

BKJ-A/BKJ-A-D EMBEDDING TYPE INCLINATION TRANSDUCER INSTRUCTION MANUAL

This Instruction Manual describes essential precautions when using BKJ-A/BKJ-A-D Embedding Type Inclination Transducer (hereinafter referred to as the BKJ-A) by installing into KYOWA's standard aluminum guide pipe B-30, applying grout, and connecting to measuring instrument. Do not forget to read the Instruction Manual before use.

1. PACKING LIST

- Embedding Type Inclination Transducer.....1
- Inspection Report.....1(BKJ-A-D: Provided for every X and Y directions.)

○Warranty.....1

○Instruction Manual.....1

Note: Since sensor portion of Biaxial type BKJ-A-D is independent for every sensitivity direction, the Inspection Report is attached for every sensor.

2. PRECAUTIONS FOR TRANSPORTATION AND STORAGE

- 2-1 Always carry and store the BKJ-A upright (with the "UP" seal on the package box or cable outlet of the BKJ-A facing up).
- 2-2 Do not apply any impact during transportation or storage or, the BKJ-A may be damaged.

3. PRECAUTIONS FOR INSTALLATION

- 3-1 When setting the BKJ-A, if it is unavoidably laid sideways, quietly turn it down and set it within a short period of time.

- 3-2 When installing the BKJ-A into an aluminum guide pipe, see a sensitivity direction seal attached on the BKJ-A to check the correct sensitivity direction.
- 3-3 When installing the BKJ-A into the aluminum guide pipe, always hold the BKJ-A mainbody or a connection rod and do not hold only the cable.
- 3-4 Use a specified extension cable to be used in the aluminum guide pipe.
- 3-5 Set bending radius of the extension cable to at least more than 10 times the cable outer diameter and use a flexible metal conduit as much as possible to protect the extension cable.

4. PRECAUTIONS FOR USE

- 4-1 After installing the BKJ-A, grouting is conducted using bentonite, etc. Then, leave the BKJ-A (approximately 3 days) until it becomes sufficiently stable before starting the measurement.
- 4-2 Do not forget to ground the grounding conductor of the connected measuring instrument. (Recommended: Class A grounding)
- 4-3 Locate the BKJ-A at a location with temperature change as little as possible. Large varying temperature may give adverse effect to the output value

5. WIRE CONNECTION

Wire Connections between the BKJ-A and extension cable as well as between measuring instrument are described in the following figure.

