FHVI prevents urban pluvial flooding

In the project 'Adaptation to extreme rainfall; demonstration of FHVI to prevent damage by urban pluvial flooding' the technique FHVI (Fast High Volume Infiltration) was tested in the Netherlands. The results show that the technique is an excellent way to rapidly discharge excessive rainwater into the underground, and therefore to prevent pluvial flooding.

1. Problem

More extreme rainfall

Climate change scenarios predict more frequent and larger extremes in rainfall. Pluvial flooding will increasingly cause damage because of climate change and continuing urbanisation.

Limited means of discharge in cities

Many cities in the EU have combined sewer systems, with capacities much too small to cope with extreme rainfall. Separated sewer systems have a limited capacity and often costs are prohibitive. Natural infiltration of rainwater is constrained by the relatively limited permeable surface in cities.

2. Solution

Existing solutions have disadvantages

Nowadays, there are many solutions in the market to cope with the problem of pluvial flooding. Systems like buried crates, wadis, or permeable road surfaces are used. These systems are all based on slow infiltration into the underground. But since the infiltrated water is not treated, there is a considerable chance of clogging. This can only be solved by high maintenance costs.

Another possibility, and the economic one, is direct discharge to surface water. However, there is not always surface water available. A further disadvantage is that the water (freshwater!) cannot be used locally in case of drought at a later time.

New solution: FHVI

Another possibility is Fast High Volume Infiltration (FHVI). A deep infiltration well, such as FHVI, can be a feasible solution to rapidly discharge rainwater in places with limited space. Additional benefit is that the water replenishes the groundwater, and therefore stays available in dry times.

FHVI allows a rapid infiltration of large volumes of water. It is an innovative technique, with no pump or moving parts, so very low-maintenance. Its installation takes up little space. If it is carried out simultaneously with infra technical adjustments and/or works, it does not cause any inconvenience to the surrounding area. The FHVI system is designed to last for decades.

The FHVI technique was first developed by German geo-hydrologist Werner Wils for lowering the groundwater table at construction sites. Here huge quantities of groundwater are pumped up and infiltrated again in groundwater layers.

Wils performed intensive research and discovered that large quantities of water can be discharged quickly into an underground aquifer. He discovered that, by using the right infiltration layer, more water can be infiltrated than would be expected by normal infiltration. Although this technology was patented, the scientific proof had not yet been delivered. Scientific research has led to two thesis studies at two Dutch universities. For that reason there is, since 2020, solid scientific proof for this phenomenon.

FHVI for rainwater infiltration

This scientific proof has led to the search for other applications. The hypothesis was that this would also work for infiltration of rainwater. During heavy rainfall, large amounts of rainwater have to be discharged. The last years many technologies have been developed, mostly based on infiltration. The difference with FHVI is that, although FHVI is higher in construction costs, it is considerably lower in maintenance costs.

Infiltrated water is treated

The most important point however, is that the infiltrated water is treated, and that it can be used at a later stage (dry times, cooling the city etc.). The pre-treatment is very simple, small and cost-effective: it is a container of about one cubic meter made of plastic or concrete, filled with sand and/or gravel. It mimics the passing of water through layers of soil. The composition of the sand and gravel can be adapted to the situation. Rainwater is fed into it from above from the street level drain, and drains out at the bottom through a perforated drainage pipe. The bed of sand and gravel catches virtually all solid particles without becoming clogged. It even filters out many dissolved substances.

We can summarize FHVI for rainwater discharge as follows:

1. rainwater goes from street level to the drain, where the largest pollutants are already stopped: coarse leaves and litter;
2. the pre-treatment catches solid particles without becoming clogged;
3. the water goes into the infiltration well: a deep pipe with a perforated section at the bottom at the level of an aquifer (sometimes 15-30 m).

See also our animation of how an FHVI works.

https://aerfit.eu/en/fhvi/

3. Research on practice scale

The technology was already used on a small scale in several places in the Netherlands and Germany. In 2018, it became clear that it was time for a bigger scale.

In the Municipality of Apeldoorn, the Netherlands, 150 FHVI infiltration systems were installed from 2019 to 2022. The municipality wants to be climate robust by 2050, and has been disconnecting as much rainwater from the sewer system as possible since 2006, using several earlier techniques. However, in several places, where the rainwater sewer had been disconnected, flooding occurred again after heavy showers.

