Influence of Spatial Variability on the Shear Capacity of RC Members without Shear Reinforcement

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INTRODUCTION

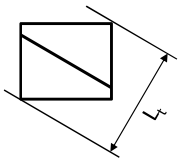
- Shear capacity is critical to RC members without shear reinforcement (such as concrete slab bridges)
- Shear failure is brittle and with large scatter (from beam test results)
- Weak spot of beam specimens may influence the shear behavior

INTRODUCTION

- Concrete strength of existing concrete slab bridges tested shows large spacial variability
- Relatively large width of a slab allows force redistribution when local failure happens
- This redistribution effect can hardly be validated in normal slab test, thus special experiment is designed to check this

FEASIBILITY STUDY - ATENA

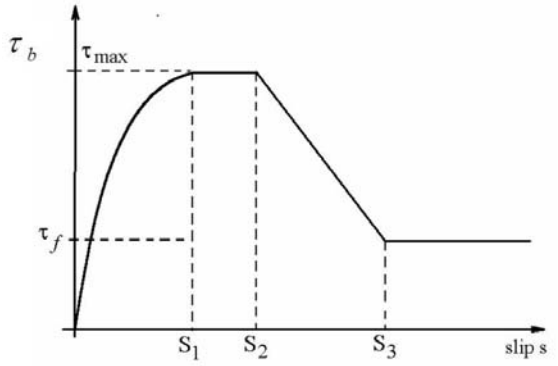
- Concrete
- Material Model: 3-D nonlinear cementicious 2
  - Smeared Crack Formulation
  - Crack Band Model
  - Fixed Crack Model
  - Rankind-Fracturing Model for Concrete Cracking
  - Hordijk Softening Curve
  - Shear Factor s_F = 20, with shear strength



$$\sigma_{ij} \le \frac{0.18\sqrt{f_c'}}{0.31+\frac{24\,w}{a_g+16}}, \quad i \ne j$$

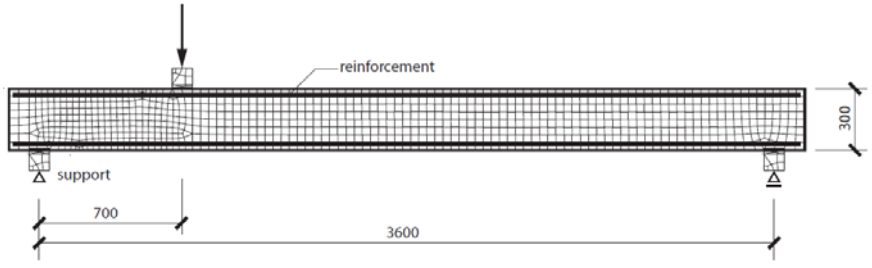
FEASIBILITY STUDY - ATENA

- Reinforcement
- Material Model: Truss Element
  - Bond Slip Law: CEB-FIP Model Code 1990



