Port Modernization Perspective in the Netherlands and Japan
Highlighting the Contribution of Dutch Civil Engineers

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Abstract

In the 19th century, civil engineers outlined new planning perspective for port modernization or reform through hydraulic engineering: dredging, land reclamation, river improvement, dyke building and channel creation. In addition, these works for port modernization were closely connected with spatial urban development. Dutch civil engineers created the basic designs of the ports in Rotterdam and Osaka, which were the two leading modern ports in Europe and Asia from the 19th century to the 20th century. Owing to advances in port function contributed by Dutch civil engineers, this paper explores how to change urban structures by considering two ports from the Netherlands and Japan, using their investigative reports, design drawings and survey maps. In the Rotterdam Port project, Caland, a Dutch engineer, provided a comprehensive plan for improving the functions of rivers and ports. Rijke, a Dutch engineer, and other Japanese civil engineers also provided an effective plan for the Osaka Port Project. However, owing to topography, people's opposition and historical background, the project was not realised completely. The transition of the two ports shows how port modernisation provides modern industry and urban development, in which civil engineers played crucial roles as the first trigger.

Keywords

Comprehensive Planning, River Planning, Port City, Civil Engineering, Dutch Engineers.

How to cite

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INTRODUCTION

During the mid-19th century, modern ports were established around the world in cities such as London, Hamburg, and Rotterdam. The port cities were the hub for the global economy with networks of trade and transport.[1] Therefore, urban elites desired and challenged the creation of new port using the given new technology through the Industrial Revolution. However, switching to the modern port was challenging and crucial for civil engineers and governments. To fulfil this mission, civil engineers outlined new planning perspectives for modernizations. Simultaneously, Rijkswaterstraat, the Directorate-General for Public Works and Water Management in the Netherlands, had appeared as a pioneer on the stage of hydraulic engineering in the world.[2] Their technology approaches, which included dredging, land reclamation, river improvement, dyke building, and channel creation, were progressive. They proved their status through the improvement of Rotterdam Port in 1872. After a while, Osaka Port started improving the port function for large steamships.[3] The history of modern Japanese ports started with European engineers from the Netherlands, the United Kingdom, and France.[4] This article reveals that Dutch civil engineers created the basic designs of the ports of Rotterdam and Osaka, which were the two leading modern ports in Europe and Asia from the 19th century to the 20th century. Schubert[5] mentioned that the Industrial Revolution provided a new connection of production, transportation and distribution through the port, making the transportation system that included large steamships more plannable. Thus, improving port function and developing urban structure were possible, which were contributed by the main actors of port modernisation, such as civil engineers, since the 19th century.

The new planning perspectives had to consider river improvements, port city development, waterway transformation and the defence of multiple natural hazards. Owing to the construction of large steamships, the narrow waterways of Rotterdam Port were no longer attractive to merchants. To address this situation, Pieter Caland, a Dutch civil engineer, provided an effective plan to improve Rotterdam Port. In 1872, new waterways were opened to traffic, and Rotterdam Port became the leading modern port in Europe.[6] Concurrently, Osaka Port in Japan faced a more complicated problem. In the 19th century, Japan's contact with the world was limited to Nagasaki Port, where only Dutch and Chinese representatives had been allowed to enter. To help with the modernization and to facilitate international trade, the Japanese government invited foreign experts to lead this transformation.[7] Several foreign engineers, including English, Dutch and Japanese, participated in the design process of Osaka Port from the 1860s. Finally, the construction was carried out based on Johannis de Rijke's design, a Dutch civil engineer. His comprehensive planning was divided into port and river parts for economic reasons.

This paper explores how to change urban structures due to the improvement in port function by considering two ports from two countries, using their investigative reports, design drawings and survey maps. Each case study was considered in different situations: topography, economy, technology and historical background. In conclusion, this paper highlights the contribution of Dutch civil engineers to the creation of modern ports and the development of urban areas in two countries, the Netherlands and Japan, from civil engineering and planning perspectives.

