

A Study on Ganui-Dae's External Form and Its Modeling for Restoration

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Ganui-Dae, built in the reign of King *Sejong*, *Joseon* Dynasty, is a comprehensive observatory. It has various instruments for observation and time signal such as *Ganui*, *Gyupyo*(Gnomon), water-hammering type *Honui* and *Honsang*, and so on. Studying on *Ganui-Dae* has been focused on its location, history, criterion, etc, so far. However, studying on its external form and construction method has been conducted insufficiently. This study suggests the model for restoration of *Ganui-Dae*. The model is based on the analysis about external form of *Ganui-Dae* in various antique maps, and its construction method in those days.

Keywords: *Ganui-Dae* (royal observatory in *Joseon* Era), *Ganui* (simplified armillary sphere), *Gyeongbokgung-Do* (antique map of *Gyeongbokgung* palace)

1. INTRODUCTION

King *Sejong* (世宗) of *Joseon* Daynasty (朝鮮時代) made a remarkable astronomical achievements in the Korean history(Jeon 1994, Nam 2002, Nha 2006). Making various astronomical instruments such as *Ganui* (簡儀) in this period influenced the making of 『*Chiljeongsan Naeoebyeon* (七政算内外篇)』 and national time system. Thus, *Ganui* and *Ganui-Dae* (簡儀臺, 1432~33) were the main astronomical projects. The *Ganui-Dae* is not just a support (臺) that the *Ganui* is constructed on. It is comprehensive observatory with the various instruments for observation and time signal (時報) such as *Ganui*, *Gyupyo*, Water-hammering type *Honui*, *Honsang*, and so on (Nam 2002).

Historically, various world powers (列強) built astronomical observation facilities in large scale and devoted to their scientific techniques. For example, Ulugh Beg Observatory (1424~1429) was built what is current day Samarkand, Uzbekistan in Timurid Dynasty. Also, *Guanxing-tai* (觀星臺, current day 古觀象臺, 1442) was built in Beijing (北京), China, in Ming Dynasty (明代), and

Greenwich Observatory (Royal Observatory, Greenwich, 1675) was built in Greenwich, England. These observatories represent each country's history of scientific techniques and come into the spotlight as important tourism resources. *Ganui-Dae* is the comprehensive observatory that can stand comparison with the listed observatories above, and it can perform the same function (Kim et al. 2011). However, *Ganui-Dae* doesn't exist. Even though its restoration is needed, its exact external form isn't suggested.

Until now, major studying on *Ganui-Dae* was its location, history and construction criterion and so on (Jeon 1964, Lee 1996, Nha 1997, Nam 2008, Chung 2010, Mihn et al. 2010, Kim et al. 2011). On the contrary, few studying on external form and construction method of *Ganui-Dae* is performed. Some suggested models of *Ganui-Dae* (such as model of culturecontent.com of Korea Creative Contents Agency (KCCA)) cannot suggest exact basis of external form and construction method etc.

This study analyzes the external form of *Ganui-Dae* in the antique maps and suggests new restoration model based on the analysis of construction method.

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2. EXTERNAL FORM OF GANUI-DAE

2.1 Survey of previous studies

In the previous studies, *Sitian-tai* (司天臺, 1279), built in the Beijing during the Yuan Dynasty (元代), is believed that it influenced on Ganui-Dae (Kim et al. 2011, Fig. 1). There are several basis that the *Sitian-tai* influenced the construction of *Ganui-Dae*. The first basis is 'Ganuidaegi' (簡儀臺記) in 『*Sejong Sillok*』 (世宗實錄). It is direct record of the construction of *Ganui-Dae*. It also said that method to make various instruments like *Ganui* follows 『*Yuanshi*』 (元史) in the *Ganuidaegi*¹. The second basis is 『*Yeonryeosilgisul*』 (練藝室記述) written by Lee Gung-ik (李肯翊) in the late Joseon Dynasty. The record of the 『*Yeonryeosilgisul*』 said that the King *Sejong* ordered *Jang Young-sil* (蔣英實) et al. to go to China and to learn the construction techniques of astronomical instruments in 1421. It also said that the King *Sejong* made them who came back in following year (1422) participate in constructing astronomical instruments.²

