HEALTHY AND RESILIENT HOMES

registration number: **HHDC65**


Building complex

Site

The Healthy Homes competition defines the site as an old football field situated on the very north tip of the old town of Pernis in Rotterdam. The site is placed right by the Maas, the large river flowing through Rotterdam, in an industrial context, surrounded by industrial harbors, shipyards, petrochemical industry, and factories. The old town of Pernis is protected from flooding by a surrounding dike, and since there is no space left for expansion in the protected area, the town needs a solution for expanding to the flood-prone area outside the dike

Flooding

With so many people at risk, it's not sustainable to only create new expensive developments that can restrict water. The creation and development of technologies and solutions that can be retrofitted in existing buildings and implemented in situations where retention is not an option, is crucial to ensure all people the opportunity to adapt to the future. Tomorrow's problems need to be solved today. A new reality where flooding is a part of society is approaching. Today flood events are commonly categorized as disasters, but in some parts of the world it's already part of their life without being categorized as such.

Disaster:

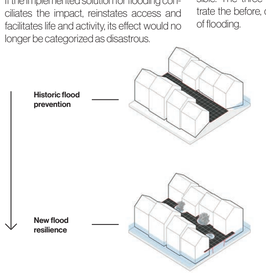
"An event or occurrence of a ruinous or very distressing nature; a calamity; esp. a sudden accident or natural catastrophe that causes great damage or loss of life."

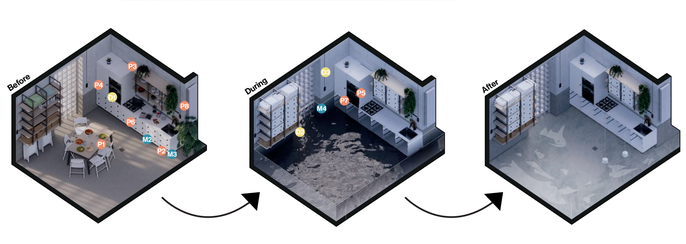
- Oed.com. 2021

If the implemented solution for flooding conciliates the impact, reinstates access and facilitates life and activity, its effect would no longer be categorized as disastrous.

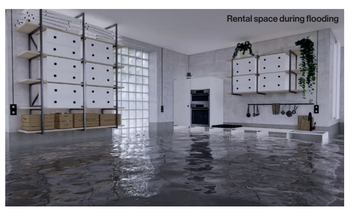
A flood-resilient building goes beyond limiting or preventing water ingress to a building. It includes measures as making the interior wet proof/recoverable, reconfiguring the ground floor or adding a story, design for drying out quickly, and suitability for moving back in the house quickly after a flood.
Simple solutions such as using products that are resilient to getting wet, placing electrical outlets higher, and using doors and windows with flood-resistant seals can minimize future damage. Also, the use of a 'sump pump' connected to drains in the floor gets water out of the house. Flood resilience is a rather low-tech solution to flooding. (cam.ac.uk) (bre.co.uk)

On the ground floor measures have been made in order to resist flooding. In the wall and floor, a cavity drainage barrier layer is installed to lead the flood water to the sump pump placed under the floor. This will also help to drain the water when water needs to be removed in the recovery period.
In the rooms placed on the ground floor, it is necessary to make different actions in order for the room to take as little damage as possible. The three isometric renderings illustrate the before, during, and after scenarios of flooding.