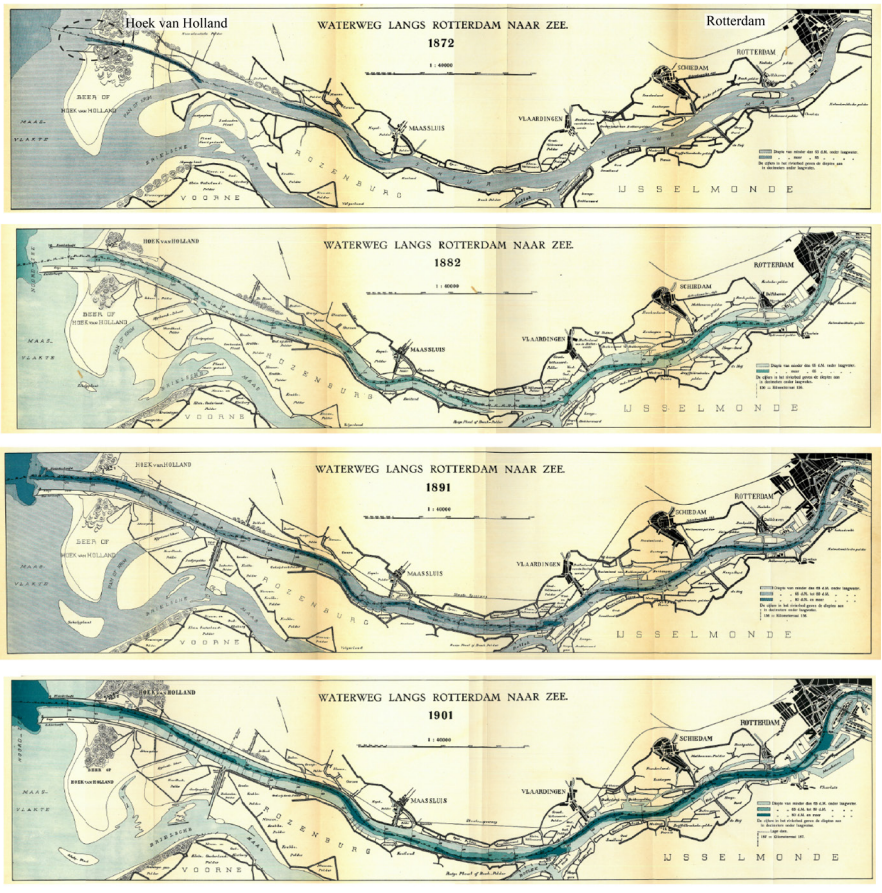


Fig. 1. Transition of the Rotterdam and 'Nieuwe Waterweg' from 1872 to 1901

ROTTERDAM, NEW WATERWAY PROJECT

The Industrial Revolution significantly impacted European ports, which were functioning as leading ports (e.g. Rotterdam Port). In the 14th century, the Rotterdam Port was just one in the Netherlands. However, after executing the project 'Nieuwe Waterweg' in 1872, Rotterdam began walking to Europort. Before this project's execution, Rotterdam Port was one of the ports holding the same mission as other European ports; thus, other projects were neglected. Rotterdam Port had nonuniform depth and narrow waterways and locks of various sizes in the routes from the sea to the port,[8] making it unattractive to merchants. In 1857, A. Greve, a Dutch civil engineer, who was working at the Rijkswaterstaat, provided an improvement plan for the new Maas River for Rotterdam Port ordered by the Dutch government.[9] Simultaneously, Pieter Caland, a Dutch civil engineer who was working at the Rijkswaterstaat, also made and submitted an

improvement plan containing almost the same content as Greve's. In both plans, building two dykes with fascine works on the new Maas River mouth was considered the main content for improvement. After a year, Caland resubmitted a largely improved plan and proposed the creation of a new channel that directly connected Rotterdam Port and the sea by cutting through 'Hoek van Holland.' This unique plan was inspired by an old Dutch civil engineer, and Caland upgraded it through scientific research.[10] The commissioner decided to adopt the second plan of Caland with some slight modifications, and mentioned that other plans were expensive and vulnerable to disaster.[11] Caland's plan was started as a 6-year project of $2,500,000 from 1863.

