Sytze Wierda – Ventilating the Republic:

How did the architectural discourse of the nineteenth century on physical wellbeing influence Sytze Wierda in his work.

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Abstract

Sytze Wierda lived in a time in which ventilation and healthcare became increasingly important themes in architecture. Wierda was actively involved in this discussion, designing a stove that is more efficient and using natural ventilation in fairly inventive ways. Sytze Wierda knew how to judge new novelties and when it would be a good idea to implement them. Early in his career he discarded ideas of air heating, while later he was to implement them in his design for the Palace of Justice in Pretoria. It shows the adaptability of the architect.

Introduction

Sytze Wierda came to the Zuid Afrikaanse Republiek in 1887 to start working for 'het departement publieke werken' (departement for public works). He mainly got this job because of his knowledge in the construction of railroads, something in which he made a fast career in the Netherlands. But as the planning of new rail infrastructure came to an end in the Netherlands he had to start looking for a new opportunity.

The opportunity came with the new politics of the ZAR that asked for skilled engineers from the Netherlands (as a 'sister' country). These engineers, that the ZAR lacked, had to help built up the newly independent country. Sytze Wierda was, as a skilled engineer with knowledge of railroad-construction, an ideal candidate. With the help of Hendrik Theodor Bührmann, he finally managed to get appointed by the new government. From November 1887 he was appointed 'Chief Engineer and Architect for the Departement Publieke Werken' for the ZAR (Rex, 1974, p. 323; Wierda, 1871) replacing Klaas van Rijsse junior (Picton-Seymour, 1977, p. 275).

During his time in the ZAR Wierda was mainly in charge of the design of major public buildings. He came to be one of the most important architects of the late nineteenth, early twentieth century in the Transvaal region.

Although his buildings speak, up to this day, to many, this is mainly because of the immediate allure they show in their details and ornamentation, it is not as widely known that Sytze Wierda implemented many physiological design ideas on ventilation, heating and cooling in his buildings. In this paper we will look into the climatic ideas and designs of Wierda and we will place them into the common practice of his time and age.

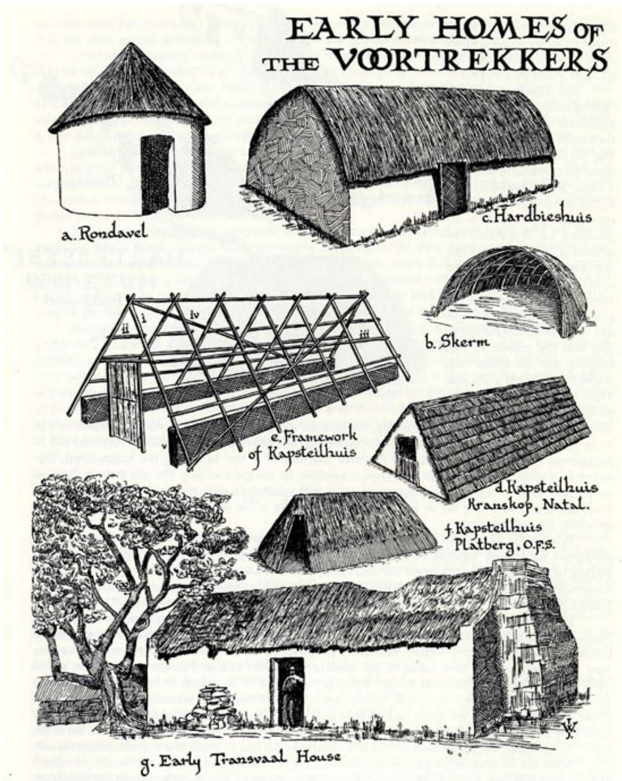
Wierda lived in a time in which many new inventions were accounted for in the field of building physics and healthcare. Before Wierda, most people lived in substandard conditions. At least compared to our standards, that have greatly improved over the last two centuries. Major leaps forward have been made in the fields of ventilation, heating, hygiene and comfort. In this paper the focus will be on ventilation and heating, two interrelated subjects that greatly contribute to comfort. I want to research the influence Wierda had on the architectural discourse on physical wellbeing and vice versa.

For my research I will firstly, to get a better grasp on what was the architectural practice of the ZAR when Wierda arrived, look into the history of Transvaal architecture. Secondly I will show Wierda's design for a heating stove he made for a school in the Netherlands. This design was nationally introduced in the magazine for building engineers, in which it was presented as an article written by Wierda himself. And from this article we will compare his ideas to the ideas of other contemporaries. Thirdly I will be looking at buildings Wierda and the DPW designed and that have solutions for ventilation and cooling.

To conclude we will combine all the retrieved information to be able to better place Wierda in the discussion on ventilation that was fought in the nineteenth century.

African architecture in the early years of the Transvaal

British domination of the Cape Colony in the southwest tip of the continent during the nineteenth century provided an essential cause for an organised emigration of thousands of Afrikaner frontier farmers and their labourers in the direction of what was to become the ZAR (Fisher, Roux, & Maré, 1998, p. 25). The 'Voortrekkers' as they are commonly called had three sources for their building culture; tradition, innovation and borrowing (Labuschagne, 1998, p. 25). In the light of these sources the vernacular Afrikaner architecture came into existence. These first houses and buildings where often of a less permanent character due to the nature of the Voortrekkers and made of wattle-and-daub, sod, clay, and cob or rammed earth. Brick houses were not very common in the early years of the Transvaal and mostly used for more permanent and main buildings while the secondary buildings were to be built of other more resourceful building materials. Stone was also one of the materials used, but it has been argued that the Voortrekkers were not the first to build buildings out of stone and that it was already used by the indigenous tribes. Stone was mainly collected from the surface because quarrying would require the wagons in which the families lived to be used. Were stones to be quarried, than it would always be from a place



