



INSTRUCTION MANUAL

FIELD VANE SHEAR TESTER

Model M-1000 (NILCON)

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Installation and use of this product may sometimes be dangerous. It must only be used by qualified personnel. The instructions in this manual are for guidance only and are subject to change. The Company does not accept any responsibility for any damage or loss which may arise from installation or use of this product.

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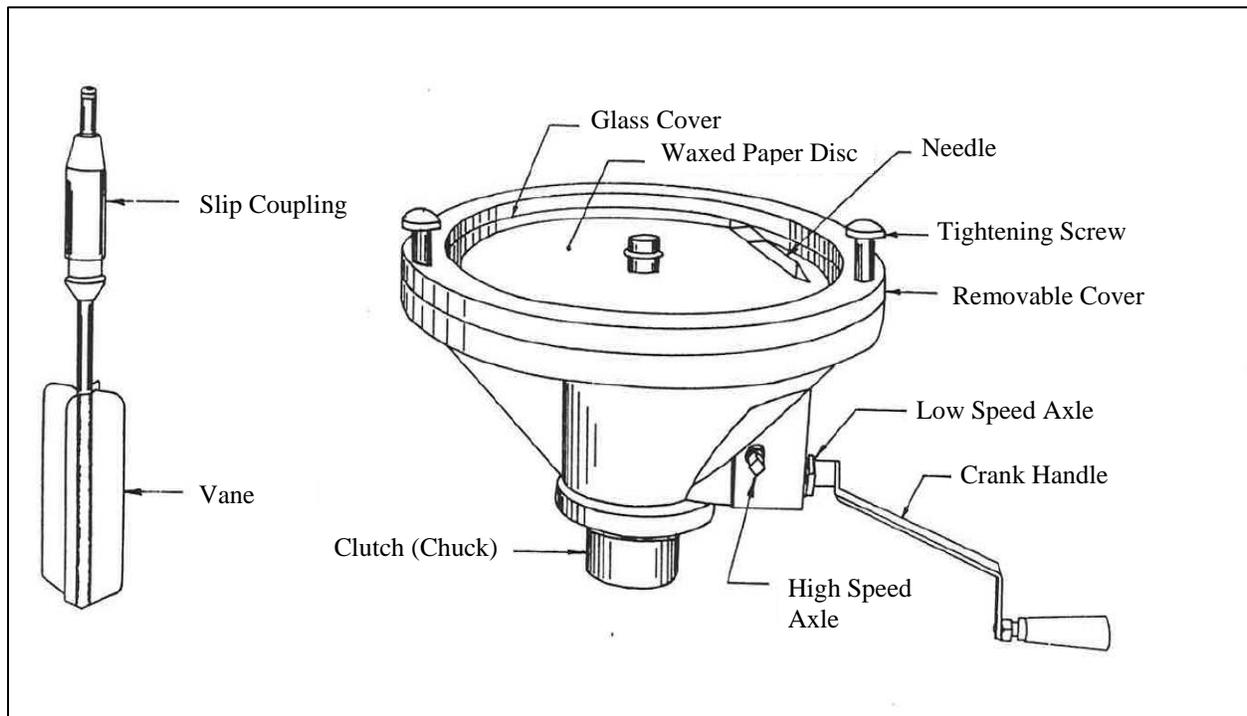
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1. DESCRIPTION

The M-1000 (NILCON) shear vane tester is a measuring device used to estimate in situ the shear strength of cohesive soils. Test results are recorded on a waxed paper disk to form a permanent record.

The recording head is mounted on either a casing or a hollow auger using an adapter, and the vane is pushed at the bottom of the borehole, or it is mounted on a portable boring rig used for pushing the rods into the ground. The test can be performed at various depths.



General arrangement of the M-1000

1.1 Vanes

The vane consists of four orthogonal blades secured to a central shaft. Three sizes of vanes are available: 5 x 11 cm, 6.5 x 13 cm, and 8 x 17.2 cm.

A 10 x 20 cm vane is sometimes used in very soft ground. The standard vanes are Type 3, i.e. they are fitted with a conical point at the bottom.

