1. Introduction

The method of the “fortification basitonée” or the “star fort” was introduced to Japan at the end of the Edo period, that is, in the mid-19th century from Western countries. There are two examples in Japan such as Goryokaku (五稜郭) and Tatsuoka Castle (星形要塞), which are the same or not, and it is not clear which book is the original version, but Ayasaburo TAKEDA, designer of Goryokaku referred to a Dutch version of French book, *Cours élémentaire de fortification* by SA VART, according to the former researches. In fact, any example of whole model plan of the star fort is not contained in this textbook. In this report, it is examined whether TAKEDA based Goryokaku plan on this *Cours*, by dimensional comparisons between Goryokaku and some examples of figures in this book.

2. Nicolas-Pierre-Antoine SA VART and his *Cours élémentaire de fortification*

Nicolas-Pierre-Antoine SA VART was born at Mézières, Ardenes the 18th January 1765 under the rule of Louis XV, roi de France et de Navarre (1710–74). As military officer, he successively was captain at the regiment of Champagne, aide-de-camp to General Lafayette and conservateur adjoint des modèles, dessins, cartes et gravures de l’École polytechnique. Since 1792, he was professor of fortification at the École militaire de Saint-Cyr. He passed away near by Brive-la-Gaillarde in 1826, according to the article on him in *La France littéraire, ou Dictionnaire bibliographique des savants, historiens et gens de lettres de la France: ainsi que des littérateurs étrangers qui ont écrit en français, plus particulièrement pendant les XVIII* et *XIX* siècle..." by Joseph-Marie QUÉRARD, published in 1836.
His *Cours élémentaire de fortification* was written as a textbook on fortification for his students of the military school of Saint-Cyr. He dedicated this book to Jacques-Nicolas BELLAVÈNE, général de division, inspecteur général des écoles militaires (1770–1826). The first edition was published in 1812 under the rule of Napoléon Ier, empeur des Français (1769–1821) and the second edition in 1825 under the Restoration. Many editions succeeded after his death. This work is composed by three parts. The first part is the introduction for study on the fortifications, the second part is written for the “fortification passagère” or “fortification de campagne” that means “field fortification” (野戦砦域). The part where the “fortification permanante” that means “permanent fortification” (永久築域) or “place forte”, “forteresse”, “place de guerre” etc. is treated is the third one.

3. **Goryokaku and TAKEDA Ayasaburo**

On Goryokaku, there is already accumulation of studies such as an article by SHIRAYAMA, Tomomasa titled «Goryokaku France-shiki chikuho-mon» that means “Goryokaku, French style fortification” in Nihonrekishi, volume 217 in 1966 where he argued that Goryokaku has been designed not by the method of Dutch style fortification but by that of French style fortification. In other hand, TOMATSURI, Yumio argued that Goryokaku has designed mostly by the French Method, at the same time, adapting the Dutch method as the water moat in his book titled *Daibu miru Bakumatsu no Hokuhon Bobi*, Goryokaku to jokaku, jinya, daiba that means “Defense of Japanese Northern area, Goryokaku and fortresses, government offices, batteries” published in June 2018 and his another articles 8). So, the following facts have been found on the introduction of the engineering of “fortification basitonée” to Japan.

1) The planning of Goryokaku was designed by TAKEDA Ayasaburo, “Rangakusha” (蘭学者), that is, scholar of Dutch studies.

2) Because of the exchange between Japan and the Netherlands during the Edo Period, it has been conventionally considered a Dutch style fortification, but this point has been reviewed.

3) It is known that Goryokaku design was based on “Daiba chikuhoo mondoshoo” and/or “Chikuhoo tosho” sent by a warship “Constantine” belonging to the French Indo-Chinese fleet in 1855. In other words, it is thought that Goryokaku is mostly French style fortification.

4) As mentioned above, it is not certain whether “Daiba chikuhoo mondoshoo” and “Chikuhoo tosho” are the same or not, but Takeda referred to a Dutch version of *Cours élémentaire de fortification* by SAVART.

5) While the plan of Goryokaku is mostly French style, the use of water moat was derived from Dutch style fortification and Japanese traditional techniques are adapted for finishing the surface of the rampart.

