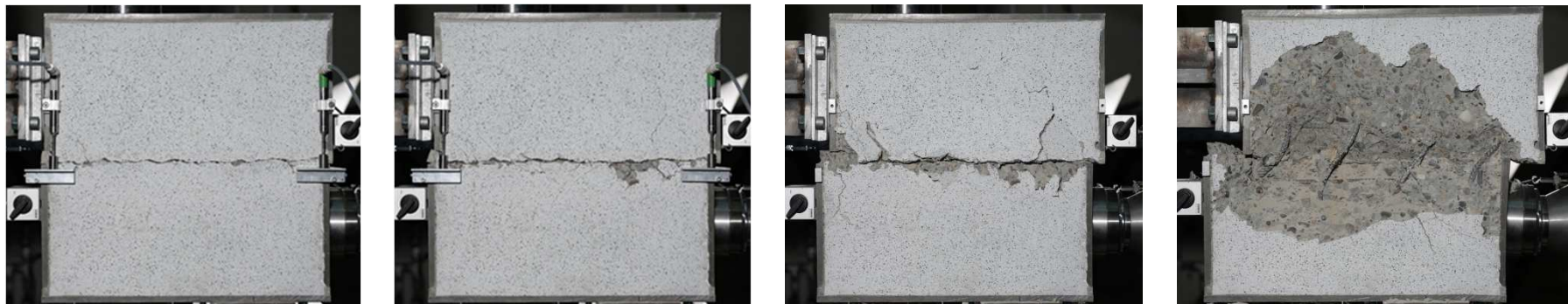


## Interaction of Sliding, Shear, and Flexure for Earthquake Design of Reinforced Concrete Shear Walls

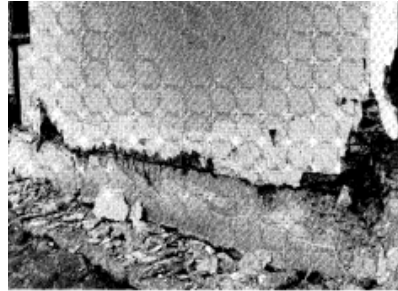


Dr. Burkhard Trost, Institute of Civil Engineering, FHNW

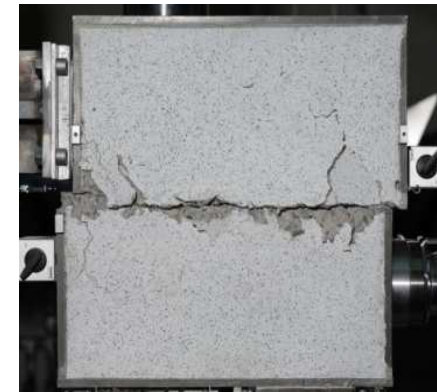
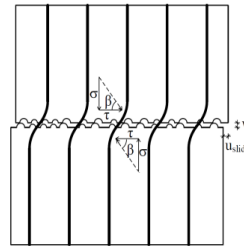
Prof. Dr. Harald Schuler, Institute of Civil Engineering, FHNW

Prof. Dr. Bozidar Stojadinovic, Institute of Structural Engineering, ETHZ

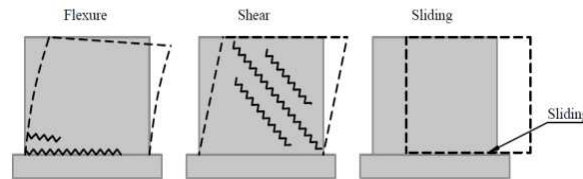
- Sliding Problem



- Experimental Investigation

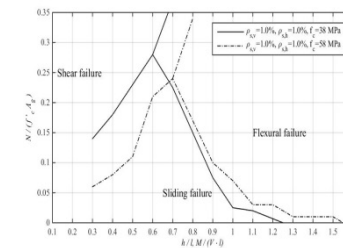


- Sliding Model

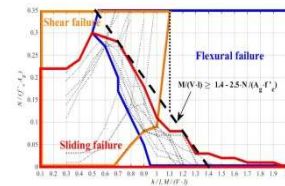


- Wall Model

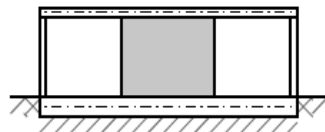
- Interaction Diagram of Sliding, Shear, and Flexure



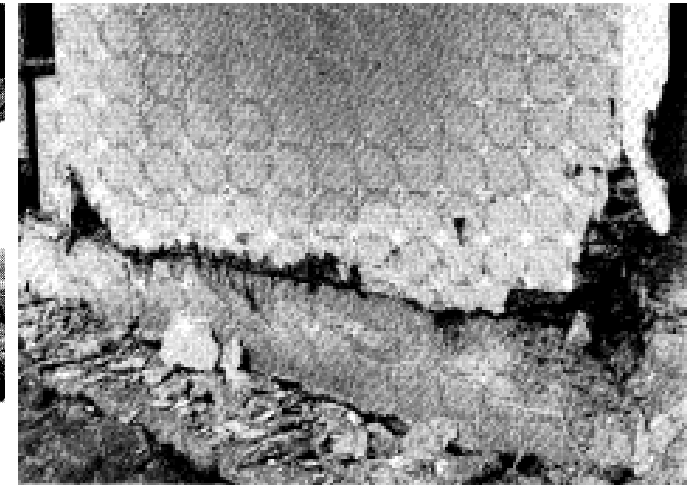
- Design Recommendation



1985 - Vina del Mar, Chile

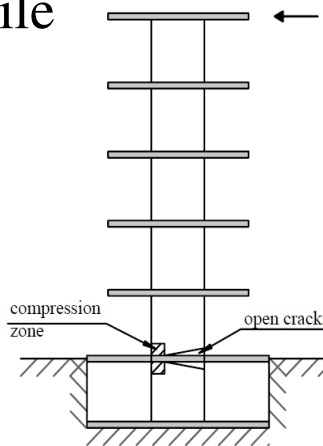


[1]



[1]

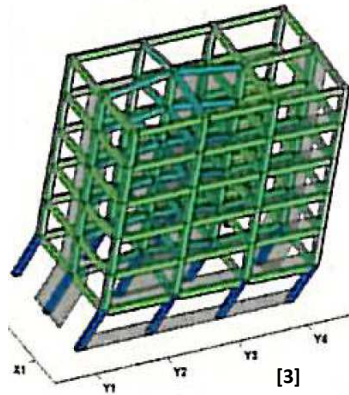
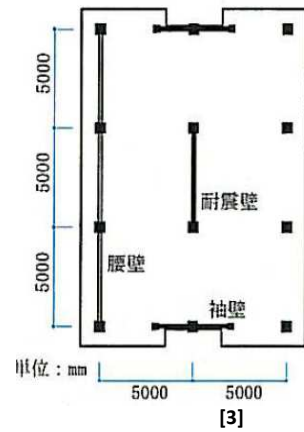
2010 – Santiago, Chile



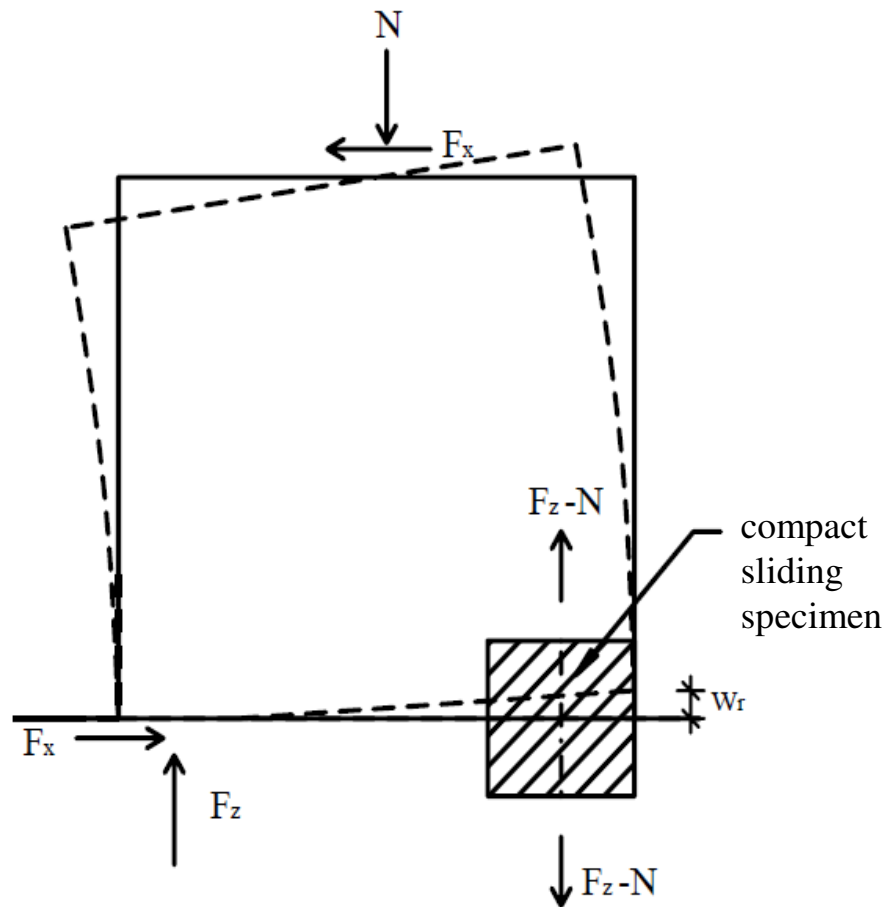
[2]



