ALIGNMENT DESIGN AND STATUS OF TAIWAN PHOTON SOURCE

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Abstract

The construction of Taiwan Photon Source (TPS) will be finished recently. The entire building was constructed half underground at the depth of up to 12 m relative to Taiwan Light Source (TLS) for stability reasons; for these reasons, the survey and alignment work is confined and difficult. To overcome the rigorous terrain, the network includes a preliminary Global Positioning System (GPS) network and a laser tracking network. The network needs to be maintained regularly during the construction and the temperature change. At the mean while, the magnets are installed on the datum plane of girders. To avoid the particles caused by the construction landing on the datum plane, the magnets of TPS were assembled on girders before it was moved to the construction site. The detailed survey and alignment design, variation of network, and the installation process are described in this paper.

INTRODUCTION

Taiwan Photon Source is a new 3-GeV ring under construction at the NSRRC in Taiwan with a circumference of up to 518.4 m and 24 double-bend cells. For stability reasons, the entire building is being constructed half underground. After a long time for excavating and constructing, the building will be finished recently. The accuracy of our control points is critical for positioning the building and the component. In this paper, we propose the procedure of the survey network obtained from several survey apparatus is important. To improve the accuracy of global network, the global coordinates of the network obtained from the survey using the GPS network. Furthermore, we expand the area of the laser tracker network by connecting the experiment station area and the storage ring area.

After the network has been improved and employed to align components of TPS, we still need to maintain and correct the network persistently; the change of temperature, unremitting construction and the variation of concrete floor would influence the network seriously. In this paper, we recorded the coordinates of the survey network and discussed the reasons which influence the variation of the survey network. After the network has been constructed, the alignment work was continued. However, executing the installation work in the environment with insufficient implement was difficult. For executing the work of alignment readily, several mechanisms designed and procedure of alignment are described in this paper.

THE TPS NETWORK DESIGN

There are many kinds of alignment works done in the TPS project, composition of girders, magnets, vacuum elements, and beam line systems are aligned by the survey network. The network is the groundwork to complete the alignment assignment of the TPS project. The main laser tracker network is located at the storage ring. However, the network at the long and narrow the storage ring cannot provide a précis position on the global coordinate. We promote two ways to acquire the precise position of the laser tracker network.

The first one is to expand the area of the TPS network. For stability reason, the TPS building is constructed half underground. The experimental area is the only zone that can be expanded of a survey network. To accomplish the goal, there is a survey hole on each shielding wall, and the survey targets are installed on the two side of the wall, as shown in figure 1. The survey network could connect the survey of the storage ring and the experimental area by these view holes.

Figure 1: The storage ring and survey hols

The other one is to add global coordinate to the network. Before the civil of construction, there are 8 GPS fiducial points to be dispersed around the TPS building. Considering the variation of outdoor temperature, the GPS fiducial points are made by granite to reduce the effect of thermal expansion as shown in figure 2. Due to that the survey data in height direction obtained from the GPS system is not sufficiently accurate. The 8 GPS fiducial points are only employed to combine with the network in the transverse direction. The height direction obtained from precise levelling instrument would be corrected within the TPS network. The accuracy in height direction measured by a levelling instrument is within 0.3 mm.

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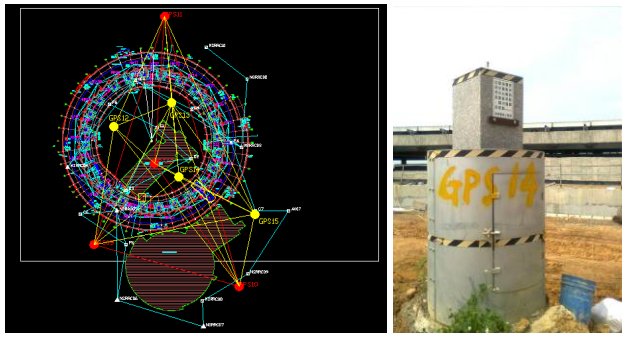

Figure 2: The GPS network of TPS

It should be mentioned that the accuracy of the network is important to be positioned during the TPS construction. To confirm and maintain the accuracy of the TPS network, there are several windows installed on the inner wall in the TPS construction that are available for surveying through a theodolite. We can obtain the reliable location information by integrating the survey data obtained from the GPS and the laser tracker network of the storage ring and experiment area, as shown in figure 3.

