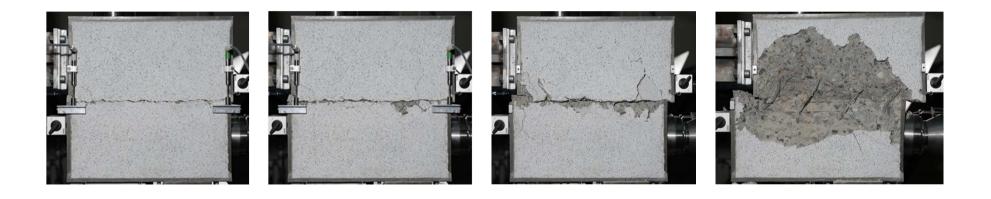


Interaction of Sliding, Shear, and Flexure for Earthquake Design of Reinforced Concrete Shear Walls



Dr. Burkhart Trost, Institute of Civil Engineering, FHNW Prof. Dr. Harald Schuler, Institute of Civil Engineering, FHNW Prof. Dr. Bozidar Stojadinovic, Institute of Structural Engineering, ETHZ



University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering



Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

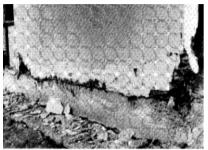
Outline

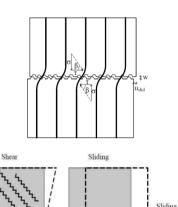
The Concrete Convention and Exposition

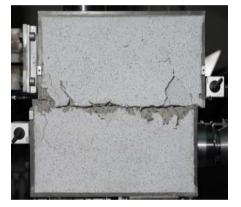
- Sliding Problem

aci

- Experimental Investigation
- Sliding Model



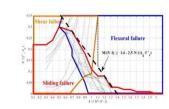


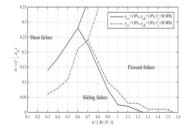


- Wall Model
- Interaction Diagram of Sliding, Shear, and Flexure

Flexure

- Design Recommandation







University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering

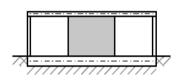


Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Sliding Damage after Earthquakes and Exposition

1985 -Vina del Mar, Chile

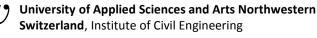
aci



2010 – Santiago, Chile

n







Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

[2] Dr. Burkhart Trost October 17, 2017 3

[1]





University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering **ETH** zürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Shear Walls under Cyclic Loading aci and Exposition

2nd half cycle: Sliding

Dynamics and Earthquake Engineering Group

October 17, 2017

5

1st half cycle: Pre-cracking

Switzerland, Institute of Civil Engineering

n

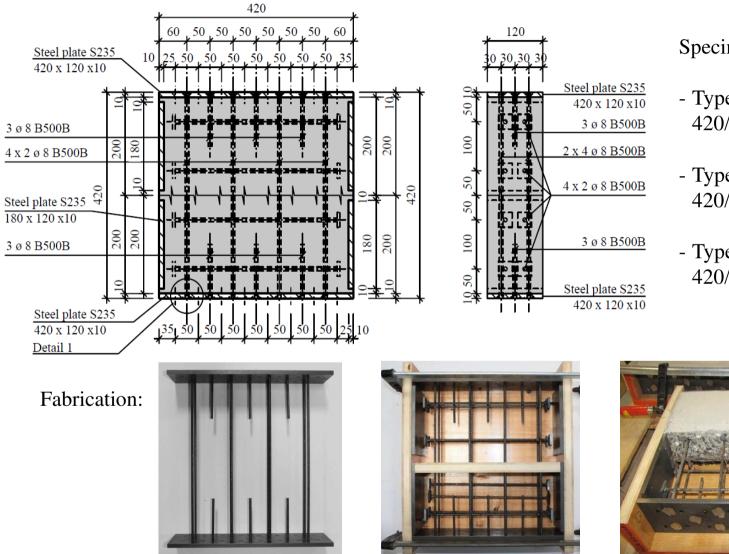
Ν Uslid ₩ Fz-N Fz compact compact sliding sliding specimen specimen F₂ Wr Fx Fx Fz-N •Fx $\mathbf{F}_{\mathbf{z}}$ Fz-N Fz Institute of Structural Engineering, Structural University of Applied Sciences and Arts Northwestern Dr. Burkhart Trost **ETH** zürich



n

Compact Sliding Specimen

The Concrete Convention and Exposition



Specimen types:

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







University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering



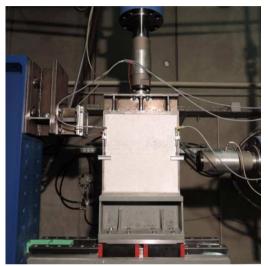
Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group



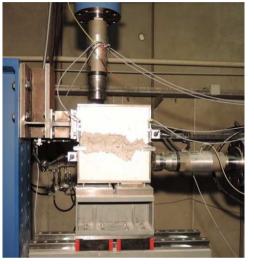
Test Setup

The Concrete Convention and Exposition

Phase 1: Pre-cracking

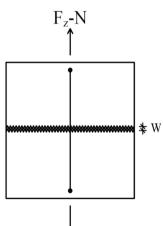


Phase 2: Sliding



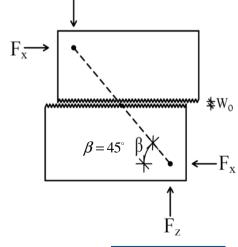
Compact sliding specimens:

compact shaing specimens:				
w	$p_s = 0.46\%$	$\rho_{s} = 0.83\%$	$\rho_{s} = 1.11\%$	Loading protocol
1 mm		PK09, PK10		Cyclic 1
2 mm	PK21,PK2 2	PK02, PK03, PK04	PK17, PK18	Cyclic 1
		PK07, PK08		Cyclic 2
		PK05, PK11		Monotoni c



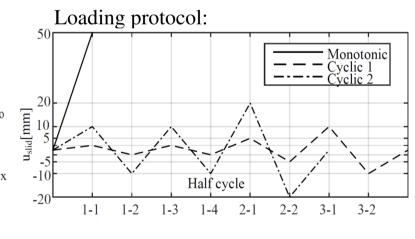
 F_z -N

n



ETH zürich

F.



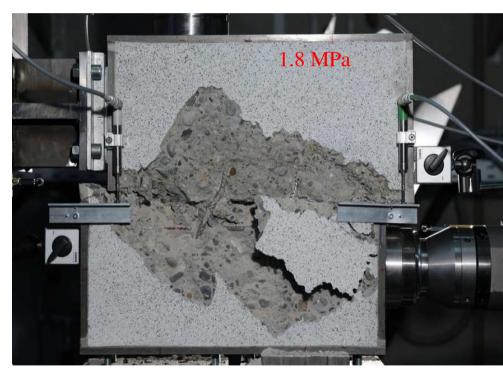


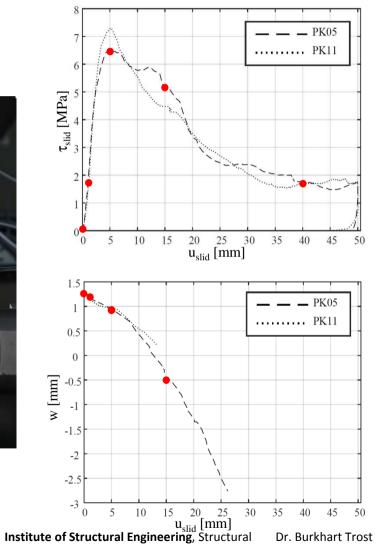
Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Sliding Shear-Displacement Response and Experition aci and Exposition

PK05

n





University of Applied Sciences and Arts Northwestern **ETH** zürich Switzerland, Institute of Civil Engineering

