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Comparable Parameters for the Qualification of Surveying Tripods

1. Introduction

The daily work of a surveyor normally doesn't require the high level of accuracy that the surveying accessories have coincidently influenced. However, that statement becomes invalid immediately with the requirement of high precision measurements. Then, every potential influence on a single measurement must be considered. This includes such aspects as air temperature, air pressure, humidity etc, along with prism target characteristics and even centring accuracy.

A tripod is generally accepted as an accessory that works without having to put any thought to its influences to measurements. Following, an overview is given which parameters could be interesting for surveyors to judge and compare the quality of tripods.

Normally a surveyor expects no problems from a tripod. Also including tribrachs, prism holders and prism poles, the trust in these types of survey products is very high. It is to the point that no one thinks to inquire about the measurement specifications of such products.

In principle, every survey requires a stable support. However, dependent on the level of precision demanded, it could be the precision is only being achieved with a fixed measurement pillar. But the circumstances of the task or for economic reasons a measurement pillar can be unrealistic.

It's at this moment that the fundamental knowledge about the use of these survey accessories is required. Some of its aspects have been elaborated and shall be shown in the current paper.

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2. Standardized Quantities

The ISO standard 12858 Part 2 defines certain parameters that quantify tripod types as well as quality (accuracy):

- height stability (Fig. 1),
- torsional rigidity,
- general tripod measurements and headshape,
- weight and max. allowed load.

Those values can be taken as comparative criteria. The above parameters mainly refer to tripod use under static conditions with according procedures restricted to measurements or observations at a particular time. But the test procedures do not describe the tripod behaviour over time under changing or dynamic influences and load.

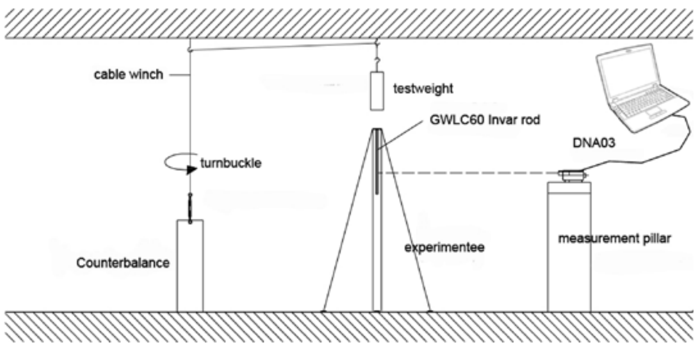

Fig. 1. Auomatized height stability test setup

3. Measurement Principles and Observed Deformations

Weight load from the instrument is the determining component generating a vertical deformation. In principle, the deformation direction is assumed equal for all three of the tripod legs, but normally this does not happen 100% equal. Because of this, a change in the (horizontal) orientation of the tripod head is expected as well. A digital level was used to detect the vertical variations, respectively the height stability. But to measure the horizontal component of the weight impact further sensors would have been required on each of the tripod legs. Remaining strain in the tripod legs probably caused by over tightening of the leg clamps could also cause unexpected and uncontrolled movements. However, this is most probably too little in its amplitude to measure.

The models used combined with the results from the previous investigations delivered plausible coherences and thereby the above mentioned possible influence was not further investigated. This doesn't mean that the horizontal deformation is neglected, it is just contained in a separate, integral treatment of the Hz--stability.

Figure 2 shows the vertical deformation of a tripod (Leica GST1209) loaded with 30 kg. Measuring periods: 5 min without a load, 25 min with 30 kg load, and 5 min after load removed. The weight was put onto the tripod head using a special cable winch system to ensure avoiding the creation of oscillations in the tripod legs. The experiment showed that for the particular investigated experiment during the load time the deformation remains within the allowed limits defined by ISO [1] (=0.05 mm for heavy tripods). These results give evidence that the height stability can be treated as non-critical, validity for aluminium-, fibreglass- and wooden tripods [2]. Torsional rigidity as defined in the ISO 12858 part 2 [1] refers to a deformation (turn or rotation) of the tripod head plate of 60′, after the release the remaining deformation (hysteresis) must be smaller than 8″.

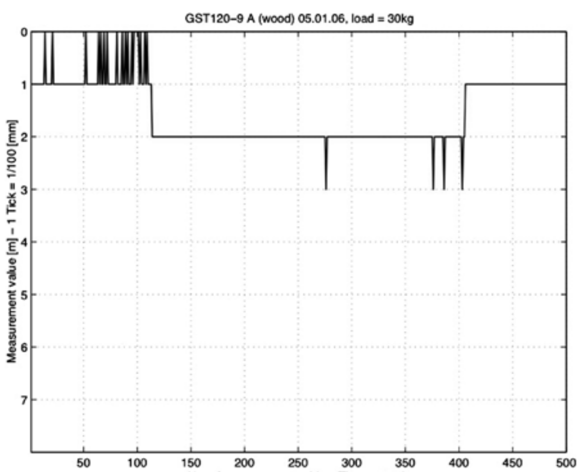

Fig. 2. Height stability of Leica GST120-9

The curves in figure 3 show a comparison of two tripod models during a measurement period of 3.5 min.

During the measuring time a motorized tachymeter (Leica TCA2003) was measuring in an automated manner to two prisms in two faces. The peaks refer to the acceleration and breaking movements when performing the measurements before face changes, including load reversal.

