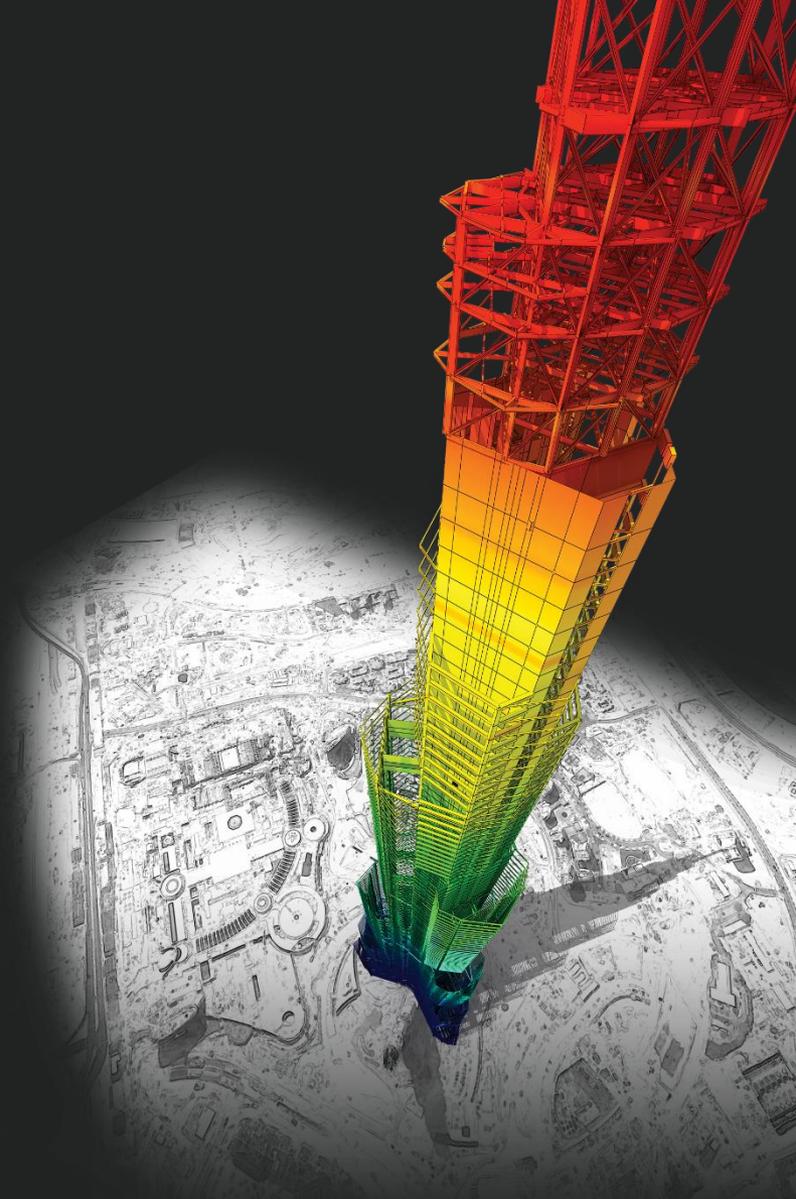


Release Note

Release Date : April. 2020

Product Ver. : midas Gen 2020 (v2.1) and Design+2020(v2.1)



DESIGN OF General Structures

Integrated Design System for Building and General Structures

midas **Gen**

Enhancements

- **midas Gen**

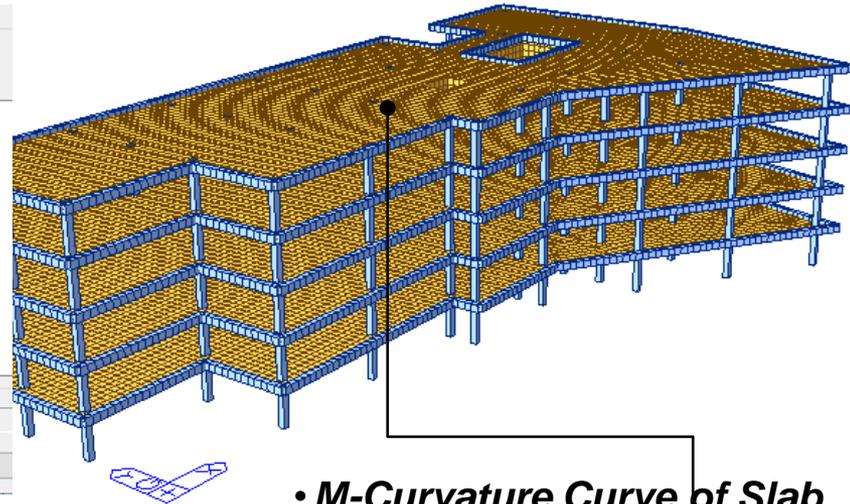
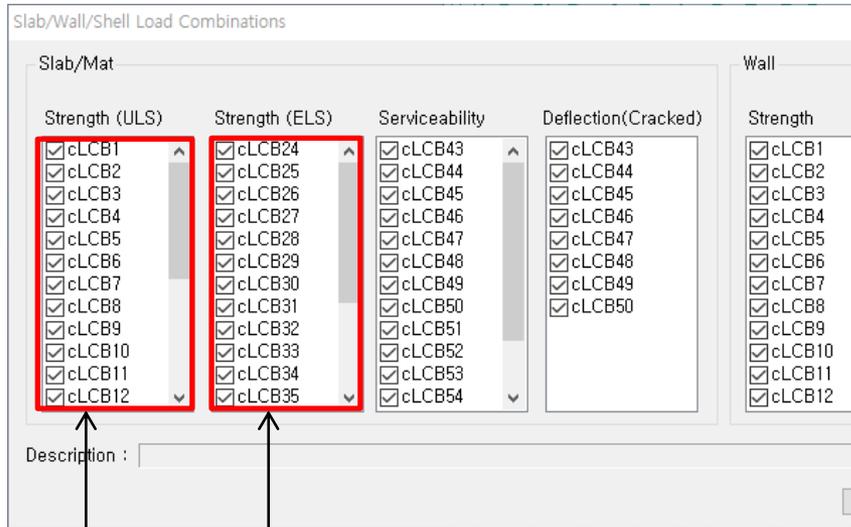
1) Non-dissipative element design for slab as per NTC2018	4
2) Improvement of design speed for non-dissipative element	5
3) Apply partial safety factor in inelastic material model	6
4) Add column design by constant P	7
5) Improvement of joint design as per EC2 and NTC	8
6) Improvement of slab design as per EC2 and NTC	11
7) Cyclic shear resistance check as per NTC2018	12
8) Insert strength loss option for EC8 hinge type	14
9) Improvement about masonry pushover analysis and post processing	15
10) Improvement of hinge model as per EC	20
11) Energy result graph & additional damping ratio in time-history analysis results	21
12) Add reaction table for each step in pushover	24
13) Revit 2020 interface	25
14) Select Inelastic Hinge Result Output in Inelastic time history analysis	26
15) Improvement in analysis speed for inelastic time history analysis	28
16) Add result summary table of fiber beam, wall for inelastic hinge	29

- **midas Design+**

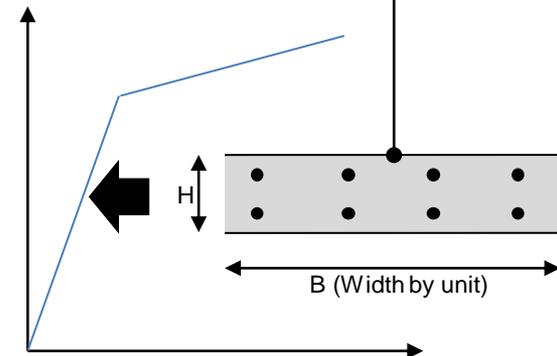
1) Steel design tool as per AISC	31
2) Anchor bolt module as per ACI	37

1. Non-dissipative element design for slab as per NTC2018

Add Non-dissipative element design for Slab.



• **M-Curvature Curve of Slab**



• Slab Design as Non-dissipative element

Strength (ULS)

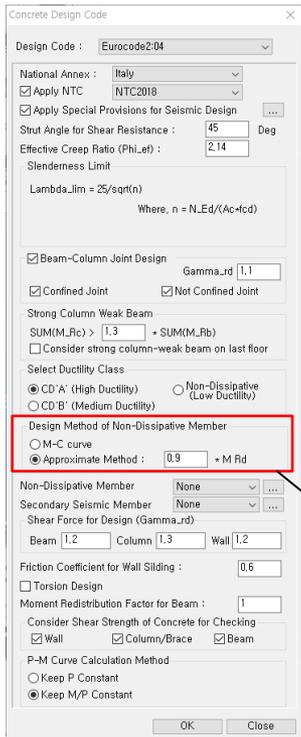
: Shear design uses only load Comb. Of Gravity loads

Strength (ELS) (Add)

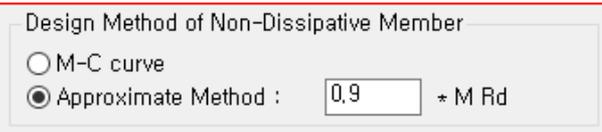
: Flexural design uses only ELS load Comb..

2. Improvement of design Speed for Non-dissipative element

Improvement of design Speed for Non-dissipative element → Add Approximate Method



Add Option



Bending Moment Capacity

	END-I	MID	END-J
(-) Load Combination No.	21	21	5
Moment (M _{Ed})	141604.88	59413.77	134663.44
Factored Strength (M_{Rd})	152013.72	84276.96	123768.52
Check Ratio (M _{Ed} /M _{Rd})	0.9315	0.7050	1.0880
Neutral Axis (x/d)	0.1670	0.1172	0.1445

(+) Load Combination No.	5	5	21
Moment (M _{Ed})	99836.64	63882.84	96479.04
Factored Strength (M _{Rd})	84427.01	84276.96	84489.36
Check Ratio (M _{Ed} /M _{Rd})	1.1825	0.7580	1.1419
Neutral Axis (x/d)	0.1150	0.1172	0.1157

Elastic Bending Moment Capacity (for Non-Dissipative Element)

	END-I	MID	END-J
(-) Load Combination No.	53	53	37
Moment (M _{Ed})	101482.80	38922.76	96260.94
Elastic Strength (M_{yd})	143255.27	74502.94	112471.78
Check Ratio	0.7084	0.5224	0.8559

(+) Load Combination No.	37	37	53
Moment (M _{Ed})	59714.55	43391.82	58076.53
Elastic Strength (M _{yd})	74757.76	74502.94	74901.73
Check Ratio	0.7988	0.5824	0.7754

M_{yd}' = 0.9 * M_{Rd}

3. Apply partial safety factor in inelastic material model

Apply "Partial Safety Factor" in Inelastic Material Model

Inelastic Material Model

Name : steel

Material Type : Concrete

Hysteresis Model : Kent & Park Model

Reference Material : B&C Import

Skeleton Curve

fc' 24 N/mm² ε_{co} 0,002

K 1 Z 1000000

ε_{cu} 0,0025 > ε_{c1} = 0,8/Z + ε_{co}

OK Cancel Apply

Partial Safety Factor for Material

Partial Safety Factor :

OK Cancel

* Default : 1.0

Inelastic Material Model

Name : steel

Material Type : Steel

Hysteresis Model : Menegotto-Pinto Model

Reference Material : None Import

Skeleton Curve

fy 400 N/mm² Ru 20

E 200000 N/mm² a1 18,5

b 0,5 a2 0,15

OK Cancel Apply

Partial Safety Factor for Material

Partial Safety Factor :

