COMPARISON OF MULTISTORY WALL RESULTS BETWEEN ADAPT-EDGE[1] AND ETABS[2] – CONCRETE FRAME WITH SHEARWALLS

INTRODUCTION

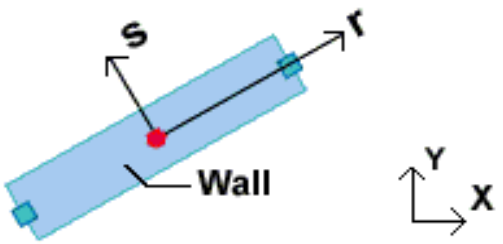
This Technical Note details a comparison of lateral loading results for an 8-story concrete shearwall structure modeled in ADAPT-Edge and Etabs. The latest versions (v2015) of each program were used for the study. Linear static analysis was used for determining wall forces and global-X lateral loading was applied to each floor at the intensity of 500 lb/ft2. Gravity loading was ignored for the study.

The primary purpose of the study was to investigate result similarities for shearwalls including openings. The use of "Piers" was employed in Etabs for walls directly above openings so as to correlate with the element formulation used in ADAPT-Builder. The following forces/actions for walls and directional diplacements are compared in this document:

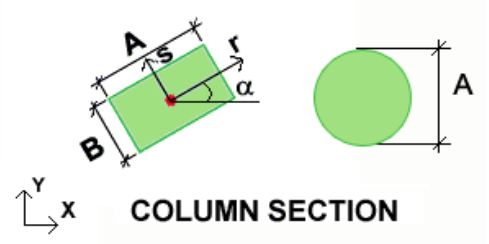
- Walls: Axial, in-plane shear, Moment about axis normal to plane
- Slabs: Center-of-Mass displacements in direction of applied lateral load (X) and top fiber stresses (psi)
- Walls: Displacements in direction of applied lateral load (X)

The images below define the global and local coordinate system of components in each program relative to this study.

ADAPT-Builder:

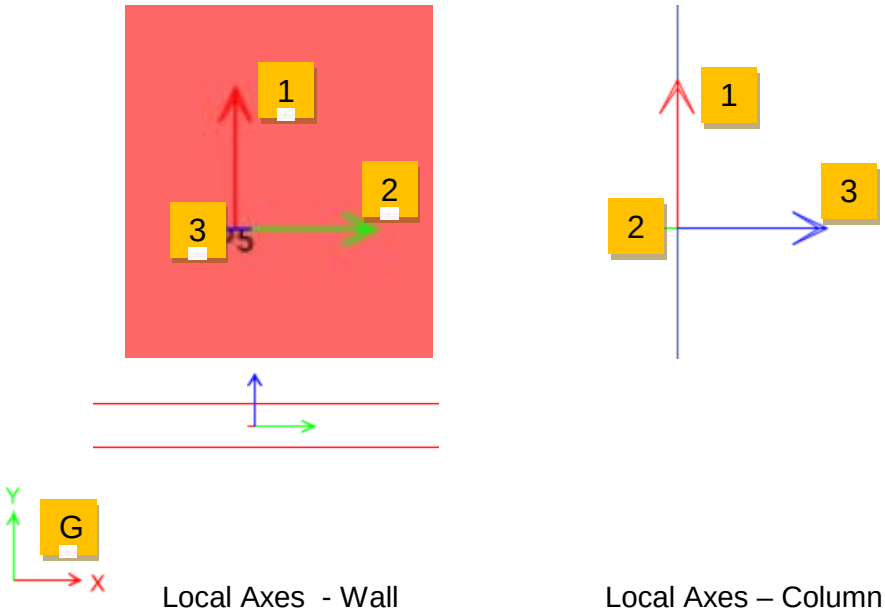


Local Axes - Wall



Local Axes – Column

Etabs:



Local Axes - Wall Local Axes – Column

RESULT NOMENCLATURE

To correlate results for walls (forces and moments) relative to the program nomenclature, the following information correlates the program local axes to force direction.

Component	Action	Direction	ADAPT-local axis	Etabs-local axis
Wall	Shear	In-plane	r	2
Wall	Moment	Strong axis	about s	about 3
Wall	Axial	Vertical	Z	1

