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#### **Abstract**

Plan C, a landmark building in Rotterdam erected in 1889, represents a significant chapter in the city's urban development. Amidst Rotterdam's rapid modernization during the late 19th century, Plan C emerged as a multifunctional solution to address pressing traffic congestion issues and symbolized innovative urban renewal strategies. This research thoroughly investigates the emergence and disappearance of Plan C and its influence on urban renewal in Rotterdam.

Through archival research and analysis of primary and secondary sources, the establishment, evolution, and eventual demise of Plan C is investigated. Primary sources include architectural archives, historical documents, and visual materials from the Rotterdam Stadsarchief and Nieuwe Instituut. Secondary sources encompass scholarly articles, newspaper clippings, and historical books, providing comprehensive insights into Plan C's historical significance and urban impact.

The journey of Plan C in Rotterdam encapsulates the city's urban evolution and societal challenges. From its inception as a traffic solution to its demise during World War II, it intertwines with Rotterdam's growth narrative. Plan C's establishment in 1889 marked a milestone, reflecting forward-thinking urban planning amid mixed sentiments. Initially thriving, it later declined due to demographic shifts and economic challenges. World War II's bombing ended its existence, leaving behind a reminder of resilience and urban adaptation. Plan C's story highlights urban complexities, emphasizing the importance of thoughtful planning and preservation amid urban evolution.

Overall, this research offers valuable insights into the complexities of urban renewal and the enduring significance of architectural heritage in shaping sustainable urban environments.

#### Figure 1. (previous page)

Oudehaven with Plan C on Oudehavenkade in the background, seen from the east. 22. Rotterdam Plan C, 1900, accessed April 8, 2024, https://hdl.handle.net/21.12133/D0BE203E13C3495A8BF8CC8476E84E66.

#### Table of contents

	Introduction	4
1.	Context of Rotterdam as a 'Modern City'	7
2.	Establishment	10
3.	Construction	14
4.	Utilisation	19
	Conclusion	22
	Bibliography	24

#### Introduction

The name 'Plan C' is a familiar yet enigmatic phrase to many Rotterdammers. But what exactly was Plan C? What historical forces led to the birth of this name? And where is Plan C now? The original Plan C was a multi-purpose building designed by architect C. Muysken in 1880, and in Rotterdam's historiography regarded as a testament to innovative urban renewal strategies in Rotterdam (fig. 2&3). Inaugurated in 1889, Plan C was a pivotal component of an extensive urban planning initiative led by G.J. de Jongh, the director of Public Works of Rotterdam between 1879 and 1910 (Engelfriet 2006; Vanstiphout 2005). This intervention addressed pressing traffic issues by reimagining the area between the Kolk and the Oude Haven, situating Plan C amidst the Oude Haven, Spaanschekade, and Westnieuwland (fig. 4).

At the close of the nineteenth century, Rotterdam found itself amidst a transformative period. While pockets of the city still grappled with poverty, a societal shift was underway (Gestman Gerardts 2020). A burgeoning middle class was emerging, no longer confined to relentless financial struggles but with some disposable income at hand. This newfound prosperity kindled a desire among many to partake in the luxuries once reserved for the elite. The seeds of consumer culture were being sown, prompting the rise of commercial establishments that catered to these aspirations.

However, the origin of Plan C did not stem from extravagant shopping desires but rather from the realm of urban infrastructure. Positioned amidst the rapid modernization of the late 19th century, Rotterdam experienced a confluence of factors that reshaped its urban landscape. The opening of the Nieuwe Waterweg and the Suez Canal, coupled with economic revolutions in the hinterlands, spurred a surge in maritime trade and industrial activity, propelling Rotterdam into a new era of prosperity (Camp and Provoost 1990). Traffic congestion had become a pressing issue in Rotterdam's medieval core, particularly around Beursstation and the Oude Haven. The clash between traditional inland shipping and modern rail and road networks underscored the need for comprehensive urban planning.

Central to this period of urban evolution in Rotterdam was Gerrit Johannes de Jongh, Director of Public Works from 1879 to 1910. De Jongh's visionary leadership propelled Rotterdam into a new age of urban planning, characterized by pragmatism, innovation, and a keen focus on the integration of infrastructure and city life. Hyacinth Hermans (1925) described De Jongh's approach to urban planning as deeply pragmatic, rooted in a military-engineering ethos that prioritized efficiency and functionality. His seminal contributions, such as the introduction of the Maashaven, revolutionized Rotterdam's port infrastructure and garnered international acclaim.

As plans were laid out for infrastructure improvements, including bridge renovations and quay expansions, the concept of Plan C emerged as a holistic solution. Contrary to common misconception, Plan C wasn't an aftermath of Plans A and B but an integral part of a larger urban renewal endeavour. Its scope extended beyond traffic management, encompassing the creation of a landmark building atop a combined bridge-dam structure in the heart of Oude Haven.

The acceptance of Plan C wasn't without resistance, with concerns ranging from navigational challenges for inland skippers to the perceived erosion of Rotterdam's maritime essence (Gestman Gerardts 2020). Yet, amidst debates and deliberations, with De Jongh's adept navigation of political challenges, Plan C received approval, leading to the construction of the business complex and revitalizing Rotterdam's economic dynamism within a transformed urban landscape. This shift heralded a new era, wherein accessibility and buildable surface area supplanted traditional determinants of urban value, reshaping Rotterdam's core and positioning it for future growth and prosperity.

Architecturally, Plan C introduced a new scale to Rotterdam's urban landscape, epitomizing an efficient form of public-private collaboration (Vanstiphout 2005). Its design seamlessly integrated various elements, including hydrology, real estate strategy, quay construction, urban ornamentation, traffic improvement, and architecture. Seventeen ground-floor shops, complemented by shopkeeper residences on the mezzanine, formed the heart of Plan C, while two floors above housed exclusive apartments. Facing the Oude Haven and the Kolk, the building featured inviting arcades, fostering a vibrant waterfront shopping experience. Despite its irregular ground plan, Plan C boasted perfectly symmetrical facades constructed with natural and brick stone, showcasing the attention to detail.

