Post-Tensioned Transfer Slab in Vertically Irregular Building

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DAELIM

A. PT Transfer Slab Application

PT Transfer Slab in High-rise Building

The Cullinan, Kowloon Hong Kong (68F)

Belcher Garden, Hong Kong (63F)

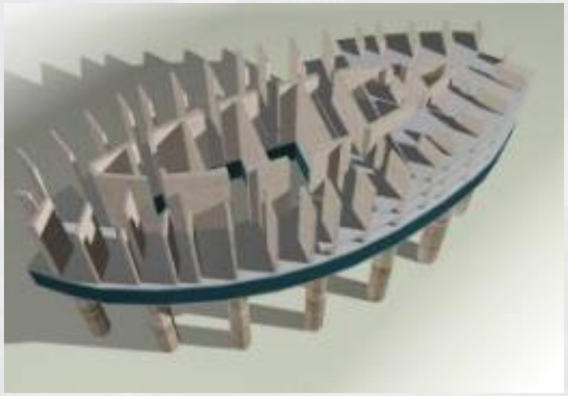
Pacific Place Building (VSL Hong Kong, 1988)

Pacific Place Building (61F)

1st PT Transfer Slab

(Designed by Prof. Peter Marti)

- PT Transfer Slab Thickness 4.5m
- Rebar (480kg/m^3 → 180kg/m^3)
- Better Structural Performance
- Easier Construction
- Economy



Pacific Place Building (VSL Hong Kong, 1988)

Installation of Side Formwork

Installation of Anchorage

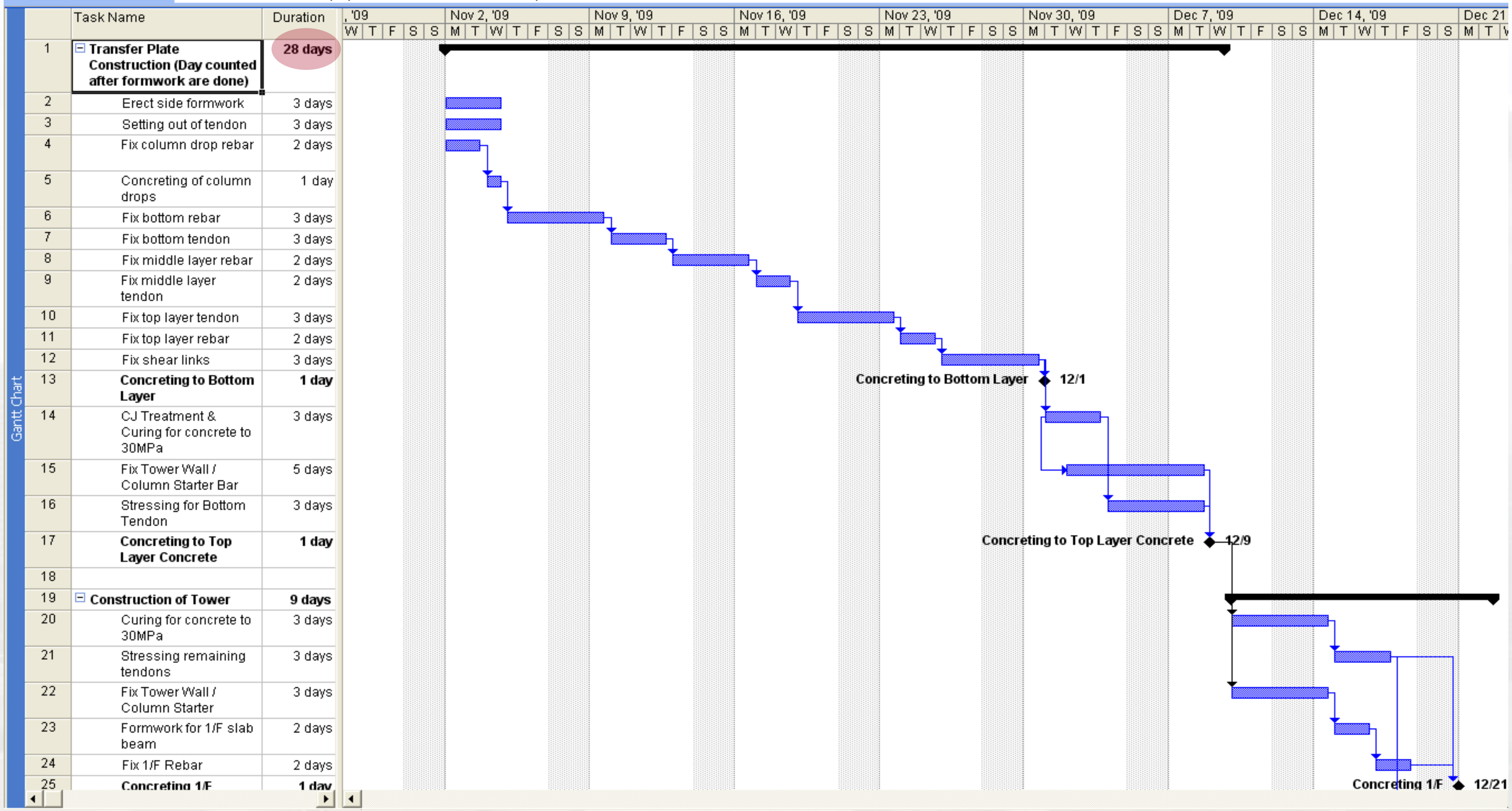
Installation of Reinforcement & Tendon

Installation of Reinforcement & Tendon

Pacific Place Building (VSL Hong Kong, 1988)

Transfer Plate Construction (Day counted after formwork are done)

	Task Name	Duration
1	**Transfer Plate Construction (Day counted after formwork are done)**	**28 days**
2	Erect side formwork	3 days
3	Setting out of tendon	3 days
4	Fix column drop rebar	2 days
5	Concreting of column drops	1 day
6	Fix bottom rebar	3 days
7	Fix bottom tendon	3 days
8	Fix middle layer rebar	2 days
9	Fix middle layer tendon	2 days
10	Fix top layer tendon	3 days
11	Fix top layer rebar	2 days
12	Fix shear links	3 days
13	**Concreting to Bottom Layer**	**1 day**
14	CJ Treatment & Curing for concrete to 30MPa	3 days
15	Fix Tower Wall / Column Starter Bar	5 days
16	Stressing for Bottom Tendon	3 days
17	**Concreting to Top Layer Concrete**	**1 day**
18		
19	**Construction of Tower**	**9 days**
20	Curing for concrete to 30MPa	3 days
21	Stressing remaining tendons	3 days
22	Fix Tower Wall / Column Starter	3 days
23	Formwork for 1/F slab beam	2 days
24	Fix 1/F Rebar	2 days
25	**Concreting 1/F**	**1 day**



