OPERATING INSTRUCTIONS

‘Demec’ Mechanical Strain Gauges

35-2838, 35-2846, 35-2854

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1 Introduction

1.1 A demountable mechanical strain gauge has advantages of accuracy, reliability and cost over other methods of strain measurement. However, the desired accuracy is only obtained by precision manufacture and care in the use of the instrument.

With practice, 200 strains per hour may be measured with an accuracy of about $\pm 5 \times 10^{-6}$ under most laboratory test conditions. Even greater accuracy has been obtained using the gauge in its ideal horizontal position and with the readings lying within a small range on the dial. In development tests of this kind 90 per cent of measured strains were within $\pm 3 \times 10^{-6}$ of the mean.

The instrument, which uses a lever and dial gauge arrangement mounted on an Invar Main Beam, is easy to use, and is located on 50 mm (EL35-2838) or 200 mm (EL35-2846) gauge lengths which are formed by pairs of punched and drilled stainless steel discs (EL35-2854) glued to the surface under examination.

The choice of material for the main beam and the reference bar has been determined by the requirement for a metal with a low coefficient of thermal expansion.

Although many references in these notes are to concrete the instrument is suitable for use on a wide variety of materials and structures.

1.2 Principle and Design

Any two rigid bodies, or two small, sensibly rigid, parts of an elastic body, may exhibit six degrees of freedom relative to each other, and an instrument which is designed to connect these two parts must, in general, allow these six movements in order to eliminate internal straining of the instrument. In the instrument under discussion two virtual point connections are used between the instrument and the specimen, and translational freedom between connections is provided by a moving arm pivoting about a knife edge and seating.

The practical form of connection used is that of a cone locating into an initially cylindrical hole. Examination under a microscope shows that the first applications of the hardened cone, on the setting out bar, into the hole cause plastic deformation of the steel seating and an approximately toroidal surface is produced. The combination of cone and toroid provides a fixed centre of rotation about the x and y axes as well as the z axis for a sufficiently large range of angular movement to make the operation of the instrument satisfactory. The apex angle of the cone is 60 degrees.

The 6.3 mm diameter stainless steel locating discs are blanked and blind hole drilled 1 mm diameter.

On any gauge length the rotation of the moving arm for various concrete strains is very small so that the cosine variation error of readings is negligible (0.3 per cent for 1,000 lb/sq. in.) in concrete.

A point of considerable interest in designing the instrument is to ensure that the locating force applied by the operator is directed along the axes of the instrument points. A subsidiary frame can be provided to ensure this but it has been found that so long as the handles of the instrument are placed so that no deformation is caused by the locating force, it is not difficult to eliminate, with practice, other sources of error such as horizontal thrust and variations of the instrument from the vertical.

The dial used is a Mercer 254 Series.

1.3 Practical Consideration in using the Instrument

1.3.1 The Reference Discs

Care is required in fixing the discs to the surface. The surface should first be emery-papered or, if necessary, ground to remove irregularities, so that the surfaces of the two discs are as nearly as possible in the same plane. If the surface is greasy or coated with shutter oil it must be cleaned with acetone, and the reference discs themselves may be shaken in a bottle of acetone. A thin layer of adhesive is applied to the concrete and allowed to harden. A second layer is then applied and the discs pressed on in the required position, exact location being ensured by use of the setting out bar. In the case of vertical or underside surfaces, they should be held in place by the setting out bar for a minute to allow initial setting. Care should be taken not to get adhesive into the hole in the disc, and for this reason the holes do not pass right through the disc. Twenty-four hours should elapse between fixing the discs and using them.

If all the gauge lengths are set out using one setting out bar the cosine variation amongst the individual gauge lengths is eliminated.

When computing strains on the upper and lower surfaces of models, allowance must be made for the thickness of the reference discs.

1.3.2 Holding the Gauge

A number of fairly obvious points are to be taken into consideration. Perhaps the most important is that the pressure applied should be just sufficient to provide good contact; any increase causes wear of the discs and of the instrument and increases the likelihood of longitudinal thrust. In thin models undue pressure will, of course, produce local strains in the concrete.

The operator should adopt as comfortable a position as possible : greater accuracy is obtained if he is able to rest the sides of his hands on the structure. To obviate parallax errors, and to ensure that the gauge is held in a vertical plane, he should be able to look perpendicularly onto the face of the instrument. The instrument should always be used the same way round on a particular gauge length, as on the Invar dummy bar, and it is thought to be easier if the instrument is held with the moving point in the right hand. Finally, when measuring vertical gauge lengths the fixed point should be in the lower disc.

1.4 The Invar Reference Bar

Although it may be argued that, in conditions where the concrete is going to change in temperature during testing, a concrete dummy bar, which will behave in a similar manner to the structure, is required, the practical difficulties are considerable. It is thought better to eliminate the temperature effect on the instrument by checking against an Invar bar and to allow separately for known temperature changes in the structure if these are serious.