This research thoroughly investigates the emergence and disappearance of Plan C and its influence on



Figure 2. View of the Oudehavenkade and surroundings, with the Plan C building in the middle and the Hoofdsteeg and Nieuwehaven on the right. In the foreground part of the Oudehaven and in the background the towers of the City Hall on Coolsingel, the Sint-Laurenskerk and the City Hall on Kaasmarkt, *IX-2358-00-02*, 1920, Gemeente Rotterdam (Stadsarchief). Accessed April 4, 2024, https://hdl.handle.net/21.12133/7D417E60C7464A889FB0AF61900C7A9



Figure 3. The Kolk. In the background, Plan C. *XIV-190-1*, 1923, Gemeente Rotterdam (Stadsarchief). Accessed April 4, 2024, https://hdl.handle.net/21.12133/87062E4201CB42CCB25EF804D91ADB5A

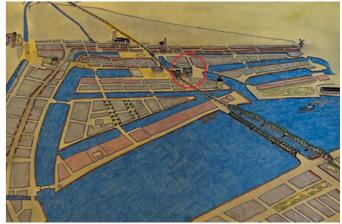


Figure 4. Plan C (red circle). M&M Cie, *untitled*, in D'Laine Camp and Michelle Provoost, "Stadstimmeren - 650 Jaar Rotterdam Stad." (1990), p. 29)

urban renewal in Rotterdam. The main research question is: "How has Plan C, an early example of a multifunctional building, manifested itself as an innovative solution for urban renewal in Rotterdam?" The study focuses primarily on the establishment of Plan C and evaluates how it contributed to the urban developments of Rotterdam. The research will also explore and assess the societal perception of this architectural endeavour.

Through a comprehensive analysis of primary and secondary sources, an answer to this question will be sought. Delving into architectural archives and historical documents, such as archives, newspapers and books, the study seeks to enrich understanding regarding the conceptualization and realization of Plan C. Furthermore, this thesis will investigate the public perceptions and the impact of city developments on Plan C. By analysing primary sources such as the "Archief van Bouwmaatschappij Plan C" and visual materials from the Rotterdam Stadsarchief and Nieuwe Instituut with secondary sources like articles and newspaper clippings, this research aims to unravel the layers of significance embedded within Plan C, shedding light on its lasting impact on Rotterdam's urban fabric and collective memory.

This thesis, following this introduction, is divided into four chapters. The first chapter delves into Rotterdam's evolution as a 'modern' city from the 19th to early 20th centuries. It traces the city's transition from a bustling mercantile hub to Europe's primary port, emphasizing key developments like modern transportation networks and major transit ports such as Rijnhaven and Maashaven. This period also brought challenges like environmental pollution and social inequality. The chapter discusses extensive redevelopment projects that reshaped the city's urban landscape, focusing on improving traffic flow while preserving historical value. It highlights debates around preservation efforts and integration of modern infrastructure, showcasing Rotterdam's journey towards modernization amid economic growth and societal changes.

The second chapter explores the establishment of Plan C in Rotterdam's urban history. It delves into the context of urban challenges faced by the city, leading to the inception of Plan C as a transformative solution. The chapter outlines the pressing need for change, focusing on issues such as overpopulation, congestion, outdated infrastructure, and inefficient

traffic management. It also touches upon the initial opposition faced by the plan, highlighting the economic and logistical complexities involved. Furthermore, the introduction introduces key figures like Director of Public Works De Jongh, whose vision and leadership played a pivotal role in the development and acceptance of Plan C. Overall, this chapter provides a comprehensive overview of the historical background and key factors leading to the establishment of Plan C in Rotterdam.

Chapter three delves into Plan C as a building envisioned by Constantijn Muysken in the 19th century. The chapter begins with an exploration of the building's architect, Constantijn Muysken. It discusses the functional aspects of Plan C, emphasizing its clever design that accommodated both commercial and residential needs. The chapter also delves into the construction challenges faced, showcasing how Muysken and his team overcame technical hurdles to create a monumental yet functional structure. Plan C's heritage and lasting impact on Rotterdam's urban landscape, social fabric, and economic development are also examined, cementing its status as a symbol of progress and modernity in the city's history.

The fourth and final chapter explores Plan C's evolution in Rotterdam, from a bustling hub to its eventual decline and destruction. It reflects Rotterdam's urban improvements and challenges, tracing its transformation from a traditional city to a major port city. Economic shifts, changing dynamics, and wartime events influenced Plan C's fate, highlighting the complex interplay between urban development, societal perceptions, and historical significance.

# Chapter 1: Context of Rotterdam as a 'modern' city

Rotterdam, a city of entrepreneurship and resilience, has undergone several transformations throughout the centuries that have shaped it into what it is today. This chapter explores three crucial periods in Rotterdam's history: the Trading City (1813-1850), the Transit City (1880-1940), and the Industrial City (1945-1975). It describes how Rotterdam evolved from a thriving trading hub to an international maritime powerhouse, and how social, economic, and political changes influenced its identity.

#### **The Trading City (1813-1850)**

Rotterdam embarked on its journey as a prominent trading city between 1813 and 1850 (Van de Laar 2000). During this period, trade was the driving force behind the city's prosperity and power. Rotterdam's elite was closely linked to commercial activities, with the city experiencing strong rivalry with Amsterdam as a trading centre. While Amsterdam dominated international trade, Rotterdam focused on trade within Europe and its colonies. This phase marked the beginning of Rotterdam's economic boom and laid the groundwork for its future role as a trading hub.

#### **The Transit City (1880-1940)**

From 1880 to 1940, Rotterdam grew into Europe's primary port city (Van de Laar 2000). This period of growth and transformation resulted from various factors, including investments in infrastructure and the increasing globalization of trade routes. The Maashaven and Waalhaven were crucial projects contributing to the expansion of the Port of Rotterdam and its position as one of the world's foremost transit ports.

Investments in infrastructure were essential for Rotterdam's growth as a transit port. The Maashaven, completed in 1905, and the Waalhaven, completed in 1910, were modern port facilities that enabled the reception of larger ships and processing of more goods. These ports quickly became important hubs for trade in Europe, with Rotterdam serving as a crucial link in international trade routes.

The growth of the Port of Rotterdam also brought an influx of migrants seeking work and a better life, as described in (Van de Laar 2000). Rotterdam became a melting pot of cultures and nationalities, where people from all corners of Europe and beyond converged in their pursuit of economic progress. This diversity contributed to the dynamism and vitality of the city, enriching Rotterdam's cultural life.

Introduction 6

The rise of Rotterdam as Europe's primary port city marked a turning point in its history. The city transformed from a modest port town into an economic powerhouse, playing a crucial role in international trade and transit. Rotterdam became a symbol of Dutch entrepreneurial spirit, and its emergence as a global port city laid the foundation for its future growth and prosperity.

