

Transferring bridge and road construction technology in the 1700s: French engineer Jean Marmillod as an innovator in Denmark

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This article describes how technological progress in constructing roads and bridges was distributed in the 1760s and 1770s from the country leading the trade: France. Because people with tacit knowledge were needed to efficiently distribute knowledge about trades, a rapid method, presented herein, was to acquire experienced artisans. Recognising the substandard state of its national infrastructure system compared with other countries, the Danish government turned its attention to France.

Cultural connections between France and Denmark in the 1700s

Two people became mediators for the project to transfer knowledge from France to Denmark. One was Joachim Wasserschlebe (1709–1787), who, as secretary for the ambassador at the Danish embassy in Paris appointed in 1731, developed a large circle of acquaintances. With his connections and knowledge of art, Wasserschlebe brokered contact with French artisans and artists to decorate the soon-to-be-erected royal Christiansborg Palace. The sculptor Louis Auguste Le Clerc was one such French artist who subsequently arrived in Denmark, where he designed portals, figurines, fireplaces and other delicate Rococo decorations beginning in 1735. Apart from Le Clerc, 35 other French artists were hired to paint panels, landscapes and portraits, among other works, for the marvellous castle, including Jean-Baptiste Oudry, Charles Parrocel, Jean-Marc Nattier and François Boucher. Unfortunately, all of their works were lost when the castle burnt in 1794.¹

The other mediator, also German-born, was J. H. E. Bernstorff (1712–1772), who assumed the post of ambassador to France in 1744 and, in 1749, led the negotiations that ended with agreements between France and Denmark. When Bernstorff became minister of foreign affairs in Denmark in 1751, Wasserschlebe entered the Danish administration too and continued to mediate contact with French artists. As a result, architect Nicolas-Henri Jardin came to Denmark, where he became an influential professor at the Academy of Fine Arts and a royal inspector of buildings. Researchers later dubbed him “the father of Danish classicism”.²



Figure 1. L'école Royale des Ponts et Chaussées – today École des Ponts Paris Tech– was established in Paris 1747 by Daniel-Charles Trudaine. Under its first director Jean-Rodolphe Perronet it became an international famous institution for research and education in construction of roads and bridges. The engraving by Louis-Jean Desprez shows an imagined situation (Musée Carnavalet, no. D.8157).



Johann Hartwig Ernst von Bernstorff (1712–1772) was a Danish member of the central administration, diplomat and Minister of Foreign Affairs. He established contact with Marmillod in France and supported him during his work in Denmark. Although no portraits of Marmillod are known to exist, he likely would have worn the same fashion, marked by a wig and shirt frill (Louis Tocqué, Nationalhistorisk Museum).

French road construction technology

Since roughly 1500, the policy of the French government for having a centralised kingdom had been maintaining good roads. On that count, progress began in earnest with the establishment of the civil central road authority, Le Corps des Ponts et Chaussées ('Bridges and Roads Corps'), in 1716. To support the government's intentions with plans for better French roads, l'École Nationale des Ponts et Chaussées ('National School for Bridges and Roads') was established in 1747 to educate engineers and, by some judges, was the world's first polytechnic institute. There, for nearly 50 years, the school's administrator was Jean-Rodolphe Perronet, often called "the father of engineering education".³

Another important figure in French road construction was Pierre-Marie-Jérôme Trésaguet, who followed Perronet as leader of the l'École Nationale des Ponts et Chaussées in 1775. His constructions were inspired by Inspecteur General des Ponts et Chaussées Henri (Hubert) Gautier (1660–1737), who in the 1693 manual *Traité de la construction des chemins* ('Treaty of the construction of roads) described an optimal road built with layers of large foundation stones covered by another layer of smaller stones in turn covered by crushed stones. However, one important construction detail was missing: the curved profile to remove the water from the road. That construction, later known as "chaussée" in Denmark, was presented by Trésaguet in 1775.⁴

Road construction in Denmark

By the mid-18th century, the roads in Denmark had long been terrible. The country was mostly lowlands without any stone from mountains. Moreover, because the Roman Empire had not entered such a northern part of Europe, the tradition of using paved roads and bridges built with stone had not been introduced in the region. Denmark, then as now, consisted of islands and a peninsula that made sailing essential for the internal distribution of goods. Although roads were occasionally broached in towns, their counterparts in the countryside were wheel tracks.

