MEMS PORTABLE TILT METER

INSTRUCTION MANUAL

PROMAT

GEOSENSE

Contents

LIST OF FIGURES

1 INTRODUCTION

The Micro-Electro-Mechanical System (MEMS) Portable Tilt meter System permits the precise measurement of changes in tilt of engineering structures. The system consists of three components, (1) individual Tilt meter base plates which are secured to the structure at points of interest, (2) the MEMS Portable Tilt meter which indexes the Tilt meter base plates in a repeatable manner and senses the tilt via MEMS tilt sensor/s (uniaxial/biaxial), and (3) a MEMS Portable Tilt meter Readout to display the Tilt meter data.

1.1 TILT Base Plate

The Tilt meter base plates are precision-machined stainless steel or brass plates with 4 indexing studs located 90 degrees apart on a 100 mm diameter circle. Each stud is numbered from 1 to 4 (see Figure 2). The Tilt base plates are fastened to the structure of interest by methods which depend on the material of the structure. Both stainless steel and brass materials are resistant to corrosion in many construction environments.

1.2 MEMS PORTABLE TILTMETER

The MEMS Portable Tilt meter is a precision stainless steel instrument which can be indexed precisely and in a repeatable manner on the Tilt meter base plate. It can be fixed in 4 positions which together permit the tilt of the instrument to be sensed along 2 orthogonal axes with normal and reversed readings which permit cancellation of face error. The measurement is made via a MEMS tilt sensor/s, which converts the tilt measurement to a highly precise analog signal.

1.3 MEMS PORTABLE TILTMETER READOUT

The Tilt meter is typically read via the Geosense MP12 MEMS Portable Tilt meter Readout.

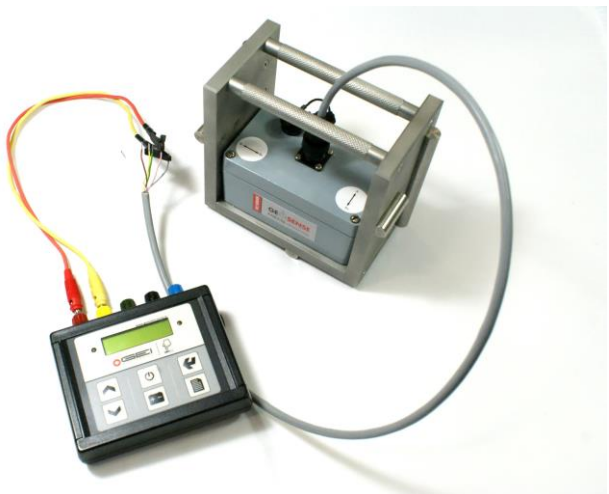

Figure 1: MEMS Portable Tilt meter & MEMS Portable Tilt meter Readout

2 TILTMETER BASEPLATE INSTALLATION

In order for the Tilt meter installation to be successful, the Tilt meter base plate must be rigidly connected to the structure of interest, free of long-term adverse factors including corrosion, form distortion, and impact damage.

2.1 Fresh Concrete Horizontal

In a typical installation on new concrete, the following procedure is suggested:

After the concrete has been placed and levelled in the location of interest, work the Tilt meter Base plate into the concrete until the top surface of the plate is level with the concrete surface, with the diagonal stud pairs aligned with the desired measurement axes, ideally with the orientation of the studs consistent across the entire site.

If desired, increased strength of placement may be achieved by fitting countersunk brass screws through the mounting holes and tightening nuts on the back side, leaving 50 mm of threads exposed below the Tilt meter base plate.

Ensure that no concrete is permitted to remain on the top of the Tilt meter base plate, especially on the studs. If necessary, carefully clean the studs with a damp cloth. Ensure that the Tilt meter base plate is protected from damage during curing, form stripping, and subsequent operations.

2.2 Fresh Concrete Vertical

In order to avoid damage during form stripping, it is suggested that a separate form segment be built in such a manner that the Tilt meter base plate is stripped separately. The separate form segment can be drilled to suit the studs and greased to facilitate the stripping of the form and subsequent clean-up of the Tilt meter base plate. The separate form segment may ideally be recessed slightly below the main vertical surface to give enhanced safety from damage.

The Tilt meter base plate should be mounted with its face vertical and the axis from stud 1 to stud 3 vertical.

2.3 Existing Concrete

The Tilt meter base plate may be attached to existing concrete using mechanical fasteners, using grout, or a combination of methods. Mechanical fasteners require precise concrete drilling and/or a central adapter plate. The effectiveness of grouts, either cement-type or chemical, is highly dependent on the concrete condition, surface preparation, site conditions and other variables.

Figure 2: Tilt Meter Base Plate

3 DATA REDUCTION

The data is reduced by calculating the average change for an opposed pair of positions, i.e.:

$$\Delta \sin \theta_{1,3} \times 10^3 = \frac{(\sin'\theta_1 \times 10_3 - \sin'\theta_3 \times 10_3) - (\sin\theta_1 \times 10_3 - \sin\theta_3 \times 10_3)}{2}$$

and

$$\Delta \sin \theta_{2,4} \times 10^3 = \frac{(\sin'\theta_2 \times 10_3 - \sin'\theta_4 \times 10_3) - (\sin\theta_2 \times 10_3 - \sin\theta_4 \times 10_3)}{2}$$

where:

$\sin \theta_1 \times 10_3$ = the raw initial data with stud 1 visible

$\sin \theta_2 \times 10_3$ = the raw initial data with stud 2 visible

$\sin \theta_3 \times 10_3$ = the raw initial data with stud 3 visible

$\sin \theta_4 \times 10_3$ = the raw initial data with stud 4 visible

$\sin' \theta_1 \times 10_3$ = the raw new data with stud 1 visible

$\sin' \theta_2 \times 10_3$ = the raw new data with stud 2 visible

$\sin' \theta_3 \times 10_3$ = the raw new data with stud 3 visible

$\sin' \theta_4 \times 10_3$ = the raw new data with stud 4 visible

e.g.: A tilt monument plate with raw initial data of:

$\sin \theta_1 \times 10_3 = 15.1$
$\sin \theta_3 \times 10_3 = -14.9$

and new raw data of:

$\sin' \theta_1 \times 10_3 = 17.6$
$\sin' \theta_3 \times 10_3 = -17.4$

$$\Delta \sin \theta_{1,3} \times 10_{3} = \frac{(17.6 - [-17.4]) - (15.1 - [-14.9])}{2}$$

$$\Delta \sin \theta_{1,3} \times 10_{3} = 2.5$$

$$\Delta \sin \theta_{1,3} = 2.5 \div 1000 = 0.0025$$

$\Delta\theta_{1,3} = \arcsin(0.0025) = 0.14°$ = change in angle θ along studs 1-3 between initial data and new data

The same procedure can be repeated for data along the stud 2, 4 axis.

4 CARE AND MAINTENANCE

The Tilt meter should be treated gently like any precision instrument. In particular, care should be taken to avoid any bumps or impact, both to protect the MEMS tilt sensor and to avoid denting or distorting the machine plates and alignment bars. Any dust or grit on the Tilt meter base plates should be carefully wiped off with a damp cloth prior to readings to avoid scratches on the Tilt meter base plate.

The connectors should be kept clean and dry to avoid electrical errors.

A reference Tilt meter base plate should be maintained in a convenient, stable location to permit the instrument to be regularly checked.