Department for Transport

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Using cementitious mixtures at road works

This is one in a series of Traffic Advisory Leaflets providing guidance on methods of working and innovative techniques aimed at reducing traffic congestion due to road works. The series is aimed at utility companies, highway authorities, contractors, equipment suppliers and others involved in road (or street) works. Each leaflet in this series is based on research carried out by TRL Limited on behalf of the Department for Transport and Transport for London.

Figure 1 - Cement Bound Granular Mixture

Introduction

This Traffic Advisory Leaflet covers the use of cementitious mixtures in road work reinstatements and provides guidance on what is required before they can be trafficked or overlaid. The Specification for the Reinstatement of Openings in Highways (SROH) specifies how cementitious mixtures can be used. Use of cementitious mixtures outside the scope of SROH will require the agreement of the highway authority. Cementitious mixtures, including high early strength mixtures, are used to replace cementitious and unbound materials; they are not generally used to replace asphalt. Cementitious mixtures used in highway construction and maintenance works generally fall into three categories. In order of declining strength, they are:

- Concrete;
- Cement Bound Granular Mixtures (CBGM); and
- Foamed Concrete for Reinstatement (FCR).

These mixtures are used for different purposes. Typically, concrete is used to replace cementitious material in rigid pavements, CBGM is used to replace cementitious material in composite pavements, and FCR can be used to replace unbound materials in the base and sub-base of flexible roads and in footways. Figure 1 shows CBGM ready for discharge into a reinstatement.

While CBGM is preferred for replacing cementitious material in composite pavements that have a minimum asphalt overlay of 100 mm, FCR can also be used here. Concrete is not listed in the SROH as a reinstatement material in such cases, but it is known to be used.

CBGM or FCR can also be used to replace unbound materials in the sub-base of rigid and composite pavements. However, this requires very careful consideration because cementitious mixtures can make breaking out in future difficult. The short term benefits need to outweigh any such long term disadvantages.

A number of specialist concrete and FCR mixtures are also available with high early strength properties and some are designed to allow curing to take place at lower temperatures. The main advantage of FCR is the speed and ease with which it can be laid - it is self-levelling (see Figure 2) and does not need to be compacted. FCR is particularly useful where there is a need to return the road to use quickly. Concrete and FCR can also be useful for stabilising collapsed excavations in an emergency.

Figure 2 - Foamed Concrete for Reinstatement in use

Because of their free-flowing properties, concrete and FCR in particular have the potential to percolate into services buried below or alongside the immediate excavation. For this reason, these materials should not be used within 300 mm of a gas pipe, or where they might encase cables or hidden apparatus. Such penetration can make future access to the affected services difficult to achieve without damaging them on breaking out.

Strength requirements

Cementitious mixtures gain strength with time. Strength requirements for trafficking or overlaying can be specified by the compressive strength required, or by the time required for the mixture to achieve this strength.

The SROH has a compressive strength requirement for concrete in rigid roads (S7.3.6) of 25 N/mm². There is no equivalent requirement for concrete in composite roads. For CGBM as the base (S6.3.2), the SROH has a time requirement for it to cure in 7 days for Type 0 and 1 roads, and 3 days for Type 2, 3 and 4 roads, with the CBGM having to be overlaid, either immediately after compaction (see Figure 3) or following completion of these time periods.

Figure 3 - CBGM being compacted

The SROH has no requirement regarding trafficking for FCR other than “surfacing materials shall not be reinstated until the ARM has attained sufficient strength to allow adequate compaction of asphalt materials and to sustain adequate traffic loading” (ARMs are Alternative Reinstatement Materials, of which FCR is one type). The required ultimate strengths of Foamed concrete are given in Table A9.1. Guidance in SROH on the wider use of concrete is not available yet.