Smaller vanes are only used if the maximum strength of the ground cannot be attained with the recommended sizes.

Always check and clean the vanes before use. No defects (such as gouges, breakages, distortion or rust holes) are acceptable, since they can affect the results.

1.2 Slip Coupling

The slip coupling is installed right above the vane and enables the rods to rotate by 15 degrees without the vane rotating. Periodically check that slip coupling can rotate 15 degrees without any abnormal resistance. Be sure to also frequently check the condition of the rubber protector on the coupling. Replace the rubber protector if it becomes damaged.

1.3 Boring Rods

The rods are designed to prevent them from rotating with respect to each other when they are properly tightened. They are fitted with flats at each end so that they can be locked with an open-ended spanner. The rods must be smooth, clean and dry (free of oil or grease) for the clutch to engage correctly. Do not use an adjustable wrench; use the spanners supplied by the manufacturer. Always ensure that the assembled rods are straight. To do this, rods can be rolled on a rectilinear surface to check that they are straight.

Also, ensure that they are firmly secured to each other. Rods that are not properly screwed together will tighten up during the tests. Clean the rods thoroughly while removing them and after each use. If this is not done, soil will build up in the clutch and recording unit, and will stop them from working.

1.4 Recording unit

The Nilcon vane tester has a recorder which automatically marks out test curves on a waxed paper disk. The applied torque is recorded radially and the angular rotation is recorded tangentially. The recording unit must be kept in its steel carrying case when not in use. Keep the recording unit protected from rain and snow.

The recording unit consists of the following parts:

1. Glass removable cover

The cover is secured with two large screws. It can be taken off for installing waxed paper disks. The graph trace can be viewed through it. The paper is held in place by a metal ring located at the centre of the glass cover. During use, the cover must be tightened sufficiently (to prevent the needle from moving the paper), but it must not be too tight. After use, the cover should be loosened to improve service life.

The aluminum platen must stay dry.

Avoid exposing the cover to sunlight for prolonged periods of time.

2. Slow and fast transmission axles

The slow transmission axle is for performing the shear test. The crank handle is put onto the axle for this transmission speed after the fast transmission axle has been pulled out by about 1 cm.

The fast transmission is used to reset the needle to zero after a test. To do so, fit the crank handle onto the pushed-in fast transmission axle to create a low transmission ratio.

The high-to-low transmission ratio is 30 : 1.

3. Clutch (Chuck)

A clutch (at the base of the recording unit) transmits the movement of the crank to the vane tester rods when it is engaged. The clutch is the component that causes the most operating problems, mainly because of dirt build up. It must be removed and cleaned regularly.

The clutch should be operated as follows:

Clutch with rods engaged: In this position, the spring (3) is partially released, the locking screw is offset by about ¼ of a turn compared to the screw holding the spring and the ring is in the raised position. In order to engage the clutch, push the clutch's ring up and turn it counterclockwise when viewed from above.

Clutch with rods disengaged: In this position, the spring is tensioned, the screw holding the spring and the locking screw are vertically aligned and the ring is in the low position. To do so, turn the clutch's ring clockwise (when viewed from above) while lowering it (towards the ground).

The rods should be released from from the recording unit when : these are being inserted or removed from the ground, the rods are being rotated for the remolded test, or to enable the slip coupling to move freely.

