# Cross-Cultural Engineering: The Role of Dutch Civil Engineering in Modern Port Planning in Japan (1870s-1890s)

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This is particularly true for the Japanese case, where civil engineering has played a major role in the country's modernization and westernization since the mid-19th century. The design and engineering of Japanese ports from the 1870s to 1890s is a case in point. This contribution explores the degree to which civil engineering engaged with port city design by studying investigative reports, design drawings and survey maps established by Dutch civil engineers in collaboration with Japanese practitioners. It identifies three types of cross-cultural engineering. 1. Building a new port: Some Dutch engineers proposed complex projects combining water management and port basins, jetties with urban form, but these were only partially implemented. 2. Improvement of Port Functions: The Japanese engineers were particularly receptive for the design of breakwaters, the practice of dredging and the construction of basins; notably the technique of breakwaters became a staple in textbook and spread through Japan. 3: Development of the Port. The engineers developed a complete vision for a new port, but diverse reasons hindered realization, including natural features that disturbed the construction of the port. These three types stand as examples of the intricacies of cross cultural engineering in engineering and planning.

**Keywords:** Cross-cultural Engineering, Civil Engineering, Port Planning, Dutch Engineers.

## Introduction

In 2015, Misumi port, a key site of Japan's Meiji Industrial Revolution was certified as a World Heritage by UNESCO[1]. Home to Iron and Steel, Shipbuilding and Coal Mining and a symbol of industrialization of Japan in the 19th century, Misumi port is an intriguing lens for the cross-cultural exchange between Japan and the West. Designed by A.T.L. Rouwenhorst Mulder, a Dutch civil engineer, the heritage of Misumi port integrates Western engineering with Japanese expertise.

Civil engineering has shaped urban form and urban planning in Japan for a long time, drawing heavily on foreign expertise since the opening up of the country after the Meiji Restoration in 1868. The country has long been threatened by multiple natural hazards and engineering traditionally provides the necessary defences. The country's rapid modernization relied on engineered infrastructures, road, rail, port and waterways. In the 19th century, Japanese civil engineers gained expertise water management from projects such as river systems, soil-erosion control structures and ports, from Dutch civil engineers[2]. New types of construction for river improvement were particularly important for Japanese development[3]. Most of the foreign engineers who were employed by Japanese government as advisors, had returned to their own countries by 1900s[4]. Since some of the Japanese who went to Europe to study engineering, returned to Japan, and Japanese engineers who worked with foreign engineers, acquired engineering skills from them. It meant that by 1900s, cross-cultural engineering was active. Mulder reported that nobody had knowledge about surveying and designing in water engineering when van Doorn arrived in Japan[5]. In order to realize urban planning and development urban form in a modern port city, building the secure water area for trade and acquiring new land for urban development was necessary. This paper explores the influence of Dutch civil engineers on the design and engineering of Japanese ports from the 1870s to the 1890s, through the lens of cross-cultural exchange in civil engineering. In other words, it aims to show how Japanese civil engineers obtained the knowledge of modern engineering necessary to build modern port cities through by examining their investigative reports, design drawings and survey maps.

After the Meiji Restoration, which saw the adoption of a new calendar system in 1868, the new Japanese government wanted to create a new industrial development policy. Toshimichi Okubo, the Secretary of the Interior, presented the policy of Fukoku Kyohei (Rich Country, Strong Army), which aimed to improve the educational system, the military system and the tax system, and in addition, encourage new industry. In order to implement the policy, they invited engineers from all over the world, from countries such as the Netherlands, France, the United Kingdom and the United States of America.

