Controlling urban runoff

TEXT AND PHOTO: MINNA KÄRKKÄINEN
Pictures: VTT / Erika Holt

With new inventions and smart urban planning, new urban areas handle heavy rainfall better and better. Also old and densely built cities will benefit from new solutions to managing storm water problems.

A beautiful summer day can turn into a rainstorm, pouring down dozens of millimeters of rain in one night. Soon streets are suitable only for canoeing. Cars are stuck in flooded underpasses. Sewers are blocked, buildings and citizens in danger.

This kind of heavy rain is luckily quite uncommon – for now. Extreme weather conditions are expected to increase in the future.

"Great variation in the amount of rainfall is a huge issue for cities. Winds and horizontal rain are also increasing", says research professor **Miimu Airaksinen** from VTT technical research center of Finland.

Controlling storm water runoff is an important issue for a functional city. Solutions for future cities have been researched at the VTT in the international Smart City -project led by Miimu Airaksinen.

In co-operation with the Finnish Meteorological Institute, the VTT has developed a simulation which can generate a 3D city model with elevations, networks and surface penetration. With this model, it is possible to investigate, where water will start to pool, where it can penetrate structures and which are the high-risk areas. This model will also show if a crucial building is in the danger zone.

"This is crucial information for property owners, cities and insurance companies alike, as it is one of insurance risk factors. Being aware of the risks isn't enough though, we have to have solutions for them. We have studied how we can prepare better for heavy rainfall. For example, special coatings can be installed and we can develop temporary rainwater harvesting systems", Airaksinen lists.

VTT research professor Miimu Airaksinen and her team are solving big questions about urban planning: how to effectively create a functional and sustainable city.

According to Airaksinen, the infrastructure in Finland, such as houses, water and sewage systems as well as roads, have huge potential for improvement. It is important that the needs for improvement are found well in advance and plans how to improve the quality of the system in the future are done at the same time. This way the price tag for improvements stays reasonable.

Smart technology, such as sensors in sewage systems, will also remove the need for unnecessary and premature repairs. With accurate real-time data, maintenance funds can be invested where they are needed the most.

"New technology can create surprising flexibility and can help break away from traditional thinking patterns."

City planning

"Nature based solutions are a widely discussed topic at the moment: for example, how recreational areas can also be used as buffering for storm waters", Airaksinen explains.

In new developments, introducing novel solutions is naturally much easier compared to old urban structures. In new areas under construction at the moment, the managing of storm waters has been planned particularly well. City planners are well up to date with the latest developments.

"The city rarely dictates one certain way to deal with storm water management. Usually all that needs to be done is to prove the functionality of the solution, because it is always possible for someone else to come up with a more brilliant idea."

There are many ways to prepare for rainfall. Airaksinen says that usually the cheapest way to control rain waters is permeable paving. A backup plan is always incorporated into the design of the sewage system. In case a system fails, it has already been thought out, how another system will carry out its function.

This kind of planning creates other benefits as well. For example, building wetlands or lakes to incorporate rainwater makes the area more attractive, and cost-efficiency is improved as the amount of water conveyed to the sewage systems is reduced.

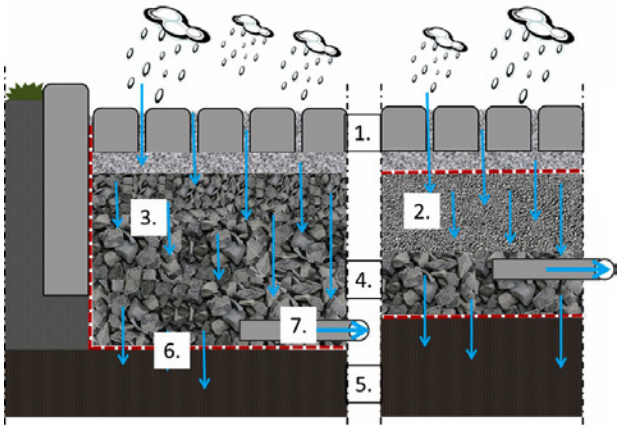
Airaksinen mentions Vuores suburb in the city of Tampere as an interesting new area regarding rain water control. There professionals have planned how the existing sewage system can cope with the expansion of the development. While planning the placement of houses, the function of green areas as buffer zones is taken into consideration. The utilization of green roofs has also been considered.

Below the surface and under the sky

Asphalt is a pleasant surface to walk and drive on, but is impervious to water. New pavement materials are pleasantly smooth, but can also be permeable to even large amounts of water. Permeability has been researched in the VTT laboratory and Airaksinen says result are very promising.

