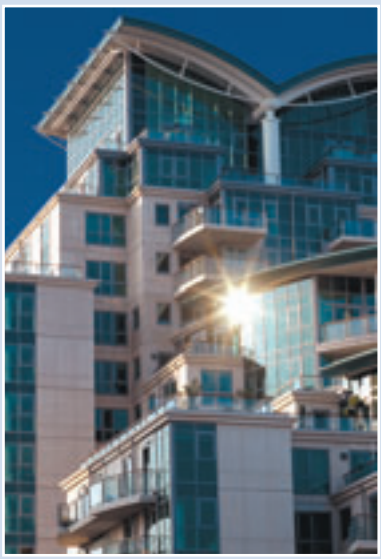
St George Wharf Case Study



Introduction

The European Concrete Building Project at Cardington was a joint initiative aimed at improving the performance of the concrete frame industry. It led to the preparation of a series of Best Practice Guides, giving recommendations for improving the process of constructing in-situ concrete frame buildings.

As part of a programme to disseminate and apply what has been learnt from Cardington, BRE has subsequently worked directly with those involved in St George Wharf, a high-profile, mixed-use, phased project on the River Thames.

BRE worked jointly with the developers, St George (South London), their engineers, White Young Green, and specialist concrete contractors, Stephenson, to develop and implement process improvements tailored to the St George Wharf site.

This work has led to a series of innovations being trialled, the results of which are summarised in this series of Best Practice Case Studies.

Early age concrete strength assessment

Figure 1: Lok test being carried out on a floor slab

Reliable methods for determining early age strength are a prerequisite to striking slabs at early ages (see companion Case Study, *Early age construction loading*) and can be useful for other purposes (e.g. prestressing).

Key points

This publication discusses the experiences and benefits of using pull-out tests to determine concrete slab strengths at early ages.

- Work at Cardington coupled with the work undertaken here suggests that the Lok test itself is reliable but other factors come into play once the structure is sampled.
- Where striking time is critical, Lok tests offer particular advantages. If time permits, other more established methods (i.e. cube tests) can be used.
- In general the equivalent strengths derived from Lok test strength measurements were less than those from corresponding air-cured cubes, which had hitherto been used as the basis for striking
- The work has highlighted the inherent variability of concrete strengths at early ages and suggests caution should be exercised in assessing strength based on limited sampling - whichever test method is used.
- Lok tests can be regarded as being more representative than cube tests as the concrete in the structure is being sampled.

Basis of Lok test and experience from Cardington

The Best Practice guide, *Early age strength assessment of concrete on site (see back cover)* highlights the merits of a quick and simple test for determining the in-situ concrete strength. Based on the work completed at Cardington, the guide recommends the use of pull-out inserts cast into the concrete to determine the early age strength for purposes such as early striking and prestressing.

For horizontally cast members (e.g. slabs) the Best Practice guide recommends that the inserts are located using a floating cup device on the top surface of the slab near the end of the pour.

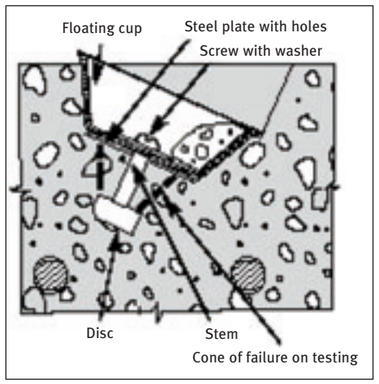


Figure 2: Floating Lok test insert

At Cardington, to eliminate as many sources of variability as possible, Lok tests were carried out on companion cubes cast from the same batch of concrete and stored adjacent to the conventionally tested air-cured cubes.

Figure 4 illustrates that, with careful control of all factors influencing variability, a good correlation can be obtained between strengths predicted using Lok tests on companion cubes and from conventionally tested cubes. Further, the work at Cardington showed good agreement for a range of concretes between a site-derived correlation and the standard recommended correlation provided by the manufacturer.

This suggests that the test itself is reliable; however other factors come into play once the structure is sampled.

When conventionally tested air-cured cubes were used to predict the in-situ strength as measured using Lok tests, the results were more variable. In fact a better overall correlation was obtained with conventionally tested water-cured cubes even though these take no account of the environmental effects on the structure. This was thought to be due to the air-cured cubes being at a lower temperature than the slab and in general, therefore, giving lower strengths.

