GROUND MOTION AND MAGNET ALIGNMENT OF J-PARC MR

M. J. Shirakata, K. Ishii, K. Niki, K. Okamura, T. Oogoe, E. Yanaoka, M. Yoshioka, KEK, Tsukuba, Japan
Y. Iwama, S. Kokusen, T. Kurosawa, NAT, Tokai, Tsukuba, Japan

Abstract

The construction of the main ring tunnel of J-PARC has finished in November 2006. The floor level has been measured since September 2005 when the first construction part was completed. The floor level is still unstable in some areas. The time dependence of the floor level fluctuation and the magnet alignment method of the main ring are presented.

INTRODUCTION

The Japan Particle Accelerator Research Complex (J-PARC) is constructed in the southmost area of Japan Atomic Energy Agency (JAEA). It consists of LINAC, Rapid Cycling Synchrotron (RCS) and Main Ring (MR). It is very close to the pacific ocean and the river 'Sinkawa' goes beside of the main ring. In Tokai area, there are three rivers: Kujigawa, Shinkawa, and Nakagawa as shown in Fig. 1. These rivers made valley structure in the ground along their way by erosion due to the water flow with very long time. Sinkawa is the smallest one, however, its accompanied valley is very deep. Unfortunately, the main ring is located just on the valley.

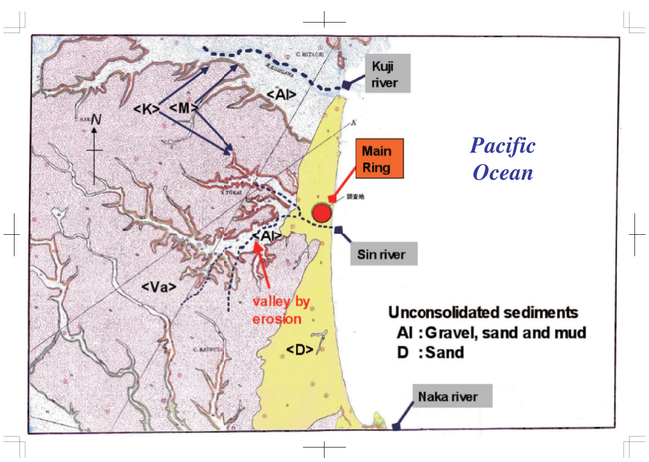

Figure 1: Surface geological distibution of the Tokai distinct.

Fig. 2 shows the bedrock contour around the main ring. The slope of an underground valley is steep and the deepest place is more than 60 meters below (shown as red area). The MR tunnel stands on a valley with piles whose length varies from 20 to more than 60 meters depending on the height from the bedrock. Large amount of underground water flows along this valley still now. The MR tunnel is under the influences of underground water in addition to the ocean tide and swell.

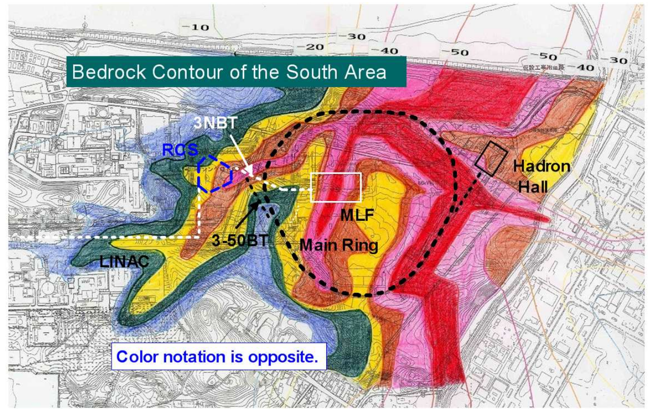

Figure 2: Bedrock contour around the MR.

Fig. 3 shows the construction schedule of the MR tunnel. The construction started from the area-A and went to the clockwise direction. The last part area-D2 was completed the earthwork at the end of September 2006. The construction of the hadron experimental hall was continued to March 2007. For the neutrino beam line, the target station is still under construction.

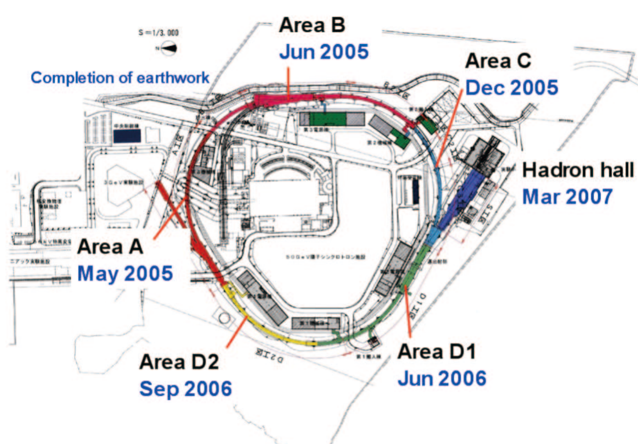

Figure 3: Construction schedule of the MR tunnel.