Dobokuryo, the governmental Department of Civil Engineering, invited only Dutch engineers, six engineers and five assistant engineers in the period 1872 to 1903. They carried out several water management projects and had the achievements such as diversion Kiso three rivers, the introduction of a water level maker, erosion and flood

| Name | Nobiru | Mikuni(Sakai) | Nagasaki | Misumi | Yokohama |
|---|---|---|---|---|---|
| Cost(japanese yen) | 300,000 | 300,000 | 290,000 | 330,000 | 2,000,000 |
| Designer | Doorn | Escher, Reijke | Reijke | Mulder | Palmer(English) |
| Project Type | New Port City | Improvement | Improvement | New Port City | Development |
| Planning Scale | Port, New town | Port | River | Port, New Town, Train | Port |
| Presently Condition | Not Working | Working | Working | Almost Not Working | Working |
| Tarin | × | 1911 | 1897 | × | 1872 |
| Project term(year) | 7 | 8 | 12 | 4 | 8 |
| Completion Year | 1884 | 1885 | 1893 | 1887 | 1896 |

Table.1 Analysis of Five Port Projects

control in the mountain. By the 1870s, modern ports had been born around the world in cities such as London and Rotterdam[6]. Some scholars argue that the starting point for the modern Japanese port was in Yokohama in 1888[7]. However, before this, a number of Dutch civil engineers had already contributed to modern port construction. This study highlights the modern Japanese port construction designed by Dutch engineers from the 1870s to the 1890s.

More concretely, this paper aims to show the relationship with and contribution of Dutch civil engineering in the building of modern ports, by focusing on the history of planning and construction using five case studies from the ports of Nobiru, Mikuni, Nagasaki, Misumi and Yokohama. This paper shows the diverse patterns of cross-cultural engagement (Table.1). The construction of these ports can be classified into three types; 1. building a new port city, 2. improvement of port functions and 3. development of a port. In the case of building a new port city, which includes Nobiru and Misumi, the Dutch engineers, Cornelis Johannes van Doorn and Anthonie Thomas Lubertus Rouwenhorst Mulder attempted to design not only the port but also an adjacent new town and land-side infrastructure. In both cases, the new port city project was not built in its entirety due, in one case to a typhoon and in another case to an incomplete land infrastructure. In the case of the improvement of a port function, which includes Mikuni (Sakai) and Nagasaki, the engineers struggled with sand deposition at the river mouth, and the Dutch engineers, George Arnold Escher and Johannis de Rijke, proposed a new layout for the river, which required dredging the seabed and building a breakwater, thus allowing the two ports to be revitalized. In the case of the development of a port, which is Yokohama, four foreign engineers participated in the design process. The topographical requirements of Yokohama was disadvantage for building new port city. However, that disadvantage was overcame by civil engineering. In the design of Yokohama port, the design of Johannis de Rijke was rated highly because of the stronger structure of the breakwater and a larger basin. Ultimately however, the design by Henry Spencer Palmer, a British engineer, was chosen due to political reasons.

## Modern Port Construction Designed by Dutch Engineers

### Building a New Port City: The Case of Nobiru Port

In this chapter, each type of construction, in particular those which used Dutch engineering and perspectives, are introduced through the three examples, Nobiru, Mikuni (Sakai) and Yokohama. The first case is Nobiru. Okubo presented the policy for national prosperity and defence (Fukoku Kyohei) in which, as part of the plan to encourage new industry, it was proposed to build up a new port in the Tohoku region in the North, intended for international trade, especially with the United States of America. In order to build the new port, C.J van Doorn, the Dutch civil engineer, was assigned by the public works section in 1876. The following year, van Doorn spent six months investigating the situation and concluded that the Nobiru area was the best location for building a new port, from the perspective of the sediment deposit from the river, water depth and accessibility of a land transportation system.

In those days, when deciding the location for a port construction, topographical conditions were the most important. In the case of Nobiru, choosing a river mouth meant that water depth was shallow in general. Therefore, it was difficult for steam ships to moor at Nobiru, so in his design the port was divided into an inner port and an outer port, which created significant difficulties. Thus Masanao Matsudaira, Miyagi prefecture governor, opposed the project because Nobiru was not easily accessible for ships arriving from Matsushima bay, particularly when seas were rough, as the outer port was cut off from the inner port[8]. However, van Doorn did not change his proposal, because, he argued, other places also had some weak points. In the case of Nobiru, it was possible to overcome the problem by construction. He designed an inner port as the first stage of construction, and an outer port as the second stage of construction. The contents of the design in the first stage of construction are as follows[9]. (Fig.1)