In future city pavements, the gaps in brick paving are well optimized. Streets have to be comfortable

In Vuores suburb in Tampere, controlling rain water is thoroughly planned. This park is a recreational area, but it will also help in controlling rain waters.



1. Pervious interlocking concrete pavement
2. Pervious concrete (base)
3. Porous aggregate base
4. Porous aggregate subbase for water retention
5. Subgrade
6. Geotextile
7. Underdrainage and piping when needed

Examples on climate-adaptive surfaces, i.e. pervious pavements. Surface layer is designed to have high water permeability, and base and subbase structures are with high porosity and permeability, and are designed for water detention. Picture: Erika Holt.

Hydrological simulation of water pervious structures and pavements. Water infiltration capacity, retention capacity, and if needed also water purification capacity, is simulated in a full-scale (adjustable: 330 -1000 mm) rig, with continuous measurement of the amounts of water: sprinkler irrigation and water passed through the structure. Photo: Erika Holt.

Please check this image in better resolution on the REHVA Journal digital version.

for walking and driving, and work well under winter conditions. Simultaneously, the material between bricks works effectively allowing water penetration.

If not in a groundwater area, rain waters can be left to freely absorb to the ground. The water can be removed also after the permeating layer, if need be. Furthermore, roofing materials are now researched, as in urban areas roofs constitute a large percentage of the overall surface area.

Green roofs are very common in Europe and are making their way to Finland as well. But similar to other construction, building green roofs requires more effort in the northern altitudes. Plants that are selected to green roofs must tolerate the heat of the summer days, but also the snow and freezing temperatures of winter.

Airaksinen also points out that a green roof cannot be added to any building, particularly of the existing housing stock. But a well-functioning green roof can offer a refreshing recreational area, which increases the value of the real estate. In hot weather, the green roof has a cooling effect on the microclimate of the building.

Smart City

Smart city offers an ideal living environment. Everyday life runs smoothly and pollution prevention is cost-effective. In the VTT, this is considered one of the key points of focus.

The team of 50 experts that makes up Smart City consists of energy, construction, transport, power and ICT specialists and behavioral scientists.

"Smart technology is created to make everyday life easier, not because it is fun to have as many technological gadgets as possible", says the project leader, research professor Miimu Airaksinen.

One of Smart City's focus areas is energy systems.

"For example, we research how the energy systems of a city should change. We're looking for the optimum level of how much to improve a building's energy efficiency and how to get full benefit of the systems."

Smart City researchers have noticed that even small adjustments can bring great savings at the regional level, which is noticeable in energy production as well. Furthermore, emissions are reduced.

"We have developed self-learning algorithms for predicting the residents' needs in the building. This way we can optimize conditions and energy use. We always prioritize optimal conditions", Airaksinen emphasizes. CITYkeys Smart City performance measurement – project is carried out in cooperation with Tampere and four other European cities. The network consists of 20 other European cities and the number is growing. Results will be published at the end of the year.

Detailed information

Highly developed technology, such as remote sensors, can predict extreme situations and help in controlling storm water.
"When sensor technology and wireless data transfer develop further, we are more prepared, for example, to call for assistance."

In the future, the need for extra pumping systems in different parts of the city can be predicted even before there is water on the streets.

"This is a big leap in development. Rain can cause severe structural damage, but also create acute security risks. For example, if fire trucks or ambulances are prevented from getting to those in need of help", Airaksinen describes.

It is very typical in cities, that rainwater and sewage waste are transported through the same pipes. Therefore, controlling rainwater is critical, because flooding also creates a hygiene risk. Who would want to wade in faeces?

Finnish cities are spacious compared to many other European cities. European metropolises have mostly stone paved streets, which have very little permeable surfaces and floods are a common problem.

Highly innovative industry is also an advantage in Finland. According to Airaksinen, many sensor and automation manufacturers and companies specialized in pavement technology welcome opportunities of product development in research cooperation with the VTT. An example of cooperation is the CLASS-project lead by the VTT (www.vtt.fi/sites/class).

"Know-how is needed from both industries: pavements and sensing technology. Developing new solutions has been easy together with the industry, as new innovations have been incorporated into practice immediately. In many countries this is not so easy."

Certainly development is also fast elsewhere. In Southern Europe the possibilities of collecting and storing rainwater for relieving subsequent droughts is under investigation. ■

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