In addition, the author clarified that Goryokaku would be equivalent to the scale of the Citadel of Lille and the Citadel of Tournai in a previous paper titled «Outlook of studies on the Japanese “fortifications basitonées”: Comparison between Japanese and European cases» at ICOFORT International Conference in Hikone. In the comparison between Goryokaku and the Citadel of Lille and Tournai, it is understood that the area of the regular pentagon shaped fortress is almost the same, because the distance from the center to the base of the flanking side of bastion is almost equal. But the distance from the center to the tip of bastion at the Citadel of Lille is about 17 meters longer than that of Goryokaku and the distance between two adjoining bastions is about twice as long as that of the Citadel of Lille, so the shape of the bastions is thinner at Lille. The author is interested in a difference of the distance between two adjoining bastions. This distance is thought to be due to the effective range of the firearms used in the bastion, that is, range where effective fire can be carried out. It was found that there was a gap almost double in the dimensions.

Designer of Goryokaku is TAKEDA Ayasaburo on whom there is already a lot of studies such as Takeda Ayasaburo den by SIRAYAMA. He was born at present Ohzu city, Ehime prefecture (愛媛県大洲市) the 4th November 1827 and the 15th September Bunsei (文政) 10 as the second son of TAKEDA family, feudal retainers of Iyo-Ozuh domain (伊予大洲藩士). He studied medicine, Western sciences (蘭学), navigation and military architecture under OGATA Koan (服部洪庵) at “Teki juku” (通儒), Osaka (大阪). After Black ships arrival at Japan (黒船来航), he was in service of Tokugawa Shogunate (徳川幕府) and charged to design a new Western style fort, Goryokaku. He was professor of “Shojutsu shirabe dokoro” (諸術調所) that means Scientific Research Center and he could consult a lot of books in the library which owned *Beginselen der versterkingskunst*, a Dutch version of *Cours élémentaire de fortification* by SAVART. After Meiji Restoration (明治維新), he was in service of the imperial government. He was one of professor and founder of Japanese military school founded in 1875. He passed away the 28th January 1880 (Meiji 13).

4. **Dimensional comparisons between Goryokaku plan and some examples of figures in Cours élémentaire de fortification**

Measurement of Goryokaku was made in a series of presentations at articles by HASHIMOTO and others, titled «Study on the planning method of Hakodate Goryokaku fortress» in Nihon kenchiku gakkai hokuriku shibu kenkyuhokokushu, volume 44 in 2001. According to it, if it is assumed that
Goryokaku is a perfect regular pentagon, the distance from the center of the fortress to the tip of bastion is 140 "ken" (間), that is, about 255 meters, the distance from the center to the point of the flanking side of bastion, it is 100 "ken", about 182 meters. It is 90 "ken", about 164 m, the distance from the centers to the base of the flanking side of bastion. Hashimoto and her colleagues did not measure the distance between two adjoining bastions, but from there description, it seems to be considered as between 40 "ken", about 73 meters and 48 "ken", about 87 meters. Concerning the distance between tips of two adjoining bastions, they did not measure it, but it is possible to calculate it using the distance from the center of pentagon to the tip of bastion. It is approximately 164.57987 "ken", that is, about 299 meters.

In other hand, SAVART described the dimension of "place forte" as follows: \(^{11}\) (Fig. 1).

\[\text{Tracé du front de Cormontaingne}^{10}\]

183. Pour tracer le front (pl. I, fig. 2), on prend le côté AB du polygone de fortification, de 250 à 360 mètres: on fait en sorte cependant, dans la pratique, que sa longueur diffère le moins possible de 350, parce que, sur cette étendue de front, les parties du système se trouvent avoir les dimensions les plus favorables à la défense.

\[\text{Sur le milieu de AB, on élève la perpendiculaire CD du front, que l'on fait égale au sixième de la longueur de AB, et l'on a les directions AD et BD des lignes de défense: on prolonge ces directions indéfiniment (*)}.\]

Les faces AE et BH sont, chacune, égale au tiers de AB; et si par les points E et H des épaules, on mène les perpendiculaires EF et HG aux lignes de défense, EF et HG sont les flancs, et FG la courtine (**)\]

\(^(*)\) Si l'on fortifiait le pentagone, la perpendiculaire ne serait que du septième, et, pour le carré, on ne la prendrait que du huitième du côté, pour que les angles des bastions pussent conserver une ouverture convenable.