This period of transition and growth laid the groundwork for Rotterdam's later development as one of the most dynamic and diverse cities in Europe. Its role as a transit port and economic centre would only increase in the following decades, solidifying Rotterdam's position as one of the world's key cities.

#### **The Working City (1945-1975)**

After the devastating Second World War, Rotterdam faced the immense task of reconstruction and recovery. As one of the hardest-hit cities in Europe, the city had to rebuild its economy, infrastructure, and community. This period of reconstruction marked the beginning of the Industrial City phase, during which Rotterdam further strengthened its character as a city of hard workers and a pragmatic approach.

The reconstruction of Rotterdam was an impressive display of determination and resilience. The city had to not only restore its physical structure but also bolster its economic foundations. The port, severely damaged during the war, was central to the recovery process. Through large-scale investments and modernizations, the Port of Rotterdam grew into the largest and most advanced in the world (Van de Laar 2000).

This development was made possible by increasing globalization and the growing demand for international trade. Rotterdam, with its strategic location at the mouth of the Rhine and the Maas rivers, played a crucial role in facilitating trade routes between Europe and the rest of the world. The city became a hub of logistics and transportation, where goods and raw materials from all corners of the globe were processed and transited. Rotterdam's status as the world's leading port city in 1962 was a milestone in its history. It was the result of decades of hard work, innovation, and investments in port infrastructure. Rotterdam was recognized as an economic powerhouse and a symbol of Dutch entrepreneurial spirit.

However, alongside economic progress, this period also brought challenges. The rapid industrialization of the port had an impact on the urban landscape and the living environment of Rotterdam's population. Growing shipping and increased port activities led to congestion, pollution, and other environmental issues.

Furthermore, Rotterdam had to deal with social and economic inequality within its community. Despite economic growth, some parts of the city remained mired in poverty and disadvantage. There was a growing gap between prosperous dockworkers and the marginalized communities in the city.

The Working City phase was thus a period of contrasts and challenges, but also of opportunities and progress. Rotterdam transformed itself from a war-torn city into a symbol of resilience and renewal. Its economic growth and industrial development laid the foundation for its future role as one of the most dynamic and diverse cities in Europe.

## The Role of Infrastructure and Changes in Mental Perspectives

The historical development of Rotterdam cannot be separated from broader societal changes in Europe and the Netherlands (Van der Woud 2006). The political and mental upheavals of the nineteenth century, characterized by political uprisings and the rise of systematic thinking, had a profound influence on the development of cities like Rotterdam. The emergence of infrastructure such as railways and telegraphy played a crucial role in shaping modern societies and cities, and Rotterdam was no exception.

These changes not only brought about a shift in the way people thought about progress and social order but also had practical implications for urban planning and development. Rotterdam, as a city that had always been closely linked to trade and transit, greatly benefited from the development of transportation and communication networks, allowing it to consolidate and expand its role as a major port city.

Additionally, significant social and demographic changes were underway (Van der Woud 2010). The mass migration to cities in the nineteenth century brought about a wave of transformation that reshaped urban societies. Rotterdam grew rapidly as a result of this migration, leading to new challenges such as overcrowding and sanitation issues. These social

and demographic changes provided the context in which Rotterdam developed its identity and evolved through different historical phases.

#### The Crisis Years

The economic crisis that spread worldwide after the stock market crash of 1929 also had significant consequences for Rotterdam (Mens 2007). The city, heavily dependent on the international economy due to its port, was overwhelmed by forces beyond its control. The number of people relying on social support skyrocketed, with nearly half of the population needing assistance at the depth of the depression. This crisis was not simply an economic setback but a complex interplay of various issues reinforcing each other.

In the political arena, heated debates raged over international issues such as the recognition of the Soviet Union and the rise of fascism, with the city gripped by both left-wing and right-wing tensions. Despite these turbulent times, Rotterdam continued the development of the city, now fully dependent on government support, especially from the Works Fund. This fund financed numerous projects to employ the unemployed and improve the city, such as the Forest and Park Plan and preparations for the Maas Tunnel.

However, the crisis also brought significant changes in urban development. Large-scale expansion plans were replaced by more modest projects, and Rotterdam had to adapt to a slower growth pace. Urban planning strategies were revised, shifting focus to integrating Rotterdam into the regional plan of IJsselmonde and addressing local issues such as the Hofplein problem and the airport dilemma.

Nevertheless, Rotterdam managed to adapt to the new reality and further develop the city. Although the grand urban visions of the twenties seemed farther away than ever, pride was still drawn from the city's achievements in tackling the crisis and improving the living conditions of its residents.

#### Conclusion

The history of Rotterdam tells a story of continual adaptation and growth amidst challenges. From its origins as a trading city to its rise as a global port power, Rotterdam has shaped its identity through its ability to innovate and adapt to changing circumstances. While strengthening its economic and infrastructural foundations, social and political

challenges also emerged. Nonetheless, Rotterdam has always held onto its pioneering spirit and determination, establishing itself as a highly dynamic and diverse city.

Chapter 1 8

## **Chapter 2: Establishment**

Amid Rotterdam's dynamic development in the 19th century, the need for change became increasingly apparent. The transformation of the city from a traditional trading centre to a bustling industrial centre emphasised the urgent need for urban planning and infrastructure improvements. Overcrowding and traffic congestion stifled economic activity and prompted a search for solutions. The clogged arteries around Kleine Draaisteeg and the Rijn station epitomised the challenges. Besides proposals such as Plan A and Plan B, Director of Public Works De Jongh also presented Plan C, a radical intervention to revitalise Rotterdam's old centre. This chapter explores the motivations, opposition and triumphs surrounding the establishment of Plan C.

#### **Need for Change**

In the 19th century, Rotterdam underwent significant changes that shaped the structure of the city and its identity. The city evolved from a traditional mercantile city to a transit city and later to a major industrial and port city, as described in chapter two. Overpopulation and congestion were pressing issues, with the growing city overburdening its existing infrastructure, hindering economic activities and mobility (IJsselsteyn 1907). These problems underscored the urgent need for large-scale urban planning and infrastructure improvements to modernize Rotterdam and fully leverage its economic potential.

Pressing traffic problems also arose in the area around the Kleine Draaisteeg and the Rijn railway station. The area was crowded with both pedestrians and vehicles, including carts, wagons, and early forms of motorized traffic (Rotterdamsch nieuwsblad 1933). This congestion was worsened by limited space and the need to allow ships to pass through the Kleine Draaibrug. These factors together caused traffic jams and inefficiencies in the area, leading to the need for a new solution to improve access to the station and regulate traffic flows.