In this project, various factors were considered, such as the channel width, draft depth, dredging, structure of jetties and dykes with fascine works, calculation of tide stream, sediment deposit at the river mouth and cutting off the land. Therefore, the completion of this project was postponed in the 1870s. While under construction in Rotterdam, the Suez Canal was completed and a new trade route from the Netherlands to the colonial areas was built in 1869.[12] In addition, the new channel 'Nieuwe Waterweg' opened to the world in 1872. Simultaneously, Rotterdam Port became a mighty attractive port and started extending. In 1886, the Rotterdam and Delfshaven cities merged, and the population of Rotterdam City increased to 200,000. After the completion of the above project, the government of Rotterdam City had to spend to extend and maintain the port. The construction of bridges, dyke and wharves was included in the project, and $5,000,000 was expended from 1874 to 1888. Consequently, the Rotterdam Port acquired the 70 ha area of the basin in 1887, which was 2.6 times that of 40 years ago.[13] The project effects of 'Nieuwe Waterweg' were remarkable. First, the distance from the sea to Rotterdam Port was shortened from over 100 km to 15–34 km, depending on the entrance. This was more pronounced when converted to transit time. Before creating the channel, the merchants needed 2 to 5 days to reach Rotterdam Port from the sea. However, after creating the channel, they needed only 2 to 3 hours to reach there. Second, the towage between the sea and Rotterdam Port decreased from $15 to $7 on average, depending on the seasons. The merchants could also use free here to use in transit. Finally, all the ships went through Rotterdam Port directly, without locks and bridges. In later years, Caland indicated that 'Nieuwe Waterweg' was incomplete; in particular, water depth by dredging was shallower than his plan.[15] However, Rotterdam Port attracted numerous merchants and cargoes due to the success of the 'Nieuwe Waterweg' project.

Figure 1 shows the transition of Rotterdam and 'Nieuwe Waterweg' from 1872 to 1901 with four maps. In the first map of 1872, although the route width was still narrow, the new channel 'Nieuwe Waterweg' appeared in Rotterdam Port. Through the first to the fourth maps, from 1872 to 1901, some content was improved: land reclamation, new water route construction, channel widening, water depth deepening, urban area expansion and railway extension. In particular, the opposite bank development in Rotterdam Port was remarkable. After opening the 'Nieuwe Waterweg', the new docks for petroleum were built, and the railway networks were extended; thus, modern industrial areas emerged there. In addition, the 'Nieuwe Waterweg' project led to another development project near the river mouth area, 'Hoek van Holland'. Figure 2 shows the new development plan for 'Hoek van Holland' and 's-Gravenzande.[16] The railway networks had already been built from Rotterdam City to 'Hoek van Holland' in 1893. This plan had two purposes: the first was to include the 's-Gravenzande into the railway

networks, and the second was to create the new channel from the 'Nieuwe Waterweg' to the 's-Gravenzande and Scheveningen and to build the railway from there to the Scheveningen beach. Scheveningen was located near 'Den Haag' and attracted people who enjoyed leisure activities, such as fishing. Thus, the implementation of this plan was going to contribute strongly to the development of Den Haag through the construction of channel railway networks with Rotterdam Port.