OK Cancel

* Default : 1.0

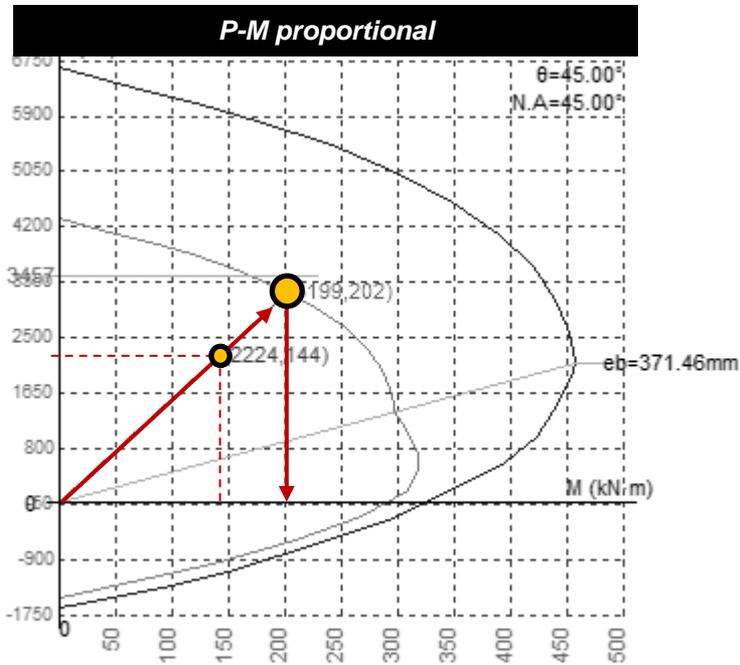
4. Add Column Design by Constant P

Add Column Design by Constant P
 → Add P-M Curve Calculation Method Option

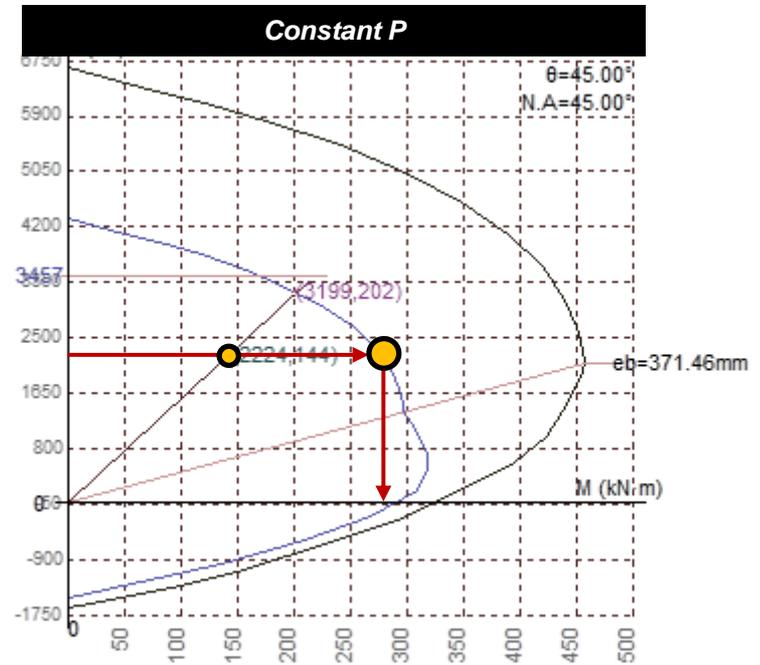
Add Option

P-M Curve Calculation Method

- Keep P Constant
- Keep M/P Constant



Gen 2020 v1.1



Gen 2020 v2.1

5. Improvement of Joint design as per EC2 and NTC

Joint Design as per EC and NTC

→ It is possible to skip a Joint design for “Not confined” condition

Concrete Design Code

Design Code : Eurocode2:04

National Annex : Italy

Apply NTC NTC2018

Apply Special Provisions for Seismic Design ...

Strut Angle for Shear Resistance : 22 Deg

Effective Creep Ratio (Phi_Lef) : 2,14

Slenderness Limit

$\Lambda_{lim} = 25/\sqrt{n}$

Where, $n = N_{Ed}/(A_c \cdot f_{cd})$

Beam-Column Joint Design Gamma_rd 1,2

Confined Joint Not Confined Joint

Strong Column Weak Beam

$SUM(M_{Rc}) > 1,3 * SUM(M_{Rb})$

Consider strong column-weak beam on last floor

Select Ductility Class

Add Option

Beam-Column Joint Design Gamma_rd 1,2

Confined Joint Not Confined Joint

5. Improvement of Joint design as per EC2 and NTC

Add Hoop Spacing of Joint in Design

Detail report

```
( ). Compute horizontal hoops
-. Ash.req = Ash.req2 = 0.002 m^2.
-. Legs = 2
-. Num = 20
-. Ash.use = Av1*Legs*Num = 0.003 m^2.
-. Rat.Ash = Ash.req / Ash.use = 0.838 < 1.000 ---> O.K.

( ). Check space of horizontal hoops.
-. sh.min = MAX[ Bar Dia, Gravel Dia, 20mm ] + Bar Dia = 0.0345 m.
-. sh.use = 0.0308 m. < s.min ---> AN INCONGRUENT SPACING !!!
```

If applied spacing $s < s_{min}$, Printout "AN INCONGRUENT SPACING !!!" In Detail report

Design result table

Code : Eurocode2:04,NTC2018 Unit : kN , m Primary Sorting Option

Sorted by Member Property Results Strength Serviceability

MEMB	SE	Section	fck	fyk	CHK	LC	V-Rebar	N_Rdma	Uc	N_Ed	M_Edy	M_Edz	V_Rdc.end	V_Rds.end	V_Rdc.mid	V_Rds.mid	LC	V_Ed.end	Rat-V.end	Ash.req
SECT	L	Bc Hc	Height	fyw		B		x	Rat-Uc	Rat-N	Rat-My	Rat-Mz	Rat-Vc.end	Rat-Vs.end	Rat-Vc.mid	Rat-Vs.mid	B	V_Ed.mid	Rat-V.mid	Rat-J
253	<input checked="" type="checkbox"/>	C1	24000.0	400000	J	4	26-7-D22	19339.7	0.019	267.920	579.245	7.40708	425.238	1134.57	431.760	1134.57	7	1082.58	0.954	0.00239
103	<input checked="" type="checkbox"/>	1.000 1.000	4.0000	400000	J	4			0.000	0.315	0.313	0.314	2.546	0.954	2.507	0.954	7	1082.58	0.954	0.838
335	<input type="checkbox"/>	C1	24000.0	400000	J	6	26-7-D22	19339.7	0.012	81.5272	74.5034	11.2563	397.202	1134.57	403.725	1134.57	7	1027.76	0.906	0.00241
103	<input type="checkbox"/>	1.000 1.000	4.0000	400000	J	6			0.000	0.032	0.032	0.031	2.588	0.906	2.546	0.906	7	1027.76	0.906	0.845

Printout "J" in red color In Design result table

Graphic result

[JOINT] y : 6 (l) z : 6 (l)

Ash.req / Ash.use 0.00239 / 0.00285 = 0.838 0.00239 / 0.00285 = 0.838

Joint Ratio 0.838 < 1.000 O.K 0.838 < 1.000 O.K

Ash.jnt Check Spacing Check Spacing

Printout "Check Spacing" In graphic,

5. Improvement of Joint design as per EC2 and NTC

Joint Design as per EC and NTC

→ Improvement to check a hoop area and spacing in Joint design

Detail report

```
( ). Compute maximum spacing of ties/spirals.
-. Smax = 0.100 m. (Hoop spacing for shear)

( ). Compute horizontal shear force in local-z direction.
[ LCB = 4, POS = 1 ]
[ NTC2018, 7.4.4.3.1 ]
-. Applied axial force : Pu = 798.87 kN.
-. Applied shear force : Vcz = 20.090 kN.
-. Beam Top Reinforcement : As1 = 0.0015 m^2.
-. Beam Bottom Reinforcement : As2 = 0.0015 m^2.
-. Gamma_rd = 1.2000
( Interior Column )
-. Vjhdz = Gamma_rd * (As1+As2) * fyd - Vcz = 1248.863 kN.

( ). Check diagonal compression.
[ NTC2018, 7.4.4.3.1 ]
-. Eta = 0.6 * (1-fck/250) = 0.5424
-. Vjhd < Eta*fcd*sqrt(1-Nu_d/Eta)*bj+hjc = 6272.541 kN.
-. Rat = 0.199 < 1.0 ----> O.K!
```

```
( ). Compute horizontal hoops to limit the maximum diagonal tensile stress of concrete.
[ NTC2018, 7.4.4.3.1 ]
-. Nu_d = 0.055
-. fctd = 1164.8469 KPa.
-. fvj = {Vjhd/(bj+hjc)}^2 / (fctd + Nu_d*fcd) = 1305.825 KPa.
-. Ash.req.1 = (fvj-fctd)*bj+hjw/fywd = 2.362e-004 m^2.

( ). Compute horizontal hoops to ensure integrity of the joint after diagonal cracking.
[ NTC2018, 7.4.4.3.1 ]
-. Gamma_rd = 1.2000
-. Beam Top Reinforcement : As1 = 0.0015 m^2.
-. Beam Bottom Reinforcement : As2 = 0.0015 m^2.
-. Ash.req.2 = Gamma_rd*(As1+As2)*fyd*(1.0-0.8*Nu_d)/fywd = 0.003 m^2.

( ). Compute horizontal hoops
-. Ash.req = MIN[ Ash.req1, Ash.req2 ] = 2.362e-004 m^2.
-. Legs = 2
-. Num = 12
-. Ash.use = Avl*Legs*Num = 0.002 m^2.
-. Rat.Ash = Ash.req / Ash.use = 0.138 < 1.000 ----> O.K.

( ). Check space of horizontal hoops.
-. sh.min = MAX[ Bar Dia, Gravel Dia, 20mm ] + Bar Dia = 0.0345 m.
-. sh.use = 0.0498 m. > s.min ----> O.K.
```

Design result table

Eurocode2:04 RC-Column Checking Result Dialog

Code : Eurocode2:04.NTC2018 Unit : kN , m Primary Sorting Option

Sorted by Member Results Strength SECT MEMB

Property Serviceability

MEMB	SE	Section	fck	fjk	CHK	LC	V-Rebar	N_Rdma	Uc	N_Ed	M_Edy	M_Edz	V_Rdc.end	V_Rds.end	V_Rdc.mid	V_Rds.mid	LC	V_Ed.end	Rat-V.end	Ash.req
SECT	L	Bc	Hc	Height	fyw	B		x	Rat-Uc	Rat-N	Rat-My	Rat-Mz	Rat-Vc.end	Rat-Vs.end	Rat-Vc.mid	Rat-Vs.mid	B	V_Ed.mid	Rat-V.mid	Rat-J
80	<input checked="" type="checkbox"/>	C2	24000.0	400000	OK	7	24-7-D22	17482.8	0.056	802.368	718.331	179.889	445.291	1021.12	451.896	1021.12	7	971.662	0.952	0.00116
202		0.900 1.000	4.5000	400000					0.000	0.363	0.358	0.342	2.182	0.952	2.150	0.952	7	971.662	0.952	0.679

Graphic result

[JOINT]	y : 6 (l)	z : 4 (l)
Ash.req / Ash.use	0.00116 / 0.00171 = 0.679	0.00024 / 0.00171 = 0.138
Joint Ratio	0.679 < 1.000 O.K	0.138 < 1.000 O.K
Ash.jnt	2-12 D10	2-12 D10

6. Improvement of slab design as per EC2 and NTC

Add "Check ratio of x/d" and "Check Stress by Quasi-permanent Load combinations"

Check x/d as per NTC2018 4.1.2.1.2.1

```
<< BOTTOM >>
-. Information of Parameters.
Elem No. : 52
Thickness : 0.3000 m.
Materials : fck = 1631.5459 tonf/m^2.
           fcd = 1087.6973 tonf/m^2.
           fyk = 40788.6485 tonf/m^2.
Covering : dB = 0.0750 m.
           dT = 0.0750 m.
LCB No. : 1

-. Information of Design.
b = 0.0010 m. (by Code Unit Length).
d = 0.2250 m.
lambda = 0.800
a = lambda * x = 0.021 m.
eta = 1.000
Cc = eta*fcd*b*a = 0.0233 tonf.
M_Rd = Cc*(d-a/2) = 4.9982 tonf-m./m.

-. Information of Moments and Result.
Rein. Bar : D16 @300
As_req = 0.0003 m^2/m. ( 0.0003 m^2/m.)
M_Ed = 1.6544 tonf-m./m.
M_Rd = 4.9982 tonf-m./m.
RatM = M_Ed / M_Rd = 0.331 < 1.0 ----> O.K !
```

```
-. Check ratio of neutral axis depth to effective depth.
x/d = 0.053
Limit(x/d) = 0.450 ( fck <= 50 MPa.)
x/d ratio = 0.053/ 0.450 = 0.118 ----> O.K
```

4.1.2.1.2.1.

Per le travi continue, le travi di telai in cui possono essere trascurati gli effetti del secondo ordine e le solette, il rapporto x/d nelle sezioni critiche non deve comunque superare il valore 0.45 per $f_{ck} \leq 50$ MPa e 0,35 per $f_{ck} > 50$ MPa.