However, it is hard to believe that *Sitian-tai* is the original form of *Ganui-Dae*. It is because there is no direct describes about *Ganui-Dae* in the *Ganuidaegi*. Furthermore, there is a possibility of loss of *Sitian-tai* in the middle period of visit of *Jang Young-sil* et al. This is specified in 『*Yeonryeosilgisul*』. The possibility of loss of *Sitian-tai* is based on the construction of another observatory, *Guanxing-tai* (觀星臺, current day 古觀象臺), is built on Beijing in 1442, Ming Dynasty (Kim et al. 2011). Construction of *Guanxing-tai* can be considered as a replacement of lost *Sitian-tai*. As a result, the year of 1442, when the *Guanxing-tai* was constructed, is middle period of visit of *Jang Young-sil* et al, so there is a quite possibility of loss of *Sitian-tai*. This implies that the *Sitian-tai* cannot be the original form of *Ganui-Dae*'s external form.

Another observatory, Dengfeng (登封) *Guanxing-tai* (觀星臺, 1279, Fig. 1), is constructed in Yuan Dynasty (Kim et al. 2011). However, there is no record of installation of instruments like *Honchunui*, so it is guessed that the company of *Jang Young-sil* wouldn't visit the Dengfeng *Guanxing-tai*.

'Culturecontent.com' of KCCA suggested the 3D model of *Ganui-Dae*. It seems to be based on the *Guanxing-tai* in Ming Dynasty³ (Fig. 2). However, as mentioned above, it is hard to consider that the *Guanxing-tai*, constructed in Ming Dynasty, is the external form of *Ganui-Dae*, because

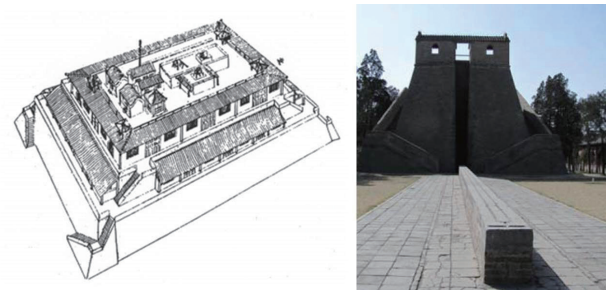


Fig. 1. Illustration of *Sitian-tai* on Beijing in Yuan Dynasty (Li 1997, left) and Dengfeng *Guanxing-tai* (Kim et al. 2011, right).



Fig. 2. The Beijing Ancient Observatory (left) on Beijing and 3D Model of *Ganui-Dae* (right) on 'Culturecontent.com'.

Guanxing-tai was constructed after the visit of *Jang Young-sil* company.

To synthesize the content above, both *Sitian-tai* in Yuan Dynasty and *Guanxing-tai* in Ming Dynasty in Beijing were hard to be the original form of *Ganui-Dae*. Therefore, the new external form model of *Ganui-Dae* is needed.

2.2 A Study on external form of Ganui-Dae in old maps

There are some old maps (古地圖) which shows the original appearance of *Gyeongbokgung* palace. Moreover, the maps which show *Ganui-Dae* are 『*Gyeongbokgung-Do*』 (景福宮圖) in the National Folk Museum of Korea, 『*Gyeongbokgungjun-Do*』 (景福宮全圖) in Samsung Museum of Publishing, 『*Doseong-Do*』 (都城圖) in Kyujanggak (奎章閣) Institute For Korean Studies, and 『*Gyeongbokgung-Do*』 (景福宮圖) in Sotheby's and so on.

Among these maps, 『*Gyeongbokgungjun-Do*』 in Samsung Museum of Publishing only shows the name of *Ganui-Dae*, and 『*Gyeongbokgungjun-Do*』 in Samsung Museum of Publishing and 『*Doseong-Do*』 in Kyujanggak Institute For Korean Studies show unclear shape of *Ganui-Dae* with the name. Therefore, it is hard to use for studying of external form of *Ganui-Dae* (Fig. 3).

『*Gyeongbokgung-Do*』 in Sotheby's was known by being auctioned in Sotheby's on New York in 1997. It is valuable material which shows the appearance of *Gyeongbokgung* Palace before the loss, caused by two wars. This

¹Sejong Sillok』 77, Sejong(1437) April 15.