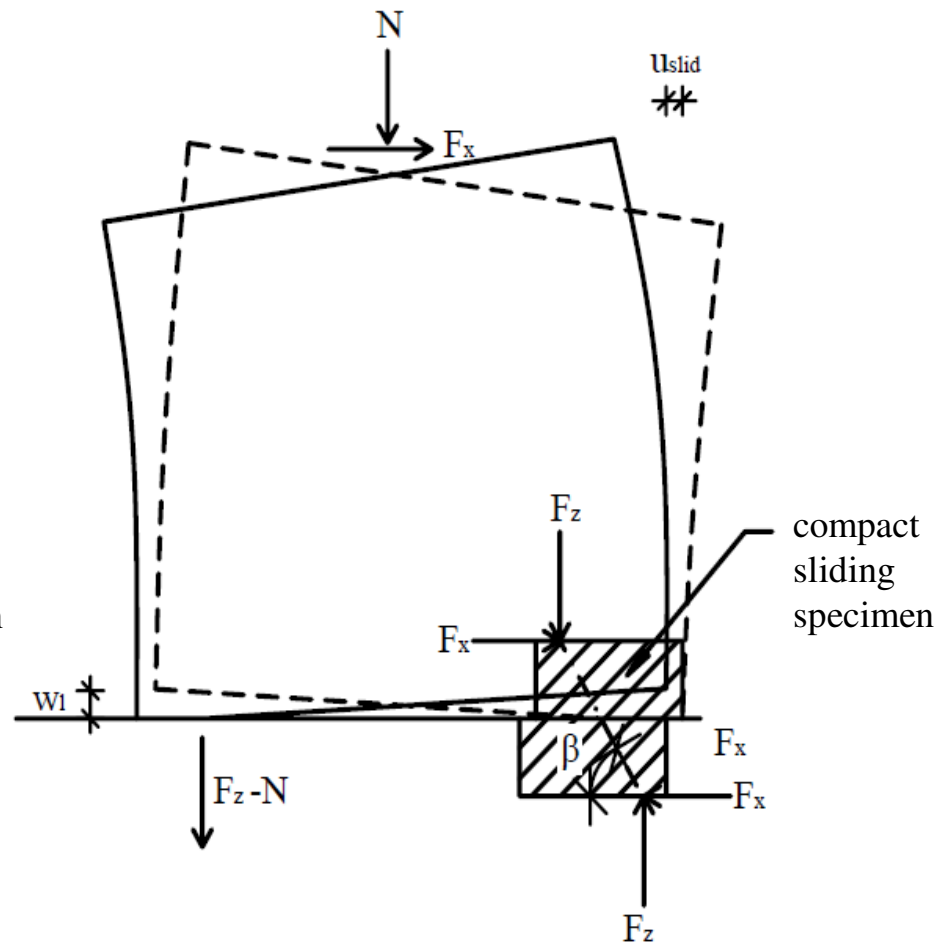
[2]



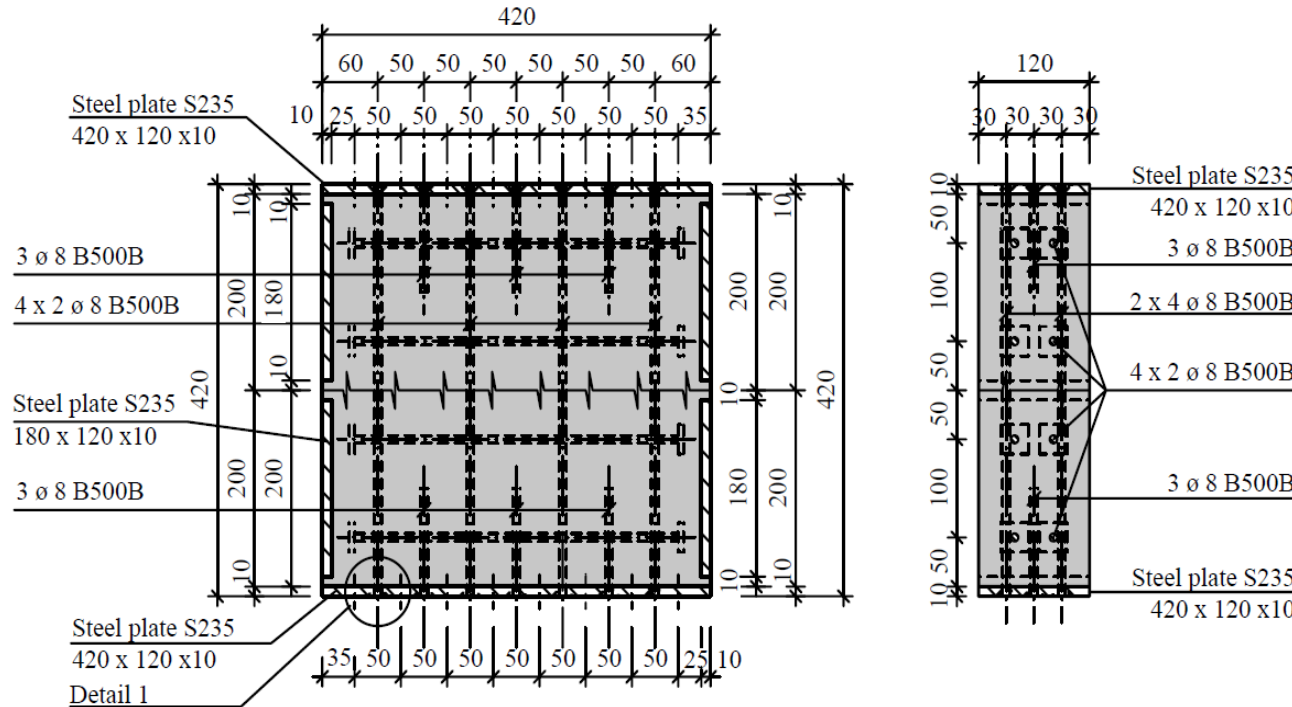
1<sup>st</sup> half cycle: Pre-cracking



2<sup>nd</sup> half cycle: Sliding



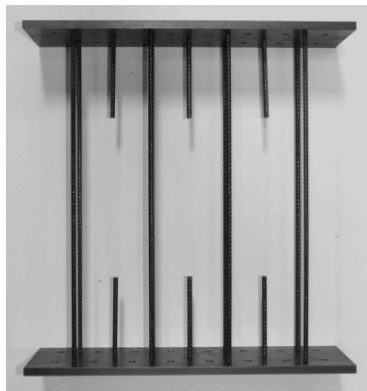




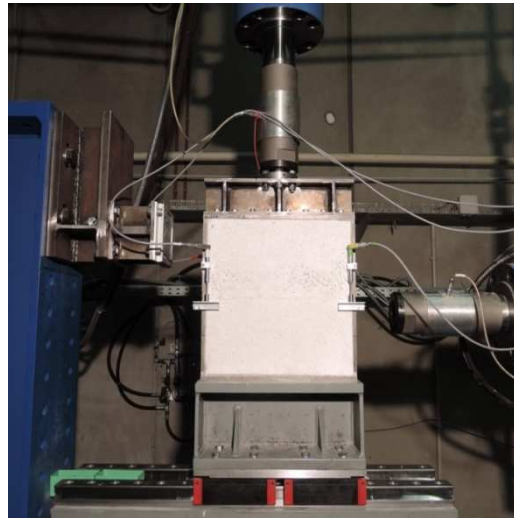
### Specimen types:

- Type 1,  $\rho_s=0.85\%$ , 420/420/120 mm,  $d_s=8$  mm
- Type 2,  $\rho_s=0.47\%$ , 420/420/120 mm,  $d_s=6$  mm
- Type 3,  $\rho_s=1.13\%$ , 420/420/80 mm,  $d_s=8$  mm

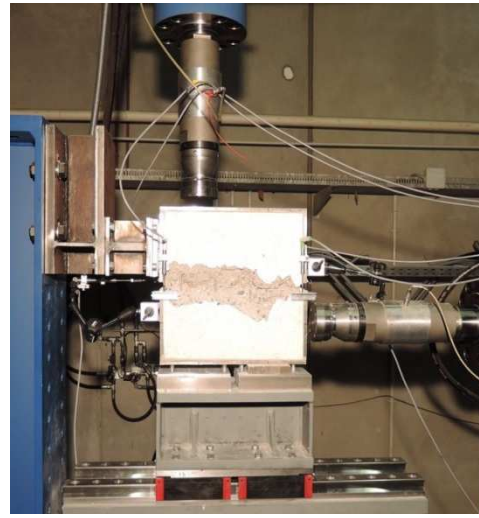
### Fabrication:



Phase 1: Pre-cracking

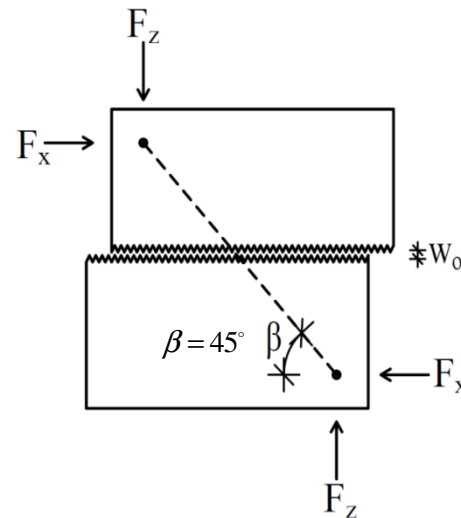
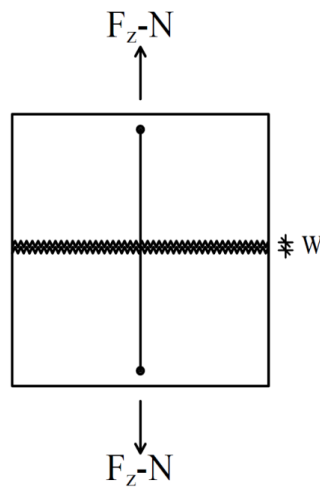