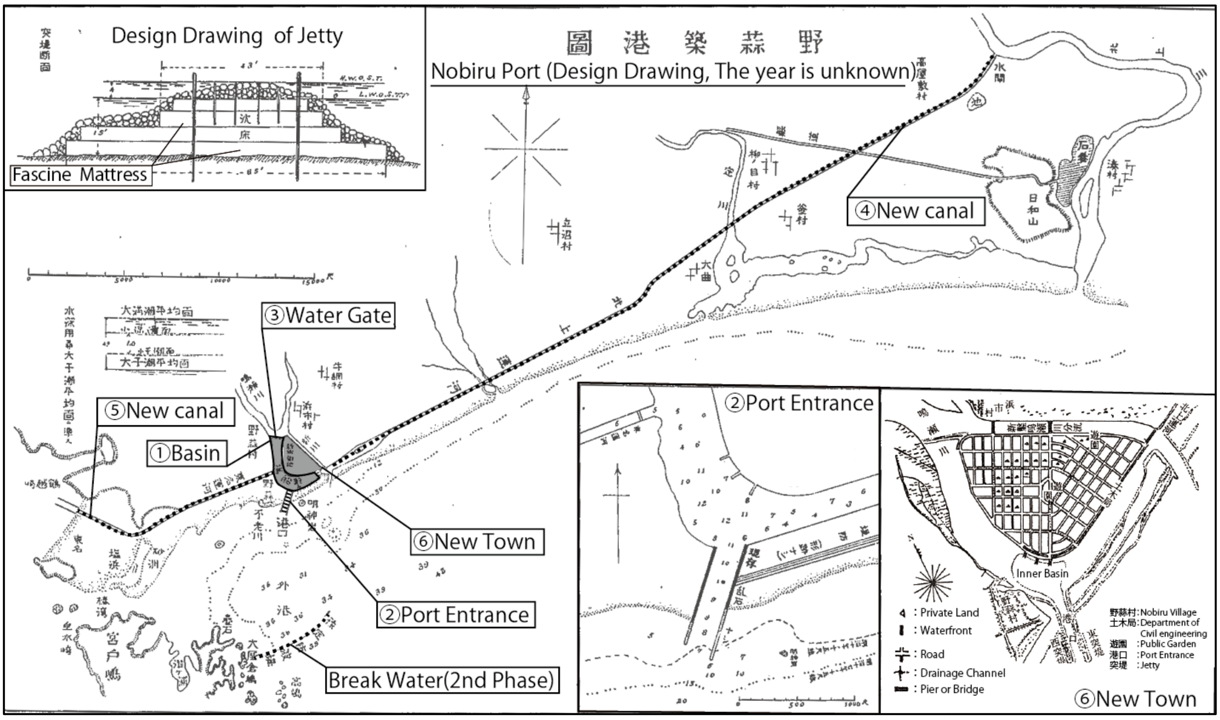


Fig.1 The Design of Nobiru Port

1. Building the basin as an inner port in the river mouth of Naruse river
2. Building the port entrance for connecting inner port and sea
3. Executing the closing and switching of Naruse river
4. Excavation of the Kitakamigawa canal between Nobiru and Kiatakamigawa
5. Excavation of the Tounan canal between Nobiru and Matsushima bay
6. Building the new town
7. Other works

In addition, the steam dredging machines, which were able to dredge 40 tons per hour, were first introduced to Japan by van Doorn[10]. He designed the outer port using a breakwater on the eastern edge of Miyako island and connecting it here to Nobiru port during the second stage of construction, after completing the first stage of construction.