To address this situation, three plans were submitted by Director of Public Works, De Jongh in 1880 (Bouwkundig Weekblad 1887; IJsselsteyn 1907). Plan A and Plan B and C (fig 5 & 6). Plan A involved a station with a stern at Oude Havenstraat and a movable bridge over the Kleine Draaisteeg (now known as the Kolk). Plan B proposed a fixed bridge, but would leave the situation unchanged. Both plans were eventually considered unfeasible for various reasons. Plan A would lead to significant traffic jams

and was impractical given the congestion in the area. With Plan B, the traffic problem would persist, and it was evident that under current circumstances, with a growing city and increased trade activity, such a solution would not be sufficient. Plan C was presented as a more radical bus also more practical and future-proof solution.

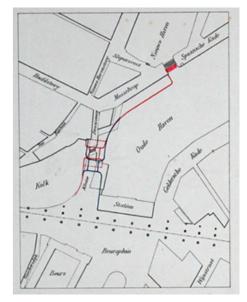
With Plan C, De Jongh proposed a new plan to improve traffic routes in the old city centre (fig 6). Plan C was a radical but ambitious proposal to fill in an area between Beurs Station and Hoofdsteeg, while maintaining the passages for shipping. This plan also involved widening the Geldersche kade and renovating the Jan Kuitenbrug.

#### **Opposition and Triumph**

The plans for Plan C were ambitious and reflected the growing urge for urban renewal in Rotterdam. The design included a modern complex with both commercial and residential functions (Rotterdamsche Courant 1889). Architects worked on facades that had a distinguished appearance, introducing a contemporary style to the cityscape.

Despite the ambitious plans and the desire for urban renewal, economic challenges also brought complications for the execution of Plan C. Construction costs were significant, and the financial returns were not always favourable (Dagblad van Zuidholland en 's Gravenhage 1889). This underscored the complexity of urban development projects and the importance of careful planning and execution. The path to the realization of Plan C in Rotterdam was characterized by an interplay of urban visions, municipal engagement, architectural ambitions, and economic reality. These factors laid the foundation for the development of this once iconic building in Rotterdam's urban landscape.

In addition to technical and economic challenges, fierce opposition arose during the presentation of Plan C. Many feared that the plans would come at the expense of crucial mooring places for inland shipping, which would harm trade (IJsselsteyn 1907). Despite the opposition, De Jongh succeeded in convincing the City Council of the benefits of Plan C (Bouwkundig Weekblad 1887). He argued that there was sufficient space for inland shipping on the right bank of the Maas and that the plan provided room for growth and modernization. Finally, on September 30, 1882, Plan C received the green light from the City Council, paving the way for the



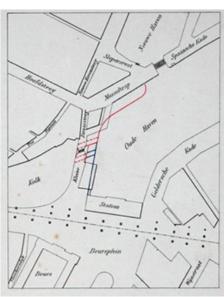


Figure 5. Plan A (above) & Plan B (below) for improving traffic circulation at the Kleine Draaisteeg, *II-38*, 1880, Gemeente Rotterdam (Stadsarchief). Accessed March 12, 2024, https://hdl.handle.net/21.12133/65D-6B155CDD44513B165D10BDE0968B6



Figure 6. Plan C to improve traffic circulation at the Kleine Draaisteeg, *II-39*, 1880, Gemeente Rotterdam (Stadsarchief). Accessed March 12, 2024, https://hdl.handle.net/21.12133/0711193134614D368F4D-325F29790CCF

11

transformation of Rotterdam's old centre (IJsselsteyn 1907).

#### **Arguments and Motives**

A more thorough examination of the records of the City Council sessions from that time sheds light on the specific arguments used to justify Plan C against opposition. These arguments, documented in Bouwkundig Weekblad (1887), focused on some crucial aspects of urban development.

An important point that repeatedly surfaced was the necessity of urban modernization. Rotterdam was experiencing a period of rapid growth, but the old city centre could no longer meet the needs of the growing population and commercial activity. Another much-discussed topic was addressing traffic problems in the old city centre. Congestion around the old Fish Market was seen as a growing problem that hindered trade and daily life in the city.

Additionally, the economic potential of Plan C was emphasized. By investing in new trading facilities and infrastructure improvements, the project was expected to stimulate economic activity in the city centre and create new opportunities for traders and entrepreneurs. Lastly, the lack of space in the old city centre was also cited as a reason to execute Plan C. With the growing population and commercial activity, there was an increasing need for additional space for trade and residential purposes.

#### Gerrit Johannes de Jongh

A name that comes up frequently in articles and books regarding the establishment of Plan C is Gerrit Johannes de Jongh (1845-1917). But not only was he very important for Plan C, he also played an important role in the entire development of Rotterdam in the 19th century according to an article in the Maasbode (1925).

In this article P. Hyacinth Hermans described Gerrit Johannes de Jongh as a significant figure in the last decades of the nineteenth century. Although his fame is primarily anchored in the monumental port complexes he brought into being, his legacy extends far beyond the harbour quays alone. His name is a lively tribute in Rotterdam's history, not only due to his impressive harbour creations but also because of his invaluable contributions to improving urban life. De Jongh stood at the helm of urban development at a crucial moment, as Rotterdam prepared for a period of unprecedented growth. While his focus

mainly lay on the harbour projects that would earn the city a worldwide reputation, his impact in other areas must not be underestimated. He was an architect of progress, a visionary who built not only large structures but also laid the foundations for a liveable city.

One of De Jongh's most remarkable achievements was his dedication to providing drinking water. In a time when cities were plagued by devastating cholera epidemics, he recognized the urgency of a reliable water supply system. Through his initiatives, he succeeded in providing the city with an extensive network for clean drinking water, resulting in significant decreases in mortality rates and an improvement in public health.

Additionally, De Jongh focused on illuminating the city. Under his leadership, gas lighting evolved from a sparse private enterprise into a municipally operated system. He saw the potential of electricity and encouraged its development in Rotterdam, not just for lighting but also for industrial applications, such as in the harbour.

His city expansion plans were also groundbreaking. He not only designed new neighbourhoods and infrastructure but also managed to balance the interests of trade and liveability. His vision of a modern city encompassed not only economic growth but also liveable neighbourhoods, green spaces, and good connections for residents.