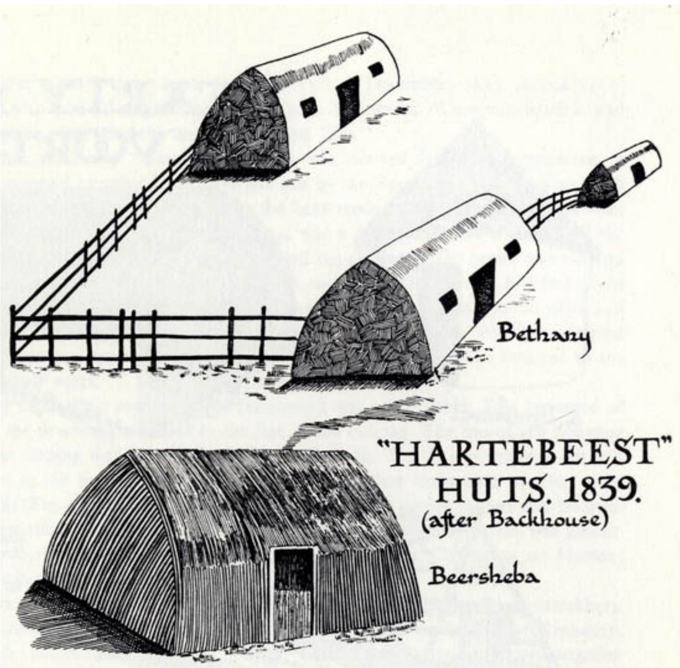
1. Early Transvaal houses - J. Walton, Homesteads and villages

near the building site. (Labuschagne, 1998, pp. 26-35).
Wood was a relatively rare material and very valuable. The best types of trees were to be used in the wagon building, while lesser quality timber (regarding straightness and thickness) was used in building construction.
As mentioned earlier the first buildings were of simple construction and layout often taking inspiration from the indigenous buildings. These 'rondavels' existed of a round, cylindrical base, with diameters between 4 and 6 meters and a conical thatched roof. The rondavels were commonly used as first farmhouses around 1880 and were also built as annex for a kitchen or as a separate house for the sons of the farmer. Another early building type was the hartbees house. These houses were built up with a low wall and thatched roofs that nearly stretch to the ground often approaching verticality. Closely related to the hartbees house was the Kapstyl house. Kapstyl houses were built by erecting around eight A-frames, that were placed one after another and again it was finished with a thatched roof.

Early types of more permanent structures were initially formed by a concatenated row of rooms that followed the I-plan. The plan was suitable for saddle or hipped roofs. Sometimes the basic I-plan was morphed into a T, or L-shaped plan often housing the kitchen in the short leg, closer to the yard.

During the latter half of the nineteenth century corrugated iron roofs came into being as a favoured building material for roofs, with as its main advantages; weight and transport volume. Around 1900 it was the prevailing roofing material in the ZAR.

Verandas were not very common during the early days of the Transvaal settling. Most houses however had a 'stoep' a slightly raised patio in front of the house. The stoep became a typical part of Transvaal architecture from the early days onward and eventually evolved into the covered porch/veranda.



2. Hartebeest huts - J. Walton, Homesteads and villages

Circulating Stove and ventilation technology

As mentioned before the climatic adaptations in the ZAR buildings were mainly limited to the addition of covered outside spaces. These spaces were and still are common practise in South Africa and proof to be efficient spaces that block the harsh summer sun while still allowing the cooling effect of the wind.

During Wierda's lifetime there were many developments occurring in the field of climate control. The C19 was a time in which air pollution, in the rapidly growing cities, was probably an even more urgent issue than it would be now.

"...the mere fact that the combustion of illuminants was inefficient and that most of the outdoor pollutants were wastes, gave an immediate and compelling motive for environmental improvement without waiting upon humanitarian legislation or political action by the victims of pollution." (Banham, 2013, p. 30)

"Volgens de toenmalige inzichten was 'luchtbederf' ook verantwoordelijk voor wat men miasmatische ziekten noemde. Er zou namelijk een zekere relatie bestaan tussen de slechte kwaliteit van lucht en vochtige grond en het voorkomen van bepaalde ziekten." (Stokroos, 2001, p. 32)

The scholars of the late nineteenth century were convinced that many of the diseases that arose because of an increasingly industrialized Europe could be accounted for by evil organisms that flew in the air. It was shortly after proven that these organisms, bacteria, accounted for cholera and typhus (van der Woud, 2011, p. chapter 7). Academics and technological intellectuals started to think of solutions. They saw a better way of combustion and increased ventilation as suitable solutions. At that time houses were predominantly heated by the means of small stoves that were solely capable of heating the room they were situated in.
The Franklin stove, after a system of heating that was introduced by Benjamin Franklin in 1742, was a system widely used in the C19 and consisted of a small stove with a syphon fume outlet in which the syphon functioned as a heat-exchanger passing an air duct that came from under the stove and led air into the room above the stove. The hot fumes heated the air so it would rise and enter the room, sucking cooler air in from elsewhere. With his invention, Benjamin Franklin was one of the first to heat a room with hot air instead of using the stove as a direct means; it was by the separation of warmed air and smoke or fumes that this was achieved (Banham, 2013, p. 48; Snow, 1923, p. 213; Stokroos, 2001). Franklin however was not the inventor of neither of the systems he utilized and the basic set-up of his stove had already been theorized by the Frenchman Nicolas Gauger (ca. 1680 – 1730) which he published in his book 'La Mécanique du Feu'. This book was translated into English and has most likely been read by Benjamin Franklin. Franklin however improved Gaugers design to make it produce more heat and produce less smoke (Cohen, 1990, pp. 200-203).
In the time of Wierda most houses and buildings in north-west Europe were heated by a stove or an open or partially open fireplace. Many of these had problems regarding health and comfort. Wierda himself, presenting his own stove-design for heating a school building, states the following:

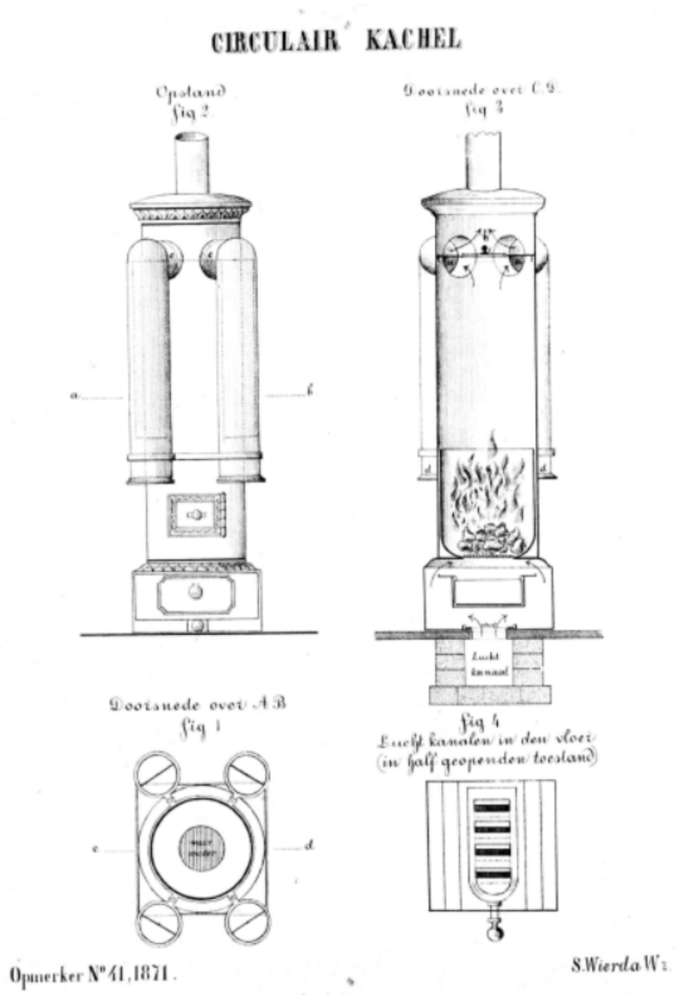
"Since long, regarding the valuable fuel, technicians have strived to construct a stove that is not only economical in fuel use but also spreads an even, comfortable and in no way

harmful heating. There is no shortage of heating systems but the dissatisfaction that is often encountered from different sides, proves that there is much to do in this field, as in so many others."[1] (Wierda, 1871, p. 2)

This brought him to designing a stove through which the hot fumes would circulate for the optimal exchange between the hot combusted air and the to-be-heated air in the classrooms. This 'circulating stove' is not to be confused with the circulating stove Franklin designed as mentioned above. Their respective systems of heating the room differ completely. Franklin's stove heats an air duct which generates a circular airflow whereas Wierda's stove heats the room by an increased contact surface and does not stimulate airflow circulating. Wierda argued that ventilating a room with preheated air was not favourable over his system.

"Many make use of ventilation by the inflow of preheated air. The experience of such is possibly still too shallow to be judged, but with little knowledge of physics it can be understood that the thus heated air, due to its high temperature will rise directly after entering the space, and only slowly penetrate to the layers of air below. Besides this, the ventilation vents for the removal of foul air, also allow the fresh air to leave the space, which makes them difficult or nearly impossible to heat. In these cases it became necessary to build in air-outlets at floor level. A system that works against the laws of physics and can only be realized with the use of health-disadvantageous artificial power.[2] After all the application shows us that the foul air will be drained through outlets in or near the ceiling, where tubes lead it through the roof out and that through inlets, close to the floor, cold and fresh air will be let in, but not vice versa. The way of ventilating that I have followed exists of a upward air purification because of which the outlets are situated as much as possible in the middle of the ceiling. Because the fresh air, that is let through the exterior walls, will push the foul air a little more to the middle. These outlets are provided with shutters which make control of the ventilation possible. The inlet of fresh air takes place outside in the plinth and continues straight up through the exterior walls and enters the classrooms at a height of two metres above the floor though iron rosettes that can also be adjusted. The mentioned height is a little more than that of a man to prevent draught. For the air layer that is below these inlets, which is not thoroughly ventilated because of the existence of people and furniture, inlets are provided on the floor along the walls that can be opened and closed and are directly connected with the outside air, to thus be able to realize a fast purification."[3] (Wierda, 1871, p. 2)

These sections out of his article, in which he markets his new improved design for a circulating stove, clearly show the capacities of Wierda, as a skilled craftsman and intellectual, capable of utilizing physical laws in his building designs. Wierda shows an interest in the wellbeing of the users of his buildings and at the same time addresses an issue at the interest of his clients. It is his system that efficiently reduces fuel consumption with a mere fifty percent by using one stove for two classrooms, as it is placed in a niche in the partitioning wall. And through a sophisticated system of syphons enlarges the surface area drastically, exploiting heat exchange. He agitates against the use of mechanical ventilation, being mainly ventilators, a system that had started to become widely used in the United States from the 1860s onward. In those days however, the system was still very inconvenient. It required a large power source to propel the ventilator. It would be the invention of the alternating-



3. Circulair Kachel - S. W. Wierda, de Opmerker v6 n41, 1871

currents motor by Nikola Tesla and the development of domestic electrification which both took place in the 1880s, that truly started the mechanical ventilation era (Banham, 2013, pp. 53-54). The ventilator could be placed anywhere in the building and could force an airflow in any wanted direction. Wierda was very much against the use of preheated air because it would leave the building before the cooler foul air. This could only be prevented by turning around the airflow and this would go against the laws of physics, basically just slowly pushing out the foul air by a buoyant layer of fresh blown-in air.
On the field of maintenance Wierda also showed his compassion with the eventual users of the building. The stove exists of simple elements. The fire burns in a pot with a grill in the bottom which allows air to flow in for the combustion. The pot is enclosed in a metal column which is sealed near the top by a partition. Along the sides of the column, four tubes run down that take the hot air down from the partition and lead it through them to come back up into the top of the column just above the partition and make it leave the building through a flue. All elements that need regular cleaning are demountable and there are special places where ash will collect to further improve easy maintenance. The stove is made of wrought iron, a type of iron containing less carbon than the otherwise used cast iron. This was done to reduce the effect the glowing stove had on the surrounding air and which was to cause either carbon mono-oxide or carbon dioxide. Furthermore the fire pot was extra high, minimizing the possibility of fire getting in direct contact with the column.
Ventilation was an important topic for doctors and scientists during the nineteenth century in the industrialising countries. It