Add stress check by Quasi-permanent

```
<< TOP >>
-. Information of Parameters.
Elem No. : 91
LCB No. : 44
Materials : fck = 1631.5459 tonf/m^2.
           fyk = 40788.6485 tonf/m^2.
Thickness : 0.3000 m.
Covering : dB = 0.0750 m.
           dT = 0.0750 m.

-. Information of Checking.
gamma_c = 1.500 (for Concrete)
gamma_s = 1.150 (for Reinforcement)
fcd = fck / gamma_c = 1087.6973 tonf/m^2.
fyd = fyk / gamma_s = 35488.39002 tonf/m^2.
b = 0.0010 m. (by Code Unit Length).
d = 0.2250 m.
As_use = 0.0007 m^2/m. ( 0.0007 m^2/m.)

-. Information of Stress Checking Result.
k1 = 0.80000
k3 = 0.80000

(Assumed Uncracked Section)
M_Ed = 3.95 tonf-m./m.
n = 13.98215 (Long Term) .
fctm = 0.30 + fck (2/3) = 194.24383 tonf/m^2.
fr1 = (1.5 - H/1000) * fctm = 252.51698 tonf/m^2.
fctm,fl = MAX( fctm, fr1 ) = 252.51698 tonf/m^2.
ybar_t = 0.1509 m.
lyy = 0.00230 m^4./m.
Ss_con (Tens.) = M_Ed*(H-ybar_t)/lyy = 254.61148 tonf/m^2.
Ss_con (Tens.) > fctm,fl ----> Check Cracked Section !!!

[ Dead Load Cases ]
M_Ed,D = 2.56 tonf-m./m.
n = 13.98215 (Long Term) .
X = 0.066 m.
lcr = 0.0003 m^4./m.
ybar_t = 0.056 m.
Ss_con,D = M_Ed,D*ybar_t/lcr = 442.81327 tonf/m^2.
Ss_stl,D = M_Ed,D*(d-ybar_t)*n/lcr = 18688.77997 tonf/m^2.

[ Live Load Cases : Quasi-permanent ]
M_Ed,L = 0.03 tonf-m./m.
n = 13.98215 (Long Term) .
X = 0.066 m.
lcr = 0.0003 m^4./m.
ybar_t = 0.056 m.
Ss_con,L = M_Ed,L*ybar_t/lcr = 4.84833 tonf/m^2.
Ss_stl,L = M_Ed,L*(d-ybar_t)*n/lcr = 204.62213 tonf/m^2.

[ Etc. Load Cases ]
M_Ed,E = 1.37 tonf-m./m.
n = 6.99107 (Short Term) .
X = 0.041 m.
lcr = 0.0002 m^4./m.
ybar_t = 0.041 m.
Ss_con,E = M_Ed,E*ybar_t/lcr = 313.84428 tonf/m^2.
Ss_stl,E = M_Ed,E*(d-ybar_t)*n/lcr = 9765.27236 tonf/m^2.

Ss_con = Ss_con,D + Ss_con,L + Ss_con,E = 761.50587 tonf/m^2.
Ss_stl = Ss_stl,D + Ss_stl,L + Ss_stl,E = 28658.67446 tonf/m^2.
S3_con > k3*fck = 704.19587 tonf/m^2. ----> Not Acceptable !!!
Ss_stl < k3*fyk = 32630.91882 tonf/m^2. ----> O.K !
```

```
[ Live Load Cases : Quasi-permanent ]
M_Ed,L = 0.03 tonf-m./m.
n = 13.98215 (Long Term) .
X = 0.066 m.
lcr = 0.0003 m^4./m.
ybar_t = 0.056 m.
Ss_con,L = M_Ed,L*ybar_t/lcr = 4.84833 tonf/m^2.
Ss_stl,L = M_Ed,L*(d-ybar_t)*n/lcr = 204.62213 tonf/m^2.

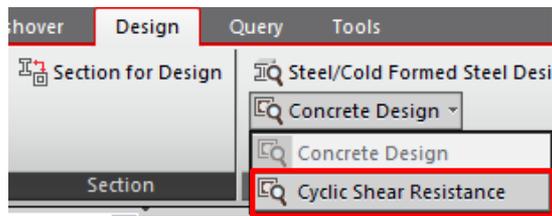
[ Etc. Load Cases ]
M_Ed,E = 1.37 tonf-m./m.
n = 6.99107 (Short Term) .
X = 0.041 m.
lcr = 0.0002 m^4./m.
ybar_t = 0.041 m.
Ss_con,E = M_Ed,E*ybar_t/lcr = 313.84428 tonf/m^2.
Ss_stl,E = M_Ed,E*(d-ybar_t)*n/lcr = 9765.27236 tonf/m^2.

Ss_con = Ss_con,D + Ss_con,L + Ss_con,E = 761.50587 tonf/m^2.
Ss_stl = Ss_stl,D + Ss_stl,L + Ss_stl,E = 28658.67446 tonf/m^2.
S3_con > k3*fck = 704.19587 tonf/m^2. ----> Not Acceptable !!!
Ss_stl < k3*fyk = 32630.91882 tonf/m^2. ----> O.K !
```

7. Cyclic shear resistance check as per NTC2018

Check of Cyclic shear Resistance as per NTC2018 in Existing RC building

- ULS Design



Set Cyclic Shear Resistance Parameters

Set Cyclic Shear Resistance Parameters

Load Case/Combination: ALL COMBINATION

Cyclic Shear Resistance Table Type: Show Selected Elements

Confidence Factor: 1.2

Displacement Behavior Factor(qd): 1.5

Importance Factor(le): 1.5

OK Cancel

Result Table for Cyclic shear Resistance checking

Elem	Location	Seismic Element	Load	Cyclic Shear Resistance					
				VRy			VRz		
				Demand	Capacity	Remark	Demand	Capacity	Remark
Confidence Factor = 1.20, qd = 1.50, le = 1.50									
Press right mouse button and click 'Set Cyclic Shear Resistance Parameters' menu to change Load Case/Combination/Confidence Factor/Displacement Behavior Factor/Importance Factor									
353	I-end	Primary	ALL COMB	18.0504	496.6250	OK	25.3188	430.5590	OK
353	J-end	Primary	ALL COMB	18.0504	382.5840	OK	25.3188	285.4860	OK

Demand : Design Shear Force

Capacity : Vr by Equation below

$$V_R = \frac{1}{\gamma_{el}} \left[\frac{h-x}{2L_V} \min(N; 0,55A_c f_c) + (1 - 0,05 \min(5; \mu_{\Delta}^{pl})) \cdot \left[0,16 \max(0,5; 100\rho_{tot}) \left(1 - 0,16 \min\left(5; \frac{L_V}{h}\right) \right) \sqrt{f_c} A_c + V_w \right] \right]$$

Demand ≤ Capacity → O.K

Demand > Capacity → N.G.

7. Cyclic shear resistance check as per NTC2018

Check of Cyclic shear Resistance as per NTC2018 in Existing RC building - Result of Pushover Analysis



Result Table for Cyclic shear Resistance checking

Elem	Location	Seismic Element	Load	Cyclic Shear Resistance					
				VRy			VRz		
				Demand	Capacity	Remark	Demand	Capacity	Remark
Step for Demand = USER (Step 23), Confidence factor = 1.00									
Press right mouse button and click 'Set Cyclic Shear Resistance Parameters' menu to change step or loadcase									
95	I-end	Primary	PO-X	42166.900	137079.00	OK	3501.6800	149689.00	OK
95	J-end	Primary	PO-X	42166.900	147994.00	OK	3501.6800	136127.00	OK

Set Cyclic Shear Resistance Parameters

Set Cyclic Shear Resistance Parameters

Pushover Load Case
PO-X

Step for Demand
 Life Safety (SLV)
 Collapse Prevention (SLC)
 User Defined 23

Cyclic Shear Resistance Table Type
 Show Selected Elements
 Show All Elements

Confidence Factor 1.0

OK Cancel

Demand : Shear Force in Step n

Capacity : Vr by Equation below

$$V_R = \frac{1}{\gamma_{el}} \left[\frac{h-x}{2L_V} \min(N; 0,55A_c f_c) + (1 - 0,05 \min(5; \mu_{\Delta}^{pl})) \cdot \left[0,16 \max(0,5; 100\rho_{tot}) \left(1 - 0,16 \min\left(5; \frac{L_V}{h}\right) \right) \sqrt{f_c} A_c + V_w \right] \right]$$

Demand ≤ Capacity → O.K

Demand > Capacity → N.G.

8. Insert strength loss option for EC8 hinge type

Insert Strength loss option for EC8 hinge type

Directional Properties of Pushover Hinge : Eurocode 8 : 2004

Input Method
 Auto-Calculation User Input

Strength Loss
 Yes
 No [Figure](#)

Properties

Type
 Symmetric Asymmetric

Class of cross section
 Auto Class1 Class2

Primary Curve

Compliance Criteria

	(+)	(-)
Damage Limitation (DL)	1 *DY [rad]	1 *DY [rad]
Significant Damage (SD)	0.75 *DU [rad]	0.75 *DU [rad]
Near Collapse (NC)	1 *DU [rad]	1 *DU [rad]

Initial Stiffness

6EI/L 3EI/L 2EI/L

User (+) 1 (-) 1 kN*m

Elastic Stiffness :

Yield Strength (MY)

(+)	(-)	
1	1	kN*m

Yield Rotation (DY)

(+)	(-)	
DY 1	1	[rad]
DU 9	9	[rad]

Yield Strength (MY) Table:

	M/MY	D/DY
-E	-0.2	-12
-D	-0.2	-9
-C	-1.001	-9
-B	-1	-1
A	0	0
B	1	1
C	1.001	9
D	0.2	9
E	0.2	12

Strength Loss

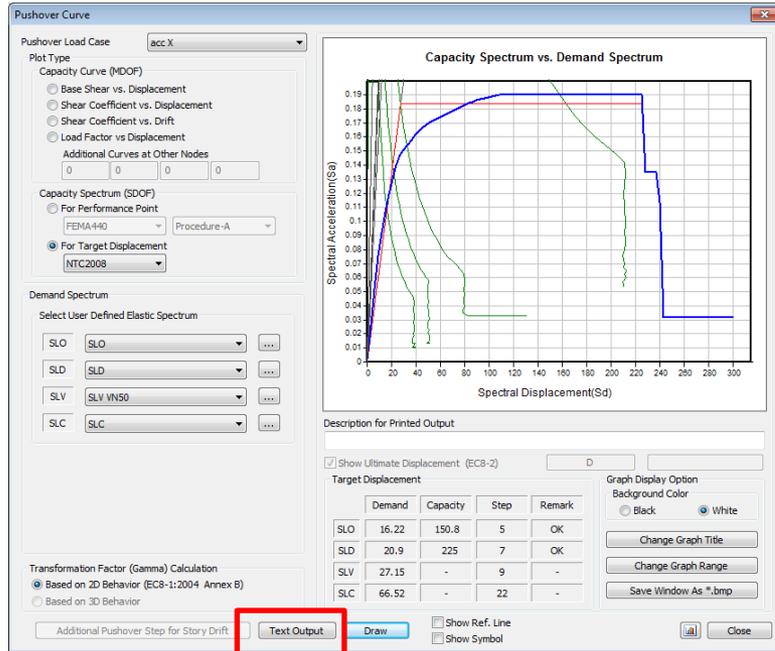
Strength Loss : Yes

Strength Loss : No

9. Improvement about masonry pushover analysis and post processing

Improvement about Masonry pushover analysis and post processing

→ Add “q*” in Text Output



$$q^* = \frac{S_{Ae}(T^*)m^*}{F_y^*}$$

```

MIDAS/Text Editor - [App6_Pushover_2D RC Structure]
File Edit View Window Help
- Target Displacement of SLO
m* = 543.086
Gamma = 1.43752
Fy* = 4194.52
T* = 0.836137
q* = 0.0152
det* = 0.0249265
dt* = 0.0249265 (medium or long period range)
dt = 0.0358322
- Target Displacement of SLD
m* = 543.086
Gamma = 1.43752
Fy* = 4194.52
T* = 0.836137
q* = 0.0152
det* = 0.0249265
dt* = 0.0249265 (medium or long period range)
dt = 0.0358322
- Target Displacement of SLV
m* = 543.086
Gamma = 1.43752
Fy* = 4194.52
T* = 0.836137
q* = 0.0152
det* = 0.0249265
dt* = 0.0249265 (medium or long period range)
dt = 0.0358322
- Target Displacement of SLC
m* = 543.086
Gamma = 1.43752
Fy* = 4194.52
T* = 0.836137
q* = 0.0152
det* = 0.0249265
dt* = 0.0249265 (medium or long period range)
dt = 0.0358322
    
```

9. Improvement about masonry pushover analysis and post processing

Target Displacement Capacity of SLV and SLC in Masonry

	Demand	Capacity	Step	Remark
SLO	16.77	150/8	5	OK
SLD	20.9	225	7	OK
SLV	27.15	-	9	-
SLC	60	-	22	-

SLO
Displacement of limit elastic $dSLD \times 2/3$

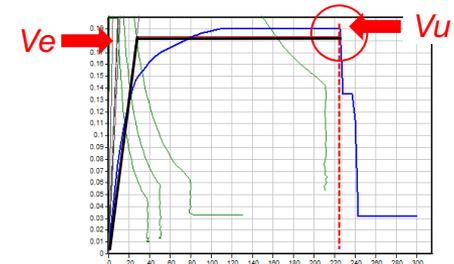
SLD
Capacity of SLD
= Min.Displacement of V_e and $3/4 V_u$