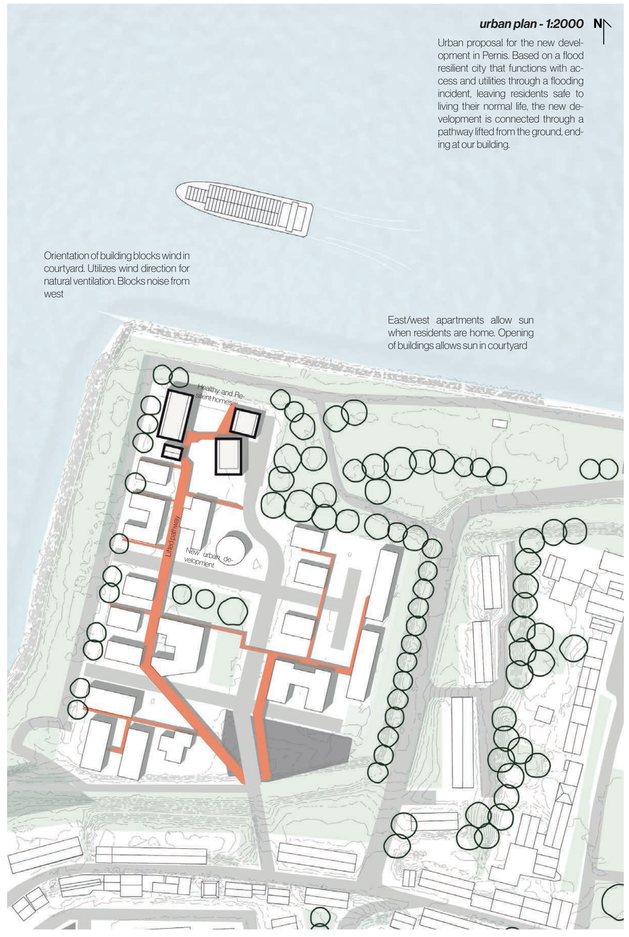

Rental space


Rental space during flooding


Circulation

The town

The old town of Pernis has a long varied history, starting as a farming and fishing village, affected by the First World War, overshadowed and physically enclosed by the thriving economy and expanding industry of Rotterdam. Pernis became a part of the municipality of Rotterdam and a metro station was added, combined with a bicycle tunnel to Rotterdam and good bus routes, the town has excellent conditions for alternative and more sustainable transport than cars. The old and unbothered town with its village-like atmosphere (in the middle of industry and city) and cute, old, ornamented, and historic houses, with each its own front yard and front door, showing the individualistic nature of the people of Pernis, and in the Netherlands as a whole, inhabit a less diverse population group than the rest of Rotterdam and the Netherlands. The plans for the future of the town states to change this with new urban developments with diverse housing opportunities. Furthermore, the new developments are to push the historic town to a more contemporary urban area, strengthening the relation to Rotterdam.



urban plan - 1:2000

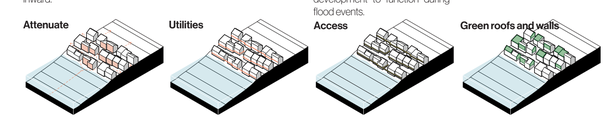
Urban proposal for the new development in Pernis. Based on a flood resilient city that functions with access and utilities through a flooding incident, leaving residents safe to living their normal life, the new development is connected through a pathway lifted from the ground, ending at our building.

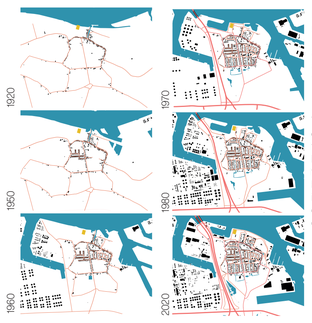
Configuring permanent structures within the urban development in an attenuating pattern, creating an urban breakwater, can reduce the velocity and size of waves when they move further inward.

Elevating utilities like power and communications above flood risk level enables the urban development to stay operative and helps to distinguish which areas will be prone to flooding.

Access routes elevated from flood risk level ensure safe retreat during flood conditions. The range of access throughout a development integrates the scheme vertically but also allows the urban development to function during flood events.

Green roofs and walls use living vegetation as surface cover to buffer and slow the movement of rainwater. They can also increase biodiversity, reduce overheating, and attenuate noise.

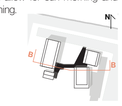




Diagrams showing the structural growth of Pernis through the last 100 years, showing that Pernis as a village has outlived the industrialisation of Rotterdam, creating a village island amongst harbour.

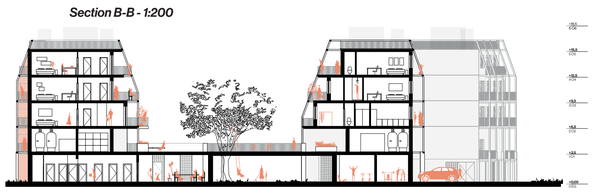
The ground floor has a mix of communal and public use in an everyday scenario. In case of flooding the 1st floor will inhabit the public zone and work in a new context to support the circumstances.
All apartments have their own front door and front garden/area, while the ground floor and 1st floor inhabit apartments, café, bike parking, a gym and retail.

