Contribution of Plasterboard Finishes to Structural Performance of Multi-Storey Light Wood Frame Buildings

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Outline

- Background:
  - Canadian NEWBuilds network project
  - Light wood frame buildings (LWFB)
- Objective
- Methodology
- Analysis results
- Conclusions

NEWBuildS Project

- Strategic Network on Innovative Wood Products and Building Systems (NEWBuildS) funded by NSERC Canada (2010-2015)
  - Goal: Promoting utilization of wood in mid-rise buildings
  - Involving several Canadian universities, wood industries, architects, consultant engineers, and government research institution
  - Four major themes:
    - Cross laminated timber (CLT)
    - Hybrid buildings
    - Fire & acoustic & vibration serviceability
    - Durability

Light wood frame buildings (LWFB)

Up to 5-6 storeys allowed

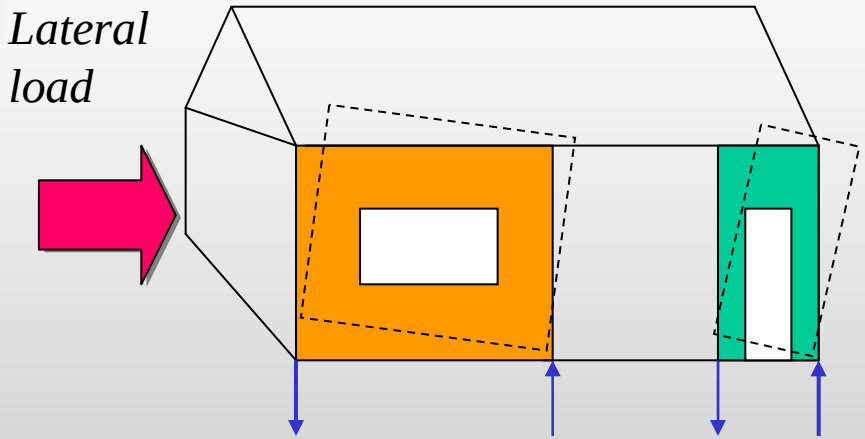
5-storey building

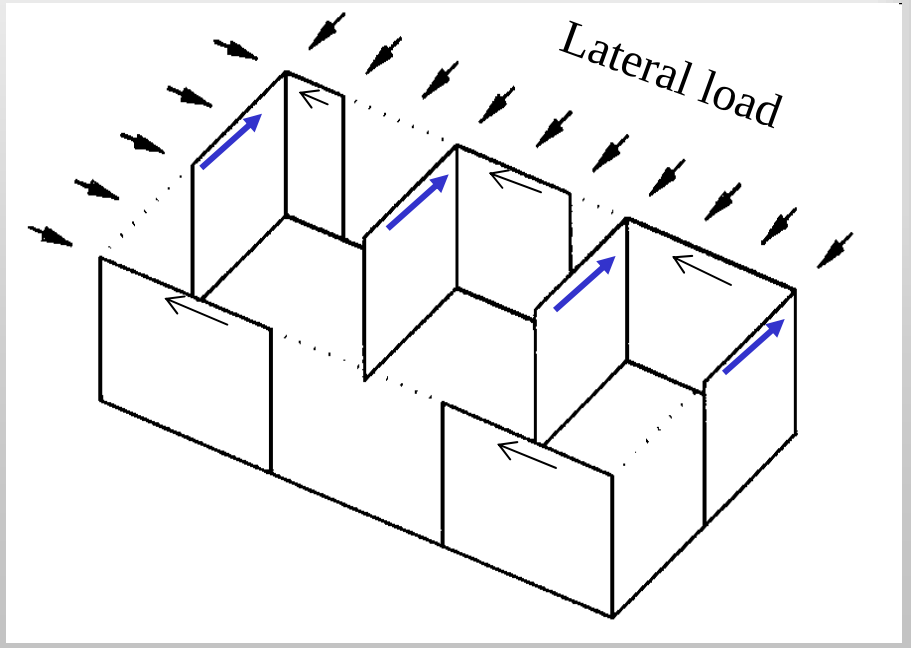
Hybrid concrete-wood

6-storey tested structure

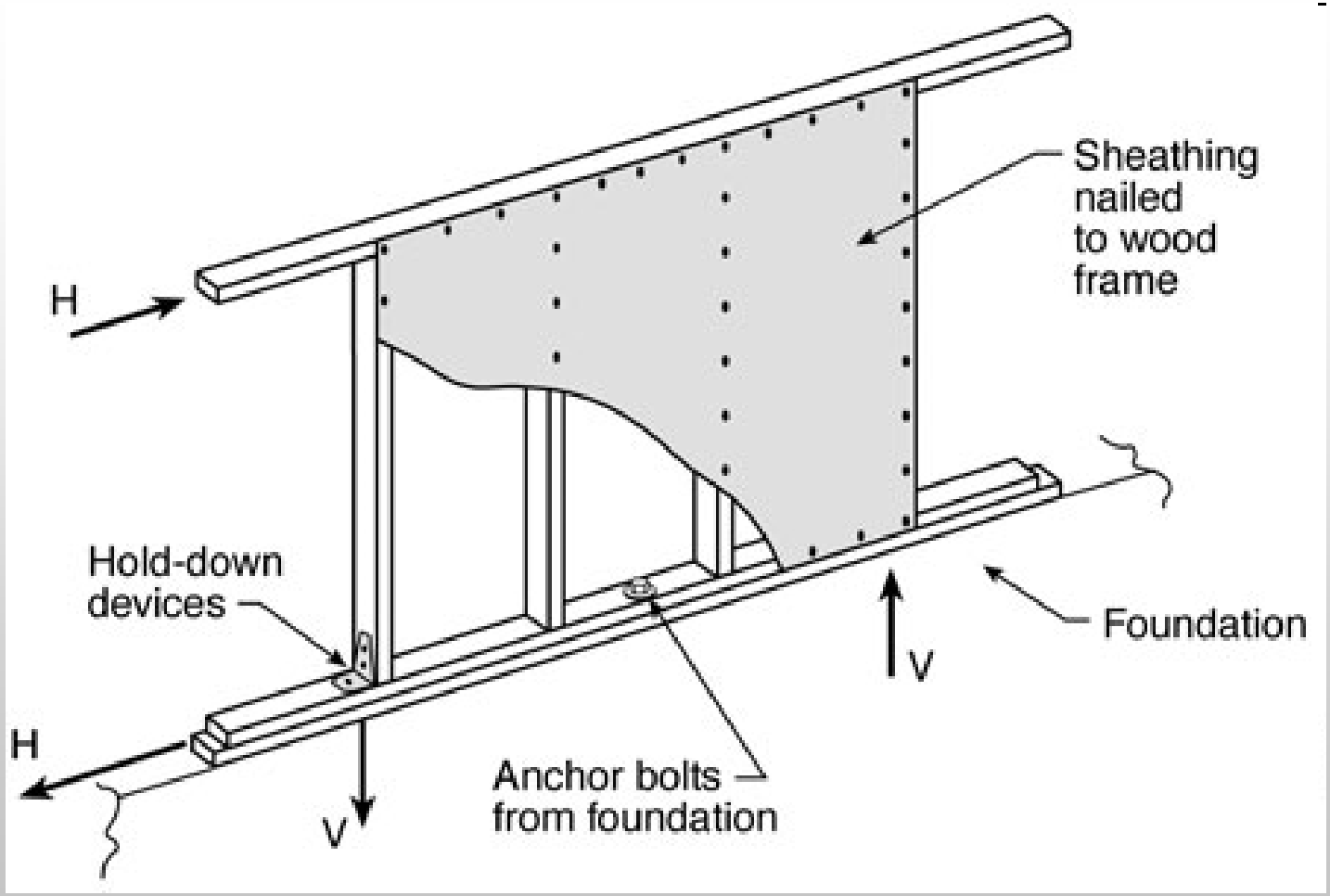
Lateral Loads

- Carried by wood panel shear walls



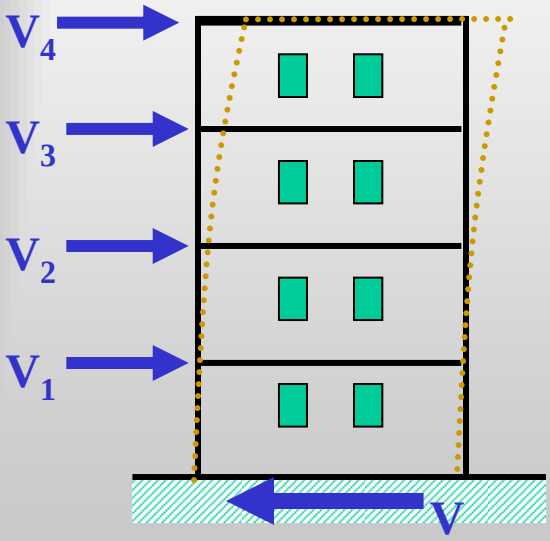


Wood panel shear wall



Issue to be investigated

- Plasterboard (e.g. gypsum wallboard) contribution



Canadian timber design code (CSA O86 Table 9.5.4):
Maximum percentage of total shear forces resisted by GWB in a storey

