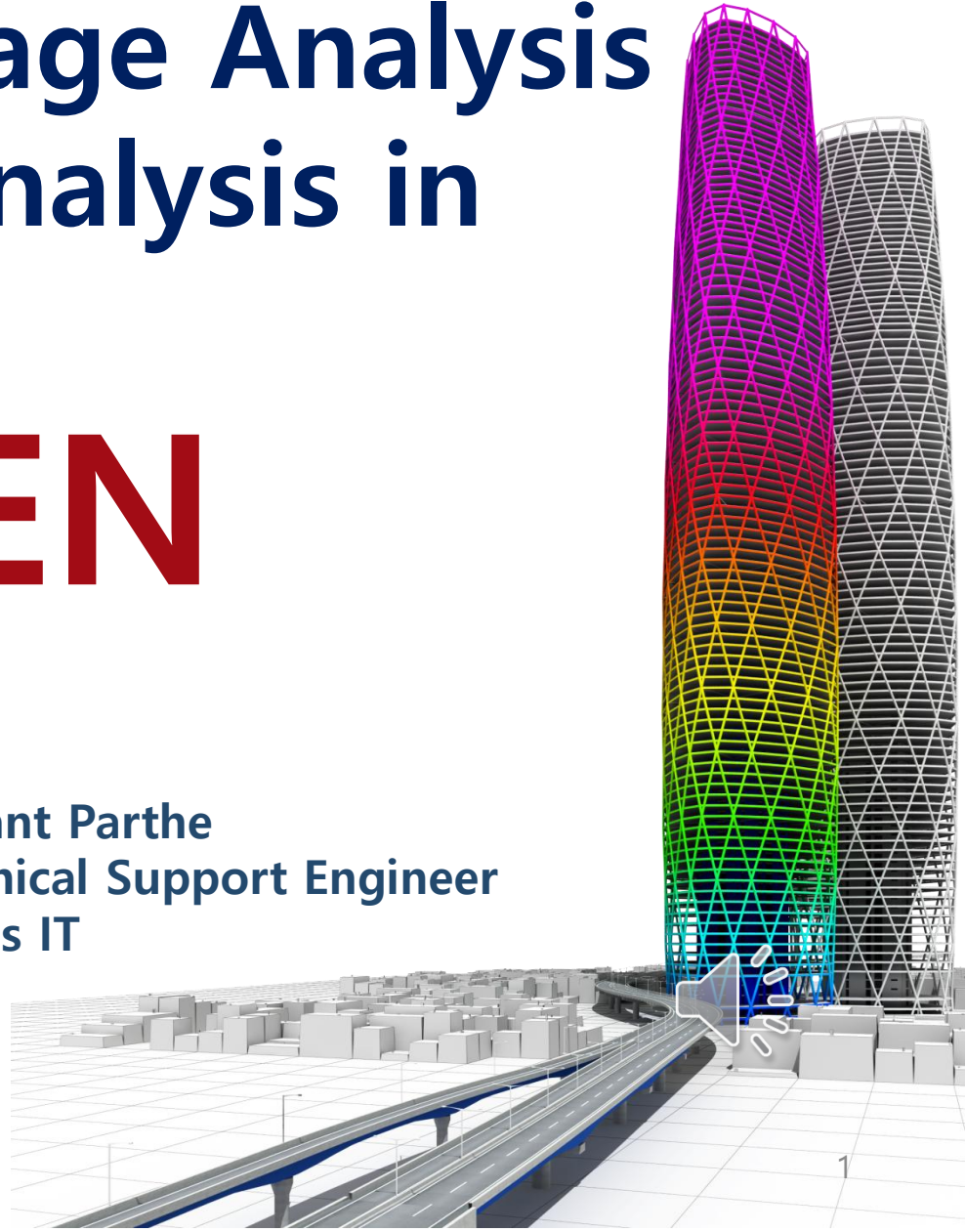
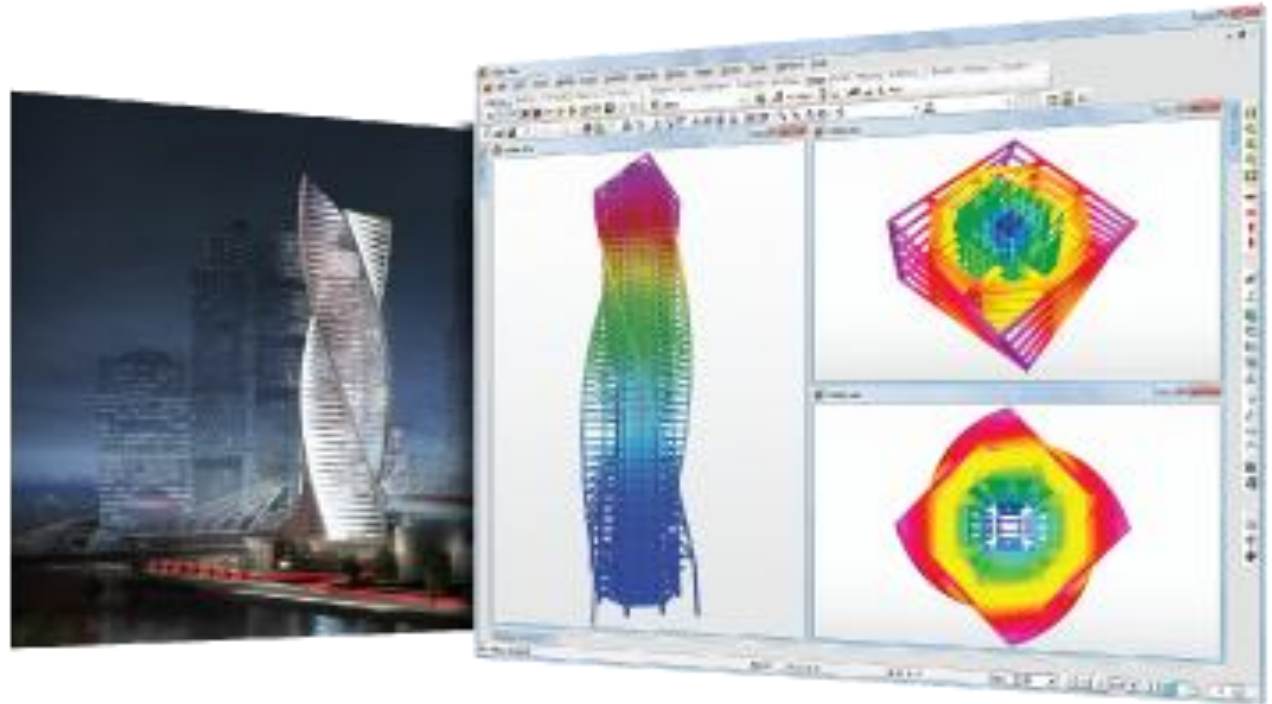


Construction Stage Analysis & Wind Load Analysis in Buildings on **Midas GEN**

- Vikrant Parthe
Technical Support Engineer
Midas IT



Tall Building Projects



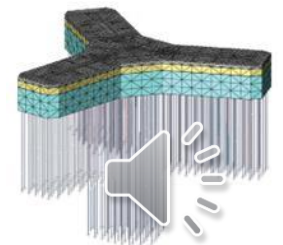
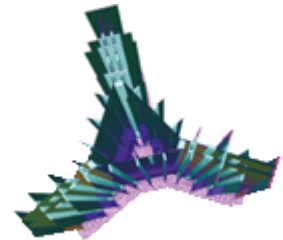
Moscow City Palace Tower (Russia)

