Standard FA and Anlegg

Characteristics, fresh concrete properties and durability

Dr Knut O Kjellsen

Norcem AS R&D Dept

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Norcem cements - Iceland
Standard FA and Anlegg

	STD FA	ANL
Type	CEM II/A-V 42,5 R	CEM I 52,5 N
k-factor	no	no
CO_2* (kg/tn)	613	733

*EPD, www.epd-norge.no

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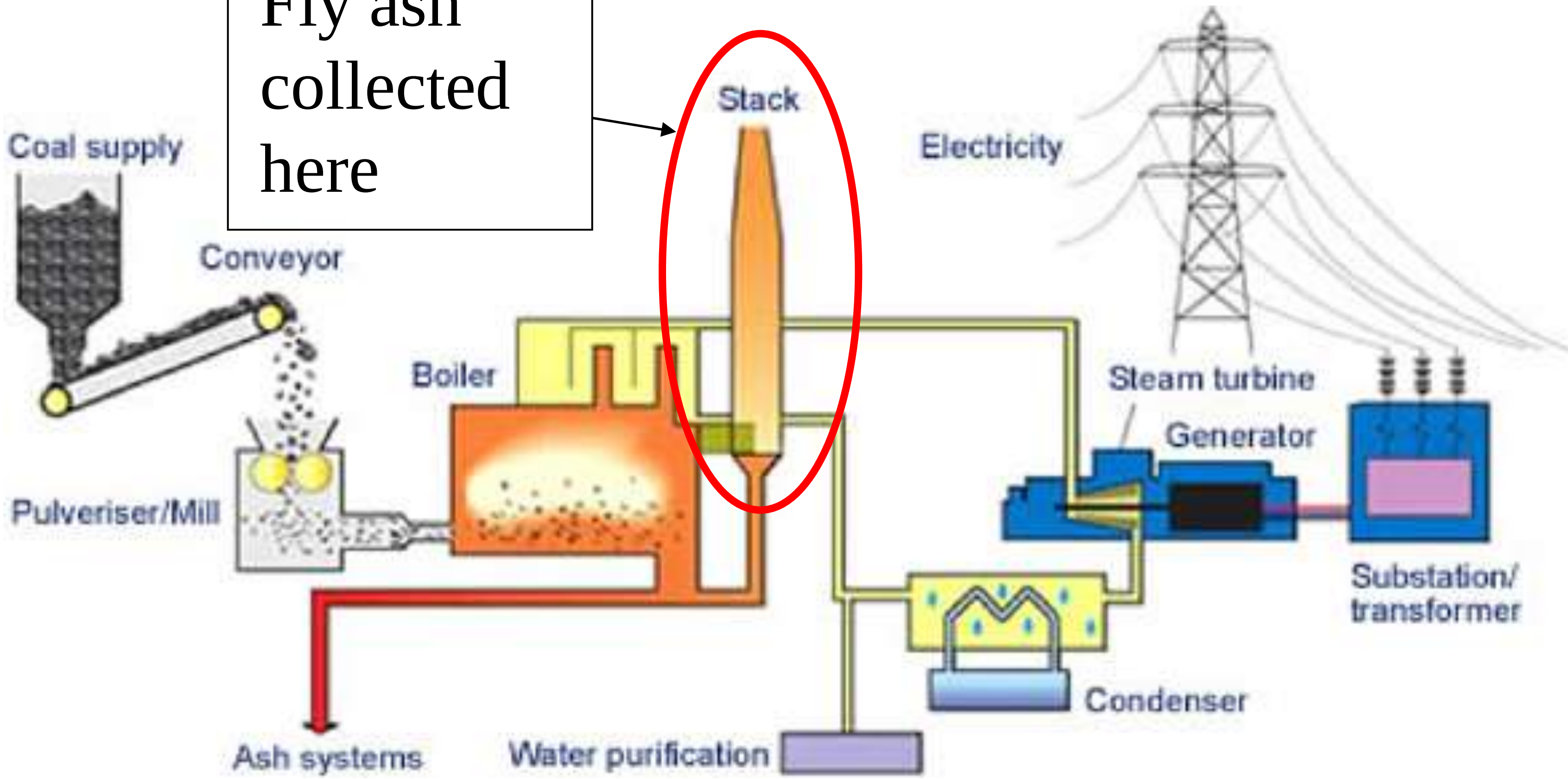
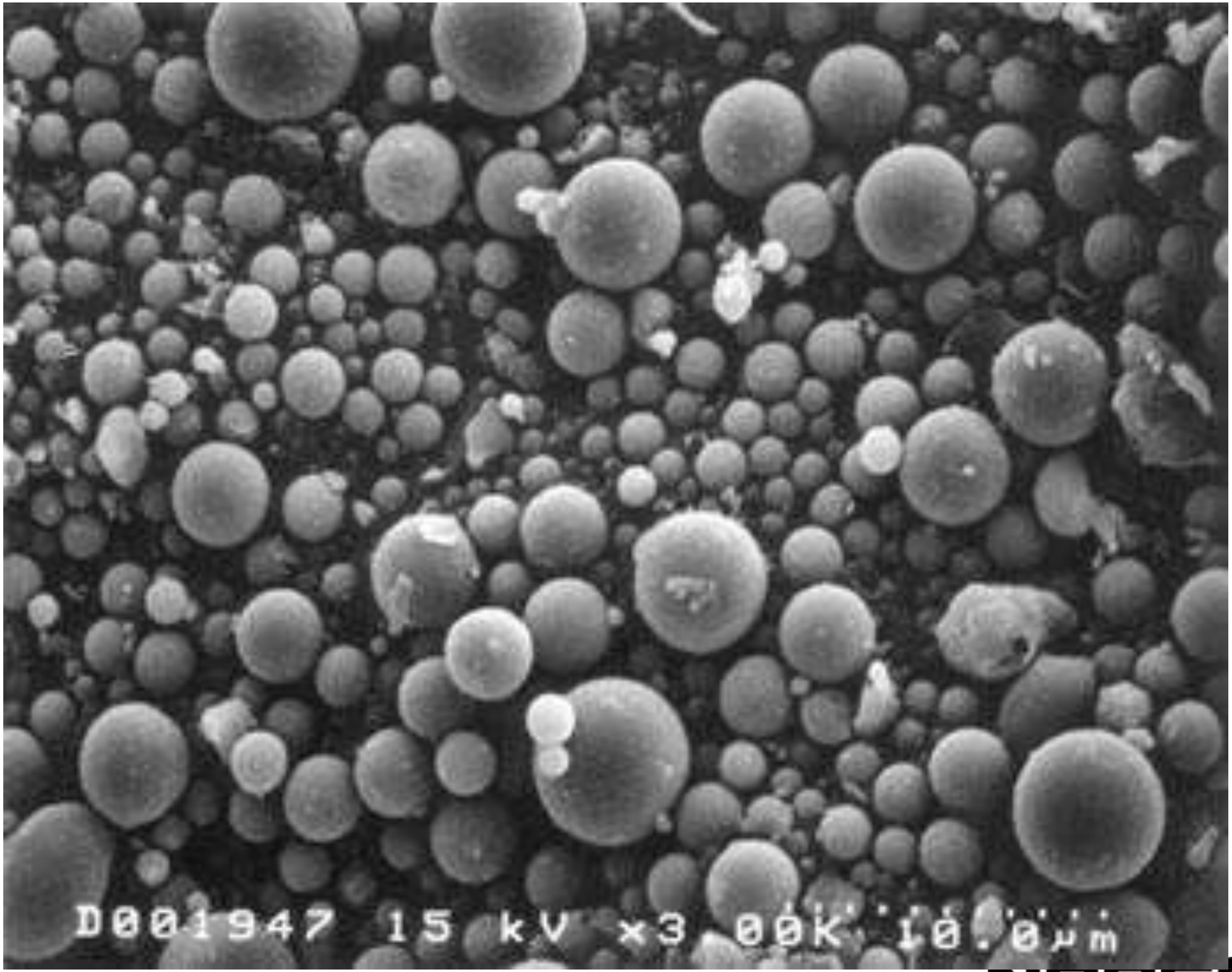
Norcem cements - Iceland
STD FA – fly ash

