SWEDISH GEOTECHNICAL SOCIETY

RECOMMENDED STANDARD FOR FIELD VANE SHEAR TEST

SGF Report 2:93E

SVENSKA GEOTEKNISKA FÖRENINGEN
SWEDISH GEOTECHNICAL SOCIETY

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Recommended Standard for Field Vane Shear Test

Approved by the Board of

the Swedish Geotechnical Society,

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1. Introduction

The Vane shear test is an in situ method used for determination of the undrained shear strength t_{fu} and the sensitivity S_t in cohesive soil. The Vane shear test is carried out with a vane consisting of four plates fixed at right angles to each other and connected to a system of jointed extension rods. Pushed into the soil to the desired depth, the vane is rotated, Figure 1. By measuring the torque required to achieve failure in the soil, along the cylindrical surface circumscribing the vane, a value of the undrained shear strength can be calculated. After extensive rotation of the vane whereby the soil becomes thoroughly remoulded, the soil's remoulded shear strength can be measured and its sensitivity can be calculated. With instruments registering moment as a function of torsion, information is obtained on the character of the failure in the soil.

2. Definitions

Failure surface

The failure surface is assumed to be a rotational symmetrical body circumscribing the vane, Figure 1. The shear strength is assumed to be fully mobilized and equal over the whole surface at failure, so also at the upper and lower boundary surfaces.

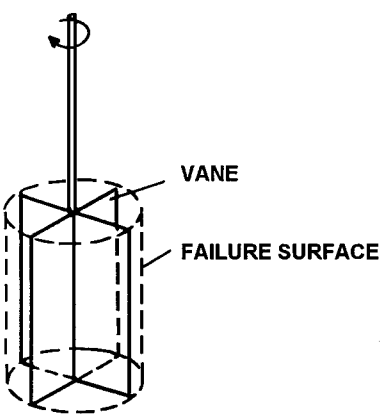

Figure 1. Assumed failure surface.

Maximum torque, M_{max}

Maximum torque, or failure moment, is the torque required to obtain failure in the cylinder surrounding the vane.

Shear strength value in undisturbed condition, τ_v

τ_v is defined as the shear strength value for the soil in undisturbed condition.

Shear strength value after remoulding, τ_{Rv}

τ_{Rv} is defined as the shear strength value after remoulding.

Sensitivity, S_{tv}

S_{tv} is a measure of the soil's sensitivity and is defined as the relation between the shear strength value t_v in undisturbed condition and τ_{Rv} after remoulding.

Undrained shear strength, τ_{fu}

τ_{fu} is defined as the soil's undrained shear strength after correction with regard to the soil's liquid limit.

3. Equipment

Extension rods

The rods shall have a diameter of at least 20 mm.

Thread eccentricity in relation to the outer diameter shall be less than ± 0.1 mm for sounding rods. Maximum permitted bending for rods is 2 mm over each 1,000 mm of length, calculated as height of arch (also applicable to two jointed rods).

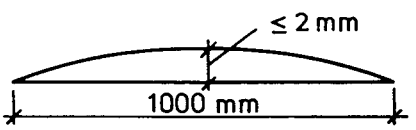

Figure 2. Maximum permitted bending of rods.

Vane

The vane shall be undamaged during tests. The blades shall be parallel with the extension rods and no distortion is allowed. The thickness of the blades and the shaft both influence the disturbance of the clay. Consequently, the blades should be thin. The blade thickness (t) shall not exceed 3.0 mm and shall not be less than 0.8 mm, see Figure 3. The average thickness shall be ≤ 2 mm. The diameter of the vane shaft, as well as possible welding seams, punch marks etc. in the centre of the vane shall not exceed 14 mm. If the vane is equipped with a protec-

tive casing, the length of the protrusion at the test shall be within the interval 0.35-0.5 mm.

The relation between the height (H) and the diameter (D) of the vane shall be 2.0. The maximum vane size (D x H) is 100 mm x 200 mm and the minimum vane size is 40 x 80 mm. The vane shall be equipped with a device (e.g. a loose-coupling) making it possible to separate the torque of the vane from that of the rods.

