Floor Level Fluctuation in Accelerator Tunnel

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1. Introduction

Magnet alignment is one of the most important factor for stable particle aceleration. In the KEK–PS main ring, the magnets are aligned in 100 μm. In 1996 fall, the magnet realignment was done in order to expand the vertical acceptance during the beam injection period. Since the main ring was constructed, a continuous degradation of the floor has been observed for about 20 years. The floor subsidence was mostly brought about by the radiation shields located in the experimental hall. In fact, when the north experimental hall was constructed, the large subsidence of the floor around the beam extraction area was observed[1]. The most origin of the continuous floor subsidence is the heavy materials for the radiation shields, and even now the floor is moving very slowly.

The floor subsidence accompanies the corresponding floor upheaval in opposit side of the main ring. As a result, the main ring tunnel inclines and the difference between lowest and highest points has exceeded 2 mm.

This floor level fluctuation was considered as rather slow phenomenon in the order of years. In these days, the problem with the floor level fluctuation is closed up since the fast floor movement was observed. The floor level fluctuation damages on the precise magnet alignment and causes the reduction of aperture. It is conjectured that the fast floor fluctuation comes from the moisture in the soil.

2. Observed Floor Level Fluctuation

Although the magnet realignment works were carried out several times, they ended the correction only for the largely deviated magnets and the correspondency with the booster ring was not considered. The systematic magnet realignment was needed in order to achive the higher beam intensity in the main ring.

In the summer shutdown period of 1996, magnet alignment was carried out from September 2 to 13[2]. Figure 1 shows the height of 56 quadrupole magnets before and after the alignment. The first measurement corresponds to the before alignment and the others are after alignment. The zero level corresponds to the height of the exit of the booster ring. As shown in it, the MR tunnel is inclined and have some bumps. Roughly seeing, the injection area subsided and the opposite area raised around the booster extraction height as the center. Especially, quadrupole magnets No.1 to 16 and No.53 to 56 were located in very low level. At first, No.3 to 16 were tried to be adjusted to the level of No.2, which was often refered as I–1D and was the first quadrupole magnet for the injected beam.

In this work, a significant unconformity of the magnet height which became about 1 mm was observed by the second height measurement. The height of the quadrupole magnet differed after a round trip. It must be notified that the quadrupole magnets No.3 to 9 have already been adjusted to the No.2 (called I–1D) by the alignment work. In the first height measurement, magnet No.3 to 10 were apparently located lower with respect to the No.2. After the weekend these magnets became higher, especially for No.10, it became already higher than No.2, which is the reference magnet.