Fly ash collected here





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Norcem cements - Iceland
Standard FA – fly ash

- Spherical particles
- Amorphous structure SiO_2, Al_2O_3, Fe_2O_3
- Pozzolanic material
- Fly ash comply with EN-450 Category A

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Norcem cements - Iceland
Standard FA and Anlegg

	STD FA	ANL
Application	Buildings -Residential -Business -Pre-cast Infrastructure	Infrastructure High-strength

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Norcem cements - Iceland
Standard FA and Anlegg

	STD FA	ANL
Blaine (m^2/kg)	450	360
Setting time (min)	120	120
Water demand (%)	30	27
Spec. weight (kg/m^3)	3.01	3.16
Strength, 2 day (MPa)	31	30
Strength, 28 day (MPa)	52	60

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STD FA
Workability

- Low spec weight
- Increased pastevolume (ca 2 liter/100 kg cement)
- SCC
  - Improved stability
- Excellent workability in building concrete and lean concretes.
  - Improved surface finish
  - Improved compaction in dry-concrete (pre-cast)

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STD FA and AAR

EFFEKT AV SILIKASTØV PÅ ALKALI-SILIKA REAKTIVITETEN AV SEMENT

EFFECT OF SILICA FUME ON THE ALKALI-SILICA REACTIVITY OF CEMENT

Håkon Ólafsson

IBLANDING AF SILIKASTØV I SEMENT – PRAKTISKE ERFARINGER

PRODUCTION OF BLENDED CEMENT BASED ON SILICA FUME – PRACTICAL EXPERIENCES

Gudmundur Gudmundsson

1. Indledning.

I snart tre år har man i Statens Sementfabrik i Akranes Island iblandet portlandsement med 5-6% af silika-støv. Sementfabrikken i Akranes startede produktion 1958. Dette er en lille fabrik med kun een ovn. Kapaciteten er 90 - 100.000 tons per år og baseres på vådproces. Råstoffene til sementtilverkningen er meget uvanlige, skjellsand som kalkkomponent og liparite, glasartigt materiale af vulkanisk oprindelse som siliciumkomponenten. På grund af skjellsandet har sementen et høyt indheld af alkali som bevirker på styrkeudviklingen, positivt på tidligstyrken, negativt på slutstyrken. For 15-20 år siden opdagedes at betongtilslagsmaterialer i brug i Reykjavík-området og flere steder i Island var alkalireaktive. På grund af sementens alkaliindhold blev igangsat undersøgelser på hvilken måde man kunne undgå faren af byggeskader på grund af alkalireaktioner. Disse undersøgelser blev udført på Byggforskningsinstitutet i Reykjavík. Man kom til det resultat at den mest fornuftige løsning af problemet var brug af pozzolaniske materialer, som mest praktiskt kunne tilsættes til sementen. Mange vulkaniske materialer i Island har pozzolaniske egenskaber. På sementfabrikken startede man pozzolaniblanding 1972 og fortsatte den årene efter. Man brugte først liparite som blev tilmalet til sementen. Man fandt ud at man kunne blande op til 10% liparite uden merkelig reaktion på 28 dage sementstyrken men iblandingen bevirkede reduktion på alkaliexpansioner som opfyldte ASTM-standardens krav for reaktive tilslagsmaterialer.

Silica Fume to Enhance Concrete Quality, Icelandic Experience Concerning Alkali-Silica Reactions

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ABSTRACT

Silica fume has been intermilled with Icelandic cement since 1979. The main reason why silica fume is utilised in this way is to reduce or eliminate alkali-silica reactions in concrete. Now after more than 20 years of service there are no signs of alkali-silica reactions in concrete in Iceland. These findings are supported by standardised alkali silica test methods.

However, the homogeneity of silica fume both in cement and hardened concrete is not always as good as expected since small clusters of silica fume can be found in hardened concrete and test results have shown these lumps to be alkali silica reactive.

Key words: Alkali-silica reactions, silica fume, durability.

1. INTRODUCTION

Silica fume has been utilised in concrete for some decades now. Initially it was used as a cement replacement material, but in recent years silica fume is used more and more as a solid additive (micro filler) in concrete (1). Increased strength and improved durability are the main benefits. Incorporation of superplasticizers and silica fume offers flowable concrete with low w/c - ratio. In other words silica fume affects concrete quality in many ways and when properly proportioned it will greatly improve the quality of both fresh (green) and hardened concrete. Moreover, the utilisation of silica fume in concrete effects the environment in a very beneficial way. Silica fume is a by- or a waste product, mainly from ferrosilicium plants. As a cement replacement material, its usage will lower the cement consumption hence, less carbon dioxide

Pergamon

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CEMENT AND CONCRETE RESEARCH

