CAPO-TEST

Instruction and Maintenance Manual
for
CAPO-TEST EQUIPMENT

November 1st, 2018

CAPO-TEST in progress for testing the compressive strength of joints
at the Ohio River Bridge, Louisville, Kentucky, USA

GERMANN INSTRUMENTS A/S
Emdrupvej 102 - dk-2400 Copenhagen Nv - Denmark
Phone: (+45) 39 67 71 17 - fax: (+45) 39 67 31 67
e-mail: germann-eu@germann.org, internet: www.germann.org

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Test Smart – Build Right

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This manual does not address all of the safety concerns, if any, associated with the use of the test system. It is the responsibility of the user of the equipment to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Contents

1. The CAPO-TEST Equipment

To perform the Capo-Test, the following equipment is needed:

The Capo-Test Preparation Kit (C-101), fig. 1
The Capo-Test SV Kit (C-102), fig. 2, optional
The Capo-Test Hydraulic Pull machine (C-104), fig. 3
Drill machine 650 W
Capo-Inserts (C-112), one for each test, fig. 4
and
A cover meter
Bucket with water (2-3 liter per test)
Electricity (junction box with min. 4 outlets & extension cord)

The Capo-Test SV kit (C-102) is used to ensure the correct initial operations, coring of the center hole, planning of the surface and recess routing, using the suction plate. There has to be a sufficient large surface area available (350 mm in diameter) and a rather smooth and air tight surface for the suction plate to operate.

Otherwise, the initial three operations have to be performed hand-held, section 2.2.2, page 12

1.1 CAPO-TEST Preparation Kit, C-101

1.Vernier caliper for check of router dimensions
2.Two water hoses
3. Screwdriver for breaking the core
4.Tweezers for removing of center hole core
5.Two 14 mm wrenches
6.In pouch, one green diamond drill bit for use with suction plate (only if the SV-Kit is ordered
7.Marking chalk
8.One 13 mm and one 17 mm wrench, for dismantling the router shaft from the recess router machine
9.Two 19 mm and one 17 mm wrench, for unthreading the coring bits (red or green) or the diamond planner
10.Allen key 4 mm for recess router housing dismantling
11.CAPO oil
12.Centering brass governing rod, fig.30
13.Water pump
14.Counter pressure
15.Expansion unit with coupling (inside the counter pressure), fig. 32
16.Diamond surface planner, fig.30
17.Planner housing for diamond surface planner, fig.30
18.Drill housing with red diamond bit, fig.29
19.Diamond recess router, fig.31
20.Separately delivered, 600 W drill machine

Tray containing:

21.Distance piece 25 mm for check of router bit position
22.Flange for surface planner unit, fig.30
23.Wrench, 46 mm
24.Adjustable wrench
25. Metal detector for reinforcement location
26.Flange for drill housing, fig.29

Fig. 1 The CAPO-TEST Preparation Kit, C-101

1.2 1.2. The SV-Kit (Suction plate and Vacuum pump), C-102

(Previously named the “DSV-Kit”)

Fig. 2. The SV-Kit, C-102

1.3 CAPO-TEST Hydraulic Pullmachine, C-104

The Hydraulic Precision Pull Machine is shown in fig. 3.

This machine is supplied with an electronic microprocessor gauge that features digital readout of the pull force with 0.1 kN least division. The maximum pull force is 100 kN equivalent to 119 MPa (16,800 psi) standard cylinder compressive strength or 146 MPa (20,700 psi) standard cube compressive strength.

It has maximum hold position after the test has been completed, and the last performed 500 test results are saved in the gauge’s computer allowing the results to be printed out via an office PC. The following information is given: test number up to 65,000, peak value in kN, date and time of testing, along with instrument identification number and last calibration date.

The loading takes place by hand-operating the outer handle in a steady motion producing a constant uniform loading rate. One pullout has to last at least 15 seconds from start of loading until rupture of the concrete tested.

1.Manual and calibration certificate, calibrated to either standard cylinder or to standard cube strength, as required
2. AMIGAS printout software on CD
3.The hydraulic pull machine
4.USB computer cable
5.Spare AA batteries, 4 pcs
6.Small screwdriver for removal of top sign, if oil refilling is needed
7.Large screwdriver for removal of top screw when oil refilling is needed
8.Bottle with 1000 cts silicone oil for refilling
9.Cup for refilling

In the case are cut-outs prepared for parts to be used for LOK-TEST and BOND-TEST with the same pull machine calibrated for

Fig. 3. The Capo-Test Hydraulic Pull Machine, C-104, with Electronic Microprocessor Gauge

1.4 CAPO-Inserts, C-112

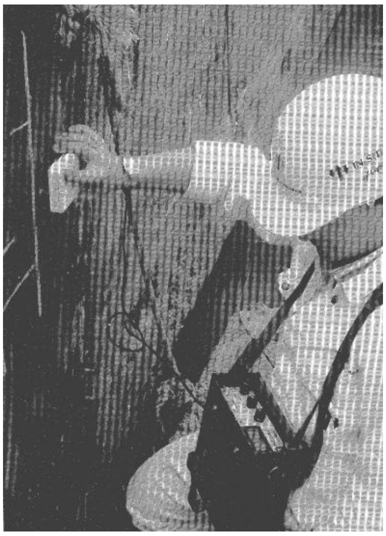
Fig. 4. CAPO-INSERTS, supplied in bags of 10 pcs, C-1122.

2. Test procedure (Instruction video on Google: "CAPO-TEST video")

When testing needs to be done it is important to bring the parts mentioned page 3 along with a sufficient number of Capo-inserts. Make sure the checklist page 34 has been completed and signed by the technician. Water and electricity supply should be brought along if not available at the testing site.
Submerge the dive pump with attached hose into a bucket of water. Connect all the electrical tools to the electricity outlet box. The testing then takes place as outlined in the following.

2.1 Locating the reinforcement

The reinforcement is located using a cover meter or the metal locator (item 20) supplied in the CAPO-TEST Preparation Kit, fig. 1.



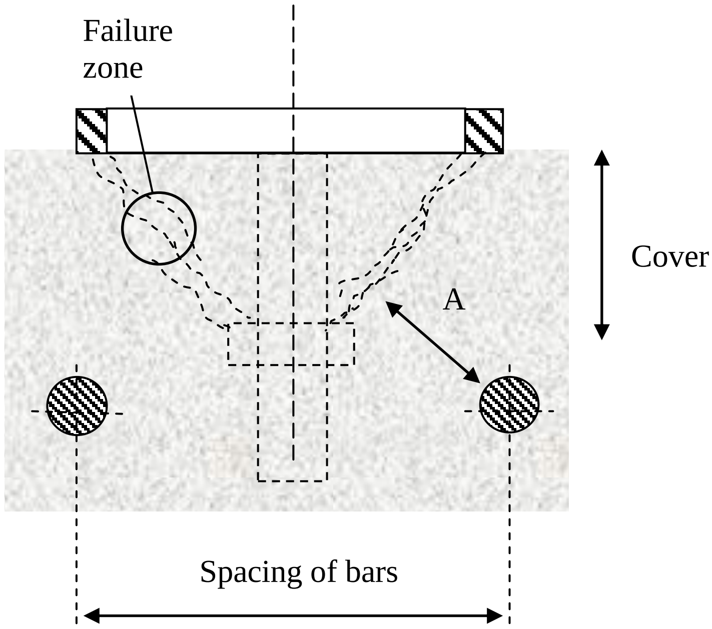


Figure 5: Cover meter measurement for location of the reinforcement.

The test location is selected, in the middle of the reinforcement mesh. The distance "A" from the reinforcement to the failure zone has to be minimum the maximum aggregate size

1.For a cover more than 25 mm
The spacing of the reinforcement is of no importance. Select the position of the CAPO-TEST in the middle of the rebar mesh to avoid rebars during coring and recessing.
2.For a cover less than 25 mm
The distance "A" in fig. 7 has to be > 12 mm, no matter the maximum aggregate size.
The practical rule for a cover less than 25 mm is that the spacing of the reinforcement has to be more than 75 mm.
Select the position of the CAPO-TEST in the middle of the rebar mesh to avoid rebars during coring and recessing.

The test location has to be minimum 100 mm from any edges and corners, otherwise radial cracking may turn up during pullout. Such radial cracking will produce a slightly lower pullout result. If more than one test is required in the same area, the tests are placed in the same horizontal layer with an internal distance of minimum 200 mm, maximum 300 mm. It is recommended to test a minimum of two Capo-Test inserts in the same area and the use the average as one observation.
Mark the test locations.

2.2 Coring the center hole, planning the surface and routing the recess

To perform correctly the coring of the center hole, the planning of the surface and the routing of the recess, it is advised to use the suction plate – at least until proper training is achieved - to control the operations as outlined in section 2.2.1 below. However, using the suction plate may be impossible if the surface is highly permeable, rough, curved or if the space is limited. Also, a well-trained technician may consider the use of the suction plate to be tedious and time consuming. In such cases, the three basic operations are performed as outlined in section 2.2.2 page 13.

2.2.1 Testing with the suction plate

The two blue fastening pliers are attached to the suction plate with the nuts. The pliers should be able to rotate. The vacuum hose is connected to the inlet nipple of the suction plate. Turn on the vacuum pump and press the plate against the concrete surface. A clear change in the sound emission from the vacuum pump can be heard when the vacuum is established. The vacuum gauge will show the vacuum, usually around –0.8 BAR. The vacuum plate is now firmly attached to the concrete surface.

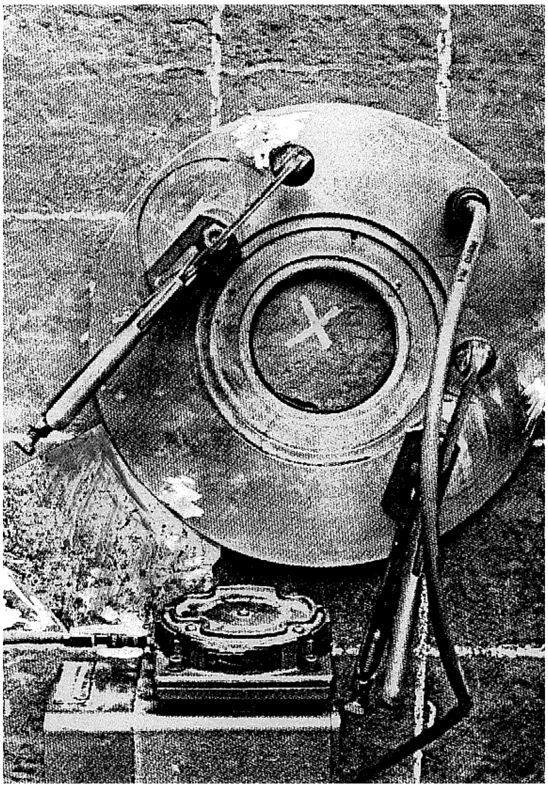


Figure 6: The vacuum plate attached to the concrete surface.

2.2.1.1 Center hole coring

Place the drill unit with the green diamond bit centered in the suction plate. Adjust the pliers and tighten them against the flange, figure 7. Attach the water hose from the pump to the drill housing nipple closest to the drill machine. Another hose may be connected to the outlet nipple for waste water to be hosed away.

Activate the water pump and wait until water flows easily through the system. Then press axially on the drill machine and drill to maximum depth. Make sure the water is flowing all the time and it is colored with waste material. During drilling the drill machine has to be pulled backwards for each 3-4 mm cored to allow the water efficiently to flush away waste material from the tip of the drill bit.

Should water not flow through the system the cause may be blockage at the diamond tip slots. In this case release the pliers and clean the slots

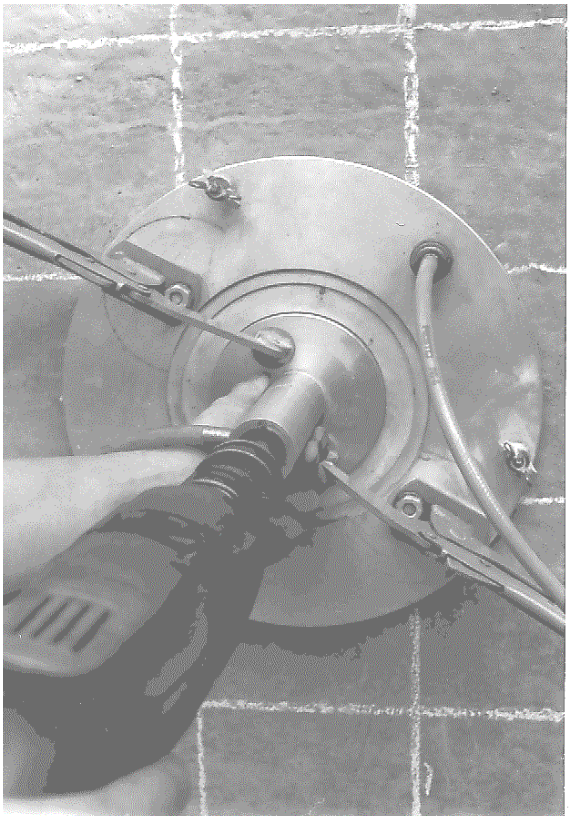


Figure 7: Drilling of the center hole with the drill unit attached to the vacuum plate.

Note:
Coring with the green diamond bit produce the quired depth. Should the green bit be too long (depending on the height of the suction plate after suction, the red bit is initially used followed up by the green bit

The drill machine is pulled back, still while turned on. The blue fastening pliers are released by pressing the top knobs downwards. The drill unit is removed.

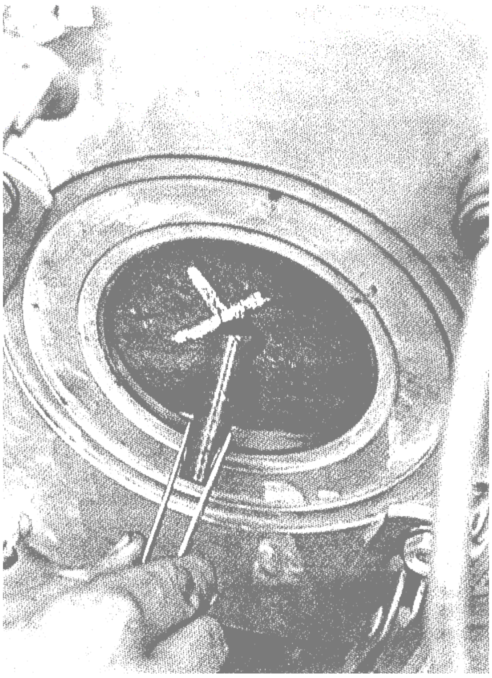


Figure 8: The drilled core is broken with the screwdriver and removed in its full 65 mm length by means of the tweezers.

The core is excellent for evaluating the depth of carbonation, after it has been sprayed with the Deep Purple or the Rainbow Indicator.

The core left standing in the concrete is broken with a screwdriver (press gently the core side-wards) and removed it with the tweezers. The core may be sprayed with Deep Purple or Rainbow Indicator to measure the depth of carbonation.

Make sure the core is removed in its full length 65 mm so the expansion unit, when inserted in the hole, rests with the sliding disk against the surface. Otherwise, remove the remaining part with the screwdriver (twist it at the bottom, remove the concrete particles with the tweezers and flush with water).

NOTE: Only use the coring equipment supplied for coring the center hole. Using a masonry drill bit will not work, causing cracking in the concrete, the recess routing to be inaccurate, trouble with inserting and expanding the expansion tool, and not at least to produce erroneous test results

2.2.1.2 Planning of the surface

The diamond surface-planning unit connected to the drill machine is attached to the suction plate as with the drill unit. The water supply hose and waste water hose is connected to the two nipples of the housing, the inlet hose to the nipple closest to the drill machine.

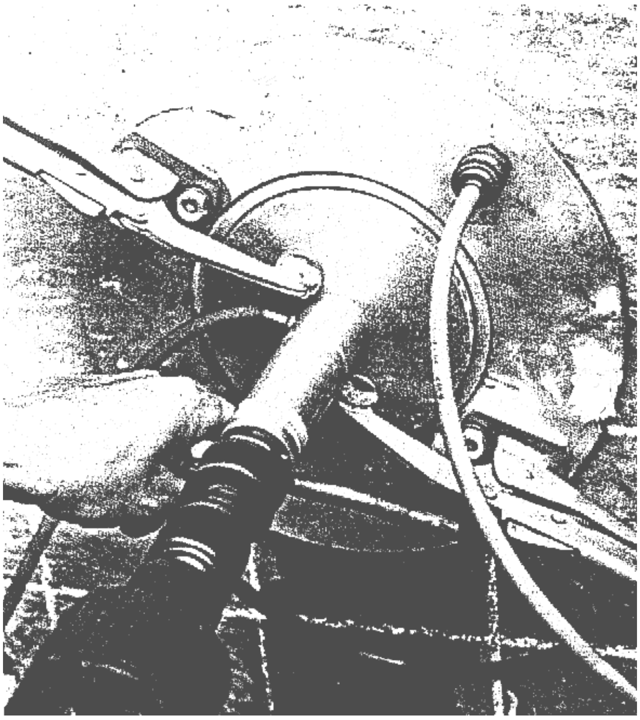


Figure 9: Planning the surface with the diamond surface-planning unit attached to the suction plate.

Plan to a depth of 2-4 mm

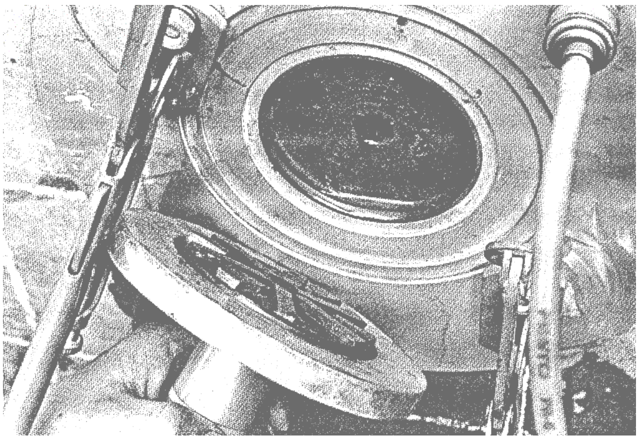


Figure 10: Completed surface planning.

NOTE: Always use the surface planner, no matter how plane the surface may be.

Water is supplied by means of the water pump. Surface planning takes place by pressing the drill machine axially. Then the surface should be completely flat and plane as illustrated in figure 10. The blue pliers are released by pressing the two top knobs downwards and the unit removed.

2.2.1.3 Routing the recess

The recess router is inserted in the center hole, fig. 11, Water is supplied to the nipple (use only a limited amount of water) and the flange of the housing is pressed against the concrete surface and should remain so during the recess routing. The machine is turned on and the flange is moved in bigger and bigger circles sideward until the flange follows the suction plate in it total inner circumference, see arrow fig. 12. Keep all the time the flange pressed firmly against the surface of the concrete as illustrated. Note the positioning of the fingers in fig. 12.