Although there are no explicit requirements in the SROH for FCRs, the same principles can be applied using 75% of the 28-day strengths of 1.5 N/mm^2 for C 1.5/2 and 3 N/mm^2 for C 3/4. The most comprehensive set of strength requirements is given in HD 27/04, Pavement Construction Methods (www.dft.gov.uk/ha/standards/dmrb/vol7/section2/hd2704.pdf)

which says (using the old nomenclature):

Before use by any traffic, the following are the characteristic compressive strengths which each pavement layer shall be expected to reach ….:

Pavement quality concrete surface slabs	*25 N/mm²*
Pavement quality concrete roadbases	*20 N/mm²*
Roller compacted concrete, cement bound material or wet-lean concrete of the following grades:	
CBM 4 or C20 concrete	*15 N/mm²*
CBM 3 or C15 concrete	*10 N/mm²*
CBM 2 or C10 concrete	*7 N/mm²*
CBM 1 or C 7 concrete	*4.5 N/mm²*

HD 27.04 does not include any requirements for FCR.

Evaluating properties for loading

Although the compressive strength required before trafficking or overlaying can take place can be specified, in situ strength measurement to confirm compliance is difficult and only happens in exceptional situations. However, some site tests (such as the Immediate Bearing Index test) can be used to estimate the strength before overlaying.

An easier alternative to measuring strength in situ is to specify the time after which the required strength should have been achieved. This approach is based on the predicted ultimate (or at least 28 day) strength and the assumed rate of cure for the mix in question. Actual cure rates can vary considerably and will depend on, for example, the use of accelerated curing mixtures to allow for early trafficking. The target minimum compressive strength for any cementitious mixture can be taken from HD 27/04, and is generally between 62% and 70% of the required 28-day strength.

The target time is the time required for the mixture to achieve the target strength. This can be derived from a typical plot of strength against time for the mixture in question. However, a reasonable factor of safety is required to allow for variability in the component materials, mixing, transporting and laying, and in the testing.

The conditions under which a cementitious mixture is placed and cured will affect early strength gain and ultimate strength. The target time on site will, therefore, most likely be different from that obtained by tests on cementitious mixtures prepared and cured under laboratory controlled conditions. Figure 4 shows samples being cured and tested in a laboratory. In general, early strength gain and ultimate strength are reduced in wetter and/or colder conditions.

Issues that need to be considered are the precision of the test, variability in the component materials, standards of workmanship (particularly compaction), and weather conditions (primarily moisture during laying and temperature during curing). Note that ground temperature is generally around 15°C at depth, which is less than the 20°C used for laboratory specimens, and this will slow the strength gain. Incorporating any precipitation that takes place during transporting, laying or compaction will increase the water/cement ratio and, hence, reduce its strength. Adding water to help the mixture flow will also have this effect.

Figure 4 - Laboratory curing and testing of cementitious mixture samples

Recommended further reading

- Specification for the Reinstatement of Openings in Highways. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/11042/sroh.pdf
- Specification for Highway Works. http://www.dft.gov.uk/ha/standards/mchw/vol1/
- Manual handling. (The Health & Safety Executive). http://www.hse.gov.uk/toolbox/manual.htm
- The safe use of vehicles on construction sites: A guide for clients, designers, contractors, managers and workers involved with construction transport. (The Health & Safety Executive). http://www.hse.gov.uk/pubns/books/hsg144.htm
- BD 21/01 The Assessment of Highway Bridges and Structures. http://www.dft.gov.uk/ha/standards/dmrb/vol3/section4/bd2101.pdf
- HD 27/04 Pavement Construction Methods. http://www.dft.gov.uk/ha/standards/dmrb/vol7/section2/hd2704.pdf
- The Construction (Design and Management) Regulations. http://www.legislation.gov.uk/uksi/2007/320/contents/made
- New Roads and Street Works Act 1991. http://www.legislation.gov.uk/ukpga/1991/22/contents
- The Street Works (Records) (England) Regulations 2002. http://www.legislation.gov.uk/uksi/2002/3217/pdfs/uksi_20023217_en.pdf
- The Construction Plant-hire Association publications. http://www.cpa.uk.net/publications/
- BS 5975:2008+A1:2011 Code of practice for temporary works procedures and the permissible stress design of falsework. http://shop.bsigroup.com/ProductDetail/?pid=000000000030240690
- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. http://shop.bsigroup.com/ProductDetail/?pid=000000000030258086

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