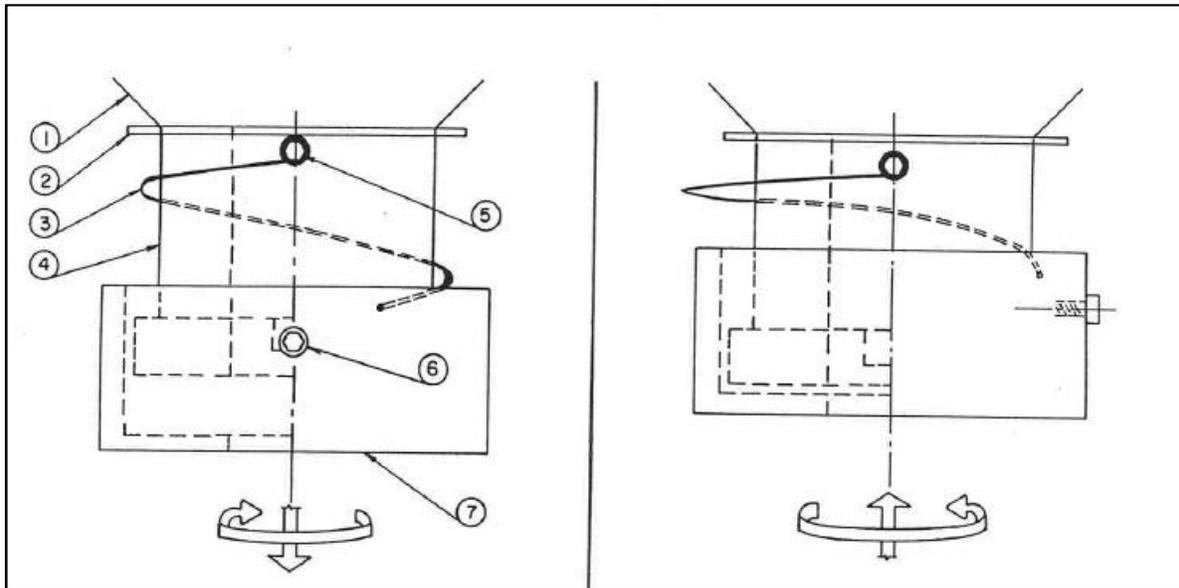
Before each test, ensure that the clutch spring is not distorted or out of position.

Replace the spring if necessary. Contact the manufacturer for more information about this.

Do not force the spring when manipulating the clutch.

Do not move the rods with the clutch engaged; this will damage it.

Note that if the rods and the recording unit are not well aligned, the clutch will be difficult to operate and the results will be affected.



Clutch in disengaged and engaged position

1.5 Installation Support

The M-1000 recording head requires an installation support.

Three options are possible:

- The test can be performed in a cased borehole using a boring rig. The recording unit is secured to the casing with an adapter (provided by Roctest).
- Instead of using a borehole casing, a hollow auger can be used for advancing the borehole and holding the recording unit. A special adapter should then be provided by the user in order to attach tightly the recording unit to the auger. It is very important that this adapter to be designed so that the recording unit does not slip and is properly aligned with the rods (to be checked with a level).
- A portable boring rig to insert the set of rods into the ground (this is rarely used).



Importance of carefully aligning the recording unit with the borehole casing (auger) and the rods

2. INSTRUCTIONS FOR USE IN A CASED BOREHOLE

- Select a size of vane for the expected hardness of the ground. The vane, slip coupling and set of rods are then assembled and lowered into the bottom of the borehole. When tightening a rod or the vane to the slip coupling, the flat on the coupling next to the rod/vane head must be used to prevent damage to the slip coupling. A small pipe wrench is used to hold the shaft of the vane head. The spanners provided by RocTest are used for holding the rods, and an adjustable wrench is used for holding the slip coupling.
- Rods with clean threads in good condition can, for the most part, be tightened by hand. Final tightening is then performed using the supplied spanners. If tightening the rods is difficult, clean the threads, or replace the rods.
- In holes deeper than 5 m, guide rings can be installed on the rods to keep them centered in the casing. Contact RocTest for more details.
- When the vane and rods reach the bottom of the borehole, the adapter is secured to the casing. The length of the rod coming out of the tubing must be about 0.6 m longer than the length suggested for the shear test, under the bottom of the borehole. The clutch is then unlocked, and the recording unit is inserted over the rod and then fixed to the adapter.
- The rods are then pushed in by hand or using the drill rig until the vane reaches test depth. This must be done slowly, without exaggerated effort, so as not to damage the vane.

Note : The vane can withstand high forces but is relatively brittle because of the hardening treatment it has received. Side pressure must not be applied to it. Such forces can occur in rocky backfill, layers of crushed brick or similar materials. In this case, a pilot hole must be bored first.