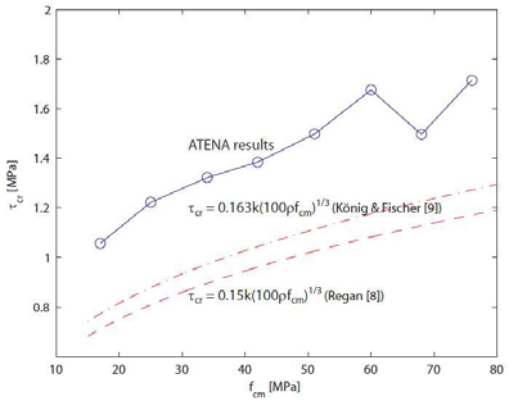
FEASIBILITY STUDY - ATENA

- Influence of concrete strength
- Modelled in ATENA-2D



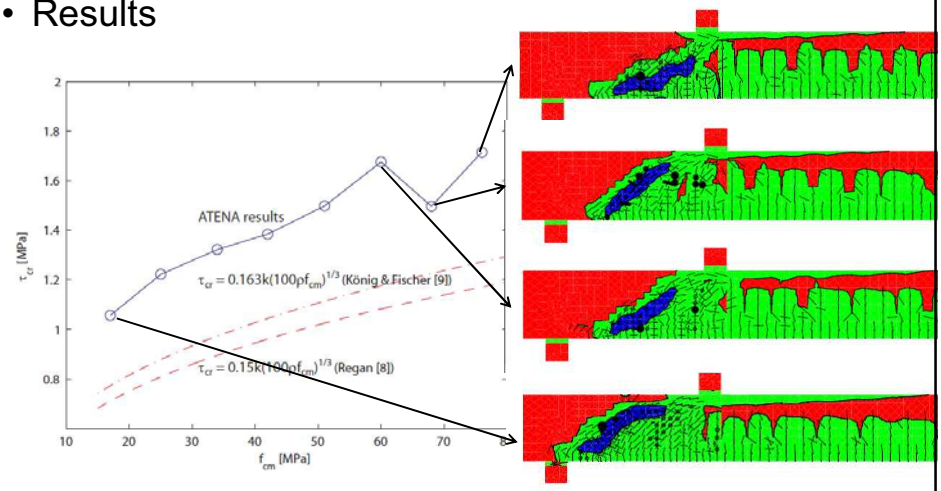
FEASIBILITY STUDY - ATENA

- Results



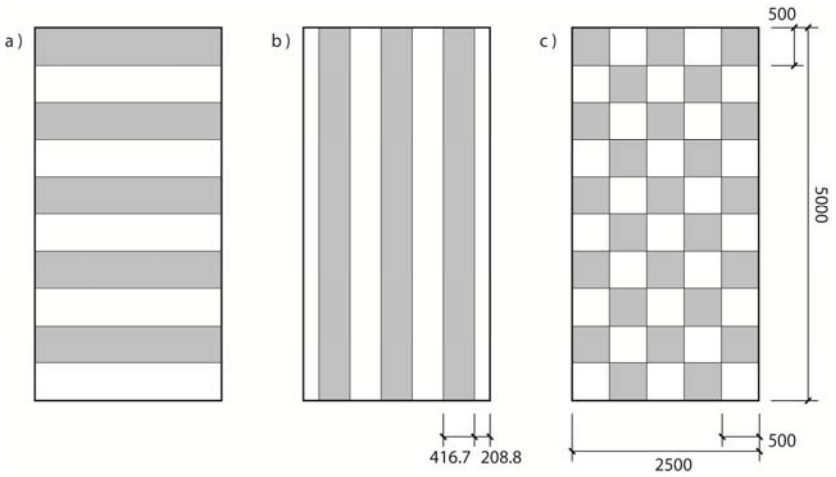
FEASIBILITY STUDY - ATENA

- Results



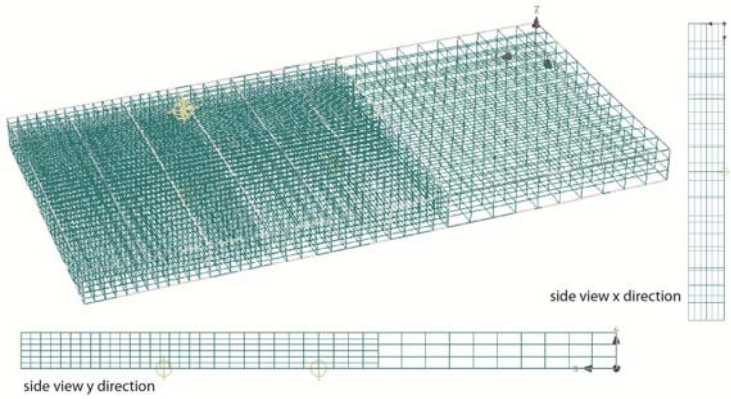
FEASIBILITY STUDY - ATENA

- Specimen Layouts



FEASIBILITY STUDY - ATENA

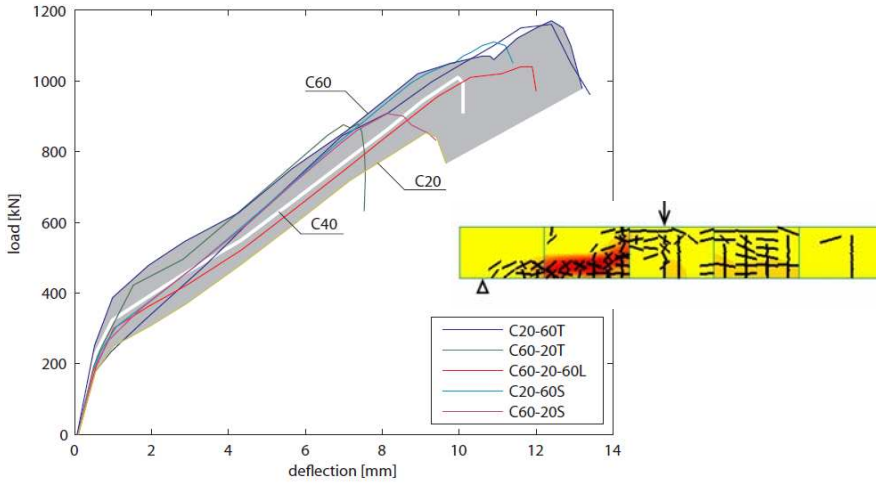
- ATENA 3D



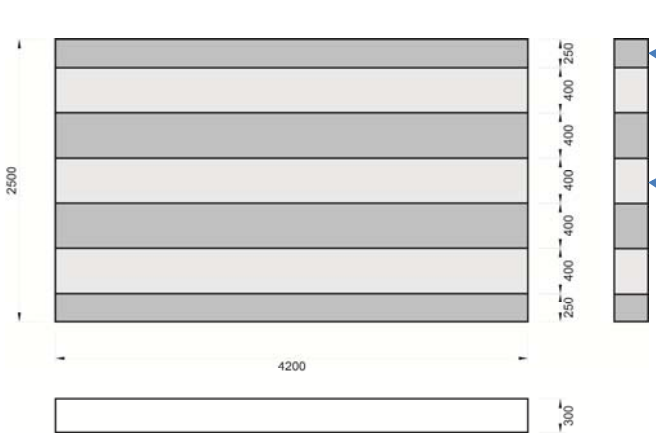
FEASIBILITY STUDY - ATENA

Model No.	Layout	P_{max}	V_u	Misc
C20-60T	a	1160	870.0	First strip in critical shear span start with C20
C60-20T	a	878	658.5	First strip in critical shear span start with C60