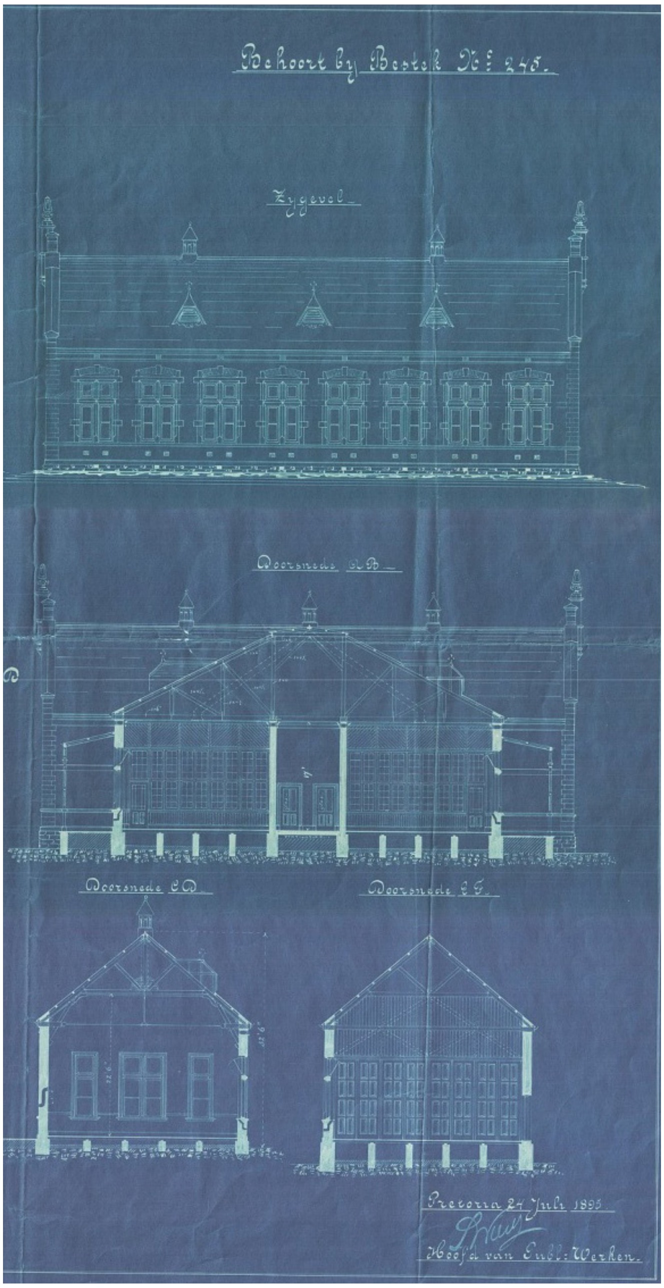
was however not common practise to have a ventilated house around 1860 in the Netherlands. But there were already easily implementable systems that would not be expensive (Stokroos, 2001, p. 33). Small pipes which could be built in the brick wall, which could allow airflow when a hatch was to be opened, were a solution that were among the easiest applicable and that Wierda used in his designs throughout his career. It was during this time that many inventions were promoted that would reduce the problems these systems would sometimes have. The iron foundry F.W. Braat in Delft had a large collection of air exhausts that could be mounted on top of chimneys to increase suction and prevent rain from entering as did they produce several vent covers. Wierda used products like these frequently in his architecture and since Braat was a well-known name in the Republic (Bakker, Clarke, & Fisher, 2014, p. 173) it is very likely that Wierda used these in his designs.
Ventilation in combination with heating was a relatively new concept of the time. And as mentioned before, Wierda was not in favour of it as it still had many flaws. This had to do with the sometimes weird consequences of implementing such a system; pollution of the heated air, air flows that had to be guided with ventilators, dry and uncomfortable atmospheres and a devious way to employ are amongst the most mentioned arguments (Banham, 2013, p. 52; Stokroos, 2001, pp. 39,43,44). For larger public buildings, large systems were installed that looked complex and took up much space. These heating machines were often placed in the basement and were mainly effective in an upward column in close range of the machine. This asked for several machines spread over the entirety of the basement floor in case of a large building. Fresh air would thus be heated in the basement and would be guided in its upward direction through pipes and through the rooms above the machine, to finally leave the building through the roof. The preheating of air would drastically lower the humidity of the rooms and measures had to be taken, very similar to the ceramic pots, filled with water, that were hung on radiators as late as one decade ago.

Wierda in the Republic, 1887

After arriving in the ZAR, Wierda was rapidly appointed Government Architect for the Dienst Publieke Werken. In this function he designed several governmental buildings in the new republic. The first one being the Ou Raadsaal (1888-1892) and later the Staatsdrukkerij (1895-1896) (with K. van Rijsse) and the Paleis van Justitie (1897-1904), which he never saw finished. He and his fellows developed a style inspired by the influence the Beaux-Arts and Karl Friedrich Schinkel had on European mainland (Fisher & Clarke, 2014) and often being referred to as nineteenth century eclectic Wilhelmiens (Bakker et al., 2014) or Transvaal Republican style (Picton-Seymour, 1977). It is a style characterized by the Dutch roots of many of the architects in the department who had to look for a style appropriate for governmental functions. During his time working as chief architect for the department, Wierda designed and co-authored several buildings. These buildings often took special measures and advanced techniques to cope with the sometimes harsh climate found in the ZAR, which was characterized by hot and wet summers and dry and cold winters. One of these buildings is the Staats Model School.

