

Green Roof and Rainwater Management for Mobile Classrooms

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Motivation

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- Many **container mobile classrooms** are planned and used in Hamburg;
- No any **decentralized rainwater management** are considered in planning→ consequently, the containers will be connected to the **sewer system**;
- The discussion of School authorities & HAMBURG WASSER → develop the container classrooms with **green Roof**.

Scope

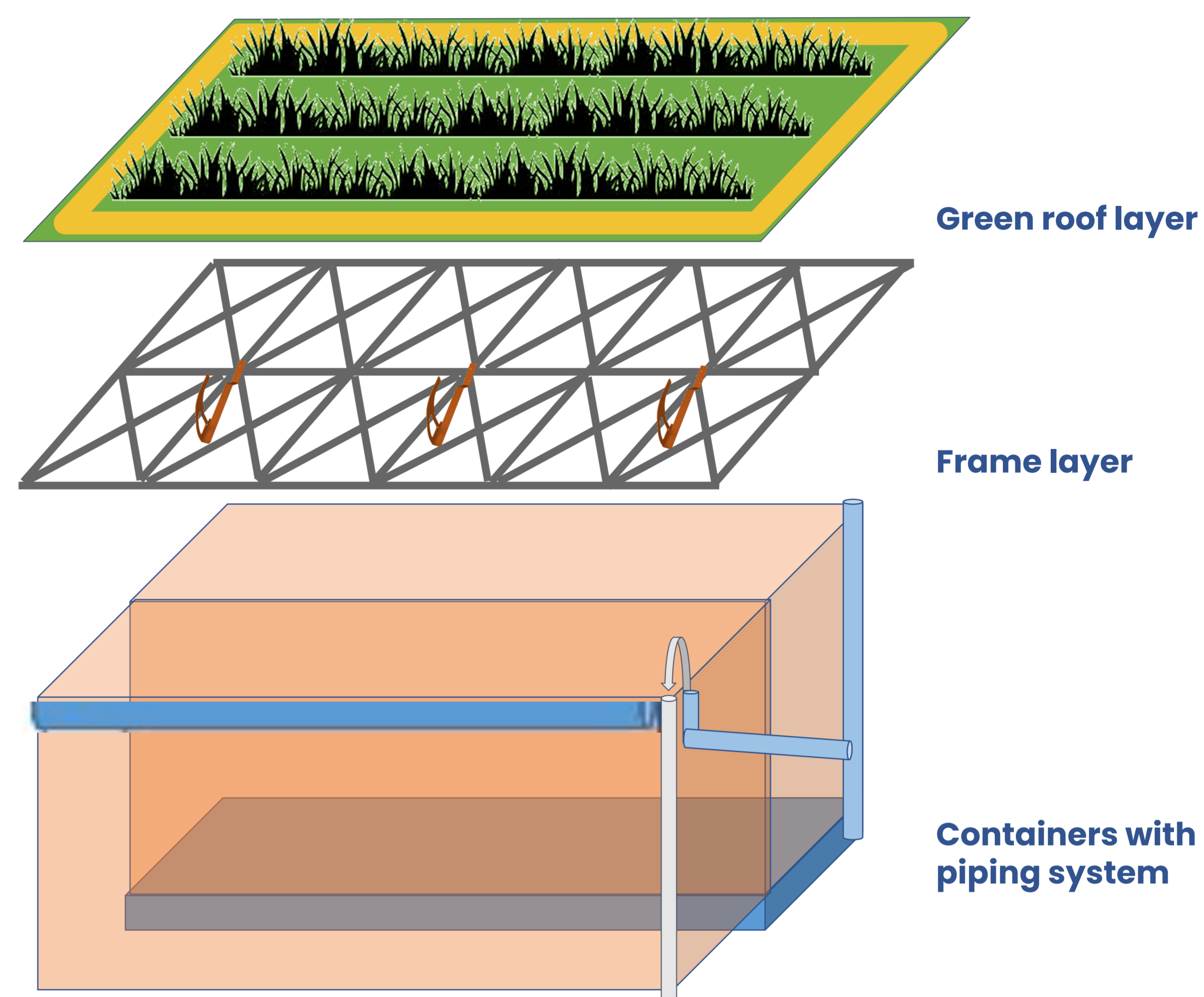
- Green roof → serve for **decentralized rainwater management** and relief of sewage system
- **Modular concepts** for different quantities of container groups with integrated rainwater management → safe, convenient to construct, acceptable cost, well-adapted;
- Consider the use of rainwater as a resource (i.e. for school garden, etc);
- Evaluate developed solutions (energy need, room climate, way of access, etc);
- Develop concepts for integration water sensitive urban planning into school programs to raise the awareness for **water balance, biodiversity**, etc.

