
Standard Method of Test for

Field Vane Shear Test in Cohesive Soil

AASHTO Designation: T 223-96 (2000)



1. SCOPE

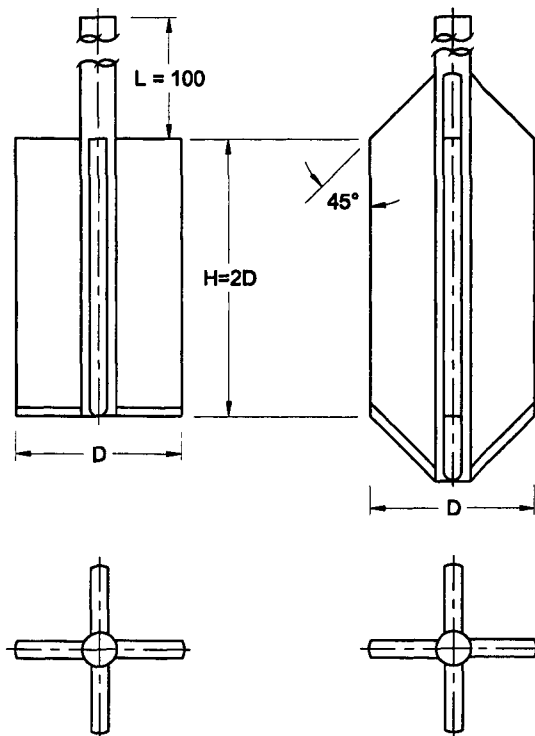
- 1.1. This method covers the field vane test in soft, saturated, cohesive soils. Knowledge of the nature of the soil in which each vane test is to be made is necessary for assessment of the applicability and interpretation of the test.
- 1.2. The values stated in SI units are to be regarded as the standard.

2. SUMMARY OF METHOD

- 2.1. The vane shear test basically consists of placing a four-bladed vane in the undisturbed soil and rotating it from the surface to determine the torsional force required to cause a cylindrical surface to be sheared by the vane; this force is then converted to a unit shearing resistance of the cylindrical surface. It is of basic importance that the friction of the vane rod and instrument be accounted for; otherwise, the friction would be improperly recorded as soil strength. Friction measurements under no-load conditions (such as the use of a blank stem in place of the vanes, or a vane that allows some free rotation of the rod prior to loading) are satisfactory only provided that the torque is applied by a balanced moment that does not result in a side thrust. As torsional forces become greater during a test, a side thrust in the instrument will result in an increase in friction that is not accounted for by initial no-load readings. Instruments involving side thrust are not recommended. The vane rod may be of sufficient rigidity that it does not twist under full-load conditions; otherwise a correction must be made for plotting torque-rotation curves.

3. APPARATUS

- 3.1. The vane shall consist of a four-bladed vane as illustrated in Figure 1. Vane dimensions shall be as specified in Table 1. Sizes other than those specified in Table 1 shall be used only with the permission of the engineer in charge of the boring program. The ends of the vane may be tapered. (See Figure 1.) The penetrating edge of the vane blade shall be sharpened having an included angle of 90 degrees.
- 3.2. The vane shall be connected to the surface by means of steel torque rods. These rods shall have sufficient diameter such that their elastic limit is not exceeded when the vane is stressed to its capacity (Note 1). They shall be so coupled that the shoulders of the male and female ends shall meet to prevent any possibility of the coupling tightening when the torque is applied during the test. If a vane housing is used, the torque rods shall be equipped with well-lubricated bearings where they pass through the housing. These bearings shall be provided with seals to prevent soil from entering them.
- The torque rods shall be guided so as to prevent friction from developing between the torque rods and the walls of casing or boring.



