



Budapest University of Technology and Economics  
Faculty of Architecture Engineering  
Department of Building Constructions



# **EXPLOITED FLAT ROOFS**

## **BALCONIES, TERRACES**

Horváth Sándor - Fülöp Zsuzsanna Ph.D

Budapest 2017.

# CLASSIFICATION OF FLAT ROOFS

Non exploited flat roofs

walking on the roof surface only for maintenance;

• **Exploited flat roofs**

**balconies, loggias, terraces**

green roofs

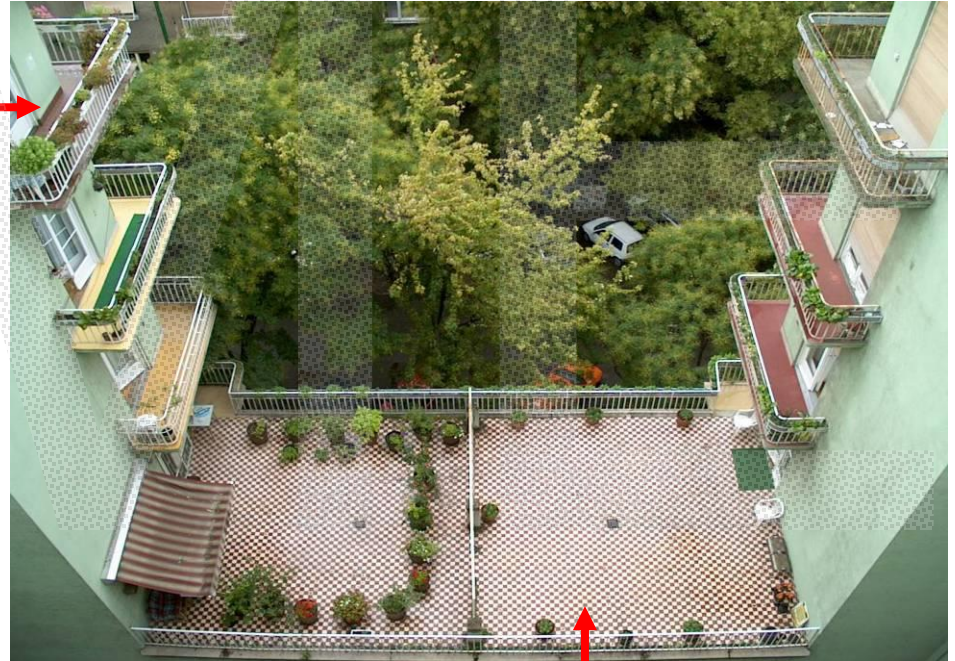
roads, parking areas.



# EXPLOITED FLAT ROOFS

## BALCONIES, LOGGIAS, TERRACES

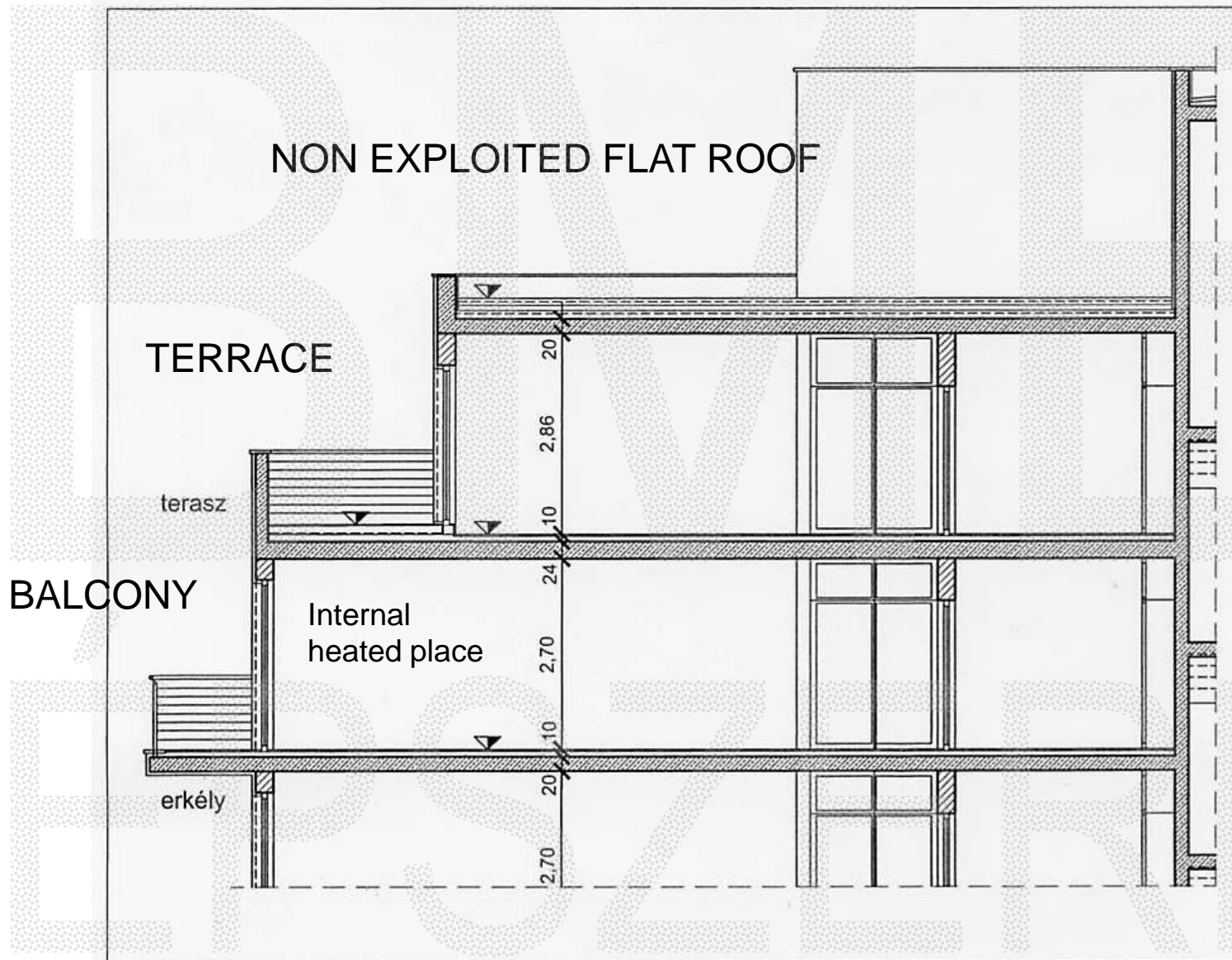
BALCONIES

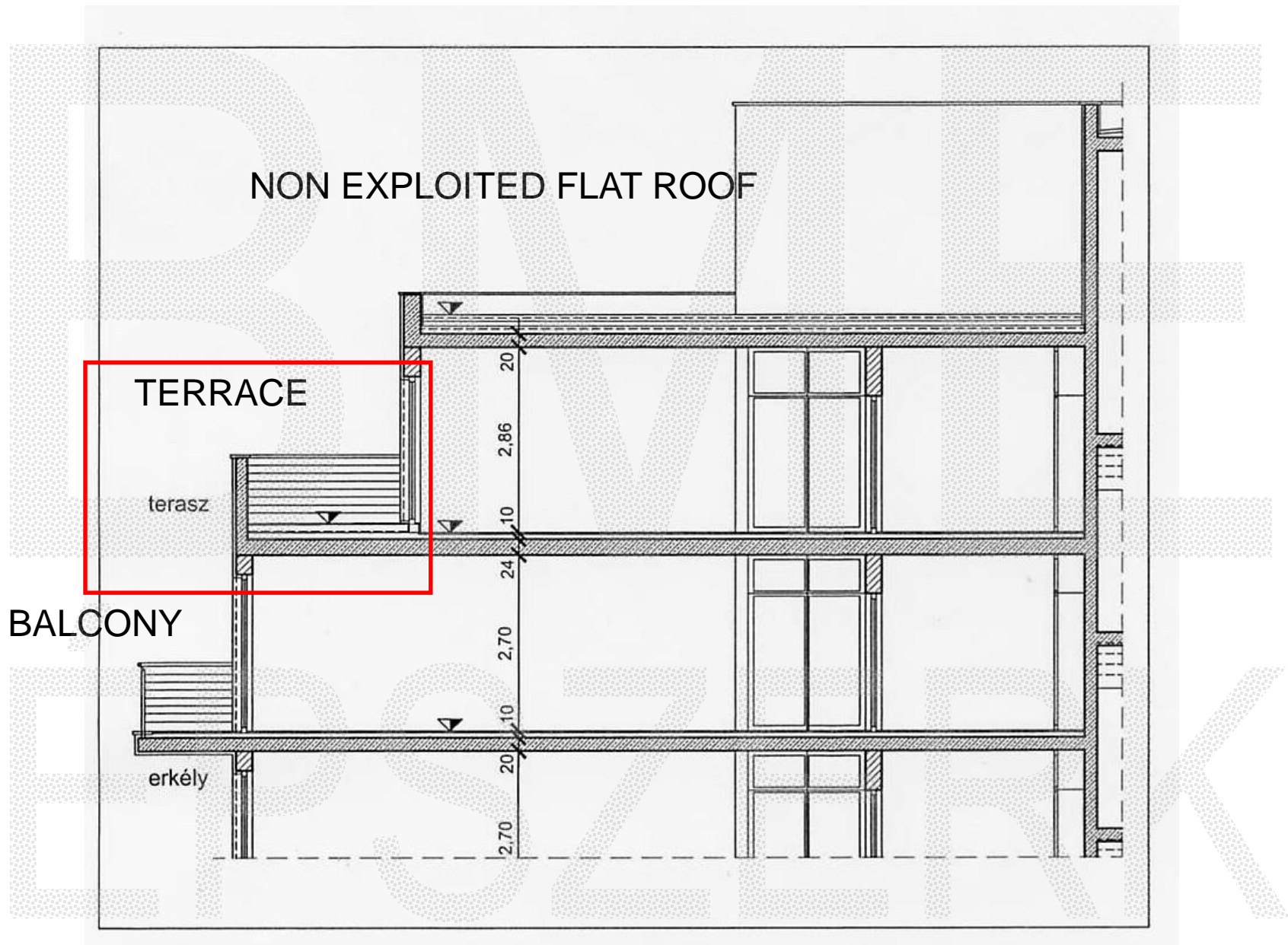


LOGGIAS

TERRACES



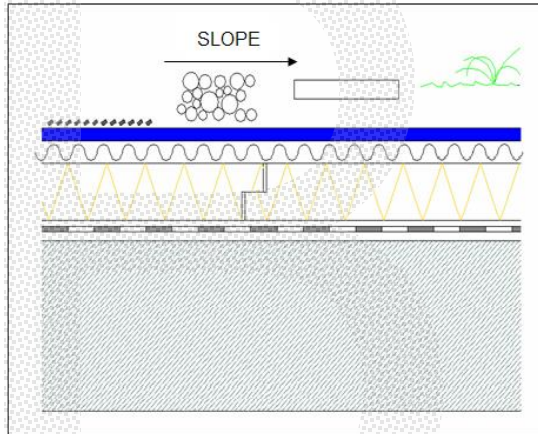






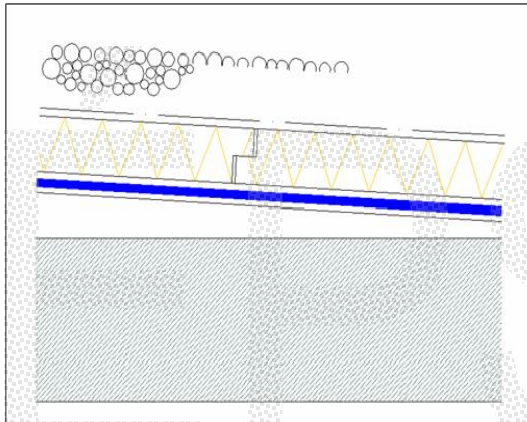
# LAYERS OF NON EXPLOITED ROOF

## NORMAL ROOF



UV protection  
Waterproofing  
(fixing, slope)  
Separation  
Thermal insulation  
Vapour barrier  
Screed  
Load bearing slab

## INVERTED ROOF



Ballasting  
Separation  
Thermal insulation  
Waterproofing  
Screed  
Load bearing slab

OR

## EXPLOITED FLAT ROOFS - TERRACES

LAYERS OF  
FLOOR  
COVERING

COMPLEX  
MEASUREMENT OF  
THE WHOLE  
CONSTRUCTION !