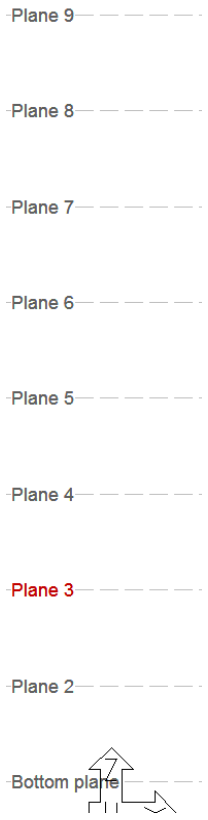
DEFINITION OF STRUCTURAL MODELS

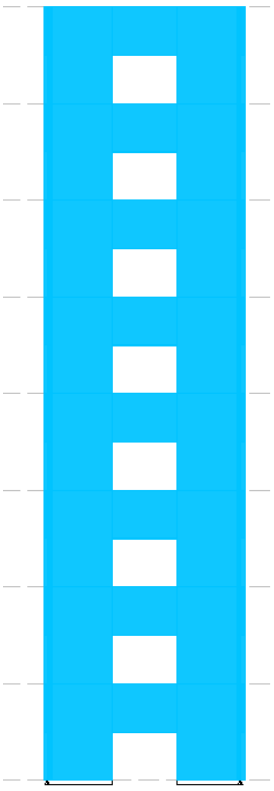
The validation model consists of two-way concrete slabs supported by an interior core of shearwalls in each direction, with openings and circular columns at the exterior of the slabs. Each wall was subdivided into 3 segments (piers) of 8’ in length and 12” thickness. The middle pier is open at the bottom over a height of 6’ at each level. The structure is symmetric about the global X and Y axes. There are 3 bays (28’-24’-28’) in each direction with 8 stories at 12’ each. The overall dimensions are 80’x80.’

Dimensions:

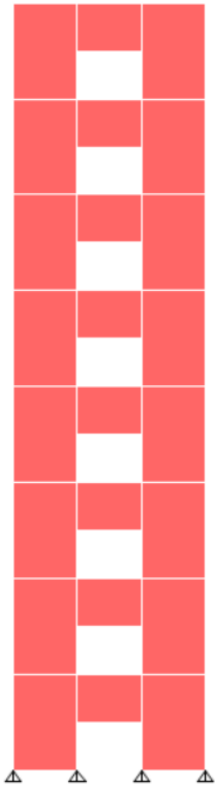
- Two-way slab = 8” normal weight concrete slab

- Columns = 22” diameter
- Walls = 24’ long x 12” thick
- Floor-to-floor heights:
    - Level 2 = 12’-0”
    - Level 3 = 12’-0”
    - Level 4 = 12’-0”
    - Level 5 = 12’-0”
    - Level 6 = 12’-0”
    - Level 7 = 12’-0”
    - Level 8 = 12’-0”
    - Roof = 12’-0”