Rectangular Vane

Tapered Vane

Figure 1—Geometry of Field Vane

Table 1—Recommended Dimensions of Field Vanes^a

Minimum Casting Requirement		Diameter		Height		Thickness of Blade		Diameter of Vane Rod	
		mm	in.	mm	in.	mm	in.	mm	in.
Acker Type	A	38.1	1.5	76.2	3	1.59	0.0625	12.7	0.5
	B	50.8	2	102	4	1.59	0.0625	12.7	0.5
	N	63.5	2.5	127	5	3.18	0.125	12.7	0.5
	H	92.1	3.625	184	7.25	3.18	0.125	12.7	0.5
Sgi ^b Type	H	55	2.17	110	4.33	2	0.078	11	0.43
	H	65	2.56	130	5.12	2	0.078	11	0.43
Nilcon ^c Type	B	50	1.97	110	4.33	2 ^d	0.078	20	0.79
	N	65	2.56	130	5.12	2	0.078	20	0.79
	H	80	3.15	172	6.77	2	0.078	20	0.79

^a Selection of the vane size is directly related to the consistency of the soil being tested, that is, the softer the soil, the larger the vane diameter.

^b This is a totally self-contained, portable vane shear unit, which is capable of providing its own cased hole. Where overburden is too stiff, casing is required for the 77-OD mm vane housing.

^c This is a totally self-contained, portable shear unit, which is capable of being pushed directly into the soil. The vane is followed by a slip coupling during penetration, which provides for rod friction calibration before each test. Where overburden is too stiff, casing is required.

^d This is the average thickness. Vane blades are tapered 2.5 mm (0.098 in.) at the shaft to 1.5 mm (0.059 in.) at the edge.

- 3.3. Torque shall be applied to the torque rods, thence to the vane. The accuracy of the torque reading should be such that it will produce a variation not to exceed ± 1.2 kPa (25 lb/ft²) shear strength.
- 3.4. It is preferable to apply torque to the vane with a geared drive. In the absence of a geared drive, it is acceptable to apply the torque directly by hand with a torque wrench or equivalent. The duration of the test should be controlled by the requirements of Section 4.3.

Note 1—If torque versus rotation curves are to be determined, it is essential that the torque rods be calibrated (prior to use in the field). The amount of rod twist (if any) must be established in degrees per meter (foot) per unit torque. This correction becomes progressively more important as the depth of the test increases and the calibration must be made at least to the maximum depth of testing anticipated.

4. PROCEDURE

- 4.1. In the case where a vane housing is used, advance the housing to a depth that is at least five vane housing diameters less than the desired depth of the vane tip. Where no vane housing is used, stop the hole in which the vane is lowered at a depth such that the vane tip may penetrate undisturbed soil for a depth of at least five times the diameter of the hole.
- 4.2. Advance the vane from the bottom of the hole or the vane housing in a single thrust to the depth at which the test is to be conducted. Take precautions to make sure no torque is applied to the torque rods during the thrust.
- 4.3. With the vane in position, apply the torque to the vane at a rate that should not exceed 0.1 degrees per second. This generally requires a time to failure of from two to five minutes, except in very soft clays where the time to failure may be as much as 10 to 15 minutes. In stiffer materials, which reach failure at small deformations, it may be desirable to reduce the rate of angular displacement so that a reasonable determination of the stress-strain properties can be obtained. During the rotation of the vane, hold it at a fixed elevation. Record the maximum torque. With apparatus with geared drives it is desirable to record intermediate values of torque at intervals of 15 seconds or at lesser frequency if conditions require.
- 4.4. Following the determination of the maximum torque, rotate the vane rapidly through a minimum of 10 revolutions; the determination of the remolded strength should be started immediately after completion of rapid rotation and in all cases within 60 seconds after the remolding process.
- 4.5. In the case where soil is in contact with the torque rods, determine the friction between the soil and the rod by means of torque tests conducted on similar rods at similar depths with no vane attached. Conduct the rod friction test at least once on each site; this shall consist of a series of torque tests at varying depths.
- 4.6. In apparatus in which the torque rod is completely isolated from the soil, conduct a friction test with a blank rod (Note 2) at least once on each site to determine the magnitude of the friction of the bearings. In a properly functioning vane apparatus, this friction should be negligible.
- 4.7. Conduct undisturbed and remolded vane tests in cohesive soils only. Do not conduct the vane test in any soil that will permit drainage or dilates during the test period, such as sands or silts or in soils where stones or shells are encountered by the vane in such a manner as to influence the results.