* V_e = max shear of bilinear
* V_u = max shear of MDOF curve

SLV
Last displacement of bilinear $\times 3/4$

Add Remark here

SLC
Last displacement of bilinear $\times \gamma$



9. Improvement about masonry pushover analysis and post processing

Updating My Masonry Pier hinge Type
 → **Masonry > Pier Type**

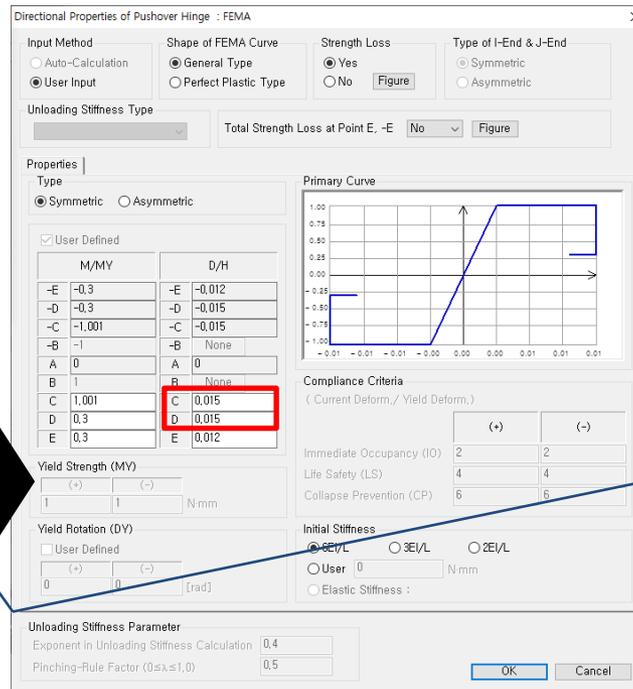
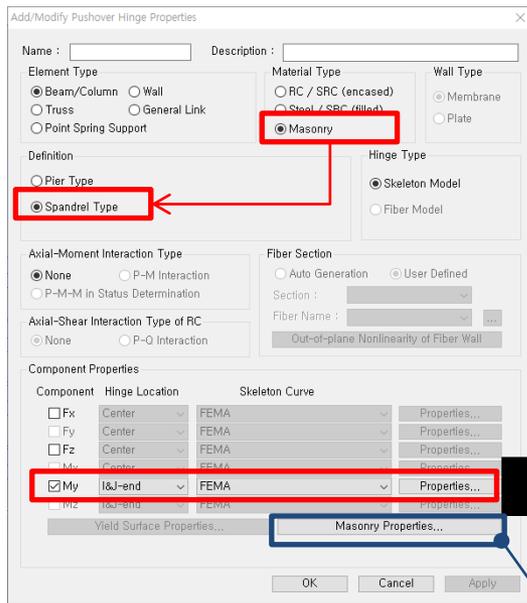
M/MY	D/H
-E -0.3	-E -0.009
-D -0.3	-D -0.01
-C -1.001	-C -0.01
-B -1	-B None
A 0	A 0
B 1	B None
C 1.001	C 0.01
D 0.3	D 0.01
E 0.3	E 0.009

Values of D/H

Point	New Building	Existing Building
C	0.01	0.01
D	0.01	0.01

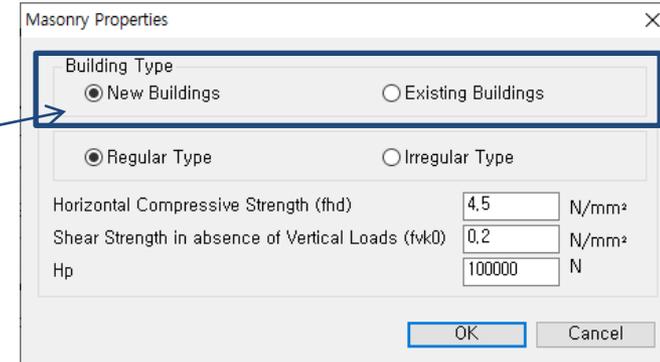
9. Improvement about masonry pushover analysis and post processing

Updating My Masonry Pier hinge Type
 → **Masonry > Spandrel Type**



Values of D/H

Point	New Building	Existing Building
C	0.008	0.015
D	0.008	0.015



9. Improvement about masonry pushover analysis and post processing

Updating Fy Masonry Spandrel hinge Type

Masonry Properties

Building Type
 New Buildings Existing Buildings

Regular Type Irregular Type

Horizontal Compressive Strength (fhd) N/mm²
 Shear Strength in absence of Vertical Loads (fvk0) N/mm²
 Hp N

OK Cancel

Masonry Properties

Building Type
 New Buildings Existing Buildings

Regular Type Irregular Type

Horizontal Compressive Strength (fhd) N/mm²
 Shear Strength in absence of Vertical Loads (fvk0) N/mm²
 Hp N

OK Cancel

Shear Resistance =

$$\text{Min. } [V_t = ht f_{vko}, V_p = 2M_u/l]$$

$$\text{where } M_u = \frac{H_p \cdot h}{2} \left(1 - \frac{H_p}{0.85 \cdot f_{vd} \cdot h \cdot t} \right)$$

Where,

$$H_p \begin{cases} \text{(i) } 0.4 \cdot f_{vd} \cdot h \cdot t \\ \text{(ii) } H_p : \text{ User Defined Value} \\ \text{minimum value} \end{cases}$$

Shear Resistance =

$$\text{Min. } [V_t = LT1.5f_{vko}/\beta \times \sqrt{1 + P/1.5f_{vko}}, V_p = 2M_u/l]$$

$$\text{where } \beta \begin{cases} = 1.5 ; 1.5 \leq H/L \\ = H/L ; 1.0 < H/L < 1.5 \\ = 1.0 ; H/L \leq 1.0 \end{cases}$$

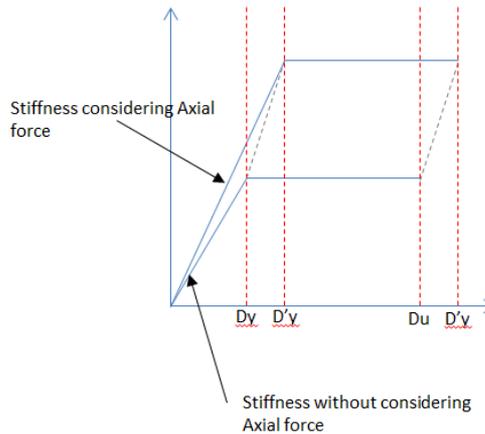
10. Improvement of hinge model as per EC

Improvement of Hinge model as per EC

Old version

The current calculation of Gen

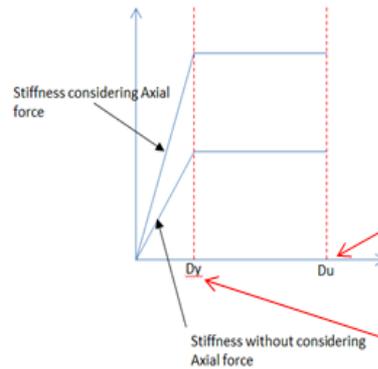
The stiffness and D_y are changed by axial force Under PMM or PM



New version

Your request

The stiffness are changed by axial force and D_y must not be changed Under PMM or PM



DU = Update step by step by follow formulas:

$$\theta_u = \frac{1}{\gamma_{d1}} 0.01 \left(3^v \left[\frac{\max(0.01, \omega)}{\max(0.01, \omega)} f_c \right]^{0.225} \left(\frac{L_y}{h} \right)^{0.35} 2.5^{\left(\alpha_{pm} \frac{f_{yw}}{f_c} \right)} 1.25^{\epsilon_{100} \rho_s} \right)$$

DY = constant value throughout the analysis (do not update) and calculated according to:

$$\Phi_{i,y} = k * \text{Epsilon}_y / D$$

hinge type	k				
	rectangular section			circular section	
	column	beam	wall	column	beam
none	2.1	1.7	2	2.25	-
PM e PMM	2.1	1.7	2	2.25	-

Displacemet based Seismic Design of Structures- pg 165

Priestley; Calvi; Kowalsky

11. Energy result graph & additional damping ratio in time-history analysis results

Improvement of Energy Result Graph : Energy Percentage Result of all step

Time History Energy Graph

Structure Energy Graph

Time History Energy Graph Select

- Dissipated Inelastic Energy (Eh) [Inelastic Hinge]
- Kinetic Energy (Ek)
- Elastic Strain Energy (Es)
- Damping Energy (Ed)
- Maxwell Damper Energy (Em) [Oil Damper]
- Velocity Dependent Device Energy (Ev) [Viscous | Viscoelastic Damper]
- Strain Dependent Device Energy (Et) [Elas. + Inel.][Steel | Hyst. Isolator]
- Isolator Device Energy (Eo)
- Plastic Strain Energy (Ep) [Plastic Material (Plate)]
- Input Energy (Ei)

Type of Display

- Cumulative Value Type
- Value Percentage

Time History Load Case

LD = 1 (DYNA)

Display Options

- No Fill Solid Fill

Percentage Text Result

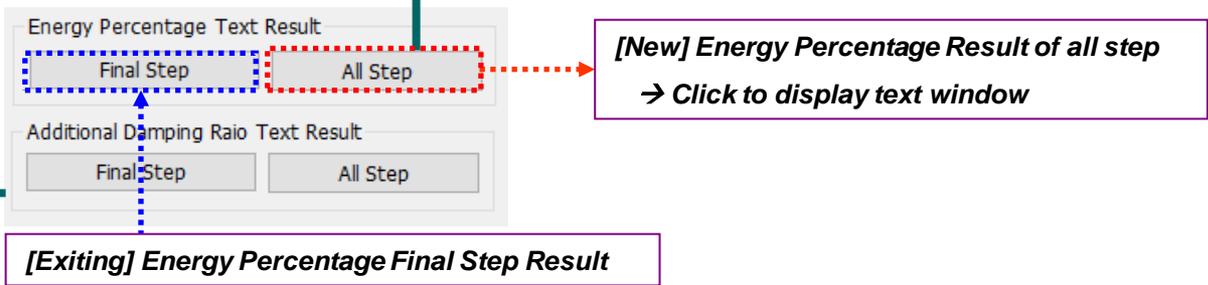
Apply Close

MIDAS/Text Editor - [ENERGY_PERCENT_ALL_STEP.F]

TIME HISTORY ANALYSIS | ENERGY RESULT PERCENTAGE ; TIME HISTORY LOADCASE NO. = 1

Time (sec)	[1] Dissipated Inel. Energy (Eh)	[2] Kinetic Energy (Ek)	[3] Elastic Strain Energy (Es)	[4] Damping Energy (Ed)	[5] Maxwell Damper Energy (Em)	[6] Velocity Depen. Device Energy (Ev)	[7] Strain Depen. Device Energy (Et)	[8] Isolator Device Energy (Eo)	[9] Plastic Strain Energy (Ep)	[10] Input Energy (Ei)	[10] - Sum[1-9] Error (E)
0.010	0.000	98.727	0.236	0.606	0.002	0.000	0.248	0.178	0.000	100.000	0.000
0.020	0.000	98.037	0.403	0.818	0.004	0.000	0.427	0.309	0.000	100.000	0.000
0.030	0.000	97.042	0.658	1.073	0.006	0.000	0.706	0.775	0.000	100.000	0.000
0.040	0.000	95.852	0.978	1.321	0.010	0.000	1.062	1.477	0.000	100.000	0.000
0.050	0.000	94.529	1.345	1.545	0.015	0.000	1.477	1.086	0.000	100.000	0.000
0.060	0.000	93.090	1.750	1.751	0.020	0.000	1.945	1.441	0.000	100.000	0.000
0.070	0.000	91.521	2.194	1.945	0.026	0.000	2.467	1.844	0.000	100.000	0.000
0.080	0.000	89.826	2.673	2.128	0.033	0.000	3.040	2.297	0.000	100.000	0.000
0.090	0.000	88.048	3.174	2.294	0.041	0.000	3.650	2.790	0.000	100.000	0.000
0.100	0.000	86.218	3.685	2.442	0.051	0.000	4.283	3.318	0.000	100.000	0.000
0.110	0.000	84.365	4.199	2.575	0.061	0.000	4.932	3.875	0.000	100.000	0.000
0.120	0.000	82.484	4.707	2.691	0.073	0.000	5.595	4.456	0.000	100.000	0.000
0.130	0.000	80.541	5.198	2.791	0.087	0.000	6.229	5.051	0.000	100.000	0.000
0.140	0.000	78.557	5.663	2.875	0.102	0.000	6.848	5.652	0.000	100.000	0.000
0.150	0.000	77.159	6.094	2.945	0.118	0.000	7.432	6.249	0.000	100.000	0.000
0.160	0.000	75.568	6.485	3.002	0.136	0.000	7.972	6.835	0.000	100.000	0.000
0.170	0.000	74.100	6.832	3.048	0.155	0.000	8.461	7.402	0.000	100.000	0.000
0.180	0.000	72.759	7.132	3.086	0.177	0.000	8.891	7.943	0.000	100.000	0.000
0.190	0.000	71.588	7.382	3.115	0.200	0.000	9.260	8.453	0.000	100.000	0.000
0.200	0.000	70.567	7.581	3.141	0.225	0.000	9.561	8.922	0.000	100.000	0.000
0.210	0.000	69.714	7.729	3.162	0.253	0.000	9.794	9.346	0.000	100.000	0.000
0.220	0.000	69.029	7.828	3.182	0.282	0.000	9.959	9.719	0.000	100.000	0.000
0.230	0.000	68.510	7.876	3.202	0.315	0.000	10.058	10.058	0.000	100.000	0.000
0.240	0.000	68.154	7.878	3.224	0.349	0.000	10.094	10.298	0.000	100.000	0.000
0.250	0.000	67.952	7.838	3.243	0.386	0.000	10.072	10.500	0.000	100.000	0.000
0.260	0.000	67.896	7.760	3.277	0.426	0.000	9.998	10.641	0.000	100.000	0.000
0.270	0.000	67.973	7.648	3.311	0.468	0.000	9.877	10.722	0.000	100.000	0.000
0.280	0.000	68.171	7.505	3.350	0.513	0.000	9.716	10.743	0.000	100.000	0.000
0.290	0.000	68.475	7.336	3.395	0.561	0.000	9.523	10.707	0.000	100.000	0.000
0.300	0.000	68.871	7.146	3.448	0.611	0.000	9.304	10.618	0.000	100.000	0.000

