LOK-TEST

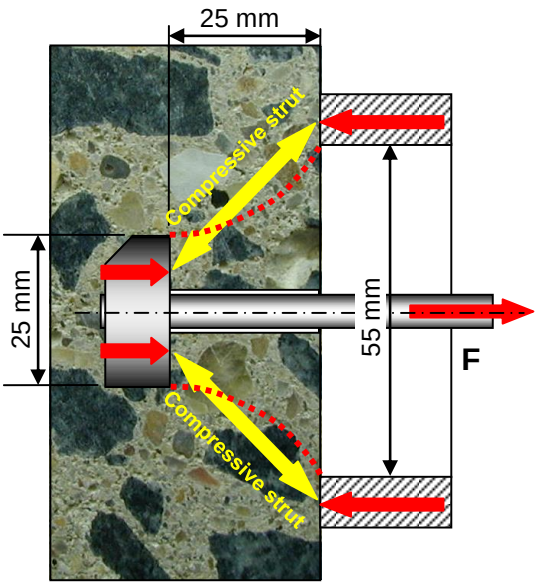
Purpose

The **LOK-TEST** system is used to obtain a reliable measurement of the in-place compressive strength of concrete in newly cast structures in accordance with the pullout test method described in ASTM C900, BS 1881:207, or EN 12504-3. **LOK-TEST** can be used for:

- Determining whether in-place concrete strength is sufficient for timing of early and safe loading operations, such as due to formwork removal or application of prestressing.
- Determining whether the in-place strength is sufficient for terminating curing and thermal protection.
- Quickly evaluating the quality of the critical cover layer protecting the reinforcement in the finished structure.
- Substituting laboratory testing cylinders or cubes for testing final strength of structures on-site.

Principle

An insert with a steel disc, 25 mm in diameter at a depth of 25 mm, is cast into concrete either by attaching it to formwork before placing concrete or by inserting it manually into the fresh concrete. Various **LOK-TEST** inserts are available. Deeper testing is shown in the Canadian Standard CSA A23.2-15C [14].



Once the concrete has hardened, the disc is pulled centrally against a 55 mm diameter counter pressure ring bearing on the testing surface. The force **F** required to pullout the insert generates compression stresses in the strut between the disc and the counter pressure ring. Therefore, the pullout force **F** is a direct measure of the compressive strength.

Loading is performed either to a required force, in which case the test is nondestructive, or to the peak-load, which results in a slightly raised, 55-mm diameter circular crack on the surface. If pulled out, the conical hole can be easily patched with a repair non-shrink mortar.

Correlation and Accuracy of Estimated Strength

LOK-TEST provides a quick and accurate estimate of in-place strength as the peak pullout force has a robust correlation to compressive strength measured either by standard cylinders or cubes. Test methods to estimate compressive strength like rebound hammer (Schmidt hammer), ultrasonic pulse velocity or Windsor probe, require individual correlations for every concrete mixture that are usually insensitive and present large scatter. By contrast, the more than 30 years of correlation experience with **LOK-TEST** and **CAPO-TEST**, from all over the world, indicates that **one general correlation** can be applicable for all normal density concrete mixtures. A significantly different correlation, however, has been found for concrete made with lightweight (low density) aggregate.

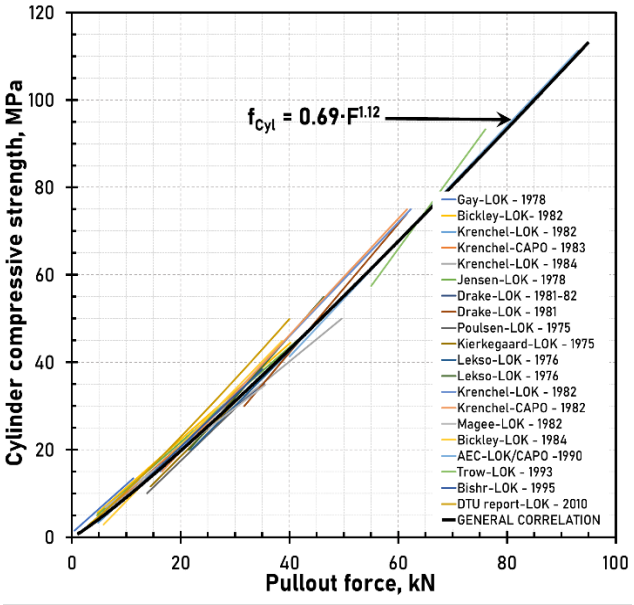
The general correlations between pull-out force and standard compressive strength shown in the following figures are summarized from 32 major independent studies performed by various laboratories in Denmark, Sweden, Norway, Holland, Canada, the United States, Poland, and England.[1,2,5]. It has been shown that these general correlations are not affected by types of cementitious materials, water-cementitious materials ratio (w/cm), maturity, use of self-consolidating concrete, air entrainment, use of admixtures, fibers, curing conditions, stresses in the structure, rigidity of the member, carbonation, as well as shape, type, and size of aggregate up to 38 mm.

