Survey Monument Preparation for SuperKEKB

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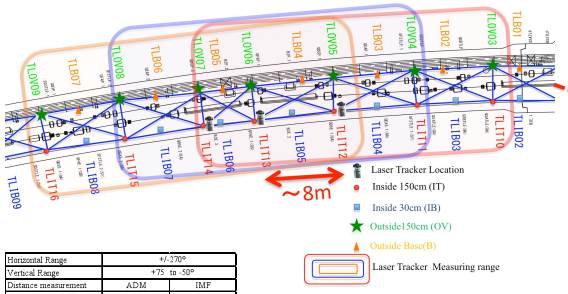
1 . INTRODUCTION

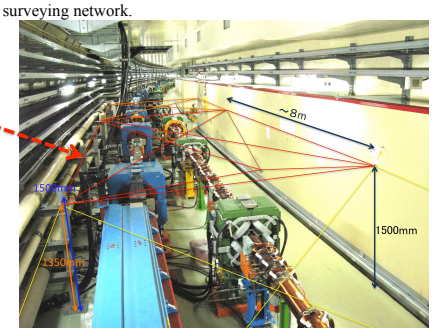
KEKB is a colliding-beam accelerator which consists of two rings, one for electrons (8 GeV, HER) and the other for positrons (3.5 GeV, LER), in the former TRISTAN accelerator tunnel of approximately 3 km in circumference. Between the 1998 starting of beam commisioning and the termination of operation on June 30, 2010, KEKB produced impressive results including experimental verification of Kobayashi-Maskawa's Theory. We are currently discussing a plan to dramatically increase the luminosity (SuperKEKB Project). This SuperKEKB project plans to replace and realign the magnets to reduce beam emittance. An effective method for installing and aligning many magnets efficiently with high precision within the limited construction period is to pre-install the surveying network. This article reports on the monument setting method, procedures, and the targets to be placed on the monument essential for the surveying network.

2 .NEW STRATEGY

When KEKB was constructed, three-dimensional alignment was conducted by combining a level meter and a laser tracker. When an magnet was installed, the height of the TRISTAN quadrupole magnet which was marked on the inner tunnel wall (passage side) and the floor monument were used as the reference. The alignment precision was then improved by repeatedly measuring magnets and making adjustments .

The SuperKEKB, we will install the magnets according to the prepared coordinates from the surveying network installed ahead of the time in the tunnel. If the surveying network is constructed with high precision in advance, the process of alignment convergence can be omitted, reducing the overall time for alignment.





Horizontal Range	+/-270°	
Vertical Range	+75 to -50°	
Distance measurement	ADM	IMF
Resolution	0.5μm	0.15μm
Accuracy	8μm+0.4μm/m	3μm+0.4μm/m
Angular accuracy	10μm+2.5μm/m	10μm+2.5μm/m
Weight	17.7kg	

Table 1: FARO Laser Tracker ION Specifications

3.MONUMENT PREPARATION

This surveying network is constructed as successive rectangles surrounding the accelerator ring. One side of each rectangle is approximately 8 m in length, and the reference monument is installed on the outer and inner walls of the ring tunnel at this interval. This monument needs to be designed by taking into consideration the shape and size of the target to be placed over it. With KEKB, magnets had been aligned using two Leica Laser Trackers. Thus in this case, 75 mm corner cubes and cat's-eyes had been used as the targets. However, these laser trackers lost the original precision through years of use, we decided to purchase new ones. The basic specification of the new tracker is summarized in Table 1.Since the new laser trackers do not support the types of targets we had been using, we had to create a new surveying network incorporating a monument supporting 1.5-inch targets. In actual surveying process, approximately 32 m long (equivalent to four of the unit rectangles) area was considered to be one measurement unit area. Since we shift 8 meters between the successive surveying processes, each measurement overlapping area of 24meters long.