C60-20-60L	b	1040	780.0	-
C20-60S	c	1110	832.5	First grid in critical shear span start with C60
C60-20S	c	907	680.2	First grid in critical shear span start with C20
C20		853	639.7	
C40		1014	760.5	
C60		1168	876.0	

FEASIBILITY STUDY - ATENA

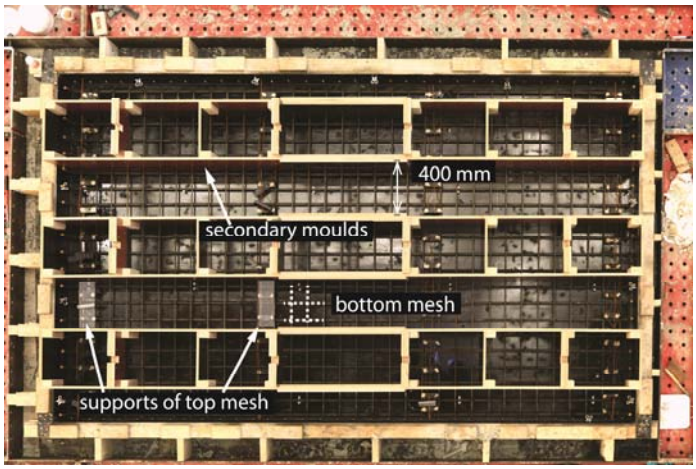


SPECIMEN LAYOUT



CASTING PROCESS

- Casting mould



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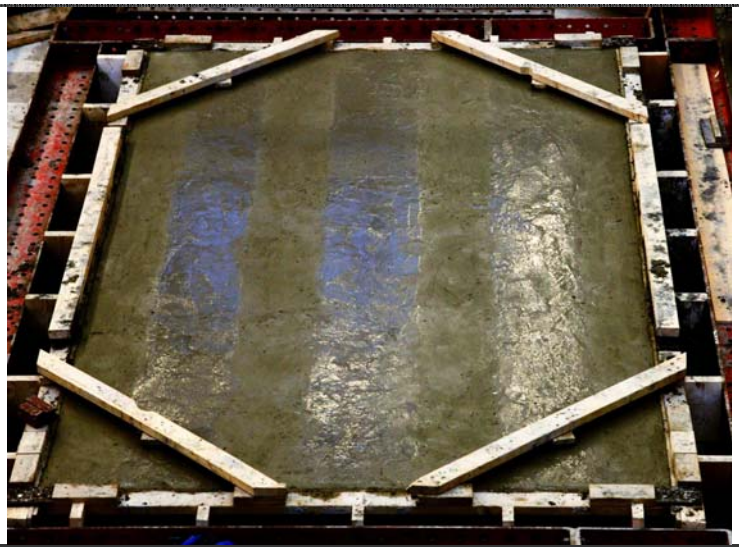


CONCRETE MIXTURE

Mixture of high strength concrete

Content	*Mass* [kg]
CEM I 52.5	280
CEM III 42.5	145
Sand 0-4 mm	775
Gravel 4-16 mm	900
Fly Ash	60
SPL VC 1550	3.541
VTR VZ 1	1.213
Water	171
Total	2336

