# Anthonie Rouwenhorst Mulder
## Perspectives on Port City Planning in 19th Century Japan

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**Abstract**

Anthonie Thomas Lubertus Rouwenhorst Mulder is a Dutch civil engineer involved in the design of port cities in 19th-century Japan. In 1879, as part of Japan's modernization efforts, Mulder was employed as a foreign expert under the Ministry of Home Affairs. Over his approximately eleven-year stay, Mulder contributed to the planning and design of various projects, including rivers, reclamation, and port cities. Notably, his designs for Moji and Misumi ports exemplify his work and the transplantation of European technology and ideas into Japanese port cities. This paper analysed multiple reports on Japan submitted by Mulder, aiming to clarify his perspective as an engineer. Given the absence of engineers in Japan who met European standards at the time, Mulder found it challenging to implement modern technologies such as concrete, leading him to predominantly utilize natural materials like fascines and stone. His designs not only focused on immediate engineering needs but also included comprehensive urban planning elements such as the expansion of port facilities, improvement of land transportation, and enlargement of residential areas through reclamation. These contributions highlight Mulder's role that extended beyond that of a civil engineer to that of an urban planner, significantly impacting the design of Japanese port cities.

**Keywords**
Port City Planning, Civil Engineering, Japanese Port City, Mulder, Dutch Engineer

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## INTRODUCTION

This paper focuses on Dutch civil engineers who, in the latter half of the 19th century, were the only foreign civil engineers employed by the Japanese government. Their technical and planning theories have been well-known for significantly contributing to the development of civil engineering in Japan[1]. This is particularly evident in the fields of river management and erosion control, where their approaches have received high acclaim. Moreover, several structures still in existence have been designated as Modern Civil Engineering Heritage by the Japan Society of Civil Engineers[2]. Additionally, in 2015, the Mikuni Port (currently Mikuni West Port), designed by Anthonie Thomas Lubertus Rouwenhorst Mulder,a Dutch civil engineer, focused on in this paper, was registered as part of the "Sites of Japan's Meiji Industrial Revolution: Iron and Steel, Shipbuilding and Coal Mining" on the World Heritage list, thereby receiving global recognition[3].

On the other hand, the technologies imported into Japan by Dutch civil engineers did not always receive positive evaluations. Historically, in "The History of Port Construction in Japan" [4] by Isamu Hiroi, the Nobiru Port construction project designed by Cornelis Johannes van Doorn, a Dutch civil engineer, is cited as an example where the selection of the site and the technologies employed were criticized. This previous study mentioned were based on analyses using historical documents and design drawings stored in Japan. In contrast, Kamibayashi discovered the personal letters by Johannis de Rijke's, a Dutch civil engineer, and other historical materials stored in the Netherlands and conducted translations and analyses of these documents[5]. As a result, he highlighted their technological expertise, particularly in river engineering techniques such as water control and fascine mattress construction, and the concept of mountain conservation. He reevaluated the impact of Rijke's design philosophy on Japan, contributing significant research findings. Kamibayashi's methodological approach provides substantial implications for this paper, indicating that discovering and analyzing documents left by Dutch civil engineers themselves can lead to a fundamentally different understanding of design philosophies and the history of technology transfer. In a time when there is a growing movement to preserve civil engineering structures designed by Dutch engineers as heritage, conducting analysis from an international perspective is a crucial research task in the field of urban planning history. In light of the foregoing, this paper attempts to explore the design philosophy of Dutch civil engineer using historical materials, including design drawings and reports by Mulder, which the author found in the Netherlands and Japan.

## THE ROLE OF DUTCH CIVIL ENGINEERS AND THEIR HISTORICAL MATERIALS

### DUTCH CIVIL ENGINEERS AND JAPANESE CIVIL ENGINEERING PROJECTS

Following the Industrial Revolution in the 18th century, ports played a crucial role as hubs of international economy and exchange[6]. Such technological innovations provided significant opportunities for engineers and planners. However, the construction of port cities necessi-

tated a thorough understanding of the natural terrain of the project sites, making it essential for elite planners with significant technical expertise to design the scale and function of port cities appropriately. Among these, Rotterdam in the Netherlands commenced its journey as a leading international port city with the implementation of the New Waterway project in 1872[7]. Civil engineers from Rijkswaterstaat, including Pieter Caland, made substantial contributions to this project[8]. To conduct a detailed analysis of the construction of port cities in the 19th century, focusing on civil engineers is a valuable research opportunity. It enables an international contextualization of how these engineers interacted with natural terrain and contributed to the dissemination of European knowledge through technological transfer.