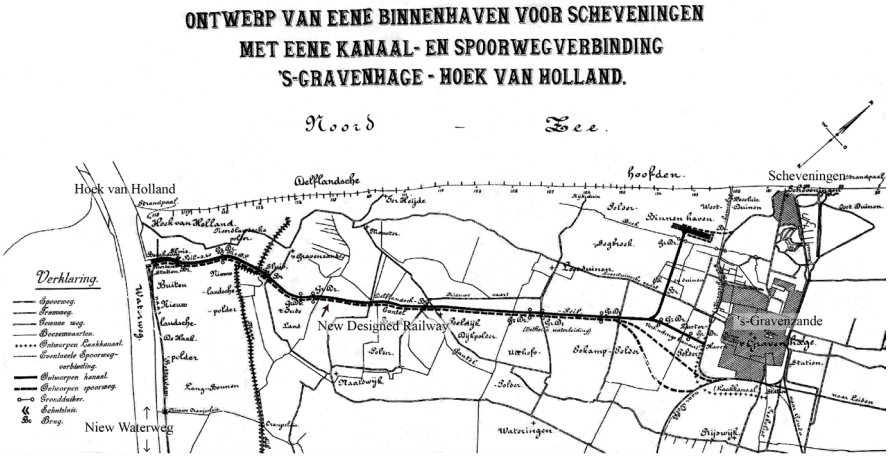


Fig. 2. New development plan for the 'Hoek van Holland' and 's-Gravenzande.

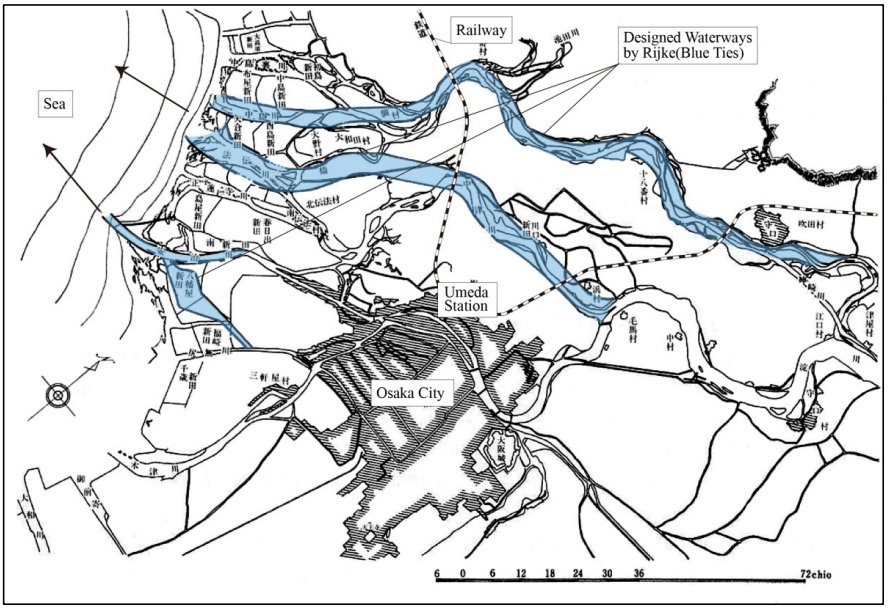


Fig. 3. New comprehensive plan '大阪築港並淀川洪水通路改修計画', designed by Rijke in 1887

OSAKA, NEW SEAPORT PROJECT

Osaka Port was the leading modern port in Asia from the 19th century to the 20th century. However, in the early 19th century, Osaka Port lost its function for trade with international merchants. In 1858, the Japanese government concluded opening five ports—Hakodate, Kanagawa, Nagasaki, Niigata and Hyogo—in the treaty of Amity and Commerce between the United States and the Empire of Japan.[17] In this treaty, the Japanese government purposely did not choose Osaka Port as an opening port because it accounted for 70% of the benefits accrued from national trade in Japan. In other words, the Japanese government was afraid of foreign merchants usurping the benefits. Finally, although Osaka Port was opened in 1868, the modern port function almost moved to Hyogo Port, which also opened in 1868. No large Western ships used Osaka Port in 1875 because the train connecting Osaka and Kobe had Hyogo Port.