# TERRACES

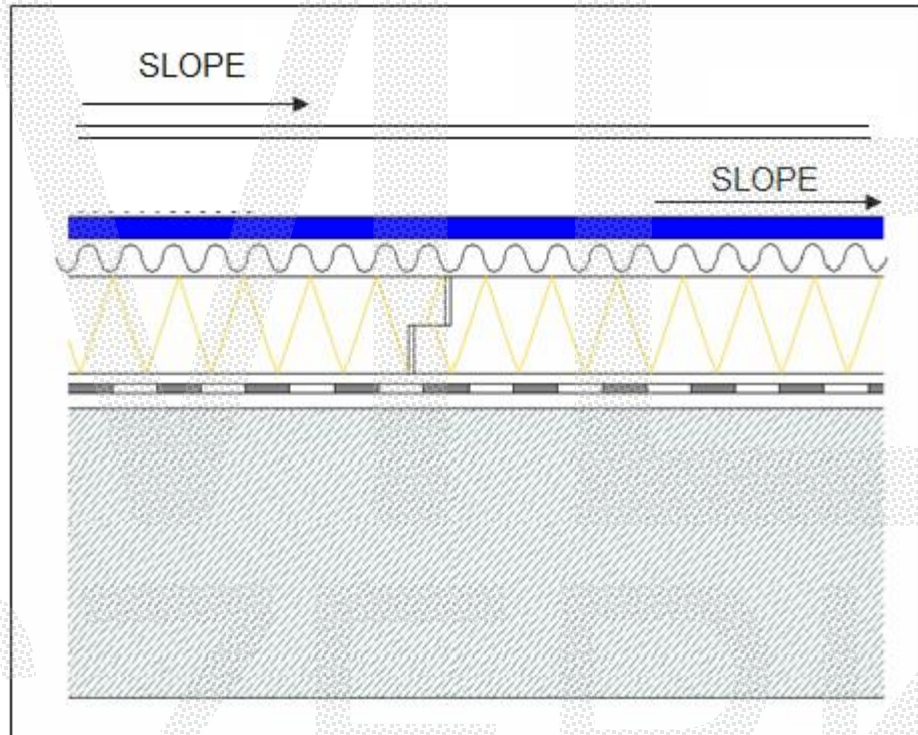
## ON NORMAL ROOF

### FLOOR COVERING SYSTEM

+

### NORMAL (CONVENTIONAL) FLAT ROOF

- UV protection
- Waterproofing
- Separation
- Thermal insulation
- Vapour barrier
- Screed
- Load bearing slab



**COMPLEX MEASUREMENT OF THE WHOLE CONSTRUCTION !**

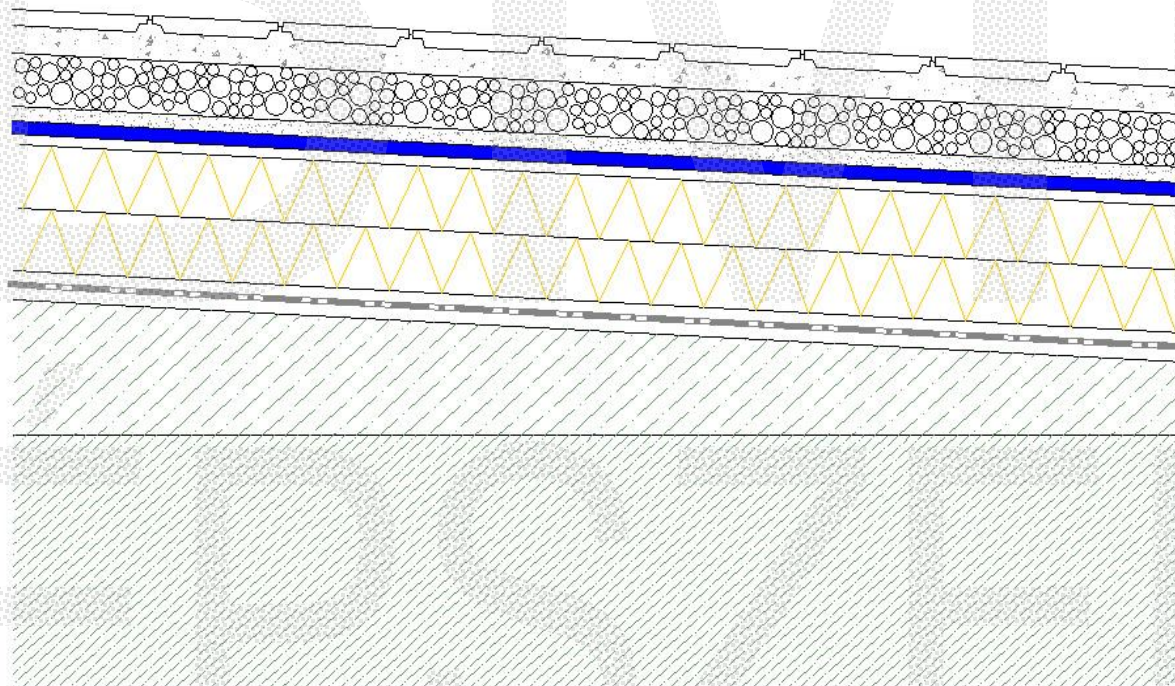


# TERRACES

## ON NORMAL ROOF

„traditional“, closed joints

(frost resistance!)



- tiles
- cement mortar
- filter screed
- drain (sand)

+

**LAYERS OF  
NORMAL ROOF**



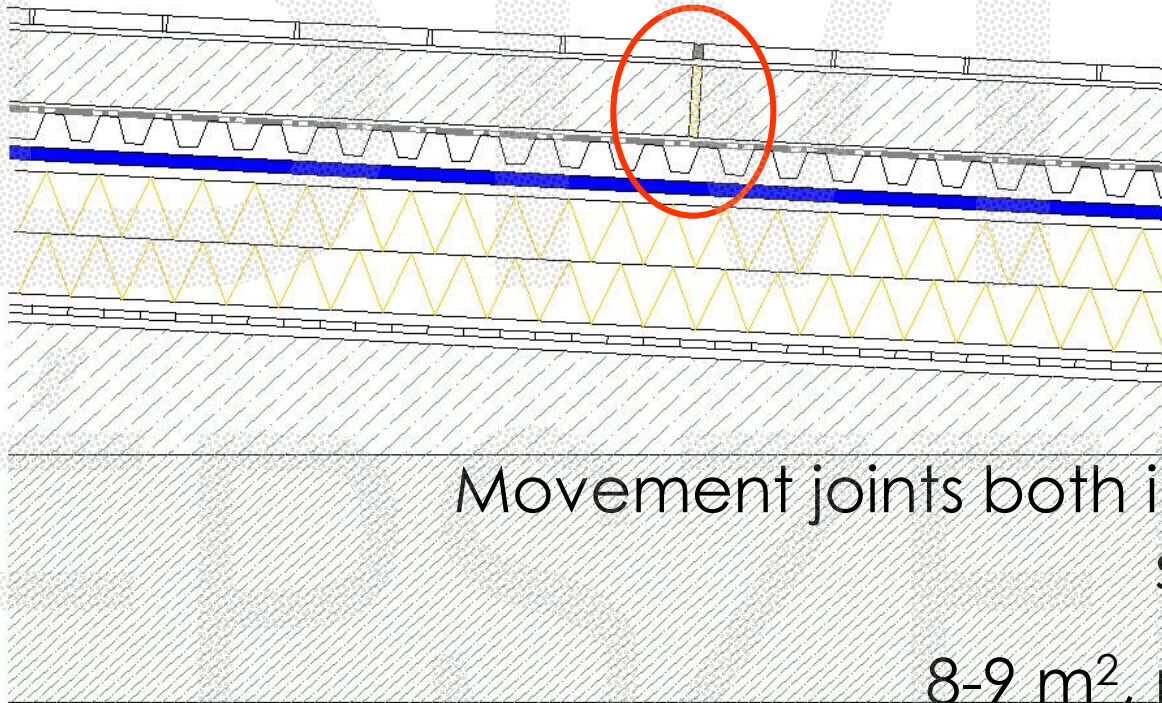


# TERRACES

## ON NORMAL ROOF

Glued tiles covering, closed joints  
(floor covering in slope, frost resistance)

- tiles
- gluing
- screed
- drain sheet



+  
**LAYERS OF  
NORMAL ROOF**

Movement joints both in covering and  
screed at each

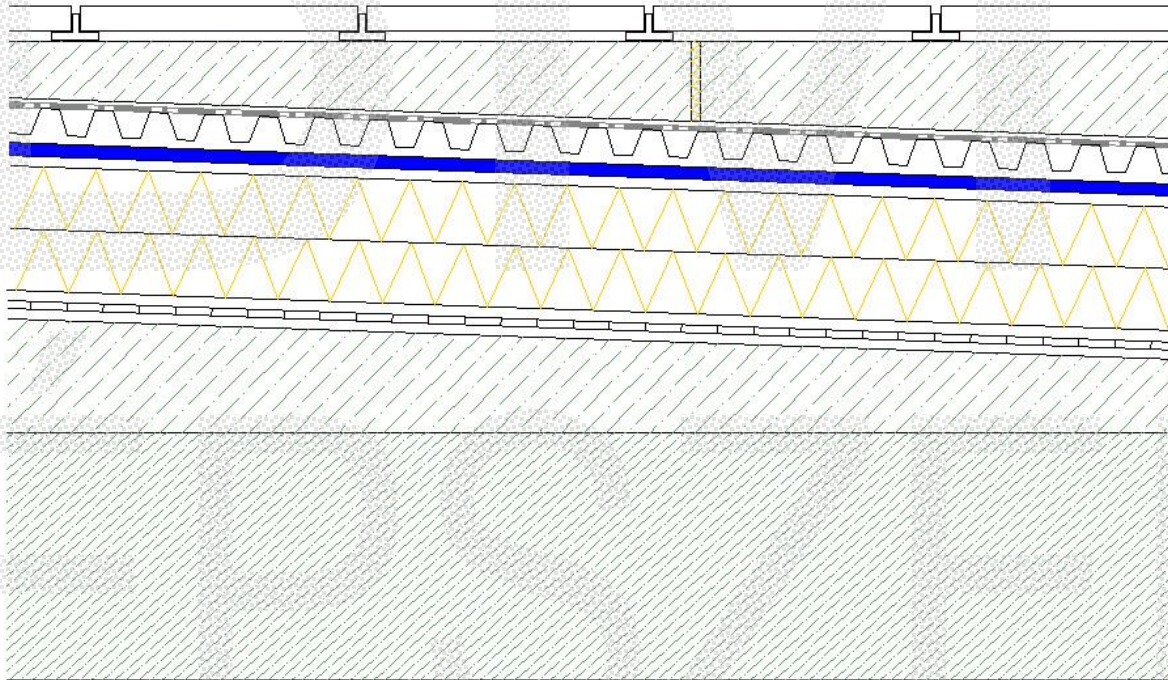
8-9 m<sup>2</sup>, max length 3 m



# TERRACES

## ON NORMAL ROOF

Supported floor covering, open joints  
(floor covering without slope)



