

Guide to

Assessment of concrete strength in existing structures

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- Incorporated Association of Architects and Surveyors
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Foreword

The need to assess the strength of the concrete in an existing structure can arise from a variety of reasons, such as doubts following non-compliance of standard cube strength results or possible deterioration due to aggressive environments or a wish to check that the strength is acceptable for a particular loading system, especially when additional loading is being considered.

The drilling and testing of cores has been common practice for many years and several non-destructive tests have been available, well established test methods being described in BS 1881 and BS 4408.

This guide presents information on the standard method and on certain other methods that will assist in the selection of the method and testing programme most appropriate to the circumstances that prevail. The interpretation of the test results and the factors that influence the relationship between the standard cube strength and the strength of the concrete in the structure are also discussed.

The recommendations in this standard are intended to provide guidance only; they are not intended to supplant engineering judgement or to inhibit the development and use of other test methods.

Numbers in parentheses in the text of the standard refer to the numbered references given in appendix A.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, 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 British Standard gives information on tests that are available to determine strength of concrete in a structure. Relative merits of these tests are indicated and methods of carrying out such tests are given.

This standard also contains guidelines to assist the engineer in interpreting results of tests, and outlines possible ways of comparing test results with the required strength for design purposes.

The information given in this standard amplifies sections of CP 110-1:1972 concerned with tests to measure and assess the strength of concrete in structures, including:

6.8.2.3 Action to be taken in the event of non-compliance with the testing plan.

9.2 Check tests on structural concrete.

2 References

The titles of the standards publications referred to in this standard are listed on the inside back cover. A bibliography of some appropriate references is given in appendix A.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1

standard cube strength

the measured compressive strength of a cube made, cured and tested in accordance with BS 1881-1, BS 1881-3 and BS 1881-4

3.2

cylinder strength

the compressive strength of a cylinder with a length/diameter ratio (λ) of 2 made and cured in accordance with clause 5 of BS 1881-3:1970, and tested in accordance with 3.2 of BS 1881-4:1970

3.3

core strength

the compressive strength of a core, cut, prepared and tested in accordance with the requirements of BS 1881-4, for a stated length/diameter ratio

3.4

estimated in-situ cube strength

the strength of concrete at a location in a structural member estimated from indirect means and expressed in terms of specimens of cubic shape

NOTE A direct measure of the in-situ cube strength cannot be obtained because it is not possible to produce a cast cubic specimen from that location. However, it is possible to obtain an estimated in-situ cube strength by using one or more of the methods described in clause 5.

3.5

location

a region of concrete that, for practical purposes, is assumed to be of uniform quality

3.6

characteristic cube strength

the value of the standard cube strength (which in CP 110 is measured at 28 days) below which 5 % of the population of all possible strength measurements are expected to fall

3.7

design strength

the strength of concrete as used in calculations so that the allowable stress as defined by the relevant code of practice or other design basis employed is not exceeded under the loading conditions appropriate to that code or other design basis

3.8

design load capability of a structural member

a level of loading that a structural member is designed to sustain with the appropriate partial safety factors against collapse, deflection or local damage

NOTE Direct measurement of capacity of a member to withstand such a load will not destroy the member under test unless this is inadequate for its envisaged purpose. (See 9.6 of CP 110-1:1972 for details of test loads and assessment of results.)

3.9

ultimate strength of a structural member

a measure of the maximum load that a member is capable of sustaining, the loading pattern being that applied in service

NOTE Direct measurement of the ultimate strength of a member results in destruction of that member, but in some cases it may be necessary to undertake such a test to assess the loadbearing capacity of similar members. (A suitable test method applicable to individual precast units is described in 9.5.3 of CP 110-1:1972.)

4 Planning an investigation

4.1 Information required from tests.

A knowledge of in-situ strength of concrete in a structural member may be required for one or more of the following reasons.

- Doubt concerning the strength of concrete in the structure as a result of non-compliance of standard cube test results carried out in accordance with a specified compliance plan.
- Doubt concerning workmanship involved in batching, mixing, placing, compacting or curing of concrete.

c) Deterioration of concrete due to:

- overloading;
- fatigue;
- chemical action;
- fire;
- explosion;
- weathering.

d) To ascertain whether the in-situ strength of concrete is acceptable for:

- the designed loading system;
- the actual loading system;
- a projected loading system for a new use.

Any structural investigation should be carefully planned and executed if the engineer is to obtain information which can be used to provide a reliable assessment of concrete strength in a structure. The detailed test programme will depend upon the reason for the investigation and whether:

- 1) an estimate of the in-situ strength of concrete in a structural member is required;
- 2) a comparison of the suspect concrete with satisfactory concrete in other parts of the structure is adequate;
- 3) the investigation is required on the immediate surface, near to the surface, or in greater depth;
- 4) additional information is required, e.g. uniformity and density of concrete and quality of materials used.

4.2 Acceptance of test data. Before any programme is commenced, it is desirable that there is complete agreement between the interested parties on the validity of the proposed testing procedure, the criteria for acceptance and the appointment of a person and/or laboratory to take responsibility for the testing.

4.3 Aspects of concrete strength. Table 1 provides a broad guide to various test methods to assess different aspects of the strength of concrete in the structure, or of a structural member.

4.4 Selecting a test programme

4.4.1 General. The test programme will be determined by the objectives of the investigation, the site conditions and economic factors, as outlined in 4.4.2 to 4.4.5.

4.4.2 Choice of test methods. The relative merits and limitations of tests for various depths from the surface are summarized in Table 2. The symbol **** indicates that the test compares well with other methods. The symbol * indicates that the test has disadvantages compared with others.

The particular test method used will depend upon the following.

a) *Test location* (see also 3.5). Factors to be considered include:

- 1) position of suspect concrete in the member;
- 2) position of highly stressed sections;
- 3) variation of strength through depth of lift;
- 4) position of reinforcement identified by the use of drawings or cover meter;
- 5) need to avoid detrimental effect on reinforcement;
- 6) presence of local defects that may influence test results.

b) *Effect of damage.* The choice between destructive and non-destructive methods be influenced by the effect of:

- 1) testing on the surface appearance of member;
- 2) drilling of holes (e.g. in small columns or retaining walls);
- 3) cutting of reinforcement.

c) *Testing accuracy required.* This will depend upon the nature of the investigation and, often, upon the magnitude of the measured strength; if the measured strength is considerably higher than that required, precision may not be necessary. The level of accuracy that can be achieved will depend upon:

- 1) test method;
- 2) number of measurements;
- 3) accuracy and reliability of available correlations (e.g. between pulse velocity and strength).

4.4.3 Accuracy of estimates of in-situ strength.

Confidence with which it is possible to assess in-situ strength of concrete will increase with the number of assessments made. In the case of some tests (e.g. ultrasonic pulse velocity, surface hardness) little extra cost is incurred by obtaining a large number of test results. In other cases (e.g. core and gamma-ray testing) the cost of each test is appreciable. The decision on the number and type of tests to be made will, therefore, be based upon an assessment of the cost of obtaining a result of adequate reliability.

Benefit may be obtained by combining different testing techniques, e.g. combining pulse velocity measurements with core tests. Pulse velocity measurements on cores prior to crushing can increase the accuracy of strength estimates from pulse velocity measurements. The ease of taking a large number of pulse velocity measurements on structural components can provide a more comprehensive evaluation of the strength of a structure.