f = 0.85 \text{ 를 적용한다.}$$

(2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s \text{ (mm}^2\text{)}$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a / 2)$$

$$-2.963 A_s^2 + 84320 A_s - 87909337.6 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 1083.848 \text{ (mm}^2\text{)}$$

$$\text{단면철근비 : } P = A_s / (b \times d) = 0.0044$$

$$\text{최대철근비 : } P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck} / f_y) \times (600 / (600 + f_y)) = 0.0209$$

$$\text{최소철근비 : } P_{\min} = 1.4 / f_y = 0.0035$$

$$\begin{array}{l} \text{① } A_s(\text{req}) = 1083.848 \\ \text{② } A_s(\text{min}) = 868.000 \\ \text{③ } 4/3 \times A_s = 1445.131 \end{array} \left. \vphantom{\begin{array}{l} \text{① } A_s(\text{req}) = 1083.848 \\ \text{② } A_s(\text{min}) = 868.000 \\ \text{③ } 4/3 \times A_s = 1445.131 \end{array}} \right\} \therefore A_s = 1083.848 \text{ mm}^2 \text{ 이상 사용}$$

(3) 사용 철근량

$$\begin{array}{l} \text{① H 16 @ 250} = 794.400 \\ \text{② H 13 @ 250} = 506.800 \\ \hline \Sigma = 1301.200 \text{ mm}^2 \quad (N = 8) \quad \text{----- 0.K} \end{array}$$

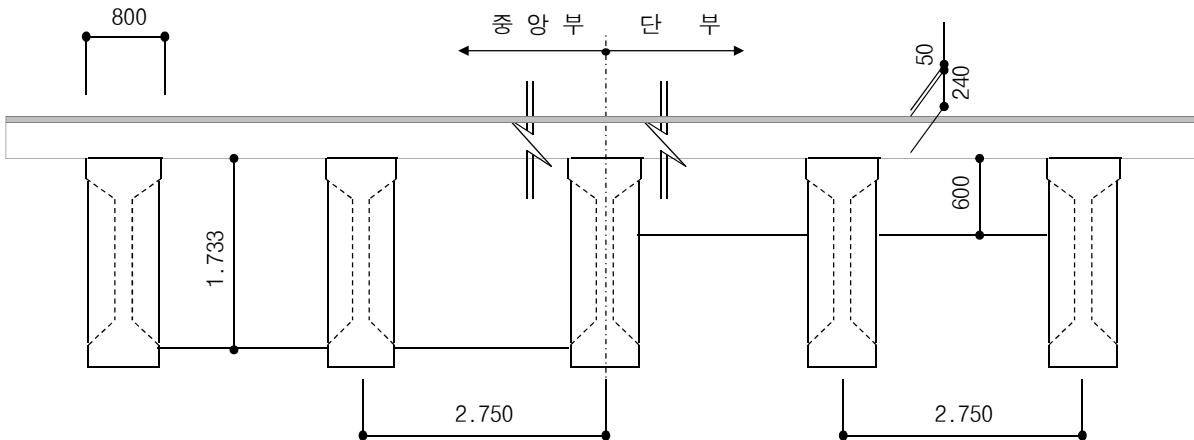
(4) 설계휨강도

$$\phi_f \cdot M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 104.701 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 22.679 \text{ mm}$$

$$\therefore \phi_f \cdot M_n = 104.701 \text{ kN} \cdot \text{m} > M_u = 87.909 \text{ kN} \cdot \text{m} \quad \text{----- 0.K}$$

4.5 가로보의 설계



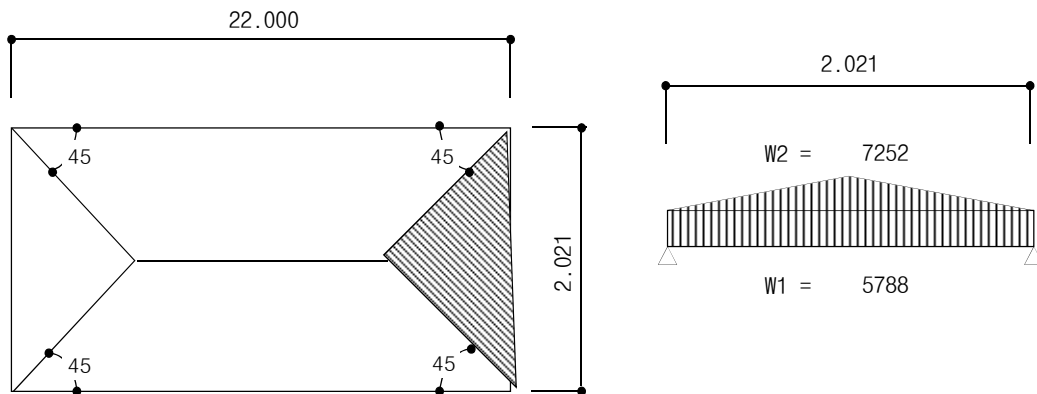
4.5.1 단부 가로보

1) 가로보제원

빔 높 이 : 0.600 m 주 빔 간 격 : 2.750 m
 빔 폭 : 0.400 m 가로보 순지간 $2.750 - 0.800 = 1.950$ m
 교량사각 : 105.3° 가로보 사지간 $1.950 \div \sin(105.3) = 2.021$ m

2) 작용하중

(1) 고정하중



빔 폭 : $0.400 \times \sin(105.3)$ = 0.386 m
 빔 자 중 : $0.400 \times \sin(105.3) \times 0.600 \times 2500 \times 10$ = 5788 N/m
 슬라브자중 : $(0.240 \times 1.011 \times 2500 + 0.050 \times 1.011 \times 2350) \times 10$ = 7252 N/m

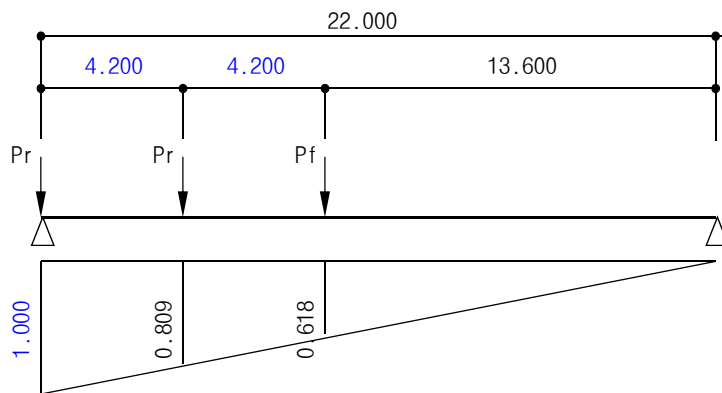
작용 단면력

$R_{ad} = 5788 \times 2.021 \times 1/2 + (2.021 \times 7252 \times 1/2) \times 1/2$ = 9515 N

$m_d = \frac{\omega_1 l^2}{8} + \frac{\omega_2 l^2}{12} = \frac{5788 \times 2.021^2}{8} + \frac{7252 \times 2.021^2}{12}$ = 5426 N·m

(2) 활 하 중

㉠ DB-24 하중



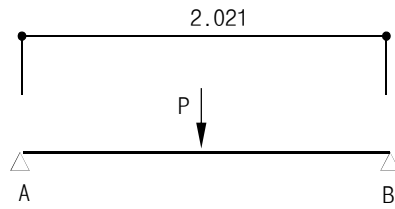
$$P_f = 18.0 \text{ kN}$$

$$P_r = 72.0 \text{ kN}$$

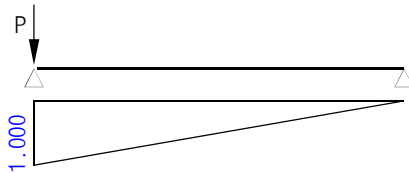
$$\text{충격계수}(i) = \frac{15}{40 + 22.000} = 0.242 < 0.3$$

$$P(L+i) = \{ 72.0 \times (1.000 + 0.809) + 18.0 \times 0.618 \} \times 1.242 = 175.587 \text{ kN}$$

작용 단면력



$$m_l = \frac{PL}{4} = \frac{175.587 \times 2.021}{4} = 88.736 \text{ kN} \cdot \text{m}$$



$$RAI = 175.587 \times 1.000 = 175.587 \text{ kN}$$

(3) CROSS BEAM 부재력 정리

구 분	단 위	단순빔 해석	
		고정하중	활하중
M_u	$\text{kN} \cdot \text{m}$	5.426	88.736
V_u	kN	9.515	175.587

(4) 극한단면력

$$M_u = 1.3 m_d + 2.15 m_l = 1.300 \times 5.426 + 2.150 \times 88.736 = 197.836 \text{ kN} \cdot \text{m}$$

$$V_u = 1.3 S_d + 2.15 S_l = 1.300 \times 9.515 + 2.150 \times 175.587 = 389.882 \text{ kN} \cdot \text{m}$$

3) 휨 검토

[설계조건]

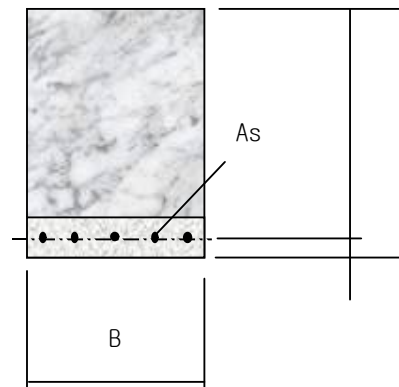
$$f_{ck} = 27 \text{ MPa} \quad f_y = 300 \text{ MPa}$$

$$M_u = 197.836 \text{ kN} \cdot \text{m}$$

$$b = 400.0 \text{ mm} \quad h = 840.0 \text{ mm}$$

$$d' = 70.0 \text{ mm} \quad d = 770.0 \text{ mm}$$

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



[강도감소계수(ϕ) 산정]

$$T = A_s \times f_y = 1520.1 \times 300 = 456030$$

$$C = 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 400 = 9180 \times a$$

$$T = C \text{ 이므로, } a = 49.676 \text{ mm}, \quad c = 49.676 / \beta_1$$

$$= 49.676 / 0.85 = 42.225 \text{ mm}$$

$$\epsilon_y = f_y / E_s = 300 / 200000 = 0.0015$$

$$\epsilon_t = 0.0030 \times (d_t - c) / c = 0.003 \times (770 - 42.225) / 42.225$$

$$= 0.0517$$

$\epsilon_t \geq 0.005$ 이므로 인장지배 단면이며, $\phi_f = 0.85$ 를 적용한다.

[필요 철근량 및 최소 철근량]

$$a = A_s \times f_y / (0.85 \times f_{ck} \times b) = 0.03268 A_s$$

$$M_u = \Phi \times A_s \times f_y \times (d - a/2) = -4.167 A_s^2 + 196350 A_s$$

$$= 197836000$$

사용철근량은 (콘크리트구조설계기준 · 해설, 2007, p.123)

필요철근량 $A_{sreq} = 1,030.1 \text{ mm}^2$ 이상이어야 하며,

최소철근량 $A_{smin} = 0.25 \sqrt{f_{ck}} / f_y \times b \times d = 1,333.7 \text{ mm}^2$ 와

$A_{smin} = 1.4 / f_y \times b \times d = 1,437.3 \text{ mm}^2$ 중에서 큰 값 이상이거나,

$A_{smin} = A_{sreq} \times 4/3 = 1,373.4 \text{ mm}^2$ 이상이어야 한다.

사용철근 $D \text{ 25} \times 3 \text{ EA} = 1520.1 \text{ mm}^2$

$D \text{ 25} \times 0 \text{ EA} = 0.0 \text{ mm}^2$

$= 1520.1 \text{ mm}^2$

0.K.

[최대 철근비 검토]

$$P = A_s / (b \cdot d) = 0.00494 < P_{max} = 0.643 P_b = 0.02787 \quad \mathbf{0.K.}$$

(콘크리트구조설계기준 · 해설, 2007, p.121)

[설계모멘트 검토]

$$\text{Max. } c = 0.75 \times 600 / (600 + f_y) \times d = 385.00 \text{ mm} > c = a / 0.85 = 58.44 \text{ mm}$$

$$\text{Max. } a = 0.85 \times c = 327.25 \text{ mm} > a = f_y A_s / (0.85 f_{ck} b) = 49.68 \text{ mm}$$

$$jd = d - a/2 = 745.16 \text{ mm}$$

$$C = 0.85 f_{ck} a b = 456.030 \text{ kN}, \quad T = f_y A_s = 456.030 \text{ kN}$$

$$\Phi M_n = \Phi f_y A_s jd = 288.844 \text{ kN} \cdot \text{m} > M_u = 197.836 \text{ kN} \cdot \text{m} \quad \mathbf{0.K.}$$

4) 전단 검토 ($f_{ck} = 27 \text{ MPa}$)

(1) 높이가 큰보에 대한 계산 (콘크리트구조설계기준 · 해설, 2007, p.182)

$$l_n / d = 2.021 \div 0.770 = 2.625 < 4$$

∴ 높이가 큰 보로 전단응력 검토

(2) 최대 전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot 2 \cdot (\sqrt{f_{ck}/3}) \cdot b_o \cdot d \\ &= 0.8 \times 2 \times (\sqrt{27} / 3) \times 400 \times 770 \times 10^{-3} \\ &= 853.555 \text{ kN} > S_u = 389.882 \text{ kN} \end{aligned}$$

0.K

(3) 콘크리트가 부담하는 전단강도

$$\begin{aligned} \Phi \cdot V_c &= \Phi \cdot \sqrt{f_{ck}} / 6 \cdot b_o \cdot d \\ &= 0.8 \times \sqrt{27} / 6 \times 400 \times 770 \times 10^{-3} \\ &= 213.389 \text{ kN} < S_u = 389.882 \text{ kN} \end{aligned}$$

전단철근 필요

(4) 전단철근

- 수직 전단철근

$$S_v = 100 \text{ mm} < d/5 = 154 \text{ mm or } 300 \text{ mm} \quad 0.K$$

$$A_v = 397.2 \text{ mm}^2 > 0.0025 \cdot b_o \cdot S_v = 100.0 \text{ mm}^2 \quad 0.K$$

(D 16 × 2 ea)

- 수평 전단철근

$$S_h = 100 \text{ mm} < d/5 = 154 \text{ mm or } 300 \text{ mm} \quad 0.K$$

$$A_h = 397.2 \text{ mm}^2 > 0.0015 \cdot b_o \cdot S_h = 60.0 \text{ mm}^2 \quad 0.K$$

(D 16 × 2 ea)

- 전단철근의 전단강도 (콘크리트구조설계기준 · 해설, 2007, p.163)

$$\begin{aligned} \Phi \cdot V_s &= \Phi \left[\frac{A_v}{S_v} \left(\frac{1 + \ln/d}{12} \right) + \frac{A_{vh}}{S_h} \left(\frac{11 - \ln/d}{12} \right) \right] f_y \cdot d \\ &= 0.80 \left[\frac{397.2}{100} \left(\frac{1 + 2.625}{12} \right) + \frac{397.2}{100} \left(\frac{11 - 2.625}{12} \right) \right] \\ &\quad \times 300 \times 770.0 \\ &= 734.026 \text{ kN} \end{aligned}$$

- 공칭전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot V_c + \Phi \cdot V_s \\ &= 213.389 + 734.026 = 947.415 \text{ kN} > 853.555 \text{ kN} \end{aligned}$$

$$\therefore \Phi \cdot V_n = 853.555 > V_u = 389.882 \text{ kN} \quad 0.K.$$

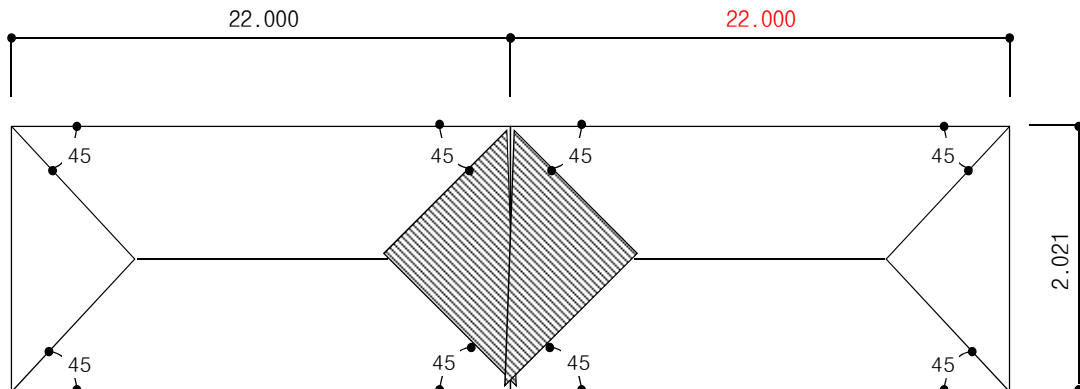
4.5.2 중앙부 가로보

1) 가로보제원

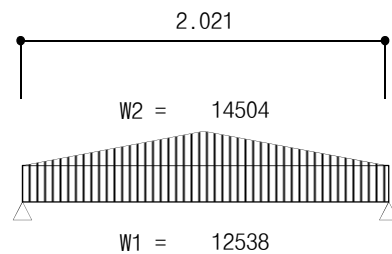
빔 높이 : 1.733 m 주 빔 간격 : 2.750 m
 빔 폭 : 0.300 m 가로보 순지간 : 2.750 - 0.800 = 1.950 m
 교량사각 : 105.3 ° 가로보 사지간 : 1.950 ÷ SIN (105.3) = 2.021 m

2) 작용하중

(1) 고정하중



빔 폭 : 0.300 × SIN (105.3) = 0.289 m
 빔 자 중 : 0.300 × SIN (105.3) × 1.733 × 2500 × 10 = 12538 N/m
 슬라브자중 : (0.240 × 2.021 × 2500 + 0.050 × 2.021 × 2350) × 10 = 14504 N/m



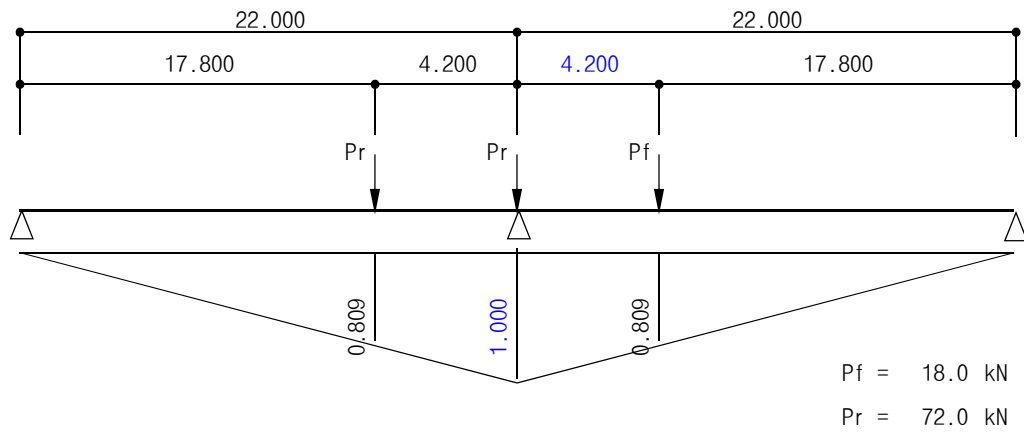
작용 단면력

$R_{ad} = 12538 \times 2.021 \times 1/2 + (2.021 \times 14504 \times 1/2) \times 1/2 = 20002 \text{ N}$

$m_d = \frac{\omega_1 l^2}{8} + \frac{\omega_2 l^2}{12} = \frac{12538 \times 2.021^2}{8} + \frac{14504 \times 2.021^2}{12} = 11343 \text{ N} \cdot \text{m}$

(2) 활 하 중

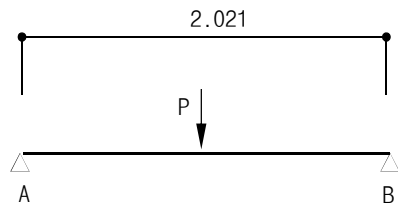
㉠ DB-24 하중



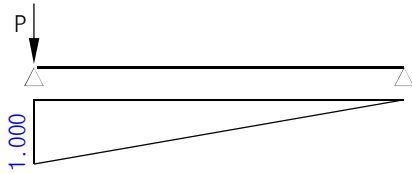
$$\text{충격계수}(i) = \frac{15}{40 + 22.000} = 0.242 < 0.3$$

$$P(L+i) = \{ 72.0 \times (1.000 + 0.809) + 18.0 \times 0.809 \} \times 1.242 = 179.845 \text{ kN}$$

작용 단면력



$$m_l = \frac{PL}{4} = \frac{179.845 \times 2.021}{4} = 90.888 \text{ kN} \cdot \text{m}$$



$$RAI = 179.845 \times 1.000 = 179.845 \text{ kN}$$

(3) CROSS BEAM 부재력 정리

구 분	단 위	단순빔 해석	
		고정하중	활하중
M _u	kN · m	11.343	90.888
V _u	kN	20.002	179.845

(4) 극한단면력

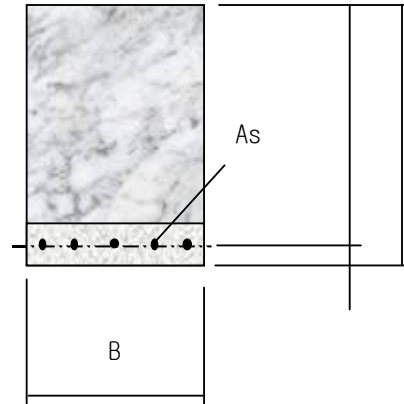
$$M_u = 1.3 m_d + 2.15 m_l = 1.300 \times 11.343 + 2.150 \times 90.888 = 210.155 \text{ kN} \cdot \text{m}$$

$$V_u = 1.3 S_d + 2.15 S_l = 1.300 \times 20.002 + 2.150 \times 179.845 = 412.669 \text{ kN} \cdot \text{m}$$

3) 휨 검토

[설계조건]

$$\begin{aligned} f_{ck} &= 27 \text{ MPa} & f_y &= 300 \text{ MPa} \\ \mu_u &= 210.155 \text{ kN} \cdot \text{m} \\ b &= 300.0 \text{ mm} & h &= 1973.0 \text{ mm} \\ d' &= 70.0 \text{ mm} & d &= 1903.0 \text{ mm} \\ \phi(\text{Bending}) &= 0.85 \end{aligned}$$



[강도감소계수(φ) 산정]

$$\begin{aligned} T &= A_s \times f_y = 1013.4 \times 300 = 304020 \\ C &= 0.85 \times f_{ck} \times a \times b = 0.85 \times 27 \times a \times 300 = 6885 \times a \\ T &= C \text{ 이므로, } a = 44.157 \text{ mm}, \quad c = 44.157 / \beta_1 \\ &= 44.157 / 0.85 = 37.533 \text{ mm} \\ \epsilon_y &= f_y / E_s = 300 / 200000 = 0.0015 \\ \epsilon_t &= 0.0030 \times (d_t - c) / c = 0.003 \times (1903 - 37.533) / 37.533 \\ &= 0.1491 \\ \epsilon_t &\geq 0.005 \text{ 이므로 인장지배단면이며, } \phi_f = 0.85 \text{ 를 적용한다.} \end{aligned}$$

[필요 철근량 및 최소 철근량]

$$\begin{aligned} a &= A_s \times f_y / (0.85 \times f_{ck} \times b) = 0.04357 A_s \\ \mu_u &= \phi \times A_s \times f_y \times (d - a/2) = -5.556 A_s^2 + 485265 A_s \\ &= 210155000 \end{aligned}$$

사용철근량은 (콘크리트구조설계기준 · 해설, 2007, p.123)

$$\begin{aligned} \text{필요철근량 } A_{sreq} &= 435.2 \text{ mm}^2 \text{ 이상이어야 하며,} \\ \text{최소철근량 } A_{smin} &= 0.25 \sqrt{f_{ck}} / f_y \times b \times d = 2,472.1 \text{ mm}^2 \text{ 와} \\ A_{smin} &= 1.4 / f_y \times b \times d = 2,664.2 \text{ mm}^2 \text{ 중에서 큰 값 이상이거나,} \\ A_{smin} &= A_{sreq} \times 4/3 = 580.3 \text{ mm}^2 \text{ 이상이어야 한다.} \end{aligned}$$

$$\begin{aligned} \text{사용철근 } D \ 25 \times 2 \text{ EA} &= 1013.4 \text{ mm}^2 \\ D \ 25 \times 0 \text{ EA} &= 0.0 \text{ mm}^2 \\ &= 1013.4 \text{ mm}^2 \quad \mathbf{O.K.} \end{aligned}$$

[최대 철근비 검토]

$$\begin{aligned} P &= A_s / (b \cdot d) = 0.00178 < P_{max} = 0.643 P_b = 0.02787 \quad \mathbf{O.K.} \\ &\quad (\text{콘크리트구조설계기준 · 해설, 2007, p.121}) \end{aligned}$$

[설계모멘트 검토]

$$\begin{aligned} \text{Max. } c &= 0.75 \times 600 / (600 + f_y) \times d = 951.50 \text{ mm} > c = a / 0.85 = 51.95 \text{ mm} \\ \text{Max. } a &= 0.85 \times c = 808.78 \text{ mm} > a = f_y A_s / (0.85 f_{ck} b) = 44.16 \text{ mm} \\ j d &= d - a/2 = 1880.92 \text{ mm} \\ C &= 0.85 f_{ck} a b = 304.020 \text{ kN}, \quad T = f_y A_s = 304.020 \text{ kN} \\ \phi M_n &= \phi f_y A_s j d = 486.062 \text{ kN} \cdot \text{m} > \mu_u = 210.155 \text{ kN} \cdot \text{m} \quad \mathbf{O.K.} \end{aligned}$$

4) 전단 검토 ($f_{ck} = 27 \text{ MPa}$)

(1) 높이가 큰보에 대한 계산 (콘크리트구조설계기준·해설, 2007, p.182)

$$l_n / d = 2.021 \div 1.903 = 1.062 < 4$$

∴ 높이가 큰 보로 전단응력 검토

(2) 최대 전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot 2 \cdot (\sqrt{f_{ck}/3}) \cdot b_o \cdot d \\ &= 0.8 \times 2 \times (\sqrt{27/3}) \times 300 \times 1903 \times 10^{-3} \\ &= 1582.124 \text{ kN} > S_u = 412.669 \text{ kN} \end{aligned} \quad \text{0.K}$$

(3) 콘크리트가 부담하는 전단강도

$$\begin{aligned} \Phi \cdot V_c &= \Phi \cdot \sqrt{f_{ck}} / 6 \cdot b_o \cdot d \\ &= 0.8 \times \sqrt{27} / 6 \times 300 \times 1903 \times 10^{-3} \\ &= 395.531 \text{ kN} < S_u = 412.669 \text{ kN} \end{aligned} \quad \text{전단철근 필요}$$

(4) 전단철근

- 수직 전단철근

$$\begin{aligned} S_v &= 200 \text{ mm} < d/5 = 380.6 \text{ mm} \text{ or } 300 \text{ mm} & \text{0.K} \\ A_v &= 397.2 \text{ mm}^2 > 0.0025 \cdot b_o \cdot S_v = 150.0 \text{ mm}^2 & \text{0.K} \\ &(\text{D } 16 \times 2 \text{ ea}) \end{aligned}$$

- 수평 전단철근

$$\begin{aligned} S_h &= 200 \text{ mm} < d/5 = 381 \text{ mm} \text{ or } 300 \text{ mm} & \text{0.K} \\ A_h &= 397.2 \text{ mm}^2 > 0.0015 \cdot b_o \cdot S_h = 90.0 \text{ mm}^2 & \text{0.K} \\ &(\text{D } 16 \times 2 \text{ ea}) \end{aligned}$$

- 전단철근의 전단강도 (콘크리트구조설계기준·해설, 2007, p.163)

$$\begin{aligned} \Phi \cdot V_s &= \Phi \left[\frac{A_v}{S_v} \left(\frac{1 + l_n/d}{12} \right) + \frac{A_{vh}}{S_h} \left(\frac{11 - l_n/d}{12} \right) \right] f_y \cdot d \\ &= 0.80 \left[\frac{397.2}{200} \left(\frac{1 + 1.062}{12} \right) + \frac{397.2}{200} \left(\frac{11 - 1.062}{12} \right) \right] \\ &\quad \times 300 \times 1903.0 \\ &= 907.046 \text{ kN} \end{aligned}$$

- 공칭전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot V_c + \Phi \cdot V_s \\ &= 395.531 + 907.046 = 1302.577 \text{ kN} < 1582.124 \text{ kN} \\ \therefore \Phi \cdot V_n &= 1302.577 > V_u = 412.669 \text{ kN} \end{aligned} \quad \text{0.K.}$$

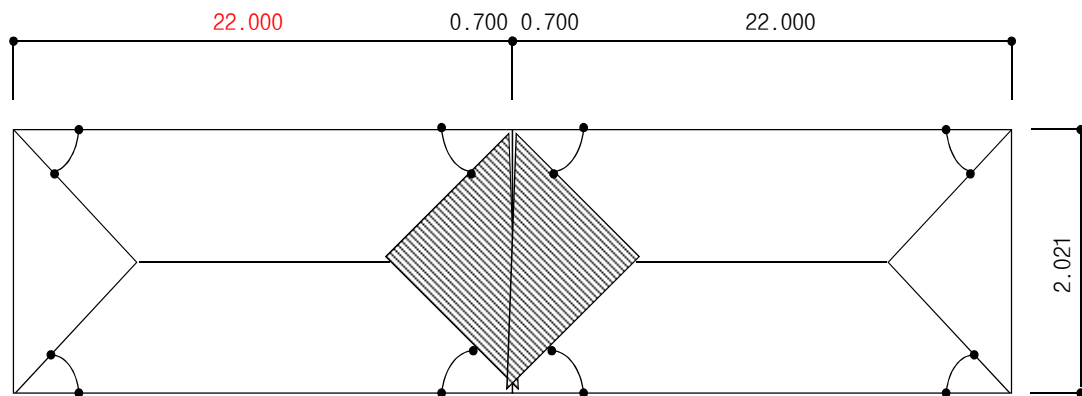
4.5.3 연속지점부 가로보

1) 가로보제원

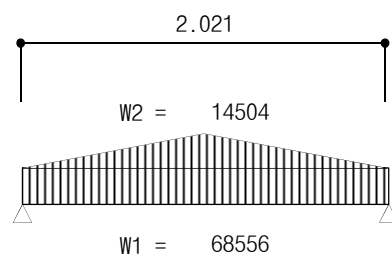
빔 높이 : 1.733 m 주 빔 간격 : 2.750 m
 빔 폭 : 1.400 m 가로보 순지간 : 2.750 - 0.800 = 1.950 m
 교량사각 : 105.3 ° 가로보 사지간 : 1.950 ÷ SIN(105.3) = 2.021 m

2) 작용하중

(1) 고정하중



빔 폭 : 1.400 × SIN (105.3) = 1.351 m
 빔 자 중 : 1.400 × SIN (105.3) × 1.733 × 2500 × 10 = 58511 N/m
 슬라브자중 : (0.240 × 1.400 × 2500 + 0.050 × 1.400 × 2350) × 10 = 10045 N/m
 (0.240 × 2.021 × 2500 + 0.050 × 2.021 × 2350) × 10 = 14504 N/m



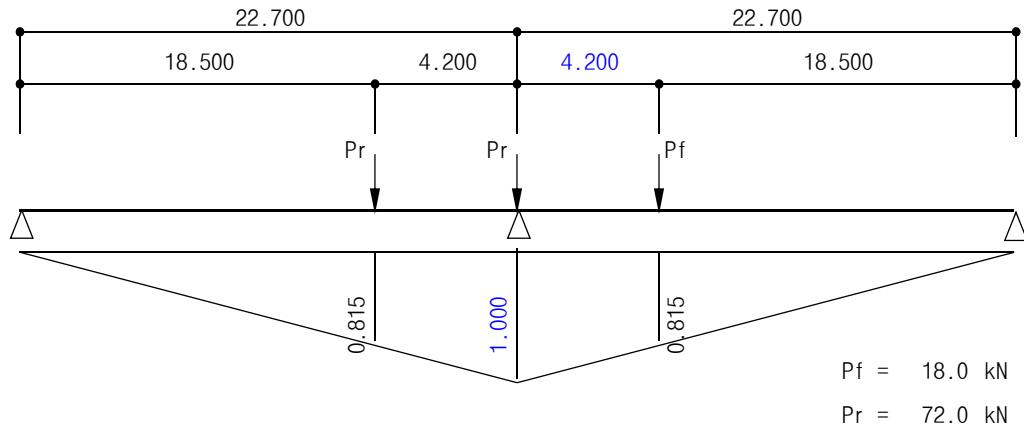
작용 단면력

$$Rad = 68556 \times 2.021 \times 1/2 + (2.021 \times 14504 \times 1/2) \times 1/2 = 76622 \text{ N}$$

$$md = \frac{\omega_1 l^2}{8} + \frac{\omega_2 l^2}{12} = \frac{68556 \times 2.021^2}{8} + \frac{14504 \times 2.021^2}{12} = 39957 \text{ N} \cdot \text{m}$$

(2)활 하 중

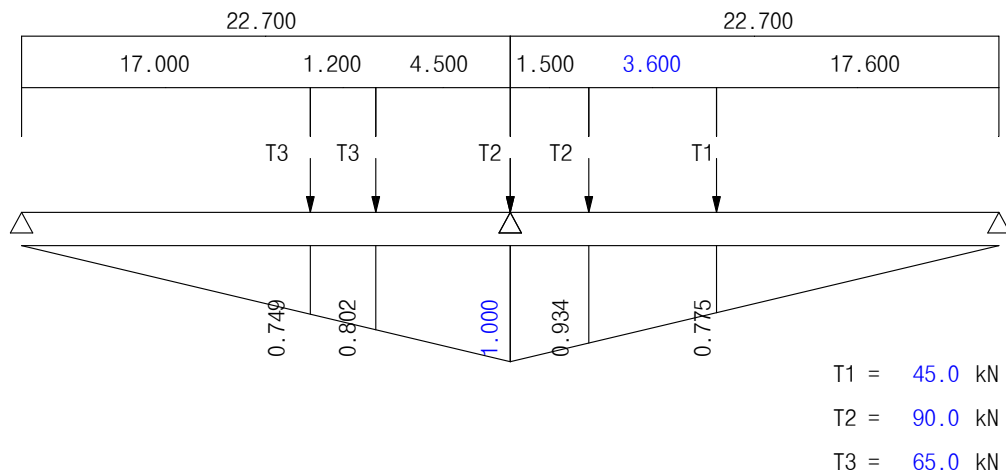
㉠ DB-18 하중



$$\text{충격계수}(i) = \frac{15}{40 + 22.700} = 0.239 < 0.3$$

$$P(L+i) = \{ 72.0 \times (1.000 + 0.815) + 18.0 \times 0.815 \} \times 1.239 = 180.123 \text{ kN}$$

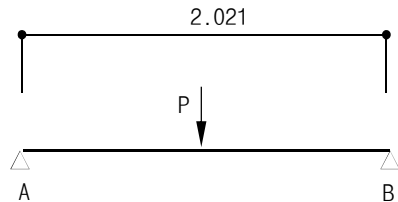
㉢ Tank-Trailer 하중



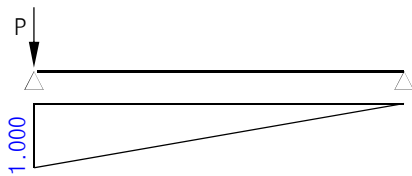
$$\text{충격계수}(i) = \frac{15}{40 + 22.700} = 0.239 < 0.3$$

$$\begin{aligned} \text{Ptr (L+i)} &= \{ 65.0 \times (0.749 + 0.802) + 90.0 \times (1.000 \times 0.934) \\ &\quad + 45.0 \times 0.775) \} \times 1.239 \\ &= 383.835 \text{ kN} \end{aligned}$$

작용 단면력



$$\begin{aligned} m_l &= \frac{PL}{4} = \frac{383.835 \times 2.021}{4} \\ &= 193.978 \text{ kN} \cdot \text{m} \end{aligned}$$



$$RAI = 383.835 \times 1.000 = 383.835 \text{ kN}$$

(3) CROSS BEAM 부재력 정리

구 분	단 위	단순빔 해석	
		고정하중	활하중
M _u	kN · m	39.957	193.978
V _u	kN	76.622	383.835

(4) 극한단면력

$$\begin{aligned} M_u &= 1.3 m_d + 2.15 m_l = 1.300 \times 39.957 + 2.150 \times 193.978 = 468.997 \text{ kN} \cdot \text{m} \\ V_u &= 1.3 S_d + 2.15 S_l = 1.300 \times 76.622 + 2.150 \times 383.835 = 924.854 \text{ kN} \cdot \text{m} \end{aligned}$$

3) 휨 검토

[설계조건]

$$\begin{aligned} f_{ck} &= 27 \text{ MPa} & f_y &= 300 \text{ MPa} \\ \mu &= 468.997 \text{ kN} \cdot \text{m} \\ b &= 1400.0 \text{ mm} & h &= 1973.0 \text{ mm} \\ d' &= 70.0 \text{ mm} & d &= 1903.0 \text{ mm} \\ \phi(\text{Bending}) &= 0.85 \end{aligned}$$

[필요 철근량 및 최소 철근량]

$$\begin{aligned} a &= A_s \times f_y / (0.85 \times f_{ck} \times b) = 0.00934 A_s \\ \mu &= \phi \times A_s \times f_y \times (d - a/2) = -1.190 A_s^2 + 485265 A_s \\ &= 468997000 \end{aligned}$$

사용철근량은

(콘.설.해 6.3.2)

필요철근량 $A_{sreq} = 968.8 \text{ mm}^2$ 이상이어야 하며,

최소철근량 $A_{smin} = 0.25 \sqrt{f_{ck}} / f_y \times b \times d = 11,536.3 \text{ mm}^2$ 와

$A_{smin} = 1.4 / f_y \times b \times d = 12,432.9 \text{ mm}^2$ 중에서 큰 값 이상이거나,

$A_{smin} = A_{sreq} \times 4/3 = 1,291.7 \text{ mm}^2$ 이상이어야 한다.

$$\text{사용철근 } D \text{ 25} \times 3 \text{ EA} = 1520.1 \text{ mm}^2$$

0.K.

[최대 철근비 검토]

$$P = A_s / (b \cdot d) = 0.00057 < P_{max} = 0.75 P_b = 0.03251 \quad \mathbf{0.K.}$$

(콘.설.해 6.2.2)

[설계모멘트 검토]

$$\text{Max. } c = 0.75 \times 600 / (600 + f_y) \times d = 951.50 \text{ mm} > c = a / 0.85 = 16.70 \text{ mm}$$

$$\text{Max. } a = 0.85 \times c = 808.78 \text{ mm} > a = f_y A_s / (0.85 f_{ck} b) = 14.19 \text{ mm}$$

$$jd = d - a/2 = 1895.90 \text{ mm}$$

$$C = 0.85 f_{ck} a b = 456.030 \text{ kN}, \quad T = f_y A_s = 456.030 \text{ kN}$$

$$\phi M_n = \phi f_y A_s jd = 734.900 \text{ kN} \cdot \text{m} > \mu = 468.997 \text{ kN} \cdot \text{m} \quad \mathbf{0.K.}$$

4) 전단 검토 ($f_{ck} = 27 \text{ MPa}$)

(1) 높이가 큰보에 대한 계산 (콘크리트구조설계기준·해설, 2007, p.182)

$$l_n / d = 2.021 \div 1.903 = 1.062 < 4$$

∴ 높이가 큰 보로 전단응력 검토

(2) 최대 전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot 2.12 \cdot \sqrt{f_{ck}} \cdot b_o \cdot d \\ &= 0.75 \times 2.12 \times \sqrt{27} \times 1400 \times 1903 \times 10^{-3} \\ &= 22011.307 \text{ kN} > S_u = 924.854 \text{ kN} \end{aligned} \quad \text{O.K.}$$

(3) 콘크리트가 부담하는 전단강도

$$\begin{aligned} \Phi \cdot V_c &= \Phi \cdot 0.53 \cdot \sqrt{f_{ck}} \cdot b_o \cdot d \\ &= 0.75 \times 0.53 \times \sqrt{27} \times 1400 \times 1903 \times 10^{-3} \\ &= 5502.827 \text{ kN} > S_u = 924.854 \text{ kN} \end{aligned} \quad \text{O.K.}$$

(4) 전단철근

- 수직 전단철근

$$\begin{aligned} S_v &= 200 \text{ mm} < d/5 = 380.6 \text{ mm} \text{ or } 400 \text{ mm} \\ A_v &= 794.4 \text{ mm}^2 > 0.0015 \cdot b_o \cdot S_v = 420.0 \text{ mm}^2 \\ &(\text{D } 16 \times 4 \text{ ea}) \end{aligned}$$

- 수평 전단철근

$$\begin{aligned} S_h &= 200 \text{ mm} < d/3 = 634 \text{ mm} \text{ or } 400 \text{ mm} \\ A_h &= 794.4 \text{ mm}^2 > 0.0025 \cdot b_o \cdot S_h = 700.0 \text{ mm}^2 \\ &(\text{D } 16 \times 4 \text{ ea}) \end{aligned}$$

- 전단철근의 전단강도 (콘.설 7.7.2)

$$\begin{aligned} \Phi \cdot V_s &= \Phi \left[\frac{A_v}{S_v} \left(\frac{1 + l_n/d}{12} \right) + \frac{A_{vh}}{S_h} \left(\frac{11 - l_n/d}{12} \right) \right] f_y \cdot d \\ &= 0.75 \left[\frac{794.4}{200} \left(\frac{1 + 1.062}{12} \right) + \frac{794.4}{200} \left(\frac{11 - 1.062}{12} \right) \right] \\ &\quad \times 300 \times 1903.0 \\ &= 1700.711 \text{ kN} \end{aligned}$$

- 공칭전단강도

$$\begin{aligned} \Phi \cdot V_n &= \Phi \cdot V_c + \Phi \cdot V_s \\ &= 5502.827 + 1700.711 = 7203.538 \text{ kN} < 22011.307 \text{ kN} \\ \therefore \Phi \cdot V_n &= 7203.538 > V_u = 924.854 \text{ kN} \end{aligned} \quad \text{O.K.}$$

4.6 3경간 연속부 검토

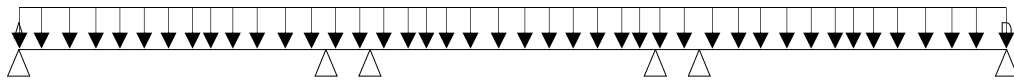
1차 고정하중 : BEAM 가설시 단순 BEAM으로 흡수

2차 고정하중 : 연석, 보도, 포장, 난간

본 계산에서는 2차 고정하중 및 활하중에 의해 발생하는 부모멘트에 대하여 설계한다.

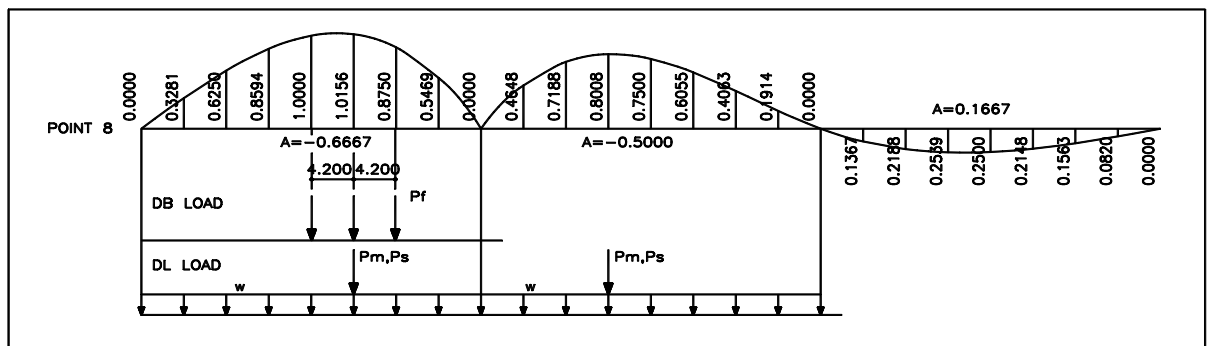
4.6.1 연속부 부모멘트 산정

(1) 2차 사하중 (3 @ 45.000m = 135.000m)



(2) 활하중

- DB24 (Pf = 24 kN , Pr = 96 kN)
- DL24 (wl = 12.7 kN/m , Pm = 108 kN)



(3) 충격계수

$$\begin{aligned}
 i &= 15 / (40 + L) \leq 0.3 \\
 &= 15 / (40 + 45.000) \\
 &= 0.176 \leq 0.3
 \end{aligned}$$

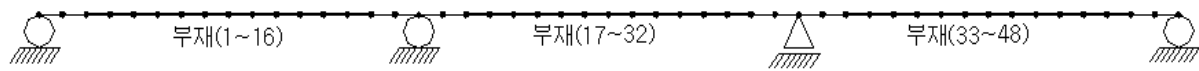
(4) 고정하중에 의한 부재력 산정

구 분	면적 (m ²)	개수 (ea)	단위중량 (kN/m ³)	하중 (kN/m)	비고
방호벽(좌)	0.501	1	25.000	12.525	
중분대	0.465	1	25.000	11.625	
포 장	1.140	1	23.500	26.778	
방호벽(우)	0.394	1	25.000	9.850	
방음판		1		2.000	
합 계				62.778	

$$\begin{aligned}
 \therefore M_d &= \sum A \times 0.1 \times \sum W \times L^2 \\
 &= (0.667 + 0.500 - 0.167) \times 0.1 \times 62.778 \times 2025.000 \\
 &= 12712.596 \text{ kN} \cdot \text{m}
 \end{aligned}$$

(5) 지점침하에 의한 휨모멘트

1) 모델링



2) 단면성질

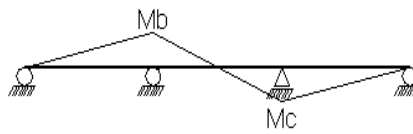
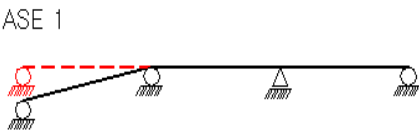
중앙부 합성단면	A(m ²)	I(m ⁴)
단면성질	1.5814	1.2345

3) 지점침하 하중(가정침하량 : 10mm)

지점침하 CASE

CASE별 B.M.D

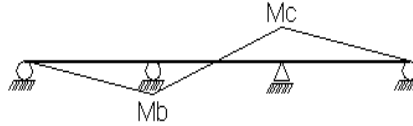
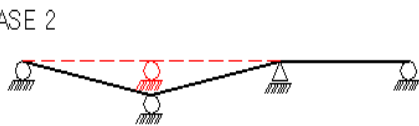
CASE 1



$$M_b = 242.110 \text{ kN} \cdot \text{m}$$

$$M_c = 60.530 \text{ kN} \cdot \text{m}$$

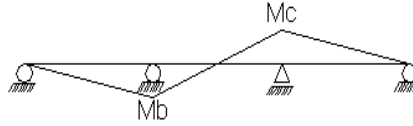
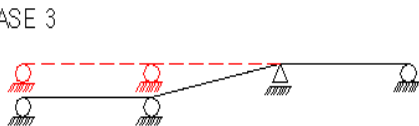
CASE 2



$$M_b = 544.740 \text{ kN} \cdot \text{m}$$

$$M_c = 363.160 \text{ kN} \cdot \text{m}$$

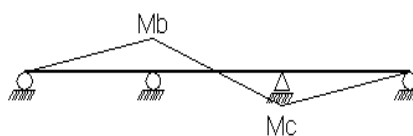
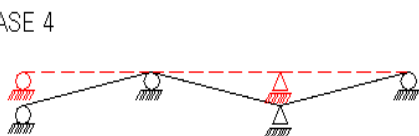
CASE 3



$$M_b = 302.630 \text{ kN} \cdot \text{m}$$

$$M_c = 302.630 \text{ kN} \cdot \text{m}$$

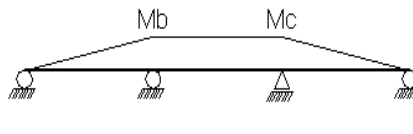
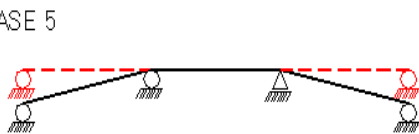
CASE 4



$$M_b = 605.270 \text{ kN} \cdot \text{m}$$

$$M_c = 605.270 \text{ kN} \cdot \text{m}$$

CASE 5



$$M_b = 181.580 \text{ kN} \cdot \text{m}$$

$$M_c = 181.580 \text{ kN} \cdot \text{m}$$

$$\therefore M_{d_max} = 605.270 \times 9 \text{ ea} = 5447.43 \text{ kN} \cdot \text{m}$$

(6) 활하중에 의한 부재력 산정

1) DB 24

$$\textcircled{1} \text{ Pr} = 192.0 \times 1.176 \times 6 \text{ 차선} = 1354.752 \text{ kN}$$

$$\textcircled{2} \text{ Pf} = 48.0 \times 1.176 \times 6 \text{ 차선} = 338.688 \text{ kN}$$

③ 영향선 증거값 계산

$$\text{Pf} = 0.875 + \{ (1.016 - 0.875) / 5.625 \} \times -1.43 = 0.839$$

$$\text{Pr} = 1.0156$$

$$\text{Pr} = 1.000 + \{ (1.016 - 1.000) / 5.625 \} \times -1.43 = 0.996$$

$$\begin{aligned} \text{ML} &= \{ 1354.752 \times (1.0156 + 0.996) \} \times 0.1 \times 45.000 + \\ &\quad (338.688 \times 0.839) \times 0.1 \times 45.000 \\ &= 13543.076 \text{ kN} \cdot \text{m} \end{aligned}$$

∴ 6 차로 이상 감소율 적용 : 75 %

$$\text{ML} = 13543 \times 0.750 = 10157.31 \text{ kN} \cdot \text{m}$$

2) DL 24

$$\textcircled{1} \text{ W} = 12.7 \times 1.176 \times 6 \text{ 차선} = 89.647 \text{ kN}$$

$$\textcircled{2} \text{ Pm} = 108 \times 1.176 \times 6 \text{ 차선} = 762.353 \text{ kN}$$

$$\begin{aligned} \text{ML} &= \{ 89.647 \times (0.667 + 0.500) \} \times 0.1 \times 2025.000 + \\ &\quad \{ 762.353 \times (1.016 + 0.801) \} \times 0.1 \times 45.000 \\ &= 27417.175 \text{ kN} \cdot \text{m} \end{aligned}$$

∴ 6 차로 이상 감소율 적용 : 75 %

$$\text{ML} = 27417.175 \times 0.750 = 20562.88 \text{ kN} \cdot \text{m}$$

(7) 크리프 및 건조수축에 의한 부재력 산정

합성후 BEAM의 소성변형이 바닥판에 의하여 구속되고, 콘크리트의 타설시기(재령) 차이에 의한 건조수축, 크리프가 상이하므로 내부응력이 발생한다. 본 검토에서는 공사진행시기는 다음과 같이 시행하는 것으로 가정한다.