Phase 2: Sliding

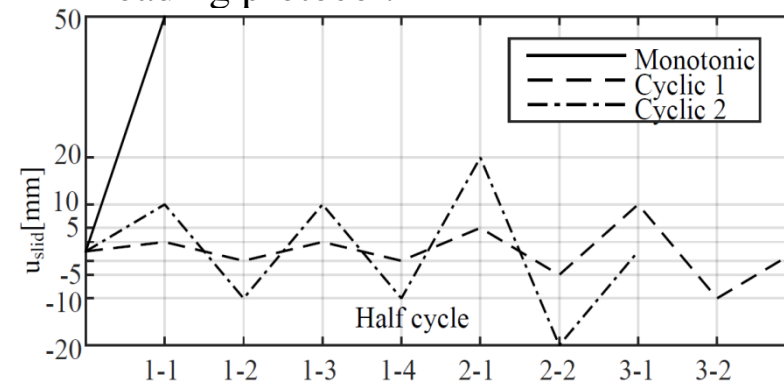


Compact sliding specimens:

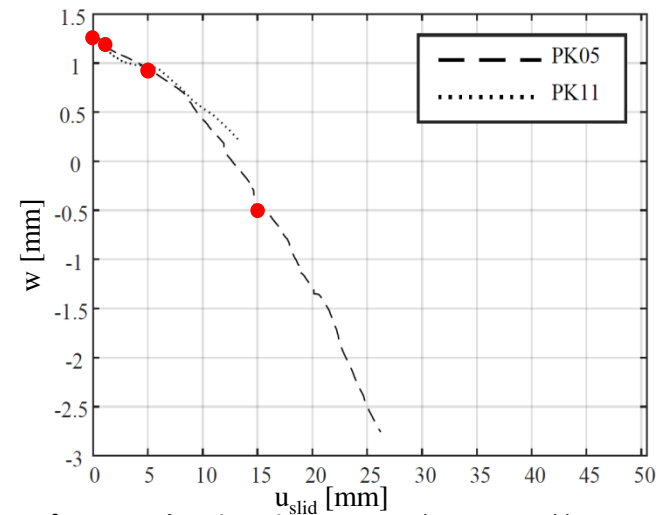
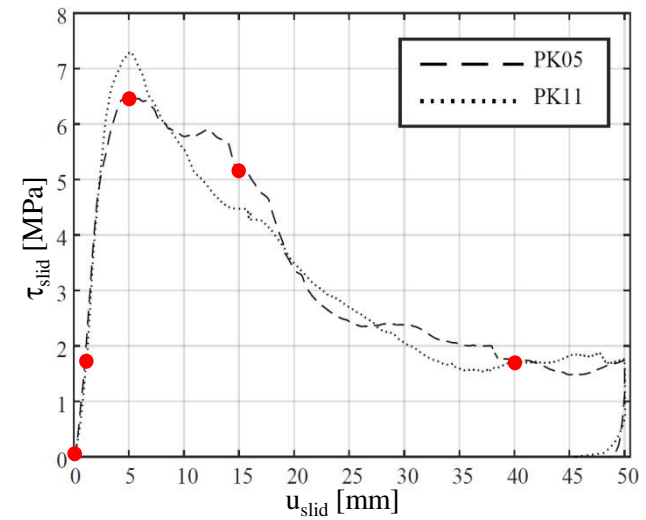
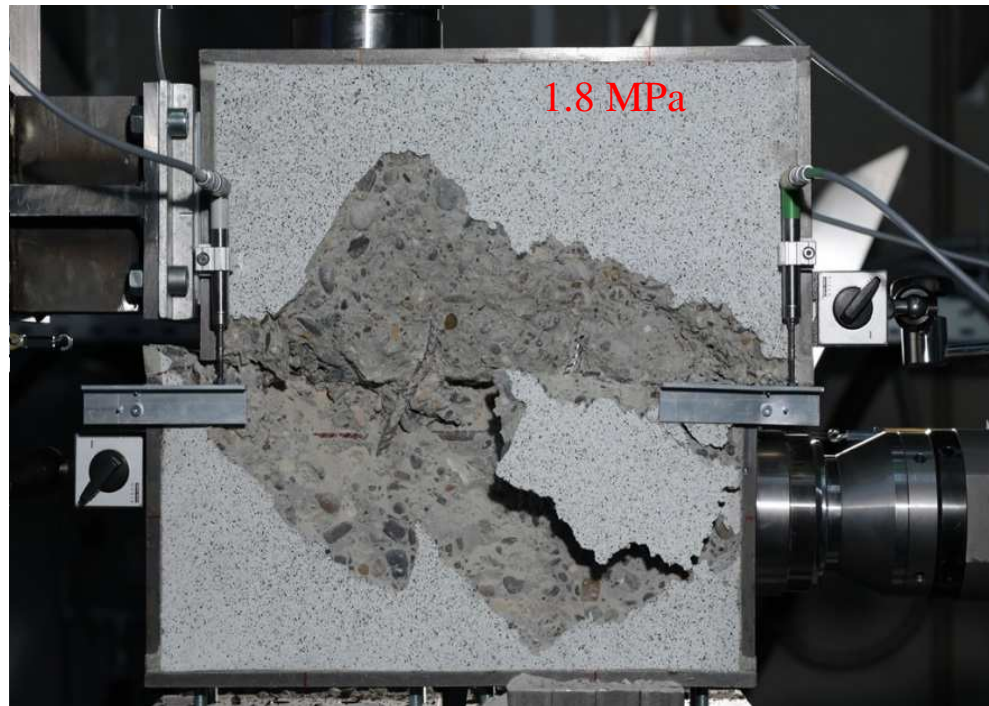
w	$\rho_s = 0.46\%$	$\rho_s = 0.83\%$	$\rho_s = 1.11\%$	Loading protocol
1 mm		PK09, PK10		Cyclic 1
2 mm	PK21, PK22	PK02, PK03, PK04	PK17, PK18	Cyclic 1
		PK07, PK08		Cyclic 2
		PK05, PK11		Monotonic



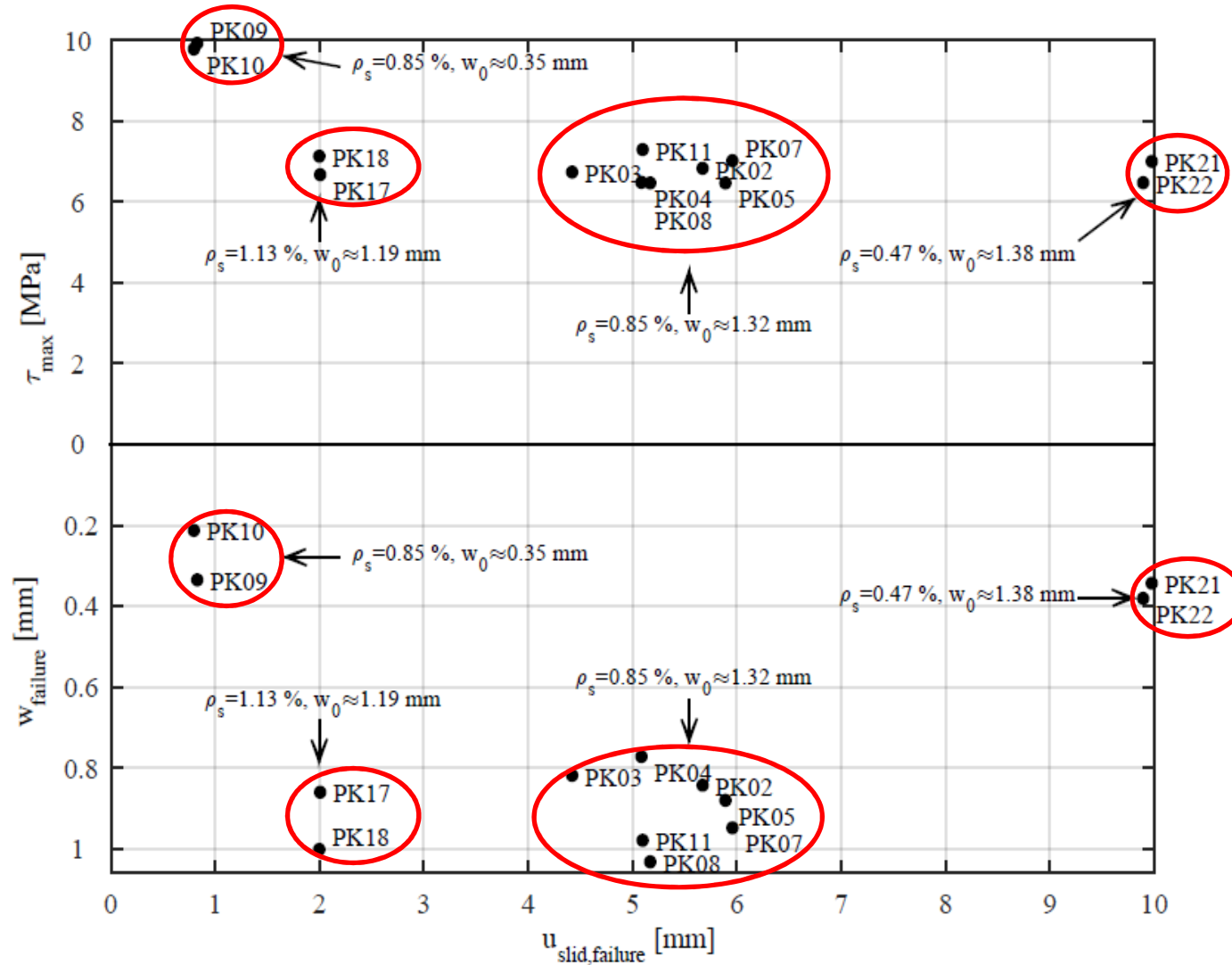
Loading protocol:



PK05

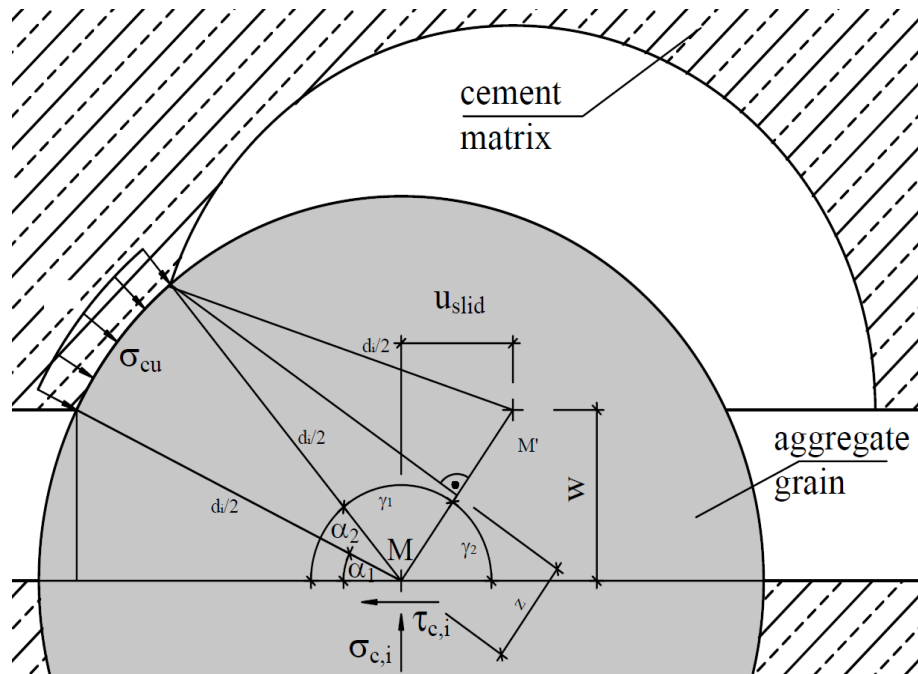




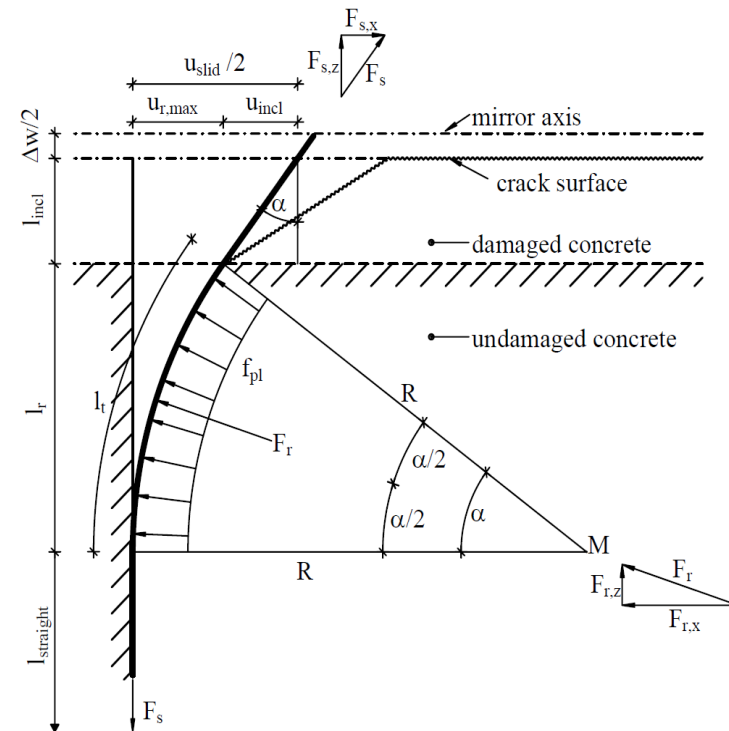


$$\tan \beta = \frac{\sigma_c(u_{slid}, w) + \overline{\sigma}_s(u_{slid}, w)}{\tau_c(u_{slid}, w) + \overline{\tau}_s(u_{slid}, w)}$$

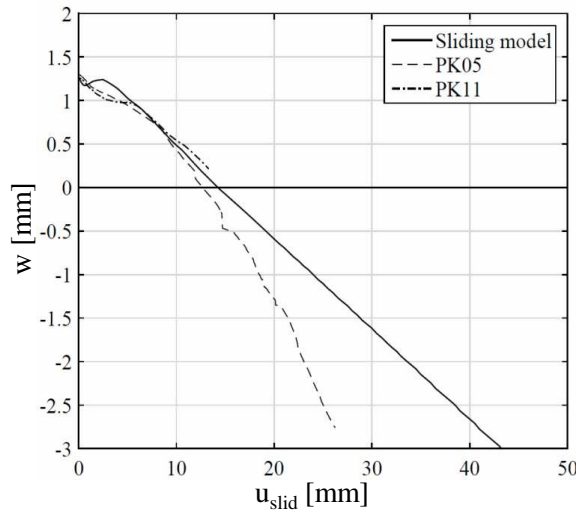
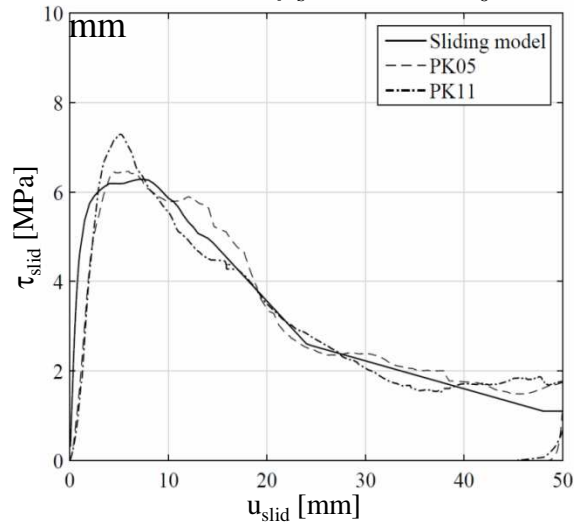
### Aggregate interlock model



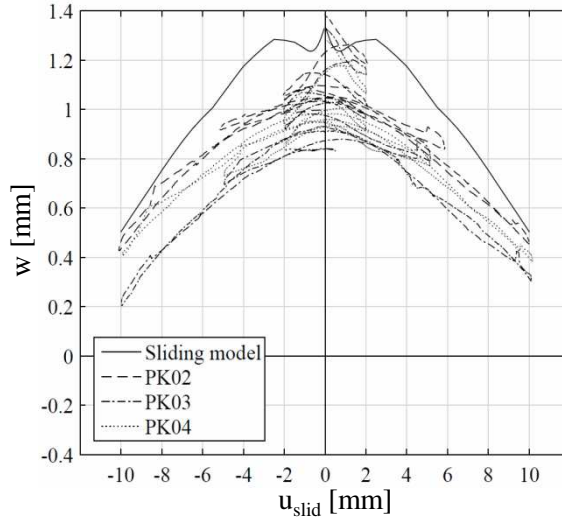
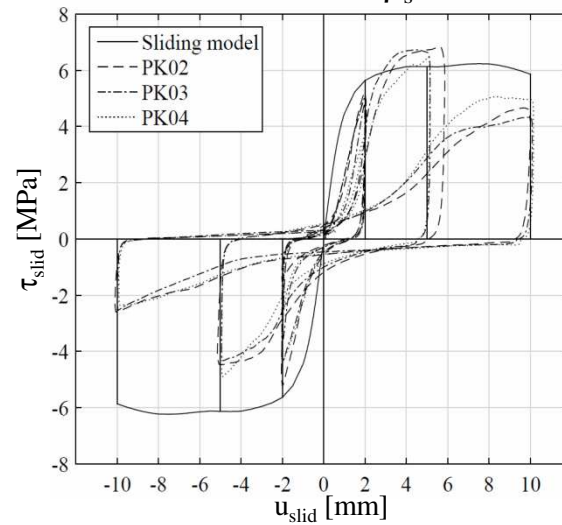
### Deformation of reinforcement bars



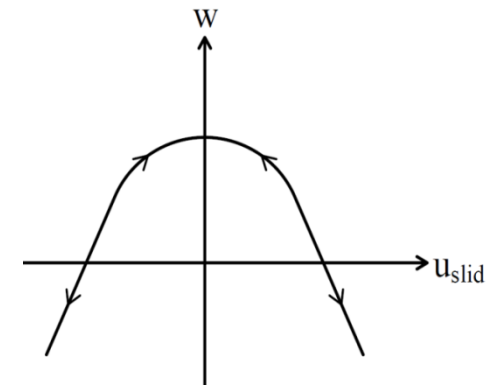
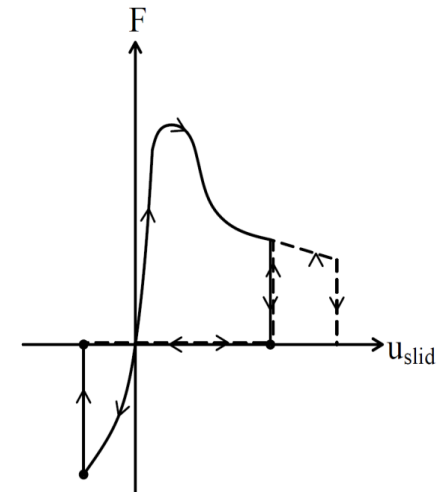
PK05, PK10,  $\rho_s=0.85\%$ ,  $w_0=1.28$