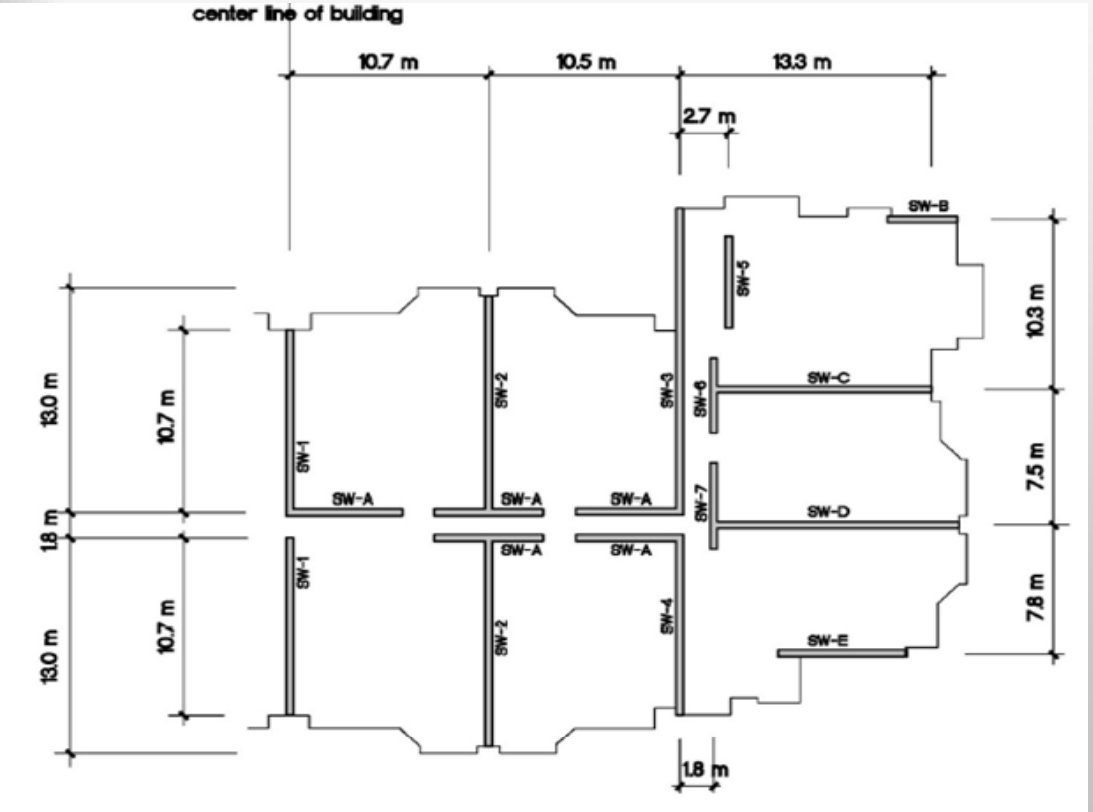
	Percentage of shear forces			
Storey	4-storey building	3-storey building	2-storey building	1-storey building
4th	80	—	—	—
3rd	60	80	—	—
2nd	40	60	80	—
1st	40	40	60	80

Objective

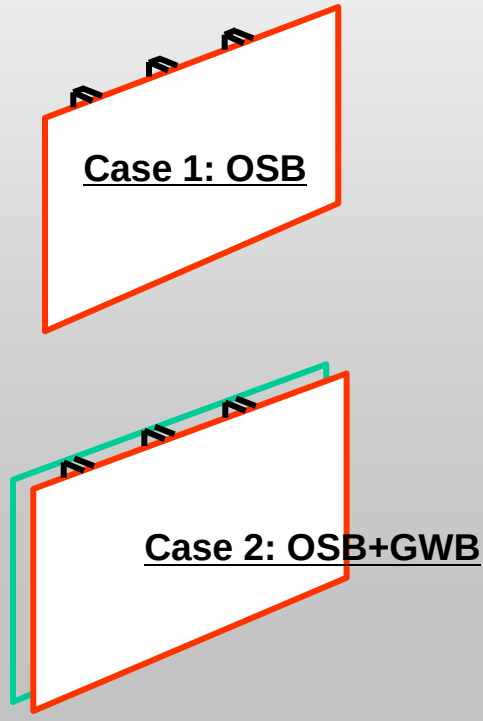
- to investigate the contribution of plasterboard finishes made of gypsum wall board (GWB) to the structural performance of multi-storey LWFB subjected to earthquake load