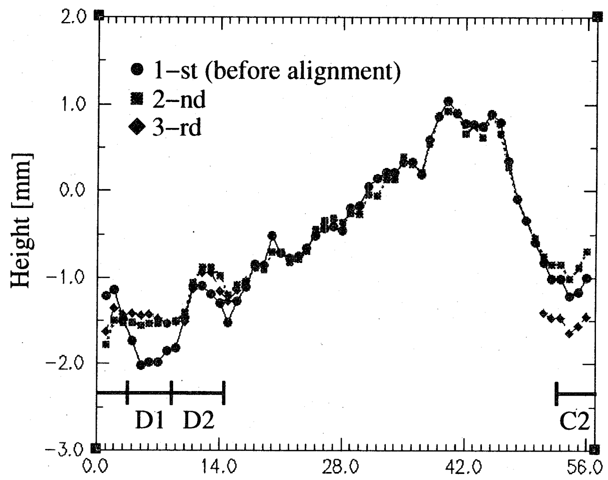


Figure 1. Height of Quadrupole magnets

Height zero corresponds to the height of the exit of the booster synchrotron

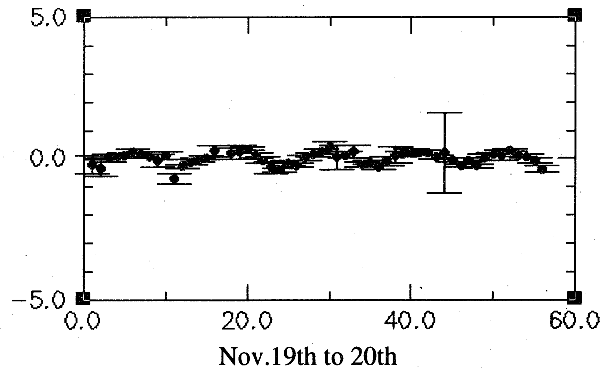
Though the lattice structure of the KEK–PS accelerator has a four–time symmetry, the constructions of the foundation are not. The floor in the main ring tunnel consists of eight separated blocks but they don't have any symmetry. Around the beam injection area, the floor is divided into three plates called as C2 , D1 and D2. The quadrupole magnets No.53 to 56 and No.1 to 3 are on the plate C3. The No.4 to 8 are on the plate D1. And the No.9 to 14 are on the plate D2.

The floor level unconformity shown in Fig.1 can be explained by assuming these conditions:

(1) Plate C2 is inclined (downstream end is LOWER)
(2) Plate D1 is inclined (downstream end is HIGHER)
(3) Plate D2 is raised

It must be considered that the quadrupole magnets were moved according to the floor plates in order to explain this unconformity of the magnet height. After the first height measurement, there were two days of blank time before beginning the alignment work because of the weekend. There was a heavy rain from the Sunday to the Monday morning after long sunny days. It is supposed that plenty of water of this rain might move the floor plates in the main ring tunnel. In the third height measurement, the magnet height can be seen returning to the first state. The quadrupole magnets around the joint of the plates C2 and D1, and those on the plate D2 became higher compared to the second measurement. It collaterally supports the assumption that the rain makes the floor plates move upward and downward.

In November 1996, the beam orbit fluctuation were recorded with the weather condition[3]. Figure 2 shows the changes of the vertical COD in the main ring. This orbit recording was carried out from Nov. 5 to 25.