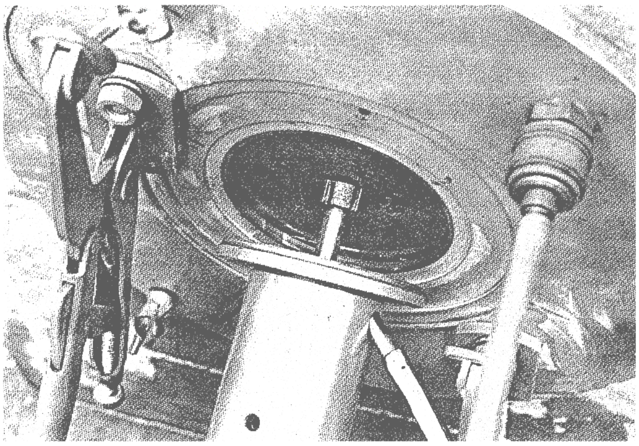


Figure 11: The recess router is inserted in the drilled hole.

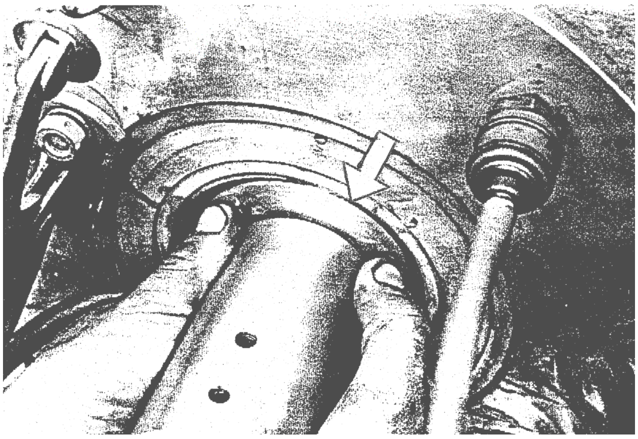


Figure 12: Routing the recess.

NOTE the positioning of the technician's fingers.
Recess routing takes place until the flange of the recess router follows the inner cavity of the suction plate

The machine is turned off, the water supply stopped and the recess router removed.

NOTE: During the initial three operations water is required. It is important to keep the hands and all the electrical parts dry to avoid electrical shocks or circuit shortcuts. To meet this requirement, use as little water as possible and only when needed. Use the on-off valve on the drill and planning housing frequently. Only use limited amount of water when routing the recess. It is also important to maintain the equipment as described in clause 3 to avoid excessive water leakage. Also blot dry any excessive waiter on the equipment.

As a substitute for water, compressed air may be used, especially if testing has to be made from below and upwards.
Floating nitrogen has also been used to avoid water spillage.

Turn off the vacuum pump. Release the hose nipple from the vacuum plate valve by pressing the nipple ring towards the plate. Release the vacuum by inserting a screwdriver in the bottom of the valve and press it downwards. Keep a firm grip on the plate. Continue as instructed in clause 2.3 page 14

2.2.2 Testing without the suction plate

If the suction plate is not used, the coring of the center hole, the planning of the surface and the routing of the recess are performed by hand as outlined in the following three sections.

2.2.2.1 Center hole coring

The drill unit with the red drill bit is connected to the drill machine and to the water hose, the inlet hose to the nipple closest to the drill machine.

NOTE: The green drill bit used for coring with the suction plate is 9 mm longer than the red diamond bit to compensate for the height of the suction plate, and achieving the proper length of the cored hole, 65 mm deep for the expansion unit to be fully inserted in the cored hole.

The flange is pressed against the concrete surface, water is activated, the inlet valve opened and the drill machine turned on. Press the flange firmly against the surface all the time. Press the drill machine axially and core to half depth, fig. 13. Pull back the unit, break the core with the screwdriver and remove the core with the tweezers. Continue drilling to full depth and remove the core all the way to the bottom, 65 mm.

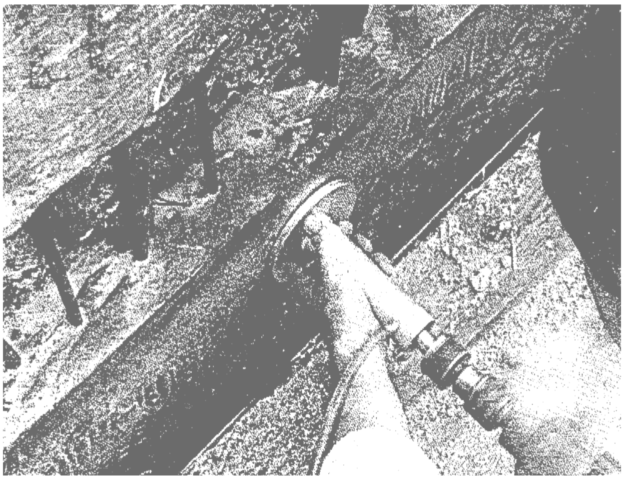


Figure 13: Drilling of the center hole by hand.

2.2.2.2 Planning of the surface

The governing brass rod is inserted in the hole and the diamond surface-planning unit is placed centered on the brass rod. Water is supplied to the inlet nipple closest to the drill machine. The flange is pressed with one hand against the surface and with the other hand the drill machine is turned on and pressed against the surface, fig. 14.

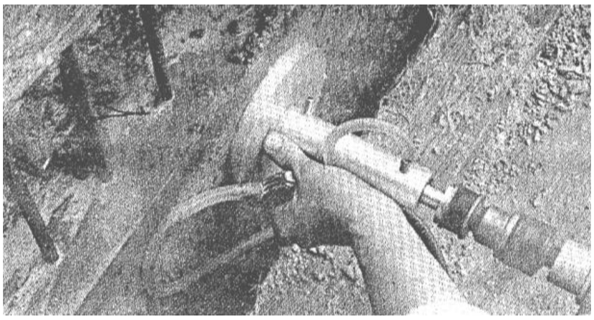


Figure 14: Surface planning by hand.

Step on the flange if testing has to be made up-side-down.

Make sure the complete testing surface is planned, fig. 15.

Figure 15: Completed surface planning

The governing rod is removed.

After completion of the planning, the surface should look like shown in fig. 16.

Figure 16: Close-up of the completed surface planning. The governing brass rod is removed.

2.2.2.3 Routing of the recess

The recess router diamond is inserted in the hole. Water is supplied to the nipple of the housing. The flange is pressed towards the surface, see fig. 17, and the machine is turned on.

Move the flange in bigger and bigger circles until the router shaft follows the circumference of the cored hole.

The flange of the router has to be pressed against the surface and follow the circumference of the planned surface.

The flange has to be moved sideward 3,5 mm, which is half the difference between the diamond recess router (18 mm) and the router shaft (11 mm) diameters. Rout until the flange follow the circumference of the planed groove.

Also a clear change in the emitted sound from the routing may be observed at that stage. The recess routing usually takes 10-15 seconds.

NOTE: It is important to press the flange against the surface with the fingers positioned as shown in fig. 17.

Figure 17: Recess routing by hand.

The router flange is all the time pressed against the planned concrete surface

NOTE: Do not continue routing after the recess has been completed. Such excessive routing will only wear the router shaft holding the diamond to a smaller dimension, producing a larger recess than required. Also, the drilled hole will be enlarged. The diameter of the recess has to be within the tolerance 25.0 mm to 25.4 mm for the Capo-Insert to expand properly, page 32.

2.3 Expansion of the Capo-Insert

Assemble the expansion unit correctly, page 19.

The coupling of the expansion unit is unthreaded from the expansion unit, which is inserted in the center hole, fig. 18. If the hole has been drilled to full 65 mm depth and the core totally removed, the flange of the expansion unit should rest against the surface with the sliding disc in between.

If the depth is insufficient, resume coring. Break the remaining core with the screwdriver and remove it with the tweezers. Remember to flush with water to remove left-over particles inside, especially in the recess. Left-over particles in the recess may prevent the insert from being expanded properly.

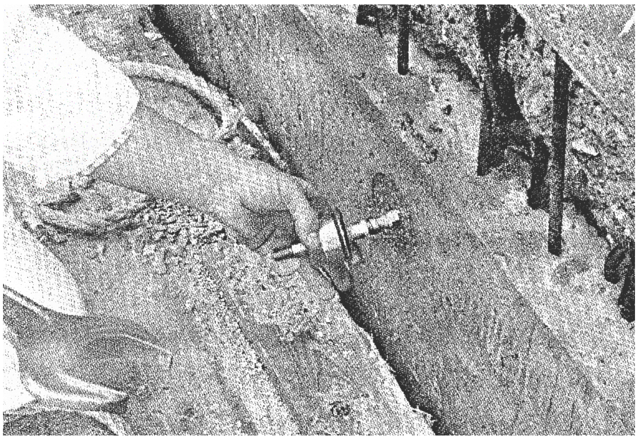


Figure 18: The expansion unit is inserted in the hole.

Make sure the expansion unit is correctly assembled, section 2.9 and insert it into the hole

Hold the base pull bolt of the expansion unit in the same position with the adjustable 12” wrench and turn the big nut clockwise with the 46 mm wrench, about 9 rotations.

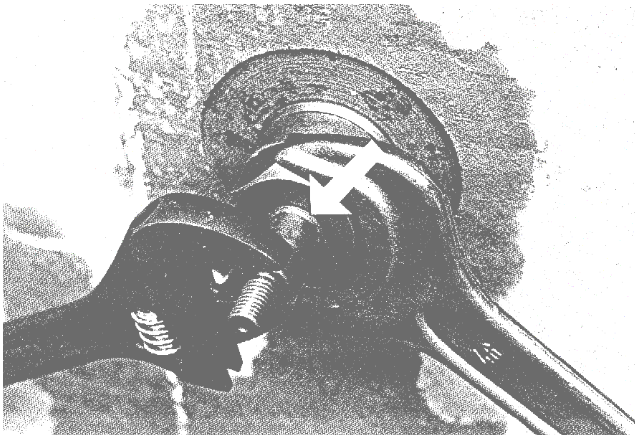


Figure 19: Fully expanded Capo-Insert.

NOTE: The thread of the base pull bolt has emerged above the nut (see arrow).

When the expansion of the Capo-Insert has been completed, the thread of the base pull bolt will emerge and a hard resistance will be felt. Then, back off the nut 1/8 rotation anti-clockwise, still with the base pull bolt kept in the same position with the adjustable wrench.

2.4 Attachment of the counter pressure and the coupling

The counter pressure is placed around the expansion unit with its plane face resting against the concrete surface. Then, thread the coupling on the base pull bolt 2-3 rotations. Make sure the three small pins of the coupling are pointing towards the concrete.

Figure 20: Counter pressure and coupling installed.

2.5 Coupling of the hydraulic pull machine

The Capo-Test hydraulic pull machine's telescoping handle, see fig. 33, page 28, is rotated anti-clockwise 39 rotations to its fully extended position.

Use the inner handle to quickly extract the telescope. The front casings three large screws are governed into the holes of the coupling. The instrument coupling plate has to flush with the coupling pressed against it. Twist the coupling through the front port holes 1/4 rotation anti-clockwise to fully coupled position, fig. 21.

Make sure the coupling is fully engaged.

Figure 21: Coupling of the hydraulic pullmachine.

NOTE: A gap (see arrow) is left between the instrument from casing and the counter pressure.

The instrument has now been coupled, but there is still a gap between the front instrument casing and the counter pressure. This gap is removed by turning the instrument clockwise. Make sure the recess of the counter pressure catches the 55 mm in diameter instrument front hole.
NOTE: The base pull bolt must not turn with the coupling during this operation. If it turns, then
uncouple, remove the instrument, coupling and counter pressure, and tighten the nut further, relative to the base pull bolt. Reassemble the parts and remove the gap as illustrated on the previous page.
The instrument is now in full contact with the counter pressure and ready to be loaded.

2.6 Pullout

Press the green gauge activation button half a second. When turning on the gauge and the display show “0.0” kN the gauge is reset and has an internal accuracy of 0.01 kN. If it shows “-0.0” or e.g. “0.1” resetting takes place as follows:

Press the activation button until “----“ and “-00-“ is indicated.
Release the button. “0000” is shown and the gauge turns off
Turn on the gauge. “0.0” kN is now shown and the gauge has been reset

If the gauge is not showing “0.0” at the beginning of the loading, the Highest Value will not be shown at the end of the pullout.

Hold one hand on the pistol handle between the two cylinders of the pull machine. Loading is commenced by turning the loading handle (use the outer handle knob) clock-wise at a speed of about one rotation per two seconds, constantly all the time, until rupture occurs.

The digital display will indicate the pull force in kN (kilo Newton). Before the peak-load occurs, the kN loading rate will decrease. Keep on turning the handle with one rotation every two seconds. After the peak-load has been reached, the handle is turned quickly clock-wise until no more travel is left on the telescope handle.

Usually, the instruments 7 mm travel is sufficient for releasing the pullout cone. Should the travel be <5-6 mm refill the oil as instructed in section 3.6.1, page 27.

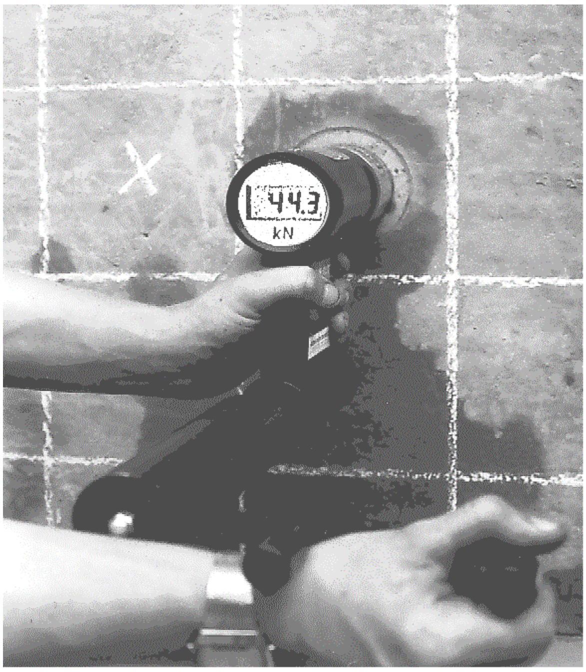


Figure 22: Loading of the Capo-Testing in progress.

NOTE: Keep a firm grip on the pistol handle, all the time. The pullout cone may come out abruptly, especially if high-strength concrete is tested. Also it is important to produce a sharp 55 mm diameter counter pressure edge left by the pullout cone, after the test has been completed, to make sure the test has been correctly performed. This edge will not be sharp if the instrument is not supported in a firm grip by one hand in the final pull-out sequence.

If the pullout cone has not been released when the telescoping handle has been turned all the way to the bottom position, turn the handle anti-clockwise 15-20 rotations, uncouple and engage the coupling another 2-3 thread, couple and load again. The changed position of the coupling on the base pull bolt will give an extra travel to the instrument. Repeat the loading. Then the pullout cone will be released.

NOTE: If the hydraulic pull machine has been fully oil-refilled and correctly attached, the pullout cone will usually be released the first time the loading is performed.

To release the pullout cone DO NOT TWIST OR PULL THE INSTRUMENT. Such abuse will only damage the instrument and create oil leakages.

Also failure on the surface will be non-acceptable .

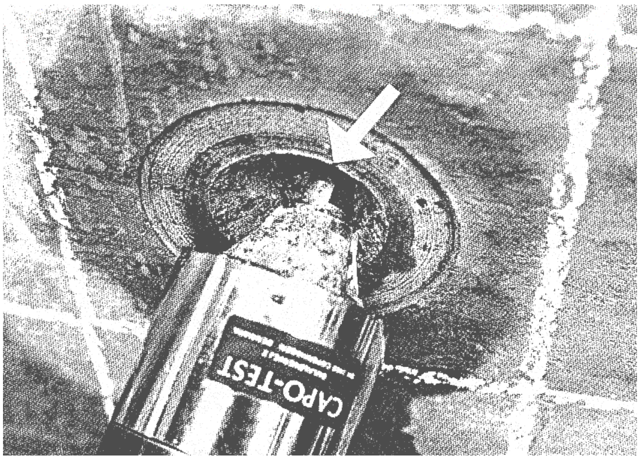


Figure 23: Acceptable CAPO pullout cone fully dislodged.

NOTE: The sharp 55 mm edge (arrow) from the counter pressure.

The peak-value will, after the test has been completed, be shown on the display with an “H” in front, “H” for highest.

The peak-value is saved in the gauge’s microprocessor for later print-out. Turn off the gauge by pressing the button and releasing it.

Printout of the test data is made at the office as instructed in section 7, page 36.

2.7 Transforming the pullout load to compressive strength

The peak-load in kN is written on the concrete surface together with the instrument – and technician ID-number and the date of testing. The data are entered in the logbook with all the relevant data related to the testing and is statistically evaluated according to the specification requirements.

The peak-load in kN is transformed to actual pull force in kN and correlated to compressive strength in MPa (or PSI), either to cylinder strength or to cube strength, tabulated in the hydraulic pull machine’s calibration table. The equations for the general correlations to either standard cylinder strength or standard cube strength are stated in ref.2 page 45 and the CAPO-TEST video on Google. Normal variations in ref. 4 and 5.

2.8 Disassembling the expansion unit and re-assemble it

Turn the coupling through the front instrument port holes clockwise. Remove the coupling with the expansion unit, counter pressure and dislodged pullout cone from the instrument. The coupling is unthreaded from the base pull bolt and the counter pressure is removed.

The expansion unit is disassembled by holding the base pull bolt in a fixed position with the 12” adjustable wrench and turning the recessed top part of the cone pull bolt clockwise with a 14 mm wrench.

Unthread the cone pull bolt fully from the base pull bolt. Remove the pullout concrete cone and place it in a plastic bag, properly labeled. The unfolded Capo-insert is hit gently axially on the cone pull bolt, released and removed.

Expanded Capo-Inserts rings may be reused after resizing of the rings as illustrated in section 8, page 42.

2.9 Assembling the expansion unit

All parts are cleaned. The threads and the surface below the sliding disc are oiled with Capo oil. A new Capo-Insert is installed and the expansion unit reassembled as shown in the figures 24-28.

Figure 24: The Capo-Insert is mounted on the cone pull bolt with the inner sharp edge resting against the cone. Remember to oil the cone with Capo oil.

Figure 25: The base pull bolt threaded partly into the nut.

NOTE: The line (arrow) on the base pull bolt has to be flush with the surface of the nut when the base pull bolt is fully threaded into the nut.