- tiles 4-5 cm
- supporting
- screed  
(movement joints)
- drain sheet

+

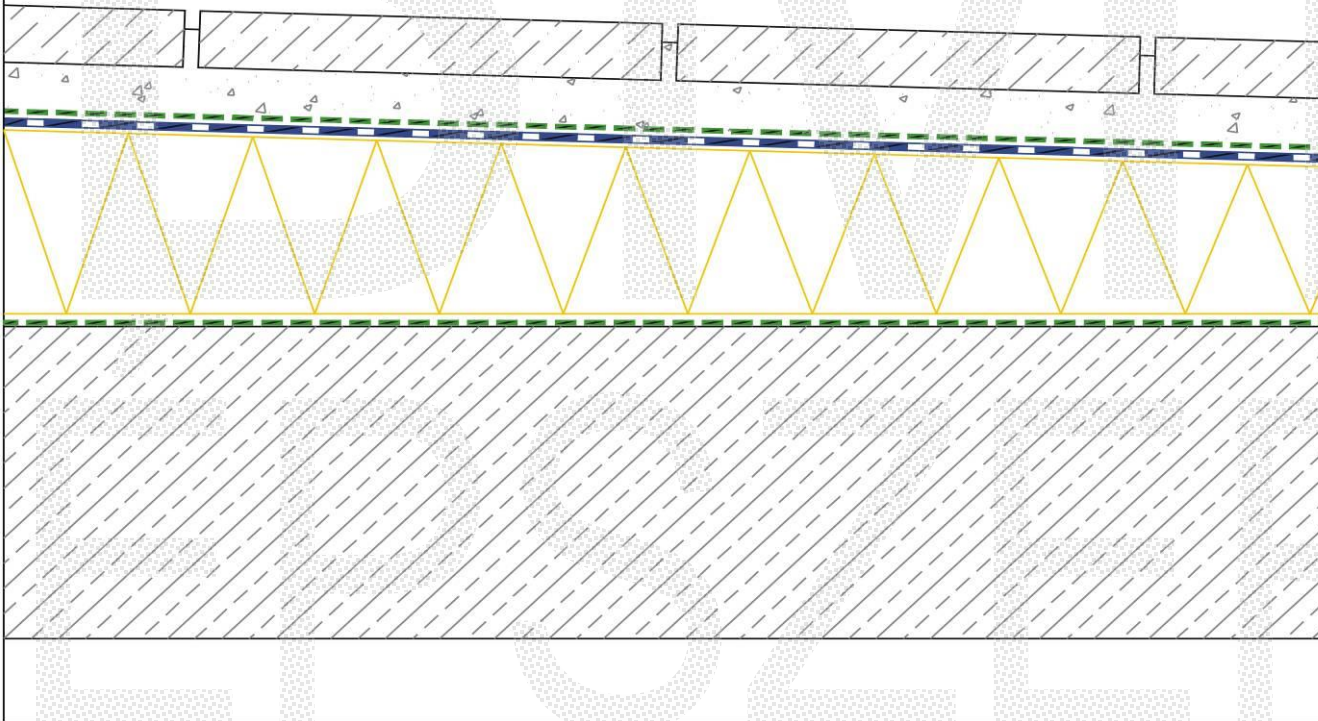
**LAYERS OF  
NORMAL ROOF**



# TERRACES

## ON NORMAL ROOF

Bedded floor covering open joints  
(floor covering in or without slope)



- tiles (4-5 cm stone or concrete)
- crashed rock (min 5 cm)
- separation protection layer

+

**LAYERS OF  
NORMAL ROOF**



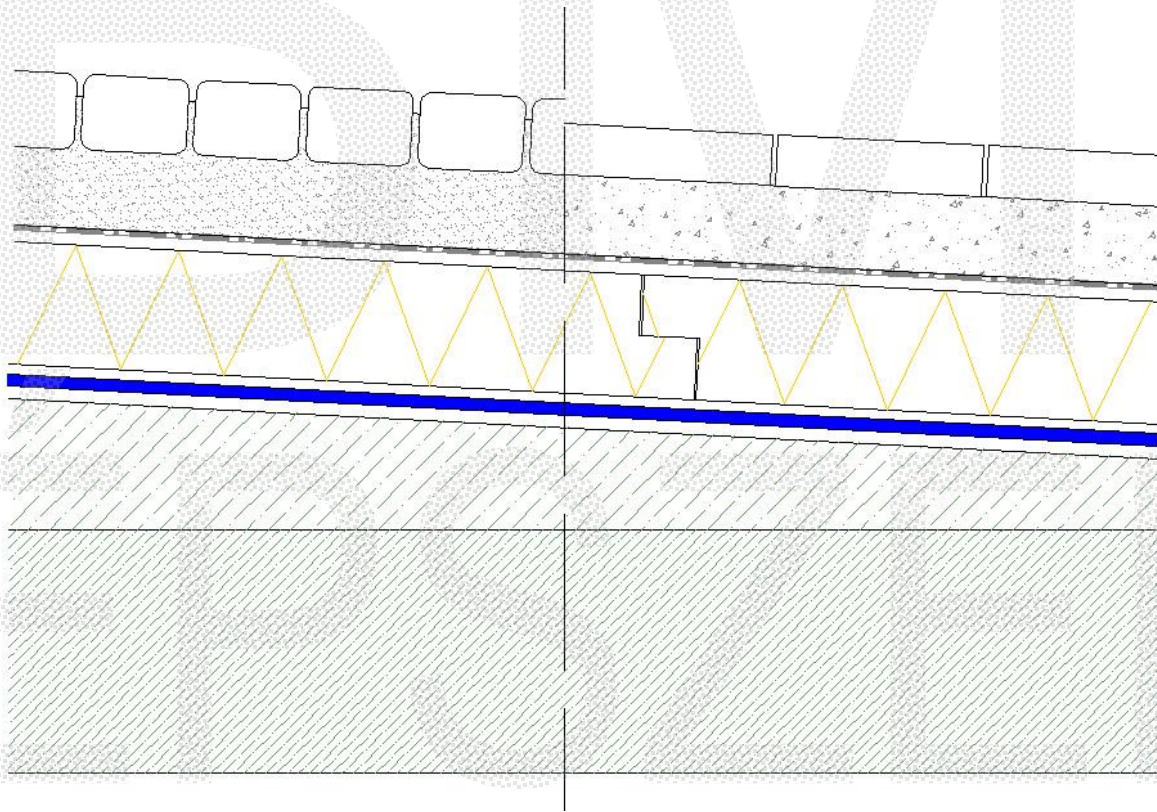


# TERRACES

## ON INVERTED ROOF

Bedded floor covering open joints

(floor covering in or without slope)



- **tiles (4-5 cm stone or concrete)**
- **crashed rock (min 5 cm)**
- **separation filter layer**

+

**LAYERS OF  
INVERTED ROOF**





# TERRACES

## FIXING

Lightweight layers are fixed by layers of terrace floor covering (or roof garden).

Wind loads are classified and measured by standards.