During the Meiji Restoration, the newly established Japanese government, under the slogan of enriching the country and strengthening the military, employed ten Dutch civil engineers as foreign experts to modernize Japan, particularly in the field of civil engineering[9]. The Japanese government recognized the indispensable need for Western knowledge, thus prioritizing the establishment of infrastructure such as streets, railways, and ports in the Western style and hiring engineers who possessed this expertise[10]. Table 1[11] shows the positions held and the number of projects involved by Dutch civil engineers. As indicated, not all Dutch civil engineers arrived in Japan with the status of "engineer"; some, like stonemasons and bricklayers, came as "craftsmen"[12]. They played a crucial role in implementing the designs of the engineers by transferring Dutch techniques to Japanese technicians. Among them, George Arnold Escher, Rijke, and Mulder were involved in a relatively large number of projects, primarily concerning rivers and ports. A notable technique they brought was the fascine mattress method for river engineering, which was highly regarded even then[13] . Regarding port projects, the Nobiru Port construction designed by Doorn ended in failure, leading to criticisms that Dutch port engineering was not suited to Japanese natural conditions[14]. However, the Mikuni Port project saw multiple design modifications by Escher, De Rijke, and Kōi Furuichi, a Japanese engineer from the Ministry of Interior, to adapt to local conditions, ultimately referencing Rotterdam's dike design to successfully complete the project[15]. This case exemplifies a valuable instance of knowledge exchange between Dutch and Japanese engineers. Thus, not all port facilities designed by Dutch engineers resulted in failures. It has become evident that the method they introduced to Japan, which involves using fascine mattress for constructing foundations such as dikes, has taken root and become widely adopted in the country[16]. In light of the above, the focal point of this paper is the perspective of Dutch engineers on their active use of natural materials such as fascine mattress and stones in their designs. According to Kamibayashi, Dutch civil engineers were criticized by their British counterparts as provincials unaware of alternative technologies such as iron and concrete[17]. However, it has been pointed out in previous studies that they were capable of planning projects using iron materials, as evidenced in the port projects in Niigata, indicating their potential to employ modern technologies. The question then arises: why did they actively opt for natural materials. Exploring this perspective aims to examine the mindset of Dutch engineers as conveyors of European knowledge and builders of Japanese port cities, assessing their technical and philosophical approach to engineering.

## THE HISTORICAL MATERIALS USED IN THIS PAPER

Regarding the previous studies and materials using Dutch historical material, the book "In Een Japanse Stroomversnelling"[18] deserves mention first. It compiles the achievements of Dutch civil engineers extensively, featuring numerous photographs and design drawings brought back by Dutch engineers and incorporates insights and materials provided by Japanese researchers. Furthermore, concerning Escher, his diary written during his stay in Japan has been translated and published as "Dutch Engineer Escher: Memoirs of Japan" which provides insights into Escher's thoughts and activities[19]. For De Rijke, there are notable studies that focus on analyzing his letters[20], as well as research that compiles his achievements in Japan using Dutch historical sources[21]. In the case of Mulder, whom this paper focuses on, Hoshino et al. have utilized some Dutch materials in their research detailing the planning and dock structures of the Misumi port construction[22]. In the materials published by the Ministry of Construction titled "A.T.L.R. Mulder's Reports and Related Documents" there are reports by Mulder written in Japanese[23]. However, the analysis of the content of these documents is scant.

In this paper, historical materials discovered in the Netherlands were primarily analyzed. These include three documents published in the "Tijdschrift van het Koninklijk Instituut van Ingenieurs" a technical journal issued by The Royal Netherlands Society of Engineers, and one document from "Tijdschrift voor geschiedenis, land-en volkenkunde" a journal focused on history and ethnology also published in the Netherlands (Table 2; hereafter, these documents are referred to as "the reports")[24].

| Name | Duration of Stay | Rank (Upon Initial Arrival in Japan) | Port | River | Others | Total |
|---|---|---|---|---|---|---|
| Cornelis Johannes van Doorn | 1872-1880 | Chief Engineer | 3 | 3 | 3 | 9 |
| Isaac Anne Lindo | 1872-1875 | Second Class Engineer | 1 | 3 | 1 | 5 |
| George Arnold Escher | 1873-1878 | First Class Engineer | 7 | 6 | - | 13 |
| Johannis de Rijke | 1873-1903 | Fourth Class Engineer | 9 | 11 | 1 | 21 |
| Dick Arnst | 1873-1880 | Technician | 2 | 2 | - | 3 |
| Alphonse Th.J.H Thissen | 1873-1877 | Third Class Engineer | 1 | 2 | 1 | 4 |
| Johannes Nicolaas Westerwiel | 1873-1878 | Technician | 1 | 2 | - | 3 |
| Josinus Aderianus Kalis | 1875-1877 | Technician | - | 1 | - | 1 |
| Anthonie Th.L Rouwenhorst Mulder | 1879-1890 | First Class Engineer | 9 | 7 | 4 | 20 |
| Arie van Mastrigt | 1879-1881 | Technician | 1 | 2 | - | 3 |
| Total | | | 34 | 39 | 10 | 83 |

Table 1. The ranks of Dutch engineers and the number of projects they were involved in.

* When multiple people are involved in a single project, each person is counted separately, so some numbers may be duplicated.

## MULDER'S CAREER AND REPORTS

Mulder's career is detailed in "A.T.L.R. Mulder's Reports and Related Documents" [25] which summarizes his life as follows. Mulder was born in 1848 in the city of Leiden, Netherlands, and in 1867, he enrolled at the Polytechnische School te Delft, the precursor to Delft University of Technology. After graduating in 1872, he joined the Rijkswaterstraat, the Dutch governmental agency responsible for public works and water management, and was assigned to Egypt. Six years later, in 1879, he came to Japan as a foreign government advisor, where he was involved in civil engineering projects until 1890 (Fig 1 and Tables 3[26]). Mulder engaged in the design and renovation of river and port projects, notably the Tone River[27] and Misumi Port[28], while also being entrusted with significant responsibilities by the government, such as investigating the failed construction project at Nobiru Port[29] and serving on the commission for the renovation proposal of Yokohama Port[30]. Additionally, he returned to the Netherlands for a brief period between 1886 and 1887, during which he contributed an article that was published in "De Ingenieur" a newspaper targeted at Dutch engineers. An excerpt from this article is presented below[31].