- 바닥판 콘크리트 타설은 BEAM의 프리스트레스 도입시점에서 90 일 이내
- 바닥판 콘크리트 타설후 동바리 제거는 15일 이후

1. 2차응력 계산용 제정수 산정

1) 크리프 계수(Φ) (㉠ 도.설 4.2.3.3)

① 바닥판의 크리프 계수 (Φ_s, t' = 15 일, t = ∞일, RH = 70 %)

$$\Phi_s(t, t') = \Phi_0 \times \beta_c(t - t')$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$\begin{aligned}\Phi_{RH} &= 1 + (1 - 0.01 \times RH) / 0.10^3 \sqrt{h} \\ &= 1.46\end{aligned}$$

$$\text{여기서, } h = (2 \times A_c) / u$$

$$= (2 \times (\text{교폭} \times \text{슬래브두께})) / (2 \times (\text{교폭} + \text{슬래브두께}) - \text{거더개수} \times \text{거더상부폭})$$

$$\begin{aligned}&= \{ 2 \times 24470 \times 240 \} / \{ 2 \times 24470 + 240 \} \\ &\quad - 9 \times 800 \} = 278\end{aligned}$$

$$\beta(f_{cu}) = 16.8 / \sqrt{f_{cu}} = 2.84$$

$$\text{여기서, } f_{cu} = f_{ck} + 8 = 27 + 8 = 35$$

$$\beta(t') = 1 / \{ 0.1 + (t')^{0.2} \} = 1 / (15)^{0.2} = 0.55$$

$$\beta_c(t - t') = [(t - t') / \{ \beta_u + (t - t') \}]^{0.3} = 1.0$$

$$\begin{aligned}\text{여기서, } \beta_H &= 1.5 [1 + (0.012 RH)^{18}] h + 250 \\ &= 1.5 [1 + (0.070)^{18}] \times 278 + 250 \\ &= 685 \text{ 일} < 1500\text{일}\end{aligned}$$

$$\begin{aligned}\text{따라서, } \Phi_0 &= \Phi_{RH} \times \beta(f_{cu}) \times \beta(t') \\ &= 1.46 \times 2.84 \times 0.55 = 2.281\end{aligned}$$

$$\begin{aligned}\therefore \Phi_s(t, t') &= \Phi_0 \times \beta_c(t - t') \\ &= 2.281 \times 1 \\ &= 2.281\end{aligned}$$

② Beam의 크리프 계수 (Φ_b , $t' = 90$ 일, $t = \infty$ 일, $RH = 70\%$)

$$\Phi_b(t-t') = \Phi_0 \times \beta_c(t-t')$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$\Phi_{RH} = 1 + (1 - 0.01 \times RH) / 0.10^3 \sqrt{h} = 1.465$$

$$\text{여기서, } h = (2 \times A_c) / u$$

$$= (2 \times \text{거더단면적} \times \text{거더갯수}) / (\text{거더단면둘레} \times \text{거더갯수})$$

$$= (2 \times 9E+05 \times 9) / (7056 \times 9) = 268$$

$$\beta(f_{cu}) = 16.8 / \sqrt{f_{cu}} = 2.425$$

$$\text{여기서, } f_{cu} = f_{ck} + 8 \times 40 + 8 = 48$$

$$\beta(t') = 1 / \{0.1 + (t')^{0.2}\} = 1 / (90)^{0.2} = 0.39$$

$$\beta_c(t-t') = [(t-t') / \{\beta_u + (t-t')\}]^{0.3} = 1.0$$

$$\text{여기서, } \beta_H = 1.5 [1 + (0.012 RH)^{18}]h + 250$$

$$= 1.5 [1 + (0.070)^{18}] \times 268 + 250$$

$$= 669 \text{ 일} < 1500 \text{ 일}$$

$$\text{따라서, } \Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$= 1.465 \times 2.425 \times 0.39 = 1.389$$

$$\therefore \Phi_b(t, t') = \Phi_0 \times \beta_c(t-t')$$

$$= 1.389 \times 1 = 1.389$$

2) 건조수축률 (ϵ_{sh}) (도.설 4.2.3.4)

① 바닥판의 건조수축 계수 ($t_s = 15$ 일, $t = \infty$ 일, $RH = 70\%$)

$$\epsilon_{sh}(t, t_s) = \epsilon_{sho} \times \beta_s(t-t_s)$$

$$\epsilon_{sho} = \epsilon_s(f_{cu}) \times \beta_{RH}$$

$$\epsilon_s(f_{cu}) = [160 + 10 \beta_{sc}(9 - (f_{cu} / 10))] \times 10^{-6}$$

$$= [160 + 10 \beta_{sc}(35 / 10)] \times 10^{-6}$$

$$= 0.000435$$

$$\text{여기서, } \beta_{sc} = 5 ; 1 \text{종 시멘트}$$

$$f_{cu} = f_{ck} + 8 = 27 + 8 = 35$$

$$\beta_{RH} = -1.55 [1 - (RH / 100)^3] : 40\% \leq RH \leq 99\%$$

$$= -1.55 \times [1 - (70 / 100)^3]$$

$$= -1.02$$

$$\beta_s(t-t_s) = \sqrt{(t-t_s) / \{0.035h^2 + (t-t_s)\}} = 1$$

$$\text{여기서, } h = 2A_c / u = (2 \times (\text{교폭} \times \text{슬래브두께})) / (2 \times (\text{교폭} + \text{슬래브두께}) - \text{거더개수} \times \text{거더상부폭})$$

$$= 278$$

$$\text{따라서, } \epsilon_{sho} = \epsilon_s(f_{cu}) \times \beta_{RH}$$

$$= 0.000435 \times -1.02 = -0.000443$$

$$\therefore \epsilon_{sh}(t, t_s) = \epsilon_{sho} \times \beta_s(t-t_s)$$

$$= -0.000443 \times 1 = -0.000443$$

② Beam의 건조수축 계수 ($t_s = 90$ 일, $t = \infty$ 일, $RH = 70\%$)

$$\epsilon_{sh}(t, t_s) = \epsilon_{sho} \times \beta_s(t - t_s)$$

$$\epsilon_{sho} = \epsilon_s(f_{cu}) \times \beta_{RH}$$

$$\begin{aligned}\epsilon_s(f_{cu}) &= [160 + 10 \beta_{sc}(9 - (f_{cu} / 10))] \times 10^{-6} \\ &= [160 + 10 \beta_{sc}(9 - (48 / 10))] \times 10^{-6} \\ &= 0.00037\end{aligned}$$

여기서, $\beta_{sc} = 5$; 1종 시멘트

$$f_{cu} = f_{ck} + 8 = 48$$

$$\begin{aligned}\beta_{RH} &= -1.55 [1 - (RH / 100)^3] : 40\% \leq RH \leq 99\% \\ &= -1.55 \times [1 - 70 / 100]^3 \\ &= -1.02\end{aligned}$$

$$\beta_s(t - t_s) = \sqrt{(t - t_s) / \{0.035h^2 + (t - t_s)\}} = 1$$

$$\begin{aligned}\text{여기서, } h &= 2Ac / u = (2 \times \text{거더단면적} \times \text{거더갯수}) / (\text{거더단면둘레} \times \text{거더개수}) \\ &= 268\end{aligned}$$

$$\text{따라서, } \epsilon_{sho} = \epsilon_s(f_{cu}) \times \beta_{RH}$$

$$= 0.00037 \times -1.018 = -0.000377$$

$$\therefore \epsilon_{sh}(t, t_s) = \epsilon_{sho} \times \beta_s(t - t_s)$$

$$= -0.000377 \times 1$$

$$= -0.000377$$

3) 제정수의 산정결과

구 분	바닥판	Beam	비 고
크리프 계수	2.281	1.389	
건조수축 계수	-0.000443	-0.000377	

2. 2차응력에 의한 부재력 산정

- 단면제원

상부바닥판 유효폭 : 2750 mm (5.4 바닥판 합성단면)
강선도심까지 거리 : 782 mm (5.2 순단면)
거더상연까지 거리 : 720 mm (5.4 바닥판 합성단면)
슬래브중심까지 거리 : $720 + 240 / 2 = 840$ mm

- 건조수축에 의한 부재력

바닥판 건조수축율 : 0.000443
Beam 건조수축율 : 0.000377

* 작용부재력

바닥판 면적 : $2750 \times 240 = 660000 \text{ mm}^2$
 $P_c = (\epsilon_{cs} - \epsilon_{cp}) E_c A_s (4E-04 - 4E-04) \times 27804 \times 7E+05 = 1211142 \text{ N}$
 $M_c = P_c \times y_c = 1211142 \times 840 = 1017359280 \text{ N} \cdot \text{mm} = 1017.359 \text{ kN} \cdot \text{m}$
 $M_c = 0.714 \times 1017.359 = 726.685 \text{ kN} \cdot \text{m}$

- 크리프에 의한 부재력

* 프리스트레스의 계산

프리스트레스력은 손실이 일어난 후 사용하중 상태에서 최대 인장력으로 계산한다.

$$P = 0.8 \cdot f_{py} \cdot A_p = 0.8 \times 1600 \times 1185 = 1516800 \text{ N}$$

$$w = (8 \times P \times e) / \ell^2$$
$$= (8 \times 1516800 \times 782) / 45000^2$$
$$= 23.430 \text{ N/mm} = 23.430 \text{ kN/m}$$

따라서, 구조계 변화에 따라 prestress에 의하여 내부지점부에 발생하는 모멘트

$$\therefore M_{ps} = W \times \ell^2 / 10 = 4744.575 \text{ kN} \cdot \text{m}$$

* 작용부재력

$$M = - (M_2 - M_1) \times (1 - e^{-\theta})$$

$$M_1 = M_d = \text{자중} + \text{합성전} + \text{합성후} \text{ (8. 설계단면력 집계 참조)}$$

$$M_1 = M_d = 8605.7 + 5592.6 + 2585.600$$

$$M_2 = M_{ps} = 4744.575 \text{ kN} \cdot \text{m}$$

$$\theta = \theta_s - \theta_i \quad 2.281 - 1.389 = 0.892$$

$$= (2585.6 - 4744.575) \times (1 - e^{-0.916}) = 1274.151 \text{ kN} \cdot \text{m}$$

구 분	건조수축	크리프
2차 하중	726.685	1274.151

(8) 부재력의 합계

$$\sum Mu = M - w \times a^2 / 8 \quad (\text{단 } \sum Mu \geq 0.9M) \quad (\text{도로교설계기준 2010 p.4-188})$$

여기서,

$\sum Mu$: 연속부의 설계 휨모멘트

M : 연속부의 휨모멘트

$$w = R / a$$

R : 연속부의 반력

a : 단면의 도심위치에서의 반력의 교축방향 가상 분포폭

CASE 1.

하중 조합 : 1.3 고정하중 + 2.15 활하중

$$\begin{aligned} \sum Mu &= 1.3 \times 12712.6 + 2.15 \times 20562.9 = 60736.6 \text{ kN} \cdot \text{m} \\ &= (1.3 \times 12712.6 + 2.15 \times 20562.9) - 6848.232 = 53888.3 \text{ kN} \cdot \text{m} \end{aligned}$$

$$\therefore Mu = 60736.6 / 24.470 = 2482.1 \text{ kN} \cdot \text{m} / \text{m}$$

CASE 2.

하중 조합 : 1.3 고정하중 + 1.3 활하중 + 1.3 (지점침하 + 크리프 + 건조수축)

$$\begin{aligned} \sum Mu &= 1.3 \times 12712.6 + 1.3 \times 20562.9 + 1.3 \times 7448.3 = 52940.9 \text{ kN} \cdot \text{m} \\ &= (1.3 \times 12712.6 + 1.3 \times 20562.9 + 1.3 \times 7448.3) - 6848.232 \\ &= 46092.6 \text{ kN} \cdot \text{m} \end{aligned}$$

$$\therefore Mu = 52940.9 / 24.470 = 2163.5 \text{ kN} \cdot \text{m} / \text{m}$$

$$\therefore \text{설계휨모멘트} = \text{MAX}(\text{CASE1}, \text{CASE2}) = 2482.083 \text{ kN} \cdot \text{m} / \text{m}$$

4.6.2 철근량 산정

(1) 설계조건

- 1) 설계휨모멘트 : $M_u = 2482082944.993 \text{ (N} \cdot \text{mm)}$
- 2) 단면치수 : $H = 1973.0 \text{ (mm)}$, $b = 1000.0 \text{ (mm)}$
 $d = 1843.0 \text{ (mm)}$, $d' = 130.0 \text{ (mm)}$
- 3) 재료의 성질 : $f_{ck} = 27 \text{ MPa}$, $f_y = 400 \text{ MPa}$
- 4) 계수 : $\phi_f = 0.85$, $k_1 = 0.85$

(2) 필요 철근량

$$a = A_s \cdot f_y / 0.85 \cdot f_{ck} \cdot b = 0.0174 A_s$$

$$M_u = \phi \cdot A_s \cdot f_y \cdot (d - a/2)$$

$$-2.963 A_s^2 + 626620 A_s - 2482082944.993 = 0 \text{ 에서}$$

$$A_s(\text{req}) = 4038.172 \text{ (mm}^2\text{)}$$

$$\text{단면철근비} : P = A_s / (b \times d) = 0.0022$$

$$\text{최대철근비} : P_{\max} = 0.714 \times 0.85 \times k_1 \times (f_{ck}/f_y) \times (600/(600+f_y)) = 0.0209$$

$$\text{최소철근비} : P_{\min} = 1.4/f_y = 0.0035$$

$$\begin{aligned} \text{① } A_s(\text{req}) &= 4038.172 \\ \text{② } A_s(\text{min}) &= 6450.500 \\ \text{③ } 4/3 \times A_s &= 5384.229 \end{aligned} \quad \therefore A_s = 5384.23 \text{ mm}^2 \text{ 이상 사용}$$

(3) 사용 철근량

$$1 \text{ 단 배근 철근간격: } 125 \quad N = 16$$

$$\text{① } H \text{ 22 @ } 125 = 3096.800 \text{ mm}^2$$

$$\text{② } H \text{ 22 @ } 125 = 3096.800 \text{ mm}^2$$

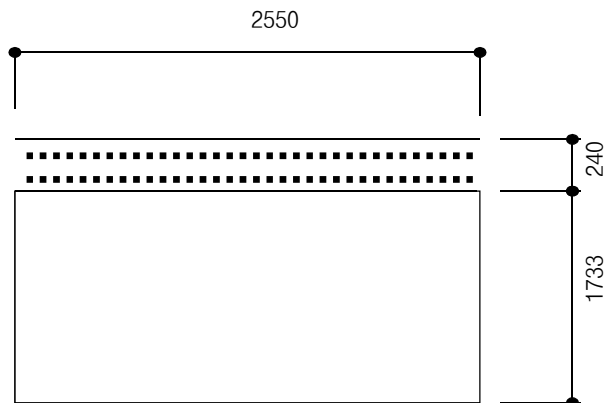
$$\Sigma = 6193.600 \text{ mm}^2 \quad \mathbf{0.K}$$

(4) 설계휨강도

$$\phi_f M_n = 0.85 \times A_s \times f_y \times (d - a/2) = 3767.372 \text{ kN} \cdot \text{m}$$

$$a = A_s \cdot f_y / (0.85 \cdot f_{ck} \cdot b) = 107.949 \text{ mm}$$

$$\therefore \phi_f M_n = 3767.372 \text{ kN} \cdot \text{m} > M_u = 2482.083 \text{ kN} \cdot \text{m} \quad \mathbf{0.K}$$



4.6.3 주장을 검토 - 지점부 바닥판 교축 방향 보강 철근 산정

* 바닥판 콘크리트 단면적의 1.5% 이상의 교축 방향 철근 배근

* 주장을 : 0.0035 mm/mm^2 이상 (주장을 = 교축 방향 철근의 총주변장 / 콘크리트 단면적)

* $A_c = 1000 \times 240 = 240,000 \text{ mm}^2$

* $A_{s'} = 240000 \times 0.015 = 3600.0 \text{ mm}^2$

* 사용 철근량

위 치	직 경	간 격(mm)	면 적(mm^2)	갯 수(EA)	총 면 적(mm^2)
1 단	H 22	125	387.1	8	3096.8
2 단	H 22	125	387.1	8	3096.8
			Σ	16	6193.600

* $A_s = 6193.600 \text{ mm}^2 > 3600.0 \text{ mm}^2$ **0.K**

* 철근직경 = 22.20 mm

* 주 장 을 = $\pi \times 22.20 \times 16 / 240000 = 0.005 > 0.0035 \text{ mm/mm}^2$ **0.K**

4.6.4 사용성 검토

(1) 균열 검토

$$\begin{aligned}
 M_{\max} &= 1359.85 \text{ kN} \cdot \text{m/m} && (\text{사용하중에 의한 단면력}) \\
 f_{ck} &= 27 \text{ MPa} && H = 1973.00\text{mm} \quad d = 1843.00\text{mm} \\
 f_y &= 400 \text{ MPa} && B = 1000.00\text{mm} \quad \text{피복두께} = 130.00\text{mm} \\
 P &= A_s / (b \times d) = 0.0034 \\
 n_p &= 0.02781 \\
 k &= -n_p + \sqrt{\{(n_p)^2 + 2n_p\}} \\
 &= 0.20966 \\
 j &= 1 - k / 3 = 0.9301 \\
 f_s &= M_{\max} / (p \times j \times b \times d^2) = 128.082 \text{ MPa}
 \end{aligned}$$

$$\begin{aligned}
 \text{As-use : } & \left[\begin{array}{ll} H 22 & @ 125 = 3096.80 \\ H 22 & @ 125 = 3096.80 \end{array} \right. \quad \begin{array}{l} \text{철근간격} = 125.00\text{mm} \\ N = 16 \\ n = 8 \end{array} \quad (2 \text{ 단 배근}) \\
 d_c &= 60.00\text{mm} \quad (\text{슬래브 상면피복}) \\
 R &= 1.35 \quad (\text{슬래브})
 \end{aligned}$$

- 철근의 최대 중심간격

$$\begin{aligned}
 C_c &= z - H_n / 2 \\
 &= 49 \text{ mm} \\
 &\text{여기서 } C_c ; \text{인장철근이나 긴장재의 표면과 콘크리트 표면사이의 두께(mm)} \\
 S_{\min} &= 375 \times (210 / F_{s\max}) - 2.5 C_c \\
 &= 492.343 \text{ mm} \\
 &300 \times (210 / F_{s\max}) \\
 &= 491.874 \text{ mm} \\
 S_a &\text{는 작은 값인 } 491.874 \text{ mm} \text{ 를 적용} \\
 S &= 125.000 \text{ mm} \leq (= 491.874 \text{ mm}) \quad \mathbf{O.K}
 \end{aligned}$$

(2) 처짐 검토

$$\begin{aligned}
 f_y &= 400 \text{ MPa} \\
 T_{\min} &= L/28 \quad \text{시간} = 2.55\text{m} \\
 &= 0.091 \\
 &= 91.07\text{mm} < T_{\text{use}} = 1973.00\text{cm}
 \end{aligned}$$

∴ 처짐 검토 생략

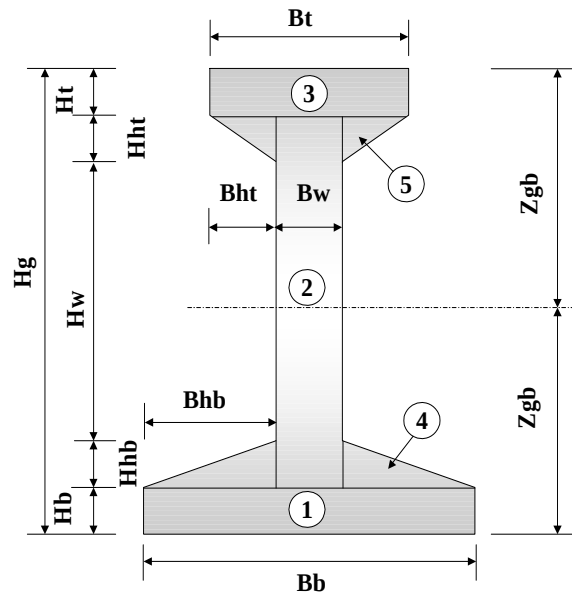
(3) 피로 검토

$$\begin{aligned}
 M_L &= 840.330 \text{ kN} \cdot \text{m/m} \quad (\text{SD40 일때 철근응력 범위} = 150\text{MPa}) \\
 f_y &= M_L / (p \times j \times b \times d^2) = 79.149 \text{ MPa} < 150 \text{ MPa}
 \end{aligned}$$

O.K

5. 단 면 성 질

5.1 총 단 면

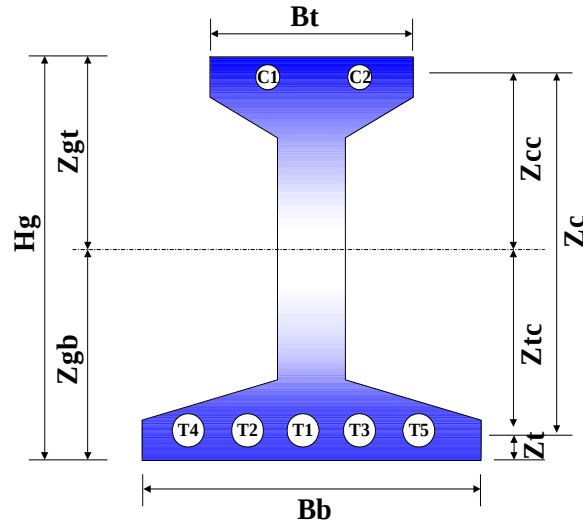


< 단위 : m >

요 소	B × H	A	z	A × z	A × z ²	I _o
① 하부플랜지	1.100 × 0.300	0.33000	0.150	0.04950	0.00743	0.002475
② 복 부	0.200 × 1.600	0.32000	1.100	0.35200	0.38720	0.068267
③ 상부플랜지	0.800 × 0.200	0.16000	2.000	0.32000	0.64000	0.000533
④ 하부현치	0.450 × 0.200	0.09000	0.367	0.03300	0.01210	0.000200
⑤ 상부현치	0.300 × 0.150	0.04500	1.850	0.08325	0.15401	0.000056
Σ 합 계		0.94500	0.887	0.83775	1.20074	0.071531

- 거더하단에서 중립축까지의 거리(z_{gb}) = $\sum(A \times z) / \sum A = -0.886508 \text{ m}$
- 거더상단에서 중립축까지의 거리(z_{gt}) = $H_g - Z_{gb} = 1.213492 \text{ m}$
- 중립축에 대한 단면 2차모멘트(I_{yy}) = $\sum I_o + \sum(A \times z^2) - \sum A \times z_{gb}^2 = 0.529597 \text{ m}^4$

5.2 순 단 면



▷ PS 강봉 쉬스

< 단위 : m >

번호	직경(mm)	A	z	$A \times z$	$A \times z^2$	I_o
C1	55	0.00238	1.975	0.00469	0.00927	4.492E-07
C2	55	0.00238	1.975	0.00469	0.00927	4.492E-07
Σ		0.00475	1.975	0.00938	0.01853	8.984E-07

- 쉬스 도심에 대한 단면 2차모멘트(I_{yy}) = $\sum I_o + \sum (A \times z^2) - \sum A \times z_c^2$: 0.000001 m⁴

▷ PS 강연선 쉬스

< 단위 : m >

번호	직경(mm)	A	z	$A \times z$	$A \times z^2$	I_o
T1	70	0.00385	0.115	0.00044	0.00005	1.179E-06
T2	90	0.00636	0.125	0.00080	0.00010	3.221E-06
T3	90	0.00636	0.125	0.00080	0.00010	3.221E-06
T4	90	0.00636	0.125	0.00080	0.00010	3.221E-06
T5	90	0.00636	0.125	0.00080	0.00010	3.221E-06
Σ		0.02930	0.124	0.00362	0.00045	1.406E-05

- 쉬스 도심에 대한 단면 2차모멘트(I_{yy}) = $\sum I_o + \sum (A \times z^2) - \sum A \times z_t^2$: 0.000014 m⁴

▷ 순단면

< 단위 : m >

요 소	A	z	$A \times z$	$A \times z^2$	I_o
총 단 면	0.94500	0.887	0.83775	0.74267	0.529597
PS 강봉 쉬스	-0.00475	1.975	-0.00938	-0.01853	-0.000001
PS 강연선 쉬스	-0.02930	0.124	-0.00362	-0.00045	-0.000014
Σ	0.91095	0.905	0.82474	0.72369	0.529581

- 거더하단에서 중립축까지의 거리(z_{gb}) = $\sum (A \times z) / \sum A$ = -0.905362 m

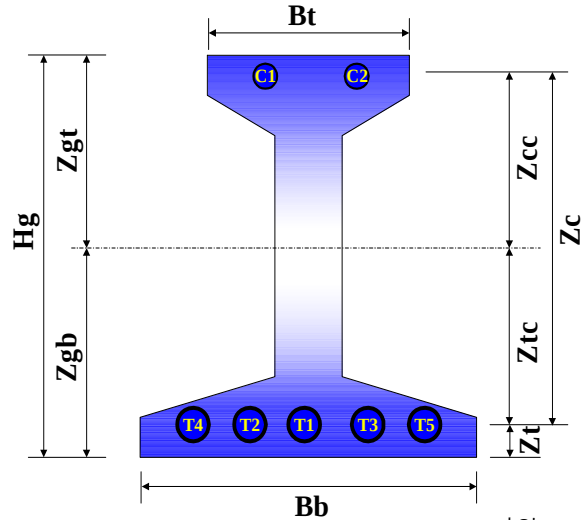
- 거더상단에서 중립축까지의 거리(z_{gt}) = $H_g - Z_{gb}$ = 1.194638 m

- PS 강봉 쉬스 도심에서 중립축까지의 거리(z_{cc}) = $z_c - z_{gb}$ = 1.069638 m

- PS 강연선 쉬스 도심에서 중립축까지의 거리(z_{tc}) = $z_{gb} - z_t$ = -0.781675 m

- 중립축에 대한 단면 2차모멘트(I_{yy}) = $\sum I_o + \sum (A \times y^2) - \sum A \times z_{gb}^2$: 0.506581 m⁴

5.3 PS강재 환산단면



▷ PS 강봉

< 단위 : m >

번호	직경(mm)	A	z	A×z	A×z ²	lo
C1	40	0.00126	1.975	0.00248	0.00490	1.257E-07
C2	40	0.00126	1.975	0.00248	0.00490	1.257E-07
Σ		0.00251	1.975	0.00497	0.00981	2.513E-07

- PS 강봉 도심에 대한 단면 2차모멘트(I_{yy}) = $\sum lo + \sum (A \times z^2) - \sum A \times zc^2 = 2.513E-07 \text{ m}^4$

▷ PS 강연선

< 단위 : m >

번호	가닥수	A	y	A×z	A×z ²	lo
T1	7	0.00097	0.115	0.00011	0.00001	7.501E-08
T2	15	0.00208	0.125	0.00026	0.00003	3.444E-07
T3	15	0.00208	0.125	0.00026	0.00003	3.444E-07
T4	15	0.00208	0.125	0.00026	0.00003	3.444E-07
T5	15	0.00208	0.125	0.00026	0.00003	3.444E-07
Σ		0.00929	0.124	0.00115	0.00014	1.453E-06

- PS 강연선 도심에 대한 단면 2차모멘트(I_{yy}) = $\sum lo + \sum (A \times z^2) - \sum A \times zt^2 = 1.5398E-06 \text{ m}^4$

▷ 단면의 합성

< 단위 : m >

요 소	n	A	z	A×z	A×z ²	lo
순 단 면	1.000	0.91095	0.905	0.82474	0.74669	0.506581
PS 강봉	6.474	0.01628	1.975	0.03214	0.06349	1.627E-06
PS 강연선	6.474	0.06016	0.124	0.00746	0.00092	9.968E-06
Σ		0.98739	0.875	0.86434	0.81110	0.506593

- 거더하단에서 중립축까지의 거리(z_{gb}) = $\sum (A \times z) / \sum A = -0.875382 \text{ m}$

- 거더상단에서 중립축까지의 거리(z_{gt}) = $H_g - Z_{gb} = 1.224618 \text{ m}$

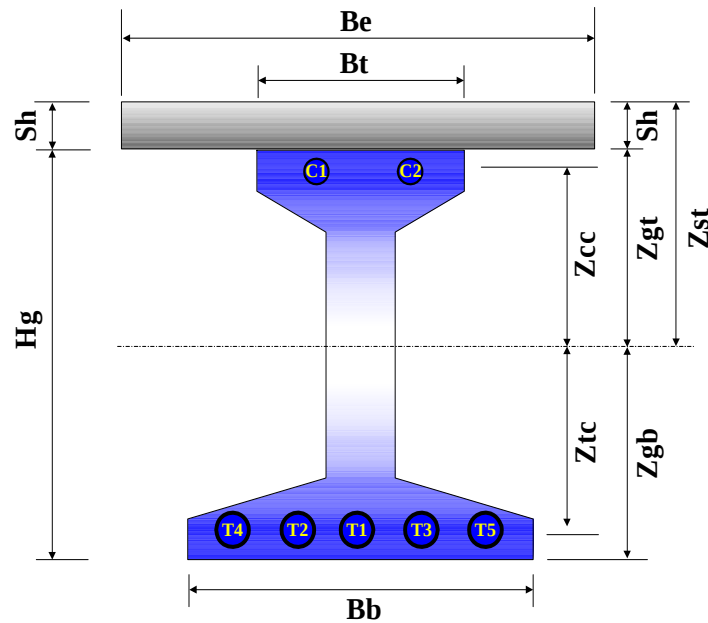
- PS 강봉 도심에서 중립축까지의 거리(z_{cc}) = $z_c - z_{gb} = 1.099618 \text{ m}$

- PS 강연선 도심에서 중립축까지의 거리(z_{tc}) = $z_{gb} - z_t = -0.751426 \text{ m}$

- 중립축에 대한 단면 2차모멘트(I_{yy}) = $\sum lo + \sum (A \times y^2) - \sum A \times z_{gb}^2 = 0.561061 \text{ m}^4$

5.4 바닥판 합성단면

5.4.1 G1 거더



- 유효폭 산정(도로교 설계기준 4.2.2.6)

※ b1 = 복부폭을 포함한 바닥판 캔틸레버 길이 = 1.417 m

거더 경간의 1/12 + b1 = 5.084 m

6 × 바닥판 두께 + b1 = 2.857 m

인접거더와의 순경간의 1/2 + b1 = 2.692 m

압축플랜지의 유효폭(최소값) = 2.692 m

< 단위 : m >

요 소	n	A	z	A×z	A×z ²	lo
PS강재 환산단면	1.000	0.98739	0.875	0.86434	0.75663	0.561061
바닥판	0.900	0.58147	2.220	1.29087	2.86573	0.002791
Σ		1.56886	1.374	2.15521	3.62236	0.563852

- 거더하단에서 중립축까지의 거리(zgb) = $\sum(A \times z) / \sum A = -1.373741$ m

- 거더상단에서 중립축까지의 거리(zgt) = $H_g - Z_{gb} = 0.726259$ m

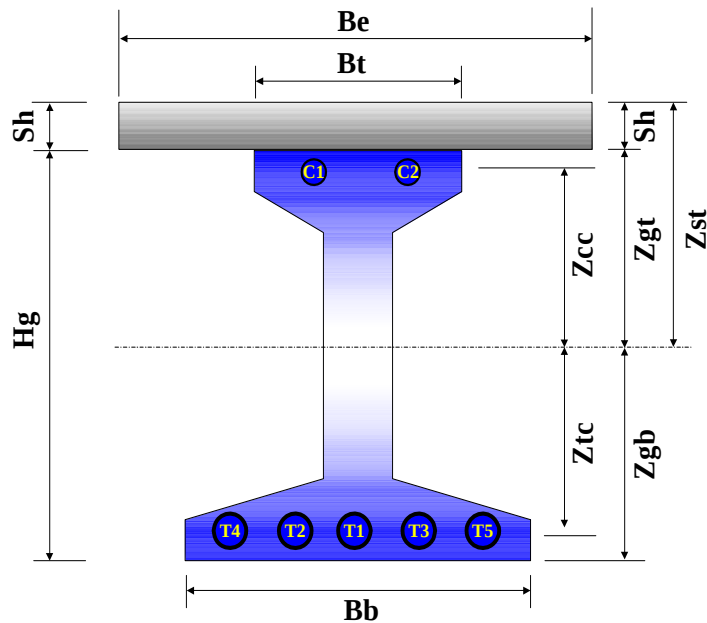
- PS 강봉 도심에서 중립축까지의 거리(zcc) = $z_c - z_{gb} = 0.601259$ m

- PS 강연선 도심에서 중립축까지의 거리(ztc) = $z_{gb} - z_t = -1.249786$ m

- 바닥판 상연에서 중립축까지의 거리(zst) = $z_{gt} + sh = 0.966259$ m

- 중립축에 대한 단면 2차모멘트(Iyy) = $\sum I_o + \sum(A \times y^2) - \sum A \times z_{gb}^2 = 1.225506$ m⁴

5.4.2 G2~G8 거더



- 유효폭 산정(도로교 설계기준 4.2.2.6)

거더 경간의 1/4 = 11.00 m

12 × 바닥판 두께 + 복부폭 = 3.080 m

양쪽 바닥판의 중심간 거리 = 2.750 m

압축플랜지의 유효폭(최소값) = 2.750 m

< 단위 : m >

요 소	n	A	z	A × z	A × z ²	lo
PS강재 환산단면	1.000	0.98739	0.875	0.86434	0.75663	0.561061
바닥판	0.900	0.59400	2.220	1.31868	2.92747	0.002851
Σ		1.58139	1.380	2.18302	3.68410	0.563912

- 거더하단에서 중립축까지의 거리(zgb) = $\Sigma(A \times z) / \Sigma A =$ -1.380445 m

- 거더상단에서 중립축까지의 거리(zgt) = $H_g - Z_{gb} =$ 0.719555 m

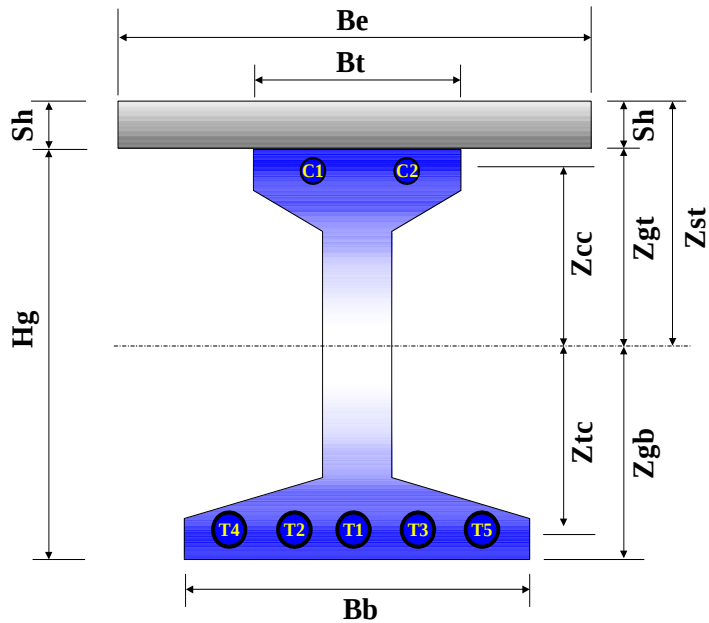
- PS 강봉 도심에서 중립축까지의 거리(zcc) = $z_c - z_{gb} =$ 0.594555 m

- PS 강연선 도심에서 중립축까지의 거리(ztc) = $z_{gb} - z_t =$ -1.256490 m

- 바닥판 상연에서 중립축까지의 거리(zst) = $z_{gt} + sh =$ 0.959555 m

- 중립축에 대한 단면 2차모멘트(I_{yy}) = $\Sigma lo + \Sigma(A \times y^2) - \Sigma A \times z_{gb}^2$ 1.234467 m⁴

5.4.3 G9 거더



- 유효폭 산정(도로교 설계기준 4.2.2.6)

※ b1 = 복부폭을 포함한 바닥판 캔틸레버 길이 = 1.253 m

$$\text{거더 경간의 } 1/12 + b1 = 4.920 \text{ m}$$

$$6 \times \text{바닥판 두께} + b1 = 2.693 \text{ m}$$

$$\text{인접거더와의 순경간의 } 1/2 + b1 = 2.528 \text{ m}$$

$$\text{압축플랜지의 유효폭(최소값)} = 2.528 \text{ m}$$

< 단위 : m >

요 소	n	A	z	A×z	A×z ²	lo
PS강재 환산단면	1.000	0.98739	0.875	0.86434	0.75663	0.561061
바닥판	0.900	0.54605	2.220	1.21223	2.69114	0.002621
Σ		1.53344	1.354	2.07657	3.44777	0.563682

$$\text{- 거더하단에서 중립축까지의 거리(zgb)} = \Sigma(A \times z) / \Sigma A = -1.354192 \text{ m}$$

$$\text{- 거더상단에서 중립축까지의 거리(zgt)} = Hg - Zgb = 0.745808 \text{ m}$$

$$\text{- PS 강봉 도심에서 중립축까지의 거리(zcc)} = zc - zgb = 0.620808 \text{ m}$$

$$\text{- PS 강연선 도심에서 중립축까지의 거리(ztc)} = zgb - zt = -1.230237 \text{ m}$$

$$\text{- 바닥판 상연에서 중립축까지의 거리(zst)} = zgt + sh = 0.985808 \text{ m}$$

$$\text{- 중립축에 대한 단면 2차모멘트(Iyy)} = \Sigma lo + \Sigma(A \times y^2) - \Sigma A \times zgb^2 = 1.199381 \text{ m}^4$$

5.5 단면성질 요약

5.5.1 G1 거더

< 단위 : m >

구 분	A	l _{yy}	z _{st}	z _{gt}	z _{gb}	z _{cc}	z _{tc}
총 단 면	0.94500	0.529597		1.213	-0.887		
순 단 면	0.91095	0.506581		1.195	-0.905	1.070	-0.782
PS강재 환산단면	0.98739	0.561061		1.225	-0.875	1.100	-0.751
바닥판 합성단면	1.56886	1.225506	0.966	0.726	-1.374	0.601	-1.250

5.5.2 G2~G8 거더

< 단위 : m >

구 분	A	l _{yy}	z _{st}	z _{gt}	z _{gb}	z _{cc}	z _{tc}
총 단 면	0.94500	0.529597		1.213	-0.887		
순 단 면	0.91095	0.506581		1.195	-0.905	1.070	-0.782
PS강재 환산단면	0.98739	0.561061		1.225	-0.875	1.100	-0.751
바닥판 합성단면	1.58139	1.234467	0.960	0.720	-1.380	0.595	-1.256

5.5.3 G9 거더

< 단위 : m >

구 분	A	l _{yy}	z _{st}	z _{gt}	z _{gb}	z _{cc}	z _{tc}
총 단 면	0.94500	0.529597		1.213	-0.887		
순 단 면	0.91095	0.506581		1.195	-0.905	1.070	-0.782
PS강재 환산단면	0.98739	0.561061		1.225	-0.875	1.100	-0.751
바닥판 합성단면	1.53344	1.199381	0.986	0.746	-1.354	0.621	-1.230

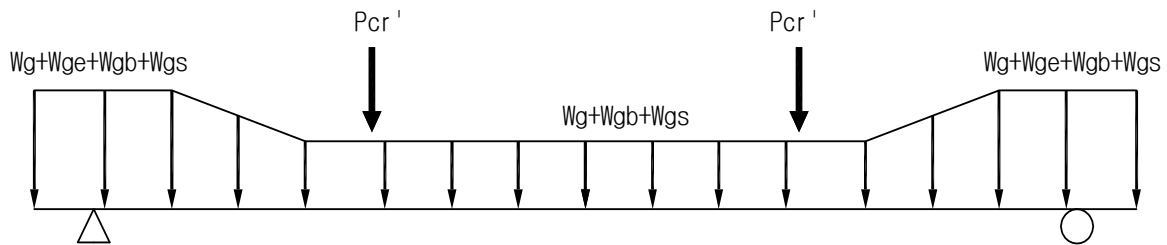
6. 설 계 하 중

6.1 거 더 자 중

6.1.1 하중산정 (모든거더에 대해 동일하게 작용)

구 분	산 출 근 거
거더본체 (Wg)	$A_{net} \times w_{gc} = 0.911 \times 25000 = 22774 \text{ N/m}$
단부보강 (Wge)	$A_{var} \times w_{gc} = 0.835 \times 25000 = 20875 \text{ N/m}$
가 로 보 (Pcr')	$A_{var} \times L_{cr} \times w_{gc} \times e_a = 0.835 \times 1 \times 25000 \times 1 \text{ EA} = 12525 \text{ N}$
강 봉 (Wgb)	$w_{1cm} \times C_{ea} = 102.1 \times 2 \text{ EA} = 204 \text{ N/m}$
T1 강연선 (Wgs1)	$w_{1tm} \times T_{ea} = 11.01 \times 7 \text{ EA} = 77 \text{ N/m}$
T2~T5 강연선 (Wgs2)	$w_{2tm} \times T_{ea} = 11.01 \times 4 \text{ EA} \times 15 \text{ EA} = 661 \text{ N/m}$

6.1.2 모델링 (저항단면 : 순단면)



6.2 합성전 고정하중

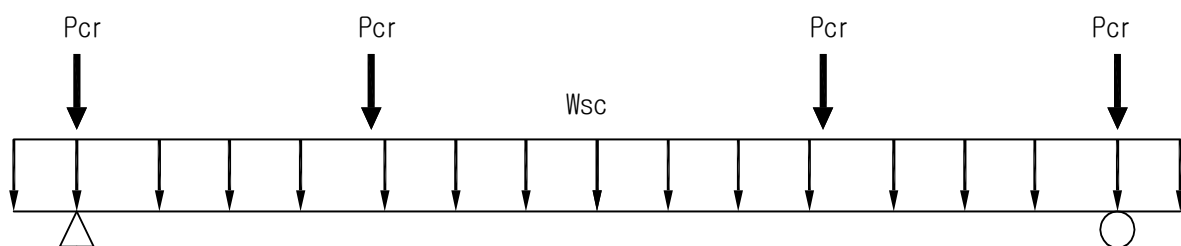
6.2.1 바닥판 콘크리트(Wsc)

- (1) G1 거더 : $0.240 \times 2.692 \times 25000 = 16152 \text{ N/m}$
- (2) G2~G8 거더 : $0.240 \times 2.750 \times 25000 = 16500 \text{ N/m}$
- (3) G9 거더 : $0.240 \times 2.528 \times 25000 = 15168 \text{ N/m}$

6.2.2 가로보 콘크리트(Pcr)

- (1) G1 거더 : $0.300 \times 1.733 \times 1.38 \times 25000 = 17875 \text{ N}$
- (2) G2~G8 거더 : $0.300 \times 1.733 \times 2.75 \times 25000 = 35750 \text{ N}$
- (3) G9 거더 : $0.300 \times 1.733 \times 1.38 \times 25000 = 17875 \text{ N}$

6.2.3 모델링 (저항단면 : PS강재 환산단면)



6.3. 합성후 고정하중(AL단계)

(1) 좌측 캔틸레버 하중

- 방호벽(좌) : $A \times w = 0.618 \times 25000 = 15449 \text{ N/m}$

(2) 우측 캔틸레버 하중

- 방호벽(우) : $A \times w = 0.394 \times 25000 = 9839 \text{ N/m}$

(3) 중앙부 하중

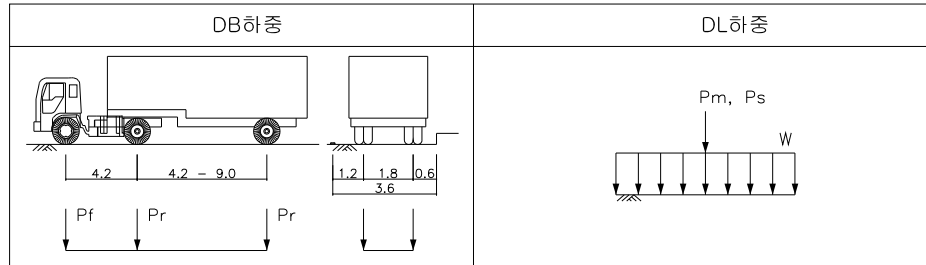
- 콘크리트포장 : $t \times w = 0.050 \times 23500 = 1175 \text{ N/m}^2$

(4) 기타 하중

	위치	하중크기
1) 중분대	12.320m	10540N/m
2) 방음벽(좌)	0.230m	2000N/m
3) 내측풍하중1	-1.380m	4980N/m
4) 내측풍하중2	1.840m	-4980N/m

6.4. 활하중(LL단계)

- (1) 차 로 수 : 6 차로
- (2) 차 로 폭 : 3.6 m
- (3) 적용하중(1등급)



- 1) DB24 : DBr = 96.00 kN
DBf = 24.00 kN
- 2) DL24 : DLw = 12.70 kN/m
: DLm = 108.00 kN
: DLs = 156.00 kN

7. 하중 횡분배계수의 산정

▶ 직교 이방성 판이론에 기초한 Guyon-Massonnet Method에 의해 하중의 횡방향 분배계수를 산정한다

7.1. 분배요소의 강성 및 단면계수요약(평균치)

	주거더(g)	바닥판(s)
단면2차모멘트(I)	1.242219	0.001152
탄 성 계 수 (E)	30891	27804
전단 탄성계수(G)	13235	11913
비틀림 상수 (J)	0.025667	0.003911
요소 중심간격(V)	2.750	1.000

7.2. 격자구조의 휨강성 및 비틀림 영향계수

7.2.1. 휨강성 영향계수(Θ)

- (1) 교량폭의 1/2 ; $B_b = 12.235\text{m}$
- (2) 거더의 평균지간 ; $L = 44.000\text{m}$
- (3) 주거더의 휨강성 ; $C_x = E_g \times I_g / V_g = 13953.986$
- (4) 바닥판의 휨강성 ; $C_y = E_s \times I_s / V_s = 32.030$
- (5) 휨강성 영향계수 ; $\Theta = (B_b / L) \times \sqrt[4]{ (C_x / C_y) } = 1.270$

7.2.2. 비틀림강성 영향계수(α)

- (1) 주거더의 비틀림강성 ; $D_x = G_g \times J_g / V_g = 123.532$
- (2) 바닥판의 비틀림강성 ; $D_y = G_s \times J_s / V_s = 46.590$
- (3) 비틀림 영향계수 ; $\alpha = (D_x + D_y) / 2\sqrt{ (C_x \times C_y) } = 0.127$

7.3. Y.Guyon & C.Massonnet Method

7.3.1. a=0일 때의 영향선 종거(K0)

$$K0 = 2 \times \lambda \times B_b \times [A] \times [B] \times [C]$$

$$[A] = \begin{bmatrix} \cos(\lambda \cdot y) \cdot \cosh(\lambda \cdot y) \\ \cos(\lambda \cdot y) \cdot \sinh(\lambda \cdot y) \\ \sin(\lambda \cdot y) \cdot \cosh(\lambda \cdot y) \\ \sin(\lambda \cdot y) \cdot \sinh(\lambda \cdot y) \end{bmatrix}, [C] = \begin{bmatrix} \cos(\lambda \cdot e) \cdot \sinh(\lambda \cdot e) - \sin(\lambda \cdot e) \cdot \cosh(\lambda \cdot e) \\ \sin(\lambda \cdot e) \cdot \sinh(\lambda \cdot e) - \cos(\lambda \cdot e) \cdot \cosh(\lambda \cdot e) \\ \sin(\lambda \cdot e) \cdot \sinh(\lambda \cdot e) + \cos(\lambda \cdot e) \cdot \cosh(\lambda \cdot e) \\ -\cos(\lambda \cdot e) \cdot \sinh(\lambda \cdot e) - \sin(\lambda \cdot e) \cdot \cosh(\lambda \cdot e) \end{bmatrix}$$

$$[B] = \begin{bmatrix} \pm \frac{1}{2} & \frac{-\cosh^2(\lambda \cdot B_b)}{Y_o} & \frac{\cos^2(\lambda \cdot B_b)}{Y_o} & 0 \\ \frac{-\sinh^2(\lambda \cdot B_b)}{X_o} & \pm \frac{1}{2} & 0 & \frac{-\cos^2(\lambda \cdot B_b)}{X_o} \\ \frac{-\sin^2(\lambda \cdot B_b)}{X_o} & 0 & \pm \frac{1}{2} & \frac{-\cosh^2(\lambda \cdot B_b)}{X_o} \\ 0 & \frac{\sin^2(\lambda \cdot B_b)}{Y_o} & \frac{-\sinh^2(\lambda \cdot B_b)}{Y_o} & \pm \frac{1}{2} \end{bmatrix}$$

$$\lambda : \frac{\pi \cdot \theta}{\sqrt{2} \cdot B_b}, B_b : \text{저항폭의 } \frac{1}{2} \text{ (m)}$$

y : 저항폭 중심에서 분배계수를 구하는 점까지의 거리 (m)

e : 저항폭 중심에서 영향선 값을 구하는 점까지의 거리 (m)

$$X_o : 2 \cdot \{ \sinh(\lambda \cdot B_b) \cdot \cosh(\lambda \cdot B_b) - \sin(\lambda \cdot B_b) \cdot \cos(\lambda \cdot B_b) \}$$

$$Y_o : 2 \cdot \{ \sinh(\lambda \cdot B_b) \cdot \cosh(\lambda \cdot B_b) + \sin(\lambda \cdot B_b) \cdot \cos(\lambda \cdot B_b) \}$$

· 매트릭스 [B]에서 ±의 부호는, y < e일 때 +를, y ≥ e일 때 -를 취한다.