Thread the base pull bolt fully into the nut

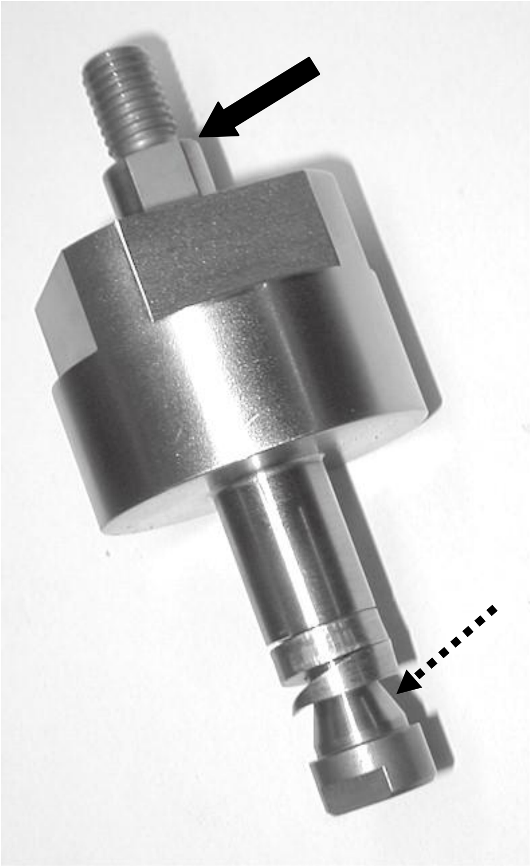


Figure 26: Hold the base pull bolt (thick arrow) with two fingers and thread the cone pull bolt (dotted arrow) with insert fully into it, left-hand thread

NOTE: Do not hold the nut, doing so may un-thread the base pull bolt from the nut preventing the right distances to be obtained.

These operations should be done by hand.

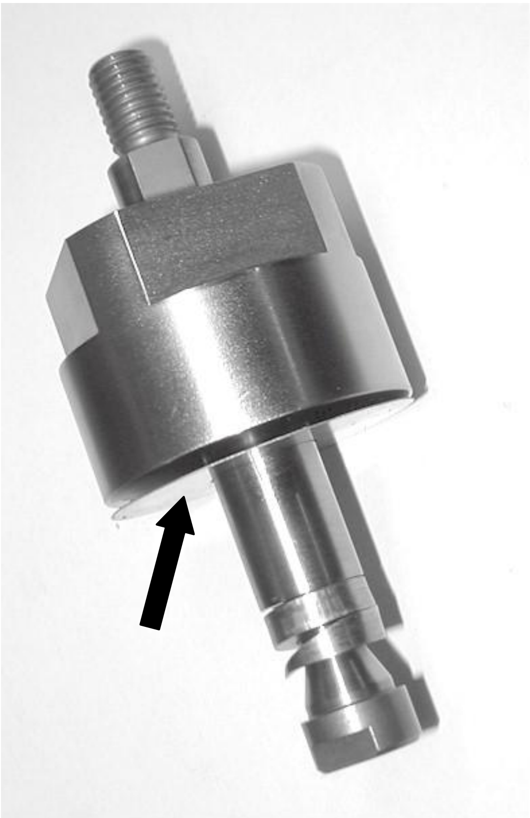


Figure 27: The sliding disc (arrow) is mounted the neck of the press part. Remember to oil the face of the sliding disc resting against the nut with Capo oil.

Figure 28: The cone pull bolt is tightened gently, if needed, to the base pull bolt with wrenches, left-hand thread (turn anti-clockwise). Do not tighten vigorously so the insert ring will start expanding preventing the expansion tool to be inserted in the cored hole

The folded ring on the cone pull bolt should be able to be moved slightly axially (~0.5 mm)

Before placing the unit in the carrying case, mount the counter pressure and thread the coupling on the base pull bolt.

3. MAINTENANCE OF THE CAPO-TEST EQUIPMENT

All the parts have to be clean and slightly oiled. The carrying cases have to be free from concrete dust and cleaned as well. The units have to pass the following checks:

3.1 Diamond drill unit

The diameter of the diamond drill bit has to be minimum 18.5 mm, otherwise the Capo-Insert cannot be inserted in the cored hole.

The distance "A" in fig. 29, has to be 0 mm when the coring bit is fully retracted, the distance "B" 68-69 mm when the drill bar is pushed forward.

Make sure the "CAPO-TEST control number" (page 32) is between 25.0 mm and 25.4 mm.

If the bearings (the white bottom bearing of or the blue top bearing) are leaking water, a set of new bearings have to be installed.

Extend the drill bar from the housing. Keep the drill bar in the same position with the 19 mm wrench secured to the upper end and twist off the drill bit with the 17 mm wrench.

Clean the thread and oil it. Remove the drill bar from the housing and unthread the flange and the two parts of the housing. Oil the sliding parts.

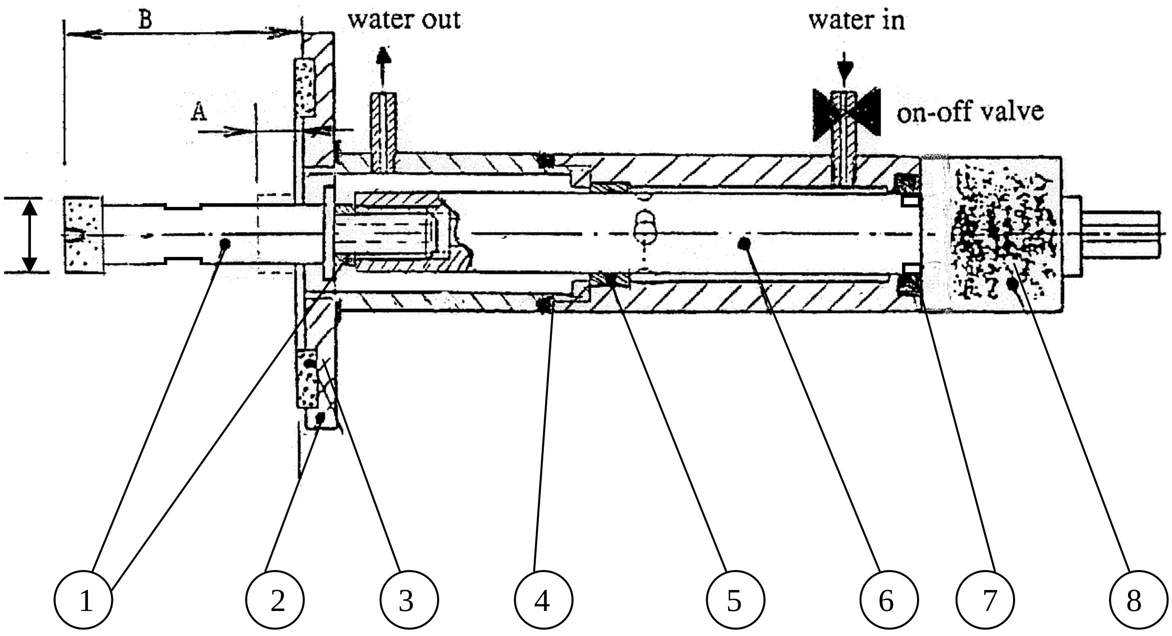
The top blue bearing may be lifted out of the casing by means of a screwdriver after the two top screws have been removed.

The white bottom bearing is pressed out with a screwdriver from behind.

Clean all parts and oil slightly. A new white bearing is installed loosely in the casing recess. Then, the two housing parts are threaded together by which the bearing will be pressed in-place.

A new blue bearing is first mounted in the drill bar, and the bearing is pressed into the housing recess, gently. Reassemble the remaining parts. Remember to oil the drill bar and the threads.

NOTE: The efficiency in coring of the diamond drill bits (red or green) can be improved by dismantling the bits from the drill bar, and hold/press the end of the bit(s) against a rotating grinding stone. In this manner the paste will be partly removed leaving the diamonds visible.



Diamond drill bit, red or green (for suction plate use)
Flange
Gasket
Drill housing, two parts
White bearing
Drill bar
Blue bearing
Rubber coupling with steel top

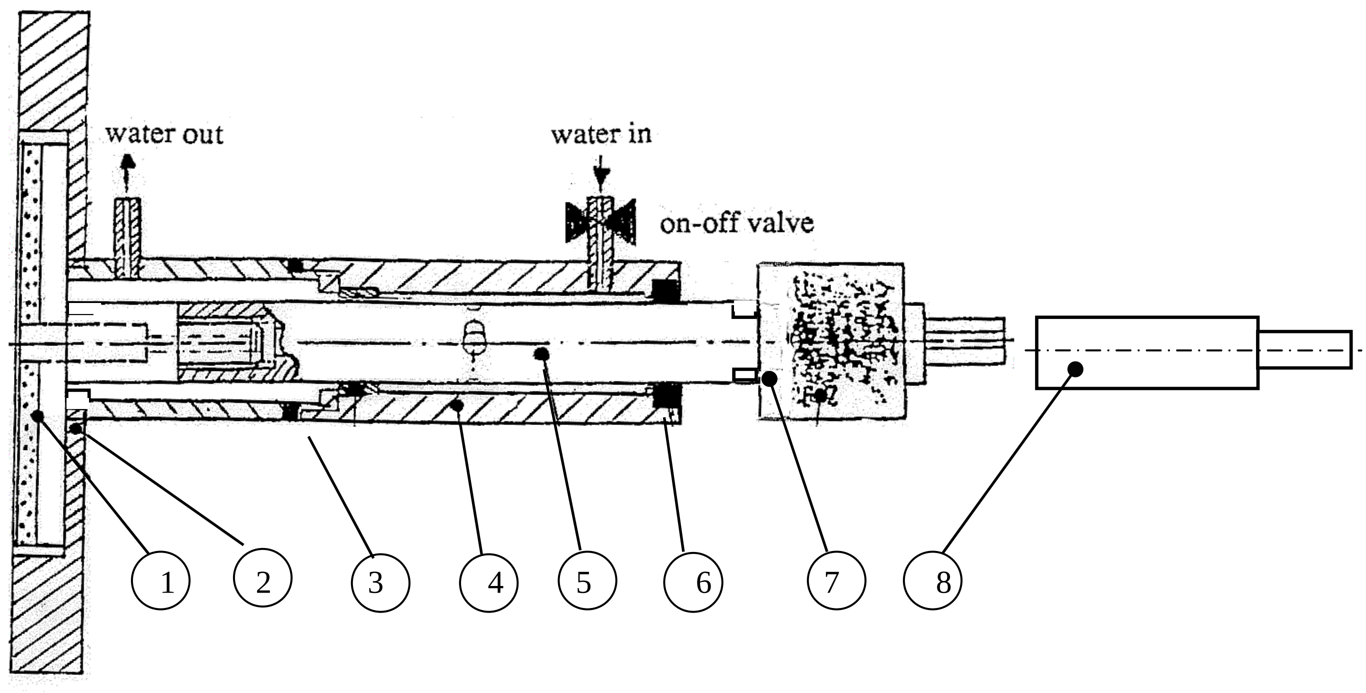
Figure 29: Diamond drill unit

3.2 Diamond surface planning unit

The diamond bits of the diamond surface planning wheel, fig. 30, have to be plane. Hold a ruler against the bits and observe for irregularities. The bits are normally worn uniformly and will stay plane. If a curved tendency is observed the diamond-planning wheel is unthreaded from the planning bar. Then the bits may be planned using a grinder with a cup stone. Remember to wear safety goggles.

If the water during operation is leaking through the bearings, new bearings are mounted in the housing as outlined in section 3.1 above. Keep all parts clean and slightly oiled,

Figure 30 on the following page shows the details of the diamond surface planning unit.

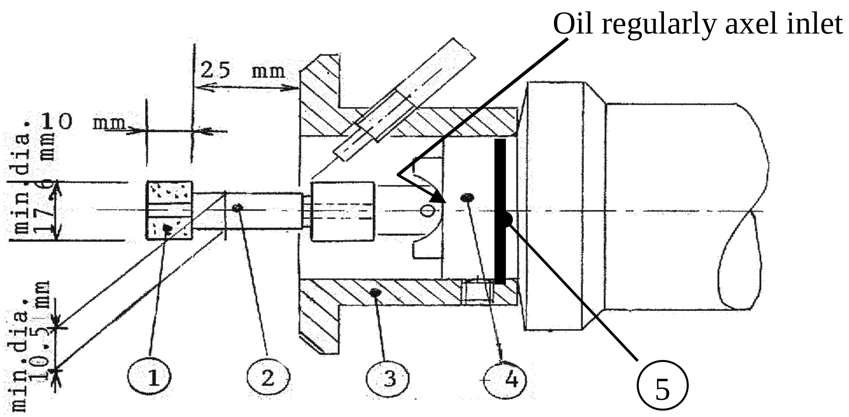


Diamond planning wheel
Flange
White bearing
Drill housing, two parts
Planning bar
Blue bearing
Rubber coupling with steel top
Governing brass tap to be inserted in the front of the diamond planning wheel

Figure 30: Diamond surface planning unit

3.3 Diamond recess router

Check the dimensions shown in fig. 31 as follows with the Vernier:
The diameter of the diamond router bit has to be minimum 17.6mm. The height 10 mm and the diameter of the router shaft minimum 10.5 mm



Diamond router
Router shaft
Router housing
Router machine and 5. O-ring

Figure 31: Diamond recess router

Calculate the “CAPO-TEST control number” as outlined in section 4, page 32. It has to be between 25.0 mm and 25.4 mm. Check the distance from the flange to the diamond bit using the distance piece (item 26, fig. 1). It has to be exactly 25 mm.

Disassembling of the router unit takes place as follows:

Release the Allen screw of the housing with the supplied 4 mm Allen key. Remove the housing from the machine. Release the nut with the supplied 19 mm and 14 mm wrenches. Unthread the nut totally from the machine axle and remove the routing shaft with diamond router from the nut. Clean all parts carefully. Make sure all rust is removed. Use if necessary gasoline and a brush.

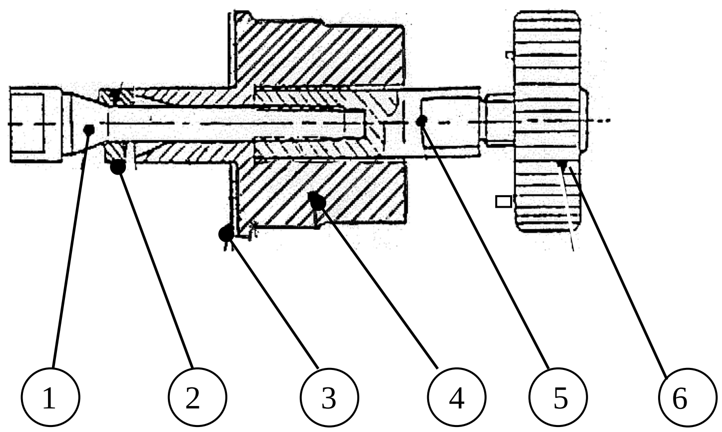
The diamond router may have to be unthreaded from the router shaft in a vice if the equipment has not been maintained properly.

Replace worn out parts and reassemble by first tightening the diamond router to the router shaft, then press the shaft into the cone part of the nut and thread it back on the axle of the machine. Tighten the nut on the axle using the wrenches. If it is not tightened sufficiently, the router shaft may be pulled out of the nut during operation, producing a routed recess in the concrete at a larger depth than the required 25 mm. Should this happens that the Capo-Insert will not be able to expand. Therefore, make sure the nut is tightened firmly.

Make also sure the machine is running smoothly. OIL REGULARLY THE AXEL INLET. The bearings of the machine may suffer from wear after a number of tests. In this case, the bearing needs to be replaced. This can only be done by an authorized workshop or by purchasing a new machine.

The router housing is cleaned and mounted on the neck of the machine with grease in between as well as the O-ring. The 25 mm distance piece is placed between the diamond router and the router flange to ensure the proper distance. Then tighten the Allen screw of the housing with the 4 mm Allen key and check again the 25 mm distance

3.4 Expansion unit



The cone pull bolt threaded in the base pull bolt with the coupling attached are at delivery tested up to 100 kN pull force

Cone pull bolt
C-112 Capo Insert (ring compressed)
Sliding disc
Nut and press part
Base pull bolt
Coupling

Figure 32: Expansion unit with coupling

Check the parts as follows:

The cone of the cone pull bolt has to be smooth without scratches, otherwise the expansion of the Capo-Insert is made more difficult.

The cone pull bolt should be able handheld to be threaded easily and fully into the base pull bolt, which in turn also should fit smoothly the thread of the nut. Otherwise, clean the threads carefully once more using gasoline and a brush. Replace worn out parts. Oil the threads with the special heavy-duty Capo oil.

The sliding disc has to be intact without damages.

All threads, the cone part of the pull bolt and the surface between the sliding disc and the press part flange has to be oiled regularly with the supplied Capo oil. Only use this oil, which is special oil made for threads and sliding surfaces with high loads.

The assembly of the expansion unit is illustrated on the pages 20-22.

3.5 Suction plate with vacuum pump

Check the suction plate with vacuum pump on a table. The vacuum drawn has to be approx. -0.8 BAR, indicated on the suction plate's gauge. The valve of the suction plate has to be kept clean and slightly oiled. The flexible vacuum gaskets below the plate have to be intact and airtight. New gaskets may be bonded to the plate by means of contact glue after cleaning the grooves with Acetone.

The filters of the vacuum pump may after some use, especially in dirty or moist environments, have to be cleaned. To do so, remove the five top screws of the lid. The filters below the plate are removed and cleaned with water. Let them dry before reassembling.

If the vacuum supplied by the pump is still too weak, the valves need to be cleaned.

The vacuum pump can stand water, but the filters need to be cleaned more often than if only air is allowed to flow through the pump.

Check the vacuum hose. It should not be damaged, and the valve should fit smoothly into the snap-on female part of the vacuum plate.

The on-off valve of the vacuum pump should be oiled slightly.

3.6 Hydraulic pull machine

The hydraulic pull machine is checked in the following manner, see drawing fig. 33.

The travel of the main piston has to be minimum 6 mm, preferably 7 mm. The travel is measured with the Vernier caliber as the difference between the distance "C" when the telescoping handle is fully retracted and when the handle is fully extended (handle rotated 39 rotations ant-clockwise).

A travel of ~7 mm will ensure the CAPO-TEST cone is fully dislodged, normally.

3.6.1 Oil refilling

If the travel is less than 5-6 mm, the instrument needs to be refilled with oil. The telescoping handle is fully extended and the instrument is kept in a vertical position.

The long compression cylinder may be fastened in a Vice with paper towels in between.

The top sign is removed using the small screwdriver to unthread the two small screws.

The oil refilling screw behind below the sign is unthreaded with the large screwdriver. Remember also to remove the O-ring behind the screw.

The oil-refilling cup is pressed gently into the hole, fig. 34. The telescoping handle is fully retracted. Oil and entrapped air will bleed out in the cup. The oil may be dirty from wear of the compression rings, but this is of no importance. Refill oil in the cup from the oil-refilling bottle to about 10 mm from the top.