Correlations have separately been performed in a large project at the University of Liverpool[3] aimed at methods for assessing early-age strength and whose efforts led to a Best Practice Guide by the British Cement Association[4] in which the pullout test is recommended for assessing early-age strength

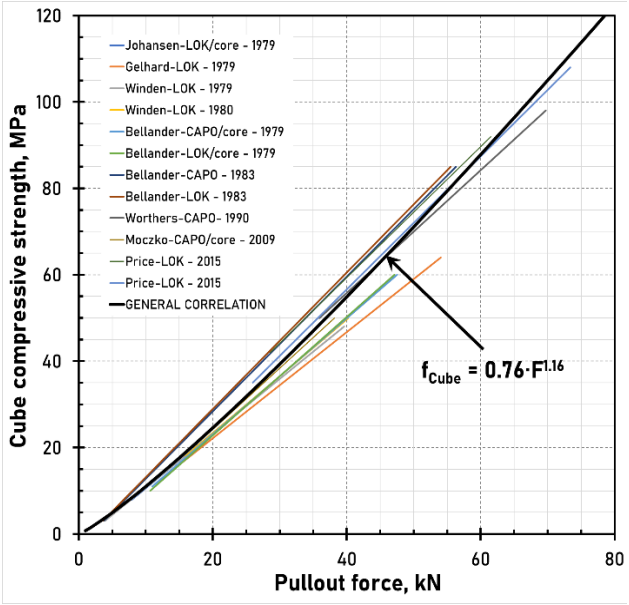
in new structures. In this British research, the general correlation between LOK-TEST and 150 mm cube strength was confirmed again for the normal-density concrete mixtures investigated.

Similarly, many reports have confirmed these findings[5,6,7,8]. In-place testing with pullout have even been used instead of using standard cylinders[7].

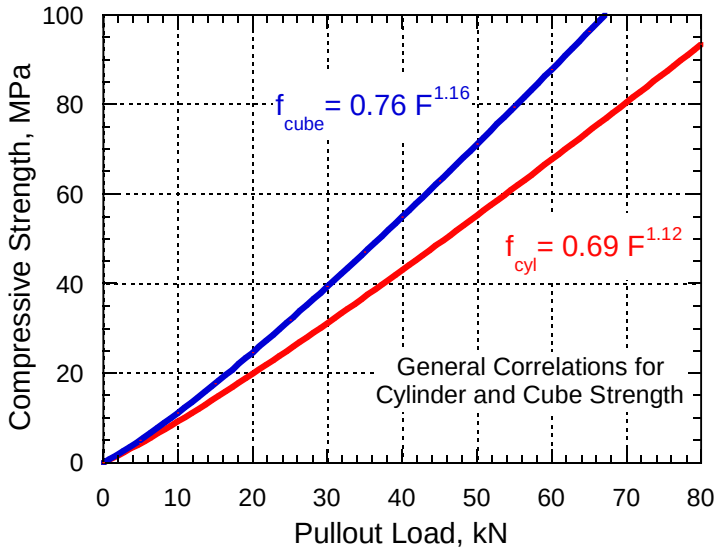
At the 95 % confidence level and for an average of 4 pullout tests, the estimated compressive strength based on the **LOK-TEST** and the general correlations indicated is within ± 4 % of the strength measured from tests of standard specimen (cylinders or cubes) for a maximum aggregate size of 38 mm. The coefficient of variation of individual **LOK-TEST** results is about 6 to 8 % for normal density concrete.



The best-fit curve to 18 correlations between pullout force and the compressive strength of 150 x 300 mm (6 x 12 in.).



The best-fit curve to 12 correlations between pullout force and compressive strength of 150 mm (6 in.) cubes



LOK-TEST

LOK-TEST inserts are supplied in four different configurations and in two strength classes: (normal strength) 0 to 50 kN and (high strength) 0 to 100 kN pullout force.

- **L-40** and **L-41**: Control inserts for nailing to wooden formwork. The formwork is removed before testing.
- **L-42** and **L-43**: Early stripping inserts, with a steel plate for attachment to a removable plug through a porthole in the formwork, for use if testing is performed before the formwork is removed.
- **L-45** and **L-46**: Disc and stem, only, for replacement of used inserts.
- **L-49** and **L-50**: Floating inserts for insertion into the top surface of newly cast concrete.

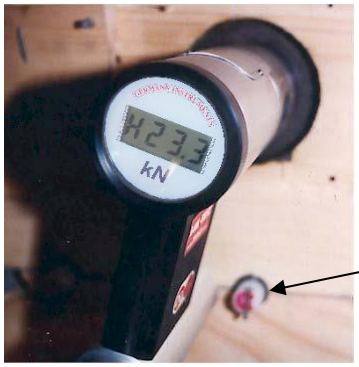
Normal strength, 0 to 50 kN

High strength, 0 to 100 kN

Example Applications

LOK-TEST *being performed on a wall for quality control of the finished structure. "H" on the display shows the highest pullout force. The L-40 Insert is used.*

Testing for in-place quality control on a slab. The L-49 floating insert is used. Maturity was measured with the **COMA-Meter**, *shown in front of technician's knee.*



COMA-Meter *reading 2 M_{20} days.*

LOK-TEST *performed from the bottom of a slab, through the formwork, for safe and early form removal. The L-42 early stripping insert was used with the L-44 steel plate attached to a removable plug through a porthole in the formwork.* **COMA-Meters** *are used for timing of the* **LOK-TEST**.