B. PT Transfer Slab Design

NEST Hotel (DAELIM, 2014)

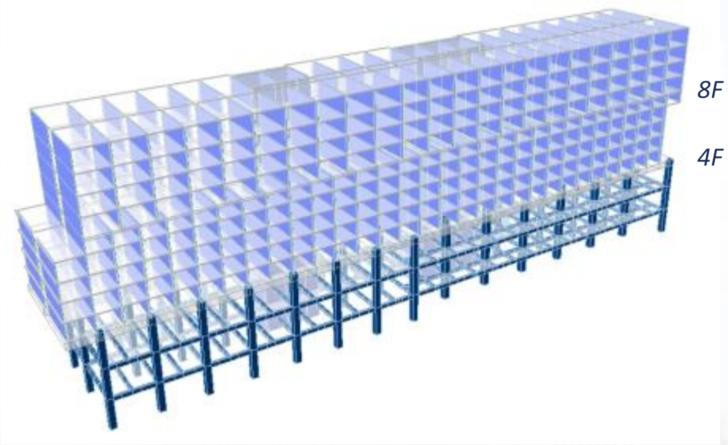
Vertically Irregular Structure _ Design Stage

NEST Hotel (DAELIM, 2014)

Vertically Irregular Structure _ Construction Stage

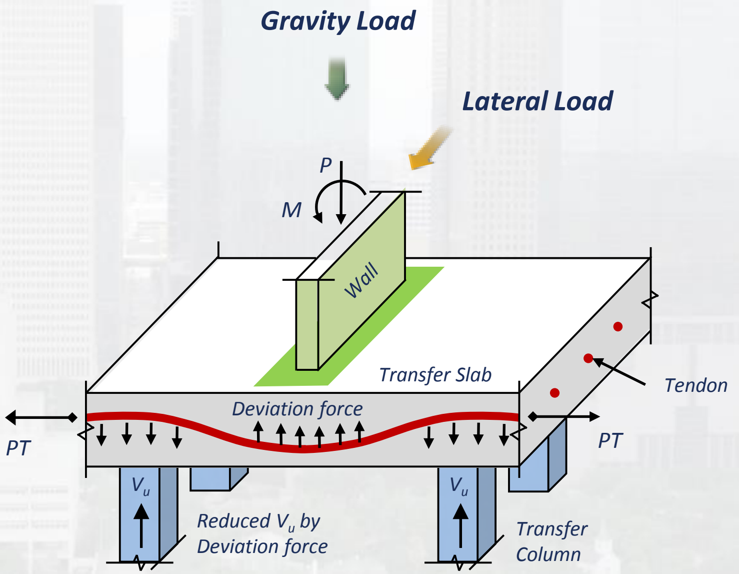
NEST Hotel (DAELIM, 2014)

Post-Tensioned Transfer Slab (Cantilevered)



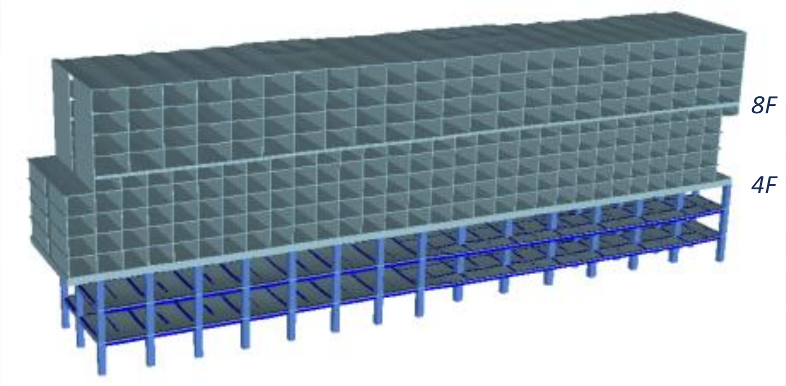
Structural Modeling by MIDAS

Why Post-Tensioning to Transfer Slab ?

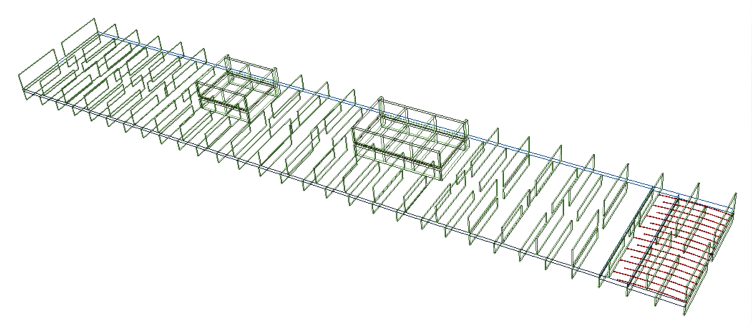


NEST Hotel (DAELIM, 2014)

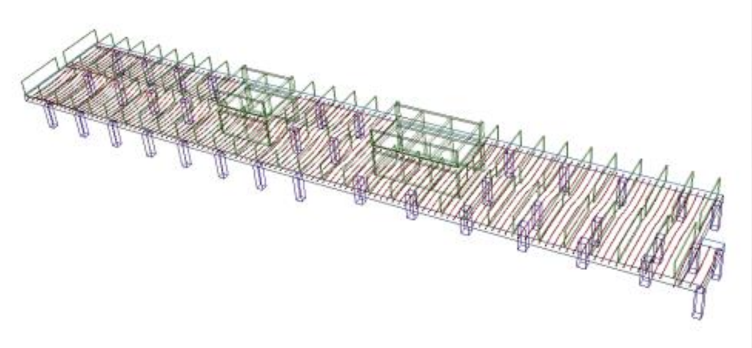
Post-Tensioned Transfer Slab (Cantilevered)



