Undercut Spring anchor를 이용한
건식 석재 시공 내진설계 구조 계산서

2020.3.17

UTEC partners | (주)유텍파트너스

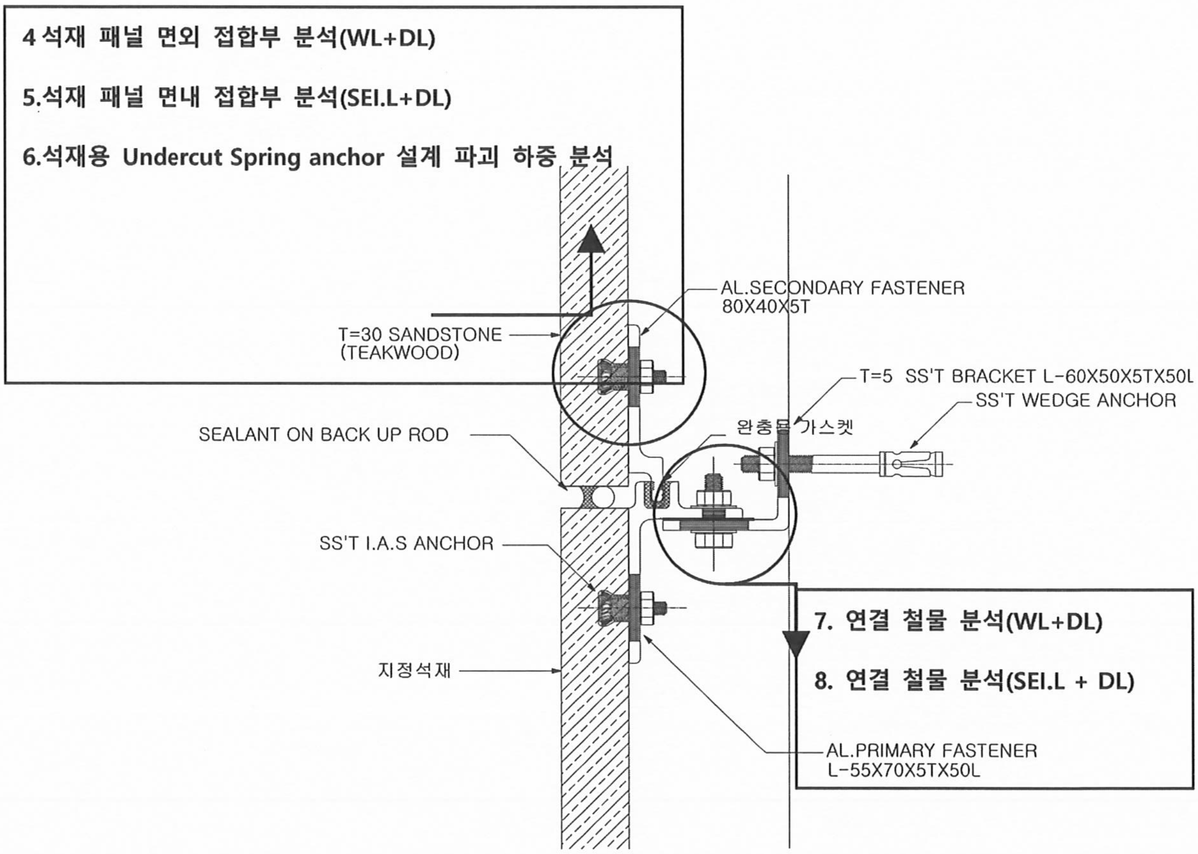
TABLE OF CONTENTS

NO.	ITEM	SHEET NO.
1	Structural Criteria	
2	Wind Load Calculation (풍하중 산정)	
3	Seismic Load Calculation (지진하중 산정)	
4	석재 패널 면외 접합부 분석 (WL+DL)	
5	석재 패널 면내 접합부 분석 (SEI.L+DL)	
6	석재용 Undercut Spring Anchor 설계 파괴 하중 분석	
7	연결 철물 분석 (WL+DL)	
8	연결 철물 분석 (SEI.L+DL)	

구조계산의 범위

- 구조 계산 설치 시스템 종류 :
  바닥확대면 i.a.spring anchor + 현장 설치용 Al. angle

- 구조 계산 대상의 범위 :
  석재 패널 접합부 +연결 철물 자체 취약부 +구조체와의 접합부



2 부분단면상세도
SCALE : 1/2

1. Structural Criteria

1) Projec Name :

→ Spring Anchor를 이용한 건식 석재 시공 내진설계 구조계산서

2) 적용자재 :

→ Granite Stone + SS'T I.A.S Anchor

3) Material :

→ Poisson's ratio : 0.25

→ Modulus of Elastidity : 400,000 kgf/cm^2

→ Fc = 500 ~ 1940 kgf/cm^2

→ Fb = 50 ~ 100 kgf/cm^2

4) Program

→ N.F.X (C.A.E Program)

→ midas Genw

5) SUMMARY

→ 30두께의 화강석에 대하여 구조검토함. 검토하중은 석재자중, 풍하중, 지진하중임.

→ 지점조건은 판의 모서리 방향에 4개의 언더컷 앵커로 지지함.

2. Wind Load Calculation (풍하중 산정)

외장재 설계용 풍하중 산정 (벽면) - 기준높이 20m이상 건축물

Ⅰ. DESIGN CONDITION

1) 건물 위치	:	서울		
2) 건물물의 기준높이 (H)	:	80	m	
3) 지표면에서의 임의높이 (z)	:	80	m	
4) 노 풍 도	:	B		
5) 유효 수압 면적 (A_C)	:	1.00	m^2	(= 1 m × 1 m)

Ⅱ. 설계 속도압 및 설계 풍속 산정

1) V_o (기본풍속) = 26m/sec

2) K_{zr} (풍속고도분포계수) = 1.18 (= 0.45 × z^{α})

- Z_b (대기 경계층 시작높이) = 15 m
- Z_g (기준 경도 높이) = 450 m
- α (풍속의 고도 분포 지수 = 0.22

3) K_{zt} (지형계수) = 1.00 (평탄한 지역)

4) I_W (중요도계수) = 1.00

5) 설계 풍속 (V_H) = $V_o \times K_{zr} \times K_{zt} \times I_w$ = 30.68 m/sec

6) 기준높이 H에 대한 설계 속도압 (q_H) = $1/2\ \rho\ V_H^2$ = 576.55 N/m^2 ρ = 1.225 $N.S^2/m^4$ 공기 밀도

Ⅲ. 외장재 설계용 가스트계수 산정

1) 외장재설계용 피크내압계수 GC_{pi} : < 표 0305.8.9 >

GC_{pi} = 0 ⓐ
= -0.52 ⓑ

2) 외장재설계용 피크외압계수 GCpe : < 표 0305.8.1 >

Case	Condition	GCpe	
Case-1 ; Positive Wind Load ; All Zone ④ ⑤	A ≤ 2 m^2	1.80	<--GOVERNS
	$2m^2$ < A ≤ $50m^2$	1.93	
	A > $50m^2$	1.20	
	Used GC_{pe} =	1.80	
Case-2 ; Negative Wind Load ; Typical Zone ④	A ≤ 2 m^2	-1.80	<--GOVERNS
	$2m^2$ < A ≤ $50m^2$	-1.89	
	A > $50m^2$	-1.40	
	Used GC_{pe} =	-1.80	
Case-3 ; Negative Wind Load ; Edge Zone ⑤	A ≤ 2 m^2	-3.60	<--GOVERNS
	$2m^2$ < A ≤ $50m^2$	-3.94	
	A > $50m^2$	-2.00	
	Used GC_{pe} =	-3.60	

Ⅳ. 외장재 설계용 풍하중 산정

(1) Positive Wind Pressure

※. 높이방향압력분포계수 산정 k_z = 0.907

-. All Zone ④ ⑤ ∴ $P_c = k_z\ q_H\ (GC_{pe} - GC_{pi})$ = 942 N/m^2 ⓐ
= 1214 N/m^2 ⓑ

(2) Negative Wind Pressure

-. Typical Zone ④ ∴ $P_c = q_H\ (GC_{pe} - GC_{pi})$ = -1038 N/m^2 ⓐ
= -738 N/m^2 ⓑ

-. Edge Zone ⑤ ∴ $P_c = q_H\ (GC_{pe} - GC_{pi})$ = -2076 N/m^2 ⓐ
= -1776 N/m^2 ⓑ

Ⅴ. WIND LOAD DIAGRAM

1) Positive Wind Pressure (Max)

-. 정압 작용시 풍하중은 임의 높이 Z에 대하여 다르게 나타나며, 적용 풍하중은 최고 높이에서의 풍하중을 적용한다.

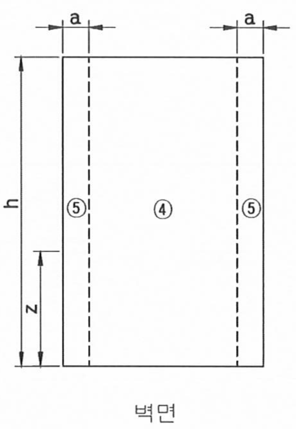
-. Maximum Wind Pressure (P_c) = **1.214** kN/m² (kPa) ④ ⑤ -. All Zone

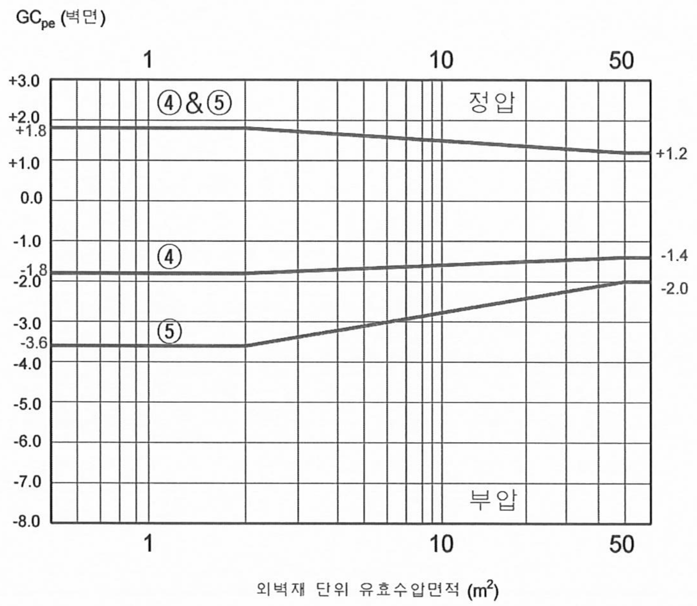
2) Negative Wind Pressure (Max)

-. 부압 작용시 풍하중은 높이에 관계없이 일정하게 나타나며, 입면상 위치에 관계하여 Typical Zone 과 Edge Zone으로 구분하여 적용하도록 한다.

-. Maximum Wind Pressure (P_c) = **-1.038** kN/m² (kPa) ④ -. Typical Zone

-. Maximum Wind Pressure (P_c) = **-2.076** kN/m² (kPa) ⑤ -. Edge Zone





Note

(1) 유효수압면적은 외장재 및 마감재의 압력을 주골조에 전달하는 단위2차 부재의 유효수압면적.

(2) 지붕경사각이 10˚ 이상인 경우 <표 0305.8.2>의 ②, ③을 사용한다.

(3) 각 외장재 벽면은 최대 정압 및 최대 부압으로 설계한다.

(4) a : 건축물 최소폭의 0.1배. 단 1m 보다 작아서는 안된다.

