

Testing concrete —

Part 207: Recommendations for the assessment of concrete strength by near-to-surface tests

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Technical Sector Board for Building and Civil Engineering (B/-) to Technical Committee CAB/4, upon which the following bodies were represented:

- Association of Lightweight Aggregate Manufacturers
- Association of Metropolitan Authorities
- Association of Quality Pulverised Fuel Ash Suppliers
- British Aggregate Construction Materials Industries
- British Cement Association
- British Civil Engineering Test Equipment Manufacturers Association
- British Precast Concrete Federation
- British Ready Mixed Concrete Association
- Building Employers Confederation
- Cement Admixtures Association
- Cementitious Slag Makers Association
- Concrete Society
- County Surveyors' Society
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property Services Agency)
- Department of Transport
- Department of Transport (Transport and Road Research Laboratory)
- Electricity Industry in United Kingdom
- Federation of Civil Engineering Contractors
- Institute of Concrete Technology
- Institution of Civil Engineers
- Institution of Highways and Transportation
- Institution of Structural Engineers
- Institution of Water and Environmental Management
- National House-Building Council
- Sand and Gravel Association
- Society of Chemical Industry

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Nuclear Fuels plc
- United Kingdom Atomic Energy Authority

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Foreword

This Part of BS 1881 has been prepared under the direction of the Technical Sector Board for Building and Civil Engineering. All aspects of testing concrete are being included as Parts of BS 1881 from sampling fresh concrete to assessing concrete in structures. Part 201 gives general guidance on the choice of non-destructive test methods, including a bibliography, and should be consulted for advice on methods which complement the use of near-to-surface strength tests or are useful as alternatives.

In recent years, several tests and devices have been developed which give a measure of the insitu strength of concrete near to the surface. Carrying out near-to-surface tests requires only one face of the concrete to be available and this face need not be as smooth as that required for some alternative tests. Although most of these tests measure a property of concrete related to its strength, correlation with compressive strength has to be established experimentally. The results obtained may be used to estimate the strength of the body of the concrete. However, placing, compacting and curing may make the concrete in the surface zone unrepresentative of the concrete at deeper levels. For some methods the same correlation can be used over a wide range of concrete types but this is not universally true. Care should be taken to ensure that the correlations adopted are relevant to the circumstances of use.

Guidance on planning and interpreting tests to assess the strength of concrete in structures is given in BS 6089, which refers to the use of near-to-surface methods. The tests described in this Part of BS 1881 are those for which there is most experience at present. Other near-to-surface techniques may be proposed, usually to meet some particular need, and their use is not precluded by this Part. The recommendations of clauses 3, 4, 5 and 11 to 13 may usefully be applied to such methods.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of BS 1881 gives recommendations on tests that are designed to assess the strength of concrete by causing localized failure in a small zone, typically up to 75 mm from the surface, according to the method. The recommendations cover the following test methods:

- a) internal fracture;
- b) pull-out;
- c) pull-off;
- d) penetration resistance;
- e) break-off.

NOTE The titles of publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 1881 the definitions given in BS 1881-201 and BS 6100-6 apply.

3 General

It should be recognized that an individual test result indicates the quality of the concrete only in the immediate vicinity of the test point. The mean result from a number of tests is needed to estimate the average quality of the surface zone.

Near-to-surface tests should not be carried out where the surface concrete is known to be unrepresentative of the concrete in the structure, unless the purpose of the investigation is to assess the condition of this surface zone. In both cases, any correlation obtained as described in clause 11 will not be valid. The surface concrete can be damaged by aggressive agents such as fire, frost, corrosive liquids, etc. Tests should not be made on frozen concrete. The surface layer can also comprise a topping added subsequent to the compaction of the main body of concrete.

All the test methods described in this Part of BS 1881 produce a localized zone of surface damage. The need for localized repairs following testing, and the implications for the appearance and durability of exposed concrete surfaces, especially if the test is carried out adjacent to reinforcing steel, should therefore be considered.

It is important that tests should be performed by trained and experienced staff if worthwhile results are to be achieved and it is recommended that two persons should normally be involved during testing on site.

