CIV2202.10: THEODOLITE ADJUSTMENT

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PREVIEW

Introduction

Apart from the obvious requirements of smooth mechanical performance, a theodolite must meet certain geometric requirements for precise single measurement. Whilst the affect of some types of mis-adjustment may be eliminated by proper observing technique, large mis-adjustments make the theodolite difficult to use.

Objectives

After completing this topic you should be able to :

- appreciate the possible mis-adjustments of a theodolite and their affect on angle observations.
- Know the specific tests for adjustments and how to perform simple adjustments.
- Recognise when a theodolite is not functioning correctly when the complexity of the adjustments requires that they be carried out by a competent instrument make

Readings

Read *Muskett,* Chapter 3.8

REQUIRED

REGULAR CHECKS

Tripod

- shoes firm on legs - no wobble or play
- clamps on telescope section of legs hold firmly
- upper end of legs firmly held in sockets on tripod head. There is usually a clamping bolt requiring periodic tightening
- leg hinges firm but not tight (This causes stress in the tripod which may release and upset the leveling of the instrument)

Footscrews

- big enough to ease levelling
- fine pitch for accurate levelling.
- should move freely

Tribrach head

- secure, with no play.
- head of theodolite should be firmly attached

Plates

- free and easy - no catches or noise - both upper and lower plates.
- clamps should lock with finger pressure.
- tangent screws - perceptible movement should give movement of telescope.
- any problems will require a workshop service

Eyepiece & Objective

- use a soft cloth to wipe off rain, sweat.

General

- instrument must be stable.
- centres of rotation of horizontal plates must correspond with vertical axis of instrument which must be directly over the ground station.
- centre of graduations of horizontal circle must lie in vertical axis.
- centre of graduations of vertical circle must lie in horizontal axis (trunnion axis).
- divisions or graduations must be accurate.
- the planes of the horizontal on vertical circles must be normal to the vertical axis and horizontal axis respectively.
- resolving power of telescope should be such that a perceptible movement of scales causes a movement of the line of sight.
- these are all considered by the manufacturer.
- problems may arise after prolonged use.

TEMPORARY ADJUSTMENTS

- centring above a ground station
- levelling
- collimation (parallax).

All of these have already been discussed. They are required at each instrument set-up.

PERMANENT ADJUSTMENTS

Plate bubble adjustment

The instrument axis should be vertical when the bubble is at the centre of its run.

Bring the bubble to the centre of its run for 2 perpendicular directions, as previously discussed.

Turn the instrument through a further 90°. If the bubble doesn't move, it's correctly adjusted.

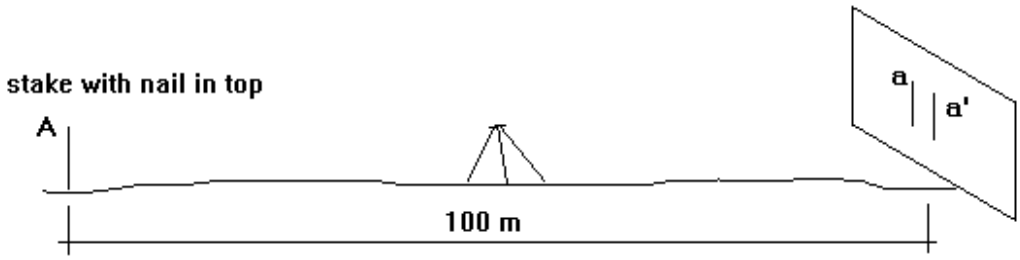
Otherwise, the displacement is twice the error: D = 2E
(one division is usually 20").

Adjust **half** the error using the bubble adjustment screws. **Repeat** the procedure until there is no error.

Even if the bubble tube is not to be adjusted, the bubble must be positioned (using the footscrews), so that it doesn't move when the instrument is rotated.

Line of Collimation - Vertical Hair

The line of collimation must be normal to the horizontal or trunnion axis.



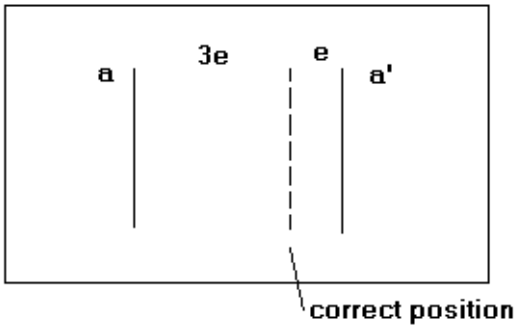
Level the instrument; aim to A and lock the plates.

Transit telescope, sight to wall, and place a vertical mark at a.

Repeat for the other face, and make mark a'

If the vertical hair is in the correct position, a and a' will correspond.