- The clutch is locked to the rods. The test can then be performed. The test must be performed within 5 minutes of inserting the vane. In very soft clay, a rod flange is used to support the vane/rod assembly during the test.

- Place a disk of waxed paper into the recording head without lifting the needle too high, so as not to bend it. Turn the paper once counterclockwise to trace a line to act as a zero-reference during the test.
- Start the test: apply torque at a rate of no more than 0.1°/s. It usually takes 2 to 5 minutes to reach the shear point, except in wet clay, where the shear point may take 10 to 15 minutes. In harder ground, it may be preferable to reduce the angular velocity to get a better view of the stress-strain characteristics.
- Torque is applied by turning the crank on the slow transmission axle and after having pulled out the fast transmission axle by about 1 cm. This will ensure slow but uniform rotation. To rotate the rod more quickly, push the fast transmission axle in and attach the crank to it.
- As a general rule, turn the crank at 2 turns per second with the slow transmission axle. As testing depth increases, the torsion on the rod will also increase, and the actual rate of shear (degrees of rotation of the vane with time) will decrease. Therefore, the speed of rotation may be increased as shown on the following table.

Test Depth (m)	Slow Transmission (Turns/sec)
0 - 10	2
11 - 20	3
21 - 30	4

- For speeds higher than about 3 rev/sec, it may be preferable to use the fast transmission axle.
- The curve traced on the waxed paper disk has an initial plateau indicating the friction between the rods and the ground. After about 15 degrees, the resistance increases up to a peak, corresponding to the yielding of the ground.
- The test must be continued for at least 20 degrees after reaching the peak to show the yielding mode of the ground. If the shear strength of the soil exceeds the capacity of the equipment, the needle will get too close from the metal ring located at the centre of the glass cover, which hold the waxed paper. Stop the test before the needle reaches a distance of 1 cm from this metal ring.
- In order to bring the needle back to zero, put the crank on the fast transmission axle (after pushing it in by 1 cm) and rotate counterclockwise. The needle frequently does not move back exactly to this line. To avoid damaging the machine, do not turn too much the fast transmission axle. On the following test, the needle should return to the reference line. Release the clutch.
- A remolded test can then be performed. To do so, a spanner is used to turn the rods and the vane clockwise 20 times to ensure complete remolding of the soil. The rods must then be turned counterclockwise to re-establish the play in the slip coupling. It is important not to turn too far counterclockwise to avoid unscrewing the rods. Just a few degrees should be enough. The end of the slip is usually felt by a significant increase in torque. If the test is deep, it will be necessary to turn a bit more for establishing the play.
- Engage the clutch. Crank at a rotation speed of 2 rev/sec using the slow transmission axle.
- The remolded clay test must be started less than 1 minute after having turned the rods to avoid thixotropic effects. Otherwise, the rods will have to be rotated 20 times again and the test will need to be performed again.

- Disengage the clutch. Screw on the next rod and continue to push it in. Tests must be at least 0.5 m apart. The point of the vane sets the depth reference.
- If a test is performed in a soft layer underlying a layer of firm and sticky clay, the results may be affected by the effect of clay accumulating on the vane when it passes through this layer. Clay in the stiff layer may stick to the vane and disturb the clay in the soft layer when the vane is pushed in. The operator must ensure that this phenomenon is not occurring. If there is any doubt, bring the vane back to the surface, clean it, lubricate it, and push it back down without stopping to the depth of the next test. Record all checks performed in the test report.
- Rod Insertion: The lower edges of the vane are slightly bevelled to make the vane rotate slightly clockwise when being pushed in, helping to bring the slip coupling back to its initial position before starting a new test. The bevel develops a slip of about 15 degrees per meter of descent. For tests performed less than 1 m in depth apart, the user must turn the rod counterclockwise before moving from one test depth to another to ensure a certain amount of slip for the next test. In fact, it is always preferable to check this, however deep the shear tester is inserted. To avoid unscrewing the rods and shear tester, do not turn it too much.
- When the vane shear test is finished, release the clutch, remove the recording unit and put it back in its box. Write the following details on the sheet: site and building, borehole number, test depth, recording unit serial number, vane size, operator name and test date.
- Secure the rubber cleaning washer to the casing adapter. The rods are then removed from the borehole, cleaned and disassembled. When removing the rods from the hole, it is recommended to hold the rod with a chain or rod puller.
- A sharp increase in the force needed to pull the device up means the vane is stuck. Do not use excessive force. Push the vane back in a few centimetres and turn it slightly clockwise before pulling the rods up again. In a cased borehole, it is possible that the vane will catch on the lower edge of the casing. In this situation, lifting out this one may facilitate removal of the vane without damaging it.
- Cleaning the vane head and slip coupling is very important. Clean the rods as they come out with a cloth and brush the threads with a wire brush.