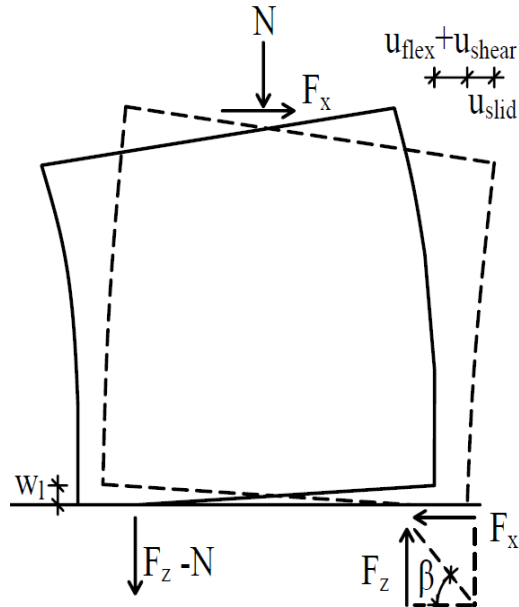


PK02, PK03, PK04,  $\rho_s=0.85\%$ ,  $w_0=1.34$  mm



Cyclic behaviour



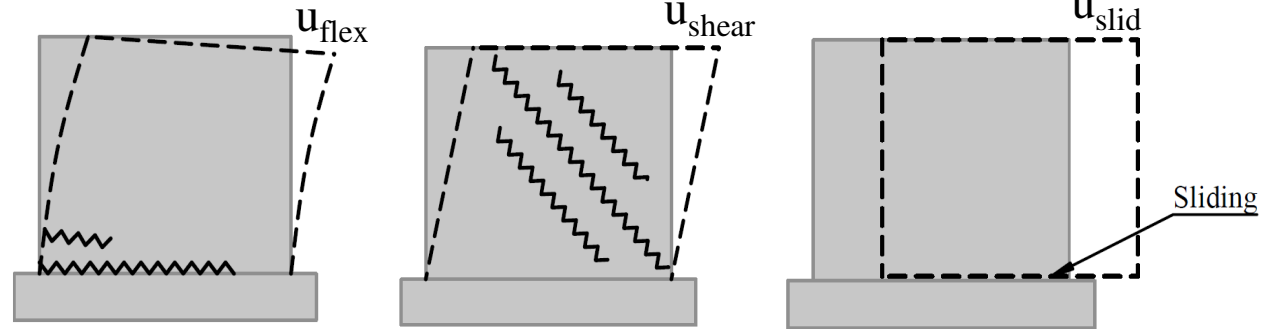


$$u(F_x, N) = u_{flex}(F_x, N) + u_{shear}(F_x, N) + u_{slid}(F_x, w_0, \beta, x_0)$$

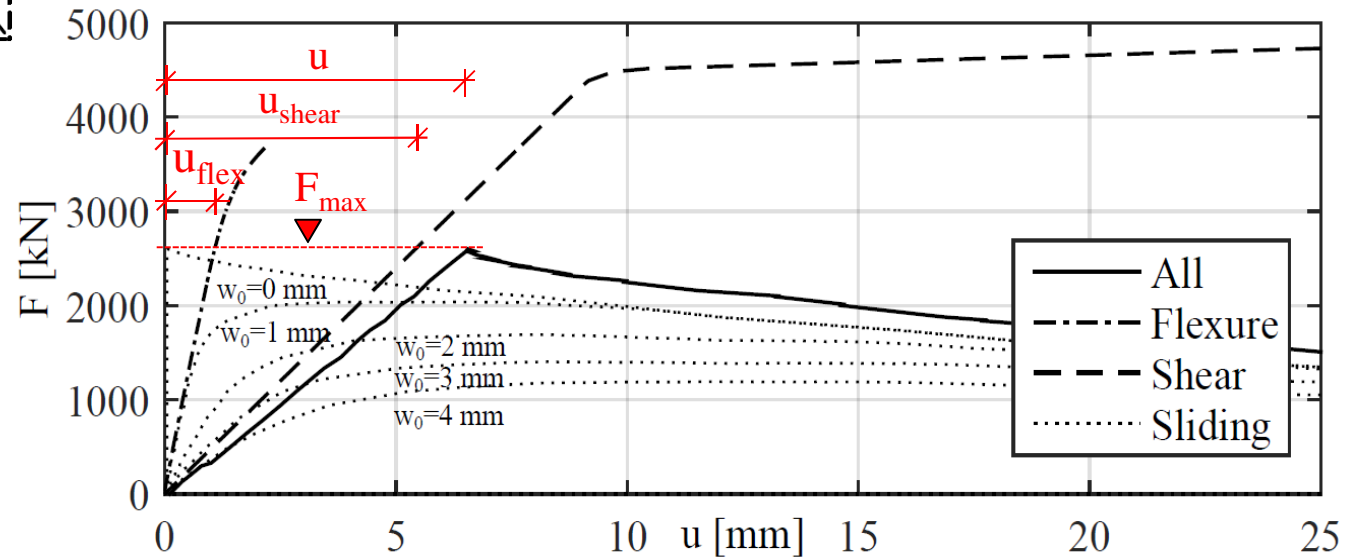
Integration of  
M- $\kappa$  relationship

Compression  
field theory

Sliding model



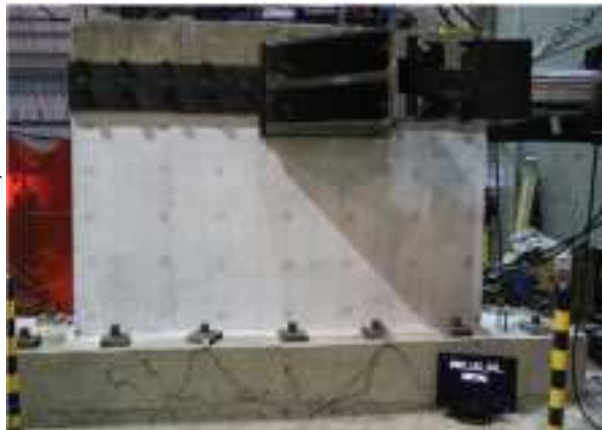
**Luna SW8:**  
 h=1.65 m  
 l=3.05 m  
 t=0.2 m  
 $f_c=24.1$  MPa  
 $\rho_{s,v}=1.5\%$   
 $\rho_{s,h}=1.5\%$





### Luna SW8:

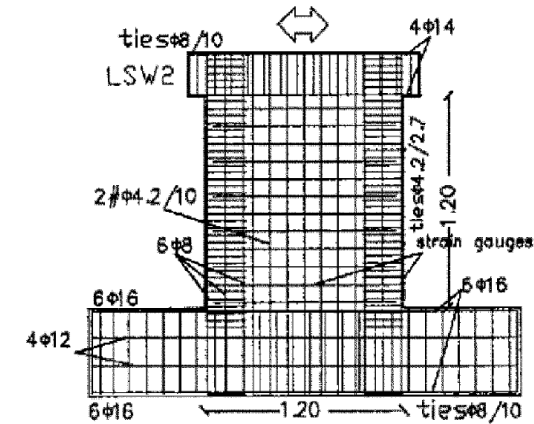
$h=1.65$  m  
 $l=3.05$  m  
 $t=0.2$  m  
 $f_c=24.1$  MPa  
 $\rho_{s,v}=1.5\%$   
 $\rho_{s,h}=1.5\%$



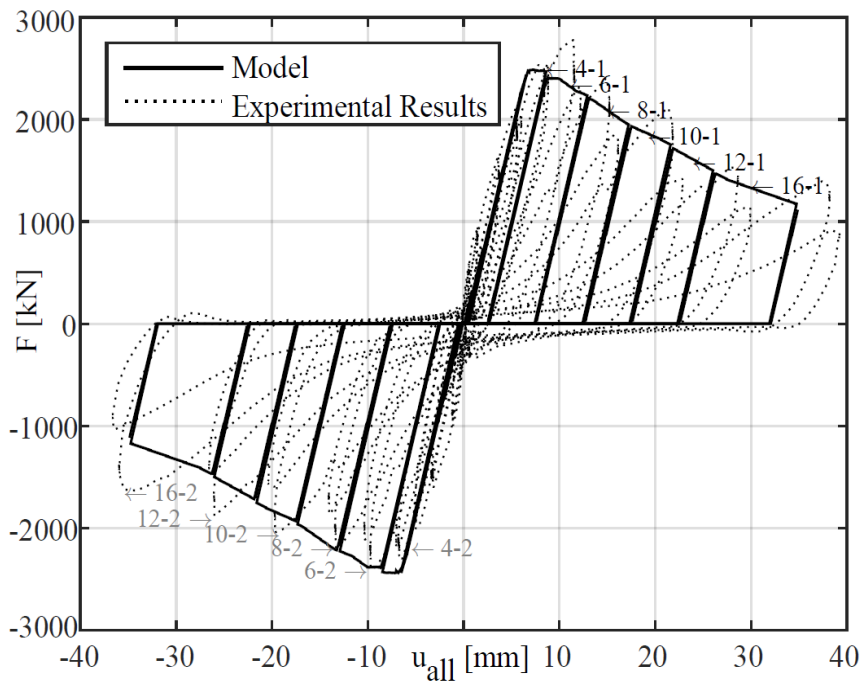
[6]