Alkali-silica reactions and silica fume 20 years of experience in Iceland

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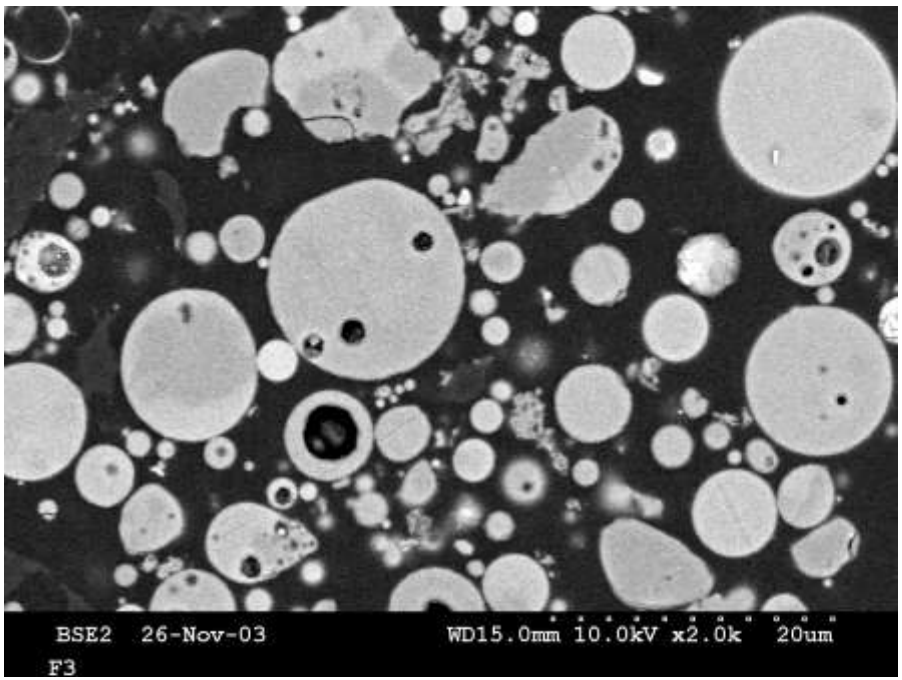
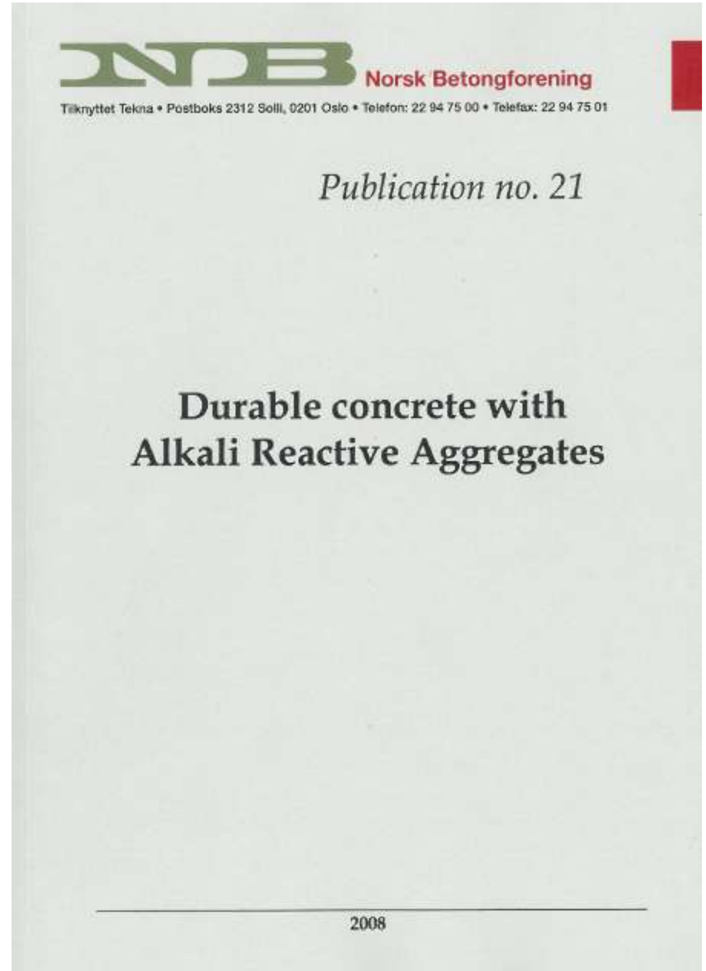
STD FA and AAR

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Durable concrete with Alkali Reactive Aggregates

2008

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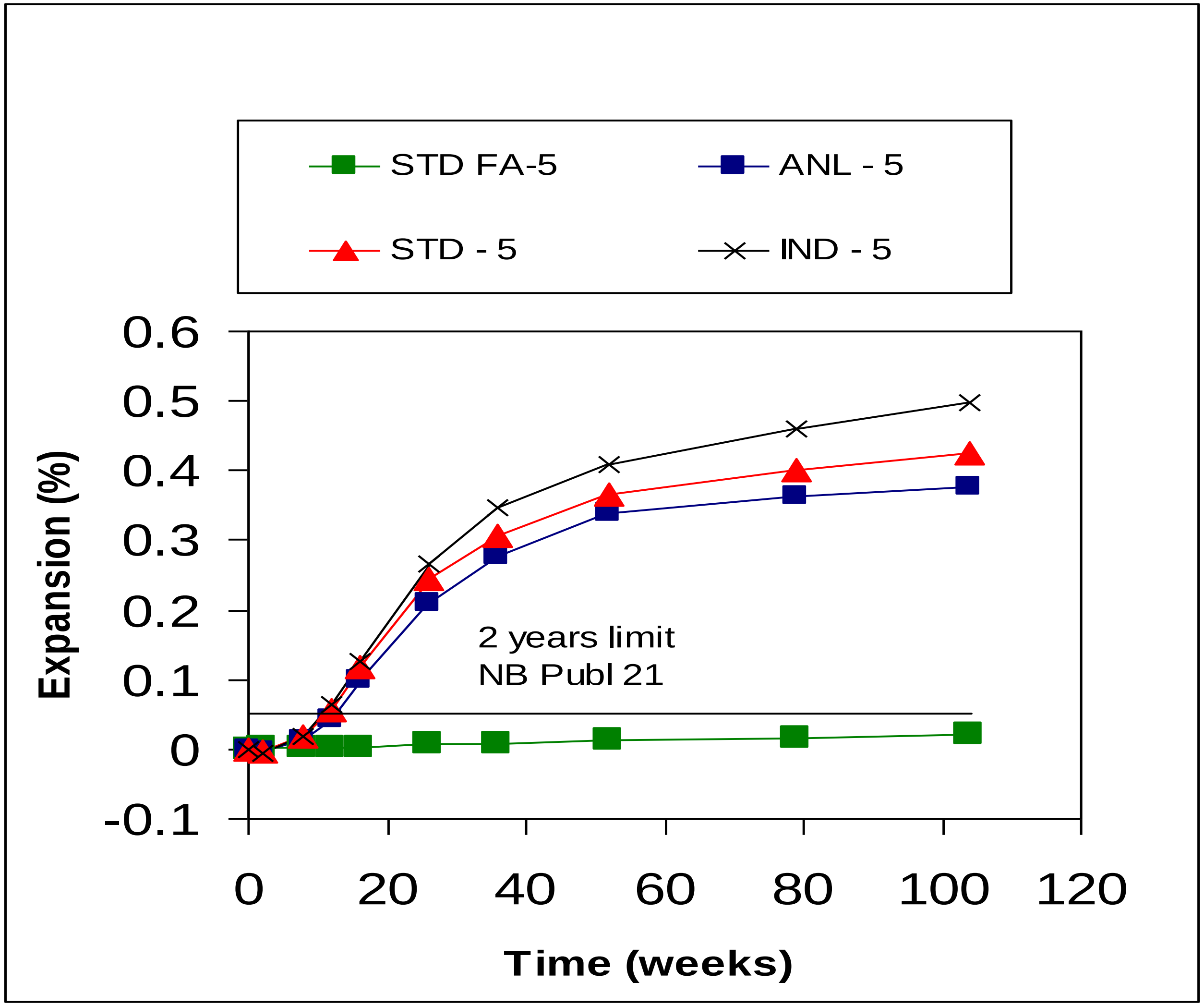
Norwegian Test results



