



Case Study

Innovative solutions please, as long as they have been proved elsewhere: The case of a polished lime-pozzolan concrete floor[☆]

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ARTICLE INFO

Article history:

Received 11 December 2013

Received in revised form 14 January 2014

Accepted 14 January 2014

Available online 4 February 2014

Keywords:

Innovation

Implementation

Polished lime-pozzolan concrete

Case-study

ABSTRACT

This case-study paper tells the story of the development of a bespoke lime-pozzolan concrete for an innovative project application. In this paper, the results of laboratory testing are contextualised by the project-story that steered the research programme. This is an example of a collaborative endeavour to implement a novel low-carbon construction technology in the field.

Evolution of the design in parallel with laboratory testing resulted in the development and specification of a polished lime-pozzolan concrete floor incorporating site-won oolitic limestone aggregate. To the disappointment of the client and the design team, this innovative solution was abandoned at the point the contractor was appointed and changed to a proprietary polished metallic dry shake floor system. The project, a new build extension to a local authority secondary school, was completed in September 2013.

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1. Introduction

The construction industry has received on-going criticism for its lack of innovation (Nam, 1989; Miozzo, 2004; Reichstein et al., 2005; Drejer and Vinding, 2006) and numerous authors have expounded the specific challenges of innovating in the context of the built environment (Blayse and Manley, 2004; Dewick and Miozzo, 2004). One of the unique challenges of innovation in construction is that novel solutions are typically not adopted within organisations, but in the context of one-off projects (Dewick and Miozzo, 2002). Given the one-off nature of construction projects, case studies are an effective tool in researching construction innovation.

Case studies celebrating the successful adoption of novel solutions are clearly valuable; both in promoting cutting-edge technologies and in encouraging others to act similarly (Sutton et al., 2011a,b,c,d). Publication of success stories alone, however, might be painting a lop-sided picture of the lived experience of construction professionals and clients in the built environment. Is the 'lack of innovation' in construction not the result of inactivity, but the collective effect of individual project endeavours frustrated by technological, economic or social circumstances? This case study is presented as an example of one such project in which the implementation of an innovative technological solution was unsuccessful despite the design team's aspiration and effort to such an end.

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2. Why was lime-pozzolan concrete considered?

- The school's aspiration was to own an ecological and educational building that would be an inspiration to building users.
- The school's desire to visibly utilise site-won material in the fabric of the new building.
- The school's express interest in research being undertaken by Ramboll and the University of Bath on low-carbon lime-based concretes.
- The discovery of a band of naturally occurring frost-shattered oolitic limestone during the Site Investigation.

3. The opportunity

The project Site Investigation (SI) was conducted by a geotechnical engineer in April 2011. The structural engineer was present during the excavation to take a sample of the soil, in order to test whether site material was suitable for construction of a rammed earth wall. During the excavation of a number of trial pits, within the footprint of the new building, a 300–700 mm thick band of frost-shattered material was encountered from approximately 0.2 metres below the surface (Fig. 1). In the trial pit log this material was described as *'loose becoming medium dense beige brown to mid-brown silty sandy GRAVEL and COBBLES of sub-angular oolitic limestone'* (SI report, April 2011).

Recognising that this naturally occurring site material might also potentially be suitable for use within the fabric of the new building, a sample of this frost-shattered oolitic limestone (FSOL), passed through a 50 mm screen, was also bagged for testing in the laboratory. Specifically preliminary testing was undertaken to establish if this site-won material might be suitable as aggregate for a lime-pozzolan concrete.

4. Preliminary laboratory testing

The particle size distribution (PSD) of the FSOL was measured by sieve analysis in accordance with BS 933-1 (2012). The results demonstrated that the material was sufficiently well graded that it could be designated as 'all-in aggregate' in accordance with BS EN 12620 (2013) and utilised without separating the fractions. On this basis a lime-pozzolan concrete with all-in FSOL aggregate was produced in accordance with BS EN 1881-125 (1986). An atypically high dosage of superplasticiser (3.2% by mass of binder) was found to be required to produce a flowing concrete. The poor workability of the material was attributed to the large proportion of fine material in the all-in aggregate. Four 100 mm³ cubes were cast and cured in accordance with BS 12390-2 (2009). This lime-concrete had a 28-day compressive strength of around 20 MPa.

5. What issues were faced and overcome?

Despite the limitations of this early trial and the shortcomings of the resulting lime-pozzolan concrete, this trial was enough to spark the imagination of the design team. Given that the lime-concrete samples were not especially attractive; the appeal of this innovative solution is thought to have been more ideological than aesthetic at this early stage. Recognised as being a *'piece of proper innovation'* this novel material technology embodied the client's design philosophy and it gave the project team the opportunity to be part of a bigger story of technological progress, *'I was very excited that we could be part of something being developed and new'* (School, April 2012). With the design team keen to pursue this novel technology, the Local Authority (the client) commissioned a local contractor to excavate a further tonne of the FSOL (<30 mm) from the school site to facilitate further laboratory testing and development.

To improve the concrete mix design the density and aggregate absorption of the FSOL aggregate was measured using the Pyknometer method described in BS EN 1097-7 (2008). The particle density on a saturated and surface-dried basis (ρ_{ssd}) was calculated to be 2470 kg/m³. The water absorption after immersion for 24-hours, WA₂₄ was measured as being 12.3%, which reflected the porous nature of this oolitic limestone.

It was decided to limit the use of the FSOL to that of 'coarse aggregate' in the anticipation that this would improve the consistence of the fresh lime-pozzolan concrete and reduce the demand for superplasticiser. The FSOL was screened by



Fig. 1. Frost-shattered oolitic limestone (FSOL) unearthed during the site investigation.

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