

TORSION OF SURFACE PLATE OF THE ACTIVE SUPPORT TABLE FOR THE ATF DAMPING RING

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ABSTRACT

Distortion of the surface plate of active support table was measured using precise tiltmeters. It is found that the surface plate is twisted when the temperature changes. The effect of this phenomenon is much smaller than the alignment tolerance of the ATF damping ring if the room temperature is controlled within 0.4°C. However, it is not negligible in the linear collider case.

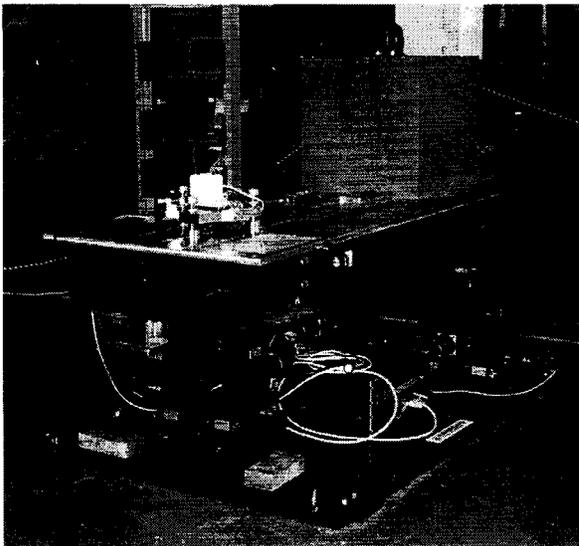
1. INTRODUCTION

The accelerator test facility (ATF) is now under construction at KEK to carry out various R&D for linear colliders. It consists of a 1.54 GeV electron linac and a damping ring[1]. Main purpose of this facility is to show feasibility of linear colliders by accelerating a multi-bunch beam and realizing a very low emittance beam.

The extracted beam from the damping ring will have the horizontal normalized emittance of 5×10^{-6} m·rad and the vertical one of 3×10^{-8} m·rad. To obtain such a small emittance beam, components of the ring should be aligned precisely. The tolerances are 50 μm in vertical position and 60 μm in horizontal. As the floor movement of the ring site is of the same order as these tolerances, real-time control of magnet position is required. Therefore, we have developed active support tables on which magnets for one cell (5 magnets: one combined function bending magnet, 2 quadrupole magnets, and 2 sextupole magnets) are installed. In the present paper, we will report the distortion phenomenon of the surface plate of the table.

2. ACTIVE SUPPORT TABLE AND ITS SURFACE PLATE

The active support table consists of a base plate, 3 movers, and the surface plate, as shown in Fig. 1. Each mover has 2 stepping motors:



**Fig.1 Active support table
for the ATF damping ring**

one for height control and the other for control of horizontal position normal to the beam direction. Tests of the performance were carried out by measuring the displacement of the table against the number of pulses fed to the pulse motors. The precision of positioning of the table was presented elsewhere[2].

The structure of the surface plate is shown in Fig. 2. It is 231 cm long, 80 cm wide, and 22 cm thick. The upper plate is made of 20 cm-thick stainless steel plate. Three long T-beams made of carbon steel are welded to it. Adjacent T-beams are connected by small plate at the bottom. Short ribs are welded at four positions as shown in Fig. 3.