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Fly ash and AAR

Long-term Experiences from the field

- In Norway (25 years)
- Lower Notch dam,
  Ontario (40 years)
- Nant-y-Moch dam,
  Wales (50 years)

50 Years Old and Still Going Strong

Fly ash puts paid to ASR

by Michael Thomas, R. Doug Hooton, Chris Rogers, and Benoît Fournier

The use of fly ash for controlling damaging alkali-silica reaction (ASR) was first reported in 1949 by Robert Blanks of the U.S. Bureau of Reclamation.[1] Since then, hundreds of papers have reported the results of laboratory studies on the efficacy of fly ash in this role. While many specifications now permit the use of potentially reactive aggregates, provided a sufficient level of fly ash (or other preventive measure) is used in the concrete, there have been relatively few documented cases of major structures where fly ash has been successfully used together with reactive aggregates.

A paper on two such cases, the Nant-y-Moch Dam in Wales, U.K., and the Lower Notch Dam in Ontario, Canada, was published by the primary author when those facilities were about 35 and 25 years old, respectively.[2] The dams were revisited in 2010 when they were about 50 and 40 years old; this article summarizes the performance of these structures with regard to ASR. Studies of performance in the field are essential for confirming the efficacy of preventive measures observed in the laboratory and for benchmarking accelerated laboratory tests intended for the rapid evaluation of such measures.

Nant-y-Moch Dam

The Nant-y-Moch Dam is part of the Cwm Rheidol Hydroelectric Scheme, which was constructed between 1957 and 1962 in central Wales, about 17 km (10 miles) east of the town of Aberystwyth. Downstream from Nant-y-Moch is the Dinas Dam, which forms part of the same hydroelectric scheme (Fig. 1). Both dams were built at the same time using aggregates from the same source. Details of the materials and mixture proportions used for these dams are given in Table 1.

Problems with the Dinas Dam were first observed in 1986 in the form of map cracking and the development of a major longitudinal crack in the arch section[3]; ASR was subsequently verified as the cause of deterioration. When the primary author visited the dam in 1991, extensive cracking of the dam was observed at all exposed locations.[2] Horizontal cracks were observed on the downstream face, along the crest, and on the visible part of the upstream face of the arch. The gravity abutments showed random map cracking, with crack widths in excess of 5 mm (0.25 in.). In 1997, survey data was used to show that the dam had experienced a total upstream radial movement of 115 mm

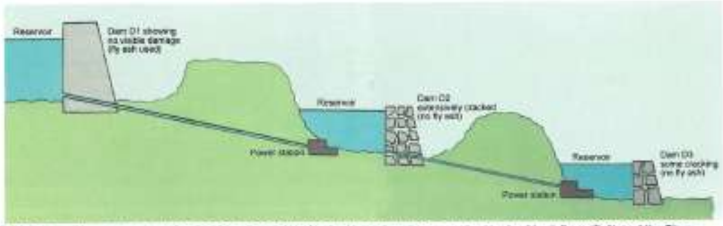
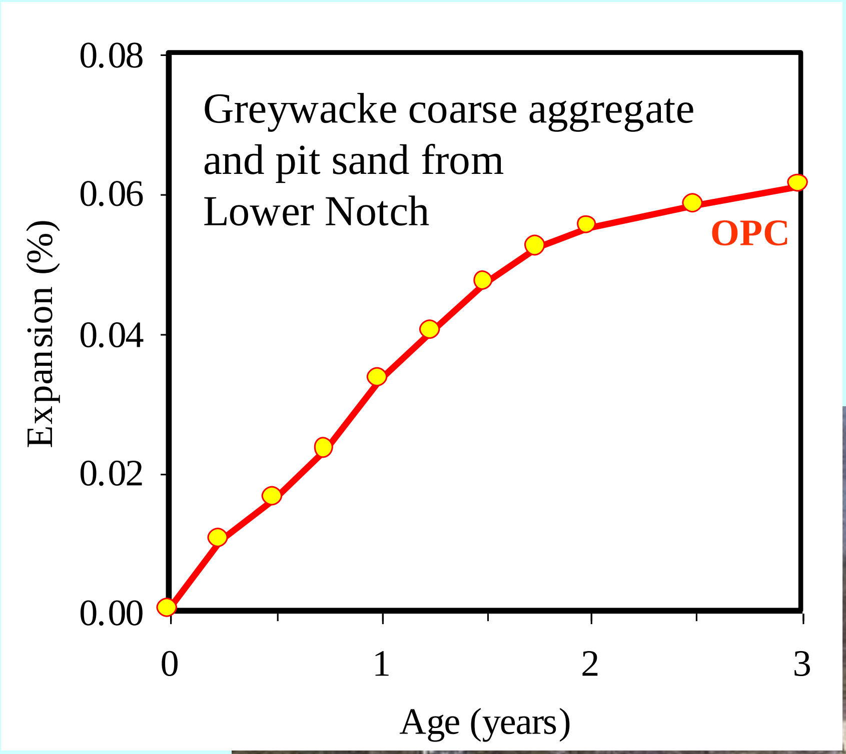
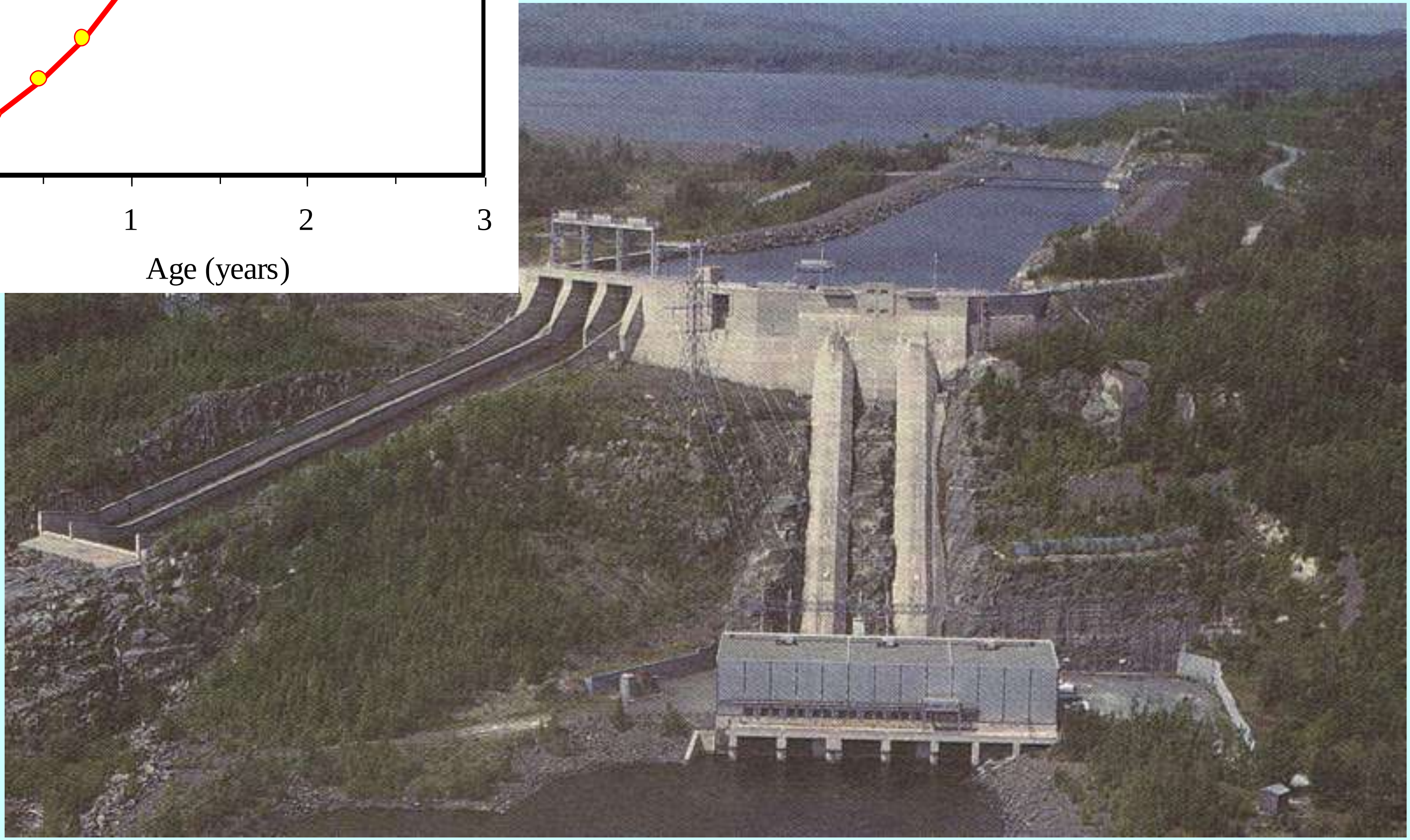