## FIXING SYSTEM

**ballasted by floor covering  
layers**



# EXPLOITED FLAT ROOFS

## DRAIN SYSTEM

### INCLINATION OF WATERPROOFING (materials!)

- On general surface: min cca. **2,5 %**
- In valleys: min cca. **1,5 %**

### INCLINATION ON THE ROOF SURFACE

max **1-1,5 %**

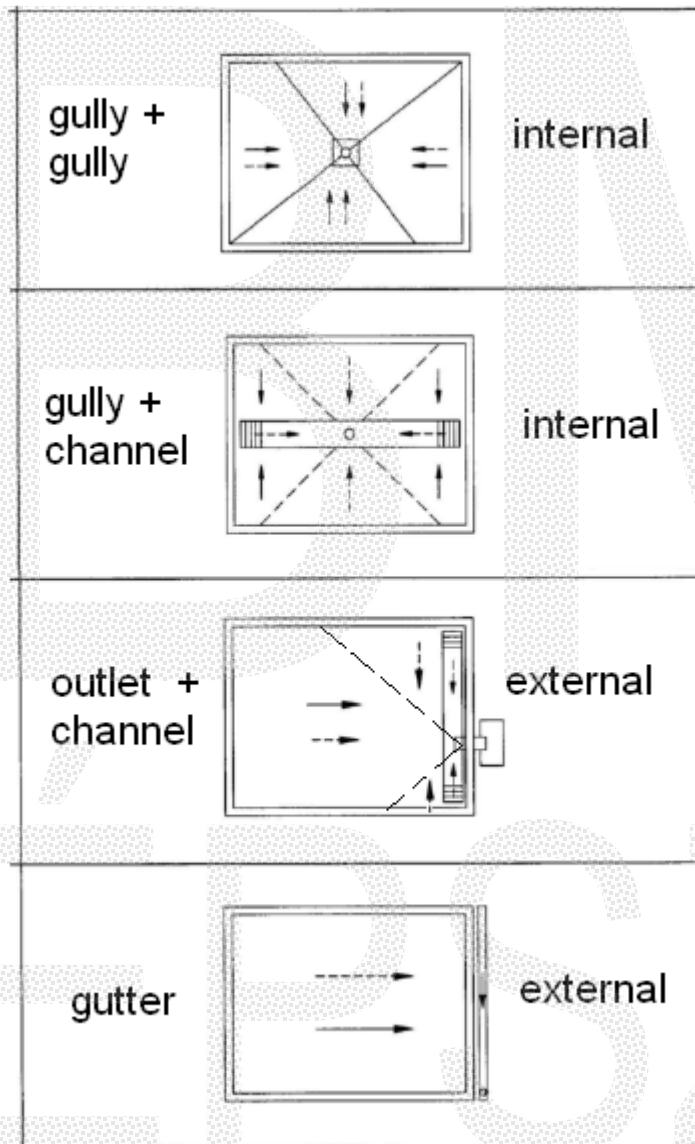
### RAINWATER MUST BE LED BOTH FROM

- SURFACE OF WATERPROOFING  
AND
- ROOF SURFACE



# TERRACES

## DRAIN SYSTEM



← - - inclination of waterproofing

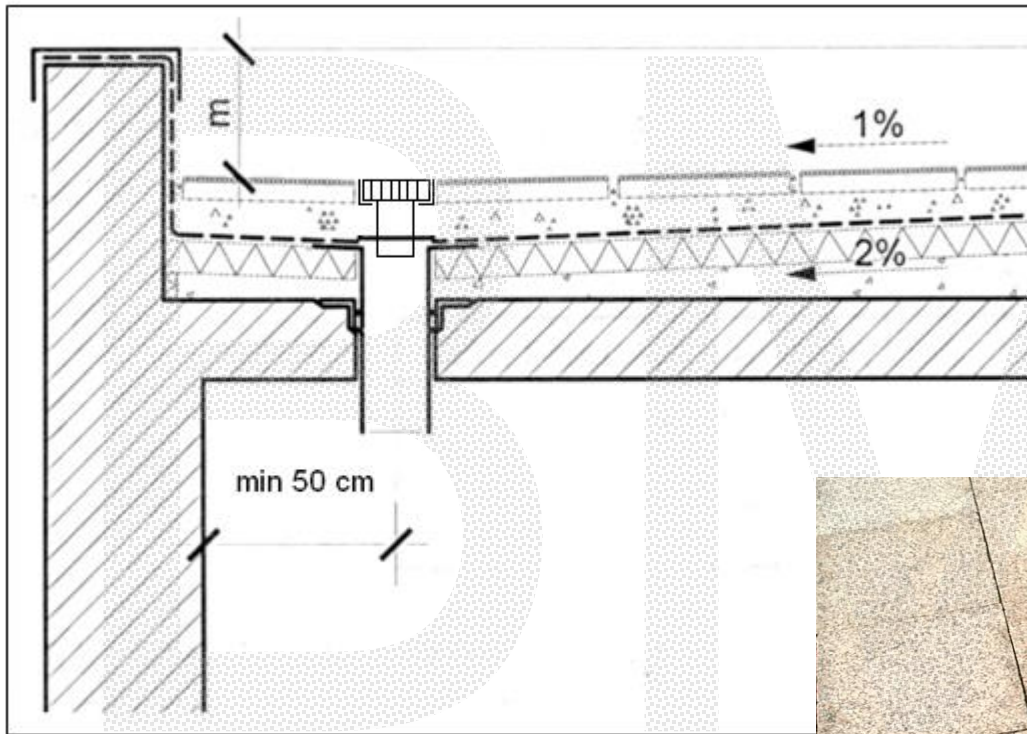
← — inclination of floor covering



# TERRACES

## INTERNAL DRAIN SYSTEM

gully +  
channel



ARRANGEMENT OF FLOOR TILES

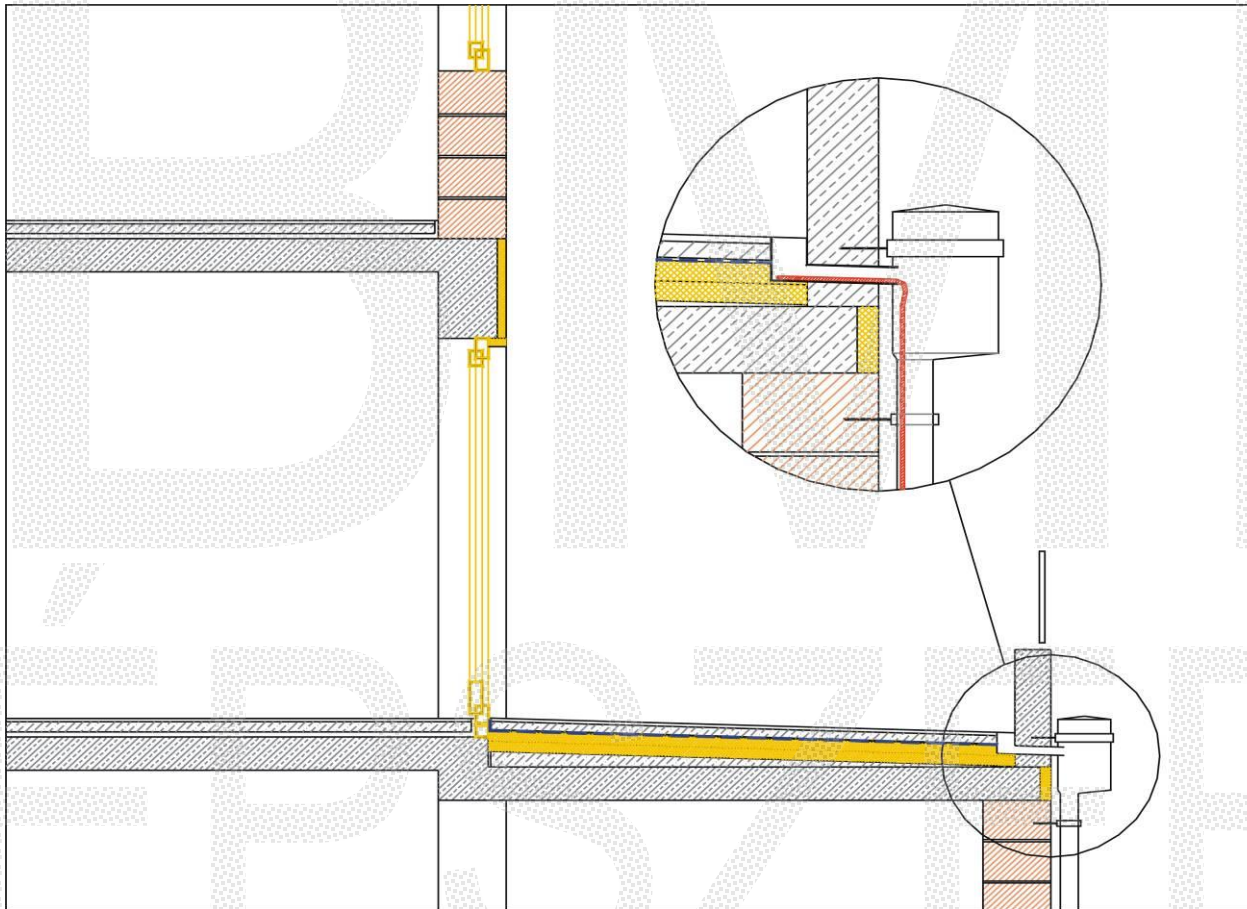
CHANEL CONNECTED TO THE GULLY





# TERRACES

## EXTERNAL DRAIN SYSTEM

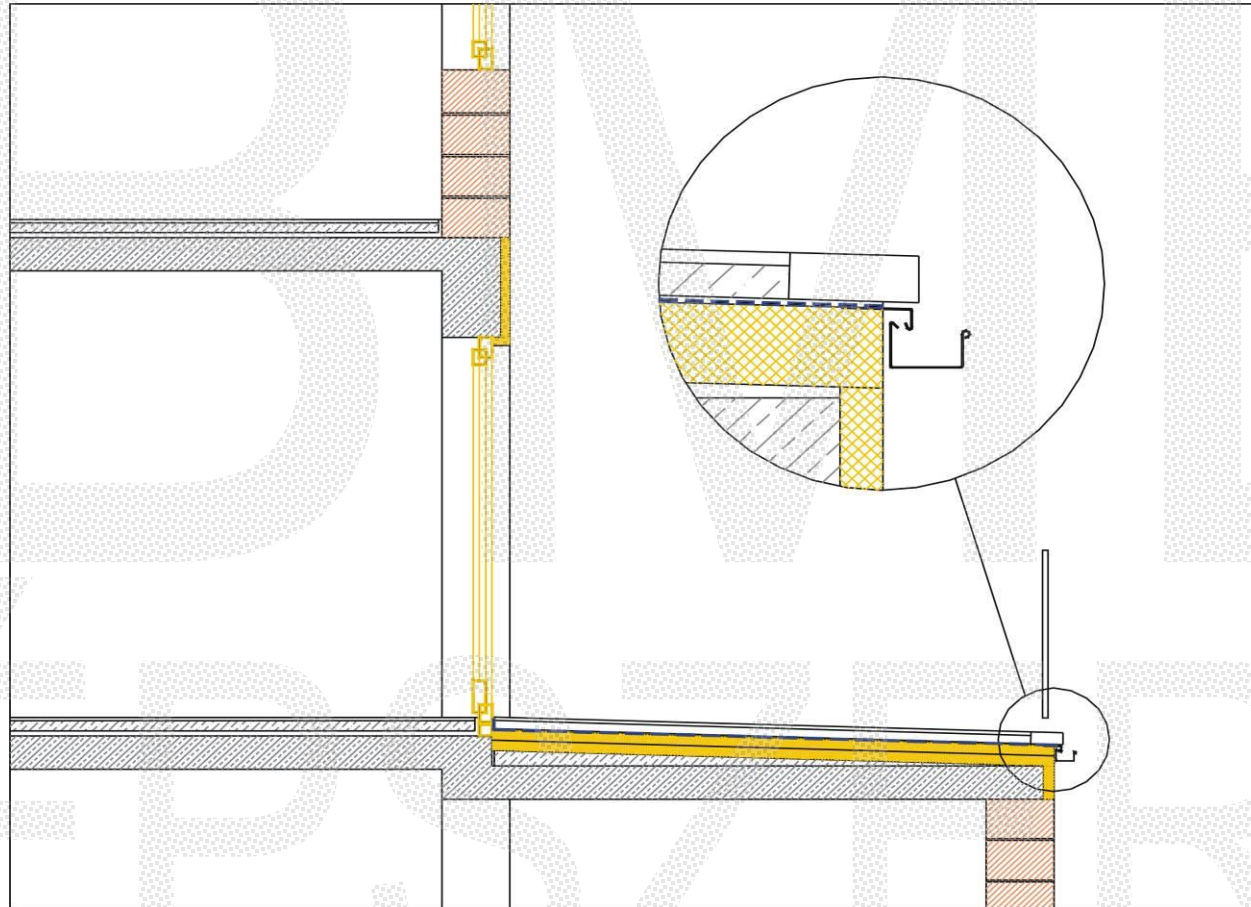


**outlet**



# TERRACES, BALCONIES

## EXTERNAL DRAIN SYSTEM



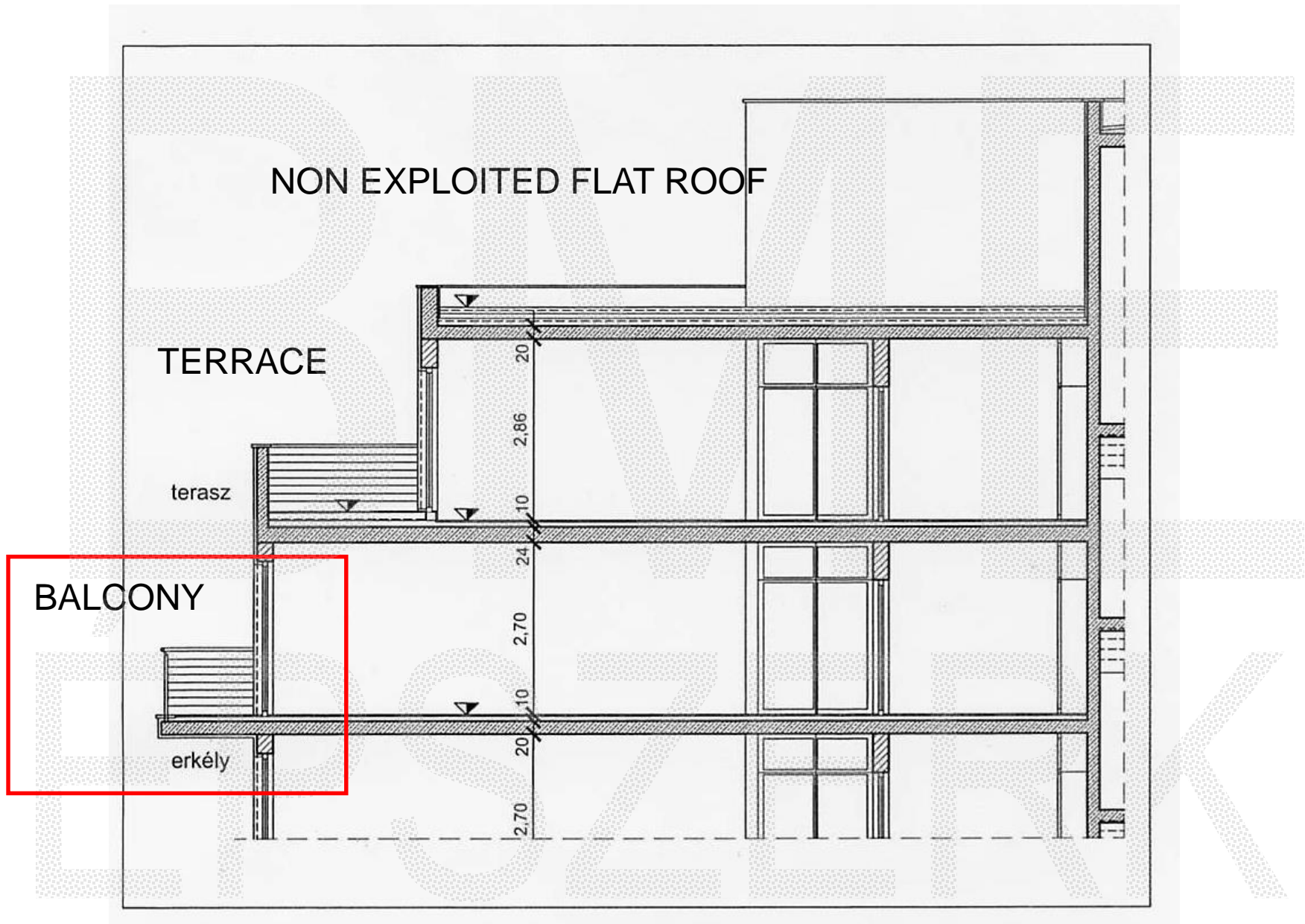
gutter



# TERRACES, BALCONIES

## EXTERNAL DRAIN SYSTEM











# BALCONIES

Glued tiles covering, closed joints  
(frost resistant floor covering in slope)