Since approximately 1550, Denmark's monarchs had attempted to improve the kingdom's roads, though their chief aim was to widen established wheel tracks so that the monarch and other officials could drive larger carriages. For decades, monarch after monarch pursued that policy but in vain. In time, the crown quit seeking to convince the citizens to drive with wider wheel tracks, and, in 1584, Frederik II unveiled a solution that would produce roads with broader wheel tracks: new roads exclusively for the monarch. Such road construction started primarily on routes to royal castles, which succeeded in Zealand with roads from Copenhagen and the first road in Jutland as well.⁵

In the long term, however, that policy did not succeed. In the 1700s, the roads in Denmark, compared with roads in other countries, remained dismal, and, in 1761, Frederick V issued a resolution for a plan for primary roads throughout the kingdom. The purpose was "both for the promotion of agriculture, commerce and internal intercourse, and for the convenience of travellers, to have new highways constructed in all provinces of the country". Even so, when a new administration for road construction was established in 1763, the king decided that the first road should lead from the border of Copenhagen to Fredensborg Palace.⁶

Denmark clearly lacked competencies in the state of the art of building roads. Knowing that the French had advanced technology, the Danish government ordered the Danish envoy in Paris to request assistance from French authorities. The French government, seeking good relations with Denmark, provided the envoy with the best help that could be found. Contact was established between the envoy and Jean-Rodolphe Perronet at École des Ponts et Chaussées, and Perronet recommended Jean Marmillod (1720–1786) as the person with the technical knowledge needed to be able to reform the Danish road system.⁷

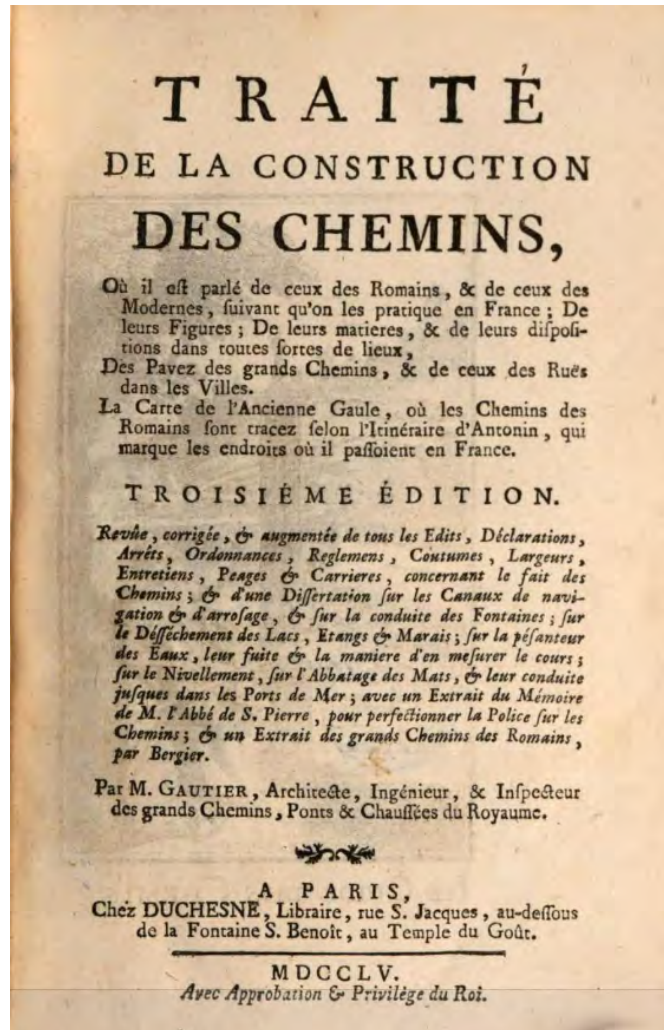


Figure 3. For years, Henri Gautier's text from 1693 was the basic book for road construction in France. This title shown page is from the third edition printed in 1755.

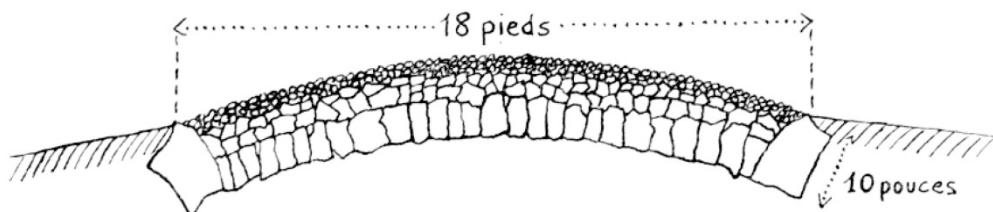


Figure 4: An improved profile was developed by Pierre Trésaguet during his experiments with roads around Limoge. What was once a horizontal surface gave way to an improved profile with a curved surface. The drawing is from his presentation in 1775. Marmillod learned to use the technology after he had worked with Trésaguet for some years.

Jean Marmillod

Jean Rodolphe Francois Marmillod was born in Château-d'Œx in the Rossinière valley in the canton of Vaud, Switzerland. His mother was a relative of Perronet from l'Ecole Nationale des Ponts et Chaussées,⁸ and as a young man, Marmillod travelled to France where he began working in road construction. Employed in the vicinity of Paris, he possibly learned techniques from Tresaguet, who worked on paving Paris from 1757 to 1764. Marmillod became sub-inspector for bridges and roads in Paris and, in 1763, was appointed inspector for the same area. In retrospect, one researcher has judged Marmillod's appointment as inspector to have been made by the "benevolent hand" of Perronet.⁹