During construction, some mistakes were made, especially in the design of the pier positioned at the port entrance, this is mainly content of the first stage construction. The piers in his design used so-called fascine mattresses, an innovation of Dutch civil engineering. The use of this structure is effective in rivers or shoals, however the coast of Nobiru was too deep. Hence the waves were stronger than in shoal areas, so the pier which used fascine mattress was destroyed by the waves. Sediment also flowed to the inner port unexpectedly. The construction started in 1878 and was completed in 1882 and incurred increased construction cost. In 1881, the new town, which was around 1.1 million square meters and build using land reclamation, was also almost completed; in this town, there were irrigation channels, streets, waterways for tugboats, bridges and dikes. Fig 1 shows newly planned urban area, which has grid street networks, three piers to connect new town and inner basin and some public gardens. The branch office of the governmental department of civil engineering, is located along the waterway. In addition, administrative offices of Miyagi prefecture and some commercial offices had already moved to the new town. From previous research, this town planning was designed by van Doorn[11]. Thus, Dutch civil engineer's works in Japan was not only civil engineering, and they who have the skill of land reclamation and water control, have been requested to make the new town plan.

Only two years after completion, the pier was destroyed by a typhoon. Van Doorn had already returned to the Netherlands in 1882. Following the destruction of the pier A.T.L Rouwenhorst Mulder and other engineers investigated and made a plan for the restoration of Nobiru port. Mulder concluded that rather than restoring Nobiru, the port should be relocated to Onagawa bay because of the high cost of restoration and the need to alter the design. In the other words, he highlighted van Doorn's design errors, in particular the poor selection of location. Following

Mulder's report, the Japanese government decided to stop the port construction. Subsequently, everything was removed from the new town in Nobiru; nowadays, there is only a pine forest.

### Improvement of Port Functions: The Case of Mikuni (Sakai) Port

Mikuni port was the first completed modern port project, designed by the Dutch engineers, Johannis de Rijke and George Arnold Escher. In the early modern times, Mikuni port had an important role as a national trade port, because it was located on the route of the Kitamae-Bune, the national trade ship[12]. Mikuni town has been shaped along the Kuzuryu river since early modern times. By 1870s, the function of Mikuni port decreased due to sediment deposit from the Kuzuryu river. In other words, it led to a crisis of an abolished port from sediment deposit at the river mouth. In 1875, the people living in Mikuni town, applied to the Japanese government through Fukui prefecture to make improvement to the port. At first, the Japanese government assigned Escher to the task of designing the improvement of the Mikuni port. He started to survey and design from 1876, after which he submitted a report. According to his report, the contents of his design were building the arc breakwater for gravel run-out from the Kuzuryu river and making a basin with an average water depth of three meters within the arc breakwater. He also mentioned the structure of the arc breakwater, which should be made using fascine mattresses and stones, and the length of this was 470 meters[13]. In additional, wooden pier was designed on the arc breakwater.

After completing the design, Escher's contract with the Japanese government was terminated and he returned to the Netherlands, and de Rijke was assigned to Mikuni port project by the Japanese government. While working on the project, he changed the design because of a miscalculation in budget made by Escher and the structure of arc breakwater was weak to withstand the Japanese waves. De Rijke proposed a new design that consisted of five layers of fascine mattresses and wooden piles which were bounded by an iron chain. He also added the four spur dikes in his design. As a result of the changes in the design, construction costs tripled, meaning that the financial load on the inhabitants increased. In 1880, without the agreement of de Rijke, Mikuni port opened to trade in the middle of construction, in order to start earning the construction cost back. In 1881, part of the arc breakwater was destroyed by the strong ocean wave, making it impossible for the construction to be managed by Mikuni town and Fukui prefecture. Afterwards, the Japanese government appointed de Rijke and Japanese civil engineers to lead the construction. This project was finally completed in 1885, by which time the total construction cost had increased 7.5 times compared with Escher's original calculation. While underway, several visitors came to the site to learn about the method of this construction.

In the meantime, due to the improvement the port function as a result of the Dutch engineering, many national trade ships visited Mikuni port, however a railway was built to Mikuni town in 1911. Moreover, with an average water depth of three meters, Mikuni port was not able to accommodate big steam ships, hence most passengers and freight were carried by train[14]. Finally, the function of Mikuni port was changed from trade port to fishing port[15]. In 2003, the breakwater in Mikuni port was declared as a national important cultural property due to the excellent construction method and used Dutch engineering.