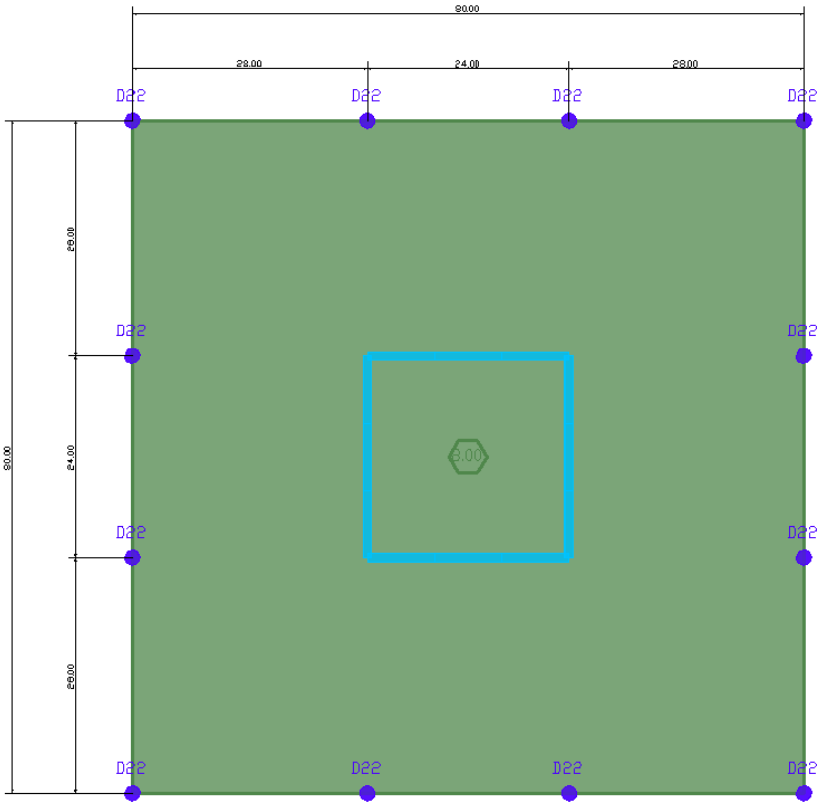




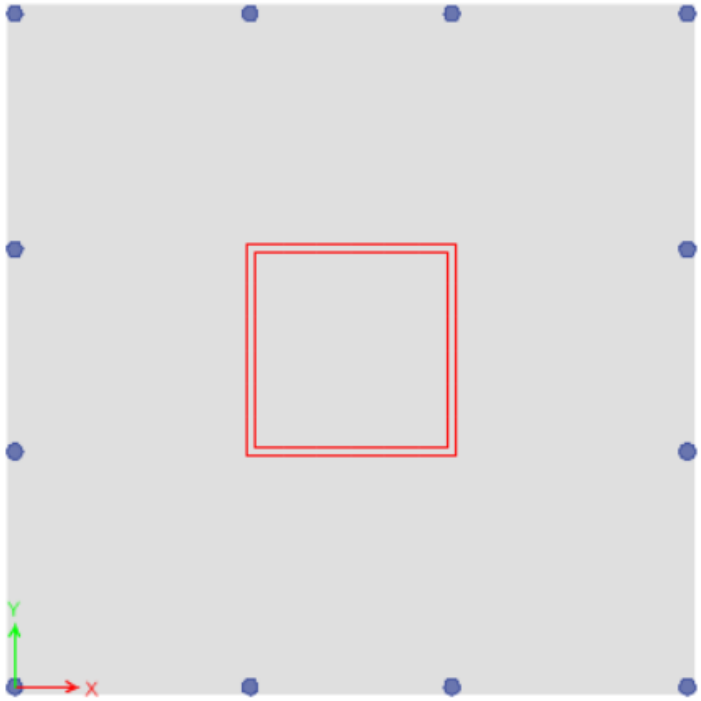
Typical wall stack - ADAPT



Typical wall stack - Etabs



Typical floor plan – ADAPT



Typical floor plan – Etabs

Loading:

Gravity loading was ignored for this evaluation. Each model was analyzed with a uniform lateral load in the global X direction of 500 lb/ft2 at each level. Eccentricity was not considered.

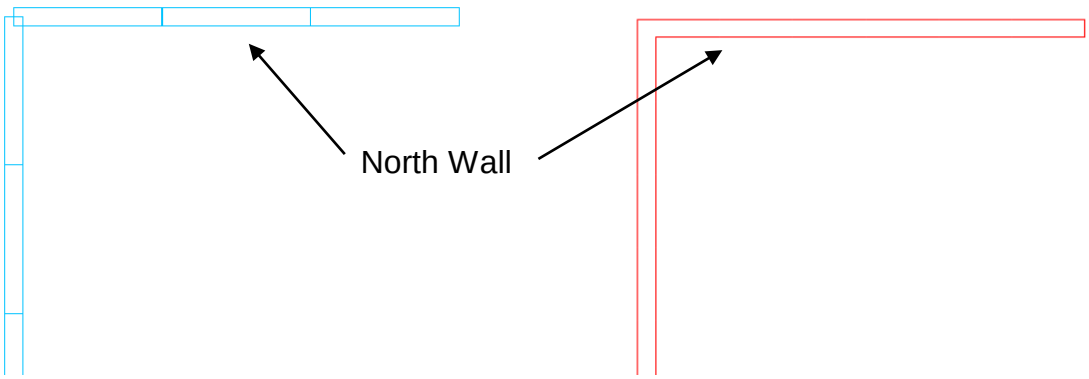
Analytical Assumptions:

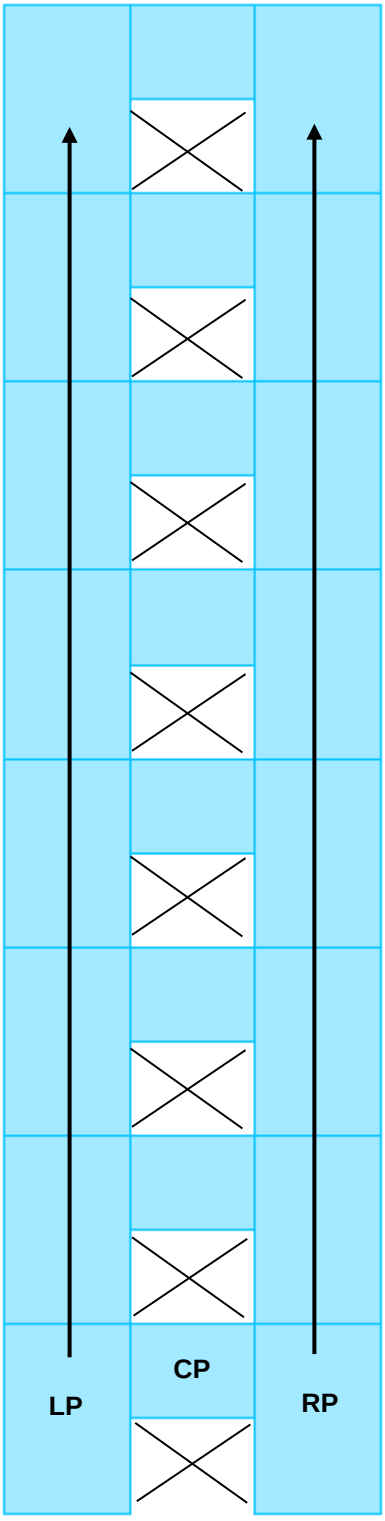
- Concrete - Elastic Modulus, E: 3600 ksi
- Concrete – Compressive Strength - F'c: 4000 psi
- Base supports: Translation and rotational fixity in X, Y and Z directions
- Joint fixity: Wall-to-slab and column-to-slabs fixed (no rotational or translational releases)
- Diaphragms: Rigid in Etabs, default formulation in ADAPT with in-plane axial stiffness and out-of-plane rotational stiffness accounted for
- Offsets: Middle segment wall in ADAPT offset 72" vertical from bottom to allow for wall opening.
- Meshing: Vertical wall mesh per segment is 2 horizontal and 4 vertical divisions. Floor meshing is uniform with 4' quadrilateral elements.
- Center wall segments above openings are modeled as "piers," not "spandrels"

RESULTS

A comparison of results is outlined below for the North Wall stack actions (axial, shear, moment), slab displacements at the Center-of-Mass (CM) in the global X-direction, and North Wall X-direction displacements. Note that the wall results are reported for the bottom location of walls at left, center, and right piers. The images below describe the wall labeling for purposes of presenting the results.