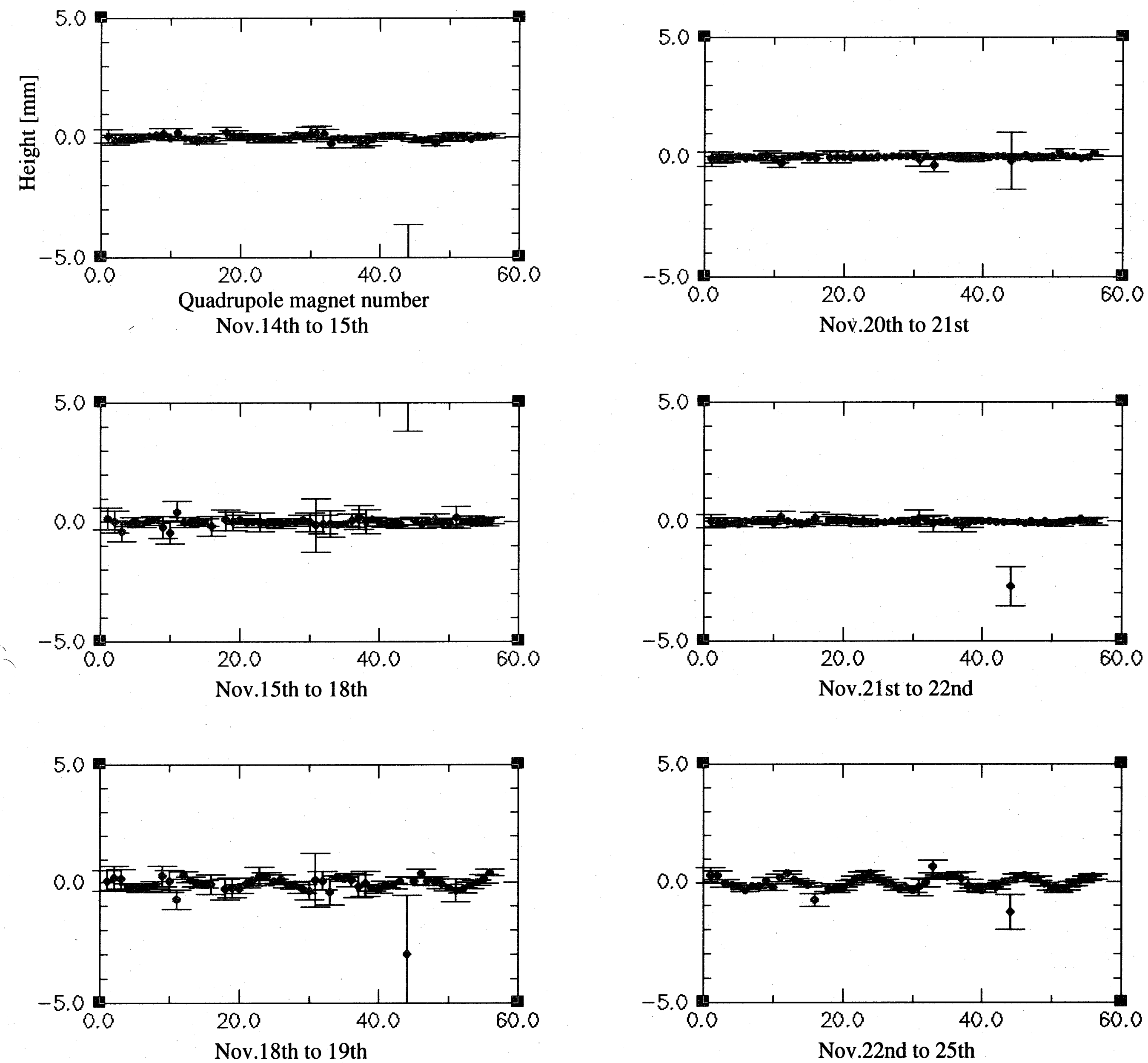


Figure 2. Orbit excursions in the vertical direction

Unfortunately, in this period little rain was observed because it was winter.

The orbit change of about 0.5 mm was observed for three days of Nov.18th through 20th and four days of 22nd through 25th. These orbit excursions corresponds to the magnet deviation of about 200 μm. During the measuring period, it rained twice on 15th and from 20th evening to 21st early morning. Soon after the latter rainfall, the large COD was observed as shown by Nov.22–25th data in Fig.2. Hence, the floor movements can be attributed to the rain. However, it is difficult to explain the correlation between the rainfall on 15th and the orbit excursion from 18th to 20th, because the amount of precipitation was little, and there was a time lag of four days until the orbit excursion appeared.

It is remarkable that the COD can change into the opposite phase. (See Nov.18–20th and 22–25th data in Fig.2.) It means the error souce of the COD changed the polarity. Although the fluctuation on the power supply makes the COD, it cannot change the polarity. The assumption of floor plate movements well explain such characteristics.

3. Origin of the floor movement

The KEK–PS was constructed on the water–rich ground. At first, it was considered that the underground water makes the floor move because there are two moisture strata below the main ring. According to the water surface level measurement from the well, any anomaly was not observed during above period discussed in section 2[4]. The velocity of water percolation downward through the soil was found very slow. It typically takes several days for making some changes onto the water levels in the moisture strata. 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 (not underground!) with the banking. In the case of this type tunnel, the stress on the constructions mainly comes from the moisture which is contained in the banking. In this mechanism, the fast effect can be explained. The moisture measuring system is now under preparation to seize the flow of water in the banking in company with the Radiation Science Center and the Geological Survey of Japan. The banking of main ring tunnel is 4.5 and partly 7.7 meter high over the tunnel roof. Osmometers are distributed in the banking with 3, 4 and 5 meter deep in the banking. It is expected to become clear the origin of the floor movement by comparing with the beam orbit excursions.

4. Conclusion

It is considered that the floor level fluctuation in the main ring tunnel mainly comes from the water in the ground. Firstly, although the underground water became the main candidate, it might not explain the fast floor movement because the percolation velocity downward through the soil was very slow. In the case of the main ring tunnel which has the banking, moisture in the soil of the banking plays an important roll geologically. It is supposed that the moisture in the banking moves the floor plates in one or two days.

The fluctuation with the range of about 1 mm observed in the KEK–PS main ring tunnel may cause serious effects on the beam in a future accelerator to be constructed in this tunnel.

References

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