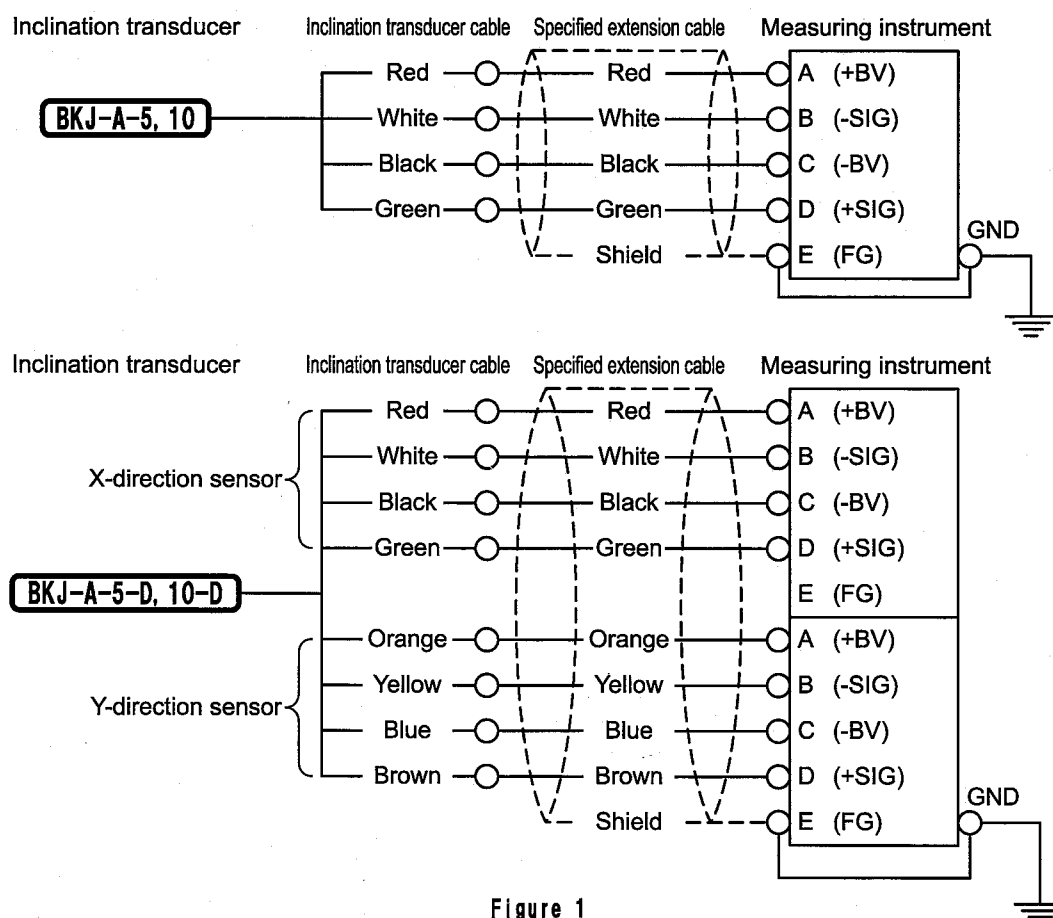


Figure 1

6. HOW TO INSTALL BKJ-A/BKJ-A-D (REF.)

- 6-1 Prepare an aluminum guide pipe B-30 having appropriate boring length and put a cap B-40 to the pipe that is to be the bottom of the boring hole. (After fixing the cap on the aluminum guide pipe with rivet, seal the cap with waterproof sealer, butyl rubber tape, pipe wrapping tape, or vinyl tape.
- 6-2 Prepare 2 grout hoses having the boring length. Bore an ellipse shaped hole in the vicinity of the bottom of the aluminum guide pipe that is to be the bottom of the boring hole, insert the tip of one of the grout hose (inner hose) from the outside of the aluminum guide pipe and then, seal the hole

outlet with waterproof sealer, butyl rubber tape, pipe wrapping tape or vinyl tape. Leave the other grout hose (outer hose) to the outside as it is and bore several holes at certain intervals between the tip and approximately 2 meters. Set the 2 hoses along the outside of the aluminum guide pipe and fix them with tapes at certain intervals.

(Put marks on both hose ends beforehand so that it is easy to distinguish inner hose from outer hoses when viewed from above ground)

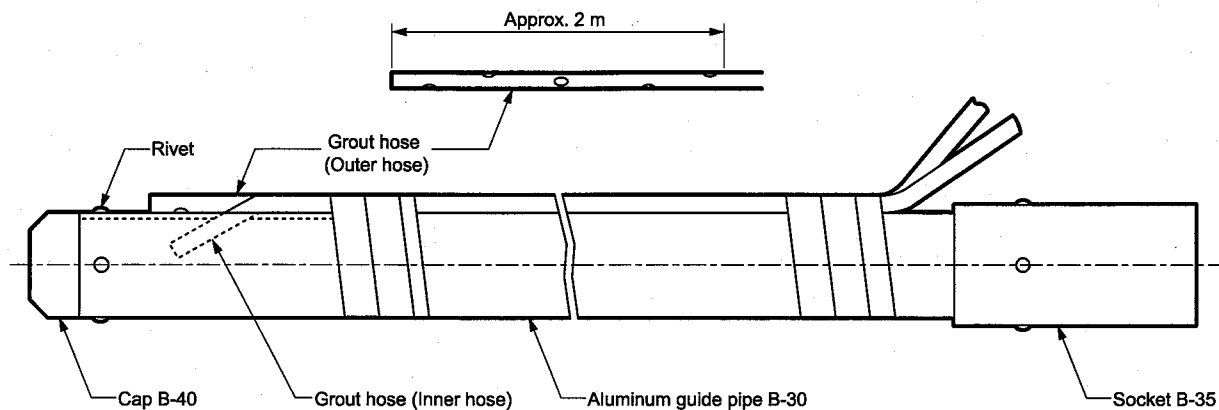


Figure 2

- 6-3 Insert the aluminum guide pipe into the boring hole. If measuring direction of the inclination is determined in advance, set the aluminum guide pipe groove to the desired direction and insert it with a socket B-35. When the aluminum guide pipe reaches the groundwater level in the boring hole,