> *…In 1873, toen de eerste Hollandsche ingenieurs in Japan werden aangesteld, bestond er geen technisch personeel (ten minste niet bij de afdeeling Waterstaat), in staat om eene behoorlijke terrein-opname te doen, of om eene eenigszins vertrouwbare waterpassing te verrichten. Daarom moesten die werkzaamheden in den beginne door de ingenieurs zei ven worden gedaan, en eerst langzamerhand kwam daarin verbetering, toen eenige ambtenaren, als leerlingen aan die ingenieurs toegevoegd, zich met ijver op dit vak toelegden.… […When the first Dutch engineers (Doorn and Lindo) arrived in Japan in 1873, there were hardly any local experts skilled in the waterstreet division (water management). As a result, implementing projects at the time of their arrival posed a considerable challenge. However, by the time subsequent Dutch engineers ( such as Escher and De Rijke) arrived, these conditions had somewhat improved.…]*

| Published Journal | Title (Year of Publication) | Brief summary of the content |
|---|---|---|
| Tijdschrift van het Koninklijk Instituut van Ingenieurs<br>[Journal of the Royal Institute of Engineers] | HET NEDERLANDSCHE HANDELS-ETABLISSEMENT TE PORT-SAID (1877)<br>[The Netherlands Trading Establishment at Port Said] | Description and opinions related to the construction and port projects engaged in at Port Said, Egypt. |
| Tijdschrift van het Koninklijk Instituut van Ingenieurs<br>[Journal of the Royal Institute of Engineers] | KORTE MEDEDEELINGEN OVER JAPAN EN MEER BEPAALD OVER DE VOORNAAMSTE HAVENS (1888)<br>[Short Communications about Japan and Specifically about the Main Ports] | This report predominantly discusses projects involving Dutch civil engineers, especially focusing on port projects. It allocates significant space to the design of Tokyo Port and the survey of Noshiro Port. |
| Tijdschrift van het Koninklijk Instituut van Ingenieurs<br>[Journal of the Royal Institute of Engineers] | EEN DRIETAL ZEESTRATEN VAN DEN JAPANSCHEN ARCHIPEL 1893<br>[Three Sea Straits of the Japanese Archipelago] | Details the specific design and survey works of Shimonoseki, Misumi, and Okayama, |
| Tijdschrift voor geschiedenis, land-en volkenkunde<br>[Journal for History, Geography, and Ethnology] | EEN EN ANDER OVER HET JAPANSCHE RIJK 1895<br>[Some Information about the Japanese Empire] | Along with basic information about Japan's climatic conditions and population, the paper introduces the port and river projects in which Mulder was involved. |

Table 2. The reports by Mulder

Fig. 1. A. T. L. R. Mulder

| Year | Events |
|---|---|
| 1848 | Born in Leiden |
| 1867 | Enrolled at the Polytechnic School of Delft. |
| 1872 | Graduated from the Polytechnic School of Delft. |
| 1873 | Joined "Rijkswaterstaat" (a government agency responsible for public works and water management).Transferred to Egypt (until 1876). |
| 1879 | Came to Japan as a foreign government advisor. |
| 1886 | Temporarily returned to his home country (until 1887). |
| 1890 | Returned to the Netherlands. |
| 1901 | Passed away in Wageningen. |

Table 3. Brief biography of Mulder

Mulder reported that upon the arrival of the initial Dutch civil engineers, including Doorn, Japan lacked engineers who met the technical standards required by the Dutch, making it difficult to implement projects. He also reported that the situation gradually improved as engineers like Doorn and Lindo taught their techniques to Japanese counterparts. The limited number of projects associated with Doorn, as compared to engineers like Escher, De Rijke, and Mulder, suggests that Doorn may have focused on education to improve the initial conditions, as indicated by article. Furthermore, the second phase of Dutch civil engineers who came to Japan included two craftsmen, who presumably taught local Japanese craftsmen appropriate techniques.

Before organizing the content of the reports by Mulder, it is important to first establish the chronological context of the four reports by Mulder analyzed in this paper. The 1877 report "Het Nederlandsche Handels-establissement te Port-said" [32] was written after Mulder's return to the Netherlands from Egypt, before his arrival in Japan. The next report, "Korte Mededelingen over Japan en meer bepaald over de voornaamste havens" [33] published in 1888, was compiled during his temporary return to the Netherlands in 1886-1887. The 1893 report "Een drietal zeestraten van den Japanschen archipel" [34] was written after Mulder had completed his service as a foreign government advisor in Japan and had returned to the Netherlands. Finally, the report "Een en ander over het Japansche rijk" [35] published in a specialized journal of history and ethnology in 1895, was released five years after his return to the Netherlands.

