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ALIGNMENT DESIGN AND STATUS OF TAIWAN PHOTON SOURCE

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Abstract

After the construction of Taiwan Photon Source (TPS) was finished, the variation of the survey fiducials was stable. However, the following precise alignment work is concerned by the change of temperature critically. In this paper, the whole process of alignment work in the TPS storage ring with the relation of survey network and thermal issues of the environment will be described. We analysed these survey data so that the correction of survey network could be estimated by the change of temperature, thus all the elements for example, booster, pedestals, and girders could be positioned within the shortest time.

INTRODUCTION

Taiwan Photon Source is a new 3-GeV synchrotron ring under construction at the NSRRC in Taiwan. For stability reasons, the entire building has been constructed half underground. Since the construction is underground, it would take more time during the process of constructing the building's foundation and the transport of heavy machinery. In order to implement the operating test of the booster immediately after the building of TPS was constructed, we need to advance the schedule of the installation work. We carried out the installation work when the building was under construction. However, there are a lot of components (beam potion monitor in the vacuum system, pedestals of storage and booster ring, and the magnets) that needed to be installed, which could not be completed in a short time.

Since the work was carried out for a long time, the building was shape shifting due to the variation of thermal issues and the proceeding of the building's construction. To provide the precise fiducial points for positioning, those components will be critical. To achieve the purpose, the survey network of TPS was constructed since July 2012 until now. According to the historical survey data and the current temperature, we can conjecture the variable of shape shift of the building approximately during positioning.

Up to present, the major part of positioning work has been completed, and the booster system of TPS is under operating test. The fiducial points of TPS are still being surveyed periodically for constructing the coordinates of the survey network. In this paper, we also describe the process of survey and installation work and the results of the positioning work.

THE TPS NETWORK DESIGN

The network is the important foundation work to complete the alignment assignment of the TPS project. For stability reason, the TPS building is constructed half underground and has an outer wall blocking the measuring instrument from measuring one site to another directly. Thus, there are 8 fiducial points of global position system (GPS) set up around the building to confirm the location and the shape of TPS construction, as shown in Figure 1. By using these fiducial points of GPS, the primary fiducial points of survey network could be constructed.

Figure 1: The photo of TPS building.

Considering the variation of outdoor temperature, the GPS fiducial points are made by granite to reduce the effect of thermal variation. After the one year of construction, the GPS fiducial points seem to stabilize within time, as shown in Figure 2.

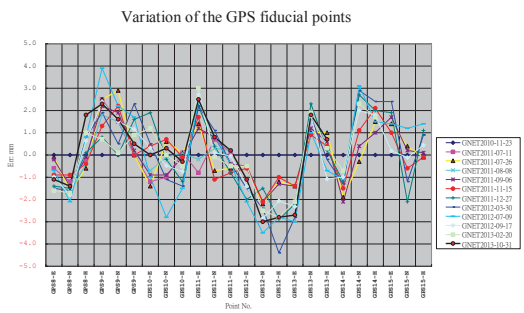

Figure 2: The variation of GPS fiducial points.

Since these fiducial points are stabilized, we can now then construct the primary survey network based on these fiducial points. The primary survey network is constructed by using theodolite and GPS due to environment issues during construction. By reasons of survey data of the altitude direction obtained from the GPS system is not sufficiently accurate. The 8 GPS

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fiducial points are only employed to combine with the network in the transverse direction. The altitude direction obtained from precise levelling instrument (DNA03) would be corrected within the TPS network. The accuracy in altitude measured by a levelling instrument is within 0.3 mm.

The primary fiducial points can provide the construction of the building to ensure the dimension of the storage ring to be precise within 5cm. There is a lot of mechanism designed to be based on the shielding wall and within limiting adjusting value, all of TPS system are design compactly. The precise construction of storage ring can avoid the matters which modify the components in the installation processes.

The coordinates of fiducial points is needed to be recorded as well as the current temperature. To construct the fiducial points of survey network, there are several windows installed on the inner wall in the TPS construction that are available for surveying through an outdoor laser tracker (AT401) , as shown in Figure 3. It can provide the longer chord length to correct the error propagation from the imprecise geometry of the TPS ring.