In the 19th century, Osaka Port had a critical defect as a modern port. The river mouth was too shallow, thereby making large steamships unable to moor there. Although Osaka City had been a commercial city since early modern times, the Osaka Prefecture Governor decided to improve Osaka Port to industrialize the city.[18] First, he ordered Richard Henry Brunton, an English civil engineer, to investigate port conditions and make an improvement plan. The key issue was how to remove the sand drift, and Brunton made a plan to build breakwater for blocking it to the port area. He also reported that his plan did not require dredging sand for a long time. However, his investigation and designed plan were not feasible. Subsequently, Cornelis Johannes van Doorn, a Dutch civil engineer, was assigned as a designer in 1872.[19] The main feature of his plan was how to remove the sand drift using tractive power. His plan was also criticized by Johannis de Rijke, a Dutch civil engineer. According to Rijke's report, the plan design by Doorn needed extraordinary cost, and tractive power could not remove only light sands. The Osaka Prefecture Governor requested a new plan from Rijke. In 1887, Rijke submitted a new comprehensive plan '大阪築港並淀川洪水通路改修計画', which included the improvement function of the river and port (Fig. 3). In 1885, the embankments collapsed owing to flood disaster two times in the Yodo River, which flowed to Osaka Port; afterwards, smallpox and abdominal typhus spread due to worsening hygiene. In 1889, a flood disaster struck the Yodo River again and cholera spread in 1890. Therefore, neighbors in Osaka strongly searched for an improvement in hygiene problems. A new comprehensive plan designed by Rijke was aimed at solving the two big problems: ports for large steamships and rivers for hygiene problems. Concurrently, the Osaka City Council decided to build new waterworks in 1890 and started construction in 1892 to improve hygiene problems in the city. For this reason, the budget for construction was reduced and Rijke's plan was delayed.

Rijke considered his plan's feasibility by exploring the Japanese economy and technique, and he outlined new lands created by reclamation near Osaka Port, indicating that his plan was connected to urban development. His plan features were also included in the survey methods. His surveys included some scientific topics, sediment amount, tide level, tide direction, its speed, sea bottom geology, wind direction and wind speed. Rijke continued to survey them after submitting his first comprehensive plan '大阪築港並淀川洪水通路改修計

画', improved it and resubmitted the new Osaka Port Plan in 1897. The new plan indicated building only ports, excluding river improvement, and constructing as a seaport, not on the river mouth (Fig. 4). The reason for cutting out the river improvement was because of his new plan of moving large steamships to Osaka Port in the future. To realize his plan, Rijke studied and referred to some other countries' ports, such as the Netherlands and Indonesia.[20] After submitting a new plan, the Osaka City Council requested a subsidy, unlike the Japanese government, which requested a plan revision to include larger ports for moving larger steamships. Ships of 3,000 tons of burden were prevalent at the end of the 19th century, but the size of ships became more than twice in the early 20th century. The Japanese government established a committee for revising Rijke's plan; Koi Furuichi and Tadao Okino, Japanese civil engineers, were included. The committee revised some points, including construction of larger and deeper ports, train station construction and building 330,000 m2 of land by reclamation for the military reservation. In 1897, Osaka Port Construction began. Initially, the Osaka City Council assigned Rijke as a project leader, but the Japanese government commended and assigned Okino to the role.