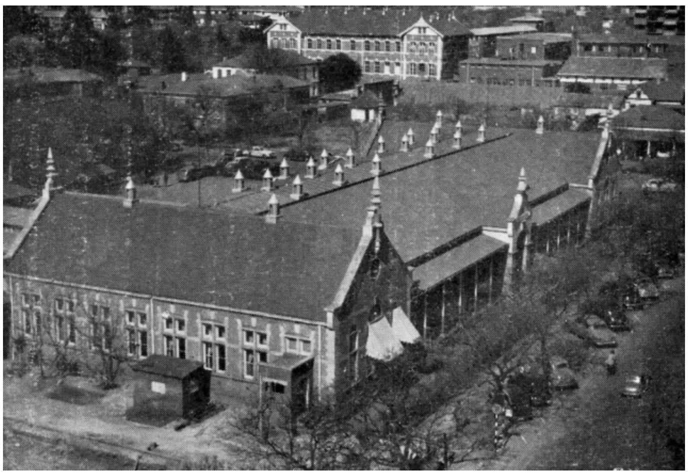
The Staats Model School

The Staats Model School (1895-1896) was built to house a teacher training facility, but served several other functions during and since the Anglo-Boer war. It was designed to be an example on how schools should be built in the ZAR. One of the most notable functions was the use as a war prison from which Winston Churchill escaped during the Anglo-Boer war. Nowadays it is owned by the Gauteng Department of Education. The Staats Model School is a typical example of architecture during the era that Sytze Wierda was in charge as chief architect. With its red brick facades and ochre dressings it was the typical way to go for governmental buildings of lesser allure (Picton-Seymour, 1977, p. 282). Looking at the plans we see a very simple, organized structure, existing of three bays, two pronounced ones at the heads of the plan and one longer main bay with a pronounced entrance. This entrance was designed to be related to the size of the imagined user and was thus small. Special classrooms like the gymnasium and the music and arts rooms were situated in the two larger bays. Between these two, in the central bay, there is a corridor connecting all classrooms and which is being crossed by an axis orthogonal to the building crossing it through the middle. These two axes form the main organization of the building. Along the perpendicular axis ten classrooms, a staffroom and a library are organized, with the two more representative functions obviously guarding the entrance.



4. Sections of the Staats Model School, DPW

The building plans show us many interesting features that show the wit of Wierda and his fellows. As many of the buildings in South Africa, it is built with saddle roofs that provide shelter from the summer heat. This roof has no use as a utilized space but has a very important function in the physical properties of the building. To prevent the rooms below from overheating the whole roof space is ventilated by air scoops, that somewhat resemble the dormer windows that were in fashion the eighteenth century in city houses in the Netherlands, and large circular air inlets in the gables, to provide extra ventilating above the larger spaces.
In front of and behind the main bay, verandas are situated that further shade the classrooms from direct summer sunlight that is very much unwanted.
The floors of the rooms are ventilated from below by ventilation openings in the plinth that ventilate the floor cavity. Ventilation is a very important topic in the climate physics of the building, which has an ingenious system of ventilation to keep the classrooms comfortable. Air was let in through openings under the windows in the exterior of the building and would let in air through a canal in the wall entering the classrooms just under the windows. By leading the air through the walls it would be precooled or heated before entering the room, improving the interior comfort. Foul air that had to be removed was sucked out of the room by simple physics. The warmer used air would rise and push on the ceiling. Where an air outlet was situated which let the air out of the room through a pipe through the roof space exiting the building on the ridge. On the ridge the ventilation pipe was topped off by a ventilation tower which sucked out the air due to the venturi-effect. Added to this the foul air would increase slightly in temperature when traveling through the plenum which adds to the upward motion, making the system even more effective.
As can be observed this system is similar to the system Wierda promoted back in the Netherlands (Wierda, 1871). Both systems make excellent use of the upward motion of warmed air and use this motion to ventilate and renew the interior air in a healthy and still relatively controlled way.
Although I can’t find proof of this, I assume the ventilation inlets in the Staats Model School would be, like Wierda suggested in his paper on the circulation stove, open and closable for optimum use. Also there seem to be ventilation openings under the roof in the top of the walls; these could have been there to rapidly let in cool air which would force the warmer air to the middle of the rooms where it would be sucked out.



5. Staats Model School - author unknown

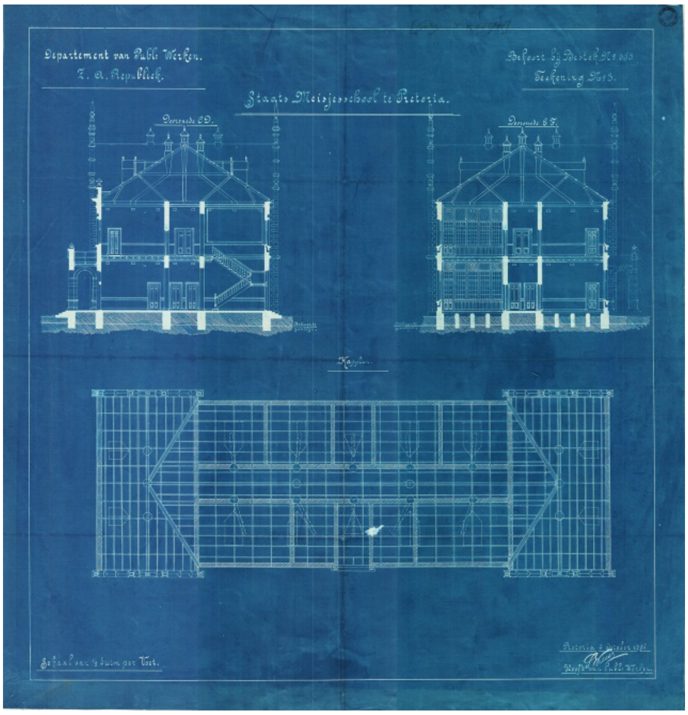
Staats Meisjesschool

Another building that was designed during the command of Wierda was the Staats Meisjesschool. It was built to educate young girls separately from boys. Early designs stem from 1896 and feature a very similar construction, architecture and building physics as the Staats Modelschool. The main difference being the extra floor level and the main bay being a little shorter having just eight classrooms instead of ten. It was, however, not built according to the original plans.

For the most part it remained more or less the same but the roof was built in chalet-style instead of a gabled roof. It was thought of that it was therefore more suitable for girls[4] and this is fairly agreed upon by Picton-Seymour, who states that the entire aspect of the building was softened by it.

It can be seen in the original plans and sections that similar features were in place as in the Staats Model School. Both ventilate the foul air through the roof out of the building and thus both roofs were adorned with a forest of ventilation towers. In the early sketches by the DPW the Staats Meisjesschool was supposed to have the central bay, which consisted of a corridor with classrooms on both sides, ventilated individually.

