Shear-Flexure-Interaction Models for Planar and Flanged Reinforced Concrete Walls

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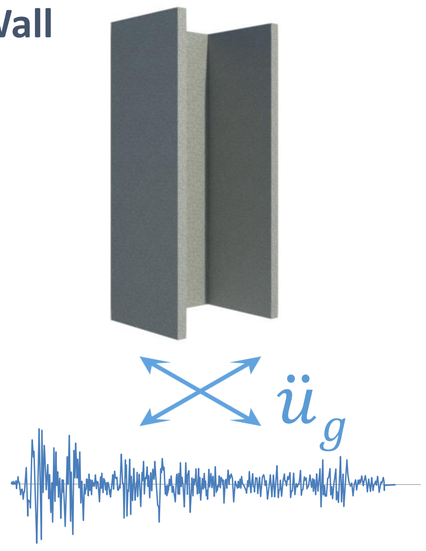
Introduction

3-D RC Structural Wall



- Widely used to resist lateral loads
- Flanged walls are commonly used in core walls
- Core walls subjected to multi directional loading

Objectives

- **Develop:** 3-Dimentional with 4-Nodes element
- **Validate** model against flanged walls test data
- **Implement** model into OpenSees

Background

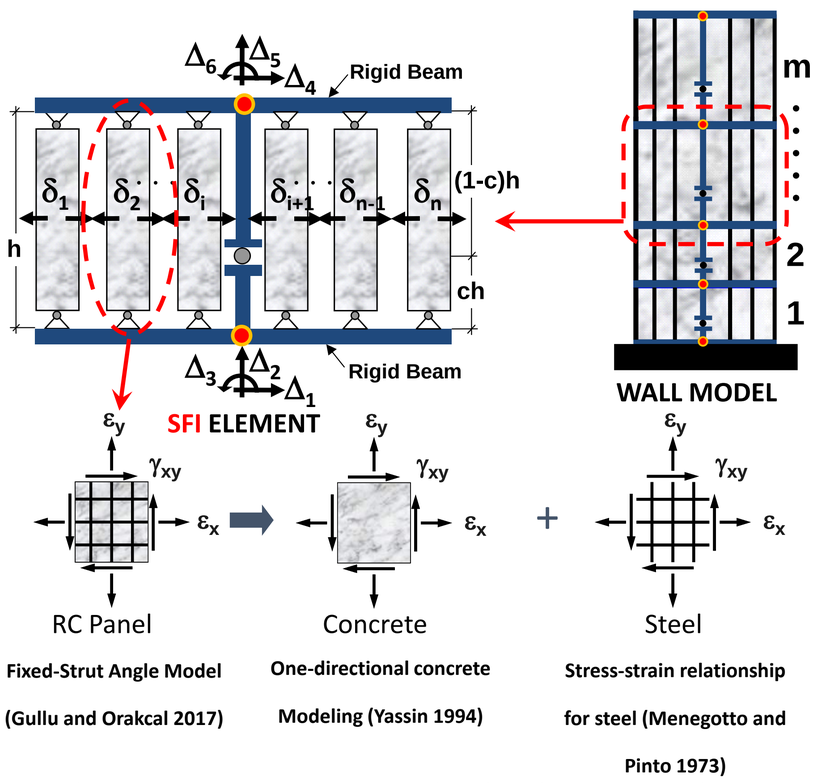
MVLEM with RC Panel Element (SFI)

(Kolozvari et. al., 2018)

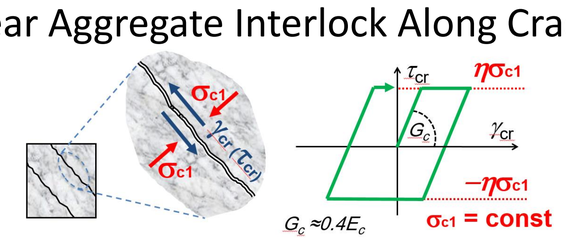
- **Axial-shear coupling** at fiber (panel) level
- **Flexural-shear coupling** at element level

Model Assumptions

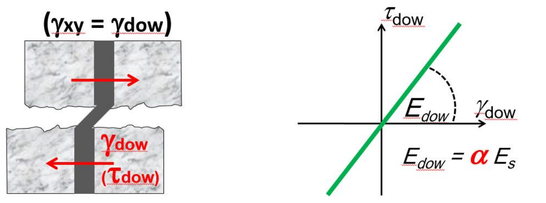
- **Plane sections** (fiber formulation) → ε_y
- **Uniform shear strain** in cross-section → γ_{xy}
- **Equilibrium equation** ($\sigma_x = 0$) to define ε_x



- Shear Aggregate Interlock Along Cracks



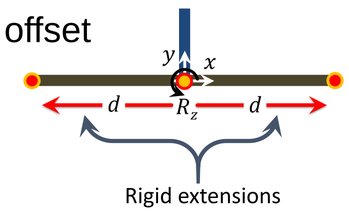
- Dowel Action of Vertical Reinforcement