In a letter from Anne-Robert Jacques Turgot to Daniel-Charles Trudaine in 1763, Marmillod is described as "a man of spirit and very hard-working". Moreover, at the same time, Turgot pleaded with Trudaine, the leader of Le Corps des Ponts et Chaussées, to prevent Marmillod from departing for Denmark: "If you think that you can take measures capable of retaining him, then I will be particularly grateful to you".¹⁰ Most likely, Perronet later intervened in the decision and made his will a reality. Beyond that, Marmillod was promised the same position upon returning from Denmark, as well as the first vacant position of general inspecteur at Le Corps des Ponts et Chaussées.¹¹

How Marmillod revolutionised road construction in Denmark

On 12 April 1764, Marmillod arrived in Denmark. Two engineers accompanied him to help him in his work: Philibert Boudin, an experienced engineer with 16 years of experience working with roads and bridges, and Hurault de Sorbée, a promising young engineer.¹² They negotiated a contract in which Marmillod would earn a fee of 2250 rigsdaler per year, a salary that underscored his importance in being 500 rigsdaler more than the fee paid to the director of the road administration. Added to that, Marmillod was to receive an annual food stipend of 260 rigsdaler and another of 60 rigsdaler for a riding horse. Meanwhile, Boudin and de Sorbée were to earn 1000 rigsdaler in fees and 200 rigsdaler in food stipends. All three also received free housing in the barracks at Jægersborg, along with lighting, wood for fuel and payment for their travel to Denmark. In 1767, for example, Marmillod received 54 m³ of wood and 143 kg of candles.¹³ In time, the two assistant engineers each received a grant of 60 rigsdaler for riding horses.

A month later, on 12 May 1764, Marmillod's plan for the work in Denmark was approved by Frederik V. According to the plan, numerous practical preparations were to be made. For one, gravel would need to be taken from all fields without crops. For another, peasants' carriages would need to be a minimum of 1.4 m long behind the coach seat and 0.7 m wide. On top of that, the land for the roads would need to be seized without requiring another institution to pay the landowners for their loss.

That same day, Marmillod also issued plans to construct the chaussée, as the new type of road had become called in Danish. According to the plan, the average chaussée built in a year would have a length of approximately 13 km. The labour force would need to provide 63,000 days of work on 150 days in the summer. Beyond that, carriages would need to be active for in total 5666 days.

Marmillod wanted to employ *piquers*—that is, technical officers used at the Le Corps des Ponts et Chaussées, whose task was to assist the works manager, supervise the work crews and ensure that the work was performed correctly.¹⁴ The chief surveyors were to earn an annual fee of 200 rigsdaler. To be specific, Marmillod wanted six piquers: four to work on the road and two to work on transport with carriages. The six piquers employed did not have Danish names; the three with French names were probably promising engineers known for building roads in France, whereas the roles of the others, likely individuals with military experience, can only be guessed.

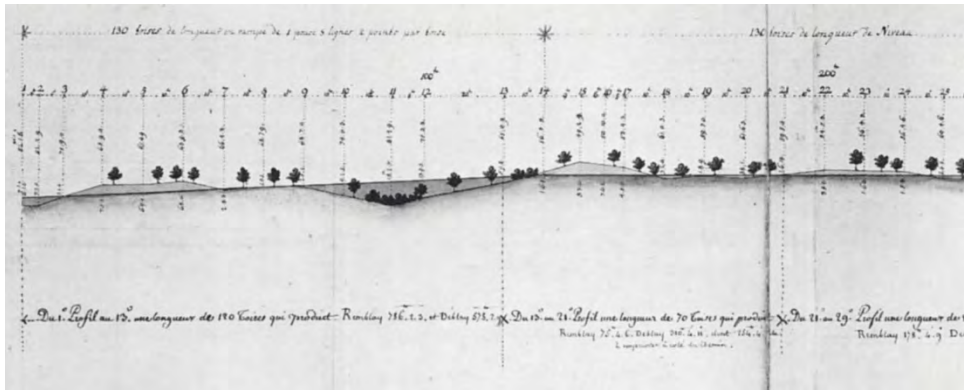


Figure 5: The drawing by Marmillod from the autumn of 1764 was used to calculate the amount of soil to be moved (Danish State Archives, Vejdirektoratet no. 1489, 13).

