FLOOR LEVEL FLUCTUATION IN THE KEK-PS TUNNEL

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Abstract

Magnet alignment, especially of the quadrupole magnet, is one of the most important factor to reduce the closed orbit distortion and thereby to stabilize the particle acceleration. The magnets were aligned in 0.1 mm in the KEK-PS main ring. However, the floor subsidence has been mostly caused by the radiation shield blocks in the experimental hall. In order to examine the aged deterioration of the alignment, the relative level between neighboring quadrupole magnets has been measured once a year. When the magnet realignment was done in 1996 fall in order to correct the accumulated level deviation, the fast floor movement was observed. In order to confirm this phenomena, continuous measurement of the relative quadrupole magnet level is going on, and the detectors for the floor tilt were set up during 1997 summer shut down. Status of this work is reported.

1. CURRENT STATUS OF THE KEK-PS

The KEK-PS complex consists of four accelerators: two 750-keV Cockcroft-Walton pre-injectors, a 40-MeV injector linac, a 500-MeV booster synchrotron and a 12-GeV main ring. Figure 1 shows a layout of the KEK-PS complex. The slow beems are extracted to the east and north counter halls by a half integer resonance, and the internal target has also served the secondary beam in the east counter hall [1]. Beam bunches accelerated in the booster except ones into the main ring are utilized in NML (Neutron and Meson Laboratory).

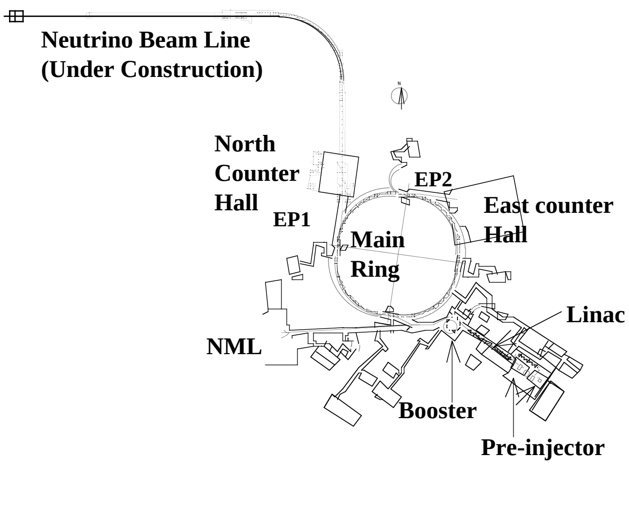

Figure 1. Layout of the KEK-PS Complex.

In order to increase the beam intensity for the need of new physics researches, especially the long-base-line neutrino-oscillation experiment [2], machine studies have been concentrated on the reduction of the beam losses during injection, at the acceleration start and at the passing the transition energy. Magnet alignment is one of the key issues of the stable particle acceleration to reduce the closed orbit distortion.

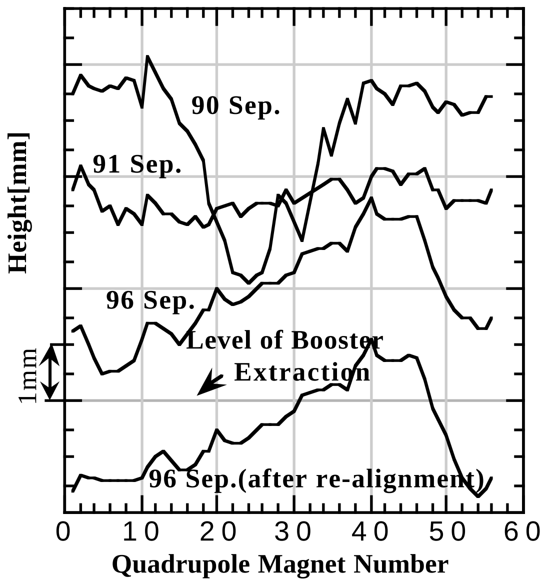

Figure 2. Height of the 56 quadrupole magnets from September 1990 through September 1996. Height is not absolute but relative value. Horizontal axis is the position of the quadrupole magnets. The first magnet is located in the injection section.

2. OBSERVED FLOOR LEVEL FLUCTUATION

Although the magnet realignment works were carried out several times, the correction were made only for the largely deviated magnets in the main ring but the adjustment to the booster ring was not considered. Figure 2 shows the heights of 56 quadrupole magnets in September 1990; significant deviation is observed. Then, the realignment work was carried out in September 1991. After the five years, the deviation became to significant level of a few mm (the second line from the bottom in Figure 2). As shown in it, the MR tunnel is inclined and have some bumps. The magnet alignment was carried out from September 2nd to 13th during the summer shutdown. The realignment was done in concentrating the

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first quadrant near injection in leaving the incline to save laborious work [3]. The resulting heights of the 56 quadrupole magnets indicated by he bottom line in Figure 2.

