The self-compacting method: concrete

Figure 1: Placement of self-compacting concrete into residential house slab.

David Rich, Jacqueline Glass, Alistair Gibb and Chris Goodier from Loughborough University present findings from research which has, for the first time, quantified the benefits of constructing with self-compacting concrete.

Table 1 – Costed construction scenarios*

		Conventional	
(All figures in £)	**SCC**	**Slow curing**	**Fast curing**
Overheads	2.00	43.33	43.33
Placement	15.22	57.02	57.02
Power float	0.00	2.37	14.20
Out of hours (O/H)	0.00	334.00	0.00
Material	380.63	252.59	252.59
Curing labour	Included in placement	Included in O/H	2.09
Curing agent	6.75	6.75	6.75
Total	£404.60	£696.05	£375.97
Difference compared with SCC	n/a	+£291.45	–£28.63

** Costs within this table have been based upon work study findings. Costs are current as of 1st quarter 2011: material costs are based upon average UK prices, labour rates are in line with minimum rates set by the Construction Industry Joint Council, out-of-hours costs are based upon two operatives for health and safety requirements and overheads are based upon nationally available plant rates.*

Self-compacting concrete (SCC) has been available in the UK construction industry for a number of years and certain benefits have since been attributed to the material. During its development and subsequent use over the past 15 years, numerous studies have explored its physical and structural performance properties, leaving its practical construction benefits largely uncorroborated. Recent reports and research have served primarily to restate potential benefits without providing transferable, quantifiable and applicable findings.

Our research, as reported previously in *Concrete*[1], has not only determined that SCC should be seen as a construction method rather than a material but has also since gone on to explore and quantify the validity of several of these perceived benefits of SCC. We now have the findings of a work measurement study based on the construction of residential ground-floor suspended slabs.

Work measurement study

Our recent study has focused on the construction of 14 residential ground-floor suspended slabs (Figure 1), directly comparing the difference between conventional concrete and SCC construction methods. The study has explored the effect that changing these methods can bring to construction time and cost, along with the implications of some of the more intangible benefits – quantitative evidence that has been sorely lacking in previous SCC research. On-site data collection was

that can save you time and effort

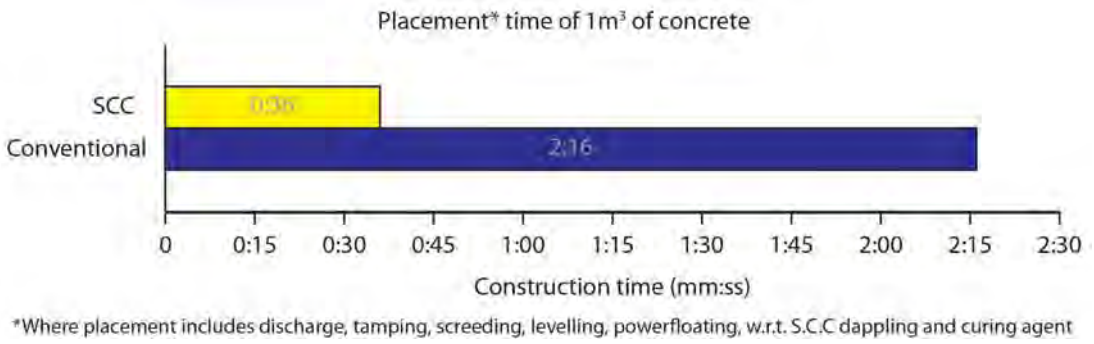

Figure 2: Comparison of conventional and SCC construction methods.