pour clean water in the aluminum guide pipe and then, insert it by balancing with buoyant force.

- 6-4 Prepare an extension cable and connection rods. For the highest stage connection rod (the top connection rod), cut a long crew thread and set a fixing cross bar.

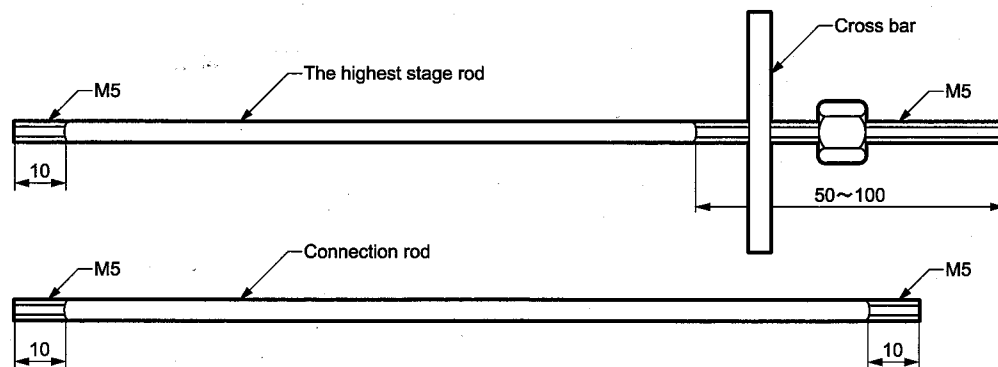


Figure 3

- 6-5 Check the serial number of the BKJ-A and put tags with the serial No. or instrument No. on both ends of the connecting extension cable.
- 6-6 Solder cable conductors of both BKJ-A and extension cable and sufficiently waterproof with waterproof tapes such as vinyl tape, etc. However, take care that outer diameter of the connected portion should be less than 20 mm.

- 6-7 Connect the cable to a portable type measuring instrument and check insulation resistance and operation of the BKJ-A (by holding the BKJ-A fairly upright and then, inclining to the sensitivity direction).
See "5. WIRE CONNECTION."

- 6-8 While checking the sensitivity direction of the BKJ-A, insert around half of the BKJ-A into the aluminum guide pipe and screw in the connection rod to M5 screw hole on the top of the BKJ-A.

- 6-9 By holding the connection rod, insert the BKJ-A into the aluminum guide pipe. Fix the cable to the connection rod with tiewrap, etc. on halfway while lifting down the BKJ-A into the aluminum guide pipe.
- 6-10 Screw in the next BKJ-A into the top of the connection rod. At this time, connect the BKJ-A by taking special care that no exceeding twist is applied to the cable outlet of the BKJ-A.
- 6-11 Connect the next connection rod according to procedures in the above items from 6-7 to 6-8. Set the lower stage cables along the side of the BKJ-A and bundle them with tiewrap, etc. to the connection rod on upper and lower portion of the BKJ-A. At this time, neatly arrange the cables when setting along the BKJ-A side or, the cables may be entangled on the rivet in the aluminum guide pipe.
- 6-12 In the same manners as described above, insert the BKJ-A into the aluminum guide pipe while connecting the BKJ-A to connecting rod one after another. Adjust the cross bar portion and hung the highest connection rod at the edge of the aluminum guide pipe.
- 6-13 Connect the BKJ-A cable to the measuring instrument and then, check the initial value as well as insulation resistance to confirm whether or not abnormality is found in the BKJ-A.
- 6-14 Apply grouting cement into the outer hose and fill up the gap between the boring hole and aluminum guide pipe. Next, fill up the inner portion of the aluminum guide pipe using the inner hose. Then, quietly leave the BKJ-A untouched until it is solid cemented.
- 6-15 After the BKJ-A is sufficiently settled (approximately after 3 days), measure the initial value of each BKJ-A to adjust zero point once again. Then, start the measurement.