In this work, a significant unconformity of the magnet height occurred in the weekend. The height of the quadrupole magnet differed by about 1 mm after a round trip. There was a heavy rain from the Sunday to the Monday morning after long sunny days. It was supposed that plenty of water of this rain might move the floor plates in the main ring tunnel. Although the lattice structure of the KEK-PS accelerator has a four-time symmetry, the floor in the main ring tunnel comprises eight separated blocks (named A1, A2, B1, B2, C1, C2, D1, D2), and they are not symmetry as shown in Figure 3. Around the beam injection area, the floor is divided into three plates as C2 , D1 and D2. The floor level unconformity can be explained by assuming following consideration:

- Plate C2 is inclined (upstream end is higher);
- Plate D1 is inclined (downstream end is higher);
- Plate D2 is raised.

In November 1996, the beam orbit fluctuation were recorded with weather condition during PS operation [3]. This orbit fluctuation was recorded from Nov. 5 to 25, but unfortunately a little rain was observed in this period. According to the water surface level measurement from the well, any anomaly was not observed during above period[4].

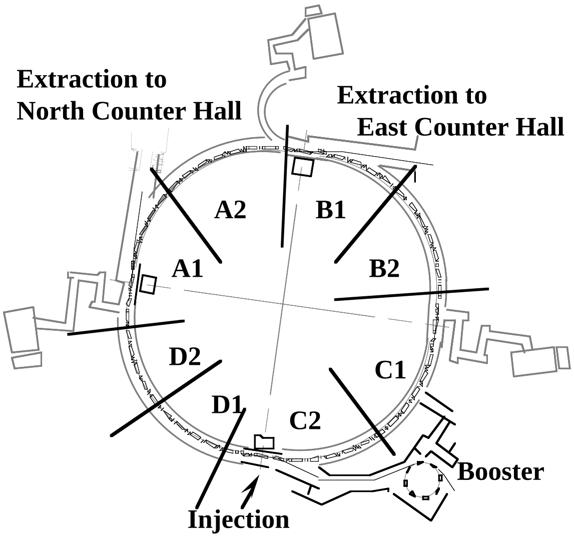

Figure 3. Foundations of the Main Ring Floor, complising eight separated plates.