### Salonikios LSW2 and LSW3:

$h=1.3$  m  
 $l=1.2$  m  
 $t=0.1$  m  
 $f_{c,LSW2}=21.6$  MPa  
 $f_{c,LSW3}=23.9$  MPa  
 $\rho_{s,v,boundary}=1.3\%$   
 $\rho_{s,v,web}=0.28\%$   
 $\rho_{s,h}=0.28\%$

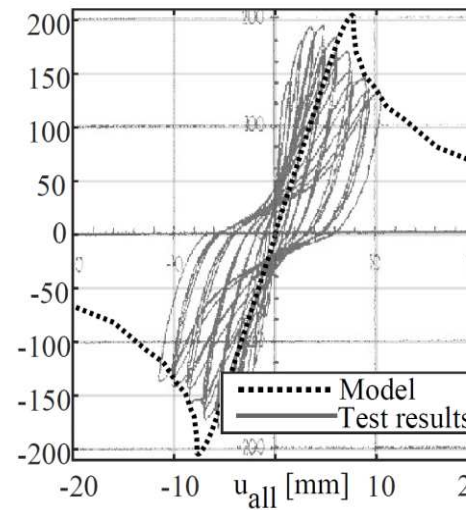


[7]



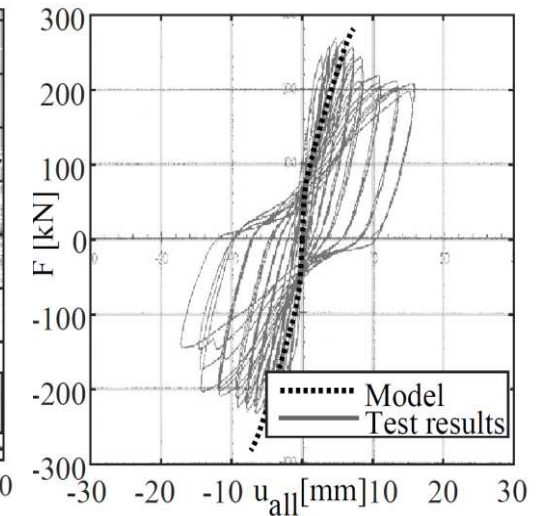
[6]

### Salonikios LSW2 (N=0.00)

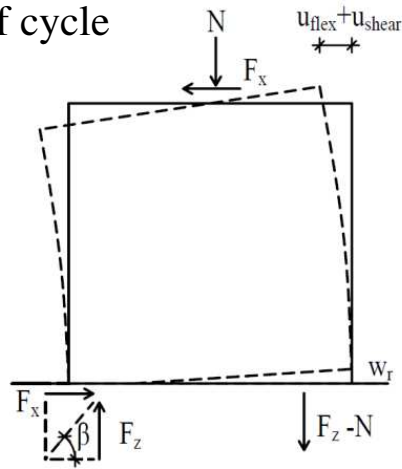


[7]

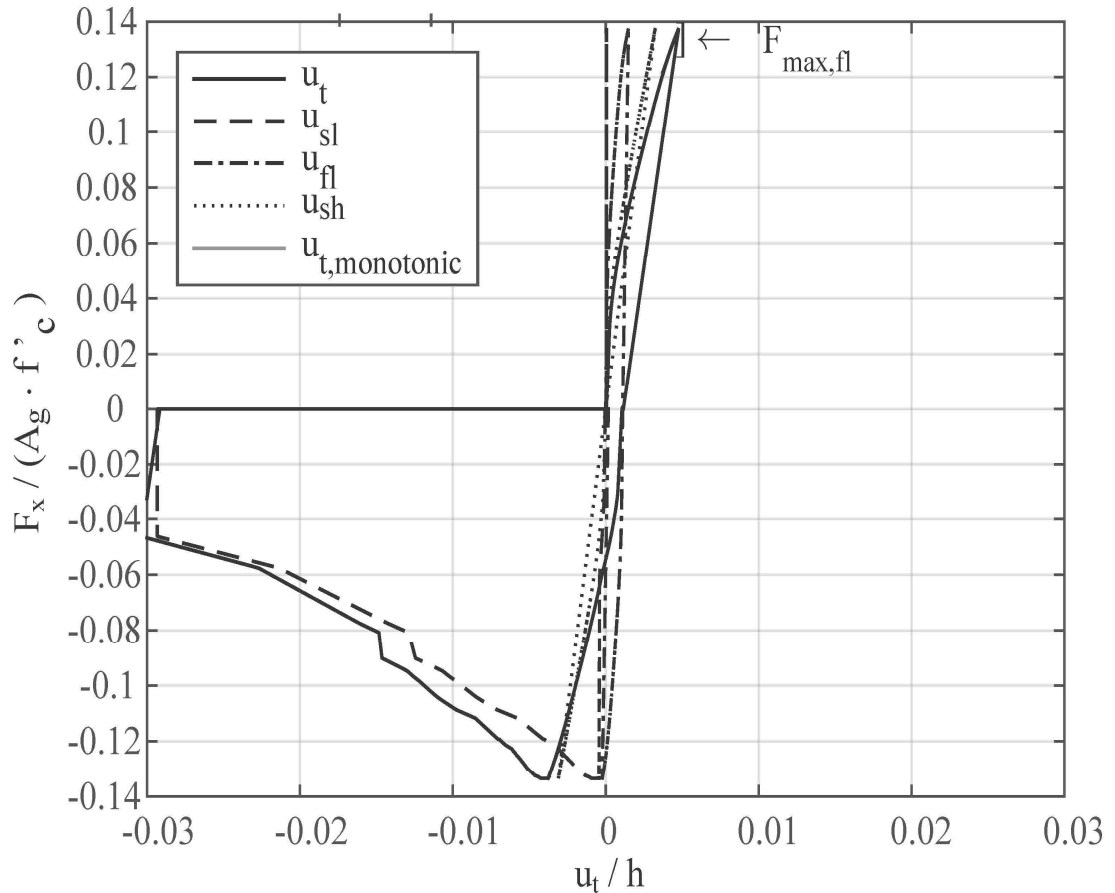
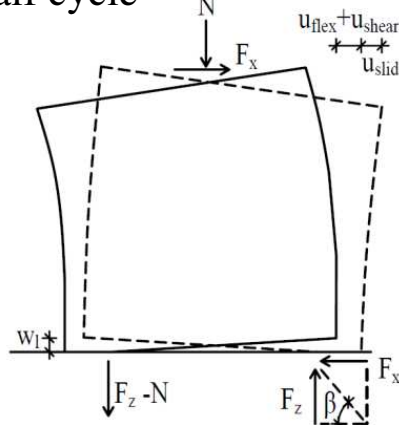
### Salonikios LSW3 (N=0.07 A<sub>c</sub> f<sub>c</sub>)

