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In situ testing of early age energy absorption in sprayed fiber reinforced concrete - HyEA – test

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In-Situ testing of early age energy absorption in sprayed fiber reinforced concrete – HyEA test

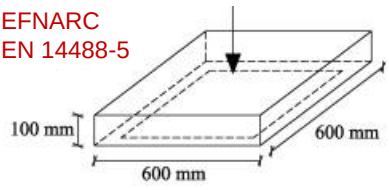
Shotcrete for Underground Support XIII
Germany, Kloster Irsee

Dr. Michael Kompatscher, September 2017

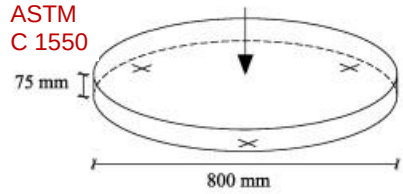
Motivation

- FRSC used often for rock support and first safety layer
- Sometimes already removed after 12 hrs.
- Performance (load bearing) within first hours after spraying essential
- 28d Energy absorption values according standards and specifications not very relevant in this view

EFNARC
EN 14488-5



ASTM
C 1550



Objectives

- Define test procedure to obtain repeatable results at early ages
- Test energy absorption in dependence of strength (age and acc. dosage)
- Correlate energy with strength and fiber content
- Compare performance of mixes with steel and synthtic macro-fibers at early ages
- Confirme earliest age of energy absorption tests

Conditions defined:

- Test at real Tunnel conditions
- Test Propex proposed mixes according ASTM C 1550 only

Test location and equipment

- Hagerbach Test Gallery with own concrete plant with 1m3 TEKA batch mixer

- Aliva telescope spraying robot with hose diameter of 65 mm served by Meyco Suprema concrete pump

Test procedure

Defined metal formwork, easy to remove

Operated by EFNARC certified nozzle man

Screeding of samples immediate after spraying to get smooth surface and constant thickness

Plate covered with plastic for curing and protection

Plate remains in place and not removed until 15min before testing

Test moment defined by needle test on comparison samples

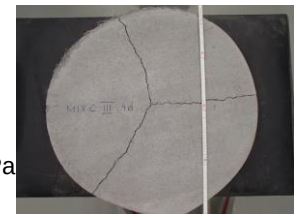
Time of earliest RDP testing

3h - 0.6 MPa

➔ Testing from ca. 1.5 MPa feasible!!

Mix C (7 kg/m3 fibers)

5h
2 MPa
73 J



4d
32 MPa
322 J

Hagerbach young Energy Absorption - Test

- Ruggedized, mobile equipment for construction site use
- Highly automatized
- Standalone operation to max peak load of 40kN
- Simple operation and presentation of test results

Investigation Program

Mix designs	Holcim CEM I 42.5 N	Microsilica SikaFume HR/TU	Propex Fibre	Fibre content	Aggregate 0-8 mm	TamCem HCA Plus	TamCem 60	TamCem HCA	w/c_{eq} (w/b)
	kg/m³	kg/m³		kg/m³	kg/m³	% bwc	% bwc	% bwc	
P10615_S_A	425	20	HE07535	35	1660	1.18	1.1	0.25	0.44
P10615_M_B	425	20	Fibremesh 665 M-S	5	1658	1.18	1.14	0.25	0.44
P10615_M_C	425	20	Fibremesh 665 M-S	7	1651	1.18	1.1	0.25	0.44
P10615_M_D	425	20	Fibremesh 665 M-S	3	1664	1.18	1.0	0.25	0.44
P10615_M_E	475	20	Fibremesh 665 M-S	8	1553	1.18	0.8	0.21	0.44

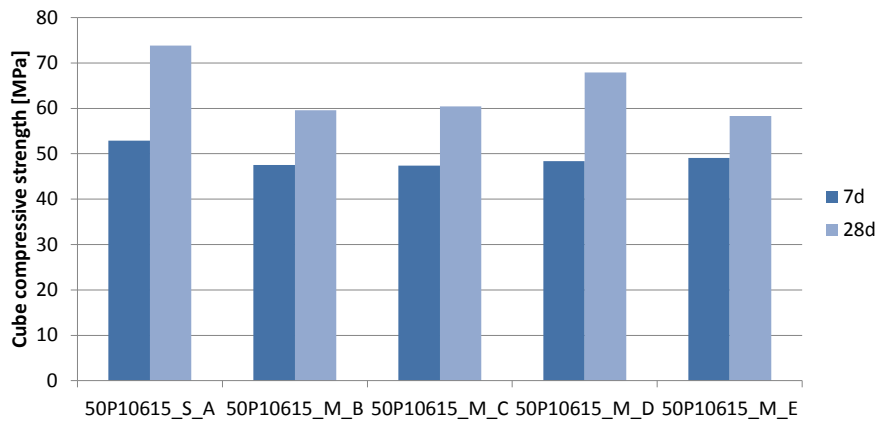
Accelerator: TamShot 80 @ 7% bwc (A,B,D) or 6.5% bwc (C,E)
Air Pressure: 4-5bar Concrete volume: 6.5 m3/h