Preconditions

- Container roof weight load: **<200 kg/m², distributed on the edge**;
Including: rainwater weight under fully saturated conditions, snow weight, wind load, weight of the maintenance staff.
- Fire protection: 30-50 cm wide of gravel strip;
- Safety insurance: roof safety hook.

Container Sketch Map

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Container Roof Design and Statistics

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- A sturdy rooftop frame can carry the weight of green roof and other payloads.
- Having a **Payload capacity of 200kg/m²** on rooftop metal structure.
- Galvanized metal frame.
- Suitable for all weather conditions, rust proof, light weight, etc.
- Easily modified as per the requirements.
- Weight of the metal frame: 104 kg/m²
- Maximum load on the top of the metal frame:
 - Saturated green roof weight: 148 kg/m²
 - Maximum Wind Load: 2.47 kg/m²
 - Maximum Wet Snow Load: 4.8 kg/m²
 - Maintenance Staff: 6.944 kg/m²
- **Total Load on the Metal Frame : 162.21 kg/m²**
- **Total Weight on the Edge of the Container : approx. 272 kg/m²**



Fig 1. Frame and Container Connection



Fig 2. Frame structure and Placement

Water Management

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- Managing rainwater in the mobile classroom ensures the **safety** of the classroom
- The rain water can be used **profitably** for watering.
- In order to store the rainwater effectively the amount of the rainwater must be calculated according to DIN 1986-100:2016-09 which are as follows:
 - Amount of rainwater is **Q_r = 0.63l/s**
 - Emergency drainage is **Q_{not} = 0.84 l/s**
 - Number of drains is **one for one container**
 - The Diameter of pipes is **DN 100 d= 98 mm**
- The water storage container has the same dimension of the container and can be easily removed when needed with a storage capacity of approximately **10,000 litres**
- Proposed drainage system is Cast iron gravity drainage.