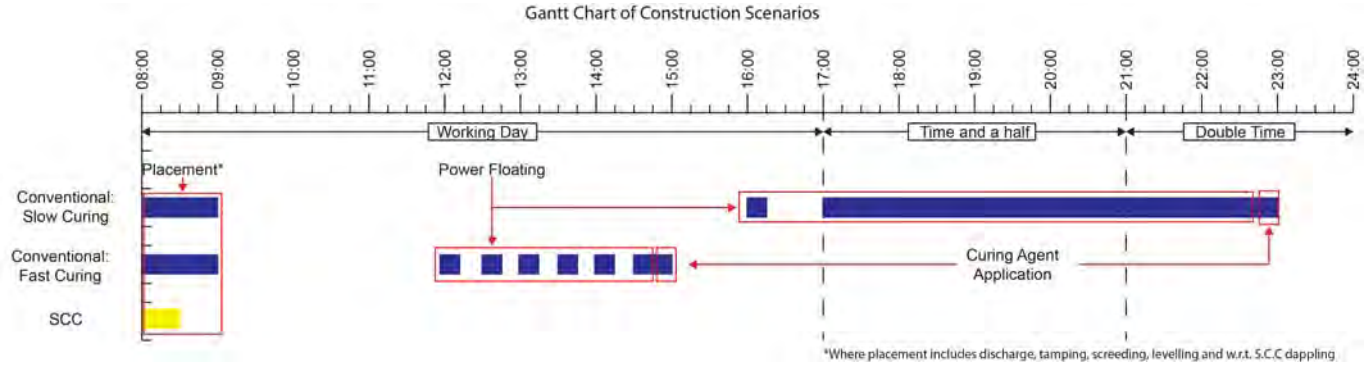

Figure 3: Gantt chart of construction scenarios, illustrating construction time.

carried out during the last quarter 2010 and first quarter 2011, and all data and any applied costs are current as of the first quarter 2011. Findings are based upon the full extent of the in-situ slab construction process, from material discharge to final application of a curing system (including levelling, screeding, compacting, tamping, floating, power floating and, in the case of SCC, dappling).

Reducing construction times with SCC

The basis of the study has been the identification, through direct measurement, of concrete construction operations, focusing on the time or duration of activities. While the study has focused on residential slabs, it would also be possible to extend the results to address broader forms of slab construction and hence understand its wider ramifications.

Accepting SCC as a method is fundamental to realising its benefits; this enables construction to be best managed to optimise the use of SCC and beneficial changes can then be made to existing practice. This approach was observed when constructing residential ground-floor slabs and the study has shown significant reductions in construction time by using SCC. On a per square metre basis with SCC a typical residential slab can be constructed more than 70% faster than with conventional concrete (Figure 2).

This significant outcome results from the simpler construction method offered by SCC, which removes much of the levelling process, compaction through tamping, screeding to final level, hand floating to a basic finish and power floating. In place of these processes, some minimal levelling is needed (due to SCC's fluid nature and the dappling surface finishing process) but overall the time (and hence labour) saving with SCC remains substantial.

Application to construction scenarios

In addition, there are wider benefits to be gained from employing SCC. When an average-sized slab is considered, say 45m^2, the conventional concreting approach measured here took 1 hour 42 minutes but the same slab with SCC took only 27 minutes – a time saving of 1 hour 15 minutes (and a reduction in gang size from four down to just two operatives).

Furthermore, conventional construction is subject to certain variables not seen in SCC construction, namely the unpredictability of curing that can delay the opportunity to power float. Observed examples in this study demonstrated such variability with power floating carried out at any point from two hours to two days after placement, which can in some instances force substantial out-of-hours working (Figure 3).

Dramatic effect

This variation can have a dramatic effect on construction and as-built costs (Table 1) and, if considered in the context of an entire project, a considerable rise in total project costs. As a consequence, SCC can present a more preferable construction option, not only for its

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more specific time and cost savings but also due to its predictability.

Constructing with SCC offers not only a simplified process, it is a method that does not permit any time delays – once started it must be finished immediately, controlling its predictability and therefore reliability in construction planning. It is possible, combined with time and cost saving, to substantially reduce project risk through the wider use of SCC. The SCC method can provide the project team with confidence that concrete operations can be completed as per the programme, avoiding delays to the project's critical path.

Benefits

SCC has been shown to be a versatile construction method; its ability to perform in specific and selected circumstances is not in doubt, but its viability for wider use has often been subject to debate. For the first time, not only have major benefits been confirmed but also the extent of the potential for SCC has been quantified and validated. SCC has been demonstrated to offer construction project time and cost savings, which is a direct challenge to those who claim that cost is a barrier to uptake[2].

Supporting this, the reliability and predictability of the SCC method offers further opportunities to assist the project management of a concrete construction site. While this research has focused on residential construction, the clear potential shown by SCC, exemplified in this research, can now be acknowledged and steps taken to incorporate it into suitable major construction projects. We welcome the opportunity to discuss these results further with any parties keen to make their concrete construction operations more cost-effective, reliable and efficient. ●

Further information:
This article is based on findings from a research project at Loughborough University focused on establishing the performance benefits of SCC, supported by EPSRC and Lafarge Aggregates, through the Centre for Innovative and Collaborative Engineering (CICE). The supervisors are Dr Jacqui Glass, Dr Chris Goodier and Professor Alistair Gibb. For further information on the research and forthcoming publications, please e-mail David Rich: D.Rich@lboro.ac.uk

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