As would be expected, differences in strength were also observed between the top and bottom of slabs. These differences were accentuated for Lok inserts placed near to column positions. These factors need to be borne in mind in any attempt to correlate cubes with Lok test measurements taken on the structure.

Use of Lok tests at St George Wharf and comparison with cube results

As they were unfamiliar with the Lok test, the contractor and designer recommended its use alongside conventionally tested cubes so as to gain confidence in the reliability of the test results.

The Best Practice guidance concerning numbers and locations of Lok tests was followed. Four floating Lok inserts were placed as a group on top of the slab towards the end of the pour.

Figure 3: Floating cups grouped at edge of pour. One has already been pulled out.

For the reasons given in the previous section it proved difficult in practice to derive a meaningful correlation on this site between results from conventionally tested air-cured cubes and from Lok tests carried out on the structure. This was not helped by the fact that the conventionally tested cubes were limited in number and generally were from different batches of concrete from those in which the Lok test inserts were placed.

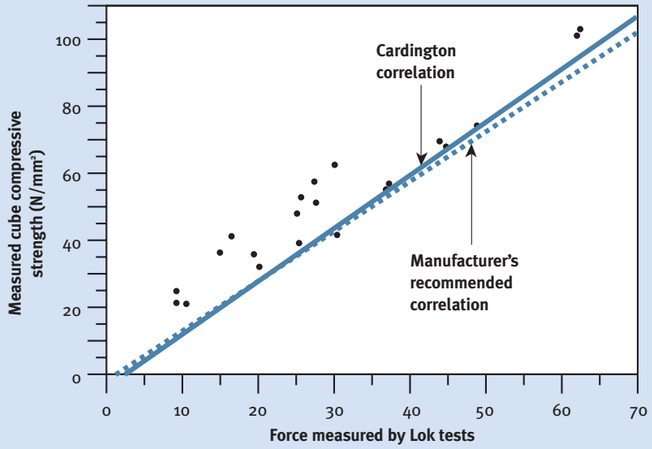


Figure 4: Correlation from Cardington between conventional tests on air-cured cubes and Lok tests on companion cubes

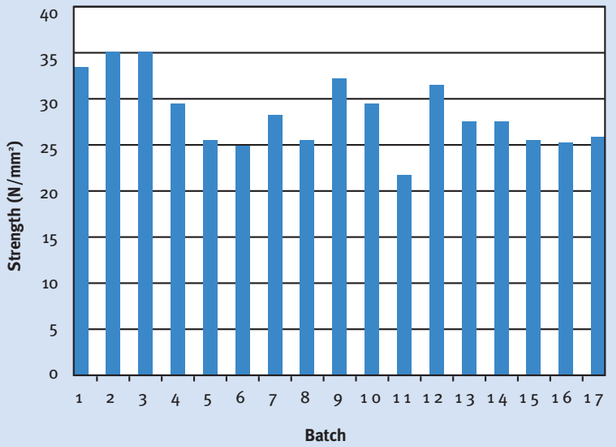


Figure 5: Variability between batches of measured 3-day water-cured concrete strengths at St George Wharf

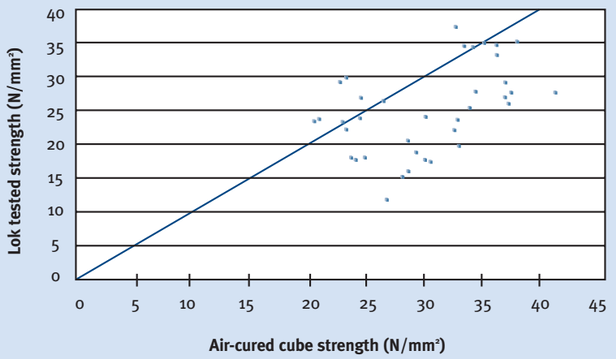


Figure 6: Comparison of concrete strengths derived from Lok test results from the structures with air-cured cubes at St George Wharf

The water-cured cubes, which should be independent of ambient environmental conditions, also showed some variability over the structure as a whole. This is shown in Figure 5, which illustrates strengths measured at three days, and suggests that account needs to also be taken of the inherent variability between batches of concrete. There was also some variability between cubes cast from the same batch, which suggests a lack of quality control in the making and testing of the cubes or in the concrete itself as supplied.