Twisting 46-story Building with Composite Columns

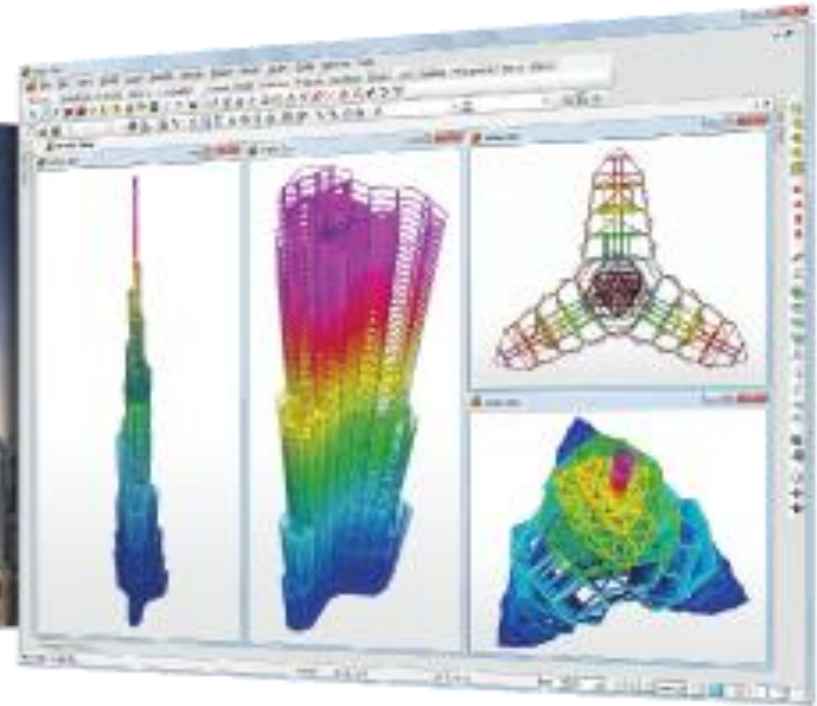
Tall Building Projects



Kingdom Tower (Saudi Arabia)
Over 1,000 meters in height



Tall Building Projects

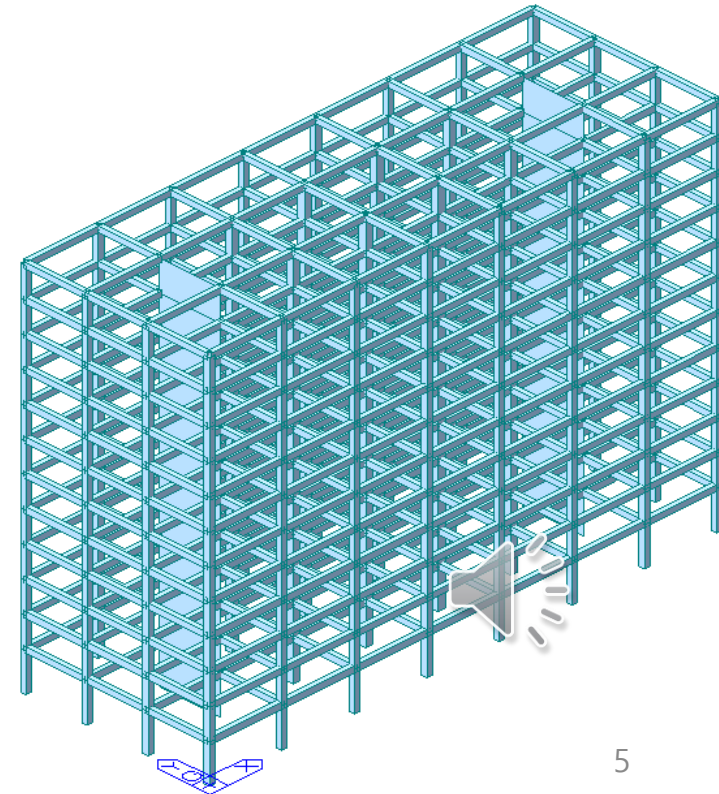


Burj Khalifa (UAE)
The World's Tallest Building



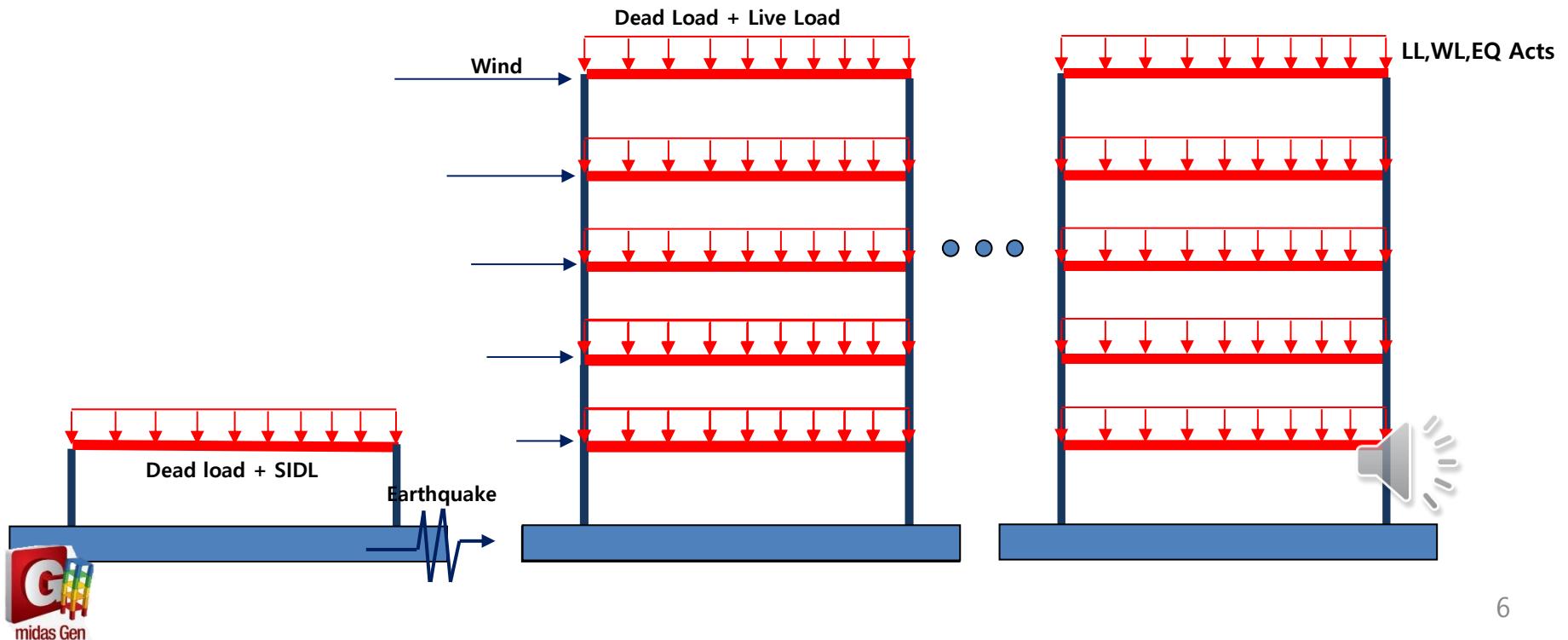
Contents

1. Basics of construction stage analysis
2. Importance of column shortening analysis & its effects
3. Construction stage analysis in Midas Gen
4. Wind Load Analysis
5. Live demonstrations
6. Summary



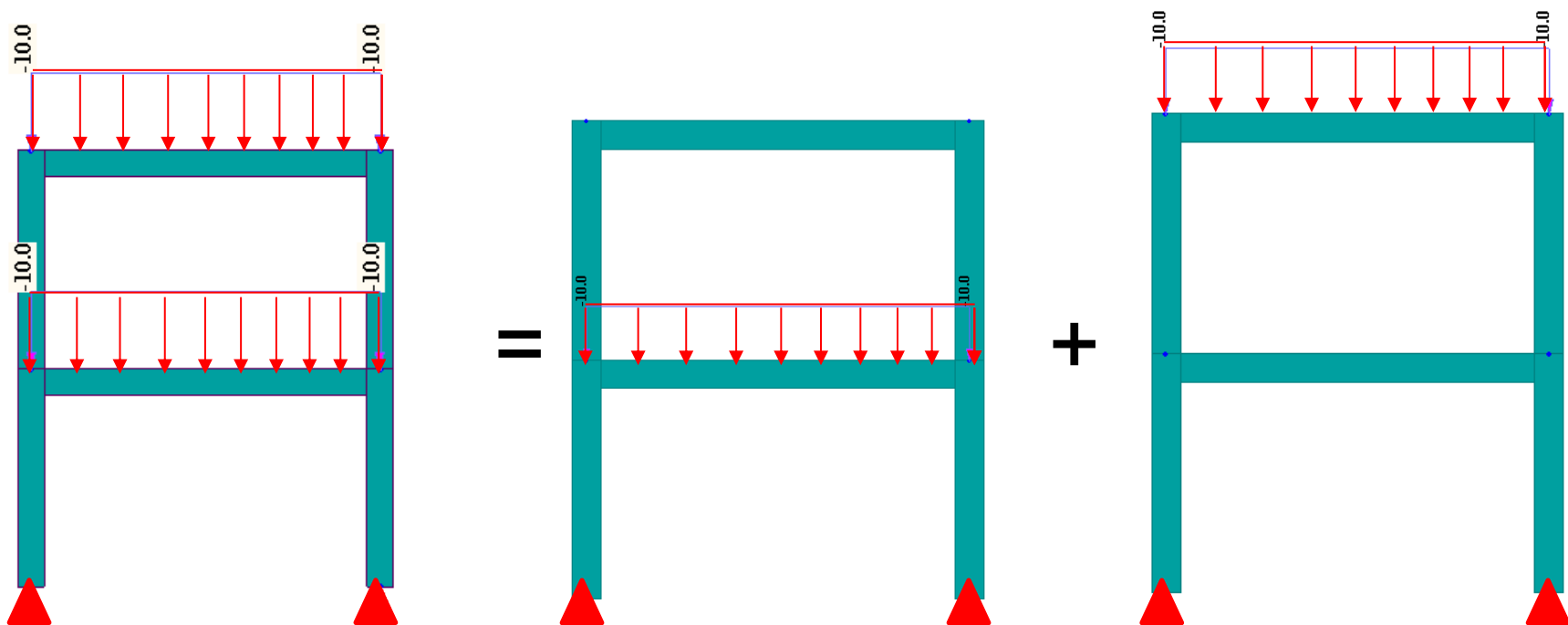
What is Construction Stage?

- Structural analysis → built and loaded in a **moment**.
- Construction of structures is a time taking process and during this period **Material Properties, Loads and Boundaries** conditions may change.



Why is CS Analysis Required?