²Yeonryeosilgisul』 Vol 15, Chunmunjeongo(天文典故) Chumseong(瞻星).

³Culturecontent.com of Korea Creative Contents Agency (<http://www.culturecontent.com/>), however, doesn't suggest exact basis or source.

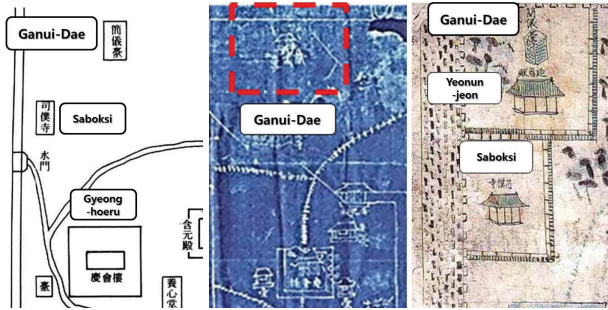


Fig. 3. Old Maps Which Show Ganui-Dae.

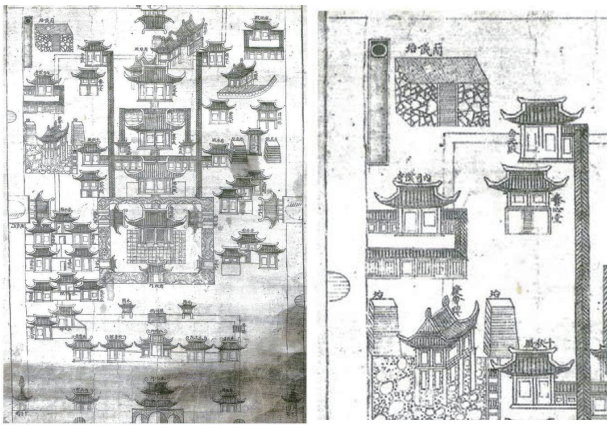


Fig. 4. 'Gyeongbokgung-Do' in Sotheby's (left) and Enlarged Picture of Ganui-Dae in the Map (right).

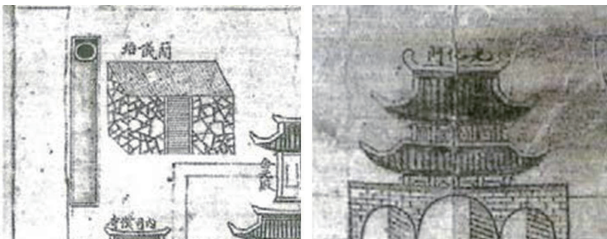


Fig. 5. Ganui-Dae in 'Gyeongbokgung-Do' of Sotheby's (left) and Enlarged Picture of Gwanghwamun in the Map (right).

Gyeongbokgung-Do guessed that it made in the reign of King Youngjo (1742~1776), late period of 18 century. Different from other *Gyeongbokgung-Do*, it is reliable that it shows the location and description of royal palace clearly (Lee 2004). On the left side of *Ganui-Dae* on 'Gyeongbokgung-Do' in Sotheby's, *Gyupyo* is described clearly, and stairs and construction method⁴ can be identified in the map (Fig. 4 right picture).

In the 'Gyeongbokgung-Do' in Sotheby's, there is need

⁴On *The Beijing Ancient Observatory* in Beijing, the world 'build (建立)' is used, but the world 'construct (築造)' is used on the *Ganui-Dae*. The world 'build' is usually used for the building and the world 'construct' is used for construction (refer to DAUM Korean Dictionary).

to focus on the external form of *Ganui-Dae*. As comparing the *Ganui-Dae* in 'Gyeongbokgung-Do' in Sotheby's with *Gwanghwamun* (光化門), the gate under the royal palace of *Gwanghwamun* looks like a building, built with the well-faced stone. However, *Ganui-Dae* looks like structure with a form of embankment or rampart, built with not-faced stone (Fig. 5). *Ganui-Dae* model of culturcontent.com of KCCA has the form of construction with well-faced stone. If 'Gyeongbokgung-Do' in Sotheby's is believed, the model would be wrong.