Figure 3: The survey window of TPS.

There are also two survey holes on each shielding wall, and the survey targets are installed on the two side of the wall, as shown in Figure 4. The survey network could then be connected so that the storage ring and the experimental area could then be observed by these holes. Thus, by using the two methods mentioned above, the whole survey network can be expanded, as shown in Figure 4. After the wide network has been constructed, we can then have a much precise fiducial point for alignment.

THE TPS NETWORK STATUS

To shorten the schedule of the installation and alignment work, a minor amount of assignments are completed in the laboratory, but there are still a lot of those which must be done in the field. Even though there are a huge amount of multifarious installation and alignment work, there are still a huge amount of other assignments that are needed to be cooperated during construction. A huge amount of time is needed for installation and alignment of the girder, vacuum and magnet system. For those reasons, it is necessary to conjecture the shape shift of the building approximately in the schedule of positioning work. When the foundation of the building is constructed completely, there are several fiducial pillars set around the experiment area. The coordinates of survey network which contains those fiducial pillars were then started to be recorded from July 2012 until now.

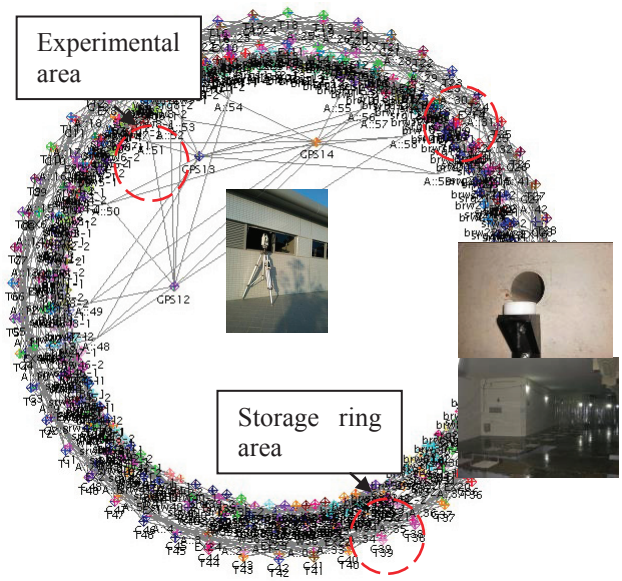

Figure 4: The survey network of TPS.

For the requirement of construction, the concrete floor is constructed 6 times until it is completed. The sequence of the concrete floor of construction is from area 1 to area 6. The area from T18 to T26 is the last one to be grouted, and it was constructed on June 2012. Other than the sixth area, the building was contracted about 5mm and the variation of temperature is approximately 15 ℃ from July 2012 to January 2013. From January 2013 to May 2013 the building was expanded at about 3mm and the variation of temperature is then 10 ℃, as shown in figure 5. According to these data base, the construction of TPS should be influenced at about 0.3mm per ℃ .The alignment of pedestals was started in June 2013, and the closest data base observed is on 14 May 2013. The temperature at that moment is around 28 ℃, after the air condition is installed, the whole building will then be reduced to 25 ℃ . According to this condition, the pedestals were aligned with the shift of 1mm.

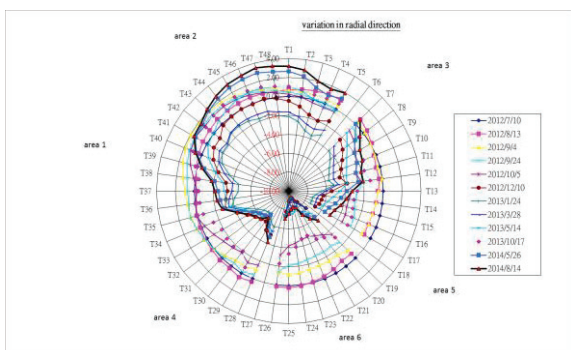

Figure 5: The variation in radial direction with time.