6. Staats Meisjesschool, author unknown



7. Section and roofplan Staats Meisjesschool, DPW

This makes that in section the corridor and the two adjacent classrooms would all be ventilated independent, and this would be shown in the architecture by having three individual ventilation towers, the middle one slightly higher.

Besides the use of the same features that were used in the Staats Model School the Staats Meisjesschool also shows ventilation shafts under the building. They cross the main bay underneath the first floor. The purpose of these shafts is not clearly explicable because they neither show in the cross section nor have any appearance in the façade drawings. It is however likely that these shafts would have a function related to ventilating the spaces above or pre cooling the air before entering the building, just as Wierda preferred it.

School building in Krugersdorp

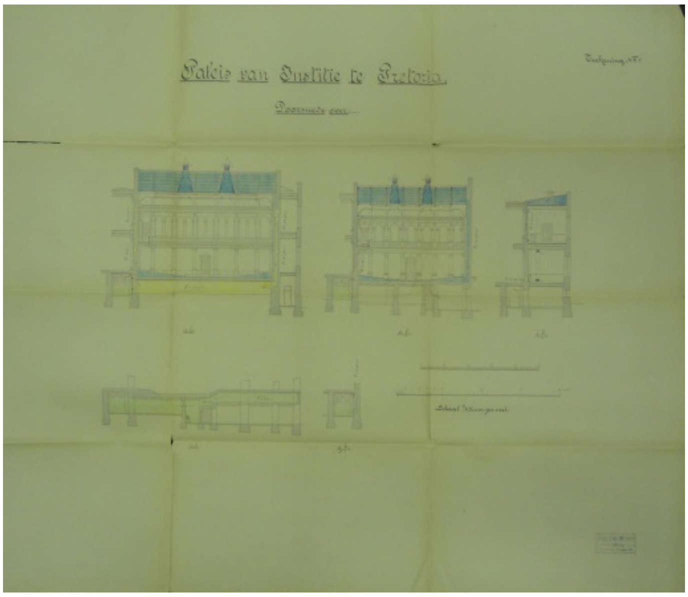
This school is an interesting example due to two found blueprints from the DPW. The first one was a sketch design for the school and it was signed the 6th of March 1899, the second was a design, signed by Wierda and, dated May 24th of the same year. It was thus designed shortly before the dreaded Anglo-Boer war and was not built. The plans show however the ideas that were suggested in the Staats Model School were not completely copied one-on-one.

In the sketch design it neither shows the use of ventilation towers nor any of the other features that were applied elsewhere except the round ventilation shutters that would cool down the plenum. In the final signed off design, however, ventilation towers were added. As were air inlets in the walls, just aside and below the windows.

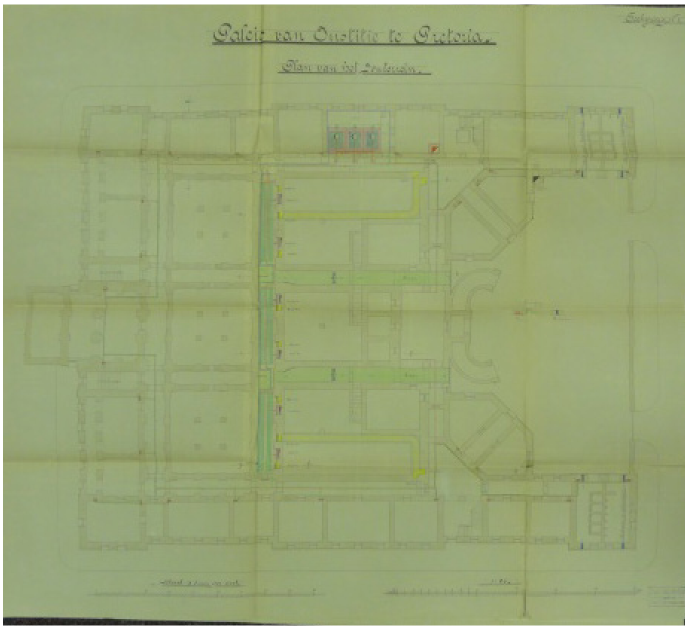
Palace of Justice in Pretoria

During the early years of the Republic the need for a big judicial building grew. It was in 1895 that the design was ready for construction. It was to be placed opposite of the Ou Raadsaal on Church Square in the heart of Pretoria. In 1899 when the war broke out, the exterior of the building was finished but the interior fittings still had to be built. After the war, the English finished the interior and the building has been used as a Supreme Court ever since (Cronje, van Niekerk, Henning, & Keitumetseoatweng, 2012). The building has a façade that is divided in five sections, with the central front flanked by two towers. The whole building is built in neo-Italian renaissance, as this was advised by Wierda to be a cheaper and still representative architectural style. The two sides are extended beyond the central area of the building, leaving a semi enclosed space at the back of the palace. This area contained a double-curved stairwell that was to be the main entrance for the judges. The prisoners would enter the building's basement underneath this stairwell. The three main courtrooms are situated in the middle of the building.
In the design for the Palace of Justice, again special attention was payed to ventilation and in the walls of the palace special ventilation canals are left open in the brickwork. In the scope statement that was released by the Department of Public Works the following was written down:

"In het metselwerk openingen en kanalen te sparen voor ventilatie, zooals nader bij de uitvoering zal worden aangewezen." (*Bestek en Voorwaarden - wegens het bouwen van een - Paleis van Justitie te Pretoria*, 1985)