## MULDER'S EXPERIENCE AND PERSPECTIVES AS SEEN IN HIS REPORTS

### EXPERIENCE IN EGYPT

The report titled "Het Nederlandsche Handels-establissement te Port-said" (Table 2) which details experiences prior to his arrival in Japan, describes Mulder's work assignments in Egypt from 1873 to 1876. This report primarily focuses on his work related to the design of break-

waters and the construction of buildings situated along the waterfront. The report contains descriptions of Mulder's experiences and thoughts as follows: In August 1873, Mulder was commissioned as the designer and overseer of construction for facilities at Port Said, including residences, warehouses, and piers. In February 1874, Mulder's plans were approved, and construction commenced in June of the same year. Related constructions were completed by September 1876, as documented in the report where Mulder described the progress of his projects. The report also detailed the materials used, the functionality of the spaces, and the sources of imported materials, suggesting that Mulder possessed significant knowledge in the field of architecture (Fig2).

Mulder reported that the quality of bricks and lime produced in Egypt was extremely poor, and due to the inability to mine high-quality stone materials locally, high transportation costs were necessary. As alternatives, such as importing bricks from France, costly measures had to be taken to complete projects. Moreover, while modern technologies like concrete and mortar were used in design, the project workforce predominantly consisted of Western staff, including Dutch, Italian, Greek, and French individuals, with Egyptians primarily engaged in simple labor tasks such as carrying materials. Thus, even before his arrival in Japan, Mulder had already accumulated experience in addressing considerations necessary for realizing construction projects abroad, such as the cost of transporting construction materials and the feasibility of projects based on the availability of expert staff.

## FIRST REPORT PUBLISHED AFTER ARRIVING IN JAPAN

Mulder first published his views on Japan in the report "Korte Mededelingen over Japan en meer bepaald over de voornaamste havens" (Table 2) written during his temporary return to the Netherlands. This report included an introduction on the post-Meiji Restoration trend of Japan seeking modernization through the hiring of foreign experts. It also described information about Japan's ports and geography, noting that the natural terrain significantly limits the number of ports where ships can safely anchor throughout the year, and that only a few ports are officially open for trade with foreign countries. Furthermore, Mulder provided detailed descriptions of specific port cities in Japan, highlighting their urban characteristics and natural geography. Within this context, he documented comprehensive information about port projects in Yokohama, Tokyo, Osaka, and Nobiru, including the roles that Dutch civil engineers played in their surveying and design processes. As a specific example, Mulder provided a detailed report of his perspectives on the Tokyo port construction plan. While documentation on the design aspects of the Meiji-era Tokyo port construction[36] and the discussions held by the Tokyo City District Revision Committee[37] has already been disclosed, this report includes breakwater drawings not attached to the aforementioned documents, accompanied by explanations of the plan (Fig3). From the drawings, it is evident that natural materials such as stone and fascine mattress were primarily used in the design of the embankments. Although Mulder's Tokyo port construction did not ultimately materialize, the inclusion of detailed designs and drawings indicates that he had advanced the project to a detailed planning stage.