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After the alignment of pedestals is completed, the coordinates of fiducial points were surveyed in October 2013. The temperature interval of that time is about 25℃, but the contraction of the building is only about 0.3mm. There is maybe two reason that causes this situation; the first situation might be because the factor of the thermal extension has been fitted in with the data base roughly, as shown in Figure 6. The second part is from the error of the survey. The repeatability of the TPS survey network is 1mm(±0.5mm).

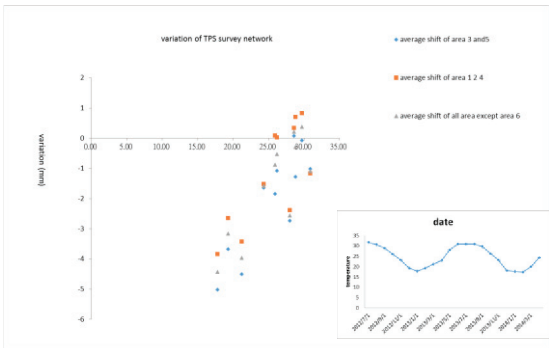

Figure 6: The Variation in radial direction with temperature.

For the requirement of installation and repair of the cement ceiling, the cement ceiling were then removed and been placed on the experiment area from October 2013 to May 2014, as shown in Figure 7. That is the reason for the data of survey network to be incomplete for a long time. If the area of survey network is just in the storage ring area, the repeatability of the TPS survey network would be approximately 2 mm. Thus, the data of survey network was recorded again when the installation and recondition was completed.

Figure 7: The state during installation and repair of the cement ceiling.

The air condition of TPS is operated on May 2014, and the internal temperature is controlled at 25 ℃. In Figure 5, the variation of the survey network is only about 1mm even if the change of temperature compared to the external ring is to up to 5℃. More survey data is needed to be recorded to understand the temperature effect on the building in the future. In Figure 8, the adjustment of the whole ring girders are less than 1mm. the reason is that the temperature on October 2013 is close to 25℃, and the temperature of building now is also controlled to 25℃ under air condition. Even when the building has been placed for over 6 months, the structure of the survey network has not changed seriously. The position data from the survey network can therefore be defined as a basis for the motorized girder system for auto-tuning and will then be applied to improve the accuracy of the alignment [1,2]. When the amount of adjustment needed to adjust is within 1mm, the adjustment time for the auto-tuning is approximately 30 minute per cycle.

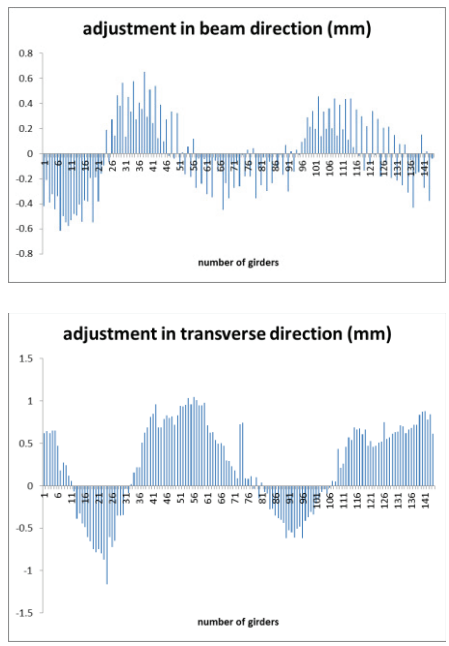

Figure 8: The adjustment of TPS on May 2014.

CONCULOTION

The survey network of TPS was constructed using GPS, theodolite, laser tracker gradually. After the main ground construction of TPS is completed, the variation of the network has a 5mm difference in radial direction during the temperature change(15℃). Therefore, it is important to maintain and correct the survey network of TPS persistently with temperature. Until now, the auto-alignment system can be implemented smoothly, but adjustment per cycle has to take approximately 30 minutes, for the TPS, 30 minutes is still to be considered slow, thus, in the future, we still have to do a lot of work to reduce the adjustment time and to make the adjustment more accurate.

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[2] M. H. Wu and others, “Auto-Alignment Status of the Taiwan Photon Source,” IPAC, 2014.