Conventional Analysis

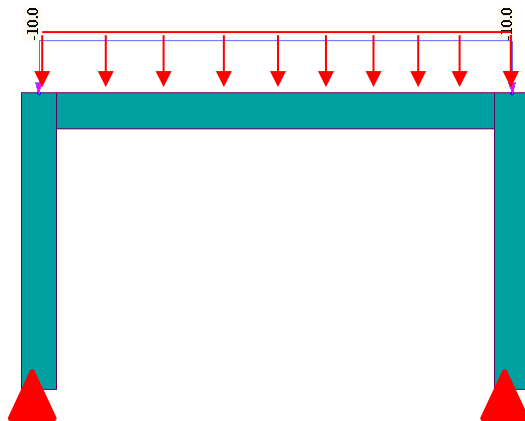


Superposition on same structure

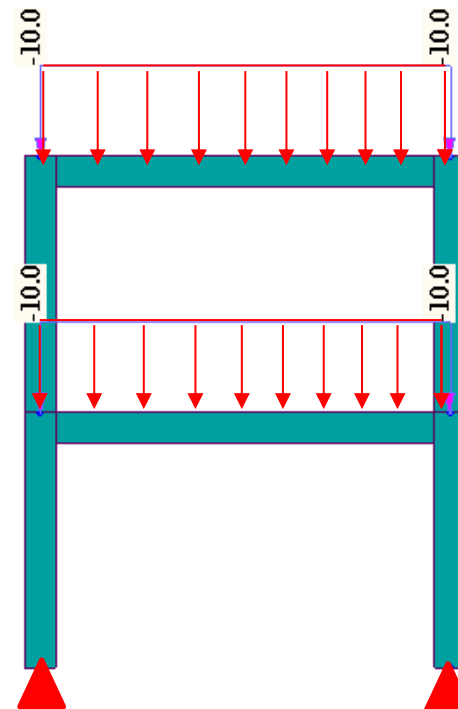


Why is CS Analysis Required?

Construction Stage Analysis



STAGE 1

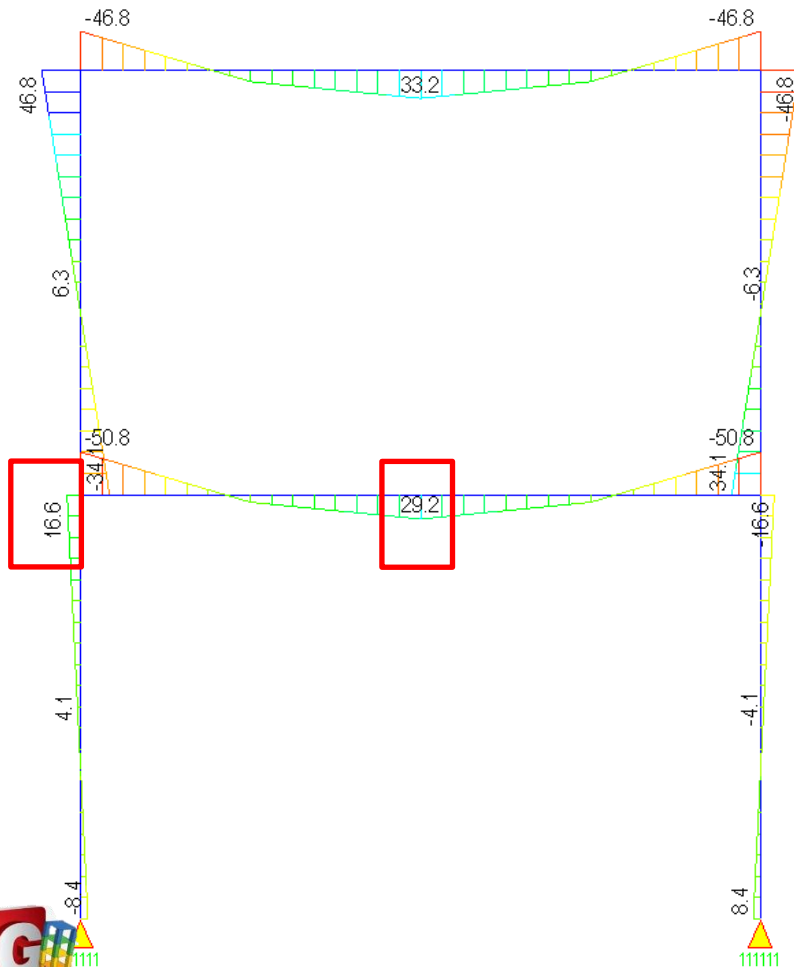


STAGE 2

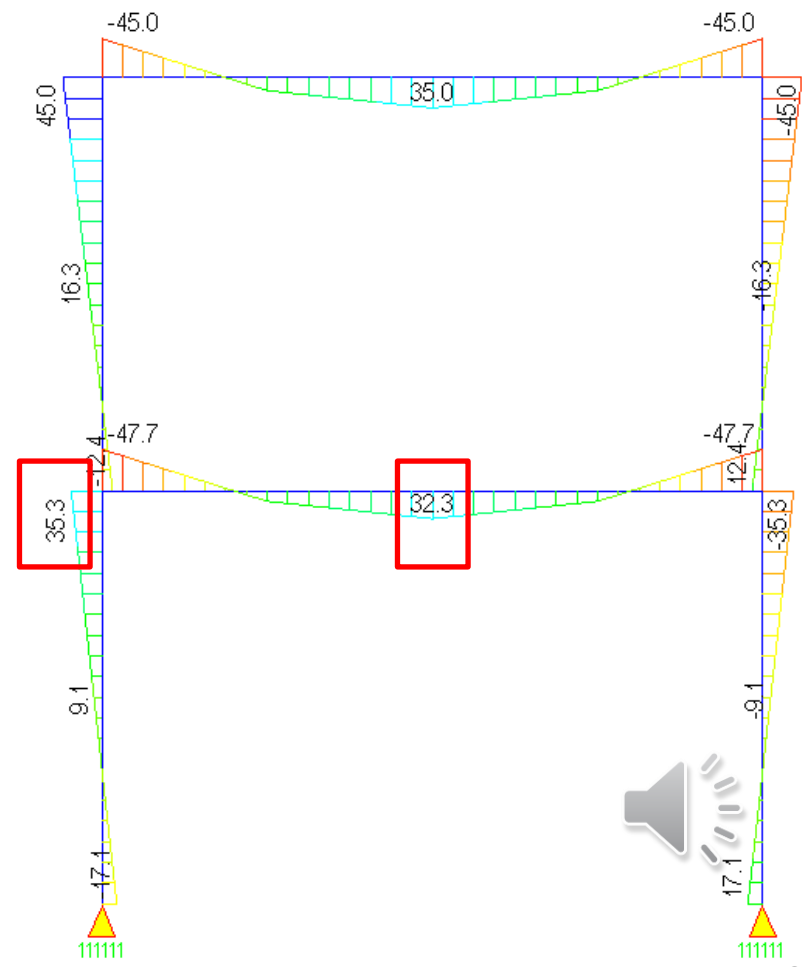


Why is CS Analysis Required?

Conventional Analysis

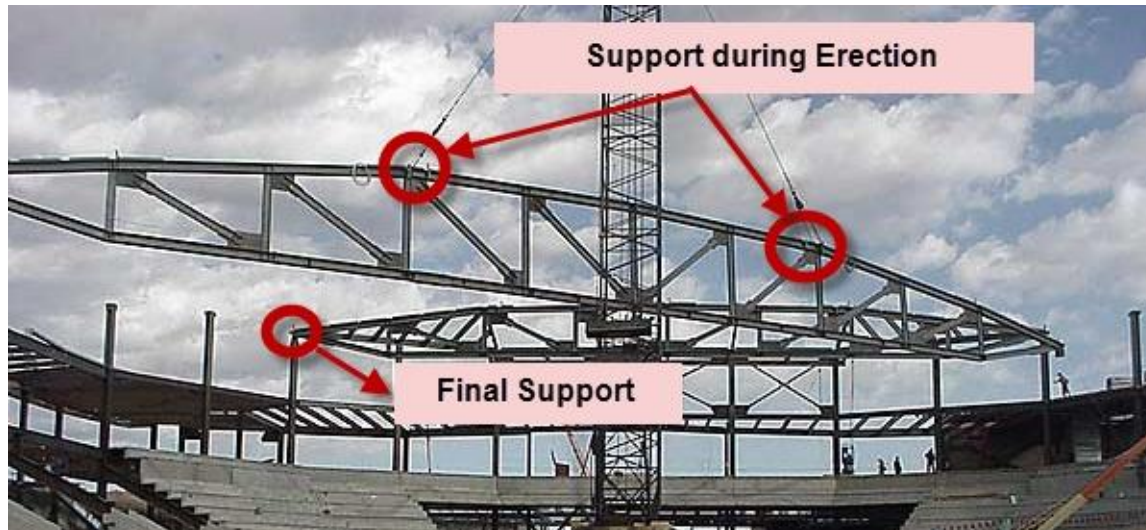


CS Analysis



Where is CS Analysis Considered?