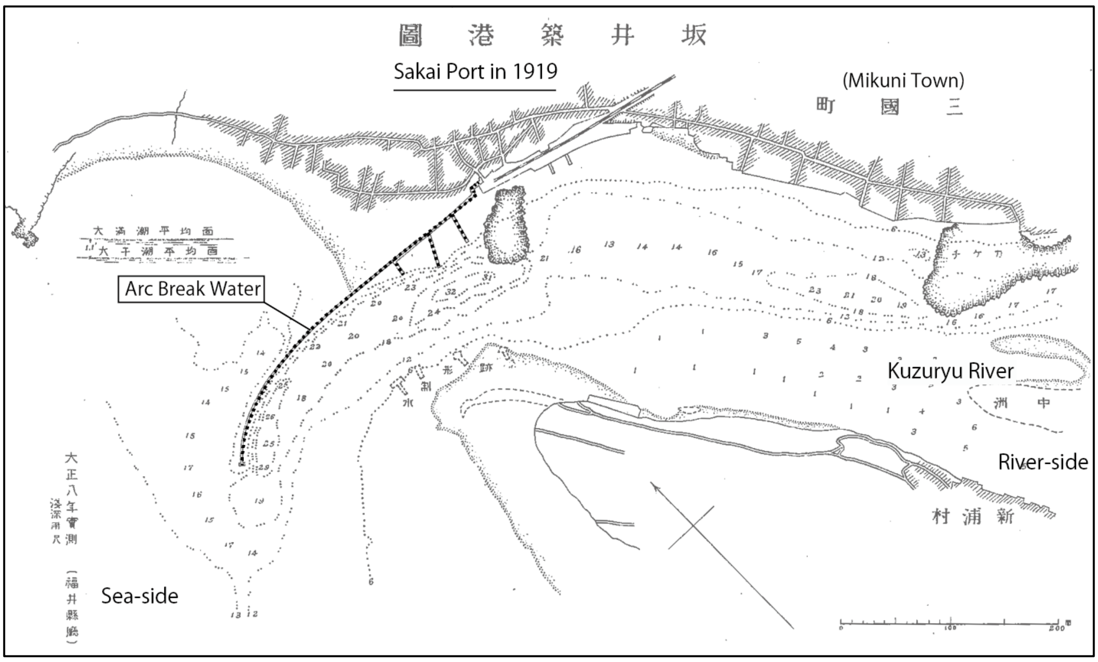


Fig.2 The Survey Drawing of Mikuni (Sakai) Port

### Development of the Port: The Case of Yokohama Port

After the opening of Yokohama port in 1859, four foreign engineers participated in the design process. In general, in order to build new port, designer have to research the topographical features of potential locations, looking for a place with a suitable cove and hill, features which are important for providing protection from the wind and waves. However, Yokohama didn't meet those requirements[16]. In fact, when strong winds blew, it was impossible to unload goods from trade ships to the port[17], making it unattractive to merchants. The Japanese government was afraid of the influence that the foreigners might have on the local people and so they tried to isolate them[18]. By the 1870s, some infrastructures had been built systematically in Yokohama, such as wide street between the foreign settlement and Japanese district as a means of fire spread prevention, and western style garden was also there[19] (Fig.3).

In the 1870s, van Doorn, a Dutch engineer, and Brunton, a British engineer, attempted to design the new port. Both of their designs were rejected by the Japanese government because of the absence of a survey and budgetary deficit. In 1872, the first railway connection in Japan, was built from Tokyo to Yokohama, the reason for creating this route, Japanese government aimed to establish a logistics network between the port city and capital[20]. In the 1880s, the United States of America made reparations to Japan for the Shimonoseki Campaign. By using this money, it was possible to start to work on new port project again. At the same time, two other foreign engineers started work on the design. Kanagawa Prefecture invited Henry Spencer Palmer, a British military engineer, to the

| | Palmer | de Rijke |
|---|---|---|
| Location of Brealwater | ○ | ○ |
| Area of basin | △ | ○ |
| Port Entrance | ○ | ○ |
| Height of Breakwater | ○ | ○ |
| The Structure of Breakwater (On Hard Ground) | ○ | ○ |
| The Structure of Breakwater (On Soft Ground) | × | △ |
| Pier | ○ | ○ |
| Katabira River | × | ○ |
| Conclusion | X | ○ |