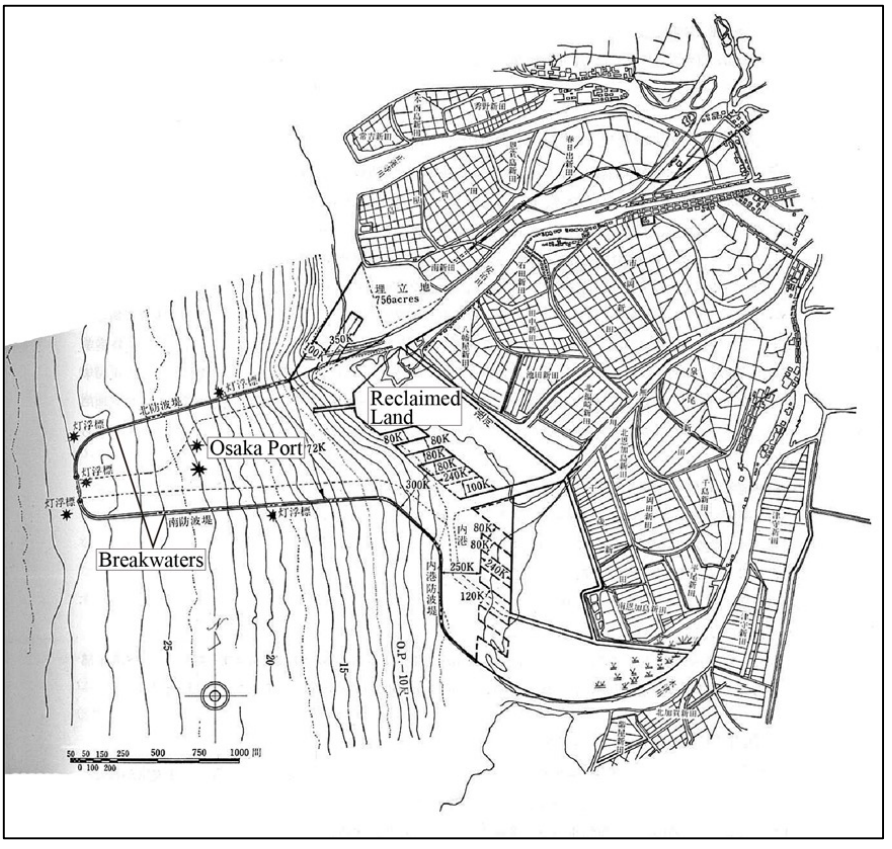
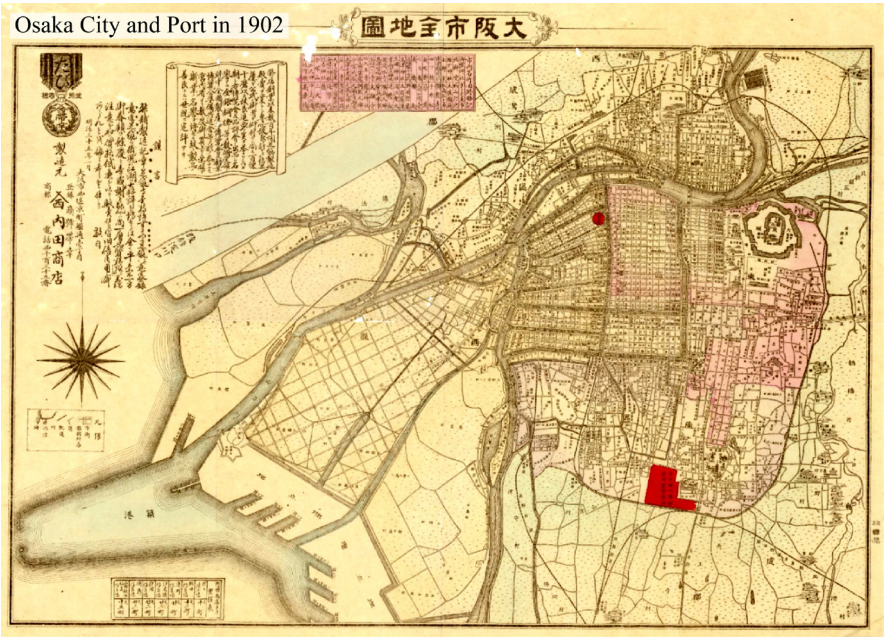