Dynamics and Earthquake Engineering Group

October 17, 2017

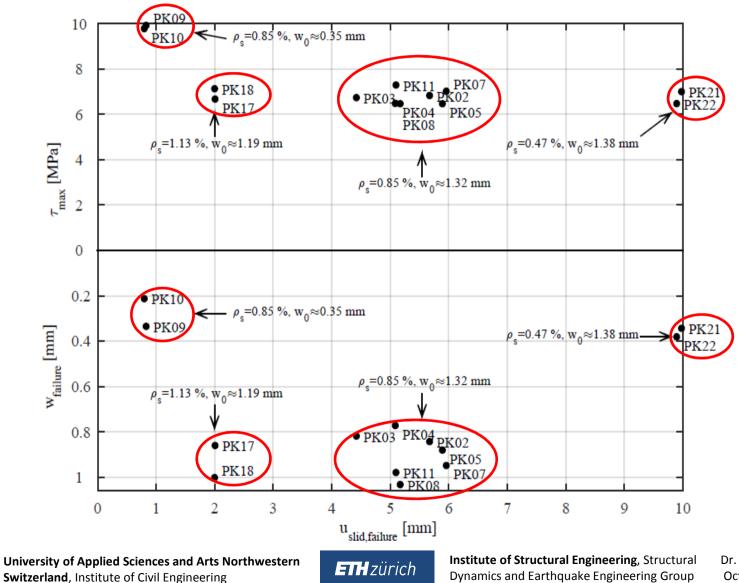
8

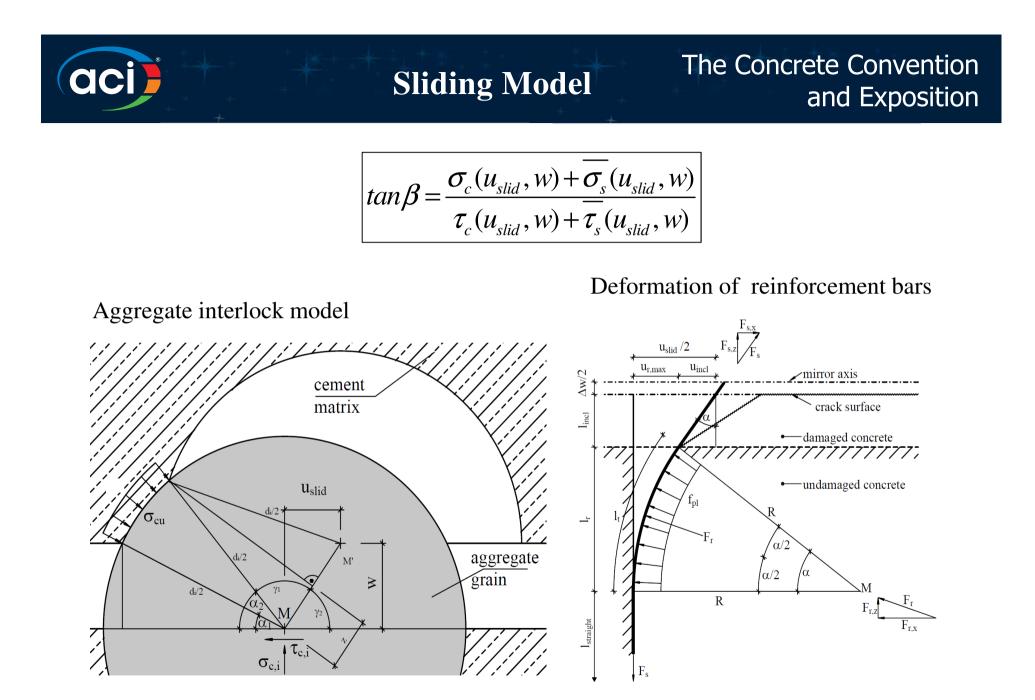


aci

n

The Concrete Convention and Exposition





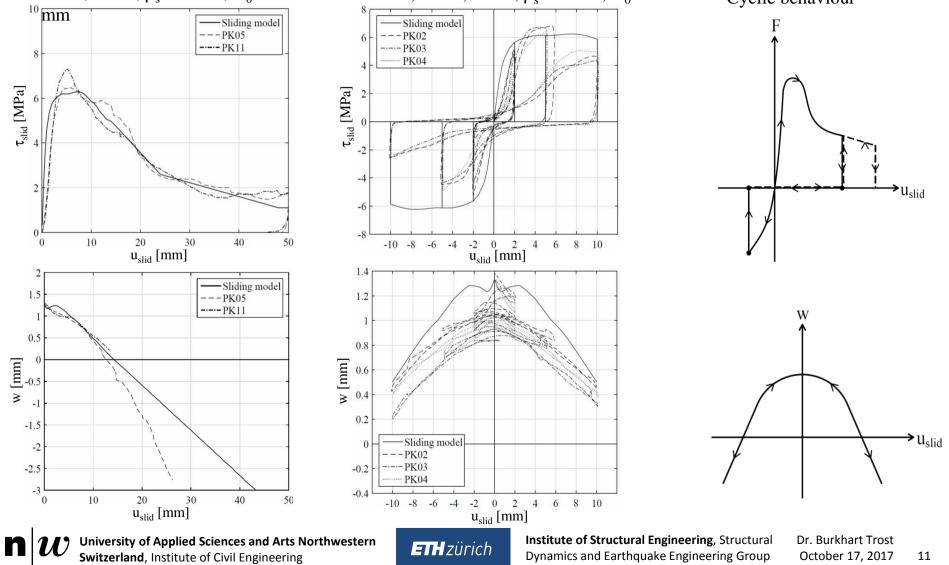
University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering

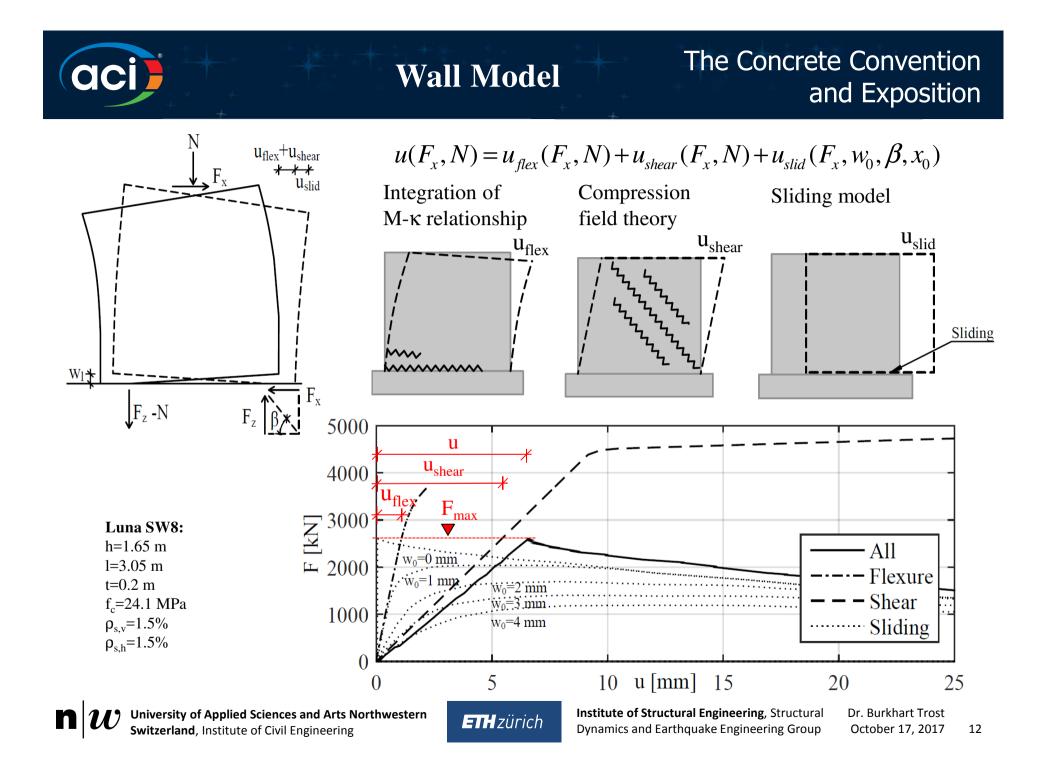
n

ETHzürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group



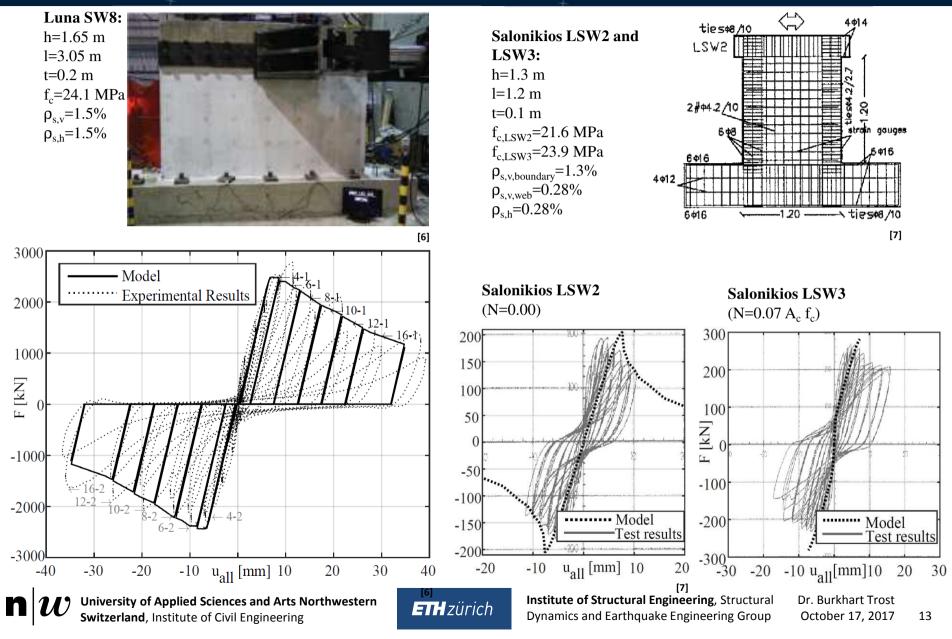






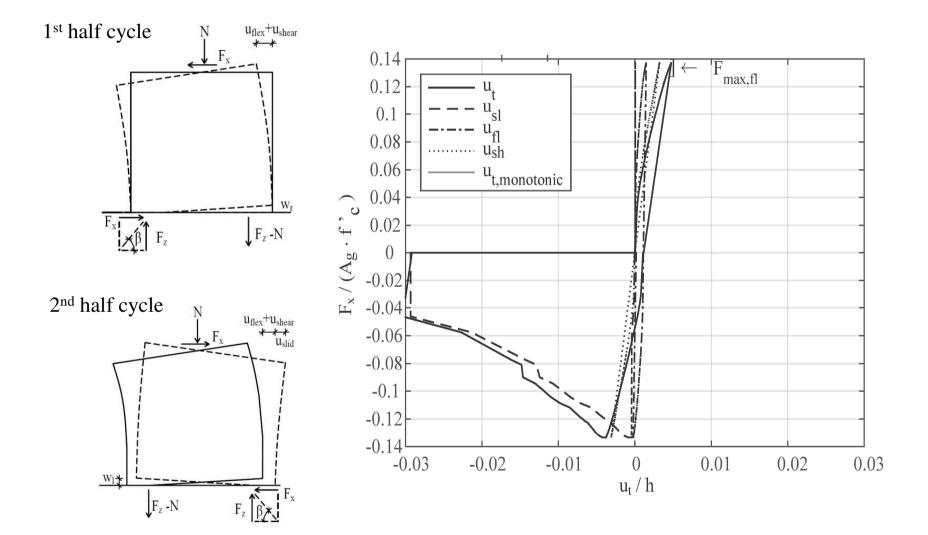
Validation

The Concrete Convention and Exposition