Structural Modeling by ADAPT



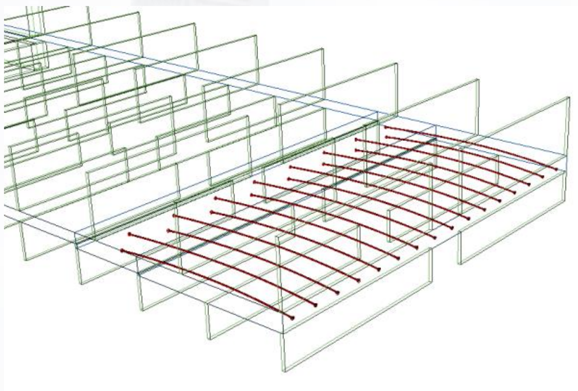
8F_PT Transfer Slab



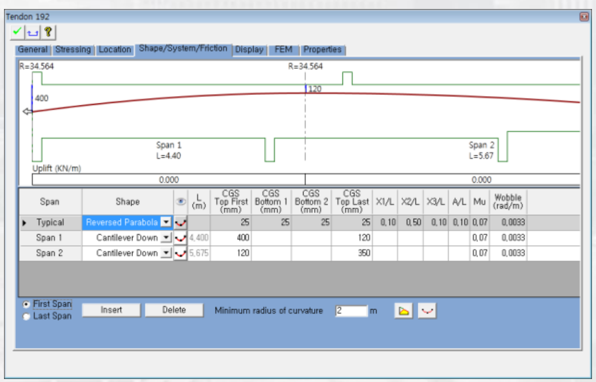
4F_PT Transfer Slab

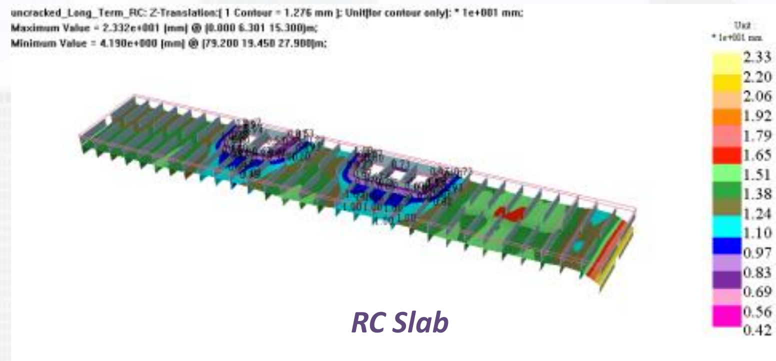
NEST Hotel (DAELIM, 2014)

8F Cantilevered Transfer Slab _ Long-term Deflection Check

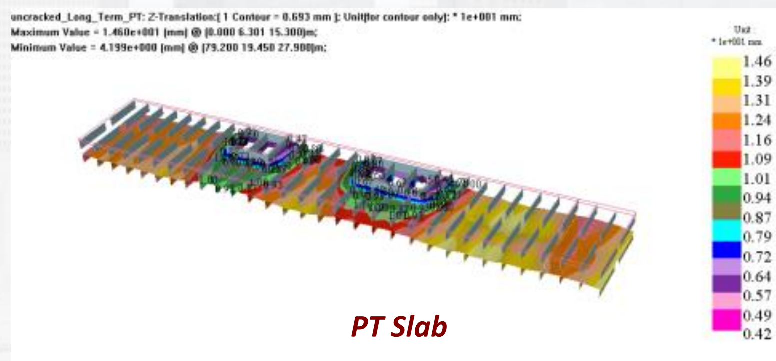


Distributed Tendon Profile
(10EA_15.2mm@1,200)





RC Slab



PT Slab

δ=23.3mm → δ=14.6mm ***(-37%)***

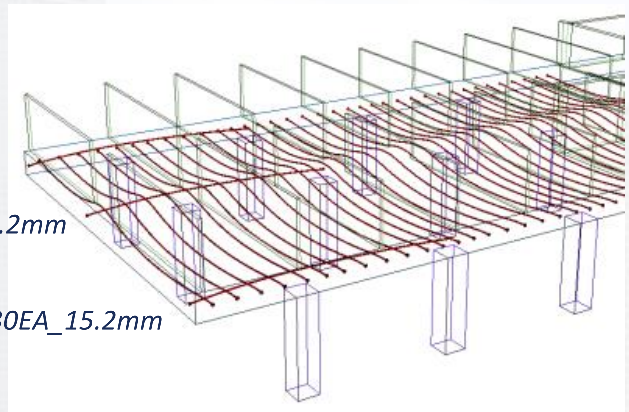
(Limit : L/240 = 15.6mm, L=3,750mm)

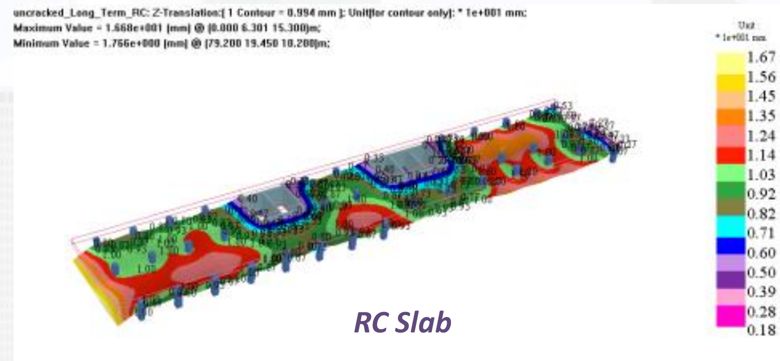
NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ Long-term Deflection Check