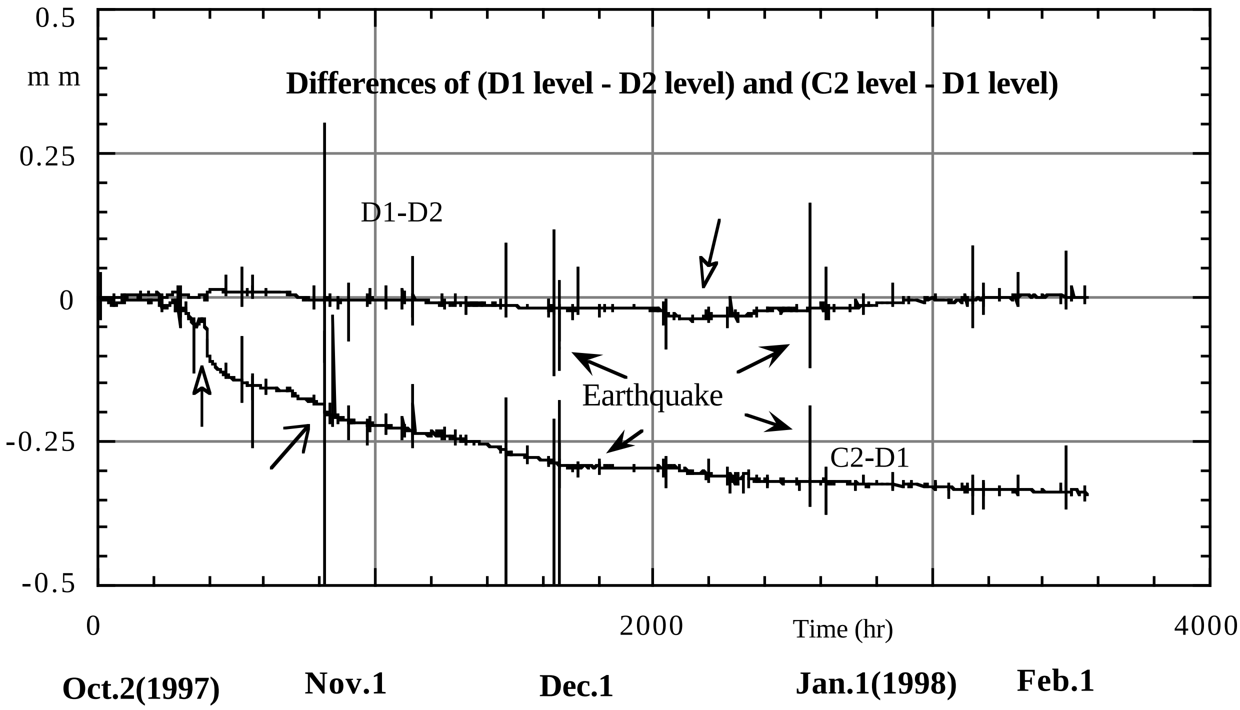

Figure 4. Time variation of the floor level differences of C2-D1, and that of D1 -D2. Floor level difference of C2-D1 changed rapidly (in fifty hours) by about 0.15 mm in the middle of October, 1997 and it increased gradually up to 0.35 mm for a few months. Many seismic vibrations were observed indicated by the dark arrows for example. At the end of Octorber, as indicated by the simple arrow, the difference did not return to the one before earthquake.

The COD changed into the opposite phase as described in the reference 3 and it means the error source of the COD changed the polarity. The fluctuation of the power supply also makes the COD, but it does not change the polarity. The assumption of floor plate movements well explain such characteristics.

3. MEASUREMENT OF THE FLOOR LEVEL FLUCTUATION AND THE ORIGIN OF THE FLOOR MOVEMENT

In order to know the floor level fluctuation, the tilt meters using accelerometer are set on the border of C2-D1 and D1-D2 [5]. Figure 4 shows the deviation of these floors versus hours from the beginning of October 1997. There are several remarkable facts in this data. One is that, in the middle of October,1997, the floor level difference of C2-D1 changed rapidly (in fifty hours) by about 0.15 mm. That of D1-D2 varied simultaneously, but very little.

Another point is the continuous variation of the C2-D1 deference, which increased gradually up to 0.35 mm over a few months. This slowly floor movement suggests the following results and it is shown in Figure 5. This movement is opposite direction of the explain result by the unconformity of realignment on Summer 1996:

- Plate C2 is inclined (downstream end is higher);
- Plate D1 is raised (and upstream end is higher);
- Plate D2 is sunk (and downstream end is lower).

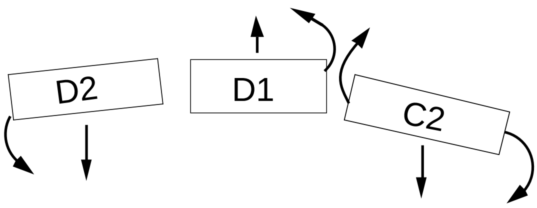

Figure 5. Speculation of the relative floor movement from October 1997 through February 1998.

One more remarks is that many seismic vibrations (spike-like fluctuation in Figure 4 indicated by dark arrows for example) are observed. The level returned to the one before earthquake in the almost cases. In the rare cases, however, the deviation remained after an earthquake, as shown by the simple arrow in Figure 4.

The KEK-PS was constructed on the water-rich ground. We once considered that the underground water caused the floor movement. There are two moisture strata below the main ring according to the water surface level measurement in a well. We did not observe any anomaly during these period. The velocity of water percolation downward through the soil was found to be very slow. It takes typically several days for the water levels in the moisture strata to change after rainfall. This fact cannot explain the rather fast (in one or two days) floor level fluctuation observed in September 1996.

The main ring tunnel was constructed on the ground and covered by a soil bank. A tunnel of this type received the stress from the moisture contained in the soil bank. This mechanism could explain the fast effect. The moisture detecting system is now being set in the cooperation with Radiation Science Center of KEK and the Geological Survey of Japan. The top of the soil bank is 4.5 meter, partly 7.7 meter, high. Osmometers made by Porous Ceramics are distributed at the depth of 3, 4 and 5 meter in the soil bank. We expect the origin of the floor movement would be clarified.

4. CONCLUSION

At the PS main ring, the floor level fluctuation in the tunnel mainly comes from the water in the ground. AS the case of the PS main ring tunnel constructed in the soil bank, moisture in the soil bank plays an important role geologically. It seems to move the floor plates in one or two days after rainfall.

The directions of the expected plates' movement in the period of the summer on 1996 are different from that measured from October 1997 through February 1998. However, we can see the opposite direction of the fast movement of the C2-D1 difference and the slow movement of the D1-D2 difference indicated by the white arrows in the Figure 4. It seems that the floor movement of the opposite direction could occure. A long time measurement of floor level is necessary to confirm the long range displacement and its correlation to the rainfall, the amount of water in the soil bank and the underground moisture strata. Anyway, an observation of the fast movement with the range of about 0.15 mm by tilt meter suggests that the movement of the order of 1 mm could occur rapidly. At this time, only two tilt meters were set up. If tilt meters will be set up at all the borders between plates, the floor level fluctuation in the PS main ring tunnel would become to clear.

The automatic or quick curing tool is necessary to correct the COD by these floor level fluctuation. This effect should be deeply considered in a future accelerator (such as the JHF 3-GeV ring) to be constructed in this tunnel.

5. REFERENCES

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