Monuments on the inner-side of the ring

3.1 Monuments placed on inner-side wall of the ring

Target holders manufactured by HUBBS were installed on the tunnel inner-side wall at 1.5 m height and 8 m interval. This was 160 mm higher than the reference plane for HER quadrupole magnets. Each HUBBS target holder was attached by epoxy resin applied between the holder and the concrete wall and also by a 4 mm diameter stainless steel screw at the center of the holder. These monuments are called IT (inner top) monuments. Approximately 350 of them were installed throughout the tunnel. In addition, other monuments were installed at different height (30 cm from the floor surface) between adjacent IT monuments, and are called IB (the inner bottom) monuments. The total number of IB monuments was approximately 270.

Monument B (base)

3.2 Monuments on the outer-side of the ring

Finding a place for them and how to attach monuments were very difficult when we installed monuments on the outer-side wall of the ring. The KEKB tunnel itself had been constructed three decades ago, and the necessity to provide present number of monuments had not been foreseen by then. Furthermore, through the past two generations of accelerator, TRISTAN and KEKB, having been installed in the same tunnel, objects such as cable racks and cooling water piping had already been occupying the outer surface of the tunnel, leaving insufficient wall surface for the new monuments.

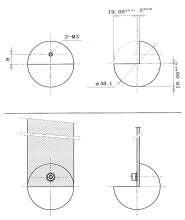
Hence, we decided to attach the monuments on the racks for cooling water piping at 8 m intervals. Each rack consisted of welded 130 × 130 mm (15mm thick) steel and 100 × 100 mm (10mm thick) angles fixed to the concrete floor and concrete wall with eight chemical anchors of 12mm diameter. However, there was a possibility that this cooling water piping rack might have to be removed and replaced with a new one during the cooling water reinforcement work, and therefore inexpensive thick, stainless steel washers were attached on the rack with epoxy resin to serve as target holders, as ancillary points for the outer monuments. These monuments are called OV (outer vertical) monuments totaling approximately 300 of them.

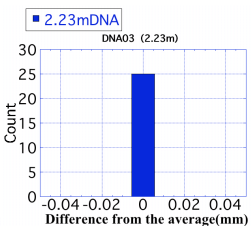
Corresponding to the IB monuments, we adopted embedded type monuments buried on the surface of the floor between the cooling water rack and the magnet . They are called B (base) monuments, and approximately 340 of them were installed. However, as it is impossible to see this IB monument directly after the magnets were placed inside the tunnel, Leica NL was used to refer to the IB monuments.

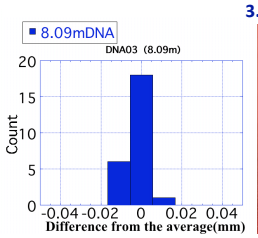
3.3 Targets

Since it was decided to use 1.5-inch targets for the laser trackers in SuperKEKB, the surveying attachments previously used had been all replaced by new ones.

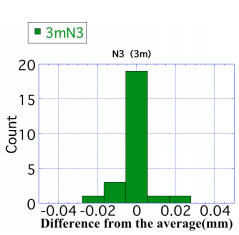
3.3-1 Target for Leica DNA03







3.3-2 Target for Leica N3



4.SUMMARY

We set up monuments for constructing a surveying network with optimal precision in the limited space of the existing tunnel. There were many difficulties to install the new monuments in a tunnel which had been used for TRISTAN and KEKB. We expect that the new surveying network will provide high precision placement of the magnets for SuperKEKB.

Approximately 1300 new monuments were installed in the tunnel. It took approximately 2 months for the two teams to measure these new monuments and the major existing groups of KEKB magnets. Although the measurement period also depends on the number of points to be measured, the time it takes to adjust (correct, etc.) the tracker for each location cannot be neglected.

The surveying network is now being analyzed. We will use it to position and install the magnets accurately. We hope we will complete the installation of the magnets for the SuperKEKB with high precision without causing a delay to the construction work.