Ready Ln 14 / 46 , Col 202 NUM



11. Energy result graph & additional damping ratio in time-history analysis results

Add Additional Damping Ratio of Energy Dissipation System

Time History Energy Graph

Structure Energy Graph

Time History Energy Graph Select

- Dissipated Inelastic Energy (Eh) [Inelastic Hinge]
- Kinetic Energy (Ek)
- Elastic Strain Energy (Es)
- Damping Energy (Ed)
- Maxwell Damper Energy (Em) [Oil Damper]
- Velocity Dependent Device Energy (Ev) [Viscous | Viscoelastic Damper]
- Strain Dependent Device Energy (Et) [Elas. + Inel.][Steel | Hyst. Isolator]
- Isolator Device Energy (Eo)
- Plastic Strain Energy (Ep) [Plastic Material (Plate)]
- Input Energy (Ei)

Type of Display

- Cumulative Value Type
- Value Percentage

Time History Load Case

LD = 1 (DYNA)

Display Options

- No Fill Solid Fill

Percentage Text Result

Apply Close

MIDAS/Text Editor - [ADDITIONAL_DAMPING_RATIO_FINAL_STEP_F]

File Edit View Window Help

```

00001 TIME HISTORY ANALYSIS | ADDITIONAL DAMPING RATIO ; TIME HISTORY LOADCASE NO. = 1
00002
00003 =====
00004
00005
00006
00007
00008
00009
00010
00011
00012
00013
00014
00015
00016
00017
00018
00019
00020
00021
00022
    
```

Energy Graph		Additional Damping Ratio (%)
(1) Dissipated Inelastic Energy [Inelastic Hinge]	Eh	1.196
(2) Maxwell Damper Energy [Oil Damper]	Em	2.149
(3) Velocity Dependent Device Energy	Ev	0.000
(4) Strain Dependent Device [Steel Hyst. Isolator]	Et	2.959
(5) Isolator Device Energy	Eo	4.559
+++++		+++++
Total Damping Ratio		5.001
+++++		+++++

Ready Ln 21 / 21 , Col 10 CAP NUM

Energy Percentage Text Result

Final Step All Step

Additional Damping Ratio Text Result

Final Step All Step

[New] Additional Damping Ratio Result of final step

→ Click to display text window

11. Energy result graph & additional damping ratio in time-history analysis results

Add Additional Damping Ratio of Energy Dissipation System

Time History Energy Graph

Structure Energy Graph

Time History Energy Graph Select

- Dissipated Inelastic Energy (Eh)
[Inelastic Hinge]
- Kinetic Energy (Ek)
- Elastic Strain Energy (Es)
- Damping Energy (Ed)
- Maxwell Damper Energy (Em)
[Oil Damper]
- Velocity Dependent Device Energy (Ev)
[Viscous | Viscoelastic Damper]
- Strain Dependent Device Energy (Et)
[Elas. + Inel.][Steel | Hyst. Isolator]
- Isolator Device Energy (Eo)
- Plastic Strain Energy (Ep)
[Plastic Material (Plate)]
- Input Energy (Ei)

Type of Display

Cumulative Value Type
 Value Percentage

Time History Load Case

LD = 1 (DYNA)

Display Options

No Fill Solid Fill

Percentage Text Result

Apply Close

MIDAS/Text Editor - [ADDITIONAL_DAMPING_RATIO_All_STEP]

File Edit View Window Help

TIME HISTORY ANALYSIS | ADDITIONAL DAMPING RATIO ; TIME HISTORY LOADCASE NO. = 1

Time (sec)	[Eh] Dissipated Inel. Energy Damping Ratio (%)	[Em] Maxwell Damper Energy Damping Ratio (%)	[Ev] Velocity Depen. Device Energy Damping Ratio (%)	[Et] Strain Depen. Device Energy Damping Ratio (%)	[Eo] Isolator Device Energy Damping Ratio (%)	[Ep] Plastic Strain Energy Damping Ratio (%)	Total Damping Damping Ratio (%)
0.010	0.00000	0.00240	0.00003	0.00240	0.00240	0.00000	100.00000
0.020	0.00000	0.00416	0.00002	0.00416	0.00416	0.00000	100.00000
0.030	0.00000	0.00694	0.00001	0.00694	0.00694	0.00000	100.00000
0.040	0.00000	0.01060	0.00001	0.01060	0.01060	0.00000	100.00000
0.050	0.00000	0.01503	0.00001	0.01503	0.01503	0.00000	100.00000
0.060	0.00000	0.02027	0.00000	0.02027	0.02027	0.00000	100.00000
0.070	0.00000	0.02643	0.00000	0.02643	0.02643	0.00000	100.00000
0.080	0.00000	0.03365	0.00000	0.03365	0.03365	0.00000	100.00000
0.090	0.00000	0.04195	0.00000	0.04195	0.04195	0.00000	100.00000
0.100	0.00000	0.05136	0.00000	0.05136	0.05136	0.00000	100.00000
0.110	0.00000	0.06199	0.00000	0.06199	0.06199	0.00000	100.00000
0.120	0.00000	0.07393	0.00000	0.07393	0.07393	0.00000	100.00000
0.130	0.00000	0.08726	0.00000	0.08726	0.08726	0.00000	100.00000
0.140	0.00000	0.10201	0.00000	0.10201	0.10201	0.00000	100.00000
0.150	0.00000	0.11827	0.00000	0.11827	0.11827	0.00000	100.00000
0.160	0.00000	0.13613	0.00000	0.13613	0.13613	0.00000	100.00000
0.170	0.00000	0.15571	0.00000	0.15571	0.15571	0.00000	100.00000
0.180	0.00000	0.17712	0.00000	0.17712	0.17712	0.00000	100.00000
0.190	0.00000	0.20045	0.00000	0.20045	0.20045	0.00000	100.00000
0.200	0.00000	0.22582	0.00000	0.22582	0.22582	0.00000	100.00000
0.210	0.00000	0.25331	0.00000	0.25331	0.25331	0.00000	100.00000
0.220	0.00000	0.28302	0.00000	0.28302	0.28302	0.00000	100.00000
0.230	0.00000	0.31507	0.00000	0.31507	0.31507	0.00000	100.00000

Energy Percentage Text Result

Final Step All Step

Additional Damping Ratio Text Result

Final Step All Step

[New] Energy Percentage Result of all step
→ Click to display text window

12. Add reaction table for each step in Pushover

Add Reaction Table for each step in PUSHOVER

Step 1. Open Records Activation Dialog box.

Step 2. Select Load case for pushover.

Step 3. Select Pushover step.

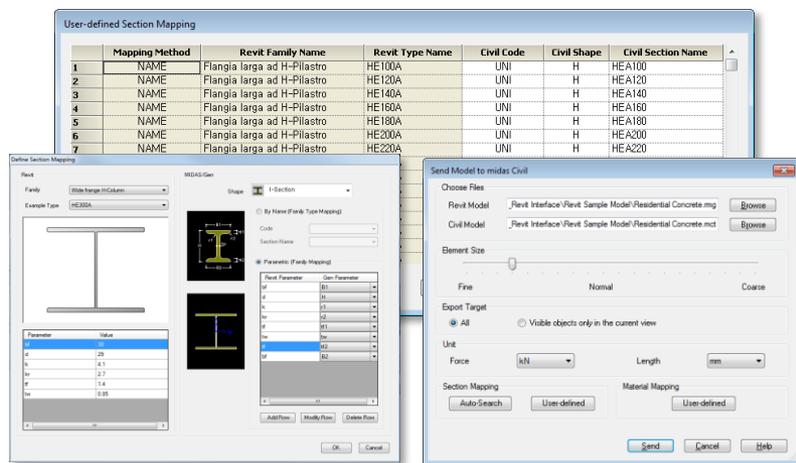
Step 4. Printout Reaction table

#	Load	Step	FX (N)	FY (N)	FZ (N)	M (N-m)
1	PO-X(all)	po_0140	334881.358304	-1554840.85599	-4880873.10232	0.0
2	PO-X(all)	po_0140				
5	PO-X(all)	po_0140				
6	PO-X(all)	po_0140				
7	PO-X(all)	po_0140				
8	PO-X(all)	po_0140				
9	PO-X(all)	po_0140				
10	PO-X(all)	po_0140				
11	PO-X(all)	po_0140				
12	PO-X(all)	po_0140				
13	PO-X(all)	po_0140				
14	PO-X(all)	po_0140				
15	PO-X(all)	po_0140				
16	PO-X(all)	po_0140				
17	PO-X(all)	po_0140				
18	PO-X(all)	po_0140				
19	PO-X(all)	po_0140				
20	PO-X(all)	po_0140				
21	PO-X(all)	po_0140				
22	PO-X(all)	po_0140				
23	PO-X(all)	po_0140				
24	PO-X(all)	po_0140				
25	PO-X(all)	po_0140				
26	PO-X(all)	po_0140				
27	PO-X(all)	po_0140	-761741.962003	297560.345405	371117.766236	0.0
28	PO-X(all)	po_0140	-378013.330894	316478.525536	-151551.510801	0.0
29	PO-X(all)	po_0140	-247941.260380	2097.558199	430720.532647	0.0
30	PO-X(all)	po_0140	-118245.235881	65575.593188	-120178.442764	0.0
31	PO-X(all)	po_0140	-233357.266245	356154.463707	608703.794247	0.0
32	PO-X(all)	po_0140	8983.656902	384491.752882	-175947.504963	0.0
45	PO-X(all)	po_0140	465795.493556	51716.628791	164905.869632	0.0
46	PO-X(all)	po_0140	437153.102811	83820.034923	-156045.856362	0.0
47	PO-X(all)	po_0140	458257.789619	123466.170823	-100660.381189	0.0
48	PO-X(all)	po_0140	423457.694260	152996.515659	-145067.406933	0.0
49	PO-X(all)	po_0140	436738.166864	194700.383591	-151945.013462	0.0
50	PO-X(all)	po_0140	397893.204894	218742.613305	-189714.180162	0.0
51	PO-X(all)	po_0140	406184.377674	260194.829149	-195658.423983	0.0
52	PO-X(all)	po_0140	364872.604321	278137.967434	-233734.197300	0.0
53	PO-X(all)	po_0140	368834.533468	318355.582790	-239336.641907	0.0

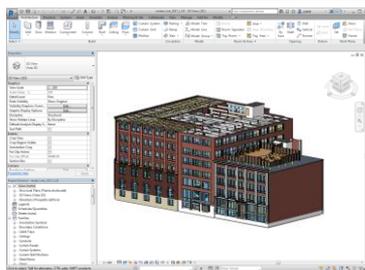
13. Revit 2020 Interface

Gen-Revit Link

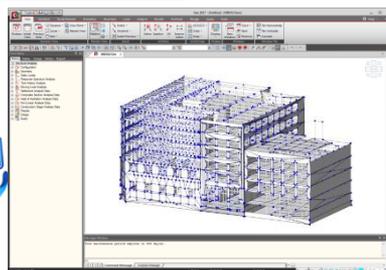
- **File > Import > midas Gen MGT File**
- **File > Export > midas Gen MGT File**



Send Model to midas Gen



Revit 2020



Gen2020

	Functions	Revit ↔ Gen
Linear Elements	Structural Column	↔
	Beam	↔
	Brace	↔
	Curved Beam	>
	Beam System	>
	Truss	>
Planar Elements	Foundation Slab	↔
	Structural Floor	↔
	Structural Wall	↔
	Wall Opening & Window	>
	Door	>
	Vertical or Shaft Opening	>
Boundary	Offset	>
	Rigid Link	>
	Cross-Section Rotation	>
	End Release	>
	Isolated Foundation Support	>
	Point Boundary Condition	>
	Line Boundary Condition	>
	Wall Foundation	>
	Area Boundary Condition	>
	Load	Load Nature
Load Case		>
Load Combination		>
Hosted Point Load		>
Hosted Line Load		>
Hosted Area Load		>
Other Parameters	Material	↔
	Level	>

14. Select Inelastic Hinge Result Output in Inelastic time history analysis

- **Properties > Inelastic Properties > Inel. Control Data > Select Inelastic Hinge Result Output(Element/General Link)**
- **Load > Dynamic Loads > Time History Analysis Data > Global Control**

▪ Select the element to print

Select Inelastic Hinge Result Output

Hinge Result Output Elements

Element Type

All Type Truss

Beam-Column Wall

Fiber Section Result

Output All each Step

Add / Replace Delete

Element	Hinge Properties	Fiber
B1	COLUMN	0
B2	COLUMN	0
B3	COLUMN	0
B4	COLUMN	0
B5	COLUMN	0

- Press 'Add/Replace' button after selecting element on model view

▪ Select General Link to print

Select Inelastic Hinge Result Output

Hinge Result Output GL-Links

Select GL-Link

Name
<input type="checkbox"/> 4 (n1:10, n2:17)
<input type="checkbox"/> 3 (n1:4, n2:11)
<input type="checkbox"/> 2 (n1:11, n2:18)
<input type="checkbox"/> 1 (n1:5, n2:12)

Select From View Unselect All

Add Delete

GL-Link List

Name
1 (n1:5, n2:12)
3 (n1:4, n2:11)

- Press 'Add' button after selecting GL-Link

▪ Global Control Setting

Nonlinear Analysis Result Output Option

Inelastic Hinge : All each Step Output Option

All Inelastic Elements
(+, Very Long Time Required)

Selected Elements in Hinge Result Output
(+, Recommended)

No Step-by-Step Results
(+, Max/Min Result Only : Hinge Result Table)

- Set to output selected elements

- By setting to output only the results of the selected element,
- It can be shorten the analysis time and check the required results.