If not, D = a - a' represents **4 x error** :



Assuming that the instrument hasn't been moved from the last position (a'), measure to correct position as shown above, and move vertical hair into position with diaphragm screws, which adjust the position of the cross-hairs.

This method is different to that given in *Muskett* 3.8 (2) Horizontal Collimation Test. This method eliminates the correlation of errors.

Vertical Collimation

Correct vertical angles are obtained when the vertical collimation is correctly adjusted.

1. Read zenith angles to some distant clearly defined object in both the face left (FL) and face right (FR) positions.

2. The sum of these angles should be 360^0.

3. Calculate the correct zenith angle:

   $FL' = FL - (FL + FR - 360^0)/2$.

4. With the telescope directed to the object, adjust the vertical index compensator until the correct reading is obtained.

5. Repeat the test.

Optical Plummet

This is used to centre the instrument over the ground mark.

It is simply a right angled telescope whose line of sight is collinear with the vertical axis. If the instrument is not levelled, the optical plummet will not sight vertically.

To check its adjustment, centre the instrument accurately over the ground mark, then rotate the theodolite 180^O about its vertical axis. The optical plummet should still be centre on the ground mark.

If not, halve the error using the foot screws, then centre the optical plummet using the adjusting screws on the optical plummet eyepiece.

Repeat the test.

These are the most frequent errors in the adjustment of a theodolite, and they are corrected by simple field checks.

The following condition are found less frequently in modern theodolites. whilst they can be detected by field tests, they can be corrected only by an instrument maker.

Trunnion Axis Test

Requirement: The trunnion axis should be normal to the vertical axis.

Expressed another way, when the vertical axis is truly vertical, the trunnion axis is horizontal.

For this test, it is necessary to sight a point at an elevation of approx. 40^o and to mark points on a level line in the same vertical plane as the elevated mark.

A clearly defined feature such as a joint or imperfection on the wall of a tall building will usually serve the purpose.

With the theodolite carefully levelled, sight the elevated mark. Plunge the telescope to the horizontal and mark a point on the wall.

Change face and repeat the process.

Most modern theodolites do not have any ready means of making this adjustment. If there is a significant difference between the two marks the instrument should be sent to the manufacturers or an instrument maker for adjustment / re-building.

Mark the mean of these points. direct the vertical hair of the telescope to this mid point, and tilt the telescope to the elevated mark.

Using the trunnion axis adjusting screws, raise or lower one end of the trunnion axis to bring the vertical hair onto the elevated mark.

Repeat the test.

Eccentricity Test - Horizontal Circle

Requirement: The centre of graduations of the circle and the vertical axis should be coincident.

This test will have a strong correlation with any error in collimation in azimuth if present.

Set up and sight a distant target on face left, and record the reading.

Change to face right, re-sight the target and record the reading

Repeat this procedure at regularly spaced intervals around the circle, say 45^o.

If there is no eccentricity, the difference between all face right and face left pairs will be 180^o + horizontal collimation error if present.

If there is eccentricity present, differences between faces will vary in a regular sinusoidal pattern.

Eccentricity is usually adjusted out by an experienced instrument maker. However, the nature of the connection between the glass circle and the metal axis is such that the adjustment cannot be regarded as permanent.

Eccentricity can be significant, and must be guarded against when setting out a square grid for building purposes. A true right angle can be set out by using both faces and using four different "zeros", e.g. O^o, $9O^o$ $18O^o$ $27O^o$.

Eccentricity Test - Vertical Circle

Requirement: That the centre of graduations of the vertical circle is coincident with the trunnion axis

It is more difficult to test the vertical circle, as it is not possible to choose different positions of the vertical circle.

This check can be applied to some extent by using targets at

a level sight

elevated by 30^o to 40^o

depressed by 30^o to 40^o

SUMMARY

The theodolite should meet geometric criteria:

The plate level should remain in the centre of the level vial when the theodolite is rotated to any position about its vertical axis.

The line of sight of the telescope should be normal to the trunnion axis.

Zenith (vertical) angles read face left and face right to the same target should sum to 360^O.

The optical plummet aimed at a ground mark, should remain aimed at the ground mark when the theodolite is rotated about its vertical axis.

These conditions can be checked and adjusted by simple field tests.

The following conditions can be checked in the field, but require adjustment by an instrument maker:

Eccentricity of the horizontal circle.

Eccentricity of the vertical circle.

Trunnion axis is not normal to the vertical axis.

REVIEW QUESTIONS

What instrumental error conditions are eliminated by taking readings in the face left and face right positions?

What instrumental error conditions are not eliminated by taking readings on both faces?

ANSWERS TO REVIEW QUESTIONS

If these answers are given, you will not do anything, and will not learn much. If you cannot answer these questions, do some research in the texts. If you are still not sure of the answers, discuss the subject with the lecturer or tutor.