Despite facing numerous challenges, from financial constraints to political opposition, De Jongh succeeded in transforming Rotterdam into a city of international allure. His legacy is not only visible in the impressive harbour infrastructure but also in the liveability, health, and prosperity of the city and its residents. Gerrit Johannes de Jongh was a pioneer of progress, whose influence is still felt today in Rotterdam's dynamics and character.

#### Conclusion

The story of Plan C marks a notable point in the history of Rotterdam. The initiative for the construction of Plan C arose from a multitude of developments and plans that reflected the growing economic and urban factors of that time. The recognition of the need for change, the persuasive presentation of Plan C by Director of Public Works De Jongh, and the eventual approval of the City Council testify to the power of collaboration and leadership in the pursuit of urban

renewal. The analysis of the arguments and motives behind Plan C not only highlights the specific reasons for justifying the project but also underscores the lasting impact of De Jongh's vision, political skill, and technical expertise on the history of Rotterdam.

Chapter 2 12

#### **Chapter 3: Construction**

This chapter delves into the architectural aspects of Plan C, exploring how Constantijn C. Muysken's innovative approach intersects with the influential Beaux-Arts movement. To gain a better understanding of how the design of Plan C came about, the course of C. Muysken's life and the development of the Beaux-Arts movement will be examined in more detail. Muysken's legacy in Dutch architecture, coupled with the broader international trends of the time, shapes the narrative of Plan C's design. This exploration aims to uncover the intricate connections between Muysken's architectural vision, the evolving architectural movements of his era, and the influence of Plan C on the architectural landscape of Rotterdam in the 19th century.

#### The Author of Plan C

The story of Plan C begins in 1880 when architect Constantijn Muysken presented his design for a business complex. Constantijn C. Muysken (1843-1922) was a prominent figure in 19th-century Dutch architecture (Het Nieuwe Instituut 1874). His influence extended to the Neo-Renaissance style, a period during which new architectural ideas flourished alongside the dominant Neoclassicism and Neo-Gothic styles. Born in Hillegom, Muysken began his education at the Polytechnic School in Delft and continued it in Hannover, where his passion for Italian Renaissance architecture emerged during an extensive journey through Northern Italy.

One of his most notable works from that time was the design for Oud Wassenaar Castle in 1876, an early example of Neo-Renaissance architecture. This marked the beginning of his involvement with the Society for the Promotion of Architecture, of which he later became chairman and played a crucial role in discussions about the national architectural style. Muysken's approach to architecture was unique for his time because he combined elements of both Dutch and Italian Renaissance styles, with a strong emphasis on picturesque effects and harmony with the surroundings.

Muysken's designs were characterized by the use of old dutch brick and sandstone, stepped gables, decorative bands, and other traditional architectural elements reflecting Dutch history. He avoided hiding the construction behind plasterwork and terracotta ornaments, instead emphasizing the nature of the materials themselves, resulting in buildings that seamlessly blended with the surrounding landscape. In addition to his architectural achievements,

Muysken was also active in various associations and committees promoting the development of architecture in the Netherlands. He played a significant role in establishing new policies within the Society for the Promotion of Architecture and was involved in various restoration projects and monument preservation efforts.

Muysken's legacy as one of the most important architects of his time is anchored in his ability to combine traditional elements with new ideas, leaving a lasting impact on the Dutch architectural landscape. His legacy continues to inspire future generations of architects.

#### **Beaux-arts**

Plan C, located in the filled-in part of the Old Harbor, was originally designed in the Beaux-Arts style, as described by Vanstiphout (2005). The Beaux-Arts movement, also known as the 'fine arts', emerged in France between 1885 and 1920 as a product of nearly 250 years of education and research at the Académie royale d'architecture, founded in 1671 and later merged with other academies to form the Académie des Beaux-Arts (Kunstbus n.d.). Beaux-Arts structures are often grand in scale, characterized by symmetrical layouts featuring rooms aligned along axes, abundant Classical ornamentation, and projecting pavilions at both ends and the centre (Britannica, n.d.).

The École des Beaux-Arts, originally established as a French design system at the Académie Royale d'Architecture, emphasized training architects as artists and theorists. These architects were trained to design monumental government buildings such as administrative offices, museums, and libraries in a style initially dominated by classicism but later evolved into lush eclecticism.

Education at the École des Beaux-Arts from 1885 onwards included lectures on theory, history, architecture, and perspective, imparting a deep knowledge of both modern construction techniques and classical iconography to students. Competitions were held according to strict protocols, instructing participants on the scale of plans and sections, the execution of coloured drawings, and even which colours could be used.

The influence of the Beaux-Arts style spread internationally, with foreign students such as Louis Sullivan and Charles Follen McKim bringing the neoclassical influences of the Parisian school to America. In the United States, the Beaux-Arts style became popular, especially in the design of skyscrapers in cities like New York. The Metropolitan Museum of Art in New York, designed by Richard Morris Hunt in 1926, is an example of a Beaux-Arts building that influenced American architecture (fig. 7).

The influence of the Beaux-Arts movement was also noticeable in the Netherlands, albeit to a lesser extent than in some other countries. Examples of Beaux-Arts architecture in the Netherlands include the Rijksmuseum and Central Station in Amsterdam, both designed by Pierre Cuypers, and the Vredespaleis (Peace Palace) in The Hague, designed by Louis Marie Cordonnier (fig. 8, 9 & 10).

The Beaux-Arts style is sometimes criticized for its excessive use of ornamentation and the tendency to conceal construction behind decorative elements, leading to terms like the 'suikertaartenstijl' (sugar cake style). Despite these criticisms, the Beaux-Arts movement had a lasting impact on architectural history and contributed to the development of international architectural styles in the early 20th century.

#### Architectural Design, Features and Challenges

Muysken's design for Plan C was a prominent example of the Beaux-Arts style (Vanstiphout 2005). The façade of the building was symmetrical and imposing, with large columns and decorative ornaments characteristic of this style. The emphasis on symmetry and grandeur was typical of the Beaux-Arts movement, which aimed to create a sense of harmony and beauty in architecture.

A notable aspect of the architectural design was the covered gallery on the side facing the Oude Haven and de Kolk (fig. 11 & 14). The gallery or promenade extended along ten spacious shops, adorned with graceful lanterns (Vanstiphout 2005). This gallery provided visitors with the opportunity to shop comfortably even in bad weather, aligning with the emerging demand for luxury and convenience among middle-class consumers. The gallery featured large windows and an elegant balustrade, giving the building an inviting appearance and making it a place of social interaction. In the façade facing the Geldersche straat, a gate was located to provide access to an inner courtyard, onto which the rear of the shop-houses opened (fig. 13).