▪ Inelastic Hinge Status Result

Inelastic Hinge Status

Inelastic Hinge Status

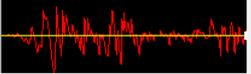
Function

Time History Load Cases Name

DYNA

Step 10

Time Function ElcentLh



Type of Result

Hinge Status (Deform, Level)

Ductility Factor(D/D1)

Ductility Factor(D/D2)

Deformation

Force

Status of Yielding

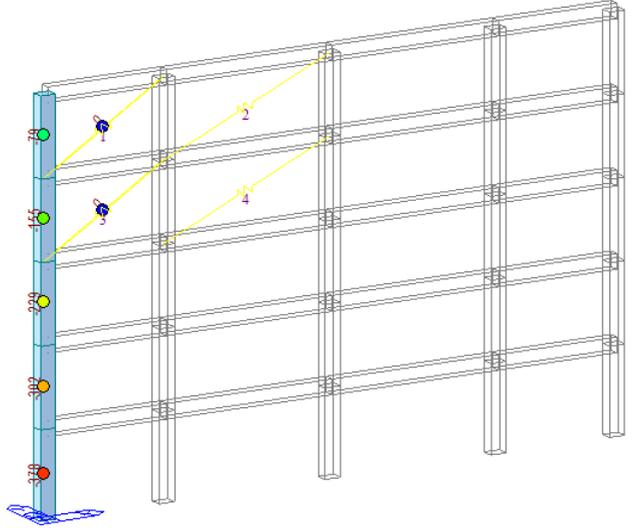
Status of Yielding (FEMA)

Performance (FEMA)

Components

Fx Fy Fz

Mx My Mz



- Check result of selected elements

14. Select Inelastic Hinge Result Output in Inelastic time history analysis

- **Properties > Inelastic Properties > Inel. Control Data > Select Inelastic Hinge Result Output(Element/General Link)**
- **Load > Dynamic Loads > Time History Analysis Data > Global Control**
- **Global Control Setting**

Nonlinear Analysis Result Output Option

Inelastic Hinge : All each Step Output Option

All Inelastic Elements
(+, Very Long Time Required)

Selected Elements in Hinge Result Output
(+, Recommended)

No Step-by-Step Results
(+, Max/Min Result Only : Hinge Result Table)

Fiber Section : All each Step Output Option

Common with Inelastic Results Option

All Inelastic Elements
(+, Not Recommended : Very Long Time Required)

Selected Elements in Hinge Result Output
(+, Recommended)

No Step-by-Step Results
(+, Max/Min Result Only : Fiber Result Table)



▪ Inelastic Hinge Status Result

Inelastic Hinge Status

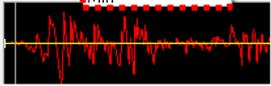
Inelastic Hinge Status

Function

Time History Load Cases Name
DYNA

Step
All

Time Func
Max



Type of Result

Hinge Status (Deform, Level)

Ductility Factor(D/D1)

Ductility Factor(D/D2)

Deformation

Force

Status of Yielding

Status of Yielding (FEMA)

Performance (FEMA)

Components

Fx Fy Fz

Mx My Mz

Type of Value

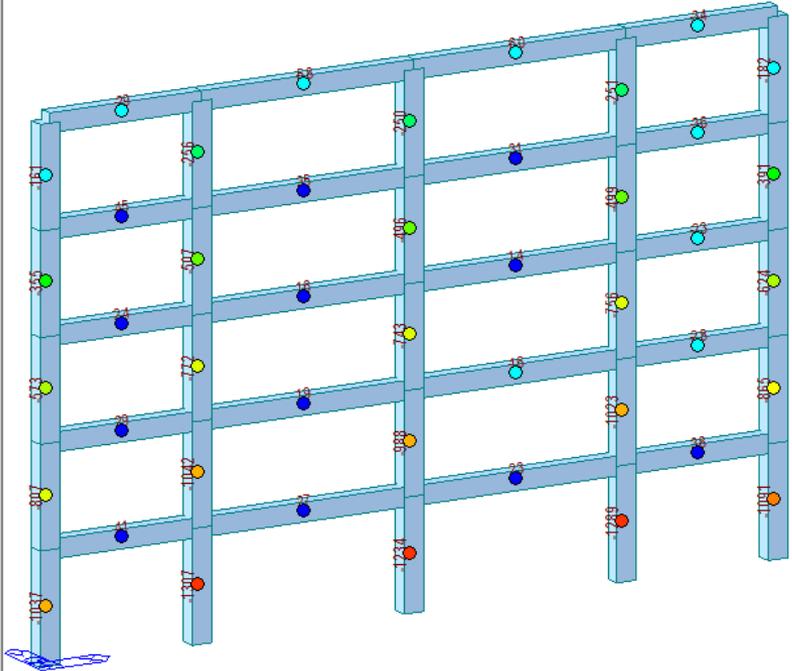
Positive Negative

Abs Max,

Type of Display

Contour Legend

Values Deform Undeformed

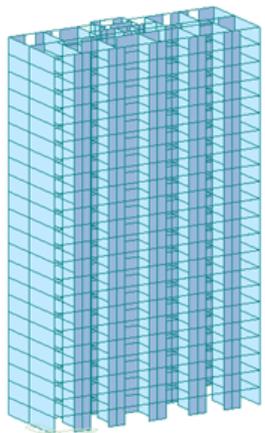


- Check Max/Min result output

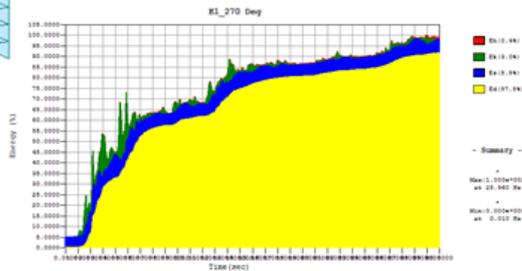
15. Improvement in analysis speed for inelastic time history analysis

Reduction of analysis time by optimizing the inelastic time history analysis program and improving the output algorithm for inelastic analysis results

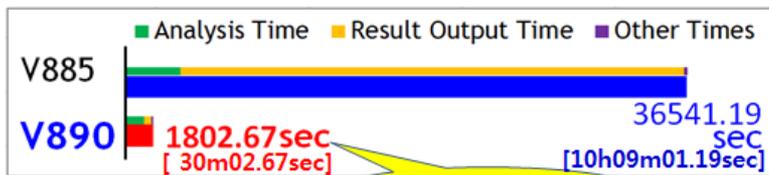
3D Fiber Wall Model (23F)



- Beam : 770 Element
- Wall : 1,320 Element
- Hinge Status : 11,880
- Fiber Cell : 950,040
- Analysis End Time : 30 sec (3000 step)

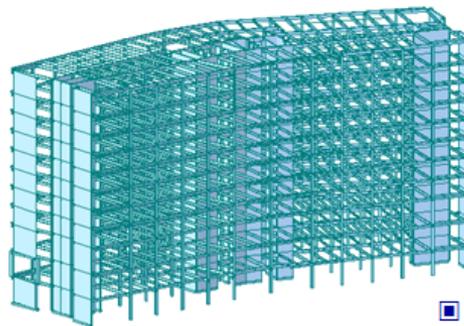


■ Total Analysis Time : V885 vs V890



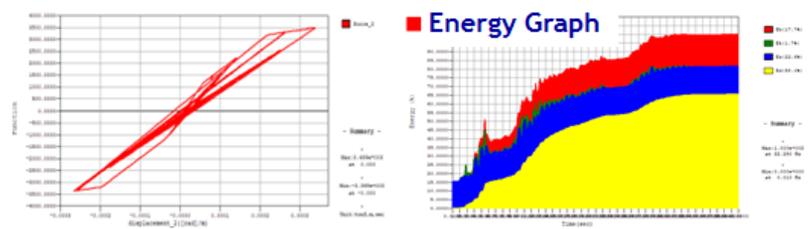
95% Time Save!!!

3D Structure Hinge Model (12F)



- Dynamic Loading
- Analysis End Time : 40 sec (4000 step)

- Beam : 5,117 Element
- Hinge Status : 4,050



■ Total Analysis Time : V885 vs V890



58% Time Save!!!

16. Add result summary table of fiber beam, wall for inelastic hinge

Results > Results Tables > Inelastic Hinge > Fiber Beam Summary, Fiber Wall Summary

Fiber Beam Summary

Element	Section Position	Material	Load	Cell	Minimum				Maximum					
					ε		Time/Step		ε		Time/Step			
Maximum and Minimum Strains at Each Section														
Element	Section	Load	Concrete						Steel					
			Minimum			Maximum			Minimum			Maximum		
Cell	ε	Time/Step	Cell	ε	Time/Step	Cell	ε	Time/Step	Cell	ε	Time/Step			
1	1-pos	DYNA	212	-1.31090e-003	3.080	2	4.51657e-003	3.090	234	-1.13533e-003	3.080	226	4.34048e-003	3.090
1	2-pos	DYNA	212	-3.65713e-004	2.990	212	6.49857e-004	6.050	234	-3.42752e-004	2.990	234	6.24902e-004	6.050
1	3-pos	DYNA	2	-2.26298e-004	3.100	212	3.83368e-004	2.660	229	-2.16190e-004	3.100	234	3.66219e-004	2.660
2	1-pos	DYNA	212	-4.33781e-004	2.080	212	1.16795e-003	5.950	234	-3.94597e-004	2.080	234	1.12444e-003	5.950
2	2-pos	DYNA	212	-1.60712e-004	2.180	212	4.11072e-004	4.560	234	-1.52268e-004	2.180	234	3.95087e-004	4.560
2	3-pos	DYNA	2	-3.94532e-004	3.060	212	7.49057e-004	3.060	226	-3.59973e-004	3.060	234	7.14507e-004	3.070
3	1-pos	DYNA	224	-2.35641e-004	2.890	212	9.42264e-004	5.950	235	-2.18520e-004	2.890	234	9.07028e-004	5.950
3	2-pos	DYNA	2	-1.55364e-004	3.060	212	2.61186e-004	2.360	226	-1.46279e-004	3.060	234	2.51061e-004	2.360
3	3-pos	DYNA	2	-4.04808e-004	3.020	212	1.01659e-003	3.030	226	-3.62026e-004	3.020	234	9.73654e-004	3.030

Fiber Beam Summary / <

Fiber Wall Summary

Story	Wall ID	Section Position	Material	Load	Cell	Minimum				Maximum					
						ε		Time/Step		ε		Time/Step			
Maximum and Minimum Strains at Each Section															
Story	Wall ID	Section	Load	Concrete						Steel					
				Minimum			Maximum			Minimum			Maximum		
Cell	ε	Time/Step	Cell	ε	Time/Step	Cell	ε	Time/Step	Cell	ε	Time/Step				
1F	1	1-pos	DYNA	1	-9.39160e-004	2.680	15	2.81189e-001	2.680	17	-7.11083e-004	2.360	24	2.80383e-001	2.680
1F	1	2-pos	DYNA	1	-8.67644e-004	2.680	15	1.67658e-001	2.680	17	-7.19437e-004	2.450	24	1.67176e-001	2.680
1F	1	3-pos	DYNA	1	-6.64995e-004	2.680	15	6.16266e-003	2.680	17	-6.45485e-004	2.680	24	6.14315e-003	2.680
1F	1	4-pos	DYNA	1	-4.82424e-004	2.680	15	2.32626e-003	2.680	17	-4.74398e-004	2.680	24	2.31824e-003	2.680
1F	1	5-pos	DYNA	1	-4.11744e-004	2.680	15	1.77338e-003	2.680	17	-4.05500e-004	2.680	24	1.76714e-003	2.680
2F	1	1-pos	DYNA	1	-4.08757e-004	2.680	15	1.77946e-003	2.660	17	-4.02511e-004	2.680	24	1.77321e-003	2.660
2F	1	2-pos	DYNA	1	-3.63986e-004	2.680	15	1.50301e-003	2.660	17	-3.58657e-004	2.680	24	1.49767e-003	2.660
2F	1	3-pos	DYNA	1	-2.97825e-004	2.680	15	1.15894e-003	2.660	17	-2.93668e-004	2.680	24	1.15478e-003	2.660
2F	1	4-pos	DYNA	1	-2.47810e-004	2.680	15	9.54822e-004	2.660	17	-2.44377e-004	2.680	24	9.51387e-004	2.660
2F	1	5-pos	DYNA	1	-2.21425e-004	2.680	15	8.47144e-004	2.660	17	-2.18374e-004	2.680	24	8.44092e-004	2.660
3F	1	1-pos	DYNA	1	-2.19067e-004	2.680	15	8.53079e-004	2.670	17	-2.16011e-004	2.680	24	8.50018e-004	2.670
3F	1	2-pos	DYNA	1	-1.99154e-004	2.680	15	7.72331e-004	2.670	17	-1.96387e-004	2.680	24	7.69557e-004	2.670
3F	1	3-pos	DYNA	1	-1.62067e-004	2.690	15	6.20154e-004	2.690	17	-1.59832e-004	2.690	24	6.17919e-004	2.690