Walls:

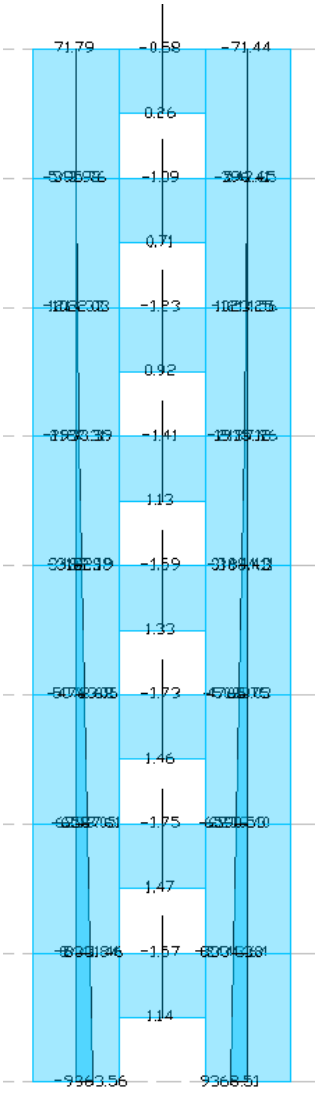


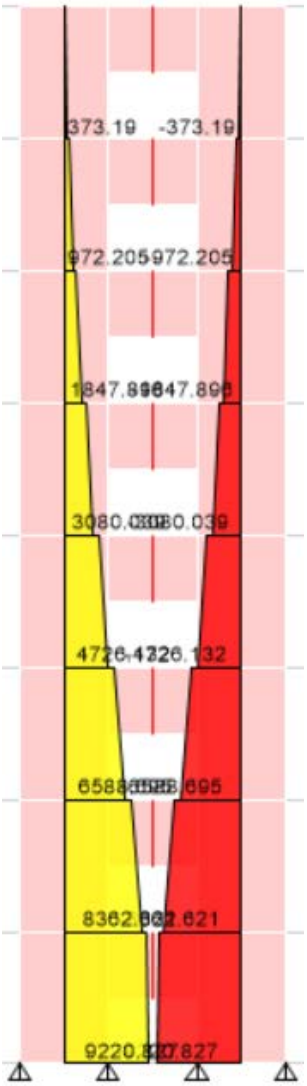


Typical Wall Stack for North Wall

Action - Axial (K)									
Level	LP			CP			RP		
	ADAPT	Etabs	%	ADAPT	Etabs	%	ADAPT	Etabs	%
Roof	396	373	5.8	0.26	0	NA	396	373	5.8
Level 8	1022	972	4.9	0.71	0	NA	1023	972	5.0
Level 7	1933	1848	4.4	0.92	0	NA	1935	1848	4.5
Level 6	3182	3080	3.2	1.13	0	NA	3184	3080	3.3
Level 5	4763	4726	0.8	1.33	0	NA	4765	4726	0.8
Level 4	6587	6588	0.0	1.46	0	NA	6590	6588	0.0
Level 3	8331	8367	0.4	1.47	0	NA	8443	8367	0.9
Level 2	9364	9221	1.5	1.47	0	NA	9368	9221	1.6