4 Applications

4.1 Comparative testing of concrete

Near-to-surface test values may be laid down so that tests can indicate when handling and transport of precast units, application of prestress and the removal of formwork or temporary supports for structural members may commence.

More detailed guidance on the use of near-to-surface tests for assessing formwork striking times may be found in CIRIA Report No. 73. These values should take due account of the limitations on accuracy of strength estimations for the particular test method used and the normal variations in properties within cast concrete.

The critical values for the near-to-surface test results should be established on the basis of laboratory calibration or past experience of performance. In acceptance testing or quality control procedures a small number of cores or destructive tests can be supplemented by a larger number of near-to-surface tests which are quicker to carry out and less damaging.

4.2 Estimation of in situ concrete strength

Near-to-surface tests can be correlated with strength tests on standard concrete specimens or on drilled cores. The estimation of strength in a concrete structure by near-to-surface testing should be made with considerable care and estimated values should be given only to the nearest 1 N/mm². In particular it should be remembered that the strength of the concrete near the surface may differ from that of the interior of a large mass and strength variations are likely to exist over the depth of a member. It is essential that test locations selected should be representative of the concrete under investigation. General guidance on the assessment of concrete strength in structures is given in BS 6089. Guidance on relating near-to-surface test results and strength is given in clause 11 of this Part. Although the most common correlation is with compressive strength, results may also be related to tensile strength.

4.3 Checking the uniformity of concrete

Near-to-surface tests can be used to define areas of different quality in a structural member and to locate areas appropriate for testing by other methods. The tests should be carried out at similar concrete maturity and ambient conditions. This approach can be applied to precast and in situ concrete.

4.4 Testing repairs to concrete

Some near-to-surface tests are also an effective means of checking the quality of repairs to concrete structures. When the bond between a substrate and a repair material is to be determined, either a pull-off test or break-off test should be used.

4.5 Long-term monitoring

Near-to-surface tests should be considered for use in situations where future deterioration of the surface concrete is expected and monitoring is required.

5 Choice of test method

Selection of the most appropriate method should take account of the purpose of the testing and practical factors relating to the nature and position of the concrete under investigation. These will include the availability and reliability of strength correlations, the acceptability of surface damage, size of member to be tested, test complexity and preparation, access requirements and test positions. Experience with all the methods described is based primarily on testing concrete containing aggregate of nominal size 20 mm or less. Caution should be exercised in interpreting results on concrete containing larger aggregates. More detailed guidance on planning an investigation is provided in BS 1881-201.

Some relevant details for each of the methods in this Part are given in Table 1.

6 Internal fracture test

6.1 General

The internal fracture test is based on the concept that a measurement of the tensile force required for a wedge anchor bolt to cause failure of the concrete can be related to the concrete compressive strength. Apparatus has been developed in which a bolt is inserted into a predrilled hole and loaded in tension through a reaction stand by means of a torquemeter acting on a greased nut. More consistent results are obtained using apparatus in which a direct axial load is applied to the bolt. See Figure 1(a).

A 6 mm diameter bolt set at 20 mm depth as described in 6.3 has been found to be suitable for use in concrete of compressive strength up to 40 MPa.

The recommendations in 6.2 and 6.3 are based on these sizes. If other sizes are used, different apparatus and criteria are required.

Table 1 — Summary of near-to-surface test methods

Test method	Number of valid tests required at a location	95 % confidence limits for strength estimate of in situ concrete	Correlation requirements	Preparation requirements
Internal fracture (clause 6)	6	$\pm 30 \%$	Specific to loading method and concrete mix	Hole drilling with masonry drill
Pull-out (clause 7)	4	$\pm 20 \%$	General for natural aggregates	Either (a) cast-in insert or (b) drilling and under-reaming with specialist equipment
Pull-off (clause 8)	6	($\pm 15 \%$ in laboratory conditions)	Specific to concrete mix	Providing a dry flat concrete surface Partial coring if required
Penetration resistance (clause 9)	3	$\pm 20 \%$	Specific to aggregate	No power supply or complex access required but safety precautions necessary
Break-off (clause 10)	5	$\pm 20 \%$	Specific to concrete mix	Test cylinder formed either (a) during casting or (b) by partial coring with specialist equipment