✓ Long Span Trusses



✓ Long Span Slabs and Beams constructed in multiple stages

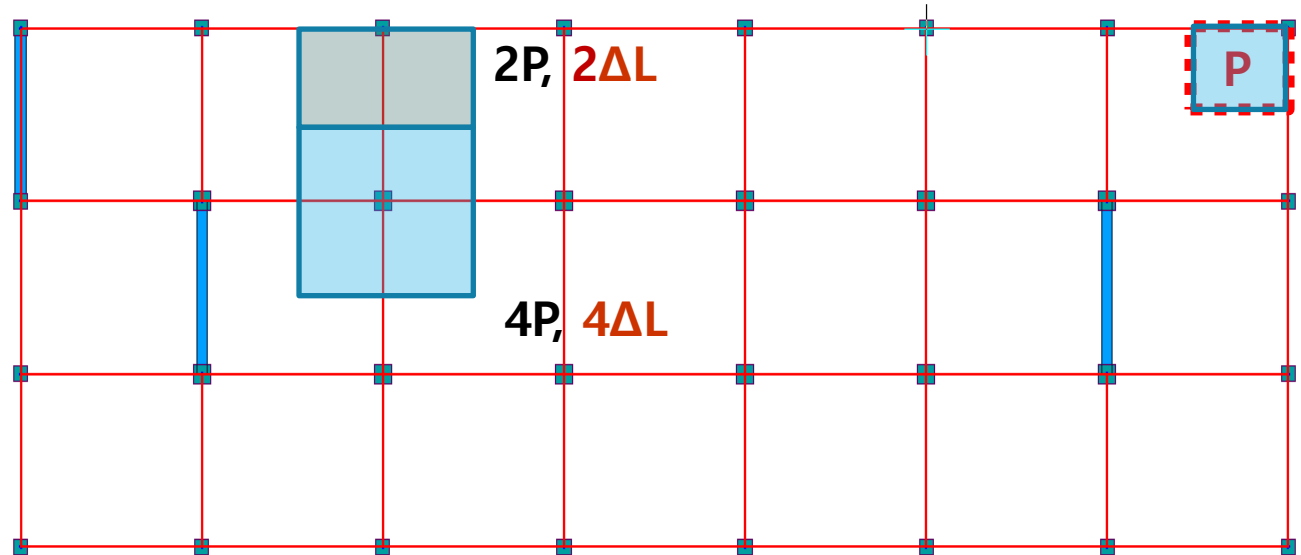
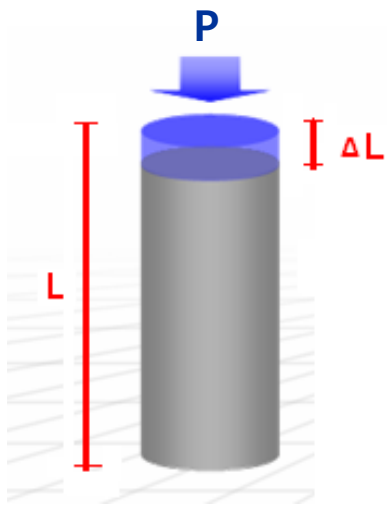
CS
Analysis



Change in Support Conditions, Loading
and Structural Configuration



Importance of Column Shortening



$$E = (\sigma / \varepsilon)$$

$$\Delta L = (PL/AE)$$

Differential shortening in Columns → **Additional forces** in Beams and Slabs

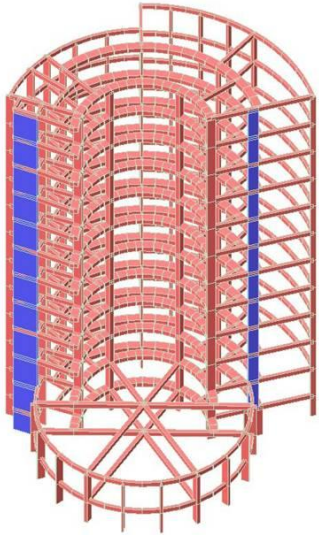


Effects of Column Shortening in Buildings

Steel Building → 80 Storey



Elastic Shortening ~ 180-255 mm



Concrete Building → 80 Storey



Elastic Shortening ~ 65 mm

Total Shortening ~ 180-230 mm

***Inelastic Shortening ~ 1 to 3 times Elastic shortening.**

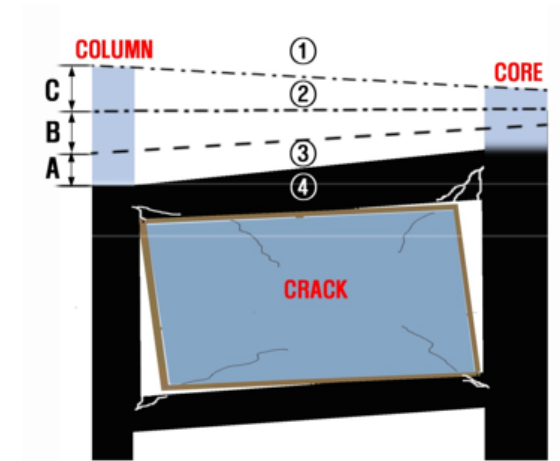
With increased height of structures, the effect of column shortening (Elastic & Inelastic) take on added significance and need special consideration in design and construction.



Compensation for Column Shortening in Buildings

Depending on the stage of construction:

- **Pre-slab installation shortenings:**
Shortenings taking place up to the time of slab installation
- **Post-slab installation shortenings:**
Shortenings taking place after the time of slab installation



① : Compensation

② : Design Level

③ : Pre-slab Installation shortening

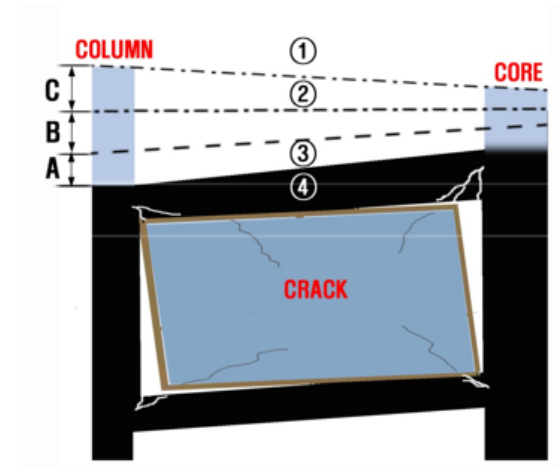
④ : Post-slab Installation shortening



Compensation for Column Shortening in Buildings

Depending on the construction material:

- **Reinforced Concrete Structure**
 - Pre-slab installation shortenings have no importance
 - Compensation by leveling the forms
 - Post-slab installation shortenings due to subsequent loads and creep/shrinkage



- ① : Compensation
- ② : Design Level
- ③ : Pre-slab Installation shortening
- ④ : Post-slab Installation shortening



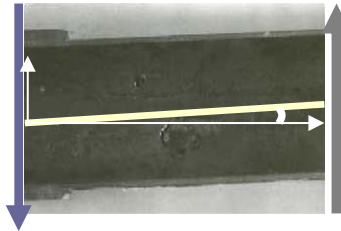
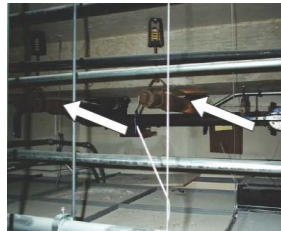
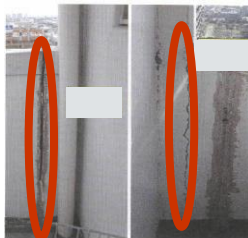
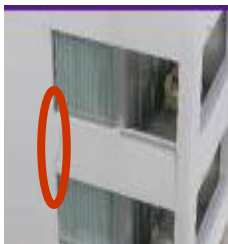
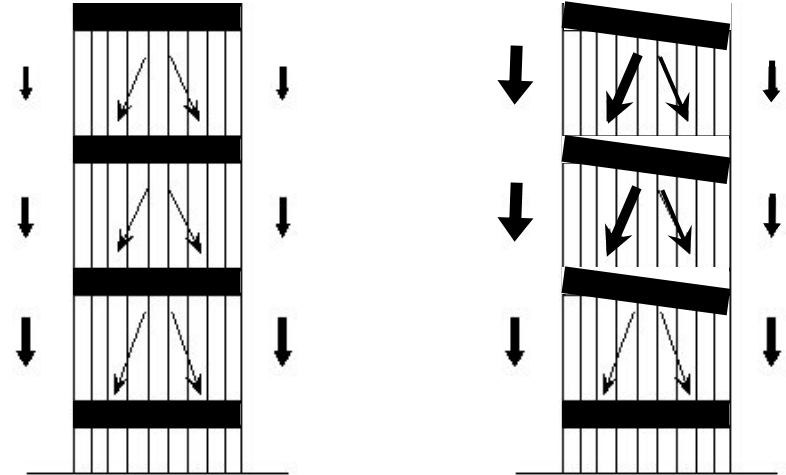
Effects of Column Shortening in Buildings

Structural Effects

- Slabs may not be truly horizontal after some time.
- Beams could be subjected to higher bending moments.
- Load transfer.