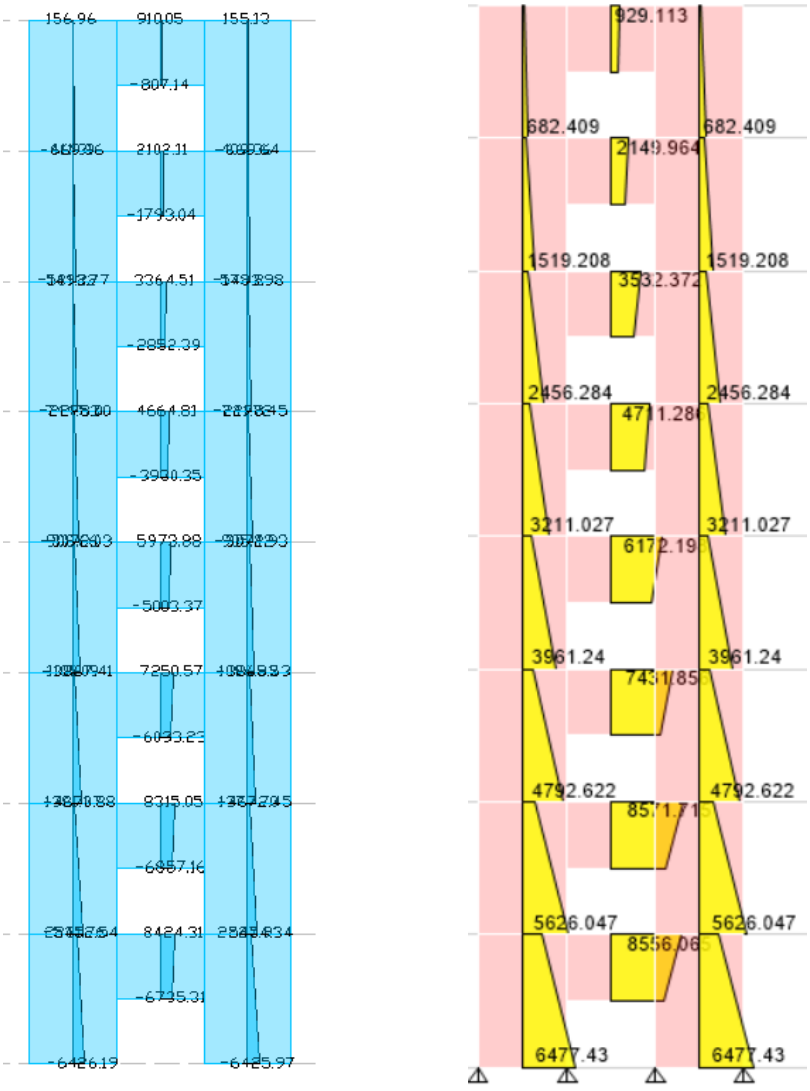
Axial Loads – North Wall





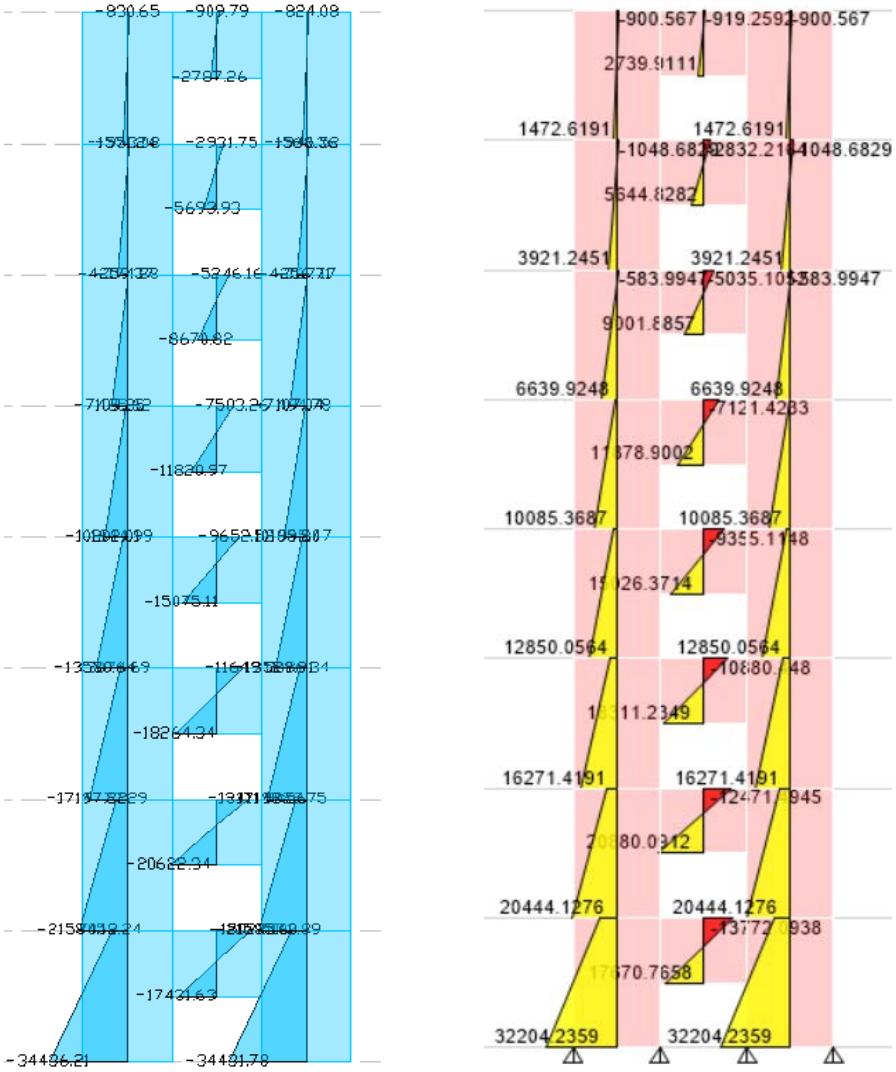
Action - In-plane Shear (K)									
Level	LP			CP			RP		
	ADAPT	Etabs	%	ADAPT	Etabs	%	ADAPT	Etabs	%
Roof	670	701	4.4	807	828	2.5	670	701	4.4
Level 8	1493	1554	3.9	1793	1905	5.9	1493	1554	3.9
Level 7	2278	2470	7.8	2852	3106	8.2	2278	2470	7.8
Level 6	3073	3280	6.3	3930	4194	6.3	3073	3280	6.3
Level 5	3867	4044	4.4	5003	5425	7.8	3868	4044	4.4
Level 4	4670	4892	4.5	6033	6517	7.4	4672	4892	4.5
Level 3	5452	5743	5.1	6857	7530	8.9	5454	5743	5.0
Level 2	6426	6477	2.1	6735	7535	10.6	6426	6563	2.1