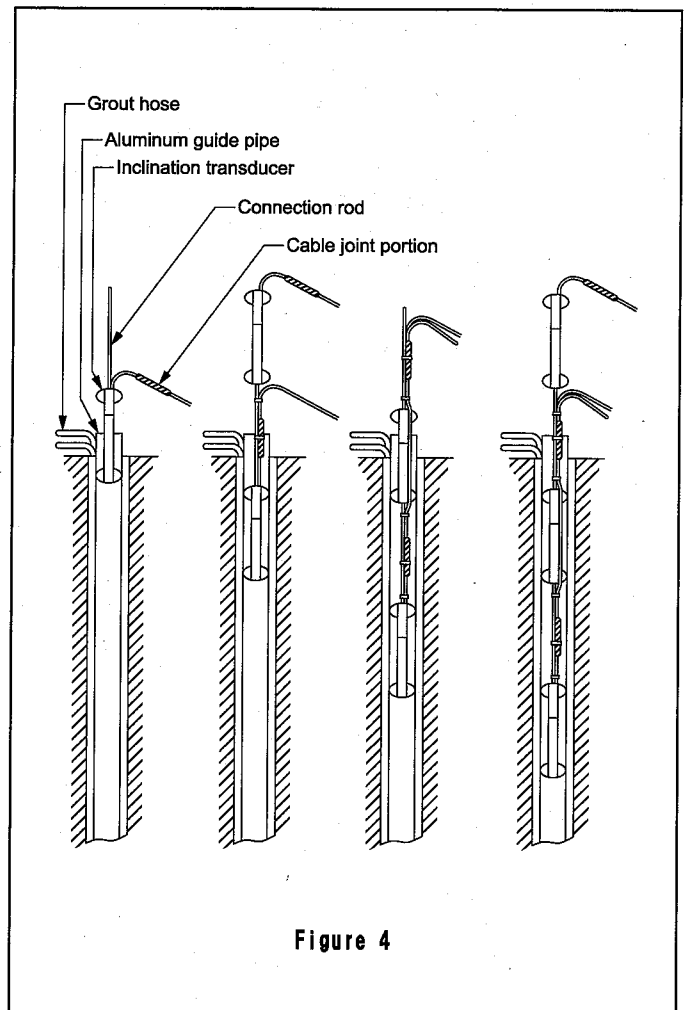


Figure 4

7. HOW TO CALCULATE DIDE DISPLACEMENT FROM INCLINATION ANGLE (REF.)

How to obtain side displacement by calculating output of each BKJ-A is described. For numerical calculation, use commercially available spreadsheet software, etc.

- 7-1 With calibration coefficient predetermined in the measuring instrument, suppose that a unit used for the recorded value is an angle indicated with "°." By setting a center point (P1) of the BKJ-A that is set at the lowest portion in the boring hole as a reference point, side displacement v_2 of the center point of the next BKJ-A (P_2) is approximated by the following equation.

$$v_2 = v_1 + \frac{L_1}{2} (\sin \theta_1 + \sin \theta_2) \dots \dots \dots \textcircled{1}$$

Therefore, the displacement v_n of the nth stage is obtained by the following equation.

$$v_n = v_1 + v_2 + v_3 + \dots + \frac{L_{n-1}}{2} (\sin \theta_{n-1} + \sin \theta_n)$$

$$= \frac{1}{2} \times \sum_{i=2}^n \{ L_{i-1} \times (\sin \theta_{i-1} + \sin \theta_i) \} \dots \dots \dots \textcircled{2}$$

