

# Effective In-Place Testing of Bond Strength with Swedish Friction Grip

by Erik Nordström and Jan-Åke Grändås

**P**ermanent modern shotcrete support in hard rock conditions is commonly based on achieving sufficient bond strength to the rock. A system with reinforced shotcrete with mesh reinforcement or fibers is dependent on the bond strength being able to carry loads from loose blocks. This is especially important where no, or very few, rock bolts are installed. Investigations<sup>1</sup> show this behavior clearly. In Sweden, a common requirement for the bond strength between shotcrete and rock is a minimum of 73 psi (0.5 MPa). It is also essential to have full interaction between different shotcrete layers with a bond level of at least 145 psi (1.0 MPa). Also, in the repair of old concrete structures, Swedish bond strength requirements for the interaction between old concrete and new shotcrete are at least 218 psi (1.5 MPa).

## Testing Bond Strength

For effective quality control of the aforementioned systems, bond strength should be verified. The two primary steps in performing these tests are: 1) drilling cores, and 2) testing the extracted cores in a laboratory or performing in-place testing. Because handling the cores after drilling increases the risk of damage (that is, microcracking and delamination), this type of testing is more vulnerable to producing lower bond strength results than properly executed in-place testing.

In-place testing of bond strength can be done in different ways. The traditional way is to drill a core, typically with a diameter ranging from 2 to 4 in. (50 to 100 mm), through the shotcrete and into the underlying substrate (for example, rock or concrete). Before drilling, the surface has to be prepared, by grinding, to get a smooth surface and to remove any loose or deficient material. To be able to apply a uniaxial load, a rigid steel disk has to be attached to the surface. Typically, this steel disk is glued to the surface with some type of epoxy glue. The process of grinding, gluing, and waiting for the glue to reach a sufficient strength level makes this type of testing very time-consuming. If there is water running on the surface, it may be almost impossible to get full interaction between the glue and the shotcrete.

## The Swedish Friction Grip

In the early 1970s, Vattenfall AB (formerly the Swedish State Power Board), the Swedish electrical power producer, developed a method to make it possible to perform in-place testing of bond strength without using glue. The so-called “friction grip” was developed to make this possible. Drilling is performed using a drill with double bits. Only the inner drill bit (inner/outer diameter = 2.8/3.4 in. [72/86 mm]) is drilling through the shotcrete and into the underlying substrate. The outer drill bit (inner/outer diameter = 4.1/4.4 in. [104/111 mm]) is only used to make a guidance



Fig. 1: Schematic sketch of drill with double bits (outer bit movable along the inner drill bit)

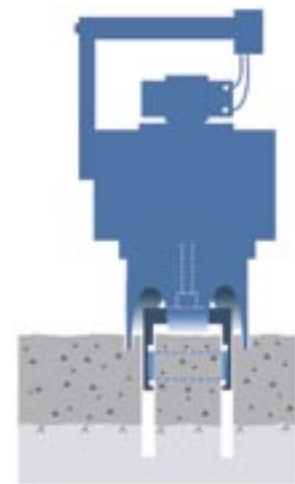


Fig. 2: Schematic sketch of testing device and core sleeve

notch for the testing device when applying the uniaxial load on the sample. The notch also ensures that the load is applied parallel to the drilling direction. After the guidance notch is created in the shotcrete surface, the outer drill bit is moved upward (refer to Fig. 1).

After drilling, the patented core sleeve is applied; and the shotcrete, via its cone-shaped ring core, is clutched to the core sleeve when reversed. After testing, the core only needs a slight tap in the other direction to be detached from the friction grip. The three-legged testing device is placed in the drilled guidance notch and connected to the core sleeve (refer to Fig. 2).

The testing device is used to apply a uniaxial load with an even rate of 363 psi/min (2.5 MPa/min) (according to the Swedish standard) with a small electrical motor until a rupture occurs in the sample. A recording unit is connected to the testing device and this registers the time and load during the test. A display shows the peak load value and the load/time diagram is plotted on a slip of paper. All data can be transferred to a file for further analysis with a standard personal computer. The recording unit (with a 12 V battery), testing device, and core sleeve are stored in a portable case (refer to Fig. 3). More technical information can be found on [www.nct.se](http://www.nct.se).

The maximum load is registered and presented in psi (MPa). In addition to the registered maximum strength level, the type of failure (A—in the shotcrete; B—in the interface between shotcrete and rock; and C—in the underlying rock) should be noted. If the failure is a combination of the aforementioned types, then the distribution is presented as a percent of the failure surface.

## Available Standards

Today, the Swedish friction grip is only a Swedish standard (SS 13 72 43). It's common practice for in-place testing of both shotcrete applied on rock and old concrete. The upcoming European standard for testing of bond strength does not deal with the



Fig. 3: Portable case with recording unit, testing device, core sleeve, and concrete sample

Swedish friction grip but still suggests the awkward method that involves gluing. In a previous edition of *Shotcrete* (V. 7, No. 1, Winter 2005, p. 18), an author also referred to the traditional gluing method when performing in-place testing according to the ASTM C 1583-04 standard.

## Future Development

Because the Swedish friction grip method saves so much time compared with other types of in-place testing, it should be beneficial for the method to be more widely used. One way to make the method more available to others would be to also adopt it as a standard in other parts of the world. The costs involved in quality control, especially when performed by a subcontractor, could be decreased with the Swedish friction grip. It's an effective way of testing bond because it eliminates the risk of damage to extracted shotcrete cores when sent to a laboratory for bond-strength testing.

## References

1. Holmgren, J., "Bergförstärkning med sprutbetong," Vattenfall, 1992. (in Swedish)



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