In-Plane Shear – North Wall



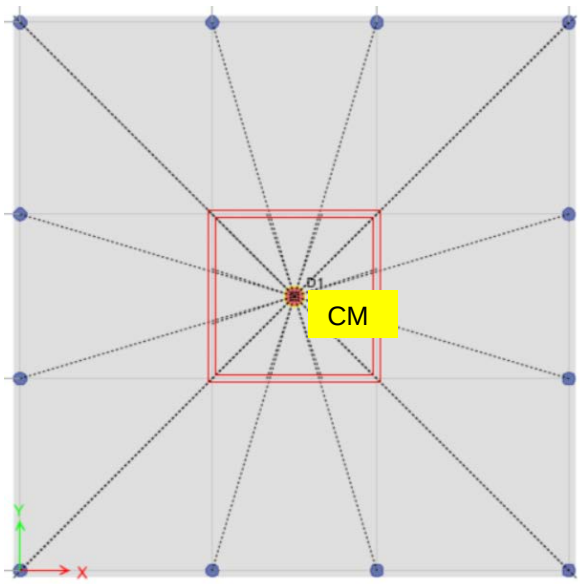
Action - Strong axis Moment (k-ft)									
Level	LP			CP			RP		
	ADAPT	Etabs	%	ADAPT	Etabs	%	ADAPT	Etabs	%
Roof	1571	1473	6.2	2787	2740	1.7	1568	1473	6.1
Level 8	4260	3921	8.0	5694	5645	0.9	4256	3921	7.9
Level 7	7109	6640	6.6	8671	9002	3.7	7107	6640	6.6
Level 6	10202	10085	1.1	11821	11879	0.5	10200	10085	1.1
Level 5	13530	12850	5.0	15075	15026	0.3	13530	12850	5.0
Level 4	17198	16271	5.4	18267	18311	0.2	17198	16271	5.4
Level 3	21585	20444	5.3	20622	20880	1.2	21585	20444	5.3
Level 2	34436	32204	6.5	17431	17671	1.4	34432	32204	6.5

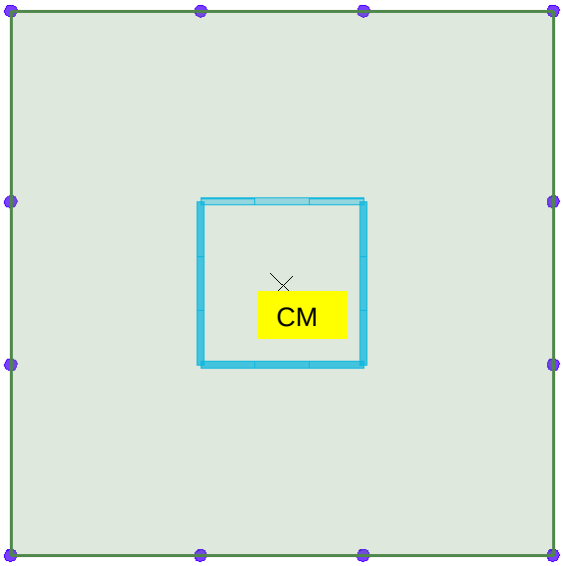
Strong Axis Moment – North Wall



Slabs:

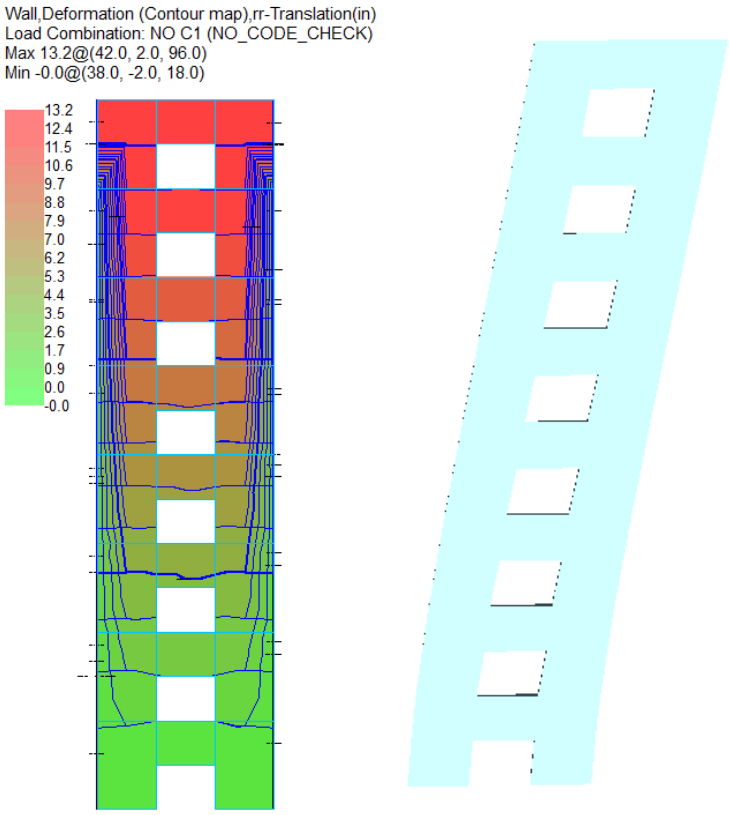
Deflections for each level are reported at the Center of Mass (CM) located at X=+40', Y=+40' from the slab origin at the bottom left corner.