Non-Structural Effects

- Cracks in Partition Walls
- Inclination in Pipelines
- Deformation of vertical systems



CS Analysis Steps in GEN

PROCEDURE

Define material and sections

Define and link time
dependent material
properties with material

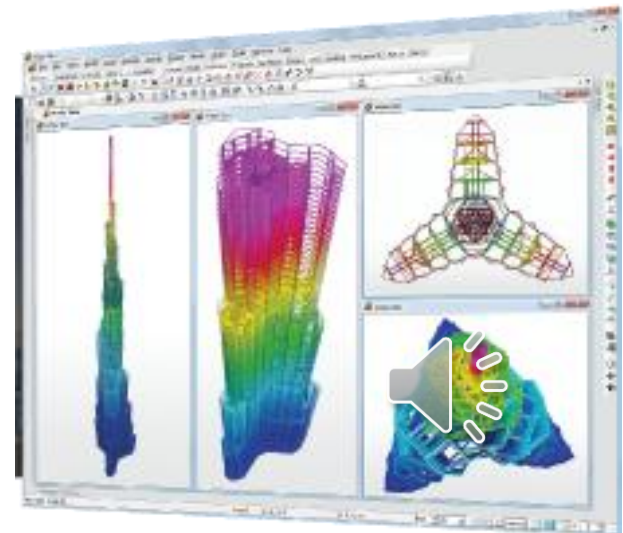
Assign elements,
boundaries and loads to the
specific groups

Specify CS analysis data

Perform analysis and check
results

→ Creep, Shrinkage and Compressive
strength Variation

→ Specify duration of CS
stage, elements loads and
boundary activation and
deactivation



Result Interpretation in GEN

Base Stage

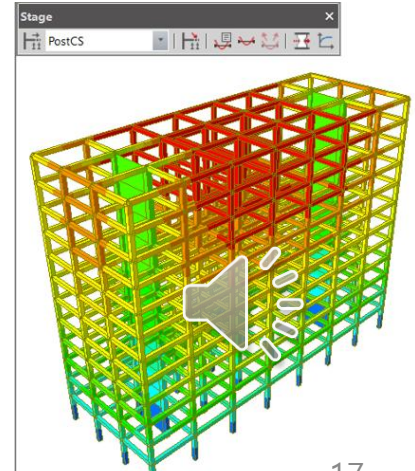
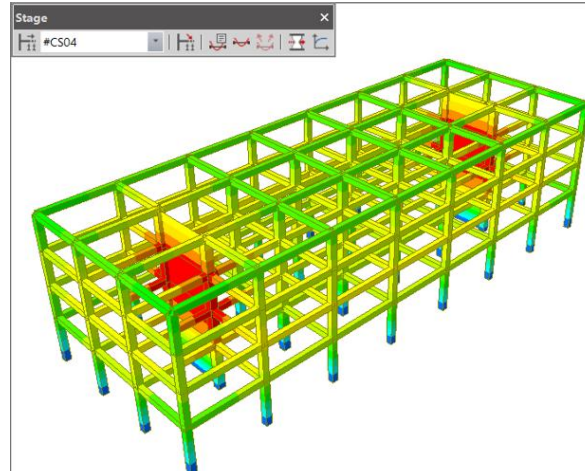
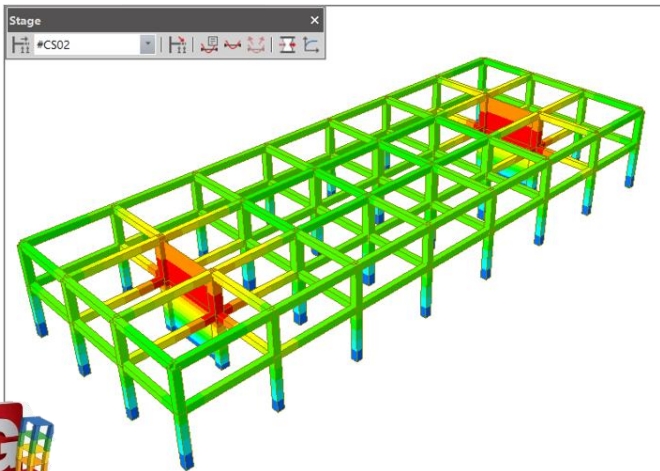
To edit the elements, loads and boundary conditions

Construction Stage Results

Results for each CS can be viewed including the creep and shrinkage effects

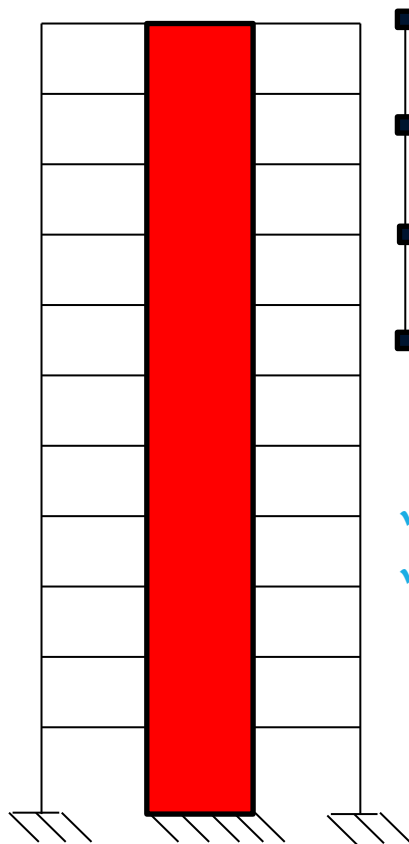
Post CS

Results for the loads acting outside the CS (Seismic, wind, temperature, etc)

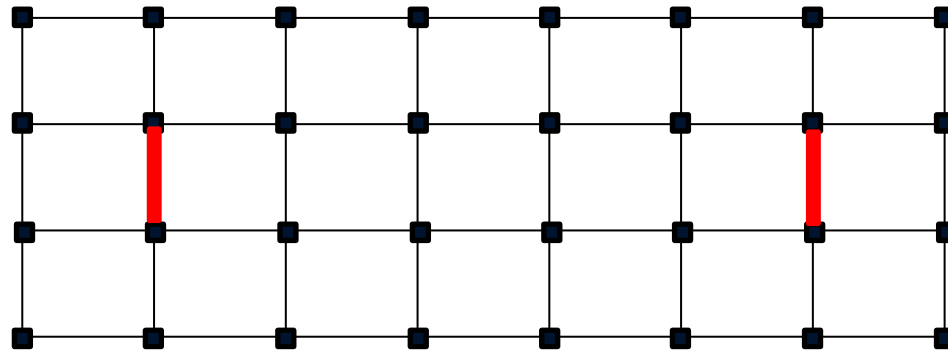


Live Demonstration

Model Details

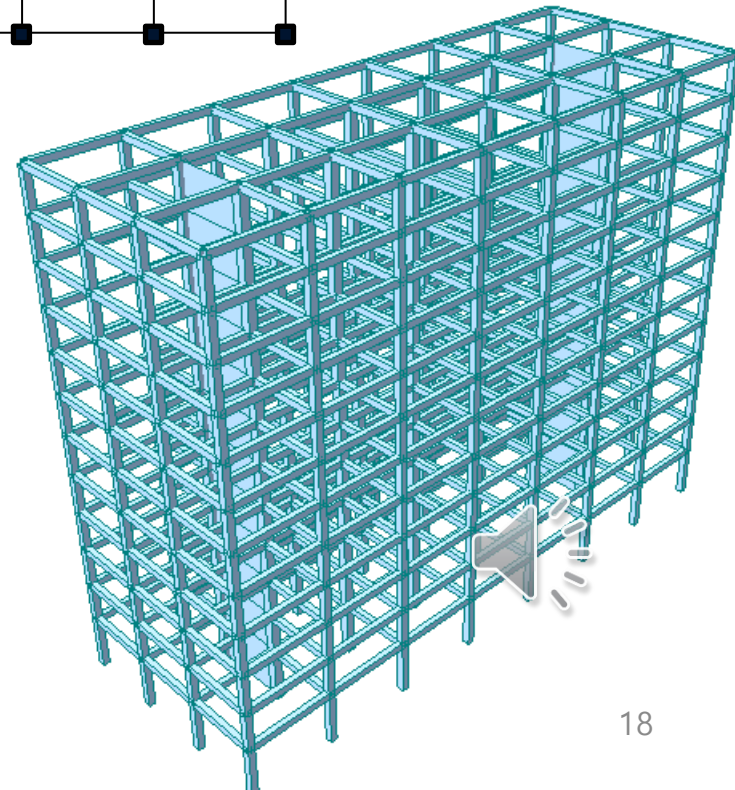


Elevation



Plan

- ✓ 12 Story
- ✓ RC Frame-Shear wall Building



Live Demonstration

Construction Stage Definitions

Automation Generation

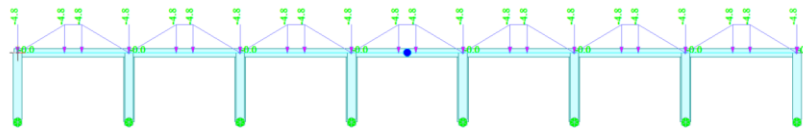
☒ Construction Stage
LoadCase: Self Weight Story Incr: 1 Stage Duration: 7 Member Age: 7

☒ Superimposed Dead Load 1
LoadCase: SIDL Story Incr: 2 Starting Day: 71 Day Incr: 3

☒ Superimposed Dead Load 2
LoadCase: Live load Story Incr: 10 Starting Day: 100 Day Incr: 1

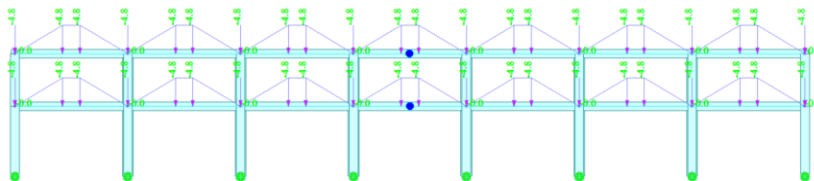
☐ Superimposed Dead Load 3
LoadCase: Story Incr: 0 Starting Day: 0 Day Incr: 0