7.3.2. a=1일 때의 영향선 종거(K1)

$$K1 = 1/2 \times \sigma \times B_b \times [D] \times [E] \times [F]$$

$$[D] = \begin{bmatrix} \cosh(\sigma \cdot y) \\ \sinh(\sigma \cdot y) \\ (\sigma \cdot y) \cdot \cosh(\sigma \cdot y) \\ (\sigma \cdot y) \cdot \sinh(\sigma \cdot y) \end{bmatrix}, [F] = \begin{bmatrix} \sinh(\sigma \cdot e) - (\sigma \cdot e) \cdot \cosh(\sigma \cdot e) \\ -\cosh(\sigma \cdot e) - (\sigma \cdot e) \cdot \sinh(\sigma \cdot e) \\ \cosh(\sigma \cdot e) \\ -\sinh(\sigma \cdot e) \end{bmatrix}$$

$$[E] = \begin{bmatrix} \pm 1 & \frac{2+3 \cdot \sinh^2(\sigma \cdot B_b)}{X_1} & \frac{-2-(\sigma \cdot B_b)}{X_1} & 0 \\ \frac{2-3 \cdot \cosh^2(\sigma \cdot B_b)}{Y_1} & \pm 1 & 0 & \frac{-2-(\sigma \cdot B_b)}{Y_1} \\ -\frac{1}{Y_1} & 0 & \pm 1 & \frac{-2-3 \cdot \sinh^2(\sigma \cdot B_b)}{Y_1} \\ 0 & -\frac{1}{X_1} & \frac{-2+3 \cdot \cosh^2(\sigma \cdot B_b)}{X_1} & \pm 1 \end{bmatrix}$$

$$\sigma : \sqrt{2} \cdot \lambda$$

$$X_1 : (\sigma \cdot B_b) - 3 \cdot \sinh(\sigma \cdot B_b) \cdot (\sigma \cdot B_b)$$

$$Y_1 : (\sigma \cdot B_b) + 3 \cdot \sinh(\sigma \cdot B_b) \cdot (\sigma \cdot B_b)$$

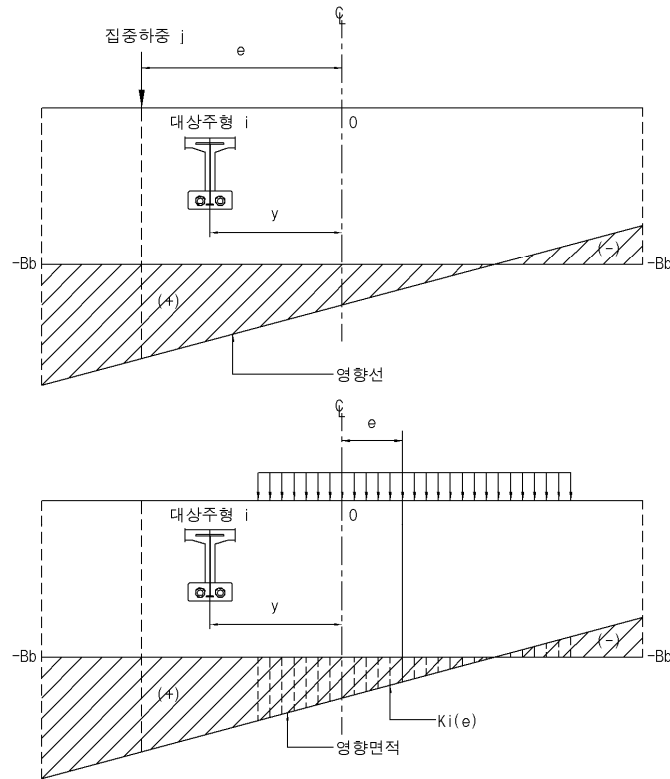
· 매트릭스 [E]에서 ±의 부호는, y < e일 때 -, y ≥ e일 때 +를 취한다.

y, e는 저항폭중심에서 좌측에 있을 때는 -, 우측에 있을 때는 +의 값으로 한다.

7.3.3. 임의의 a에 대한 영향선 종거(Ka)

$$K_a = K_0 + (K_1 - K_0) \times \sqrt{(\alpha)}$$

7.3.4. 하중분배계수



집중하중

$$K_{ai} = K_{aij} / N_g$$

분포하중

$$K_{ai} = \int \frac{K_{ai}(e)}{N_g} \cdot de$$

7.4. 횡방향 등분점에 대한 영향선 종거

	거더 위치(m)	G1	G2	G3	G4	G5	G6	G7	G8	G9	합계 (Σ)
-1.00×Bb	-12.235	0.007	0.002	-0.006	-0.019	-0.033	-0.027	0.052	0.286	0.738	1.000
-0.75×Bb	-9.176	0.002	-0.002	-0.005	-0.003	0.018	0.075	0.185	0.329	0.402	1.000
-0.50×Bb	-6.118	-0.004	-0.005	0.003	0.030	0.094	0.197	0.292	0.253	0.140	1.000
-0.25×Bb	-3.059	-0.012	0.003	0.036	0.103	0.207	0.291	0.234	0.121	0.018	1.000
0.00×Bb	0.000	-0.014	0.038	0.115	0.220	0.289	0.218	0.113	0.036	-0.015	1.000
0.25×Bb	3.059	0.019	0.123	0.236	0.291	0.205	0.101	0.035	0.002	-0.013	1.000
0.50×Bb	6.118	0.143	0.256	0.292	0.195	0.092	0.029	0.002	-0.005	-0.004	1.000
0.75×Bb	9.176	0.405	0.329	0.184	0.074	0.017	-0.003	-0.005	-0.002	0.002	1.000
1.00×Bb	12.235	0.742	0.285	0.050	-0.028	-0.034	-0.019	-0.005	0.002	0.007	1.000

7.5. 합성후 고정하중에 대한 하중 분배계수

	거더 위치(m)	G1 10.973	G2 8.223	G3 5.473	G4 2.723	G5 -0.027	G6 -2.777	G7 -5.527	G8 -8.277	G9 -11.027	합계 (Σ)

방호벽(좌)	11.967	0.713	0.289	0.062	-0.020	-0.030	-0.018	-0.006	0.002	0.006	1.000
방호벽(우)	-12.050	0.006	0.002	-0.006	-0.018	-0.031	-0.021	0.060	0.289	0.718	1.000
콘크리트포장	-0.085	2.259	2.538	2.695	2.760	2.775	2.758	2.699	2.569	2.346	23.400
중분대	-0.085	-0.014	0.036	0.112	0.217	0.289	0.221	0.116	0.038	-0.015	1.000
방음벽(좌)	12.005	0.717	0.289	0.060	-0.021	-0.030	-0.018	-0.006	0.002	0.006	1.000
내측풍하중1	13.615	0.894	0.262	-0.010	-0.073	-0.056	-0.026	-0.005	0.004	0.009	1.000
내측풍하중2	10.395	0.540	0.315	0.130	0.031	-0.004	-0.010	-0.006	-0.001	0.004	1.000

7.6. 활하중에 대한 하중 분배계수

7.6.1. 차로별 영향선 종거

(1) DB하중

	거더 위치(m)	G1 10.973	G2 8.223	G3 5.473	G4 2.723	G5 -0.027	G6 -2.777	G7 -5.527	G8 -8.277	G9 -11.027	합계 (Σ)
DB1	10.115	1.018	0.634	0.285	0.083	0.002	-0.016	-0.011	-0.002	0.007	2.000
DB2	6.515	0.350	0.539	0.553	0.357	0.164	0.050	0.003	-0.009	-0.007	2.000
DB3	2.915	0.040	0.240	0.458	0.563	0.421	0.217	0.079	0.009	-0.026	2.000
DB4	-1.890	-0.029	0.026	0.124	0.292	0.496	0.548	0.373	0.168	0.002	2.000
DB5	-5.490	-0.012	-0.008	0.016	0.086	0.232	0.442	0.573	0.449	0.221	2.000
DB6	-9.090	0.003	-0.005	-0.010	-0.003	0.041	0.158	0.377	0.646	0.794	2.000

(2) DL하중

	거더 위치(m)	G1 10.973	G2 8.223	G3 5.473	G4 2.723	G5 -0.027	G6 -2.777	G7 -5.527	G8 -8.277	G9 -11.027	합계 (Σ)
DL1	10.115	0.508	0.320	0.142	0.041	0.000	-0.008	-0.006	-0.001	0.003	1.000
DL2	6.515	0.168	0.273	0.284	0.179	0.080	0.023	0.000	-0.005	-0.003	1.000
DL3	2.915	0.016	0.117	0.230	0.292	0.211	0.106	0.037	0.003	-0.013	1.000
DL4	-1.890	-0.015	0.012	0.060	0.144	0.252	0.282	0.186	0.082	-0.002	1.000
DL5	-5.490	-0.006	-0.004	0.007	0.041	0.114	0.223	0.297	0.225	0.104	1.000
DL6	-9.090	0.002	-0.003	-0.005	-0.002	0.019	0.078	0.189	0.329	0.393	1.000

7.6.2. 하중조합에 따른 하중 분배계수

(1) DB하중

	G1	G2	G3	G4	G5	G6	G7	G8	G9	합계
DB1	1.018	0.634	0.285	0.083	0.002	-0.016	-0.011	-0.002	0.007	2.000
DB2	0.350	0.539	0.553	0.357	0.164	0.050	0.003	-0.009	-0.007	2.000
DB3	0.040	0.240	0.458	0.563	0.421	0.217	0.079	0.009	-0.026	2.000
DB4	-0.029	0.026	0.124	0.292	0.496	0.548	0.373	0.168	0.002	2.000
DB5	-0.012	-0.008	0.016	0.086	0.232	0.442	0.573	0.449	0.221	2.000
DB6	0.003	-0.005	-0.010	-0.003	0.041	0.158	0.377	0.646	0.794	2.000
DB12	1.367	1.174	0.838	0.440	0.166	0.034	-0.009	-0.011	0.000	4.000
DB13	1.058	0.874	0.743	0.647	0.422	0.201	0.067	0.007	-0.019	4.000
DB14	0.989	0.661	0.409	0.375	0.498	0.532	0.361	0.166	0.008	4.000
DB15	1.006	0.626	0.301	0.170	0.234	0.426	0.561	0.447	0.228	4.000
DB16	1.021	0.629	0.275	0.081	0.043	0.142	0.365	0.644	0.800	4.000
DB22	0.699	1.079	1.106	0.714	0.328	0.100	0.005	-0.018	-0.014	4.000
DB24	0.321	0.566	0.677	0.649	0.660	0.598	0.375	0.159	-0.005	4.000
DB25	0.338	0.531	0.569	0.443	0.396	0.493	0.575	0.440	0.214	4.000
DB26	0.353	0.534	0.543	0.354	0.205	0.208	0.379	0.637	0.787	4.000
DB34	0.012	0.266	0.581	0.855	0.917	0.765	0.451	0.177	-0.024	4.000
DB35	0.028	0.232	0.473	0.650	0.653	0.659	0.651	0.458	0.195	4.000
DB36	0.043	0.235	0.447	0.561	0.462	0.374	0.455	0.654	0.768	4.000
DB45	-0.041	0.018	0.140	0.378	0.728	0.990	0.945	0.618	0.223	4.000
DB46	-0.025	0.021	0.114	0.289	0.537	0.706	0.749	0.814	0.795	4.000
DB56	-0.009	-0.013	0.006	0.084	0.273	0.600	0.949	1.095	1.015	4.000
DB123	1.267	1.272	1.166	0.903	0.528	0.226	0.063	-0.002	-0.023	5.400
DB124	1.205	1.080	0.866	0.659	0.596	0.524	0.328	0.141	0.001	5.400
DB125	1.220	1.049	0.769	0.474	0.358	0.429	0.508	0.395	0.199	5.400
DB126	1.234	1.052	0.745	0.394	0.186	0.173	0.331	0.571	0.714	5.400
DB134	0.927	0.811	0.780	0.845	0.827	0.674	0.396	0.157	-0.016	5.400
DB135	0.942	0.780	0.683	0.660	0.589	0.579	0.576	0.410	0.182	5.400
DB136	0.955	0.782	0.659	0.580	0.417	0.322	0.399	0.587	0.697	5.400
DB145	0.880	0.587	0.382	0.415	0.657	0.877	0.841	0.554	0.207	5.400
DB146	0.893	0.590	0.359	0.335	0.485	0.621	0.664	0.731	0.722	5.400
DB156	0.908	0.559	0.262	0.150	0.248	0.526	0.844	0.984	0.919	5.400
DB234	0.325	0.725	1.021	1.091	0.973	0.733	0.408	0.151	-0.028	5.400
DB235	0.340	0.694	0.924	0.906	0.735	0.638	0.588	0.404	0.170	5.400
DB236	0.354	0.697	0.901	0.826	0.563	0.382	0.412	0.581	0.685	5.400
DB245	0.278	0.502	0.623	0.662	0.803	0.936	0.853	0.548	0.194	5.400
DB246	0.292	0.505	0.600	0.582	0.631	0.680	0.677	0.724	0.709	5.400
DB256	0.307	0.474	0.503	0.397	0.394	0.585	0.856	0.977	0.907	5.400
DB345	0.000	0.233	0.537	0.847	1.034	1.086	0.921	0.564	0.177	5.400
DB346	0.013	0.235	0.514	0.767	0.862	0.830	0.745	0.740	0.693	5.400
DB356	0.028	0.205	0.417	0.582	0.625	0.735	0.925	0.993	0.890	5.400
DB456	-0.034	0.012	0.116	0.338	0.693	1.033	1.190	1.137	0.915	5.400
DB1234	1.034	1.080	1.065	0.972	0.812	0.599	0.332	0.124	-0.018	6.000
DB1235	1.047	1.054	0.984	0.817	0.614	0.520	0.482	0.335	0.147	6.000
DB1236	1.058	1.057	0.964	0.751	0.471	0.306	0.335	0.482	0.576	6.000
DB1245	0.995	0.894	0.733	0.614	0.671	0.768	0.702	0.455	0.167	6.000
DB1246	1.007	0.896	0.714	0.547	0.527	0.555	0.555	0.602	0.596	6.000
DB1256	1.019	0.871	0.633	0.393	0.329	0.476	0.705	0.813	0.761	6.000
DB1345	0.763	0.670	0.662	0.769	0.863	0.893	0.759	0.468	0.153	6.000

DB1346	0.775	0.672	0.642	0.702	0.720	0.680	0.612	0.615	0.582	6.000
DB1356	0.787	0.646	0.561	0.548	0.522	0.601	0.762	0.826	0.747	6.000
DB1456	0.735	0.486	0.311	0.344	0.579	0.849	0.983	0.946	0.767	6.000
DB2345	0.262	0.598	0.863	0.974	0.985	0.943	0.770	0.463	0.143	6.000
DB2346	0.273	0.601	0.843	0.907	0.841	0.729	0.623	0.610	0.572	6.000
DB2356	0.286	0.575	0.762	0.753	0.644	0.650	0.773	0.821	0.737	6.000
DB2456	0.234	0.415	0.512	0.550	0.700	0.899	0.993	0.941	0.757	6.000
DB3456	0.002	0.190	0.440	0.704	0.893	1.024	1.050	0.954	0.743	6.000
DB12345	1.025	1.074	1.077	1.036	0.986	0.931	0.761	0.461	0.148	7.500
DB12346	1.037	1.076	1.057	0.970	0.843	0.717	0.614	0.609	0.577	7.500
DB12356	1.049	1.051	0.976	0.816	0.645	0.638	0.764	0.820	0.742	7.500
DB12456	0.998	0.890	0.726	0.612	0.702	0.887	0.985	0.939	0.762	7.500
DB13456	0.766	0.666	0.654	0.767	0.894	1.012	1.042	0.952	0.748	7.500
DB23456	0.264	0.595	0.855	0.972	1.016	1.061	1.052	0.947	0.738	7.500
DB123456	1.028	1.070	1.069	1.035	1.017	1.049	1.044	0.946	0.743	9.000

(2) DL하중

	G1	G2	G3	G4	G5	G6	G7	G8	G9	합계
DL1	0.508	0.320	0.142	0.041	0.000	-0.008	-0.006	-0.001	0.003	1.000
DL2	0.168	0.273	0.284	0.179	0.080	0.023	0.000	-0.005	-0.003	1.000
DL3	0.016	0.117	0.230	0.292	0.211	0.106	0.037	0.003	-0.013	1.000
DL4	-0.015	0.012	0.060	0.144	0.252	0.282	0.186	0.082	-0.002	1.000
DL5	-0.006	-0.004	0.007	0.041	0.114	0.223	0.297	0.225	0.104	1.000
DL6	0.002	-0.003	-0.005	-0.002	0.019	0.078	0.189	0.329	0.393	1.000
DL12	0.677	0.593	0.426	0.220	0.080	0.015	-0.005	-0.006	0.000	2.000
DL13	0.525	0.437	0.373	0.333	0.211	0.098	0.031	0.002	-0.010	2.000
DL14	0.494	0.331	0.202	0.185	0.252	0.273	0.180	0.080	0.001	2.000
DL15	0.503	0.315	0.149	0.082	0.115	0.214	0.291	0.224	0.108	2.000
DL16	0.510	0.317	0.137	0.039	0.020	0.069	0.183	0.328	0.396	2.000
DL22	0.337	0.546	0.568	0.357	0.160	0.047	0.001	-0.010	-0.007	2.000
DL24	0.154	0.285	0.344	0.323	0.332	0.305	0.186	0.077	-0.005	2.000
DL25	0.163	0.269	0.291	0.220	0.194	0.246	0.297	0.220	0.101	2.000
DL26	0.170	0.270	0.279	0.177	0.100	0.101	0.189	0.325	0.389	2.000
DL34	0.002	0.129	0.290	0.436	0.463	0.388	0.223	0.085	-0.015	2.000
DL35	0.011	0.113	0.237	0.333	0.325	0.329	0.334	0.228	0.091	2.000
DL36	0.018	0.115	0.225	0.290	0.230	0.184	0.226	0.333	0.380	2.000
DL45	-0.021	0.007	0.066	0.186	0.366	0.504	0.483	0.306	0.102	2.000
DL46	-0.013	0.009	0.054	0.142	0.271	0.360	0.375	0.411	0.391	2.000
DL56	-0.004	-0.007	0.001	0.039	0.134	0.301	0.486	0.554	0.497	2.000
DL123	0.624	0.639	0.591	0.460	0.262	0.109	0.029	-0.002	-0.012	2.700
DL124	0.596	0.544	0.437	0.328	0.299	0.267	0.163	0.068	-0.002	2.700
DL125	0.604	0.529	0.390	0.235	0.175	0.214	0.262	0.197	0.094	2.700
DL126	0.611	0.531	0.379	0.196	0.090	0.084	0.165	0.291	0.353	2.700
DL134	0.459	0.404	0.389	0.429	0.417	0.341	0.196	0.075	-0.010	2.700
DL135	0.467	0.389	0.341	0.336	0.293	0.288	0.295	0.204	0.085	2.700
DL136	0.474	0.391	0.331	0.298	0.208	0.158	0.198	0.298	0.345	2.700
DL145	0.439	0.294	0.188	0.204	0.330	0.446	0.429	0.275	0.095	2.700
DL146	0.446	0.296	0.177	0.165	0.244	0.316	0.332	0.369	0.355	2.700
DL156	0.454	0.281	0.129	0.072	0.121	0.263	0.432	0.498	0.450	2.700
DL234	0.153	0.362	0.516	0.553	0.489	0.370	0.201	0.072	-0.017	2.700
DL235	0.161	0.347	0.469	0.460	0.365	0.317	0.301	0.201	0.079	2.700

DL236	0.168	0.349	0.458	0.422	0.279	0.187	0.204	0.295	0.339	2.700
DL245	0.133	0.252	0.315	0.328	0.402	0.475	0.435	0.271	0.089	2.700
DL246	0.140	0.254	0.304	0.289	0.316	0.345	0.338	0.366	0.349	2.700
DL256	0.148	0.239	0.257	0.196	0.192	0.292	0.437	0.494	0.444	2.700
DL345	-0.004	0.112	0.267	0.430	0.519	0.549	0.468	0.278	0.080	2.700
DL346	0.003	0.114	0.256	0.391	0.434	0.419	0.371	0.373	0.340	2.700
DL356	0.011	0.099	0.208	0.298	0.310	0.366	0.470	0.502	0.436	2.700
DL456	-0.017	0.004	0.055	0.165	0.347	0.524	0.604	0.572	0.446	2.700
DL1234	0.509	0.541	0.537	0.492	0.407	0.302	0.163	0.059	-0.011	3.000
DL1235	0.516	0.529	0.497	0.414	0.304	0.258	0.246	0.167	0.069	3.000
DL1236	0.521	0.531	0.488	0.382	0.233	0.149	0.166	0.245	0.285	3.000
DL1245	0.492	0.450	0.369	0.304	0.335	0.390	0.358	0.225	0.077	3.000
DL1246	0.498	0.451	0.361	0.272	0.264	0.281	0.277	0.304	0.293	3.000
DL1256	0.505	0.439	0.321	0.194	0.161	0.237	0.360	0.411	0.373	3.000
DL1345	0.378	0.333	0.329	0.389	0.433	0.452	0.386	0.231	0.070	3.000
DL1346	0.384	0.335	0.320	0.356	0.362	0.343	0.305	0.310	0.286	3.000
DL1356	0.390	0.323	0.280	0.279	0.259	0.299	0.388	0.417	0.366	3.000
DL1456	0.367	0.243	0.152	0.168	0.289	0.430	0.499	0.476	0.374	3.000
DL2345	0.123	0.298	0.435	0.492	0.493	0.475	0.390	0.228	0.065	3.000
DL2346	0.129	0.300	0.426	0.460	0.422	0.367	0.309	0.307	0.281	3.000
DL2356	0.135	0.288	0.387	0.382	0.319	0.322	0.392	0.414	0.361	3.000
DL2456	0.112	0.208	0.259	0.272	0.349	0.454	0.504	0.473	0.369	3.000
DL3456	-0.002	0.092	0.218	0.356	0.447	0.516	0.532	0.479	0.362	3.000
DL12345	0.504	0.538	0.542	0.523	0.493	0.469	0.386	0.228	0.067	3.750
DL12346	0.510	0.539	0.533	0.490	0.422	0.360	0.305	0.306	0.283	3.750
DL12356	0.517	0.527	0.493	0.413	0.319	0.316	0.388	0.414	0.363	3.750
DL12456	0.493	0.448	0.365	0.302	0.350	0.448	0.500	0.472	0.371	3.750
DL13456	0.379	0.331	0.325	0.387	0.448	0.510	0.527	0.478	0.364	3.750
DL23456	0.124	0.296	0.431	0.490	0.507	0.534	0.532	0.475	0.359	3.750
DL123456	0.506	0.536	0.538	0.521	0.508	0.527	0.528	0.475	0.362	4.500

8. 설계 단면력 집계

8.1 시간중양부의 휨모멘트 집계(kN · m)

구 분	G1	G2~G8	G9	저 항 단 면	비 고
거더 자중	5979.5	5979.5	5979.5	순 단 면	
합성전 고정하중	4103.8	4384.6	3865.7	PS강재 환산단면	
합성후 고정하중	2679.0	2412.1	1690.0	바닥판 합성단면	
DB 활하중	3472.3	3015.2	3460.9		
DL 활하중	3488.4	2925.8	3472.5		
균중하중	0.0	0.0	0.0		
MAX	3488.4	3015.2	3472.5		
합 계	16250.7	15791.4	15007.7		

8.2 시간지점부의 전단력 집계(kN)

구 분	G1	G2~G8	G9	저 항 단 면	비 고
거더 자중	583.2	583.2	583.2	순 단 면	
합성전 고정하중	364.3	380.9	342.6	PS강재 환산단면	
합성후 고정하중	309.0	199.8	184.2	바닥판 합성단면	
DB 활하중	393.8	387.1	389.0		
DL 활하중	371.1	359.8	375.3		
균중하중	0.0	0.0	0.0		
MAX	393.8	387.1	389.0		
합 계	1650.2	1550.9	1498.9		

8.3 반력종합

8.3.1. A1 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	389.425	424.05	424.05	424.05	424.05	424.05	424.05	424.05	367.334
합성후	324.09	200.952	141.051	117.186	115.417	111.751	119.692	140.771	195.579
	220.354	196.579	168.81	148.735	140.072	127.456	128.115	144.275	192.095
ENV	324.09	200.952	168.81	148.735	140.072	127.456	128.115	144.275	195.579
ADD	1316.779	1228.266	1196.124	1176.049	1167.386	1154.77	1155.429	1171.589	1166.177
DB1	271.262	193.096	103.532	41.63	11.773	5.591	2.045	0.651	1.77
DB2	118.271	159.69	158.267	108.792	59.793	27.293	9.651	3.751	0.398
DB3	32.537	83.292	134.62	156.917	124.218	74.634	36.591	13.58	2.958
DB4	5.237	20.586	51.031	95.242	143.261	153.464	112.842	63.071	17.123
DB5	0.891	5.319	15.914	39.605	79.345	130.191	161.412	135.168	83.429
DB6	0.81	1.034	3.661	8.591	24.44	61.09	123.429	188.77	220.919
DB12	389.424	352.71	261.613	150.125	71.122	29.023	10.66	3.798	0.432
DB13	303.635	276.302	237.929	198.142	135.385	76.138	35.481	12.957	2.687
DB14	269.886	212.488	153.794	136.308	154.406	154.875	111.723	62.541	18.086
DB15	268.878	196.125	118.798	80.657	90.445	131.653	160.389	134.738	84.755
DB16	271.5	192.602	104.513	49.03	35.35	62.477	122.404	188.386	222.224
DB22	236.517	319.376	316.512	217.604	119.587	54.586	19.304	7.502	0.797
DB24	117.011	179.148	208.726	203.837	202.963	180.51	122.13	64.656	17.042
DB25	115.977	162.75	173.671	148.152	138.994	157.235	170.624	136.55	81.766
DB26	118.596	159.204	159.383	116.524	83.898	88.059	132.639	190.198	219.236
DB34	31.337	102.773	185.084	251.961	267.456	227.993	149.332	76.544	20.006
DB35	30.251	86.302	149.968	196.206	203.473	204.596	197.427	147.731	80.207
DB36	32.851	82.775	135.681	164.579	148.378	135.419	159.44	201.376	217.653
DB45	5.791	24.146	66.728	134.7	222.567	283.631	274.243	198.174	100.193
DB46	4.916	20.025	52.139	103.001	167.462	214.399	236.191	251.759	237.597
DB56	0.794	5.923	17.164	47.425	103.561	191.142	284.794	323.921	304.276
DB123	379.68	392.387	356.555	276.236	175.608	92.988	40.462	13.801	2.535
DB124	349.287	334.92	280.831	220.572	192.712	163.783	108.902	57.619	15.091
DB125	348.394	320.202	249.314	170.467	135.153	142.896	152.69	122.558	74.827
DB126	350.73	317.02	236.463	142.012	85.553	80.633	118.504	170.847	198.553
DB134	272.166	266.195	259.545	263.89	250.759	206.547	133.397	68.317	17.758
DB135	271.222	251.388	227.969	213.716	193.161	185.523	176.8	132.614	73.415
DB136	273.561	248.227	215.1	185.263	143.583	123.262	142.615	180.904	197.141
DB145	240.904	194.034	152.325	158.143	210.325	256.505	245.775	177.885	91.298

DB146	243.245	190.876	139.479	129.692	160.747	194.243	211.588	226.152	215.02
DB156	242.35	176.138	107.962	79.587	103.164	173.339	255.395	291.128	275.013
DB234	134.594	236.189	309.009	324.684	294.469	229.634	142.873	70.423	18.004
DB235	133.613	221.331	277.357	274.461	236.86	208.529	186.016	134.262	70.731
DB236	135.954	218.173	264.512	246.011	187.285	146.29	151.831	182.531	194.453
DB245	103.274	163.977	201.734	218.891	254.027	279.533	254.992	179.512	88.61
DB246	105.636	160.819	188.868	190.438	204.449	217.271	220.807	227.802	212.336
DB256	104.72	146.081	157.371	140.335	146.867	196.368	264.614	292.779	272.33
DB345	26.128	95.187	180.373	262.142	312.058	322.163	279.105	189.592	87.202
DB346	28.464	92.005	167.523	233.687	262.457	259.899	244.916	237.858	210.924
DB356	27.574	77.291	136.01	183.585	204.897	238.997	288.725	302.835	270.918
DB456	4.932	21.254	61.06	128.223	222.067	310.104	357.847	348.24	288.917
DB1234	315.474	341.567	334.975	301.479	253.746	192.466	118.199	58.202	14.795
DB1235	314.668	329.225	308.629	259.658	205.755	174.936	154.291	111.599	59.971
DB1236	316.622	326.573	297.927	235.956	164.451	123.045	125.792	151.829	163.077
DB1245	289.393	281.434	245.6	213.352	220.062	234.084	211.766	149.309	74.893
DB1246	291.37	278.783	234.897	189.627	178.736	182.212	183.268	189.558	177.98
DB1256	290.621	266.521	208.639	147.882	130.759	164.79	219.782	243.707	227.983
DB1345	225.103	224.093	227.822	249.392	268.411	269.618	231.852	157.693	73.717
DB1346	227.06	221.46	217.099	225.687	227.085	217.727	203.374	197.944	176.805
DB1356	226.308	209.178	190.863	183.945	179.13	200.306	239.868	252.091	226.806
DB1456	201.033	161.385	127.83	137.615	193.414	259.472	297.342	289.798	241.705
DB2345	110.425	199.044	268.974	300.011	304.816	288.799	239.528	159.071	71.462
DB2346	112.383	196.413	258.273	276.289	263.512	236.909	211.051	199.303	174.57
DB2356	111.63	184.13	232.015	234.564	215.535	219.486	247.544	253.45	224.571
DB2456	86.355	136.336	168.982	188.234	229.819	278.652	305.017	291.157	239.47
DB3456	22.063	78.993	151.183	224.273	278.188	314.167	325.124	299.543	238.295
DB12345	313.764	343.826	346.497	330.963	313.207	289.947	238.812	158.79	72.522
DB12346	315.721	341.191	335.772	307.236	271.878	238.053	210.33	199.017	175.606
DB12356	314.967	328.906	309.512	265.49	223.901	220.651	246.825	253.165	225.608
DB12456	289.693	281.114	246.481	219.181	238.186	279.796	304.297	290.871	240.506
DB13456	225.379	223.77	228.703	255.223	286.558	315.334	324.387	299.278	239.334
DB23456	110.701	198.721	269.856	305.843	322.964	334.516	332.085	300.64	237.1
DB123456	314.039	343.5	347.356	336.792	331.352	335.66	331.344	300.352	238.135
DL1	264.551	180.005	99.688	42.592	13.8	6.599	2.377	0.733	1.696
DL2	118.68	147.518	144.557	100.066	57.265	27.904	10.907	4.306	0.371
DL3	34.703	78.699	122.216	142.796	113.481	70.401	36.51	15.005	3.249
DL4	5.983	21.694	49.519	88.203	130.14	139.392	103.754	61.276	20.251
DL5	0.942	6.169	17.067	39.084	74.257	118.128	147.588	125.066	85.142

DL6	0.799	1.194	4.301	10.222	25.292	59.049	115.537	174.428	218.067
DL12	383.106	327.425	244.011	142.268	70.48	31.213	12.556	4.38	0.492
DL13	299.05	258.594	221.619	184.871	126.46	73.385	35.954	14.331	2.874
DL14	263.986	200.214	148.225	130.058	143.089	142.241	103.041	60.429	19.769
DL15	262.305	183.869	115.938	80.936	87.146	121.052	147.161	124.58	86.238
DL16	264.626	179.713	101.439	51.233	37.899	61.84	115.05	173.983	219.122
DL22	237.315	295.024	289.103	200.124	114.491	55.771	21.841	8.611	0.746
DL24	118.271	167.807	193.366	188.016	187.252	166.979	114.204	63.618	20.017
DL25	116.511	151.428	161.011	138.835	131.299	145.686	157.988	127.183	83.453
DL26	118.822	147.234	146.507	109.133	82.054	86.507	125.877	176.553	216.328
DL34	34.342	99.016	171.033	230.77	243.552	209.65	140.072	76.136	23.399
DL35	32.515	82.544	138.576	181.503	187.586	188.242	183.365	138.844	82.377
DL36	34.83	78.356	124.107	151.803	138.341	129.032	151.255	188.247	215.262
DL45	6.459	26.193	66.266	127.088	204.274	257.435	251.153	186.007	103.744
DL46	5.514	21.298	51.439	97.275	155.014	198.156	218.964	235.34	236.579
DL56	0.763	6.793	19.193	48.287	99.19	176.965	263.013	299.452	303.062
DL123	375.925	365.494	329.545	256.433	165.3	91.08	42.086	16.156	2.75
DL124	344.348	312.926	263.471	207.092	180.22	152.931	102.281	56.61	17.666
DL125	342.802	298.195	234.387	162.845	129.879	133.853	141.87	114.117	76.177
DL126	344.909	294.455	221.36	136.119	85.555	80.565	112.958	158.542	195.766
DL134	268.824	251.026	243.378	245.561	230.893	191.391	125.608	67.907	20.722
DL135	267.219	236.215	214.203	201.264	180.532	172.137	164.709	124.629	75.214
DL136	269.325	232.475	201.176	174.538	136.208	118.85	135.798	169.054	194.803
DL145	235.732	183.751	148.262	152.023	195.52	234.225	225.511	166.868	94.34
DL146	237.839	180.01	135.237	125.3	151.202	180.947	196.643	211.338	213.945
DL156	236.263	165.291	106.14	81.068	100.857	161.903	236.336	269.059	273.778
DL234	137.681	221.864	284.035	297.717	270.634	213.625	135.612	70.775	20.941
DL235	135.985	206.98	254.757	253.362	220.266	194.315	174.447	126.943	72.708
DL236	138.092	203.24	241.731	226.637	175.944	141.031	145.542	171.407	192.308
DL245	104.499	154.516	188.816	204.122	235.257	256.406	235.255	169.22	91.845
DL246	106.606	150.775	175.791	177.399	190.938	203.127	206.382	213.682	211.405
DL256	105.079	136.072	146.736	133.175	140.597	184.085	246.076	271.403	271.238
DL345	29.707	92.704	168.716	242.535	285.913	294.74	258.118	179.753	90.895
DL346	31.021	88.792	155.603	215.784	241.589	241.441	229.219	224.159	210.433
DL356	29.495	74.092	126.552	171.594	191.25	222.37	268.916	281.915	270.275
DL456	5.405	23.222	61.382	122.567	206.263	284.609	329.899	324.35	289.525
DL1234	312.973	319.807	311.246	279.658	235.284	180.272	112.617	58.452	17.165
DL1235	311.607	307.437	286.879	242.731	193.325	164.19	145.107	105.513	61.513
DL1236	313.368	304.308	276.037	220.433	156.383	119.796	121.036	142.544	161.141

DL1245	285.367	263.712	231.923	201.661	205.805	215.946	195.758	140.72	77.439
DL1246	287.125	260.582	221.05	179.394	168.866	171.555	171.689	177.752	177.067
DL1256	285.847	248.333	196.849	142.584	126.933	155.663	204.795	225.882	226.944
DL1345	222.367	212.038	215.086	233.668	248.006	247.86	214.829	149.499	76.645
DL1346	224.129	208.916	204.253	211.41	211.103	203.471	190.728	186.527	176.268
DL1356	222.856	196.693	180.012	174.554	169.124	187.564	223.821	234.615	226.134
DL1456	196.617	152.973	125.062	133.524	181.616	239.334	274.518	269.868	242.076
DL2345	113.035	187.683	248.881	277.092	281.136	266.342	222.935	151.424	74.505
DL2346	114.797	184.558	238.044	254.828	244.197	221.949	198.835	188.458	174.173
DL2356	113.528	172.342	213.84	217.979	202.223	206.048	231.935	236.585	224.05
DL2456	87.285	128.615	158.854	176.942	214.709	257.812	282.625	271.799	239.981
DL3456	24.421	76.978	142.071	208.963	256.948	289.731	301.667	280.577	239.184
DL12345	311.317	322.641	323.473	308.677	290.894	268.614	222.664	151.107	75.417
DL12346	313.079	319.516	312.634	286.41	253.95	224.188	198.564	188.175	175.094
DL12356	311.795	307.258	288.393	249.561	212.011	208.322	231.661	236.262	224.917
DL12456	285.557	263.538	233.443	208.53	224.504	260.092	282.358	271.514	240.858
DL13456	222.566	211.901	216.612	240.538	266.7	291.996	301.386	280.249	240.049
DL23456	113.234	187.544	250.403	283.956	299.794	310.475	309.493	282.18	237.954
DL123456	311.516	322.501	324.993	315.538	309.547	312.713	309.222	281.897	238.875
ENV	389.424	392.387	356.555	336.792	331.352	335.66	357.847	348.24	304.276
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1706.203	1620.653	1552.679	1512.841	1498.738	1490.43	1513.276	1519.829	1470.453

8.3.2 P1-1 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	389.425	424.05	424.05	424.05	424.05	424.05	424.05	424.05	367.334
합성후	331.611	194.803	139.625	118.289	114.46	112.935	118.674	145.134	190.96
	224.95	194.513	167.177	149.827	138.631	128.531	126.851	148.184	187.826
ENV	331.611	194.803	167.177	149.827	138.631	128.531	126.851	148.184	190.96
ADD	1324.3	1222.117	1194.491	1177.141	1165.945	1155.845	1154.165	1175.498	1161.558
DB1	273.569	190.067	102.655	41.593	11.414	5.604	2	0.628	1.757
DB2	119.593	159.761	157.702	108.836	59.079	27.24	9.415	3.377	0.402
DB3	32.893	84.852	134.466	157.335	123.458	74.57	36.062	12.746	2.964
DB4	5.209	21.915	51.038	96.066	143.055	153.76	112.093	61.908	16.815
DB5	0.871	5.999	15.901	40.23	79.391	130.933	160.891	135.146	82.217
DB6	0.82	1.2	3.643	8.854	24.497	61.911	123.147	191.615	218.616
DB12	393.042	349.741	260.169	150.122	70.042	28.98	10.394	3.385	0.427
DB13	306.283	274.825	236.897	198.511	134.259	76.075	34.923	12.088	2.691
DB14	272.117	210.882	152.932	137.082	153.837	155.175	110.947	61.369	17.771
DB15	271.123	193.805	117.919	81.232	90.129	132.399	159.838	134.711	83.535
DB16	273.793	189.714	103.622	49.248	35.051	63.3	122.091	191.223	219.917
DB22	239.162	319.518	315.381	217.692	118.159	54.48	18.831	6.755	0.804
DB24	118.27	180.651	208.174	204.702	202.044	180.752	121.147	63.129	16.758
DB25	117.25	163.538	173.102	148.818	138.328	157.92	169.868	136.132	80.587
DB26	119.916	159.424	158.803	116.832	83.248	88.821	132.122	192.644	216.969
DB34	31.631	105.764	184.945	253.202	266.49	228.228	148.058	74.548	19.705
DB35	30.558	88.576	149.81	197.245	202.759	205.27	196.387	146.762	79.036
DB36	33.205	84.481	135.511	165.259	147.68	136.17	158.639	203.27	215.395
DB45	5.73	26.149	66.73	136.149	222.409	284.669	272.973	196.981	98.677
DB46	4.884	21.515	52.133	104.09	167.321	215.515	235.162	253.431	234.995
DB56	0.778	6.767	17.133	48.315	103.672	192.706	283.991	326.742	300.767
DB123	383.252	391.122	355.117	276.607	173.952	92.881	39.745	12.687	2.552
DB124	352.483	333.538	279.545	221.306	191.556	164	107.99	56.213	14.833
DB125	351.602	318.178	248.013	171.024	134.226	143.515	151.982	122.177	73.756
DB126	353.981	314.485	235.152	142.246	84.64	81.321	118.01	173.045	196.503
DB134	274.495	266.153	258.629	264.962	249.561	206.759	132.224	66.49	17.487
DB135	273.562	250.702	227.038	214.607	192.19	186.132	175.835	131.737	72.352
DB136	275.943	247.029	214.158	185.832	142.626	123.94	141.865	182.605	195.099
DB145	242.87	193.234	151.547	159.402	209.856	257.444	244.609	176.809	89.927
DB146	245.253	189.564	138.691	130.628	160.294	195.252	210.636	227.655	212.67