Method

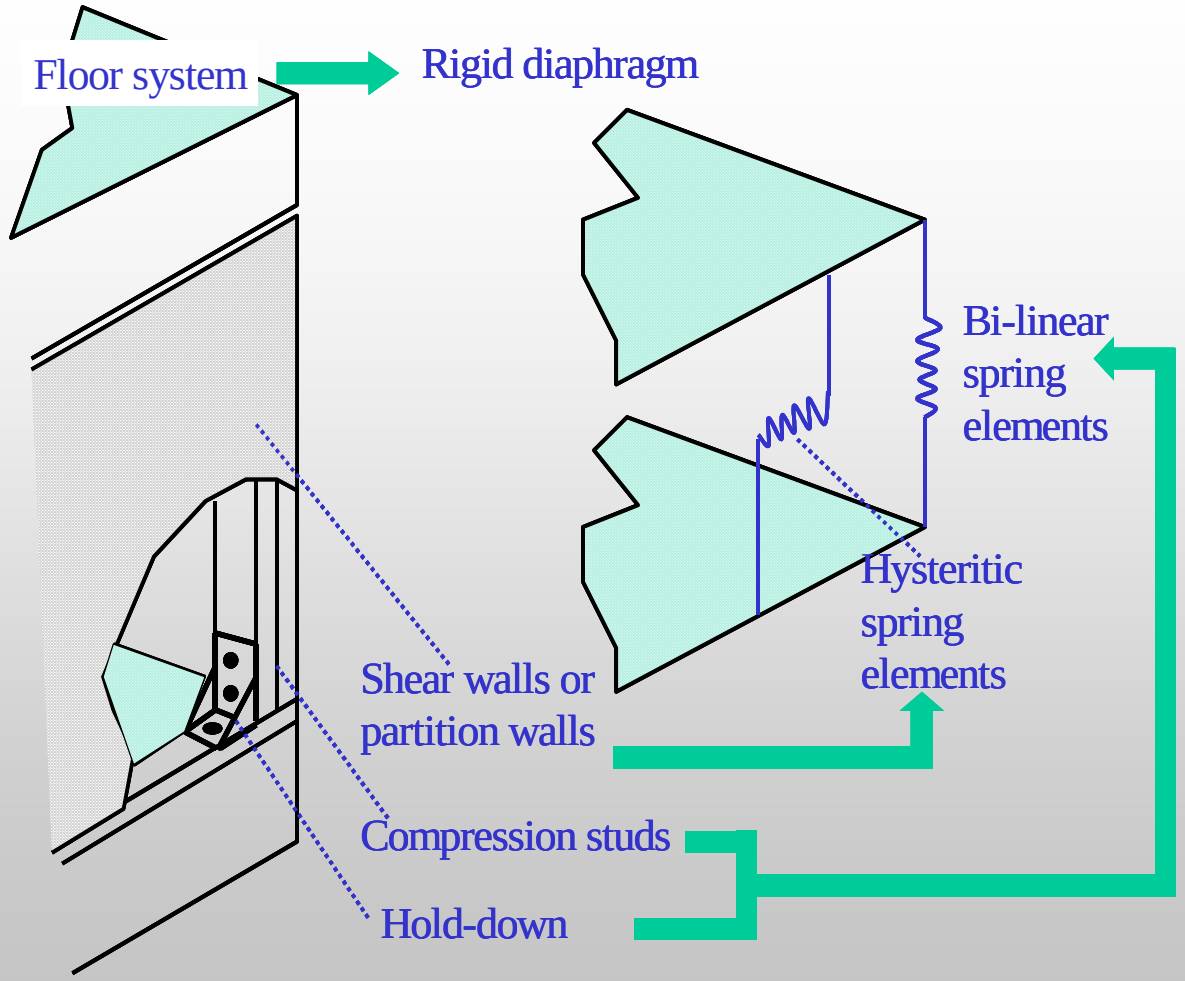
- Extensive 3-d numerical modeling using actual multi-storey LWFB loaded under dynamic EQ (ground motion)



4,5, and 6-storey buildings analyzed with:

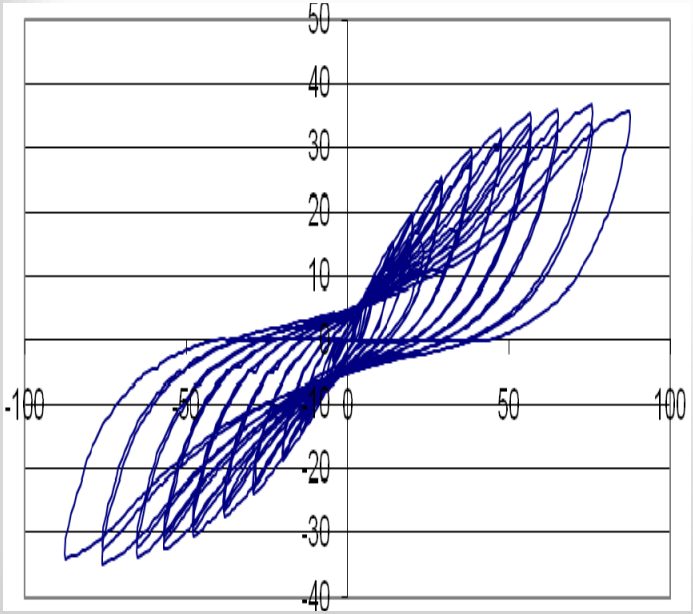


Tool: seismic analysis package SAPWood



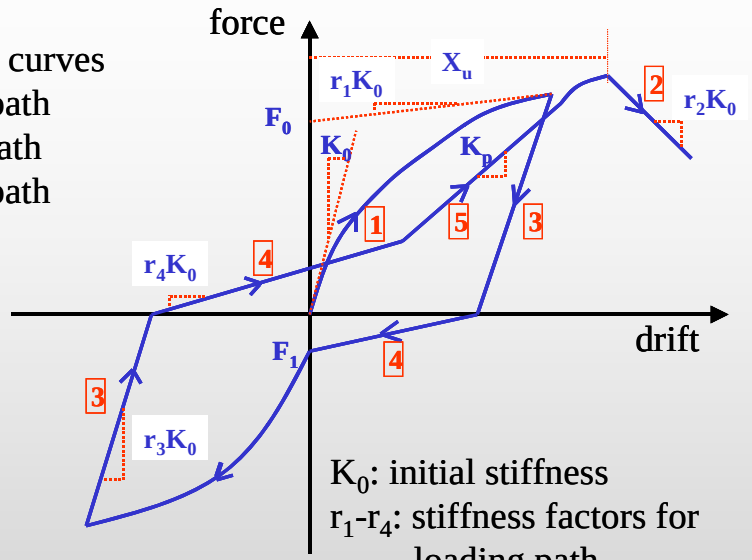
Pei & van de Lindt (2007)

Wall properties input



Wood shear wall
under cyclic load

1,2: backbone curves
3: unloading path
4: transition path
5: uploading path



K_0: initial stiffness
r_1-r_4: stiffness factors for loading path
F_0: backbone tangent intersection
F_1: loading path intersection
K_p: uploading stiffness as function of α, and β and drift