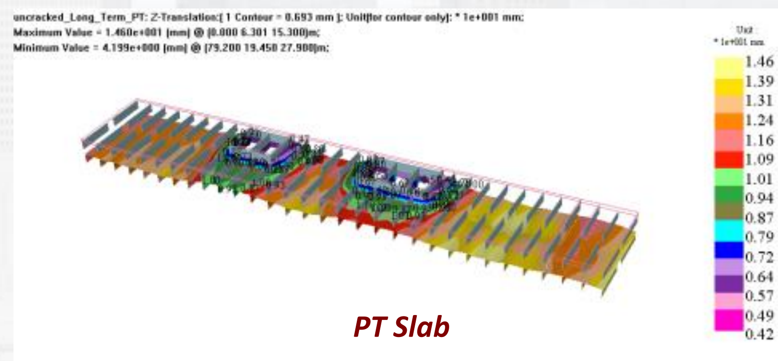
60EA_15.2mm

30EA_15.2mm



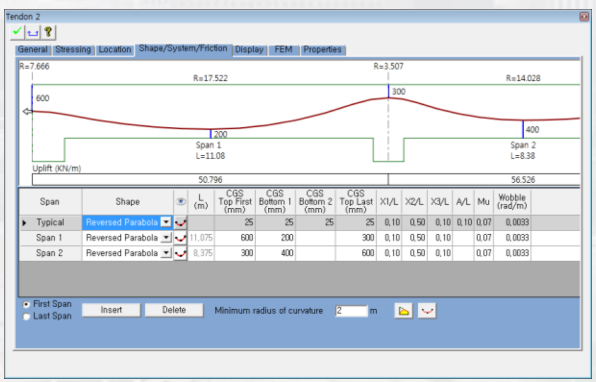


RC Slab



PT Slab

Distributed Tendon Profile
(8EA_15.2mm@1,000)



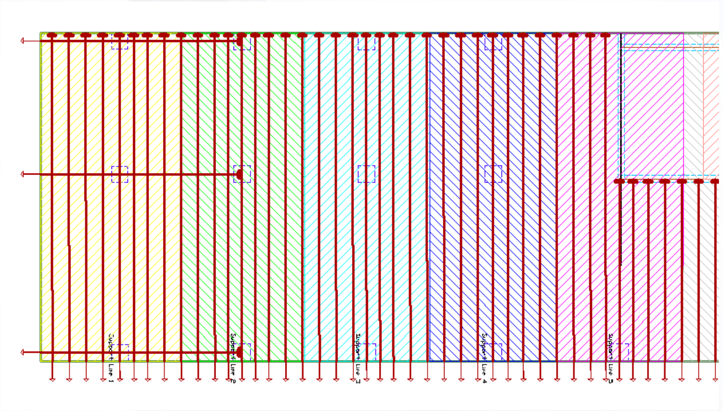
Span	Shape	L (m)	CGS Top First (mm)	CGS Bottom 1 (mm)	CGS Bottom 2 (mm)	CGS Top Last (mm)	X1/L	X2/L	X3/L	A/L	Mu	Wobble (rad/m)
Typical	Reversed Parabola		25	25	25	25	0.10	0.50	0.10	0.10	0.07	0.0033
Span 1	Reversed Parabola	11.075	600	200		300	0.10	0.50	0.10		0.07	0.0033
Span 2	Reversed Parabola	8.375	300	400		600	0.10	0.50	0.10		0.07	0.0033

δ=16.7mm → δ=12.6mm ***(-25%)***

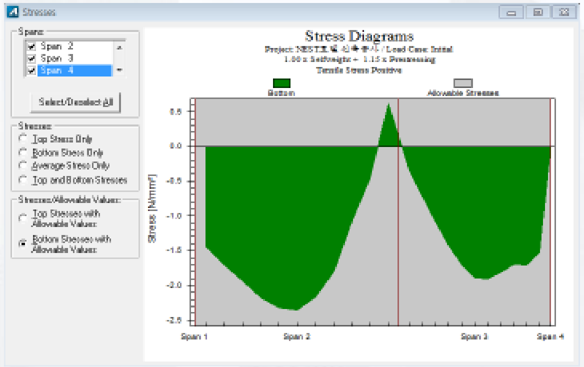
(Limit : L/240 = 17.5mm, L=4,200mm)

NEST Hotel (DAELIM, 2014)

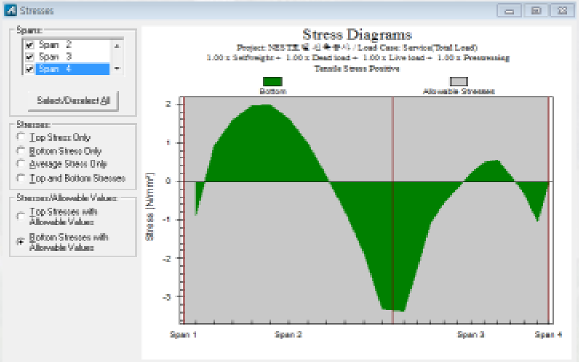
4F Cantilevered Transfer Slab _ Initial & SLS Check



< Design Strip _ Y-dir >



< Bottom Stress _ Initial >



< Bot Stress _ Serviceability >

KBC 2012 / ACI Code

1) Initial Stage

① Tensile Stress : $0.25\sqrt{f_{ci}} = 1.17\text{MPa}$ (f_{ci}=22MPa)

② Comp. Stress : $0.6f_{ci} = 13.2\text{MPa}$ (f_{ci}=22MPa)

2) Serviceability Stage

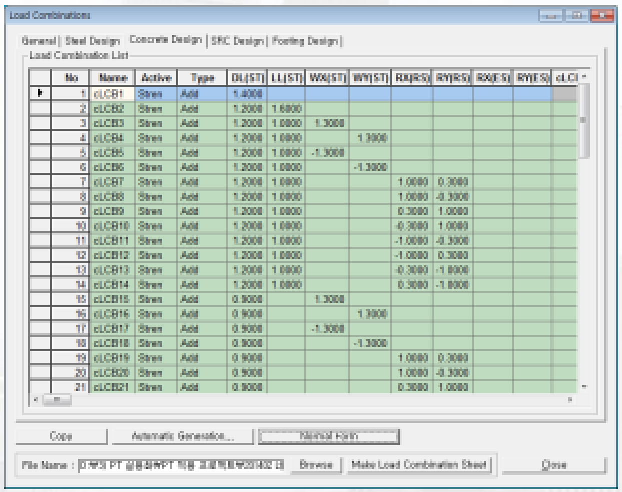
① Tensile Stress : $0.5\sqrt{f_{ck}} = 2.96\text{MPa}$ (f_{ck}=35MPa)