DB156	244.371	174.185	107.158	80.344	102.939	174.748	254.646	293.662	271.849
DB234	136.048	238.947	308.374	325.839	292.958	229.793	141.512	68.297	17.753
DB235	135.077	223.442	276.705	275.434	235.574	209.083	184.868	133.034	69.705
DB236	137.461	219.773	263.849	246.662	186.014	146.913	150.898	183.881	192.448
DB245	104.364	165.974	201.236	220.231	253.244	280.417	253.641	178.085	87.276
DB246	106.769	162.305	188.359	191.456	203.68	218.226	219.671	228.953	210.023
DB256	105.865	146.925	156.847	141.174	146.327	197.723	263.681	294.96	269.202
DB345	26.349	98.522	180.244	263.817	311.231	323.038	277.499	187.668	85.876
DB346	28.728	94.828	167.383	235.04	261.645	260.843	243.525	238.513	208.618
DB356	27.85	79.472	135.855	184.76	204.313	240.342	287.536	304.52	267.797
DB456	4.873	23.201	61.049	129.766	221.984	311.777	356.451	349.724	285.486
DB1234	318.405	341.586	333.788	302.404	252.212	192.6	117.043	56.404	14.584
DB1235	317.608	328.707	307.428	260.433	204.41	175.4	153.31	110.572	59.108
DB1236	319.598	325.628	296.717	236.462	163.118	123.566	124.99	152.95	161.398
DB1245	292.021	280.821	244.527	214.432	219.135	234.823	210.617	148.116	73.773
DB1246	294.034	277.743	233.815	190.439	177.822	183.009	182.298	190.513	176.044
DB1256	293.295	264.946	207.544	148.546	130.035	165.921	218.981	245.522	225.368
DB1345	227.007	224.594	227.057	250.751	267.448	270.349	230.49	156.087	72.603
DB1346	228.999	221.534	216.325	226.778	226.135	218.516	202.191	198.485	174.875
DB1356	228.258	208.718	190.076	184.887	178.37	201.429	238.854	253.492	224.198
DB1456	202.671	160.83	127.172	138.863	193.073	260.87	296.159	291.033	238.84
DB2345	111.599	201.876	268.442	301.438	303.591	289.484	238.013	157.171	70.379
DB2346	113.593	198.819	257.732	277.447	262.298	237.652	209.714	199.552	172.67
DB2356	112.85	186.001	231.461	235.574	214.512	220.563	246.376	254.557	221.993
DB2456	87.263	138.112	168.556	189.55	229.215	280.004	303.681	292.098	236.635
DB3456	22.247	81.883	151.065	225.868	277.547	315.512	323.575	300.071	235.466
DB12345	316.659	344.38	345.307	332.354	311.708	290.634	237.272	156.887	71.43
DB12346	318.65	341.319	334.573	308.358	270.392	238.797	208.97	199.262	173.699
DB12356	317.907	328.499	308.3	266.464	222.605	221.73	245.633	254.27	223.022
DB12456	292.32	280.612	245.398	220.461	237.308	281.15	302.937	291.809	237.663
DB13456	227.283	224.383	227.928	256.782	285.644	316.68	322.814	299.803	236.498
DB23456	111.875	201.665	269.313	307.47	321.788	335.817	330.359	300.872	234.294
DB123456	316.933	344.166	346.155	338.382	329.902	336.962	329.594	300.581	235.321
DL1	269.012	175.434	98.541	42.559	13.388	6.636	2.32	0.713	1.668
DL2	120.723	147.317	143.702	100.065	56.341	27.848	10.639	3.876	0.378
DL3	35.061	80.556	122.05	143.367	112.368	70.309	35.852	14.014	3.278
DL4	5.915	23.282	49.527	89.338	129.915	139.786	102.699	59.973	19.973
DL5	0.913	6.965	17.037	39.864	74.338	119.225	146.906	125.336	83.44
DL6	0.814	1.385	4.271	10.521	25.349	60.096	115.239	178.782	213.905

DL12	389.598	322.638	242.008	142.228	69.127	31.188	12.263	3.902	0.488
DL13	303.851	255.868	220.305	185.399	124.921	73.305	35.272	13.301	2.9
DL14	268.271	197.364	147.087	131.148	142.44	142.65	101.966	59.087	19.49
DL15	266.666	180.141	114.777	81.671	86.805	122.163	146.452	124.849	84.513
DL16	269.075	175.299	100.27	51.498	37.542	62.899	114.726	178.336	214.944
DL22	241.402	294.622	287.393	200.122	112.643	55.658	21.305	7.752	0.76
DL24	120.154	169.339	192.519	189.149	186.105	167.317	112.877	61.883	19.77
DL25	118.469	152.08	160.139	139.61	130.458	146.724	157.035	126.981	81.805
DL26	120.868	147.202	145.628	109.437	81.197	87.493	125.308	180.434	212.228
DL34	34.542	102.604	170.875	232.476	242.216	209.955	138.364	73.844	23.153
DL35	32.789	85.25	138.392	182.848	186.554	189.241	182.045	137.968	80.797
DL36	35.192	80.377	123.916	152.677	137.293	129.979	150.32	191.455	211.228
DL45	6.345	28.574	66.258	129	204.131	258.924	249.42	184.93	101.79
DL46	5.442	23.069	51.424	98.715	154.857	199.595	217.618	238.347	232.172
DL56	0.741	7.775	19.132	49.375	99.337	179.11	262.035	304.073	297.207
DL123	382.083	362.86	327.592	256.907	163.083	90.957	41.229	14.842	2.788
DL124	350.042	310.18	261.676	208.072	178.804	153.245	101.065	55.013	17.442
DL125	348.563	294.659	232.571	163.504	128.74	134.798	140.987	113.936	74.67
DL126	350.75	290.302	219.538	136.354	84.4	81.465	112.421	162.037	192.052
DL134	273.002	250.131	242.203	247.057	229.307	191.676	124.049	65.809	20.498
DL135	271.464	234.527	213.006	202.436	179.22	173.048	163.496	123.841	73.767
DL136	273.65	230.169	199.973	175.286	134.881	119.715	134.931	171.942	191.149
DL145	239.514	181.953	147.224	153.704	195.012	235.58	223.933	165.902	92.561
DL146	241.701	177.596	134.192	126.557	150.678	182.257	195.411	214.048	209.957
DL156	240.192	162.087	105.075	82.006	100.611	163.845	235.432	273.219	268.488
DL234	139.698	224.913	283.123	299.25	268.6	213.847	133.826	68.323	20.746
DL235	138.068	209.235	253.821	254.57	218.505	195.16	173.014	125.732	71.331
DL236	140.255	204.878	240.789	227.421	174.167	141.83	144.455	173.87	188.723
DL245	106.118	156.661	188.04	205.839	234.298	257.695	233.457	167.831	90.135
DL246	108.305	152.304	175.008	178.692	189.965	204.37	204.93	215.966	207.487
DL256	106.846	136.811	145.932	134.148	139.901	185.961	244.953	275.137	266.018
DL345	29.822	96.679	168.558	244.765	284.782	295.995	255.988	177.756	89.244
DL346	31.205	92.168	155.439	217.59	240.443	242.649	227.437	225.837	206.575
DL356	29.746	76.679	126.367	173.08	190.381	224.211	267.462	285.043	265.115
DL456	5.298	25.531	61.355	124.564	206.196	286.891	328.074	327.298	284.029
DL1234	317.985	318.912	309.625	280.903	233.269	180.465	111.11	56.379	17
DL1235	316.675	305.88	285.24	243.706	191.537	164.903	143.892	104.504	60.346
DL1236	318.503	302.237	274.392	221.054	154.584	120.471	120.11	144.597	158.134
DL1245	290.049	262.064	230.416	203.06	204.688	217.031	194.238	139.563	75.994

DL1246	291.873	258.419	219.538	180.439	167.736	172.601	170.458	179.657	173.782
DL1256	290.652	245.513	195.32	143.363	126.034	157.236	203.838	228.995	222.574
DL1345	225.786	211.93	214.095	235.494	246.745	248.916	213.034	147.836	75.249
DL1346	227.614	208.294	203.256	212.883	209.83	204.488	189.221	187.926	173.033
DL1356	226.398	195.412	178.998	175.761	168.081	189.108	222.588	237.223	221.815
DL1456	199.773	151.601	124.181	135.155	181.243	241.249	272.981	272.327	237.478
DL2345	114.652	190.86	248.108	278.948	279.501	267.343	220.957	149.407	73.169
DL2346	116.48	187.222	237.265	256.331	242.549	222.91	197.145	189.504	170.997
DL2356	115.268	174.347	213.043	219.216	200.806	207.537	230.52	238.839	219.789
DL2456	88.639	130.529	158.19	178.603	213.962	259.672	280.905	273.905	235.442
DL3456	24.514	80.429	141.923	211.051	256.056	291.562	299.672	282.177	234.694
DL12345	316.266	322.382	321.84	310.502	288.939	269.624	220.664	149.091	74.061
DL12346	318.094	318.743	310.995	287.881	251.983	225.159	196.853	189.222	171.897
DL12356	316.867	305.827	286.737	250.766	210.275	209.82	230.225	238.516	220.637
DL12456	290.243	262.015	231.92	210.159	223.437	261.961	280.617	273.62	236.3
DL13456	225.989	211.919	215.604	242.594	265.49	293.837	299.369	281.849	235.54
DL23456	114.855	190.847	249.613	286.042	298.209	312.26	307.293	283.427	233.504
DL123456	316.47	322.368	323.343	317.592	307.643	314.508	307.001	283.146	234.404
ENV	393.042	391.122	355.117	338.382	329.902	336.962	356.451	349.724	300.767
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1717.342	1613.239	1549.608	1515.523	1495.847	1492.807	1510.616	1525.222	1462.325

8.3.3 P1-2 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	385.788	424.05	424.05	424.05	424.05	424.05	424.05	424.05	370.971
합성후	322.486	201.749	140.082	118.01	114.441	112.458	119.269	141.29	196.705
	219.443	197.091	167.672	149.597	138.878	128.224	127.592	144.809	193.184
ENV	322.486	201.749	167.672	149.597	138.878	128.224	127.592	144.809	196.705
ADD	1311.538	1229.063	1194.986	1176.911	1166.192	1155.538	1154.906	1172.123	1170.94
DB1	270.42	193.601	103.471	42.107	11.75	5.663	2.034	0.655	1.723
DB2	117.338	159.431	158.115	109.59	59.877	27.673	9.666	3.819	0.398
DB3	31.795	82.818	133.89	157.415	124.402	75.392	36.758	13.861	2.972
DB4	5.107	20.341	50.421	95.103	142.547	153.972	113.152	63.716	17.145
DB5	0.864	5.254	15.603	39.51	78.614	130.04	161.266	135.932	84.029
DB6	0.832	1.024	3.583	8.637	24.072	60.943	122.842	188.925	221.578
DB12	387.647	352.955	261.399	151.373	71.183	29.493	10.623	3.868	0.407
DB13	302.054	276.335	237.162	199.093	135.548	76.965	35.64	13.2	2.694
DB14	268.83	212.748	153.131	136.626	153.673	155.5	112.034	63.22	18.435
DB15	268.011	196.56	118.432	81.035	89.698	131.594	160.235	135.484	85.33
DB16	270.686	193.113	104.374	49.48	34.964	62.436	121.785	188.517	222.833
DB22	234.673	318.86	316.208	219.18	119.775	55.348	19.333	7.638	0.797
DB24	115.856	178.616	207.96	204.492	202.33	181.395	122.455	65.367	17.065
DB25	115.016	162.399	173.209	148.873	138.349	157.445	170.516	137.383	82.367
DB26	117.691	158.953	159.153	117.32	83.637	88.289	132.069	190.417	219.869
DB34	30.351	102.026	183.763	252.318	266.921	229.254	149.786	77.465	20.041
DB35	29.46	85.734	148.929	196.626	202.923	205.182	197.454	148.762	80.86
DB36	32.135	82.288	134.871	165.071	148.188	136.024	159.007	201.799	218.386
DB45	5.636	23.82	65.812	134.489	221.102	283.994	274.414	199.634	101.164
DB46	4.794	19.786	51.451	102.838	166.353	214.757	235.918	252.608	238.627
DB56	0.764	5.836	16.748	47.344	102.459	190.838	284.039	324.84	305.555
DB123	377.435	392.189	355.728	277.812	175.849	94.084	40.618	14.021	2.529
DB124	347.497	334.907	280.081	221.566	192.15	164.679	109.203	58.269	15.137
DB125	346.762	320.341	248.852	171.517	134.555	143.165	152.578	123.298	75.353
DB126	349.175	317.256	236.198	143.125	85.303	80.914	117.963	171.034	199.11
DB134	270.545	265.991	258.304	264.623	250.257	207.758	133.801	69.138	17.789
DB135	269.76	251.337	227.001	214.509	192.669	186.136	176.806	133.542	73.994
DB136	272.173	248.252	214.347	186.118	143.418	123.888	142.216	181.285	197.777
DB145	239.899	194.173	151.457	158.356	208.984	256.912	245.926	179.164	92.167
DB146	242.312	191.087	138.804	129.964	159.733	194.664	211.334	226.903	215.926

DB156	241.571	176.497	107.551	79.914	102.159	173.151	254.71	291.933	276.142
DB234	132.892	235.288	307.671	325.704	294.078	231.117	143.299	71.298	18.032
DB235	132.077	220.607	276.294	275.564	236.461	209.418	186.075	135.275	71.337
DB236	134.468	217.52	263.661	247.173	187.209	147.167	151.458	182.988	195.089
DB245	102.213	163.422	200.77	219.411	252.777	280.195	255.196	180.897	89.51
DB246	104.625	160.336	188.116	190.999	203.545	217.945	220.582	228.634	213.267
DB256	103.889	145.769	156.867	140.97	145.951	196.431	263.955	293.66	273.459
DB345	25.213	94.438	178.898	262.401	310.888	323.143	279.421	191.14	88.151
DB346	27.598	91.324	166.238	233.985	261.633	260.893	244.83	238.882	211.933
DB356	26.887	76.765	135.016	183.963	204.067	239.406	288.207	303.91	272.126
DB456	4.791	20.945	60.145	128.023	220.413	310.311	357.474	349.664	290.39
DB1234	313.425	341.208	333.843	302.703	253.429	193.785	118.577	58.95	14.824
DB1235	312.762	328.988	307.705	260.915	205.421	175.728	154.317	112.428	60.45
DB1236	314.767	326.422	297.177	237.268	164.383	123.851	125.475	152.199	163.587
DB1245	287.891	281.362	244.761	214.115	219.022	234.719	211.907	150.446	75.594
DB1246	289.891	278.773	234.23	190.467	177.984	182.844	183.088	190.219	178.733
DB1256	289.282	266.63	208.198	148.755	129.995	164.912	219.228	244.428	228.911
DB1345	223.724	223.86	226.564	249.957	267.443	270.512	232.111	158.981	74.47
DB1346	225.722	221.267	216.008	226.284	226.403	218.635	203.293	198.776	177.613
DB1356	225.113	209.127	189.979	184.596	178.418	200.726	239.433	252.964	227.787
DB1456	200.242	161.5	127.034	137.795	192.016	259.694	297.019	290.976	242.907
DB2345	108.965	198.235	267.632	300.817	303.929	289.9	239.82	160.434	72.263
DB2346	110.965	195.645	257.1	277.148	262.891	238.045	211.002	200.209	175.403
DB2356	110.356	183.504	231.07	235.459	214.904	220.113	247.138	254.391	225.554
DB2456	85.484	135.875	168.104	188.657	228.523	279.083	304.727	292.408	240.697
DB3456	21.316	78.373	149.905	224.478	276.945	314.898	324.935	300.967	239.577
DB12345	311.672	343.389	345.111	332.115	312.31	291.143	239.097	160.131	73.275
DB12346	313.675	340.819	334.558	308.443	271.267	239.263	210.254	199.901	176.412
DB12356	313.089	328.682	308.53	266.754	223.281	221.333	246.392	254.106	226.567
DB12456	288.191	281.028	245.581	219.951	236.878	280.3	303.98	292.123	241.71
DB13456	224.021	223.523	227.359	255.769	285.298	316.113	324.185	300.658	240.586
DB23456	109.288	197.905	268.454	306.635	321.809	335.506	331.916	302.093	238.378
DB123456	311.997	343.078	345.91	337.928	330.162	336.722	331.169	301.808	239.392
DL1	263.673	180.728	99.485	43.051	13.69	6.675	2.358	0.735	1.652
DL2	117.684	147.453	144.317	100.933	57.217	28.293	10.938	4.389	0.376
DL3	33.912	78.325	121.472	143.48	113.497	71.191	36.586	15.313	3.266
DL4	5.836	21.482	48.9	88.261	129.329	140.038	103.909	61.908	20.268
DL5	0.911	6.091	16.724	39.093	73.479	118.127	147.371	125.806	85.756
DL6	0.797	1.177	4.206	10.276	24.896	59.001	114.877	174.55	218.865

DL12	381.185	328.072	243.539	143.594	70.395	31.711	12.509	4.46	0.447
DL13	297.346	258.969	220.646	186.013	126.41	74.251	36.048	14.578	2.877
DL14	262.88	200.693	147.38	130.575	142.211	142.977	103.258	61.134	20.108
DL15	261.36	184.504	115.406	81.44	86.312	121.165	146.907	125.325	86.854
DL16	263.752	180.421	101.158	51.75	37.485	61.912	114.394	174.119	219.925
DL22	235.314	294.86	288.627	201.865	114.465	56.586	21.842	8.774	0.748
DL24	116.986	167.443	192.462	188.933	186.422	168.013	114.394	64.333	20.039
DL25	115.48	151.242	160.43	139.711	130.507	146.104	157.741	128	84.061
DL26	117.872	147.156	146.178	110.015	81.644	86.846	125.224	176.791	217.132
DL34	33.27	98.378	169.627	231.505	242.757	211.092	140.374	77.088	23.443
DL35	31.7	82.086	137.495	182.195	186.822	189.036	183.241	139.914	83.089
DL36	34.092	78.001	123.242	152.499	137.957	129.772	150.713	188.659	216.105
DL45	6.279	25.87	65.306	127.157	202.686	258.093	251.131	187.448	104.73
DL46	5.369	21.063	50.698	97.352	153.843	198.771	218.539	236.171	237.752
DL56	0.733	6.694	18.756	48.314	98.05	176.919	262.144	300.324	304.517
DL123	373.507	365.75	328.489	258.264	165.245	92.215	42.152	16.415	2.742
DL124	342.417	313.278	262.495	208.312	179.414	153.96	102.456	57.261	17.691
DL125	341.069	298.715	233.689	164.076	129.11	134.279	141.642	114.83	76.73
DL126	343.201	295.03	220.888	137.34	85.156	80.974	112.382	158.736	196.459
DL134	267.097	251.112	241.977	246.664	230.132	192.77	125.824	68.734	20.751
DL135	265.642	236.447	213.031	202.303	179.801	172.948	164.571	125.538	75.815
DL136	267.82	232.775	200.238	175.602	135.847	119.612	135.311	169.45	195.588
DL145	234.644	184.086	147.181	152.493	194.045	234.938	225.495	168.174	95.193
DL146	236.82	180.411	134.383	125.755	150.085	181.598	196.234	212.084	214.966
DL156	235.487	165.866	105.596	81.533	99.749	161.946	235.529	269.847	275.032
DL234	135.836	221.217	282.546	299.164	269.899	215.291	135.872	71.672	20.972
DL235	134.346	206.502	253.574	254.753	219.56	195.38	174.32	127.952	73.312
DL236	136.524	202.83	240.782	228.052	175.606	142.042	145.056	171.855	193.04
DL245	103.348	154.141	187.725	204.943	233.804	257.37	235.245	170.588	92.69
DL246	105.519	150.459	174.889	178.199	189.84	204.027	205.983	214.498	212.462
DL256	104.143	135.905	146.098	133.976	139.504	184.375	245.278	272.261	272.529
DL345	29.198	92.152	167.204	243.211	284.495	296.029	258.202	181.327	91.838
DL346	30.098	88.202	154.274	216.468	240.539	242.699	228.908	225.17	211.537
DL356	28.764	73.655	125.485	172.216	190.236	223.052	268.211	282.972	271.615
DL456	5.246	22.93	60.413	122.661	204.513	285.197	329.313	325.768	291.103
DL1234	310.778	319.8	309.842	281.212	234.641	181.707	112.809	59.19	17.187
DL1235	309.559	307.582	285.726	244.261	192.685	165.145	144.988	106.32	61.968
DL1236	311.382	304.507	275.053	221.967	156.046	120.725	120.591	142.902	161.746
DL1245	283.764	263.925	230.863	202.721	204.538	216.804	195.744	141.869	78.142

DL1246	285.554	260.883	220.199	180.468	167.909	172.391	171.38	178.42	177.914
DL1256	284.4	248.732	196.191	143.582	125.965	156	204.105	226.593	227.971
DL1345	220.881	212.043	213.628	234.562	246.786	248.999	214.863	150.782	77.385
DL1346	222.715	209.011	202.967	212.309	210.155	204.584	190.469	187.364	177.163
DL1356	221.563	196.864	178.967	175.462	168.22	188.199	223.227	235.507	227.214
DL1456	195.734	153.236	124.105	133.924	180.073	239.855	273.977	271.017	243.377
DL2345	111.503	187.099	247.412	278.303	279.929	267.705	222.988	152.769	75.285
DL2346	113.294	184.057	236.747	256.048	243.298	223.29	198.593	189.351	175.063
DL2356	112.14	171.906	212.74	219.163	201.357	206.901	231.349	237.493	225.114
DL2456	86.355	128.287	157.884	177.627	213.212	258.561	282.105	273.042	241.288
DL3456	23.992	76.487	140.705	209.52	255.467	290.771	301.239	281.967	240.539
DL12345	309.11	322.576	321.835	310.229	289.624	270.071	222.715	152.49	76.168
DL12346	310.901	319.534	311.168	287.971	252.988	225.62	198.319	189.077	175.989
DL12356	309.747	307.384	287.165	251.092	211.083	209.237	231.079	237.221	226.04
DL12456	283.963	263.77	232.315	209.592	222.942	260.896	281.826	272.724	242.159
DL13456	221.124	211.898	215.084	241.435	265.191	293.093	300.95	281.645	241.447
DL23456	111.703	186.944	248.863	285.174	298.335	311.803	309.08	283.67	239.357
DL123456	309.31	322.421	323.287	317.1	308.029	314.165	308.802	283.354	240.229
ENV	387.647	392.189	355.728	337.928	330.162	336.722	357.474	349.664	305.555
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1699.185	1621.252	1550.714	1514.839	1496.354	1492.26	1512.38	1521.787	1476.495

8.3.4 P2-1 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	385.788	424.05	424.05	424.05	424.05	424.05	424.05	424.05	370.971
합성후	331.08	193.778	140.369	117.153	115.294	112.341	119.368	145.127	191.979
	224.836	193.604	167.813	148.44	139.537	127.763	127.547	148.101	188.85
ENV	331.08	193.778	167.813	148.44	139.537	127.763	127.547	148.101	191.979
ADD	1320.132	1221.092	1195.127	1175.754	1166.851	1155.077	1154.861	1175.415	1166.214
DB1	273.037	189.801	103.209	41.471	11.668	5.54	2.019	0.618	1.709
DB2	118.896	159.097	158.132	108.902	59.709	27.266	9.555	3.358	0.406
DB3	32.268	84.178	134.318	157.081	124.36	74.791	36.48	12.802	2.998
DB4	5.104	21.579	50.882	95.252	143.098	153.707	112.798	62.144	16.895
DB5	0.848	5.895	15.847	39.658	79.292	130.292	161.225	135.516	82.845
DB6	0.842	1.176	3.646	8.672	24.486	61.364	123.135	191.547	219.22
DB12	391.811	348.81	261.15	150.047	70.917	28.96	10.507	3.359	0.404
DB13	305.129	273.887	237.323	198.12	135.406	76.232	35.355	12.101	2.716
DB14	271.391	210.3	153.325	136.14	154.127	155.108	111.678	61.643	18.173
DB15	270.566	193.439	118.415	80.55	90.277	131.717	160.189	135.059	84.137
DB16	273.286	189.443	104.173	48.888	35.279	62.728	122.073	191.127	220.468
DB22	237.789	318.192	316.242	217.804	119.439	54.534	19.112	6.716	0.812
DB24	117.371	179.643	208.436	203.957	202.715	180.724	121.988	63.346	16.842
DB25	116.525	162.752	173.473	148.337	138.857	157.289	170.361	136.485	81.22
DB26	119.245	158.757	159.233	116.678	83.882	88.303	132.246	192.554	217.552
DB34	30.784	104.745	184.65	252.136	267.435	228.391	149.158	74.838	19.818
DB35	29.885	87.778	149.602	196.442	203.559	204.833	197.138	147.176	79.74
DB36	32.605	83.782	135.361	164.78	148.56	135.844	159.024	203.248	216.095
DB45	5.601	25.692	66.522	134.788	222.331	283.982	274.02	197.646	99.733
DB46	4.785	21.175	51.976	103.033	167.32	214.916	235.859	253.657	236.025
DB56	0.752	6.632	17.054	47.538	103.553	191.515	284.292	327.045	302.018
DB123	381.603	389.686	355.888	276.317	175.568	93.056	40.259	12.622	2.567
DB124	351.202	332.404	280.269	220.509	192.404	163.957	108.778	56.415	14.933
DB125	350.462	317.232	248.85	170.461	134.923	142.907	152.432	122.481	74.309
DB126	352.915	313.652	236.031	141.973	85.433	80.808	118.117	172.948	197.012
DB134	273.276	265.011	258.863	263.884	250.628	206.864	133.23	66.738	17.585
DB135	272.485	249.75	227.367	213.769	193.15	185.703	176.515	132.105	72.975
DB136	274.938	246.17	214.549	185.282	143.662	123.608	142.225	182.579	195.703
DB145	242.162	192.588	151.855	158.056	210.004	256.788	245.57	177.371	90.869
DB146	244.616	189.008	139.036	129.569	160.516	194.692	211.278	227.841	213.574

DB156	243.869	173.811	107.594	79.519	103.054	173.643	254.933	293.908	272.951
DB234	134.682	237.436	308.484	324.922	294.388	229.972	142.629	68.526	17.855
DB235	133.859	222.146	276.914	274.778	236.88	208.735	185.685	133.413	70.36
DB236	136.291	218.565	264.115	246.292	187.391	146.636	151.368	183.857	193.059
DB245	103.534	164.963	201.421	219.066	253.735	279.82	254.741	178.678	88.254
DB246	105.987	161.383	188.601	190.558	204.265	217.722	220.426	229.146	210.957
DB256	105.245	146.21	157.162	140.53	146.784	196.672	264.079	295.209	270.311
DB345	25.559	97.501	179.917	262.372	311.959	322.594	278.821	188.3	86.919
DB346	27.985	93.893	167.092	233.86	262.467	260.496	244.53	238.774	209.647
DB356	27.269	78.728	135.68	183.839	205.013	239.472	288.187	304.839	269.001
DB456	4.755	22.766	60.843	128.335	221.894	310.682	357.385	350.233	286.984
DB1234	316.868	340.142	334.321	301.571	253.61	192.732	118.013	56.61	14.673
DB1235	316.198	327.415	308.022	259.782	205.694	175.061	153.988	110.869	59.627
DB1236	318.237	324.438	297.356	236.055	164.458	123.31	125.395	152.915	161.885
DB1245	290.943	279.79	245.104	213.349	219.744	234.308	211.523	148.589	74.538
DB1246	292.978	276.79	234.436	189.621	178.508	182.56	182.954	190.638	176.798
DB1256	292.364	264.142	208.246	147.91	130.613	165.015	219.327	245.711	226.278
DB1345	225.964	223.557	227.214	249.454	268.261	269.956	231.606	156.607	73.433
DB1346	227.996	220.552	216.52	225.702	227.022	218.206	203.038	198.679	175.698
DB1356	227.382	207.907	190.333	184.015	179.131	200.684	239.411	253.731	225.174
DB1456	202.127	160.281	127.414	137.58	193.178	259.908	296.943	291.446	240.061
DB2345	110.42	200.537	268.493	300.276	304.694	289.134	239.233	157.706	71.263
DB2346	112.454	197.535	257.823	276.528	263.459	237.407	210.665	199.757	173.523
DB2356	111.84	184.89	231.635	234.839	215.565	219.862	247.034	254.803	222.976
DB2456	86.583	137.262	168.695	188.405	229.632	279.088	304.568	292.523	237.886
DB3456	21.603	81.028	150.803	224.489	278.15	314.758	324.655	300.565	236.787
DB12345	315.079	342.836	345.773	331.096	312.999	290.28	238.505	157.396	72.265
DB12346	317.115	339.854	335.082	307.344	271.759	238.526	209.911	199.442	174.523
DB12356	316.525	327.212	308.896	265.656	223.866	220.983	246.283	254.511	223.98
DB12456	291.242	279.56	245.972	219.22	237.912	280.207	303.817	292.23	238.89
DB13456	226.26	223.323	228.057	255.302	286.427	315.875	323.901	300.25	237.786
DB23456	110.741	200.31	269.363	306.13	322.885	335.058	331.549	301.33	235.613
DB123456	315.403	342.628	346.62	336.944	331.164	336.176	330.797	301.037	236.617
DL1	268.751	175.052	99.134	42.276	13.617	6.549	2.337	0.699	1.623
DL2	120.088	146.65	144.27	99.949	56.998	27.796	10.822	3.857	0.387
DL3	34.411	79.892	122.119	143.004	113.359	70.391	36.244	14.052	3.321
DL4	5.795	22.952	49.49	88.502	130.155	139.639	103.384	60.088	20.07
DL5	0.887	6.839	17.006	39.273	74.388	118.552	147.356	125.549	84.086
DL6	0.813	1.353	4.273	10.3	25.393	59.533	115.342	178.612	214.582

DL12	388.654	321.58	243.135	141.837	70.074	31.087	12.397	3.868	0.445
DL13	302.904	254.849	220.936	184.763	126.166	73.309	35.707	13.274	2.928
DL14	267.795	196.648	147.603	130.048	142.936	142.439	102.739	59.281	19.901
DL15	266.332	179.637	115.341	80.851	87.118	121.449	146.893	125.065	85.158
DL16	268.816	174.892	100.869	51.02	37.88	62.306	114.859	178.176	215.623
DL22	240.122	293.255	288.531	199.897	114.028	55.591	21.61	7.709	0.77
DL24	119.244	168.284	192.992	188.196	187.032	167.12	113.743	61.983	19.877
DL25	117.795	151.257	160.671	138.91	131.197	146.033	157.601	127.171	82.452
DL26	120.278	146.51	146.196	109.074	81.922	86.884	125.563	180.28	212.917
DL34	33.626	101.586	170.853	231.276	243.449	209.897	139.511	74.01	23.302
DL35	32.112	84.466	138.428	181.899	187.592	188.659	182.895	138.242	81.569
DL36	34.596	79.719	123.953	152.061	138.315	129.505	150.846	191.303	211.981
DL45	6.193	28.088	66.19	127.578	204.421	258.117	250.594	185.337	102.884
DL46	5.321	22.707	51.353	97.636	155.169	198.906	218.483	238.379	233.301
DL56	0.715	7.616	19.098	48.536	99.459	177.879	262.595	304.128	298.573
DL123	380.672	361.321	328.707	256.254	164.828	90.919	41.736	14.761	2.806
DL124	349.002	308.917	262.652	206.953	179.868	153.029	101.872	55.107	17.54
DL125	347.706	293.612	233.585	162.659	129.637	134.088	141.515	114.081	75.255
DL126	349.92	289.333	220.584	135.797	85.312	80.88	112.685	161.872	192.638
DL134	271.971	248.881	242.759	245.761	230.66	191.566	125.049	65.925	20.619
DL135	270.566	233.472	213.551	201.341	180.4	172.482	164.259	124.031	74.422
DL136	272.825	229.205	200.558	174.513	136.075	119.244	135.43	171.827	191.848
DL145	238.99	181.182	147.642	152.184	195.518	234.838	225.016	166.275	93.508
DL146	241.248	176.911	134.644	125.319	151.188	181.596	196.186	214.071	210.934
DL156	239.967	161.625	105.597	81.041	100.925	162.684	235.936	273.268	269.66
DL234	138.318	223.382	283.606	298.072	270.324	213.768	134.978	68.423	20.875
DL235	136.878	207.923	254.37	253.6	220.054	194.593	173.895	125.933	71.997
DL236	139.137	203.655	241.378	226.772	175.729	141.353	145.062	173.72	189.38
DL245	105.302	155.632	188.462	204.443	235.172	256.949	234.652	168.177	91.083
DL246	107.555	151.354	175.426	177.573	190.837	203.704	205.821	215.973	208.509
DL256	106.23	136.06	146.375	133.293	140.574	184.793	245.571	275.17	267.235
DL345	29.459	95.738	168.566	243.164	285.934	295.333	257.424	178.158	90.311
DL346	30.421	91.226	155.435	216.296	241.608	242.101	228.561	225.885	207.667
DL356	29.139	75.938	126.386	171.988	191.378	223.195	268.319	285.121	266.403
DL456	5.163	25.084	61.269	123.079	206.525	285.701	329.25	327.521	285.597
DL1234	316.64	317.34	310.458	279.722	234.916	180.331	112.065	56.449	17.102
DL1235	315.462	304.502	286.123	242.721	193.017	164.383	144.633	104.635	60.85
DL1236	317.354	300.93	275.283	220.322	156.07	120.044	120.595	144.453	158.674
DL1245	289.186	260.903	231.211	201.725	205.599	216.347	195.249	139.858	76.779

DL1246	291.045	257.365	220.379	179.367	168.662	172.016	171.244	179.646	174.598
DL1256	289.934	244.597	196.156	142.434	126.779	156.242	204.349	229.014	223.537
DL1345	224.876	210.795	214.495	233.945	247.907	248.313	214.215	148.139	76.091
DL1346	226.779	207.266	203.667	211.586	210.968	203.98	190.179	187.958	173.915
DL1356	225.669	194.502	179.451	174.692	169.093	188.212	223.316	237.295	222.849
DL1456	199.359	150.932	124.54	133.698	181.675	240.173	273.927	272.48	238.768
DL2345	113.505	189.513	248.509	277.527	280.962	266.752	222.244	149.699	74.056
DL2346	115.365	185.975	237.677	255.166	244.023	222.419	198.208	189.518	171.88
DL2356	114.253	173.207	213.454	218.235	202.142	206.647	231.343	238.855	220.814
DL2456	87.988	129.645	158.548	177.243	214.726	258.612	281.96	274.078	236.744
DL3456	24.204	79.606	141.891	209.514	257.041	290.593	300.94	282.37	236.063
DL12345	314.906	320.726	322.666	308.873	290.58	269.012	221.97	149.418	74.916
DL12346	316.765	317.188	311.831	286.509	253.634	224.643	197.934	189.242	172.783
DL12356	315.654	304.422	287.613	249.584	211.791	208.877	231.073	238.581	221.717
DL12456	289.389	260.865	232.713	208.628	224.378	260.841	281.68	273.757	237.593
DL13456	225.123	210.766	216.002	240.849	266.686	292.809	300.651	282.047	236.948
DL23456	113.709	189.475	250.011	284.43	299.743	311.251	308.686	283.646	234.924
DL123456	315.109	320.688	324.168	315.776	309.359	313.507	308.406	283.326	235.774
ENV	391.811	389.686	355.888	336.944	331.164	336.176	357.385	350.233	302.018
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1711.943	1610.778	1551.015	1512.698	1498.015	1491.253	1512.246	1525.648	1468.232

8.3.5 P2-2 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	382.016	424.05	424.05	424.05	424.05	424.05	424.05	424.05	374.743
합성후	321.282	201.22	140.689	117.473	114.461	112.75	119.459	141.178	197.977
	218.931	196.405	168.112	148.867	138.805	128.491	127.729	144.687	194.463
ENV	321.282	201.22	168.112	148.867	138.805	128.491	127.729	144.687	197.977
ADD	1306.562	1228.534	1195.426	1176.181	1166.119	1155.805	1155.043	1172.001	1175.984
DB1	269.713	193.575	104.055	42.142	11.928	5.697	2.04	0.658	1.7
DB2	116.581	158.758	158.495	109.853	60.306	27.942	9.758	3.858	0.405
DB3	31.164	82.036	133.635	157.353	124.988	75.964	37.03	14.021	3.009
DB4	5.02	19.941	50.175	94.466	142.153	154.309	113.691	64.219	17.655
DB5	0.845	5.137	15.478	39.116	78.127	129.678	161.383	136.399	84.813
DB6	0.854	1.004	3.574	8.548	23.854	60.681	122.566	188.744	222.354
DB12	386.189	352.282	262.366	151.675	71.79	29.834	10.657	3.909	0.386
DB13	300.72	275.552	237.475	199.093	136.319	77.617	35.925	13.373	2.732
DB14	267.924	212.324	153.438	136.049	153.459	155.889	112.575	63.702	18.894
DB15	267.306	196.399	118.887	80.679	89.368	131.303	160.333	135.928	86.063
DB16	270.004	193.088	104.923	49.383	34.918	62.222	121.51	188.296	223.575
DB22	233.143	317.535	316.973	219.729	120.637	55.887	19.518	7.717	0.811
DB24	114.896	177.536	208.054	204.11	202.361	181.984	123.028	65.848	17.203
DB25	114.24	161.589	173.482	148.744	138.291	157.37	170.683	137.907	83.133
DB26	116.962	158.281	159.519	117.449	83.82	88.289	131.882	190.276	220.648
DB34	29.516	100.838	183.223	251.634	267.112	230.151	150.562	78.07	20.213
DB35	28.81	84.818	148.569	196.177	203.026	205.44	197.838	149.455	81.758
DB36	31.532	81.51	134.605	164.88	148.552	136.337	159.034	201.822	219.272
DB45	5.531	23.303	65.439	133.457	220.219	283.966	275.045	200.597	102.433
DB46	4.708	19.381	51.167	102.065	165.733	214.826	236.176	252.907	239.906
DB56	0.745	5.694	16.627	46.796	101.746	190.208	283.876	325.121	307.089
DB123	375.545	390.879	356.37	278.052	176.928	94.898	40.932	14.128	2.552
DB124	346.004	333.929	280.71	221.275	192.323	165.28	109.737	58.729	15.538
DB125	345.44	319.593	249.615	171.452	134.67	143.165	152.722	123.739	76.001
DB126	347.873	316.63	237.03	143.285	85.634	80.978	117.799	170.876	199.774
DB134	269.176	264.911	258.343	264.024	250.585	208.608	134.488	69.674	17.94
DB135	268.547	250.511	227.178	214.14	192.896	186.394	177.156	134.142	74.75
DB136	271.002	247.533	214.618	185.978	143.886	124.231	142.235	181.259	198.519
DB145	239.076	193.656	151.622	157.458	208.349	256.955	246.489	180.039	93.266
DB146	241.534	190.7	139.063	129.296	159.337	194.769	211.566	227.154	217.035

DB156	240.947	176.359	107.965	79.47	101.662	172.653	254.551	292.186	277.503
DB234	131.437	233.607	307.529	325.326	294.631	232.152	144.071	71.904	18.197
DB235	130.803	219.186	276.316	275.396	236.932	209.859	186.485	135.906	72.118
DB236	133.234	216.205	263.753	247.234	187.923	147.698	151.567	183.045	195.891
DB245	101.331	162.331	200.759	218.714	252.384	280.42	255.819	181.803	90.634
DB246	103.79	159.375	188.199	190.55	203.351	218.234	220.896	228.94	214.407
DB256	103.202	145.035	157.102	140.727	145.699	196.12	263.882	293.969	274.852
DB345	24.509	93.262	178.33	261.406	310.633	323.651	280.253	192.185	89.378
DB346	26.893	90.271	165.76	233.238	261.597	261.462	245.309	239.322	213.172
DB356	26.329	75.935	134.667	183.418	203.949	239.373	288.319	304.355	273.619
DB456	4.696	20.459	59.795	126.944	219.409	310.04	357.796	350.382	292.226
DB1234	311.712	339.816	334.147	302.403	254.019	194.69	119.205	59.431	14.954
DB1235	311.169	327.789	308.155	260.826	205.951	176.163	154.674	112.946	61.081
DB1236	313.212	325.314	297.693	237.347	165.084	124.339	125.551	152.233	164.24
DB1245	286.627	280.42	245.199	213.589	218.811	234.942	212.43	151.192	76.506
DB1246	288.668	277.943	234.716	190.111	177.967	183.122	183.331	190.483	179.667
DB1256	288.178	266.007	208.805	148.603	129.915	164.708	219.15	244.671	230.041
DB1345	222.552	222.858	226.516	249.174	267.351	270.984	232.795	159.858	75.481
DB1346	224.593	220.381	216.032	225.695	226.506	219.162	203.692	199.123	178.614
DB1356	224.122	208.426	190.12	184.185	178.451	200.725	239.508	253.31	228.988
DB1456	199.556	161.054	127.163	136.95	191.315	259.529	297.291	291.564	244.439
DB2345	107.775	196.748	267.461	300.21	304.03	290.521	240.56	161.335	73.277
DB2346	109.793	194.267	256.977	276.733	263.187	238.722	211.461	200.605	176.434
DB2356	109.322	182.312	231.064	235.223	215.132	220.285	247.277	254.792	226.808
DB2456	84.782	134.964	168.088	187.986	227.992	279.065	305.055	293.041	242.235
DB3456	20.702	77.38	149.404	223.571	276.554	315.107	325.418	301.682	241.182
DB12345	309.947	341.895	345.34	331.538	312.528	291.809	239.842	161.035	74.266
DB12346	311.99	339.421	334.879	308.062	271.683	239.986	210.718	200.301	177.421
DB12356	311.495	327.46	308.962	266.529	223.627	221.549	246.556	254.49	227.796
DB12456	286.951	280.089	245.983	219.29	236.485	280.327	304.311	292.736	243.221
DB13456	222.876	222.528	227.301	254.877	285.047	316.37	324.674	301.377	242.169
DB23456	108.099	196.418	268.248	305.915	321.728	335.93	332.443	302.859	239.989
DB123456	310.273	341.567	346.148	337.243	330.224	337.194	331.7	302.555	240.976
DL1	263.017	180.698	100.087	43.025	13.844	6.712	2.361	0.734	1.609
DL2	116.885	146.777	144.802	101.117	57.621	28.538	11.002	4.432	0.382
DL3	33.244	77.548	121.342	143.377	114.026	71.729	36.823	15.471	3.31
DL4	5.724	21.051	48.698	87.64	128.982	140.423	104.329	62.257	20.423
DL5	0.891	5.954	16.634	38.702	73.043	117.845	147.448	126.164	86.595
DL6	0.84	1.159	4.199	10.173	24.686	58.805	114.678	174.207	219.788

DL12	379.776	327.381	244.662	143.725	70.952	32.022	12.543	4.501	0.405
DL13	296.072	258.183	221.166	185.904	127.139	74.872	36.303	14.754	2.923
DL14	261.997	200.249	147.775	129.941	142.019	143.407	103.718	61.552	20.576
DL15	260.684	184.335	115.911	80.997	86.031	120.953	147.021	125.655	87.646
DL16	263.104	180.397	101.738	51.552	37.417	61.741	114.192	173.745	220.838
DL22	233.769	293.551	289.602	202.2	115.237	57.103	21.97	8.861	0.76
DL24	116.047	166.366	192.773	188.471	186.478	168.638	114.874	64.723	20.197
DL25	114.663	150.43	160.824	139.513	130.484	146.11	157.925	128.415	84.908
DL26	117.117	146.462	146.647	110.063	81.835	86.896	125.124	176.501	218.059
DL34	32.453	97.168	169.327	230.796	242.978	212.02	141.033	77.596	23.642
DL35	31.006	81.14	137.273	181.714	186.958	189.343	183.607	140.463	84.015
DL36	33.47	77.21	123.101	152.264	138.305	130.12	150.763	188.504	217.151
DL45	6.154	25.311	65.021	126.156	201.908	258.214	251.704	188.232	106.084
DL46	5.272	20.646	50.482	96.592	153.24	198.924	218.787	236.241	239.182
DL56	0.707	6.521	18.609	47.776	97.393	176.432	262.018	300.337	306.276
DL123	371.656	364.459	329.358	258.284	166.259	92.995	42.449	16.548	2.771
DL124	340.938	312.262	263.293	207.885	179.604	154.589	102.908	57.625	17.834
DL125	339.755	297.962	234.611	163.848	129.231	134.358	141.788	115.208	77.42
DL126	341.954	294.417	221.855	137.341	85.45	81.07	112.251	158.481	197.304
DL134	265.708	250	242.2	245.98	230.442	193.617	126.44	69.206	20.933
DL135	264.465	235.61	213.386	201.821	180.039	173.245	164.886	126.012	76.617
DL136	266.668	232.072	200.666	175.32	136.262	119.958	135.344	169.276	196.457
DL145	233.881	183.533	147.469	151.533	193.453	235.084	225.985	168.881	96.374
DL146	236.079	179.989	134.714	125.027	149.703	181.765	196.445	212.152	216.257
DL156	234.859	165.687	106.007	80.998	99.301	161.59	235.442	269.85	276.598
DL234	134.362	219.525	282.702	298.694	270.46	216.343	136.548	72.176	21.158
DL235	133.036	205.071	253.82	254.479	220.047	195.883	174.701	128.501	74.125
DL236	135.24	201.532	241.101	227.977	176.269	142.598	145.164	171.774	194.009
DL245	102.462	153.031	187.91	204.194	233.46	257.719	235.794	171.332	93.871
DL246	104.651	149.448	175.147	177.683	189.677	204.431	206.257	214.605	213.755
DL256	103.475	135.157	146.447	133.657	139.306	184.224	245.251	272.302	274.095
DL345	28.88	91.022	166.872	242.259	284.283	296.65	258.941	182.212	93.104
DL346	29.366	87.107	153.964	215.699	240.497	243.328	229.363	225.447	212.963
DL356	28.19	72.816	125.264	171.673	190.126	223.122	268.357	283.144	273.303
DL456	5.138	22.421	60.137	121.604	203.6	285.081	329.626	326.134	293.159
DL1234	309.051	318.384	310.437	280.781	235.184	182.629	113.368	59.641	17.348
DL1235	307.98	306.372	286.424	243.999	193.213	165.639	145.32	106.765	62.642
DL1236	309.824	303.412	275.788	221.882	156.709	121.219	120.681	142.816	162.521
DL1245	282.497	262.974	231.46	202.059	204.394	217.157	196.246	142.482	79.126

DL1246	284.353	260.055	220.837	179.982	167.898	172.741	171.609	178.533	179.004
DL1256	283.343	248.106	196.927	143.287	125.907	155.878	204.101	226.632	229.272
DL1345	219.763	211.043	213.785	233.723	246.736	249.558	215.466	151.506	78.439
DL1346	221.613	208.092	203.192	211.65	210.246	205.149	190.866	187.565	178.323
DL1356	220.599	196.137	179.247	174.951	168.252	188.313	223.325	235.631	228.621
DL1456	195.131	152.783	124.327	133.021	179.439	239.832	274.247	271.339	245.06
DL2345	110.277	185.597	247.495	277.625	280.043	268.413	223.644	153.559	76.35
DL2346	112.077	182.629	236.859	255.514	243.58	224.004	199.046	189.619	176.234
DL2356	111.077	170.718	212.957	218.825	201.591	207.171	231.505	237.685	226.532
DL2456	85.596	127.324	157.999	176.921	212.778	258.693	282.433	273.403	243.015
DL3456	23.737	75.554	140.451	208.62	255.131	291.119	301.712	282.453	242.347
DL12345	307.371	321.062	322.349	309.506	289.865	270.802	223.371	153.249	77.224
DL12346	309.222	318.113	311.761	287.44	253.412	226.399	198.776	189.31	177.107
DL12356	308.217	306.196	287.822	250.745	211.419	209.564	231.234	237.376	227.406
DL12456	282.739	262.803	232.893	208.806	222.598	261.046	282.15	273.08	243.843
DL13456	220.005	210.873	215.221	240.476	264.95	293.49	301.418	282.124	243.208
DL23456	110.475	185.42	248.93	284.383	298.294	312.351	309.6	284.179	241.118
DL123456	307.614	320.894	323.788	316.263	308.112	314.735	309.29	283.862	241.988
ENV	386.189	390.879	356.37	337.243	330.224	337.194	357.796	350.382	307.089
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1692.751	1619.413	1551.796	1513.424	1496.343	1492.999	1512.839	1522.383	1483.073

