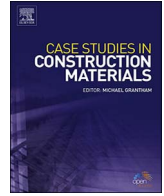




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## Case study

# A survey on problems encountered in current concrete construction and the potential benefits of self-healing cementitious materials



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## ABSTRACT

The annual costs for repair, maintenance and replacement of civil engineering infrastructure attracts significant expenditure in the UK. Anecdotal evidence suggests that a significant number of existing and new concrete structures suffer from repair and maintenance problems, but a lack of objective construction industry supported data concerning these problems makes it difficult to establish, with any certainty, the actual problems encountered in current concrete construction in the UK. To address this lack of data, a market research exercise was commissioned by the Materials for Life (M4L) EPSRC funded research project. The market research has shown that damage in the form of cracking in concrete structures was experienced by more clients, design team members and civil engineering contractors than any other problem. Structures requiring articulation and subject to dynamic loads such as bridges were noted as being the most vulnerable to damage, with this damage mostly occurring in the joints and half joints, bearings and the deck of such structures. The main consequential effects of damage in concrete structures were the need for the contractor to return for repairs as well as the need for regular monitoring. The current approaches taken to enhance a structure's longevity mainly involve the use of additional cementitious material to improve the barrier between the environment and the steel reinforcement. However, an alternative could be to use the self-healing cementitious materials that have been proposed by the M4L research team. Until now there has been insufficient evidence regarding how these materials may be deployed in the construction industry, and the applications to which they may be best suited in terms of added-value. The market research results show that highways and infrastructure generally and water retaining structures would benefit most from self-healing cementitious materials, with reduced maintenance costs over a structure's lifetime justifying a premium in the capital material cost. Reduced whole-life costs and fewer repair and maintenance interventions will have a significant influence on the economic, environmental and social impact of repair and maintenance events, which will be of benefit to the UK as a whole.

## 1. Introduction

Developed countries spend a large percentage of their infrastructure budgets on repairs, maintenance and the replacement of existing and new structures (35–45% in the UK [1], 50% in EU [2]), which points to significant inadequacies in past practice and current design and construction techniques. There is much anecdotal evidence that concrete structures have repair and maintenance problems, a fact that is supported by the high expenditure on maintenance. However, a lack of industry supported quantitative data means that it is difficult to establish, with any certainty, the most common problems encountered during the construction of today's

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concrete structures in the UK. When transport-related structures cease being serviceable there are large societal costs associated with delays and disruptions. Moreover, the cement and concrete industry have huge energy demands and produce large amounts of CO<sub>2</sub> [3]. As a result it is widely recognised that more efficient and durable cementitious materials are needed if the construction industry is to make its contribution to climate change targets [4]. Structures with more resilience may be achieved by pro-active management of damage by employing materials that have an ability to adapt, self-heal and respond to their exposure environment. Through the use of cementitious materials that have this ability, our concrete structures can evolve over their lifespan rather than being defined by individual events. Such structures, whilst having an increased capital cost would have significantly lower if not negligible maintenance costs over their life and therefore much reduced whole life costs.

In order to better understand the problems encountered during the construction of today’s concrete structures in the UK and the degree to which concrete cracking/damage is a major problem, a piece of market research was commissioned by the Materials for Life (M4L) EPSRC funded research project [5]. The three main objectives of this market research were to identify:

- (a) the nature of concrete damage and the structure types and elements vulnerable to damage;
- (b) the consequential effects of concrete damage and maintenance; and
- (c) the current approaches taken to address damage in concrete and their impact.

The market research survey was also used to explore the potential applications of self-healing cementitious materials and the benefits in their use, the findings of which will be used to inform future developments in this research area.

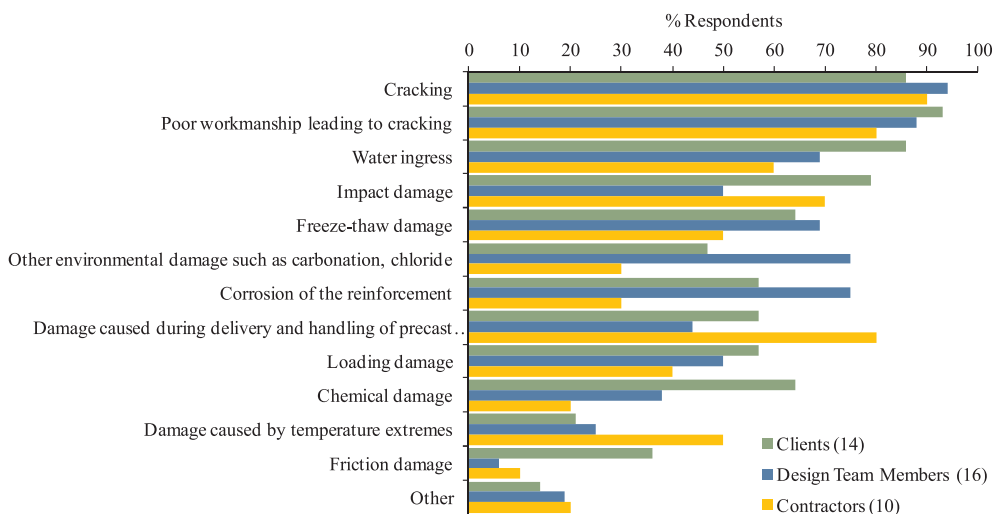
The market research was conducted by Lychgate Projects Ltd. [6] in 3 stages. The first stage included 5 in-depth semi-structured interviews with a main contractor, a concrete structures contractor, a repair contractor, a multi-disciplinary consultancy and a supplier of bulk cement. Stage 2 comprised three 20 min discussion groups with attendees at a CIRIA event in July 2016. In stage 3, a total of 40 structured interviews were conducted by phone with organisations involved in delivering infrastructure projects, including end clients (14 no.), civil engineers from large practices/design teams (16 no.) and civil engineering contractors (10 no.), henceforth referred to as the ‘participants’. This paper presents a summary of the results of the stage 3 interviews. All interviews were conducted ‘off the record’ and thus the companies participating in the survey are not identified but the participants included a number of the largest UK contractors, consultants and client bodies.

## 2. Market research results

The market research results are presented according to the questions posed to the survey participants, as compiled in the original market survey report [6].

### 2.1. Damage in concrete structures

The market research indicated that the main problems experienced with concrete (both old and new construction) in projects on which the respondents had worked over the last 5 years (presented in Fig. 1) are as follows:



*Other includes: Expansion due to ASR. Salt damage. Sulphate damage. Fire damage. Concrete specs have been higher than required which has caused cracking due to brittleness.*

Fig. 1. The main causes of damage in concrete structures (according to participants).

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