Mix design comparison - Fresh concrete properties

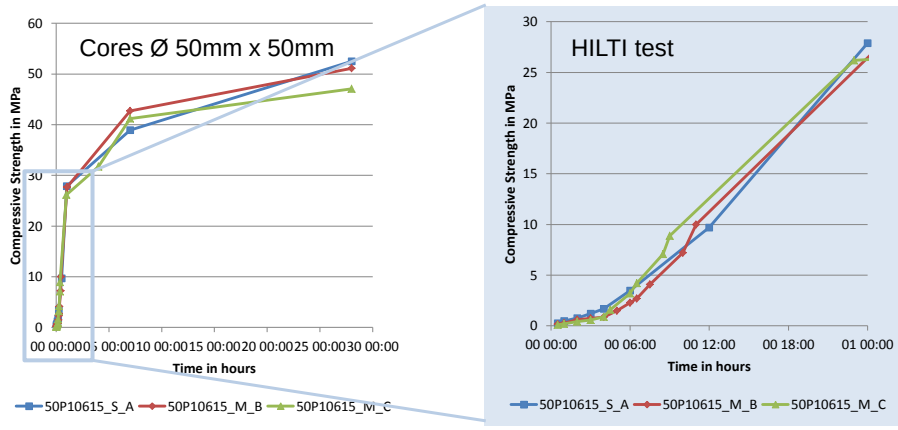
Mix Design		50P10615_S_A		50P10615_M_B		50P10615_M_C		50P10615_M_D		50P10615_M_E	
	Units	Target	Test	Target	Test	Target	Test	Target	Test	Target	Test
CEM I 42.5	kg/m³	425	424.55	425	425.4	425	425	425	425	475	475
Steel Fibre	kg/m³	35	35	5	5	7	7	3	3	8	8
Mixing time	sec	180	347	180	603	180	987	180	380	180	652
w/c_{eq}	-	0.44	0.44	0.45	0.45	0.44	0.42	0.44	0.42	0.45	0.42
Flow table	mm	600	690	600	510	600	420	600	570	600	530
density	kg/m³	2358	2429	2326	2386	2321	2316	2330	2386	2286	2321
air content	Vol.-%	2.5	0.8	2.5	0.9	2.5	3.9	2.5	1.4	2.5	2.7
Temperature	°C	-	17.3	-	18	-	21.5	-	16.7	-	20.2

- Fibers influence consistency
- Pumpability and sprayability direct the mix

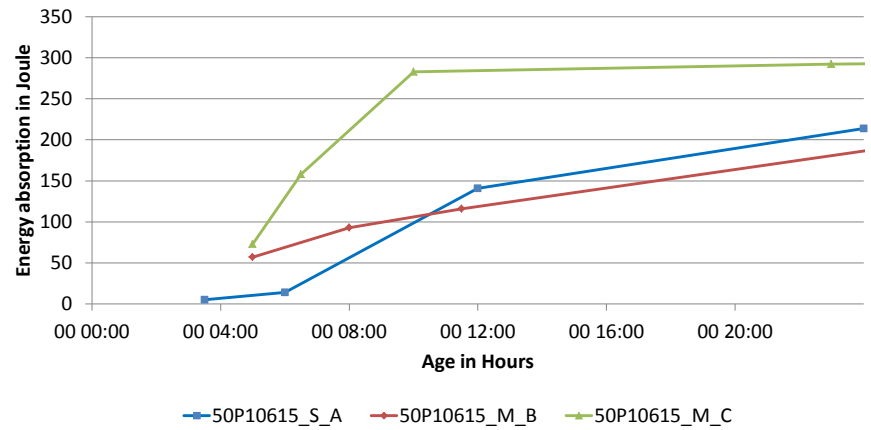
Mix design comparison – Cube compressive strength



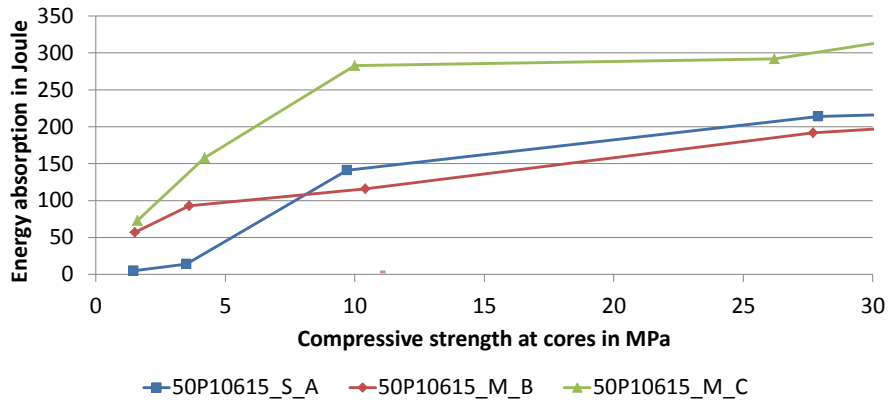
Early age compressive strength development



Energy absorption capacity according ASTM C 1550



Energy absorption vs. Compressive strength



Summary

- The HyEA-Test procedure is reproducible and repeatable
- A mobile test equipment for onsite tests was presented
- Crack behaviour at early ages is the same as at 28d
- Fibermesh 655 M-S showed superior early age (3-12 h) performance
- Fiber content further affects energy absorption capacity
- Mix designs with fibers need proper adjustment to keep workability, pumpability and sprayability
- Limit for testing is related to strength, not to time

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Glück auf!

Questions?

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