Note 1: If work is temporarily stopped, this must be done after performing a test and not after pushing the vane down to the next test depth. During a longer break - overnight for instance - the rod must be lifted a few metres before stopping work. When testing is restarted, the rod must be rotated about 10 turns, then pulled up, and pushed back down so that the clay around the rod is sufficiently dislodged. A stoppage during boring must be recorded in the log. However, it is sometimes preferable to perform tests at the same depth after several breaks following disturbance and re-mixing of the clay to measure shear strength restoration (thixotropic) effects over time. Sliding characteristics can also be used to assess thixotropic effects along the rod.

Note 2: The condition of the slip coupling must be checked frequently. The play must stay at around 15 degrees and the torque to rotate it must not exceed 5 kg x cm.

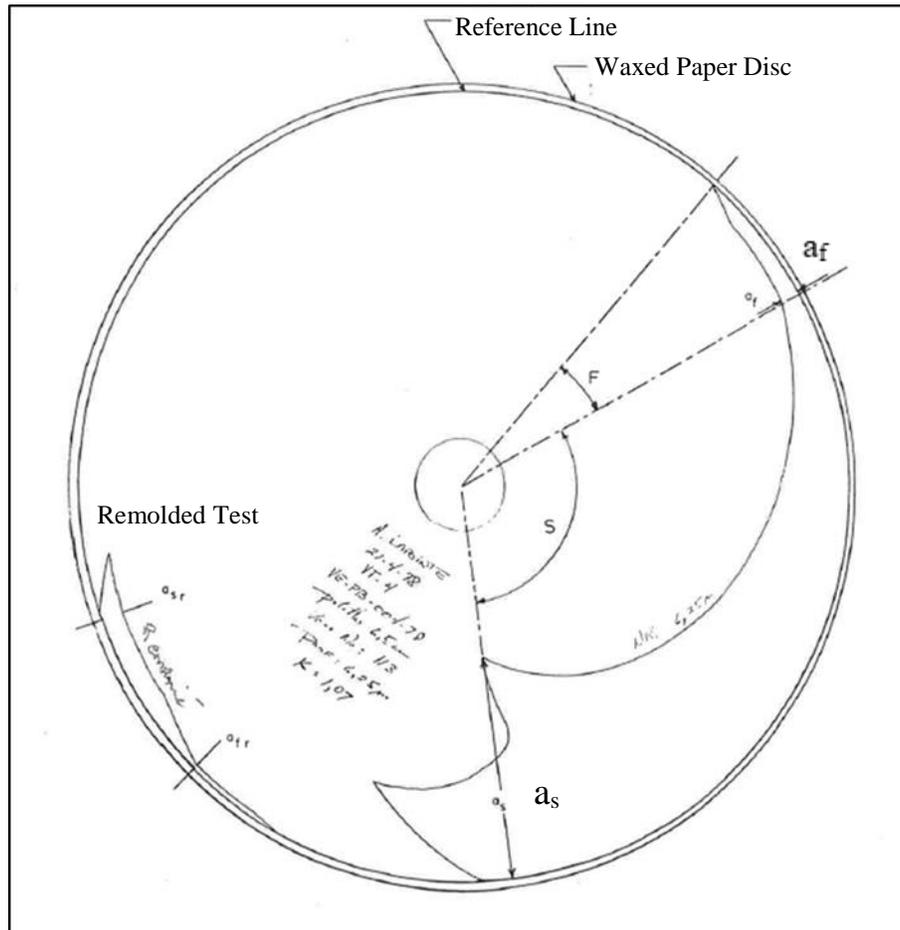
Note 3: When the needle approaches a distance of 1 cm from the metal ring at the centre of the paper, it is important not to load the vane any further. If the ground does not yield, the non-remolded test will not be completed. It is recommended that you move on to the next test depth and use a smaller vane head if necessary.