Curve fitting: 10-16 parameters

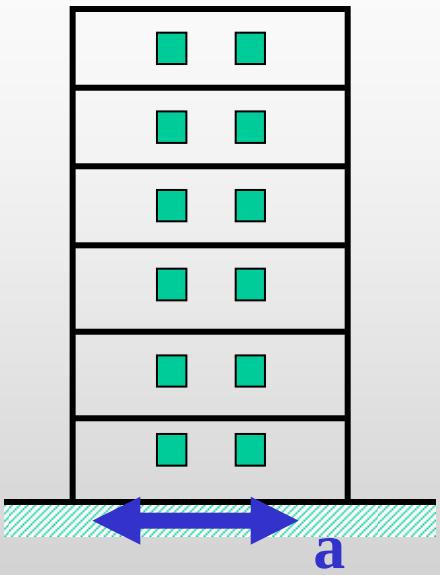
Shear walls nailing schedule

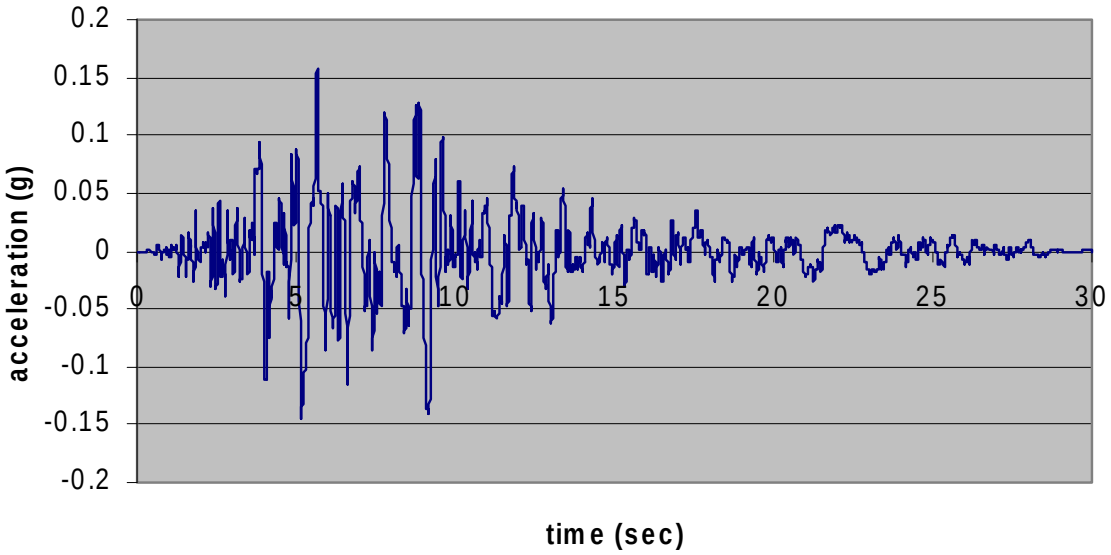
	4-storey		5-storey		6-storey	
Storey	D (mm)	Spacing (mm)	D (mm)	Spacing (mm)	D (mm)	Spacing (mm)
1	3.76	50.8	3.76	50.8	3.76	50.8
2	3.4	50.8	3.76	50.8	3.76	50.8
3	3.4	76.2	3.4	50.8	3.4	50.8
4	3.4	101.6	3.4	76.2	3.4	76.2
5	-	-	3.4	101.6	3.4	76.2
6	-	-	-	-	3.4	101.6

Note: *Common nail, OSB thickness =12.5 mm

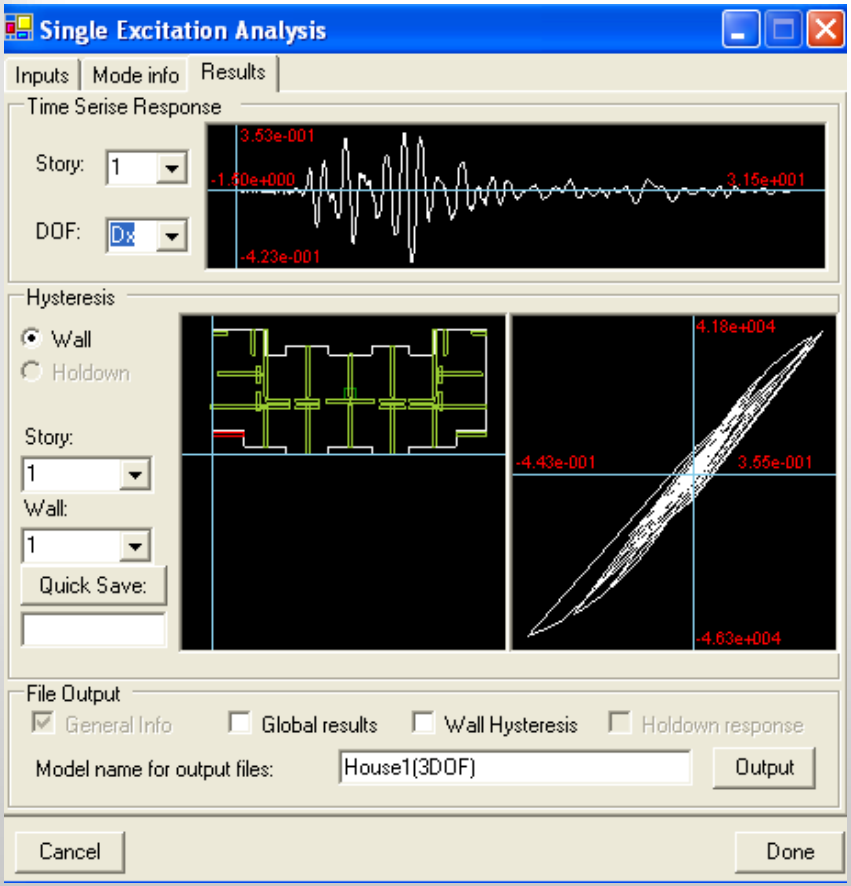
Same nailing schedule (300 mm o.c.) was used for the 12.5 mm-GWB for all storeys