Interaction Diagram of Sliding, Shear, and Flexure

The Concrete Convention and Exposition

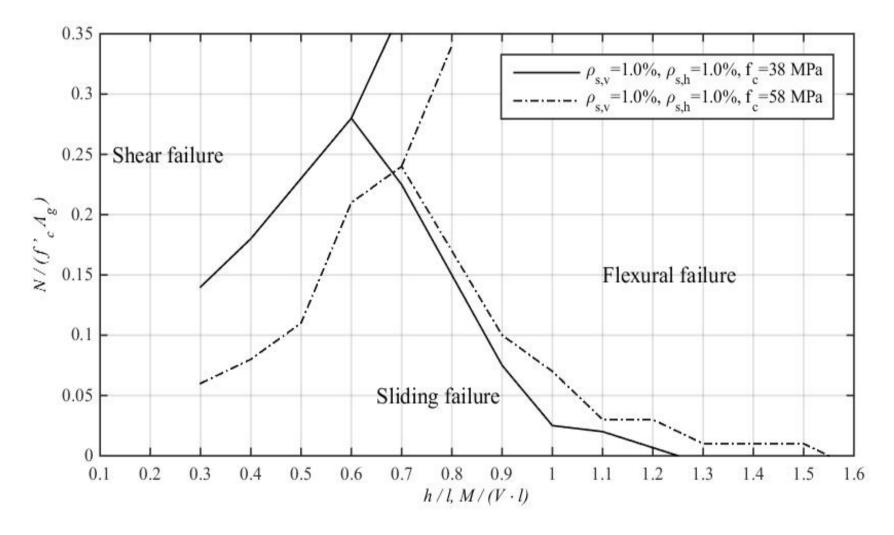


aci



Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Variation of the concrete strength and Exposition