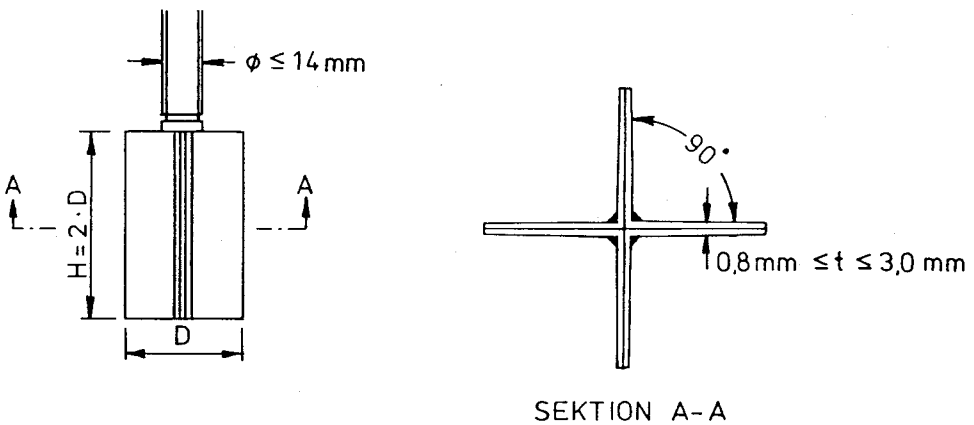

Figure 3. Stipulated dimensions of the vane.

Recording instrument

The instrument shall be designed to make it easy to read the maximum moment. The reading error shall not exceed 5 % of the applied moment, cf. Chapter 7 "Calibration".

4. Test Procedure

Predrilling

Predrilling shall be made through existing dry crust and fill when vane shear tests are to be made in the soil below such layers. This is necessary in order to prevent unprotected vanes from becoming clogged or damaged. The test can be conducted at a depth of at least 5 times the diameter of the predrilled hole below the bottom of this hole.

Pushing down the vane

The vane shall be pushed down without any use of blows, vibration or rotation.

The pushing rate should be constant and not exceed 1 m/60 s. The time from the instant when the desired test depth has been reached to the beginning of the vane test (waiting time) shall be 2-5 minutes.

The maximum deviation of the rod system from the vertical line shall not exceed 2 % when starting to push down the vane.

Determination of τ_v

The vane shall be rotated at a constant rate, making the failure occur within a 2-4 minutes, with 3 minutes as a reference value. The time to failure is defined as the time between the first application of torque to the vane until the moment when the maximum value is reached.

For vanes designed as in Figure 3 with D/H = 1:2, the shear strength value τ_v is determined by using of the following formula:

$$\tau_v = \frac{6M_{max}}{7\pi D^3}$$

where M_{max} = maximum torque for the vane. M_{max} shall be reduced by the rod friction when such occurs. The shear strength value after remoulding (τ_{Rv}) is determined by the same formula.

Determination of τ_{Rv}

After failure has occurred, the vane is rotated rapidly about 20 turns, after which a new test is performed immediately according to the instructions above. The shear strength value (τ_{Rv}) after remoulding is thereby determined.

Determination of S_{tv}

The sensitivity (S_{tv}) is calculated as the quotient between the undrained shear strength value (τ_v) and the shear strength value after remoulding, τ_{Rv}

$$S_{tv} = \frac{\tau_v}{\tau_{Rv}}$$

Determination of τ_{fu}

In order to obtain the soil's undrained shear strength, the strength value from the vane shear test is corrected with consideration to the liquid limit, with correction factors in accordance with Figure 4; $\tau_{fu} = \mu \cdot \tau_v$. A greater correction factor than 1.2 should not be used without support from supplementary investigations.