1-1,5 %

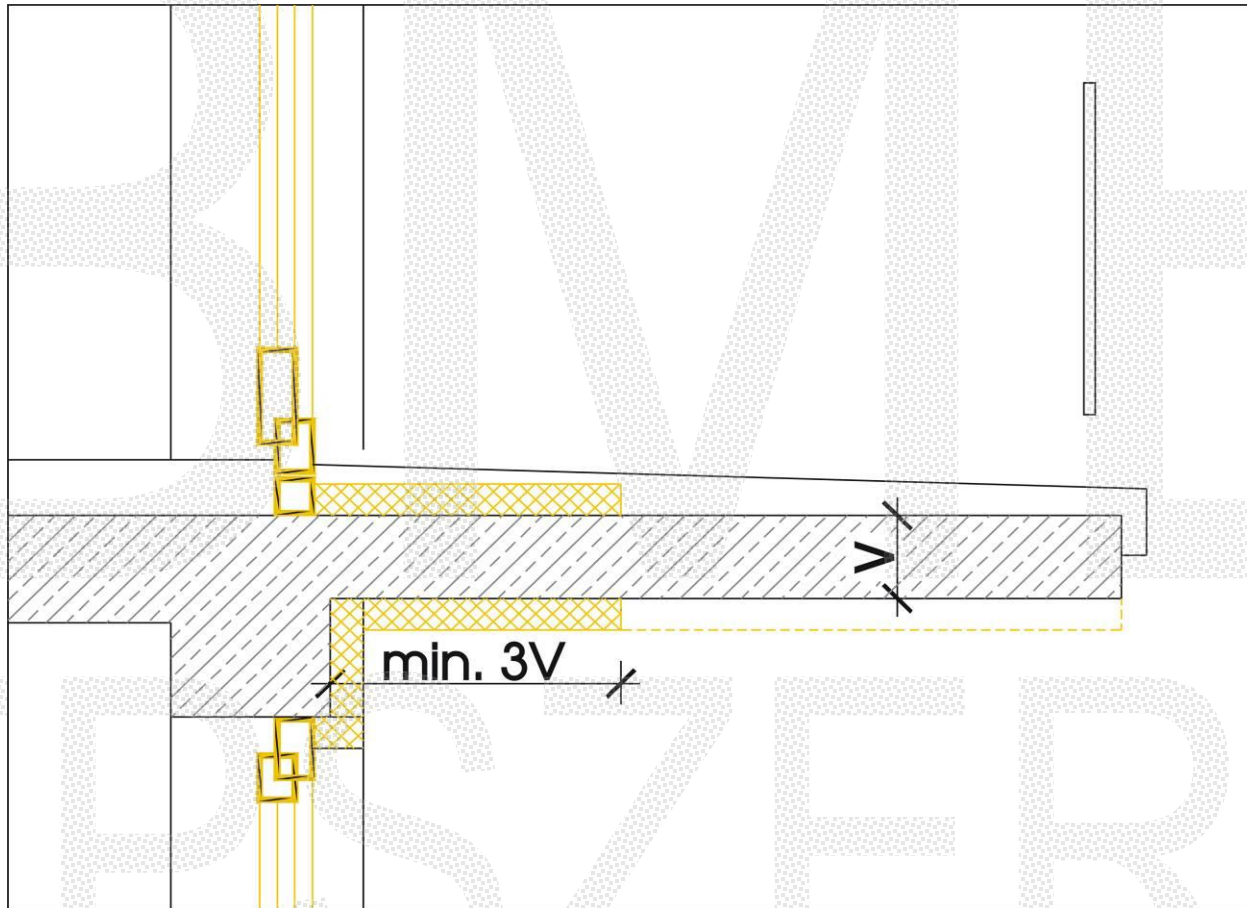
- tiles
- gluing
- sub concrete
- drain sheet
- waterproofing
- (thermal ins.)
- screed
- slab

Movement joints both in  
covering and screed at each  
8-9 m<sup>2</sup>, max length 3 m



# BALCONIES

## THERMAL INSULATION

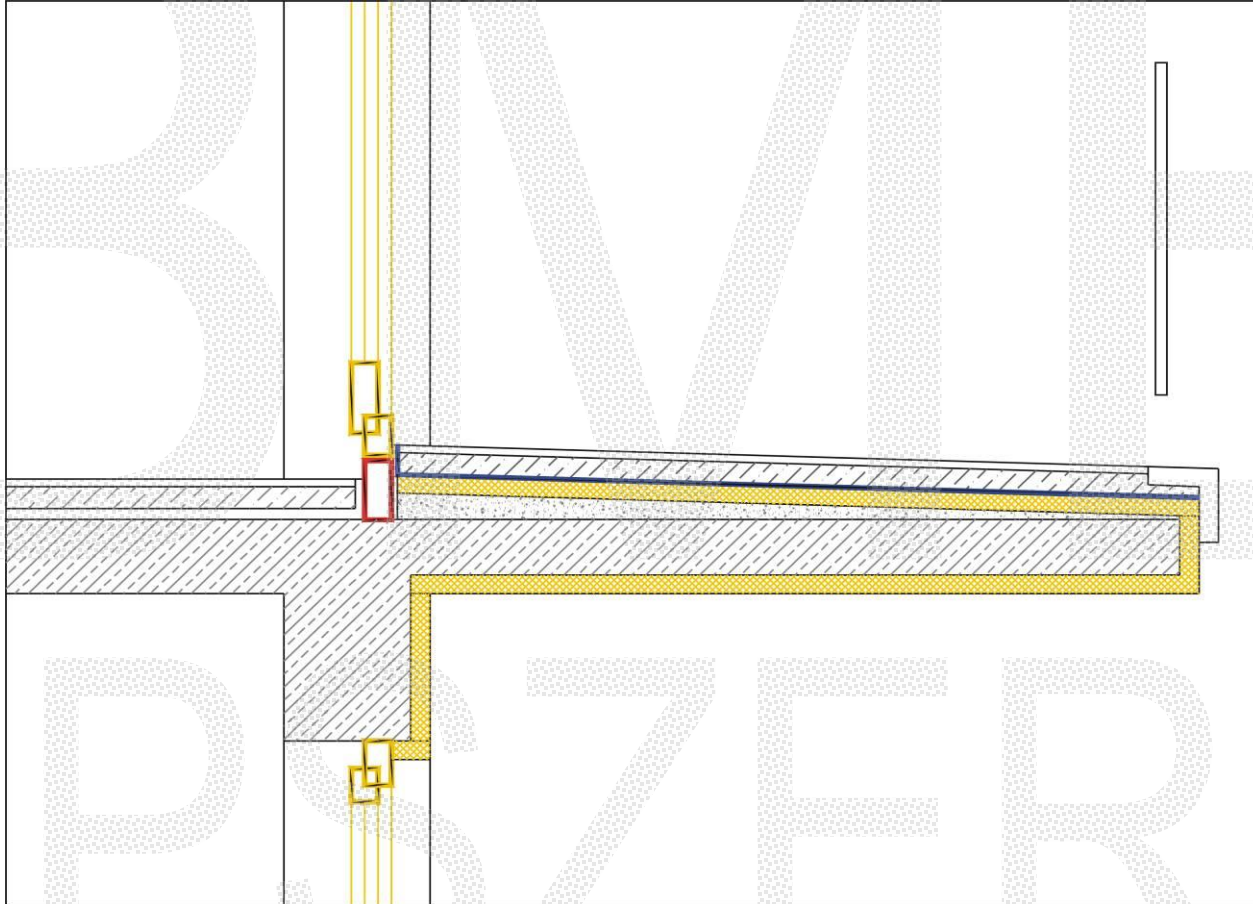


Frost resistant thermal insulation



# BALCONIES

## THERMAL INSULATION



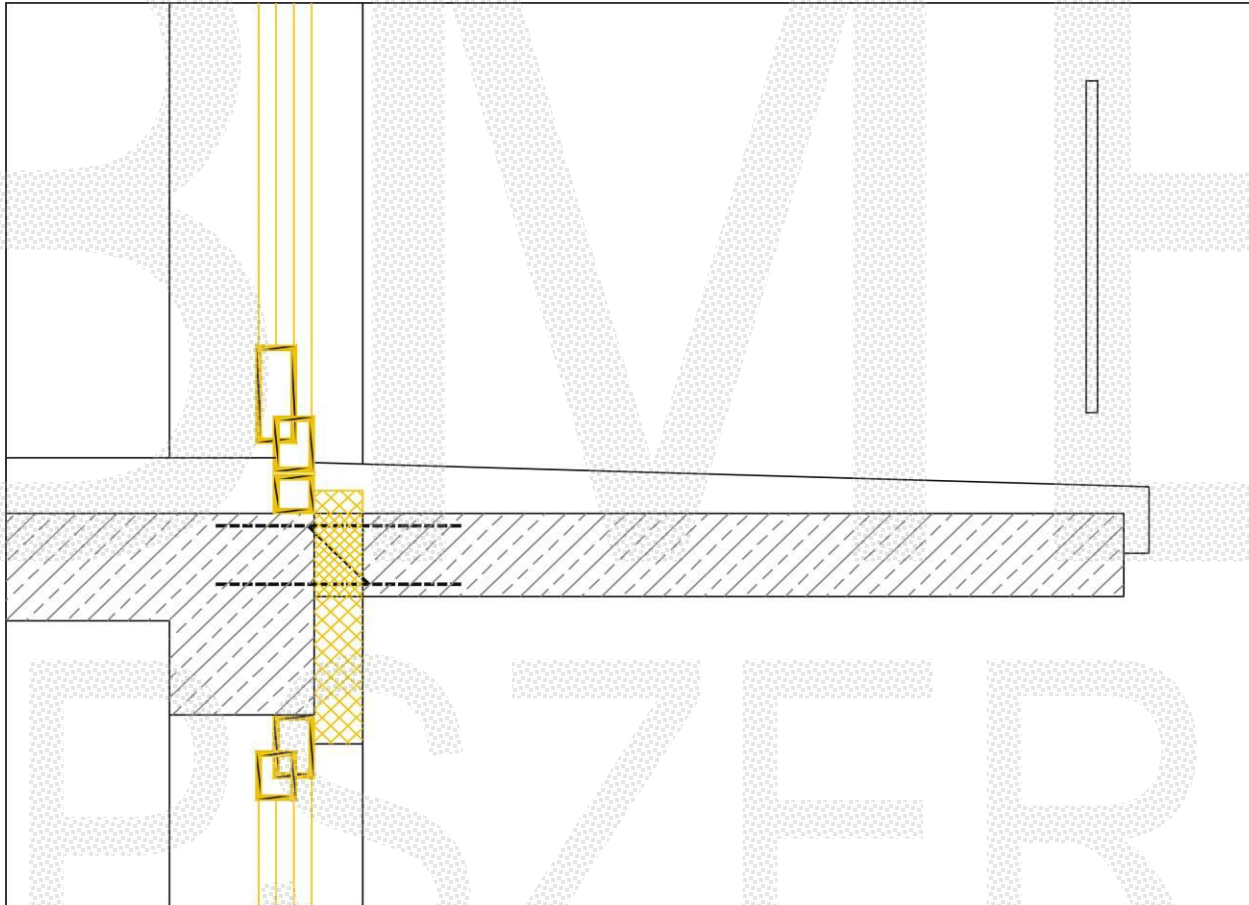
Frost resistant thermal insulation under floor covering