Model Formulation

In-Plane

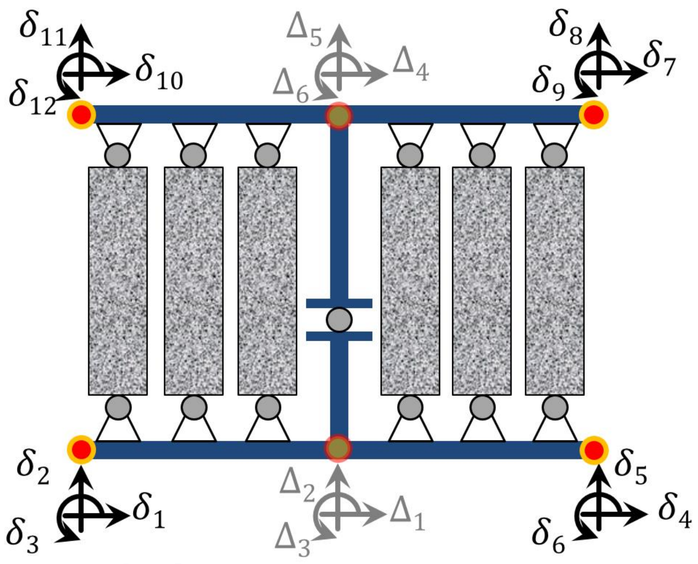
- Rigid offset



$$[C] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -d \\ 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & d \\ 0 & 0 & 1 \end{bmatrix}$$

Using Moore-Penrose pseudoinverse method: $[T] = [C]^{-1}$

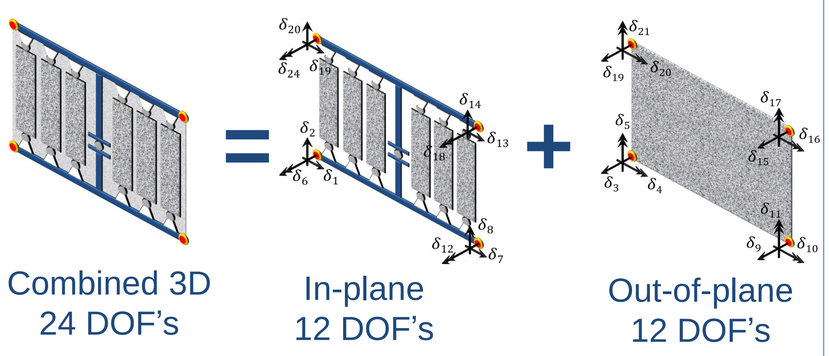
$$[K]_{12\times12} = [T]^T [K_{old}]_{6\times6} [T]$$
$$[R]_{12\times1} = [T]^T [R_{old}]_{6\times1}$$



Out-Of-Plane

- Kirchhoff plate, linear elastic

4-Node, 3-D Element



Model Validation

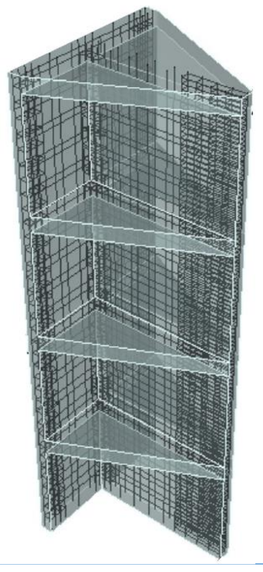
Experimental Data

Non planar walls subjected to uni and biaxial loading

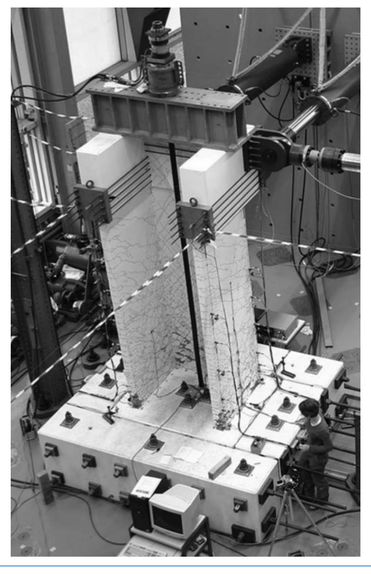
Test	Cross-section	$\frac{l_w}{t}$	$\frac{h_w}{l_w}$	ρ_{BE} (%)	ρ_{web} (%)	$\frac{N}{A_g f'_c}$
TW2	T	12.0	3.0	1.4	0.44	0.10
TUB	⊓	13.0 10.5	2.58	3.39	0.45	0.04

- Tests Configuration

TW2



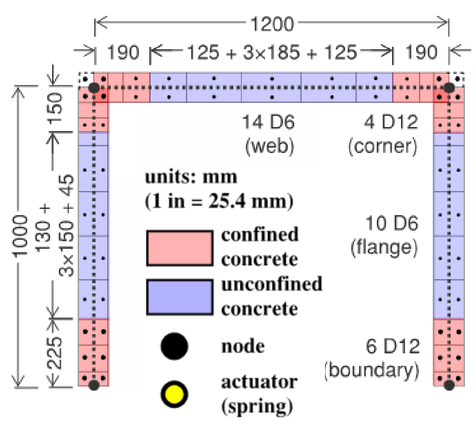
TUB

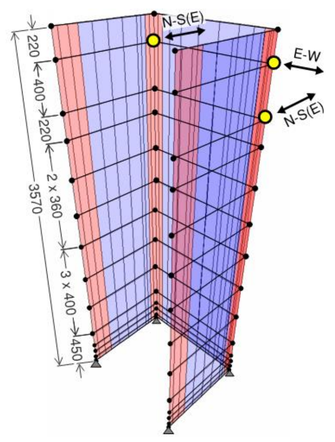


Model Validation (cont.)