3. INSTRUCTIONS FOR USE WITH A PORTABLE BORING RIG

The vane shear tester is sometime used with a portable boring rig. The instructions for inserting the vane are then different:

- The base-frame of the boring is fastened to the ground with the earth augers. These are screwed down with one of the crank handles of the boring rig, or with a power drill. Note that the base-frame must be sufficiently level to permit subsequent rod plumbing within the adjustment tolerances of the vertical frame.
- Plumb the vertical frame and tighten the securing bolts.
- Bolt the base clamp that accepts the torque-recording head to the top of the frame (2 bolts). Insert the instrument head and turn it so that the crank handle is in an unobstructed position. Lock the instrument head in the base clamp.
- Place a paper disk in the instrument and turn it counter-clockwise once only, to scribe a zero line for visual reference during the testing. Make sure that the instrument's clutch is disengaged and is not gripping a rod, if any is passing through the head.
- Assemble the vane and the slip coupling on the 80 cm starting rod. Tighten adequately. Hold the assembly under the instrument, thread a 100-cm rod through the head and tighten the 2 rods together. Add another rod to the top of the rod string just assembled.
- It is important to start the tip sounding with proper rod alignment. Put the vane point against the ground surface so that the axis of the rod is vertical and parallel with the chain when the driving yoke is in its lowest position. If required, a shallow hole may first be dug for the vane. The torque instrument itself, with clutch disengaged, serves as an upper rod guide. After checking for rod plumbness, verify that all rod connections are tightly screwed.
- Insert the rod fork in the flats machined on the rods. The rod fork, for convenience, should be placed as high as possible along the rod. Press down the vane carefully until the desired test depth is attained. The mobile part of the clutch shall be in its lowest position when driving the rod. When ready to test, push the clutch in its uppermost position and turn it counterclockwise to firmly lock it on the rods. Start the test.

4. INTERPRETATION OF THE VANE BORING CURVE



Typical graph

A graph for a typical vane shear test is shown above. The radial distance “a” from a point on the graph to the reference line is directly proportional to the torque “M” applied to the end of the vane rod, which is at the surface. The linear relationship between the radial distance and torque is expressed using a calibration constant “K” for each device where:

$$M = K \times a$$

where: M = torque in kg x m.
a = distance from zero torque reference line in cm
K = torque calibration constant for the recording head (in kg x m/cm).

On the line on the graph, the torque required to turn the rods and the slip coupling corresponds to the torque a_f . The torque needed to turn the rods and the vane to the soil yielding point corresponds to the maximum torque a_s . The difference between a_s and a_f equals the torque M_v required to turn the vane itself up to the soil yielding point.

With the remolded test, one does not in certain cases get a distinct difference between a_r and a_s . This is because the reaction torque from the disturbed clay is so small that it is not high enough to move the slip coupling. In other words, this means the torque required to turn the vane tester is less than the torque needed to turn the slip coupling (3 to 5 kg x cm).