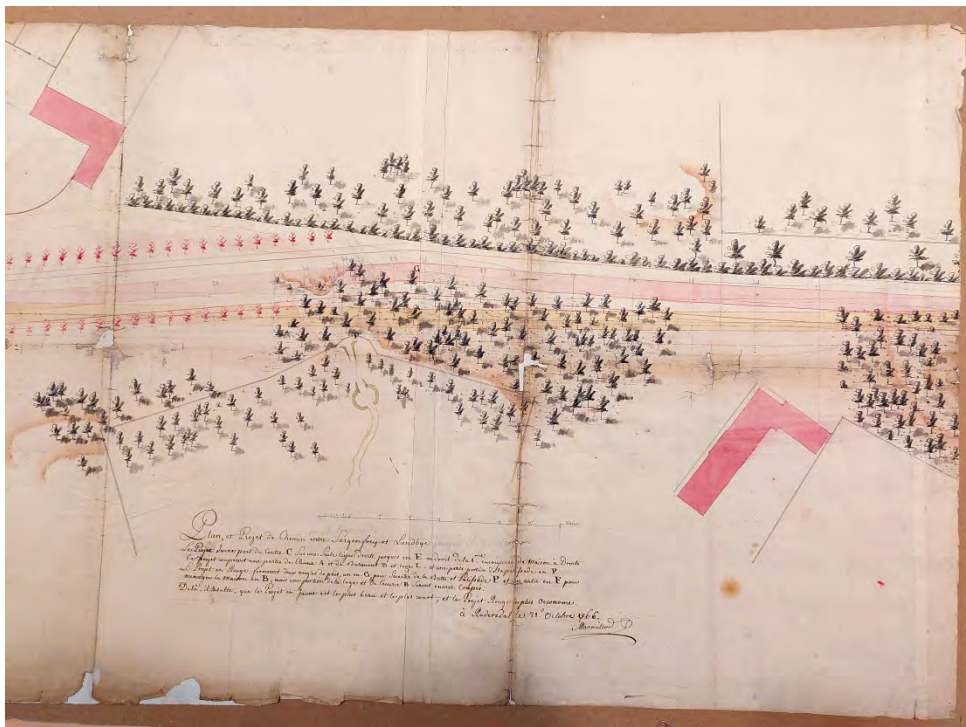


Figure 6: The king received this drawing for his decision for the route plan to his castle, Sorgenfri. There were two possibilities: one red and another yellow. Marmillod wrote: “The yellow project is the most beautiful and shortest, and the red project is the cheapest”. The straight line gave the best view, Marmillod indicated (extract of drawing from October 1765, Danish State Archives, Vejdirektoratet).

An essential part of the project for the Danish administration was the emphasis on technology transfer, as explained later. To that end, the crew contained two apprentices: Lieutenant Ægidius Gercken and Lieutenant Hans Frederik Rosenberg (1741–1806). Their importance is demonstrated by not only their annual fee of 200 rigsdaler each—a considerable sum for a young soldier—but also by their food stipend of 100 rigsdaler for a 150-day period.