LOK-TEST

LOK-TEST Specifications

- Handheld hydraulic pulling machine with electronic gauge.
- Digital display resolution = 0.1 kN
- Maximum force: 100 kN
- Maximum stroke: 6 mm
- Accuracy of measurements: ± 0.1 kN
- Operating conditions: -10 to 50°C, max. RH = 95%
- Memory capacity: 512 measurements (peak-value, time and date of testing)
- AMIGAS Software for PC communication and printout

LOK-TEST Ordering Numbers

*The **L-11-1** pull machine can be also used for **CAPO-TEST** and **BOND-TEST**. See their Technical Data Sheets.*

LOK-TEST L-11 Kit

Item	Order #
Hydraulic pull machine with electronic gauge	L-11-1
AMIGAS Printout software	L-13
Cable for printout	L-14
Centering plate	L-15
Coupling	L-16
Pull bolt	L-17
Stem removal tool	L-18
Bolt handle	L-19
Adjustable pliers	L-20
Oil refilling cup	L-24
Oil refilling bottle	L-25
Large screwdriver	C-149
Small screwdriver	C-157
Calibration table	L-32
Manual	L-33
Attaché case	L-34

Inserts

Normal strength, 0 to 50 kN

Item	Order #
Control insert	L-40
Early stripping insert with L-44 steel plate	L-42
Disc and stem, thread locked and coated	L-45
Floating insert	L-49

High strength*, 0 to 100 kN

Item	Order #
Control insert	L-41
Early stripping insert with L-44 steel plate	L-43
Disc and stem, thread locked and coated	L-46
Floating insert	L-50

*For testing high strength inserts, a special high-strength pull bolt with flange is needed, **L-17-1**, along with the high-strength coupling device **C-141**.

Undamaged inserts may be re-used provided the discs are thread locked to the stems and coated with a coating agent, **L-29**.

Load Verification Unit

The calibration of a pull machine is recommended to be verified at least once a year, after servicing or after repair.

The **L-30** Load Verification Unit has a working range of 0 to 100 kN.

The load is displayed to the nearest 0.1 kN.

References

1. Petersen, C. G., "LOK-TEST and CAPO-TEST Pullout Testing, Twenty Years' Experience," NDT in Civil Engineering Conference, Liverpool, UK, Apr. 1997, 19 pp.
2. Krenchel, H., and Petersen, C. G., "In-Situ Pullout Testing with LOK-TEST, Ten Years' Experience," Presentation at Research Session of the CANMET/ACI International Conference on In Situ/Nondestructive Testing of Concrete, Ottawa, ON, Canada, Oct. 1984, 24 pp.
3. Soutsos, M. N.; Bungey, J. H.; and Long, A. E., "In-Situ Strength Assessment of Concrete, the European Concrete Frame Building Project," Department of Civil Engineering, the University of Liverpool, Liverpool, UK, 1999, 10 pp.
4. British Cement Association, "Best Practice Guides for In-Situ Concrete Frame Building: Early Age Strength Assessment of Concrete On Site," Crowthorne, Berkshire, UK, 2000, 4 pp.
5. Moczko, Carino, and Petersen, "CAPO-TEST to Estimate Concrete Strength in Bridges", ACI Materials Journal, Technical Paper No. 113-M76, V. 113, No. 6, November-December 2016, pp. 827 – 836.
6. Bickley, J.A.: "The variability of pullout tests and in-place concrete strength", Concrete International, Apr. 1982.
7. Bickley, J.A.: "Trinity Square: Commentary on Concrete Test Data", Cement and Concrete Aggregates, ASTM, 1984.
8. Bickley, J.A. & Hindo, K.: "How to Build Faster for Less- The Role of In-Place Testing in Fast construction", ACI 1994 Spring Convention.
9. Bickley, J.A.: "A Brief History of Pullout Testing: With Particular Reference to Canada, A Personal Journey", Tenth ACI Conference, Sevilla, Spain, Oct 2009.
10. Carino, N. J., "Pullout Test," Handbook on Nondestructive Testing of Concrete, second edition, V. M. Malhotra and N.J. Carino, eds., CRC Press, Chapter 3, 2004, 36 pp.
11. ACI Committee 228, "In-Place Methods to Estimate Concrete Strength", American Concrete Institute.
12. ASTM C 900-19: "Standard Test Method for Pullout Strength of Hardened Concrete".
13. EN 12504-3: "Testing concrete in structures – Part 3: Determination of pull-out force"
14. Canadian Standard, CSA Group: "Evaluation of concrete strength in place using the pullout test", A23.2-15C, 2014.