The building is divided by two to create a sunny courtyard, while the buildings step back to give light and connection to ground floor. The grid allows for circulation and plants as solar shading. Apartments oriented west-east allow for sun morning and evening.



Creating a main public pathway with public functions as retail, library, café, and gym through the building complex invites the public to interact with it. Maintaining this flow on the ground floor creates a vertical transition zone from public to private. The residents use the 1st-floor circulation, while this upper surface also can function as a public pathway when flooded.

Section B-B - 1:200

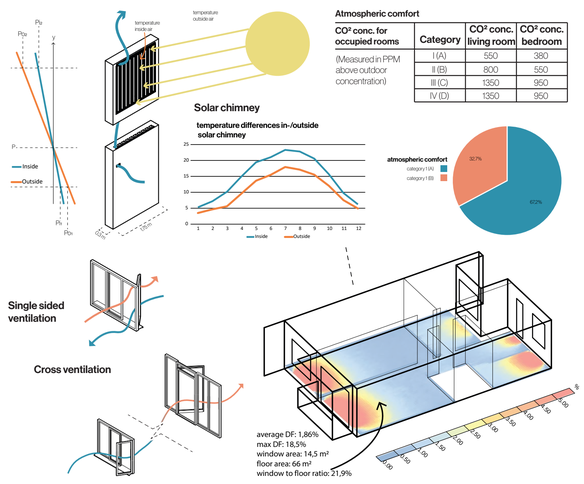


"Each apartment has its own door and stairs (if its possible). It is a very impractical solution - it can be read as a value. Dutch people are individualists"

- Birgitte Louise Hansen, 2020
architect, researcher, educator, resident of Rotterdam (translated)

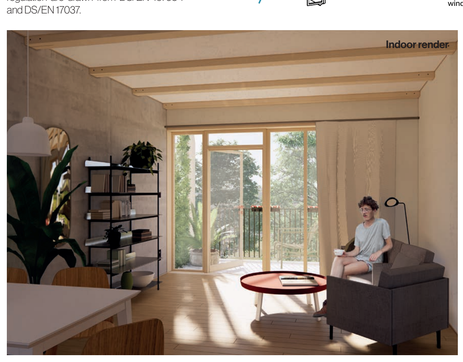
Visual & atmospheric comfort

As natural ventilation is implemented as a ventilation strategy in the cooling season, the solar chimney is a good supplement to allow for ventilation even in wind-still conditions. In addition to the stack effect present in a chimney, the solar chimney takes advantage of solar energy to heat up the air. The solar radiation is absorbed by a thermal mass in the back wall of the channel, this, in turn, heats the air through convection. The thermal buoyancy caused by exposure to the sun further increases the airflow.
To investigate the potential of a solar chimney a simple model was modeled in Bsim. A 2-meter tall chimney with a glass opening to the south was modeled to investigate the temperature difference between the inside and outside air temperature. The result showed a higher air temperature inside the chimney during the entire cooling season. This gives an opportunity to guarantee nighttime venting as a great measure against overheating
Assessment of indoor climate is typically measured in categories. Category I being the best and IV being the worst. One of the main focus points has been on developing a healthy home with a good indoor climate, category I has therefore been an aim since the beginning. The documentation has been done by analysis and simulations of a determined apartment.
By visualizing and accessing the data, it is to be determined when, where, and for how long the modeled apartment fulfills the category I regulations. The category chart and regulation are drawn from DS/EN 16798-1 and DS/EN 17037.