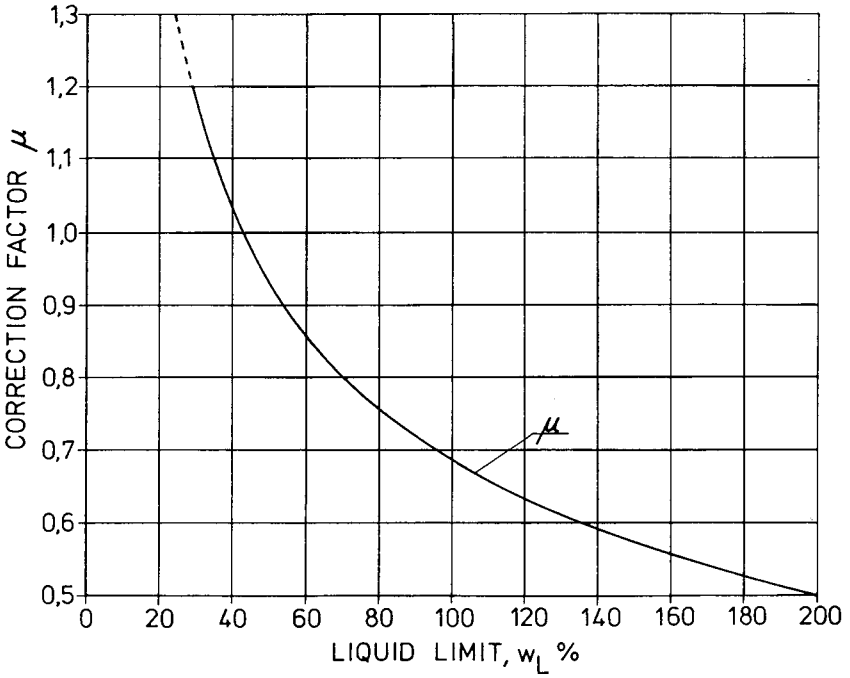

Figure 4. Correction factors for τ_v.

Distances between test points and test levels

The distance between test points shall be ≥ 2.0 m in plan.

The first test shall be conducted at a depth of at least 0.5 m below the ground surface or the depth of the predrilling. Two tests conducted in the same test point may not be carried out closer than 0.5 m from each other vertically.

Further aspects

When using an outer system with a casing protecting the vane, the water pressure in the casing system shall be the same as that in the soil at the test level. Otherwise, piping may occur, because of factors such as permeable soil layers.

When required, a casing tube shall be used in order to prevent buckling.

5. Precision of Measurements

Tolerances for measurements

- *Depth*
  The uncertainty of the determination of depth may not exceed 0.1 m.

- *Torque*
  Taking into account all sources of error, the uncertainty of measured torque may not exceed 5 %.

6. Checklist for Control Measures in the Field

When remarkably high values are obtained, check the following

- vane size
- the friction between the vane and the lower part of the protective casing
- that the rods are straight and well jointed together.
- that the pointer of the recording instrument returns to the zero position
- possible presence of stones, gravel, shells, sand, or layers of silt
- that the vane does not sink during the test
- the function of the loose-coupling device
- that the temperature of the vane is higher than 0 °C when pushed into the soil

When remarkably low values are obtained, check the following

- vane size
- possible remoulding of the clay by stones, shells etc, which have been pushed down in front of the vane
- that failure has actually been achieved and that the rods have not just been screwed together
- if the rod has been unintentionally rotated before the test
- that firm clay has not stuck to the vane
- that the temperature of the vane is higher than 0 °C when pushed into the soil

7. Calibration

The recording instrument shall be calibrated at least once a year or when it has been damaged, overloaded or repaired. Calibration shall be carried out in a special calibration device with sealed weights or equivalent. The friction shall initially be lower than 10 Nmm and then as a maximum 2 % of the applied torque. The calibration device shall be designed in such way that the field tests can be simulated. The calibration shall embrace the whole measuring range and be conducted in at least 10 steps.

8. Reporting of Test Results

Report

For both manual and automatic recording, the following shall be stated:

- Type of test equipment
- Vane size
- Instrument number
- Date, name of responsible operator
- Test location, project
- Test point
- Coordinates or other geographical positioning
- Date of last calibration
- Time to failure (the time for the activated vane only)
- Test depth
- Calibration factor for the instrument
- Observations made in connection with the test, as well as events or details not dealt with in the standard that may influence the test result

Automatic recording shall follow formats according to SGF's recommended standard.