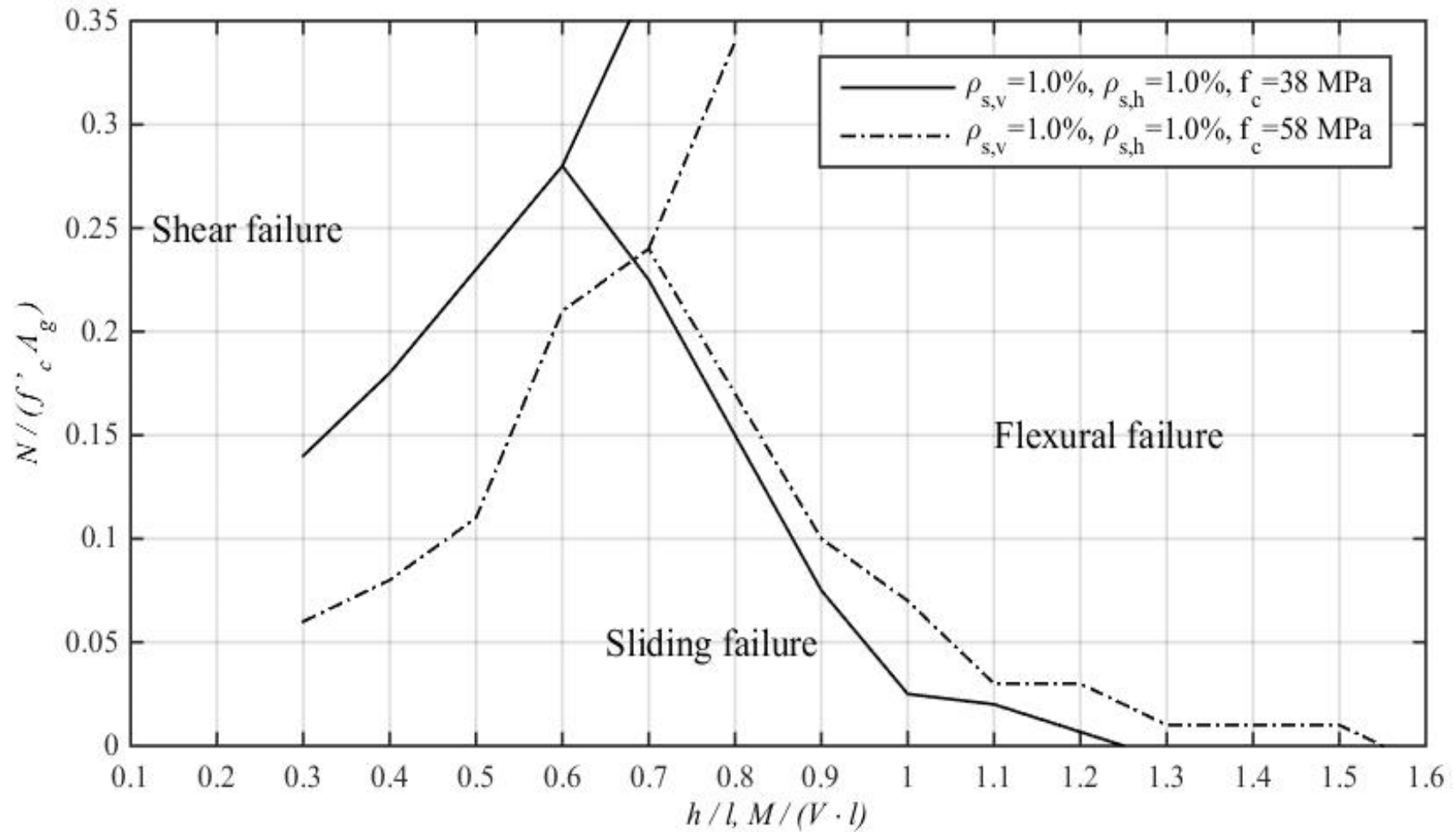


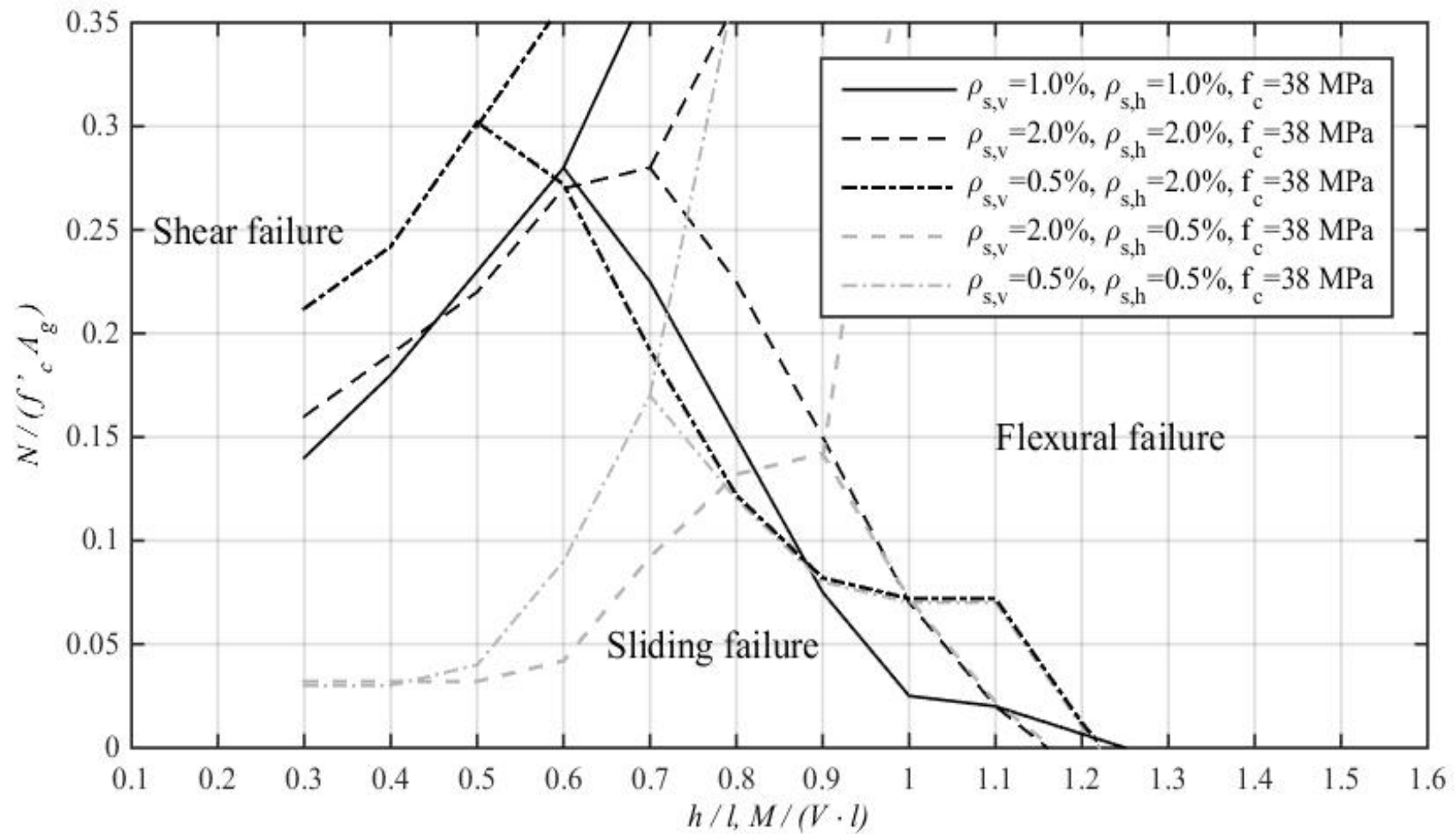
1<sup>st</sup> half cycle



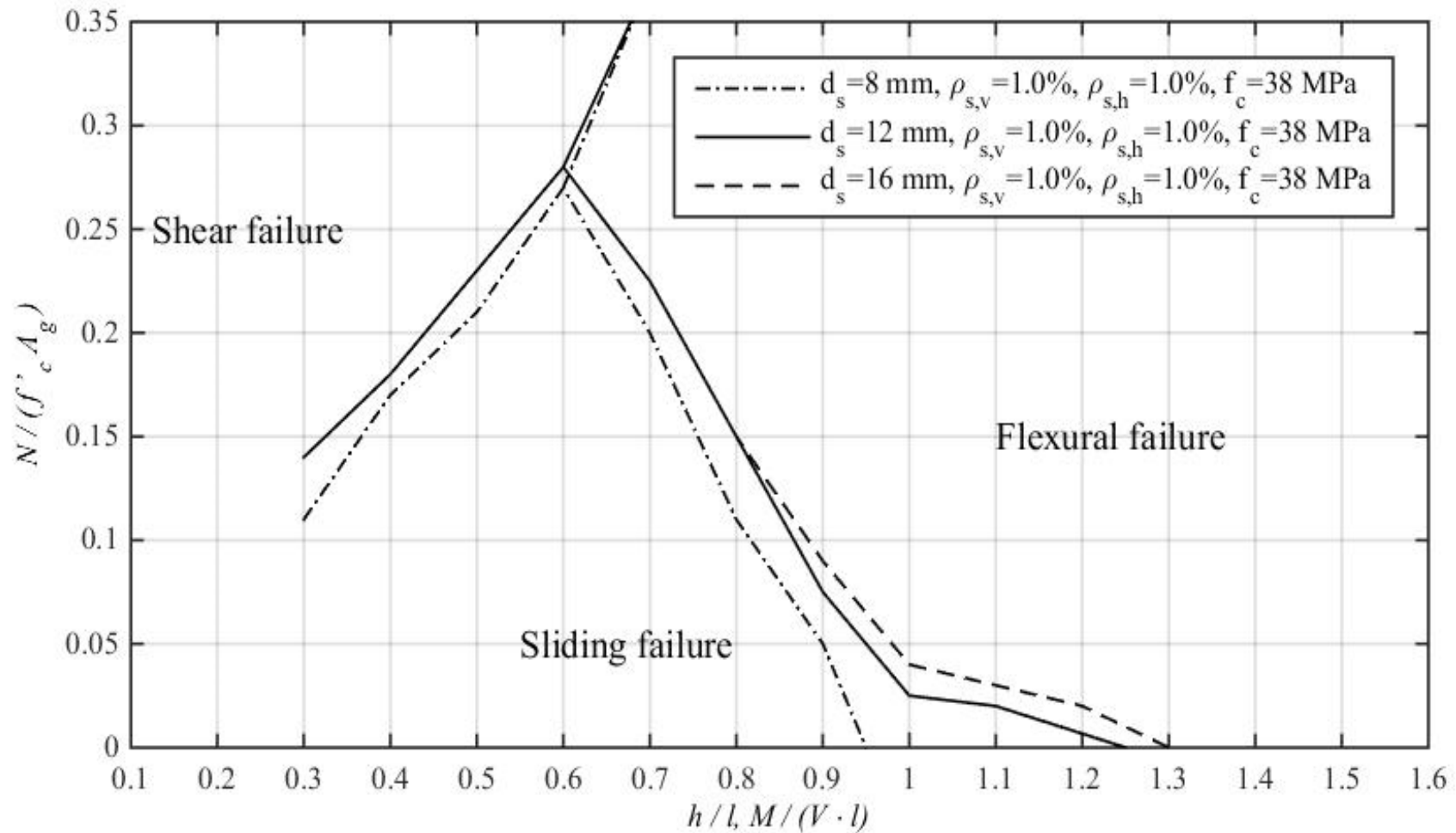
2<sup>nd</sup> half cycle

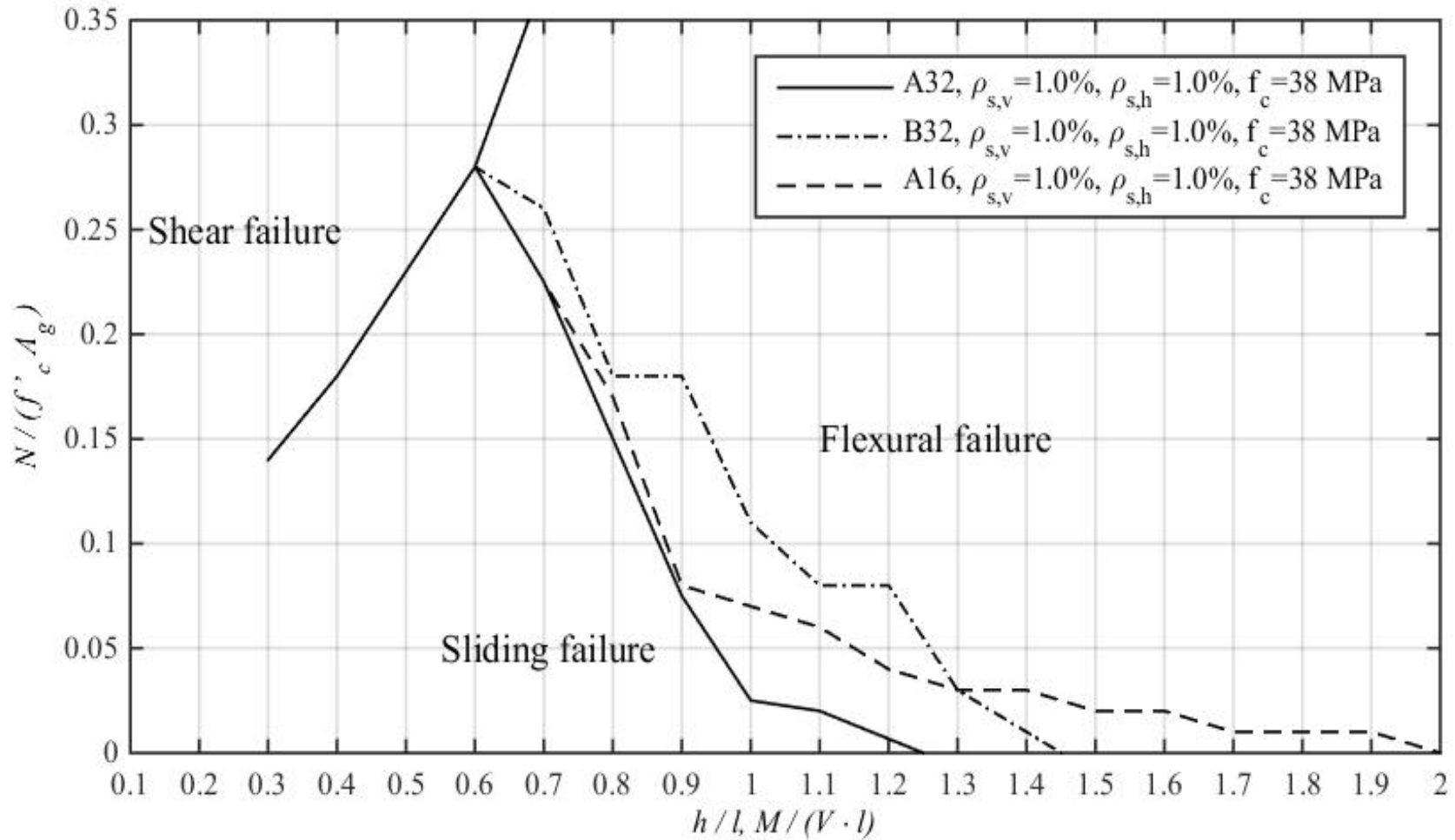


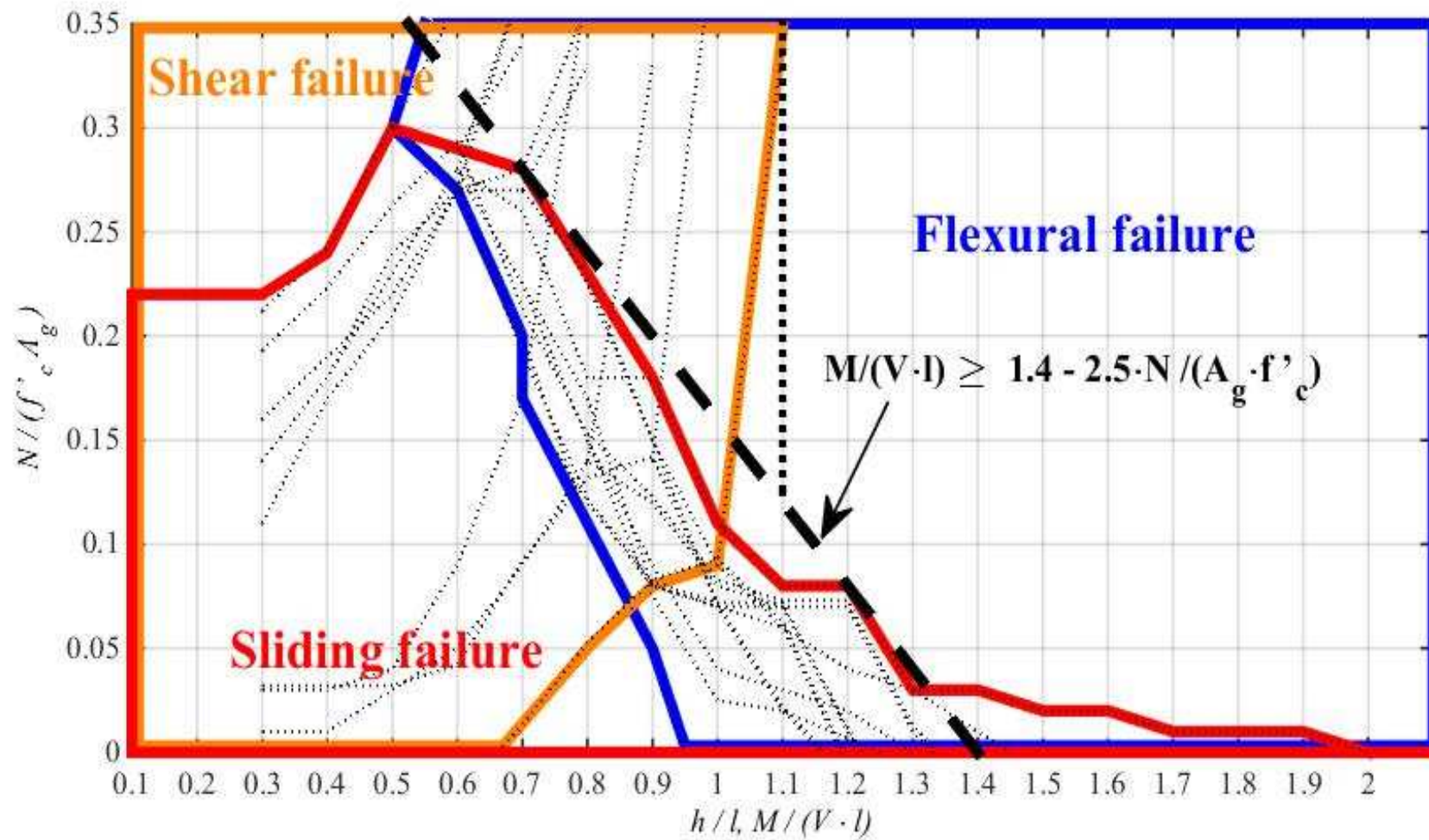




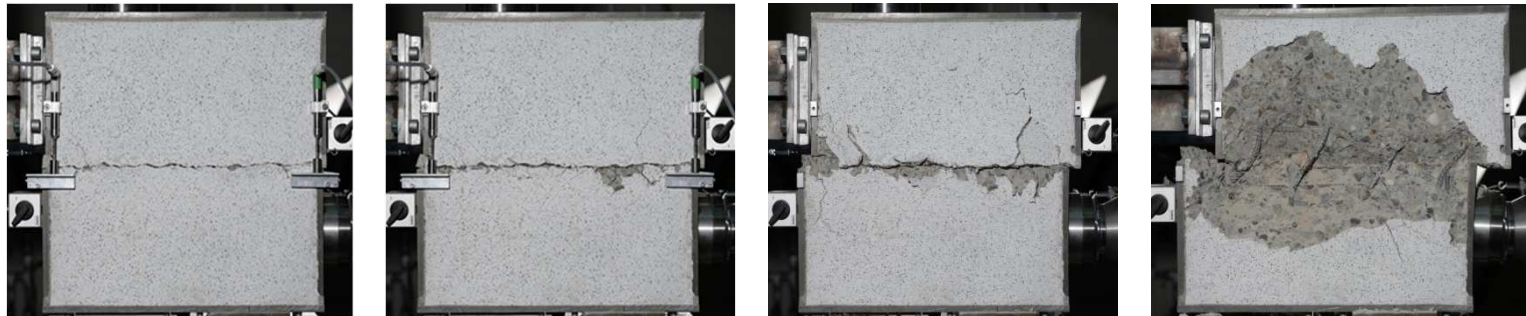








Thank you for your attention!



- [1] EARTHQUAKE ENGINEERING RESEARCH INSTITUT, The chile earthquake of march 3, 1985: Performance of structures, Earthquake Spectra, (1986), pp. 293–371.
- [2] H. KATO, S. TAJIRI, AND T. MUKAI, Preliminary Reconnaissance Report of the Chile Earthquake 2010, Japan, 2010.
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- [5] P. SOROUSHIAN, K. OBASEKI, AND M. C. RONJAS, Bearing Strength and Stiffness of Concrete Under Reinforcing Bars, ACI Materials Journal, (1987), pp. 179–184.
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