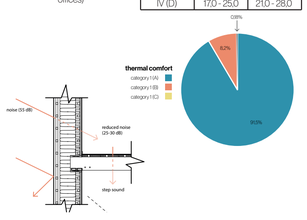
Atmospheric comfort

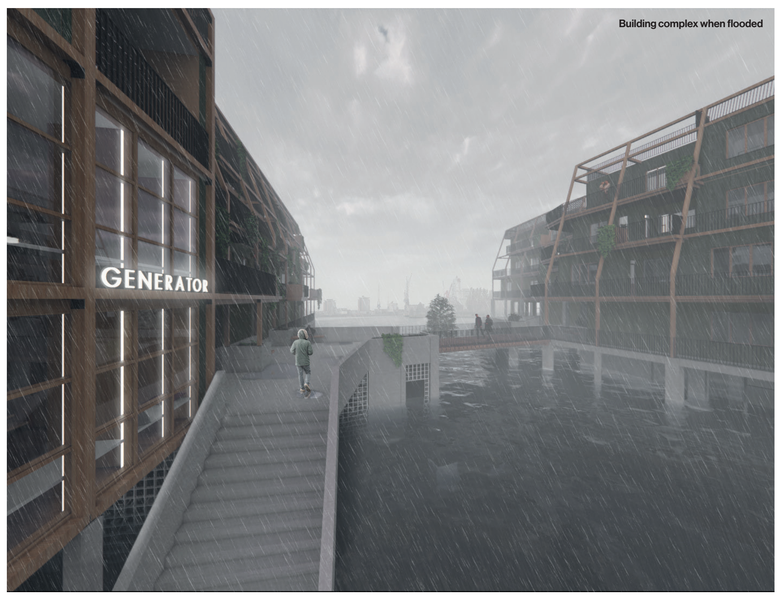
CO² conc. for occupied rooms (Measured in PPM above outdoor concentration)	Category	CO² conc. living room	CO² conc. bedroom
	I (A)	550	380
	II (B)	800	550
	III (C)	1350	950
	IV (D)	1350	950


Indoor render

Thermal comfort

Indoor temp. (operative temp. (C))	Category	Temp. winter	Temp. summer
Residential buildings (living spaces, bedrooms, kitchens and offices)	I (A)	21.0 - 25.0	23.5 - 25.5
	II (B)	20.0 - 25.0	23.0 - 26.0
	III (C)	18.0 - 25.0	22.0 - 27.0
	IV (D)	17.0 - 25.0	21.0 - 28.0

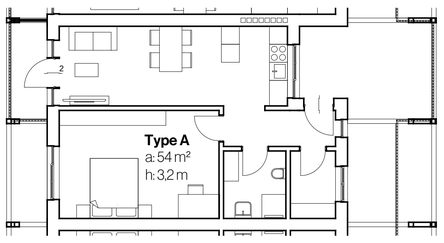


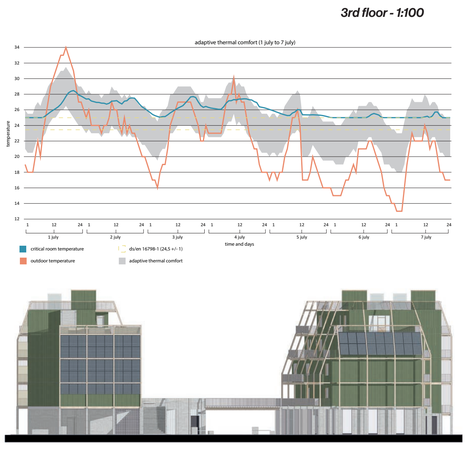


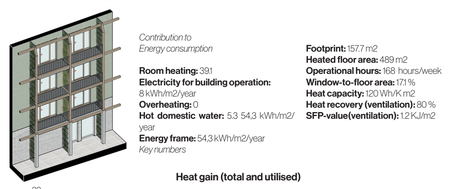
Building complex when flooded

Thermal & acoustic comfort

Assembling the knowledge and information gathered through the analysis and studies regarding the indoor environment, it is clear that many measures can be taken into consideration in terms of ventilation, shading, and user integration. Specifically, the integration of passive strategies regarding natural ventilation, window openings and solar chimney, in the design is necessary to include the user in controlling its own comfort and well-being.
Other passive strategies to implement are creating the possibility to utilize the principle of thermal mass through material choice and solar radiation, to utilize the heat, and to examine, understand and utilize solar radiation for passive heat gain in the relevant situations, either through permanent shading or utilizing the principle of plants as solar shading to prevent overheating. All passive strategies are dependent on the understanding and utilization of the local microclimate.
By basing a good and qualitative indoor environment on achieving thermal-, atmospheric-, visual-, and acoustic comfort, the design of the building is dependent on working with integrated design solutions. Structurally, concrete load bearing walls go east-west, dividing the building into segments creating a template for apartments in varying sizes. The bare concrete wall utilizes solar radiation to absorb heat through its thermal mass, and then releases the heat throughout the night