H : 기준높이 (m)

z : 지표면으로부터의 임의높이 (m)

3. Seismic Load Calculation (지진하중 산정)

1. Seismic Load Calculation (for Wall Cladding)

1] DESIGN CONDITION

[1] 지　　역 :　　서울

[2] 건물높이 :　　80　　m

2] SEISMIC LOAD

$$F_P = \frac{0.4 \times a_p \times S_{DS} \times W_P}{\left(\frac{R_P}{I_P}\right)} \left(1 + 2 \times \frac{z}{h}\right) \qquad (0306.10.1)$$

$F_P = 1.6\ S_{DS}\ I_P\ W_P$　　를 초과할 필요는 없으나,　　(0306.10.2)

$F_P = 0.3\ S_{DS}\ I_P\ W_P$　　값 이상이어야 한다.　　(0306.10.3)

여기서,

F_P			비구조요소 질량 중심에 작용하는 설계지진력 (N)
a_P =	1.0	(벽체부재)	1.0 ~ 2.5 사이의 값을 갖는 증폭계수 <표 0306.10.1>
=	1.25	(접합시스템의 조임구)	
I_P =	1.0		비구조요소의 중요도계수로서 1.0 또는 1.5 < 0306.4.1 >
h =	80.00 m		구조물의 밑면으로부터 지붕층까지의 평균높이 (m)
R_P =	2.5	(벽체부재)	비구조요소의 반응수정계수로서 1.0 ~ 5.0 사이의 값 < 표 0306.10.1 >
=	1.0	(접합시스템의 조임구)	
$S_{DS} = S \times 2.5 \times F_a \times 2/3$ =	$0.176 \times 2.5 \times 1.38 \times 2/3$		0306.3.3에 따라 결정한 단주기에서의 설계스펙트럼 가속도
=	0.41		
W_P =	0.98 kPa		비구조요소의 가동중량 W_P = 0.98 kPa
z =	80.00 m		구조물의 밑면으로부터 비구조요소가 부착된 높이 (m)

2-1] 부재 검토용 지진하중

$$F_{P1} = \frac{0.4 \times 1.0 \times 0.41 \times 0.98}{\left(\frac{2.5}{1.0}\right)} \left(1 + 2 \times \frac{80.00}{80.00}\right) = 0.193\ kN/m^2$$

$F_{P1}' = 0.3\ S_{DS}\ I_P\ W_P = 0.121\ kN/m^2$

$\therefore F_{P1} = 0.193\ kN/m^2$　　($F_{P1} > F_{P1}'$) 이어야 하므로

2-2] 접합부 및 앵카부 검토용

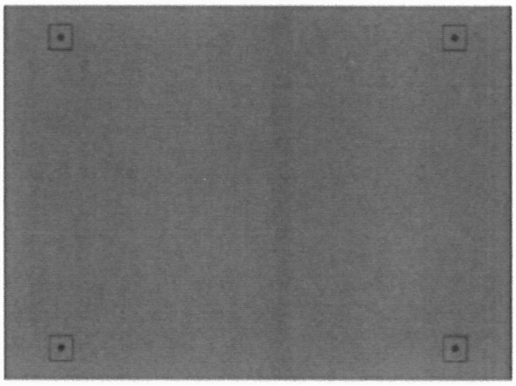
여기서,

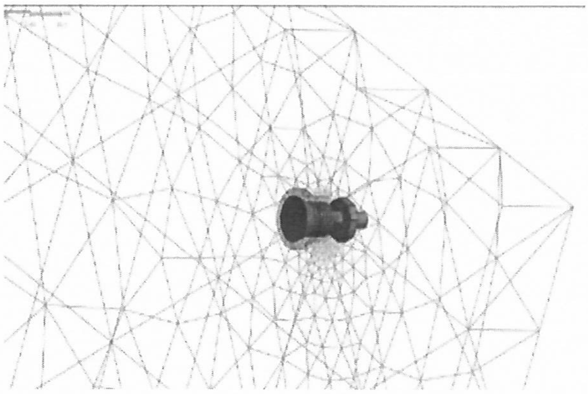
F_p			비구조요소 질량 중심에 작용하는 설계지진력 (N)
a_p =	1.0	(벽체부재)	1.0 ~ 2.5 사이의 값을 갖는 증폭계수 <표 0306.10.1>
=	1.25	(접합시스템의 조임구)	
I_p =	1.0		비구조요소의 중요도계수로서 1.0 또는 1.5 < 0306.10.1.4 >
h =	80.00 m		구조물의 밑면으로부터 지붕층까지의 평균높이 (m)
R_p =	2.5	(벽체부재)	비구조요소의 반응수정계수로서 1.0 ~ 5.0 사이의 값 < 표 0306.10.1 >
=	1.0	(접합시스템의 조임구)	
S_{DS} = $S \times 2.5 \times F_a \times 2/3$ =	$0.176 \times 2.5 \times 1.38 \times 2/3$		0306.3.3에 따라 결정한 단주기에서의 설계스펙트럼 가속도
=	0.41		
			비구조요소의 가동중량
W_p =	0.98 kPa		W_p = 0.98 kPa
z =	80.00 m		구조물의 밑면으로부터 비구조요소가 부착된 높이 (m)

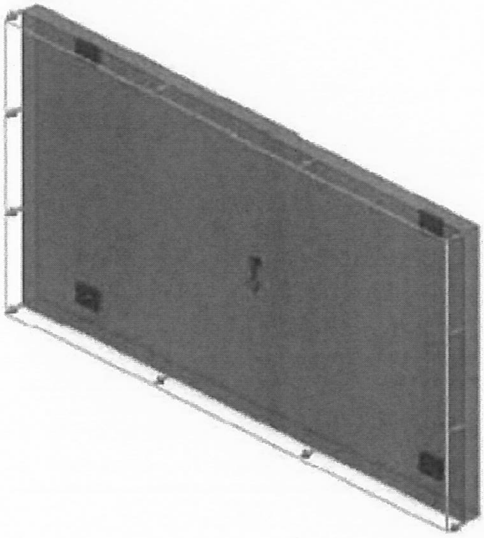
$$F_{P1} = \frac{0.4 \times 1.25 \times 0.41 \times 0.98}{\left(\frac{1.0}{1.0}\right)} \left(1 + 2 \times \frac{80.00}{80.00}\right) = \underline{0.60\ \text{kN/m}^2}$$

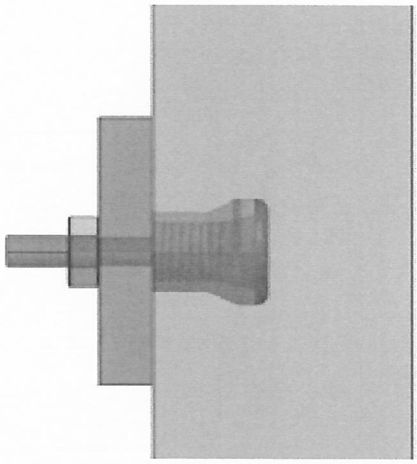
4. 석재 패널 면외 접합부 분석 (WL+DL)

LCB 1 : D.L + W.L (자중+풍하중)









석재의 종류 : 화강석 / 포천석 :

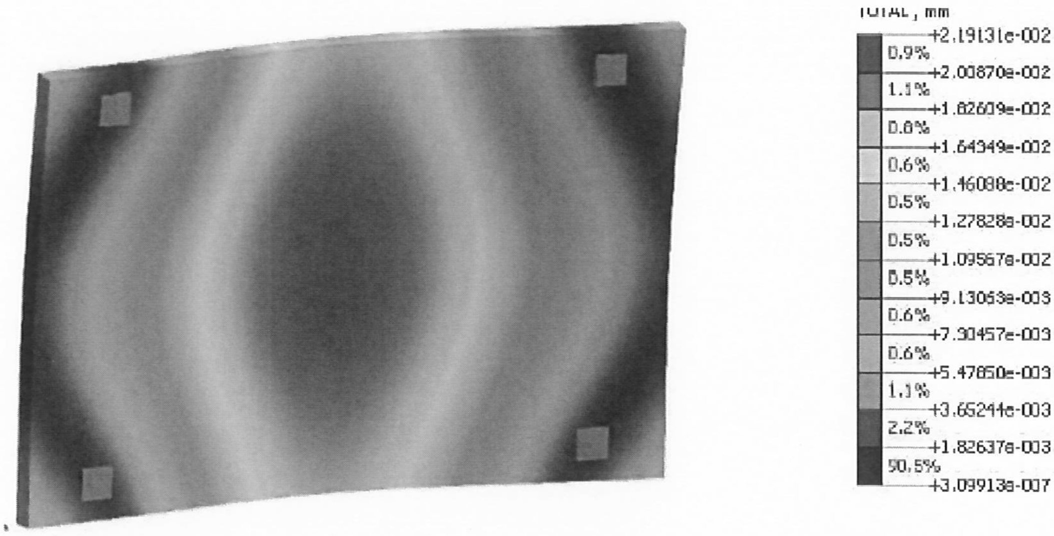
석재의 규격 : 600mm x 1200mm x 30mm

앵커 지점 지지 수량 : Support : 4ea point

바닥확대면 앵커의 지름 : 8mm

Undercut Anchor 의 허용값은 시험성적서 결과 값을 사용함.

LCB 1 : D.L + W.L (자중+풍하중)

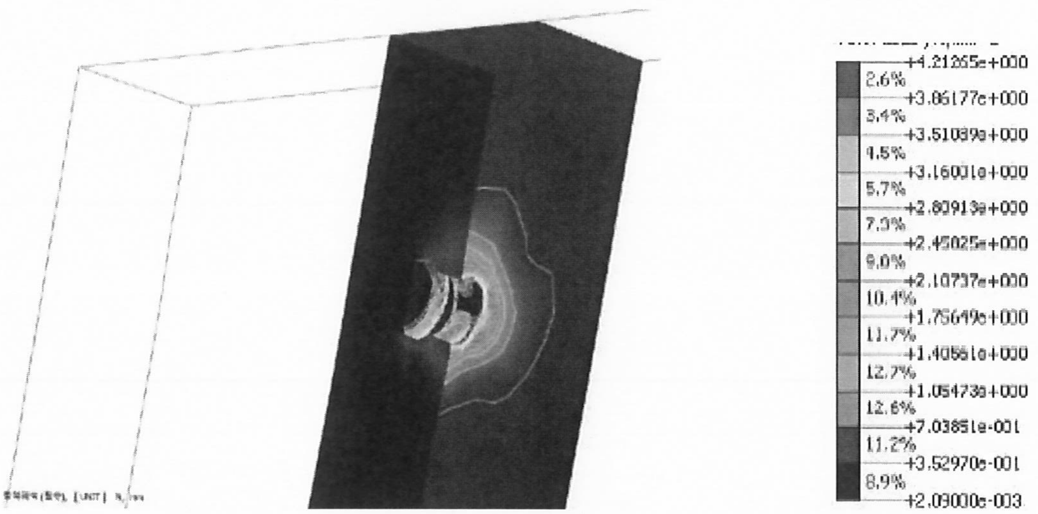


< 처짐검토 >

실제처짐값 0.1 mm 이하

허용처짐값 800 / 500 =1.6 mm

허용처짐값을 만족함.



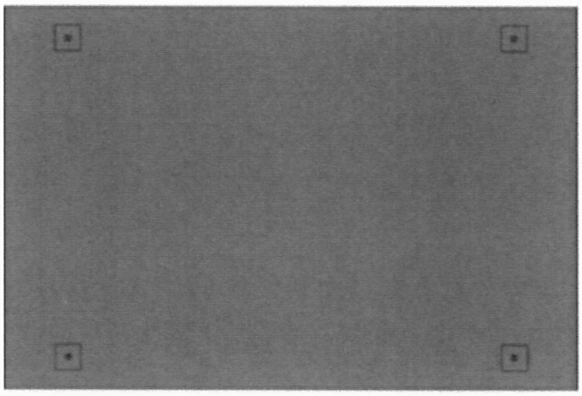
< 응력검토 >

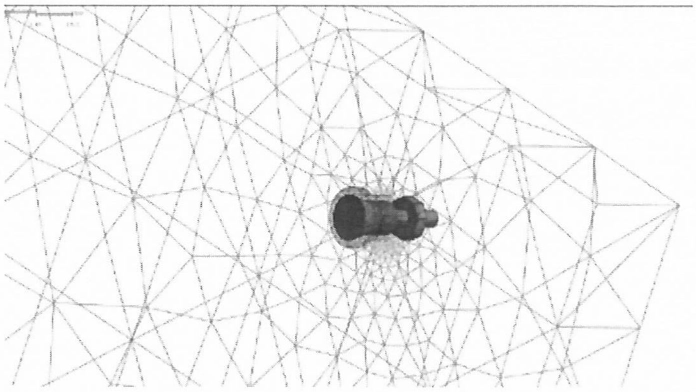
실제응력값 4.3 Mpa

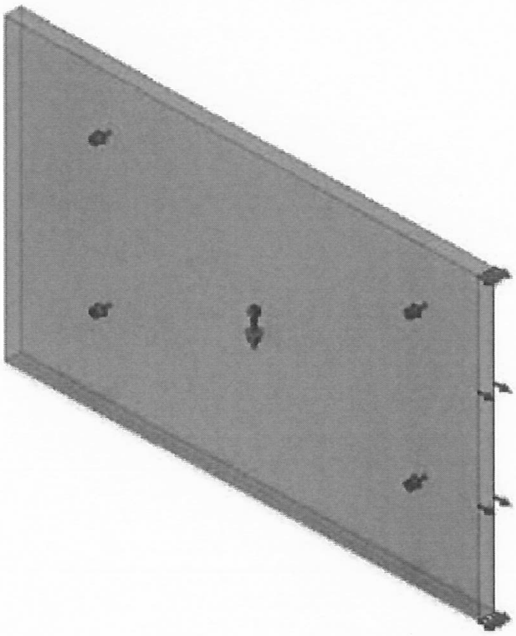
허용응력값 10.0 Mpa

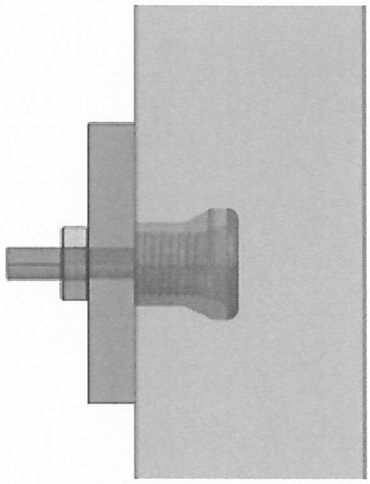
허용응력값을 만족함.