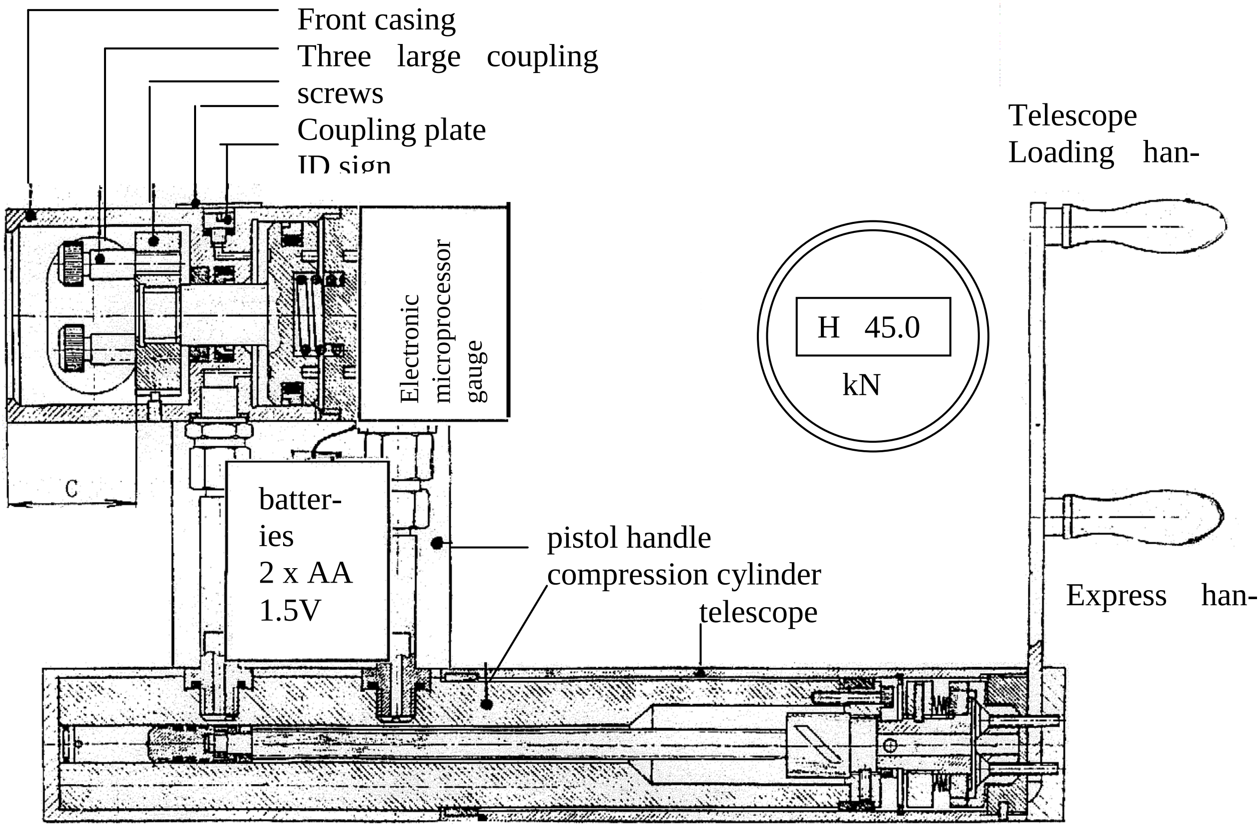


Figure 33: The Capo-Test C-104 hydraulic pull machine, in principle.

Figure 34: The oil-refilling cup is placed ready for oil refilling.

NOTE: Only use the 1000 cts silicone oil supplied, if another oil is used, the compression rings of the instrument will get damaged and the gauge will not function

When all the air has escaped the oil-refilling cup, the telescoping handle is slowly turned anti-clockwise to its fully extended position. The oil is sucked into the instrument. The procedure is repeated until no more entrapped air appears. Extend the telescoping handle a final time. Allow the oil to flow into the instrument and remove the oil-refilling cup. The difference in oil level in the cup has to be about 10 mm. Excessive oil in the cup is poured back into the oil refilling bottle.
The oil screw with O-ring is threaded into the refilling hole. Tighten the screw gently. If excessive force is used, the thread of the slim screw may snap. The sign is placed back into position at the main housing

Retract the telescope handle fully and measure with the Vernier the distance from the front casing to the coupling plate, fig. 33, distance “C”. Extend the telescope handle fully and measure the distance again. The difference in measurements has to be 7 mm, minimum 6.5 mm. Otherwise, the instrument has to be oil refilled, again. Only use the supplied Silicone Oil, 1000 cts viscosity. Other oils will ruin the stepper seals in the instrument.

3.6.2 Mending of oil leakage

The hydraulic pull machine is a sturdy instrument, designed to stand normal rough treatment and bumpy transportation as may occur on a building site and to function under all normal conditions, e.g. at high and low temperature and in moist environment. Nevertheless, it is a high precision instrument and should be treated as such. Do not handle it as if it was a crowbar. This means that it should not be dropped, pulled in or twisted excessively. If it receives such treatment, the calibration between the readings and the actual pull force may change, requiring a new calibration. Also, oil leakage may turn up.

If such leakages appear, the pressure inside the instrument will be lost during testing and oil will flow from the leakage, typically from the oil connection joints of the tubing between the cylinders.

To mend oil leakage, unthread the two pistol handle parts with the 3 mm Allen key. The joints are tightened with the supplied wrenches.

Refill oil as outlined in clause 3.6.1 and load the instrument on a calibration cell or during a Capo-Test to e.g. 25 kN. Keep the telescoping handle in the same position. The gauge should show a steady pull force and not drop. If it drops, the leakage has to be spotted and further tightening of the joints is performed until the leakage disappears. Remember to refill the instrument with oil once again before testing.

All other leakage or damage problems of the instrument have to be repaired by authorized workshops or by:

GERMANN INSTRUMENTS A/S
Emdrupvej 102, DK-2400 Copenhagen NV, Denmark
Phone: +45 39 67 71 17, Fax: +45 39 67 31 67
E-mail: germann-eu@germann.org

GERMANN INSTRUMENTS INC.
8845 Forest View Road, Evanston, Illinois 60203, USA
Phone: (847) 329 9999, Fax: (847) 329 8888
E-mail: germann@germann.org

3.6.3 Installing new batteries

Should the message "LO" turn up on the digital display, or if the display is simply not turning on, a new set of two 1.5 V AA batteries needs to be installed. Remove the lid on the pistol handle covering the batteries by e.g. a fingernail or a small screwdriver.

Remove the batteries and install new 1.5V type AA Alkaline batteries, 2 pcs. Make sure the gauge is turning on properly before reassembling the parts.

The back-up battery is placed on the back side of the battery holder. It is a 3V Lithium battery. It will last for 5 years. If it becomes flat only the clock of the gauge microprocessor will stop working.

3.6.4 Calibration

The reading of the hydraulic pull machine in "kN" (kilo Newton) has been established from the factory in relation to the actual pull force in kN as shown the calibration table delivered with the instrument.

This calibration has to be checked after each 750 tests, at least once a year, after service or if the instrument has been dropped or suffered damage.

To calibrate the hydraulic pull machine a setup as shown in fig. 35 is used. The calibration unit is parallel calibrated from an authorized state agency with an accuracy of 0.1%.

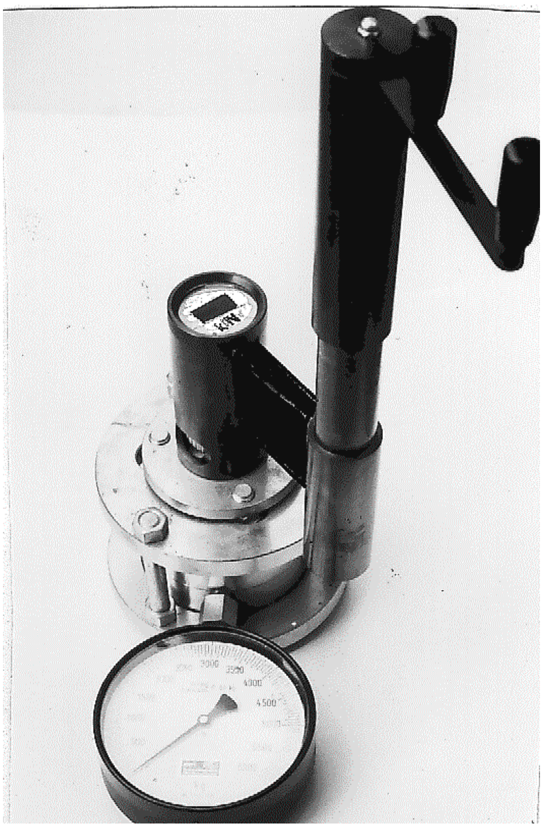


Figure 35: The hydraulic Capo-Test pull machine coupled to the calibration unit ready for calibration.

After coupling of the instrument, comparative readings are taken for each 5 kN. The readings are repeated three times.

The average is calculated and readings in between are interpolated.

In the calibration certificate following each instrument, the **correlation** between the actual pull force in kN and the compressive strength as measured on **standard cylinders** or **standard cubes** in MPa (MegaPascal or Newton per square millimeter) is also stated in a tabulated form.

These general correlations are based on large number of comparative test series and may be regarded as “general” for all types of normal concrete mixes as outlined in EN-12504-3 (ref. 14) and ref.2. The robust correlations have been investigated for all conceivable parameters, ref. (5) and (6), covering parameters as cementitious materials, w/c-ratio, age, air entrainment, admixtures, curing conditions, fibers, SCC, type, shape of aggregates, size, max. aggregate size up to 38 mm. Only for lightweight aggregates another correlation was found.

Procedure for establishment of such correlation is given in ref. (4), (5) and (6) page 45.

The calibration report further contains the following information:
Instrument ID number
Calibration number
Date of calibration
Calibration personnel initials
ID number of calibration unit and parallel calibration unit
References, remarks and signature of controller
Finally, the sign of the instrument is stamped with the date of calibration or the date of service/repair.

4. CHECKLIST FOR THE CAPO-TEST EQUIPMENT

All parts mentioned on page 3 are available and cleaned

Diamond drill unit, fig. 29, page 24:
The diameter of the red (or green) drill bit is minimum 18.5 mm ____________
When fully retracted, the drill bit is flush with the flange ____________
In forward position the tip of the drill bits is 68-69 mm from the flange ____________
The bearings are water-tight ____________

Diamond surface planning unit, fig. 30, page 25:
The brass governing rod fits snugly the center hole of the planning wheel ____________
The diamonds of the planning wheel are plane ____________
The bearings are water-tight ____________

Diamond recess router, fig. 31, page 25:
The diameter of the diamond router is minimum 17.6 mm ____________
The diamond bit is minimum 9 mm high ____________
The router shaft dia. is minimum 10.5 mm ____________
The distance from the router to the flange is 25.0 mm (use the distance piece) ____________

Expansion unit, fig. 32, page 26:
The threads fits smoothly ____________
The cone pull bolt is smooth on the cone ____________
The maximum axially travel of the insert is 0.2 mm when assembled ____________
The coupling couples easily on the hydraulic pull machine ____________

Vacuum plate and vacuum pump:
The vacuum plate with vacuum pump generates -0.8 BAR on a flat table ____________

Pullmachine, fig. 33, page 28:
The travel of the coupling plate is minimum 6.5 mm ____________
The digital display is turning on when activated ____________
The pull machine has no oil leakage ____________
The calibration table is present and is valid (max. 1 year old) ____________

Calculation of the Capo-Test Control Number:
The diameter of the diamond recess router (min. 17.6 mm) is…………………………..mm
The diameter of the router shaft (min. 10.5 mm) is…………………………………...mm
(1)The difference is ……………………………………………………………mm
(2)The diameter of the diamond drill bits (min. 18.5 mm) ……………………………...mm
Add (1) and (2) This is The Capo-Test Control Number……………………………..….mm

The Capo-Test Control Number is between 25.0 and 25.4 mm | YES | NO |

If the answer is "NO", the part(s) in question have to be corrected for / renewed

Signature Date: Jan.1st, 2018

Example of filled-out check list:

All parts mentioned on page 3 are available and cleaned ______ yes

Diamond drill unit, fig. 29, page 24:
The diameter of the red (or green) drill bit is minimum 18.5 mm ______ (end face grinded) yes
When fully retracted, the drill bit is flush with the flange ______ yes
In forward position the tip of the drill bits is 68-69 mm from the flange ______ yes
The bearings are water-tight ______ yes

Diamond surface planning unit, fig. 30, page 25:
The brass governing rod fits snugly the center hole of the planning wheel ______ yes
The diamonds of the planning wheel are plane ______ yes
The bearings are water-tight ______ (almost) yes

Diamond recess router, fig. 31, page 25:
The diameter of the diamond router is minimum 17.6 mm ______ yes
The diamond bit is minimum 9 mm high ______ yes
The router shaft dia. is minimum 10.5 mm ______ yes
The distance from the router to the flange is 25.0 mm (use the distance piece) ______ yes

Expansion unit, fig. 32, page 26:
The threads fit smoothly ______ (needs further cleaning) yes
The cone pull bolt is smooth on the cone ______ yes
The maximum axially travel of the insert is 0.2 mm when assembled ______ yes
The coupling couples easily on the hydraulic pull machine ______ yes

Vacuum plate and vacuum pump:
The vacuum plate with vacuum pump generates -0.8 BAR on a flat table ______ yes

Pullmachine, fig. 33, page 28:
The travel of the coupling plate is minimum 6.5 mm ______ (7 mm, newly oil refilled) yes
The digital display is turning on when activated ______ (new batteries installed) yes
The pull machine has no oil leakage ______ yes
The calibration table is present and is valid (max. 1 year old) ______ (another one month to go) yes

Calculation of the Capo-Test Control Number:

The diameter of the diamond recess router (min. 17.6 mm) is…………..	17.6	mm
The diameter of the router shaft (min. 10.5 mm) is………………………	10.7	.mm
(1) The difference is …………………………………………………	6.9	.mm
(2) The diameter of the diamond drill bits (min. 18.4 mm)……………….	18.4	.mm
Add (1) and (2) This is The Capo-Test Control Number…………………	25.3	mm

The Capo-Test Control Number is between 25.0 and 25.4 mm YES √ NO

If the answer is "NO", the part(s) in question have to be corrected for / renewed

Signature Date: Jan.1st, 2018

5. ACCEPTANCE CRITERIA FOR CORRECTLY PERFORMED CAPO-TEST

In the following section operation criteria are stated for correctly performed testing with the Capo-Test. Only the failure left in the concrete surface is evaluated. The reason for stating the criteria are given as well.

5.1 Sharp edge produced by the counter pressure.

The circular edge left on the concrete surface from the counter pressure's inner 55 mm diameter, see figure 36, must be sharp.

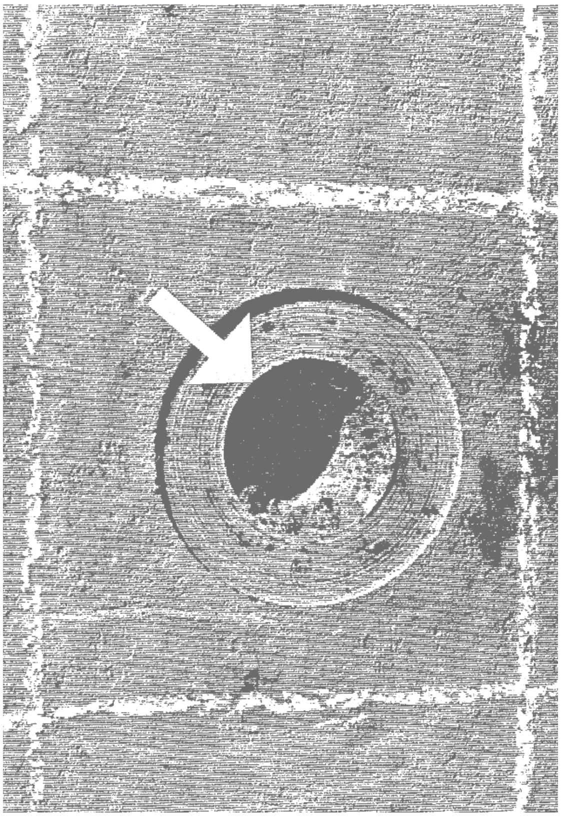


Figure 36: Sharp circular edge (arrow) left on the concrete surface from the counter pressure.

The edge has to be as illustrated in figure 37, following page, failure type “X”.

If radial cracking - failure type “Y” - or spalling - failure type “Z” is observed, the test is rejected.

Radial cracking typically occurs if the critical concrete mass around the pullout insert has been too small. This happens if the minimum distance from the center of the test to the edges or corners is less than 100 mm.

The failure type “Z” with spalling of the concrete occurs of the testing surface has not been smooth and plane or if the centerline of the insert has not been perpendicular to the testing surface.

Failure types “Y” and “Z” both produce too low pullout forces.

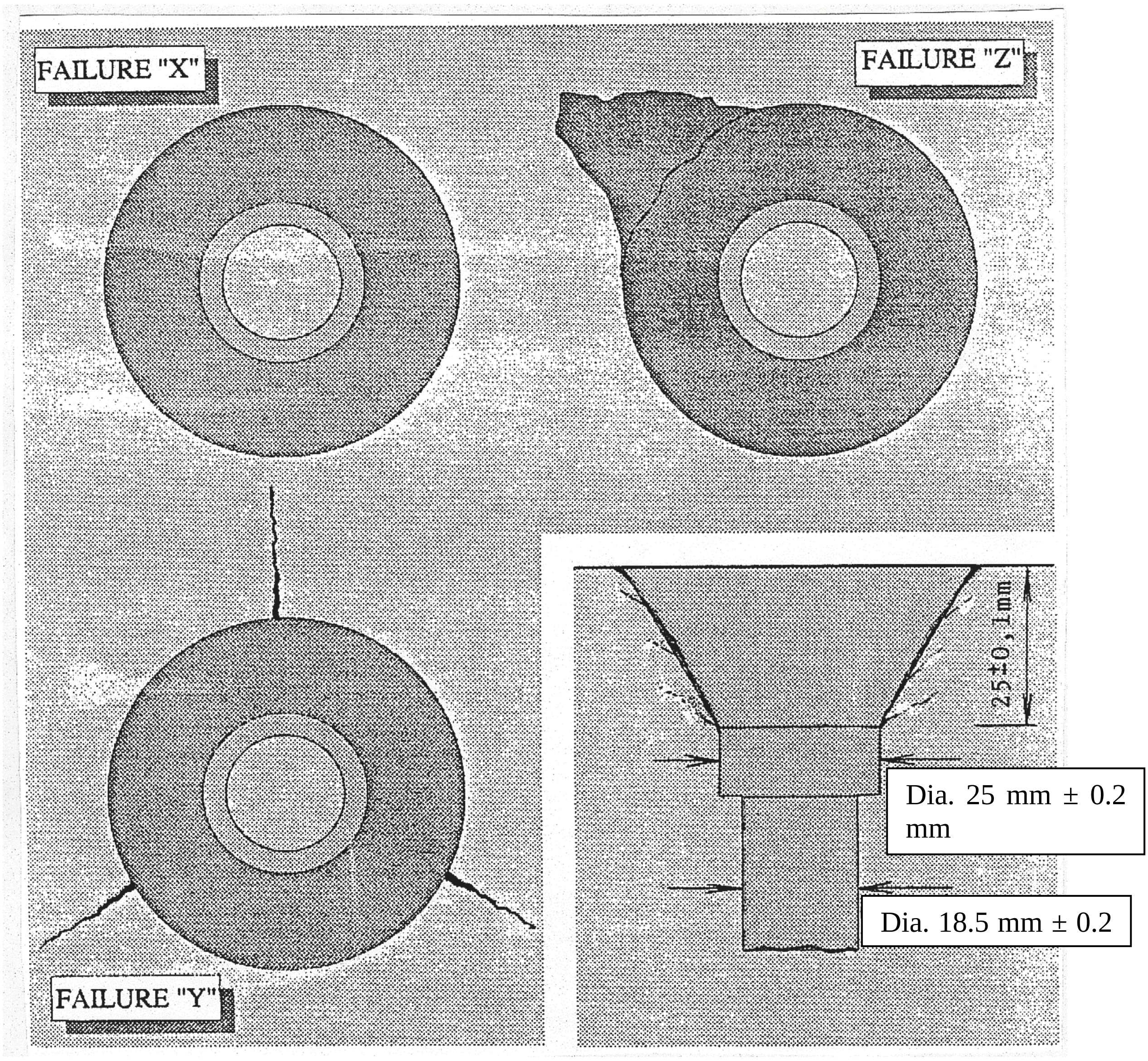


Figure 37: Possible Capo-Test failures. Only failure type "X" is acceptable.