# BALCONIES

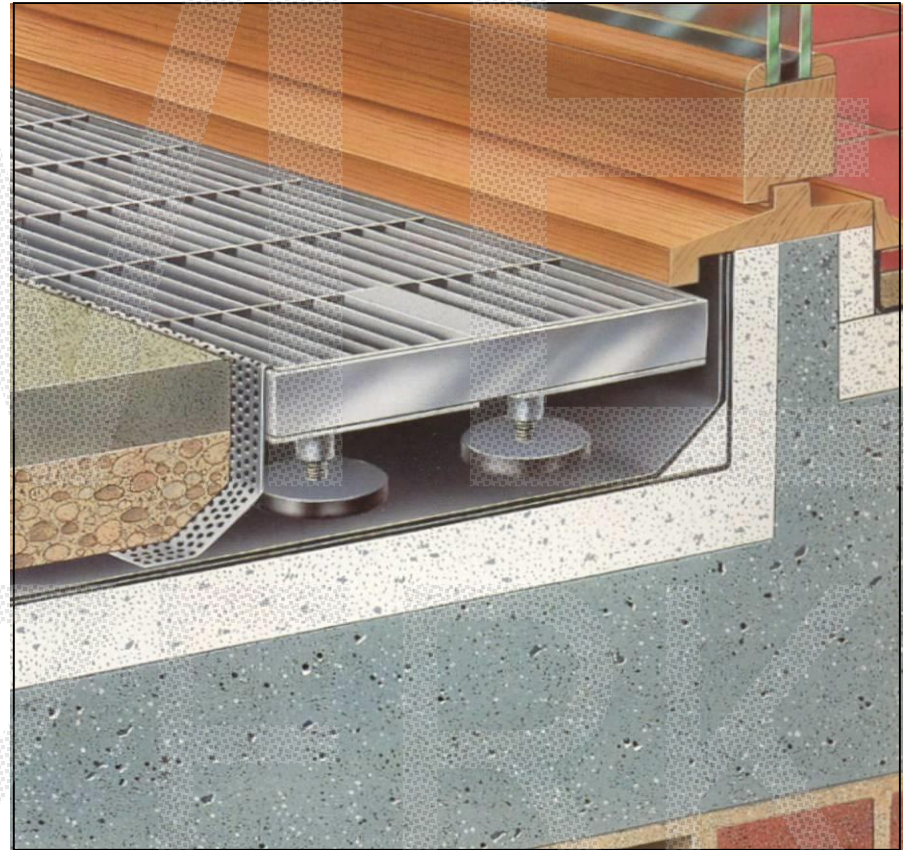
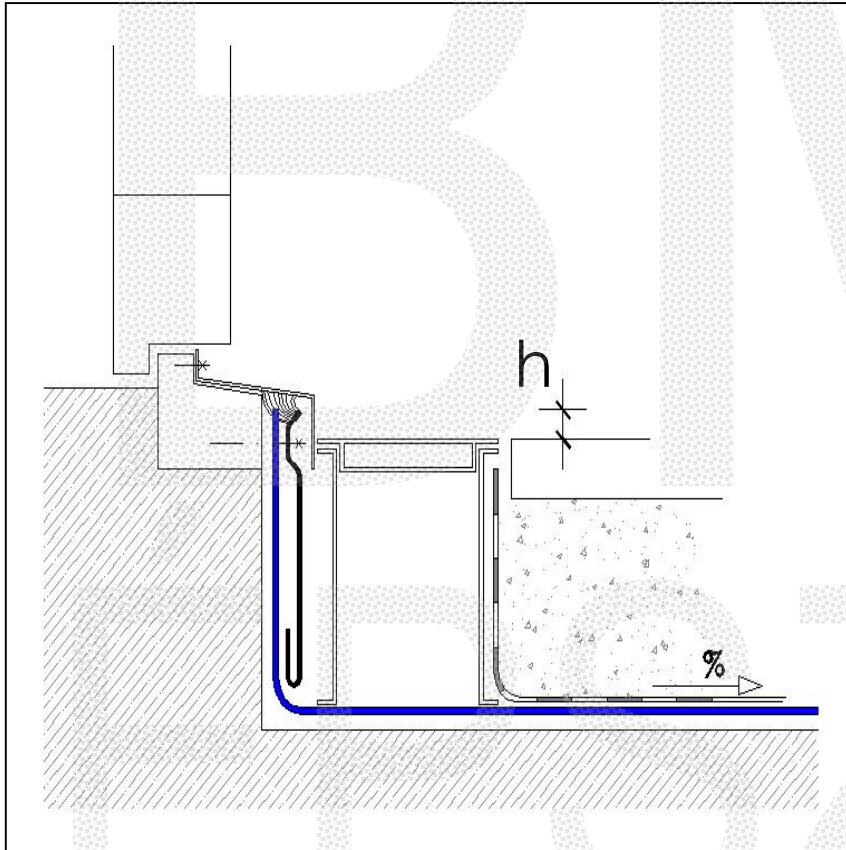
## THERMAL INSULATION



Thermal bridge thermal insulation element

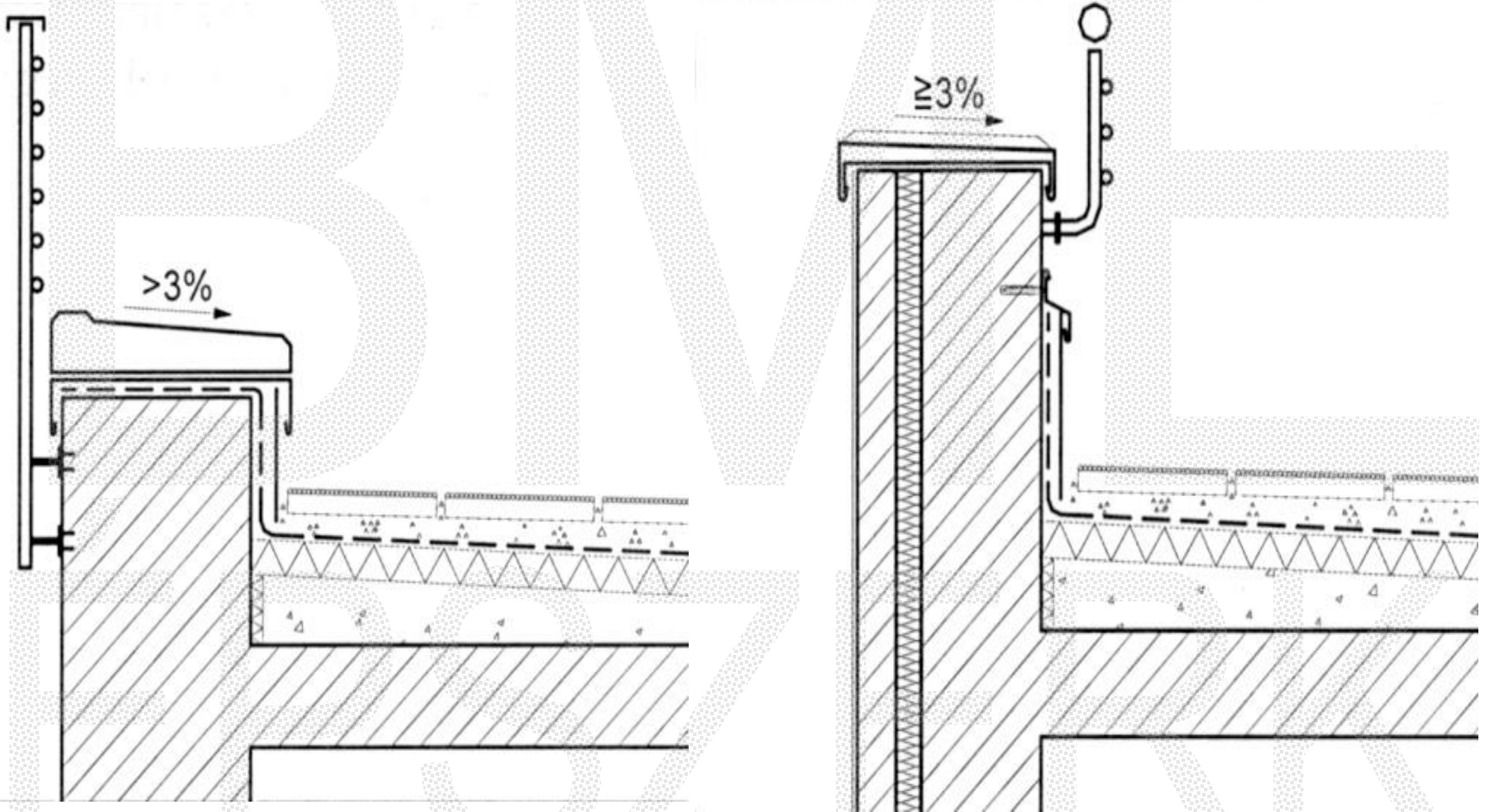
# TERRACES

## FLASHING OF WATERPROOFING AT TRESHOLD



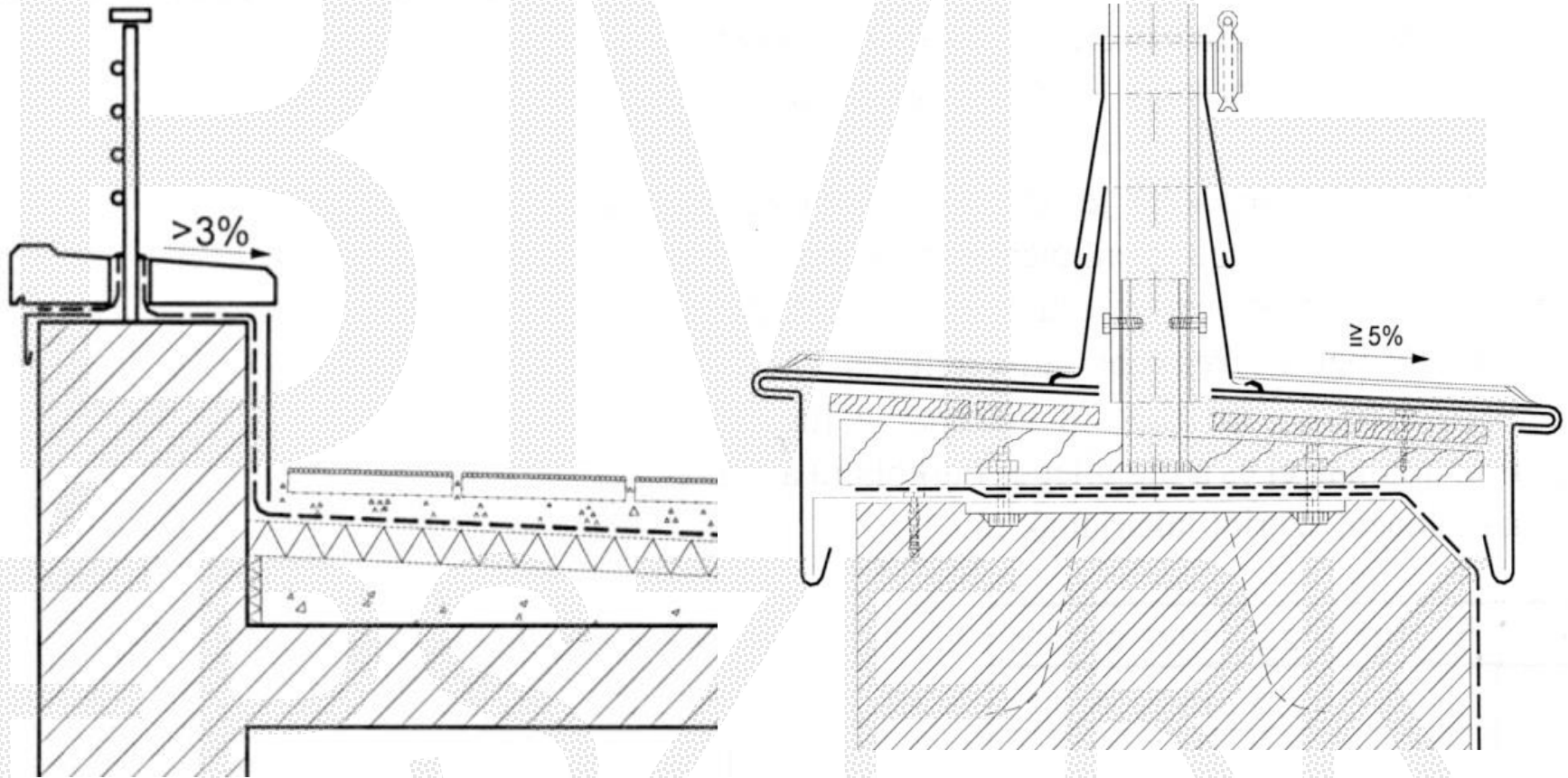
# TERRACES

## HANDRAIL



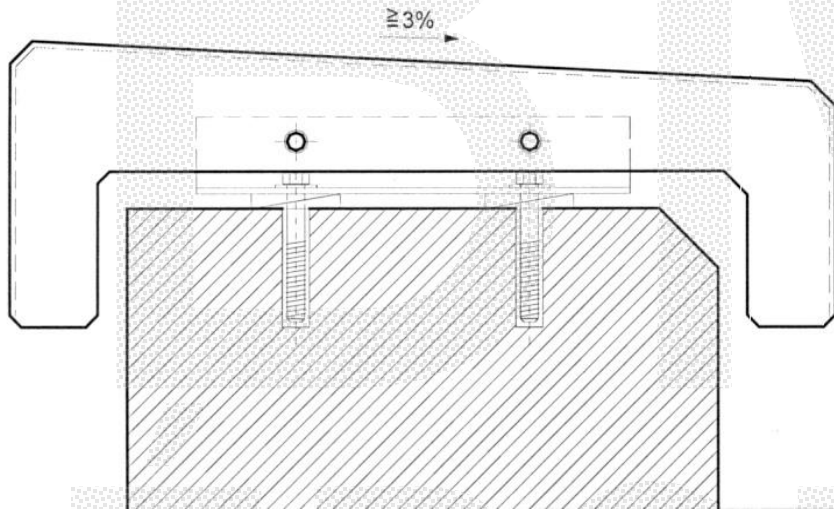
# TERRACES

## HANDRAIL



# TERRACES

## CAP OF PARAPET WALL



STONE OR ARTIFICIAL STONE







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# **EXPLOITED FLAT ROOFS**

## **GREEN ROOFS**

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Non exploited flat roofs

walking on the roof surface only for maintenance;

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balconies, loggias, terraces

roads, parking areas

**green roofs**



# GREEN ROOFS



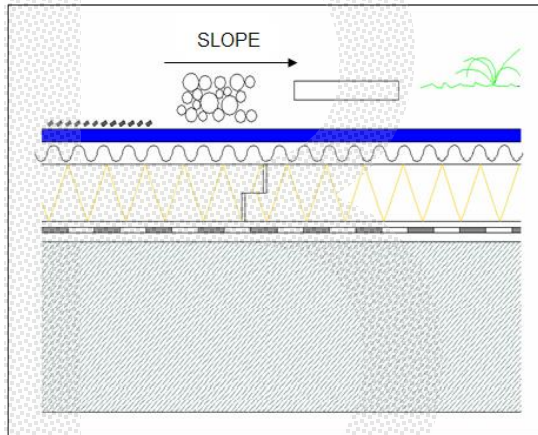
MOM Park Budapest

A green roof also called “vegetated roof cover,” “living roof,” and “eco-roof” is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It also includes additional layers such as a root barrier and drainage and irrigation systems.