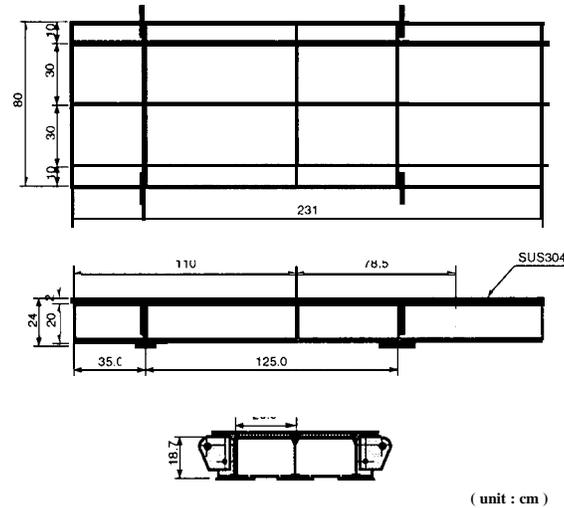


Fig. 2 Structure of the surface plate

3. MEASUREMENTS

Measurements were carried out with two tiltmeters[3]. Each tiltmeter contains 2 tilt sensors which are perpendicular to each other. The resolution of the tilt sensor is $0.05 \mu\text{rad}$. The tiltmeter has a temperature sensor in it for temperature correction. Figure 3 shows the setting positions of the tiltmeters and also defines the x- and y-directions.

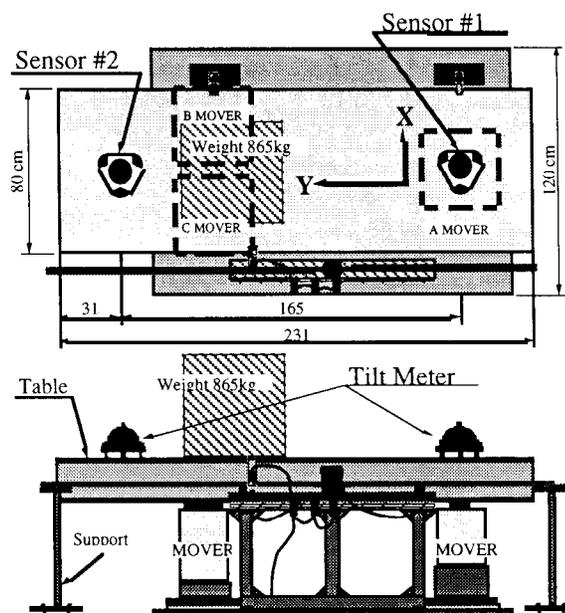
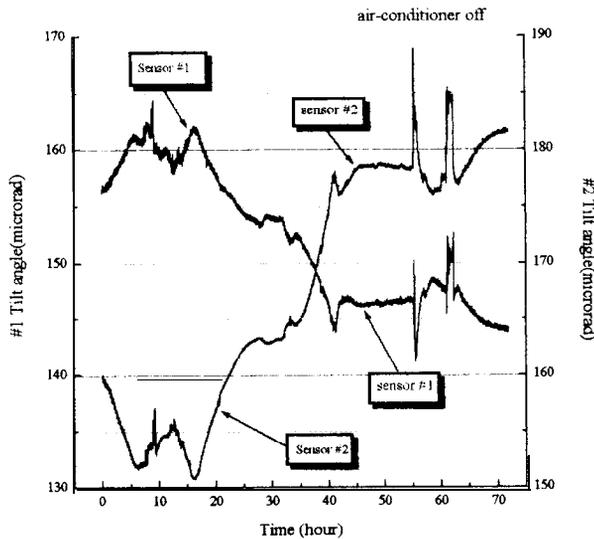
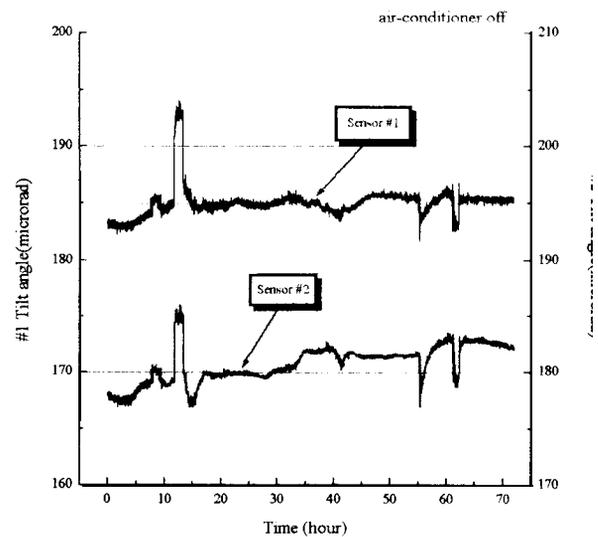