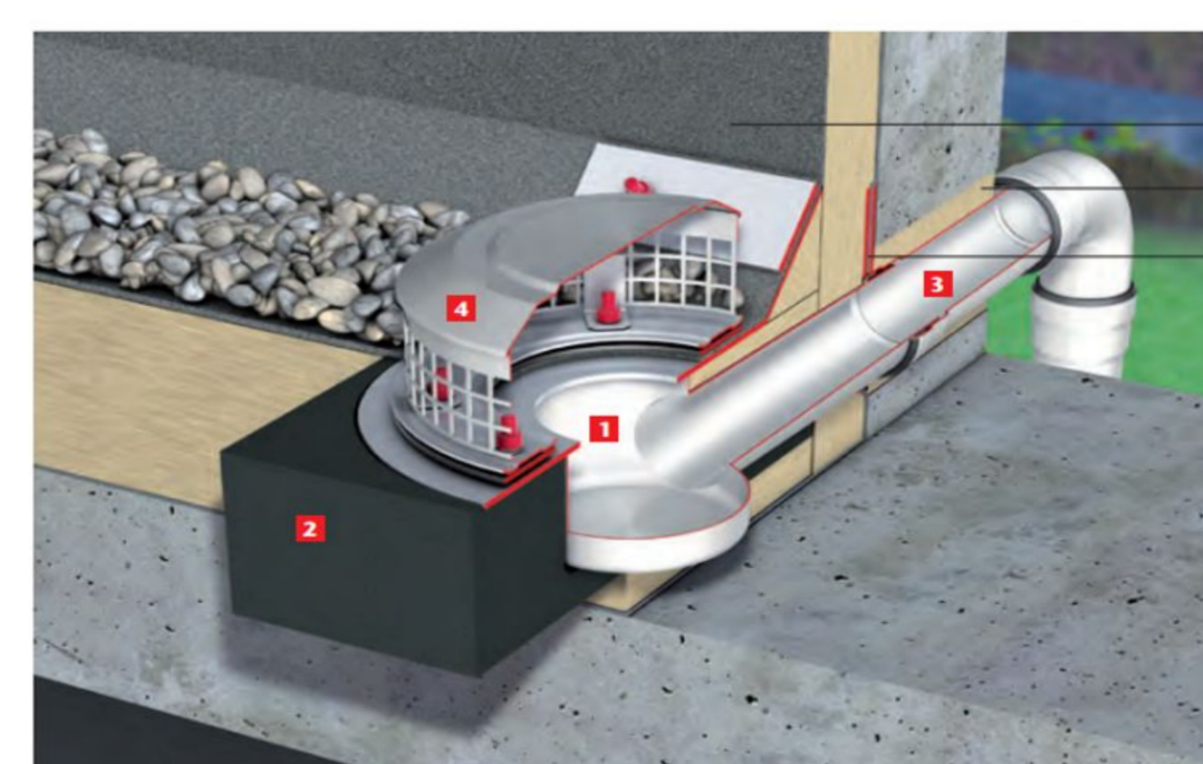


Fig 4. Emergency drainage pipes

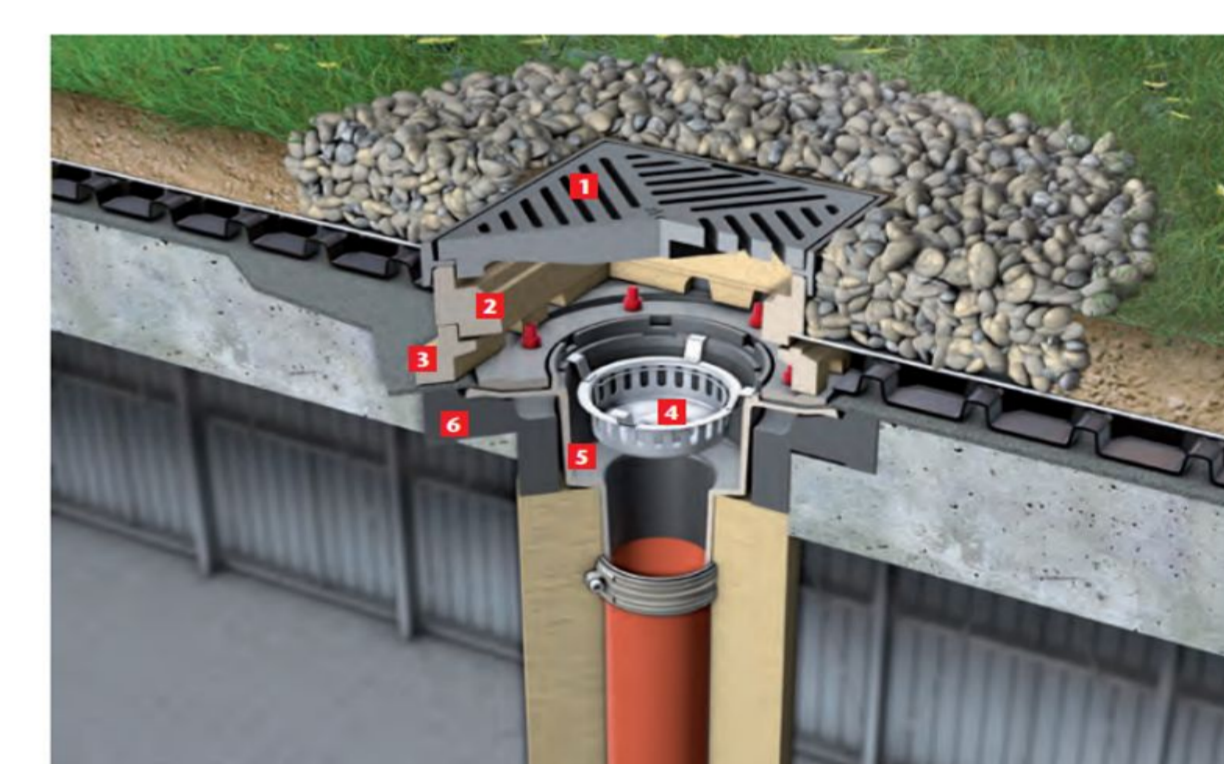


Fig 5. Cast iron gravity drainage

Green Roof Design

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Extensive green roof - modified from *Optigrün Retention Roof* :