② Comp. Stress : $0.60f_{ck} = 21\text{MPa}$ (f_{ck}=35MPa)

NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ ULS Design

Load Combination (KBC : Korean Building Code)


Load Combinations

General | Steel Design | Concrete Design | SRC Design | Footing Design |

Load Combination List

No	Name	Active	Type	DL(ST)	LL(ST)	WX(ST)	WY(ST)	RX(RS)	RY(RS)	RX(ES)	RY(ES)	cLCI
1	cLCB1	Stren	Add	1.4000								
2	cLCB2	Stren	Add	1.2000	1.6000							
3	cLCB3	Stren	Add	1.2000	1.0000	1.3000						
4	cLCB4	Stren	Add	1.2000	1.0000		1.3000					
5	cLCB5	Stren	Add	1.2000	1.0000	-1.3000						
6	cLCB6	Stren	Add	1.2000	1.0000		-1.3000					
7	cLCB7	Stren	Add	1.2000	1.0000			1.0000	0.3000			
8	cLCB8	Stren	Add	1.2000	1.0000			1.0000	-0.3000			
9	cLCB9	Stren	Add	1.2000	1.0000			0.3000	1.0000			
10	cLCB10	Stren	Add	1.2000	1.0000			-0.3000	1.0000			
11	cLCB11	Stren	Add	1.2000	1.0000			-1.0000	-0.3000			
12	cLCB12	Stren	Add	1.2000	1.0000			-1.0000	0.3000			
13	cLCB13	Stren	Add	1.2000	1.0000			-0.3000	-1.0000			
14	cLCB14	Stren	Add	1.2000	1.0000			0.3000	-1.0000			
15	cLCB15	Stren	Add	0.9000		1.3000						
16	cLCB16	Stren	Add	0.9000			1.3000					
17	cLCB17	Stren	Add	0.9000		-1.3000						
18	cLCB18	Stren	Add	0.9000			-1.3000					
19	cLCB19	Stren	Add	0.9000				1.0000	0.3000			
20	cLCB20	Stren	Add	0.9000				1.0000	-0.3000			
21	cLCB21	Stren	Add	0.9000				0.3000	1.0000			

Copy | Automatic Generation... | Normal Form

File Name : | Browse | Make Load Combination Sheet | Close

1.4D

1.2D + 1.6L

1.2D ± W + 1.0L

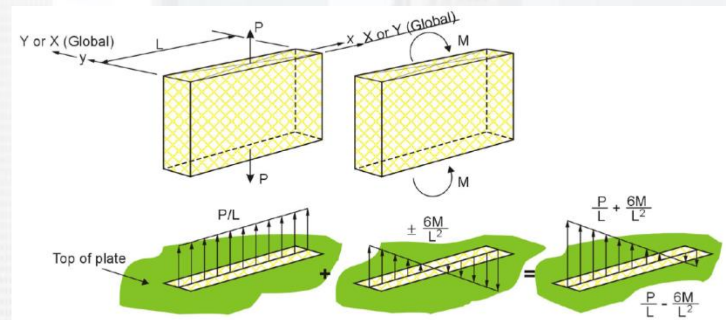
0.9D ± 1.3W

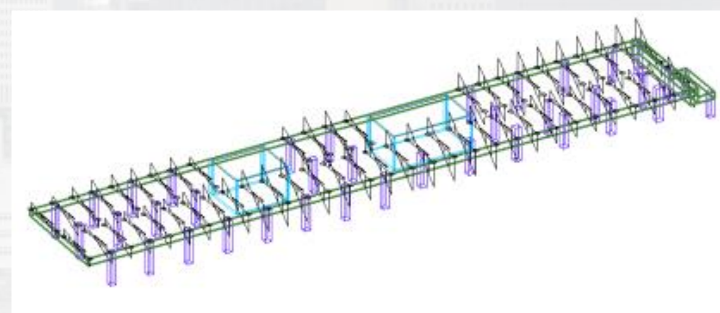
1.2D ± E_m + 1.0L

0.9D ± E_m

Equivalent Wall Line Load Calculation

: $P/L \pm 6M/L^2$





NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ ULS Design

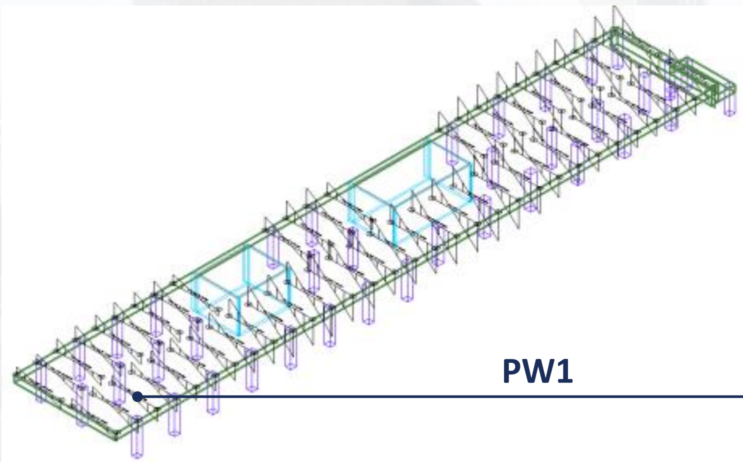
Special Earthquake Load (KBC : Korean Building Code)

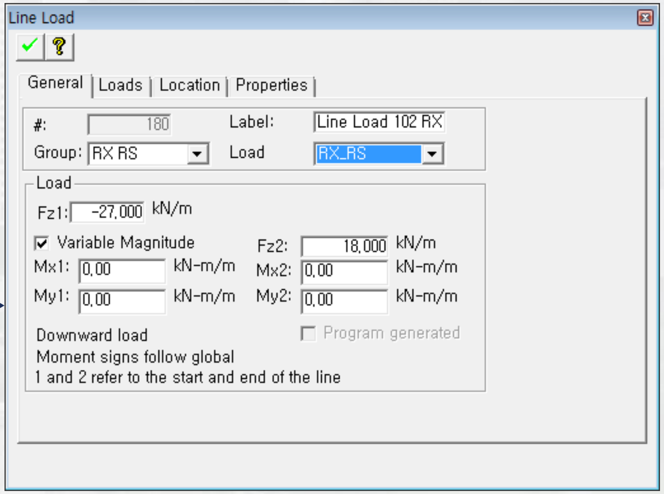
$$E_m = \Omega_o \cdot E \pm 0.2 \cdot S_{DS} \cdot D$$