MEASUREMENT AND ALIGNMENT

Survey Network

In order to make a survey network in MR tunnel, position and floor height references are prepared. Base chips for the digital level staff are distributed on the floor as shown in Fig. 4. They are placed in every about 12 meters. For the position references, L-type and O-type target bases for the

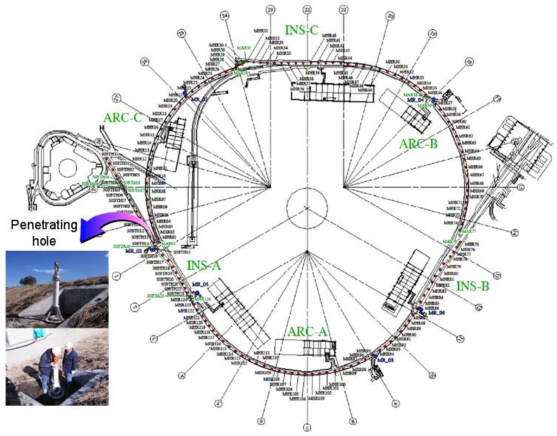

Figure 4: Distribution of the floor level references.

corner cube reflector of laser tracker are also distributed on the tunnel walls in similar way. All of them are used for the measurement in MR tunnel. On the other hand, six special references which can be observed from the ground level are prepared at the sub-tunnels to the power stations, emergency exits, and installation halls. The steinless pipes, whose diameter are about 30 cm, are placed just above the references penetrating from the gound level to the accelerator floor where is more than 10 m below. They are included in the site-wide survey network on the ground, and the global coordinates are transferred to the accelerator floor, so they are called as global references. In the tunnel, the MR survey network is composed by measuring wall references by a laser tracker. The coordinates of wall references are allocated based on ones of the global references.

Magnet Alignment

The magnet alignment was started in March 2006 before the completion of MR tunnel construction. The laser tracker reconstruct the proper coodinate system in the arbitral place in the ring by using coordinates of position references on the walls. Workers can align the magnets watching the displacement from the designed magnet position in real time. The rotation around the beam line and incline along the beam line of magnets are checked by digital tilt meters [1]. Because the magnet core of dipoles weighs more than 30 tons, it is too heavy to move by push bolts. The core mover was prepared for the dipole magnet alignment. It consists of a xy-stage formed by LM guides and oil jacks with hand pumps. Dipole magnets can be adjusted in the precision smaller than 0.1 mm with this system.

After the completion of the MR tunnel construction, the full position survey including the already aligned magnets was carried out in April 2007. Fig. 5 shows the height of dipole magnets along the beam line with counter-clockwise direction from the injection area. It was found that the upstream parts of Arc-B and Arc-C largely descended. In the period from March 2006 to April 2007, earthworks of neu-

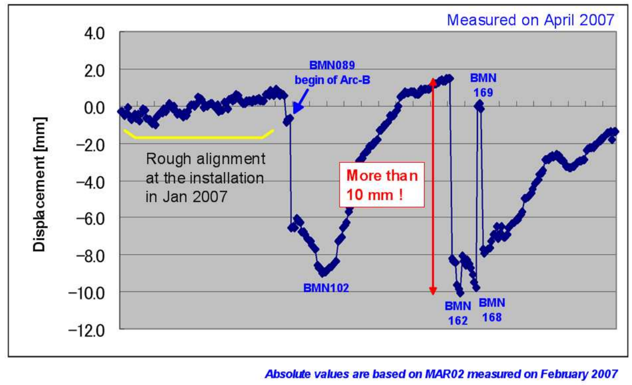

Figure 5: Height of dipole magnets. Arc-A to Arc-C with the beam direction.

trino beam line and hadron experimental hall were going on. The hadron experimental hall is constructed beside the upstream of Arc-B, and the neutrino beam line is close to the upstream of Arc-C.

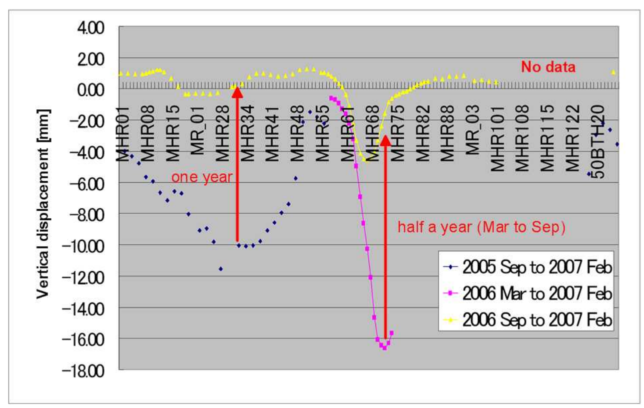

Figure 6: Floor level displacement. Horizontal axis direction is opposit to Fig. 5.