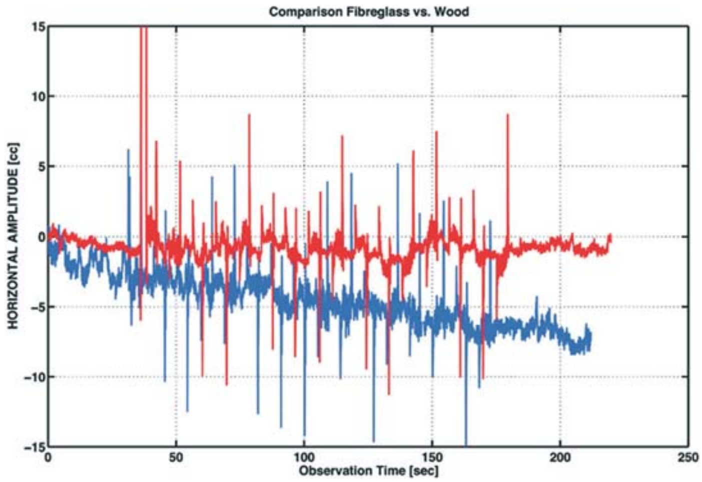

Fig. 3. Hz-Stability of fibreglass compared to a wooden model

The observation was done through an electronic autocollimator, measuring to a mirror mounted on a plate installed between the tripod head plate and tribrachs (Fig. 4).

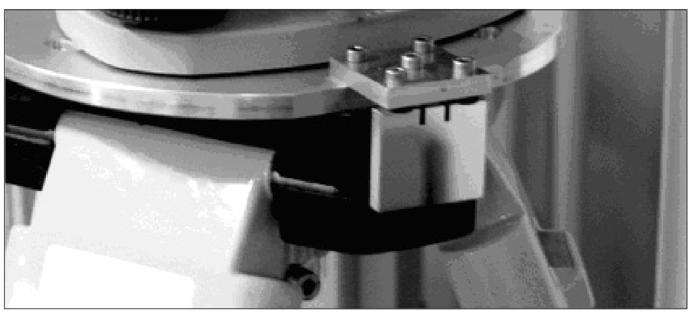

Fig. 4. Autocollimation mirror mounted between tripod and tribrach

Additionally this aluminium plate has the same milled surface structure as the actual tripod head – this is to avoid any changes of the friction coefficient. The comparison shows slightly higher amplitudes for the fibreglass model compared to the – identical in construction – wooden model. But, the horizontal drift (recognized by the difference in start and end value) shows significant differences. It stands to reason that the applied torques cause a horizontal drift that is greater for the fibreglass model. Considering only the Hz-drift observations, there is evidence enough to show the advantages of wood over aluminium. Table 1 summarizes test results regarding horizontal stability during dynamic load.

Table 1. Potential influences regarding Hz (heavy models are designed to support instruments up to 15 kg, whereas light models just support 5 kg)

Material	Trend	Hz-Drift
Heavy models		
Wood (beech)	< 1^{cc}	$6–7^{cc}$
Fibreglass	< 6^{cc}	$13–22^{cc}$
Light models		
Wood (pine, coated)	< 3^{cc}	$3–4^{cc}$
Aluminium	< 26^{cc}	$23–26^{cc}$

4. Is there a Problem? Is there a Solution?

Tripods manufactured of different materials have been the focus of this investigation. The results show that wood is the best material to produce the best tripods (to qualify this, the quality of wood must be of high standard). It is easily seen that the damping properties of oak and pine wood are far superior to those of either fibreglass or aluminium.

But for the surveyor, the question is still not answered: "which tripod is best suited for a measuring task?" The tripod is a major determiner of measurement accuracy but to answer the question, other accessories including the tribrach and of course the accuracy of the measuring instrument must still be considered. It is the measuring task that requires a level of measurement accuracy. A construction job that requires the staking of light posts does not demand the same accuracy as the placement of hydro-electric turbine foundation mounts. Starting with instruments, there are different weights, different functions or auto capabilities and of course price differences to consider before the decision of the accessories to use. Regarding tripods, the height stability investigations showed different materials and even different models offer similar results. However, more importantly the horizontal drift showed much larger variations between only the material of the tripod and then more so between the different tripod models. In table 1 wood (beach) clearly offers the best results. Wood (coated pine) also offers high results when compared to fibreglass or aluminiuim. Keep in mind, these results were achieved in a controlled environment, and do not consider the normal measuring environment such as the effects of sun and shade on tripod legs or other field influences on a tripod. It is easy to conclude that aluminiuim tripods after just 3.5 min of dynamic measurements have a very high hz-drift-rate.

Over time, then it should not be a surprise that the orientation is significantly affected. Brand new tripods were used for this investigation. Lifecycle of the different materials was not part of the investigations, but it would be a factor that has also potentially negative influences on the reliability of accuracy for all accessories in particular tripods. Even though this paper offers information relative to tripod stability and drift characteristics, sensible measurement techniques still provide the strongest means to achieve the desired measurement accuracies for a given task. Check and check again. A solid surveyor will already be prepared with a measurement method to reduce tripod deformations, eliminate instrument error and minimize general blunders.

References

[1] ISO: *Optics and Optical Instruments – Ancillary devices for geodetic instruments – Part 2: Tripods. International Organization for Standardisation*. 1999.

[2] Nindl D.: *Genauigkeitsanalyse von Vermessungsstativen und Dreifüssen unter der Belastung verschiedener Instrumente*. University of Technology, Vienna 2006 (M.Sc. Thesis).