Incorrect testing causes the failure types "Y" and "Z", and the test result should be rejected. The lower figure at right hand side illustrates the cross-section of the correct Capo-Test failure with minor circumferential cracking.

5.2 Depth of 25 mm to the routed recess

The distance from the surface to the routed recess is measured. It has to be 25 mm +/- 0.1 mm, otherwise the test is rejected. The reason is that the pullout strength is depending on the correct 25 mm depth of the recess. For each 1% deviation from the required depth, the pullout force will change 2%, approximately.

5.3 No extending edge between the routed recess and the cone surface

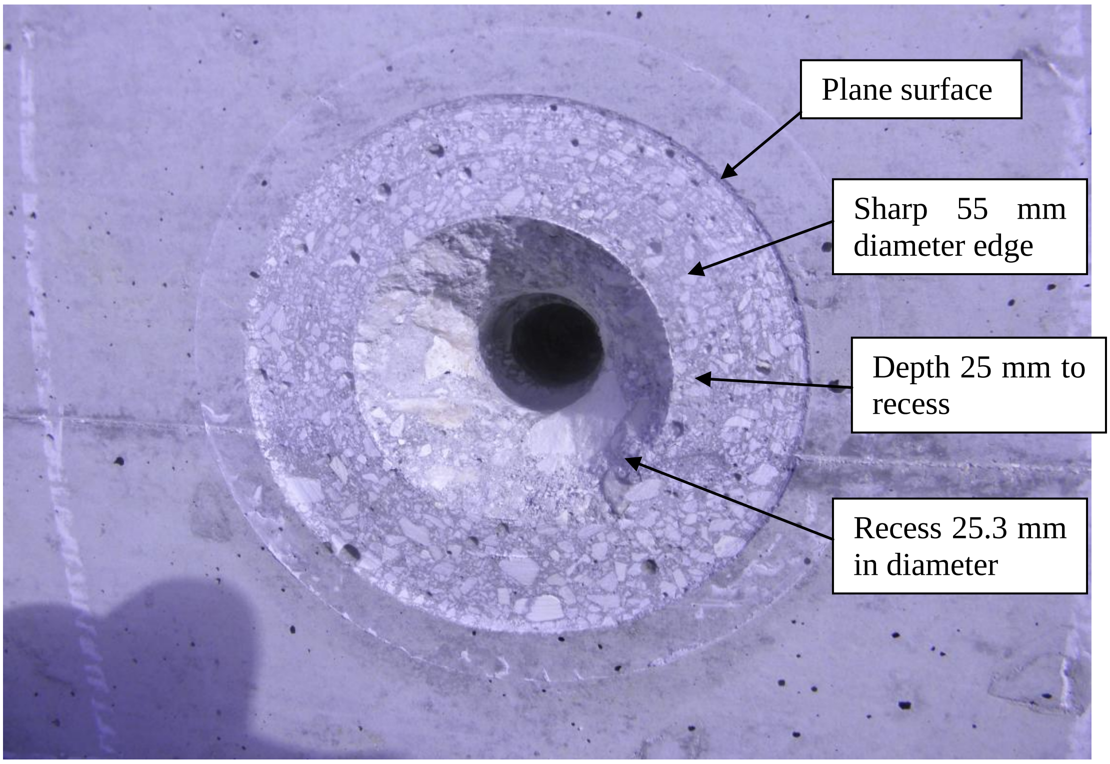
There should be no sharp edge or unbroken concrete left between the routed recess and the cone surface of the concrete. Such an edge indicates that the Capo-Inserts has not been fully expanded.

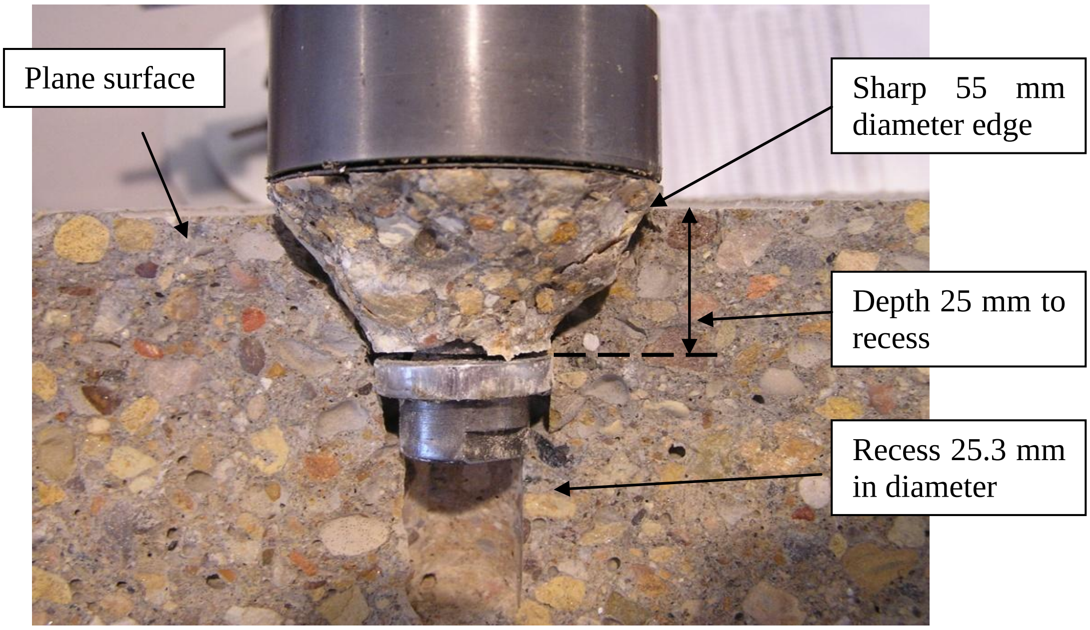
The test result should be rejected if there is an edge between the recess and the cone surface.

5.4 No foreign bodies in the failure surface

If foreign bodies like thermal wires or wooden parts are found in the failure surface, the test should be rejected, the reason being that it is the strength of the concrete that needs to be tested.

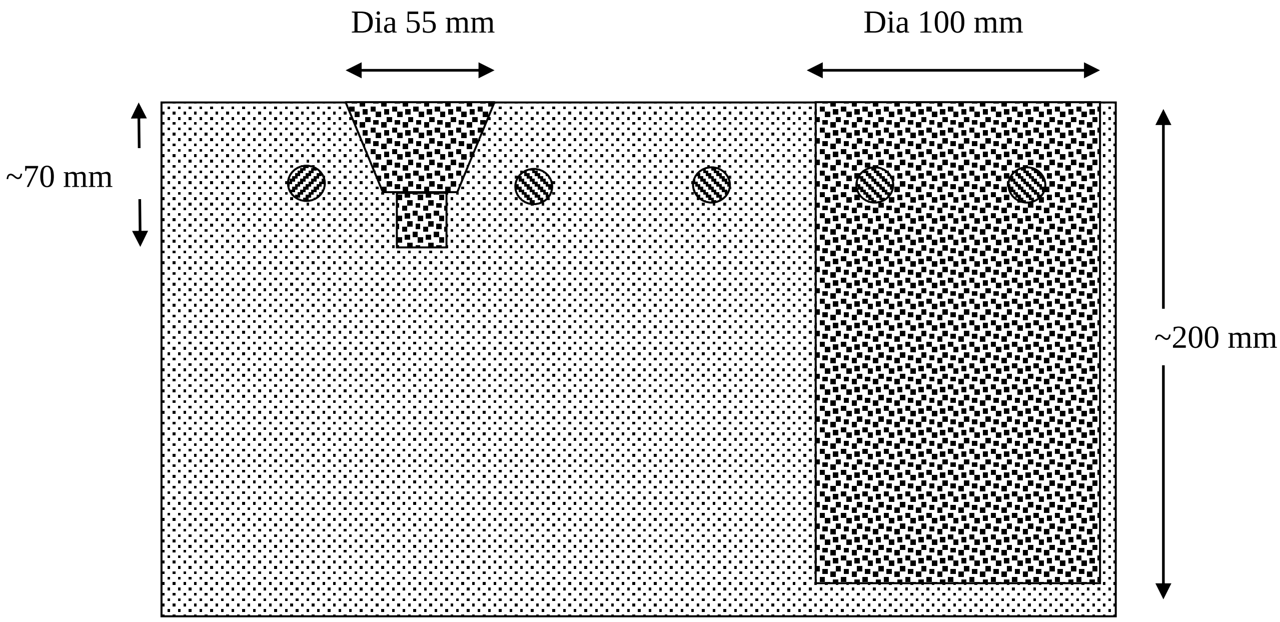
Summary:





6. REPAIR OF CONE HOLES

The failure may be left without any repair if allowed by the supervisor. Alternatively, the hole may be patched with a non-shrink polymér-modified mortar #), after the hole has been blown free of dust and the surface primed with a bonding agent or just moistened. The mortar has to be applied when the bonding agent is still wet. The surface is then made smooth and plane.



Note: The reinforcement will not be disturbed by the CAPO-TEST, while cores for compression tests will usually cut through the reinforcement

#) e,g, Quikrete Fast Set Nonshrink Grout - 1585-20

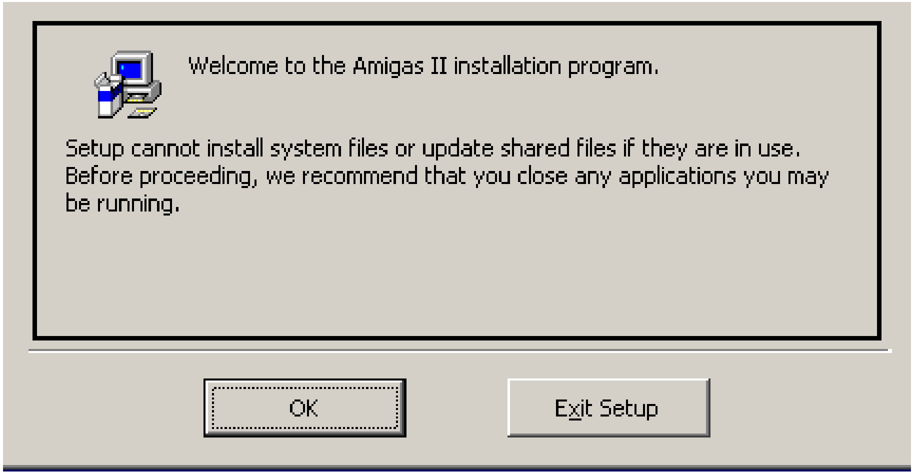
Apply a bonding agent or moisten the CAPO-TEST failure surface and press the prepared non-shrink mortar with a spatula into the cone hole and smoothen it off.

Experience has shown that the adhesion between the concrete and the mortar will be long lasting, and the permeability will not be jeopardized.

7. PRINTOUT OF TEST RESULTS AT THE OFFICE

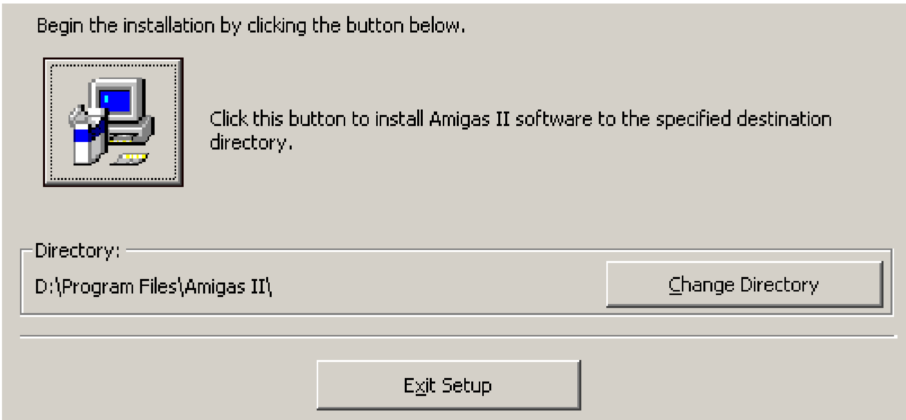
7.1 Installation of Amigas II software

- Insert the CD-ROM in the CD-ROM drive of the PC. The installation of the program will start automatically. The following window will appear:



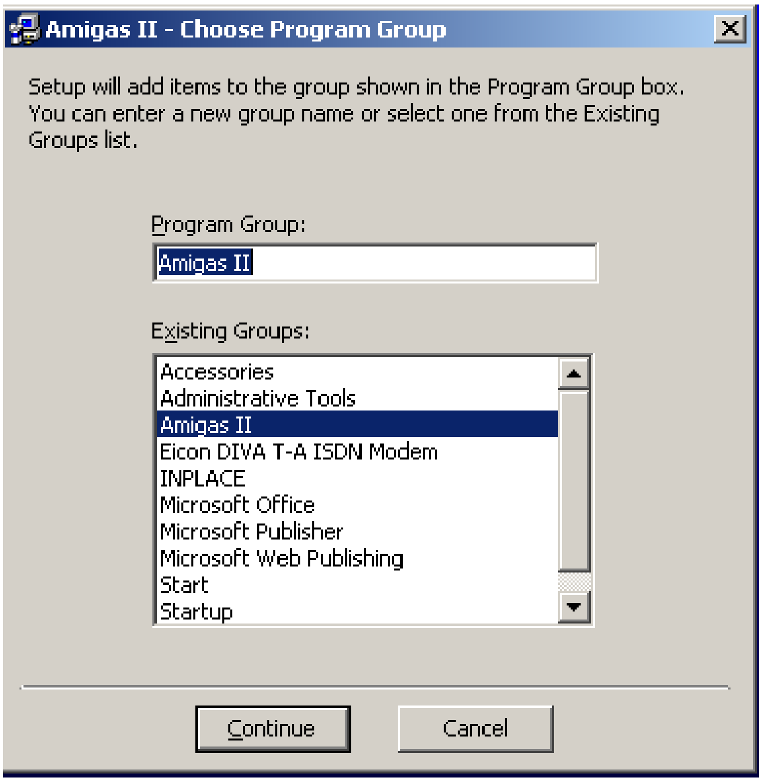
- If the installation does not start automatically do as follows: In the menu "Start", choose "Run" and type D:\AmigInst.exe (D: is your CD-ROM drive, can be named by any other letter), and press Enter.

- Press the “OK” Button and the following windows will appear.



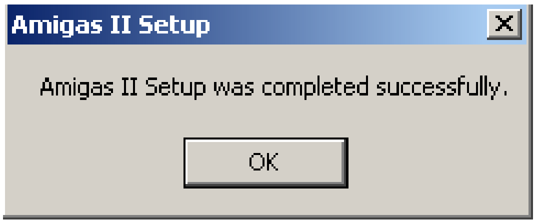
- To install the program in the suggested directory press on the button shown. To change the Directory, press the “Change Directory”- button and enter the alternative directory.

- Once the Directory is chosen and the button has been activated, the following window will appear:



- To accept the Program Group, Press Continue. When the program is installed correctly one the following window appears:

7.2

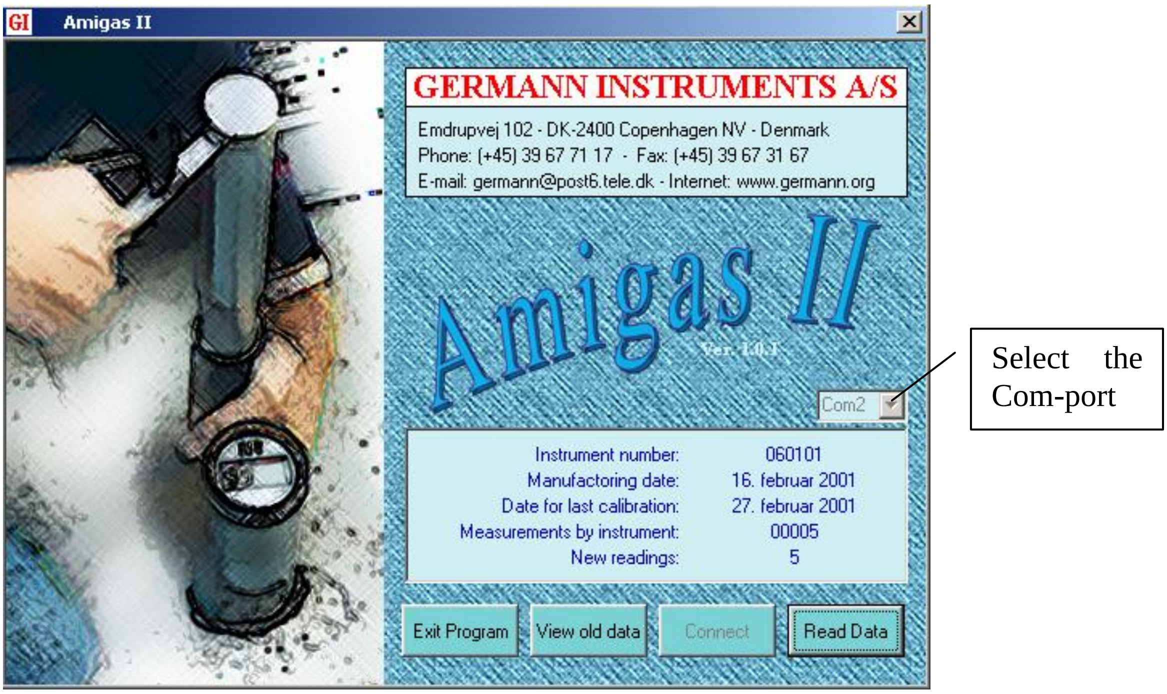


7.2. Running the Amigas II program

- Connect the cable supplied with the Electronic Pullmachine to the female plug on the Pullmachine and to e.g. the COM1 port of the computer.