$\Omega_o = 2.5$

ADAPT Wall Load Input

Name	Load	Axial (kN)	Moment (kN·m)	Length (m)	Start (kN/m)	End (kN/m)
PW1	DL	-3,139	-2,751	8.71	**-578**	**-143**
PW1	LL	-897	-641	8.71	**-154**	**-52**
PW1	RX(ES)	0	-41	8.71	**-3**	**3**
PW1	RX(RS)	39	290	8.71	**27**	**-18**
PW1	RY(ES)	113	875	8.71	**82**	**-56**
PW1	RY(RS)	146	1,348	8.71	**123**	**-90**
PW1	WX	-5	-54	8.71	**-5**	**4**
PW1	WY	-30	-343	8.71	**-31**	**24**





NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ ULS Design

Wood Armer Equation (Twisting Moment)

[Ref.] Manual for Design and Detailings of RC to Code of Practice for Structural Use of Concrete 2004 (HK Housing Department)

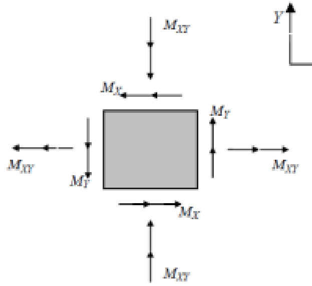


Figure D-3a – General co-existence of bending moments and twisting moment in a plate bending structure

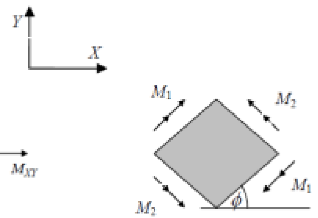


Figure D-3b – Principal moment in a plate bending structure

For bottom steel reinforcement provisions:

Generally $M_X^* = M_X + |M_{XY}|$; $M_Y^* = M_Y + |M_{XY}|$;

If $M_X^* < 0$, then $M_X^* = 0$ and $M_Y^* = M_Y + \left|\dfrac{M_{XY}^2}{M_X}\right|$

If $M_Y^* < 0$, then $M_Y^* = 0$ and $M_X^* = M_X + \left|\dfrac{M_{XY}^2}{M_Y}\right|$

For top steel reinforcement provisions:

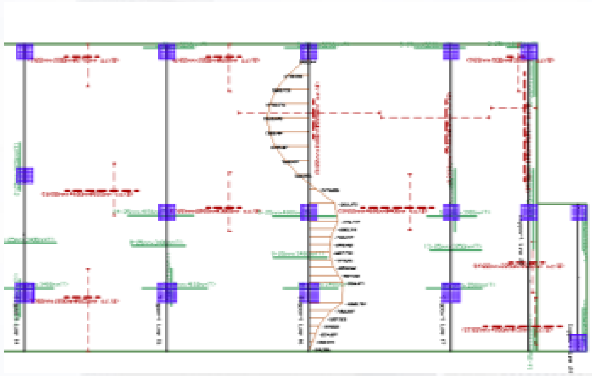
Generally $M_X^* = M_X - |M_{XY}|$; $M_Y^* = M_Y - |M_{XY}|$;

If $M_X^* > 0$, then $M_X^* = 0$ and $M_Y^* = M_Y - \left|\dfrac{M_{XY}^2}{M_X}\right|$

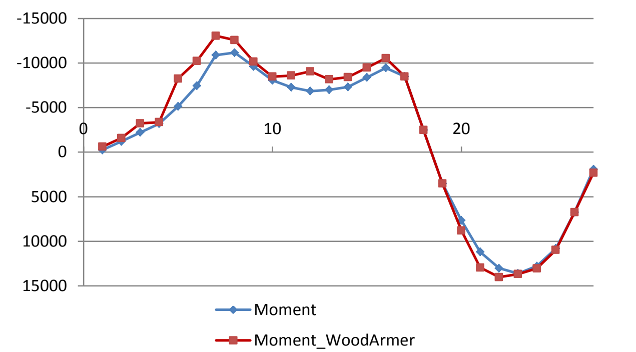
If $M_Y^* > 0$, then $M_Y^* = 0$ and $M_X^* = M_X - \left|\dfrac{M_{XY}^2}{M_Y}\right|$

NEST Hotel (DAELIM, 2014)

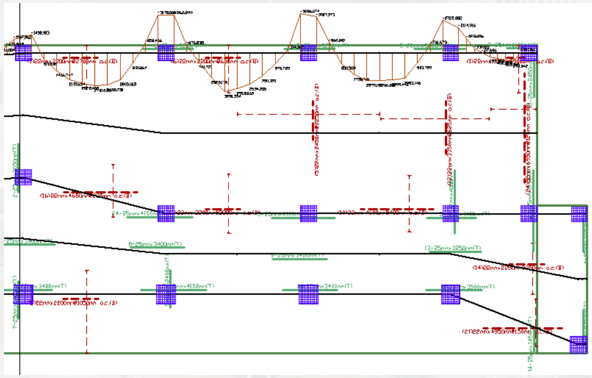
4F Cantilevered Transfer Slab _ ULS Design



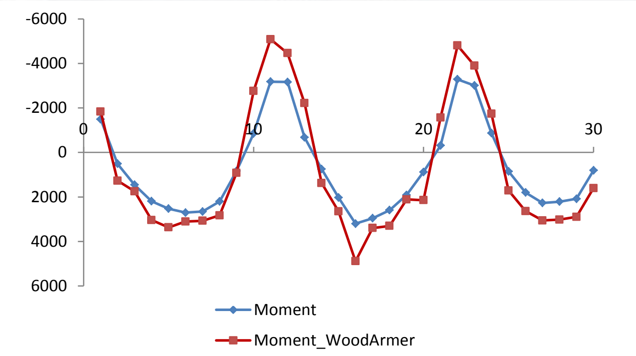
Support Line 16 Moment (Y-Dir)



Twisting Moment Increase (Y-Dir)