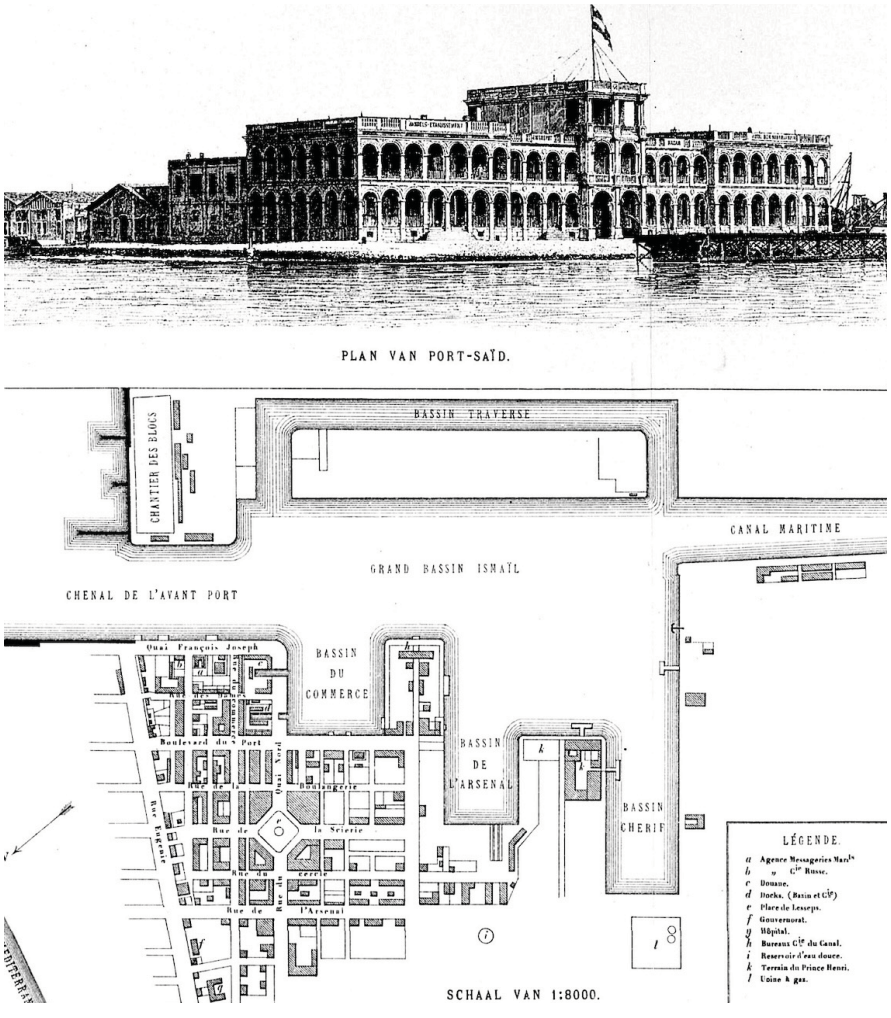


Fig. 2. The exterior of architecture and facility layout of the buildings Mulder was involved in in Egypt

## FIRST REPORT PUBLISHED AFTER RETURNING TO THE NETHERLANDS

After returning to the Netherlands in 1890, Mulder published "Een Drietal Zeestraten van den Japanschen" (Table 2) in a journal. This report detailed the surveys, designs, and diagrams related to three projects he was involved in: the Shimonoseki Strait, the Misumi Port construction, and the Kojima Bay. Among the port cities mentioned in this report, there are two instances where the designs created by Mulder were realized: Moji Port in the Shimonoseki Strait and Misumi Port. Mulder provided detailed accounts of the design processes for these two locations, which will be discussed in subsequent chapters of this paper. Additionally, this paper will explore the perspectives Mulder held as an engineer designing port cities, based on his detailed reporting on these two cases.

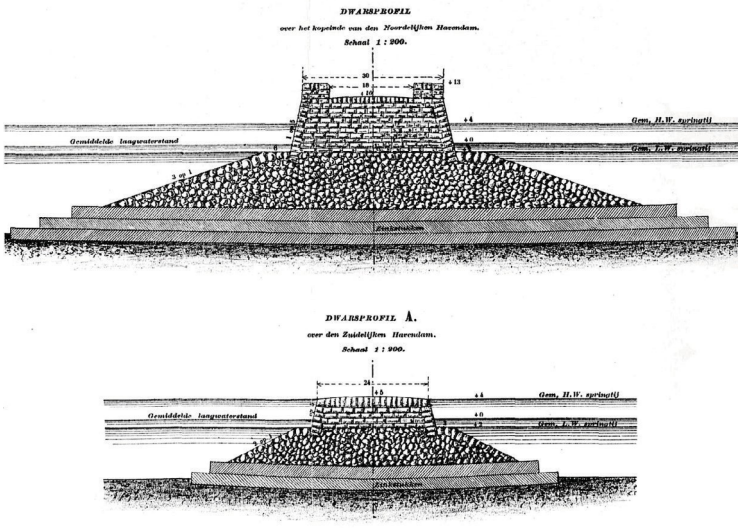


Fig. 3. The breakwater designed by Mulder for the construction of Tokyo Port

## SECOND REPORT PUBLISHED AFTER RETURNING TO THE NETHERLANDS

In 1895, five years after his return to the Netherlands, Mulder's report "Een En Ander Over Het Japansche Rijk" (Table 2) was published. Unlike the previous three reports issued by The Royal Netherlands Society of Engineers, this report appeared in a specialized journal focusing on history and ethnology. In the introduction of this report, Mulder mentioned that he was commissioned to write it with the objective of introducing Japan's geography, aquatic environments, ports, and the projects involving Dutch civil engineers. As stated in the introduction, Mulder first explained various aspects of Japan, including its geography, ocean currents, climate, types of trees, and natural disasters. Subsequently, Mulder introduced river and port projects involving Dutch civil engineers and discussed their roles. He elaborated on the position of Dutch engineers, particularly noting instances where they were tasked with river improvement and simultaneously undertook mountain conservation projects as a countermeasure. Mulder highlighted that these engineers were often constrained by limited funding and were committed to delivering high-quality results at a low cost. Among the projects he was involved in, there were instances where objections were raised due to cost considerations, and he expressed frustration over the lack of funding for projects in Japan.

Additionally, in this report, Mulder discussed the Yokohama Port renovation plan, on which he also served as a committee member. Specifically, he critiqued the proposal by Palmer, a British engineer, who had suggested using concrete for the breakwater, judging it to be too heavy and thus hazardous. Furthermore, he noted that the quality of concrete in Japan was still insufficient and inappropriate for such applications. Regarding the Yokohama Port, Mulder, as a committee member, had submitted an opinion to the government stating that Palmer's construction approach was, overall, not feasible within the budget constraints[38].