The floor level displacement from September 2005 to February 2007 is shown in Fig. 6. The construction of the middle part of neutrino beam line was done in summer of 2006, which affected around MHR28. On the other hand, the consruction of hadron experimental hall affected around MHR70. The floor level fluctuation is expected to be 1 mm without earthwork, however, it is not confirmed for the Arc-B. The magnet alignment was restarted for all magnets, base on the new data measured in April 2007.

The number of magnets to be aligned is 96 for dipoles, 216 for quadrupoles, and 80 for sextupoles, though steering dipoles are not included. The magnet alignment was completed at the end of October 2007 whose average rate was 5.8 magnets per day, that corresponds to 3 months. The distribution of magnet displacement is plotted in Fig. 7, and the rotation and incline are plotted in Fig. 8. All the magnets are very well aligned because the required displacement and rotation are 0.3 mm and 0.3 mm/m for 1σ at the beam position, respectively.

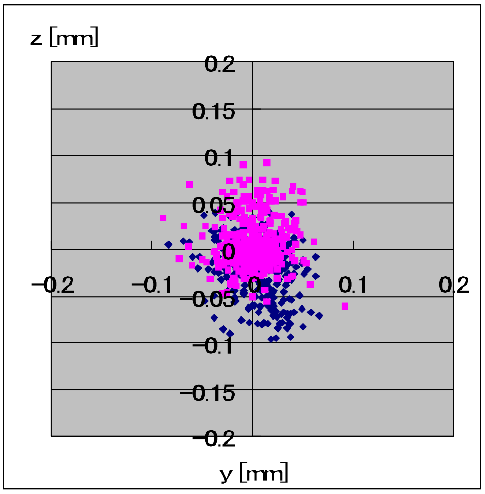

Figure 7: Displacements in the transverse plane. Blue plot corresponds to the upstream side of magnets, and red plot does to the downstream side of them.

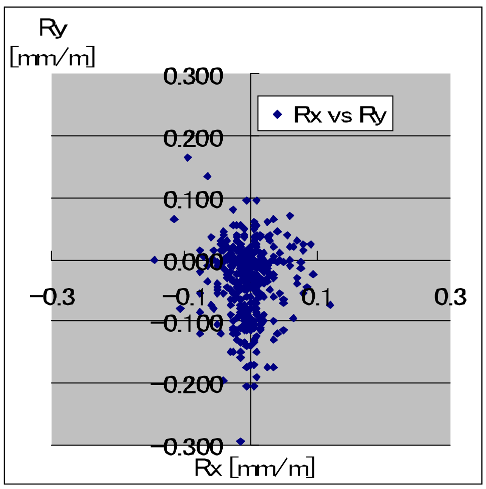

Figure 8: Rotation and incline of magnets. They are averaged values of upstream and downstream side of magnets. Rx: Rotation around the beam line, Ry: Incline along the beam line.

The twist and bend of MR magnets are shown in Fig. 9. The blue plot shows the absolute differences between the rotation around the beam line measured at the upstream and downstream target plate. As the dipole magnets are slim and long, the twist of them can be corrected in the alignment process. The dipole magets are aligned very well for the Rx, however, the bend of them is not controllable. On the other hand, both twist and rotation of quadrupoles and sextupoles cannot be corrected if it was twisted once, because the magnet cores are fat and short. Although some of them are large, they are not harmful to the beam.

SUMMARY

The summary is as follows:

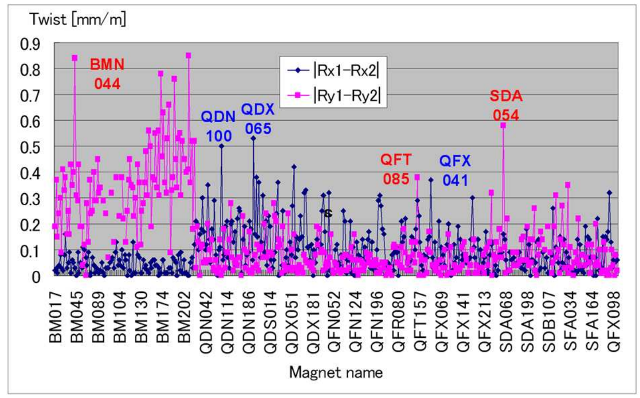

Figure 9: Twist and bend of magnets. They are defined as absolute differences between Rx's and Ry's of upstream and downstream sides, respectively.

- The ground level in J-PARC site is unstable.
- All the magnets have been aligned to satisfy the requirements, though anxieties still exist on ground motion.
- Next magnet measurement is planned in July 2008 after the first beam in May.
- Re-alignment will be carried out in autumn if it is needed.

REFERENCES

[1] M. J. Shirakata et al., APAC'07, January 2007, Indore, p.752 754, http://cern.ch/AccelConf/a07/PAPERS/THPMA083.PDF.