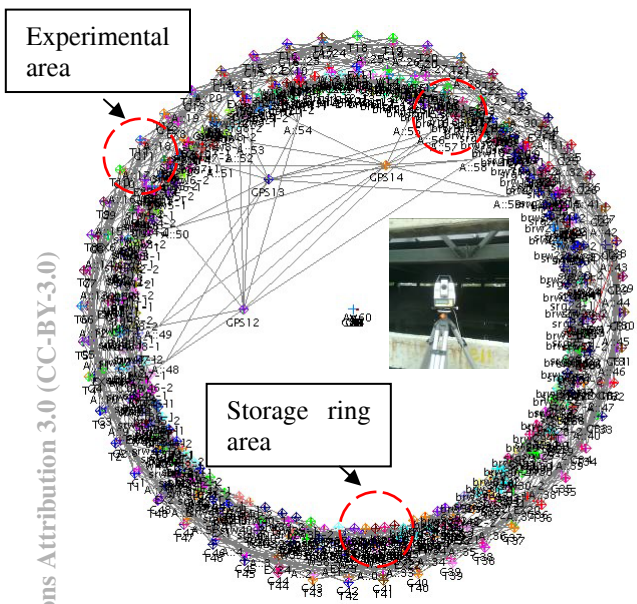

Figure 3: The network of TPS.

THE TPS NETWORK STATUS

The TPS project is a big-scaled construction, and it takes a long time to be completed, heavy machines would be employed to complete the half underground building. The survey network was needed to be constructed during the building construction. To confirm and maintain the accuracy of the TPS survey network, the interval of the recorded survey data was less than two month from January 2011 to now. After the main structure of the TPS building is completed, there are several reasons to effect the location of the TPS survey network directly. One of them is the concrete solidified process. The concrete would produce a lot of thermal energy in the beginning of the process, and it will contract with dispersing the thermal stress and mist. For the stability of ground, the building is established on the concrete floor with more than 1m in depth. For the requirement of construction, the concrete floor is constructed 6 times until it is done. The sequence of the concrete floor of construction is from area 1 to area 6, and the interval between the first area and the last one is about 6 month. In figure 4, it shows the variation in radial direction with time. The area from T18 to T26 is the last one to grout the concrete floor, and it was be constructed on June 2012.There was still a lot of stress and mist in the concrete floor in the beginning. That is the reason of the most serious variation of ground occurred in that area.

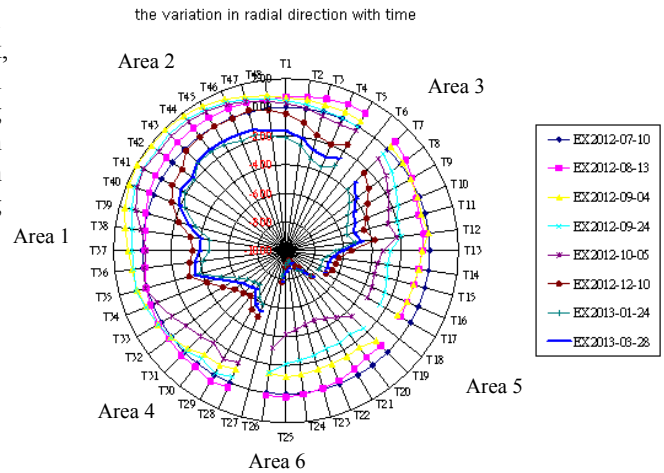

Figure 4: Variation in radial direction with time

The most serious variation is close to 12mm from July 2012 to March 2013. The major reason is the contraction of concrete floor. The other reasons are the expansion or contraction of ground with temperature change, as shown in table 1. The largest variation of temperature from October 2012 to December 2012 is 9° C. That might be the other reason cause part of the variation of the survey network. It can find that the survey network was more stable from December 2012 to March 2013. The variation of the survey network is less than 2mm. The concrete floor might be more stable pass through 6 months.