A consortium (Municipality of Apeldoorn, the Netherlands, Foundation O2Dit (member tdi), Van Tongeren Watertechniek, the Netherlands (member tdi) and Hölscher Wasserbau, Germany (member tdi)) proposed a project of 4.2 million euro, which was endorsed by the EU LIFE+ programme. In the project, 150 infiltration wells were constructed in different parts of Apeldoorn.

In a desk study, the expected drilling depth was estimated. During drilling, the exact depth was then determined, ranging from 15 to 30 metres.

During the project phase, the wells were placed in several types of locations: in parks, in lawns or between buildings, to provide as much diversity in the locations as possible.

The technique was tested under conditions of extreme rainfall in Germany and the Netherlands. This is a so-called T10 rain shower, corresponding with a peak intensity of 5.25 l/s for an area of 250 m^2: a total volume of 36 mm/h. The FHVI technique passed the tests well, so the step toward a more extensive pilot phase could be taken in this project.

4. Results

In Apeldoorn, the 150 wells were constructed and tested. A monitoring system was developed to follow the infiltration capacity of the wells for two years. A decrease in infiltration capacity can be the result of a non-optimal functioning of the pre-treatment. In some cases, it was possible to correct the pre-treatment by changing the sand composition. Most of the wells are now more than two years in use. In only three cases, it was necessary to clean the well. The pre-treatment is cleaned regularly (once a year), by removing the sand/gravel and replacing it by new sand/gravel.

There has been some cases were the FHVI system could not be applied. That was when it was not possible to find a suitable layer in the underground to infiltrate the water. For example, this was the case when the subsoil had been heavily disturbed.

In combination with the quantitative monitoring, there is also monitoring on the quality of the infiltration water. In the Netherlands there are, until now, no requirements regarding the quality of water that is infiltrated. Nevertheless, we decided to make a robust system that is also able to remove nearly all kinds of chemicals. This was not a part of the original project proposal. However, it is our vision that, although no one is asking for it, this technology can only survive when it does not pollute the underground.

The project runs until mid 2024. All infiltration wells are now constructed. 2022 and 2023 are used for intensive monitoring. In 2024, the project will be concluded with a final report.

In the meantime, a spin-off of this project is a project in Lithuania. In Lithuania, with comparable rainwater problems, there is a demonstration project with six FHVI wells and pre-treatment systems. The pre-treatment is part of that project from the beginning. The authorities in Lithuania are much stricter on the quality of the water than Dutch governmental parties.

5. Technical risk identification

During the project many adjustments and mitigation has taken place. When a project starts, everything is only on paper. In practice, many things turn out differently. It turned out that FHVI was not applicable on all project spots. Within the project, we searched and found other suitable locations. The biggest change in the project plan was the introduction of the pre-treatment. It was necessary to protect the infiltration well. Without this protection, it was necessary to clean the well twice a year to maintain its capacity. With the pre-treatment, the cleaning of the well every two years was more than enough.

In addition, the working conditions have led to adjustments. The first prototypes of the pre-treatment were functioning very well, but were too heavy to handle for the workers. In the end, we were able to develop a pre-treatment that could easily be handled (in most times a cleaning not more than once a year). This was necessary for healthy and safe working conditions.

The drilling activities have been done, according workers' safety regulations, always with at least two persons.

6. Sustainability

Sustainability and environment were important points within this project. We were able to carry out the drilling with an electrical drilling machine. The batteries were filled with electricity from green sources (wind, solar). Therefore, from the drilling, there were no extra CO_2 or nitrogen emissions.

The sand/gravel of the pre-treatment is re-usable. It goes back to the factory and is cleaned. After that, the sand/gravel can be used again.

The environmentally most important step is the purification of the infiltration water. By doing so, there is no harm to the environment or underground water layers.

7. Conclusions

FHVI is an excellent technique to prevent pluvial flooding. In short:

- It is higher in construction costs, but much lower in maintenance costs
- The construction occupies little space
- FHVI discharges water very rapidly, in most cases
- A simple pre-treatment system prevents clogging of FHVI
- The pre-treatment protects not only the quality of the groundwater, but also the well itself
- FHVI discharges rainwater into the groundwater supply, and therefore makes it possible to re-use the abundant rainwater in dry times
- FHVI cannot be used when the subsoil has been disturbed too much in the past

More information can be found at our website aerfit.eu