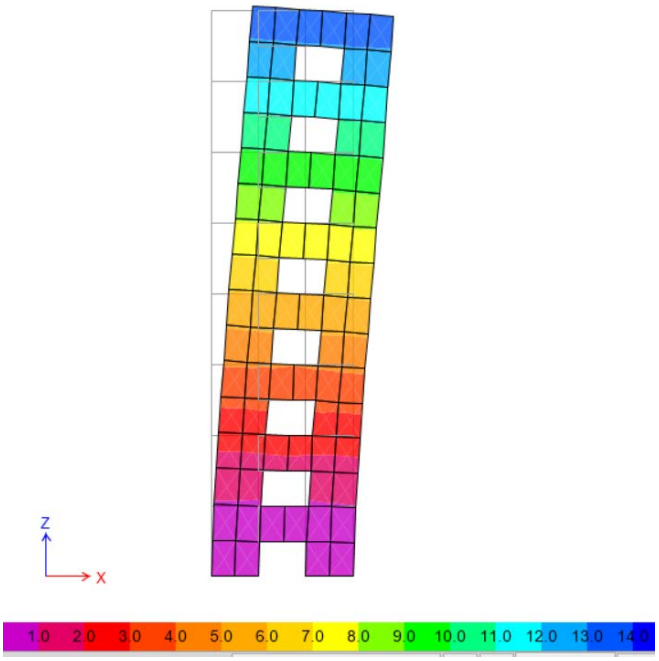


Displacements - X (in)			
Level	C.M. (40',40')		
	ADAPT	Etabs	%
Roof	13.2	13.8	4.3
Level 8	11.5	11.9	3.4
Level 7	9.7	10	3.0
Level 6	7.8	8	2.5
Level 5	6	6	0.0
Level 4	4	4.1	2.4
Level 3	2.3	2.4	4.2
Level 2	0.9	0.9	0.0