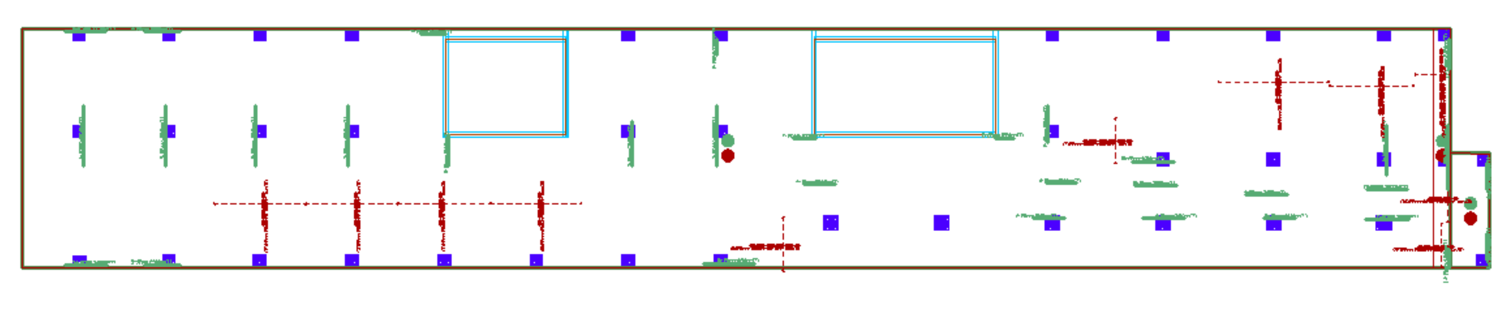
Support Line 16 Moment (X-Dir)



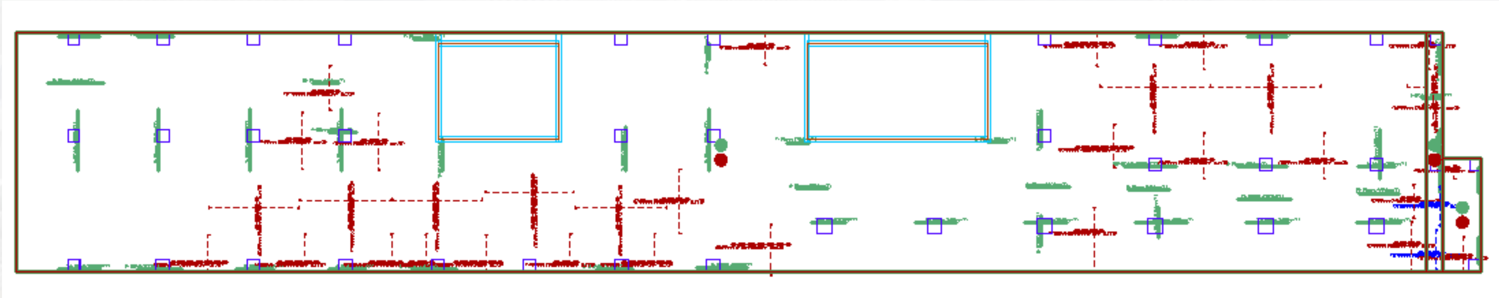
Twisting Moment Increase (X-Dir)

NEST Hotel (DAELIM, 2014)