- where v_1 : Reference point (Side displacement = 0)
 L_1 : Distance between center points of the BKJ-A (P1 and P2)
 θ_1 : Inclination angle of the BKJ-A (P1)
 θ_2 : Inclination angle of the BKJ-A (P2)
 θ_n : Inclination angle of the BKJ-A (Pn)
 L_{n-1} : Distance between center points of the nth and n-1th stage of the BKJ-As

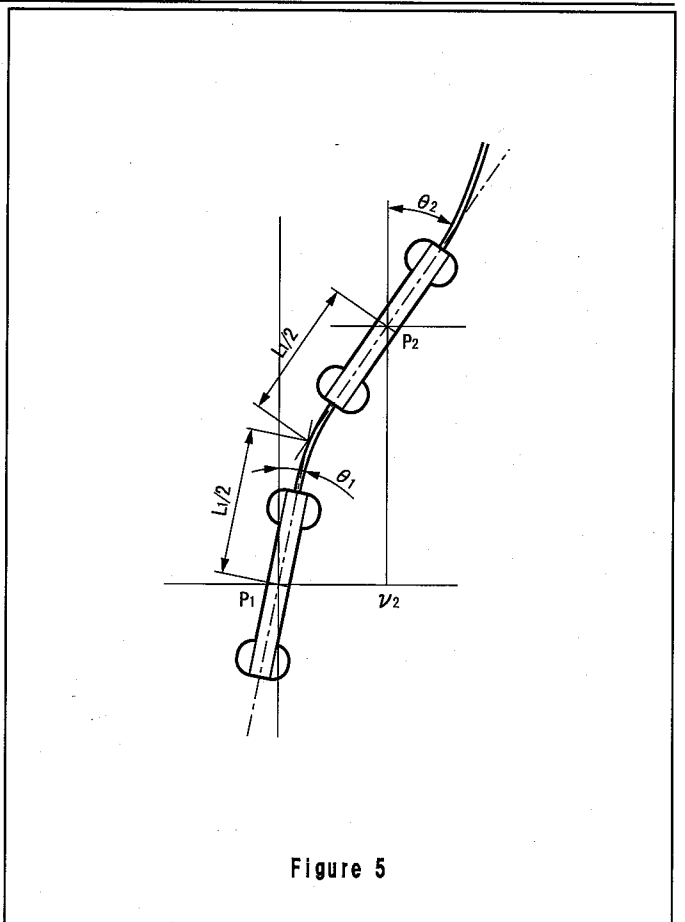


Figure 5

8. SPECIFICATIONS

1) Product name	Embedding type inclination transducer	10) Input/output resistance	$350\ \Omega \pm 1\%$
2) Model name	BKJ-A-5 ($\pm 5^\circ$ Uniaxial type) BKJ-A-10 ($\pm 10^\circ$ Uniaxial type) BKJ-A-5-D ($\pm 5^\circ$ Biaxial type) BKJ-A-10-D ($\pm 10^\circ$ Biaxial type)	11) Recommended applied voltage	2 to 10 VAC or VDC
3) Dimensions	See Figure 6. (BKJ-A-5/BKJ-A-10) See Figure 7. (BKJ-A-5-D/BKJ-A-10-D)	12) Safe overload	120%
4) Rated capacity	$\pm 5^\circ$ (BKJ-A-5/BKJ-A-5-D) $\pm 10^\circ$ (BKJ-A-10/BKJ-A-10-D)	13) Temperature compensation range	-10 to 60°C
5) Rated output	1.4 mV/V (2800 $\mu\text{m}/\text{m}$) or more (Minus rated output to plus rated output)	14) Safe temperature range	-20 to 70°C
6) Nonlinearity	Within $\pm 0.5\%$ RO	15) Cable	BKJ-A-5/BKJ-A-10 4-conductor (0.3 mm ²) chloroprene cable, 1 m long, $\Phi 6$ mm, soldered end BKJ-A-5-D/BKJ-A-10-D 8-conductor (0.3 mm ²) chloroprene cable, 1 m long, $\Phi 6$ mm, soldered end
7) Hysteresis	Within $\pm 0.5\%$ RO	16) Appearance	Stainless steel finish
8) Temperature effect on ZERO balance	Within $\pm 0.05\%$ RO/ $^\circ\text{C}$	17) Connecting portion of connection rod	M5 female screws with depth 10 mm
9) Temperature effect on output	Within $\pm 0.1\%/^\circ\text{C}$	18) Weight	BKJ-A-5/BKJ-A-10: Approx. 1 kg BKJ-A-5-D/BKJ-A-10-D: Approx. 1.2 kg

