Title	From research to practice in Finland
Author(s)	Salparanta, Liisa
Citation	Nordic Concrete Research, Research Projects 2011, Proceedings of Nordic Concrete Research Symposium Hämeenlinna, Finland 2011, pp. 51-53
Date	2011
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From research to practice in Finland

Liisa Salparanta
Research Scientist
VTT Technical Research Centre of Finland
Kemistintie 3, Espoo
P.O. Box 1000
FI-02044 VTT, Finland
liisa.salparanta@vtt.fi

ABSTRACT

Continuity and *Cooperation* are the key words of concrete technological studies that have been carried out for over 40 years in a consortium between VTT (Technical Research Centre of Finland) and several public building owners.

The Finnish Transport Agency (formerly the Road Administration and Finnish Railroad Administration), the Radiation and Nuclear Safety Authority and some city authorities have formed a consortium combining their funds and investing in concerted research. This is how they get more with the same money as they would if they acted alone. Research is focused on solving practical problems, developing processes and methods, preparing directions, setting requirements, etc.

Key words: concrete, bridges, studies

1. INTRODUCTION

The common interest of all partners is concrete structures. Nearly all parties are interested in concrete bridges, while the nuclear safety authorities are mainly interested in pre or post tensioned structures and structures in marine environments. The partners agree which topics they wish to be studied and to what extent.

This paper reviews some of the types of work that have been done over the years, shedding light on Finland's expertise on practical partnerships. Topics include examples such as corrosion, internal curing, form-liners, and structural instrumentation. The paper also examines how the practical partnership with owners has led to deeper research and development topics funded by the national government, such as long-term field performance monitoring, modifying service life tools, and interacted chloride durability research. A description about international links to the projects is included, as well as future cooperation potential.

1. WHAT HAS BEEN DONE

Numerous topics have been studied during the years. Examples of practical studies the results of which have been directly applied in practice are:

- Relative humidity and temperature measurements using cast-in sensors
- Long term durability studies
- Requirements for fresh and hardened self compacting concrete, directions for concreting and quality control of self compacting concrete
- Design and execution directions of cathodic protection
- Quality requirements and verification methods of concrete substrate to be repaired
- The quality requirements of formliners
- Mould technics for underwater concreting.

Long-term theoretical studies including service life investigations based on information compiled from real bridges have yielded simulation methods for the ageing of concrete structures, as well as models to calculate deterioration, service life, and design service life, and a calculation method for lifecycle analyses. On the bases of this work so called P factor method was developed. For more than 20 years Finnish Transport Agency has used this method by which the compliance of concrete can be verified without tests on hardened concrete. On the basis of mix design, curing and air content measured on site P factor is calculated as shown in equation 1.

$$P = \frac{46 * k_{jh} * k_{sid}}{\left[10 * (WAS)^{1,2}\right] / \sqrt{a} - 1} \qquad (1)$$

where
k_{jh} is curing factor calculated from curing time
k_{sid} is binder factor calculated from effective binder content and binder composition
WAS is reduced void-binder ratio calculated from effective water and binder contents and air content
a is air content (%).

Directions for using P factor are described in the publication /1/. The publication is available on the www-pages of the Finnish Transport Agency. An excel file for calculating P factor is also given on the Finnish Transport Agency ´s www-pages /2/.

2. WHAT IS GOING ON?

Service life investigations continue by studying the effect of the CO2 and Cl -permeability of repair materials on service life. The aim is to create a model and set parameters to determine the thickness of repair material layer with known permeability properties to reach a desired service life.

Last year also the studying of the applicability of infrared heating method equipment using liquefied petroleum gas for the heating and drying of a concrete bridge deck before the assembling of water proofing under cold and wet conditions was started.

The correlation of different freeze-thaw and frost-salt test methods will be determined. The aim is to enable replacement of expensive tests by cheaper ones.

3. GETTING INTERNATIONAL

There has a long-term field study of concrete durability been going on for four years. In this research the co-operation has widened to be international. There are partners from Norway, Canada, Portugal and USA involved in the project in which the effect of interacted deterioration parameters on service life of concrete structures in cold environments are studied. The novelty of this research is to combine different damage models to one service-life calculation model and apply this model in wide geographical area. The objective of the project is to make service life calculation models accounting for interaction when several types of deterioration are acting simultaneously. There is more information about this research in the papers by Erika Holt & Markku Leivo (Concrete durability based on coupled laboratory deterioration by frost, carbonation and chloride), Hannele Kuosa (Concrete durability and testing in Finland) and Erkki Vesikari (Modelling of carbonation and chloride penetration interacted by frost damage in concrete).

4. REPORTS

All the directions and instructions prepared within the co-operation and also many of the reports are available on the Finnish Transport Agencys www-pages. The studies that are partly funded by private companies are normally not public and therefore not available in the internet.

5. FINALLY

The co-operation goes on year after year. New needs for research appear and new studies are planned continuously. As the co-operation between orderers and researchers is intensive, all parties are well aware of each others needs and potentials and the studies are planned and accomplished in such a way that all parties get the best benefit out them.

The experiences of all parties involved have been positive. The orderers get more with their money than they would if they acted alone. The research results are well spread through all participants. The continuity of the co-operation combined with interesting topics are an ideal combination from the researchers point of view. In addition to this is very rewarding to see that the results are applied with success. You get a feeling that your work is useful.

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