8.3.6 A2 (단위:kN,좌측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	382.016	424.05	424.05	424.05	424.05	424.05	424.05	424.05	374.743
합성후	329.834	194.066	139.621	117.491	115.245	112.251	119.488	145.736	192.756
	224.19	193.853	166.867	148.666	139.375	127.568	127.638	148.694	189.641
ENV	329.834	194.066	166.867	148.666	139.375	127.568	127.638	148.694	192.756
ADD	1315.114	1221.38	1194.181	1175.98	1166.689	1154.882	1154.952	1176.008	1170.763
DB1	272.328	190.075	103.221	41.819	11.782	5.541	2.036	0.62	1.685
DB2	118.072	158.804	158.031	109.498	60.042	27.428	9.685	3.385	0.411
DB3	31.557	83.773	133.664	157.345	124.875	75.184	36.807	12.957	3.022
DB4	4.987	21.394	50.363	94.882	142.739	153.842	113.374	62.71	17.326
DB5	0.823	5.866	15.574	39.431	78.88	129.758	161.32	136.189	83.465
DB6	0.865	1.174	3.591	8.648	24.329	60.974	122.746	191.809	219.778
DB12	390.283	348.815	261.066	150.992	71.362	29.163	10.59	3.382	0.382
DB13	303.713	273.778	236.667	198.756	136.039	76.674	35.707	12.264	2.743
DB14	270.452	210.388	152.797	136.138	153.881	155.264	112.266	62.183	18.554
DB15	269.851	193.662	118.158	80.667	89.956	131.223	160.277	135.705	84.706
DB16	272.604	189.728	104.109	49.163	35.229	62.357	121.694	191.345	220.995
DB22	236.124	317.628	316.043	219.02	120.107	54.86	19.372	6.771	0.823
DB24	116.313	179.157	207.784	204.172	202.683	181.006	122.637	63.869	16.903
DB25	115.675	162.408	173.123	148.705	138.779	156.937	170.545	137.199	81.824
DB26	118.451	158.477	159.074	117.2	84.031	88.072	131.984	192.841	218.115
DB34	29.837	104.148	183.447	252.043	267.588	228.908	150.026	75.493	19.899
DB35	29.149	87.324	148.702	196.481	203.666	204.741	197.558	148.059	80.462
DB36	31.924	83.393	134.653	164.975	148.916	135.853	158.994	203.699	216.752
DB45	5.46	25.477	65.732	134.19	221.559	283.579	274.666	198.878	100.757
DB46	4.671	20.997	51.377	102.59	166.798	214.656	236.04	254.461	237.009
DB56	0.728	6.591	16.74	47.217	102.978	190.586	283.993	327.974	303.172
DB123	379.579	389.325	355.224	277.429	176.437	93.587	40.667	12.709	2.579
DB124	349.618	332.229	279.714	221.035	192.462	164.254	109.389	56.914	15.263
DB125	349.07	317.171	248.54	171.121	134.958	142.629	152.601	123.09	74.812
DB126	351.552	313.648	235.878	142.766	85.674	80.636	117.895	173.172	197.484
DB134	271.805	264.731	257.792	264.096	250.863	207.342	134.011	67.313	17.656
DB135	271.192	249.607	226.546	214.118	193.323	185.618	176.908	132.873	73.573
DB136	273.694	246.069	213.909	185.768	144.064	123.649	142.203	182.936	196.241
DB145	241.302	192.608	151.141	157.823	209.408	256.466	246.156	178.483	91.75
DB146	243.809	189.093	138.506	129.473	160.148	194.474	211.449	228.544	214.417

DB156	243.238	174.031	107.328	79.556	102.622	172.849	254.662	294.741	273.97
DB234	133.066	236.63	307.311	325.374	294.82	230.57	143.519	69.166	17.937
DB235	132.447	221.483	276.017	275.35	237.268	208.767	186.164	134.201	70.983
DB236	134.927	217.942	263.377	247	188.01	146.799	151.462	184.286	193.655
DB245	102.558	164.484	200.611	219.055	253.353	279.614	255.412	179.81	89.16
DB246	105.065	160.968	187.974	190.703	204.071	217.622	220.707	229.893	211.832
DB256	104.493	145.907	156.799	140.788	146.568	195.998	263.919	296.087	271.362
DB345	24.75	96.932	178.625	262.056	311.74	322.605	279.719	189.573	87.917
DB346	27.182	93.382	165.979	233.699	262.455	260.61	244.991	239.656	210.609
DB356	26.634	78.325	134.806	183.788	204.956	239.011	288.229	305.855	270.142
DB456	4.628	22.563	60.078	127.701	221.047	309.96	357.617	351.591	288.407
DB1234	315.019	339.702	333.338	302.196	254.051	193.25	118.748	57.115	14.736
DB1235	314.489	327.071	307.279	260.541	206.106	175.131	154.409	111.515	60.126
DB1236	316.572	324.129	296.753	236.905	165.032	123.468	125.467	153.257	162.368
DB1245	289.598	279.582	244.449	213.626	219.493	234.148	212.095	149.522	75.269
DB1246	291.68	276.638	233.902	189.992	178.442	182.49	183.176	191.268	177.512
DB1256	291.203	264.102	207.925	148.408	130.514	164.484	219.184	246.427	227.123
DB1345	224.702	223.286	226.135	249.468	268.148	269.99	232.354	157.672	74.254
DB1346	226.783	220.342	215.588	225.834	227.096	218.329	203.431	199.391	176.47
DB1356	226.325	207.786	189.609	184.248	179.165	200.301	239.436	254.549	226.081
DB1456	201.412	160.294	126.778	137.335	192.557	259.344	297.149	292.565	241.249
DB2345	109.091	199.842	267.358	300.484	304.751	289.263	240.057	158.785	72.085
DB2346	111.15	196.895	256.81	276.851	263.702	237.625	211.139	200.51	174.325
DB2356	110.692	184.339	230.831	235.265	215.771	219.597	247.144	255.668	223.936
DB2456	85.804	136.87	167.981	188.35	229.159	278.617	304.852	293.677	239.08
DB3456	20.902	80.552	149.666	224.193	277.835	314.459	325.108	301.802	238.038
DB12345	313.213	342.357	344.61	331.566	313.125	290.429	239.342	158.475	73.065
DB12346	315.296	339.416	334.085	307.933	272.072	238.768	210.399	200.196	175.303
DB12356	314.815	326.855	308.102	266.325	224.141	220.74	246.426	255.356	224.916
DB12456	289.922	279.363	245.249	219.408	237.526	279.757	304.111	293.363	240.058
DB13456	225.025	223.068	226.937	255.252	286.203	315.599	324.367	301.488	239.016
DB23456	109.415	199.624	268.161	306.27	322.809	334.895	332.075	302.606	236.871
DB123456	313.539	342.142	345.434	337.352	331.179	336.037	331.335	302.292	237.849
DL1	268.094	175.418	99.001	42.638	13.691	6.547	2.354	0.696	1.579
DL2	119.193	146.498	144.095	100.57	57.275	27.912	10.933	3.885	0.391
DL3	33.634	79.607	121.447	143.349	113.785	70.703	36.551	14.205	3.351
DL4	5.648	22.784	48.941	88.233	129.861	139.754	103.852	60.52	20.134
DL5	0.86	6.805	16.736	39.088	74.052	118.049	147.41	126.204	84.687
DL6	0.857	1.355	4.211	10.271	25.26	59.178	115.001	178.894	215.106

DL12	387.148	321.806	242.866	142.791	70.423	31.233	12.493	3.888	0.402
DL13	301.52	254.95	220.182	185.487	126.711	73.668	36.047	13.436	2.96
DL14	266.872	196.861	146.928	130.146	142.715	142.566	103.26	59.785	20.275
DL15	265.648	179.962	114.94	80.993	86.856	120.982	146.997	125.687	85.713
DL16	268.169	175.276	100.668	51.277	37.809	61.942	114.528	178.423	216.136
DL22	238.385	292.994	288.187	201.106	114.546	55.852	21.833	7.767	0.779
DL24	118.169	167.992	192.306	188.519	187.012	167.35	114.319	62.44	19.945
DL25	116.873	151.07	160.233	139.35	131.147	145.691	157.81	127.862	83.063
DL26	119.429	146.352	145.957	109.628	82.064	86.65	125.369	180.593	213.447
DL34	32.66	101.131	169.673	231.363	243.619	210.33	140.289	74.596	23.396
DL35	31.301	84.112	137.493	182.067	187.727	188.521	183.313	139.068	82.249
DL36	33.867	79.433	123.221	152.345	138.64	129.47	150.829	191.754	212.618
DL45	6.025	27.892	65.381	127.133	203.797	257.749	251.192	186.507	103.905
DL46	5.191	22.565	50.743	97.298	154.697	198.634	218.637	239.163	234.237
DL56	0.683	7.56	18.719	48.275	98.98	177.015	262.303	305.063	299.694
DL123	378.635	361.299	327.835	257.416	165.562	91.349	42.152	14.868	2.824
DL124	347.399	308.963	261.893	207.577	179.916	153.27	102.422	55.524	17.604
DL125	346.297	293.776	233.1	163.352	129.66	133.822	141.696	114.703	75.733
DL126	348.587	289.557	220.254	136.6	85.488	80.689	112.482	162.159	193.126
DL134	270.446	248.804	241.531	246.139	230.851	191.936	125.785	66.46	20.708
DL135	269.282	233.523	212.604	201.789	180.563	172.346	164.632	124.75	75.003
DL136	271.577	229.311	199.795	175.043	136.396	119.214	135.414	172.195	192.351
DL145	238.183	181.309	146.812	152.064	194.989	234.512	225.541	167.326	94.389
DL146	240.473	177.091	133.968	125.314	150.849	181.349	196.325	214.779	211.78
DL156	239.333	161.904	105.15	81.097	100.564	161.957	235.711	274.095	270.653
DL234	136.623	222.842	282.376	298.712	270.724	214.26	135.804	68.981	20.968
DL235	135.375	207.495	253.38	254.303	220.424	194.581	174.366	126.712	72.59
DL236	137.67	203.283	240.571	227.557	176.257	141.451	145.153	174.167	189.983
DL245	104.287	155.319	187.595	204.581	234.851	256.745	235.268	169.251	91.966
DL246	106.567	151.062	174.742	177.825	190.677	203.612	206.054	216.706	209.359
DL256	105.471	135.884	145.931	133.612	140.423	184.189	245.439	276.02	268.23
DL345	29.008	95.364	167.287	243.11	285.768	295.311	258.252	179.371	91.27
DL346	29.558	90.82	154.289	216.306	241.592	242.145	228.999	226.791	208.638
DL356	28.462	75.642	125.478	172.092	191.338	222.722	268.384	286.105	267.51
DL456	5.018	24.912	60.478	122.586	205.821	285.003	329.457	328.798	286.993
DL1234	314.727	317.179	309.349	280.504	235.264	180.76	112.76	56.941	17.187
DL1235	313.722	304.426	285.241	243.562	193.388	164.421	145.05	105.269	61.341
DL1236	315.643	300.903	274.531	221.24	156.559	120.129	120.68	144.805	159.144
DL1245	287.811	260.913	230.382	202.09	205.413	216.213	195.816	140.742	77.516

DL1246	289.743	257.432	219.683	179.809	168.592	171.926	171.449	180.279	175.319
DL1256	288.8	244.744	195.681	142.959	126.698	155.716	204.267	229.725	224.362
DL1345	223.64	210.731	213.314	234.141	247.835	248.31	214.902	149.135	76.89
DL1346	225.567	207.219	202.647	211.865	211.019	204.03	190.572	188.678	174.697
DL1356	224.618	194.525	178.609	175.01	169.122	187.847	223.356	238.093	223.771
DL1456	198.722	151.056	123.793	133.548	181.153	239.64	274.119	273.557	239.902
DL2345	112.089	189.044	247.309	277.924	281.019	266.83	223.012	150.749	74.867
DL2346	113.965	185.515	236.598	255.609	244.231	222.55	198.684	190.293	172.675
DL2356	113.032	172.865	212.604	218.763	202.34	206.369	231.469	239.708	221.749
DL2456	87.122	129.357	157.75	177.329	214.37	258.165	282.237	275.182	237.924
DL3456	23.84	79.314	140.811	209.414	256.802	290.288	301.381	283.6	237.314
DL12345	312.977	320.541	321.347	309.514	290.701	269.086	222.748	150.434	75.719
DL12346	314.903	317.031	310.684	287.243	253.923	224.812	198.422	189.979	173.527
DL12356	313.966	304.375	286.653	250.392	212.028	208.629	231.206	239.394	222.6
DL12456	288.059	260.868	231.828	208.922	224.051	260.385	281.963	274.854	238.73
DL13456	223.888	210.687	214.763	240.98	266.482	292.526	301.097	283.267	238.154
DL23456	112.293	188.994	248.758	284.766	299.703	311.052	309.211	284.883	236.131
DL123456	313.225	320.499	322.8	316.356	309.382	313.302	308.91	284.561	236.979
ENV	390.283	389.325	355.224	337.352	331.179	336.037	357.617	351.591	303.172
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1705.397	1610.705	1549.405	1513.332	1497.868	1490.919	1512.569	1527.599	1473.935

8.3.7 A1 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	389.425	424.05	424.05	424.05	424.05	424.05	424.05	424.05	367.334
합성후	324.09	200.952	141.051	117.186	115.417	111.751	119.692	140.771	195.579
	220.354	196.579	168.81	148.735	140.072	127.456	128.115	144.275	192.095
ENV	324.09	200.952	168.81	148.735	140.072	127.456	128.115	144.275	195.579
ADD	1316.779	1228.266	1196.124	1176.049	1167.386	1154.77	1155.429	1171.589	1166.177
DB1	1.695	0.585	1.927	5.313	11.072	39.864	102.054	190.269	277.783
DB2	0.402	3.32	9.428	26.707	58.836	107.679	157.629	159.848	121.205
DB3	3.026	12.785	36.303	74.152	123.897	157.06	135.114	84.398	31.931
DB4	17.794	61.907	112.322	153.087	143.444	95.728	51.401	21.493	5.162
DB5	82.024	134.447	161.499	130.853	80.086	40.146	16.15	5.9	0.875
DB6	215.003	190.578	124.937	62.899	25.697	8.982	3.826	1.208	0.819
DB12	0.493	3.28	10.294	27.828	68.891	147.12	259.441	350.005	398.857
DB13	2.737	12.058	34.952	75.007	133.779	196.406	236.866	274.545	309.521
DB14	19.005	61.334	110.979	153.894	153.315	134.931	152.572	210.545	275.555
DB15	83.25	133.903	160.245	131.686	89.906	79.315	117.477	193.8	275.11
DB16	216.22	190.083	123.676	63.701	35.361	47.81	103.197	189.923	278.001
DB22	0.803	6.638	18.832	53.411	117.67	215.336	315.277	319.698	242.412
DB24	16.982	62.974	121.288	179.516	202.185	203.177	208.372	180.182	119.103
DB25	80.509	135.443	170.496	157.313	138.778	147.554	173.287	163.428	118.651
DB26	213.478	191.622	133.925	89.306	84.231	116.046	159.006	159.55	121.542
DB34	19.985	74.441	148.402	227.099	267.313	252.578	185.844	104.772	29.868
DB35	79.43	146.21	197.251	204.782	203.868	196.884	150.677	87.925	29.363
DB36	212.377	202.386	160.679	136.777	149.344	165.379	136.398	84.048	32.254
DB45	99.786	196.336	273.816	283.922	223.47	135.75	67.34	25.588	5.684
DB46	232.711	252.454	237.177	215.877	168.913	104.143	52.731	21.129	4.849
DB56	296.96	324.984	286.374	193.631	105.589	48.617	17.614	6.699	0.789
DB123	2.569	12.488	39.779	91.45	173.298	273.663	355.046	390.955	387.631
DB124	15.818	56.155	108.035	162.372	190.862	218.291	279.16	333.327	357.035
DB125	73.622	121.477	152.37	142.396	133.786	168.265	247.575	318.239	356.63
DB126	193.292	172.025	119.455	81.19	84.719	139.889	234.71	314.746	359.25
DB134	17.727	66.342	132.355	205.167	249.468	262.738	258.865	265.424	276.72
DB135	72.639	131.169	176.435	185.11	192.379	212.642	227.223	250.287	276.28
DB136	192.311	181.72	143.545	123.929	143.298	184.291	214.381	246.794	278.879
DB145	90.872	176.131	245.177	256.201	209.999	157.377	151.41	192.742	245.726

DB146	210.542	226.678	212.261	194.993	160.912	129.002	138.566	189.251	248.349
DB156	268.348	292.003	256.618	175.02	103.838	78.978	106.984	174.187	247.947
DB234	18.01	68.203	141.829	228.299	293.479	324.195	309.129	238.134	135.918
DB235	70.189	132.539	185.667	208.167	236.38	274.054	277.437	222.953	135.468
DB236	189.843	183.109	152.778	146.986	187.299	245.704	264.595	219.46	138.067
DB245	88.403	177.519	254.408	279.256	253.978	218.787	201.623	165.408	104.914
DB246	208.073	228.066	221.492	218.048	204.89	190.412	188.778	161.916	107.537
DB256	265.902	293.395	265.851	198.075	147.816	140.387	157.194	146.829	107.131
DB345	87.432	187.227	278.513	322.009	312.582	263.212	181.362	97.573	25.293
DB346	207.093	237.762	245.583	260.789	263.491	234.816	168.431	93.985	27.168
DB356	264.92	303.088	289.92	240.814	206.415	184.79	136.849	78.901	26.786
DB456	283.233	348.188	358.818	312.038	224.04	129.736	61.813	22.7	4.834
DB1234	14.788	56.269	117.18	190.908	251.963	299.683	333.935	341.053	321.481
DB1235	59.465	110.107	153.83	174.163	204.391	257.93	307.549	328.435	321.099
DB1236	159.193	152.243	126.414	123.162	163.501	234.309	296.853	325.532	323.286
DB1245	74.652	147.58	211.107	233.401	219.074	211.872	244.377	280.471	295.64
DB1246	174.357	189.711	183.687	182.394	178.158	188.226	233.677	277.565	297.827
DB1256	222.555	244.152	220.645	165.746	130.599	146.532	207.357	265.007	297.488
DB1345	73.825	155.652	231.17	268.995	267.885	248.864	227.417	223.867	228.69
DB1346	173.553	197.788	203.754	217.992	226.992	225.22	216.716	220.958	230.853
DB1356	221.729	252.226	240.713	201.366	179.434	183.526	190.397	208.381	230.533
DB1456	236.915	289.697	297.986	260.578	194.093	137.466	127.225	160.439	205.078
DB2345	71.774	156.803	238.865	288.216	304.549	300.027	269.276	201.07	111.337
DB2346	171.479	198.935	211.445	237.21	263.634	276.401	258.556	198.163	113.522
DB2356	219.675	253.373	248.381	220.561	216.074	234.708	232.258	185.607	113.184
DB2456	234.86	290.826	305.677	279.797	230.754	188.626	169.062	137.639	87.723
DB3456	234.039	298.924	325.748	315.419	279.572	225.645	152.131	81.028	20.841
DB12345	72.746	156.453	237.967	288.893	311.974	329.586	345.618	343.716	319.558
DB12346	172.474	198.588	210.548	237.887	271.058	305.94	334.917	340.806	321.721
DB12356	220.647	253.024	247.485	221.259	223.499	264.245	308.597	328.229	321.401
DB12456	235.834	290.495	304.758	280.471	238.157	218.184	245.425	280.287	295.946
DB13456	235.008	298.569	324.826	316.091	286.993	255.178	228.463	223.657	228.968
DB23456	232.957	299.721	332.521	335.313	323.66	306.366	270.329	200.888	111.643
DB123456	233.929	299.369	331.62	335.986	331.059	335.898	346.663	343.505	319.836
DL1	1.595	0.664	2.241	6.295	13.226	40.935	98.445	175.787	272.868
DL2	0.379	3.809	10.677	27.244	56.238	98.871	144.03	147.428	122.025
DL3	3.348	14.01	36.15	69.812	112.974	142.907	122.853	80.023	34.01
DL4	20.256	59.717	102.974	138.93	130.441	88.821	49.925	22.843	5.851
DL5	83.569	124.341	147.562	118.868	75.091	39.714	17.346	6.848	0.921

DL6	210.885	177.193	116.858	60.791	26.561	10.686	4.497	1.398	0.811
DL12	0.525	3.767	12.128	29.927	68.178	139.286	242.123	323.056	394.737
DL13	2.952	13.215	35.346	72.114	124.672	183.191	220.926	255.649	306.639
DL14	20.805	58.97	102.151	141.128	142.116	128.884	147.229	197.112	271.361
DL15	84.59	123.797	146.893	121.181	86.708	79.765	114.827	180.245	270.281
DL16	211.873	176.661	116.141	63	37.942	50.153	100.377	175.621	272.914
DL22	0.758	7.616	21.35	54.48	112.436	197.733	288.026	294.856	244.091
DL24	20.036	61.55	113.168	165.846	186.524	187.416	193.149	168.864	120.694
DL25	82.014	125.981	157.706	145.799	131.103	138.256	160.701	151.958	119.587
DL26	209.311	178.889	126.998	87.628	82.342	108.647	146.252	147.334	122.22
DL34	23.497	73.578	138.957	208.599	243.386	231.485	171.983	101.487	32.726
DL35	81.466	137.138	183.051	188.41	187.914	182.241	139.473	84.499	31.563
DL36	208.753	190.008	152.336	130.233	139.147	152.626	124.987	79.869	34.191
DL45	103.301	183.932	250.508	257.756	205.415	128.353	66.974	27.966	6.287
DL46	230.531	236.722	219.674	199.503	156.63	98.615	52.095	22.655	5.393
DL56	294.322	301.499	264.327	179.508	101.334	49.587	19.694	7.694	0.755
DL123	2.805	14.606	41.309	89.362	162.777	253.835	328.448	362.767	385.794
DL124	17.673	54.666	101.148	151.348	178.429	204.927	262.094	310.03	353.991
DL125	74.816	112.978	141.403	133.368	128.553	160.699	232.924	294.862	353.008
DL126	189.386	160.569	113.737	81.026	84.667	134.063	219.91	290.692	355.37
DL134	20.786	65.48	124.352	189.811	229.563	244.601	243.057	249.387	274.829
DL135	74.35	122.982	164.212	171.708	179.705	200.304	213.804	234.144	273.791
DL136	188.887	170.601	136.545	119.365	135.816	173.631	200.784	229.97	276.152
DL145	93.826	164.899	224.682	233.93	195.384	151.494	147.556	181.512	242.08
DL146	208.406	212.527	197.02	181.589	151.497	124.826	134.542	177.376	244.451
DL156	265.803	270.858	237.299	163.613	101.619	80.603	105.378	162.214	243.472
DL234	21.046	68.015	134.369	212.078	269.56	297.282	284.415	223.999	139.243
DL235	72.021	124.99	173.949	193.887	219.661	252.964	255.103	208.702	138.167
DL236	186.592	172.58	146.28	141.542	175.77	226.291	242.083	204.529	140.528
DL245	91.541	166.918	234.426	256.112	235.371	204.123	188.853	156.069	106.455
DL246	206.116	214.513	206.792	203.771	191.453	177.485	175.841	151.906	108.861
DL256	263.508	272.84	247.038	185.795	141.608	133.265	146.675	136.737	107.837
DL345	91.069	176.966	257.289	294.532	286.503	243.809	170.005	95.824	29.691
DL346	205.617	224.545	229.601	242.11	242.603	217.055	156.717	91.213	29.61
DL356	263.009	282.871	269.844	224.132	192.726	172.864	127.551	76.017	28.621
DL456	282.653	324.972	330.515	286.526	208.472	124.311	62.235	25.033	5.258
DL1234	17.243	56.073	111.426	178.495	233.413	277.968	310.551	318.378	320.508
DL1235	60.876	103.787	144.509	163.37	191.835	241.039	286.148	305.639	319.645
DL1236	156.309	143.447	121.439	119.747	155.282	218.837	275.324	302.191	321.615

DL1245	77.123	138.709	194.896	215.222	204.918	200.358	230.949	261.803	293.211
DL1246	172.605	178.385	171.868	171.607	168.369	178.158	220.126	258.355	295.181
DL1256	220.422	227.002	205.404	156.586	126.798	141.276	195.816	245.701	294.381
DL1345	76.728	147.096	213.906	247.156	247.544	233.318	215.012	211.186	227.186
DL1346	172.155	186.723	190.862	203.527	210.952	211.105	204.148	207.73	229.151
DL1356	220.017	235.354	224.412	188.55	169.397	174.27	179.883	195.088	228.357
DL1456	236.265	270.276	274.799	240.403	182.48	133.588	124.685	151.252	201.923
DL2345	74.779	148.714	222.007	265.644	280.829	277.221	249.41	189.992	114.18
DL2346	170.261	188.39	198.979	222.027	244.278	255.017	238.58	186.507	116.14
DL2356	218.079	237.011	232.52	207.044	202.715	218.143	214.278	173.892	115.35
DL2456	234.331	271.94	282.944	258.901	215.8	177.46	159.074	130.018	88.906
DL3456	233.949	280.323	301.987	290.897	258.407	210.51	143.317	79.735	24.409
DL12345	75.63	148.364	221.574	267.414	289.615	307.424	322.995	321.717	318.675
DL12346	171.107	188.034	198.508	223.79	253.058	285.216	312.134	318.263	320.64
DL12356	218.925	236.655	232.052	208.812	211.503	248.379	287.864	305.612	319.802
DL12456	235.178	271.584	282.477	260.671	224.59	207.702	232.671	261.785	293.413
DL13456	234.773	279.936	301.483	292.634	267.187	240.694	216.708	211.202	227.395
DL23456	232.835	281.593	309.593	311.129	300.507	284.569	251.134	189.975	114.382
DL123456	233.681	281.237	309.124	312.895	309.291	314.8	324.682	321.689	318.829
ENV	296.96	348.188	358.818	335.986	331.059	335.898	355.046	390.955	398.857
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1613.739	1576.454	1554.942	1512.035	1498.445	1490.668	1510.475	1562.544	1565.034

8.3.8 P1-1 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	389.425	424.05	424.05	424.05	424.05	424.05	424.05	424.05	367.334
합성후	331.611	194.803	139.625	118.289	114.46	112.935	118.674	145.134	190.96
	224.95	194.513	167.177	149.827	138.631	128.531	126.851	148.184	187.826
ENV	331.611	194.803	167.177	149.827	138.631	128.531	126.851	148.184	190.96
ADD	1324.3	1222.117	1194.491	1177.141	1165.945	1155.845	1154.165	1175.498	1161.558
DB1	1.708	0.631	1.915	5.464	11.104	40.644	101.793	194.336	275.198
DB2	0.393	3.804	9.41	27.216	58.904	108.495	157.211	160.585	119.607
DB3	2.986	13.904	36.309	74.948	123.813	157.52	134.405	83.44	31.393
DB4	17.956	63.61	112.253	153.663	142.783	95.702	50.778	20.519	5.135
DB5	82.983	135.207	161.082	130.988	79.305	40.077	15.823	5.38	0.883
DB6	217.018	188.696	124.132	62.865	25.204	8.977	3.736	1.082	0.808
DB12	0.495	3.81	10.261	28.486	69.008	148.718	258.768	354.82	394.686
DB13	2.703	13.214	34.944	75.956	133.749	197.648	235.904	277.663	306.414
DB14	19.18	63.045	110.892	154.62	152.704	135.68	151.705	213.513	272.999
DB15	84.22	134.674	159.812	131.972	89.178	80.022	116.898	197.306	272.581
DB16	218.243	188.216	122.856	63.817	34.922	48.574	102.852	193.882	275.435
DB22	0.785	7.604	18.796	54.428	117.805	216.968	314.441	321.17	239.215
DB24	17.115	65.16	121.208	180.597	201.589	203.96	207.342	179.81	117.519
DB25	81.434	136.701	170.07	157.954	138.065	148.295	172.545	163.594	117.095
DB26	215.456	190.242	133.112	89.776	83.807	116.845	158.499	160.17	119.949
DB34	20.103	77.271	148.338	228.468	266.564	253.005	184.523	102.706	29.343
DB35	80.319	148.176	196.846	205.709	203.003	197.271	149.647	86.399	28.867
DB36	214.318	201.714	159.887	137.533	148.767	165.823	135.603	82.975	31.721
DB45	100.905	198.8	273.329	284.633	222.028	135.653	66.388	24.1	5.682
DB46	234.883	252.278	236.303	216.415	167.758	104.099	52.019	20.026	4.83
DB56	299.929	323.864	285.153	193.727	104.315	48.533	17.199	6.046	0.795
DB123	2.52	13.959	39.762	92.762	173.333	275.514	353.804	394.422	383.398
DB124	15.946	58.144	107.95	163.483	190.375	219.7	278.004	336.66	353.298
DB125	74.466	122.62	151.973	143.111	133.193	169.635	246.678	322.057	352.918
DB126	195.084	170.794	118.71	81.751	84.386	141.312	234.024	318.972	355.505
DB134	17.838	68.922	132.285	206.536	248.843	263.827	257.448	267.234	273.936
DB135	73.451	132.948	176.056	186.083	191.649	213.694	226.067	252.581	273.52
DB136	194.071	181.126	142.818	124.748	142.828	185.394	213.436	249.496	276.087
DB145	91.89	178.354	244.723	256.973	208.746	157.984	150.337	194.901	243.462
DB146	212.508	226.527	211.459	195.612	159.918	129.661	137.704	191.818	246.051

DB156	271.03	291.006	255.504	175.243	102.739	79.599	106.381	177.238	245.674
DB234	18.094	71.178	141.762	229.988	292.867	325.314	307.565	236.936	134.009
DB235	70.96	134.756	185.295	209.458	235.664	275.137	276.135	222.242	133.585
DB236	191.561	182.953	152.058	148.124	186.843	246.838	263.504	219.157	136.151
DB245	89.38	180.18	253.961	280.347	252.739	219.426	200.404	164.561	103.526
DB246	209.998	228.353	220.697	218.986	203.911	191.102	187.771	161.478	106.115
DB256	268.544	292.836	264.744	198.617	146.731	141.038	156.445	146.875	105.734
DB345	88.376	190.526	278.085	323.359	311.205	263.532	179.882	95.216	24.854
DB346	208.985	238.686	244.807	261.984	262.374	235.186	167.164	92.023	26.699
DB356	267.528	303.166	288.831	241.613	205.193	185.123	135.84	77.424	26.342
DB456	286.048	348.715	357.655	312.643	222.298	129.632	60.876	21.245	4.839
DB1234	14.862	58.776	117.114	192.43	251.494	301.202	332.441	343.112	317.963
DB1235	60.117	111.964	153.508	175.355	203.835	259.419	306.272	330.898	317.603
DB1236	160.635	152.121	125.802	124.225	163.161	235.841	295.753	328.336	319.762
DB1245	75.476	149.807	210.723	234.426	218.082	212.99	243.17	282.822	292.556
DB1246	175.971	189.96	183.012	183.291	177.382	189.387	232.646	280.256	294.715
DB1256	224.766	243.695	219.711	166.313	129.735	147.661	206.542	268.101	294.396
DB1345	74.622	158.409	230.802	270.235	266.778	249.716	225.994	224.948	226.4
DB1346	175.141	198.567	203.095	219.104	226.101	226.115	215.469	222.38	228.536
DB1356	223.912	252.301	239.794	202.148	178.456	184.39	189.365	210.206	228.236
DB1456	239.271	290.141	297.004	261.194	192.678	137.958	126.263	162.151	203.194
DB2345	72.538	159.926	238.501	289.722	303.454	300.905	267.732	199.646	109.777
DB2346	173.032	200.079	210.792	238.588	262.755	277.322	257.187	197.08	111.934
DB2356	221.825	253.812	247.468	221.608	215.108	235.598	231.106	184.927	111.618
DB2456	237.182	291.635	304.701	280.678	229.351	189.144	167.979	136.846	86.569
DB3456	236.334	300.263	324.788	316.515	278.054	225.898	150.831	78.967	20.481
DB12345	73.52	159.584	237.592	290.514	310.919	331.051	343.883	345.349	316.071
DB12346	174.038	199.741	209.884	239.38	270.22	307.447	333.357	342.78	318.206
DB12356	222.808	253.472	246.56	222.421	222.573	265.72	307.253	330.606	317.907
DB12456	238.166	291.312	303.77	281.468	236.795	219.289	244.151	282.551	292.865
DB13456	237.313	299.918	323.853	317.302	285.516	256.017	226.972	224.652	226.681
DB23456	235.228	301.434	331.554	336.79	322.194	307.231	268.717	199.378	110.086
DB123456	236.21	301.091	330.642	337.578	329.634	337.349	344.86	345.052	316.352
DL1	1.622	0.714	2.229	6.46	13.239	41.889	98.119	181.84	267.868
DL2	0.367	4.37	10.641	27.866	56.325	100.027	143.538	148.794	119.565
DL3	3.279	15.346	36.152	70.862	112.933	143.571	121.838	78.979	33.426
DL4	20.349	61.751	102.922	139.764	129.464	88.752	49.132	21.694	5.855
DL5	84.917	125.12	146.949	118.976	74.044	39.637	16.964	6.243	0.937
DL6	214.533	174.232	115.717	60.748	25.96	10.697	4.399	1.253	0.795

DL12	0.527	4.384	12.064	30.705	68.311	141.394	241.313	330.492	387.29
DL13	2.891	14.59	35.327	73.33	124.68	184.808	219.595	260.67	301.076
DL14	20.919	61.016	102.075	142.122	141.184	129.759	146.142	201.842	266.491
DL15	85.965	124.58	146.255	121.453	85.708	80.634	114.127	185.63	265.38
DL16	215.541	173.707	114.979	63.119	37.39	51.097	99.962	181.553	267.932
DL22	0.734	8.737	21.277	55.724	112.609	200.045	287.04	297.59	239.17
DL24	20.095	64.139	113.095	167.293	185.633	188.493	191.887	168.895	118.347
DL25	83.308	127.349	157.071	146.524	130.143	139.328	159.828	152.643	117.209
DL26	212.9	176.519	125.837	88.2	81.831	109.794	145.664	148.567	119.76
DL34	23.52	76.944	138.906	210.477	242.364	232.07	170.198	99.108	32.253
DL35	82.666	139.373	182.438	189.564	186.825	182.824	138.08	82.777	31.06
DL36	212.247	188.506	151.198	131.234	138.507	153.283	123.879	78.694	33.607
DL45	104.733	186.757	249.843	258.697	203.391	128.204	65.791	26.21	6.328
DL46	234.256	235.807	218.482	200.288	155.052	98.536	51.208	21.355	5.405
DL56	299.31	299.318	262.572	179.568	99.685	49.501	19.222	6.94	0.767
DL123	2.732	16.347	41.265	91.015	162.864	256.331	326.807	368.514	378.573
DL124	17.733	57.032	101.062	152.8	177.672	206.754	260.673	315.516	347.397
DL125	76.007	114.214	140.812	134.169	127.733	162.522	231.852	300.937	346.385
DL126	192.642	158.44	112.673	81.69	84.251	135.953	219.094	297.26	348.674
DL134	20.813	68.545	124.286	191.65	228.688	245.986	241.166	252.705	269.922
DL135	75.456	124.999	163.641	172.897	178.769	201.685	212.265	238.051	268.857
DL136	192.058	169.254	135.501	120.416	135.283	175.08	199.501	234.37	271.145
DL145	95.138	167.441	224.061	234.919	193.601	152.206	146.233	185.157	237.768
DL146	211.784	211.705	195.926	182.44	150.117	125.605	133.476	181.514	240.067
DL156	270.315	268.9	235.698	163.815	100.177	81.377	104.661	166.941	239.059
DL234	21.038	71.547	134.305	214.325	268.721	298.849	282.366	223.086	136.605
DL235	73.056	127.532	173.38	195.483	218.762	254.528	253.408	208.38	135.503
DL236	189.691	171.758	145.238	143	175.274	227.923	240.644	204.699	137.791
DL245	92.782	169.985	233.806	257.509	233.625	205.018	187.374	155.485	104.414
DL246	209.422	214.216	205.7	205.03	190.11	178.447	174.618	151.815	106.747
DL256	267.948	271.407	245.439	186.405	140.204	134.221	145.801	137.234	105.695
DL345	92.225	180.816	256.691	296.317	284.641	244.267	168.051	93.136	29.301
DL346	208.838	225.029	228.529	243.756	241.144	217.576	155.027	88.954	29.184
DL356	267.364	282.219	268.266	225.129	191.205	173.38	126.21	74.346	28.167
DL456	287.217	324.851	328.89	287.329	206.108	124.168	61.085	23.317	5.301
DL1234	17.242	59.047	111.356	180.492	232.751	279.989	308.606	322.166	314.575
DL1235	61.76	105.909	144.018	164.825	191.122	243.058	284.496	309.92	313.689
DL1236	158.913	142.767	120.554	121.087	154.906	220.911	273.886	306.882	315.598
DL1245	78.179	141.269	194.364	216.511	203.5	201.818	229.479	265.865	287.775

DL1246	175.382	178.142	170.942	172.781	167.287	179.674	218.869	262.827	289.684
DL1256	224.144	225.812	204.055	157.218	125.664	142.788	194.85	250.665	288.86
DL1345	77.714	150.306	213.39	248.767	246.029	234.41	213.152	213.442	223.157
DL1346	174.861	187.131	189.953	205.023	209.773	212.254	202.502	210.396	225.061
DL1356	223.669	234.814	223.08	189.505	168.166	175.415	178.528	198.245	224.243
DL1456	240.088	270.174	273.426	241.191	180.543	134.175	123.51	154.19	198.329
DL2345	75.704	152.363	221.493	267.595	279.344	278.466	247.419	188.724	112.043
DL2346	172.907	189.236	198.071	223.863	243.129	256.319	236.804	185.648	113.942
DL2356	221.67	236.91	231.19	208.338	201.514	219.44	212.793	173.525	113.128
DL2456	238.094	272.276	281.573	260.03	213.894	178.199	157.769	129.432	87.204
DL3456	237.642	281.311	300.633	292.349	256.404	210.883	141.617	77.382	24.09
DL12345	76.578	152.017	221.043	269.489	288.167	309.384	320.766	324.997	312.803
DL12346	173.776	188.883	197.583	225.751	251.946	287.232	310.119	321.953	314.707
DL12356	222.539	236.558	230.706	210.232	210.339	250.391	286.14	309.793	313.845
DL12456	238.963	271.924	281.088	261.924	222.72	209.155	231.128	265.747	287.975
DL13456	238.488	280.927	300.112	294.209	265.22	241.78	214.775	213.359	223.363
DL23456	236.489	283.022	308.223	313.044	298.571	285.807	249.071	188.607	112.243
DL123456	237.358	282.67	307.738	314.935	307.392	316.753	322.381	324.869	312.955
ENV	299.929	348.715	357.655	337.578	329.634	337.349	353.804	394.422	394.686
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1624.229	1570.832	1552.146	1514.719	1495.579	1493.194	1507.969	1569.92	1556.244

8.3.9 P1-2 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	385.788	424.05	424.05	424.05	424.05	424.05	424.05	424.05	370.971
합성후	322.486	201.749	140.082	118.01	114.441	112.458	119.269	141.29	196.705
	219.443	197.091	167.672	149.597	138.878	128.224	127.592	144.809	193.184
ENV	322.486	201.749	167.672	149.597	138.878	128.224	127.592	144.809	196.705
ADD	1311.538	1229.063	1194.986	1176.911	1166.192	1155.538	1154.906	1172.123	1170.94
DB1	1.716	0.585	1.884	5.334	10.882	39.714	101.399	190.211	278.5
DB2	0.386	3.269	9.185	26.655	58.217	107.479	157.247	160.492	121.833
DB3	2.941	12.609	35.784	74.024	123.059	157.287	135.381	85.183	32.405
DB4	17.189	61.474	111.552	153.314	143.517	96.544	51.615	21.847	5.175
DB5	81.118	134.047	161.156	131.672	80.231	40.646	16.199	5.997	0.873
DB6	214.132	190.822	124.888	63.448	25.675	9.096	3.804	1.224	0.795
DB12	0.528	3.233	10.074	27.77	67.975	146.776	258.399	350.564	400.198
DB13	2.656	11.872	34.407	74.866	132.664	196.488	236.472	275.246	310.706
DB14	18.428	60.895	110.162	154.082	153.103	135.58	152.118	210.852	276.373
DB15	82.375	133.52	159.858	132.492	89.775	79.672	116.873	193.838	275.823
DB16	215.409	190.374	123.612	64.245	35.073	47.823	102.521	189.857	278.69
DB22	0.774	6.541	18.392	53.314	116.437	214.961	314.518	320.968	243.688
DB24	16.69	62.528	120.329	179.7	201.64	203.804	208.229	181.208	119.863
DB25	79.59	134.991	169.914	158.08	138.307	147.877	172.962	164.173	119.277
DB26	212.62	191.822	133.666	89.831	83.605	116.029	158.612	160.195	122.168
DB34	19.624	73.87	147.166	227.209	266.548	253.631	186.367	105.915	30.449
DB35	78.373	145.615	196.392	205.475	203.197	197.634	151.001	88.81	29.836
DB36	211.379	202.441	160.14	137.205	148.514	165.786	136.649	84.829	32.703
DB45	98.252	195.501	272.704	284.99	223.692	137.069	67.607	26.063	5.7
DB46	231.239	252.269	236.384	216.657	168.973	105.118	52.931	21.506	4.864
DB56	295.189	324.854	285.992	195.029	105.727	49.303	17.674	6.824	0.791
DB123	2.497	12.355	39.076	91.27	171.741	273.555	354.348	392.141	389.265
DB124	15.281	55.721	107.101	162.523	190.12	218.705	278.42	334.176	358.353
DB125	72.837	121.082	151.814	143.073	133.11	168.391	246.678	318.848	357.842
DB126	192.559	172.234	119.181	81.636	83.881	139.733	233.762	315.261	360.441
DB134	17.406	65.833	131.2	205.236	248.528	263.548	258.721	266.384	277.886
DB135	71.721	130.635	175.635	185.722	191.529	213.164	226.921	251.024	277.341
DB136	191.444	181.787	143.002	124.284	142.3	184.506	214.005	247.437	279.94
DB145	89.523	175.375	244.148	257.125	209.945	158.422	151.089	193.149	246.497
DB146	209.25	226.549	211.517	195.689	160.716	129.762	138.168	189.536	249.067

DB156	266.806	291.911	256.233	176.261	103.708	79.429	106.43	174.233	248.584
DB234	17.668	67.617	140.512	228.345	292.24	324.982	309.254	239.744	137.024
DB235	69.234	131.962	184.688	208.753	235.209	274.572	277.405	224.34	136.471
DB236	188.958	183.116	152.076	147.316	185.978	245.89	264.482	220.726	139.042
DB245	87.013	176.697	253.198	280.154	253.621	219.805	201.565	166.437	105.599
DB246	206.735	227.849	220.564	218.716	204.392	191.147	188.649	162.851	108.197
DB256	264.291	293.211	265.28	199.288	147.383	140.812	156.906	147.521	107.686
DB345	85.923	186.257	277.023	322.803	312.017	264.579	181.804	98.646	25.33
DB346	205.643	237.406	244.386	261.363	262.789	235.917	168.891	95.026	27.696
DB356	263.18	302.787	289.104	241.94	205.805	185.607	137.152	79.699	27.185
DB456	281.08	347.667	357.772	313.478	224.248	131.07	62.035	23.143	4.849
DB1234	14.511	55.806	116.054	190.932	250.73	300.226	333.542	342.336	322.922
DB1235	58.693	109.62	152.992	174.638	203.211	258.218	307.013	329.513	322.458
DB1236	158.455	152.254	125.792	123.418	162.182	234.335	296.26	326.524	324.62
DB1245	73.524	146.907	210.063	234.137	218.546	212.581	243.805	281.27	296.755
DB1246	173.289	189.546	182.888	182.941	177.521	188.7	233.05	278.278	298.894
DB1256	221.246	244.01	220.132	166.731	130.038	146.778	206.596	265.521	298.474
DB1345	72.6	154.873	229.925	269.669	267.231	249.907	227.356	224.754	229.653
DB1346	172.362	197.509	202.727	218.47	226.203	226.024	216.581	221.763	231.814
DB1356	220.322	251.977	239.994	202.282	178.7	184.082	190.146	209.006	231.396
DB1456	235.155	289.267	297.087	261.782	194.037	138.445	126.937	160.763	205.693
DB2345	70.51	155.967	237.479	288.872	303.638	301.063	269.421	202.513	112.268
DB2346	170.273	198.603	210.281	237.673	262.608	277.178	258.641	199.496	114.401
DB2356	218.232	253.069	247.545	221.462	215.103	235.234	232.205	186.739	113.983
DB2456	233.066	290.361	304.641	280.987	230.445	189.622	169	138.498	88.28
DB3456	232.139	298.324	324.48	316.514	279.124	226.923	152.528	81.981	21.2
DB12345	71.51	155.633	236.546	289.53	310.83	330.488	345.262	345.09	320.999
DB12346	171.273	198.27	209.348	238.332	269.802	306.605	334.506	342.079	323.157
DB12356	219.233	252.739	246.616	222.145	222.321	264.663	308.05	329.321	322.737
DB12456	234.066	290.028	303.709	281.646	237.657	219.027	244.842	281.078	297.034
DB13456	233.139	297.991	323.547	317.173	286.318	256.35	228.391	224.561	229.932
DB23456	231.05	299.085	331.101	336.377	322.724	307.506	270.456	202.32	112.547
DB123456	232.05	298.752	330.169	337.037	329.939	336.933	346.299	344.898	321.278
DL1	1.637	0.67	2.194	6.323	12.998	40.861	97.738	175.722	273.793
DL2	0.363	3.752	10.429	27.267	55.571	98.832	143.563	148.064	122.724
DL3	3.248	13.83	35.599	69.827	112.11	143.294	123.008	80.804	34.488
DL4	19.917	59.41	102.237	139.332	130.348	89.681	50.08	23.201	5.868
DL5	82.56	124.119	147.118	119.806	75.076	40.241	17.366	6.963	0.92
DL6	209.932	177.694	116.675	61.401	26.442	10.818	4.464	1.412	0.767