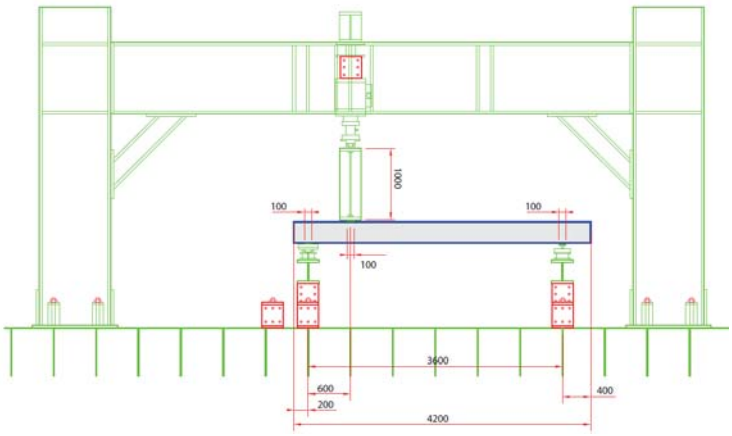
Mixture of low strength concrete

Content	*Mass* [kg]
CEM I 42.5	150
Limestone Powder	80
Fly Ash	100
Sand 0-4 mm	872
Gravel 4-16 mm	907
Water	185
Total	2294

CONCRETE MIXTURE

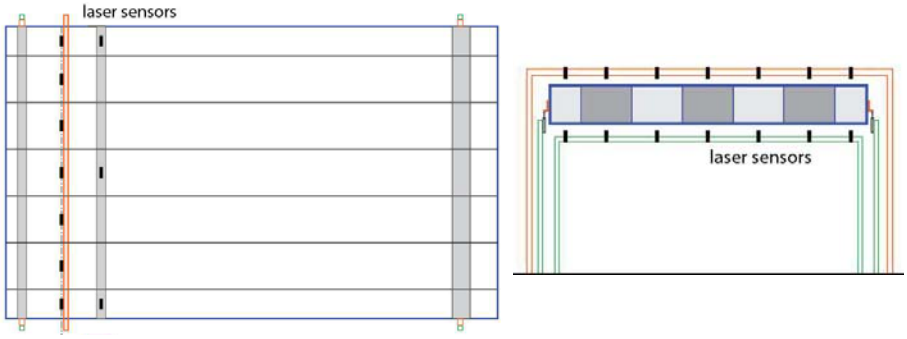
specimens	$f_{cm,l}$	$f_{cm,h}$	f_{cm}	f_{ck}	
L016A	23,2	-	23,2	23,1	Series 1: a = 600 mm
H026A	-	61,0	61,0	57,3	
M036A	30,6	69,7	50,2	15,0	
M046A	25,6	64,8	45,2	9,9	
M056B	31,0	73,1	52,0	14,2	
L018B	26,3	-	26,3	25,9	Series 2: a = 800 mm
H028B	-	67,8	67,8	64,5	
M038B	37,3	72,9	55,1	22,8	
M048B	31,2	69,0	50,1	15,8	
M058A	-	67,8	67,8	64,5	