LCB 2 : D.L + SEI.L (자중 + 지진 하중)









석재의 종류 : 화강석 / 포천석 :

석재의 규격 : 600mm x 1200mm x 30mm

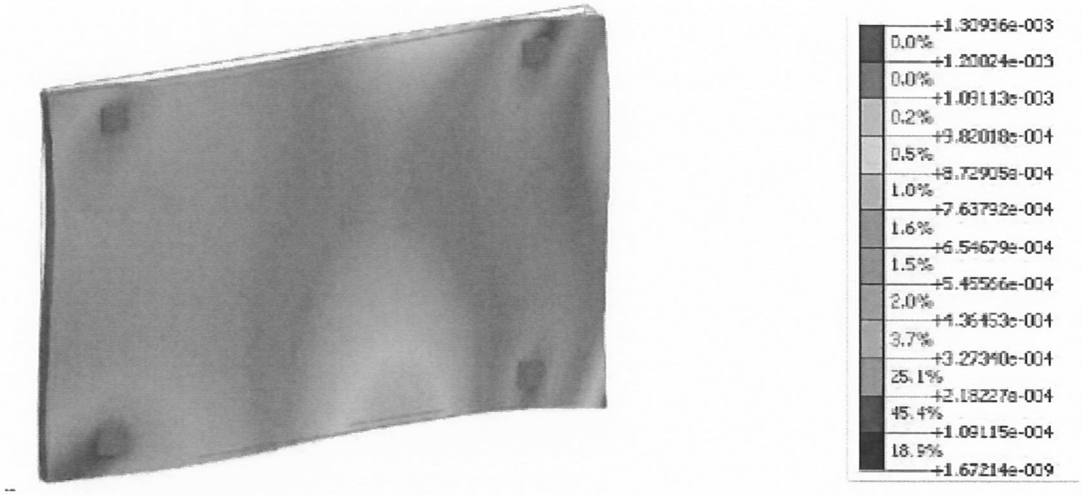
앵커 지점 지지 수량 : Support : 4ea point

바닥확대면 앵커의 지름 : 8mm

Undercut Anchor 의 허용값은 시험성적서 결과 값을 사용함.

5. 석재 패널 면내 접합부 분석 (SEI.L+DL)

LCB 2 : D.L + SEI.L (자중 + 지진 하중)

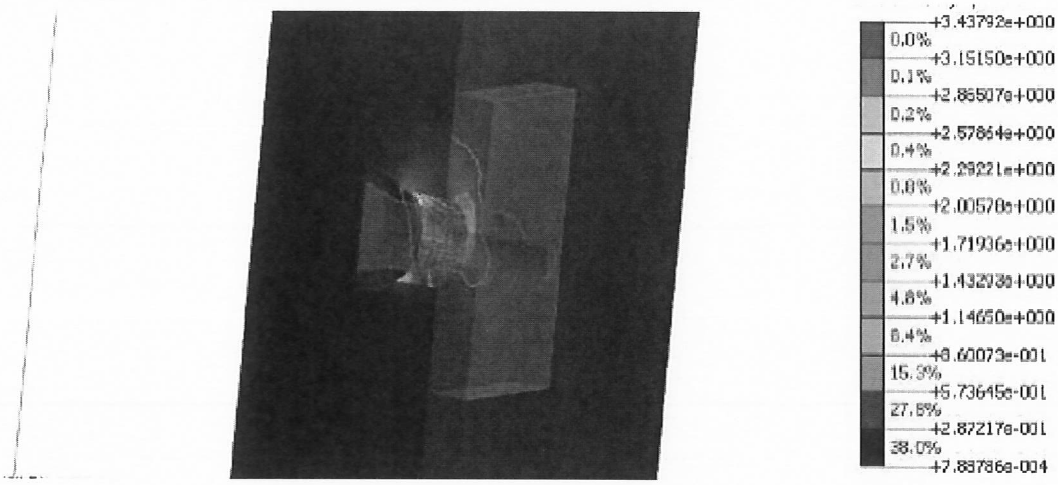


< 처짐검토 >

실제처짐값 0.1 mm 이하

허용처짐값 800 / 500 =1.6 mm

허용처짐값을 만족함.



< 응력검토 >

실제응력값 3.5 Mpa

허용응력값 10.0 Mpa

허용응력값을 만족함.

6. 석재용 Undercut Spring Anchor 설계 파괴 하중 분석

1. Undercut Anchorage

1. General

1.1 Stone Size 600mm x 1200mm x 30T

2. Pull-out

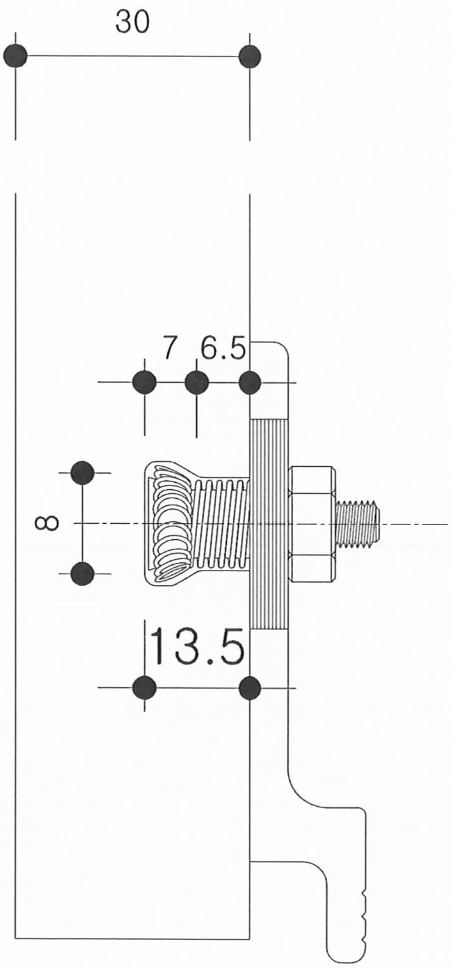
2.1 Mininum stone think

t-$_{min}$ = t - du > 0.4 x t

30 - 13.5 = 16.5 mm > 0.4 x 30 = 12 mm " O.K "

2.2 PULL-OUT

$$F_{brd}\ \mathbf{D}\ \frac{\sigma_{Rtk} \cdot \pi \left(h_v^2 \cdot \cot^2\alpha\ \mathbf{C}\ h_v \cdot \phi_u \cdot \cot\alpha\right)}{k_u} \cdot \frac{\eta}{\gamma_M} \qquad \mathbf{(7.20)}$$



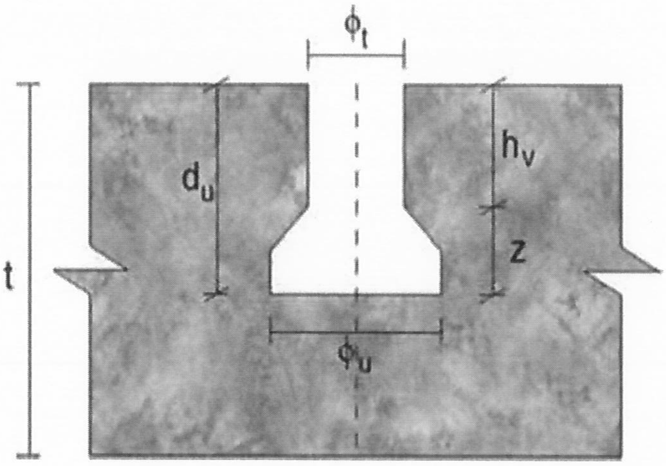


Table 4.2

Table 4.2 Consequence class according Eurocode 1990

Consequence class	Description	Example for building works	
CC1	Low consequence for loss of human life, or negligible economic, social or environmental consequences.	Agricultural buildings, sheds, greenhouses, i.e., construction or buildings where people do not normally enter.	
CC2	Medium consequence for loss of human life, or considerable economic, social or environmental consequences.	Construction for which the consequences of failure are significant, e.g., apartment's or office buildings, hotels, schools, access bridges, etc.	CC2
CC3	High consequence for loss of human life, or very important economic, social or environmental consequences.	Construction for which the failure consequences are severe, stadiums, grandstands, theatres, high-rise buildings, bridges, dams, etc.	

Table 4.3

Table 4.3 Partial safety factors for dimension stone cladding for three classes of consequences according to EC 1990

	Class of consequence		
Coefficient of variation of stone properties, V_R	CC1	CC2	CC3
<0.1	1.50	1.88	2.40
0.1–0.2	2.40	3.48	5.20
0.2–0.25	2.90	4.25	6.60
0.25–0.30	3.80	5.90	9.80
0.30–0.35	4.80	8.20	14.60
0.35–0.40	6.10	10.60	19.40

CC2

0.2-0.25 가정치

4.25

* 변위계수 VR은 실험데이터를 사용

Table 4.4

Table 4.4 Aging factors for dimension stone cladding

	Exposure conditions (Expected life cycle of 30 years)	
Stone type	Humid environment without frost	Humid with frost and de-icing salts
Fine to medium grained granite	1.00	0.95
Oolitic limestone	0.90	0.85
Fine to medium grained marble	0.85	0.75

Table 7.3

Table 7.3 Spall angles and stress concentration factors for use in Eq. (7.20)

Stone identification	Spall angle α	Concentration factor k_u
Fine to medium grain size granite	**19ö ñ 20ö**	**4.9**
Medium to gross grain size granite	**16ö ñ 18ö**	**4.6**
Oolitic limestone	**19ö ñ 20ö**	**6.9**
Calcitic marble	**15ö ñ 16ö**	**9.0**

	F_{brd} :	Value of the design breaking load of the Anchorage	
47	σ_{Rtk} :	Design value of the tensile strength of the stone	Mpa
4.25	γ_m :	Partial safety factor for dimension stone, Table4.3	
0.95	η :	Loss of strength of the stone, Table4.4	
14	ϕu :	Diameter of the undercut	mm
6.5	hv :	(du - z) 13.5 - 7 = 6.5 mm	mm
30	t :	Stone(tile) think	mm
19	α :	Spall angle	
4.9	k_u :	Stress concentration factor for the undercut	
8.43	$\cot^2\alpha$		
2.90	$\cot\alpha$		

$$Fbrd = \frac{\sigma_{Rtk} \times \pi \times (h^2v \times \cot^2\alpha + hv \times \phi u \times \cot\alpha)}{ku} \times \frac{\eta}{\gamma m}$$

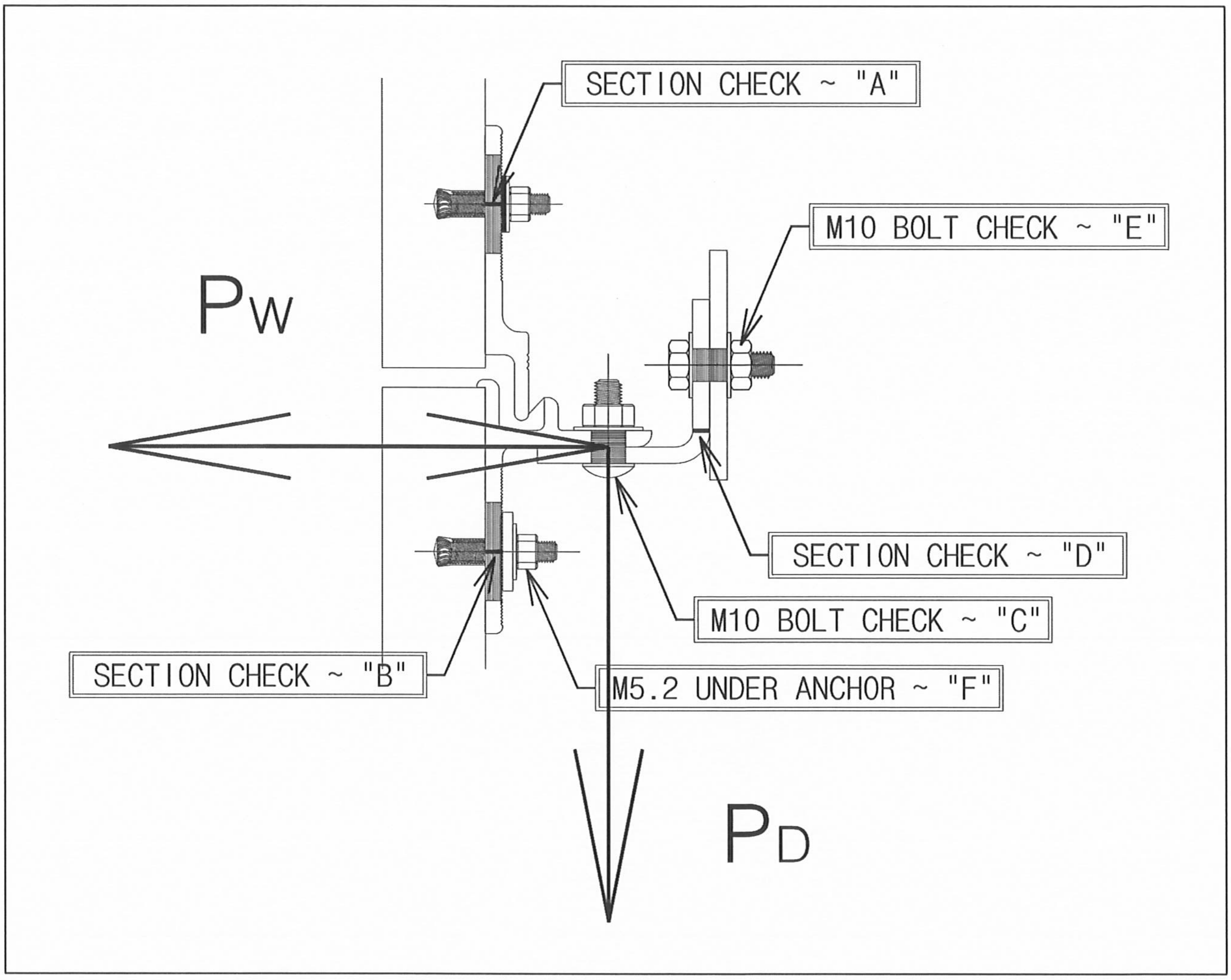
= 2410 N

3. Result

F_{brd} = 2410 N

7. 연결 철물 분석 (WL+DL)