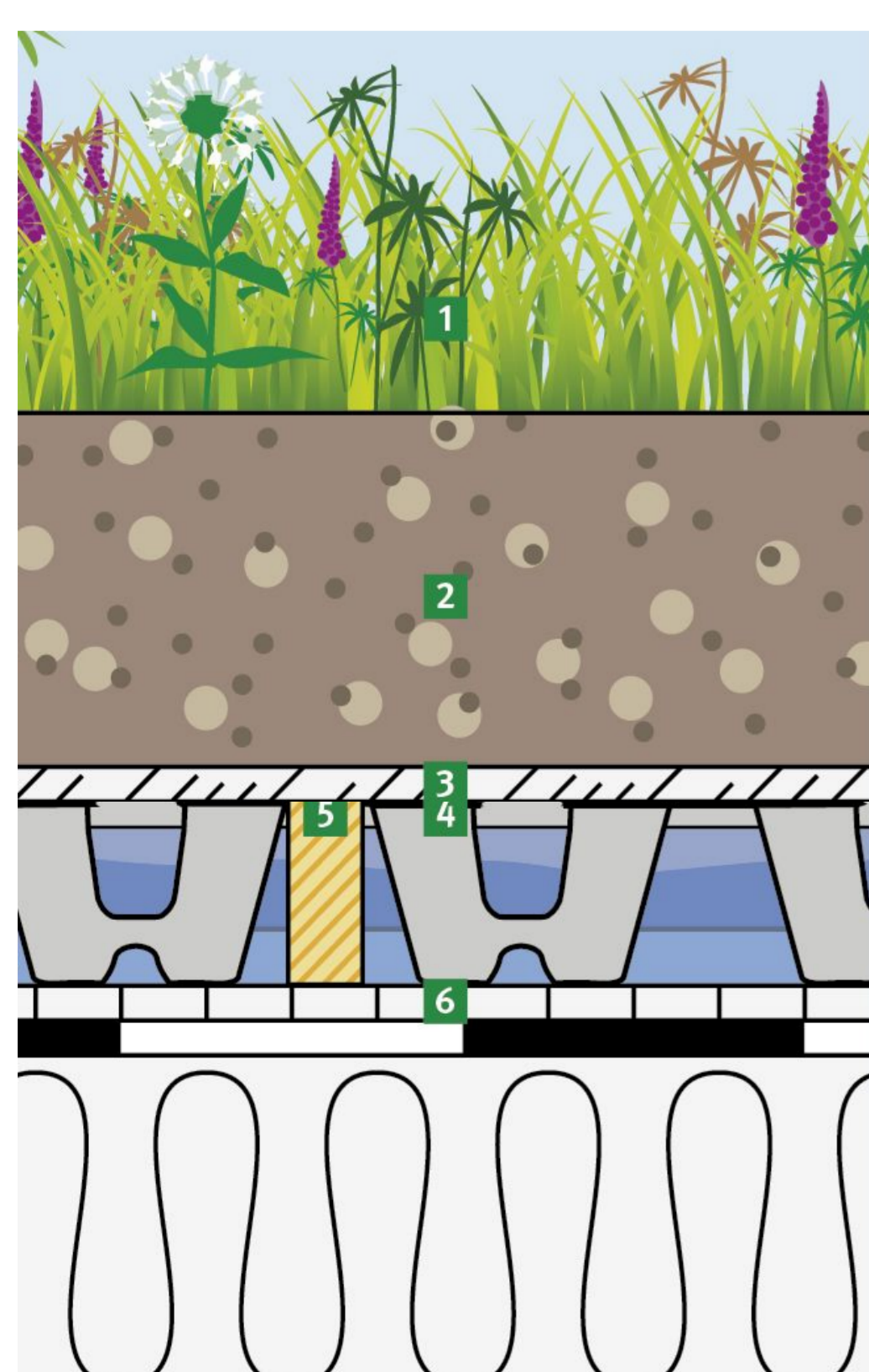


Fig 3. Cross sectioner view of green roof

- Water storage and better microclimates.
- Low weight due to cavity type construction of the water retention box WRB.
- Low **rainwater discharge** and **runoff delay**.