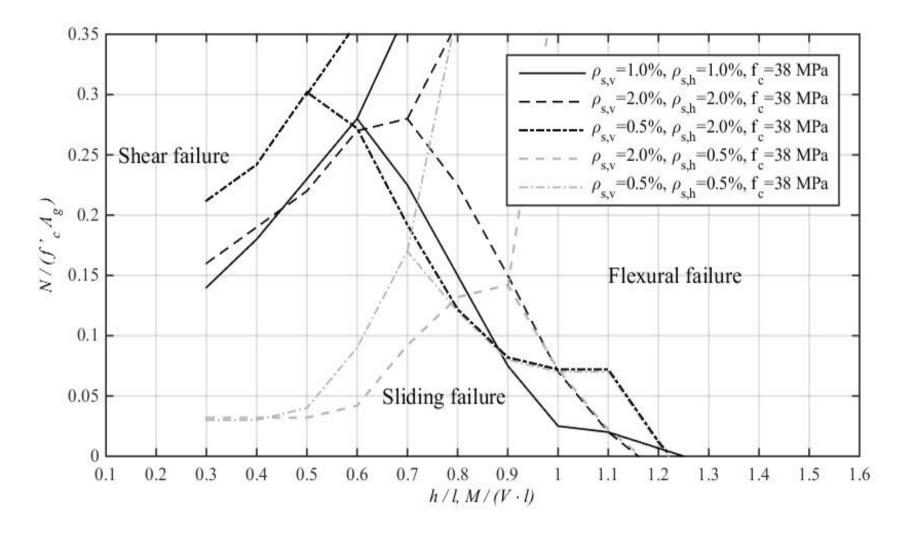
aci

University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering

ETH zürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Variation of the horizontal and The Concrete Convention vertical reinforcement ratios and Exposition