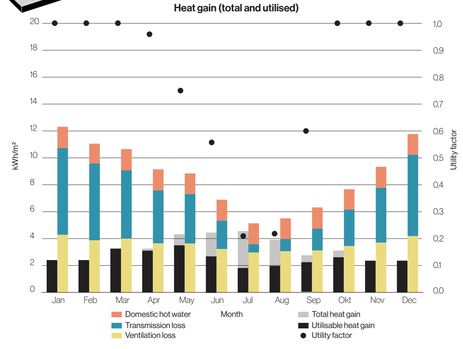


Contribution to Energy consumption

Room heating: 39.1
Electricity for building operation: 8 kWh/m2/year
Overheating: 0
Hot domestic water: 5.3 54.3 kWh/m2/year
Energy frame: 54.3 kWh/m2/year
Key numbers

Footprint: 157.7 m2
Heated floor area: 489 m2
Operational hours: 168 hours/week
Window-to-floor area: 17.1 %
Heat capacity: 120 Wh/K m2
Heat recovery (ventilation): 80 %
SFP-value(ventilation): 1.2 KJ/m2

Heat gain (total and utilised)



To simulate the building's energy frame BE18 is used. The critical building is the smallest one towards the north-east, it was chosen by comparing the three buildings' surface-to-volume ratio, where the building with the highest ratio was chosen.

The results show an energy consumption of 71.4 kWh/m2/year. This is higher then the required 60 kWh/m2/year. This is a result of emphasis on the indoor climate, where the shape of the building and its air change rate greatly contribute to heat loss. 40 m2 photovoltaic is incorporated in the design, if this is taken into account in the simulation, the results are lowered to 54,3 kWh/m2/year.

Overall the energy frame simulated an estimate further work and assessment of each value would be necessary to lower the heat losses and thereby the heating demands, ultimately lowering the kWh/m2/year.

The elevations show the proportions of the building from different angles. The materials used on the facades are green painted wood finish on the upper floors and metal railing with a water-resistant coating. The concrete dominating the ground floor gives the separation from the more private to public, while also giving back an aesthetic gesture in the reminder of flooding with its green stains from past floods. The wood grid can be seen covering the building giving the facade an extra dimension.

Position
- P1 Freestanding table rather than fitted island
- P2 Elevated cabinets on legs for drying
- P3 Air gap bewtween cabinet and wall to aid drying
- P4 Cabinet doors fitted with quick release hinges
- P5 Locate appliances in ancillary, lower risk-space
- P6 Drawers designed to easily be removed
- P7 Appliances positioned at higher level
- P8 Radiator placed on higher level

Material
- M1 Worktops uses material with low water absorption
- M2 Cabinets in non-porous material
- M3 Cabinet legs in water-compatible material
- M4 Water-resistant material in flood risk level

Devices
- D1 Cookers can be removed prior to flooding
- D2 Acceptance of some goods requiring replacement post-flood
- D3 Electricity from above

Section A-A - 1:300

Section of construction

The construction principle used utilizes the material properties of wood and concrete. The combination makes it a hybrid construction playing into the strength of both materials. Whilst concrete is durable at compression and timber is good for tension.

The east and west facing facades is a light, non load bearing construction with an external wooden finish whilst a handful of internal walls are made of concrete for the structural properties and increased thermal mass. The internal floors are made of a wooden beam structure with a wooden slab, pressure proof insulation and wooden flooring. Impact noise prevention is important in regards to the internal flooring, it has therefore been equipped with a 25 mm noise-reduction block to minimize noise moving though the floor. The concrete foundation and ground floor wall is chosen for its structural load bearing properties in combination with its ability to withstand a prolonged exposure to water. The insulation at ground floor has to be closed cell spray foam insulation because of its water resistant properties.