The materials used in the construction of the Plan C building were of high quality (Gestman Gerardts 2020). The facades were made of hewn stone and brick, to ensure durability and a monumental look. Using a combination of these materials made the project technically challenging in creating a cohesive appearance. But in 1889, a local paper wrote that Muysken managed to overcome these challenges and created a building that was both functional and aesthetically impressive (Bouwkundig Weekblad 1887).

Furthermore, the front facade was adorned at both ends with two tower-like buildings, which added splendour to the solid structure. On the four facades, allegorical figures of trade and shipping were depicted in plaster at eight locations (fig. 15). The detailing of the facades added to the aesthetic value of the building, which ensured it became a recognizable landmark in the city of Rotterdam (Rotterdamsche courant 1889).

In addition to its impressive architecture, the Plan C building offered a range of functions and amenities that made it a significant centre of trade and social activity (Vanstiphout 2005). Plan C contained 16 plots, each comprising as many shops and 17 upper houses (fig. 16). The shop were diverse, including bookstores, clothing stores, and other retail outlets. This diversity of shops made it an attractive destination for both local residents and visitors from outside the city.

A unique feature of the Plan C building was the shipping tunnels that ran beneath it, connecting the Old Port to the Kolk (fig. 17) (Gestman Gerardts 2020). Although these tunnels were only suitable for flat barges with minimal cargo, they were an innovative solution to maintain shipping activity in the area even after part of the harbour was filled in.

The building served not only as a shopping centre but also as a meeting place and symbol of modernity and progress for Rotterdam (Vanstiphout 2005). The covered gallery provided visitors with a comfortable environment for shopping and enjoying social interaction, while the diverse shops and amenities contributed to the vibrancy and diversity of the area.

With its combination of impressive architecture, diverse functions, and social amenities, the Plan C building became an important cultural and economic centre in Rotterdam, still remembered as an iconic



Figure 7. The Metropolitan Museum of Art, New York, 1870, accessed April 10, 2024, https://cdn.sanity.io/images/cctd4ker/production/909fa245367580e643fff7bedflf5ca129443163-1200x630.jpg?w=600&q=75&auto=format.



Figure 8. Rijksmuseum, Amsterdam, 1798, accessed April 10, 2024, https://cdn-imgix.headout.com/media/images/dd53844d4840a22b17f273049f19f5b0-544-amsterdam-amsterdam-rijksmuseum-01.jpg.



Figure 9. Central Station, Amsterdam, 1889, accessed April 10, 2024, https://www.amsterdam.info/sitemedia/photos-800/amsterdam-transport-central-station-build-ing-entrance-800x450.jpg.



Figure 10. Vredespaleis (Peace Palace), Den Haag, 1913, accessed April 10, 2024, https://denhaag.com/sites/default/files/styles/image\_paragraph\_700x400/public/5527f48e-94c2-48af-9006-1d3d464125ed.jp-g?h=a5a3d7ef&itok=9D9ucGpe.



Figure 11. Façade of Plan C (Oude Havenkade), Rotterdam, 1887, Gemeente Rotterdam (Stadsarchief).



Figure 12. Façade of Plan C (Gelderschekade), Rotterdam, 1887. Gemeente Rotterdam (Stadsarchief).



Figure 13. Façade of Plan C (Gelderschestraat), Rotterdam, 1887, Gemeente Rotterdam (Stadsarchief).

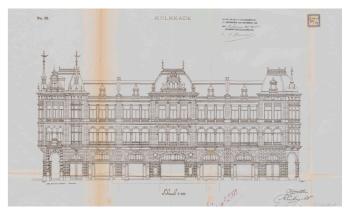


Figure 14. Façade of Plan C (Kolkkade), Rotterdam, 1887, Gemeente Rotterdam (Stadsarchief).



Figure 15. Part of the façade of Plan C on Kolkkade, *XIV-190-00-02*, 1936, Gemeente Rotterdam (Stadsarchief). Accessed April 4, 2024, https://hdl.handle.net/21.12133/7A3C93674C8942B58A-2541B071A3FE87.



Figure 16. Floorplan of Plan C (ground floor), Rotterdam, 1887, Gemeente Rotterdam (Stadsarchief).

Chapter 3 16

example of nineteenth-century urban architecture and urban development (Gestman Gerardts 2020; Vanstiphout 2005).

#### Conclusion

In conclusion, the exploration of Plan C's architecture uncovers the fusion of Constantijn C. Muysken's inventive style with the influential Beaux-Arts movement. Muysken's legacy in Dutch architecture, blending Dutch and Italian Renaissance elements, laid the groundwork for Plan C's grandeur and functionality. Adhering to Beaux-Arts principles, evident in its symmetrical facades and high-quality materials, enhanced the building's aesthetic and utility. Plan C's innovative features, like the covered gallery and shipping tunnels, reflected societal needs while establishing it as a cultural and economic centre in Rotterdam. This chapter illuminates the intricate links between architectural innovation, historical influences, and societal progress, showcasing Plan C as a timeless inspiration and a significant piece of architectural history.



Figure 17. *Floorplan of Plan C (basement)*, Rotterdam, 1887, Gemeente Rotterdam (Stadsarchief).

**Chapter 4: Utilisation** 

Plan C not only represents an architecturally and historically significant building but also symbolizes the ongoing transformations in urban development and public perception. Designed as a thriving shopping and office area, the city of Rotterdam has undergone numerous changes over the years reflecting the evolution of urban dynamics and societal needs. The result is a building that once provided a good solution to a traffic problem but in its final years became a hindrance to further urban development. This chapter explores the historical context of Plan C, shifts in public perception, and the impact of urban development projects on this once iconic building in the heart of Rotterdam.

#### The beginning

On March 4, 1889, Plan C opened its doors. Located along the Oude Haven, the building initially served as a shopping gallery and office space, housing various businesses such as the eau de cologne manufacturer J.C. Boldoot, the sports store Perry, and a shoe store named Weytens (Wolters 1990). Throughout its history, Plan C served as an important shopping centre and a meeting place for the local population. It provided space for different businesses and shops, playing a central role in Rotterdam's commercial and social life.

At the opening of Plan C, there were mixed reactions from the local population and businesses. Some saw it as a positive step for urban improvement and economic growth, while others criticized the construction costs and the impact on the surroundings, such as the filling-in of parts of the Oude Haven (Rotterdamsch Nieuwsblad 1933; Wolters 1990). The Chamber of Commerce at that time also opposed the arrival of Plan C because they saw a significant danger to inland shipping in the loss of a part of the Oude Haven. Inland shipping would have to be relocated to other parts of Rotterdam with the arrival of Plan C.