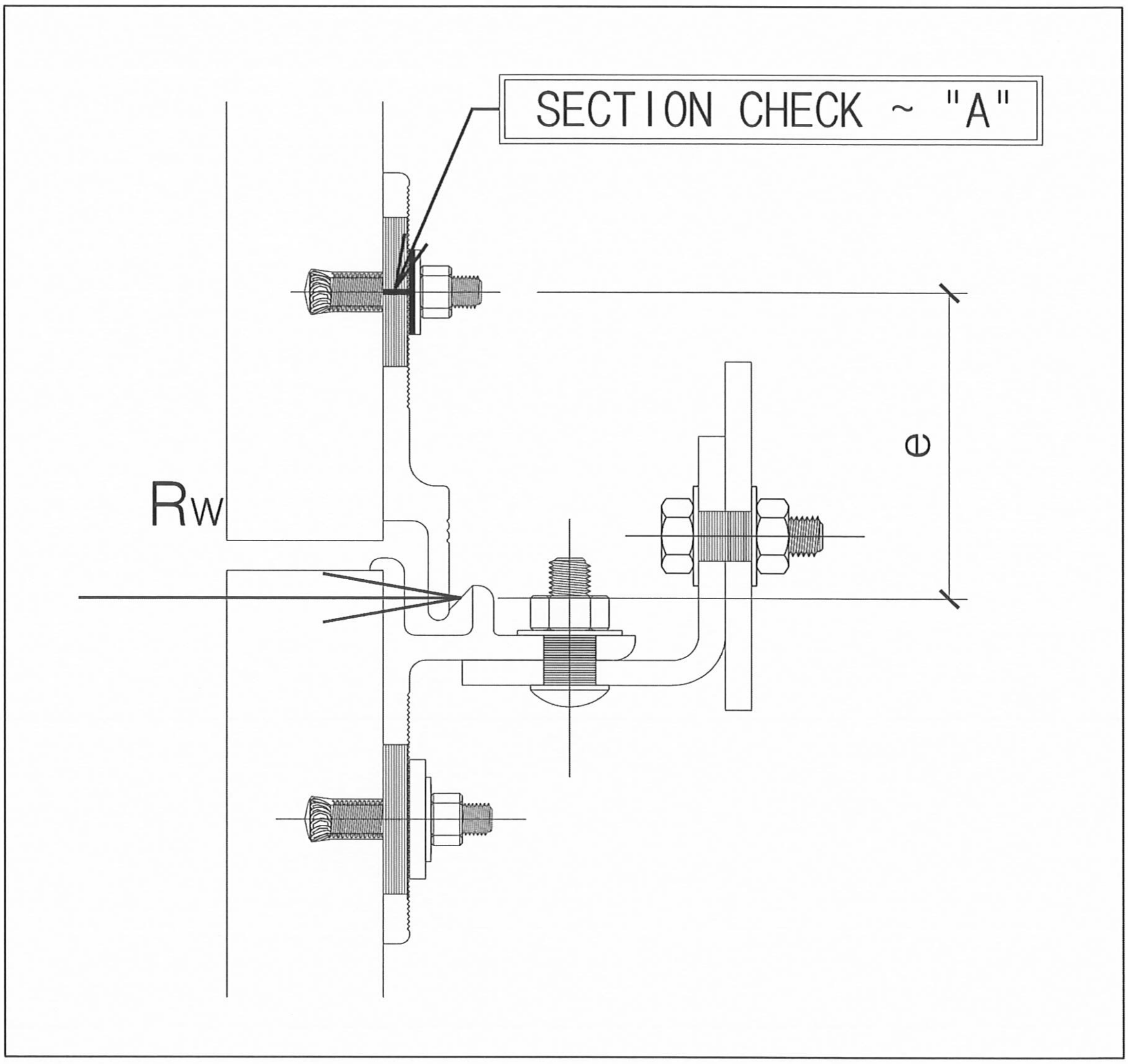
1. 석재 연결 철물 검토 (WL+DL)



$P_{W(P)}$	=	0.19 kN	=	190.0 N
$P_{W(N)}$	=	0.16 kN	=	160.0 N
P_D	=	0.29 kN	=	290.0 N

1) AL. SECTION CHECK ~ "A"

-. 5T-40LG, Alloy & Temper 6063-T6. (ADM 2010 Table 2-21)



[1] Actual Stress

R_W = $P_{W(P)}$ = 190.00 N

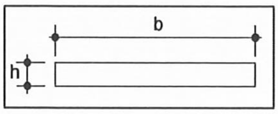
M = $R_W \times e$ = 11685.00 N.mm   e = 61.5 mm

b = 40 - 6.2 = 33.8 mm   h(t) = 5.00 mm

A = 169.00 mm^2

Z_X = 140.83 mm^3 Z_Y = 952.03 mm^3

f_b = M / Z_X = 82.97 N/mm^2 (Mpa)



[2] Allowable Stress

F_{ty} = 170 Mpa

F_b = 19.7 ksi = 135 Mpa (F.8.1.2, F.4.1)

F_S = 9.1 ksi = 62.7 Mpa (G.2)

[b / t = 6.76 ≤ S_1 = 38.7]   b = 33.8 mm

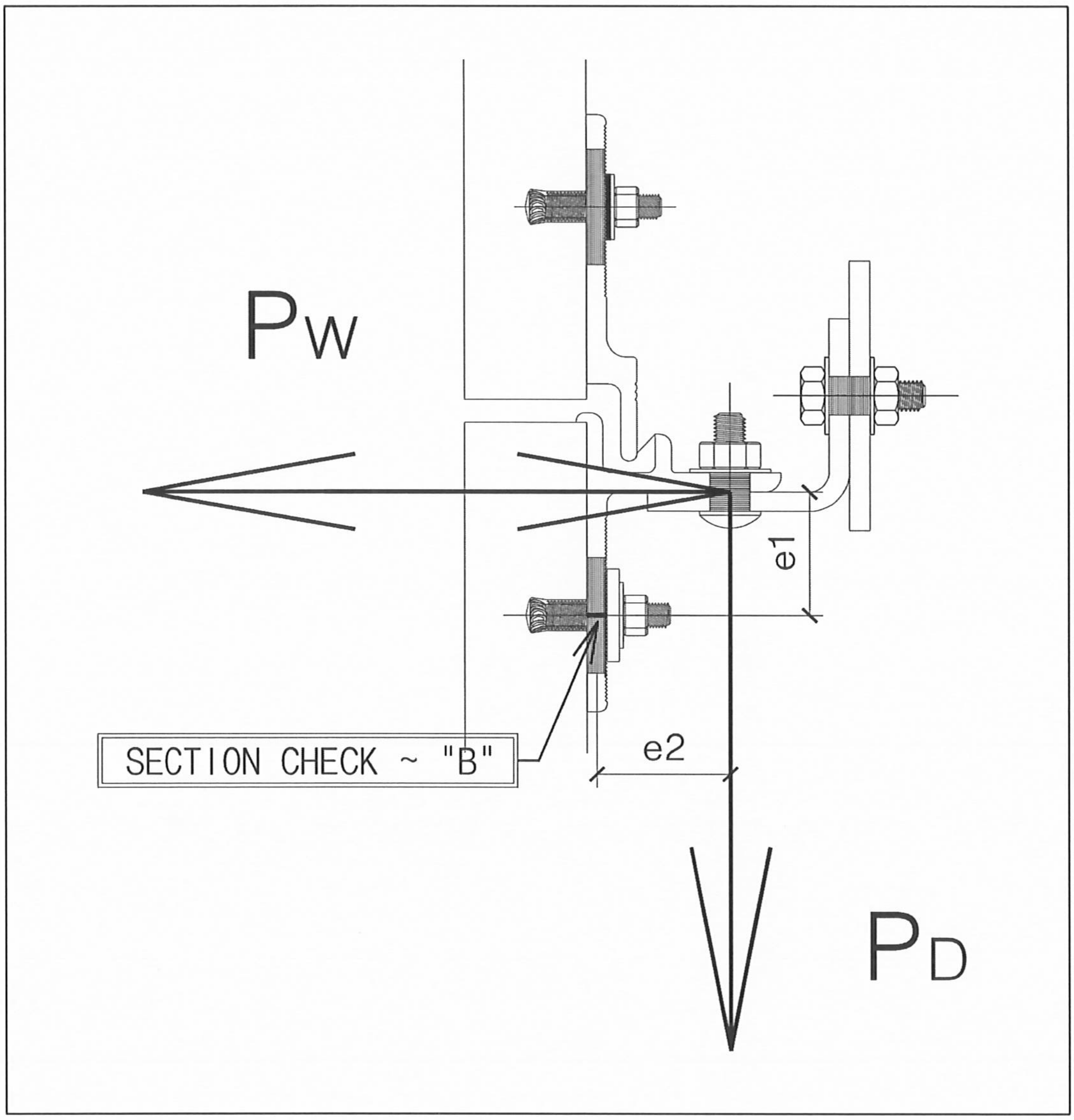
t = 5.00 mm

[3] Stress Ratio

$\frac{f_b}{F_b}$ = 0.61 < 1.0   ∴ O. K.

2) AL. SECTION CHECK ~ "B"

-. 5T-60LG, Alloy & Temper 6063-T6. (ADM 2010 Table 2-21)



[1] Actual Stress

$M = P_{W(P)} \times e_1 + P_D \times e_2 =$ 15650.00 N.mm

e_1 = 32 mm

e_2 = 33 mm

b = 60 - 6.2 = 53.8 mm

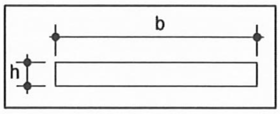
h(t) = 5.00 mm

A = 269.00 mm^2

Z_X = 224.17 mm^3

Z_Y = 2412.03 mm^3

$f_b = M / Z_X$ = 69.81 N/mm^2 (Mpa)



[2] Allowable Stress

F_{ty} = 170 Mpa

F_b = 19.7 ksi = 135 Mpa (F.8.1.2, F.4.1)

F_S = 9.1 ksi = 62.7 Mpa (G.2)

[b / t = 10.76 ≤ S_1 = 38.7]

b = 53.8 mm

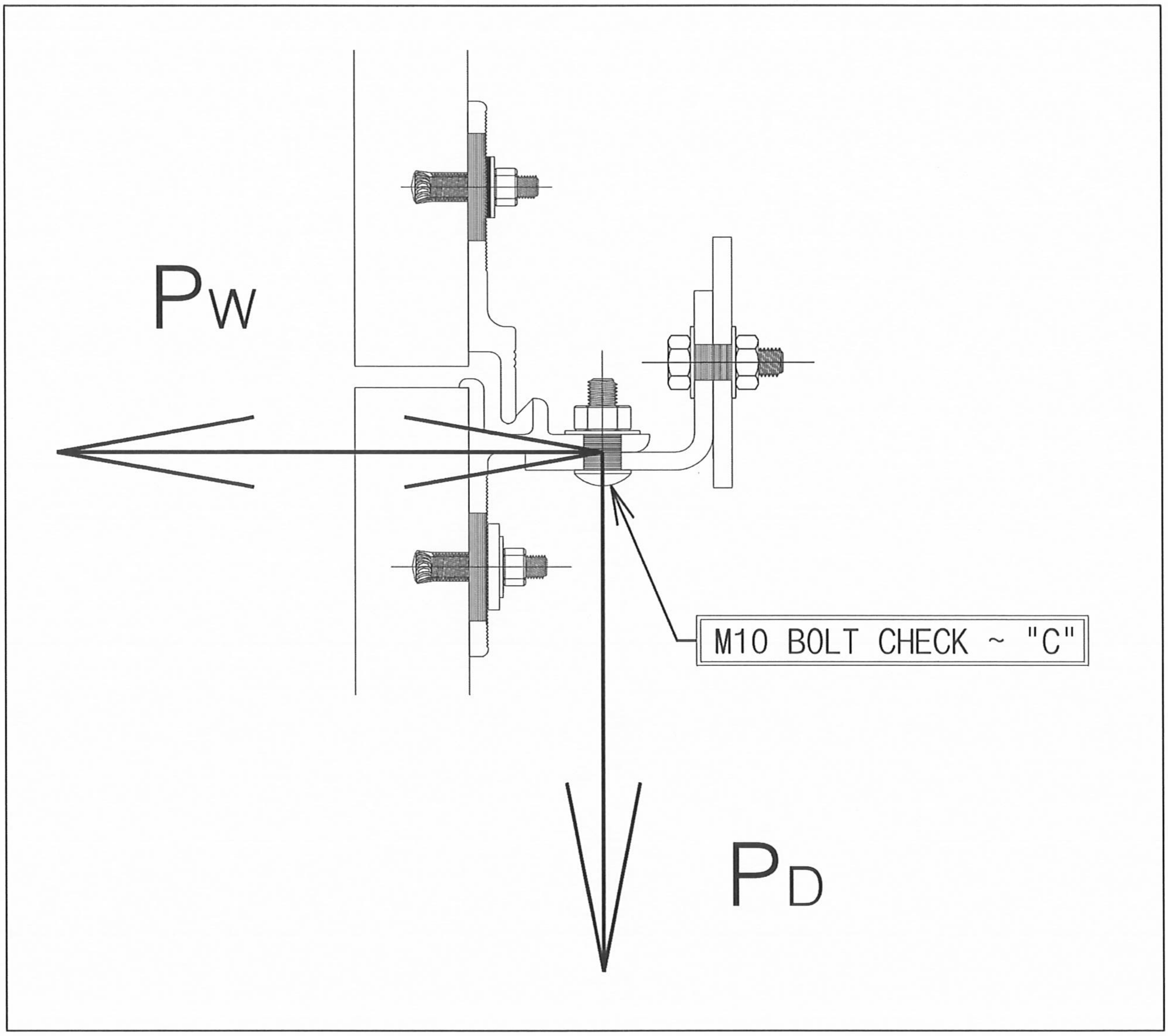
t = 5.00 mm

[3] Stress Ratio

$\frac{f_b}{F_b}$ = 0.52 < 1.0 ∴ O. K.