| Contents | Description |
|---|---|
| Wharf | Regarding the strait connecting to Misumi Port, particularly near the northern entrance, it is planned to construct a wharf. |
| | The quay walls of the wharf will be constructed without using mortar, instead employing natural stone, and the seaward side will be covered with crushed stone. |
| | The natural stone intended for use at the wharf is anticipated to be granite, which can be abundantly sourced from near the project site, thus allowing construction to be economical due to low transportation costs. |
| | The seabed at the construction site of the wharf is covered with hard rock. While there are some clayey areas, these are relatively compacted, reducing the likelihood of significant subsidence after the wharf's construction. |
| | At several wharf walls, stone stairs will be installed down to the height of low tide, enabling small barges to dock easily. Floating piers made of wood will be constructed at the quay walls for mooring ships. |
| Floating Pier | Floating piers made of wood will be constructed at the quay walls for mooring ships. |
| | Due to significant tidal variations at the project site, the floating piers are designed with adjustable ranges to facilitate loading and unloading operations regardless of the tide level. |
| | To prevent corrosion, parts of the mooring facilities and the undersides of the floating piers that are frequently in contact with seawater will be covered with copper. |
| | In anticipation of future needs for greater area, additional floating piers can be constructed adjacent to the existing ones. Connectors and fixtures will be pre- installed on the floating piers to facilitate their expansion by linking them together. |
| Waterway | Drainage channels are designed to encompass the new urban areas on the landward side, ensuring effective connection with existing streams and the bay. |
| | Drainage channels will also be installed to efficiently channel rainwater from the nearby hills. |
| | In Japan, there exists a cultural practice of utilizing human excreta as compost; therefore, sewage systems will not be established. Land for the new urban area will be secured by cutting and filling the hills around the floating pirers. |
| Urban Area | Land for the new urban area will be secured by cutting and filling the hills around the floating pirers. |
| | In the future, should there be a need to expand the urban area, it will be possible to extend the quay walls as indicated by the dotted lines on the map. |
| | It will also be possible to construct piers in the future at Iwaya Bay, located across from Misumi Port. |
| Land Transportation | In addition to improving the road connecting Kumamoto, Uto, and Matsubashi to Yashiro, a road will be constructed from Mismi Port along the coast to Uto Village on the Uto Peninsula. These roads will be 36 km from Misumi Port to Kumamoto and 46 km from Misumi Port to Yashiro, and they will be constructed with sufficient width to accommodate potential future railway developments. |
| | A railway connecting Kumamoto and Misumi Port will be constructed. |
| Others | For the existing Hyakkan Port, deepening the river channel and adding multiple waterways will alter the shape of the river mouth, facilitating mooring for boats and barges. This plan can be implemented at a relatively low cost. |
| | A new waterway of approximately 8.5 km will be established to connect Matsubashi and Kawajiri. |

**Table 4.** Mulder's Perspectives on Misumi Port and Associated Projects

# PORT CITY DESIGN BY MULDER

## MISUMI PORT CONSTRUCTION PROJECT

This chapter introduces two examples of Japanese port cities that were designed and realized by Mulder. The discussion focuses on clarifying his design perspective through the processes that led to these designs. The first port city design project that Mulder undertook in Japan was for Misumi Port, located in the Kyushu region. His design proposal for Misumi Port was entirely original and differed from the initial project he was asked to work on. The background leading to Mulder's involvement in constructing the port at Misumi is documented in his report[39] and can be organized as follows.

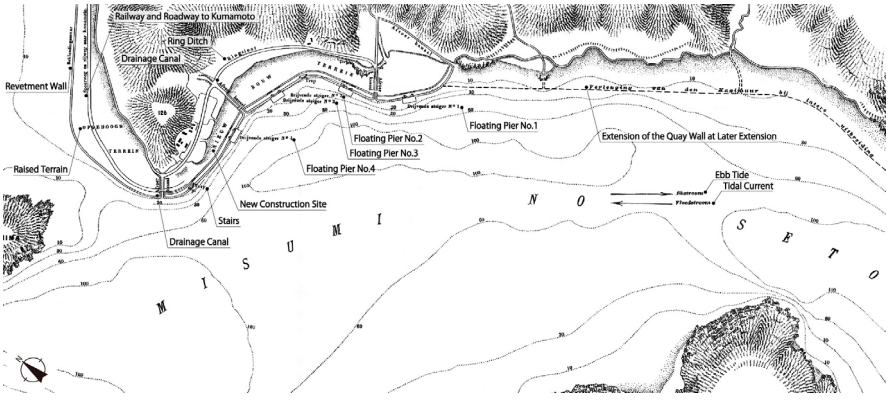


Fig. 4. Design drawings for the Misumi Port construction project by Mulder

Mulder was tasked with evaluating the feasibility of constructing a modern port near a small harbor town called Hyakkan, approximately 4 kilometers from Kumamoto City, the capital of Kumamoto Prefecture. The condition set for this project was to determine whether it was technically possible to construct the port with a total project budget of $400,000. In response, Mulder surveyed the tidal levels and seabed geology adjacent to Hyakkan. His findings indicated that constructing two breakwaters, each extending at least 6,500 meters, was necessary. However, due to the soft nature of the seabed, the project would require substantial expenditures for subsidence mitigation, making it highly challenging. Consequently, he concluded that construction within the $400,000 budget was impossible. Therefore, even though it meant moving away from Kumamoto City, Mulder decided to search for another location where the port could be built within the budget.

Following Mulder's investigations, which considered factors such as water depth, tidal variations, and ground conditions, Misumi was determined to be a suitable site for port construction. However, Mulder recognized the challenge posed by Mikuni's location, 35 kilometers away from Kumamoto City. Consequently, he proposed a comprehensive project that included road improvements and railway construction. The specific details of Mulder's proposals for the con-

struction of Mikuni Port and the port city are outlined in Table 4[40] and Fig4. From these documents, it is evident that he made a comprehensive proposal covering land development and the construction of floating piers, addressing both port functionality and urban development.