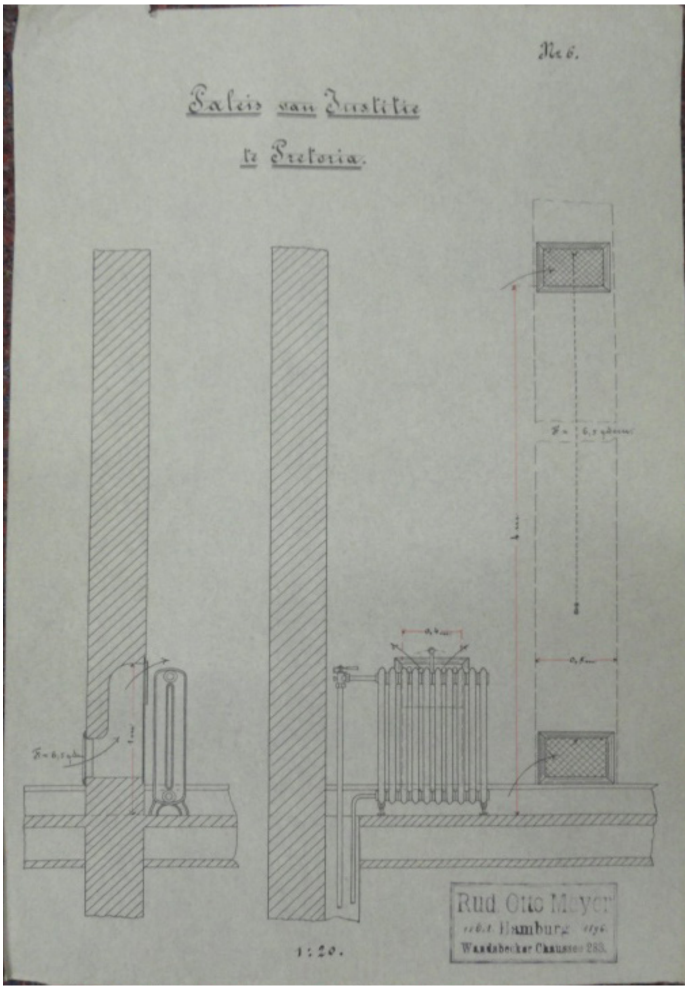


8. Section of ventilation system Palace of Justice, Rud Otto Meyer - DPW



9. Plan of the basement with steam heating, Rud Otto Meyer - DPW

10. Palace of Justice, 27 march 2016 -http://www.andrewcusack.com/2015/kerkplein-pretoria/



11. Radiators in combination with sections
Palace of Justice, Rud Otto Meyer - DPW

Looking closely at some of the technical drawings that show the heating principle, we can see that air is first handled in the basement. Via two main corridors, fresh air from the open space is led into the centre of the building. Here the air passed a valve like object.[5] After which it continued and proceeded to a low pressure steam heating. This at least is according to the drawings made by Rud Otto Meyer, a Hamburg based firm that still exists up to this day.
Low pressure steam heating was first developed by Bechem & Post from Germany in 1878. The system was built up of a boiler made of wrought iron, bricked in in the basement where also the fire was located. During the heating the whole space would be sealed airtight with valves regulating the air influx. Steam would circulate through a system of tubes that, in the rooms would have an enlarged surface (Stokroos, 2001, pp. 48-49). The system by Rud Otto Meyer[6] was built up of the same principles, having three steam pipe boilers that were located under each of the main courtrooms. These would heat the steam inside the pipes, which would then heat the different smaller rooms by the circulation of the steam. Inside the rooms, smooth radiators would enlarge the contact surface between air and steam while also being easy to clean.[7] The radiators were placed in front of a hole in the wall between the room and the corridor. This would allow for a corridor, through which slightly fresher air would run which could then be heated in each individual room.
The three courtrooms were heated with warm air. This is a strange fact considering the ideals of Wierda, but ROM explained their system to be as following. The cold air would reach the boilers as mentioned before. The hot steam pipes, running horizontally through the room, would heat the air after which it went up through a wall opening (in the plans shown as a rectangle divided into a white and red triangle, cool exhaust-air was shown with a blue triangle) and entered the courtrooms at balcony level, where it was blown in the room. Air would exit the space via the ceiling, where six (two each) air outlets led it directly out of the roof through Boyles air pump ventilators (*Bestek en Voorwaarden - wegens het bouwen van een - Paleis van Justitie te Pretoria*, 1985). Another portion of the air was led to the space under the podium, after which it was guided via a wall shaft into the roof space and led out of the ventilators.

Concluding

From the research we can conclude that Wierda had a major influence in South Africa. We can be fairly certain that it was his engineering approach to architecture was a decisive factor in the designs of the different schools that were designed during his years as chief architect for the DPW. We can also see that the architectural evolution on the field of, amongst others, physical wellbeing is evident. If anything Wierda, and the other Dutch architects raised the bar significantly during their time. They took many of the ideas that were discussed in Europe and started implementing them in South Africa. Wierda proved to be very able to implement physical principles in the different climates. It shows his versatile personality, especially when we consider that Wierda worked on a very broad range of designs and constructions when he was still in the Netherlands and obviously after in the Republic (Rex, 1974).

Besides this, his flexibility was also tested in another way. The turn of the 19th century was an important time for physical wellbeing. It was around this time that architecture and health were seriously seen as interwoven. Because of this increased importance many new inventions where published annually. Luckily, for Wierda this proved to be not so big a problem, during his career he reinterpreted building-physics strategies and made use of them when their times came. Secondly, this meant he lived in times in which innovations preceded each other at a fast pace. During his early years, in which he came up with his stove, the technological benefits of air heating were still very much unwanted because of its downsides. Thus, he argued against this kind of heating. Later, as he gained more experience and as technology advanced, he could have probably changed his mind or be persuaded by colleagues. In any case he investigated into the possibilities for air heating in his later masterpiece, the Palace of Justice and it is was executed the same way. It was during this time that steam heating became a serious option for larger buildings. It also shows the interest and knowledge that Wierda possessed on the technical level, always implementing and looking for the most optimal solutions to provide the greatest comfort with the least possible effort. All the designs that have been issued in this research can be seen as examples of this principle, making use of natural processes that are, as efficiently as possible, benefited from. The schools make maximum use of the stack-effect (the effect that warmer air rises) to pull in fresh cooler air. The heated air is even heated more, as it flows to the much warmer roof space amplifying the effect.