○ : Consent
△ : Revision is necessary
× : Dissent

| | Palmer | de Rijke |
|---|---|---|
| Forme of Breakwater (Part of North) | △ | ○ |
| Forme of Breakwater (Part of East) | △ | △ |
| Location of Port Entrance | △ | ○ |
| Area of Port Entrance | ○ | ○ |
| Ooka River | ○ | ○ |
| Katabira River | △ | △ |
| Location of Wharf | − | △ |
| Link with Train | − | ○ |
| Height of Breakwater | × | △ |
| The Structure of Breakwater | × | △ |
| Construction Cost | × | ○ |
| Conclusion | × | ○ |

Table.2 The Evaluation of "Furuichi and Gisaburo (Left-side)" and "Mulder (Right-side)"

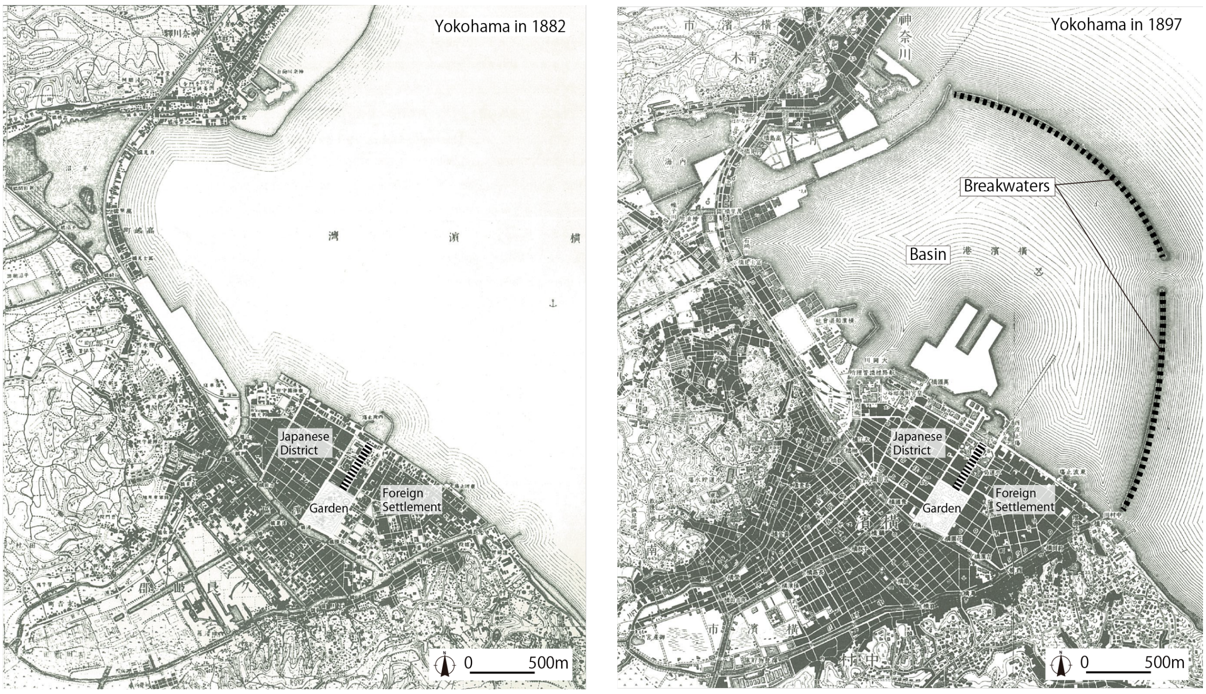


Fig.3 Yokohama Port, "Before Construction (Left-side)", "After Construction (Right-side)"

new port project. He designed two wharves in Yokohama port, but de Rijke dissented in his plan and designed two large breakwaters to surround Yokohama port. Finally, the Foreign Office awarded the new port design to Palmer, while de Rijke was awarded the same plan by the Department of the Interior.