Fig. 4. Resubmitted plan for Osaka Port in 1897



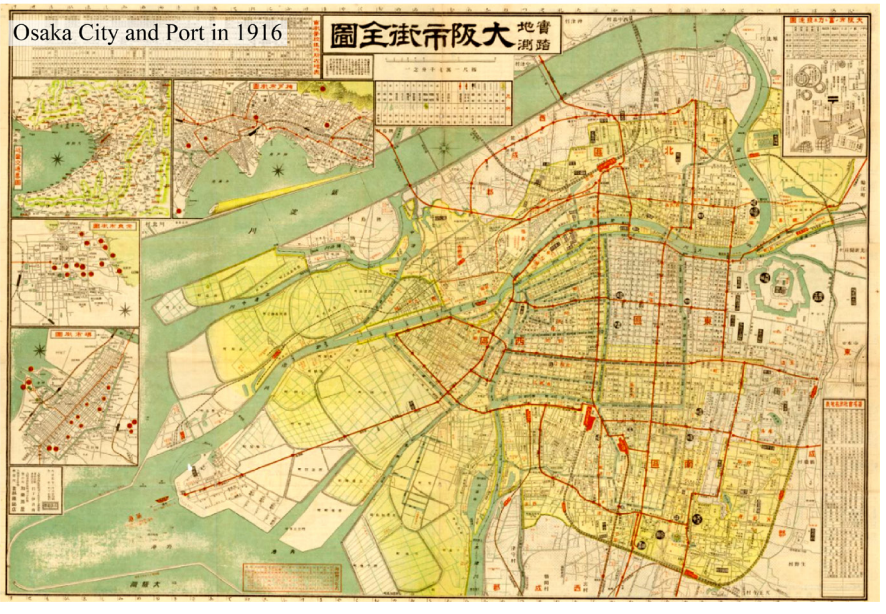


Fig. 5. Transition of the Osaka City from 1902 to 1916.

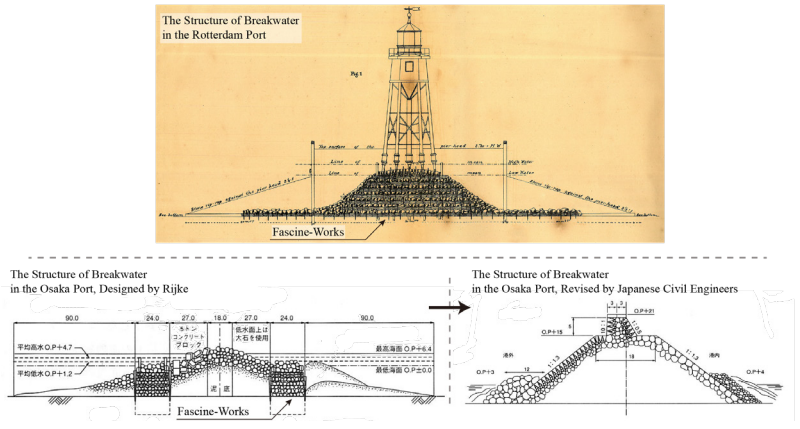


Fig. 6. Each breakwaters in Rotterdam and Osaka

The first construction was building breakwaters for the inner port in 1897. Okino changed the construction method and structure of the breakwaters from Rijke's plan because his plan was considered too difficult by the committee. The construction of dredging and reclamation was executed using steam machines imported from Germany, Scotland and the Netherlands. Lands of 500,000 m^2 were to be created by reclamation; however, only lands of 150,000 m2 were created due to a lack of construction costs. Furthermore, iron piers, with a total length of 455 m and a width of 27 m, were built on Osaka Port in 1903. These constructions progressed smoothly, and the port was partly opened in 1903. During the Russo–Japanese War, 1904–1905, numerous ships moored Osaka Port, which functioned as a supply base for the Japanese army; hospital and provision stores were built on the reclaimed land[21]. However, after the Russo–Japanese War, the progress of the port construction was slowed: building revetment, dock, quay wall and land transportation were not still there. The port construction of the second period was restarted in 1915. Finally, after completion, Osaka Port gained an international trade network with those of the United Kingdom and Germany.[22]

The influence of Osaka Port construction on urban development was huge. In 1903, Osaka City started to construct the electric tramway from downtown of Osaka City to Osaka Port through the reclaimed land. Generally, the tramway project was implemented by a private company; however, this project was proposed and implemented by Osaka City. Therefore, this project was completed in only seven months. Numerous factories were built on the urban suburb and reclaimed land near Osaka Port; hence, the people residing in Osaka City used the electric tramway as a means of moving to the factories and port. The Osaka City Government also issued the discount ticket in the morning to them. Osaka City obtained and kept human resources and income and thus became a modern industrial city. Figure 5 shows the transition of Osaka City from 1902 to 1916. The road, electric tramway, and train network were expanded; additionally, new urban districts, factories and port facilities appeared on the map. This development meant that building a new port connected the building of the transport network on land and urban expansion. However, as a modern industrial city, Osaka City had to face the pollution problem owing to much smoke from the factories. This pollution problem indicates a modernization transition.

