Civil Engineering & Construction Instruments

Since we produced Carlson type transducers in Japan, Kyowa has obtained many successful achievements in designing and manufacturing measuring instruments and systems for management, maintenance, design and research of large-scale civil engineering works and structures in Japan and abroad.

Now, Kyowa offers not only various civil engineering transducers but also special measuring equipment, applicable for safe execution and maintenance of civil engineering and construction works automatic monitoring, and data processing systems with regard to rock bed, landslide, structure and dam behavior.

### Strain-gage Civil Engineering Transducers

All Kyowa civil engineering transducers adopt self-temperature-compensated foil strain gages, for all of sensing elements which are incorporated into a Wheatstone bridge. Using the strain gages, these transducers convert soil or water pressure to corresponding voltage for measurement with strain amplifiers and other peripheral equipment. The applied self-temperature-compensated foil strain gages ensure stable measurement with less drift due to temperature changes. Kyowa also provides unique civil engineering transducers which enable measurement of temperature together with strain, stress or displacement.

#### Features
- Unique models available for measurement of physical quantities together with temperature.
- Nonlinearity, hysteresis and repeatability are excellent.
- Stable against temperature change; no compensation is required with regard to thermal effect on measurement.
- Since they can be connected directly to strain amplifiers and peripheral equipment, automatic measuring systems can easily be configured.
- Excellent environmental capability ensures safe measurement under adverse temperature, humidity and vibration conditions.
- Countermeasures against lightning are available.

#### T Series Civil Engineering Transducers with Temperature Measuring Function

Since the strain-gage transducers, ordinary strain-gage civil engineering transducers cannot measure temperature together with strain, stress or displacement. Thus, thermometer need to be additionally installed when embedding these transducers in concrete structures. To solve such problems, Kyowa has developed civil engineering transducers with a temperature measuring function. The function is provided for strain transducers, reinforcing-bar stress transducers, joint transducers and water level transducers. These transducers have a platinum resistance thermometer mounted at the output side of ordinary civil engineering transducers.

#### Independent Measurement of Physical Quantity and Temperature during Measurement

The platinum resistance thermometer is connected to the output of the bridge circuit and has no electrical concern with the input of the instruments, thereby giving no effect to measurement of physical quantity. By a different circuit from the physical quantity measuring circuit, temperature is measured based on resistance change of the temperature measuring resistor. Generally, instruments providing constant-current bridge excitation are used for civil engineering transducers with a temperature measuring function and such instruments are not affected by the resistance of extension cable.

#### Relation between Strain and Voltage of Transducer Output

Kyowa civil engineering transducers output detected strain quantity in \( \times 10^{-6} \) strain or output voltage in mV/V or \( \mu \) V/V when excited to bridge circuit with 1 V. The strain value (\( \varepsilon \)) and output voltage (\( E \)) has the following relation.

\[
\varepsilon = \frac{3 \cdot 10^{-6} \cdot K_s \cdot E}{E}
\]

where:
- \( K_s \): Gage factor of the civil engineering transducer
- \( E \): Excitation voltage

For the gage factor \( K_s \) is 2.00,

\[
\frac{E}{E} = \frac{1}{2} \quad \text{and thus, if } E = 1 \text{ V, } 2e = \varepsilon
\]

Accordingly, the relation between transducer voltage output and strain is always 1:2 when gage factor is 2.00.

E.g. 1.5 mV/V = 1500 \( \mu \)V/V = 3000 \( \times 10^{-6} \) strain

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*For “Terms to Express Characteristics of Strain-gage Transducers”, see page 9-11.*
Small to Large-scale Measurement for Deformation Monitoring and Control

<table>
<thead>
<tr>
<th>Cable</th>
<th>Temp. Measurement with T Series</th>
<th>Bridge Excitation of Measuring Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>No</td>
<td>Constant voltage</td>
</tr>
<tr>
<td>Long</td>
<td>Yes</td>
<td>Constant current</td>
</tr>
</tbody>
</table>

- **Constant-voltage Bridge Excitation System**
  - Transducers: Strain, pressure, soil pressure, reinforcing bar, stress, displacement, joint, etc.
  - 1-point measurement
  - Instrumentation Amplifier WGA-710C
  - Data Logger UCAM-60C (Either constant voltage or constant current available)
  - RS-232C
  - LAN

- **Constant-current Bridge Excitation System**
  - Transducers: Strain*, pore pressure*, soil pressure, reinforcing bar*, stress*, displacement, joint*, etc.
  - Temperature measuring function enables simultaneous measurement of temperature.

### Conversion of Measured Strain (Transducer Output Voltage) to Physical Quantity

Strain or voltage measured by a pore pressure transducer, a joint transducer or a load cell is converted into physical quantity in proper engineering unit using the calibration factor stated in the Test Data Sheet as follows.

**In the case of using a strain amplifier**

Required physical quantity = Measured strain \( \times 10^6 \) strain \( \times C \)

where, \( C \) is the calibration factor indicating the physical quantity corresponding to reference equivalent strain of \( 1 \times 10^6 \) strain.

**In the case of using an amplifier other than a strain amplifier or a recorder**

Required physical quantity = \( \frac{\text{Bridge output voltage (} \mu \text{V})}{\text{Bridge excitation voltage (V)}} \times B \)

where, \( B \) is the calibration factor indicating the physical quantity corresponding to 1 \( \mu \text{V} \) output per 1 V bridge excitation voltage.

### Bridge Excitation Systems for Civil Engineering Transducers

**1. Types**

Amplifiers used in conjunction with civil engineering transducers are available in 2 bridge excitation systems: constant voltage and constant current. These two systems have their respective features shown in the table below, to permit selection according to measurement purposes and applications.

All Kyowa strain-gage transducers, including those for civil engineering, are calibrated at the factory using the constant-voltage system.

<table>
<thead>
<tr>
<th>Bridge Excitation System</th>
<th>Constant-voltage Bridge Excitation System</th>
<th>Constant-current Bridge Excitation System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil engineering transducers</td>
<td>Measurement of physical quantity possible</td>
<td>Measurement of physical quantity possible</td>
</tr>
<tr>
<td>T series transducers</td>
<td>Measurement of physical quantity possible</td>
<td>Temperature measurement together with physical quantity possible*</td>
</tr>
<tr>
<td>Applicable gage bridge</td>
<td>90 to 1000 ( \Omega )</td>
<td>350 ( \Omega )</td>
</tr>
<tr>
<td>Calculation for compensation of declined sensitivity due to cable extension</td>
<td>Required</td>
<td>Not required</td>
</tr>
<tr>
<td>Applications</td>
<td>Measurement with cable not extended too long. Mainly for experimental measurement</td>
<td>Measurement through extension cable. Mainly for field measurement</td>
</tr>
</tbody>
</table>

* T series is provided with temperature measuring function.

2. The reason why constant-current bridge excitation is used for civil engineering measurement with cable extended

If a 100 m long cable with cross-section 0.5 mm² is used for connection between a Kyowa civil engineering transducer with bridge resistance of 350 \( \Omega \) and an amplifier of the constant-voltage bridge excitation system, sensitivity declines by approximately 2%. To avoid such inconvenience, it is recommended to use an amplifier of the constant-current bridge excitation system, which ensures measurement with less error. For details, see page 9-17.

*For use under corrosive liquid or gaseous environment, contact us.