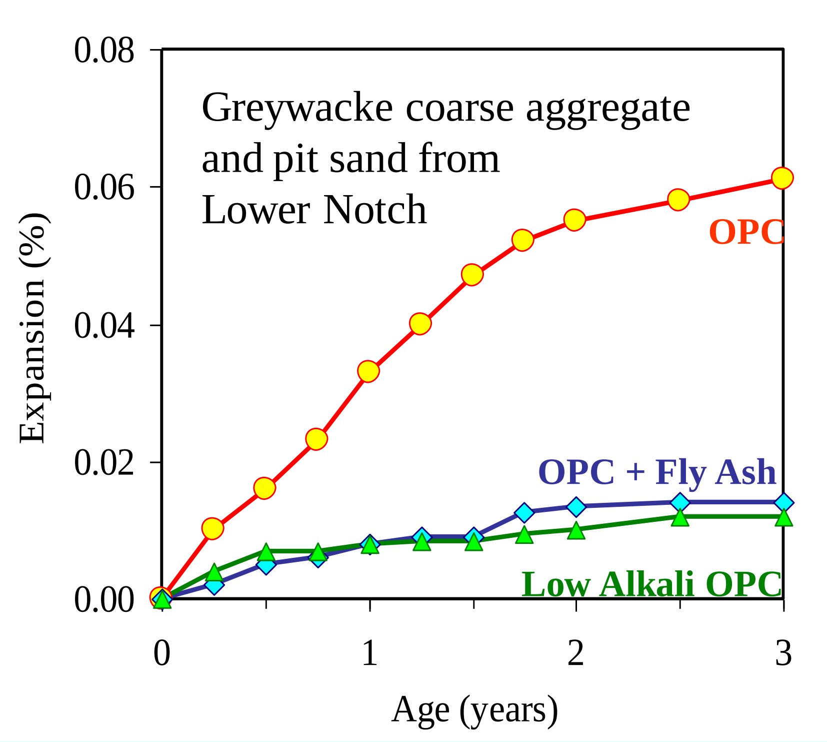
Fig 1: Schematic diagram showing the Cwm Rheidol Hydroelectric system, including the Nant-y-Moch Dam (D-1) and the Dinas Dam (D-2)



Lower Notch Dam

Built ~ 1970





20% to 30% fly ash used with high-alkali cement and highly reactive aggregate

<u>Current condition (at 40 years) is excellent</u>

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STD FA and AAR

- Lab studies show STD FA prevent AAR
- Long-term field studies show fly ash to be effective in preventing AAR

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STD FA and AAR
Documentation testing with Icelandic aggregates

- Testing according to Icelandic Building Regulation (no 441/1998 131.4
- ASTM C-227 + RILEM AAR-3
- Normal reactive aggregate (Perla A)
- Highly reactive aggregate (Type H)