3) M10 BOLT CHECK ~ "C"

-. Steel. Grade 4.8 - 1ea.



[1] Actual Force

V_{act} = $P_{W(P)} \times 2$ = 380.00 N

[2] Allowable Force

T_{allow} = [$0.75 \times F_Y \times A(S)$] = 14263.52 N

V_{allow} = [$0.75 \times F_Y \times A(R) / \sqrt{3}$] = 7465.68 N

Bolt diameter = 10 mm

F_y = 340 MPa

A(S) = 55.94 mm^2

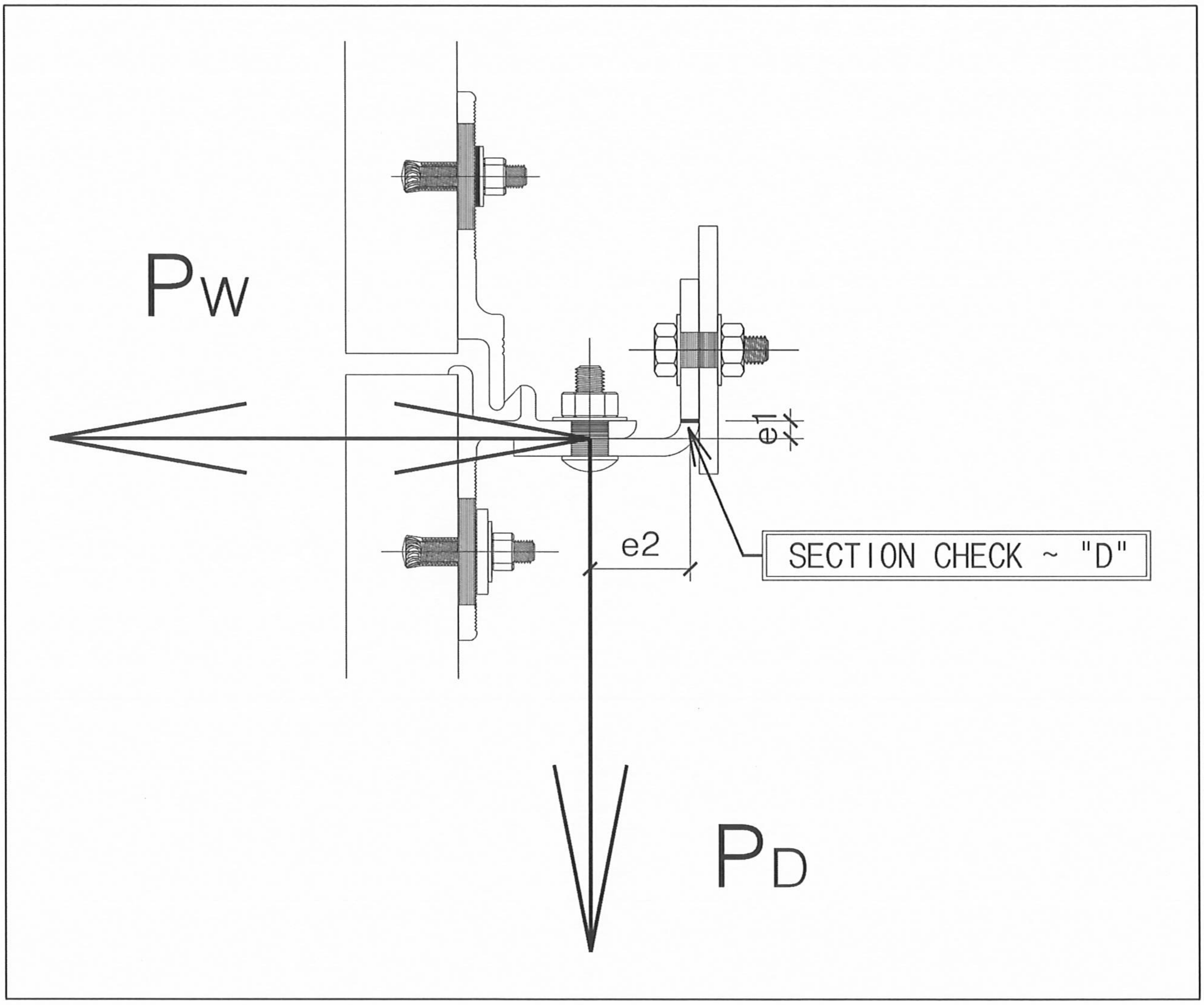
A(R) = 50.71 mm^2

[3] Force Ratio

$$\frac{V_{act}}{V_{allow}} = 0.05 < 1.0 \quad \therefore \text{O. K.}$$

4) SS'T SECTION CHECK ~ "D"

-. 5T-50LG, STS 304, Condition A



[1] Actual Stress

$M = P_{W(P)} \times e_1 \times 2 + P_D \times e_2 =$ 9730.00 N.mm

e_1 = 5 mm

e_2 = 27 mm

b = 50 mm

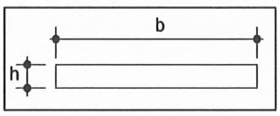
h(t) = 5.00 mm

A = 250.00 mm^2

Z_X = 208.33 mm^3

Z_Y = 2083.33 mm^3

$f_b = M / Z_X$ = 46.70 N/mm^2 (Mpa)



[2] Allowable Stress

F_y = 30.0 ksi = 206.7 N/mm^2

$F_b = F_y / 1.85$ = 111.7 N/mm^2

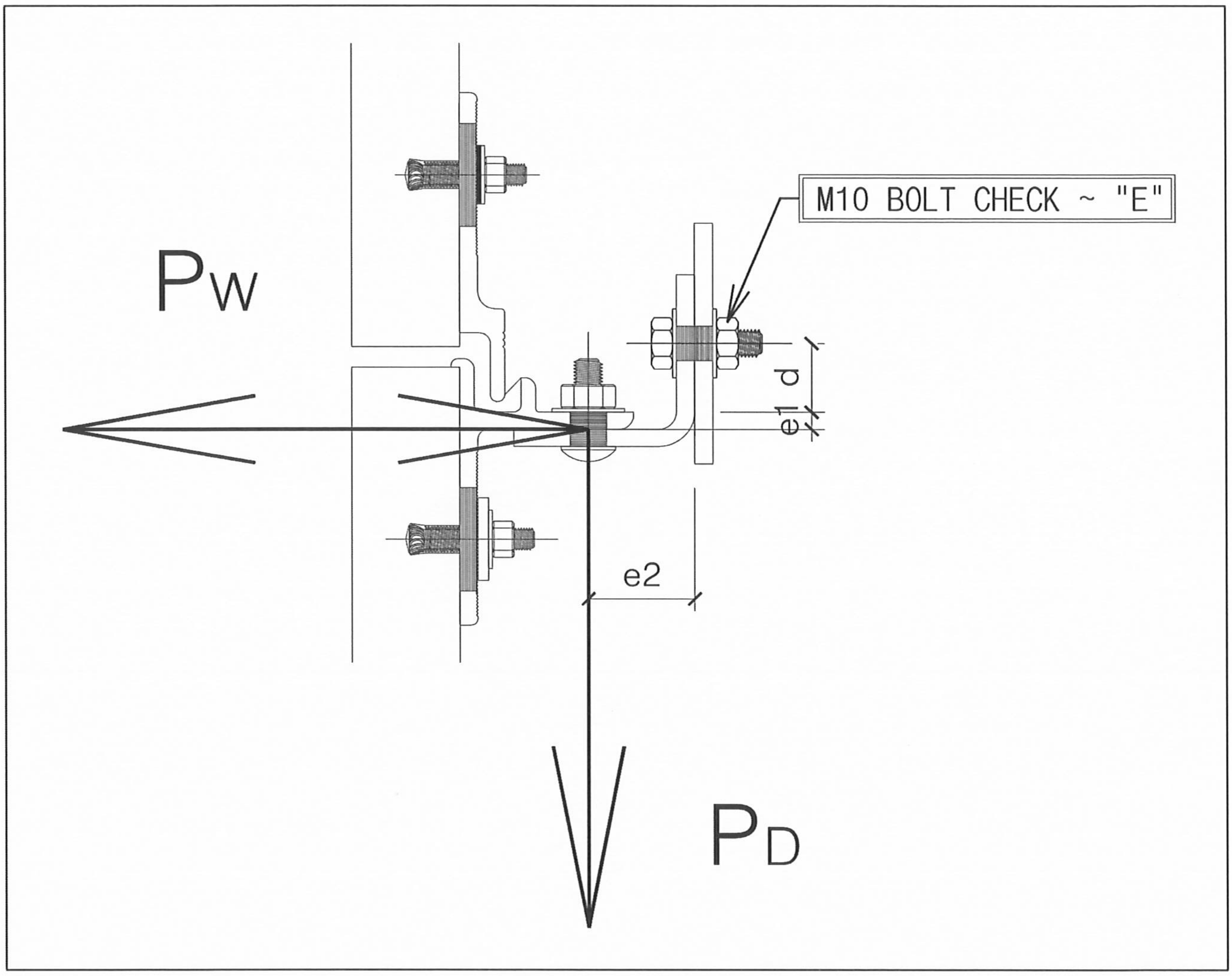
$F_S = F_y / 1.64$ = 126.0 N/mm^2

[3] Stress Ratio

$\frac{f_b}{F_b}$ = 0.42 < 1.0 ∴ O. K.

5) M10 BOLT CHECK ~ "E"

-. Steel. Grade 4.8 - 1ea.