Green roofs are known by many names and take many forms, but beneath each is an [engineered roofing system](#) that enables the growth of vegetation on conventional rooftops. Unlike traditional rooftop gardens that rely on individual containers and heavy planters, a green roof system allows extensive plant cultivation over a wide expanse of the roof.

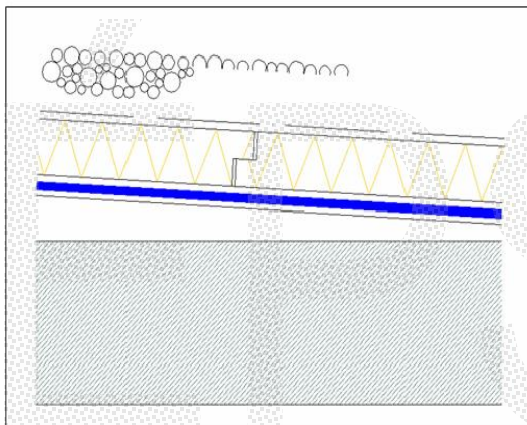


## NORMAL (CONVENTIONAL) FLAT ROOF



UV protection  
**Waterproofing**  
**(fixing, slope)**  
Separation  
Thermal insulation  
Vapour barrier  
Screed  
Load bearing slab

## INVERTED FLAT ROOF



Ballasting  
Separation  
Thermal insulation  
**Waterproofing**  
Screed  
Load bearing slab

OR

# GREEN ROOFS

**LAYERS FOR  
VEGETATION**








**COMPLEX MEASUREMENT OF  
THE WHOLE CONSTRUCTION!**



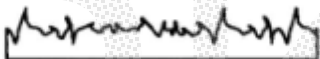






# NON EXPLOITED ROOF +

1. Loadbearing slab	 r.c.	 trapezoid metal sheet
3. Drain system	internal (gully) - external (gutter)	
4. Waterproofing (DPC)	plastic or bitumen membranes	
5. Slope of DPC	loadbearing structure	concrete  thermal insulation
7. Thermal insulation	 plastic foam	 mineral wool
8. Vapour barrier	plastic or bitumen membranes	
9. Separation layer	glass or plastic fleece	

## GREEN ROOFS

### LAYERS FOR VEGETATION

Layers	
1. plant	
2. soil	
3. filter	
4. drain sheet + water storage	
5. root protection	



# GREEN ROOF TYPES

## EXTENSIVE

thickness of soil substrate: 3-30 cm

weight: 25-100 kg/m<sup>2</sup>

vegetation: sedum, grass, moss

maintenance: self-sustaining

## INTENSIVE

30 cm ... m

300 ...

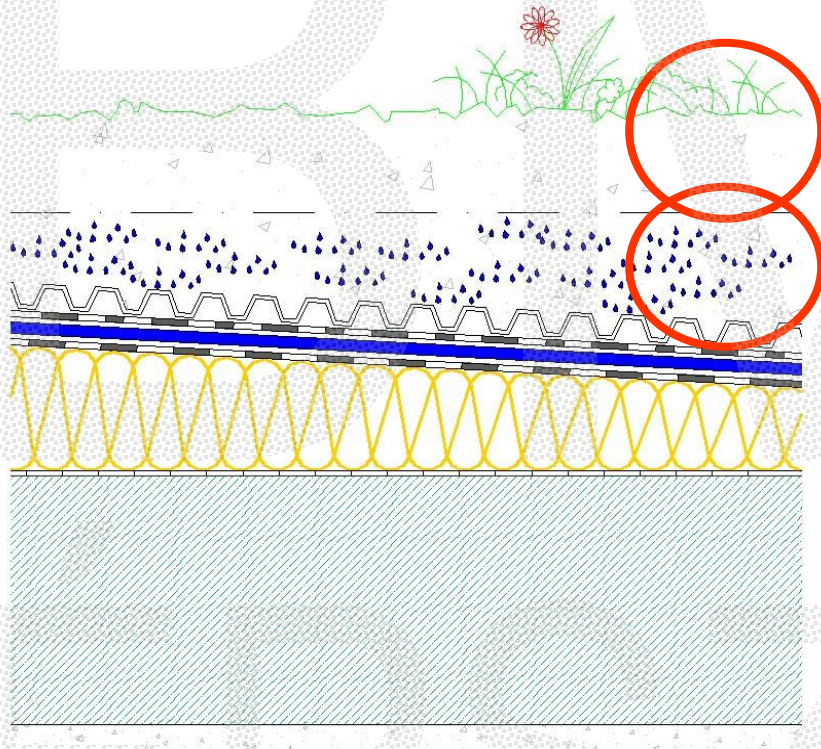
bigger plants

irrigation,  
feeding etc.



# GREEN ROOFS

## EXTENSIVE OR INTENSIVE



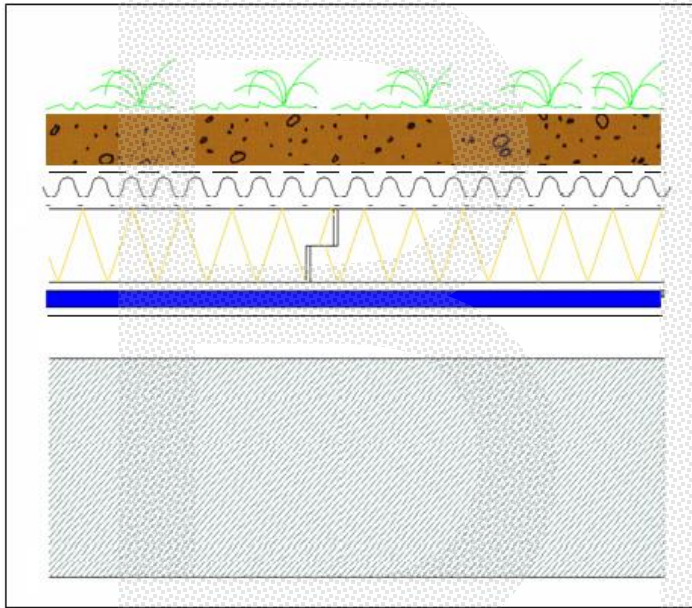
- Soil substrate for plants
- Separation filter layer
- Drain and water storage
- Root protection

+

- **LAYERS OF NORMAL ROOF**

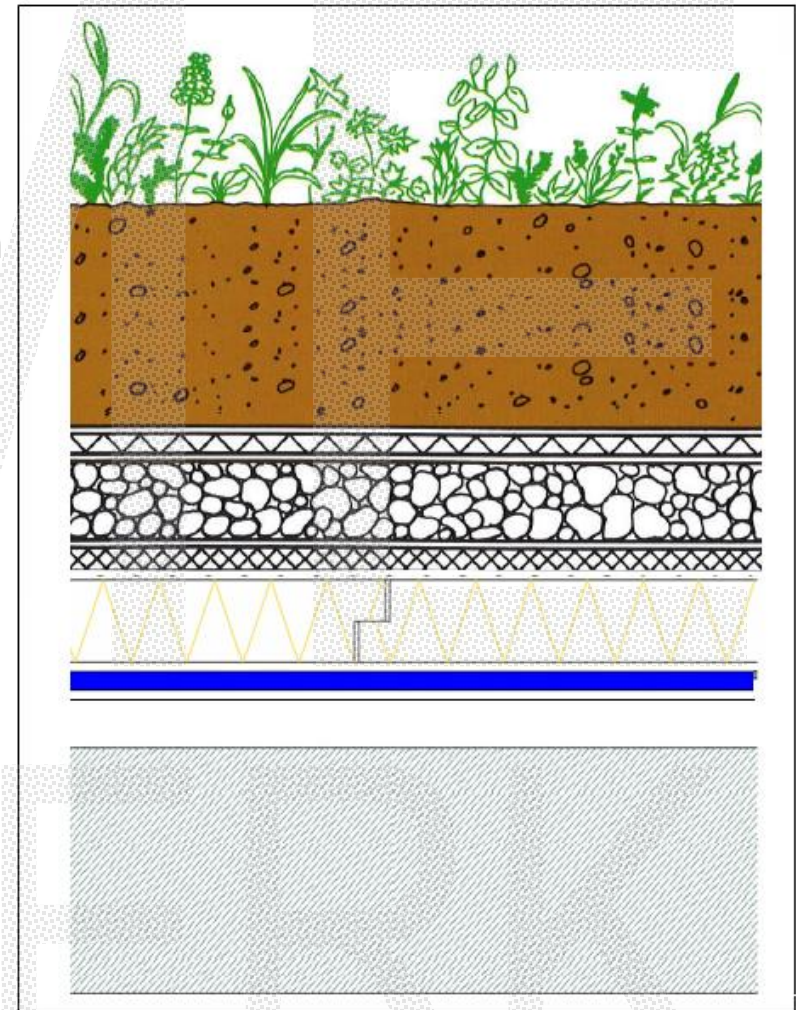


# GREEN ROOFS



- Soil substrate for plants
- Separation filter layer
- Drain and water storage
- Root protection