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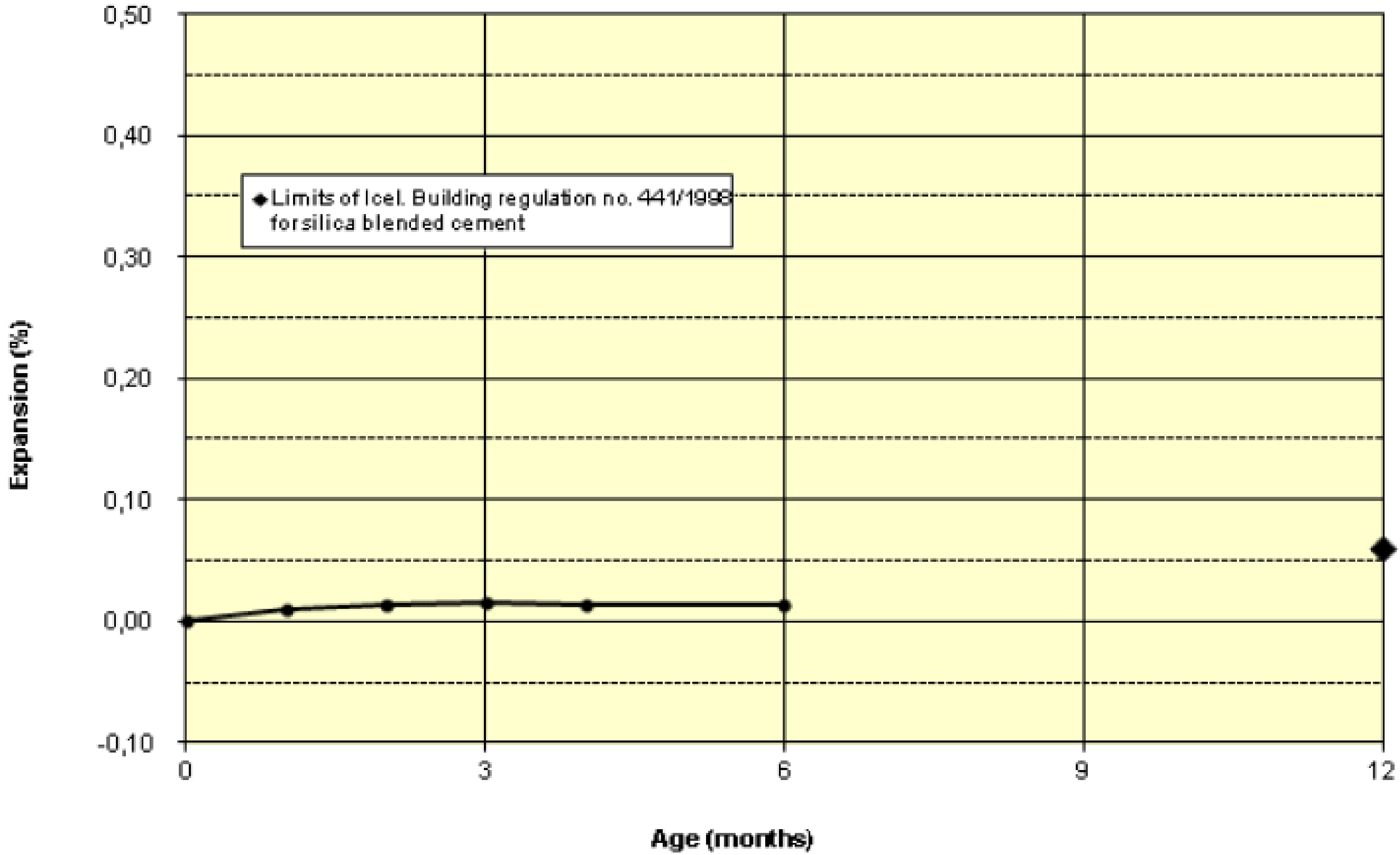

Figure 2. Average expansion of mortar bars according to ASTM C 227, with very high reactive aggregate ("Type H") with Norcem Standard FA cement.

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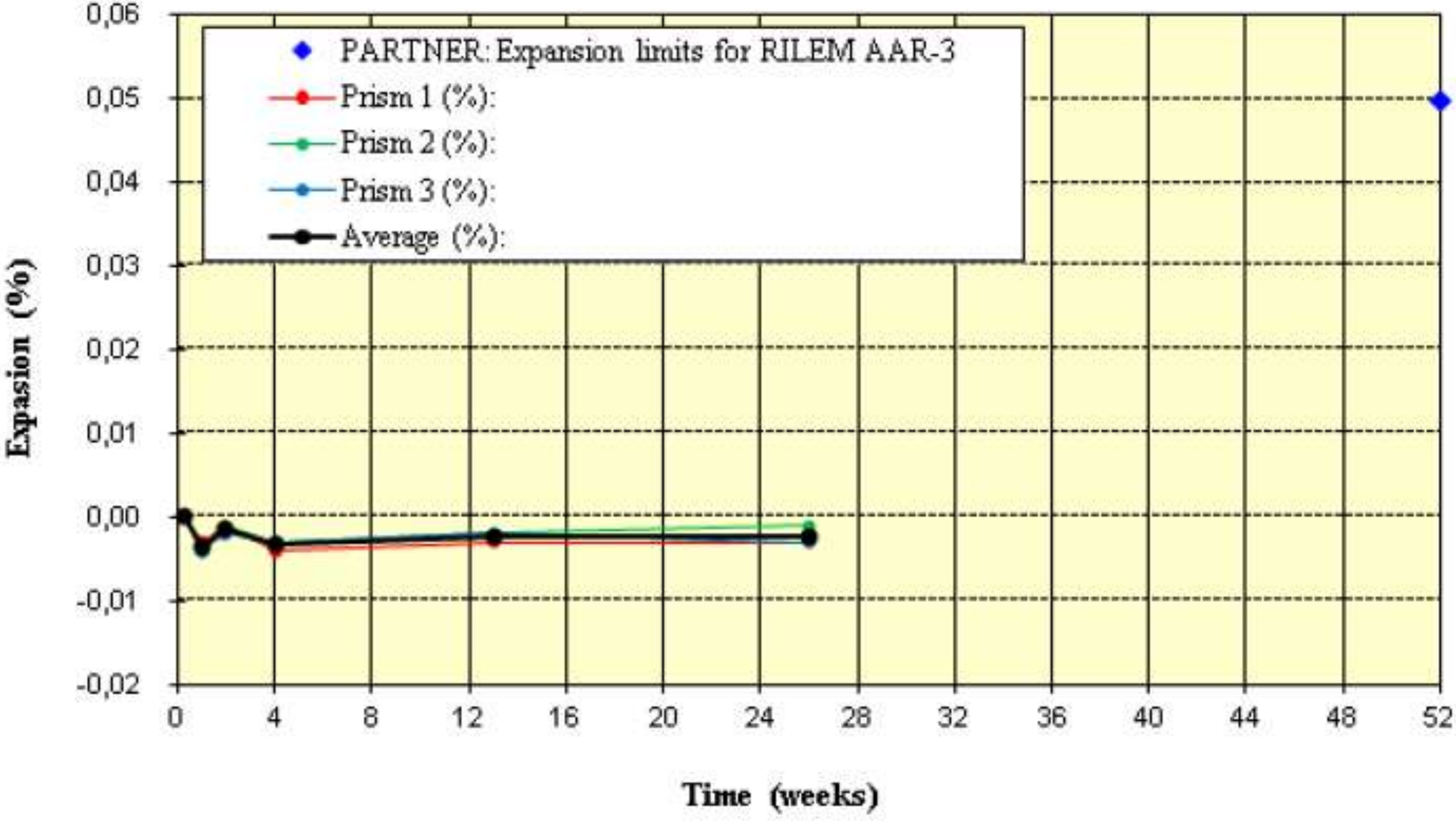

Figure 4. Expansion of concrete prisms according to RILEM AAR-3, with very high reactive aggregate ("Type H") with Norcem Standard FA cement.