- Turn on the Electronic Pullmachine by pressing the button on the pullmachine and keeping it pressed until "PO" appears on the display. Then release the button.

- Start the Amigas II program. Choose the "Start" menu and then the folders "Programs", "Amigas II" and the subfolder Amigas II. The following window will now appear:



- Select the com-port on your computer where you connected the cable to and then press the Connect-button. The Instrument number, Manufacturing date, Date of last calibration, Measurements by instruments (total numbers of measurements made so far with the instrument, maximum 65.000) and New Readings (maximum 512 are stored in the memory and the number shown will be number of readings made since last transfer has been made) will be shown. NOTE: if more than 512 readings are made before a transfer of data is made, only the last 512 readings are stored.

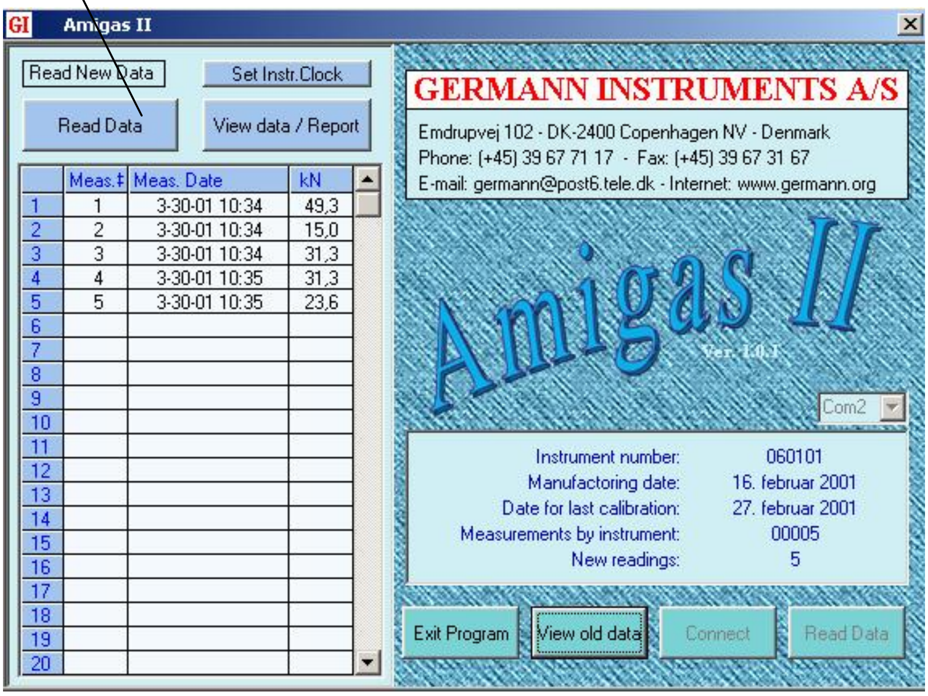
- All date being downloaded will be saved in a database with the name Amigas II.mdb in the directory where the software is installed.

- To read the data in the pullmachine press the "Read Data" button.

Press this button to read new data in instrument

- Please note only new data will be downloaded. Previous downloaded data will not be shown on the display. To show the data that has been downloaded now, press the Read Data-button as shown below:

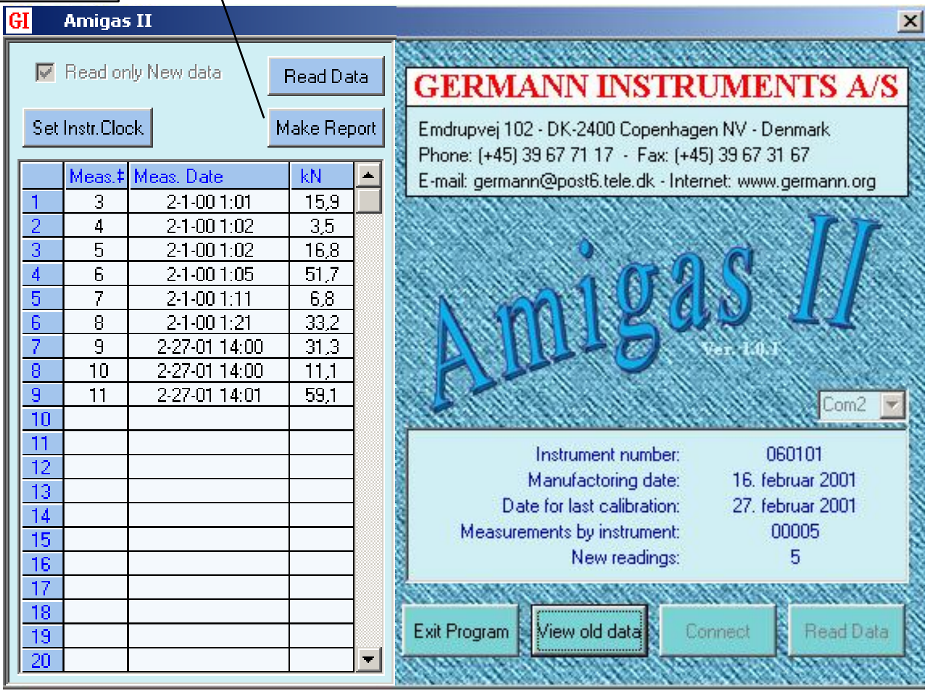
Press this button to show data on display



- To set the clock in the instrument press the "Set Inst. Clock"- button.

- The data downloaded now will be displayed as shown below. To make a report press the Make Report-button as shown below:

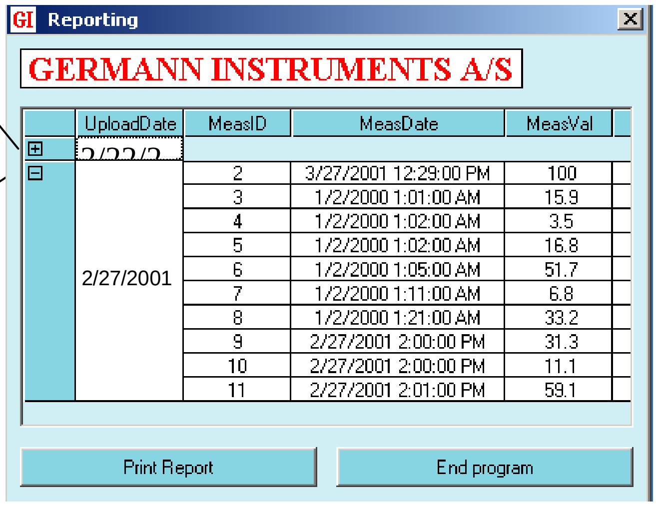
Press this button to make a report of the data



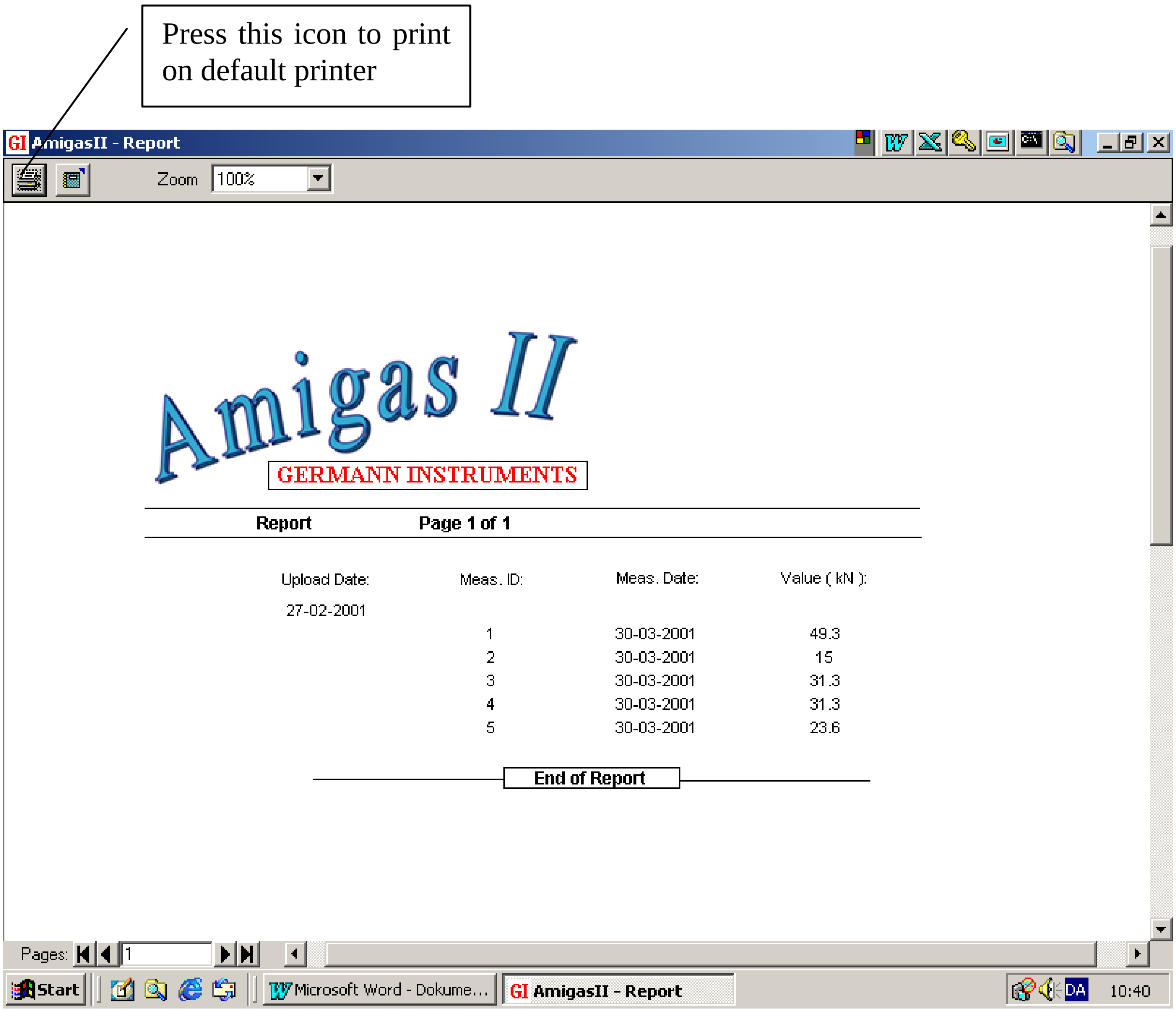
- The following window will now appear. To show data or hide data from a specific date, press the "+" or "-"buttons as shown below:

Pressing the "+" will shown the data hidden

Pressing the "-" will hide the data

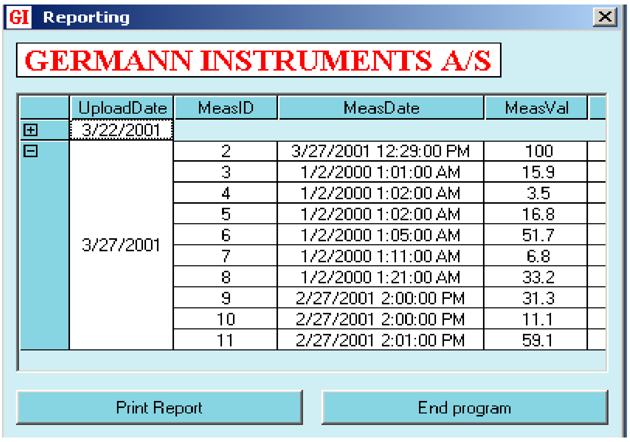


- To print a report press the “Print Report Button” and a report will be shown as e.g. shown below. To print the report press the Printer Icon at the top left corner as illustrated.



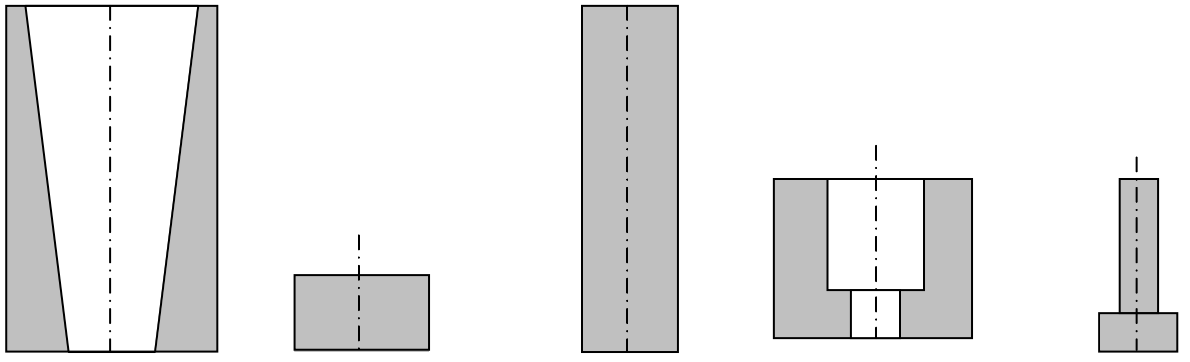
- To export the reports to an html or htm-file press the Export-button adjacent to the printer icon.

- To close report press the X at the top right corner and the following screen will appear again. Press the “End program” button to close the program.



8. REZISING EXPANDED CAPO-INSERTS

The expanded Capo-Inserts is inspected for visual cracks of the steel. If cracks are present the ring is discarded, otherwise it may be resized using the C-111 resizing tool illustrated below.



Cone tool Drift 1 Drift 2 Reziser Drift 3

Besides the C-111 resizing tool a vice, a hammer and the Capo-Oil is needed.

Grease the cone part of the cone tool with the Capo-Oil.
Insert the expanded Capo-Insert in the cone tool with the inner sloping edge visible.
Press drift 1 against the ring in a vice and continue with drift 2 until the ring is at the bottom of the cone tool.
Remove the unit from the vice and tap with a hammer drift 2 until the ring is released.
Insert the ring in the reziser with the sloping inner edge visible, insert drift 3 in the center hole and press the drift through the hole using a vice.
Remove the reziser Capo-Insert from the reziser.

9. REFERENCES

CAPO-TEST Instruction video on Google ”CAPO-TEST Video”

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2. Moczko, A,, Carino, N.J. & Petersen, C.G.: “CAPO-TEST to Estimate Concrete Strength in Bridges”, ACI Materials Journal, Nov. – Dec. 2016, No 113-M76´
3. Carino, N.J.: “In-Place Strength without Testing Cores, the Pullout Test”, 6th International Seminar on Advances in Cement and Concrete Technology for Sustainable Development, China, March, 2018
4. Petersen, C.G. & Poulsen, E.: “Pullout testing by Lok-Test and Capo-Test with particular reference to the in-place concrete of the Great Belt Link”, Danish Concrete Institute, Bredevej 2, 2830 Virum, Denmark, 1992
5. Krenchel, H. & 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, Ottowa, ON, Canada, Oct. 1984, 24 pp.
6. Petersen, C.G.: “Lok-Test and the Capo-Test pullout testing, Twenty Years Experience”, Proceedings, Non-Destructive Testing in Civil Engineering Conference, University of Liverpool, April 8-11th,1997.
7. Bungey, J.H. & Soutsos, M.N.: “Reliable & Partially Destructive Tests to Assess the strength of Concrete on site”, Fifth CANMET/ACI International Conference on Durability of Concrete, Proceedings of Near-to-surface Testing for Strength and Durability of Concrete, Barcelona, Spain, 4-9th June, 2000.
8. Soutsos, M.N., Bungey, J.H. & long, A.E.: “In-Situ Strength Assessment of Concrete - The European Concrete Frame Building Project”, University of Liverpool, UK, 1999.
9. BCA, BRE, Construct, Reinforced Concrete Council & DETR: Early age Strength assessment of Concrete On Site”, Best Practice Guide for In-Situ Concrete Frame Buildings, CONCRETE, 2000.
10. Mozcko, A.: “Comparison between compressive strength tests from cores, Capo-Test and Schmidt Hammer”, Deptm. Of Civil Engr., Wroclaw University, Poland, May 1st, 2002.
11. Yun, C.H., Choi, R.K., Kim, S.Y. & Song, Y.C: “Comparative evaluation of nondestructive test methods for in-place strength determination”SP 112-8, ACI Special Publication, 1988, ACI, Detroit, USA
12. ASTM C 900-15: “Standard Test Method for Pullout Strength of Hardened Concrete”. ASTM International, West Conshohocken, PA, 2015, 10 pp.
13. British Standard BS 1881 pt 207: 1999, “Testing Concrete - Recommendations for the assessment of concrete strength by near-to-surface tests”, BSI, London, 16p.
14. European Standard EN-12504-3: “Testing Concrete in Structures – Part 3: Determination of pull-out force”. European Committee for Standardization (CEN), Brussels, Belgium, 2005, 10 pp.
15. European Standard EN 13791: “Assessment of In-Situ Compressive Strength in Structures and Precast Concrete Components”, European Committee for Standardization (CEN), Brussels, Belgium, 2005, 29 pp.
16. CSA A23.1-14/A23.2-14: “Concrete Materials and Methods od Concrete Construction – Test Methods and Standard Practices for Concrete”, Canadian Standards Association, Mississauga, ON, Canada, Aug. 2014, 690 pp

10. Appendix A. Procedure for performing CAPO-TEST from below on a structure

1. Locate reinforcement and position the test center of the CAPO-TEST in the middle
2. Cover the drill machine with a plastic bag taped to the neck of the machine right behind the chuck, having access to the operation of the drill machine from the bottom opening of the bag.
3. Press the flange of the CAPO-TEST drill unit against the surface for the gasket of the flange to be compressed against the concrete surface, open for the water supply and core the center hole in 3-4 steps.

Alternatively, use two blue adjustable pliers pressing the flange against the surface after the pliers have been anchored to the surface.

4. Plane the surface dry with the diamond surface planer centered by the governing brass rod.
5. Dip the recess diamond router in water and perform the recess routing in steps, removing the grinding dust in water, step-by step until the recess is made
6. Insert the expansion tool with the C-112 CAPO expandable ring installed correctly and expand the ring to fully expanded position
7. Mount the counter pressure and the coupling on the tool.
8. Couple the extended CAPO hydraulic pull machine to the coupling, remove the slack by turning the machine clockwise.
9. Turn on the hydraulic pull machines electronic gauge (Zero if needed) and perform the pullout.
10. Record the maximum pull force and correlate the force to compressive strength by means of the supplied calibration table.

11. Appendix B. CAPO-TEST pullout testing on Shotcrete Procedure and an On-Site Testing Example

The following instruction is from testing of shotcrete in a tunnel mining project, where no electricity was allowed, hence the use of battery-operated power tools

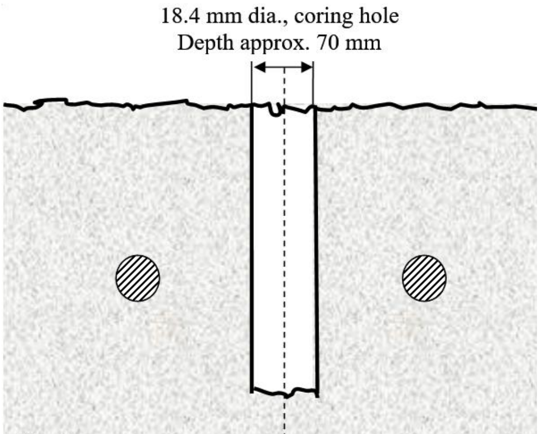


Fig. 1

After locating reinforcement, the test position is chosen in the center of the reinforcement mesh. Coring with a water-cooled 18.4 mm diamond coring bit takes place to full 70 mm depth of the coring bit.