The torque needed to only turn the vane itself M_v is obtained as described below. It is then converted into undrained shear strength (S_u) in kPa using the following relations:

$$\begin{aligned} M_v &= K (a_s - a_r) \\ S_u &= M_v \times C \\ \mathbf{S_u} &= \mathbf{98.2 \times K (a_s - a_r) \times C} \end{aligned}$$

where:

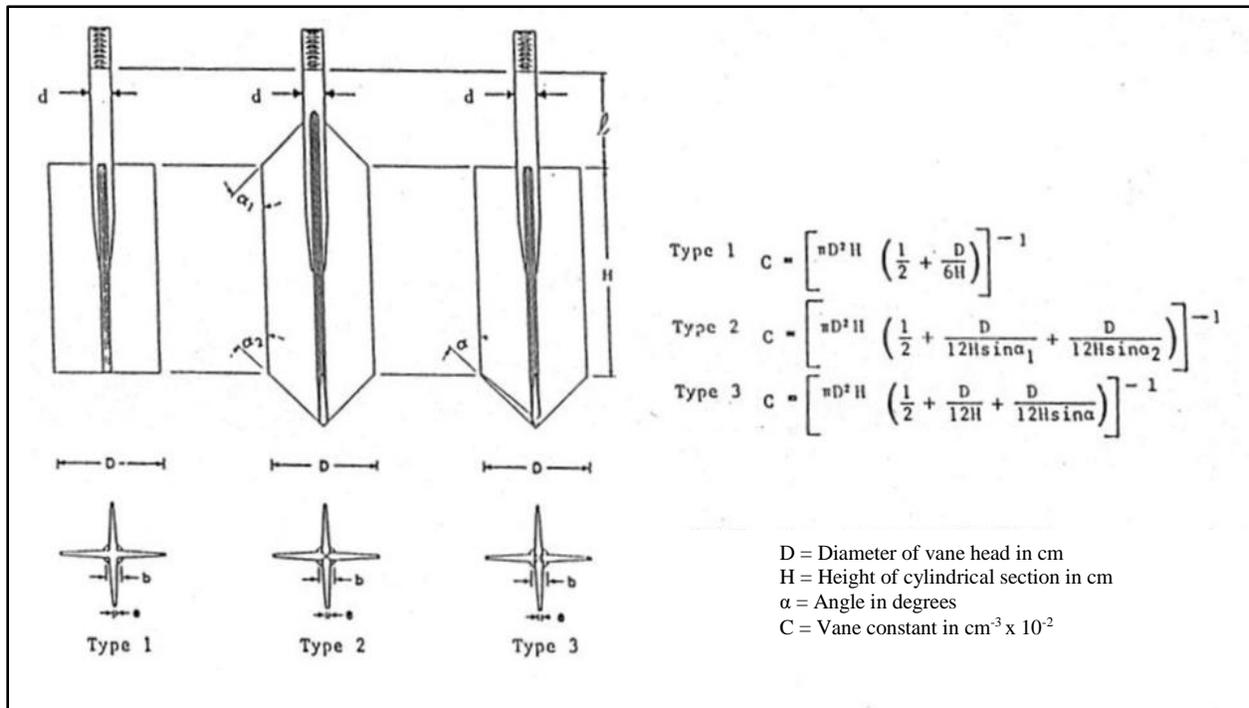
- M_v = torque needed to turn the vane tester alone in kg x m.
- a_s = distance in cm between the reference line and the top of the graph.
- a_r = distance in cm between the reference line and the circular arc traced during the first 15 degrees of rotation (which corresponds to the friction of the rod).
- S_u = undrained shear strength in kPa.
- C = constant for the geometry of the shear tester in $10^{-2} \times \text{cm}^{-3}$
- K = calibration constant for the recording head (in kg x m/cm).

The vane tester constants for Type 3 shear testers are as follows:

Vane Size (cm)	C ($10^{-2} \times \text{cm}^{-3}$)
5 x 11	0.2
6.5 x 13	0.1
8 x 17.2	0.05
10 x 20 (option)	0.026

Vane constants can be determined from the formula below.

With the method described above, the user can obtain shear strength readings for both intact and disturbed ground. In addition, the graph shows the strength of the ground immediately after yielding, which is very important for assessing the effects of progressive deformation. The shape of the graph after yield indicates the nature of the ground. In pure clay soils, the post-yield section of the curve will be regular but if sand or silt is present, this part of the curve will be more irregular.