CONCLUSION: PORT MODERNIZATION PERSPECTIVE IN THE NETHERLANDS AND JAPAN

This section discusses the crucial roles played by civil engineers in spatial urban development. Considering the two port projects explored earlier, some commonalities and differences are highlighted. First, the motivation for the two projects was almost the same: a considerable amount of money was invested in improving the port for large steamship navigation. In contrast, the strategies used by the civil engineers differed: creating a new channel by cutting the land near the sea, as in the Rotterdam case, and building the basin on the sea by dredging and land reclamation, as in the Osaka case. However, as civil engineers, similar approaches were used to remove drift sand from the sea, indicating that knowledge of Dutch civil engineering was transported from the Netherlands to Japan with practice in Osaka. In addition, the Dutch civil engineers employed by the Japanese government provided their knowledge with several practices. In particular, the design of breakwaters with fascine works in both countries followed the same line of Dutch technology. Rijke also used it to design breakwaters in the Osaka Port Project because the sea bottom was weak and soft. Meanwhile, other Japanese civil engineers modified his design to a simpler one and implemented it (Fig. 6). However, during the construction, the new design caused flow failure on the sea bottom because it did not adapt to the ground type. Considering these results, Japanese civil engineers might have inherited Rijke's theory from the Osaka Port Project.

Second, regarding the influence of port construction on spatial urban development, the same country's civil engineers, the Netherlands and Japan, made a basic plan; each case had some characteristic points. A common point was the connection of trade network, both internationally and nationally, through the sea to the inland by building transportation infrastructures: railway, road and port. This improvement provided numerous benefits to the cities: job creation, city area expansion, enterprise attraction and population growth. By considering the process of improving the two port cities, the contrast of each benefit completely differed owing to some other conditions: politics issues, topography and urban strategies. They created the spatial characteristics of each urban space. For Rotterdam, the city area and port were located in the upper part of the new Maas River. Therefore, after building the railway from the center of Rotterdam City to the south, the opposite bank in the Rotterdam Port and the west, 'Hoek van Holland', new areas were reclaimed that included industrial, leisure and residential places. For Osaka, the city area and port were located close to the sea due to the nonflat ground and river. Hence, the railway was first constructed from the central city to the port area. Simultaneously, hinterland and the middle areas between port and city were included, becoming new areas of industry and residence. However, some issues remained to be improved: transporting smoothly to the hinterland and creating some leisure places. Thus, Osaka Port and City required expansion. Rotterdam Port and City, however, chose to expand and connect with the near satellite city. In particular, the urban actors in Rotterdam had enough area to expand and develop the city from the center of Rotterdam to the river mouth; this was attractive for them.

Port modernization provides modern industry and urban development. In this regard, civil engineers contributed as the first trigger in the Netherlands and Japan. Their plans provided a

framework for tangible and intangible urban development. In the Rotterdam project, Caland provided a comprehensive plan for improving the function of the river and port. Rijke and other Japanese civil engineers also provided an effective plan for the Osaka project. However, owing to topography, people's opposition and historical background, the project was not completely realized. Finally, some parts of the port were completed, and Osaka Port gained a new global shipping network like Rotterdam Port. Simultaneously, these two ports caused the expansion and change of urban structures with the construction of other infrastructures, such as railways.

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NOTES ON CONTRIBUTOR

Kazumasa Iwamoto, Ph.D. (Engineering), is Assistant Professor in the Faculty of Design and Architecture, Kyoto institute of Technology. His research focuses on cross-cultural engineering and port planning through the lens of civil engineering.

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