Slab Displacements – X Direction

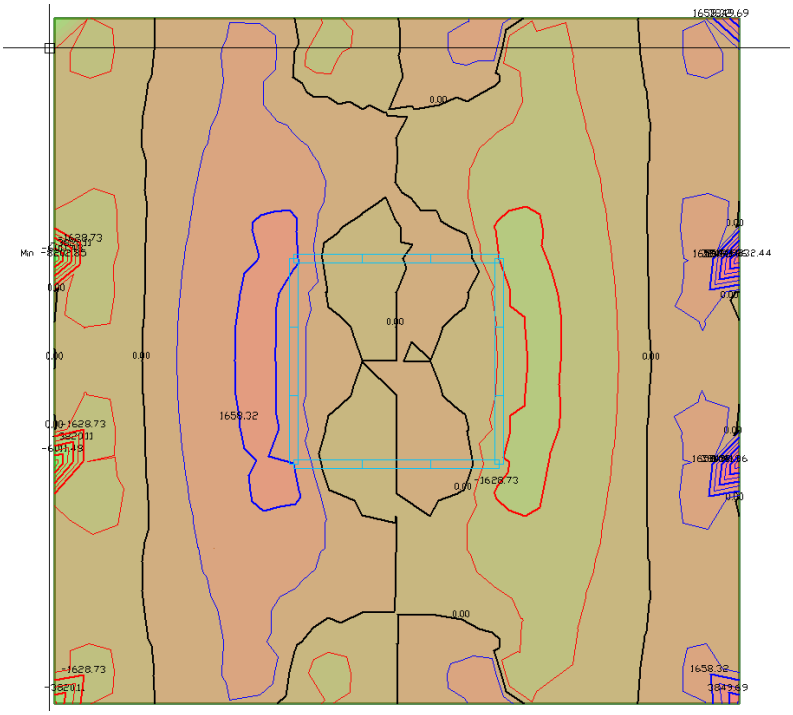


ADAPT-Builder North Wall Displacements and Deflected Shape

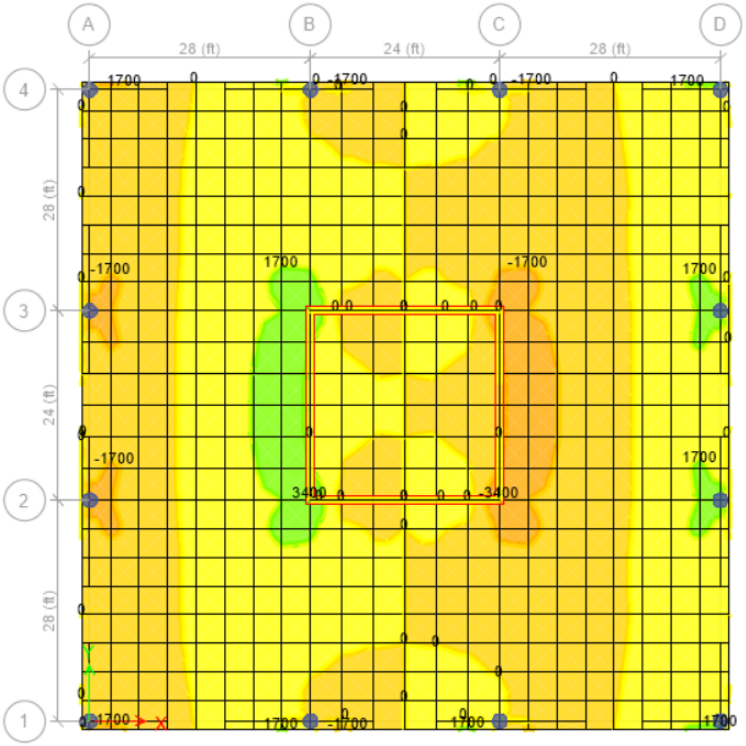


Etabs North Wall Displacements and Deflected Shape

The images below show top fiber slab stresses in the X direction relative to the applied lateral loading at the Roof Level.

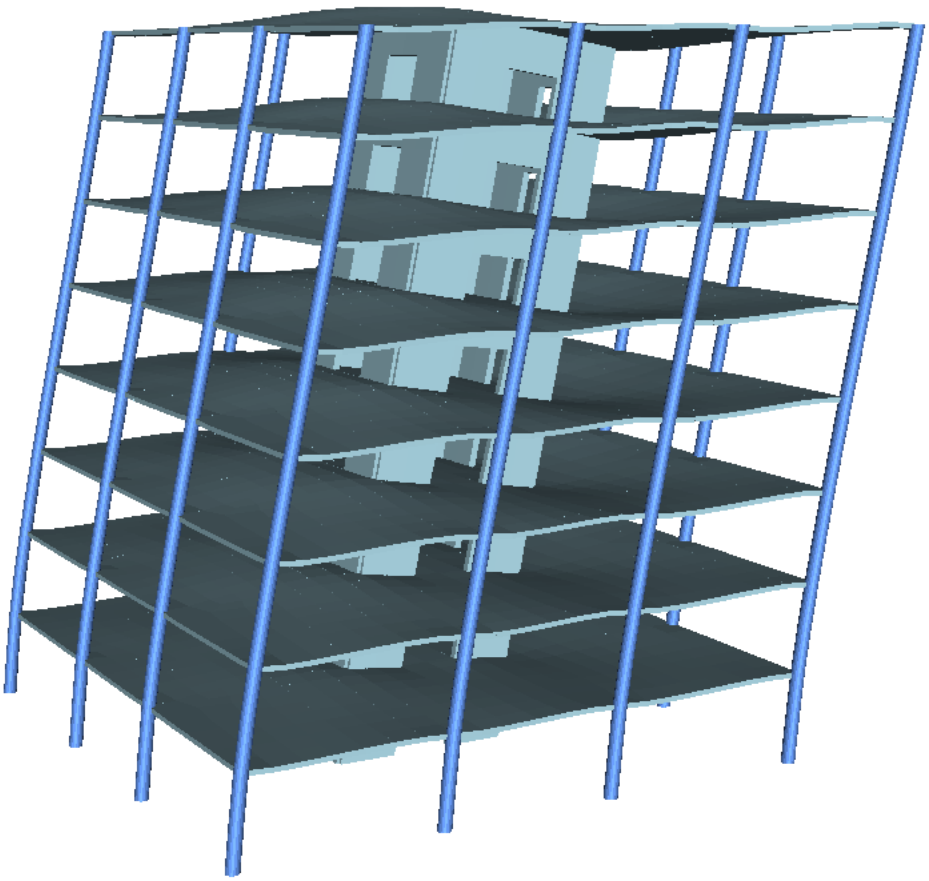


ADAPT- Roof Level top fiber stress (psi) along Global X



Etabs- Roof Level top fiber stress (psi) along Global X

The images below shows the deformation compability between ADAPT slabs and walls relative to the applied lateral loading set. ADAPT's analytical formulation of slab shells acting as hybrid membrane and shell elements with both out-of-plane and in-plane stiffness allowing for in-plane and flexural deformation, result in compatible displacements between slabs and walls. The close agreement between the two results indicates that for somewhat regular floor plan and common wall geometry, the assumption of rigid diaphragm, that is infinite stiffness in the plane of the slab, results in solutions that closely agree with the that obtained when the in-plane stiffness of the floor is properly accounted for as in ADAPT-Edge.



ADAPT – Global X direction displacement

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