As for the characteristics of Mulder's port city designs, a key feature was his consideration of using modern techniques such as mortar, though he ultimately favored the use of more traditional materials like stone. Mulder provided the following reasons for this choice:

| Contents | Description |
|---|---|
| Land Reclamation | Land is to be reclaimed along the contours of 10ft (approximately 3m) and 15ft (approximately 4.5m) depth lines, ensuring that the existing tidal currents are not altered. |
| | Excavation of the neighboring clay-rich hills will be conducted for the purpose of land reclamation. |
| Ship Basin | A ship basin for small steam vessels and mooring will be constructed. |
| | The location of the ship basin is planned near the proposed Moji Station, currently an inlet, which allows for cost reduction in the construction process. |
| | The dimensions of the ship basin will be approximately 900 feet (about 274.3 meters) in length and 600 feet (about 182.9 meters) in width, designed to maintain a depth of 6 feet (about 1.8 meters) below the lowest tidal level. |
| | The entrance of the ship basin will be approximately 180 feet (about 54.9 meters) wide. |
| | Along the sides of the ship basin, it is possible to construct warehouses and lay railway tracks that directly connect to the Kokura area. |
| Water Depth | To stabilize the regularity of depth contours in the bay, dredging will be conducted at six locations indicated by dashed lines. |
| Canal | A canal, designed to connect with the planned ship basin and cross Moji Village to flow into the northeastern part of the bay, is being planned. This canal will be accessible from various parts of the village. |
| | Along the canal to the pier, it will be possible to construct warehouses to store goods transported by moored vessels. |
| Quay Walls | The quay walls will be constructed using dry stone stacking, and the stone materials can be sourced from the vicinity of Moji Village. |
| | The foundation stones for the quay walls will be placed by divers, and as most of the seabed consists of sand, gravel, and hard clay layers, the risk of subsidence of the quay walls is minimal. |
| | The ship basin and canal are designed similarly to the quay walls, including a gradient that facilitates mooring, and some areas are equipped with stairs. |
| Coal Storage Facilities | A permanent coal storage facility for the Japanese Navy is planned, with provisions to supply coal to ships via mooring in the future. A small ship basin is also planned to serve as a loading and unloading site for moored vessels and as a refuge during bad weather. |
| Pier | Should the size of vessels increase in the future, the current design may prove insufficient for trade functions. In such a case, it would be possible to accommodate by constructing a pier perpendicular to the existing facilities near Moji Station. |
| | The pier would enable the mooring of larger ships, and dredging would stabilize the tidal currents in the bay, minimizing their impact. |

**Table 5.** Mulder's Perspectives on Moji Port and Associated Projects

> *…Daar graniet van uitstekende kwaliteit, in onbeperkte hoeveelheid en in de onmiddellijke nabijheid van het werk (van een van de rotsen nabij den zuidelijken ingang der straat) verkrijgbaar was, en daar verder de arbeidsloonen in die streken ) verbazend laag waren, zoo bleek de bovengenoemde constructie van den kaaimuur de meest economische, die kon worden toegepast. …* […*Because granite of excellent quality was available in unlimited quantities and in close proximity to the site (from one of the rocks near the southern entrance of the strait), and since the labor costs in that region were astonishingly low, the aforementioned construction of the quay wall proved to be the most economical option that could be implemented.*…]

In contrast to the situation in Egypt previously mentioned, the Misumi project was able to utilize high-quality natural stone abundantly available near the site, allowing for designs that did not require importing materials from Europe. Furthermore, in the Misumi project, Mulder planned a comprehensive urban design that included the construction of a new district through water channels that would later be recognized as a World Heritage site, and though it was not realized, he also planned railway construction. Notably, Mulder, considering it impossible to implement a comprehensive plan including the port construction all at once, executed the minimum necessary projects (including road construction) to enable the port's functionality. He devised a phased plan to complete the remaining projects as trade and traffic volumes increased.

## MOJI PORT CONSTRUCTION PROJECT

As port cities designed by Mulder, this paper will include not only Misumi Port, as previously mentioned, but also Moji Port. A common feature of both ports is that prior to the modern era, these locations lacked trading functions, with port city constructions only taking place in the modern period. The design plans for these ports were crafted by Mulder, making them exemplary cases for examining his perspective on port city construction. Under the above perspective, the content of Mulder's reports[41] will be used as a basis to organize the design details of Moji Port as follows.

In 1887, the Minister of the Interior requested Mulder to verify the design proposal for Moji Port. Subsequently, Mulder, along with Kōi Furuichi, an engineer from the Ministry of the Interior, and other Japanese colleagues, undertook surveys of the local tidal conditions. Based on the survey results, significant technical revisions were made to the preliminary plan proposed by the Moji Port Corporation, the regional development company. The details of Mulder's proposed modifications are presented in Table 5[42] and Fig5. A notable feature of his proposal was land reclamation. Considering the impact on tidal flows, Mulder preferred not to significantly alter the shape of the bay. His design revisions were based on the survey results, limiting the reclamation to areas that would not adversely affect the currents. Additionally, he proposed the inclusion of a ship basin, an essential feature for a modern port, and a canal connecting the port to the urban area to enhance the efficiency of land and maritime transport, thereby improving the convenience for trade purposes.