TEST SETUP



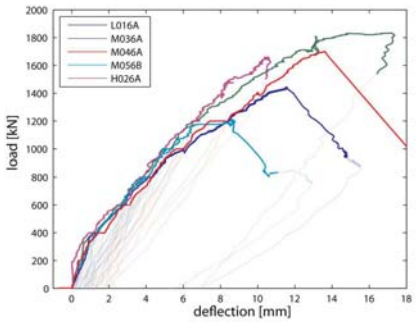
TEST SETUP

- Measurement

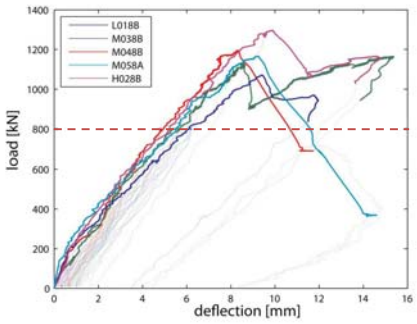


TEST RESULTS

Series 1:
Shear span *a* = 600 mm

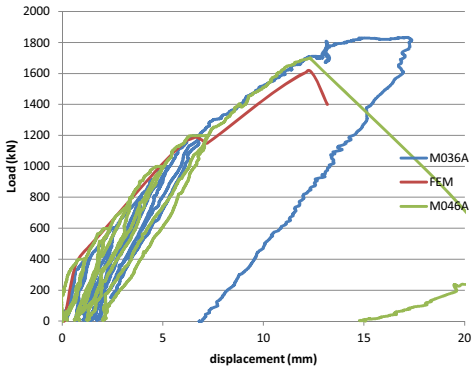


Series 2:
Shear span *a* = 800 mm



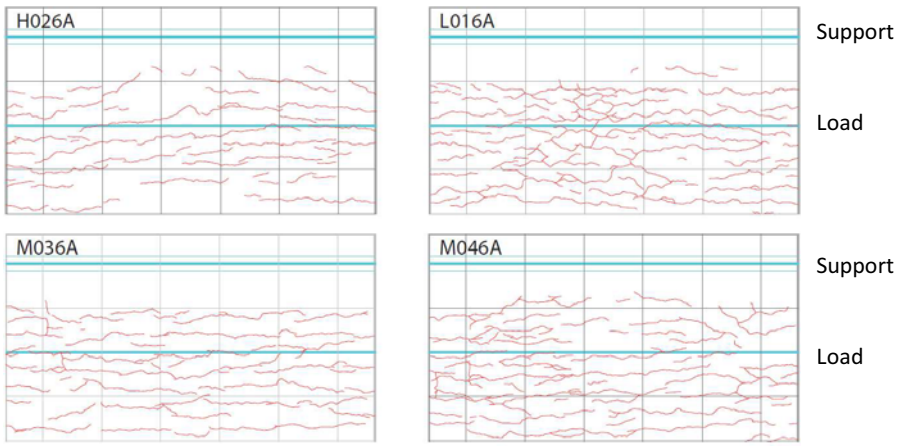
TEST RESULTS

- Compare with FEM



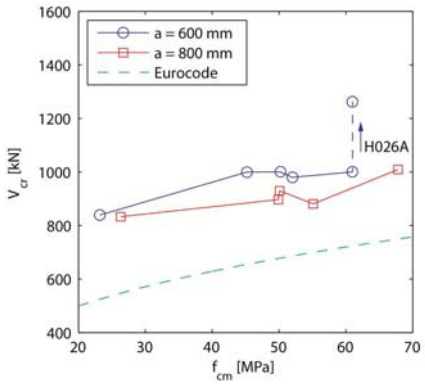
TEST RESULTS (CRACK PATTERN)

- Series 1: P = 800 kN

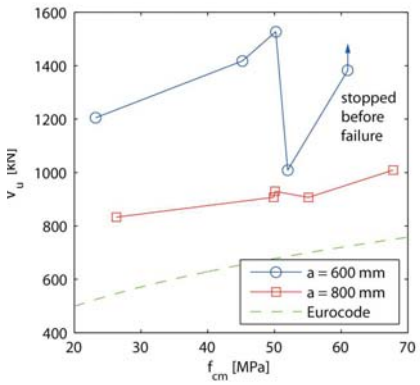


TEST RESULTS

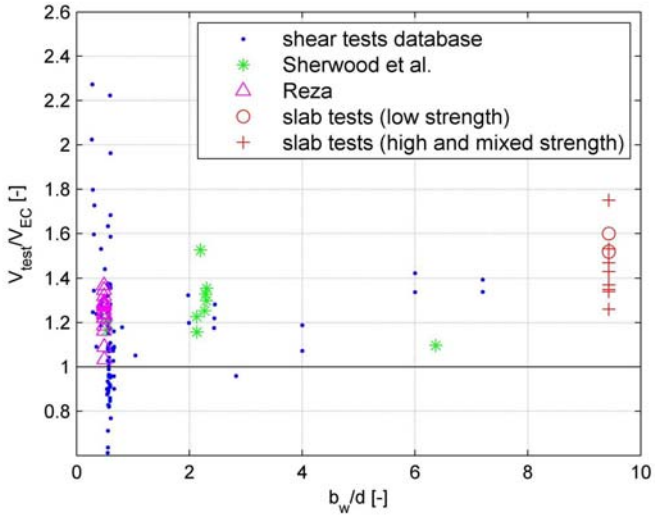
Inclined cracking load



Ultimate load



COMPARISON WITH OTHER TESTS



CONCLUSIONS

- The slabs with strips of alternating concrete strength retained the structural integrity.
- The shear capacity of a mixed concrete slab can be evaluated by considering the mean concrete strength.
- The test results clearly show that for structures like slabs with a large width compared to the depth, the shear capacity may be higher than for beam structures and the design formula in Eurocode.

Thanks for your attention,
Questions?