Minimum reinforcement spacing and depth, page 51

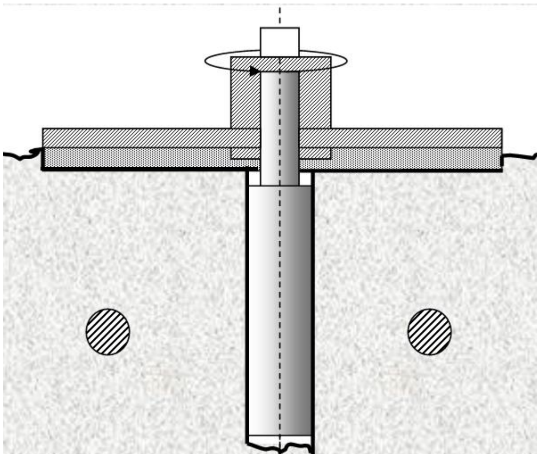


Fig. 2

The centering brass rod is inserted in the hole and the diamond planning wheel is centered on the rods top. Planning takes place water-cooled by pressing the unit's axel connected to the drill machine against the surface, which must be plane in its total circumference.

The diamond recess router shown above is inserted in the drilled hole and turned on. The bit is water cooled. The flange of the recess router must rest firmly against the planed surface

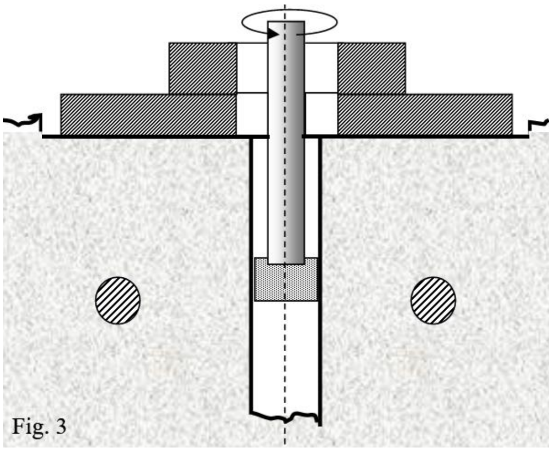


Fig. 3

Recess routing takes place by pressing the flange of the router against the planed surface and moving it side wards in bigger and bigger circles until the recess router shaft follows the side face of the cored 18.4 mm hole.
Notice the position of the operator's fingers.
The diameter of the recess must be 25.4 mm ± 0.2 mm after routing and the depth to the recess

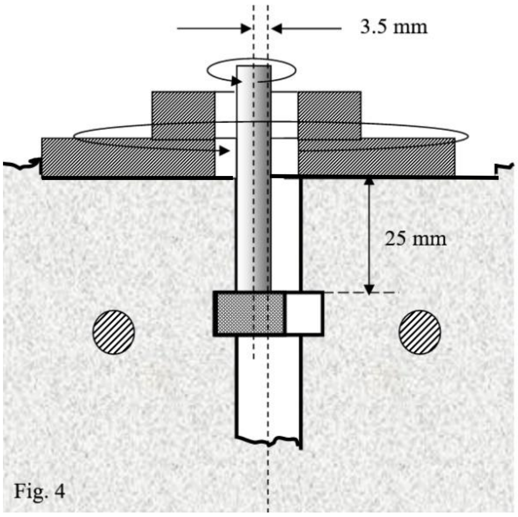


Fig. 4

The assembled expansion tool with installed CAPO ring (above) is inserted in the hole and expansion of the ring takes place as shown below by turning the big nut to fully expanded position of the ring while keeping the center pull bolt in the same position. The cone pull bolt will be pulled against the CAPO ring, which will unfold in the routed recess.

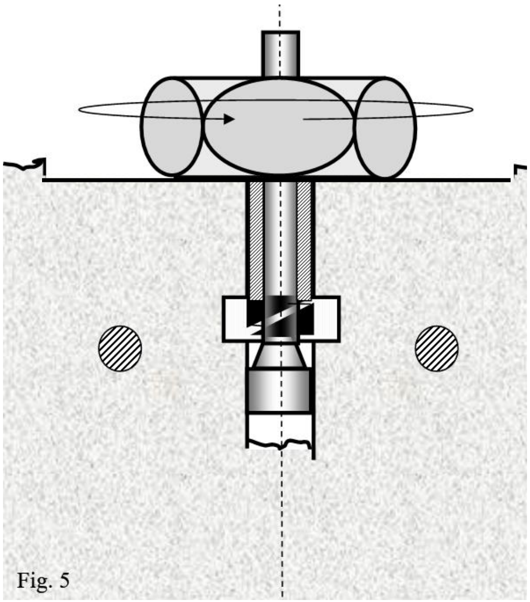


Fig. 5

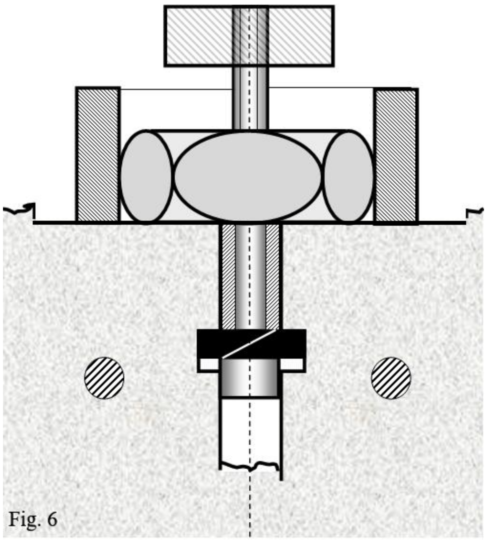


Fig. 6

After fully expansion of the CAPO ring in the routed recess the counter pressure is installed on the surface and the coupling threaded to the center pull bolt

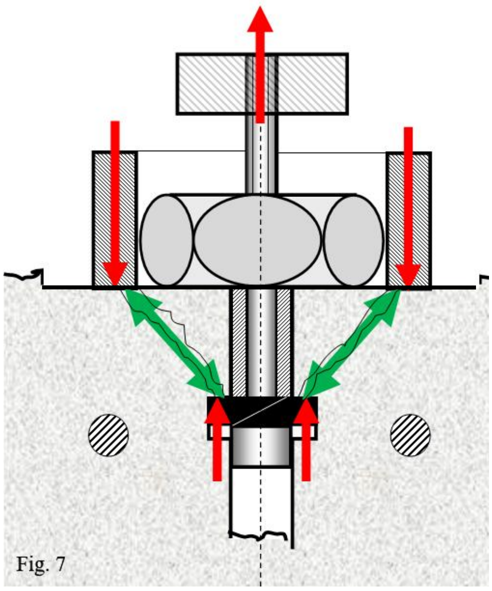


Fig. 7

The hydraulic CAPO-TEST instrument is coupled to the coupling and the slack removed between instrument and counter pressure. Loading takes place by turning the instruments handle slowly.

During pullout compression forces are formed in a strut between the expanded ring and the counter pressure on the surface. Therefore, the pullout force correlates very well to compression test made on standard specimens.

At the end of the softening regime a sliding failure is formed between the outer edge of the expanded ring and the inner edge of the counter pressure.
The maximum load in kN is recorded by the instrument and correlated to standard compressive strength of e.g. cylinders.

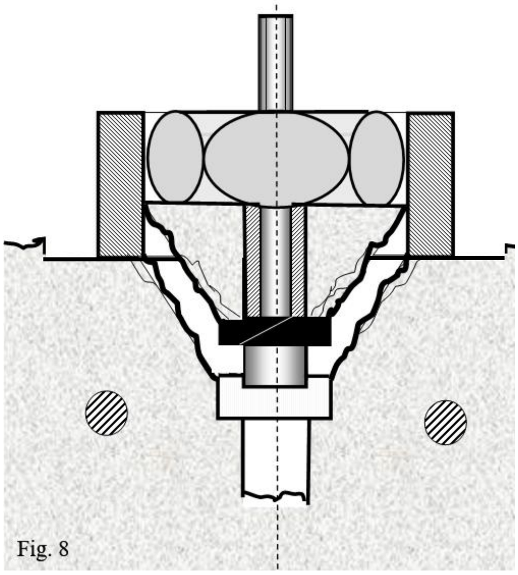
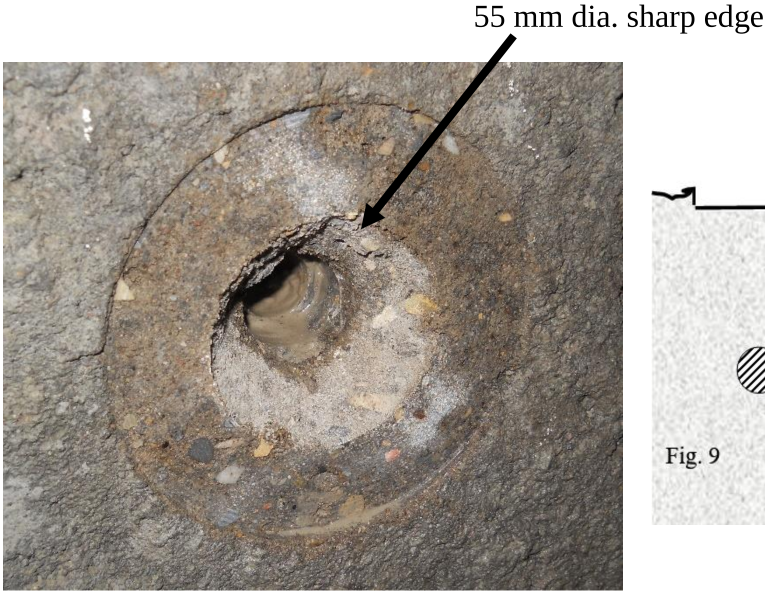


Fig. 8

The completed CAPO-TEST.
Notice the unfolded CAPO ring on the cone pull bolt.



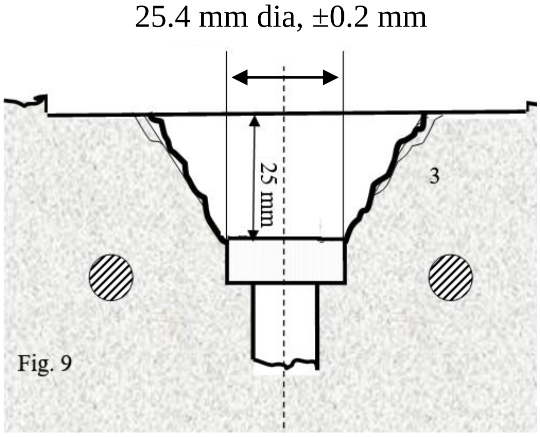


Fig. 9

CAPO-TEST failure.

The criteria's for correctly performed testing:

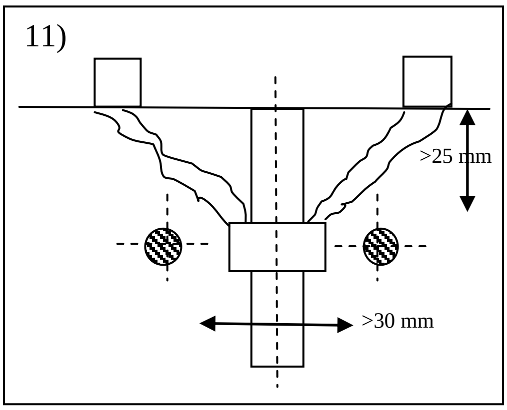
1. Sharp 55 mm in diameter edge (no spalling on the planed surface) from the inner edge of the counter pressure
2. Routed recess diameter 25.4 mm ± 0.2 mm
3. Depth to the recess 25 mm from the planed surface

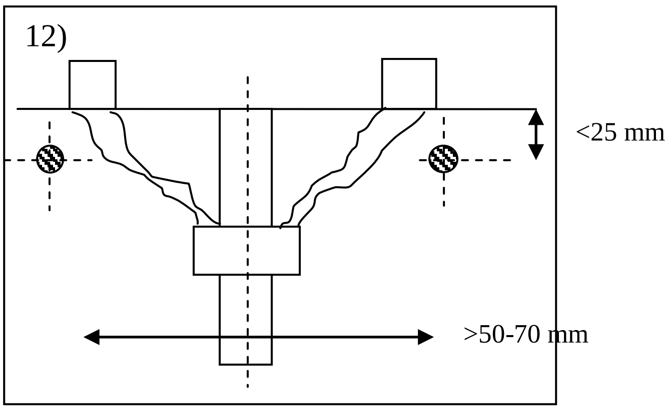
Fig.10 CAPO-TEST failure on shotcrete with steel fibers

Reinforcement spacing and the depth of reinforcement:

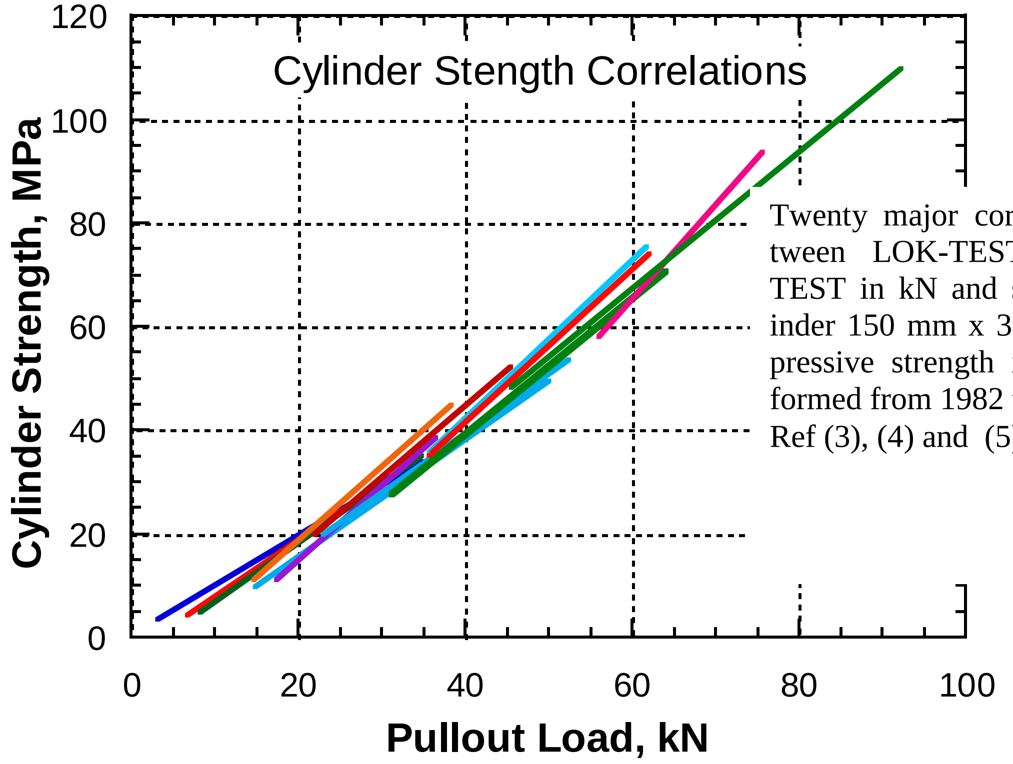
The compression strut is narrow for shotcrete with smaller aggregates
Reinforcement must be outside the strut for the pullout force not to be affected by rebars, meaning:

1. For a depth of reinforcement larger than 25 mm the test must be positioned in the middle of the reinforcement mesh with a minimum spacing of 30 mm, fig. 11
2. For a depth of reinforcement less than 25 mm the test must be positioned in the middle of the reinforcement and the spacing has to be minimum 50-70 mm, depending on the depth, fig. 12)