OK Cancel



CS-1

Load: Self Weight
Stage Duration: 7 Days
Member age: 7 Days
Story Increment: 1



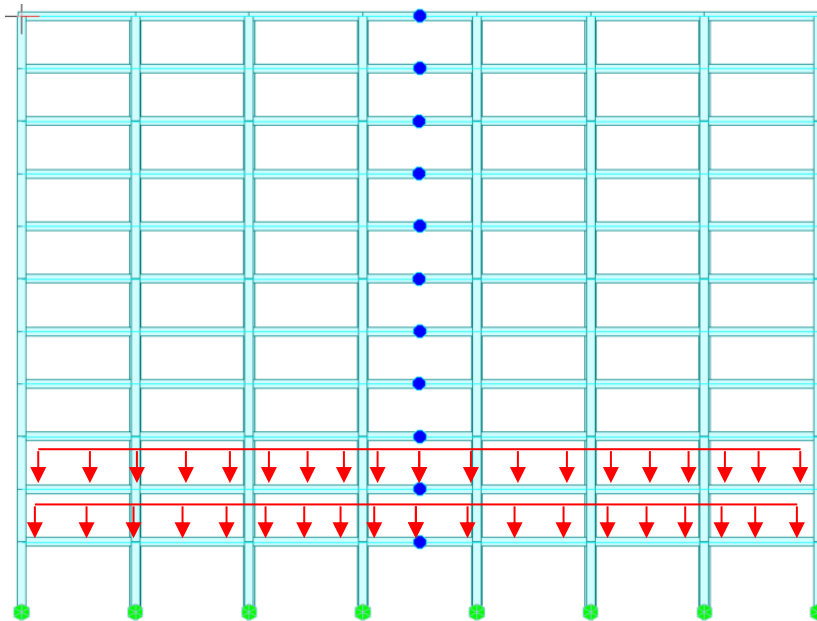
CS-2

Load: Self Weight
Stage Duration: 7 Days
Member age: 7 Days
Story Increment: 1



Live Demonstration

Construction Stage Definitions



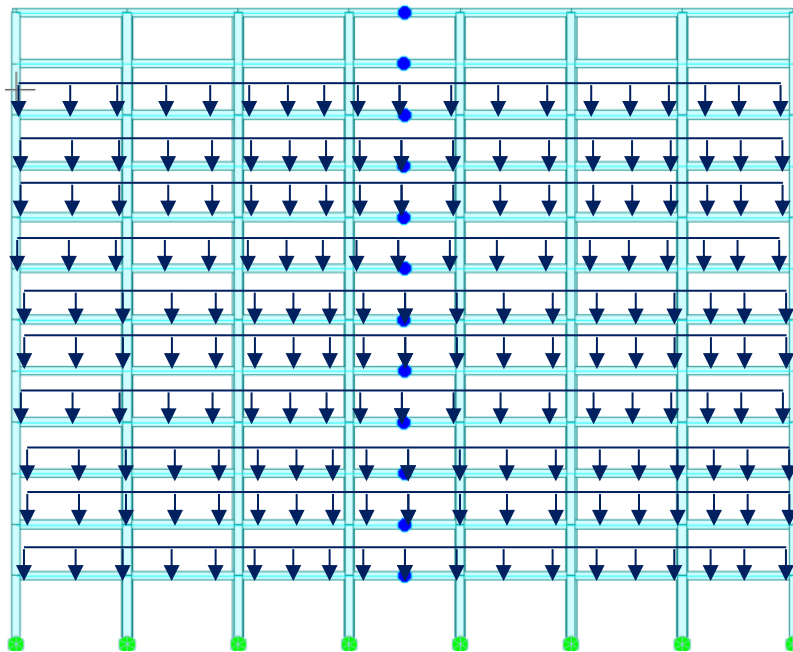
CS-11

Load: SIDL
Stage Duration: 7 Days
Starting day: 71st Day
Story Increment: 2
Day Increment: 3



Live Demonstration

Construction Stage Definitions



CS- Dummy

Load: Live Load
Stage Duration: 17 Days
Starting day: 100th Day
Story Increment: 10
Day increment: 1 day

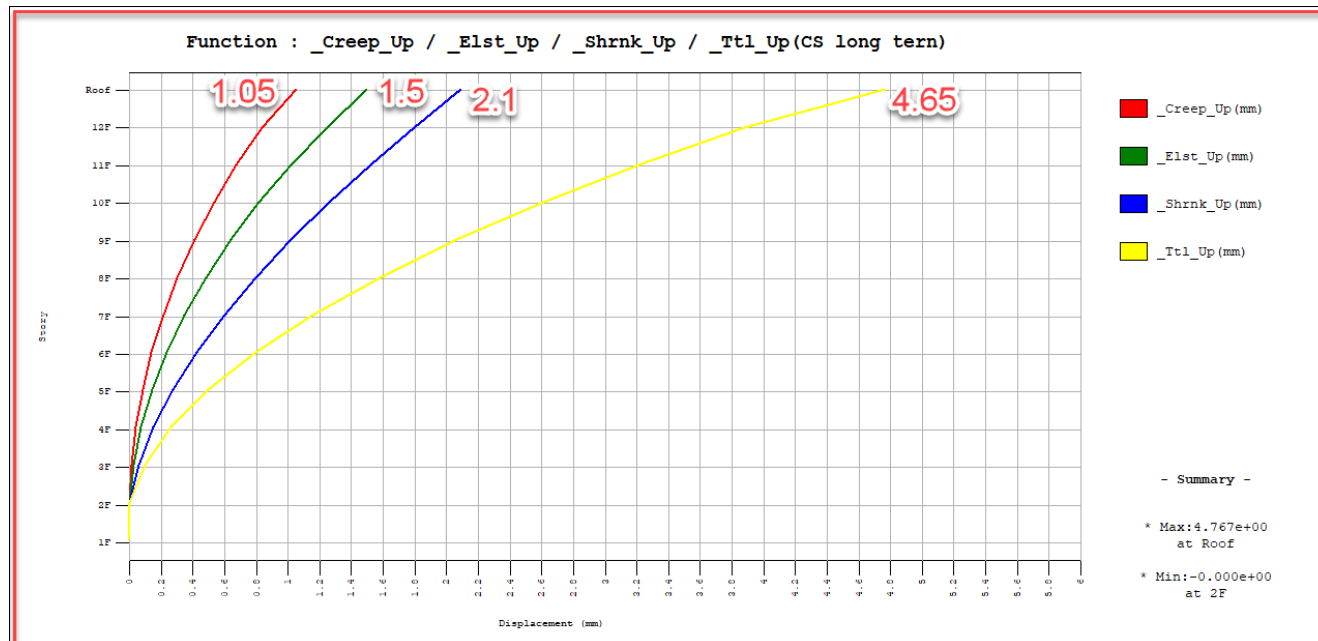


Capabilities of CS Analysis in GEN

Column Shortening Graphs

Data Availability

- ✓ Separate data for shortening by elastic deformations, creep and shrinkage.
- ✓ Data for up to casting and subsequent to casting.



Capabilities of CS Analysis in GEN

Tendon Loss

Add/Modify Tendon Property

Tendon Type

Tendon Name :

Tendon Type :

Material :

Total Tendon Area : mm²

Duct Diameter : mm

☒ Relaxation Coefficient :

Name :

Ultimate Strength : N/mm²

Yield Strength : N/mm²

Curvature Friction Factor :

Wobble Friction Factor : 1/mm

Anchorage Slip(Draw in)

Begin : mm

End : mm

Bond Type

☒ Bonded

☐ Unbonded

OK Cancel Apply

Add/Modify Tendon Profile

Tendon Name : Group :

Tendon Property :

Assigned Elements :

Input Type

☒ 2-D ☐ 3-D

Curve Type

☒ Spline ☐ Round

Straight Length of Tendon

Begin : mm

End : mm

☐ Typical Tendon No. of Tendons :

Transfer Length

User defined Length Begin : End : mm

Debonding Data

Debonded Length Begin : End : mm

Profile

Reference Axis : ☐ Straight ☐ Curve ☒ Element

☐

y

1203.85

-3796.15

0 5000 15000 25000 35000 45000 x

	x(mm)	y(mm)	fix	Rz(deg)
1	0.0000	0.0000	<input type="checkbox"/>	0.00
2	50000.0000	100.0000	<input type="checkbox"/>	0.00
3			<input type="checkbox"/>	

z

1653.85

-3346.15

0 5000 15000 25000 35000 45000 x

	x(mm)	z(mm)	fix	Ry(deg)	BO
1	0.0000	0.0000	<input type="checkbox"/>	0.00	<input type="checkbox"/>
2	50000.0000	1000.0000	<input type="checkbox"/>	0.00	<input type="checkbox"/>
3			<input type="checkbox"/>		<input type="checkbox"/>

Point of Sym.: ☐ First ☒ Last ☐ Make Symmetric Tendon

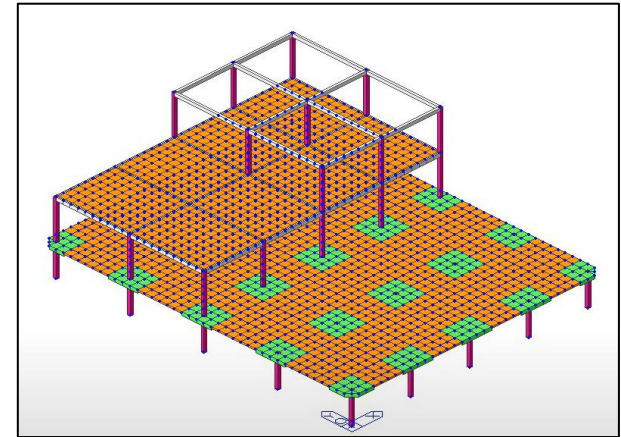
Profile Insertion Point : ☒ End-I ☐ End-J of Elem.

x Axis Direction : ☒ I -> J ☐ J -> I of Elem.

x Axis Rot. Angle : [deg] ☒ Projection

Offset y : mm z : mm

OK Cancel Apply



Capabilities of CS Analysis in GEN

Composite Section in CS

Section Data

DB/User | Value | SRC | Combined | Tapered | Composite

Section ID: 4 Shape: Rect-IBeam

Name:

Concrete Data

HC: 3 ft
BC: 3 ft

Steel Data

☒ User ☐ DB UNIT:

Steel Name:

☒ Built-Up Section

H: 2.5 ft
B1: 2.5 ft
tw: 0.3 ft
tf1: 0.3 ft
B2: 2.5 ft
tf2: 0.3 ft

Material

Select Material from DB...