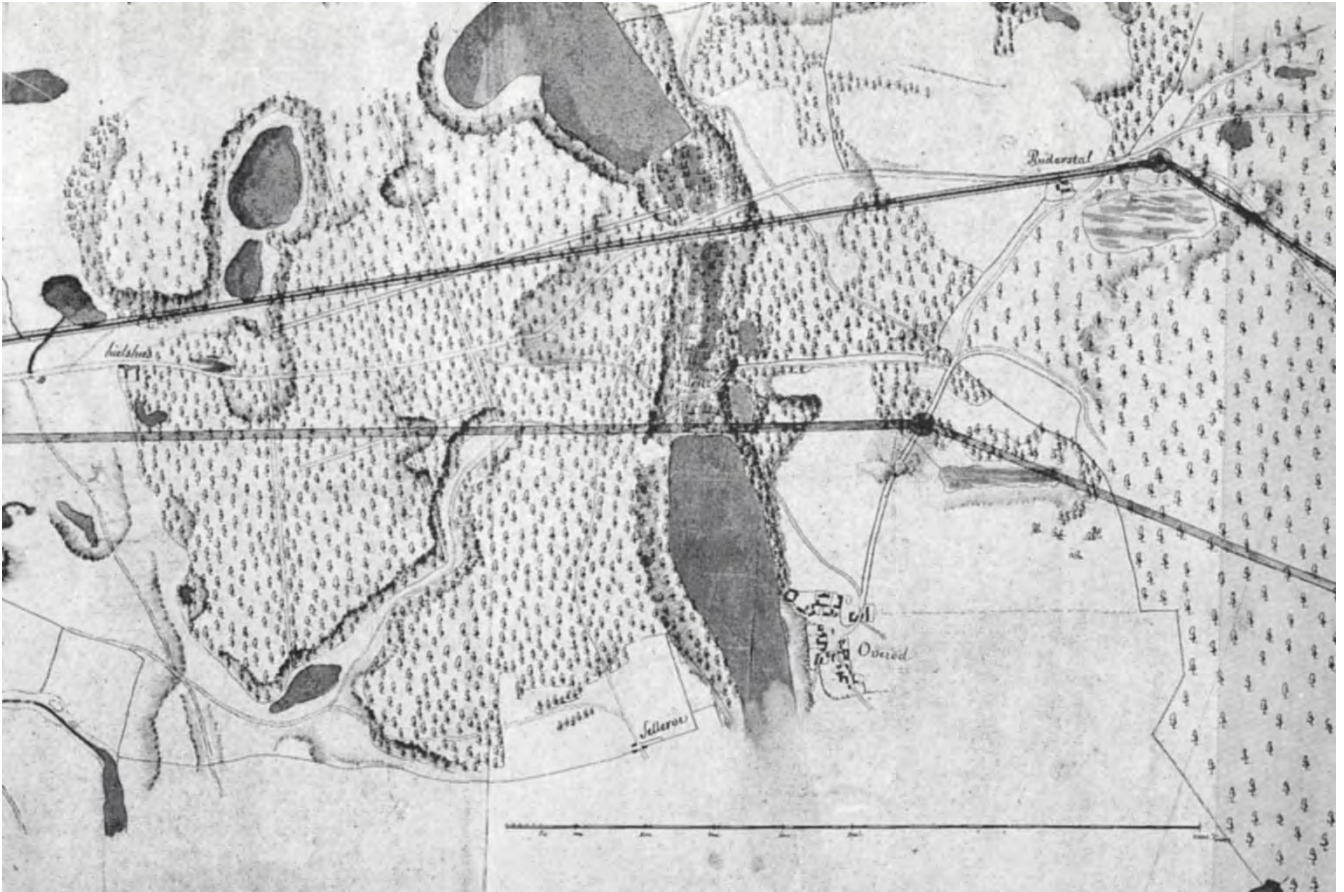


Figure 7: The drawing shows suggestions for road routes for chaussées north of Copenhagen. Note the straight course of the roads, whereas older roads had more complicated courses (Danish State Archives, Vejdirektoratet).

The administrative staff

Aside from the central technical staff was the administrative part of the road construction project. Responsible for the project was a director paid 2000 rigsdaler. Although the pay was 250 less than Marmillod's, the director probably had a supplemental income as well.

Many practical helpers were also needed to handle practical matters. Approximately 40 coachmen were to be ready to transport gravel and stone in the summer, whereas only 20 were necessary for the winter. They had 80 horses to pull their carts, both large and small, and carriages with the materials. A feed master and a groom took care of the horses, while a smith, a wheelman and a saddler ensured that the transport system was up to date.

Of course, the permanent staff did not handle all work with bridges, which had its own account due to the need for carved stone and wood. For that work, master artisans were likely hired.