There is another appreciable thing in the 'Gyeongbokgung-Do' in Sotheby's. It is that the stairs, in front of *Ganui-Dae*, were straight. *The Beijing Ancient Observatory* in Beijing, which culturcontent.com of KCCA used as the original form of *Ganui-Dae*, has winding stairs, not the straight. Comparing with straight stairs of 'Gyeongbokgung-Do' in Sotheby's, *Ganui-Dae* model of culturcontent.com of KCCA is wrong.

Considering of the reliability of 'Gyeongbokgung-Do' of Sotheby's (Lee 2004), external form of *Ganui-Dae* needs suggestion of new model in the form of construction. Moreover, study on the construction method of embankment or rampart in the reign of the King *Sejong* is also needed.

2.3 A Study on construction method of Ganui-Dae

There is a purpose of establishment of *Ganui-Dae*, described in 'Sejong Sillok' as follows;

The 19th Year of King Sejong (1437) April 15th (甲戌)

There was first made using wood. Use it was determined that the north pole is 38 degree from the ground. This is almost to the *Yuanshi* (元史). Finally *Ganui* made of copper was completed. Give instructions to Hojo-panseo (戶曹判書) Ahn-Soon. A platform of 31 cheok high and 47 cheok long, 32 cheok width was built around the northern part of *Gyeonghoeru*. Placed on the platform were *Ganui*. *Jeongbangan* is placed in the south. And, *Dongpyo* in height of 8 cheok and height has five times from platform placed on the west side of the platform.

In this record, King *Sejong* assigned *Ahn-Soon* (安純)⁵,

⁵The Academy of Korean Studies, 2013, Encyclopedia of Korean Culture; *Hojo-panseo* also served the production like *Sungonggam* (繕工監) etc.; 'Sukjong Sillok' 51, *Sukjong* (1712) April 10; There is a case that the *Hojo-panseo* performed the work as he served the production of *Sungonggam*. Kim Woo-Hang, *Hojo-panseo*, managed the repair of *Bukhan Sanseong* by command of King *Sukjong*. Therefore, in the aspect of position, it was not surprised, but natural that the *Ahn-Soon*, *Hojo-panseo*, participated in the construction of *Ganui-Dae*. However, an undeniable fact is that *Ahn-Soon* had experience of

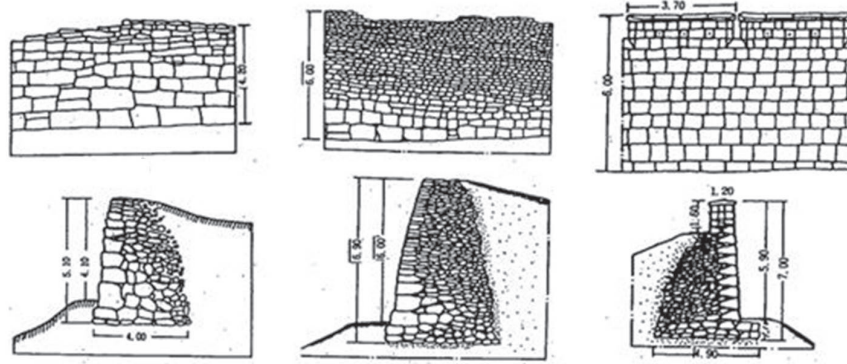


Fig. 6. Chronological Construction Method in Joseon Dynasty Shown at Seoul Fortress (From left, the Reign of the King Taejo, Sejong, Sukjong) (Cultural Heritage Administration of Korea 2001).



Fig. 7. Real Figure of Seoul Fortress in Mt. Bukaksan (From up left, Clockwise, the Reign of King Taejo, Sejong, Sukjong, Foreground) (CHAOK 2012).

Hojo-panseo (戶曹判書), for the construction of *Ganui-Dae*. This suggests very important fact. According to 『*Sejong Sillok*』, *Ahn-soon* was in charge of removal of *Gyeongwon-Sung* (慶源城) before construction of *Ganui-Dae* in 1432. At that time, King *Sejong* ordered *Hwang-Hee* (黃喜), *Younguijeong* (領議政), to remove *Gyeongwon-Sung*, and *Hwang-Hee* recommended *Ahn-soon*⁶. This suggests that *Ahn-soon* had construction knowledge about a castellation. It is connected with that *Ganui-Dae*, shown in

castellation. It would be the main reason that the *Ahn-Soon* recommended for the construction director of *Ganui-Dae*.