Es/Ec: 0
Ds/Dc: 0

Ps: 0 Pc: 0

Combined Ratio of Conc.: 1

Replace: ☒ Steel ☐ Concrete

☒ Consider Shear Deformation.
☐ Consider Warping Effect(7th DOF)

Offset: Center-Center
Change Offset ...

Show Calculation Results... OK Cancel Apply

Add/Modify Composite Section for Construction Stage

Active Stage: #CS01

Section: 4 4: SRC

Composite Type: Normal

Section Type: SRC

Section Shape: RHB

Element List:

Construction Sequence

Part	Material Type	Material	Composite Stage	Age	h	v/s	M	Stiff.	Stiff. Scale	Comp
1	Material	2: S45	Active Sta	0	0	0.0	0.0			
2	Material	1: Grad	#CS02	7	0	0.0	0.0			

OK Cancel Apply



Wind Load Analysis

Wind load cases

- ✓ Wind load in X direction
- ✓ Wind load in Y direction

Add/Modify Wind Load Specification

Load Case Name : WX ...
Wind Load Code : Eurocode-1(2005) Import
National Annex : Singapore
Description :

☐ Wind Load Parameters
Structure Type 2
Friction Coefficient (Cfr) 0
Fund. Basic Wind Velocity (Vb,o) 20 [m/s]
Directional Factor (Cdir) 1
Seasonal Factor (Cseason) 1
Turbulence Factor (KI) 1
Building Height (h) 38.65 m

External Pressure Coefficients
☒ Automatic ☐ User Defined
Windward(A=10) Windward(A=1) Leeward Coef.
0.8 1 -0.7

Lack of Correlation Factor
☒ Automatic ☐ User Defined 1

Parameters for Mean Wind Velocity (Vm)...

Structural Factor (CsCd) 1 ...
☐ Load Evaluation Using Force Coefficient
Force Coefficient (Cf) 1

Wind Load Direction Factor (Scale Factor)
X-Dir 1 Y-Dir 0 Z-Rot 0

Additional Wind Loads (Unit:kN,m)
Story Add.-X Add.-Y Add.-RZ Add

Wind Load Profile... OK Cancel Apply

Add/Modify Wind Load Specification

Load Case Name : WY ...
Wind Load Code : Eurocode-1(2005) Import
National Annex : Singapore
Description :

☐ Wind Load Parameters
Structure Type 2
Friction Coefficient (Cfr) 0
Fund. Basic Wind Velocity (Vb,o) 20 [m/s]
Directional Factor (Cdir) 1
Seasonal Factor (Cseason) 1
Turbulence Factor (KI) 1
Building Height (h) 38.65 m

External Pressure Coefficients
☒ Automatic ☐ User Defined
Windward(A=10) Windward(A=1) Leeward Coef.
0.8 1 -0.7

Lack of Correlation Factor
☒ Automatic ☐ User Defined 1

Parameters for Mean Wind Velocity (Vm)...

Structural Factor (CsCd) 1 ...
☐ Load Evaluation Using Force Coefficient
Force Coefficient (Cf) 1

Wind Load Direction Factor (Scale Factor)
X-Dir 0 Y-Dir 1 Z-Rot 0

Additional Wind Loads (Unit:kN,m)
Story Add.-X Add.-Y Add.-RZ Add

Wind Load Profile... OK Cancel Apply

Wind Load Analysis

Wind load Profile

- ✓ Story shear
- ✓ Overturning moment

Add/Modify Wind Load Specification

Load Case Name: WX
Wind Load Code: Eurocode-1(2005)
National Annex: Singapore
Description:

☐ Wind Load Parameters

Structure Type: 2
Friction Coefficient (Cfr): 0
Fund. Basic Wind Velocity (Vb,o): 20 [m/s]
Directional Factor (Cdir): 1
Seasonal Factor (Cseason): 1
Turbulence Factor (KI): 1
Building Height (h): 38650 mm

External Pressure Coefficients

☒ Automatic ☐ User Defined

Windward(A=10) Windward(A=1) Leeward Coef.
0.8 1 -0.7

Lack of Correlation Factor

☒ Automatic ☐ User Defined

Parameters for Mean Wind Velocity (Vm)...

Structural Factor (CsCd): 1

☐ Load Evaluation Using Force Coefficient

Force Coefficient (Cf): 1

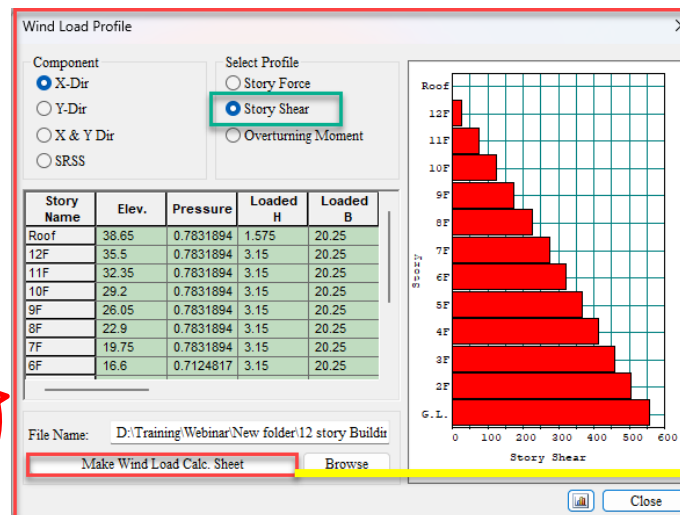
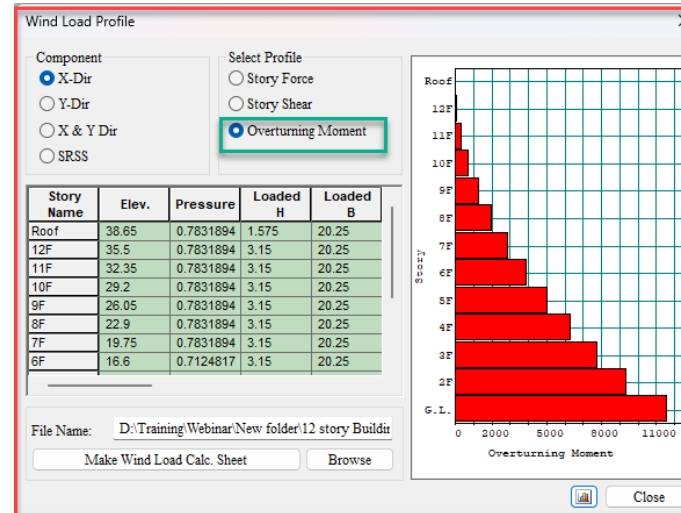
Wind Load Direction Factor (Scale Factor)

X-Dir: 1 Y-Dir: 0 Z-Rot: 0

Additional Wind Loads (Unit:kN,mm)

Story	Add-X	Add-Y	Add-RZ

Wind Load Profile... OK Cancel Apply



MIDAS/Text Editor - [12 story Building.apl]

File Edit View Window Help

WIND LOADS BASED ON EUROCODE-1(2005) [UNIT: kN, mm]

```
00001
00002
00003
00004
00005 Scaled Wind Force : F = ScaleFactor * Fw
00006 Resultant Wind Force : Fv = Fw * e + Ffr
00007 External Force : Fve = Fv * Aref
00008 Frictional Force : Ffr = Ffr * Afr
00009 Net Wind Pressure Across a Surface : Ff = CwCd * (We_front - We_rear) * Lack
00010 Frictional Wind Pressure in Side Wall : Ffr = Cfr * Qp
00011 External Wind Pressure : We = Qp * Cp
00012 Exposure Factor : Ce = Qp / Qz
00013
00014 Peak Velocity Pressure : Qp = 0.5 * (1 + Iv) * rho * Vm * Vm
00015 Basic Velocity Pressure : Qb = 0.5 * rho * Vb * Vb
00016 Turbulence Intensity : Iv = Vb / Vm * ln(2 / Z0)
00017 Mean Wind Velocity [m/sec] : Vm = Cc * Vb * B
00018 Basic Wind Velocity [m/sec] : Vb = Cdir * Vm * sc * Vb0
00019 Roughness Factor : Cc = Rz * ln(10 / Z0)
00020 Air Density [kg / m^3] : rho = 1.194
00021
```