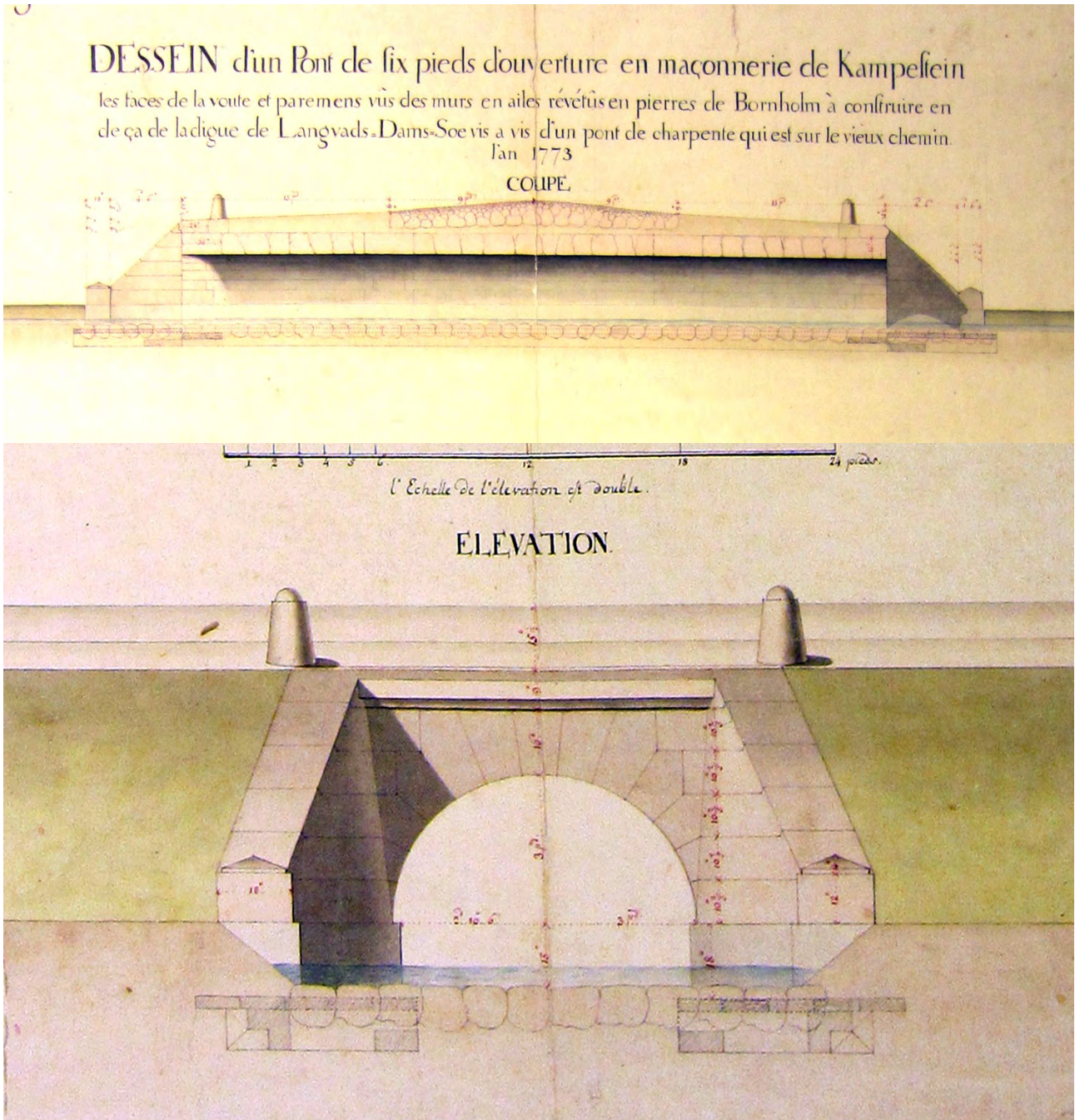


Figure 8: This drawing of a bridge from 1773 shows how Marmillod did not write in Danish. In his French text is the Danish word *Kampestein* ('boulder'), referring to stones from Denmark's mountainous island of Bornholm that were used for the bridge. Note the curved profile of the road (Danish State Archives, *Vejdirektoratet*).

Many of Marmillod's bridges remain in service today. At heavily trafficked roads are they often made wider.

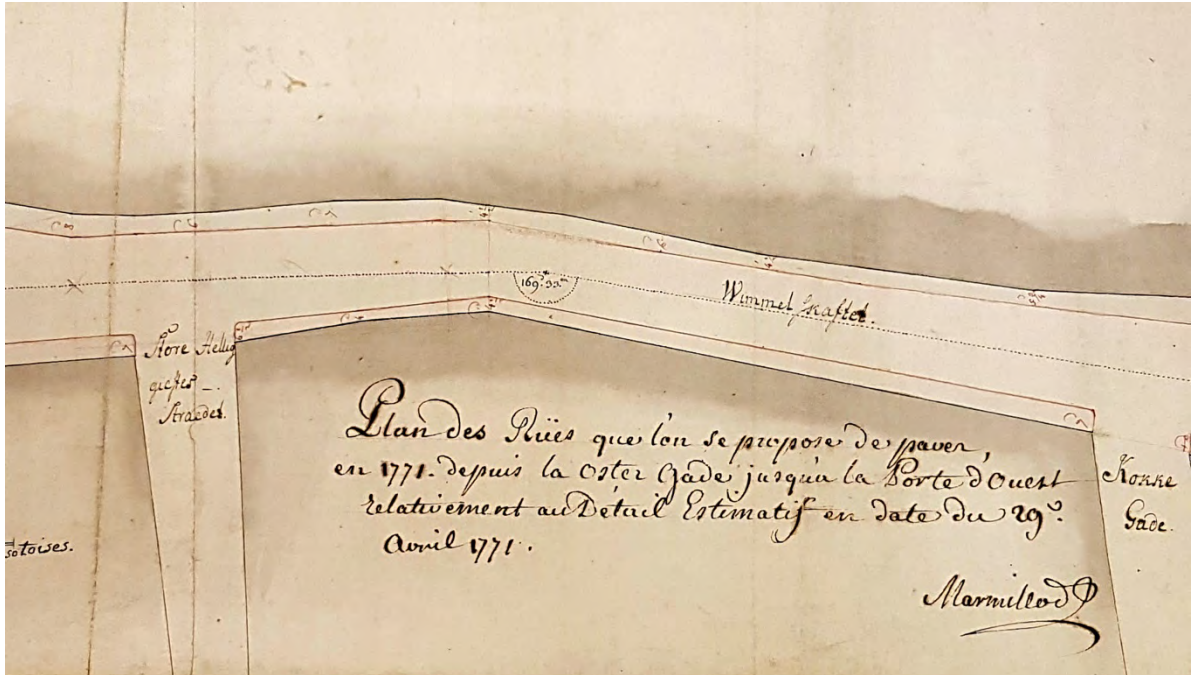


Figure 9: Marmilloid introduced sidewalks in Copenhagen, became consultant for the town and advised on the construction of infrastructure. The figures A-B were the old profiles of the streets and C his suggestion for improvement (Københavns Stadsarkiv).



Figure 10: The first chaussée was painted by Andreas Juel in 1851. The house on the right at the foot of Geels Bakke is a tollbooth to generate revenue for road maintenance (Rudersdals Museer).

The daily work

The practical work in the fields was performed by soldiers. Albeit from different regiments, the soldiers were later grouped within the newly established Corps of Engineers.¹⁵ Although they started in 1764 with 100 men, when a larger workforce proved necessary, their ranks were increased. In 1766, the workforce increased to 630, but that number was reduced to between 308 and 411 soldiers in the years that followed.¹⁶

To lead the soldiers, some non-commissioned officers joined the staff. One year, 12 officers were involved, though the amount was fewer in most other years. In all years, two drummers also joined the soldiers; besides working as drummers, they served as *ordonnans* ('messengers') and supervised the paperwork and instruments used in the project.

The soldiers did not work on all days. In 1766, for example, they worked on only 180 weekdays. Such limitations in work performed were probably due to the weather or the need for labourers in other jobs. Indeed, there was so much work available in the construction project that they even worked on 36 holidays.