Graphical presentation and symbols

Graphical presentation of the results from field vane tests shall be made according to SGF's recommended standard for geotechnical symbols.

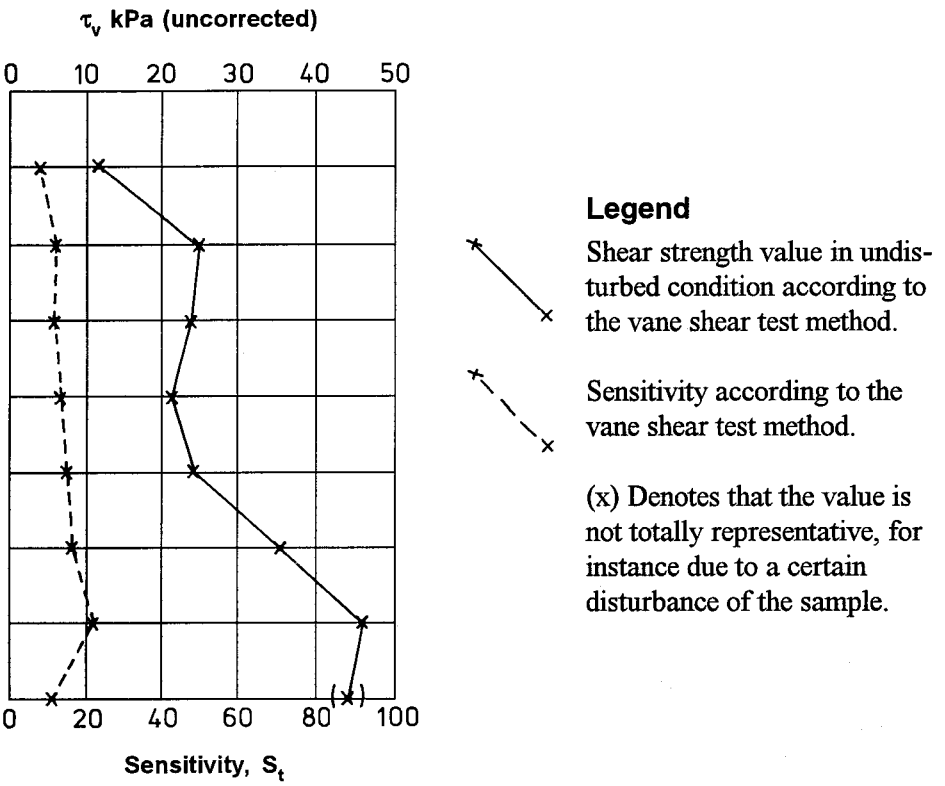

Figure 5. Example of presentation.

SGF Rapport/Report

1:93 Rekommenderad standard för CPT-sondering.

1:93E Recommended Standard for Cone Penetration Tests.

2:93 Rekommenderad standard för vingförsök i fält.

2:93E Recommended Standard for Field Vane Shear Test.

1:95 Rekommenderad standard för dilatometerförsök.

2:95 Några pionjärprofiler i svensk geoteknik.
SJ Geotekniska Kommission 1914-1922.

The Swedish Geotechnical Society (SGF) was formed in 1950 and has currently 650 members with at least two years experience in geotechnics. In addition, there are some 35 corporate members comprising institutions, universities, official bodies, consultants, contracting companies and manufacturers with activities in the area of geotechnics.

The objective of the SGF is to promote development in geotechnics and foundation engineering through lectures, discussions and committee work, and to cooperate with Swedish, Nordic and other international bodies having a similar orientation.

The SGF is the Swedish representative of the International Society for Soil Mechanics and Foundation Engineering (ISSMFE). Every member of the SGF is also a member of the international society.

The series of Reports published by the SGF contains recommendations for geotechnical standards, in addition to monographs and documentation from conferences, seminars and other events.

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