Note 2—In some cases it is not necessary to remove the vane for the friction test. As long as the vane is not in contact with the soil, that is, where it is retracted into a casing, the friction measurements are not affected.

5. CALCULATION

- 5.1. Calculate the shear strength of the soil in the following manner: The turning moment required to shear the soil is as follows:

$$T = s \times K \text{ where: } T = \text{torque, kN}\cdot\text{m (or lbf}\cdot\text{ft)}, s = \text{shear strength of the clay kPa (or lbf/ft}^2\text{);}$$
$$K = \text{constant, depending on dimensions and shape of the vane, m}^3 \text{ (or ft}^3\text{).}$$

- 5.2. Assuming the distribution of the shear strength is uniform across the ends of a cylinder and around the perimeter, calculate the value of K as follows:

SI Units:

$$K = \frac{\pi}{10^9} \times \frac{D^2 H}{2} \times \left[1 + \frac{D}{3H} \right] \quad (1)$$

U.S. Customary Units:

$$K = \frac{\pi}{1728} \times \frac{D^2 H}{2} \times \left[1 + \frac{D}{3H} \right] \quad (2)$$

where:

D = measured diameter of vane, mm (in.); and

H = measured height of vane, mm (in.).

It is important that these dimensions are checked periodically to ensure the vane is not distorted or worn.

- 5.3. If the ratio of length to breadth of the vane is 2:1, the value of K may be simplified in terms of the diameter so that it becomes the following:

SI Units:

$$K = \frac{3.66}{10^9} \times D^3 \quad (3)$$

U.S. Customary Units:

$$K = \frac{2.12}{10^3} \times D^3 \quad (4)$$

- 5.4. Since the value of s is required, it is more useful to write the equation as follows:

$$s = T \times K \quad (5)$$

where:

T = the torque, is measured so that s can be calculated.

- 5.5. For the tapered vane of Figure 1, the following modified equation may be used for the vane constant:

SI Units:

$$K = \frac{1}{10^9} \left[\pi D^3 + 0.37(2D^3 - d^3) \right] \quad (6)$$

U.S. Customary Units:

$$K = \frac{1}{1728} \left[\pi D^3 + 0.37(2D^3 - d^3) \right] \quad (7)$$

where:

d = rod diameter, mm (in.).

6. REPORT

- 6.1. For each vane test, record the following observations:
 - 6.1.1. Date of test;
 - 6.1.2. Boring number;
 - 6.1.3. Size and shape of the vane (tapered or rectangular);
 - 6.1.4. Depth of the vane tip;
 - 6.1.5. Depth of the vane tip below the housing or bottom of the hole;
 - 6.1.6. Maximum torque reading, and intermediate readings if required for the undisturbed test;
 - 6.1.7. Time to failure of the test;
 - 6.1.8. Rate of remolding;
 - 6.1.9. Maximum torque reading for the remolded test; and
 - 6.1.10. Notes on any deviations from standard test procedure.
- 6.2. In addition, record the following observations for the boring:
 - 6.2.1. Boring number;
 - 6.2.2. Location;
 - 6.2.3. Location of the soil conditions;
 - 6.2.4. Reference elevation;
 - 6.2.5. Method of making the hole;
 - 6.2.6. Description of the vane, that is, housed or not;
 - 6.2.7. Description of the method of applying and measuring the torque;
 - 6.2.8. Notes on the driving resistance;
 - 6.2.9. Name of the drilling foreman; and
 - 6.2.10. Name of the supervising engineer.