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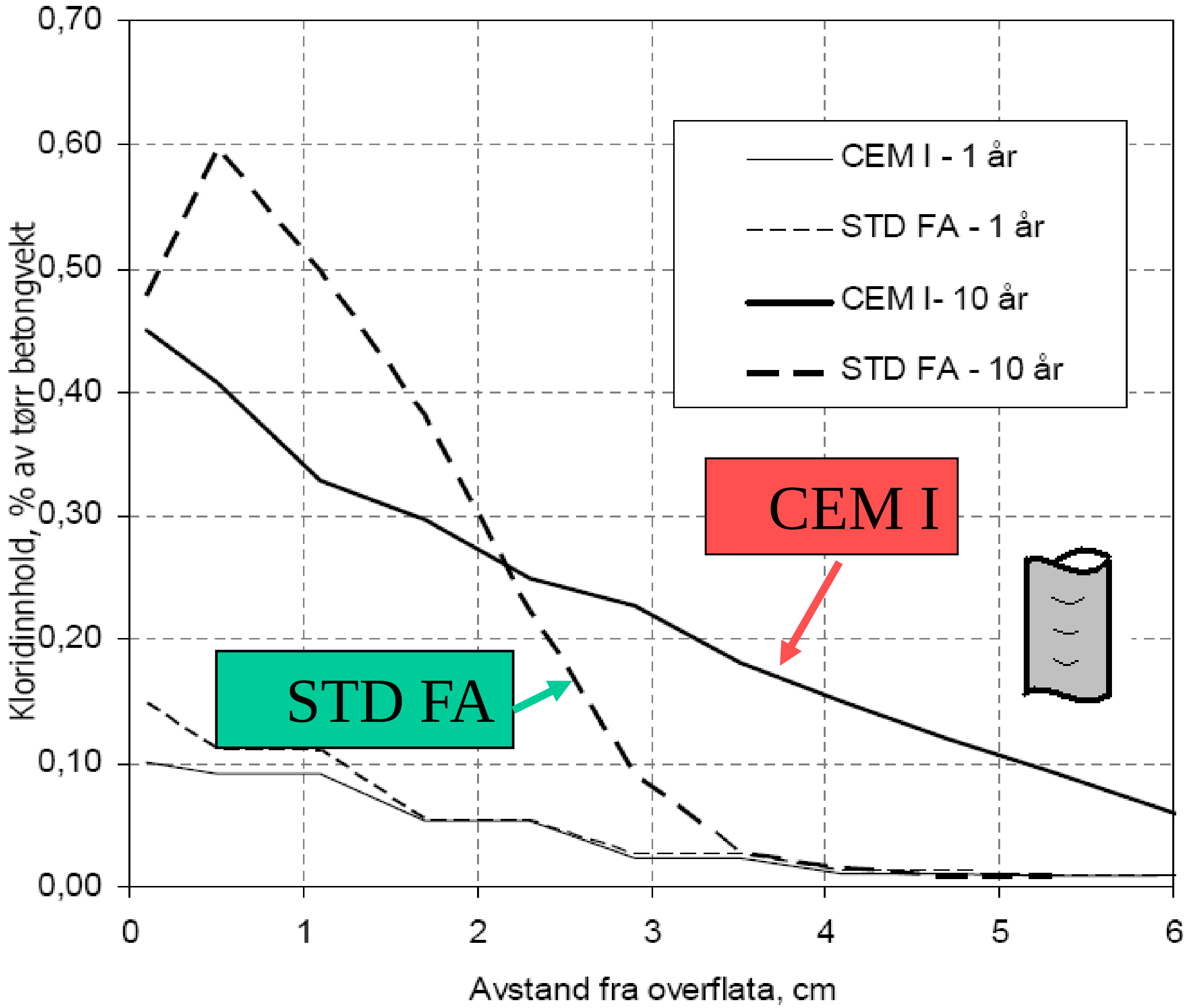
STD FA and AAR
Status, Iceland

- 6 months regulatory testing shows very good results, expansion well below the limits
- Final 12 months testing in june 2012

STD FA and chloride intrusion

STD FA and chloride intrusion



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STD FA and chloride intrusion

- Recommended in the publication 'Durability of Concrete Structures in Marine Environment', Norwegian Concrete Association

- Recommended by the Norwegian Road Administration

norsk betongforening

Publikasjon nr. 35

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2011

STD FA and freeze-thaw resistance

- STD FA => excellent freeze-thaw resistance provided entrained air-system
- 4% air
- Borås method SS 137244
  - – $m_{S,56} < 0.5$ kg/m^2
  - – $m_{S,56} / m_{S,28} < 2$