Table 1: the variation of temperature with date

Date	Temperature (° C)	Date	Temperature (° C)
2012/0710	29.7	2012/1005	25.5
2012/0803	28.6	2012/1210	16.1
2012/0904	28.1	2013/0124	17.1
2012/0924	27.5	2013/0328	20.0

INSTALATION PROCESS

After the TPS building floor was grouted, the survey network become more stable. All the holes screwed and bolts of the storage ring need to be set up by the survey network. We do the survey setting out by using line in a

carpenter's ink markers by laser tracker. The contractor drilled the premiering hole according to the markers, and glue was infused into the premiering holes for bonding the bolts on the ground and screw holes on the wall. We design templates for aligning bolts and screw holes, and the contractor could position the bolt and screw holes by using the laser tracker. After the glue is dry and solidified, all the bolts and screw holes are combined accurately within 2mm, as shown in figure 5.

Figure 5: The construction of screw holes and bolt

For aligning pedestal conveniently and precisely, an adjusting mechanism was designed to adjust the pedestals. It could be installed and removed easily at the limited space. The adjusting mechanism was fixed by screws on the ground before pedestal has been set up. After aligning and fixing pedestals, the adjusting mechanism could be removed by loosening the screws and fixed bars, as shown in figure 6.

Figure 6: Installation of the pedestals.

In the design of an auto-alignment system [1], the adjusting value of the motors on pedestal is about 4mm. To make sure that there still is an adequate adjusting value of the auto-alignment system, the accuracy of pedestals has been checked by a laser tracker with the error within 0.2 mm, as shown in figure 7. The pedestals and ground was commented together by the comment to increase the nature frequency of the girder system. [2].

Figure 7: The construction site of TPS.

The storage ring of TPS is still under construction. To avoid the particles caused by the construction landing on the plane with the magnets, the magnets of TPS were assembled on girders before it was moved to the construction site. However, there is no fixed crane in our laboratory. A forklift truck is substituted for fixed crane to help positioning the magnets. A forklift truck is easy to be adjusted in vertical and transverse direction. However, a forklift truck is hard to make magnets located at the right position because it must be operated by the driver driving in beam direction. To solve this problem, we designed a hanging-rack to assemble the magnets and girders at the right position easily. The adjusting mechanism of a hanging-rack was constructed using screws and linear guideways. It can easily be adjusted to the position we want using a hanging-rack and an electric screw driver, as we use our electric screw driver, we can move the rack connected to the magnet to move in the direction we want, as shown in figure 8.

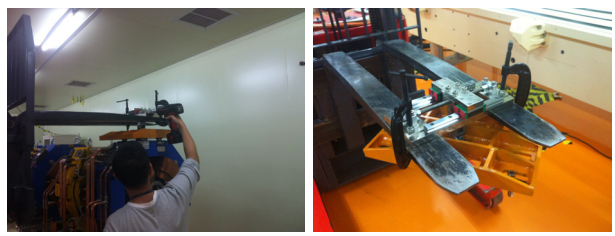

Figure 8: Installation of the magnets.

CONCLUSION

To overcome the rigorous terrain, the survey network of TPS was constructed using GPS, theodolite, laser tracker gradually. After the main construction of TPS is completed, the accuracy of survey network is under 0.5mm recently. However, the variation of the ground is has a difference of up to 2mm during the temperature change. Therefore, it is important to maintain and correct the survey network of TPS persistently. The survey network can provide precise position to align all kinds of objects and also employed to monitor the building construction precision. The position data from the survey network can therefore be defined as a basis for the motorized girder system to auto-tune and applied to improve the accuracy of alignment [3, 4].

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