⁶『*Sejong Sillok*』 55, *Sejong* (1432) March 1; 召領議政黃喜曰:“移設慶源城, 延議已久而未斷, 或以爲:‘土地封(疆) [疆], 受諸祖宗, 雖尺寸不可變, 宜固守不移’; 或以爲:‘此雖確說, 然遷都徙邑, 當順民情. 今此慶源, 地本增薄, 不宜耕稼, 且一邑之民, 只耕一面, 其餘三面, 則畏賊不禦. 因此居計日艱, 民之所望, 皆在於古慶源, 龍城之地. 民之艱苦若是, 不可不徙’惟此二論, 皆近理而難斷. 予心以爲移慶源於龍城, 以爲巨鎮, 使良將固守, 民人布散業農. 築石城於今慶源之基, 令神將率兵二三百, 守城禦變, 且於賊路, 築烟臺以候鼠竊, 則於此二論, 庶得兼全矣. 然予未得目擊, 難以遙度, 欲遣卿審定便否, 然後決之. 且吉州城基移設之處, 河敬復成達生所議不同, 卿可兼審.”喜曰: “臣性本淺露, 老疾俱攻, 昧於施爲. 況此實國家億萬年無窮之計, 以臣衰老, 恐難獨決, 請與戶曹判書安純同往審定”從之.

『*Gyeongbokgung-Do*』 of Sotheby's, has form of castellation.

A study on the castellation method rose from 『*Gyeongbokgung-Do*』 of Sotheby's and the case of *Ahn-soon* proceeded with the Seoul Fortress. Seoul Fortress is suitable for studying because it shows the chronological changes of construction method in Joseon Dynasty (Culture Haritage Administration of Korea, shortly CHAOK 2001).

Seen in Fig. 6, ramparts were built with the various sizes of well-faced natural stones in the reign of King Taejo. Compared with the reign, more faced rectangular (長方形) stones were used at the construction. In the reign of King Sukjong, ramparts were built with standardized square (正方形) stones.

Differences were identified in the real figure of Seoul Fortress in Fig. 7. Therefore, the model of *Ganui-Dae* which would be suggested should follow the construction method in the reign of King Sejong.

3. DRAWING AND 3D MODELING OF GANUI-DAE

3.1 Basis of drawing and 3D modeling

Historically, *Sitian-tai* in Yuan Dynasty and *Guanxing-tai* in Ming Dynasty were hard to be the original form of *Ganui-Dae*, considering that visiting time of *Jang Young-sil* company was not matched with their loss and construction. The external form of *Ganui-Dae* shown in 『*Gyeongbokgung-Do*』 in Sotheby's has different construction form from existing models. Lastly, through the survey of the past of *Ahn-Soon*, the construction director of *Ganui-Dae*, the construction form of *Ganui-Dae* was the form of castellation.

These three facts emphasize that the new external form model of *Ganui-Dae* is needed. In the study, Seoul Fortress