Fig. 3 Set-up for the measurements

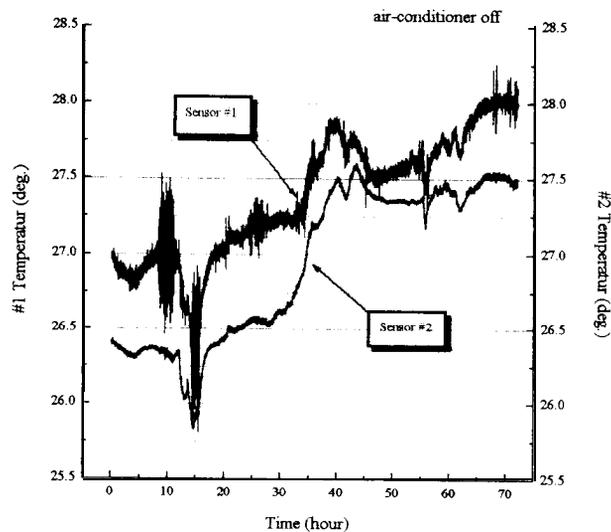
First, we carried out the measurement without any weight on the plate. Figure 4 (a) shows time dependence of tilt in the x direction at the sensor-1 and sensor-2 positions. The period of the measurement is 72 hours. When the output of sensor-1 increases, that of sensor-2 decreases, and vice versa. This means that the surface plate is twisted. On the other hand, the change of tilt in the y-direction was relatively small, as shown in Fig. 4 (b). The big peaks around $t = 12$ hr are due to an external disturbance. When these measurements were carried out, the air-conditioner was not ready. Therefore, the change of the room temperature is rather large. The difference of sensor temperature at $t = 0$ and 72 hr is about 1.1°C , as shown in Fig. 4 (c). There is clear correlation between the amount of tilt and the sensor temperature. Comparing the tilts at $t = 0$ and 72 hr, the tilt of sensor-1 decreased by $15\ \mu\text{rad}$ while that of sensor-2 increased by $22\ \mu\text{rad}$. The total amount of relative torsion was, therefore, $37\ \mu\text{rad}$.



**Fig. 4 (a) Tilt in X-direction
(without dummy weight)**



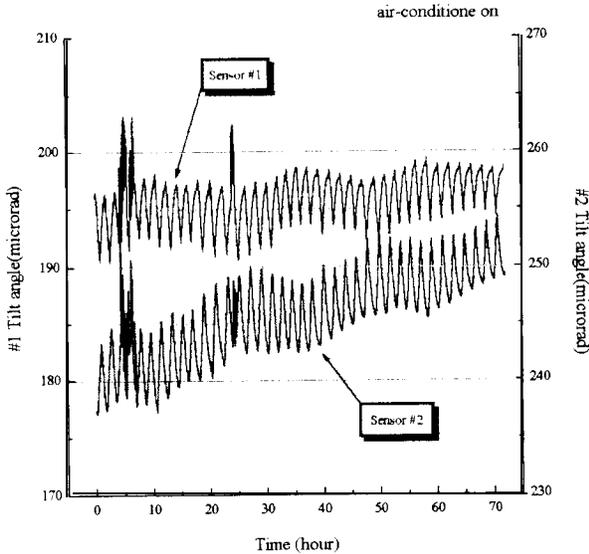
**Fig.4 (b) Tilt in Y-direction
(without dummy weight)**