In general the cube strengths derived from Lok test strength measurements were less than those of corresponding air-cured cubes, which had hitherto been used as the basis for striking. This is shown in Figure 6.

It was not feasible to prepare temperature-matched cured cubes at St George Wharf. Since there was no independent true strength measurement of the concrete in the slabs, it is not possible to say that relying on Lok test results as the basis for striking is necessarily any better or worse than relying on conventionally tested air-cured cubes. More confidence should, however, be able to be placed on the Lok tests as it is the concrete in the structure that is being sampled.

Costs and convenience of test methods

The costs and convenience of carrying out Lok tests was compared with that of making and testing cubes and found to be favourable.

The principal advantage of Lok tests is where the results are required quickly. At St George Wharf this wasn't an issue as striking was aimed for three days minimum and in practice was usually longer. On this site there was no programme benefit in striking earlier than three days because of the time taken to construct the vertical elements.

Conclusions

1. Lok tests offer specific benefits where there is requirement to strike at very early ages.

2. The frame contractor and the designer were not fully convinced of the reliability of the results from the Lok test. This was mainly because of the difficulty on this site in achieving good correlation with the existing test method of using air-cured cubes.

Figure 7: The floating cup

3. It is considered prudent to initially run Lok tests in parallel with existing test methods in order to gain confidence in the test and a feel for the variations in concrete strength that are likely to be detected. The inherent limitations in doing this and likely sources of variability should, however, be recognised.

4. One way to give assurance on specific projects would be to cast Lok test inserts in large cubes as was done at Cardington, and store these alongside the structure; this would remove the effect of variations within the pour of concrete. Similarly good correlation to that shown in Figure 4 would be expected, but the advantage of sampling the concrete in the structure would be lost.

5. Whichever test method is used, care should be exercised when interpreting the results. The likely inherent variability of concrete strengths, particularly at very early ages, should be catered for either by increased sampling to gain confidence in the results or allowing a greater margin between the measured and the lower bound strength.

6. The recommendations given in the existing Best Practice guide are still believed to be valid. However where Lok tests are used recognition should be given to the variability of concrete that can occur naturally at different locations within a given pour area.

Figure 8: The Lok-test jack in position

7. The reliability of the results from the Lok tests has already been demonstrated by the work at Cardington. Further work could be undertaken to investigate in a controlled manner the influence of environmental conditions (i.e. wind and rain) not present at Cardington. The fact that the Cardington work showed that Lok tests performed on large cubes correlated very well with results from conventional tests on similar test cubes stored under the same conditions suggests, however, that environmental conditions will not be a major factor.

8. The comparison made at St George was not devised as a scientific test but was carried out within realistic site constraints. Taking these into account the variation in results obtained is not considered that surprising.

9. It should be recognised that, even after eliminating all other sources of variability, Lok test results from positions within the structure would not necessarily be expected to correlate perfectly with results from cube tests.

10. More reliance should be placed on the Lok test. Reference 1 suggests applying a factor to cube strength measurements to allow for possible differences between the cube and slab strengths. This is not necessary with Lok test results from the structure as it is the concrete within the slab that is being sampled.

The work undertaken and the conclusions reached in relation to the innovations described above should be viewed in the context of the particular project on which the innovations have been trialled.

This Case Study is underpinned by a full report [2] giving the background and further information on the innovations.

References

1. ***Guide to flat slab formwork and falsework,*** by Eur Eng P. F. Pallett. Published by The Concrete Society on behalf of Construct. Ref. CS 140, 2003

2. ***Best practice in concrete frame construction: practical application at St George Wharf,*** by R.Moss BRE Report BR462, 2003

Acknowledgements

The support of the DTI for this project carried out under its Partners in Innovation scheme is gratefully acknowledged.

The Best Practice guide ***Early age strength assessment of concrete on site*** summarises work carried out on this topic during the construction of the in situ concrete building at Cardington. This can be downloaded free at www.rcc-info.org.uk/pdf/LinkEarly_Age_Web.pdf and at http://projects.bre.co.uk/ConDiv/concrete%20frame/default.htm

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