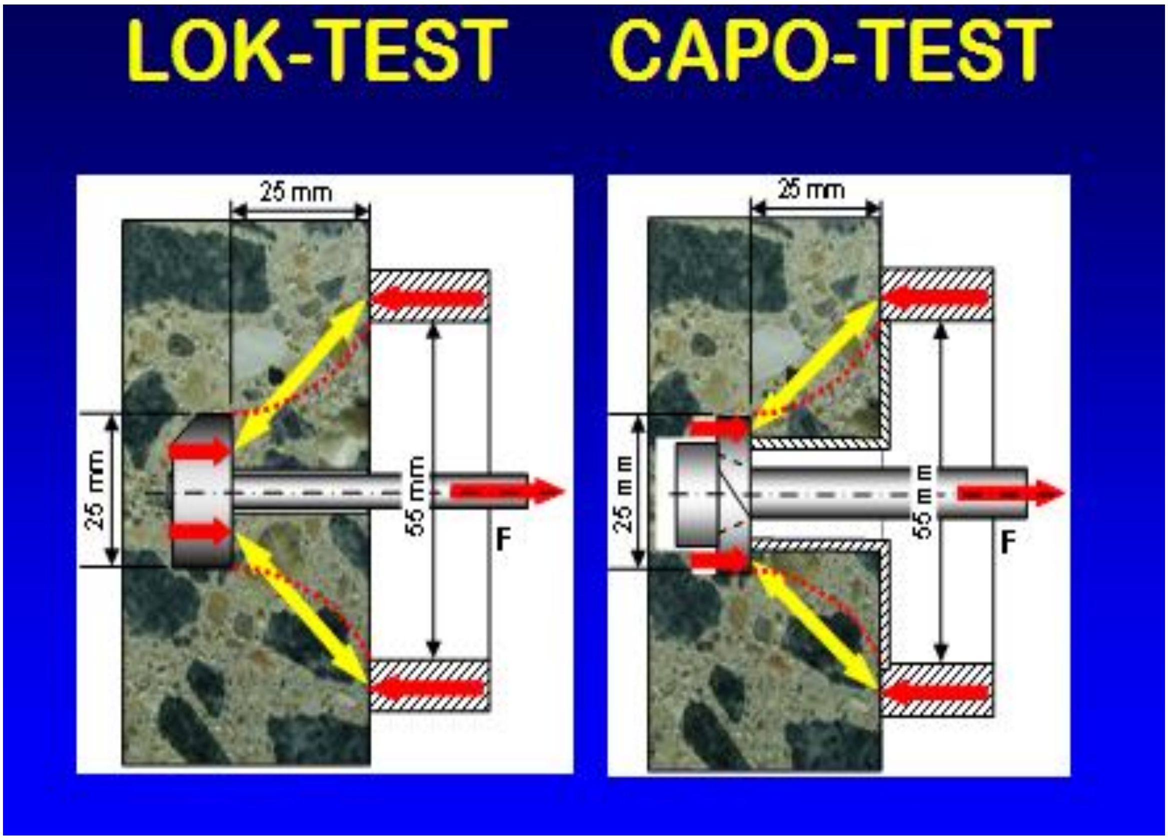


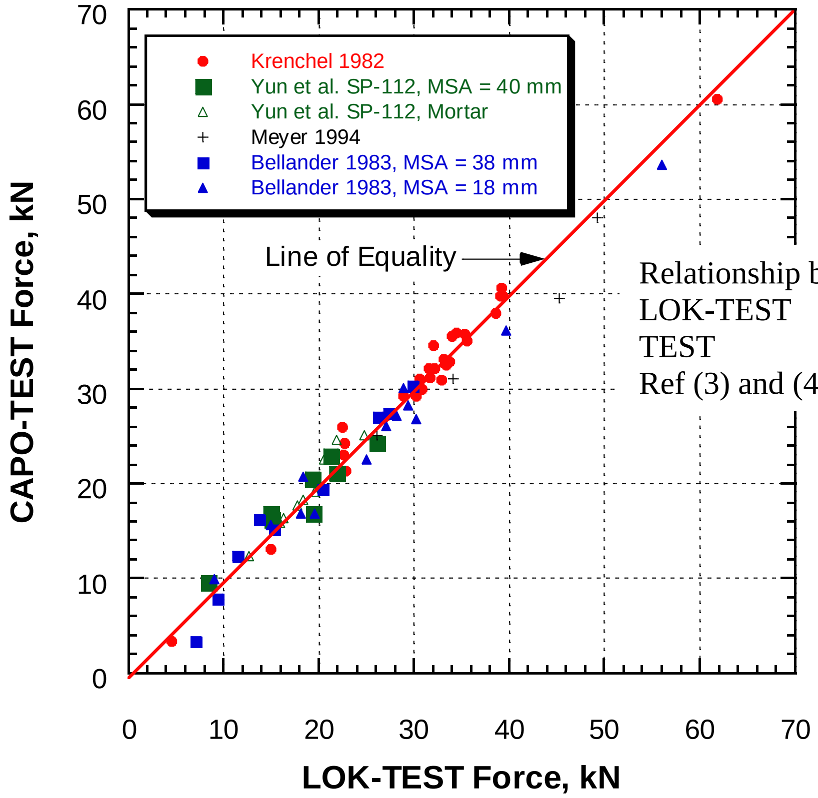


Correlations to 150 mm x 300 mm cylinder strength

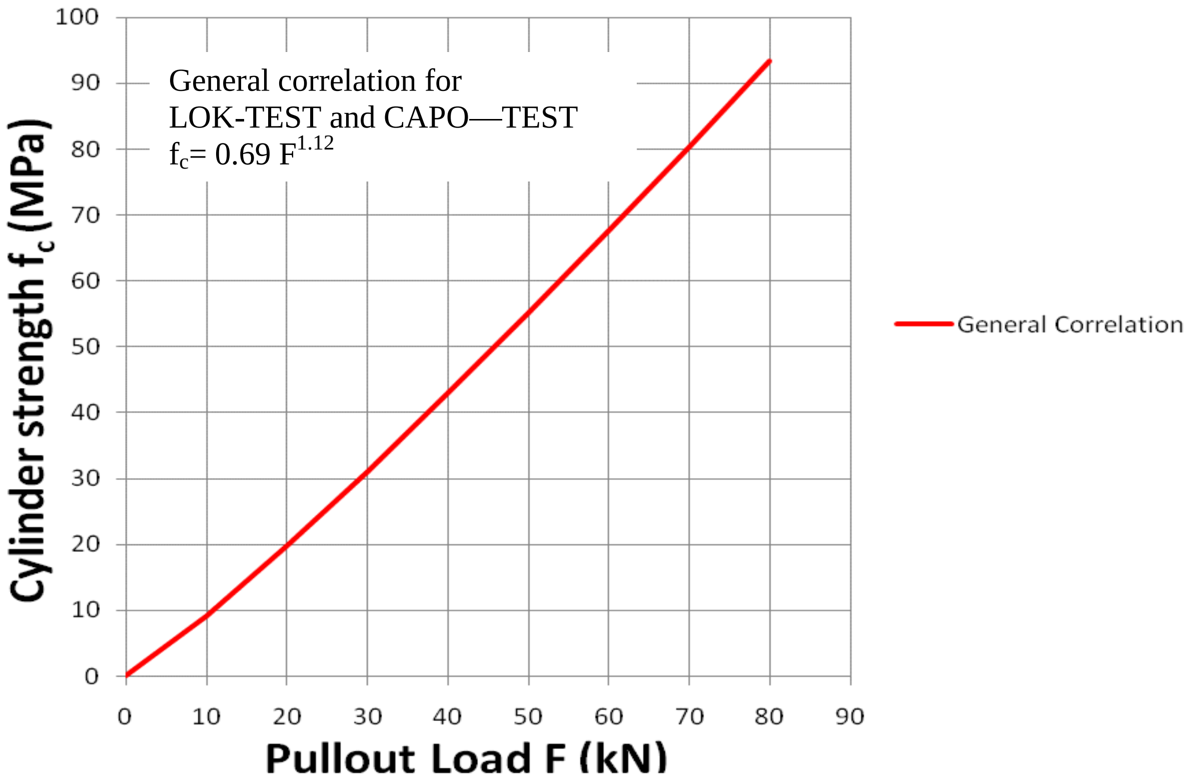


Twenty major correlations between LOK-TEST / CAPO-TEST in kN and standard cylinder 150 mm x 300 mm compressive strength in MPa performed from 1982 to 2010
Ref (3), (4) and (5)

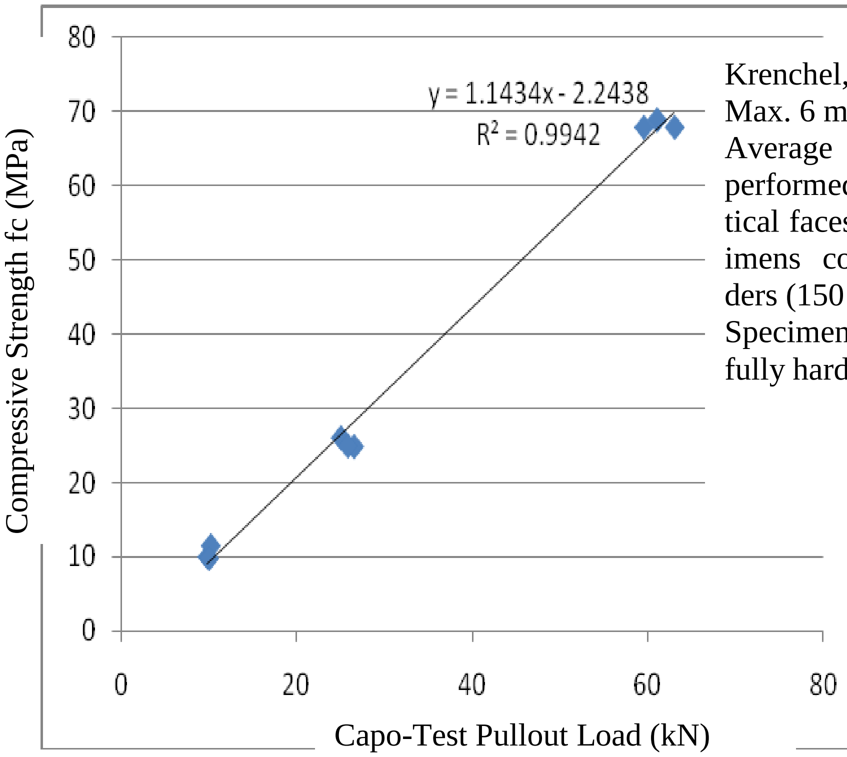




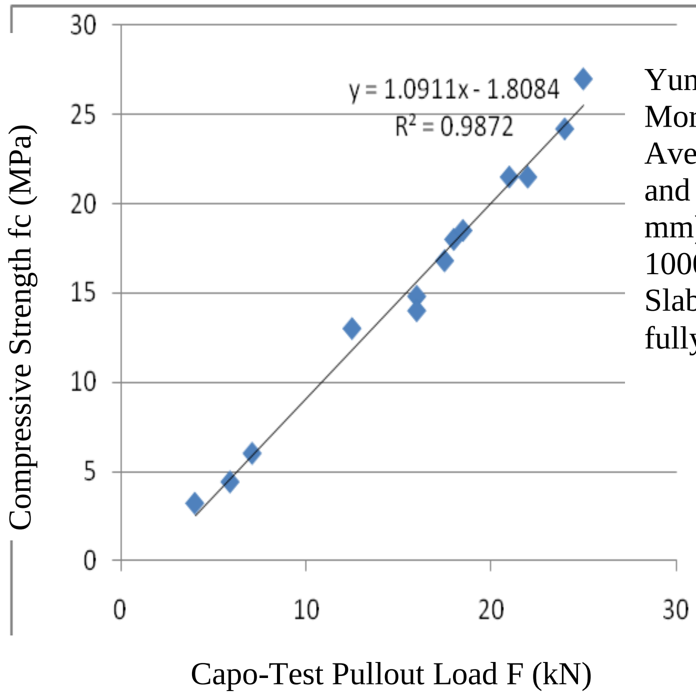
Relationship between LOK-TEST and CAPO-TEST
Ref (3) and (4)



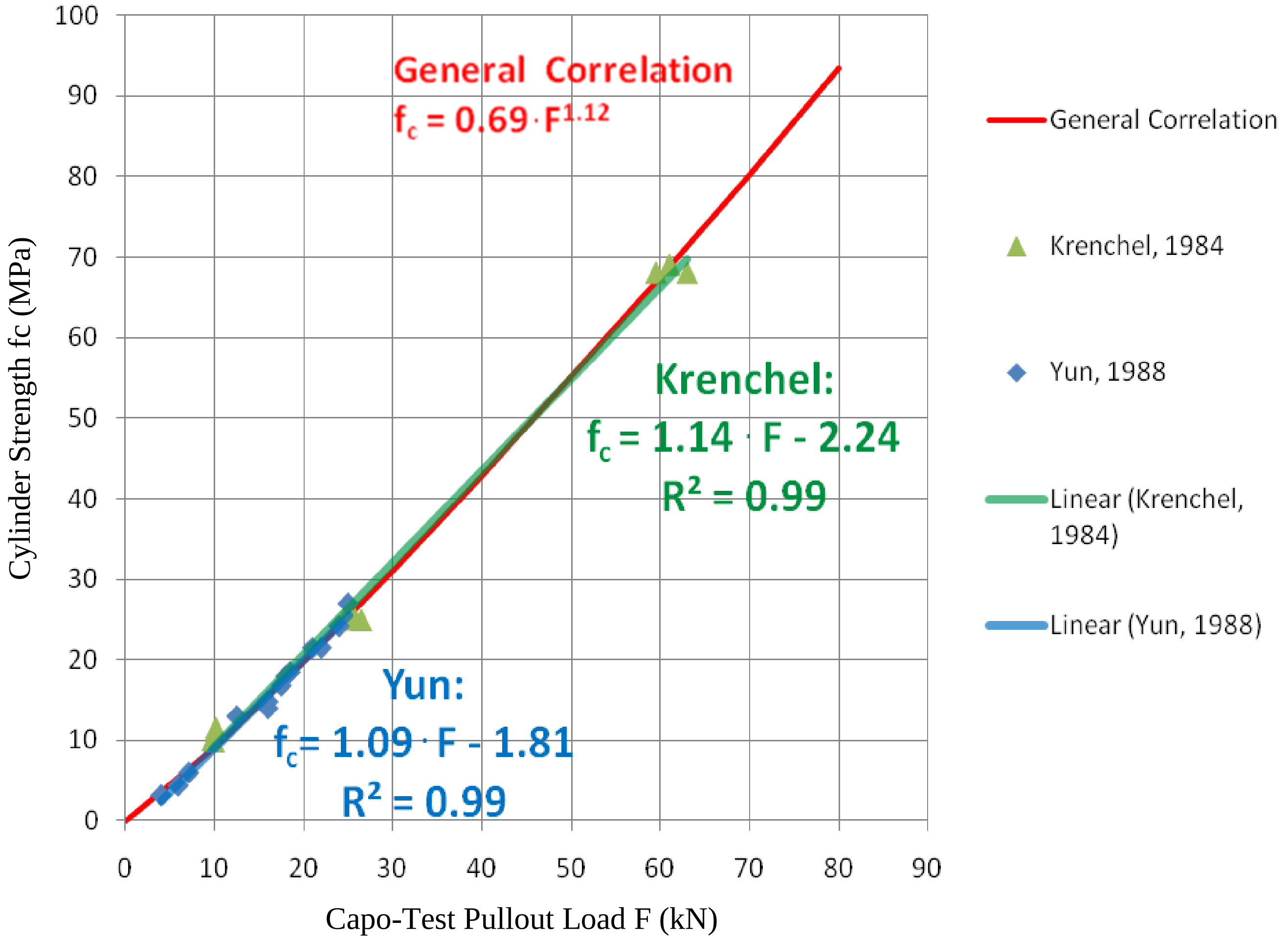
Examples of correlations made for maximum aggregate size less than 6 mm (as with shotcrete)



Krenchel, 1982, ref. (4)
Max. 6 mm aggregate size
Average of 2 CAPO-TEST performed on opposite vertical faces on 200 mm specimens compared to cylinders (150 mm x 300 mm). Specimens water cured and fully hardened



Yun et all, 1988, ref (6)
Mortar
Average of 2 CAPO-TEST and 4 cores (150 mm x 300 mm) on slabs 1000 mm x 1000 mm x 300 mm
Slabs cured with wet burlap, fully hardened.

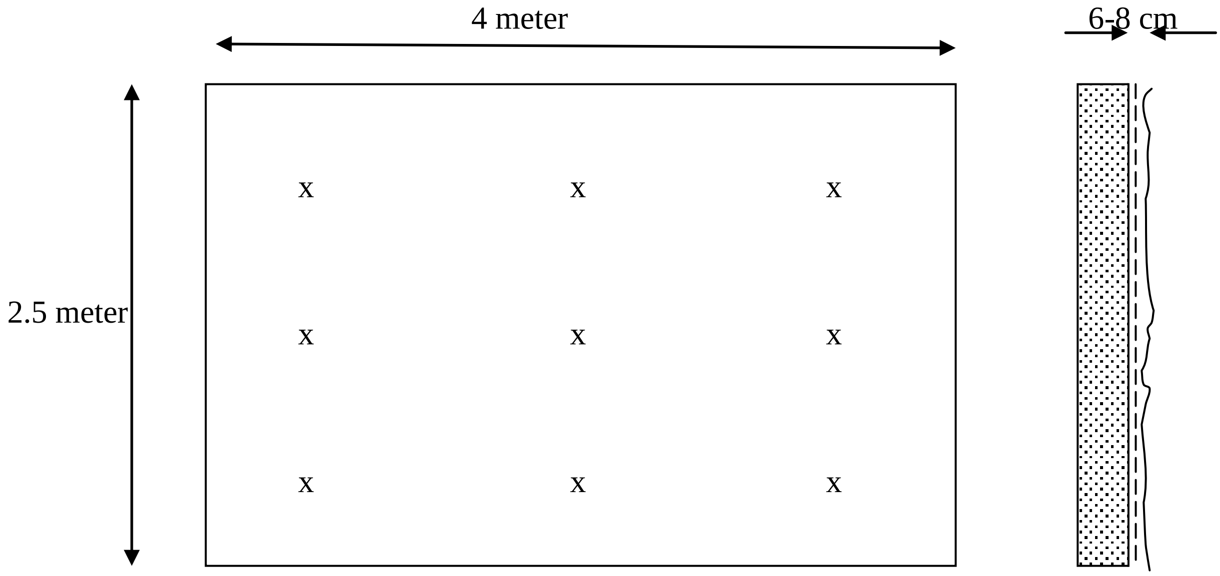


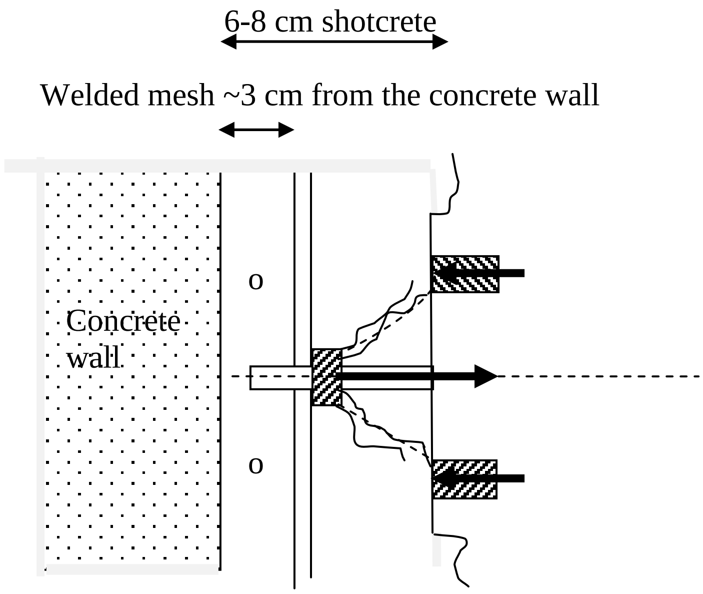
For comparison to 150 mm cube strength the general cube equation is used:
$f_{cube} = 0.76\ F^{1.16}$, f_{cube} in MPa and F in kN

Variations are stated in ref. (4)

On-Site Testing Example:

CAPO-TEST were performed on fully hardened shotcrete walls, 2.5 meter x 4 meter, 60 mm to 80 mm thick, ref (4)
In every wall 9 CAPO-TEST ´s were performed
In the middle of the shotcrete layer was positioned a welded mesh, spacing 5 x 5 cm, 6 mm thickness of the mesh





Test result extracts from the tested walls are shown below

Site No Wall #	no's	CAPO Strength F Average (kN)	S (kN)	V (%)	Related Cylinder Strength x) fc, Average (MPa)
16 Wall 1	9	29.3	2.7	9.2	30.3
64 Wall 3	9	24.1	1.9	7.9	25.4
86 Wall 2	9	36.8	3.1	8.4	39.1

x) Related 150 mm x 300 mm cylinder strength fc in MPa calculated from Capo-Strength F in kN, using the general correlation fc = 0.69 . F1.12

Note:
Cores for comparison were not made due to the limited thickness and position of the welded wire mesh in the middle of the shotcrete layer obstructing the compression tests of the cores.

Shotcreting in boxes for comparison was not performed.

Adhesion strength using 50 mm discs was measured as well, ranging from 1.6 MPa to 2.2 MPa

References:

1) ASTM C900-15: "Standard Test Method for Pullout Strength of Hardened Concrete", ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conchohocken, PA 19428-2959, USA
2) EN 12594-3: "Testing of Concrete in Structures, Part 3: Determination of Pull-Out Force", European Committee for Standardization, rue de Stassart 36, B-1050 Brussels, Belgium
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