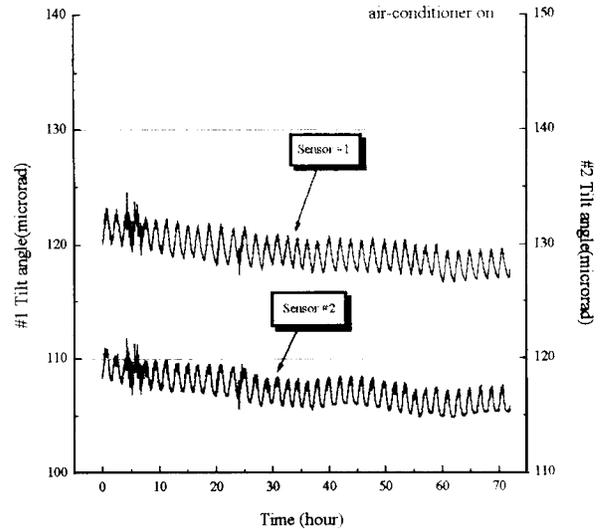
**Fig. 4 (c) Temperature of the sensors
(without dummy weight)**

Next, a few weeks after the first measurement, we measured the tilt with a dummy weight of 865 kg. The results are shown in Fig. 5. As the air-conditioner had been completed by then, the temperature change was small. Although the temperature changed by 0.7°C (peak-to-peak) with the period of about 110 minutes, the change of average temperature was less than

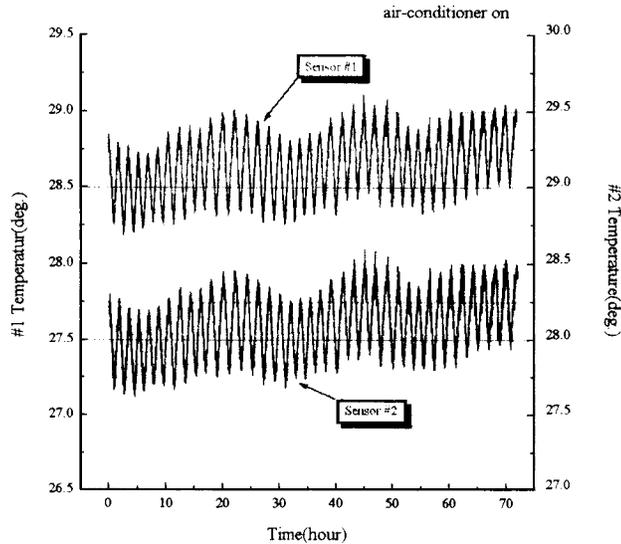
0.3°C during 72 hours. The relative amount of twist was about 6 μrad (Fig. 5 (a)). Here we neglected the structure of short period and compared the average values of the fluctuation with the period of 110 minutes at $t = 0$ and 72 hr. When the temperature changed by 0.7°C, the tilt of the sensor-1 changed about 5 μrad , and the sensor-2 about 7 μrad . As shown in Fig. 5 (a), the phase of these changes are opposite. Therefore, the relative twist between these two points was about 12 μrad . The change of tilt in the y-direction is small. Moreover, the tilt at the sensor-1 position and that of the sensor-2 position changes in phase (Fig. 5 (b)).



**Fig. 5 (a) Tilt in X-direction
(with dummy weight)**



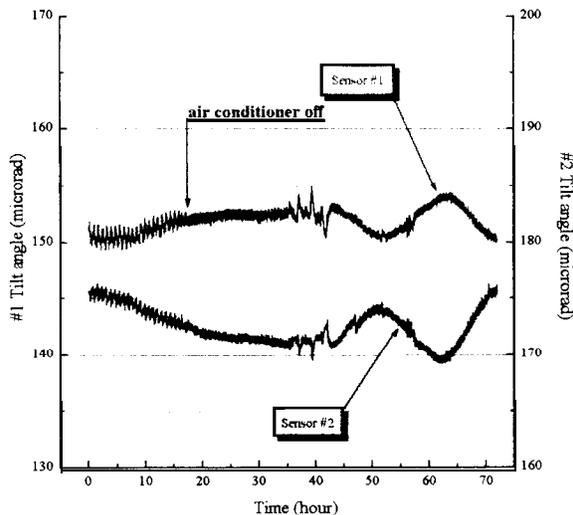
**Fig. 5 (b) Tilt in Y-direction
(without dummy weight)**