Fiber Wall Summary / <

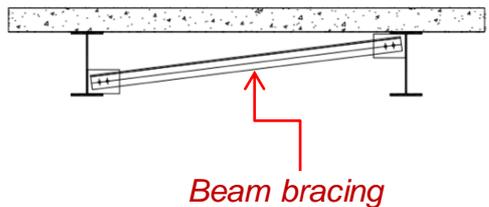
midas **Design+**

1. Steel design tool as per AISC

Unbraced Length of Beam bracing

CHK	Section						Material	Lateral Force Resisting System	Unbraced Length						
	Shape	Use DB	Name	Size1 (mm)	Size2 (mm)	Size3 (mm)			Size4 (mm)	Size5 (mm)	Size6 (mm)	Fy (MPa)	Es (MPa)	ry (mm)	Lb (m)
✓	H Section	✓	H 400x200x8/13	400.00	200.00	8.00	13.00	16.00	-	SS275	Special Moment Frames	275.00	210000.00	45.40	2.98
✓	H Section	✓	H 450x200x9/14	450.00	200.00	9.00	14.00	18.00	-	SS275	Intermediate Moment Frames	275.00	210000.00	44.00	5.71
✓	H Section	✓	H 496x199x9/14	496.00	199.00	9.00	14.00	20.00	-	SS275	Intermediate Moment Frames	275.00	210000.00	42.70	5.54
✓	H Section	✓	H 500x200x10/16	500.00	200.00	10.00	16.00	20.00	-	SS275	Intermediate Moment Frames	275.00	210000.00	43.30	5.62

AISC 341-16



(c) Beam bracing shall have a maximum spacing of

$$L_b = 0.19r_y E / (R_y F_y) \quad (D1-2)$$

where r_y = radius of gyration about y-axis, in. (mm)

$R_y = 1.1$ usually. When $R_y = 1.1$, AISC is the same as Korean code

2b. Highly Ductile Members

In addition to the requirements of Sections D1.2a.1(a) and (b), and D1.2a.2(a) and (b), the bracing of highly ductile beam members shall have a maximum spacing of $L_b = 0.095r_y E / (R_y F_y)$. For concrete-encased composite beams, the material properties of the steel section shall be used and the calculation for r_y in the plane of buckling shall be based on the elastic transformed section.

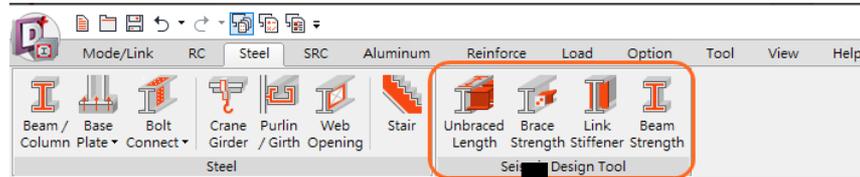
Korean code

Intermediated Moment
 $\rightarrow L_b = 0.17r_y E / F_y$

Special Moment Frames
 $\rightarrow L_b = 0.085r_y E / F_y$

1. Steel design tool as per AISC

Brace Strength (Beam)



Korean code is the same as AISC

AISC

1b. Point Bracing

In the direction perpendicular to the longitudinal axis of the beam, the required strength of end and intermediate point braces is

$$P_{br} = 0.02 \left(\frac{M_r C_d}{h_o} \right) \quad (A-6-7)$$

and, the required stiffness of the brace is

$$\beta_{br} = \frac{1}{\phi} \left(\frac{10M_r C_d}{L_{br} h_o} \right) \quad (\text{LRFD}) \quad (A-6-8a)$$

$$\beta_{br} = \Omega \left(\frac{10M_r C_d}{L_{br} h_o} \right) \quad (\text{ASD}) \quad (A-6-8b)$$

$$\phi = 0.75 \quad (\text{LRFD}) \quad \Omega = 2.00 \quad (\text{ASD})$$

where

L_{br} = unbraced length adjacent to the point brace, in. (mm)

M_r = largest of the required flexural strengths of the beam within the unbraced lengths adjacent to the point brace using LRFD or ASD load combinations, kip-in. (N-mm)

When the unbraced lengths adjacent to a point brace have different M_r / L_{br} values, the larger value shall be used to determine the required brace stiffness.

For intermediate point bracing of an individual beam, L_{br} in Equations A-6-8a or A-6-8b need not be taken less than the maximum effective length, L_o , permitted for the beam based upon the required flexural strength, M_r .

(a) When $\frac{P_r}{P_c} \geq 0.2$

$$\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx} + M_{ry}}{M_{cx} + M_{cy}} \right) \leq 1.0 \quad (H1-1a)$$

(b) When $\frac{P_r}{P_c} < 0.2$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx} + M_{ry}}{M_{cx} + M_{cy}} \right) \leq 1.0 \quad (H1-1b)$$

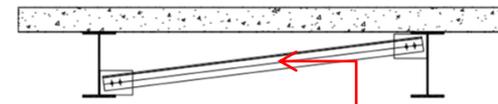
Korean code (LSD)

③ 횡지지가새 부재 검토 및 상세 - 0713.9.8

- 소요강도 $P_{br} = 0.02M_r C_d / h_o$

- 소요강성 $\beta_{br} = \frac{1}{\phi} \left(\frac{10M_r C_d}{L_{br} h_o} \right)$

(여기서 $\phi=0.75$, $M_r = M_u = R_y Z F_y$, $C_d = 1.0$)



(a) When $\frac{P_r}{P_c} \geq 0.2$

$$\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx} + M_{ry}}{M_{cx} + M_{cy}} \right) \leq 1.0$$

(b) When $\frac{P_r}{P_c} < 0.2$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx} + M_{ry}}{M_{cx} + M_{cy}} \right) \leq 1.0$$

Beam bracing

Brace Design Variables				Brace Strength		
ϕM_n (kN.m)	h_o (mm)	ϕ	Pbr (kN)	β_{br} (kN/m)	ϕP_n (kN)	Ratio
248.82	387.00	0.75	25.72	3429.00	195.93	OK(0.066)
418.27	436.00	0.75	38.37	25582.57	195.93	OK(0.098)
472.73	482.00	0.75	39.23	26153.53	195.93	OK(0.200)
539.55	484.00	0.75	44.59	29727.27	195.93	OK(0.228)

1. Steel design tool as per AISC

Brace Strength (Beam)

Flexural strength of beam (it is defined by the user)

CHK	Beam					Brace					Bracing Type	Force				Brace Design Variables				Brace Strength Ratio		
	Shape	Use DB	Name	Material	Lb (m)	Shape	Use DB	Name	Material	Lb (m)		Use Sect. φMn	Cb	Mr (kN.m)	Cd	φMn (kN.m)	ho (mm)	φ	Pbr (kN)		φbr (kN/m)	φPn (kN)
<input checked="" type="checkbox"/>	H Section	<input checked="" type="checkbox"/>	H 400x200x8/13	SS275	4.00	Angle	<input checked="" type="checkbox"/>	L 100x7	SS275	2.00	Nodal Bracing	<input checked="" type="checkbox"/>	1.00	1000.00	2.000	277.60	387.00	0.7	28.69	4782.0	148.38	OK(0.097)
<input type="checkbox"/>	H Section	<input checked="" type="checkbox"/>	H 450x200x9/14	SS275	1.00	Angle	<input checked="" type="checkbox"/>	L 100x7	SS275	1.00	Nodal Bracing	<input checked="" type="checkbox"/>	1.00	0.00	2.000	418.27	436.00	0.75	2.37	25582.57	196.93	OK(0.098)
<input type="checkbox"/>	H Section	<input checked="" type="checkbox"/>	H 496x199x9/14	SS275	1.00	Angle	<input checked="" type="checkbox"/>	L 100x7	SS275	1.00	Nodal Bracing	<input checked="" type="checkbox"/>	1.00	0.00	2.000	472.73	482.00	0.75	39.23	26153.53	195.93	OK(0.200)

Axial strength of brace (it is defined by the user)

Nodal Brace → $P_{br} = 0.02 \left(\frac{M_r C_d}{h_o} \right)$

Relative Brace → $P_{br} = 0.008 \left(\frac{M_r C_d}{h_o} \right)$

[Combination stress check]

(a) When $\frac{P_r}{P_c} \geq 0.2$

$$\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0$$

(b) When $\frac{P_r}{P_c} < 0.2$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0$$

In here,
 $M_r/M_c = 0$ Because a brace does not have a moment
 $P_r = P_{br}$
 $P_c = \phi P_n$

1. Steel design tool as per AISC

Link Stiffener Design



4. Link Stiffeners for I-Shaped Cross Sections

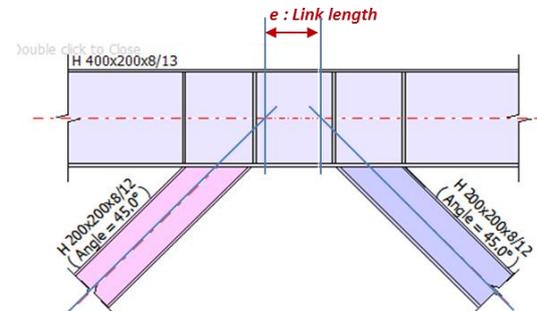
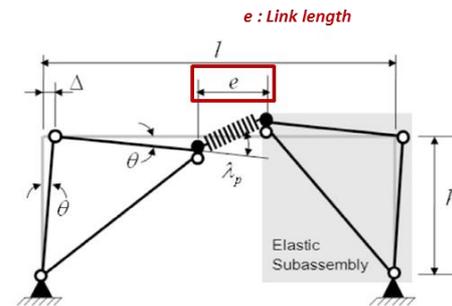
Full-depth web stiffeners shall be provided on both sides of the link web at the diagonal brace ends of the link. These stiffeners shall have a combined width not less than $(b_f - 2t_w)$ and a thickness not less than the larger of $0.75t_w$ or $\frac{3}{8}$ in. (10 mm), where b_f and t_w are the link flange width and link web thickness, respectively.

Links shall be provided with intermediate web stiffeners as follows:

- (a) Links of lengths $1.6M_p/V_p$ or less shall be provided with intermediate web stiffeners spaced at intervals not exceeding $(30t_w - d/5)$ for a link rotation angle of 0.08 rad or $(52t_w - d/5)$ for link rotation angles of 0.02 rad or less. Linear interpolation shall be used for values between 0.08 and 0.02 rad.
- (b) Links of length greater than or equal to $2.6M_p/V_p$ and less than $5M_p/V_p$ shall be provided with intermediate web stiffeners placed at a distance of 1.5 times b_f from each end of the link.
- (c) Links of length between $1.6M_p/V_p$ and $2.6M_p/V_p$ shall be provided with intermediate web stiffeners meeting the requirements of (a) and (b) in the preceding.

Intermediate web stiffeners shall not be required in links of length greater than $5M_p/V_p$.

*Seismic Provisions for Structural Steel Buildings, July 12, 2016
American Institute of Steel Construction*



Sect. F3.1

ECCENTRICALLY BRACED FRAMES (EBF)

9.1-75

Intermediate web stiffeners shall be full depth. For links that are less than 25 in. (630 mm) in depth, stiffeners shall be provided on only one side of the link web. The thickness of one-sided stiffeners shall not be less than t_w or $\frac{3}{8}$ in. (10 mm), whichever is larger, and the width shall not be less than $(b_f/2) - t_w$. For links that are 25 in. (630 mm) in depth or greater, intermediate stiffeners with these dimensions shall be provided on both sides of the web.

1. Steel design tool as per AISC

Link Stiffener Design

Link Length = 'e'

CHK	Section			Material	Link		Link Stiffener									
	Shape	Use DB	Name		Length (m)	Angle (Deg.)	Zx (mm ²)	Aweb (mm ²)	Fy (MPa)	Mp (kN.m)	Vp (kN)	Mp/Vp (mm)	breq (mm)	treq (mm)	sreq (mm)	Dbl Stif.
✓	H Section	✓	H 400x200x8/13	SS275	1.00	45.00	1330000.00	2992.00	275.00	365.75	493.68	740.86	184.00	10.00	160.00	No

$A_{lw} = (d - 2t_f)t_w$ for I-shaped link sections

(F3-4)

$M_p = F_y Z$ for $\alpha_s P_r / P_y \leq 0.15$

(F3-8)

$V_p = 0.6 F_y A_{lw}$ for $\alpha_s P_r / P_y \leq 0.15$

(F3-2)

$V_n = 2 M_p / e$

(F3-7)

Minimum [Vp, Vn]

Full-depth web stiffeners shall be provided on both sides of the link web at the diagonal brace ends of the link. These stiffeners shall have a combined width not less than $(b_f - 2t_w)$ and a thickness not less than the larger of $0.75t_w$ or $3/8$ in. (10 mm), where b_f and t_w are the link flange width and link web thickness, respectively.