4F Cantilevered Transfer Slab _ ULS Design



Flexural Reinforcement without Twisting Moment

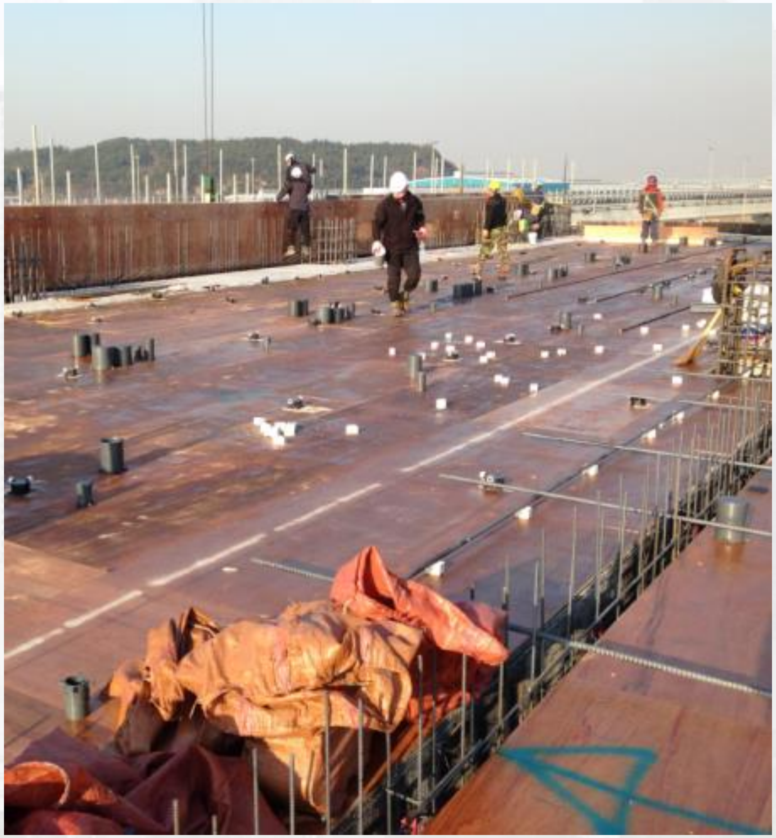


Flexural Reinforcement with Twisting Moment

C. PT Transfer Slab Construction

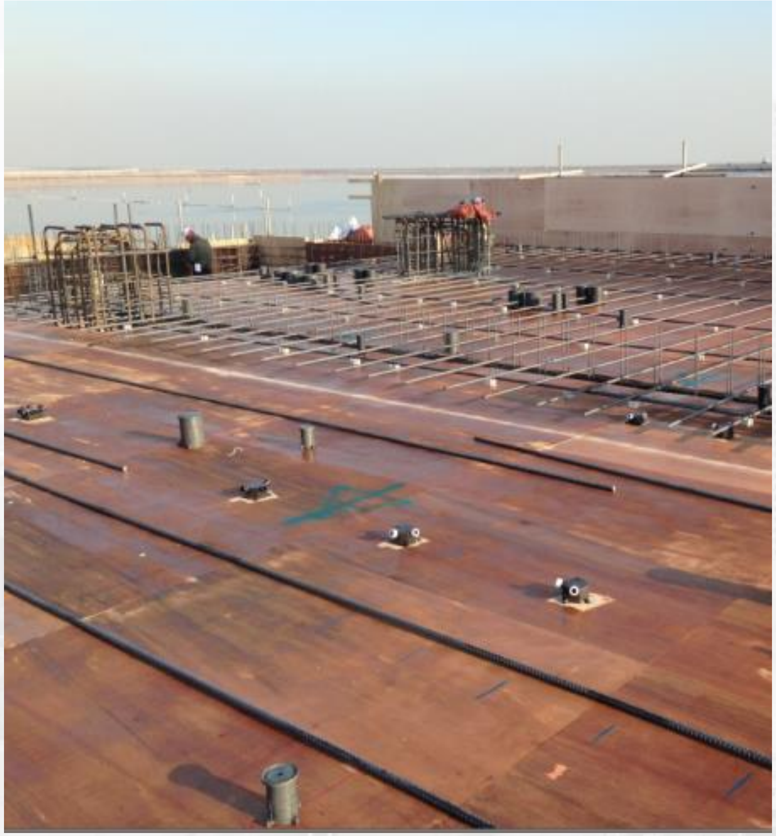
NEST Hotel (DAELIM, 2014)

Construction _ 01 Formwork



NEST Hotel (DAELIM, 2014)

Construction _ 02 Bottom Rebar



NEST Hotel (DAELIM, 2014)

Construction _ 03 Unbonded Tendon

NEST Hotel (DAELIM, 2014)

Construction _ 04 Distributed Tendon

NEST Hotel (DAELIM, 2014)

Construction _ 05 Concentrated Tendon

NEST Hotel (DAELIM, 2014)

Construction _ 06 Anchorage Reinforcement

NEST Hotel (DAELIM, 2014)

Construction _ 07 Top Rebar

NEST Hotel (DAELIM, 2014)

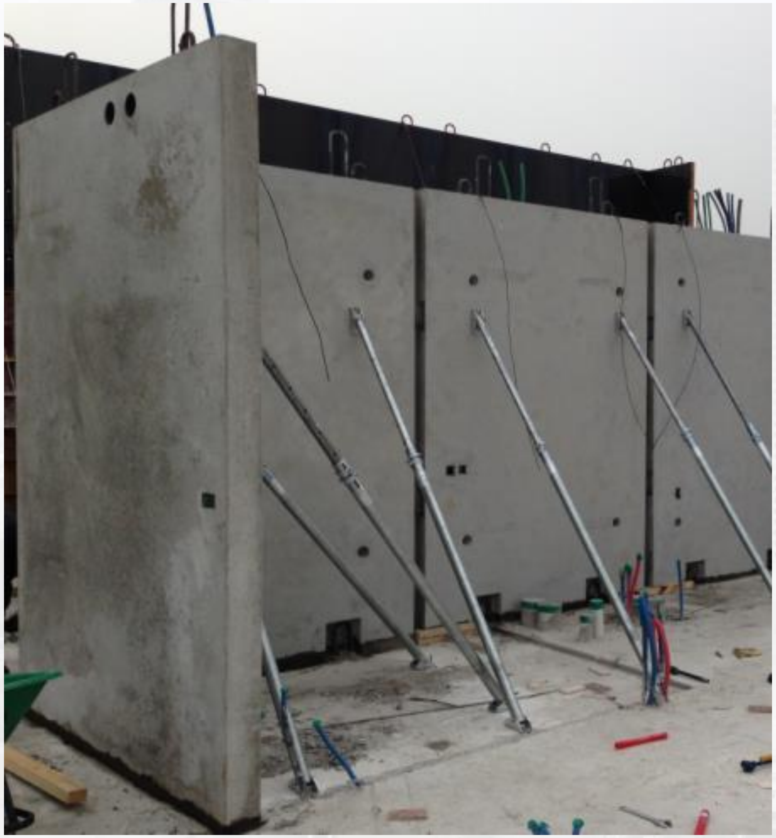
Construction _ 08 Punching Shear Reinforcement

NEST Hotel (DAELIM, 2014)

Construction _ 09 Tendon Stressing

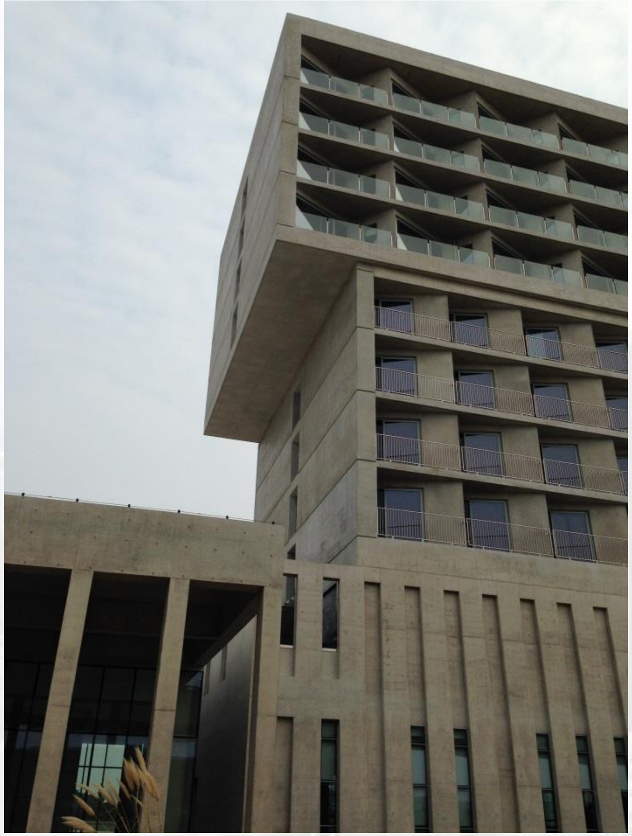
NEST Hotel (DAELIM, 2014)

Precast Wall above PT Transfer Slab



NEST Hotel (DAELIM, 2014)

Vertically Irregular Building



THANK YOU