The soldiers were to work from 5 to 11 a.m., weather permitting. After a two-hour rest, they continued from 1 to 7 p.m. According to the regulations, the superior soldier was to allow them to rest on Sundays and holidays; however, in some years, they apparently worked on those days as well. Even so, such work was done only in the afternoon, which explains why they received only half-pay for those days.¹⁷

When the work was near Copenhagen, it also involved the use of slave labour, presumably performed by prisoners at the House of Chastisement and Improvement.

Marmillod, or one of his two assistants, issued instructions concerning the site of the work, while the superior soldier equipped the camp for the soldiers close to the site with tents, including berths and carpets for the soldiers and other equipment. Although one camp was initially established, as the soldiers began to work at several sites, camps were established near those places as well.¹⁸

Four times a day, the drummer would announce roll call before and after a work period to ensure the participation of all soldiers. Because the authorities did not trust the officers, one of the piqueurs was made responsible for the soldiers' presence as well.

Peasant work

Delivering the necessary stones was the task of peasants living in the area near the coming roads. In their usual work, they transported stones via carts from their property to the road, at distances of up to nearly 2 km.

Although peasants were initially intended to play an essential role in the workforce, the harsh realities of the work presented them with severe limitations. They complained about having to perform a great deal of work for the crown while also running their farms, complaints brought into particular relief by the fact that the first roads built were near royal palaces and castles. They could not handle both their agricultural work and the unpaid work of road construction.

Understanding the peasants' complaints, the road administration procured the money to rent carriages and began paying peasants for their work. On average, 40 peasants were employed in the summer and 20 in the winter.

The construction

Before construction could commence, the administration and, in the end, the monarch needed to approve the plans for the routes. Two land surveyors conducted a topographic survey along a route approximately 70 m wide, and, later, for the first part of the project, two specially appointed soldiers measured the route.

However, when the work needed to be performed in several places simultaneously, including along the relatively long route to Roskilde, eight soldiers were involved.

The approved plan mostly envisioned straight lines. Once the many landowners were compensated for the transfer of their lands, the first task was to fell trees and perhaps pull up roots.

Marmillod or one of his assistants drew a levelling map from which the amount of land that had to be moved could be calculated. Soldiers dug the roadway in preparation for processing. The road had a width of 17.9 m total, with the central stone-coated part measuring 5.6 m, the dirt road for riders and pedestrians measuring 4.1 m and ditch on each side measuring 1.9 m. For each metre of the road, 2 m³ stones were used, which at their halfway points formed a bottom 0.3 m high. At the bottom, the soldiers placed large stones and, upon them, somewhat smaller ones. On top, they stampede gravel down with rammers, and the construction was held fast with large stones at the sides.

The organisation of practical matters often created problems. For instance, when the peasants were unable to sacrifice the necessary number of workdays, another solution was necessary: using soldiers supplied with hired workers paid by the public purse. At another point, when the peasants would not replace their smaller carriages with larger ones, the demand for the larger dropped. It was also necessary to acquire tools for the work, including hammocks for the soldiers' overnight stays. In that case, one acquisition was 40 simple gravel harps bought from France.

Beyond practical matters, in January 1766, King Frederik V died, and the new king, Christian VII, did not prioritise his own castles north of Copenhagen. Instead, the most essential road in Denmark, from Copenhagen to Roskilde, began to be constructed even though the road to Fredensborg was incomplete.

Marmillod not only assessed the new constructions but also the handling of repairs. He realised that peasants were filling the road surfaces with mud from cleaned ditches, after which they would distribute sand and gravel on the surface from the backs of their carriages. As a consequence, the road surface usually fell into disrepair rather quickly. In response, in 1767, Marmillod issued formal advice to the county official of Copenhagen County about how the surface of the roads should be maintained.

When longer pieces of roads were finished, milestones became relevant. The Royal Postal Service had many stones made of Norwegian marble intended for the duchies and donated 36 stones to the finished roads in 1771.¹⁹

French sidewalks in Copenhagen

Knowledge of the French expertise in road construction spread to the town of Copenhagen. Marmillod was hired to build sidewalks, or *trottoirs* as the French model was called, as experiments. The city praised the results, and, in 1765, Frederik V established a commission to work on further renovating the roads and sidewalks. A few years later, in 1769, Christian VII regulated the use of the new sidewalks. It "is forbidden to ride, roll with wheelbarrows ... on the trottoirs ('tiled sidewalks')". Apparently, the new thing was the tile on sidewalks.²⁰ According to the king's description of the task, the project was to extend from one side of the town to the other. In that light, the commission also worked with gutters and the diversion of water into the harbour.

Marmillod also suggested paving the streets in Copenhagen. For the new construction, he recommended using small cubical cobblestones and made careful drawings of profiles with gutters and sewers. As the constructions show, the suggestions were apparently followed.