Ready Ln9/248, Col1 NUM

Wind Load Analysis

Storey checks

- ✓ Story Drift
- ✓ Story Displacement
- ✓ Torsional irregularity

	Load Case	Node	Story	Level (mm)	Story Height (mm)	Maximum Displacement (mm)	Average Displacement (mm)	Maximum / Average
	WX	385	Roof	38650.00	0.00	4.0059	4.0059	1.0000
	WX	353	12F	35500.00	3150.00	3.9536	3.9536	1.0000
	WX	321	11F	32350.00	3150.00	3.8548	3.8548	1.0000
	WX	289	10F	29200.00	3150.00	3.7004	3.7004	1.0000
	WX	257	9F	26050.00	3150.00	3.4878	3.4878	1.0000
	WX	225	8F	22900.00	3150.00	3.2168	3.2168	1.0000
	WX	193	7F	19750.00	3150.00	2.8880	2.8880	1.0000
	WX	161	6F	16600.00	3150.00	2.5034	2.5034	1.0000
	WX	129	5F	13450.00	3150.00	2.0653	2.0653	1.0000
	WX	97	4F	10300.00	3150.00	1.5763	1.5763	1.0000
	WX	65	3F	7150.00	3150.00	1.0439	1.0439	1.0000
	WX	1	2F	4000.00	3150.00	0.4949	0.4949	1.0000
	WX	0	1F	0.00	4000.00	0.0000	0.0000	0.0000

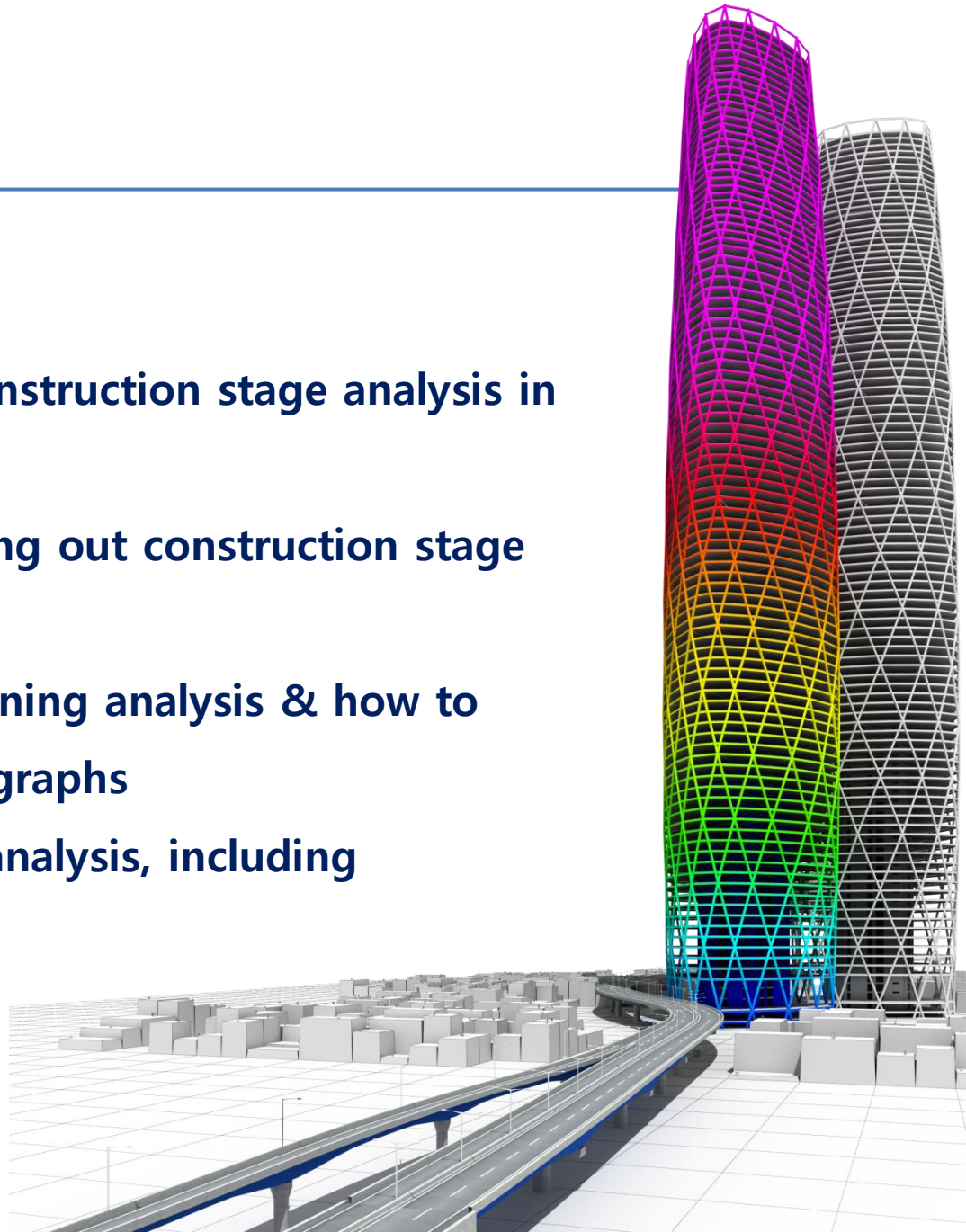
Start Page MIDAS/Gen Result-[Story Drift] Result-[Story Displacement] Result-[Torsional Irregularity Check]															
Load Case	Story	Story Height (mm)	P-Delta Incremental Factor (ad)	Allowable Story Drift Ratio	Maximum Drift of All Vertical Elements					Drift at the Center of Mass					
					Node	Story Drift (mm)	Modified Drift (mm)	Story Drift Ratio	Remark	Story Drift (mm)	Modified Drift (mm)	Drift Factor (Maximum/Current)	Story Drift Ratio	Remark	
RMC,Not Used, Cd=1, Ie=1.5, Scale Factor=1, Allowable Ratio=0.015 Press right mouse button and click 'Set Story Drift Parameters...' menu to change RMC or Cd/Ie/Scale Factor/Allowable Ratio/Beta!															
WX	12F	3150.00	1.00	0.0150	355	0.0523	0.0523	0.0000	OK	0.0523	0.0523	1.0000	0.0000	OK	
WX	11F	3150.00	1.00	0.0150	323	0.0987	0.0987	0.0000	OK	0.0987	0.0987	1.0000	0.0000	OK	
WX	10F	3150.00	1.00	0.0150	291	0.1545	0.1545	0.0000	OK	0.1545	0.1545	1.0000	0.0000	OK	
WX	9F	3150.00	1.00	0.0150	259	0.2125	0.2125	0.0001	OK	0.2125	0.2125	1.0000	0.0001	OK	
WX	8F	3150.00	1.00												
WX	7F	3150.00	1.00												
WX	6F	3150.00	1.00												
WX	5F	3150.00	1.00												
WX	4F	3150.00	1.00												
WX	3F	3150.00	1.00												
WX	2F	3150.00	1.00												
WX	1F	4000.00	1.00												

Start Page MIDAS/Gen Result-[Story Drift] Result-[Story Displacement] Result-[Torsional Irregularity Check]															
Load Case	Story	Level (mm)	Story Height (mm)	Average Value of Extreme Points		Maximum Value									
				Story Drift (mm)	1.2*Story Drift (mm)	Node	Story Drift (mm)								
WX	12F	35500.00	3150.00	0.0523	0.0628	355	0.0523								

Load Case	Story	Level (mm)	Story Height (mm)	Average Value of Extreme Points		Maximum Value		Remark
				Story Drift (mm)	1.2*Story Drift (mm)	Node	Story Drift (mm)	
WX	12F	35500.00	3150.00	0.0523	0.0628	355	0.0523	Regular
WX	11F	32350.00	3150.00	0.0987	0.1185	323	0.0987	Regular
WX	10F	29200.00	3150.00	0.1545	0.1854	291	0.1545	Regular
WX	9F	26050.00	3150.00	0.2125	0.2551	259	0.2125	Regular
WX	8F	22900.00	3150.00	0.2710	0.3252	227	0.2710	Regular
WX	7F	19750.00	3150.00	0.3288	0.3946	195	0.3288	Regular
WX	6F	16600.00	3150.00	0.3847	0.4616	163	0.3847	Regular
WX	5F	13450.00	3150.00	0.4381	0.5257	131	0.4381	Regular
WX	4F	10300.00	3150.00	0.4890	0.5868	99	0.4890	Regular
WX	3F	7150.00	3150.00	0.5324	0.6389	67	0.5324	Regular
WX	2F	4000.00	3150.00	0.5490	0.6588	3	0.5490	Regular
WX	1F	0.00	4000.00	0.4949	0.5939	35	0.4949	Regular

Summary

- ✓ Studied the importance of construction stage analysis in buildings
- ✓ Learned the process of carrying out construction stage Analysis in midas GEN
- ✓ Learned about column shortening analysis & how to generate column shortening graphs
- ✓ Studied the static wind load analysis, including story checks



Thank You

Contact us at: <https://midas-support.zendesk.com>