Apart from the criticism of some, it was later acknowledged that Plan C had been very successful in its early years. Around 1882, Rotterdam had only 150,000 inhabitants, and for a city of this size and in that era, it was considered a significant urban improvement (Rotterdamsch nieuwsblad 1933). The traffic situation in the area had drastically improved, and with the arrival of Plan C, there was a prospect of a profitable investment that could recoup the costs of the combined bridge-dam structure and Plan C in the long term.

#### Impact on Plan C

As the 19th century gave way to the 20th, Plan C's trajectory mirrored Rotterdam's evolving urban landscape. Transitioning from its successful inauguration amidst mixed local sentiments, the building soon became a pivotal hub in the city's commercial and social fabric. However, shifting demographics and urban visions as described in chapter one gradually altered the centre's dynamics.

These shifting demographics and urban visions had a direct impact on Plan C and its surroundings. The growing population combined with the everchanging visions of the city, resulted in a shift of the city centre. The movement of the shopping area towards the west of the city centre in combination with the crisis in the 1930s led to vacancies in Plan C, both in the shops and the offices above the shops (De Bankier 1938). Due to the exodus of offices and shops, the neighbourhood even earned the nickname the 'Graveyard' (Wolters 1990).

According to an article in the Rotterdamsch Nieuwsblad (1936) the deterioration of the urban area around Plan C was due not solely to the crisis but also to several other issues. This article describes the establishment of the committee: 'Verkeersweg Zuid-Noord' ('Traffic route South-North'). The committee was composed of businessmen with a vested interest in this part of the city who came together due to the decline in the retail sector. The committee attributed this decline to several factors, including the lack of attention to a proper North-South traffic route and rerouting tram lines, and the absence of a clear vision for the development of shopping streets. The committee was urging the city council to develop a tangible plan for a north-south connecting road and to implement measures to preserve the city centre as a hub for retail. They emphasize the need for a well-functioning circuit for pedestrian and shopping traffic and advocate for additional measures such as proper street lighting, street cleaning, and the removal of disruptive buildings between shops.

However, implementing all these plans would maybe have resulted in the preservation of the city centre as a hub for retail, it would have still meant the downfall of Plan C. The goal of the South-North traffic route was to create an effective traffic route that would run from South to North through the district of Rotterdam and would benefit traffic regulation (De Bankier 1938; Rotterdamsch Nieuwsblad 1938). To realise the arrival of this route, Plan C would have

to be demolished. The fact that Plan C was camping with vacancy at that time which made it merely an obstacle, strengthened the justification for the demolition of Plan C.

#### The end

Although plans to demolish Plan C were already in the works, these plans were never carried out. Uninvitedly, the Germans carried out this task in May 1940 by bombing the city (Wolters 1990). The original Plan C was completely destroyed except for a few arches of what were once the galleries (fig. 18 & 19).

The barren plain that remained in the centre of Rotterdam in 1940 allowed the implementation of solutions to previously pressing infrastructure problems (Oudenaarden 1994). The site where Plan C had stood underwent significant changes during the reconstruction period. Since there was less transport by flat-bottomed boats after the war, the two maritime tunnels under the complex were also sealed off (fig. 20) (Gestman Gerardts 2020). Thus, an important and remarkable piece of Rotterdam's history vanished. What remains of the original Plan C today is merely a small section of the balustrade on the north side of the Oude Haven, along with various images and memories of an older generation who have once shopped there.

#### Conclusion

From its original role as a thriving shopping and office area to its later years of vacancy and neglect, Plan C reflects the ongoing transformations in urban development and public perception. The opening of Plan C in 1889 marked a significant step in Rotterdam's urban improvement, with the building serving as a central hub for commercial and social activities. However, the changing urban dynamics in the 20th century brought new challenges, resulting in plans for the demolition of Plan C. Ultimately, the bombing of 1940 destroyed Plan C before demolition could commence. Despite its physical disappearance, the historical significance and symbolic value of Plan C continue to endure as an illustration of the complex relationship between urban development, economic changes, and societal perceptions.



Figure 18. View from the Witte Huis of the area of Oudehaven-kade, Kolk, Blaak, damaged by the German bombardment of 14 May 1940, including Plan C, Beursstation and Sint-Laurenskerk, 2005-5375, 1940, Gemeente Rotterdam (Stadsarchief). Accessed April 10, 2024, https://hdl.handle.net/21.12133/49DAFB4E3A-1C4EE184E5967ED53BAC64.



Figure 19. The Kolk hit by the bombing of 14 May 1940 with the facades Plan C in the background. Ships and pieces of debris lie in the water of the Kolk, *1980-5099*, 1940, Gemeente Rotterdam (Stadsarchief). Accessed April 10, 2024, https://hdl.handle.net/21.12133/32D32062F25C4D-01BE8905A751E96D76.



Figure 20. View from the Witte Huis of part of the Oudehaven and Oudehavenkade with surroundings, a bomb-damaged area, and further on the Municipal Library on Botersloot and Nieuwemarkt. On the left the railway viaduct and the Sint-Laurenskerk, *IV-339-10*, 1941, Gemeente Rotterdam (Stadsarchief). Accessed April 10, 2024, https://hdl.handle.net/21.12133/4466B1FC78EE-4924955B4A6BE07CF4D4.

#### Conclusion

In conclusion, the journey of Plan C in Rotterdam reflects not only the evolution of urban development but also the broader societal shifts and challenges faced by the city throughout its history. From its inception as a solution to traffic congestion in the bustling port city to its eventual demise during the tumultuous events of World War II, Plan C's story is intertwined with Rotterdam's narrative of growth, resilience, and adaptation.

The establishment of Plan C marked a significant milestone in Rotterdam's urban planning history. Designed to alleviate traffic problems and accommodate the city's growing commercial activities, it symbolized a forward-looking approach to urban development. Its opening in 1889 was met with a mix of optimism and scepticism, reflecting the complex sentiments surrounding urban renewal projects in rapidly changing cities like Rotterdam.

During its early years, Plan C thrived as a vibrant shopping and social hub, contributing to the vitality of Rotterdam's city centre. However, shifting demographics, economic challenges, and changing urban visions gradually led to its decline. The exodus of shops and offices, coupled with the broader economic downturn of the 1930s, resulted in vacancies and a decline in the surrounding urban area. Despite efforts to revitalize the neighbourhood, including proposals for improved traffic infrastructure and pedestrian circulation, Plan C ultimately faced an uncertain future.