In 1888, three engineers, Koi Furuichi, Gisaburo Tanabe and A.T.L. Rouwenhorst Mulder, examined the two plans and according to their reports the contents of the designs were almost the identical. In fact, in both designs, Yokohama port was surrounded by two breakwaters, training dikes were to be built for the Katabira and Ooka rivers, and a pier was planned in inner harbor. The principal issue was the structure of the breakwater, especially the degree of difficulty of work and maintenance, repair and strength. In Palmer’s design, the lower part of the breakwater was built in bagged concrete, and the upper part was concrete. In contrast, in de Rijke’s design, the lower part of the breakwater was built with fascine mattresses, and the upper part consisted of gravel and sand and so on. Table 2 shows the opinions of the two Japanese engineers, Koi Furuichi and Gisaburo Tanabe. Especially on soft ground, when the breakwater is damaged, they indicate that Palmer's design is harder to repair than de Rijke’s in terms of technique. Mulder also speaks highly of de Rijke’s design, of using the fascine mattress in the breakwater, while he contradicts Palmer’s design. In Mulder's report, he argued that the fascine mattress is able to adapt to any form on the seabed, that it functions long-term, has been used elsewhere in the world in place such as in Rotterdam, and that there are many suitable materials for the fascine mattress. On the other hand, Mulder mentioned that Palmer's survey result was initially incorrect, and his design was at risk of subsidence on soft ground. Finally, in case of adapting Palmer’s design, Mulder believed that construction costs would exceed Palmer's calculation. This meant a budget deficit, hence he objected. For quite a while, Mulder had argued for the construction of a new port in Tokyo[21]. Therefore, as an additional remark, Mulder mentioned that proceeding with Tokyo port was a better option than improving Yokohama port due to the fact that there was plenty of land in Tokyo which was suitable for development [22].

In 1889, the Japanese government ignored these opinions and decided to adopt Palmer's design (Fig3). From previous research it appears that this decision was part of a diplomatic effort aimed at the revision of an unequal treaty with the United Kingdom. However, as was expected, the breakwaters were destroyed during building work[23]. After completion, the secure water area had been acquired by the building of two breakwaters, urban development continued on the hinterland and on the reclaimed land.

### The influence of Dutch civil engineering on the Japanese port design

Through exploring these projects, this paper shows some examples of Dutch engineering in Japanese port construction, in particular, the design of breakwaters and the practice of dredging. In the construction of Nobiru port, van Doorn introduced Dutch steam dredging machines and used the fascine mattress to build a breakwater. In those days, most Japanese ports were located at a river mouth, therefore, dredging was necessary to maintain the function of the port. The Dutch steam dredging machines made it possible to establish and maintain the necessary water depth. Escher also introduced the fascine mattress for building the breakwater at the first modern port in Mikuni. The fascine mattress was able to adapt to slow flowing parts of the river[24] (Fig.4). Therefore, Japanese civil engineers used it mainly in river construction, and nowadays the fascine mattress is considered a “Japanese traditional technique” [25]. Understandably, it is possible to use it in the port, but only for shelving the bottom. In the case of Nobiru, the water was deeper and the waves stronger. Building a breakwater in these conditions became technically possible after 1955[26]. However, through the case of Nobiru and Mikuni, Japanese civil engineers studied and gained the knowledge of how to build an artificial basin. Grasping this concept has been very significant for Japanese port history.

In the case of Yokohama, there were two design plans, and finally the big issue was remained. In spite of the fact that some civil engineers recommended Rijke’s plan for its feasibility and technical strength, Palmer’s design was chosen. It is worth mentioning that the sloping-type breakwater which de Rijke designed is structurally weaker than Palmer's composite-type breakwater. However, the problem was that Japan was not able to make high quality concrete yet. Even nowadays, it is still necessary to take into consideration whether or not the materials that are used in construction are able to be prepared easily. In fact, Palmer's breakwater failed while under construction because of low quality concrete[27]. On the other hand, there was an abundance of high quality materials available in Japan for the construction of the fascine mattress. It is pointed out that the fascine mattress was also effective in the construction of Yokohama port[28].