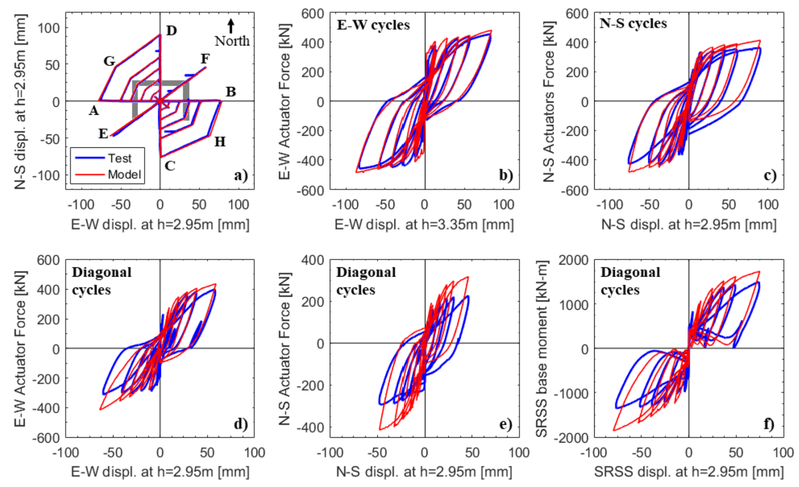
TUB (Beyer et al. 2008)

- Analytical model

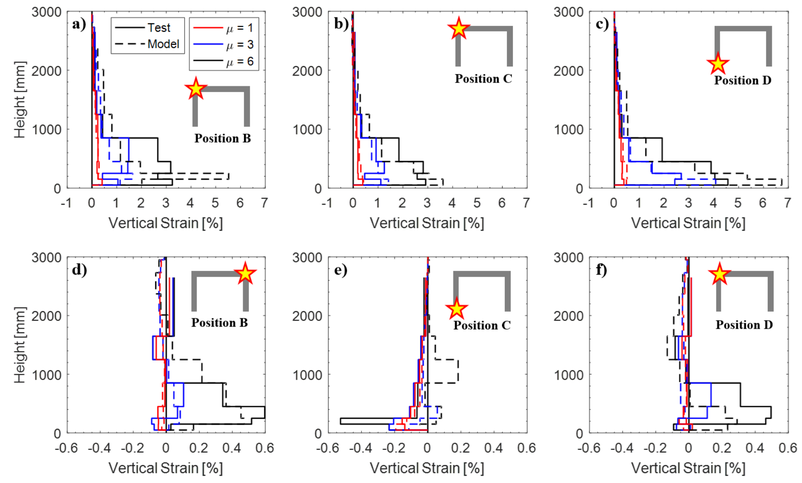




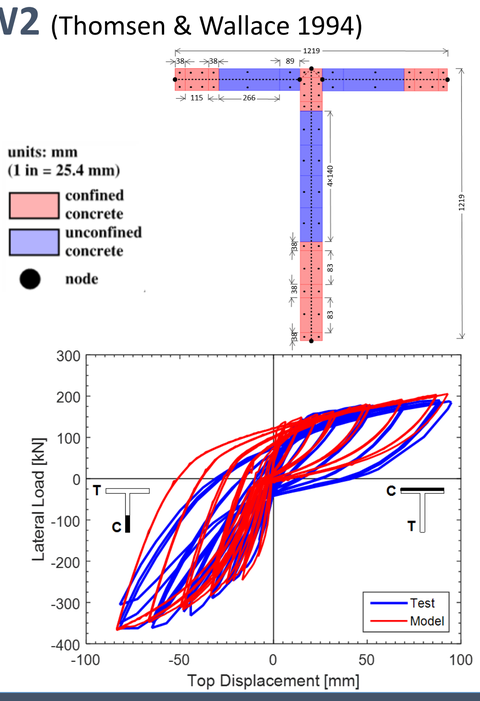
- Global results

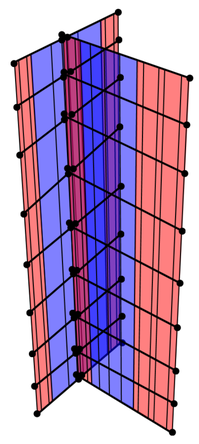


- Local results



TW2 (Thomsen & Wallace 1994)





Conclusion & Future Work

- Reasonable prediction of local and global responses under multi directional loading
- publically available in OpenSees in 2019
- Much faster than similar FEM models so enable engineers to use in dynamic analysis

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