[1] Actual Force

$M = P_{W(P)} \times e_1 \times 2 + P_D \times e_2 =$ 10455.00 N.mm

e_1 = 5 mm

e_2 = 29.5 mm

d = 20 mm

$T_{act} = M / d =$ 522.75 N

$V_{act} = P_D =$ 290.00 N

[2] Allowable Force

Bolt diameter = 10 mm

$T_{allow} = [\ 0.75 \times F_Y \times A(S)\ ] =$ 14263.52 N

$V_{allow} = [\ 0.75 \times F_Y \times A(R) / \sqrt{3}\ ] =$ 7465.68 N

F_y = 340 MPa

$A(S)$ = 55.94 mm^2

$A(R)$ = 50.71 mm^2

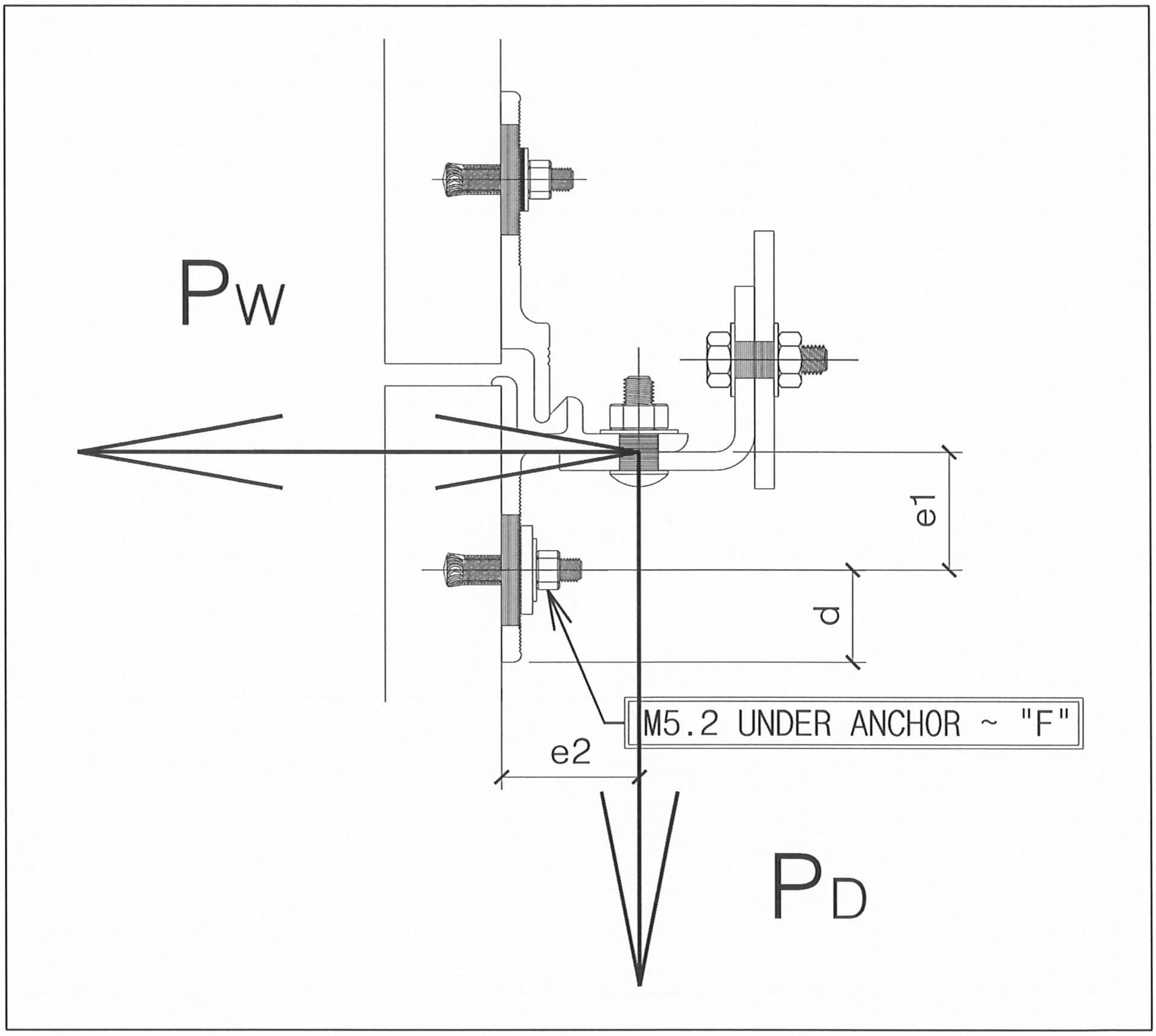
[3] Force Ratio

$\frac{V_{act}}{V_{allow}} =$ 0.04 < 1.0 ∴ O. K.

$\frac{T_{act}}{T_{allow}} =$ 0.04 < 1.0 ∴ O. K.

6) M5.2 UNDER ANCHOR CHECK ~ "F"

-. STS 304, Condition A



[1] Actual Force

$M = P_{W(P)} \times e_1 + P_D \times e_2 =$		16375.00 N.mm	e_1	=	32 mm
			e_2	=	35.5 mm
$T_{act} = M / d =$	545.83 N		d	=	30 mm
$V_{act} = P_D =$	290.00 N				

[2] Allowable Force

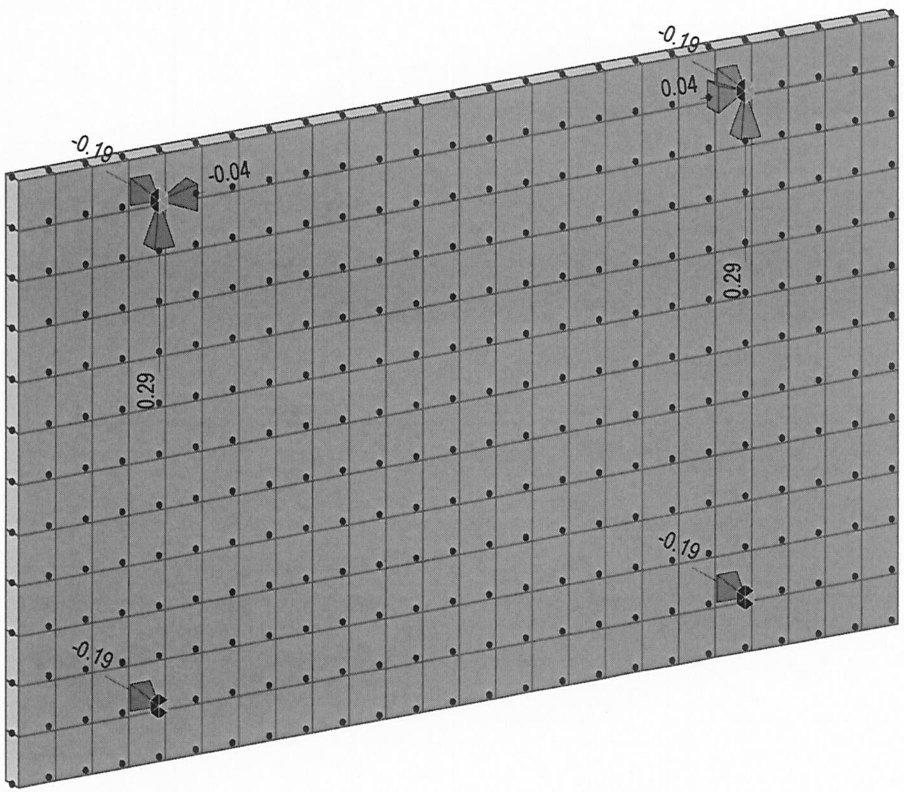
		Bolt diameter	=	5.2 mm
$T_{allow} =$	739.00 N	F_y	=	206 MPa
$V_{allow} = [\ 0.75 \times F_Y \times A(R) / \sqrt{3}\ ] =$	949.55 N	A(S)	=	12.26 mm^2
		A(R)	=	10.65 mm^2

[3] Force Ratio

$$\frac{V_{act}}{V_{allow}} = 0.31 < 1.0 \quad \therefore \text{O. K.}$$

$$\frac{T_{act}}{T_{allow}} = 0.74 < 1.0 \quad \therefore \text{O. K.}$$

-. REACTION



midas Gen
POST-PROCESSOR

REACTION FORCE

FORCE-XYZ

MIN. REACTION
NODE= 326
FX: 0.0000E+000
FY: -1.8574E-001
FZ: 0.0000E+000
FXYZ: 1.8574E-001

MAX. REACTION
NODE= 52
FX: 4.1314E-002
FY: -1.8574E-001
FZ: 2.8596E-001
FXYZ: 3.4348E-001

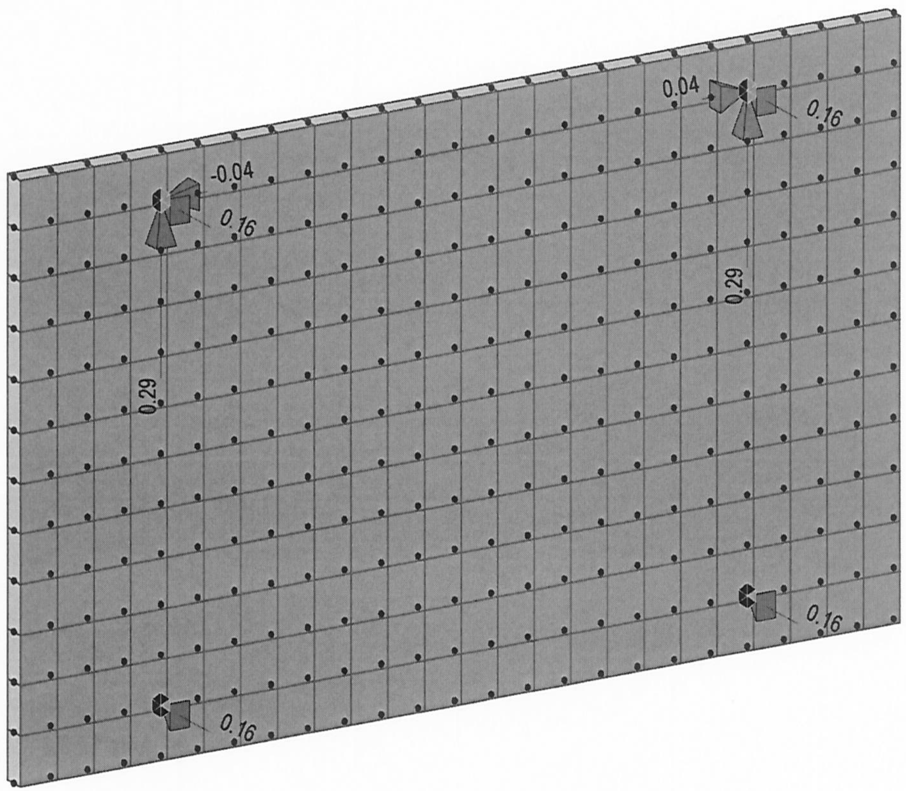
CBS: sLCB1

MAX : 52
MIN : 326

FILE: 석재 30T (~
UNIT: kN
DATE: 02/27/2020

VIEW-DIRECTION
X:-0.483
Y:-0.837
Z: 0.259

-. REACTION



midas Gen
POST-PROCESSOR

REACTION FORCE

FORCE-XYZ

MIN. REACTION

NODE= 326

FX: 0.0000E+000

FY: 1.5881E-001

FZ: 0.0000E+000

FXYZ: 1.5881E-001

MAX. REACTION

NODE= 52

FX: 4.1314E-002

FY: 1.5881E-001

FZ: 2.8596E-001

FXYZ: 3.2970E-001

CBS: sLCB2

MAX : 52
MIN : 326

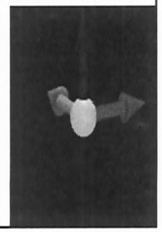
FILE: 석재 30T (~
UNIT: kN
DATE: 02/27/2020

VIEW-DIRECTION

X:-0.483

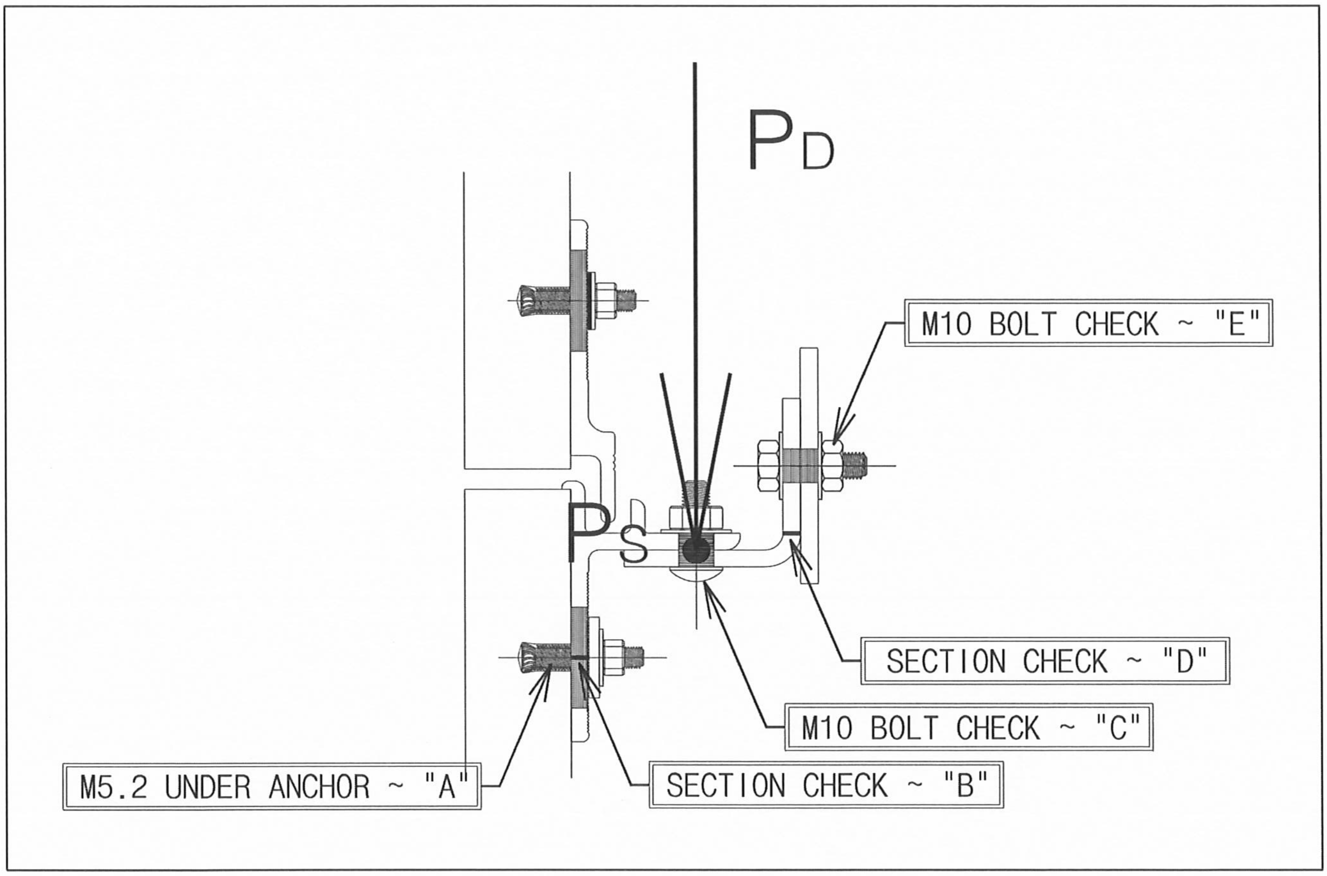
Y:-0.837

Z: 0.259



8. 연결 철물 분석 (SEI.L+DL)