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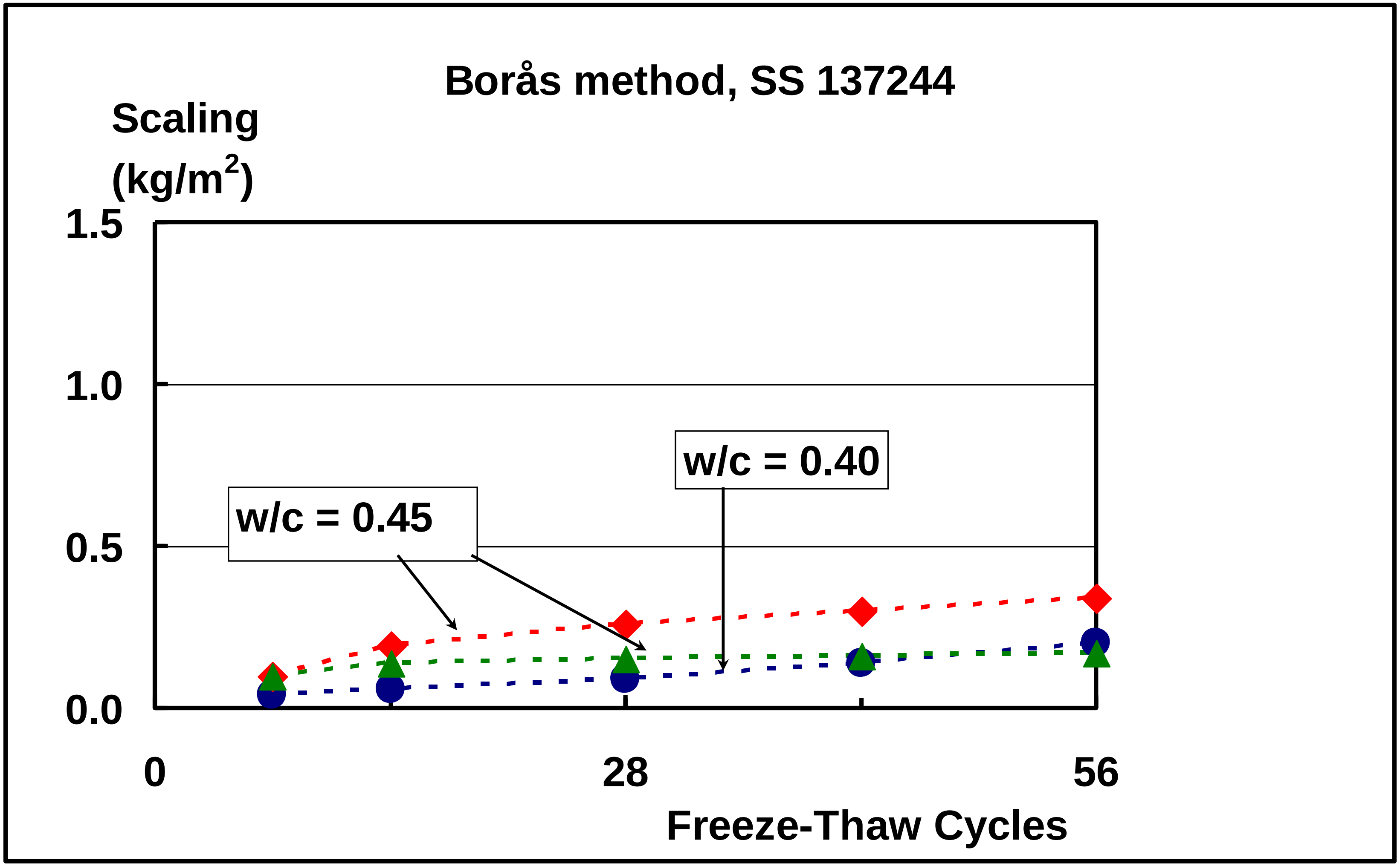
STD FA and freeze-thaw resistance



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STD FA and freeze-thaw resistance

Results: STD FA concrete tested according to SS 137244

$m_{S,56}$	$m_{S,56} / m_{S,28}$
0.24 kg/m^2	1.53

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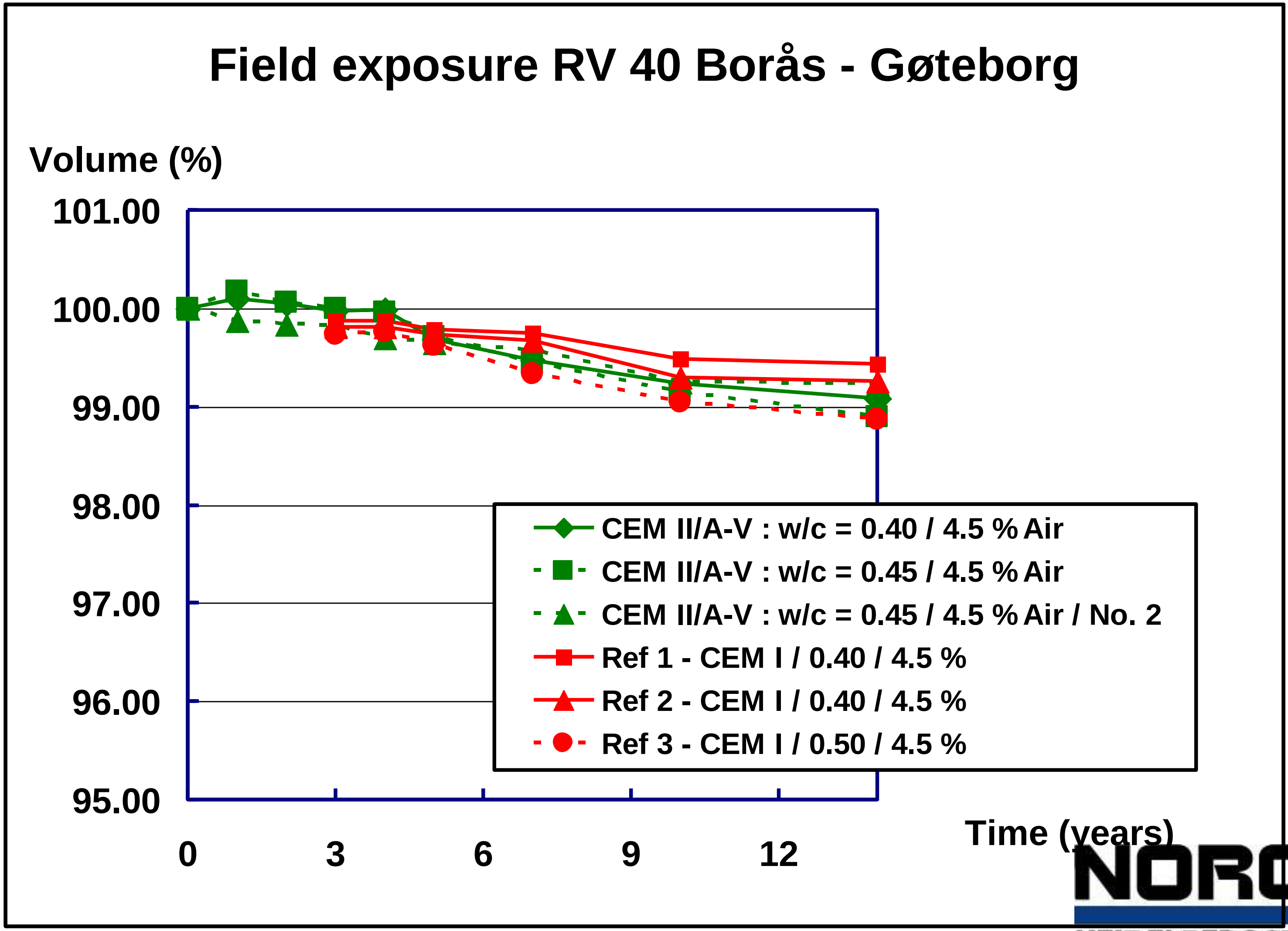
STD FA and freeze-thaw resistance
Long-term field test results (RV40 Borås-Gøteborg)

STD FA and freeze-thaw resistance
Long-term field test results



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STD FA and freeze-thaw resistance

- Freeze-thaw resistant provided air-entrainment
- Increased dosage of air-entraining agent
  - May be needed
  - Residue of coal in the fly ash

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Curing technology – Winter Concreting

- HETT 97
  - Simulate temperature and strength development
  - Planning of concrete works in cold weather and for massive structures

Curing technology – Winter Concreting

- HETT 97
  - ’www.norcem.no’
  - Materialdatabase

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