The Invar bar should be supported so that application of the instrument does not cause bending, and if the Invar is contained in, say, a wooden housing, this should not apply any restraint resulting in straining of the Invar due to movement of the wood. Also, since Invar is a comparatively soft material, annealed carbon steel plugs containing the locating holes for the instrument are provided.

2 Taking Readings : 50 mm Gauge Length

The 'Demec' mechanical strain gauge has one fixed location point and one moveable measuring point at the gauge length.

Changes in this gauge length are transmitted through a pivot to the measuring dial gauge. The pivot lever has a nominal ratio of 1:2, i.e. 0.5:1.

Therefore, 0.5 mm real movement at the gauge length will read 1.0 mm on the dial gauge.

(A) **Extension**

Is the increase in length from the original gauge length and is measured in mm.

(B) **Strain**

Is extension expressed in relation to the original gauge length.

i.e. strain = $\frac{\text{extension}}{\text{gauge length}}$

Let us assume as a first example the following:

From our original set gauge length of 50 mm and the dial gauge set at 0.00, the next dial gauge reading we take is 0.01.

i.e. the pointer on the gauge has moved one small division.

Then the following calculation applies.

(a) **Extension**

Is 0.5 (nominal pivot lever ratio) x 1 (1 small division of the dial gauge) x 0.002 mm (one small division of dial gauge).

Therefore extension = 0.001 mm.

Then

(b) **Strain** is calculated as follows:

Strain = $\frac{\text{extension}}{\text{gauge length}} = \frac{0.001 \text{ mm}}{50 \text{ mm}}$

Therefore strain = .00002 **or** 2.0×10^{-5}

Let us assume as a second example the following:

From our original set gauge length of 50 mm and the dial gauge set at 0.00, the next dial gauge reading we take is 5.00.

Then the following calculation applies:

(a) **Extension**

is 0.5 (nominal pivot lever ratio) x 500 (5 full revolutions of the dial) x 0.002 mms (1 small division of dial gauge).

Therefore:

Extension = 0.5 mm.

Then

(b) **Strain** is calculated as follows:

$$\text{Strain} = \frac{\text{extension}}{\text{gauge length}} = \frac{0.5\text{ mms}}{50\text{ mms}}$$

Therefore:

Strain = .01

3 Taking Readings : 200mm Gauge Length

The 'Demec' mechanical strain gauge has one fixed location point and one moveable measuring point at the gauge length.

Changes in this gauge length are transmitted through a pivot to the measuring dial gauge. The pivot lever has a nominal ratio of 8:10, i.e. 0.8:1.

Therefore, 0.8 mm real movement at the gauge length will read 1.0 mm on the dial gauge.

(A) **Extension**

Is the increase in length from the original gauge length and is measured in mm.

(B) **Strain**

Is extension expressed in relation to the original gauge length.

$$\text{i.e. strain} = \frac{\text{extension}}{\text{gauge length}}$$

Let us assume as a first example the following:

From our original set gauge length of 200 mm and the dial gauge set at 0.00, the next dial gauge reading we take is 0.01.

i.e. the pointer on the gauge has moved one small division.

Then the following calculation applies.

(a) **Extension**

Is 0.8 (nominal pivot lever ratio) x 1 (1 small division of the dial gauge) x 0.002 mm (one small division of dial gauge).

Therefore extension = 0.0016 mm.

Then

(b) **Strain** is calculated as follows:

$$\text{Strain} = \frac{\text{extension}}{\text{gauge length}} = \frac{0.0016\text{ mm}}{200\text{ mm}}$$

Therefore strain = 0.000008 **or** 0.8×10^{-5}

Let us assume as a second example the following:

From our original set gauge length of 200 mm and the dial gauge set at 0.00, the next dial gauge reading we take is 5.00.

Then the following calculation applies:

(a) **Extension**

Is 0.8 (nominal pivot lever ratio) x 500 (5 full revolutions of the dial) x 0.002 mm (1 small division of dial gauge).

Therefore:

Extension = 0.8 mm.

Then

(b) **Strain** is calculated as follows:

$$\text{Strain} = \frac{\text{extension}}{\text{gauge length}} = \frac{0.8\text{ mm}}{200\text{ mm}}$$

Therefore:

Strain = .004

4 Care of the Instrument

4.1 Keep the gauge in it's box while not in use.

4.2 Ensure that the points of the setting out bar are kept free from adhesive.

4.3 Under no circumstances should the dial gauge spindle be oiled as small particles of debris may be transported into the bearings, thus destroying the gauge.

5 Accessories

EL35-2854 : Stainless Steel Locating Discs. (Box of 100).