Unstable situation

With the new king, Christian VII, sick with schizophrenia, the state administration was unstable. The economy for road construction had exceeded the state economy why economic cuts were implemented. A new leader responsible for the road administration was engaged, and his plan for the future involved salary cuts for Marmillod and his two assistants. Marmillod refused to accept the cuts, and by the end of 1766, the administrator had dismissed all three Frenchmen.²¹

However, Marmillod had proponents who convinced Christian VII that Marmillod should be rehired. In April, Marmillod received a new contract with the same conditions as before, including that he could leave the country after seven years of “faithful service” with a yearly pension of 600 rigsdaler. The contract was expanded with agreements concerning his work on paving Copenhagen and that allowed his son to be employed as an apprentice in the Danish navy.

From the outset, two trainees were affiliated with the project—Ægidius Gercken and Hans Frederik Rosenberg—both of whom received 200 rigsdaler and, for food stipends, 100 rigsdaler for 150 days of work. Philibert Boudin and Hurault de Sorbée ended their engagement as conductors in 1767, and, in their place, Rosenberg and a former piqueur, Champayel, assumed their roles. At the time, Rosenberg’s younger brother, Johan Frederik Rosenberg (1745–1811), may have assumed the position as an apprentice after his brother.²²

Denmark’s weak economy was also a recurring problem. In 1770, it seemed that revenue from the national lottery administered by the Royal Foster Home and the Poorhouse would be dedicated to road construction. However, the lottery did not yield the expected amount, and the administration had to make cuts in the budget. A new income was introduced in 1773 with a toll for driving on the new roads that tenants were responsible for collecting.

The Danish literature on Marmillod’s merits is rather long. Unstable political decision-making processes caused by Christian VII resulted in the French engineer’s dismissal, although a coup d’état a few years later produced a new political situation. In all, Marmillod’s position as leader of road construction in Denmark was threatened six times, but he survived in his position until 1775, when a defamation trial spelled his fate. In September 1775, people in Copenhagen gathered and bore witness to the auction of his belongings. The household goods were of a quality suited to the upper class, with French and English books, silver, copper, furniture in mahogany and so on. For the family’s transport, they drove in a lacquered tub or mail cart pulled by two mares. For his personal transport, Marmillod rode a mare.²³

A study on Marmillod’s work has characterised him as a competent professional. Beyond that, he was a skilled administrator able to delegate tasks and at once maintain control and actively supervise. Most important, during his 11-year survival in the role, he understood how to play the political game even though he continued to write and probably speak in French.²⁴



Figure 11: The memorial stone was erected in 1925 on the occasion of the sesquicentennial celebration of the first chaussée in Denmark. The text reads “Frederik V summoned 1764 / From France oberst Marmillod, / who supervised the installation of this / Denmark’s oldest highway”.



Figure 12: Marmillod trained his apprentice Hans Frederik Rosenberg to be experienced enough to assume responsibility for building Danish roads at the time that Marmillod would return to France (Royal Library, Copenhagen).

When Marmillod returned to France in 1775, he became first engineer in Fontainebleau. Later, in 1777, he became chief engineer in Dauphiné, where he built dykes and bridges at Rhône and Isère. In 1785, he became inspector general, a role that he held until he died in 1786.²⁵

Marmillod's legacy in Denmark

J. H. E. Bernstorff is mentioned as the essential figure behind Danish connection to Marmillod. On several occasions, he was a member of commissions that helped the Frenchman, and he was important for the affiliation of the Rosenberg brothers as apprentices as well. Their father was an important architect, Johann Gottfried Rosenberg, who built a palace for Bernstorff in Copenhagen. When Marmillod departed Denmark, Hans Frederik Rosenberg assumed his role as chief inspector of the roads. In 1785, he also took over responsibility for the entire national road administration. When he died in 1806, his brother Johan Frederik took over the position until 1809. The Rosenberg dynasty did not end here, for a son to Johan Frederik, Gottfried Rosenberg (1784–1849), became colonel at the Corps of Engineers and responsible for building chaussées in Jutland.²⁶ In the mid-1800s, the last of the planned chaussées were built in Jutland, and the plan from 1784 was fulfilled.

In the history of roads in Denmark, Marmillod is a vital figure who raised road construction in the kingdom from poor standards to the standards of France. Though Marmillod worked only 11 years in Denmark and though only approximately 100 km of roads were built in his time, his work left an impression on Danish infrastructure. Equally important was his effort in teaching Danish technicians to handle French technology. His plans were followed, and a hundred years later, his designs characterise the primary roads throughout the country. Even today, the straight roads and solid bridges that he designed are used in everyday life.

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- ¹³ Hertz (Note 11) pp. 67 and 93.
- ¹⁴ www.cnrtl.fr/definition/piqueur
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- ¹⁶ Hertz (Note 11) p. 167.
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- ¹⁸ *Ibid.*, p. 26.
- ¹⁹ Hertz (Note 11) pp. 85-86.
- ²⁰ *Ordbog over det danske Sprog*, lookup on "Trottoir".
- ²¹ According an account for 1766 the last payment for Marmillod and others were 31th of August.
- ²² There has been confusion about the persons. For instance, in L. Bobé, *Efterladte papirer fra den Reventlowske familiekreds*, Copenhagen, Lehmann & Stage, 1922, p. 351, is problematic information.
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