The outbreak of World War II brought an abrupt end to Plan C's existence. The bombing of Rotterdam by German forces in May 1940 obliterated the original building, leaving behind only remnants of its once grand façade. The devastation of the city centre provided an opportunity for post-war reconstruction and infrastructure improvements, but it also meant the loss of a significant piece of Rotterdam's architectural heritage.

Today, what remains of Plan C serves as a reminder of the city's resilience and ability to adapt to changing circumstances. While the physical structure may have disappeared, the memories and legacy of Plan C endure through archival records, historical photographs, and the stories passed down by older generations. Its brief but impactful existence reflects the broader challenges and transformations faced by cities undergoing rapid urbanization and economic change.

In a broader context, the story of Plan C offers valuable insights into the complexities of urban development and the interconnectedness of historical, social, and economic factors. It underscores the importance of thoughtful planning, community engagement, and adaptability in shaping sustainable urban environments. As Rotterdam continues to evolve in the 21st century, the lessons learned from Plan C's journey remain relevant, reminding us of the enduring significance of our urban heritage and the need to balance progress with preservation.

## **Bibliography:**

- Bouwkundig Weekblad. 1887 nr. 13. 'Verslag van de Toelichting van Plan C Door Architect
  C. Muijsken Bij de Vergadering van de Afdeling Rotterdam van de Maatschappij
  Tot Bevordering Der Bouwkunst Op 24
  Maart,' 1887.
- Britannica. n.d. 'Beaux-Arts Style Summary'.

  Accessed 1 April 2024.

  https://www.britannica.com/summary/
  Second-Empire-style.
- Camp, D'Laine, and Michelle Provoost. 1990.

  'Stadstimmeren 650 Jaar Rotterdam Stad.

  Phoenix & den Oudsten.
- Dagblad van Zuidholland en 's Gravenhage. 1889. *'Binnenlandsch Nieuws'*, 4 March 1889.

  https://resolver.kb.nl/e?urn=MMKB19:0035

  99108:mpeg21:a00053.
- De Bankier. 1938. 'Het Gymnasium in Ruil Voor

  Plan C?', 12 October 1938.

  https://resolver.kb.nl/esolve?urn=ddd:01085

  4464:mpeg21:a0115.
- Engelfriet, Aad. 2006. 'De 0,5 Meter Plankbrug van Rotterdam, de Kleine Draaibrug En Dus Gaat Het Ook over Rotterdam En de Oude Haven, de Nieuwe Haven, Het Haringvliet, Plan C, En Nog Veel Meer....' http://www.engelfriet.net/Alie/Hans/draaisteeg.htm#bottom.
- Gestman Gerardts, Jaap. 2020. 'Plan C'. In *Ons*Rotterdam.- Jrg. 42, nr. 02, 40-43.

  Stichting Ons Rotterdam.

- Hyacinth Hermans, Pater. 1925. 'Rotterdam in de Negentiende Eeuw III', *Maasbode* 9

  January 1925.

  https://resolver.kb.nl/e?urn=MMKB04:0001
  94057:mpeg21:a0072.
- IJsselsteyn, H.A. 1907. *De Haven van Rotterdam*. Nevens.
- Kunstbus. n.d. 'Beaux-arts'. Accessed 1 April 2024. https://www.kunstbus.nl/architectuur/beaux-arts.html.
- Laar, Paul van de. 2000. Stad van Formaat:

  Geschiedenis van Rotterdam in de

  Negentiende En Twintigste Eeuw.

  Waanders Uitgevers, Zwolle.
- Mens, Noor. 2007. W. G. Witteveen En Rotterdam:

  Monografien Van Stedebouwkundigen. 010

  Publishers.
- Muysken, C. (Constantijn) / Archivalia. 1874.

  'Geschiedenis van de archiefvormer',

  1843-1922. Het Nieuwe Instituut.

  https://zoeken.nieuweinstituut.nl/nl/
  archieven/details/MUYS/keywords/
  muysken
- Oudenaarden, Jan. 1994. 'Rotterdamse sloopzucht',

  NRC Handelsblad 12 February 1994.

  https://resolver.kb.nl/urn=KBNRC01:00

  0030777:mpeg21:a0263.

- Rotterdamsche courant. 1889. *'Binnenland'*, 3

  March 1889.

  https://resolver.kb.nl/esolve?urn=ddd:0110
  05939:mpeg21:a0038.
- Rotterdamsch nieuwsblad. 1933. 'Vijftig Jaar Plan

  C. Hoe Een Stad Verandert!', 12 October

  1933.
  - https://resolver.kb.nl/rsolve?urn=MMKB32: 164667048:mpeg21:a00118.
- Rotterdamsch nieuwsblad. 1936. 'Verkeersweg

  Zuid-Noord', 24 October 1936.

  https://resolver.kb.nl/e?urn=MMKB32:1646

  85047:mpeg21:a00080.
- Vanstiphout, Wouter. 2005. 'Maak een stad:

  Rotterdam en de architectuur van J.H. van
  den Broek.' 010 Publishers.
- Wolters, Rein. 1990. 'De Pappegay: Aflevering

  180', Het vrije volk: democratischsocialistisch dagblad 30 July 1990.

  https://resolver.kb.nl/esolve?urn=ddd:01094

  8924:mpeg21:a0101.
- Woud, Auke van der. 2006. Een Nieuwe Wereld:

  Het Ontstaan van Het Moderne Nederland.

  Uitgeverij Bert Bakker Amsterdam.
- Woud, Auke van der. 2010. Koninkrijk Vol Sloppen:

  Achterbuurten En Vuil in de Negentiende

  Eeuw. Uitgeverij Bert Bakker Amsterdam.

#### Figure 21. (next page)

Aerial view of the Oudehaven area, with the Bolwerk and part of the railway bridge over the New Maas on the front left, near the Wijnhaven. At the corner of the Oudehaven near the Geldersekade the White House. At the end of the Oudehaven the Plan C building and behind it the Beursstation, *VII-449*, 1933, Gemeente Rotterdam (Stadsarchief). Accessed April 10, 2024, https://hdl.handle.net/21.12133/60A03296AD1843E5AD9878FA472DB747.



## THE RISE AND FALL OF PLAN C

A Historical Analysis on Rotterdam's Urban Development

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