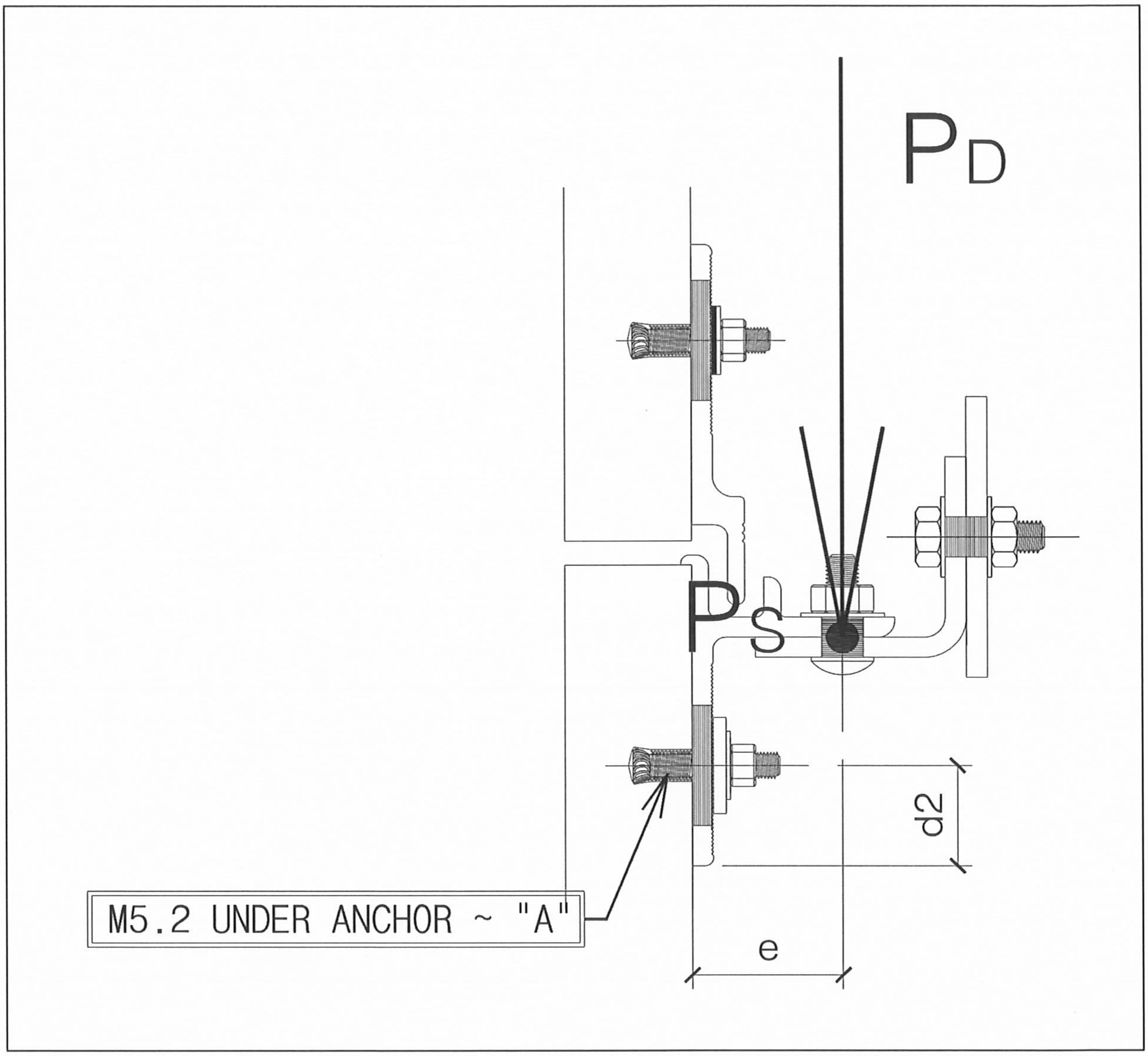
1. 석재 연결 철물 검토 (SL+DL)



P_S	=	0.19 kN	=	190.0 N
P_D	=	0.38 kN	=	380.0 N

1) M5.2 UNDER ANCHOR CHECK ~ "A"

-. STS 304, Condition A



[1] Actual Force

M_1	$= P_S \times e =$	6745.00 N.mm	e	=	35.5 mm
M_2	$= P_D \times e =$	13490.00 N.mm			
T_{act}	$= M_1 / d_1 + M_2 / d_2 =$	674.50 N	d_1	=	30 mm
V_{act}	$= \sqrt{[(P_S^2) + (P_D^2)]} =$	424.85 N	d_2	=	30 mm

[2] Allowable Force

Bolt diameter = 5.2 mm

T_{allow} = 739.00 N

$V_{allow} = [0.75 \times F_Y \times A(R) / \sqrt{3}] =$ 949.55 N

F_y = 206 MPa

A(S) = 12.26 mm^2

A(R) = 10.65 mm^2

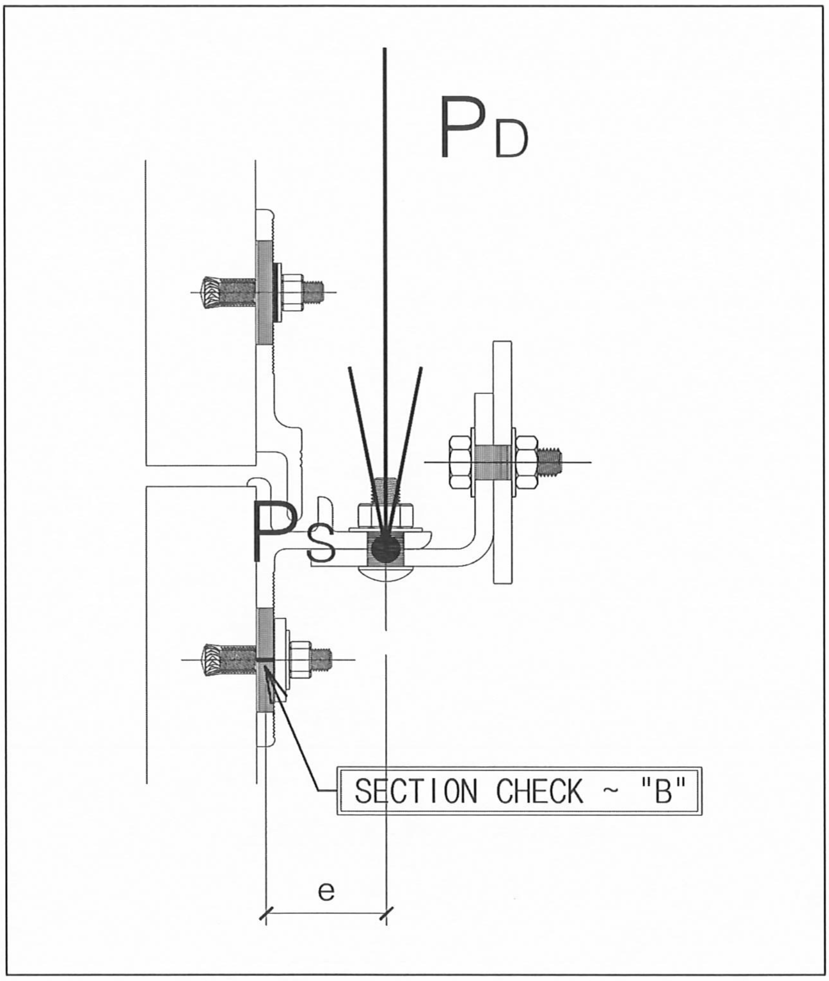
[3] Force Ratio

$\frac{V_{act}}{V_{allow}}$ = 0.45 < 1.0 ∴ O. K.

$\frac{T_{act}}{T_{allow}}$ = 0.91 < 1.0 ∴ O. K.

2) AL. SECTION CHECK ~ “B“

-. 5T-60LG, Alloy & Temper 6063-T6. (ADM 2010 Table 2-21)



[1] Actual Stress

$M_1 = P_S \times e =$ 6270.00 N.mm

$M_2 = P_D \times e =$ 12540.00 N.mm

e = 33 mm

b = 60 - 6.2 = 53.8 mm

h(t) = 5.00 mm

A = 269.00 mm^2

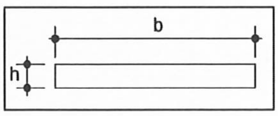
Z_X = 224.17 mm^3

Z_Y = 2412.03 mm^3

J = 2241.67 mm^4

$f_b = M_2 / Z_X =$ 55.94 N/mm^2 (Mpa)

$f_S = M_1\, t / J =$ 13.99 N/mm^2 (Mpa)



[2] Allowable Stress

F_{ty} = 170 Mpa

F_b = 19.7 ksi = 135 Mpa (F.8.1.2, F.4.1)

F_S = 9.1 ksi = 62.7 Mpa (G.2)

[b / t = 10.76 $\leq S_1$ = 38.7]

b = 53.8 mm

t = 5.00 mm

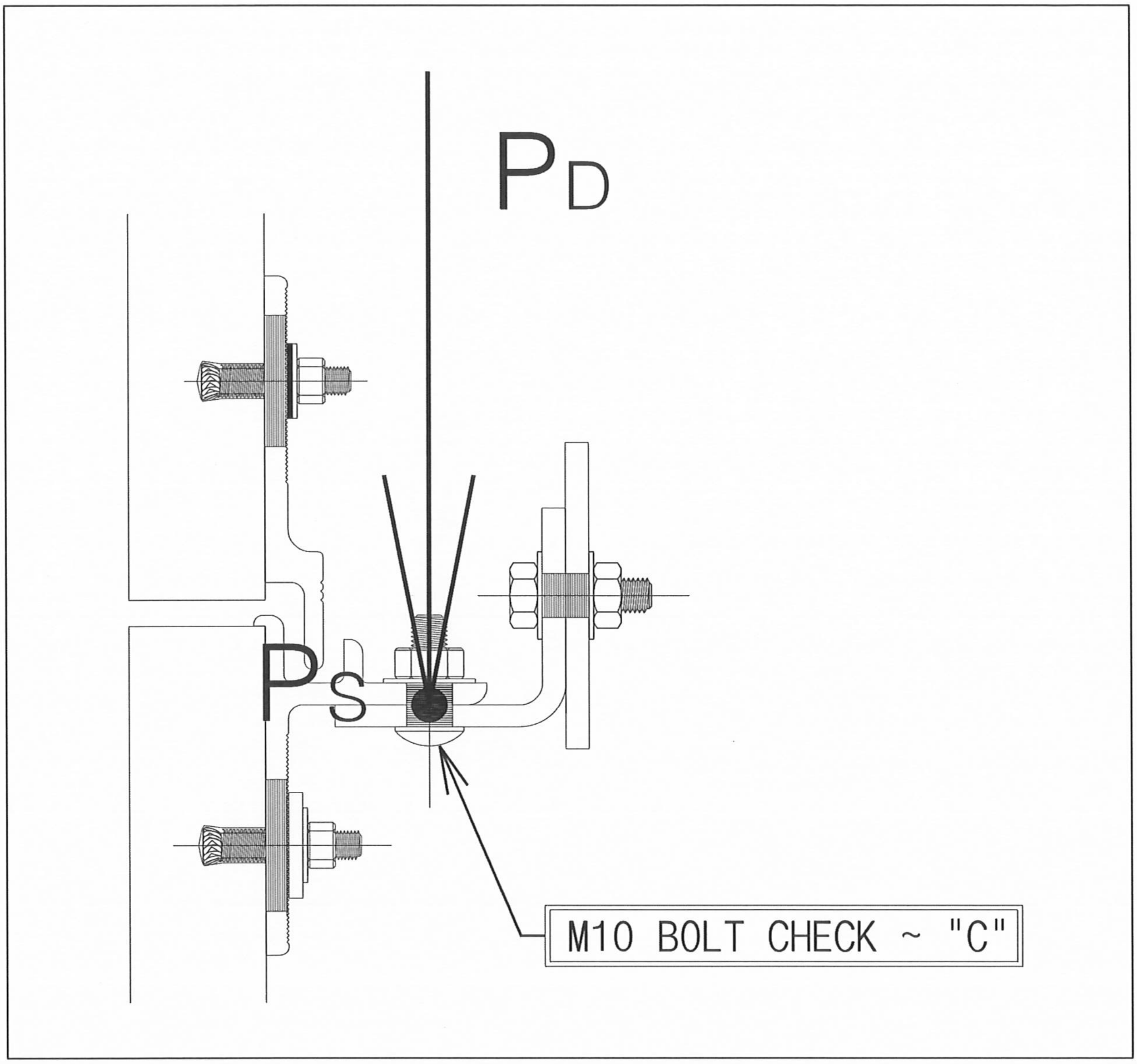
[3] Stress Ratio

$\frac{f_b}{F_b}$ = 0.41 < 1.0 ∴ O. K.

$\frac{f_S}{F_S}$ = 0.22 < 1.0 ∴ O. K.

3) M10 BOLT CHECK ~ “C“

-. Steel. Grade 4.8 - 1ea.