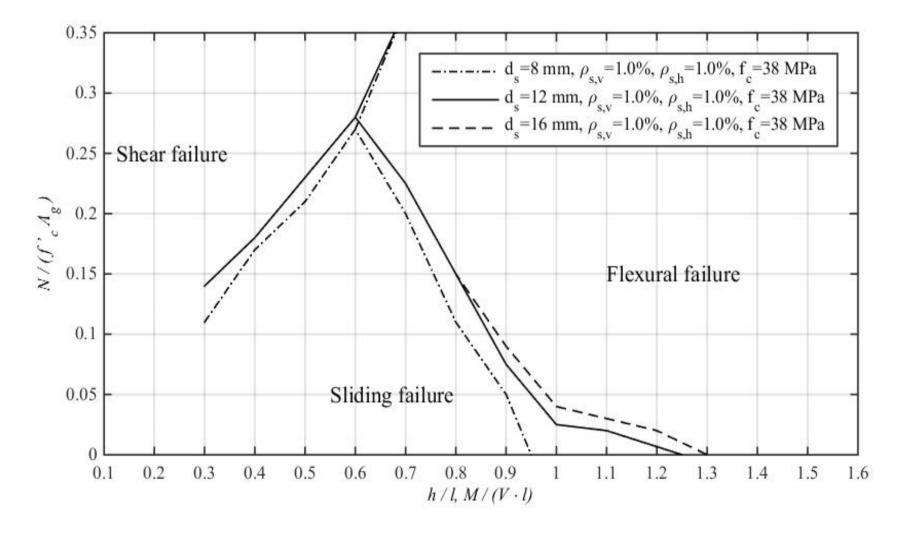
aci

University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering

ETHzürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

OCIVariation of the reinforcementThe Concrete Convention
and Exposition



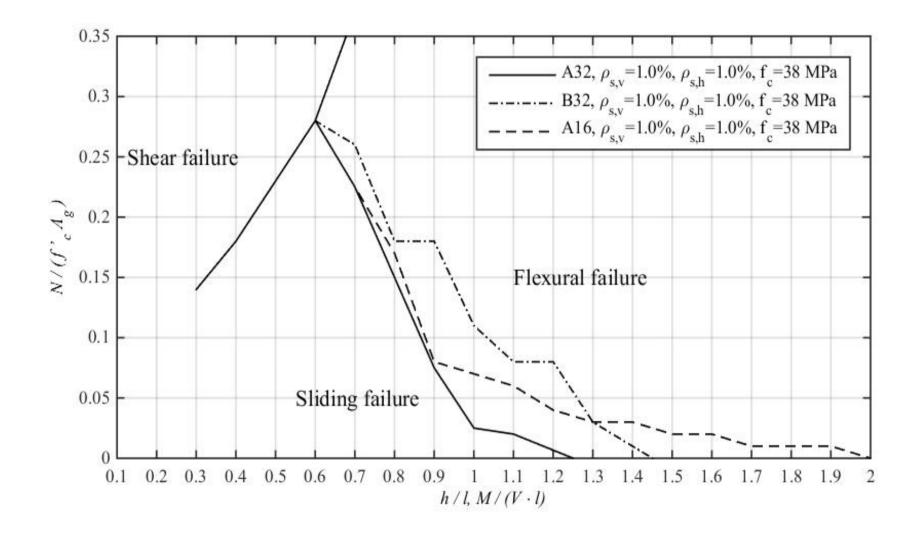


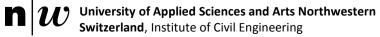
University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering

ETH zürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Variation of the concrete
aggregate grain mixThe Concrete Convention
and Exposition



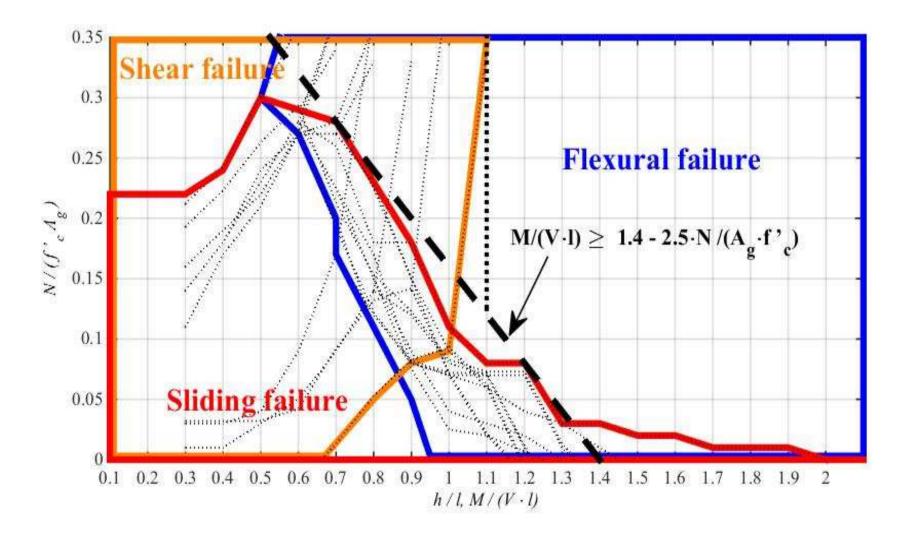


aci

ETHzürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group

Design RecommendationThe Concrete Convention and Exposition





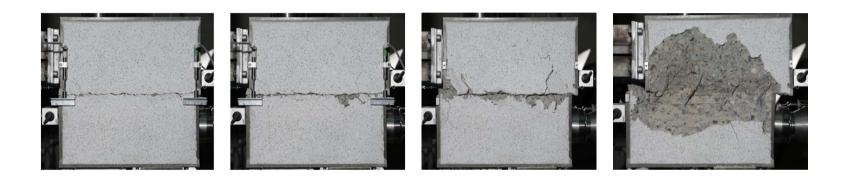
ETHzürich

Institute of Structural Engineering, Structural Dynamics and Earthquake Engineering Group



The Concrete Convention and Exposition

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.

[3] Hyogo Earthquake Engineering Research Center, E-Defense shake table tests , 2016.

[4] J. C. WALRAVEN AND H. W. REINHARDT, Theory and experiments on the mechanical behaviour of cracks in plain and reinforced concrete subjected to shear loading, vol. 26, Heron, Delft, 1981.

[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.

[6] B. N. LUNA, J. P. RIVERA, AND A. S. WHITTAKER, Seismic Behavior of Low- Aspect-Ratio Reinforced Concrete Shear Walls, ACI Structural Journal, (2015), pp. 593-604.

[7] T. N. SALONIKIOS, A. J. KAPPOS, I. A. TEGOS, AND G. G. PENELIS, Cyclic Load Behavior of Low-slenderness Reinforced Concrete Walls: Design Basis and Test Results, ACI Structural Journal, (1999), pp. 649–660.



University of Applied Sciences and Arts Northwestern Switzerland, Institute of Civil Engineering



Institute of Structural Engineering, StructuralDr. BuDynamics and Earthquake Engineering GroupOctob