Layers of the green roof:

1. **Sedum sprouts** with Ekr herb seed mix
2. **Extensive substrate**: high water storage capacity
3. Suction and capillary fleece: good water distribution
4. **Water retention box**: 36L/m² retention capacity
*original retention capacity: 72L/m²
modification: remove upper layer of retention box*
5. **Capillary column**: 2 column/m²
6. Separation, protection and storage fleece

Total weight (fully saturated): 148.2 kg/m²

Fire protection strip: gravel with 30 cm in width, 45 kg/m²

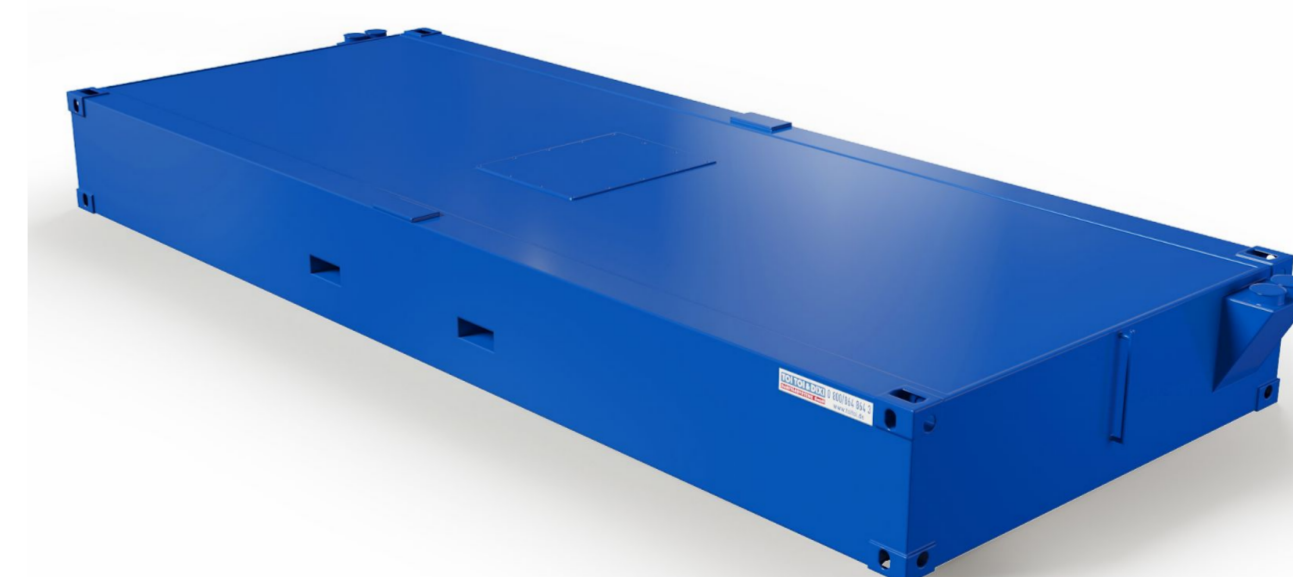


Fig 6. Storage container

Conclusion and Outlook

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- The rooftop structure is designed to sustain all the payload exerted on it by green roof, weather conditions, etc.
- Extensive green roof is chosen for its lightweight and good water retention capacity. Adjustment of the retention box is made for the lighter weight.
- Simple techniques which are already existing in the field of toilet wagons are used for rainwater storage in the container along with the cast iron gravity pipes design as well as emergency pipes.
- The rainwater in the storage container will be used for other usages, for example, school garden irrigation and cleaning.
- In the future design, the modular green roof could be combined with more green infrastructure such as solar panel, and can have more functions with different designs.