Links shall be provided with intermediate web stiffeners as follows:

- (a) Links of lengths $1.6M_p/V_p$ or less shall be provided with intermediate web stiffeners spaced at intervals not exceeding $(30t_w - d/5)$ for a link rotation angle of 0.08 rad or $(52t_w - d/5)$ for link rotation angles of 0.02 rad or less. Linear interpolation shall be used for values between 0.08 and 0.02 rad.
- (b) Links of length greater than or equal to $2.6M_p/V_p$ and less than $5M_p/V_p$ shall be provided with intermediate web stiffeners placed at a distance of 1.5 times b_f from each end of the link.
- (c) Links of length between $1.6M_p/V_p$ and $2.6M_p/V_p$ shall be provided with intermediate web stiffeners meeting the requirements of (a) and (b) in the preceding.

Intermediate web stiffeners shall not be required in links of length greater than $5M_p/V_p$.

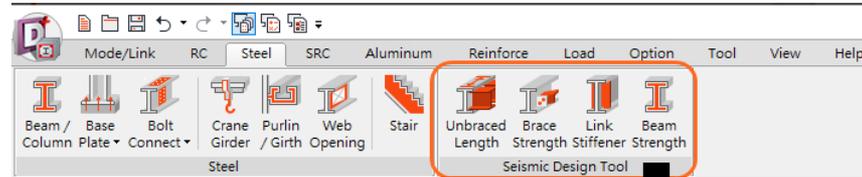
"No" : To provide on one side is possible
 "Yes" : To provide on one side is not possible
 *** it is just to inform whether one side is possible.
 And all results is for both side.

Link		Link Stiffener									
Length (m)	Angle (Deg.)	Zx (mm ²)	Aweb (mm ²)	Fy (MPa)	Mp (kN.m)	Vp (kN)	Mp/Vp (mm)	breq (mm)	treq (mm)	sreq (mm)	Dbl Stif.
5.00	45.00	-	-	-	-	-	-	-	-	-	-

If $e > 5M_p/V_p$, "-" will be output

1. Steel design tool as per AISC

Beam Strength (Beam design with K-brace)



Chk	Beam					Brace1					Brace2														
	Shape	Use DB	Name	Material	Length (m)	Shape	Use DB	Name	Material	Type	User	Ry	Length (m)	Cb	Angle (Deg.)	Shape	Use DB	Name	Material	Type	User	Ry	Length (m)	Cb	Angle (Deg.)
✓	H Section	✓	H 400x200x8/13	S5275	2.00	H Section	✓	H 200x200x8/12	S5275	Tension Brace	Γ	1.100	1.00	1.00	45.00	H Section	✓	H 200x200x8/12	S5275	Compression Brace	Γ	1.100	1.00	1.00	45.00

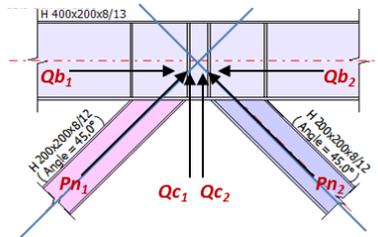
Design Forces					Check Result of Brace					Check Result of Beam															
Dead Load		Live Load			Seismic Load	Brace1			Brace2			Design Forces			Design Strength			Strength Ratio							
Factor	Mux (kN.m)	Vuy (kN)	Factor	Mux (kN.m)		Vuy (kN)	Fy (MPa)	Pn (kN)	Qb (kN)	Qc (kN)	Fy (MPa)	Pn (kN)	Qb (kN)	Qc (kN)	Fy (MPa)	Mux (kN.m)	Vuy (kN)	φPn (kN)	φMn (kN.m)	φVn (kN)	Pux / φPn	Mux / φMn	Vuy / φVn	Comb.	
1.20	100.00	100.00	0.50	150.00	150.00	1.00	275.00	2271.20	1605.98	1605.98	275.00	512.70	362.53	362.53	275.00	1968.51	195.00	2163.51	1869.26	329.18	528.00	NG(1.053)	OK(0.592)	NG(4.098)	NG(1.580)

$F_D Mux_D Vuy_D F_L Mux_L Vuy_L$

In case of Tension,
 $Pn = Fy * Area * Ry$ (Tension)

In case of compression,
 Pn is the value considered the buckling

$Qb = Qc = Pn / \text{sqrt}(2)$
* Angle is reflected only with 45.0°



$Pux = Qb_1 + Qb_2$

$Mux = F_D * Mux_D + F_L * Mux_L$

$Vuy = F_D * Vuy_D + F_L * Vuy_L + Qc_1 + Qc_2$

[Combination stress check]

(a) When $\frac{P_r}{P_c} \geq 0.2$

$$\frac{P_r}{P_c} + \frac{8}{9} \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0$$

(b) When $\frac{P_r}{P_c} < 0.2$

$$\frac{P_r}{2P_c} + \left(\frac{M_{rx}}{M_{cx}} + \frac{M_{ry}}{M_{cy}} \right) \leq 1.0$$

In here,
 $P_r = Pux, P_c = \phi Pn$
 $M_{rx} = Mux, M_{cy} = \phi Mn$

2. Anchor bolt module as per ACI

RC > Anchor Bolt

- Applied Code : ACI318-14(M),11(M),08(M),NSR-10
- Spacing, Tensile, Shear Strength, Combined Ratio Check for Post-Installed / Cast-In-Place Anchor Bolt

The screenshot displays the midas Design software interface for the Anchor Bolt module. The 'Member' dialog box is open, showing general information for member 'AB04' and section properties. The 'MIDASIT RC ANCHOR BOLT LIST' dialog is also open, showing two columns of anchor bolt specifications (AB03 and AB04) with their respective plate sizes and installation types. The 'Report' window on the right shows the calculation results for tensile strength, including a table of values and diagrams illustrating the anchor bolt configurations.

Category	N_u	N_n	$N_u / (\phi N_n)$	Note
Steel strength* (kip)	1.185	0.226	0.192	$\phi = 0.750$
Concrete breakout strength** (kip)	0.803	19.29	0.041	$\phi = 0.850$
Pullout Strength* (kip)	1.185	0.744	0.210	$\phi = 0.850$
Concrete side face blowout strength** (kip)				
Bond Strength of Adhesive Anchor** (kip)				

2. Anchor bolt module as per ACI

Procedure of Anchor Bolt Design

Section

Section Force Anchor Layout	
Material	
Concrete	27 MPa
Anchor Bolt	KS-B-1016-4.6
<input type="checkbox"/> Light Weight Concrete	
Factor	1
Plate Section	
Left	80.00 mm
Right	80.00 mm
Top	80.00 mm
Bottom	80.00 mm
Thickness	6.00 mm
RC Section	
<input checked="" type="radio"/> Crack	<input type="radio"/> Uncrack
<input checked="" type="checkbox"/> Left	120.00 mm
<input checked="" type="checkbox"/> Right	120.00 mm
<input checked="" type="checkbox"/> Top	120.00 mm
<input checked="" type="checkbox"/> Bottom	120.00 mm
<input type="checkbox"/> Thickness	500.00 mm
<input checked="" type="checkbox"/> Grout	5.00 mm

Step 1.
Define concrete, Anchor bolt material and element information.

Force

Section Force Anchor Layout	
Force	500.00 kN
Moment (x)	10.00 kN.m
Moment (y)	20.00 kN.m
Shear (x)	30.00 kN
Shear (y)	40.00 kN
Torsion	5.00 kN.m
<input type="checkbox"/> Load Combinations (1) ...	

Step 2.
Define Force Data.
(Axial, Moment, Shear, Torsion)

Anchor

Section Force Anchor Layout	
Anchor	
Install Type	Cast-In-Place Anchor I
Anchor Type	Headed Stud
Diameter	M12
Length (hef)	180.00 mm
Pullout Strength (Np)	30.00 kN
Dist. of J/L-Bolt (eh)	30.00 mm
Strength Reduction Factor	
Concrete, Tension	0.650
Concrete, Shear	0.750
Anchor, Tension	0.750
Anchor, Shear	0.650
Design	
Breakout Strength Coefficient (kc)	10.000

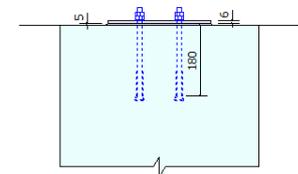
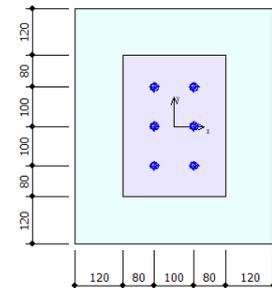
Step 3.
Define Anchor Bolt information.

Cast-In-Place Anchor : Headed Stud/Headed Bolt/Hooked Bolt(L/J)
Post-Installed Anchor:
Expansion(Torque, Displacement), Undercut, Adhesive anchors

Layout

Section Force Anchor Layout	
Layout Type	
Layout Type	Grid Type
Space (Int. x)	130.00 mm
Space (Int. y)	100.00 mm
Space (Ext. x)	100.00 mm
Space (Ext. y)	100.00 mm
Num. of Row	3
Num. of Col	2

Step 4.
Define the layout type & spacing
Number of Anchor bolt.



2. Anchor bolt module as per ACI

Summary Calculation Report

7. Calculation Summary

(1) Required edge distances, spacings, and thicknesses to preclude splitting failure

Category	Value	Criteria	Ratio	Note
Minimum spacing of anchors (mm)	100	72.00	0.720	s_{req} / s_{min}
Minimum edge distances (mm)	-	-	-	-
Limit of embedment depth (mm)	-	-	-	-

(2) Tensile strength

Category	N_{us}	N_n	$N_{us} / (\phi N_n)$	Note
Steel strength* (kN)	0.000	33.72	0.000	$\phi = 0.750$
Concrete breakout strength** (kN)	0.000	0.000	0.000	$\phi = 0.650$
Pullout Strength* (kN)	0.000	50.38	0.000	$\phi = 0.650$
Concrete side-face blowout strength** (kN)	-	-	-	-

* anchor having the highest loading

** anchor group (anchors in tension)

(3) Shear strength

Category	V_{us}	V_n	$V_{us} / (\phi V_n)$	Note
Steel strength* (kN)	8.333	26.98	0.475	$\phi = 0.650$
Concrete breakout strength** (Dir. X) (kN)	15.00	41.67	0.480	$\phi = 0.750$
Concrete breakout strength** (Dir. Y) (kN)	13.33	34.73	0.512	$\phi = 0.750$
Concrete pryout strength** (kN)	-	-	-	-

* anchor having the highest loading

** anchor group (relevant anchors)

(4) Combined Ratio

Category	Value	Criteria	Ratio	Note
Combined Ratio	0.512	1.000	0.512	

Detail Calculation Report

11. Required edge distances, spacings, and thicknesses to preclude splitting failure

[KDS 14 20 54 : 2016, Sec. 4.6(2)]

Calculation Summary (Required edge distances, spacings, and thicknesses to preclude splitting failure)

(1) Minimum center-to-center spacing of anchors

s_{min}	s_{req}	s_{req} / s_{min}
100mm	72.00mm	0.720

- $s_{min} = 100mm$
- $s_{req} = 6 d_s = 72.00mm$
- $s_{min} = 100mm > s_{req} = 72.00mm \rightarrow O.K$

(2) Check Distance from Concrete Edge to Center of Anchor Bolt

Post-installed anchors only.

(3) The limitations on the value of h_{ef}

Expansion or undercut post-installed anchors only.

(4) The critical edge distance (c_{ac})

Post-installed anchors only.

13. Calculate Shear Strength

Failure modes for anchors. (Shear loading)

(1) Steel strength

(2) Pullout Strength

(3) Concrete breakout strength

Calculation Summary (Shear strength)

(1) Calculate Strength of Steel

[KDS 14 20 54 : 2016, Sec. 4.4.1, ref. ACI 318-14 17.5.1]

- $\phi = 0.650$
- $f_{ts} = \min(f_{ts} , 1.9f_{ts} , 860.0) = 400MPa$
- $A_{se,v} = 84.30mm^2$

For cast-in headed stud anchor

- $V_{ss} = n A_{se,v} f_{ts} = 33.72kN (n = 1)$

Where anchors are used with built-up grout pads

- $V'_{ss,grout} = 0.8 V_{ss} = 26.98kN$
- $V_{n1} / (\phi V_{ss}) = 0.475 < 1.0 \rightarrow O.K$

(2) Calculate Concrete Break-Out Strength

[KDS 14 20 54 : 2016, Sec. 4.4.2]

- $\phi = 0.750$
- $d_s = 12.00mm$
- $\lambda = 1.000$

Where l_e is the load-bearing length of the anchor for shear.

- $l_e = \min(8d_s , h_{ef}) = 96.00mm$

- Choose Summary/Detail Calculation Report
- Easy to check by printing standard(code)chapter in detail calculation report.