In Japanese technical book, fascine and fascine mattress appeared as progressive and useful technic in 1889[29]. In this book, it was stated that the fascine could be used for breakwater, the base of embankment, improvement of rivers, spur dike, dam, sand control and the base of road on wetland soil. The fascine mattress provides water purification, so it can be useful for keeping the water clean and as the spawning ground for fishes and shellfishes[30]. This means that this function is beneficial for an aquatic environmental up until now. The fascine mattress was

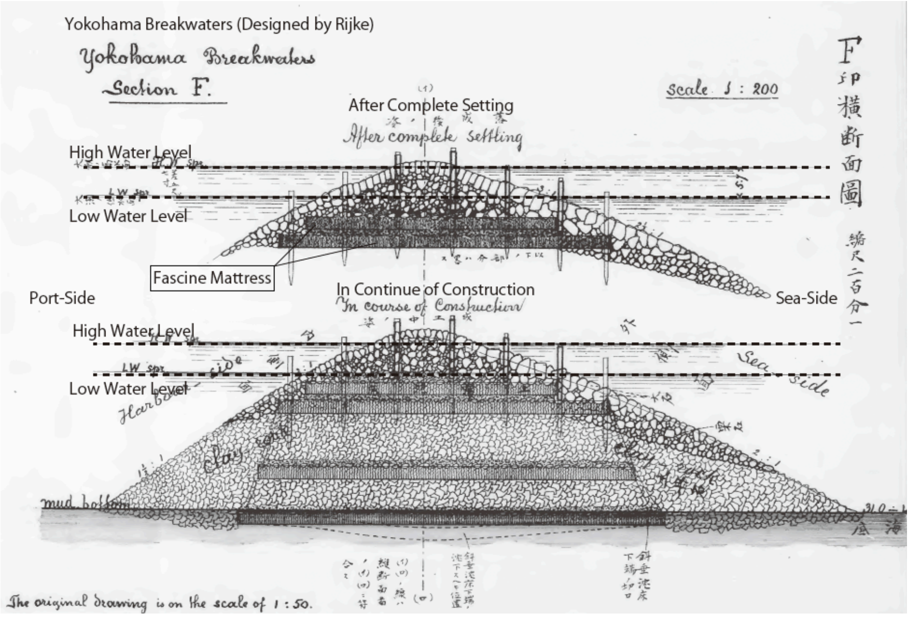


Fig.4 The Section of the Breakwater with Fascine Mattress

also used into Rotterdam port[31] and in the Maas river in the 19th century, in the project named "Niew Waterweg (New Water Street)". The purpose of this project was also to make a new water way for the large ships. The point to note that Dutch civil engineers exported their modern techniques in those days to Japan. Thus, Japan obtained the modern techniques of water management through cross-cultural engineering.

## Conclusion

After the opening up of the country, Japan had to adapt to international trade with the world through the building modern port. However, Japan did not possess the engineering capability to build a modern port, and so it invited Dutch civil engineers to contribute to river and port water management. As a result, they produced excellent results in river improvement projects, but on the other hand, in port projects, they were not able to build modern ports such as Yokohama port where continued to develop to the present day. However, Dutch contribution, in particular by teaching the use of the fascine mattress technique for breakwaters and in importing steam dredging machines, has been very significant for the construction of basins and the maintenance of modern port function. Through these engineering techniques, Japan was able to obtain the knowledge of how to realize the basin in the modern port for the first time.

Cross-cultural engineering was not successful in terms of importing a full system of planning and engineering. However, select technologies have been adopted, to the point where they are actually perceived as being Japanese. Exchange with foreign engineers allowed Japanese engineers to grow into their own.

## Notes on contributors

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