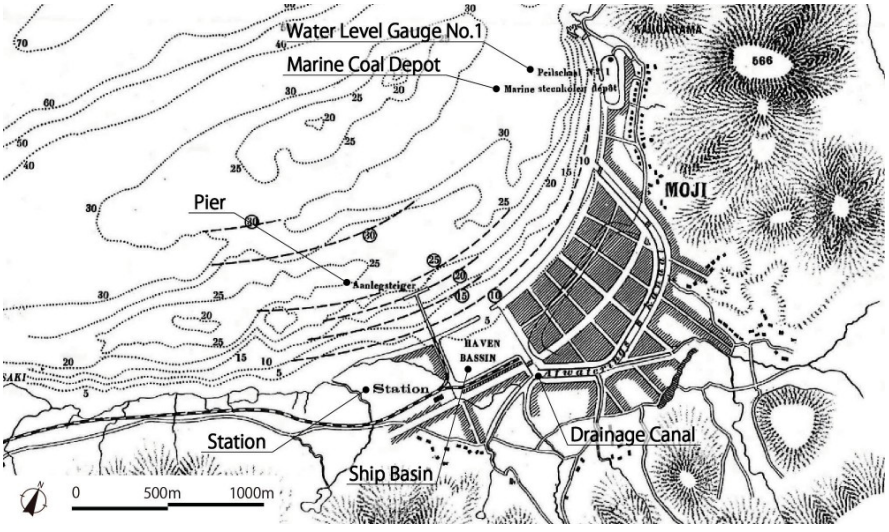


Fig. 5. Design drawings for the Misumi Port construction project by Mulder

Furthermore, it is notable that Mulder proposed the construction of additional piers. He believed that, should the trade volume at Moji Port increase in the future, the existing ship basin might become inadequate in terms of draft depth. In such cases, constructing additional piers would make it possible to accommodate larger vessels. Moreover, the rock walls at Moji Port were designed using stonework, with materials that could be sourced from the surrounding area of the port. Thus, Mulder was designing new modern port cities considering the use of locally suitable materials while also taking into account the potential for future development.

## CONCLUSION

This paper has explored Mulder's perspective on exporting European knowledge to Japanese port cities, assessing his technical and philosophical approach to engineering. It has been determined that Mulder faced three main constraints when designing port cities in Japan. Firstly, there was a shortage of engineers. When the initial Dutch civil engineers such as Doorn arrived in Japan, there were virtually no personnel who could be called engineers by their standards. Consequently, while providing on-site training to Japanese workers, proposing designs that assumed established modern technologies like concrete manufacturing was considered risky due to these educational gaps. Secondly, there was a lack of financial resources. As Mulder himself reported, projects in Japan were conducted under limited budgets. This was closely linked to the shortage of engineers and the low level of technological capability, where attempting to introduce new technologies experimentally could lead to extended construction periods and increased material costs. Thirdly, the terrain posed challenges. Unlike the Netherlands, which has many reclaimed flatlands, Japan has many

mountains and hilly areas. Moreover, the conditions of the straits resulting from these terrain differences required accurate identification of suitable locations for constructing port cities.

As described in this paper, Mulder successfully designed two port cities under the constraints of three specific conditions. In this process, it is evident that he utilized the knowledge of water control likely acquired at Delft University of Technology, as well as insights from projects he had previously undertaken in Egypt. Particularly from his experiences in Egypt, Mulder understood the substantial costs involved in adopting European materials and technologies in foreign settings. He managed to realize the construction of port cities in Misumi port and Moji port within the budget constraints set by the Japanese government. In fact, it can be inferred that Mulder was seeking feasible plans under constrained conditions, as evidenced by his opposition to British engineer Plamer's proposal to use concrete in the Yokohama port project due to budget and quality (technology) concerns. The perspective of European engineers, who engaged in the construction of port cities under such constraints, should be academically recognized as a significant achievement.

As an engineer, Mulder was capable of employing modern technologies such as mortar and iron in his designs. However, Japan was abundant in high-quality natural materials like fascine and stone, which he frequently utilized in his designs. This approach can be seen as a successful maneuver under the three constraints previously discussed. Additionally, a review of port construction projects in the Rotterdam, the Netherlands, at the time reveals that designs using natural materials were not considered outdated[43]. As demonstrated in the plans for Misumi Port and Moji Port that Mulder handled, he was not only capable of designing the functionality of the ports but also planning comprehensive schemes including new urban districts and railway layout. Moreover, his designs were not implemented all at once but proposed as phased developments, taking into consideration future growth, which is a point of particular note. Overall, Mulder should be recognized not merely as a civil engineer but as a urban planner with a broad knowledge encompassing urban design. The insights gained by Japanese engineers through his practices in Japan should be deemed a valuable contribution to the modernization of Japanese port cities.

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## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

## NOTES ON CONTRIBUTOR(S)

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Figure 2 Tijdschrift van het Koninklijk Instituut van Ingenieurs HET NEDERLANDSCHE HANDELS- ETABLISSEMENT TE PORT-SAID, 1877

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