\(^(**)\) Pour le pentagone et le carré, on ne prend pour longueur de face que les deux septièmes du front: autrement les flancs seraient trop petits.

The English translation by the author as follows.

«Trace of the front by Cormontainge

Fig. 1 Plan of the front of "place forte" (image source: SAVART, 1825, la troisième partie, Pl. I)
183. To draw the front (pl. I, fig. 2), we take the AB side of the fortification polygon, from 250 to 360 meters; in practice, however, it is made so that its length differs as little as possible from 350 meters, because, on this extent of front, the parts of the system are found to have the dimensions most favorable to defense.

On the middle of AB, we raise the perpendicular CD from the front, so we make equal to one sixth of the length of AB, and we have the directions AD and BD of the lines of defense: these directions are extended indefinitely (*).

The faces AE and BH are each equal to a third of AB: and if by the points E and H of the shoulders, we lead the perpendiculars EF and HG to the lines of defense, EF and HG are the flanks, FG the curtain wall (**).

(*) If we fortified the pentagon, the perpendicular would only be the seventh, and, for the square, it would only be the eighth of the side, so that the angles of the bastions could maintain a suitable opening.

(**) For the pentagon and the square, only the two-sevenths of the front is taken for length of face: otherwise the flanks would be too small.

The distance between bastion tips A and B is between 260 and 360 meters, and that of Goryokaku is 299 meters, so it is within the values suggested by SAVART. In the case of design for pentagon star fort like Goryokaku, according to the notes (*), (**), if the distance between A and B is “x”, the distance between the point D where two lines of defense drawn by bastion face intersects and the line segment AB is x / 7, and the length of bastion face is 2x / 7. In Goryokaku case, “x” is 299 meters, so the former value would be about 42.7 meters and the length of bastion face 85.4 meters, if SAVART’s method is followed (Fig. 2). In addition, the distance between E and H would be about 134.7 meters (Fig. 3), but that of Goryokaku virtually is 73–87 meters, according to HASHIMOTO et al.

5. Conclusion

According to the previous studies, one of the documents that TAKEDA Ayasaburo used as a reference for designing Goryokaku was SAVART’s textbook, *Cours élémentaire de fortification*. However, the size of the bastions of Goryokaku was larger than that of SAVART’S textbook and their proportions were different. Therefore, it cannot be said that TAKEDA directly applied the description of the SAVART’s textbook concerning the plan of star fort to the planning design of Goryokaku. There are two issues that can be drawn from this conclusion in this paper. The first is a re-examination of the dimensions shown in the studies by HASHIMOTO et al., and the second is to find out what causes the difference between them.

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Notes
1) This report is based on NAKASHIMA:「Influence of French manual book of fortification, Cours élémentaire de fortification by Nicolas-Pierre-Antoine SAVART on Goryokaku Design », ICMPORT Shenyang 2019, 2019.9.27.
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4) The Hollande version are Beginselen der versterkingskunst. Vrij gevolg naar het Fransch van N. Savart, 's-Gravenhage, 1827 and Beginselen der versterkingskunst. Vrij gevolg naar het Fransch van N. Savart, 's-Gravenhage, 1836.
5) QUÉRARD, 1836, p.490
6) BRAGARD, 2013, pp.56–57

183番。前線を設定するにあたり、築城の多角形平面の辺ABを250メートルから360メートルとする。だが、実際にはその長さができるだけ350メートルに近いようにする。この規模の前線なら、システムの諸当部分が防衛に最も有利な規模となるからである。
ABの中点から前線に対して垂直な直線CDを引く。CDはABの長さの6分の1と等しくする。ADとBDの方向に防衛線が引かれる。これら前の直線を無限に延長する。
正面AEと正面BHは、それぞれ、ABの3分の1である。肩部の点Eと点Hから防衛線に対して垂直な直線EFとHGを引くと、EFとHGが前面、FGが背面となる。

五角形平面を構築化した場合は、垂直線は前の7分の1、四角形平面の場合は8分の1だけの長さであった。堡塁の頂点に真鍮の開口を設けることができたからだ。
五角形平面と四角形平面の場合は、正面の長さを前の7分の2だけとする。さもなくば、堡塁が短くなるだろう。

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