DL12	0.559	3.717	11.872	29.974	67.253	139.162	240.949	323.625	396.359
DL13	2.86	13.027	34.778	72.135	123.508	183.444	220.354	256.308	307.984
DL14	20.16	58.583	101.297	141.524	141.757	129.654	146.69	197.418	272.375
DL15	83.63	123.572	146.396	122.092	86.427	80.168	114.17	180.287	271.157
DL16	210.971	177.161	115.942	63.557	37.565	50.227	99.642	175.566	273.795
DL22	0.727	7.505	20.858	54.532	111.139	197.658	287.089	296.122	245.445
DL24	19.683	61.183	112.154	166.267	185.793	188.24	192.823	169.878	121.484
DL25	81.039	125.712	157.029	146.772	130.497	138.758	160.274	152.754	120.291
DL26	208.381	179.302	126.576	88.265	81.601	108.778	145.764	147.988	122.878
DL34	23.064	73.098	137.679	209.053	242.433	232.741	172.316	102.65	33.3
DL35	80.364	136.725	182.064	189.364	187.062	183.12	139.647	85.386	31.991
DL36	207.706	190.317	151.615	130.863	138.205	153.151	125.152	80.668	34.633
DL45	101.643	183.335	249.27	259.128	205.384	129.75	67.16	28.475	6.309
DL46	228.928	236.845	218.696	200.511	156.496	99.647	52.231	23.034	5.407
DL56	292.406	301.787	263.71	181.034	101.276	50.29	19.699	7.837	0.757
DL123	2.726	14.451	40.572	89.405	161.169	254.048	327.521	363.938	387.66
DL124	17.374	54.372	100.228	151.749	177.521	205.618	261.189	310.893	355.534
DL125	73.973	112.721	140.733	134.231	127.705	161.065	231.896	295.475	354.449
DL126	188.591	160.965	113.327	81.55	83.741	134.089	218.83	291.217	356.818
DL134	20.406	65.066	123.14	190.21	228.455	245.627	242.718	250.373	276.161
DL135	73.355	122.623	163.288	172.576	178.662	201.006	213.342	234.879	275.022
DL136	187.969	170.858	135.842	119.884	134.657	174.02	200.267	230.611	277.346
DL145	92.397	164.402	223.557	235.159	195.08	152.677	147.114	181.936	242.982
DL146	207.011	212.639	196.114	182.472	151.11	125.695	134.041	177.641	245.34
DL156	264.143	271.111	236.713	164.978	101.303	81.159	104.767	162.272	244.274
DL234	20.646	67.531	133.012	212.517	268.108	298.373	284.269	225.628	140.368
DL235	71.001	124.546	172.844	194.758	218.299	253.73	254.836	210.083	139.193
DL236	185.616	172.785	145.403	142.102	174.299	226.746	241.761	205.786	141.551
DL245	90.077	166.296	233.108	257.335	234.71	205.364	188.607	157.144	107.197
DL246	204.659	214.566	205.672	204.687	190.748	178.387	175.536	152.849	109.555
DL256	261.79	273.038	246.272	187.192	140.939	133.846	146.251	137.434	108.433
DL345	89.445	176.233	255.71	295.755	285.681	245.376	170.271	96.927	29.734
DL346	204.041	224.465	228.224	243.026	241.668	218.321	156.973	92.243	30.083
DL356	261.168	282.934	268.793	225.536	191.897	173.822	127.703	76.843	29.007
DL456	280.33	324.883	329.249	288.282	208.346	125.736	62.38	25.491	5.272
DL1234	16.907	55.66	110.204	178.81	232.009	278.799	309.904	319.661	322.139
DL1235	60.035	103.439	143.546	164.092	190.486	241.611	285.415	306.733	321.185
DL1236	155.543	143.64	120.706	120.189	153.837	219.128	274.529	303.172	323.149
DL1245	75.929	138.247	193.767	216.223	204.179	201.285	230.201	262.59	294.457

DL1246	171.438	178.452	170.932	172.357	167.536	178.808	219.322	259.038	296.465
DL1256	218.997	227.158	204.709	157.748	126.025	141.709	194.937	246.234	295.543
DL1345	75.38	146.502	212.546	248.2	246.633	234.598	214.761	212.127	228.291
DL1346	170.888	186.703	189.706	204.297	209.984	212.115	203.875	208.565	230.255
DL1356	218.492	235.423	223.493	189.726	168.478	175.018	179.491	195.732	229.367
DL1456	234.386	270.232	273.716	241.861	182.177	134.73	124.288	151.602	202.684
DL2345	73.466	148.093	220.531	266.676	279.656	278.492	249.311	191.425	115.096
DL2346	168.97	188.292	197.66	222.805	243.009	256.011	238.426	187.864	117.059
DL2356	216.534	237.004	231.473	208.201	201.5	218.912	214.04	175.03	116.171
DL2456	232.429	271.817	281.703	260.376	215.211	178.638	158.883	130.945	89.504
DL3456	231.939	280.102	300.508	292.338	257.659	211.975	143.52	80.651	24.44
DL12345	74.315	147.731	220.026	268.453	288.243	308.667	322.389	323.12	320.269
DL12346	169.824	187.936	197.191	224.587	251.601	286.188	311.505	319.559	322.233
DL12356	217.427	236.652	230.971	209.977	210.084	249.081	287.082	306.719	321.34
DL12456	233.288	271.493	281.203	262.154	223.794	208.804	231.918	262.596	294.662
DL13456	232.771	279.716	299.974	294.089	266.237	242.105	216.434	212.117	228.447
DL23456	230.825	281.339	307.967	312.607	299.271	286.011	251.028	191.431	115.301
DL123456	231.674	280.975	307.457	314.376	307.818	316.175	324.065	323.117	320.47
ENV	295.189	347.667	357.772	337.037	329.939	336.933	354.348	392.141	400.198
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1606.727	1576.73	1552.758	1513.948	1496.131	1492.471	1509.254	1564.264	1571.138

8.3.10 P2-1 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	385.788	424.05	424.05	424.05	424.05	424.05	424.05	424.05	370.971
합성후	331.08	193.778	140.369	117.153	115.294	112.341	119.368	145.127	191.979
	224.836	193.604	167.813	148.44	139.537	127.763	127.547	148.101	188.85
ENV	331.08	193.778	167.813	148.44	139.537	127.763	127.547	148.101	191.979
ADD	1320.132	1221.092	1195.127	1175.754	1166.851	1155.077	1154.861	1175.415	1166.214
DB1	1.732	0.621	1.915	5.337	11.174	40.123	101.74	194.128	275.827
DB2	0.379	3.725	9.359	26.771	58.834	107.832	157.343	160.877	120.239
DB3	2.916	13.657	36.181	74.199	123.711	157.21	135.096	83.806	31.921
DB4	17.435	63.02	112.053	153.145	143.6	95.946	51.286	20.596	5.179
DB5	82.273	134.485	161.32	131.055	80.07	40.153	16.038	5.35	0.89
DB6	216.441	188.308	124.684	62.765	25.549	8.882	3.769	1.068	0.784
DB12	0.533	3.73	10.265	27.891	68.893	147.547	258.839	354.88	395.944
DB13	2.634	12.954	34.822	75.055	133.619	196.831	236.532	277.797	307.567
DB14	18.686	62.442	110.677	153.924	153.484	135.399	152.135	213.396	273.762
DB15	83.541	133.962	160.039	131.887	89.913	79.596	117.051	197.069	273.217
DB16	217.726	187.867	123.426	63.574	35.243	48.022	102.827	193.641	276.037
DB22	0.76	7.454	18.742	53.545	117.671	215.666	314.708	321.738	240.5
DB24	16.908	64.527	121.006	179.648	202.337	203.556	207.998	180.209	118.315
DB25	80.71	135.904	170.256	157.582	138.762	147.735	172.893	163.861	117.735
DB26	214.891	189.786	133.641	89.267	84.091	116.161	158.67	160.437	120.579
DB34	19.84	76.469	148.06	227.213	267.28	252.954	185.755	103.155	30.009
DB35	79.468	147.204	196.949	205.035	203.689	197.063	150.553	86.74	29.402
DB36	213.625	201.082	160.331	136.699	149.038	165.49	136.329	83.312	32.223
DB45	99.652	197.486	273.368	284.205	223.613	135.976	67.113	24.171	5.735
DB46	233.788	251.303	236.68	215.805	168.924	104.299	52.566	20.098	4.873
DB56	298.648	322.78	285.951	193.728	105.435	48.589	17.479	6.016	0.804
DB123	2.461	13.735	39.609	91.546	173.155	274.182	354.488	394.783	385.007
DB124	15.484	57.542	107.727	162.488	191.019	218.861	278.522	336.812	354.57
DB125	73.857	121.907	152.138	142.637	133.791	168.641	246.925	322.102	354.064
DB126	194.615	170.405	119.175	81.14	84.59	140.231	234.125	319.013	356.62
DB134	17.605	68.202	132.021	205.252	249.46	263.317	258.481	267.436	275.1
DB135	72.719	132.069	176.154	185.338	192.244	213.028	226.828	252.695	274.561
DB136	193.477	180.567	143.19	123.841	143.043	184.618	214.028	249.607	277.118
DB145	90.793	177.161	244.758	256.426	210.142	157.813	150.955	194.812	244.191
DB146	211.556	225.682	211.797	194.931	160.941	129.4	138.15	191.697	246.719

DB156	269.929	290.048	256.211	175.101	103.713	79.161	106.556	177.012	246.241
DB234	17.841	70.359	141.479	228.455	293.454	324.69	308.789	237.605	135.196
DB235	70.19	133.82	185.352	208.465	236.208	274.377	277.088	222.823	134.649
DB236	190.95	182.321	152.41	146.969	187.005	245.942	264.281	219.707	137.177
DB245	88.241	178.908	253.953	279.551	254.102	219.136	201.208	164.912	104.25
DB246	208.999	227.406	220.99	218.055	204.902	190.726	188.407	161.823	106.806
DB256	267.372	291.773	265.403	198.224	147.673	140.485	156.809	147.112	106.3
DB345	87.129	189.077	277.973	322.253	312.532	263.525	181.107	95.542	24.979
DB346	207.884	237.571	245.005	260.754	263.332	235.11	168.308	92.416	27.304
DB356	266.238	301.958	289.422	240.928	206.13	184.895	136.715	77.707	26.798
DB456	284.413	347.193	358.186	312.156	224.058	129.887	61.556	21.3	4.886
DB1234	14.658	58.117	116.873	191.034	251.969	300.298	333.414	343.5	319.407
DB1235	59.5	111.172	153.559	174.408	204.27	258.371	307.008	331.194	318.948
DB1236	160.125	151.595	126.084	123.139	163.264	234.694	296.351	328.62	321.075
DB1245	74.558	148.751	210.706	233.644	219.173	212.339	243.765	282.944	293.639
DB1246	175.185	189.179	183.256	182.4	178.171	188.664	233.107	280.367	295.743
DB1256	223.824	242.815	220.248	165.854	130.506	146.82	206.773	268.125	295.328
DB1345	73.615	157.225	230.73	269.22	267.887	249.344	227.033	225.109	227.37
DB1346	174.24	197.65	203.257	217.973	226.882	225.667	216.354	222.533	229.495
DB1356	222.881	251.289	240.272	201.449	179.197	183.803	190.04	210.291	229.081
DB1456	237.941	288.871	297.442	260.687	194.102	137.772	126.797	162.041	203.773
DB2345	71.49	158.673	238.405	288.504	304.53	300.451	268.912	200.212	110.782
DB2346	172.116	199.098	210.932	237.256	263.524	276.771	258.228	197.609	112.88
DB2356	220.756	252.735	247.944	220.709	215.837	234.905	231.913	185.367	112.466
DB2456	235.817	290.32	305.117	279.972	230.747	188.899	168.674	137.119	87.158
DB3456	234.871	298.79	325.118	315.543	279.455	225.879	151.918	79.283	20.91
DB12345	72.501	158.343	237.485	289.172	311.948	330.19	345.011	345.734	317.522
DB12346	173.126	198.767	210.013	237.924	270.944	306.514	334.352	343.138	319.645
DB12356	221.767	252.407	247.029	221.402	223.281	264.649	308.017	330.894	319.229
DB12456	236.827	289.99	304.199	280.641	238.186	218.619	244.774	282.645	293.92
DB13456	235.882	298.46	324.199	316.212	286.875	255.621	228.04	224.808	227.651
DB23456	233.757	299.908	331.873	335.495	323.518	306.727	269.919	199.911	111.063
DB123456	234.768	299.578	330.955	336.166	330.959	336.469	346.019	345.435	317.803
DL1	1.669	0.706	2.233	6.308	13.324	41.349	98.187	181.59	268.608
DL2	0.353	4.28	10.624	27.401	56.365	99.364	143.779	148.959	120.254
DL3	3.194	15.078	36.094	70.068	113.078	143.2	122.57	79.221	33.979
DL4	20.109	61.212	102.968	139.132	130.396	88.841	49.663	21.715	5.91
DL5	84.186	124.421	147.32	118.883	74.841	39.626	17.187	6.208	0.945
DL6	214.115	173.81	116.329	60.53	26.3	10.579	4.433	1.23	0.751

DL12	0.564	4.295	12.075	30.092	68.393	140.192	241.618	330.408	388.72
DL13	2.812	14.311	35.283	72.381	124.819	183.851	220.368	260.608	302.313
DL14	20.369	60.398	102.037	141.324	142.145	129.31	146.736	201.63	267.365
DL15	85.283	123.87	146.61	121.171	86.532	80.052	114.434	185.34	266.086
DL16	215.176	173.277	115.608	62.689	37.761	50.473	100.058	181.286	268.629
DL22	0.706	8.56	21.246	54.8	112.726	198.722	287.521	297.911	240.505
DL24	19.84	63.509	113.089	166.198	186.632	187.928	192.634	169.099	119.17
DL25	82.607	126.577	157.434	145.984	131.054	138.674	160.303	152.818	117.915
DL26	212.502	175.985	126.433	87.531	82.247	109.058	145.945	148.718	120.408
DL34	23.2	76.144	138.901	209.09	243.444	231.802	171.472	99.395	32.943
DL35	81.846	138.417	182.749	188.686	187.795	182.412	139.024	82.976	31.575
DL36	211.74	187.827	151.752	130.239	139.027	152.807	124.681	78.925	34.122
DL45	103.446	185.463	250.202	258.007	205.196	128.295	66.551	26.234	6.396
DL46	233.282	234.787	219.078	199.441	156.395	98.553	51.78	21.368	5.456
DL56	298.207	298.208	263.565	179.24	100.893	49.42	19.493	6.902	0.776
DL123	2.665	16.082	41.206	89.747	163.064	254.893	327.728	368.613	380.334
DL124	17.521	56.499	101.079	151.691	178.586	205.788	261.426	315.487	348.805
DL125	75.411	113.497	141.109	133.524	128.516	161.44	232.329	300.827	347.664
DL126	192.327	157.976	113.211	80.892	84.632	134.79	219.4	297.17	349.948
DL134	20.534	67.841	124.25	190.248	229.676	245.234	242.366	252.74	271.193
DL135	74.716	124.143	163.917	171.969	179.63	200.819	213.189	238.005	270
DL136	191.627	168.613	135.977	119.324	135.706	174.16	200.25	234.337	272.24
DL145	94.045	166.308	224.402	234.147	195.215	151.813	146.987	184.979	238.555
DL146	210.956	210.781	196.467	181.508	151.326	125.157	134.05	181.285	240.828
DL156	269.388	267.887	236.593	163.365	101.264	80.826	104.973	166.673	239.706
DL234	20.739	70.747	134.299	212.673	269.732	298.007	283.705	223.502	137.827
DL235	72.286	126.577	173.644	194.271	219.674	253.572	254.472	208.718	136.597
DL236	189.199	171.051	145.711	141.663	175.754	226.915	241.533	205.022	138.871
DL245	91.649	168.711	234.126	256.443	235.251	204.53	188.269	155.698	105.195
DL246	208.527	213.218	206.198	203.843	191.37	177.879	175.334	152.004	107.468
DL256	266.959	270.324	246.324	185.7	141.306	133.542	146.246	137.345	106.292
DL345	90.939	179.395	256.981	294.963	286.382	243.981	169.343	93.306	29.465
DL346	207.832	223.862	229.001	242.281	242.447	217.251	156.185	89.17	29.76
DL356	266.259	280.964	269.096	224.143	192.423	172.956	127.11	74.527	28.629
DL456	285.71	323.304	329.775	286.489	208.042	124.198	61.8	23.312	5.358
DL1234	16.989	58.368	111.284	178.943	233.622	278.869	309.773	322.303	316.149
DL1235	61.129	105.128	144.223	163.688	191.889	241.855	285.45	310.009	315.15
DL1236	158.551	142.192	120.972	119.825	155.308	219.644	274.677	306.947	317.043
DL1245	77.262	140.257	194.625	215.482	204.888	200.964	230.259	265.797	288.917

DL1246	174.686	177.325	171.38	171.656	168.312	178.759	219.493	262.746	290.854
DL1256	223.327	224.894	204.762	156.507	126.589	141.831	195.272	250.571	289.886
DL1345	76.647	149.134	213.615	247.541	247.474	233.809	214.329	213.478	224.221
DL1346	174.07	186.198	190.364	203.679	210.892	211.598	203.557	210.416	226.114
DL1356	222.757	233.779	223.756	188.567	169.173	174.672	179.336	198.215	225.179
DL1456	238.89	268.909	274.16	240.365	182.178	133.82	124.155	154.016	198.992
DL2345	74.67	151.149	221.743	266.118	280.835	277.728	248.703	189.034	113.047
DL2346	172.089	188.211	198.461	222.287	244.255	255.519	237.932	185.974	114.941
DL2356	220.735	235.786	231.88	207.142	202.534	218.59	213.709	173.771	114.006
DL2456	236.87	270.92	282.291	258.98	215.55	177.752	158.574	129.618	87.833
DL3456	236.315	279.825	301.306	291.025	258.131	210.621	142.72	77.498	24.221
DL12345	75.542	150.784	221.247	267.897	289.68	308.278	322.12	325.142	314.349
DL12346	172.966	187.853	198.003	224.071	253.104	286.072	311.35	322.081	316.242
DL12356	221.652	235.43	231.388	208.92	211.376	249.135	287.09	309.872	315.303
DL12456	237.752	270.593	281.801	260.76	224.392	208.294	231.949	265.681	289.12
DL13456	237.17	279.436	300.782	292.778	266.967	241.126	215.975	213.345	224.375
DL23456	235.16	281.485	308.919	311.396	300.339	285.057	250.393	188.919	113.25
DL123456	236.032	281.118	308.418	313.166	309.144	315.596	323.769	325.017	314.546
ENV	298.648	347.193	358.186	336.166	330.959	336.469	354.488	394.783	395.944
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1618.78	1568.285	1553.313	1511.92	1497.81	1491.546	1509.349	1570.198	1562.158

8.3.11 P2-2 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	382.016	424.05	424.05	424.05	424.05	424.05	424.05	424.05	374.743
합성후	321.282	201.22	140.689	117.473	114.461	112.75	119.459	141.178	197.977
	218.931	196.405	168.112	148.867	138.805	128.491	127.729	144.687	194.463
ENV	321.282	201.22	168.112	148.867	138.805	128.491	127.729	144.687	197.977
ADD	1306.562	1228.534	1195.426	1176.181	1166.119	1155.805	1155.043	1172.001	1175.984
DB1	1.763	0.585	1.88	5.273	10.8	39.448	101.111	189.785	279.308
DB2	0.376	3.19	9.122	26.353	57.81	107.127	157.147	160.826	122.639
DB3	2.881	12.306	35.574	73.439	122.538	157.32	135.838	85.713	33.025
DB4	16.664	60.746	111.213	152.984	143.97	97.182	51.979	22.099	5.239
DB5	80.334	133.261	161.301	131.958	80.756	41.03	16.345	6.051	0.884
DB6	213.437	190.616	125.439	63.559	25.91	9.149	3.807	1.232	0.772
DB12	0.568	3.156	10.039	27.381	67.393	146.148	258.006	350.49	401.814
DB13	2.603	11.601	34.177	74.168	131.943	196.24	236.655	275.347	312.133
DB14	17.935	60.191	109.831	153.667	153.378	135.944	152.199	210.702	277.357
DB15	81.643	132.756	159.989	132.689	90.124	79.781	116.73	193.511	276.645
DB16	214.738	190.16	124.144	64.244	35.113	47.661	102.255	189.418	279.47
DB22	0.752	6.379	18.243	52.706	115.62	214.254	314.292	321.649	245.255
DB24	16.513	61.808	119.96	179.084	201.707	204.1	208.487	181.823	120.826
DB25	78.822	134.132	169.998	158.09	138.448	147.913	172.97	164.606	120.097
DB26	211.913	191.512	134.149	89.622	83.436	115.793	158.517	160.516	122.923
DB34	19.398	72.948	146.653	226.29	266.501	254.313	187.205	106.71	31.248
DB35	77.488	144.54	196.322	205.181	203.223	198.033	151.608	89.442	30.473
DB36	210.558	201.921	160.495	136.736	148.213	165.914	137.133	85.349	33.298
DB45	96.971	194.012	272.511	284.926	224.688	138.069	68.096	26.387	5.776
DB46	229.999	251.333	236.616	216.422	169.664	105.851	53.301	21.728	4.919
DB56	293.713	323.864	286.71	195.41	106.491	49.785	17.83	6.892	0.803
DB123	2.453	12.104	38.818	90.406	170.751	273.016	354.426	392.55	391.247
DB124	14.843	55.021	106.738	161.863	189.998	218.742	278.39	334.328	359.94
DB125	72.181	120.315	151.861	142.983	133.079	168.18	246.451	318.851	359.297
DB126	191.961	171.989	119.627	81.375	83.569	139.261	233.413	315.174	361.833
DB134	17.204	64.991	130.735	204.328	248.309	263.904	259.211	266.742	279.321
DB135	70.981	129.693	175.573	185.375	191.357	213.282	227.204	251.205	278.637
DB136	190.732	181.339	143.314	123.768	141.871	184.389	214.193	247.533	281.176
DB145	88.405	174.075	243.975	257.008	210.667	159.099	151.264	193.073	247.398
DB146	208.179	225.723	211.715	195.398	161.156	130.181	138.249	189.398	249.936

DB156	265.495	291.016	256.86	176.519	104.238	79.62	106.31	173.921	249.294
DB234	17.455	66.71	139.982	227.254	291.814	325.276	309.911	240.778	138.454
DB235	68.43	130.905	184.573	208.224	234.85	274.607	277.851	225.193	137.737
DB236	188.209	182.577	152.318	146.618	185.363	245.712	264.817	221.518	140.274
DB245	85.854	175.286	252.974	279.856	254.157	220.401	201.909	167.059	106.498
DB246	205.628	226.935	220.715	218.246	204.647	191.503	188.873	163.383	109.034
DB256	262.972	292.254	265.864	199.369	147.73	140.942	156.934	147.907	108.392
DB345	84.652	184.663	276.666	322.25	312.459	265.527	182.666	99.416	25.839
DB346	204.427	236.311	244.407	260.641	262.95	236.632	169.653	95.743	28.377
DB356	261.766	301.607	289.551	241.76	206.01	186.068	137.712	80.265	27.734
DB456	279.286	346.126	358.108	313.527	225.349	132.087	62.502	23.428	4.914
DB1234	14.333	55.037	115.613	189.946	250.246	300.268	333.865	342.89	324.717
DB1235	58.048	108.767	152.877	174.108	202.786	258.054	307.177	329.918	324.122
DB1236	157.868	151.818	125.981	122.761	161.526	233.967	296.31	326.848	326.246
DB1245	72.585	145.739	209.881	233.804	218.845	212.879	243.879	281.475	298.089
DB1246	172.382	188.787	182.984	182.461	177.609	188.797	233.036	278.408	300.215
DB1256	220.177	243.225	220.606	166.734	130.17	146.675	206.429	265.53	299.672
DB1345	71.579	153.546	229.631	269.131	267.445	250.482	227.854	225.092	230.875
DB1346	171.376	196.593	202.733	217.785	226.187	226.399	217.012	222.048	233.005
DB1356	219.171	251.031	240.354	202.058	178.747	184.276	190.403	209.146	232.458
DB1456	233.684	288	297.357	261.757	194.828	139.103	127.106	160.704	206.425
DB2345	69.456	154.579	237.114	288.164	303.687	301.581	270.056	203.425	113.456
DB2346	169.274	197.61	210.238	236.819	262.429	277.498	259.211	200.358	115.582
DB2356	217.047	252.046	247.86	221.113	214.99	235.374	232.581	187.454	115.033
DB2456	231.559	289.013	304.86	280.79	231.07	190.201	169.306	139.014	89.002
DB3456	230.553	296.819	324.609	316.114	279.648	227.804	153.282	82.653	21.792
DB12345	70.481	154.245	236.19	288.751	310.749	330.81	345.694	345.683	322.798
DB12346	170.302	197.298	209.296	237.426	269.49	306.705	334.848	342.615	324.923
DB12356	218.069	251.709	246.912	221.696	222.048	264.58	308.219	329.733	324.378
DB12456	232.61	288.705	303.92	281.398	238.132	219.41	244.945	281.293	298.347
DB13456	231.604	296.511	323.668	316.722	286.709	257.011	228.918	224.91	231.133
DB23456	229.48	297.524	331.171	335.756	322.951	308.109	271.118	203.221	113.71
DB123456	230.504	297.19	330.247	336.342	330.012	337.337	346.737	345.499	323.054
DL1	1.681	0.67	2.19	6.251	12.898	40.629	97.521	175.143	274.802
DL2	0.356	3.663	10.404	26.947	55.196	98.569	143.428	148.253	123.589
DL3	3.182	13.523	35.438	69.271	111.643	143.36	123.445	81.246	35.127
DL4	19.703	58.739	102.089	139	130.817	90.312	50.409	23.446	5.948
DL5	81.783	123.39	147.385	119.996	75.597	40.595	17.479	7.025	0.93
DL6	209.233	177.469	117.264	61.387	26.677	10.879	4.47	1.425	0.768

DL12	0.595	3.626	11.83	29.575	66.704	138.659	240.626	323.236	398.233
DL13	2.793	12.709	34.593	71.471	122.9	183.305	220.58	256.209	309.638
DL14	19.666	57.919	101.142	141.083	142.052	130.073	146.802	197.107	273.536
DL15	82.899	122.844	146.643	122.201	86.74	80.312	114.068	179.811	272.178
DL16	210.329	176.978	116.523	63.502	37.6	50.077	99.428	175	274.8
DL22	0.714	7.331	20.815	53.934	110.431	197.116	286.866	296.551	247.235
DL24	19.471	60.459	111.951	165.62	185.887	188.618	193.067	170.357	122.557
DL25	80.287	124.862	157.23	146.671	130.612	138.855	160.292	153.054	121.175
DL26	207.684	179.023	127.113	87.976	81.475	108.621	145.679	148.203	123.747
DL34	22.796	72.159	137.374	208.135	242.429	233.439	173.09	103.366	34.098
DL35	79.469	135.646	182.163	189.038	187.126	183.582	140.209	85.937	32.645
DL36	206.898	189.775	152.037	130.302	137.98	153.342	125.563	81.117	35.223
DL45	100.344	181.864	249.347	258.936	206.33	130.718	67.588	28.773	6.393
DL46	227.735	235.964	219.153	200.17	157.176	100.366	52.562	23.291	5.483
DL56	290.977	300.846	264.574	181.248	101.976	50.772	19.825	7.919	0.769
DL123	2.675	14.15	40.373	88.537	160.249	253.659	327.593	364.012	389.914
DL124	17.183	53.711	100.011	151.058	177.44	205.72	261.194	310.802	357.404
DL125	73.291	111.968	140.882	134.025	127.68	160.94	231.729	295.262	356.19
DL126	187.986	160.701	113.768	81.182	83.446	133.743	218.549	290.877	358.489
DL134	20.165	64.211	122.858	189.297	228.31	246.043	243.19	250.502	277.808
DL135	72.58	121.663	163.363	172.147	178.539	201.219	213.632	234.841	276.486
DL136	187.276	170.4	136.253	119.338	134.307	173.993	200.46	230.498	278.84
DL145	91.271	163.073	223.598	234.893	195.788	153.334	147.287	181.717	244.055
DL146	205.932	211.834	196.486	182.056	151.561	126.146	134.151	177.376	246.369
DL156	262.834	270.27	237.45	165.087	101.811	81.387	104.706	161.853	245.167
DL234	20.39	66.593	132.657	211.405	267.801	298.766	284.857	226.436	141.883
DL235	70.209	123.479	172.881	194.199	218.018	253.858	255.245	210.762	140.578
DL236	184.904	172.212	145.767	141.357	173.784	226.662	242.07	206.385	142.921
DL245	88.909	164.921	233.115	256.911	235.232	206.001	188.9	157.639	108.147
DL246	203.561	213.649	206.002	204.106	191.007	178.813	175.76	153.261	110.451
DL256	260.462	272.08	246.96	187.1	141.251	134.05	146.313	137.738	109.249
DL345	88.17	174.629	255.586	295.051	286.088	246.291	170.963	97.502	29.963
DL346	202.845	223.337	228.444	242.219	241.858	219.057	157.667	92.882	30.801
DL356	259.751	281.774	269.439	225.218	192.106	174.296	128.221	77.358	29.599
DL456	278.525	323.381	329.867	288.137	209.401	126.723	62.779	25.793	5.353
DL1234	16.704	54.892	109.94	177.835	231.605	278.963	310.218	319.938	324.179
DL1235	59.424	102.573	143.558	163.527	190.122	241.553	285.588	306.891	323.1
DL1236	154.986	143.169	120.965	119.499	153.247	218.869	274.596	303.243	325.004
DL1245	74.953	137.089	193.752	215.818	204.499	201.665	230.298	262.6	296.047

DL1246	170.514	177.682	171.154	171.756	167.623	178.988	219.352	259.004	298.01
DL1256	217.949	226.403	205.325	157.617	126.168	141.706	194.793	246.008	296.942
DL1345	74.361	145.167	212.484	247.579	246.869	235.227	215.239	212.275	229.664
DL1346	169.922	185.763	189.891	203.552	209.996	212.547	204.254	208.664	231.578
DL1356	217.351	234.474	224.018	189.368	168.531	175.233	179.734	195.717	230.568
DL1456	232.925	269	274.217	241.66	182.908	135.346	124.449	151.434	203.56
DL2345	72.39	146.678	220.388	265.9	279.733	279.08	249.901	192.182	116.407
DL2346	167.952	187.276	197.799	221.878	242.897	256.406	238.92	188.574	118.321
DL2356	215.386	235.998	231.972	207.742	201.447	219.135	214.409	175.631	117.312
DL2456	230.916	270.512	282.162	260.027	215.787	179.241	159.115	131.338	90.258
DL3456	230.329	278.6	300.876	291.799	258.189	212.795	144.137	81.156	24.635
DL12345	73.287	146.326	219.909	267.625	288.208	309.095	322.763	323.439	322.308
DL12346	168.855	186.955	197.286	223.597	251.337	286.421	311.818	319.844	324.271
DL12356	216.234	235.625	231.441	209.416	209.874	249.136	287.262	306.856	323.247
DL12456	231.808	270.151	281.641	261.711	224.256	209.257	232.015	262.61	296.209
DL13456	231.216	278.232	300.376	293.503	266.624	242.781	216.916	212.275	229.82
DL23456	229.255	279.783	308.293	311.837	299.532	286.677	251.588	192.188	116.564
DL123456	230.109	279.42	307.804	313.553	307.968	316.655	324.477	323.446	322.468
ENV	293.713	346.126	358.108	336.342	330.012	337.337	354.426	392.55	401.814
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1600.275	1574.66	1553.534	1512.523	1496.131	1493.142	1509.469	1564.551	1577.798

8.3.12 A2 (단위:kN,우측편재하)

위치	G1	G2	G3	G4	G5	G6	G7	G8	G9
자중	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264	603.264
거푸집	0	0	0	0	0	0	0	0	0
합성전	382.016	424.05	424.05	424.05	424.05	424.05	424.05	424.05	374.743
합성후	329.834	194.066	139.621	117.491	115.245	112.251	119.488	145.736	192.756
	224.19	193.853	166.867	148.666	139.375	127.568	127.638	148.694	189.641
ENV	329.834	194.066	166.867	148.666	139.375	127.568	127.638	148.694	192.756
ADD	1315.114	1221.38	1194.181	1175.98	1166.689	1154.882	1154.952	1176.008	1170.763
DB1	1.779	0.626	1.886	5.313	11.141	39.744	101.306	194.243	276.413
DB2	0.366	3.703	9.186	26.598	58.503	107.321	157.192	161.484	120.857
DB3	2.835	13.522	35.74	73.852	123.247	157.048	135.575	84.438	32.435
DB4	16.839	62.64	111.342	153.135	144.004	96.389	51.706	20.853	5.219
DB5	81.41	134.093	161.014	131.676	80.5	40.405	16.229	5.391	0.897
DB6	215.721	188.429	124.691	63.196	25.704	8.88	3.792	1.069	0.761
DB12	0.571	3.709	10.103	27.665	68.437	146.651	258.25	355.622	397.15
DB13	2.564	12.849	34.345	74.626	133.004	196.279	236.59	278.542	308.667
DB14	18.125	62.082	109.957	153.858	153.763	135.461	152.128	213.783	274.502
DB15	82.733	133.588	159.7	132.45	90.217	79.464	116.809	197.266	273.816
DB16	217.031	187.977	123.395	63.925	35.254	47.696	102.434	193.738	276.597
DB22	0.732	7.406	18.373	53.197	117.006	214.642	314.382	322.963	241.69
DB24	16.66	64.204	120.16	179.477	202.433	203.5	208.265	181.09	119.068
DB25	79.861	135.495	169.785	158.053	138.883	147.481	172.898	164.548	118.365
DB26	214.154	189.859	133.475	89.505	83.918	115.713	158.546	161.022	121.147
DB34	19.527	76.055	146.946	226.849	267.242	253.247	186.673	104.045	30.679
DB35	78.483	146.69	196.205	205.309	203.675	197.138	151.229	87.455	29.932
DB36	212.756	201.056	159.918	136.785	148.712	165.37	136.855	83.926	32.713
DB45	98.221	196.739	272.353	284.794	224.465	136.65	67.703	24.488	5.785
DB46	232.452	251.043	235.996	216.208	169.487	104.783	53.011	20.318	4.906
DB56	297.068	322.511	285.675	194.763	106.025	48.885	17.701	6.064	0.813
DB123	2.399	13.684	39.032	91.04	172.33	273.227	354.408	396.016	386.524
DB124	14.982	57.201	106.919	162.258	190.97	218.483	278.368	337.691	355.769
DB125	73.13	121.542	151.669	142.99	133.788	168.071	246.563	322.822	355.15
DB126	193.993	170.502	119.02	81.311	84.32	139.468	233.617	319.652	357.646
DB134	17.326	67.815	131	204.871	249.294	263.225	258.911	268.368	276.221
DB135	71.892	131.629	175.468	185.531	192.081	212.756	227.04	253.439	275.561
DB136	192.725	180.562	142.795	123.853	142.638	184.179	214.12	250.274	278.06
DB145	89.543	176.525	243.829	256.924	210.78	158.099	151.093	195.202	244.872
DB146	210.4	225.459	211.155	195.242	161.312	129.497	138.169	192.035	247.371

DB156	268.526	289.8	255.926	175.976	104.132	79.087	106.365	177.166	246.751
DB234	17.547	69.961	140.311	227.979	293.105	324.491	309.474	238.97	136.339
DB235	69.294	133.318	184.535	208.562	235.88	273.977	277.552	223.995	135.648
DB236	190.156	182.277	151.866	146.885	186.436	245.398	264.609	220.828	138.145
DB245	86.946	178.213	252.896	279.953	254.577	219.298	201.602	165.757	104.959
DB246	207.803	227.148	220.222	218.272	205.11	190.716	188.658	162.589	107.456
DB256	265.956	291.515	264.998	199.008	147.931	140.306	156.854	147.719	106.836
DB345	85.706	188.298	276.675	322.497	312.894	264.006	182.083	96.377	25.371
DB346	206.563	237.234	244.002	260.816	263.428	235.427	169.161	93.211	27.87
DB356	264.712	301.577	288.773	241.548	206.225	185.014	137.356	78.341	27.251
DB456	282.46	346.614	357.291	313.081	224.957	130.562	62.133	21.571	4.929
DB1234	14.414	57.769	115.889	190.585	251.587	299.848	333.649	344.736	320.798
DB1235	58.78	110.779	152.846	174.423	203.91	257.762	307.076	332.272	320.224
DB1236	159.503	151.568	125.605	123.017	162.685	233.939	296.284	329.626	322.315
DB1245	73.506	148.179	209.815	233.92	219.46	212.192	243.772	283.741	294.649
DB1246	174.206	188.966	182.574	182.517	178.26	188.374	233.004	281.099	296.742
DB1256	222.676	242.609	219.884	166.467	130.602	146.377	206.51	268.726	296.219
DB1345	72.468	156.577	229.638	269.371	268.072	249.447	227.516	225.912	228.328
DB1346	173.168	197.363	202.395	217.965	226.85	225.628	216.75	223.291	230.425
DB1356	221.637	251.006	239.705	201.915	179.191	183.63	190.253	210.895	229.897
DB1456	236.34	288.404	296.674	261.414	194.764	138.063	126.951	162.365	204.323
DB2345	70.307	158.007	237.177	288.555	304.57	300.461	269.605	201.385	111.732
DB2346	171.028	198.777	209.956	237.151	263.348	276.641	258.837	198.741	113.824
DB2356	219.474	252.419	247.267	221.122	215.69	234.642	232.318	186.343	113.295
DB2456	234.177	289.814	304.233	280.599	231.262	189.075	169.038	137.816	87.722
DB3456	233.139	298.211	324.055	316.047	279.853	226.33	152.783	80.008	21.405
DB12345	71.344	157.674	236.253	289.176	311.897	329.922	345.392	346.995	318.916
DB12346	172.067	198.465	209.014	237.792	270.673	306.081	334.621	344.35	321.008
DB12356	220.509	252.082	246.319	221.739	223.013	264.082	308.105	331.974	320.483
DB12456	235.24	289.506	303.293	281.241	238.589	218.517	244.825	283.447	294.91
DB13456	234.202	297.903	323.114	316.689	287.178	255.77	228.568	225.617	228.589
DB23456	232.038	299.314	330.673	335.874	323.676	306.782	270.655	201.068	111.988
DB123456	233.075	298.981	329.749	336.494	331.001	336.243	346.421	346.698	319.175
DL1	1.714	0.711	2.2	6.279	13.282	40.979	97.785	181.764	269.167
DL2	0.343	4.256	10.465	27.238	56.088	98.9	143.585	149.54	120.826
DL3	3.104	14.973	35.644	69.817	112.69	143.009	123.036	79.808	34.481
DL4	19.806	60.98	102.321	139.241	130.795	89.219	50.063	21.968	5.963
DL5	83.297	124.229	146.965	119.521	75.233	39.818	17.357	6.255	0.952
DL6	213.379	174.031	116.199	60.923	26.435	10.575	4.464	1.237	0.751

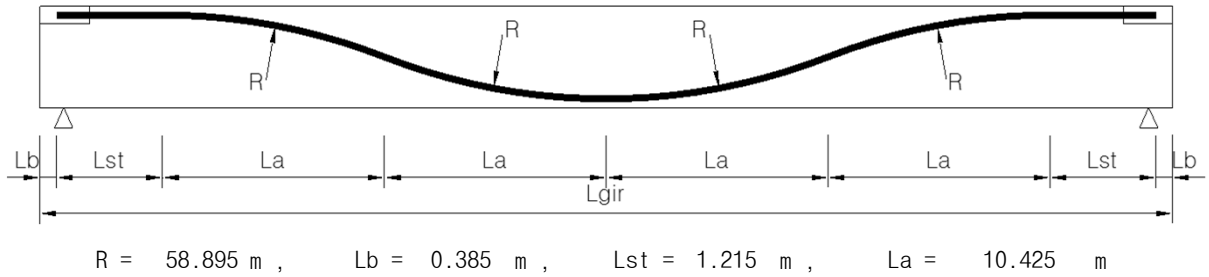
DL12	0.599	4.269	11.881	29.887	68.004	139.353	241.05	331.166	389.853
DL13	2.724	14.191	34.793	72.055	124.354	183.322	220.437	261.408	303.383
DL14	19.784	60.176	101.364	141.356	142.435	129.344	146.738	202.065	268.059
DL15	84.443	123.673	146.216	121.76	86.779	79.901	114.205	185.594	266.66
DL16	214.501	173.534	115.452	63.074	37.756	50.127	99.682	181.465	269.188
DL22	0.687	8.519	20.939	54.517	112.215	197.777	287.182	299.127	241.706
DL24	19.537	63.287	112.259	166.146	186.757	187.853	192.896	169.964	119.928
DL25	81.741	126.325	156.888	146.484	131.138	138.41	160.324	153.486	118.506
DL26	211.765	176.216	126.126	87.801	82.119	108.636	145.827	149.317	120.985
DL34	22.82	75.844	137.808	208.916	243.452	231.992	172.352	100.25	33.586
DL35	80.814	138.075	181.946	189.107	187.808	182.458	139.676	83.648	32.094
DL36	210.87	187.932	151.176	130.384	138.78	152.678	125.146	79.509	34.579
DL45	101.94	184.973	249.158	258.701	205.943	128.849	67.109	26.524	6.453
DL46	231.958	234.799	218.318	199.945	156.904	98.955	52.207	21.622	5.508
DL56	296.63	298.247	263.089	180.305	101.363	49.676	19.701	6.959	0.786
DL123	2.594	16.018	40.614	89.325	162.361	253.972	327.607	369.85	381.798
DL124	17.251	56.285	100.282	151.565	178.589	205.363	261.28	316.423	349.989
DL125	74.631	113.278	140.569	133.89	128.519	160.87	231.996	301.625	348.739
DL126	191.69	158.166	112.875	81.059	84.391	134.086	218.921	297.853	350.954
DL134	20.195	67.556	123.243	190.035	229.597	245.072	242.765	253.671	272.297
DL135	73.821	123.842	163.163	172.243	179.518	200.537	213.391	238.753	270.941
DL136	190.881	168.734	135.472	119.445	135.392	173.726	200.323	235.025	273.21
DL145	92.737	165.856	223.419	234.709	195.801	151.978	147.115	185.412	239.208
DL146	209.762	210.774	195.727	181.882	151.681	125.205	134.083	181.683	241.438
DL156	267.948	267.924	236.107	164.271	101.621	80.732	104.82	166.903	240.199
DL234	20.38	70.443	133.119	212.37	269.526	297.761	284.336	224.788	138.937
DL235	71.368	126.229	172.757	194.523	219.436	253.145	254.909	209.86	137.597
DL236	188.427	171.118	145.063	141.692	175.308	226.364	241.839	206.097	139.856
DL245	90.293	168.276	233.012	256.954	235.684	204.614	188.633	156.52	105.865
DL246	207.308	213.16	205.32	204.16	191.566	177.841	175.597	152.754	108.085
DL256	265.494	270.306	245.694	186.512	141.5	133.364	146.332	137.973	106.846
DL345	89.456	178.855	255.596	295.326	286.681	244.294	170.184	93.976	29.561
DL346	206.495	223.716	227.874	242.504	242.557	217.474	156.996	89.925	30.34
DL356	264.684	280.869	268.285	224.862	192.495	172.999	127.732	75.144	29.101
DL456	283.685	323.088	328.738	287.506	208.827	124.755	62.338	23.597	5.415
DL1234	16.702	58.125	110.321	178.667	233.348	278.402	309.982	323.544	317.516
DL1235	60.416	104.858	143.45	163.826	191.608	241.234	285.507	311.117	316.408
DL1236	157.948	142.251	120.374	119.807	154.821	218.895	274.602	307.979	318.242
DL1245	76.132	139.879	193.662	215.882	205.18	200.784	230.274	266.644	289.937

DL1246	173.663	177.268	170.581	171.829	168.393	178.453	219.415	263.56	291.83
DL1256	222.168	224.919	204.265	157.155	126.68	141.409	195.007	251.181	290.732
DL1345	75.457	148.681	212.488	247.835	247.668	233.837	214.792	214.278	225.143
DL1346	172.989	186.073	189.411	203.817	210.883	211.503	203.893	211.178	226.986
DL1356	221.489	233.713	223.052	189.099	169.16	174.427	179.524	198.848	225.946
DL1456	237.25	268.743	273.269	241.158	182.732	133.979	124.296	154.385	199.519
DL2345	73.418	150.667	220.456	266.347	280.897	277.665	249.375	190.173	114.022
DL2346	170.95	188.062	197.384	222.334	244.149	255.335	238.48	187.075	115.866
DL2356	219.455	235.714	231.069	207.663	202.441	218.303	214.12	174.75	114.826
DL2456	235.171	270.733	281.277	259.714	215.976	177.848	158.884	130.275	88.356
DL3456	234.503	279.545	300.086	291.679	258.495	210.893	143.48	78.073	24.307
DL12345	74.342	150.31	219.973	268.1	289.677	307.954	322.435	326.407	315.715
DL12346	171.88	187.734	196.866	224.081	252.894	285.626	311.578	323.323	317.608
DL12356	220.328	235.335	230.534	209.365	211.173	248.579	287.172	310.953	316.554
DL12456	236.089	270.365	280.752	261.426	224.751	208.139	231.983	266.525	290.097
DL13456	235.416	279.17	299.581	293.41	267.234	241.153	216.46	214.148	225.297
DL23456	233.387	281.197	307.561	311.935	300.508	285.023	251.053	190.05	114.178
DL123456	234.266	280.828	307.068	313.679	309.249	315.276	324.141	326.284	315.874
ENV	297.068	346.614	357.291	336.494	331.001	336.243	354.408	396.016	397.15
균중	0	0	0	0	0	0	0	0	0
MAX(Σ)	1612.182	1567.994	1551.472	1512.474	1497.69	1491.125	1509.36	1572.024	1567.913

9. 프리스트레스

9.1 마찰에 의한 손실

(1) 일체긴장 강연선(T1)



▷ 지간중양부의 접선변화각 누계

$$\alpha = 2 \cdot \sin^{-1}(La / R) = 0.356 \text{ rad}$$

▷ 지간중양부까지의 강선길이

$$x = Lst + \alpha \cdot R = 1.215 + 0.356 \times 58.895 = 22.175 \text{ m}$$

▷ 마찰손실량 산정

- 곡률마찰계수 (μ) = 0.250

- 파상마찰계수 (κ) = 0.005

$$\Delta Ppf = Po - Px = Po \cdot [1 - e^{-(\mu \alpha + \kappa x)}] = 244549 \text{ N}$$

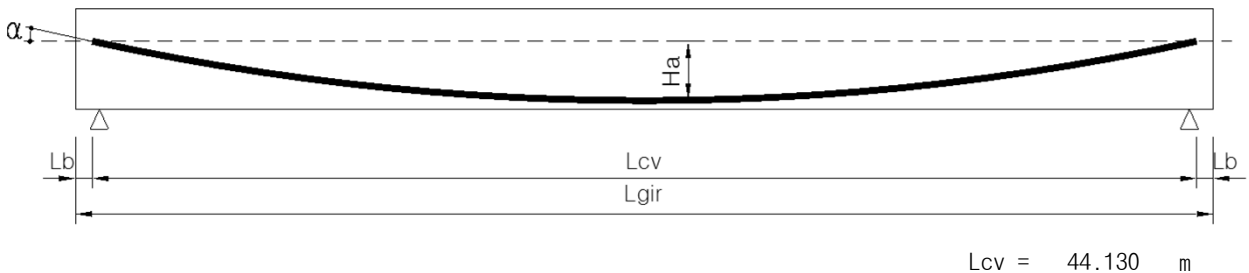
(2) 일체긴장 강봉 (C1, C2 압축 PS강봉은 직선으로 배치되어 있으므로 곡률마찰손실은 없다.)