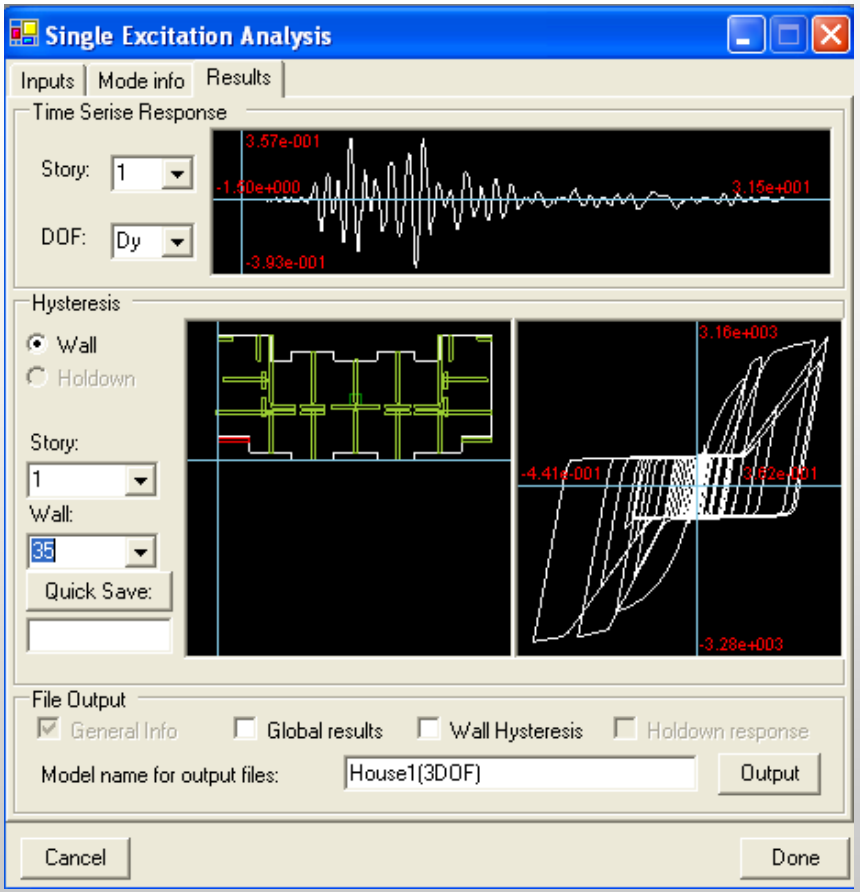
Ground motion input





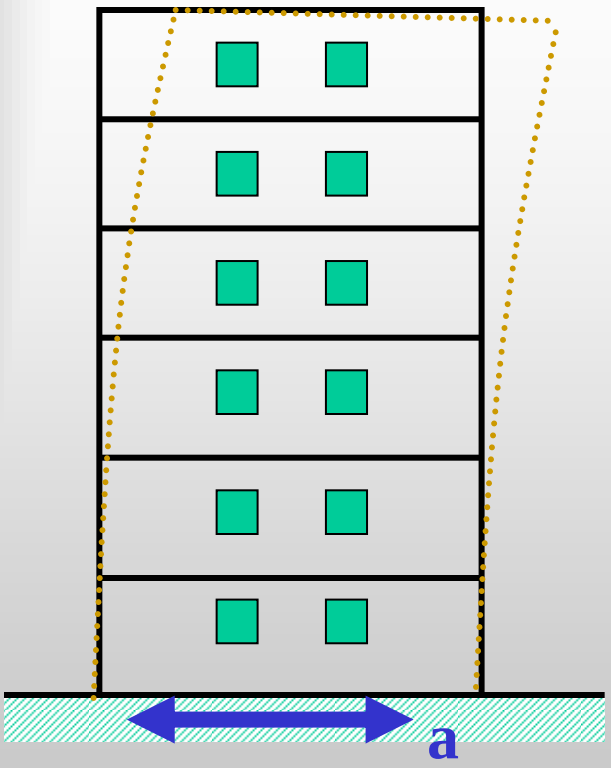
Failure criteria

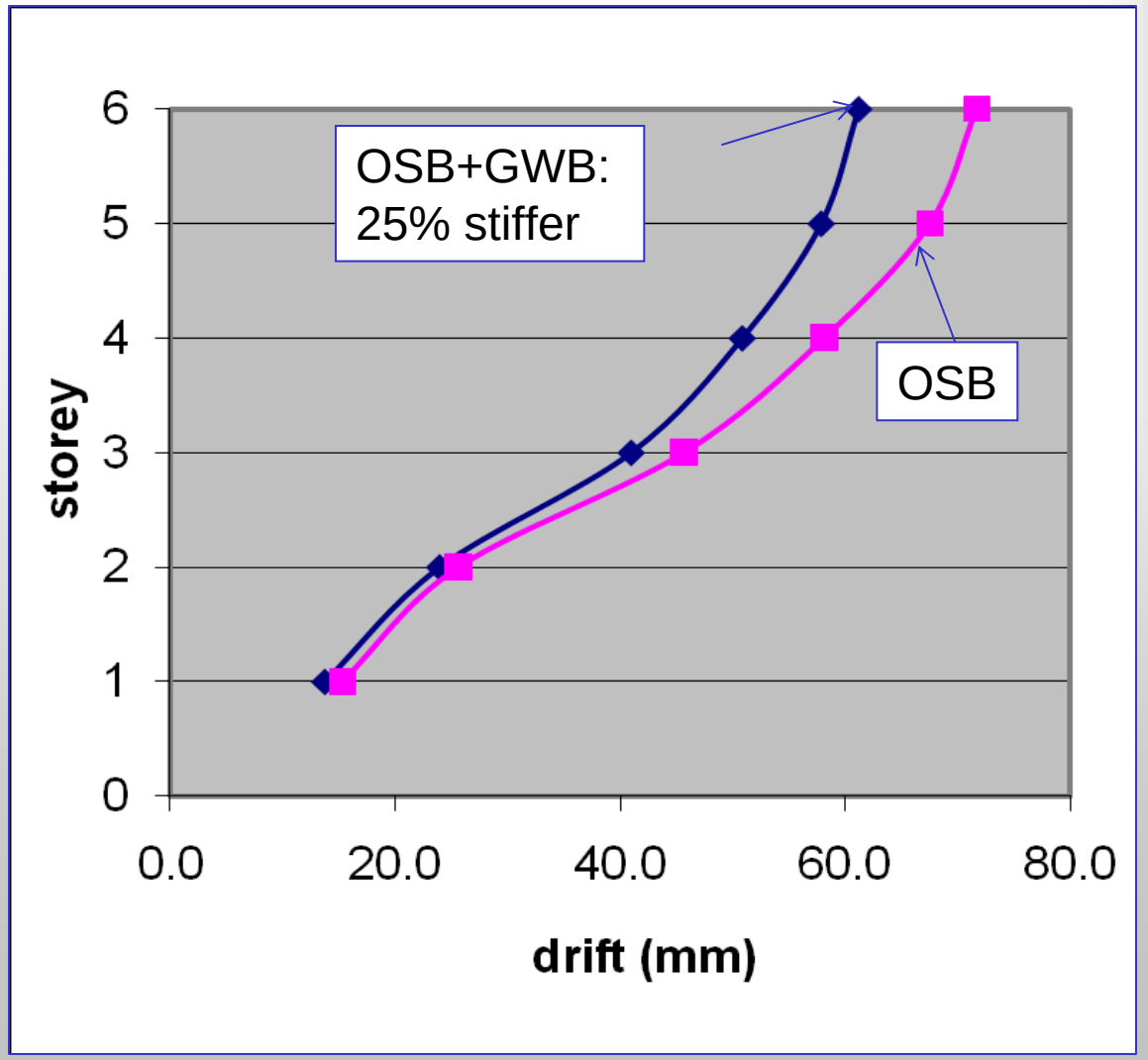




Low drift ratio (less than 1%)

Results: lateral drifts





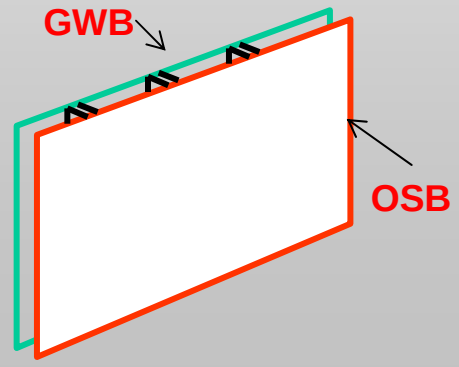
Fundamental structural periods (seconds)

sheathing	4-storey	5-storey	6-storey
OSB	0.62	0.75	1.01
OSB+GWB	0.46	0.58	0.67

Storey (shear) force distributions

	4-storey		5-storey		6-storey	
	K_{ratio} (%)	GWB	K_{ratio} (%)	GWB	K_{ratio} (%)	GWB
1st	15	5	15	5	15	5
2nd	30	10	15	5	15	5
3rd	45	10	30	10	30	10
4th	55	20	45	10	30	10
5th	-	-	55	20	45	15
6th	-	-	-	-	55	20

Note: Stiffness, $K_{ratio}=K_{GWB} / (K_{GWB} + K_{OSB})$



Conclusions

- GWB used in combination with wood-based structural sheathing (e.g. OSB) in shear walls affects the structural performance
- Incorporating GWB in the analysis leads to stiffer structures
- The percent storey force resisted by GWB is a direct result of the relative stiffness of the OSB- and GWB-sheathed wall
- Provisions to suggest percent values are needed based on the ductility and relative stiffness.

Acknowledgements

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