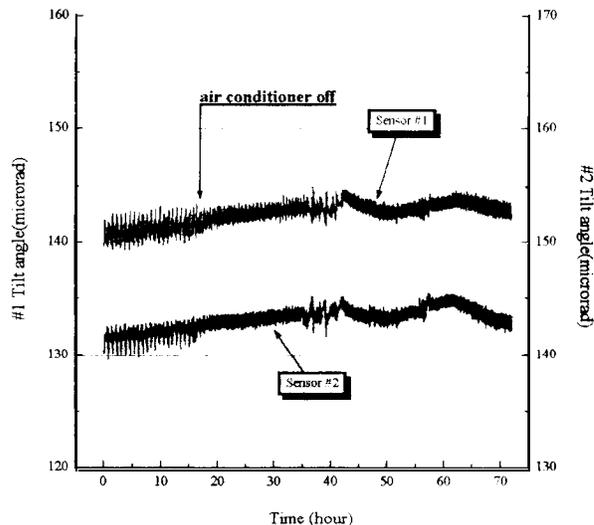
**Fig. 5 (c) Temperature of the sensors
(without dummy weight)**

We carried out the measurement without the dummy weight again. The results of that measurement are given in Fig. 6. Figure 6 (c) shows the change of the temperature. The air-conditioner was turned off around $t = 17$ hr, and the disturbance from $t = 35$ to 43 hr is due to an earthquake. We compared the data at $t = 17$ and 72 hr. The tilt in the x-direction changed by -1.5 μrad at the sensor-1, and by 3.5 μrad at the sensor-2. The relative twist was, therefore, about 5 μrad when the temperature changed by 0.3°C.

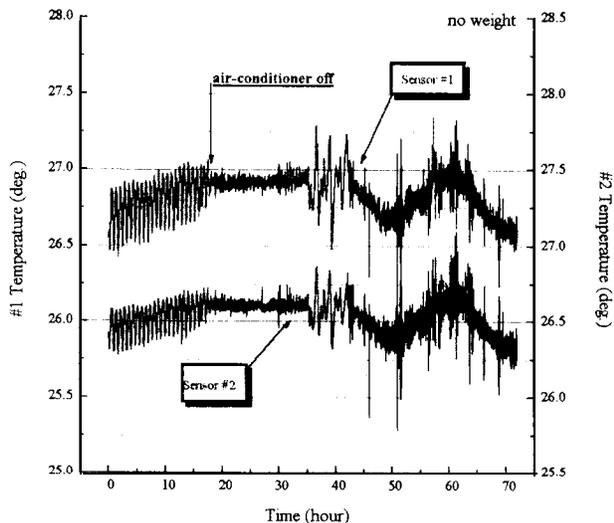
After the second measurement, adjustment of the air-conditioner was carried out. The temperature inside the shield is controlled within 0.4°C : (peak-to-peak) now, as shown in Fig. 6 (c) ($t = 0$ to 17 hr). If we assume the torsion is linearly dependent on the temperature change (Δt) in small Δt region, the torsion is estimated to be about $8 \mu\text{rad}$ when $\Delta t = 0.4^{\circ}\text{C}$. Then the relative displacement of the magnet center due to this torsion is about $3 \mu\text{m}$ because the beam line is 40 cm above the surface plate. This value is much smaller than the alignment tolerance of the ATF damping ring.



**Fig. 6 (a) Tilt in X-direction
(with dummy weight)**



**Fig. 6 (b) Tilt in Y-direction
(without dummy weight)**



**Fig. 6 (c) Temperature of the sensors
(without dummy weight)**

4. SUMMARY

We measured the distortion of the surface plate using precise tiltmeters and found the torsion of the plate. There is some correlation between the amount of the torsion and the temperature change. As the room temperature is controlled within 0.4°C , the torsion is as small as $8 \mu\text{rad}$. The relative displacement between field center of magnets due to this torsion is estimated to be about $3 \mu\text{m}$. This value is much smaller than the alignment tolerance of the ATF damping ring. However, this is not negligible in the alignment of linear colliders. Therefore, we have to be more careful when we design support structures of linear colliders.

REFERENCES

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