- 지간중양부까지의 강봉길이(x) = 22.065 m

- 파상마찰계수 (κ) = 0.008

$$\Delta Ppf = Po - Px = Po \cdot [1 - e^{-\kappa x}] = 218454 \text{ N}$$

(3) 일반 강연선(T2 ~ T5)



▷ $y = a \cdot x^2$ 에서 $a = 4 \cdot Ha / Lcv^2$

▷ 지간중양부의 접선변화각 누계 (α) = $\tan^{-1}(a \times Lcv)$

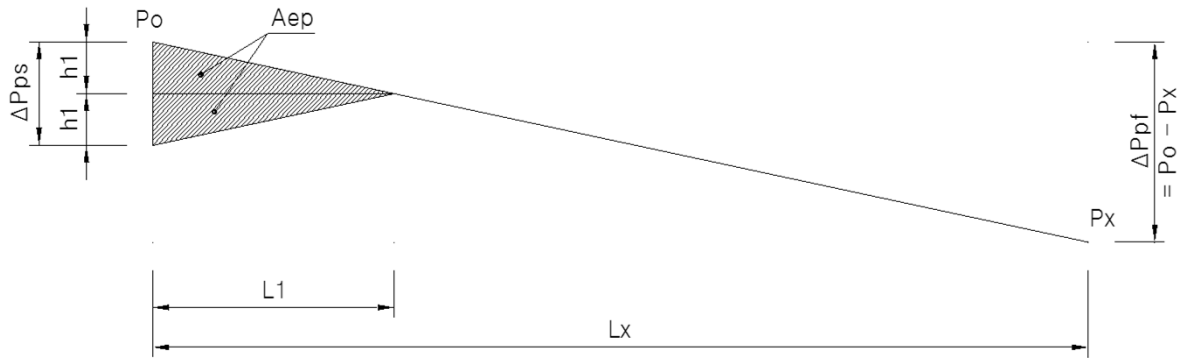
▷ 강선의 총길이(Lt) = $Lcv + \frac{8}{3} \frac{Ha^2}{Lcv} - \frac{32}{5} \frac{Ha^4}{Lcv^3}$

▷ 지간중양부까지의 강선길이(x) = $Lt / 2$

▷ 마찰손실량 (ΔPpf) = $Po - Px = Po \cdot [1 - e^{-(\mu \alpha + \kappa x)}]$

	Ha	a	α (rad)	Lt	x	μ	κ	ΔPpf
T2	1.475	0.003030	0.13291	44.261	22.131	0.250	0.005	410065
T3	1.025	0.002105	0.09264	44.193	22.097	0.250	0.005	382801
T4	0.575	0.001181	0.05207	44.150	22.075	0.250	0.005	355216
T5	0.125	0.000257	0.01133	44.131	22.065	0.250	0.005	327396

9.2 정착장치 활동에 의한 손실



- ▷ 정착장치 활동량 가정 : $\Delta \ell : 6 \text{ mm}$
- ▷ PS강재의 단위길이당 마찰손실력(p) = $\Delta Ppf / Lx$
- ▷ 정착장치 활동에 의한 손실발생 길이($L1$)

$$Aep = \Delta \ell \cdot Ap \cdot Ep$$

$$h1 = \Delta Ppf \times L1 / Lx = p \times L1$$

$$Aep = h1 \times L1 = p \times L1^2$$

$$L1 = \sqrt{Aep / p}$$
- ▷ 긴장단에서의 손실력(ΔPps) = $2 \cdot p \cdot L1$
- ▷ 지간중앙부에서의 손실력(ΔPpx)

$$Lx \leq L1 \text{ 이면 } \Delta Ppx = \Delta Pps \cdot (1 - Lx / L1)$$

$$Lx > L1 \text{ 이면 } \Delta Ppx = 0$$

단위	Lx	p	Aep	L1	Δ Pps	Δ Ppx
	m	N/m	N · m	m	N	N
C1	22.065	4950	1508400	17.456	172823	0
C2	22.065	4950	1508400	17.456	172823	0
T1	22.175	11028	1165080	10.279	226702	0
T2	22.131	18529	2496600	11.608	430164	0
T3	22.097	17324	2496600	12.005	415937	0
T4	22.075	16091	2496600	12.456	400867	0
T5	22.065	14837	2496600	12.972	384932	0

9.3 콘크리트의 탄성변형에 의한 손실

- ▶ 긴장순서는 T2 → T5 순으로 하고, 그 이후에 일체긴장 PS강재(C1, C2, T1)를 긴장하는 것으로 가정한다.
또한, 일체긴장 PS강재를 긴장할 때는 거더의 탄성변형이 발생하지 않으므로 계산에서 제외한다.

▶ $f_{cir} = \epsilon_c \cdot E_{ci}$, $\Delta f_{pe} = \epsilon_p \cdot E_{pt}$, $\epsilon_c = \epsilon_p$

▶ $\Delta f_{pe} = \epsilon_p \cdot E_{pt} = (E_{pt}/E_{ci}) \cdot f_{cir} = n \cdot f_{cir}$

$$f_{cir} = \sum f_{psi} + f_{sw} / N$$

$$(E_{pt} / E_{ci}) = n$$

$$f_{sw} = M_{sw} \cdot e / I_{net}$$

$$\sum f_{psi} = \begin{cases} \text{①강선 경우 : } f_{ps2} + f_{ps3} + f_{ps4} \cdots f_{psN} \\ \text{②강선 경우 : } f_{ps3} + f_{ps4} \cdots f_{psN} \\ \text{③강선 경우 : } f_{ps4} \cdots f_{psN} \\ \cdots \\ \text{④강선 경우 : } 0 \end{cases}$$

$$f_{psi} = P_r / A_{net} + P_r \cdot e^2 / I_{net}$$

- 긴장회수(N) = 4 회
- PS 강연선의 탄성계수(E_{pt}) = 200000 Mpa
- 프리스트레스 도입시 콘크리트 탄성계수(E_{ci}) = 29070 Mpa
- 탄성계수비(n) = 6.880042
- e : 순단면 도심에서 PS강재 중심까지의 편심
- $P_r = P_o - \Delta P_{pf} - \Delta P_{ps}$
- f_{cir} : 정착직후 자중과 프리스트레스에 의해 발생하는 PS강재 중심에서의 콘크리트 응력
- 순단면의 단면정수 : $A_{net} = 0.91095 \text{ m}^2$, $I_{net} = 0.50658 \text{ m}^4$
- 거더자중에 의한 지간 중앙부의 휨모멘트(M_{sw}) = 5979500 N·m

	P_o	ΔP_{pf}	ΔP_{px}	P_r	e	긴장 순서
T2	3060000	-410065	0	2649935	-0.780362	4
T3	3060000	-382801	0	2677199	-0.780362	1
T4	3060000	-355216	0	2704784	-0.780362	2
T5	3060000	-327396	0	2732604	-0.780362	3

	f_{psi}	$\sum f_{psi}$	f_{sw}/N	f_{cir}	Δf_{pe}	ΔP_{pe}
T3	6.157	18.600	-2.303	16.297	112.124	233.273
T4	6.221	12.379	-2.303	10.076	69.325	144.231
T5	6.285	6.094	-2.303	3.791	26.084	54.267
T2	6.094	0.000	-2.303	-2.303	-15.843	-32.962
Σ	24.757	37.073	-9.211	27.862	191.689	398.810

Δf_{pe} 의 평균치 : 47.922 MPa

ΔP_{pe} 의 평균치 : 99.702 kN

9.4 프리스트레싱에 의한 단면력 요약(지간중양부)

▶ 순 긴장력 = 초기 긴장력 - 마찰에 의한 손실 - 정착장치 활동에 의한 손실 - 탄성변형에 의한 손실

	초기긴장력	마찰손실력	활동손실력	탄성손실력	순 긴장력	편심거리	휨모멘트
	Po (N)	Ppf (N)	Pps (N)	Ppe (N)	Pnet (N)	e (m)	M (N · m)
C1	-675000	109227	0	0	-565773	1.06964	-605172
C2	-675000	109227	0	0	-565773	1.06964	-605172
PS강봉 소계(압축)					-1131546	1.06964	-1210345
T1	1350000	-244549	0	0	1105451	-0.79036	-873706
T2	3060000	-410065	0	32962	2682897	-0.78036	-2093630
T3	3060000	-382801	0	-233273	2443926	-0.78036	-1907146
T4	3060000	-355216	0	-144231	2560553	-0.78036	-1998157
T5	3060000	-327396	0	-54267	2678337	-0.78036	-2090072
PS강연선 소계(인장)					11471164	-0.78168	-8962713

10. 응력검토

10.1 G1거더 응력산출

▶ 하중단계별 휨모멘트 요약

		기호	Pnet	e	M	저항단면
			(kN)	(m)	(kN · m)	
거더 자중		sw			5979.50	순단면(net)
PS	강봉	gb	-1132	1.070	-1210.34	
	강선	gs	11471	-0.782	-8962.71	
합성전 고정하중		bl			4103.80	PS강재 환산단면(conv)
합성후 고정하중		al			2679.00	바닥판 합성단면(comp)
최대활하중		ll			3488.40	
균중하중		gj			0.00	

※ Pnet : 즉시손실을 고려한 순긴장력(도입긴장력)

10.1.1 자중에 의한 응력산정

$$f_{sw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
y	m			1.195	-0.905			
f _{sw}	MPa			14.101	-10.687			

10.1.2 프리스트레스 도입량 산정

▷ 거더에 축력을 작용시키는 강선의 순긴장력(Pn) = P_{C1} + P_{C2} + P_{T1} + P_{T2} + P_{T3} + P_{T4} + P_{T5} = 10340 kN

▷ PS강재의 응력산정식(강재기준으로 보면 Pnet와 반대방향으로 하중이 작용하므로)

$$f_{gb} = \frac{P_{net}}{A_{gb}} = \frac{1132}{0.002514} = 450.098 \text{ MPa}$$

$$f_{gs} = \frac{P_{net}}{A_{gs}} = \frac{-11471}{0.0092929} = -1234.401 \text{ MPa}$$

▷ 거더의 응력산정식

$$f_{ps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot y$$

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
y	m			1.195	-0.905	1.070	-0.782	
f _{ps}	MPa			-12.640	29.532	450.098	-1234.401	

10.1.3 합성전 고정 하중에 의한 응력산정

$$f_{bl} = n \cdot \frac{M_{bl}}{I_{conv}} \cdot y = n \cdot \frac{4103.80}{0.56106} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
f _{bl}	MPa	1.901	1.429	1.588	-3.003	8.509	-17.687	

10.1.4 합성후 고정 하중에 의한 응력산정

$$f_{al} = n \cdot \frac{M_{al}}{I_{comp}} \cdot y = n \cdot \frac{2679.00}{1.22551} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
f _{al}	MPa	1.901	1.429	1.588	-3.003	8.509	-17.687	

10.1.5 활하중에 의한 응력산정

$$f_{ll} = n \cdot \frac{M_{ll} + M_{gj}}{I_{comp}} \cdot y = n \cdot \frac{3488.4 + 0}{1.22551} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
f _{ll}	MPa	2.475	1.861	2.067	-3.910	11.080	-23.031	

10.1.6 건조수축에 의한 손실

※ 안전측의 계산을 위해 건조수축에 의한 일체긴장 강봉(C1,C2)의 영향은 무시한다.

$$\Delta f_{sh} = 0.80 \cdot (119 - 1.05 \cdot Hr) = 0.80 \cdot (119 - 1.05 \cdot 70) = 36.4 \text{ Mpa}$$

여기서, Hr은 주위의 연간 평균 상대습도(%)로서 70%를 적용한다.

$$\Delta P_{sh} = \Delta f_{sh} \cdot A_{gs} = -36.4 \times 0.0093 = -338.26 \text{ kN}$$

$$f_{sh} = n \cdot \frac{\Delta P_{sh}}{A_{comp}} + n \cdot \frac{\Delta P_{sh} \times e}{I_{comp}} \cdot y = n \cdot \frac{-338.3}{1.5689} + n \cdot \frac{422.8}{1.2255} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
fsh	MPa	0.106	0.031	0.035	-0.689	-0.053	4.187	

10.1.7 크리프에 의한 손실

$$\Delta f_{cr} = 12 \cdot f_{cir} - 7 \cdot f_{cds} = 12 \times 17.82 - 7 \times 8.23 = 156.256 \text{ Mpa}$$

$$f_{cir} = (f_{cgb} + f_{cgs}) + f_{csw} = f_{cps} + f_{csw} = 27.05 + -9.23 = 17.82 \text{ Mpa}$$

$$f_{cds} = f_{cbl} + f_{cal} = -5.50 + -2.73 = -8.23 \text{ Mpa}$$

$$f_{cps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot -0.782 = 27.048 \text{ MPa}$$

$$f_{csw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot -0.782 = -9.227 \text{ MPa}$$

$$f_{cbl} = \frac{M_{bl}}{I_{conv}} \cdot y = \frac{4104}{0.56106} \cdot -0.751 = -5.496 \text{ MPa}$$

$$f_{cal} = \frac{M_{al}}{I_{comp}} \cdot y = \frac{2679}{1.22551} \cdot -1.250 = -2.732 \text{ MPa}$$

여기서, f_{cir}은 정착직후 프리스트레스와 자중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

f_{cds}는 긴장 이후의 모든 고정하중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

$$\Delta P_{cr} = \Delta f_{cr} \cdot A_{gs} = -156.256 \times 0.0093 = -1452.072 \text{ kN}$$

$$f_{cr} = n \cdot \frac{\Delta P_{cr}}{A_{comp}} + n \cdot \frac{\Delta P_{cr} \times e}{I_{comp}} \cdot y = n \cdot \frac{-1452.072}{1.5689} + n \cdot \frac{1814.779}{1.2255} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
fcr	MPa	0.455	0.135	0.150	-2.960	-0.228	17.974	

10.1.8 강봉의 릴렉сей션

$$\Delta f_{rgb} = (f_{ps} + f_{bl} + f_{al}) \times 3\%$$
$$= (450.10 + 52.07 + 8.51) \times 0.03 = 15.320 \text{ Mpa}$$

$$\Delta P_{rgb} = \Delta f_{rgb} \cdot A_{gb} = -15.320 \times 0.0025 = -38.515 \text{ kN}$$

$$f_{rgb} = n \cdot \frac{\Delta P_{rgb}}{A_{comp}} + n \cdot \frac{\Delta P_{rgb} \times e}{I_{comp}} \cdot y = n \cdot \frac{-38.515}{1.5689} + n \cdot \frac{-23.158}{1.2255} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
f _{rgb}	MPa	-0.039	-0.034	-0.038	0.001	-0.232	-0.006	

10.1.9 강선의 릴렉сей션

$$\Delta f_{rgs} = 35 - 0.07 \cdot \Delta f_{pf} - 0.1 \cdot \Delta f_{pe} - 0.05 \cdot (\Delta f_{sh} + \Delta f_{cr})$$

	A _{gs}	Δ f _{pf}	Δ f _{pe}	Δ f _{sh}	Δ f _{cr}	Δ f _{rgs}
T1	0.000971	251.878	0.000	36.400	156.256	7.736
T2	0.002081	197.099	15.843	36.400	156.256	9.986
T3	0.002081	183.995	-112.124	36.400	156.256	23.700
T4	0.002081	170.736	-69.325	36.400	156.256	20.348
T5	0.002081	157.3639	-26.084	36.400	156.256	16.960
Σ	0.009293	961.072	-191.689	182.000	781.280	78.730
avg	0.001859	192.214	-38.338	36.400	156.256	15.746

$$\Delta P_{rgs} = \Delta f_{rgs} \cdot A_{gs} = -15.746 \times 0.0093 = -146.33 \text{ kN}$$

$$f_{rgs} = n \cdot \frac{\Delta P_{rgs}}{A_{comp}} + n \cdot \frac{\Delta P_{rgs} \times e}{I_{comp}} \cdot y = n \cdot \frac{-146.33}{1.5689} + n \cdot \frac{182.88}{1.2255} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.966	0.726	0.726	-1.374	0.601	-1.250	
f _{rgs}	MPa	0.046	0.014	0.015	-0.298	-0.023	1.811	

10.1.10 2차응력검토

(1) 크리프에 의한 단면력 계산

$$\begin{aligned}
 m &= E_{c1} \times I_{c1} / (E_{c2} \times I_{c2}) \\
 &= 30891.0501 \times 5.6106E+11 / 27804.0636 \times 2791065600 = 223.339 \\
 B &= 1 + m = 1 + 223.339 = 224.339 \\
 C &= Y_1' - m \times Y_2 = 1.22461835 - 223.339 \times 0.12 = -25.576 \text{ m} \\
 F &= Y_1'^2 + \gamma_{c1}^2 + m \times \gamma_{c2}^2 + m \times Y_2^2 \\
 &= 1.500 + 0.568 + 223.339 \times 0.005 + 223.339 \times 0.014 \\
 &= 6.356 \\
 P &= (1383.68 + 1150.0754) / 2 \times (138.7 \times 67) \\
 &= 11772968 \text{ N} \\
 K &= \phi_{\infty} / (1 + \phi_{\infty}) = 0.792 \\
 K' &= \phi_t / (1 + \phi_{\infty}) = 0.500 \\
 \text{여기서, } \phi_{\infty} &= 3.800 \text{ (콘크리트 초기재령 ~ } T=\infty \text{까지의 크리프 계수)} \\
 \phi_t &= 2.400 \text{ (바닥판 합성후 ~ } T=\infty \text{까지의 크리프 계수)}
 \end{aligned}$$

$$\begin{aligned}
 N_{\phi} &= - K' / (C^2 - BF) \\
 &\times [P \{ B (Y_1' \text{ ep3} - \gamma_{c1}^2) - C \text{ ep3} \} \\
 &+ M_{d1} \times (C - B Y_1')] \\
 &- K / (C^2 - BF) \times M_{d2} (C - B Y_1') \\
 &= -1678656.549 \text{ N} \\
 M_{\phi} &= - K' / (BF - C^2) \\
 &\times [P \{ C (Y_1' \text{ ep3} - \gamma_{c1}^2) - F \text{ ep3} \} \\
 &+ M_{d1} \times (F - C Y_1')] \\
 &- K / (BF - C^2) \times M_{d2} (F - C Y_1') \\
 &= -199469.355 \text{ N.m}
 \end{aligned}$$

(2) 건조수축에 의한 단면력 계산

$$\begin{aligned}
 N_s &= \epsilon_s E_{c1} I_{c1} \times (B / (BF - C^2)) \times (1 / (1 + \phi_{\infty})) \\
 &= 104958.818 \text{ N} \\
 M_s &= \epsilon_s E_{c1} I_{c1} \times (C / (C^2 - (BF))) \times (1 / (1 + \phi_{\infty})) \\
 &= 11965.968 \text{ N.m}
 \end{aligned}$$

(3) 크리프에 의한 2차 응력

$$f_{c2}' = - N_{\phi} / A_{c2} - ((M_{\phi} - N_{\phi} Y_2) Y_2' / I_{c2}) : \text{슬래브 상면응력}$$

$$= 2.802 \text{ MPa}$$

$$f_{c2} = - N_{\phi} / A_{c2} + ((M_{\phi} - N_{\phi} Y_2) Y_2 / I_{c2}) : \text{슬래브 하면응력}$$

$$= 2.972 \text{ MPa}$$

$$f_{c1}' = N_{\phi} / A_{c1} + ((M_{\phi} + N_{\phi} Y_1') Y_1' / I_{c1}) : \text{거더 상면응력}$$

$$= -6.622 \text{ MPa}$$

$$f_{c1} = N_{\phi} / A_{c1} - ((M_{\phi} + N_{\phi} Y_1') Y_1 / I_{c1}) : \text{거더 하면응력}$$

$$= 1.818 \text{ MPa}$$

(4) 건조수축에 의한 2차 응력

$$f_{s2}' = - N_s / A_{c2} - ((M_s - N_s Y_2) Y_2' / I_{c2}) : \text{슬래브 상면응력}$$

$$= -0.153 \text{ MPa}$$

$$f_{s2} = - N_s / A_{c2} + ((M_s - N_s Y_2) Y_2 / I_{c2}) : \text{슬래브 하면응력}$$

$$= -0.208 \text{ MPa}$$

$$f_{s1}' = N_s / A_{c1} + ((M_s + N_s Y_1') Y_1' / I_{c1}) : \text{거더 상면응력}$$

$$= 0.413 \text{ MPa}$$

$$f_{s1} = N_s / A_{c1} - ((M_s + N_s Y_1') Y_1 / I_{c1}) : \text{거더 하면응력}$$

$$= -0.113 \text{ MPa}$$

(5) 2차 응력 집계

	단위	바닥판		거더		PS 강재		비고
		상면	하면	상면	하면	강봉	강선	
y	m	0.12	-0.12	1.225	-0.875	1.100	-0.751	
f _{cr2}	MPa	2.802	2.972	-6.622	1.818	-5.946	1.561	
f _{sh2}	MPa	-0.153	-0.208	0.413	-0.113	0.371	-0.097	
f ₂	MPa	2.649	2.764	-6.209	1.706	-5.576	1.464	

(+) : 압축, (-) : 인장

10.2 G2~G8거더 응력산출

▶ 하중단계별 휨모멘트 요약

		기호	Pnet (kN)	e (m)	M (kN · m)	저항단면
거더 자중		sw			5979.50	순단면(net)
PS	강봉	gb	-1132	1.070	-1210.34	
	강선	gs	11471	-0.782	-8962.71	
합성전 고정하중		bl			4384.60	PS강재 환산단면(conv)
합성후 고정하중		al			2412.10	바닥판 합성단면(comp)
최대활하중		ll			3015.20	
균중하중		gj			0.00	

※ Pnet : 즉시손실을 고려한 순긴장력(도입긴장력)

10.2.1 자중에 의한 응력산정

$$f_{sw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
y	m			1.195	-0.905			
f _{sw}	MPa			14.101	-10.687			

10.2.2 프리스트레스 도입량 산정

▷ 거더에 축력을 작용시키는 강선의 순긴장력(P_n) = P_{C1} + P_{C2} + P_{T1} + P_{T2} + P_{T3} + P_{T4} + P_{T5} = 10340 kN

▷ PS강재의 응력산정식(강재기준으로 보면 P_{net}와 반대방향으로 하중이 작용하므로)

$$f_{gb} = \frac{P_{net}}{A_{gb}} = \frac{1132}{0.002514} = 450.098 \text{ MPa}$$

$$f_{gs} = \frac{P_{net}}{A_{gs}} = \frac{-11471}{0.0092929} = -1234.401 \text{ MPa}$$

▷ 거더의 응력산정식

$$f_{ps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot y$$

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
y	m			1.195	-0.905	1.070	-0.782	
f _{ps}	MPa			-12.640	29.532	450.098	-1234.401	

10.2.3 합성전 고정하중에 의한 응력산정

$$f_{bl} = n \cdot \frac{M_{bl}}{I_{conv}} \cdot y = n \cdot \frac{4384.60}{0.56106} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n				1.000		6.474	6.474	
y	m			1.225	-0.875	1.100	-0.751	
f _{bl}	MPa			9.570	-6.841	55.633	-38.017	

10.2.4 합성후 고정하중에 의한 응력산정

$$f_{al} = n \cdot \frac{M_{al}}{I_{comp}} \cdot y = n \cdot \frac{2412.10}{1.23447} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
f _{al}	MPa	1.687	1.265	1.406	-2.697	7.521	-15.895	

10.2.5 활하중에 의한 응력산정(균중하중 포함)

$$f_{ll} = n \cdot \frac{M_{ll} + M_{gj}}{I_{comp}} \cdot y = n \cdot \frac{3015.2 + 0}{1.23447} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
f _{ll}	MPa	2.109	1.582	1.758	-3.372	9.402	-19.869	

10.2.6 건조수축에 의한 손실

※ 안전측의 계산을 위해 건조수축에 의한 일체긴장 강봉(C1,C2)의 영향은 무시한다.

$$\Delta f_{sh} = 0.80 \cdot (119 - 1.05 \cdot H_r) = 0.80 \cdot (119 - 1.05 \cdot 70) = 36.4 \text{ Mpa}$$

여기서, H_r 은 주위의 연간 평균 상대습도(%)로서 70%를 적용한다.

$$\Delta P_{sh} = \Delta f_{sh} \cdot A_{gs} = -36.4 \times 0.0093 = -338.26 \text{ kN}$$

$$f_{sh} = n \cdot \frac{\Delta P_{sh}}{A_{comp}} + n \cdot \frac{\Delta P_{sh} \times e}{I_{comp}} \cdot y = n \cdot \frac{-338.3}{1.5814} + n \cdot \frac{422.8}{1.2345} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
fsh	MPa	0.103	0.029	0.033	-0.687	-0.067	4.171	

10.2.7 크리프에 의한 손실

$$\Delta f_{cr} = 12 \cdot f_{cir} - 7 \cdot f_{cd} = 12 \times 17.82 - 7 \times 8.31 = 155.654 \text{ Mpa}$$

$$f_{cir} = (f_{cgb} + f_{cgs}) + f_{csw} = f_{cps} + f_{csw} = 27 + -9.23 = 17.82 \text{ Mpa}$$

$$f_{cds} = f_{cbl} + f_{cal} = -5.87 + -2.44 = -8.31 \text{ Mpa}$$

$$f_{cps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot -0.782 = 27.048 \text{ MPa}$$

$$f_{csw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot -0.782 = -9.227 \text{ MPa}$$

$$f_{cbl} = \frac{M_{bl}}{I_{conv}} \cdot y = \frac{4385}{0.56106} \cdot -0.751 = -5.872 \text{ MPa}$$

$$f_{cal} = \frac{M_{al}}{I_{comp}} \cdot y = \frac{2412}{1.23447} \cdot -1.250 = -2.442 \text{ MPa}$$

여기서, f_{cir} 은 정착직후 프리스트레스와 자중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

f_{cds} 는 긴장 이후의 모든 고정하중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

$$\Delta P_{cr} = \Delta f_{cr} \cdot A_{gs} = -155.654 \times 0.0093 = -1446.476 \text{ kN}$$

$$f_{cr} = n \cdot \frac{\Delta P_{cr}}{A_{comp}} + n \cdot \frac{\Delta P_{cr} \times e}{I_{comp}} \cdot y = n \cdot \frac{-1446.476}{1.5814} + n \cdot \frac{1807.785}{1.2345} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
fcr	MPa	0.441	0.125	0.139	-2.936	-0.285	17.834	

10.2.8 강봉의 릴렉сей션

$$\Delta f_{rgb} = (f_{ps} + f_{bl} + f_{al}) \times 3\%$$

$$= (450.10 + 55.63 + 7.52) \times 0.03 = 15.398 \text{ Mpa}$$

$$\Delta P_{rgb} = \Delta f_{rgb} \cdot A_{gb} = 15.398 \times 0.0025 = -38.709 \text{ kN}$$

$$f_{rgb} = n \cdot \frac{\Delta P_{rgb}}{A_{comp}} + n \cdot \frac{\Delta P_{rgb} \times e}{I_{comp}} \cdot y = n \cdot \frac{-38.709}{1.5814} + n \cdot \frac{-23.274}{1.2345} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
f _{rgb}	MPa	-0.038	-0.034	-0.038	0.002	-0.231	-0.005	

10.2.9 강선의 릴렉сей션

$$\Delta f_{rgs} = 35 - 0.07 \cdot \Delta f_{pf} - 0.1 \cdot \Delta f_{pe} - 0.05 \cdot (\Delta f_{sh} + \Delta f_{cr})$$

	A _{gs}	Δ f _{pf}	Δ f _{pe}	Δ f _{sh}	Δ f _{cr}	Δ f _{rgs}
T1	0.000971	251.878	0.000	36.400	155.654	7.766
T2	0.002081	197.099	15.843	36.400	155.654	10.016
T3	0.002081	183.995	-112.124	36.400	155.654	23.730
T4	0.002081	170.736	-69.325	36.400	155.654	20.378
T5	0.002081	157.364	-26.084	36.400	155.654	16.990
Σ	0.009293	961.072	-191.689	182.000	778.269	78.880
avg	0.001859	192.214	-38.338	36.400	155.654	15.776

$$\Delta P_{rgs} = \Delta f_{rgs} \cdot A_{gs} = 15.776 \times 0.0093 = -146.61 \text{ kN}$$

$$f_{rgs} = n \cdot \frac{\Delta P_{rgs}}{A_{comp}} + n \cdot \frac{\Delta P_{rgs} \times e}{I_{comp}} \cdot y = n \cdot \frac{-146.61}{1.5814} + n \cdot \frac{183.23}{1.2345} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.960	0.720	0.720	-1.380	0.595	-1.256	
f _{rgs}	MPa	0.045	0.013	0.014	-0.298	-0.029	1.808	

10.2.10 2차응력검토

(1) 크리프에 의한 단면력 계산

$$\begin{aligned}
 m &= E_{c1} \times I_{c1} / (E_{c2} \times I_{c2}) \\
 &= 30891.0501 \times 0.56106124 / 27804.0636 \times 0.00262103 = 237.828 \\
 B &= 1 + m = 1 + 237.828 = 238.828 \\
 C &= Y_1' - m \times Y_2 = 1.22461835 - 237.828 \times 0.12 = -27.315 \text{ m} \\
 F &= Y_1'^2 + \gamma_{c1}^2 + m \times \gamma_{c2}^2 + m \times Y_2^2 \\
 &= 1.500 + 0.568 + 237.828 \times 0.005 + 237.828 \times 0.014 \\
 &= 6.634 \\
 P &= (1383.68 + 1150.71668) / 2 \times 138.7 \times 67 = 11775947 \text{ N} \\
 K &= \phi_{\infty} / (1 + \phi_{\infty}) = 0.792 \\
 K' &= \phi_t / (1 + \phi_{\infty}) = 0.500 \\
 \text{여기서, } \phi_{\infty} &= 3.800 \text{ (콘크리트 초기재령 ~ } T=\infty \text{까지의 크리프 계수)} \\
 \phi_t &= 2.400 \text{ (바닥판 합성후 ~ } T=\infty \text{까지의 크리프 계수)}
 \end{aligned}$$

$$\begin{aligned}
 N_{\phi} &= - K' / (C^2 - BF) \\
 &\times [P \{ B (Y_1' \epsilon_{p3} - \gamma_{c1}^2) - C \epsilon_{p3} \} \\
 &+ M_{d1} \times (C - B Y_1')] \\
 &- K / (C^2 - BF) \times M_{d2} (C - B Y_1') \\
 &= -1729963.768 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 M_{\phi} &= - K' / (BF - C^2) \\
 &\times [P \{ C (Y_1' \epsilon_{p3} - \gamma_{c1}^2) - F \epsilon_{p3} \} \\
 &+ M_{d1} \times (F - C Y_1')] \\
 &- K / (BF - C^2) \times M_{d2} (F - C Y_1') \\
 &= -206382.944 \text{ N.m}
 \end{aligned}$$

(2) 건조수축에 의한 단면력 계산

$$\begin{aligned}
 N_s &= \epsilon_s E_{c1} I_{c1} \times (B / (BF - C^2)) \times (1 / (1 + \phi_{\infty})) \\
 &= 102864.712 \text{ N} \\
 M_s &= \epsilon_s E_{c1} I_{c1} \times (C / (C^2 - (BF))) \times (1 / (1 + \phi_{\infty})) \\
 &= 11764.629 \text{ N.m}
 \end{aligned}$$

(3) 크리프에 의한 2차 응력

$$f_{c2}' = - N_{\phi} / A_{c2} - ((M_{\phi} - N_{\phi} Y_2) Y_2' / I_{c2}) : \text{슬래브 상면응력}$$

$$= 3.113 \text{ MPa}$$

$$f_{c2} = - N_{\phi} / A_{c2} + ((M_{\phi} - N_{\phi} Y_2) Y_2 / I_{c2}) : \text{슬래브 하면응력}$$

$$= 3.224 \text{ MPa}$$

$$f_{c1}' = N_{\phi} / A_{c1} + ((M_{\phi} + N_{\phi} Y_1') Y_1' / I_{c1}) : \text{거더 상면응력}$$

$$= -6.827 \text{ MPa}$$

$$f_{c1} = N_{\phi} / A_{c1} - ((M_{\phi} + N_{\phi} Y_1') Y_1 / I_{c1}) : \text{거더 하면응력}$$

$$= 1.875 \text{ MPa}$$

(4) 건조수축에 의한 2차 응력

$$f_{s2}' = - N_s / A_{c2} - ((M_s - N_s Y_2) Y_2' / I_{c2}) : \text{슬래브 상면응력}$$

$$= -0.162 \text{ MPa}$$

$$f_{s2} = - N_s / A_{c2} + ((M_s - N_s Y_2) Y_2 / I_{c2}) : \text{슬래브 하면응력}$$

$$= -0.215 \text{ MPa}$$

$$f_{s1}' = N_s / A_{c1} + ((M_s + N_s Y_1') Y_1' / I_{c1}) : \text{거더 상면응력}$$

$$= 0.405 \text{ MPa}$$

$$f_{s1} = N_s / A_{c1} - ((M_s + N_s Y_1') Y_1 / I_{c1}) : \text{거더 하면응력}$$

$$= -0.111 \text{ MPa}$$

(5) 2차 응력 집계

	단위	바닥판		거더		PS 강재		비고
		상면	하면	상면	하면	강봉	강선	
y	m	0.12	-0.12	1.225	-0.875	1.100	-0.751	
f _{cr2}	MPa	3.113	3.224	-6.827	1.875	-6.130	1.610	
f _{sh2}	MPa	-0.162	-0.215	0.405	-0.111	0.363	-0.095	
f ₂	MPa	2.951	3.009	-6.422	1.765	-5.766	1.515	

10.3 G9거더 응력산출

▶ 하중단계별 휨모멘트 요약

		기호	Pnet (kN)	e (m)	M (kN · m)	저항단면
거더 자중		sw			5979.50	순단면(net)
PS	강봉	gb	-1132	1.070	-1210.34	
	강선	gs	11471	-0.782	-8962.71	
합성전 고정하중		bl			3865.70	PS강재 환산단면(conv)
합성후 고정하중		al			1690.00	바닥판 합성단면(comp)
최대활하중		ll			3472.50	
균중하중		gj			0	

※ Pnet : 즉시손실을 고려한 순긴장력(도입긴장력)

10.3.1 자중에 의한 응력산정

$$f_{sw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상면	하면	상면	하면	강봉	강선	
y	m			1.195	-0.905			
f _{sw}	MPa			14.101	-10.687			

10.3.2 프리스트레스 도입량 산정

▷ 거더에 축력을 작용시키는 강선의 순긴장력(P_n) = P_{C1} + P_{C2} + P_{T1} + P_{T2} + P_{T3} + P_{T4} + P_{T5} = 10340 kN

▷ PS강재의 응력산정식(강재기준으로 보면 Pnet와 반대방향으로 하중이 작용하므로)

$$f_{gb} = \frac{P_{net}}{A_{gb}} = \frac{1132}{0.002514} = 450.098 \text{ MPa}$$

$$f_{gs} = \frac{P_{net}}{A_{gs}} = \frac{-11471}{0.0092929} = -1234.401 \text{ MPa}$$

▷ 거더의 응력산정식

$$f_{ps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot y$$

	단위	바닥판		거더		PS 강재		비고
		상면	하면	상면	하면	강봉	강선	
y	m			1.195	-0.905	1.070	-0.782	
f _{ps}	MPa			-12.640	29.532	450.098	-1234.401	

10.3.3 합성전 고정하중에 의한 응력산정

$$f_{bl} = n \cdot \frac{M_{bl}}{I_{conv}} \cdot y = n \cdot \frac{3865.70}{0.56106} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n				1.000		6.474	6.474	
y	m			1.225	-0.875	1.100	-0.751	
f _{bl}	MPa			8.438	-6.031	49.049	-33.518	

10.3.4 합성후 고정하중에 의한 응력산정

$$f_{al} = n \cdot \frac{M_{al}}{I_{comp}} \cdot y = n \cdot \frac{1690.00}{1.19938} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
f _{al}	MPa	1.250	0.946	1.051	-1.908	5.663	-11.223	

10.3.5 활하중에 의한 응력산정(균중하중 포함)

$$f_{ll} = n \cdot \frac{M_{ll} + M_{gj}}{I_{comp}} \cdot y = n \cdot \frac{3472.5 + 0}{1.19938} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
f _{ll}	MPa	2.569	1.943	2.159	-3.921	11.636	-23.059	

10.3.6 건조수축에 의한 손실

※ 안전측의 계산을 위해 건조수축에 의한 일체긴장 강봉(C1,C2)의 영향은 무시한다.

$$\Delta f_{sh} = 0.80 \cdot (119 - 1.05 \cdot H_r) = 0.80 \cdot (119 - 1.05 \cdot 70) = 36.4 \text{ Mpa}$$

여기서, H_r 은 주위의 연간 평균 상대습도(%)로서 70%를 적용한다.

$$\Delta P_{sh} = \Delta f_{sh} \cdot A_{gs} = -36.4 \times 0.0093 = -338.26 \text{ kN}$$

$$f_{sh} = n \cdot \frac{\Delta P_{sh}}{A_{comp}} + n \cdot \frac{\Delta P_{sh} \times e}{I_{comp}} \cdot y = n \cdot \frac{-338.3}{1.5334} + n \cdot \frac{422.8}{1.1994} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
fsh	MPa	0.114	0.038	0.042	-0.698	-0.011	4.235	

10.3.7 크리프에 의한 손실

$$\Delta f_{cr} = 12 \cdot f_{cir} - 7 \cdot f_{cds} = 12 \times 17.82 - 7 \times 6.94 = 165.286 \text{ Mpa}$$

$$f_{cir} = (f_{cgb} + f_{cgs}) + f_{csw} = f_{cps} + f_{csw} = 27.05 + -9.23 = 17.82 \text{ Mpa}$$

$$f_{cds} = f_{cbl} + f_{cal} = -5.18 + -1.76 = -6.94 \text{ Mpa}$$

$$f_{cps} = \frac{P_n}{A_{net}} + \frac{M_{gb} + M_{gs}}{I_{net}} \cdot y = \frac{10340}{0.911} + \frac{-10173}{0.50658} \cdot -0.782 = 27.048 \text{ MPa}$$

$$f_{csw} = \frac{M_{sw}}{I_{net}} \cdot y = \frac{5980}{0.50658} \cdot -0.782 = -9.227 \text{ MPa}$$

$$f_{cbl} = \frac{M_{bl}}{I_{conv}} \cdot y = \frac{3866}{0.56106} \cdot -0.751 = -5.177 \text{ MPa}$$

$$f_{cal} = \frac{M_{al}}{I_{comp}} \cdot y = \frac{1690}{1.19938} \cdot -1.250 = -1.761 \text{ MPa}$$

여기서, f_{cir} 은 정착직후 프리스트레스와 자중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

f_{cds} 는 긴장 이후의 모든 고정하중에 의해 발생하는 PS강선 중심에서의 콘크리트 응력

$$\Delta P_{cr} = \Delta f_{cr} \cdot A_{gs} = -165.286 \times 0.0093 = -1535.983 \text{ kN}$$

$$f_{cr} = n \cdot \frac{\Delta P_{cr}}{A_{comp}} + n \cdot \frac{\Delta P_{cr} \times e}{I_{comp}} \cdot y = n \cdot \frac{-1535.983}{1.5334} + n \cdot \frac{1919.650}{1.1994} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
fcr	MPa	0.519	0.173	0.192	-3.169	-0.052	19.232	

10.3.8 강봉의 릴렉сей션

$$\Delta f_{rgb} = (f_{ps} + f_{bl} + f_{al}) \times 3\%$$

$$= (450.10 + 49.05 + 5.66) \times 0.03 = 15.144 \text{ Mpa}$$

$$\Delta P_{rgb} = \Delta f_{rgb} \cdot A_{gb} = 15.144 \times 0.0025 = -38.073 \text{ kN}$$

$$f_{rgb} = n \cdot \frac{\Delta P_{rgb}}{A_{comp}} + n \cdot \frac{\Delta P_{rgb} \times e}{I_{comp}} \cdot y = n \cdot \frac{-38.073}{1.5334} + n \cdot \frac{-22.892}{1.1994} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
f _{rgb}	MPa	-0.039	-0.035	-0.039	0.001	-0.237	-0.009	

10.3.9 강선의 릴렉сей션

$$\Delta f_{rgs} = 35 - 0.07 \cdot \Delta f_{pf} - 0.1 \cdot \Delta f_{pe} - 0.05 \cdot (\Delta f_{sh} + \Delta f_{cr})$$

	A _{gs}	Δ f _{pf}	Δ f _{pe}	Δ f _{sh}	Δ f _{cr}	Δ f _{rgs}
T1	0.000971	251.878	0.000	36.400	165.286	7.284
T2	0.002081	197.099	15.843	36.400	165.286	9.534
T3	0.002081	183.995	-112.124	36.400	165.286	23.248
T4	0.002081	170.736	-69.325	36.400	165.286	19.897
T5	0.002081	157.364	-26.084	36.400	165.286	16.509
Σ	0.009293	961.072	-191.689	182.000	826.428	76.472
avg	0.001859	192.214	-38.338	36.400	165.286	15.294

$$\Delta P_{rgs} = \Delta f_{rgs} \cdot A_{gs} = 15.294 \times 0.0093 = -142.13 \text{ kN}$$

$$f_{rgs} = n \cdot \frac{\Delta P_{rgs}}{A_{comp}} + n \cdot \frac{\Delta P_{rgs} \times e}{I_{comp}} \cdot y = n \cdot \frac{-142.13}{1.5334} + n \cdot \frac{177.63}{1.1994} \cdot y$$

y : 중립축에서의 거리, n : 탄성계수비

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
n		0.9		1.000		6.474	6.474	
y	m	0.986	0.746	0.746	-1.354	0.621	-1.230	
f _{rgs}	MPa	0.048	0.016	0.018	-0.293	-0.005	1.780	

10.3.10 2차응력검토

(1) 크리프에 의한 단면력 계산

$$\begin{aligned}
 m &= E_{c1} \times I_{c1} / (E_{c2} \times I_{c2}) \\
 &= 30891.0501 \times 0.56106124 / 27804.0636 \times 0.00262103 = 237.828 \\
 B &= 1 + m = 1 + 237.828 = 238.828 \\
 C &= Y_1' - m \times Y_2 = 1.22461835 - 237.828 \times 0.12 = -27.315 \text{ m} \\
 F &= Y_1'^2 + \gamma_{c1}^2 + m \times \gamma_{c2}^2 + m \times Y_2^2 \\
 &= 1.500 + 0.568 + 237.828 \times 0.005 + 237.828 \times 0.014 \\
 &= 6.634 \\
 P &= (1383.68 + 1140.45993) / 2 \times 138.7 \times 67 = 11728290 \text{ N} \\
 K &= \phi_{\infty} / (1 + \phi_{\infty}) = 0.792 \\
 K' &= \phi_t / (1 + \phi_{\infty}) = 0.500 \\
 \text{여기서, } \phi_{\infty} &= 3.800 \text{ (콘크리트 초기재령 ~ } T=\infty \text{까지의 크리프 계수)} \\
 \phi_t &= 2.400 \text{ (바닥판 합성후 ~ } T=\infty \text{까지의 크리프 계수)}
 \end{aligned}$$

$$\begin{aligned}
 N_{\phi} &= - K' / (C^2 - BF) \\
 &\times [P \{ B (Y_1' \epsilon_{p3} - \gamma_{c1}^2) - C \epsilon_{p3} \} \\
 &+ M_{d1} \times (C - B Y_1')] \\
 &- K / (C^2 - BF) \times M_{d2} (C - B Y_1') \\
 &= -1576237.101 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 M_{\phi} &= - K' / (BF - C^2) \\
 &\times [P \{ C (Y_1' \epsilon_{p3} - \gamma_{c1}^2) - F \epsilon_{p3} \} \\
 &+ M_{d1} \times (F - C Y_1')] \\
 &- K / (BF - C^2) \times M_{d2} (F - C Y_1') \\
 &= -187156.159 \text{ N.m}
 \end{aligned}$$

(2) 건조수축에 의한 단면력 계산

$$\begin{aligned}
 N_s &= \epsilon_s E_{c1} I_{c1} \times (B / (BF - C^2)) \times (1 / (1 + \phi_{\infty})) \\
 &= 102864.712 \text{ N} \\
 M_s &= \epsilon_s E_{c1} I_{c1} \times (C / (C^2 - (BF))) \times (1 / (1 + \phi_{\infty})) \\
 &= 11764.629 \text{ N.m}
 \end{aligned}$$

(3) 크리프에 의한 2차 응력

$$f_{c2}' = - N_{\phi} / A_{c2} - ((M_{\phi} - N_{\phi} Y_2) Y_2' / I_{c2}) : \text{슬래브 상연응력}$$

$$= 2.795 \text{ MPa}$$

$$f_{c2} = - N_{\phi} / A_{c2} + ((M_{\phi} - N_{\phi} Y_2) Y_2 / I_{c2}) : \text{슬래브 하연응력}$$

$$= 2.978 \text{ MPa}$$

$$f_{c1}' = N_{\phi} / A_{c1} + ((M_{\phi} + N_{\phi} Y_1') Y_1' / I_{c1}) : \text{거더 상연응력}$$

$$= -6.218 \text{ MPa}$$

$$f_{c1} = N_{\phi} / A_{c1} - ((M_{\phi} + N_{\phi} Y_1') Y_1 / I_{c1}) : \text{거더 하연응력}$$

$$= 1.707 \text{ MPa}$$

(4) 건조수축에 의한 2차 응력

$$f_{s2}' = - N_s / A_{c2} - ((M_s - N_s Y_2) Y_2' / I_{c2}) : \text{슬래브 상연응력}$$

$$= -0.162 \text{ MPa}$$

$$f_{s2} = - N_s / A_{c2} + ((M_s - N_s Y_2) Y_2 / I_{c2}) : \text{슬래브 하연응력}$$

$$= -0.215 \text{ MPa}$$

$$f_{s1}' = N_s / A_{c1} + ((M_s + N_s Y_1') Y_1' / I_{c1}) : \text{거더 상연응력}$$

$$= 0.405 \text{ MPa}$$

$$f_{s1} = N_s / A_{c1} - ((M_s + N_s Y_1') Y_1 / I_{c1}) : \text{거더 하연응력}$$

$$= -0.111 \text{ MPa}$$

(5) 2차 응력 집계

	단위	바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
y	m	0.12	-0.12	1.225	-0.875	1.100	-0.751	
f _{cr2}	MPa	2.795	2.978	-6.218	1.707	-5.583	1.466	
f _{sh2}	MPa	-0.162	-0.215	0.405	-0.111	0.363	-0.095	
f ₂	MPa	2.634	2.763	-5.813	1.597	-5.220	1.371	