The Palace of Justice is a great example of the use of newer technologies as they became more widely available and more capable and adapted. It was this shift that took place around the same time as did the move from the stove as preferred heating method to more sophisticated closed central heating systems like, warm water heating and steam heating (Banham, 2013; Stokroos, 2001). It was the ingenuity with which Wierda utilised the climatic opportunities that show him as a skilled craftsman and engineer and it makes the buildings that he designed still very valuable and comfortable. This is also the case in Westfort, where the ventilated roof spaces and brick walls in almost all buildings make the interior temperature a very temperate one. This was illustrated to me by one of the residents of a Westfort patient-house, who said that the indoor-climate in the summer is always very comfortable. The temperature in winter, however, can be really cold and this forced the residents to light fires on the 'stoep'. The heating in Wierda's days was of course provided by a stove of some sort, but these devices have since long-gone.

If we take a look back at the Transvaal architecture from before the Republic and Wierda's influence we can see that no special measures were taken in relation to ventilation. The original I-shape houses with gables at both ends commonly had non-ventilated roof spaces. In the Cape, where the style originated from these roof spaces were often habitable or at least used for storage. The houses that were built in the Transvaal usually didn't have a second floor. Wierda made use of the architectural building style and adopting it to a more suitable form that made it more capable of dealing with climatic conditions and the question for an improvement in the physical wellbeing.

This paper is today very relevant. Since the invention of the air-conditioning, climate solutions have become one-size-fits-all solutions. It is like if your only tool is a hammer all the problems will look like nails. Lately however we have witnessed a rise of more sophisticated design solutions in which 'passive' has become a very important prefix. In the 'Passive Housing' trend it refers to a rigorous, voluntary standard for energy efficiency in a building, reducing its ecological footprint (Zeller, 2010). This basically boils down to the lowering of energy use and implementing systems that make use of readily available energy sources like the sun and the wind. Basically passive housing and building goes back to systems and principles that were implemented before fossil fuels made energy widely available. It builds on simple (or more complicated) physical principles that can be manipulated so they can be regulated and benefitted from.

In my design research I am looking for a way to implement passive strategies that are closely related to the systems that Wierda used in his Schools. In which hot or cold outside air is first tempered through ventilation tubes under the floors. After which the air is fed into the building and is sucked out of the building. To make it more adaptable, my design will incorporate a ventilating chimney which heats the air to increase its rising properties and thus pull the foul air out of the building. This system can also be redirected in which case it will be part of a closed system that pulls air out of the building, heats it and lets it re-enter the building. This system is more closely related to the passive housing philosophy, but it is therefore in the spirit of Wierda, who wasn't scared to implement new technologies or ideas.

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Endnotes

1 Translated out of Dutch by author: "Sedert langen tijd is met het oog op de zoo kostbare brandstof, het streven der technici geweest een kachel te construeren, die niet alleen een zeer spaarzaam gebruik van brandstof aanbiedt, maar ook tevens eene gelijkmatige, aangename en der gezondheid in geenerlei opzicht nadeelige verwarming voortbrengt. Het ontbreekt voorzeker niet aan veelvuldige verwarmings-systemen, maar de onvoldaanheid, die men nu en dan van verschillende zijden daarover verneemt, levert het bewijs dat er nog veel, ook op dit gebied gelijk op zooveel andere, te doen valt."

2 Ventilators are in this instance the most likely suspects.

3 Translated out of Dutch by author: "Velen brengen thans de ventilatie door aanvoer met verwarmde lucht in toepassing. De ondervinding daarvan is misschien nog te jong om in 't algemeen te kunnen worden beoordeeld, doch men heeft zeer weinig natuurkennis noodig om te begrijpen, dat de aldus verwarmde lucht, wegend hare hooge temperatuur, direct bij de intrede van het te verwarmen lokaal naar boven stijgt, en zeer langzaam tot de benedenste luchtlagen zal doordringen; bovendien zullen de in of nabij het plafond gemaakte openingen tot afvoer van bedorven lucht, de versche verwarmde lucht mede doen ontsnappen, waardoor de lokalen moeielijk of bijna geheel niet verwarmd kunnen worden. Bij die gevallen heeft men zich dan ook genoodzaakt gezien, de afvoer van bedorven lucht nabij den vloer te bepalen; een stelsel dat niet minder is dan een natuurwet omver zoeken te werpen, en niet anders dan door der gezondheid nadeelige, kunstmatige kracht verkregen kan worden; immers de toepassing doet ons zien, dat wel bedorven lucht wordt afgevoerd door openingen in of minstens nabij het plafond, waarop tot bovendaks kokers zijn geplaatst, en dat door dicht bij den grond gemaakte openingen, wel koude of versche lucht wordt aangevoerd, maar niet omgekeerd. De door mij gevolgde wijze van ventileeren bestaat dan ook in de opwaartsche luchtzuivering, waarvoor de openingen zooveel mogelijk midden in het plafond zijn geplaatst, omdat de versche lucht door de buitenmuren aangevoerd, langs deze wegens haar lagere temperatuur eeningzins naar boven stijgt, de bedorven lucht meer naar het midden zal dringen. Deze openingen zijn voorzien van beweegbare luiken welke tot regeling der ventilatie naar behoefte kunnen worden gesteld. De aanvoer van versche lucht geschied door openingen, buiten in het plint, die loodt recht in de muren opgaan, en op eene hoogte van 2 M. boven den vloer in de school uitmonden door beweegbare ijzeren rosetten, die eveneens naar behoefte kunnen worden geregeld. Genoemde hoogte is iets meer dan eens mans lengte om tocht te voorkomen. Ten behoeve der op den vloer aanwezige luchtlaag, welke door het vele personeel en meubilair verhindert wordt zich genoegzaam te verwisselen, zijn, langs het plint, in den vloer sluitbare openingen aangebracht, die direct met de buitenlucht in verband staan, en alzoo eene spoedige zuivering te weeg kunnen brengen."

4 Nicholas Clarke, 03-02-2016, Delft

5 This could very likely be a valve that would allow the air to pass into just one direction. Working as an air lock, it would better be able to pre-adjust the air conditions to suit the interior.

6 For convenience Rud Otto Meyer will be referred to as ROM

7 The cleaning of radiators proved to be important as dust particles would be burning on it, giving of an unpleasant smell.