Vane head constants

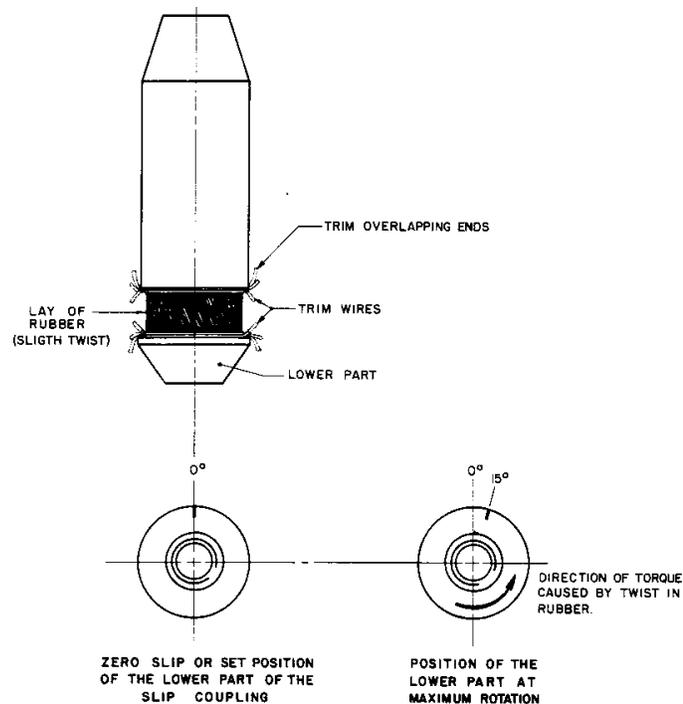
Example: C = 0.05 (8 x 17.2 cm vane head).
 K = 1.1 kg x m/cm (according to calibration certificate).
 as - af = 5.3 cm (measured on the graph with a vernier calliper or a ruler).

Then: Su = 98.2 x 1.1 x 5.3 x 0.05
 Su = 28.6 kPa

5. INSPECTION AND MAINTENANCE

- Please read all parts of the text underlined for precautions in using the device and maintenance advice.
- The M-1000 recording unit must be periodically returned to Roctest for inspection and calibration.
- The recording unit is delivered with a small piece of cardboard under the needle to protect the aluminum platen. Keep the cardboard or a piece of waxed paper folded in two under the needle when the device is being transported.
- Ensure that there is no water or dust in the transport case before storing the equipment !
- Do not oil or grease the rods.
- If the rod threads or clutch are very dirty, WD-40 can be used to clean them, but dry thoroughly afterwards.

- If the slip coupling is damaged or if a torque of more than 5 kg x cm is needed to rotate the slip coupling, it will have to be returned to the factory for repair. In an emergency, a repair can be attempted on site as follows:
 - a) The rubber sleeve must be slackened and the rod located approximately in the middle of the slip coupling must be removed using a mandrel.
 - b) The connection is undone and the needle bearings removed.
 - c) The connection and needle bearings must be cleaned thoroughly in kerosen.
 - d) The needle bearings must be greased and put back in place. The assembly is then pushed into the cylinder and the rod reinserted carefully.
 - e) A length of about 0.5 inch of rubber tubing (bicycle tire inner tube) is then cut off. Slide the sleeve over the conical end of the joint. Secure the upper end of the rubber sleeve with two lengths of wire to hold it in place. Turn the free end of the rubber sleeve clockwise and secure with wire. The torsion in the rubber sleeve should generate enough torque to keep the lower part of the joint in position, while allowing rotation of 15 degrees clockwise between the upper and lower parts of the joint.



Rubber sleeve assembly

- A rapid check on the recording head can be performed as follows:
 - a) Secure the recording head to a bench or table. If possible, use the borehole casing adapter.
 - b) Put a piece of waxed paper and a rod in the head. Engage the clutch.
 - c) Apply some torque to the rod and check that the needle responds as expected.
 - d) Apply a pair of vice grips to the rod with a low amount of force. Insert a thin piece of paper between the jaws of the vice grips and the rod. Hold the handles of the vice grips firmly and turn the crank on the head. The rod will slide inside the vice grip jaws and the needle will trace out a certain degree of resistance.
 - e) Increase the force on the vice grips and check that the needle responds correctly.