Short Communication

A Note on the Design of a Simple Load Cell

by

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A load cell is an electronic transducer capable of translating changes in force or weight into changes in voltage. The changes in voltage produce, in the out put instrument, a corresponding reproducable deflection which can be calibrated directly in terms of applied load or weight. Such an instrumentation finds diversified applications as truck-weighing, process control testing machines, jet and rocket thrust measurement, etc., etc., and can be designed for precision measurement of loads varying from a fewgrams to hundreds of tonnes, depending upon the use to which it is required to be put. The paragraphs that follow pertain to the design of a load cell employed for the measurement of the tip capacity of a scaled cast-in-place concrete pile, loaded at top.

Construction and Operation

With a view to ensuring the desired sensitivity for the anticipated range of loading, the cell was fabricated from aluminium alloy 65 S-T 6 (Modulus or elasticity $E=703\times13^3$ kg/cm² or 10×10^6 psi). It consisted of four vertical pillars 7·6 mm diameter, 3·8 cm high sung-fitted into holes in the two circular plates 9 mm thick, one each at top and bottom. The overall depth of the cell when fitted into plates was 7·6 cm. For the measurement of compressive strains, one SR-4 resistance strain gauge (resistance : $120{\cdot}5\pm0{\cdot}3$ ohms; gauge factor : $1{\cdot}94\pm2$ percent) was mounted on each of the four pillars with their axes of length parallel to the centre-line of the pillars and connected in a bridge circuit to the electronic strain-indicating device. A temperature-compensation gauge was used to counter the effects of heat of hydration from the freshly laid concrete coming in contact with the cell after the concreting operation for the installation of the pile.

The operation of the cell when loaded would depend upon the deflection of the strain gauge filament, creating a change in its resistance thereby unbalancing the bridge circuit. As a result, for a given input voltage, the output voltage of the bridge varies proportionately with the load and the change is read on the strain-indicator to which the leads are connected as shown in Figure 1. The gauges having been connected individually to the indicating instrument, total strain is given by adding the indicated strains for each of the four pillars. Before putting the cell to field use, it was calibrated for known loads in a compression machine.

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Design

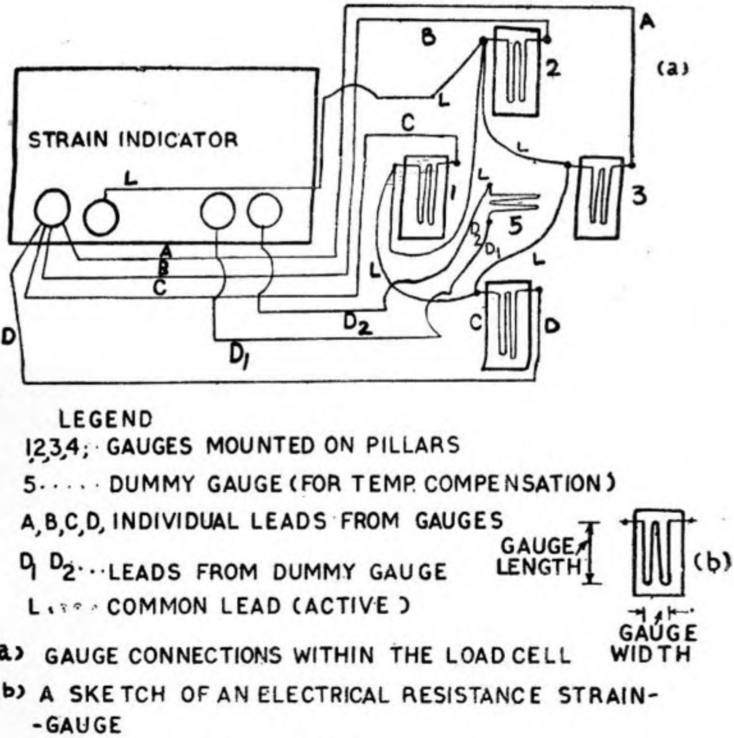

FIGURE 1.

Design

Whereas the diameter of the top and the bottom plates was made to correspond to that of the pile supported by the cell, the dimensions of the pillars were determined on the basis of the desired load capacity of the cell as follows :

With one strain gauge (gauge length $l=1{\cdot}27$ cm or $\frac{1}{2}$ inch) to be mounted on each cylinder and with separate indicator reading for each gauge, the sectional area needed for each pillar desired to show a sensitivity of 1 micro-inch per inch per pound of load is given by :

$$a=\frac{\text{load}\times l}{E.\ \text{Strain}}$$

$$=\frac{1\times\frac{1}{2}}{10\times10^{6}\times1\times10^{-6}}\times(2{\cdot}54)^{2}$$

$$=0{\cdot}32\ \text{cm}^{2}$$

giving a diameter of 0·384 cm. Since the minimum trim-width of the gauge is only 0·875 cm, it was decided to raise the diameter to the practical minimum of 7·6 mm ($a=1{\cdot}83$ cm^2). For an estimated load capacity of 2,000 kg of the load cell, the estimated maximum stress would be 2,000/1·83=1,090 kg/cm^2, which is well within the elastic range of the material. Practical minimum length of the pillars from consideration of gauge-installation is about 3·8 cm, giving a length/diameter ratio of 5.

Actual maximum strain in each cylinder for 1·27 cm gauge length

$$= \frac{1090}{703 \times 10^3} \times 1{\cdot}27$$
$$= 1{\cdot}97 \times 10^{-3} \text{ cm.}$$

Indicated strain on the instrument = Gauge factor $1{\cdot}94 \times 1{\cdot}97 \times 10^{-3}$ $= 3{\cdot}79 \times 10^{-3}$ cm, which is well within the recording range of the indicator.

Total indicated strain for the four pillars together for one kg load applied at the top of the cell shall be :

$$\frac{3{\cdot}79 \times 10^{-3}}{2000} \times 4 \quad \text{or } 7{\cdot}58 \times 10^{-6} \text{ cm.}$$

The total computed strain compared favourably with that obtained from the celibration curve.

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