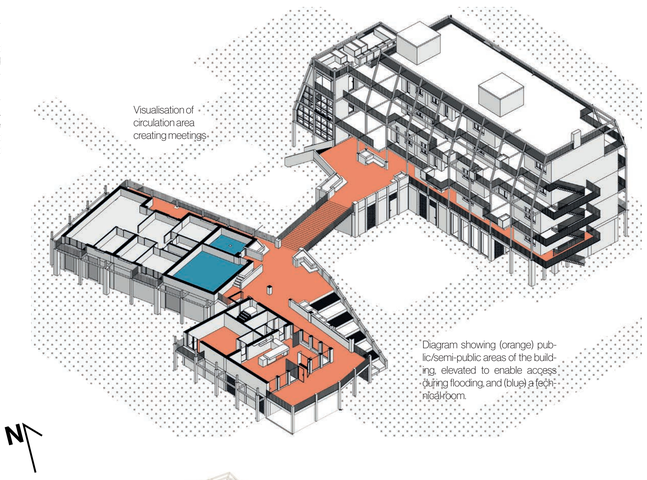
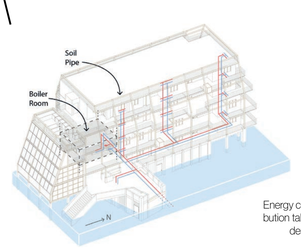
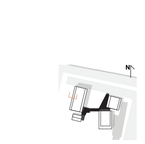
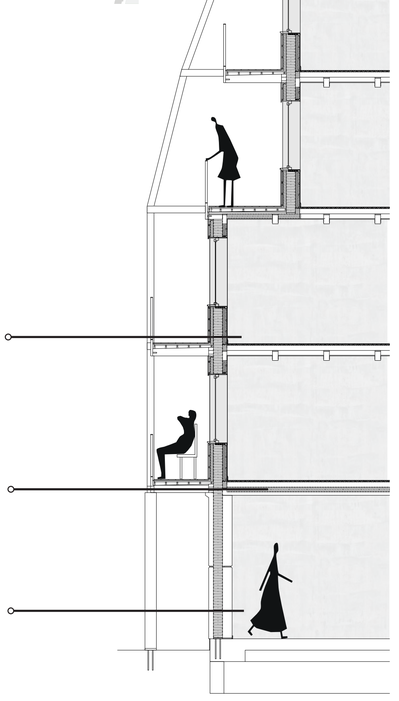

Visualisation of circulation area creating meetings

Diagram showing (orange) public/semi-public areas of the building, elevated to enable access during flooding, and (blue) a technical room.







Wall
wooden cladding 15 mm
ventilated airspace 25 mm
wind barrier 10 mm
insulation with structural wood 200 mm
vapor barrier
insulation 100 mm
slats 25x25 mm
gypsum interior finish 10mm

Floor
wooden floor 15 mm
pressure-resistant insulation 25 mm
wooden slab 200 mm
impact noise prevention 25 mm
wooden beam 200 mm
gypsum finish 10 mm

Wall
ground floor
exterior concrete 100 mm
closed cell insulation 200 mm
internal load bearing concrete 200 mm

Energy consumption and heat contribution takes internal loads into consideration for optimal energy use.

internal loads

solar chimney

Energy consumption and heat contribution takes internal loads into consideration for optimal energy use.

cross ventilation

The apartments are open, or can be opened, inside through west to east, utilizing western wind pressure to naturally ventilate.

construction

Facades as non-bearing structure with low U-value enables low transmission of heat and ultimately a lower energy consumption

As a passive strategy curtains and overhang enable optimal amount of solar radiation, more in winter and less in summer, and optimal daylight.

curtain and overhang

circulation

Outdoor circulation to apartments eliminates unnecessary heated area and allows users to have their own front door and semi-public/private area.

overhang

Carefully designed overhang, integrated as circulation, allows an optimal amount of solar radiation for passive heat and optimal amount of daylight

mechanical ventilation

In winter the apartment is ventilated through mechanic VAV mixed air ventilation. Kitchen and bathroom has suction all year.

Plants in front or beside the window area reduces amount of direct sunlight. Active in summer and inactive in winter.

greenery as shading

daylight

Rooms are postioned and designed to have optimal daylight regarding their function. Morning sun in kitchen and evening sun in living room.