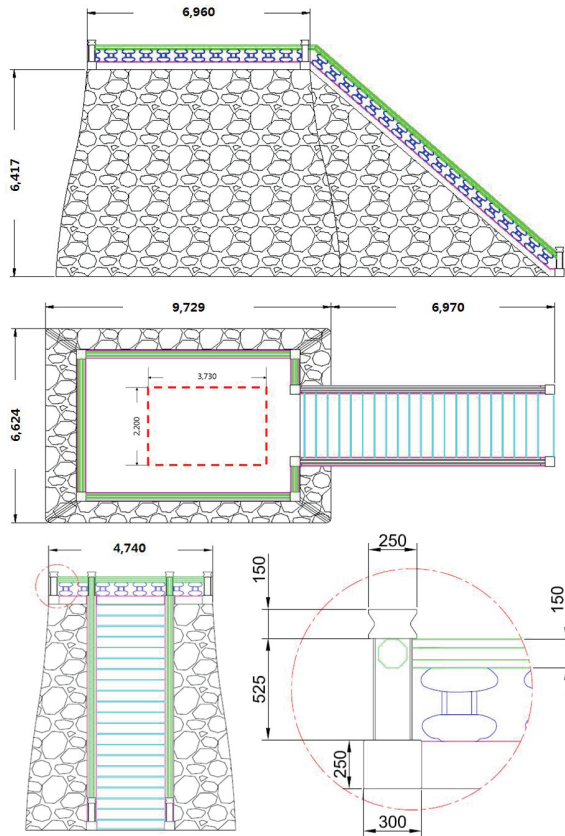


Fig. 8. Drawing of Restoration of *Ganui-Dae*; Top-Side View, Middle-Floor Plan, Bottom-Front View (Left)/Handrail (Right) (Unit: mm, Red box of floor plan is the scale of *Ganui*).

in Mt. *Bukaksan* was surveyed to make new external model of *Ganui-Dae*. The study also suggests the model of *Ganui-Dae* by using the castellation method in the reign of King *Sejong*.

In the new model of *Ganui-Dae*, its size follows the 『*Sejong Sillok*』⁷ and scale used at construction was *Ju-Cheok* (周尺), not *Youngjo-Cheok* (營造尺). The location of the stairs were settled on the north (Kim et al. 2011). Their sizes follows ones of *Geunjeongjeon* of *Gyeongbokgung* palace, because there is no statement about sizes in the document. The handrail of *Ganui-Dae* also follows *Geunjeongjeon*'s one because of no statement in document.

3.2 Scales of drawing

Scales of *Ganui-Dae* in 『*Sejong Sillok*』 were 31 cheok of height, 47 cheok of length, and 32 cheok of width⁸. In *Joseon* Dynasty, it was common that *Youngjo-Cheok* was used for

⁷ 『*Sejong Sillok*』 77, *Sejong* (1437) April 15.

⁸ 『*Sejong Sillok*』 77, *Sejong* (1437) April 15.

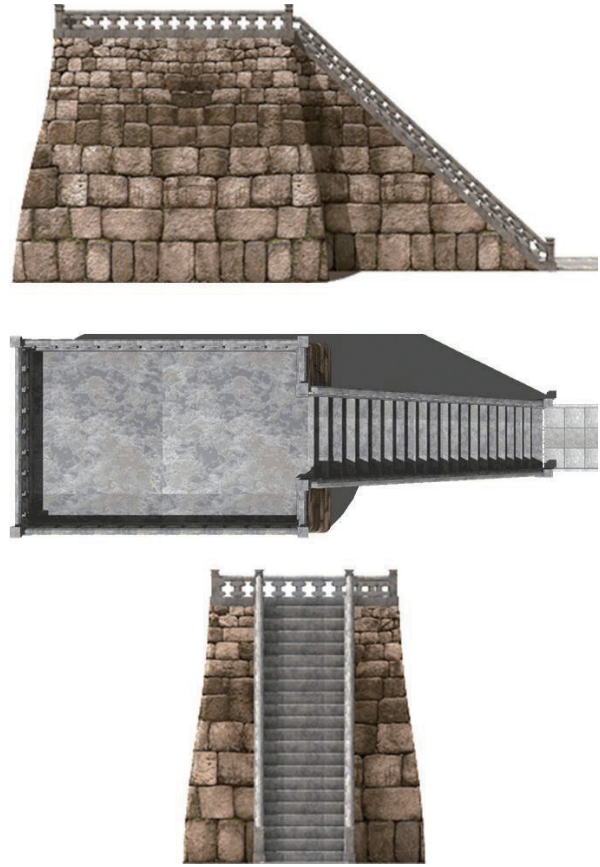


Fig. 9. The Result of 3D Modeling of *Ganui-Dae*; Top-Side, Middle-Plane, Bottom-Front.

the building and *Ju-Cheok* was used for various instruments (Nam 1995). Exact scale, used for *Ganui-Dae*, was not known, but using of *Ju-Cheok* at the construction of *Ganui-Dae* was inferred through the content in 『*Seongjong Sillok*』 (成宗實錄); only *Gyupyo* is seen, but *Ganui-Dae* isn't to be seen (Kim et al. 2011).