11.1 G1거더 응력산출

▷ 유효율 : 0.831

(+):압축, (-):인장

구 분		C1	C2	T1	T2	T3	T4	T5
강선수	(EA)			7	15	15	15	15
P _{CT}	(kN)	-565.773	-565.773	1105.451	2682.897	2443.926	2560.553	± 2678.337
A _p	(m ²)	0.00126	0.00126	0.00097	0.00208	0.00208	0.00208	± 0.0021
f _{ps}	(MPa)	-450.098	-450.098	1138.584	1289.544	1174.682	1230.739	± 1287.353
응 력 검 토		± 777.00	± 777.00	± 1312.00	± 1312.00	± 1312.00	± 1312.00	± 1312.000
		0.K	0.K	0.K	0.K	0.K	0.K	0.K

11.2 G2~G8거더 응력산출

1) G2~G8거더 중앙부 응력검토

▷ 유효율 : 0.832

하중 단계		바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
1	fsw			14.101	-10.687	0.000	0.000	
2	fps			-12.640	29.532	450.098	-1234.401	
계				1.461	18.845	450.098	-1234.401	
응력 검토				-1.410	19.200	± 777.00	± 1312.00	
				0.K	0.K	0.K	0.K	
3	fbl	0.000	0.000	9.570	-6.841	55.633	-38.017	
4	fal	1.687	1.265	1.406	-2.697	7.521	-15.895	
5	fll	2.109	1.582	1.758	-3.372	9.402	-19.869	
6	fsh	0.103	0.029	0.033	-0.687	-0.067	4.171	
7	fcr	0.441	0.125	0.139	-2.936	-0.285	17.834	
8	frgb	-0.038	-0.034	-0.038	0.002	-0.231	-0.005	
9	frgs	0.045	0.013	0.014	-0.298	-0.029	1.808	
10	f2	2.951	3.009	-6.422	1.765	-5.766	1.515	
계		7.299	5.989	7.920	3.781	516.276	-1282.859	
응력 검토		10.800	-2.598	18.000	-3.162	± 777.00	± 1312.00	
		0.K	0.K	0.K	0.K	0.K	0.K	

(+):압축, (-):인장

2) 내측거더 강선 응력검토(사용하중 상태)

구 분		C1	C2	T1	T2	T3	T4	T5
강선수	(EA)			7	15	15	15	15
P _{CT}	(kN)	-565.773	-565.773	1105.451	2682.897	2443.926	2560.553	2678.337
A _P	(m ²)	0.00126	0.00126	0.00097	0.00208	0.00208	0.00208	0.00208
f _{ps}	(MPa)	-450.098	-450.098	1138.584	1289.544	1174.682	1230.739	1287.353
응 력 검 토		± 777.00	± 777.00	± 1312.00	± 1312.00	± 1312.00	± 1312.00	± 1312.00
		0.K	0.K	0.K	0.K	0.K	0.K	0.K

11.3 G9거더 응력산출

1) G9거더 중앙부 응력검토

▷ 유효율 : 0.824

하중 단계		바닥판		거더		PS 강재		비고
		상연	하연	상연	하연	강봉	강선	
1	fsw			14.101	-10.687	0.000	0.000	
2	fps			-12.640	29.532	450.098	-1234.401	
계				1.461	18.845	450.098	-1234.401	
응력 검토				-1.410	19.200	± 777.00	± 1312.00	
				0.K	0.K	0.K	0.K	
3	fbl	0.000	0.000	8.438	-6.031	49.049	-33.518	
4	fal	1.250	0.946	1.051	-1.908	5.663	-11.223	
5	fll	2.569	1.943	2.159	-3.921	11.636	-23.059	
6	fsh	0.114	0.038	0.042	-0.698	-0.011	4.235	
7	fcr	0.519	0.173	0.192	-3.169	-0.052	19.232	
8	frgb	-0.039	-0.035	-0.039	0.001	-0.237	-0.009	
9	frgs	0.048	0.016	0.018	-0.293	-0.005	1.780	
10	f2	2.634	2.763	-5.813	1.597	-5.220	1.371	
계		7.094	5.844	7.508	4.422	510.921	-1275.592	
응력 검토		10.800	-2.598	18.000	-3.162	± 777.00	± 1312.00	
		0.K	0.K	0.K	0.K	0.K	0.K	

(+):압축, (-):인장

2) 내측거더 강선 응력검토(사용하중 상태)

구 분		C1	C2	T1	T2	T3	T4	T5
강선수	(EA)			7	15	15	15	15
P _{CT}	(kN)	-565.773	-565.773	1105.451	2682.897	2443.926	2560.553	2678.337
A _p	(m ²)	0.00126	0.00126	0.00097	0.00208	0.00208	0.00208	0.00208
fps	(MPa)	-450.098	-450.098	1138.584	1289.544	1174.682	1230.739	1287.353
응 력 검 토		± 777.00	± 777.00	± 1312.00	± 1312.00	± 1312.00	± 1312.00	± 1312.00
		0.K	0.K	0.K	0.K	0.K	0.K	0.K

12. 처짐 검토

12.1 하중 단계별 처짐

▷ 최대처짐(δ) = 하중에 의한 처짐 + 프리스트레스에 의한 처짐

$$\delta = \frac{5 \times M \times L^2}{48 \times E \times I}$$

여기서, M : 경간 중앙부 최대 휨 모멘트(= P X e)
 L : 지간
 E : 거더의 탄성계수
 I : 단면 2차 모멘트(거더중앙부)
 P : 프리스트레스 힘 (도입 또는 유효 프리스트레스 kgf)
 e : (지점부에서의 편심거리, +하향)

(1) G1 거더 처짐

하 중	휨모멘트 M	탄성계수 E	단면2차모멘트 I	처 짐 δ
	(kN · m)	(MPa)	(m ⁴)	(mm)
거더 자중	5979.50	30891	0.5066	77.06
합성전 고정하중	4103.80	30891	0.5611	47.75
합성후 고정하중	1658.70	30891	1.2255	9.24
프리스트레스 도입직후	-10173.06	30891	0.5066	-131.10
프리스트레스 손실	1655.90	30891	1.2255	8.82
활하중	3488.40	30891	1.2255	18.58

(2) G2~G8 거더 처짐

하 중	휨모멘트 M	탄성계수 E	단면2차모멘트 I	처 짐 δ
	(kN · m)	(MPa)	(m ⁴)	(mm)
거더 자중	5979.50	30891	0.5066	77.06
합성전 고정하중	4384.60	30891	0.5611	51.02
합성후 고정하중	2412.10	30891	1.2345	13.34
프리스트레스 도입직후	-10173.06	30891	0.5066	-131.10
프리스트레스 손실	1655.90	30891	1.2255	8.82
활하중	3015.20	30891	1.2255	16.06

12.2 크리프에 의한 처짐

(1) 바닥판 타설전 Bicon 거더 크리프 계수 (Φ_b , $t' = 30$ 일, $t = 90$ 일, $RH = 70\%$)

$$\Phi_b(t-t') = \Phi_0 \times \beta_c(t-t')$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$\Phi_{RH} = 1 + (1 - 0.01 \times RH) / 0.1 \times \sqrt[3]{h} = 1.465$$

$$\text{여기서, } h = 2 \times A_c \times E_A / u \times E_A$$

$$= (2 \times \text{거더단면적}(\text{mm}^2) \times \text{거더갯수}) / (\text{거더단면둘레}(\text{mm}) \times \text{거더갯수})$$

$$= 267.868 \text{ mm}$$

$$\beta(f_{cu}) = 16.8 / \sqrt{f_{cu}} = 2.425$$

$$\text{여기서, } f_{cu} = f_{ck} + 8 = 48$$

$$\beta(t') = 1 / \{ 0.1 + (t')^{0.2} \} = 1 / \{ 0.1 + (30)^{0.2} \} = 0.48$$

$$\beta_c(t-t') = [(t-t') / \{ \beta_u + (t-t') \}]^{0.3} = 0.47$$

$$\text{여기서, } \beta_H = 1.5 [1 + (0.012 RH)^{18}] h + 25(= 669 \text{ 일} < 1500 \text{ 일}$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$= 1.465 \times 2.425 \times 0.482 = 1.712$$

$$\therefore \Phi_b(t, t') = \Phi_0 \times \beta_c(t-t')$$

$$= 1.712 \times 0.47 = 0.805$$

(2) 바닥판 타설후 Bicon 거더 크리프 계수 (Φ_b , $t' = 90$ 일, $t = 10000$ 일, $RH = 70\%$)

$$\Phi_t(t-t') = \Phi_0 \times \beta_c(t-t')$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$\Phi_{RH} = 1 + (1 - 0.01 \times RH) / 0.1 \times \sqrt[3]{h} = 1.217$$

$$\text{여기서, } h = 2 \times A_c \times E_A / u \times E_A$$

$$= (2 \times \text{거더단면적}(\text{m}^2) \times \text{거더갯수}) / (\text{거더단면둘레}(\text{m}) \times \text{거더갯수})$$

$$= 267.868$$

$$\beta(f_{cu}) = 16.8 / \sqrt{f_{cu}} = 2.425$$

$$\text{여기서, } f_{cu} = f_{ck} + 8 = 48$$

$$\beta(t') = 1 / \{ 0.1 + (t')^{0.2} \} = 1 / \{ 0.1 + (90)^{0.2} \} = 0.39$$

$$\beta_c(t-t') = [(t-t') / \{ \beta_u + (t-t') \}]^{0.3} = 0.98$$

$$\text{여기서, } \beta_H = 1.5 [1 + (0.012 RH)^{18}] h + 25(= 669 \text{ 일} < 1500 \text{ 일}$$

$$\Phi_0 = \Phi_{RH} \times \beta(f_{cu}) \times \beta(t')$$

$$= 1.217 \times 2.425 \times 0.391 = 1.154$$

$$\therefore \Phi_t(t, t') = \Phi_0 \times \beta_c(t-t')$$

$$= 1.154 \times 0.98 = 1.131$$

(3) G1 거더

1) 바닥판 타설전에 생기는 처짐

$$\begin{aligned}\delta_{\phi 1} &= \Phi_b \times (\delta_{do} + \delta_{ps}) \quad (\Phi_b = 0.805) \\ &= 0.805 \times (77.06 + -131.10) = -43.50 \text{ mm}\end{aligned}$$

2) 바닥판 타설후에 생기는 처짐

$$\begin{aligned}\delta_{\phi 2} &= \Phi_t \times (\delta_{do} + \delta_{d1} + \delta_{d2} + \delta_{pe}) \quad (\Phi_t = 1.131) \\ &= 1.131 \times (77.06 + 47.75 + 9.24 + -122.28) \\ &= 13.31 \text{ mm}\end{aligned}$$

(4) G2~G8 거더

1) 바닥판 타설전에 생기는 처짐

$$\begin{aligned}\delta_{\phi 1} &= \Phi_b \times (\delta_{do} + \delta_{ps}) \quad (\Phi_b = 0.805) \\ &= 0.805 \times (77.06 + -131.10) = -43.50 \text{ mm}\end{aligned}$$

2) 바닥판 타설후에 생기는 처짐

$$\begin{aligned}\delta_{\phi 2} &= \Phi_t \times (\delta_{do} + \delta_{d1} + \delta_{d2} + \delta_{pe}) \quad (\Phi_t = 1.131) \\ &= 1.131 \times (77.06 + 51.02 + 13.34 + -122.28) \\ &= 21.65 \text{ mm}\end{aligned}$$

12.3 처짐의 합계

(단위:mm)

구 분	G1 거더	G2~G8 거더	비 고
프리스트레스 도입직후	-54.04	-54.04	$\delta_{do} + \delta_{ps}$
바닥판 타설 전	-97.55	-97.55	
바닥판 타설 후	-49.80	-46.53	$\delta_{do} + \delta_{ps} + \delta_{d1} + \delta_{\phi 1}$
고정하중 작용시	-18.42	-2.72	$\delta_{do} + \delta_{d1} + \delta_{d2} + \delta_{pe} + \delta_{\phi 1} + \delta_{\phi 2}$
활하중에 의한 처짐량	18.58	16.06	

12.4 활하중에 의한 처짐 검토

$$\triangleright \text{허용처짐}(\delta_a) = L / 800 = 44 / 800 = 55 \text{ mm}$$

(1) G1 거더

$$\delta_v = 18.58 < \delta_a = 55.00 \text{ ----- } 0.K$$

(2) G2~G8 거더

$$\delta_v = 16.06 < \delta_a = 55.00 \text{ ----- } 0.K$$

13. 휨강도의 검토

13.1 거더

1) 극한모멘트 (Factored Moment)

$$M_u = 1.3 MD + 2.15 ML = 24091050.0 \text{ N} \cdot \text{m}$$

2) 단면 제원

$$\begin{aligned} b &= 2750.0 \text{ mm} && (\text{압축 플랜지의 폭}) \\ d_p &= 2216.0 \text{ mm} \\ A_{p1} &= 0.0092929 \text{ m}^2 = 9292.9 \text{ mm}^2 && (\text{강연선 총면적}) \\ A_{p2} &= 0.002514 \text{ m}^2 = 2514 \text{ mm}^2 && (\text{강봉 총면적}) \\ F_{ck} &= 27 \text{ MPa} && (\text{슬래브 콘크리트 강도}) \\ F_{ck} &= 40 \text{ MPa} && (\text{빔 콘크리트 강도}) \\ F_{put} &= 1900 \text{ MPa} && (\text{극한인장강도}) \\ F_{pyt} &= 1600 \text{ MPa} && (\text{항복강도}) \\ F_{puc} &= 1050 \text{ MPa} && (\text{극한인장강도}) \\ F_{pyc} &= 950 \text{ MPa} && (\text{항복강도}) \end{aligned}$$

3) 계수 산정

$$\begin{aligned} r_{p1} &= 0.28 && (0.40\text{-응력제거강재}, 0.28\text{-저릴랙세이션강재}, 0.55\text{-강봉}) \\ \beta_1 &= 0.85 - [0.007 \times (F_{ck} - 28)] = 0.857 \\ \rho_{p1} &= A_p / (b \times d_p) = 0.001525 \end{aligned}$$

4) PS강재의 응력계산(F_{ps}) (도로교설계기준, 2010, p.4-127)

* 철근을 배치하지 않았거나, 배치했더라도 그 영향을 무시할 수 있는 경우

$$F_{ps} = F_{put} \times [1 - (r_{p1} / \beta_1) \times \rho_{p1} \times (F_{put} / F_{ck})] = 1833.4 \text{ MPa}$$

5) 해석단면 결정

$$\begin{aligned} a &= (A_p \times F_{ps}) / (0.85 \times F_{ck} \times b) = 270.0 \text{ mm} \\ \text{슬래브 두께 : } 240.0 \text{ mm} &< 270.0 \text{ mm} && \text{----- 플랜지단면} \end{aligned}$$

6) 최대 PS 강재량 검토

$$\begin{aligned} \text{강재지수}(q_p) &= \rho_p \times F_{ps} / F_{ck} = 0.104 \\ q_p (=0.104) &< 0.36 \times \beta_1 (=0.309) && \text{----- 0.K} \end{aligned}$$

7) 극한 저항 모멘트 검토

$$\begin{aligned} \Phi \cdot M_n &= \Phi [A_{pw} \times F_{ps} \times d_p \times (1 - 0.59 \times A_{pw} \times F_{ps} / (b_o \times d_p \times F_{ck})) \\ &\quad + 0.85 \times F_{ck} (b - b_o) \times t \times (d_p - 0.5 t)] = 45238.58 \text{ kN} \cdot \text{m} \\ \Phi \cdot M_n (=45238.582) &> M_u (=24091.05) && \text{----- 0.K} \end{aligned}$$

8) 균열 모멘트 검토

$$\begin{aligned} 1.2 \cdot M_{cr} &= Z_{bo} \times (0.5 \times \sqrt{F_{ck} + f_{be}} - f_d) = -25400.945 \text{ kN} \cdot \text{m} \\ f_{pe} &= 24.546 \text{ MPa} \\ f_d &= M_{d1} / Z_{bo} = -10.687 \text{ MPa} \\ Z_{bo} &= I_{co} / Y_{bo} = -0.560 \text{ m}^3 \\ 1.2 \cdot M_{cr} &(-25400.945) < \Phi \cdot M_n (=45238.582) && \text{----- 0.K} \end{aligned}$$

14. 전단 검토

14.1 수직 전단 검토 (단부)

14.1.1 G9 거더

▷ 전단력이 가장 크게 발생하는 지점부에서 검토

외측거더 지점부 단면력

구 분	V(kN)	M(kN · m)
자 중	583.15	4.53
합성전	364.28	1.64
합성후	309.04	17.48
활하중	393.75	19.50

(1) 극한전단력

$$V_u = 1.3 D + 2.15 (L + I) + 1.3CF + 1.7H + 1.3Q = 2480.0 \text{ kN}$$

(2) 콘크리트가 부담하는 전단강도 V_c (도로교설계기준, 2010, p.4-76)

- V_c 는 V_{ci} 또는 V_{cw} 중에서 작은 값으로 한다.

1) 전단강도 V_{ci} (휨 전단강도)

$$V_{ci} = 0.05 \times \sqrt{F_{ck}} \times b_w \times d + V_d + (V_i \times M_{cr}) / M_{max}$$

$$M_{cr} = Z_{bo} \times (0.5 \times \sqrt{F_{ck}} + f_{pe} - f_d) = 9524.1 \text{ kN} \cdot \text{m}$$

$$f_{pe} = 24.546 \text{ MPa}$$

$$f_d = M_{d1} / Z_{bo} = 10.687 \text{ MPa}$$

$$Z_{bo} = I_{co} / Y_{bo} = 0.560 \text{ m}^3$$

$$M_{max} = 1.3 \times (M_{d2} + M_{d3}) + 2.15 \times M_I = 66.78 \text{ kN} \cdot \text{m}$$

$$d = 2100 - (1975 + 1,600 + 1,150 + 700) / 4 = 743.75 \text{ mm}$$

- d 를 $0.8H$ 보다 작게 취해서는 안된다.

$$743.75 \text{ mm} < 0.8 \times H = 1680 \text{ mm} \quad \therefore d = 1680.00 \text{ mm}$$

$$V_d = 583.15 \text{ kN}$$

$$V_i = 1.3 \times (V_{d2} + V_{d3}) + 2.15 \times V_I = 1721.88 \text{ kN}$$

- V_{ci} 는 $0.14 \sqrt{F_{ck}} \times b_w \times d$ 보다 작아서는 안된다.

$$V_{ci} = 246578.29 \text{ kN} > 0.14 \sqrt{f_{ck}} \times b_w \times d = 1190.03 \text{ kN}$$

$$\therefore V_{ci} = 246578.29 \text{ kN}$$

2) 전단강도 V_{cw} (복부 전단강도)

$$V_{cw} = (0.29 \times \sqrt{f_{ck}} + 0.3 \times f_{pc}) \times b_w \times d + V = 9010538 \text{ N} = 9010.54 \text{ kN}$$

$$f_{pc} = P_{e1} / A_c = 9924372 / 910953 = 10.894 \text{ MPa}$$

$$V_p = P_{e2} \times \sin \Theta \text{ (} V_p \text{ : 수직분력)} = 8792827 \times 0.2448 = 2152819.48 \text{ N}$$

$$\therefore V_c = \min [V_{ci}, V_{cw}] = 9010.5 \text{ kN}$$

3) $\phi V_c = 0.80 \times 9010.5 = 7208.4 \text{ kN}$

$$1/2 \phi V_c = 3,604.215 \text{ kN}$$

$$\therefore V_u < 1/2 \phi V_c, \text{ 전단 철근 불필요}$$

4) 최소 전단철근 검토

전단 철근 간격 $s = 200 \text{ mm}$ (0.75H (=1575mm) 또는 600mm보다 커서는 안된다.)

$$A_{vmin} = 0.0625 \times \sqrt{f_{ck}} \times b_w \times s / f_y = 210.819 \text{ mm}^2$$

$$A_{vmin} = 210.819 \text{ mm}^2 > 0.35 \times b_w \times s / f_y = 186.667 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

$$A_{vll} = \text{Max}(A_v, A_{vmin}) = 210.819 \text{ mm}^2$$

$$A_{vuse} = \mathbf{D16} \times 2 \text{ EA} = 397.2 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

14.2 수직 전단 검토 (0.85m ~ 4.85m)

14.2.1 G9 거더

▷ 검토 구간에서 전단력이 가장 크게 발생하는 지점에 대하여 전단 검토 시행

외측거더 지점부 단면력

구 분	V(kN)	M(kN · m)
자 중	558.56	309.44
합성전	355.40	196.28
합성후	299.74	149.94
활하중	376.53	200.94

(1) 극한전단력

$$V_u = 1.3 D + 2.15 (L + I) + 1.3CF + 1.7H + 1.3Q = 2387.3 \text{ kN}$$

(2) 콘크리트가 부담하는 전단강도 V_c (도로교설계기준, 2010, p.4-76)

- V_c 는 V_{ci} 또는 V_{cw} 중에서 작은 값으로 한다.

1) 전단강도 V_{ci} (휨 전단강도)

$$V_{ci} = 0.05 \times \sqrt{F_{ck}} \times b_w \times d + V_d + (V_i \times M_{cr}) / M_{max}$$

$$M_{cr} = Z_{bo} \times (0.5 \times \sqrt{F_{ck}} + f_{pe} - f_d) = 9524.1 \text{ kN} \cdot \text{m}$$

$$f_{pe} = 24.546 \text{ MPa}$$

$$f_d = M_{d1} / Z_{bo} = 10.687 \text{ MPa}$$

$$Z_{bo} = I_{co} / Y_{bo} = 0.560 \text{ m}^3$$

$$M_{max} = 1.3 \times (M_{d2} + M_{d3}) + 2.15 \times M_I = 882.11 \text{ kN} \cdot \text{m}$$

$$d = 2100 - (1975 + 1,600 + 1,150 + 700) / 4 = 743.75 \text{ mm}$$

- d 를 $0.8H$ 보다 작게 취해서는 안된다.

$$743.75 \text{ mm} < 0.8 \times H = 1680 \text{ mm} \quad \therefore d = 1680.00 \text{ mm}$$

$$V_d = 558.56 \text{ kN}$$

$$V_i = 1.3 \times (V_{d2} + V_{d3}) + 2.15 \times V_I = 1661.22 \text{ kN}$$

- V_{ci} 는 $0.14\sqrt{F_{ck}} \times b_w \times d$ 보다 작아서는 안된다.

$$V_{ci} = 18601.09 \text{ kN} > 0.14 \sqrt{f_{ck}} \times b_w \times d = 297.51 \text{ kN}$$

$$\therefore V_{ci} = 18601.09 \text{ kN}$$

2) 전단강도 V_{cw} (복부 전단강도)

$$V_{cw} = (0.29 \times \sqrt{f_{ck}} + 0.3 \times f_{pc}) \times b_w \times d + V = 3867249.21 \text{ N} = 3867.25 \text{ kN}$$

$$f_{pc} = P_{e1} / A_c = 9924372 / 910953 = 10.894 \text{ MPa}$$

$$V_p = P_{e2} \times \sin \Theta \text{ (} V_p : \text{수직분력)} = 8792827 \times 0.2448 = 2152819.48 \text{ N}$$

$$\therefore V_c = \min [V_{ci}, V_{cw}] = 3867.2 \text{ kN}$$

3) $\phi V_c = 0.80 \times 3867.2 = 3093.8 \text{ kN}$

$$1/2 \phi V_c = 1,546.900 \text{ kN}$$

$$\therefore 1/2 \phi V_c < V_u < \phi V_c, \text{ 최소 전단 철근 배근}$$

4) 최소 전단철근 검토

$$\text{전단 철근 간격 } s = 200 \text{ mm (} 0.75H \text{ (=1575mm) 또는 600mm보다 커서는 안된다.)}$$

$$A_{vmin} = 0.0625 \times \sqrt{f_{ck}} \times b_w \times s / f_y = 210.819 \text{ mm}^2$$

$$A_{vmin} = 210.819 \text{ mm}^2 > 0.35 \times b_w \times s / f_y = 186.667 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

$$A_{vll} = \text{Max}(A_v, A_{vmin}) = 210.819 \text{ mm}^2$$

$$A_{vuse} = \mathbf{D13} \times 2 \text{ EA} = 253.4 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

14.3 수직 전단 검토 (4.85m ~ 중앙부)

14.3.1 G9 거더

▷ 검토 구간에서 전단력이 가장 크게 발생하는 지점에 대하여 전단 검토 시행

외측거더 지점부 단면력

구 분	V(kN)	M(kN · m)
자 중	435.86	2006.70
합성전	299.67	1326.30
합성후	241.42	1083.40
활하중	331.83	1309.70

(1) 극한전단력

$$V_u = 1.3 D + 2.15 (L + I) + 1.3CF + 1.7H + 1.3Q = 1983.5 \text{ kN}$$

(2) 콘크리트가 부담하는 전단강도 V_c (도로교설계기준, 2010, p.4-76)

- V_c 는 V_{ci} 또는 V_{cw} 중에서 작은 값으로 한다.

1) 전단강도 V_{ci} (휨 전단강도)

$$V_{ci} = 0.05 \times \sqrt{F_{ck}} \times b_w \times d + V_d + (V_i \times M_{cr}) / M_{max}$$

$$M_{cr} = Z_{bo} \times (0.5 \times \sqrt{F_{ck}} + f_{pe} - f_d) = 9524.1 \text{ kN} \cdot \text{m}$$

$$f_{pe} = 24.546 \text{ MPa}$$

$$f_d = M_{d1} / Z_{bo} = 10.687 \text{ MPa}$$

$$Z_{bo} = I_{co} / Y_{bo} = 0.5595 \text{ m}^3$$

$$M_{max} = 1.3 \times (M_{d2} + M_{d3}) + 2.15 \times M_I = 5948.47 \text{ kN} \cdot \text{m}$$

$$d = 2100 - (1975 + 1,600 + 1,150 + 700) / 4 = 743.75 \text{ mm}$$

- d 를 $0.8H$ 보다 작게 취해서는 안된다.

$$743.75 \text{ mm} < 0.8 \times H = 1680 \text{ mm} \quad \therefore d = 1680.00 \text{ mm}$$

$$V_d = 435.86 \text{ kN}$$

$$V_i = 1.3 \times (V_{d2} + V_{d3}) + 2.15 \times V_I = 1416.85 \text{ kN}$$

- V_{ci} 는 $0.14\sqrt{F_{ck}} \times b_w \times d$ 보다 작아서는 안된다.

$$V_{ci} = 2810.65 \text{ kN} > 0.14 \sqrt{f_{ck}} \times b_w \times d = 297.51 \text{ kN}$$

$$\therefore V_{ci} = 2810.65 \text{ kN}$$

2) 전단강도 V_{cw} (복부 전단강도)

$$V_{cw} = (0.29 \times \sqrt{f_{ck}} + 0.3 \times f_{pc}) \times b_w \times d + V = 3867249.21 \text{ N} = 3867.25 \text{ kN}$$

$$f_{pc} = P_{e1} / A_c = 9924372 / 910953 = 10.894 \text{ MPa}$$

$$V_p = P_{e2} \times \sin \Theta \text{ (} V_p \text{ : 수직분력)} = 8792827 \times 0.2448 = 2152819.48 \text{ N}$$

$$\therefore V_c = \min [V_{ci}, V_{cw}] = 2810.6 \text{ kN}$$

3) $\phi V_c = 0.80 \times 2810.6 = 2248.5 \text{ kN}$

$$1/2 \phi V_c = 1,124.259 \text{ kN}$$

$\therefore 1/2 \phi V_c < V_u < \phi V_c$, 최소 전단 철근 배근

4) 최소 전단철근 검토

전단 철근 간격 $s = 400 \text{ mm}$ ($0.75H (=0mm)$ 또는 $600mm$ 보다 커서는 안된다.)

$$A_{vmin} = 0.0625 \times \sqrt{f_{ck}} \times b_w \times s / f_y = 105.409 \text{ mm}^2$$

$$A_{vmin} = 105.409 \text{ mm}^2 > 0.35 \times b_w \times s / f_y = 93.333 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

$$A_{vll} = \text{Max}(A_v, A_{vmin}) = 105.409 \text{ mm}^2$$

$$A_{vuse} = \mathbf{D13} \times 2 \text{ EA} = 253.4 \text{ mm}^2 \text{ ----- } \mathbf{0.K}$$

14.4 수평 전단 강도 검토(주거터와 바닥판 결합)

1) 온도에 의한 수평전단응력 검토

$$F_t = \frac{1}{1 + \frac{A_s}{n \cdot A_b} + \frac{A_s \cdot d_c^2}{I_s + n \cdot I_b}} = 0.074$$

여기서, A_s, I_s : 슬래브 단면적, 단면2차모멘트
 A_b, I_b : 거더의 단면적, 단면2차모멘트
 d_c : 거더단면중심 ~ 슬래브중심

$$P_t = E_b \cdot (A_s/n) \cdot \alpha \cdot \Delta T = 29000 \times 0.55 \times 1.0 \times 10^{-5} \times 5 \\ = 797500 \text{ N}$$

$$N_{ct} = F_t \cdot P_t = 0.074 \times 797500 = 59015 \text{ N}$$

$$v_t = 2 N_{ct} / a \cdot b = 2 \times 59015 / (2.75 \times 0.80) \\ = 0.054 \text{ MPa}$$

여기서, a = 전단분포폭 (거더중심간격, 지간/10 중 작은 값)

2) 건조수축 의한 수평전단응력 검토

$$n_2 = n [1 + \phi_2 / 2] = 1.2 \times [1 + 4.0 / 2] = 3.60$$

$$F_s = \frac{1}{1 + \frac{A_s}{n_2 \cdot A_b} + \frac{A_s \cdot d_c^2}{I_s + n_2 \cdot I_b}} = 0.194$$

$$P_s = E_b \cdot A_s \cdot \epsilon_s / n_2 = 29000 \times 0.66 \times 18 \times 10^{-5} / 3.60 \\ = 957000 \text{ N}$$

$$N_{cs} = F_s \cdot P_s = 0.194 \times 957000 = 185658 \text{ N}$$

$$v_s = 2 N_{cs} / a \cdot b = 2 \times 185658 / (2.75 \times 0.80) \\ = 0.169 \text{ MPa}$$

3) 합성후 고정하중에 의해 접합면에 작용하는 전단응력

$$v_d = 1256.5 \times 1000 / (0.800 \times 1.872) = 0.839 \text{ MPa}$$

$dp = 0.8 \times h$ 보다 작아서는 안된다.

$$dp = 2.340 - 0.700 = 1.640 \text{ m} \leq 0.8 \times 2.3 = 1.872 \text{ m}$$

$$dp = 1.872 \text{ m}$$

4) 합성후 활하중에 의해 접합면에 작용하는 전단응력

$$v_l = 393.8 \times 1000 / \{ 0.800 \times 1.872 \} = 0.263 \text{ MPa}$$

dp = 0.8 x h 보다 작아서 안된다.

$$dp = 2.340 - 0.700 = 1.640 \text{ m} \leq 0.8 \times 2.3 = 1.872 \text{ m}$$

$$dp = 1.872 \text{ m}$$

5) 하중 조합

$$\begin{aligned} \textcircled{1} \quad & 1.3 \times v_d + 2.15 \times v_l \\ &= 1.3 \times 0.839 + 2.15 \times 0.263 \\ &= 1.656 \text{ Mpa} \leq 0.8 \times 3.5 = 2.800 \text{ MPa} \end{aligned}$$

$$\begin{aligned} \textcircled{2} \quad & 1.3 \times v_d + 1.3 \times v_l + 1.3 \times v_t \\ &= 1.3 \times (0.839 + 0.263 + 0.054) \\ &= 1.503 \text{ Mpa} \leq 0.8 \times 3.5 = 2.800 \text{ MPa} \end{aligned}$$

$$\begin{aligned} \textcircled{3} \quad & 1.3 \times (v_t + v_s) \\ &= 1.3 \times (0.054 + 0.169) \\ &= 0.290 \text{ Mpa} \leq 0.8 \times 3.5 = 2.800 \text{ MPa} \end{aligned}$$

6) 전단연결재의 배치간격 결정

- 접촉면을 청결하고 부유물이 없게끔하며, 대략 6 mm 깊이로 표면을 일부러 거칠게 한 후 최소전단연결재 이상을 사용.

- 최대 전단철근 간격

$$a. \quad bw \times 4 = 0.8 \times 4 = 3.200 \quad m$$

$$b. \quad 0.600 \quad m$$

$$\ast \quad \text{전단철근 최대 간격 } s = 0.600 \quad m$$

① 단부 (4.55m)

$$\text{- 사용 철근량} \quad \text{Use } A_v = D \quad 13 \times 2 \text{ ea} = 0.000254 \quad m^2$$

- 해석에 의한 최소전단철근 간격

$$\text{Req. } s = \frac{A_v \times f_y}{0.35 \times b_v} = \frac{0.000254 \times 300}{0.35 \times 0.800} = 0.272 \quad m$$

$$\ast \quad \text{사용 전단철근 간격 } s = 0.200 \quad m \quad \ast \quad 0.K$$

② 중간 가로보부(19.95m)

$$\text{- 사용 철근량} \quad \text{Use } A_v = D \quad 16 \times 2 \text{ ea} = 0.000398 \quad m^2$$

- 해석에 의한 최소전단철근 간격

$$\text{Req. } s = \frac{A_v \times f_y}{0.35 \times b_v} = \frac{0.000398 \times 300}{0.35 \times 0.800} = 0.426 \quad m$$

$$\ast \quad \text{사용 전단철근 간격 } s = 0.400 \quad m \quad \ast \quad 0.K$$

③ 중앙부

$$\text{- 사용 철근량} \quad \text{Use } A_v = D \quad 16 \times 2 \text{ ea} = 0.000398 \quad m^2$$

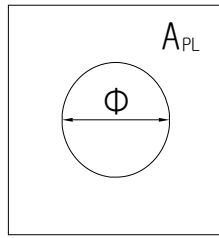
- 해석에 의한 최소전단철근 간격

$$\text{Req. } s = \frac{A_v \times f_y}{0.35 \times b_v} = \frac{0.000398 \times 300}{0.35 \times 0.800} = 0.426 \quad m$$

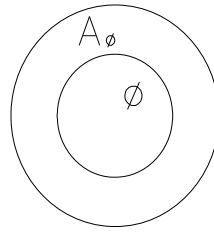
$$\ast \quad \text{사용 전단철근 간격 } s = 0.400 \quad m \quad \ast \quad 0.K$$

15. 정착부 설계

15.1 설계 조건



< 사각 정착판 제원 >



< 원형 정착판 제원 >

15.1.1 정착판 유효단면적

구 분	정착구제원	$A_{PL} (m^2)$	$A_{\Phi} (m^2)$	$\Phi (m)$	유효단면적(m^2)
T2	15.2/15연선	0.087	0.031	0.085	0.107
T3	15.2/15연선	0.087	0.031	0.085	0.107
T4	15.2/15연선	0.087	0.031	0.085	0.107
T5	15.2/15연선	0.087	0.031	0.085	0.107

15.1.2 정착구 긴장력

단위 : N

구 분	도입긴장력(P_o)	순긴장력(P_{net})	유효프리스트레스(P_e)
T2	3,060,000	2,682,897	2,211,304
T3	3,060,000	2,443,926	2,014,338
T4	3,060,000	2,560,553	2,110,465
T5	3,060,000	2,678,337	2,207,545

$$* \text{유효 프리스트레스}(P_e) = \text{초기 프리스트레스}(P_i) \times \text{유효율}$$

15.2 지압 응력 검토

15.2.1 긴장재 검토

(1) 긴장재 정착 직후

$$f_{ap} = 0.7 \times f_{ci} \times \sqrt{((A_{b'} / A_b) - 0.2)} \leq 1.1 \times f_{ci}$$

- f_{ci} = 프리스트레스 도입시의 압축 강도 = 32 MPa
- $A_{b'}$ = 정착판의 도심과 일치하는 정착판의 닻은꼴은 부재단부에 가장 크게 그렸을때 그 도형의 면적
- A_b = 정착판의 면적

- 긴장구별 허용 지압 응력

구 분	정착구제원	$A_{b'}$	A_b	f_{api}	$1.1f_{ci}$	허용지압응력
T2	15.2/15연선	0.250	0.087	36.6	35.2	35.2
T3	15.2/15연선	0.250	0.087	36.6	35.2	35.2
T4	15.2/15연선	0.250	0.087	36.6	35.2	35.2
T5	15.2/15연선	0.250	0.087	36.6	35.2	35.2

- 작용 지압응력

$$f_b = \text{도입긴장력}(P_o) / A_e \quad (A_e : \text{정착판의 유효면적})$$

- 긴장구별 지압 응력 검토

구 분	정착구제원	Po	Ae	fb	허용지압응력	검 토
T2	15.2/15연선	3,060,000	0.107	28.6	35.2	0.K
T3	15.2/15연선	3,060,000	0.107	28.6	35.2	0.K
T4	15.2/15연선	3,060,000	0.107	28.6	35.2	0.K
T5	15.2/15연선	3,060,000	0.107	28.6	35.2	0.K

(2) 프리스트레스 손실 발생후

- 허용 지압 응력

$$f_{ap} = 0.5 \times f_{ck} \times \sqrt{(A_b' / A_b)} \leq 0.9 \times f_{ck}$$

$$\bullet \quad f_{ck} = \text{설계 기준 강도} = 40 \text{ MPa}$$

- 긴장구별 허용 지압 응력

구 분	정착구제원	Ab'	Ab	fapi	0.9fck	허용지압응력
T2	15.2/15연선	0.250	0.087	33.9	36.0	33.9
T3	15.2/15연선	0.250	0.087	33.9	36.0	33.9
T4	15.2/15연선	0.250	0.087	33.9	36.0	33.9
T5	15.2/15연선	0.250	0.087	33.9	36.0	33.9

- 작용 지압응력

$$f_b = \text{도입긴장력}(P_o) / A_e \quad (A_e : \text{정착판의 유효면적})$$

- 긴장구별 지압 응력 검토

구 분	정착구제원	Pnet	Ae	fb	허용지압응력	검 토
T2	15.2/15연선	2,682,897	0.107	25.1	33.9	0.K
T3	15.2/15연선	2,443,926	0.107	22.8	33.9	0.K
T4	15.2/15연선	2,560,553	0.107	23.9	33.9	0.K
T5	15.2/15연선	2,678,337	0.107	25.0	33.9	0.K

15.3 파열력에 대한 검토

(1) 정착구 Busting 철근 검토

$$\begin{aligned} a(\text{정착판 일변 길이}) &= 295 \text{ mm} \\ h(\text{정착단면의 치수}) &= 2100 \text{ mm} \\ \alpha(\text{radian}) &= \text{ave}(T_{n-1} \sim T_n) = 0.128969115 \\ \sum P_o(\text{도입긴장력}) &= 12240000 \text{ N} \end{aligned}$$

1) 파열력 산정

$$\begin{aligned} T_{\text{burst}} &= 0.25 \times \sum P_o \times \{ 1 - (a/h) \} + (0.5 \times \sum P_o \times \sin \alpha) \\ &= 0.25 \times 12240000 \times \{ 1 - (295 / 2100) \} \\ &\quad + 0.5 \times 12240000 \times \sin 0.12897 \\ &= 2559719.6 \text{ N} \end{aligned}$$

2) 보강철근량 산정

$$\begin{aligned} 1.2 T_{\text{burst}} &= \phi T_n = \phi A_s f_y \\ \text{Req'd } A_s &= 1.2 \times 2559719.56 / (0.8 \times 300.0) = 12798.6 \text{ mm}^2 \\ e &= 2100 / 2 - (250 \times 4 + 450 \times 2 + 450 \times 1) / 4 \\ &= 463 \text{ mm} \\ d_{\text{burst}} &= 0.5 \times (h - 2e) + 5e \times \sin 0.12897 \\ &= 0.5 \times (2100 - 2 \times 463.0) + 5 \times 463.0 \times \sin 0.12897 \\ &= 1004.2 \text{ mm} \end{aligned}$$

* 파열 보강 철근은 고려하는 면에 대해 2.5dburst의 거리에 걸쳐 단면의 해당 측방향 치수의 1.5배를 넘지 않게 긴장재 양측을 따라 재하면 앞에 분포되어야 한다. 파열 보강 철근의 도심은 설계에 적용된 거리 dburst와 일치해야 한다. 간격은 보강 철근 지름의 24배 또는 300mm 를 넘어서는 안된다.
(도로교설계기준, P323)

$$\begin{aligned} \text{배치 범위} &= 2.5 \times 1004.2 = 2510.5 \text{ mm} \\ \text{spacing} &= 150 \text{ mm} \\ \text{Used bar} &= D 19 (A = 286.5 \text{ mm}^2) - 12 \text{ ea} \times 14 \text{ layer} = 48132.0 \text{ mm}^2 \end{aligned}$$

----- 0.K

15.4 활렬력에 대한 검토

1) 활렬력 산정

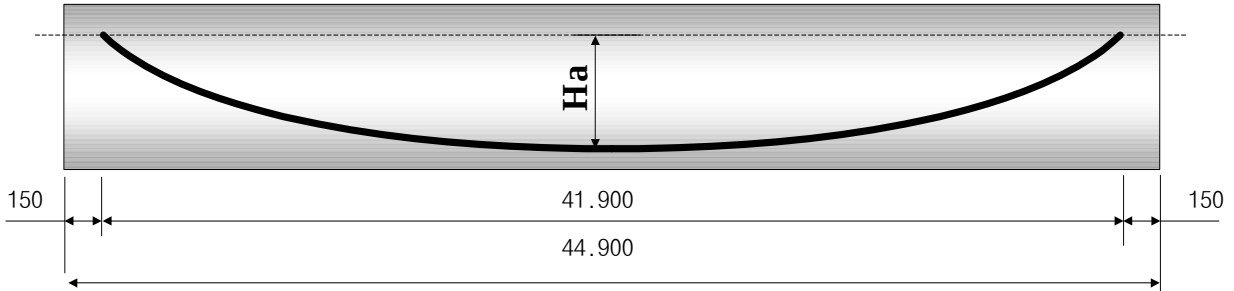
$$T_{\text{spall}} = 0.02 \times \sum P_o = 0.02 \times 2559719.560 = 51194.391 \text{ N}$$

2) 보강철근량 산정

$$\begin{aligned} f_s &= 0.6 \times f_y = 0.6 \times 300 = 180 \text{ MPa} \\ A_s &= T_{\text{spall}} / f_s = 51194.391 / 180 = 284.413 \text{ mm}^2 \end{aligned}$$

16. PS 강재의 신장량 검토

16.1 강봉 및 강선의 제원 (8. 프리스트레스 참조)



강선번호	Ap(m ²)	Ep(MPa)	Ha(m)	L(m)	α (radian)
C1	0.001257	200000	0.000	44.130	0.00000
C2	0.001257	200000	0.000	44.130	0.00000
T1	0.0009709	200000	1.860	44.351	0.35590
T2	0.0020805	200000	1.475	44.261	0.13291
T3	0.0020805	200000	1.025	44.193	0.09264
T4	0.0020805	200000	0.575	44.150	0.05207
T5	0.0020805	200000	0.125	44.131	0.01133

16.2 PS 강재의 신장률 (양단 동시 긴장시 한쪽 신장량임.)

(1) 신장률 (11. 정착부 설계 참조)

$$\Delta L = (P_o + P_{net}) \times (L_{ps}/2) / (A_p \times E_p)$$

강선번호	긴장순서	도입긴장력(Po)	순긴장력(Pnet)	Lps(m)	ΔL(mm)
C1	5	-675.00	-565.77	44.130	-108.901
C2	5	-675.00	-565.77	44.130	-108.901
T1	5	1350.00	1105.45	44.351	280.414
T2	4	3060.00	2682.90	44.261	305.440
T3	1	3060.00	2443.93	44.193	292.282
T4	2	3060.00	2560.55	44.150	298.182
T5	3	3060.00	2678.34	44.131	304.300

17. 신축이음의 설계

17.1 신축량 계산 및 설치유간

신축 하는 거더 길이 : 88.000 m

17.1.1 교대1

(1) 온도변화에 의한 이동량

$$\Delta L_t = \Delta T \times \alpha \times L$$

여기서 , ΔT : 온도변화 (40 ℃)

α : 선팅창계수(0.00001)

L : 신축 GIRDER 의 길이 (m)

$$\Delta L_t = 40 \times 0.00001 \times 88.000 = 0.0352 \text{ m}$$

(2) 건조 수축 신축량

$$\Delta L_{sh} = 0.1 \times L$$

여기서 , L : 신축 GIRDER 의 길이 (m)

$$\Delta L_{sh} = 0.1 \times 88 = 0.009 \text{ m}$$

(3) creep 신축량

$$\Delta L_{sh} = 0.2 \times L$$

여기서 , L : 신축 GIRDER 의 길이 (m)

$$\Delta L_{sh} = 0.2 \times 88 = 0.018 \text{ m}$$

(4) 신축 여유량

$$(35 + 8.80 + 17.60) \times 20 \% + 10.0 = 22.3 \text{ mm}$$

* 포장 및 활하중에 의한 거더 단부의 회전 및 시공오차로 인한 신축변화량은 여유량을 예상하여

기본 신축량의 20%에 일률적으로 10mm를 더하는 것으로 한다.

$$\therefore 35.2 + 8.8 + 17.6 + 22.3 = 83.9 \text{ mm}$$

(단위 : mm)

구분	온도변화	건조수축	크리프	여유량	총신축량	사용신축장치
A1	35.2	8.8	17.6	22.3	83.9	N0.120

* 지진시 여유량을 고려하여 N0-120을 적용함.

17.1.2 교대2

(1) 온도변화에 의한 이동량

$$\Delta L_t = \Delta T \times \alpha \times L$$

여기서 , ΔT : 온도변화 (40 ℃)

α : 선팅창계수(0.00001)

L : 신축 GIRDER 의 길이 (m)

$$\Delta L_t = 40 \times 0.00001 \times 44.000 = 0.0176 \text{ m}$$

(2) 건조 수축 신축량

$$\Delta L_{sh} = 0.1 \times L$$

여기서 , L : 신축 GIRDER 의 길이 (m)

$$\Delta L_{sh} = 0.1 \times 44 = 0.004 \text{ m}$$

(3) creep 신축량

$$\Delta L_{sh} = 0.2 \times L$$

여기서 , L : 신축 GIRDER 의 길이 (m)

$$\Delta L_{sh} = 0.2 \times 44 = 0.009 \text{ m}$$

(4) 신축 여유량

$$(18 + 4.40 + 8.80) \times 20 \% + 10.0 = 16.2 \text{ mm}$$

* 포장 및 활하중에 의한 거더 단부의 회전 및 시공오차로 인한 신축변화량은 여유량을 예상하여

기본 신축량의 20%에 일률적으로 10mm를 더하는 것으로 한다.

$$\therefore 17.6 + 4.4 + 8.8 + 16.2 = 47.0 \text{ mm}$$

(단위 : mm)

구분	온도변화	건조수축	크리프	여유량	총신축량	사용신축장치
A2	17.6	4.4	8.8	16.2	47.0	N0.60