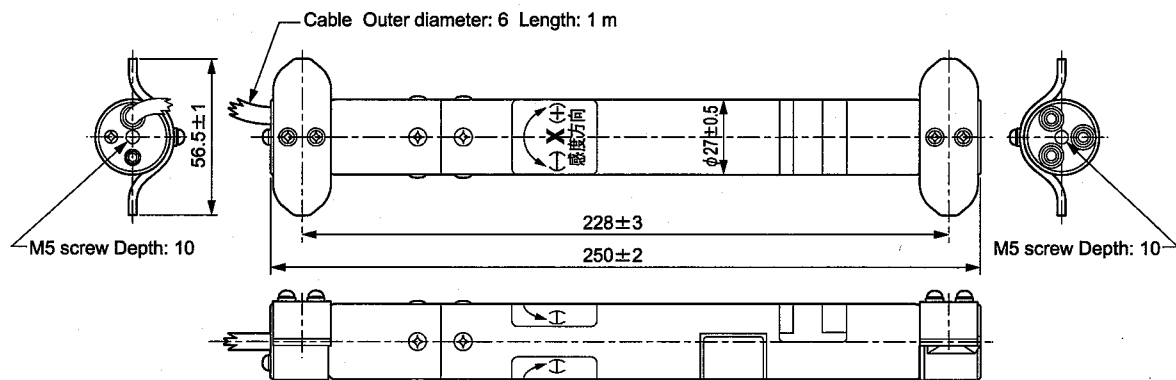


Figure 6 BKJ-A-5 and BKJ-A-10

Unit: mm

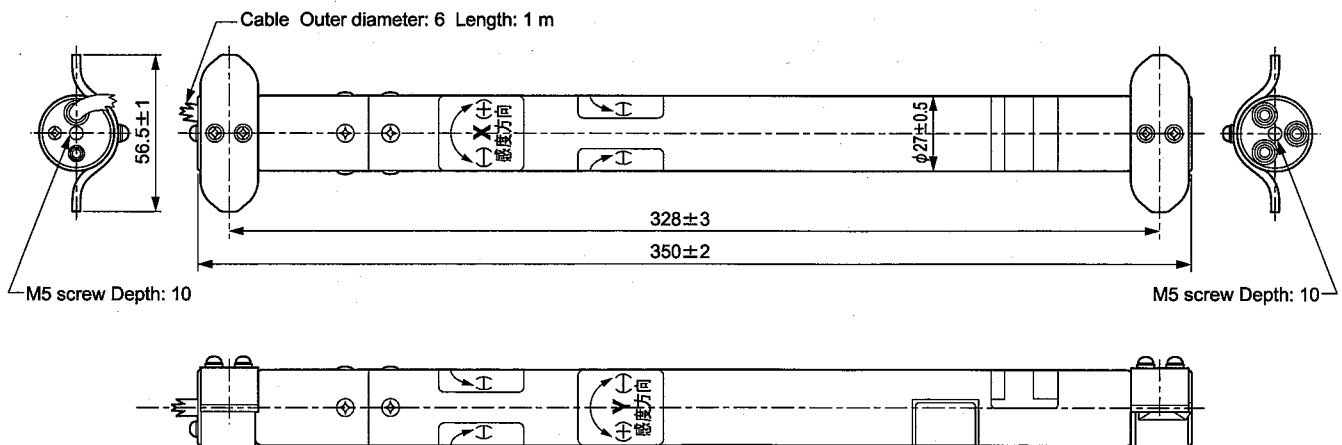


Figure 7 BKJ-A-5-D and BKJ-A-10-D

Unit: mm