As the scales of *Ganui-Dae* converted *Ju-Cheok* (1 cheok = 207 mm; Nam 1995) to the present metric system, height is 6,417 mm, length is 9,729 mm, and the width is 6,624 mm. The part of Seoul Fortress in the reign of King *Sejong* was referred on the overall external form of *Ganui-Dae*. Fig. 8 is the drawings of *Ganui-Dae* which based on results of this study.

3.3 3D modeling

Based on the drawing of *Ganui-Dae*, 3D modeling was performed. The external wall of *Ganui-Dae* was mapped with the source of exterior of Seoul Fortress. Stairs and handrail were mapped with the source of stairs and handrail of *Geunieongjeon* in *Gyeongbokgung* palace (Fig. 9). Aerial



Fig. 10. Aerial View of 3D Modeling of Ganui-Dae.



Fig. 11. Impression of Ganui-Dae in the Reign of King Sejong.

view of 3D modeling of *Ganui-Dae*, which synthesizes these contents, is in the Fig. 10.

Fig. 11 is an impression, which considers the environment in the reign of King Sejong. *Gyupyo* is placed on the left side of *Ganui-Dae*. *Gyeonghoeru* (慶會樓) is placed on the south of *Ganui-Dae* based on the *Sillok*, saying that *Ganui-Dae* was located on the north of *Gyeonghoeru*. The building, seen on the left side of *Gyupyo* is *Honuihonsanggak* (渾儀渾象閣). In the building, Water-hammering type *Honui* and *Honsang* were installed.

4. CONCLUSIONS

Ganui-Dae, constructed in the reign of King Sejong, has historical meaning of scientific technique as the comprehensive observatory which shows techniques at

that time. It is also available resource as a scientific tourism resource. Therefore, the restoration of *Ganui-Dae* is urgent. However, comparing with the importance, study on the external form of *Ganui-Dae* is insufficient. Focused on it, this study tried to approach to the external form and construction method of *Ganui-Dae*. And then, based on the new approach, the study suggested the new external model of *Ganui-Dae*.

Historically, *Sitian-tai* in Yuan Dynasty (1279) has possibility of loss, and *Guanxing-tai* in Ming Dynasty (1442) were constructed after visiting of Jang Young-sil company (1421~1422). Therefore, both *Sitian-tai* and *Guanxing-tai* were not suitable to make them as the origin of *Ganui-Dae* for Jang Young-sil company.

Many old maps used for the study of *Ganui-Dae* shows only name or simple external form, so it is hard to be used for the study of external form of *Ganui-Dae*. Otherwise, exact location and description of royal palaces were marked in 『*Gyeongbokgung-Do*』in Sotheby's in details. Therefore, its material and external form of *Ganui-Dae*, described on the map, were reliable. *Ganui-Dae* described on the 『*Gyeongbokgung-Do*』in Sotheby's was similar to construction with the form of a castle, not the form of building. Also, straight stairs in the front were verified.

By surveying of the past of *Ahn-Soon*, *Hojo-panseo* who was the construction director of *Ganui-Dae*, he was a person who participated in the construction and removal of the castle before the construction of *Ganui-Dae*. This is connected with the *Ganui-Dae*, which has form of castle described in the 『*Gyeongbokgung-Do*』in Sotheby's.

Under the supposition that *Ganui-Dae* has form of castle, the castellation method in the reign of King Sejong was analyzed. In the result of the survey of Seoul Fortress, which shows the castellation method in the reign of King Sejong, the ramparts in the reign were made with well-faced rectangular stones. The big ones were used at the down side and the small ones were used at the upper side. It is different from existing model of *Ganui-Dae*, which used standardized stones or bricks.

This study suggested the new model of *Ganui-Dae* with the basis of construction applied the method in the reign of King Sejong. To use new model for real restoration, drawing was made and 3D modeling was performed based on the drawing. With the new external model of *Ganui-Dae*, restoration of *Ganui*, the Korean representative observatory, and instillation of pride toward Korean scientific techniques were expected. Also, it is expected to utilize it as tourism resource for foreign people.

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