[1] Actual Force

V_{act} = P_S = 190.00 N

[2] Allowable Force

Bolt diameter = 10 mm

T_{allow} = [0.75 × F_Y × A(S)] = 14263.52 N

V_{allow} = [0.75 × F_Y × A(R) / $\sqrt{3}$] = 7465.68 N

F_y = 340 MPa

A(S) = 55.94 mm^2

A(R) = 50.71 mm^2

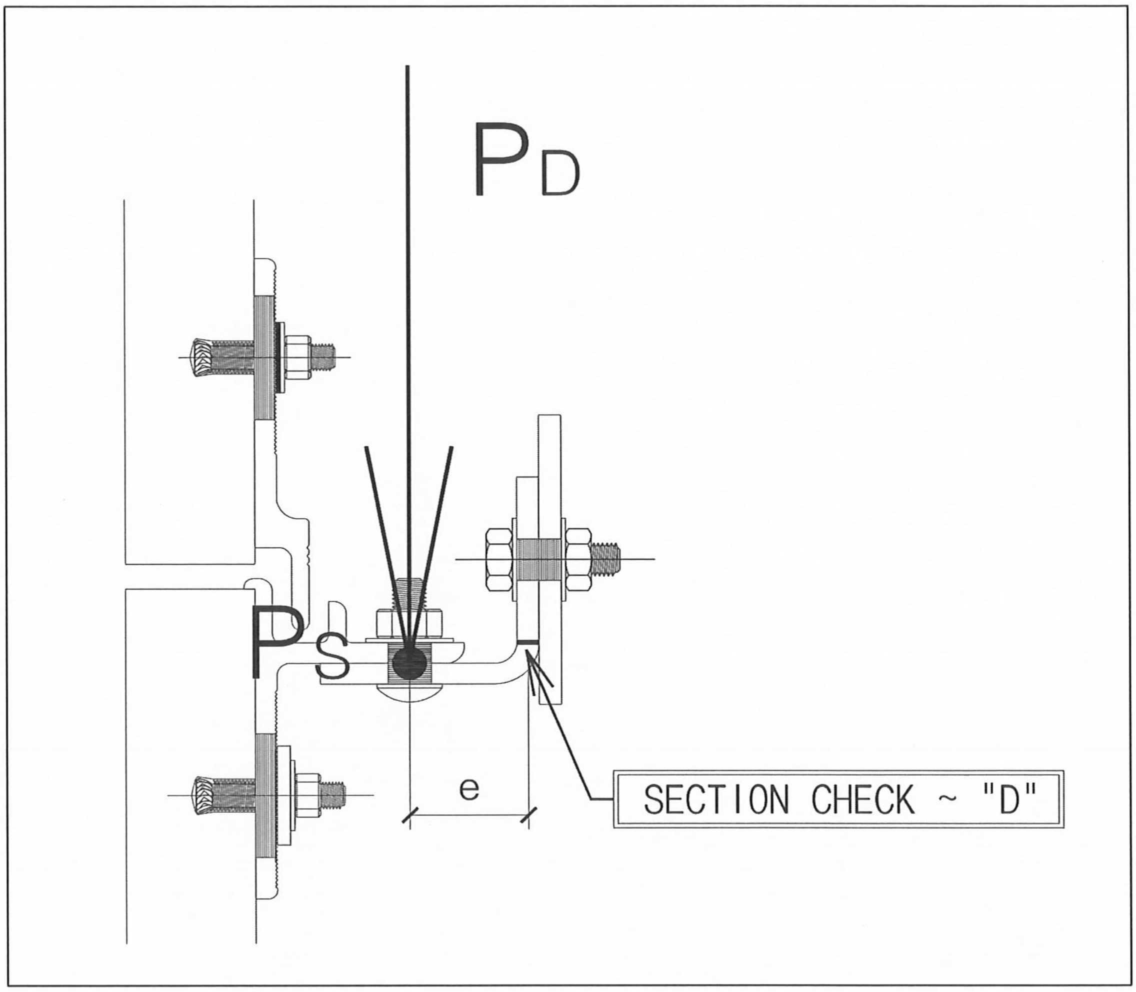
[3] Force Ratio

$$\frac{V_{act}}{V_{allow}} = 0.03 < 1.0$$

∴ O. K.

4) SS'T SECTION CHECK ~ "D"

-. 5T-50LG, STS 304, Condition A



[1] Actual Stress

$M_1 = P_S \times e =$ 5130.00 N.mm $e =$ 27 mm

$M_2 = P_D \times e =$ 10260.00 N.mm

$b =$ 50 mm $h(t) =$ 5.00 mm

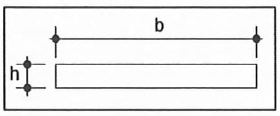
$A =$ 250.00 mm^2

$Z_X =$ 208.33 mm^3 $Z_Y =$ 2083.33 mm^3

$J =$ 2083.33 mm^4

$f_b = M_2 / Z_X =$ 49.25 N/mm^2 (Mpa)

$f_s = M_1\ t / J =$ 12.31 N/mm^2 (Mpa)



[2] Allowable Stress

$F_y =$ 30.0 ksi = 206.7 N/mm^2

$F_b = F_y / 1.85 =$ 111.7 N/mm^2

$F_s = F_y / 1.64 =$ 126.0 N/mm^2

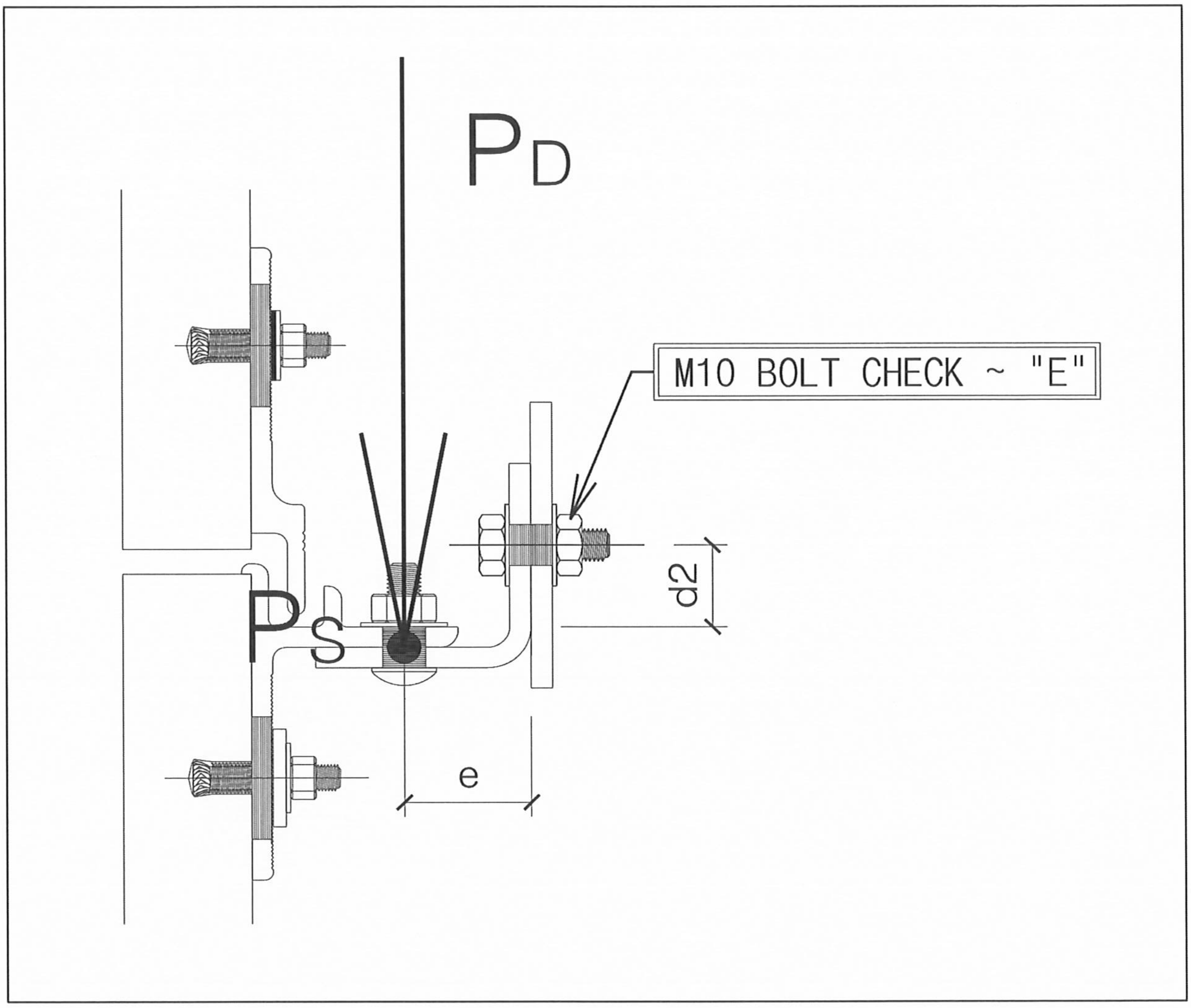
[3] Stress Ratio

$\frac{f_b}{F_b}$ = 0.44 < 1.0 ∴ O. K.

$\frac{f_s}{F_s}$ = 0.10 < 1.0 ∴ O. K.

5) M10 BOLT CHECK ~ "E"

-. Steel. Grade 4.8 - 1ea.



[1] Actual Force

M_1	$= P_S \times e =$ 5605.00 N.mm	e	= 29.5 mm
M_2	$= P_D \times e =$ 11210.00 N.mm		
T_{act}	$= M_1 / d_1 + M_2 / d_2 =$ 784.70 N	d_1	= 25 mm
V_{act}	$= P_D =$ 380.00 N	d_2	= 20 mm

[2] Allowable Force

Bolt diameter = 10 mm

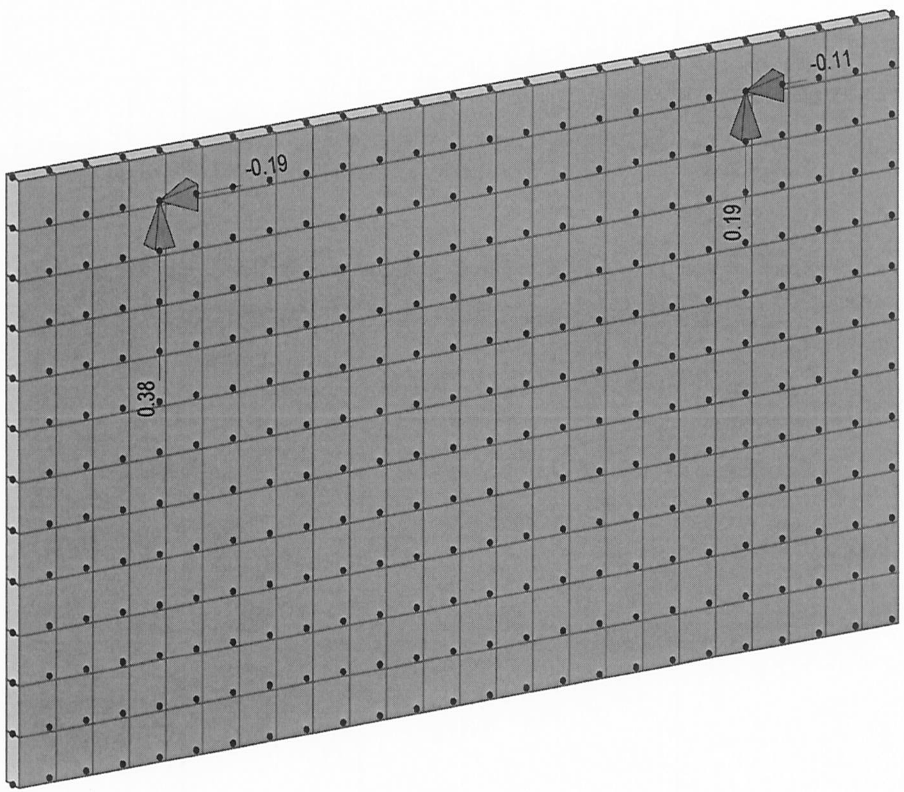
T_{allow}	$= [\ 0.75 \times F_Y \times A(S)\ ] =$ 14263.52 N	F_y	= 340 MPa
V_{allow}	$= [\ 0.75 \times F_Y \times A(R) / \sqrt{3}\ ] =$ 7465.68 N	A(S)	= 55.94 mm^2
		A(R)	= 50.71 mm^2

[3] Force Ratio

$$\frac{V_{act}}{V_{allow}} = 0.05 < 1.0 \quad \therefore \text{O. K.}$$

$$\frac{T_{act}}{T_{allow}} = 0.06 < 1.0 \quad \therefore \text{O. K.}$$

-. REACTION



midas Gen
POST-PROCESSOR

REACTION FORCE

FORCE-XYZ

MIN. REACTION

NODE= 52

FX: -1.0989E-001

FY: 0.0000E+000

FZ: 1.9146E-001

FXYZ: 2.2075E-001

MAX. REACTION

NODE= 36

FX: -1.9251E-001

FY: 0.0000E+000

FZ: 3.8046E-001

FXYZ: 4.2640E-001

CBS: sLCB

MAX : 36
MIN : 52

FILE: 석재 30T (~
UNIT: kN
DATE: 02/27/2020

VIEW-DIRECTION

X:-0.483

Y:-0.837

Z: 0.259