extensive



intensive

**+ LAYERS OF INVERTED ROOF**





# GREEN ROOFS

## WATERPROOFING

Requirement: FLL = root resistance quality

### BITUMEN MEMBRANES

metal foil (e.g. copper) reinforcement

### PLASTIC MEMBRANES

PVC, ECB, EVA, TPO

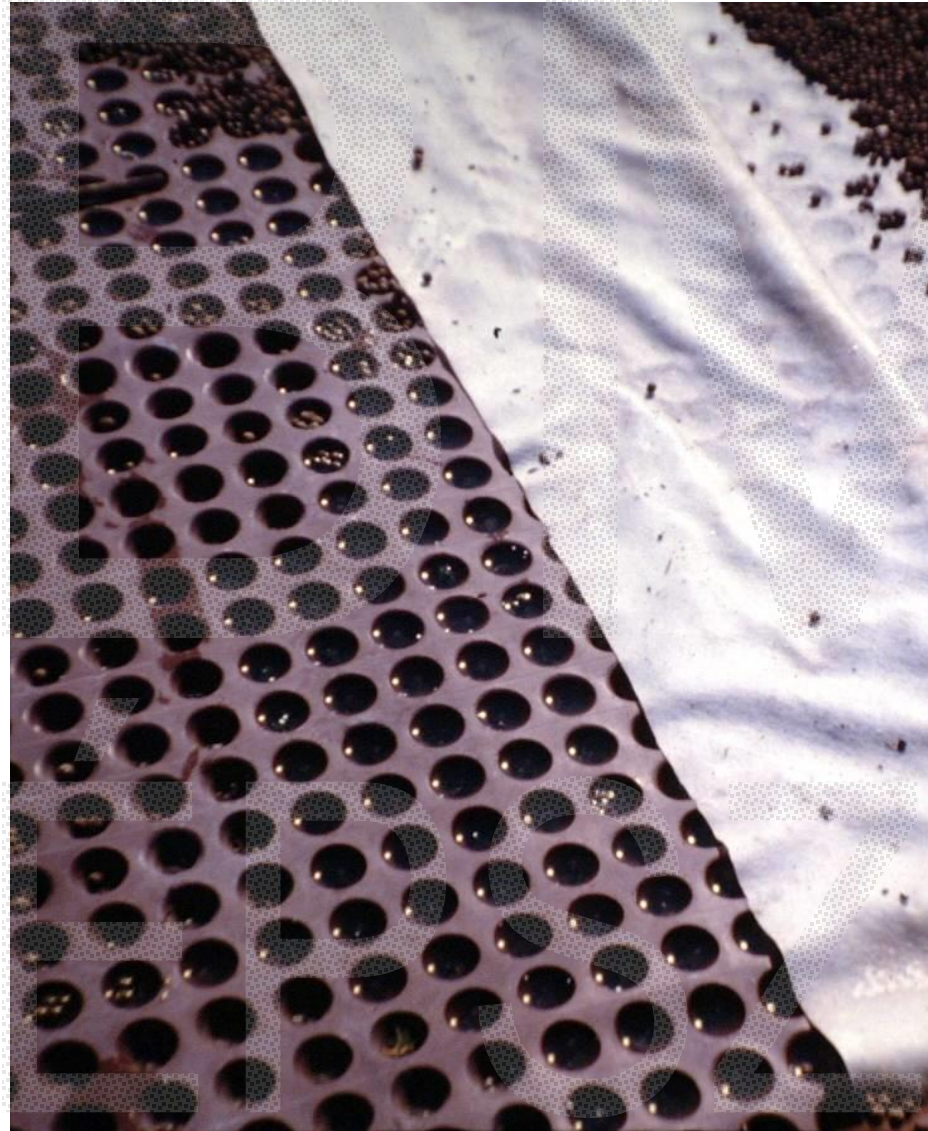




# GREEN ROOFS

## PREFABRICATED VEGETATION MAT





## **GREEN ROOFS**

**PLASTIC DIMPLED  
WATER DRAIN AND  
STORAGE SHEET  
+  
PLASTIC VEIL  
FILTER AND  
SEPARATION LAYER**







## GREEN ROOFS

SHAPED PS FOAM  
WATER DRAIN AND  
STORAGE SHEET  
+  
PLASTIC VEIL  
FILTER AND  
SEPARATION LAYER





# **GREEN ROOFS**

## **FIXING**

Lightweight layers are fixed by layers of roof garden (dry density).

Wind loads are classified and measured by standards.

### **FIXING SYSTEM**

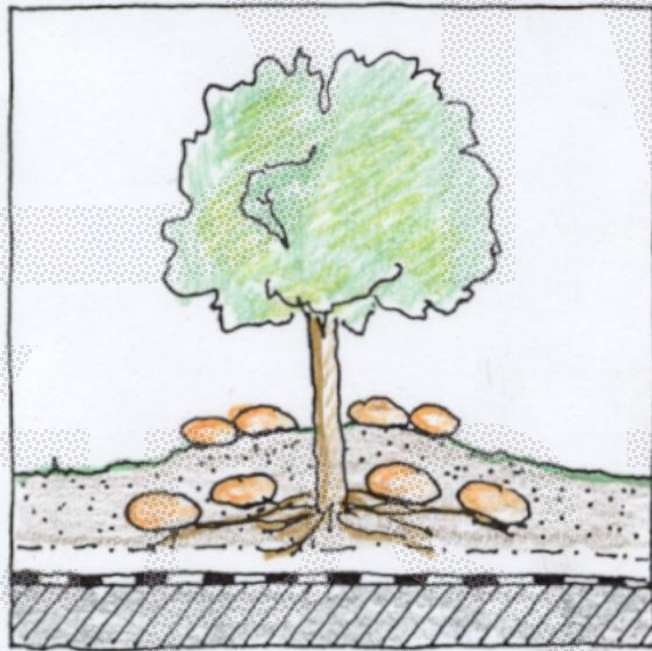
**ballasted by vegetation  
layers**



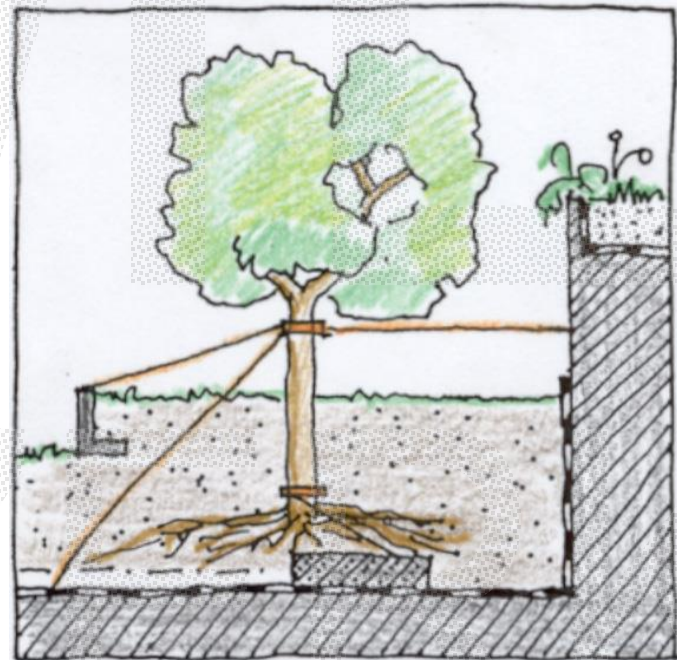
# GREEN ROOFS

## Fixing of the trees

ballasted

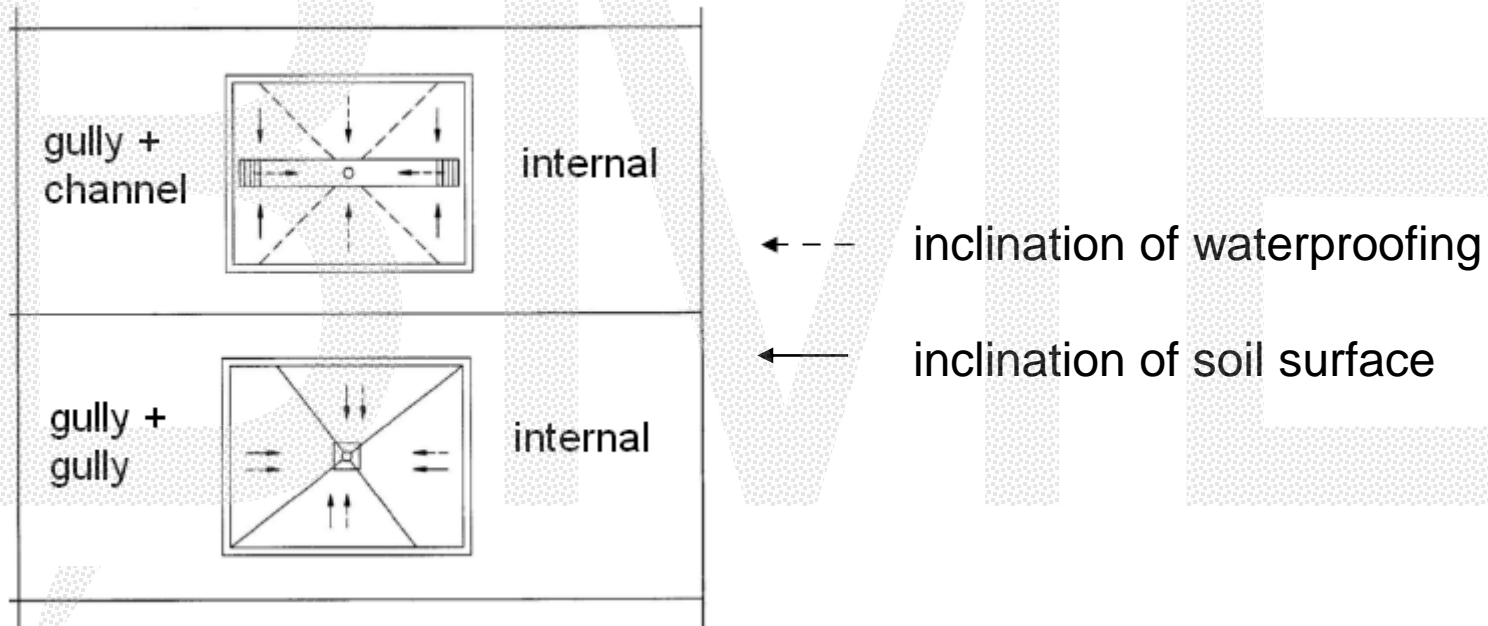


anchored



# GREEN ROOFS

## DRAIN SYSTEM



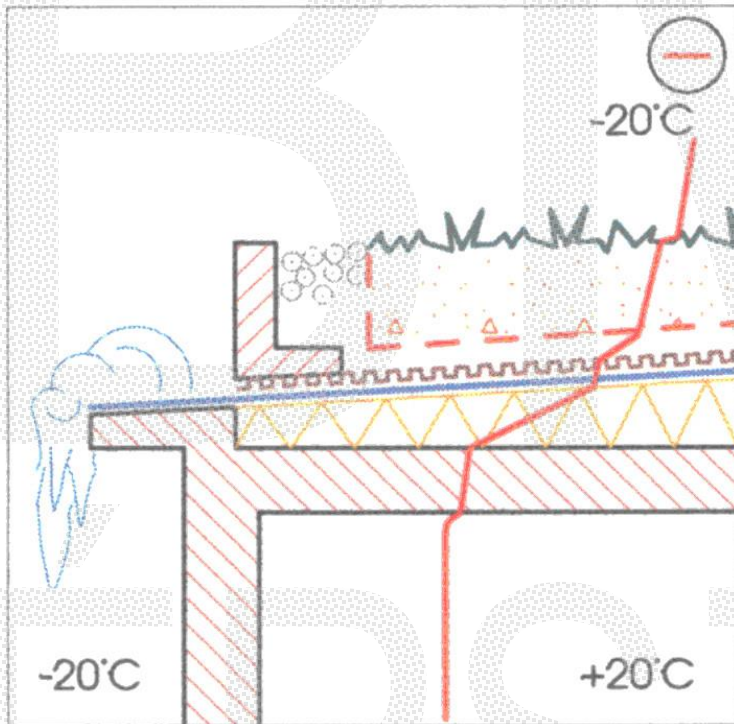
## RAINWATER MUST BE LED BOTH FROM

- SURFACE OF WATERPROOFING AND
- ROOF SURFACE

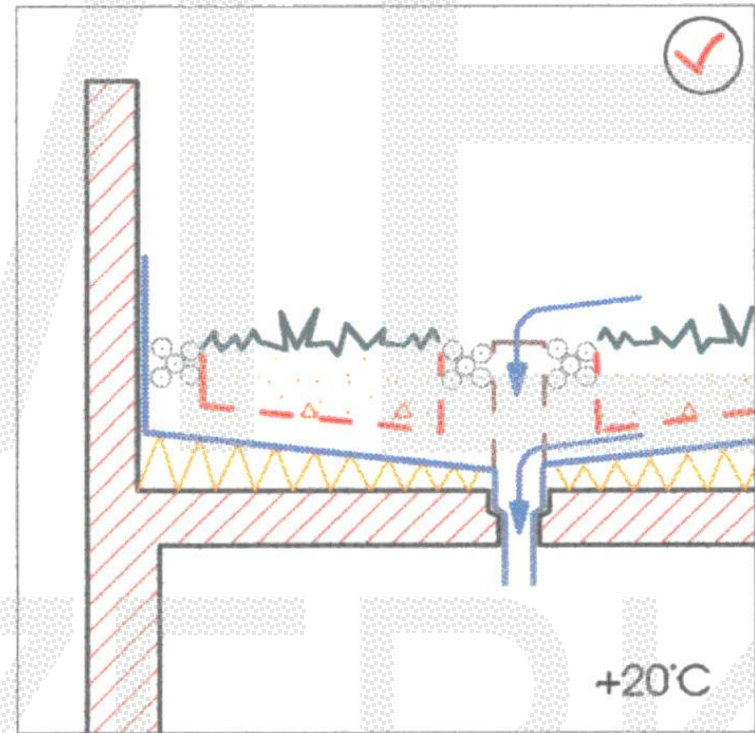


# GREEN ROOFS

## DRAIN SYSTEM



external - **not**



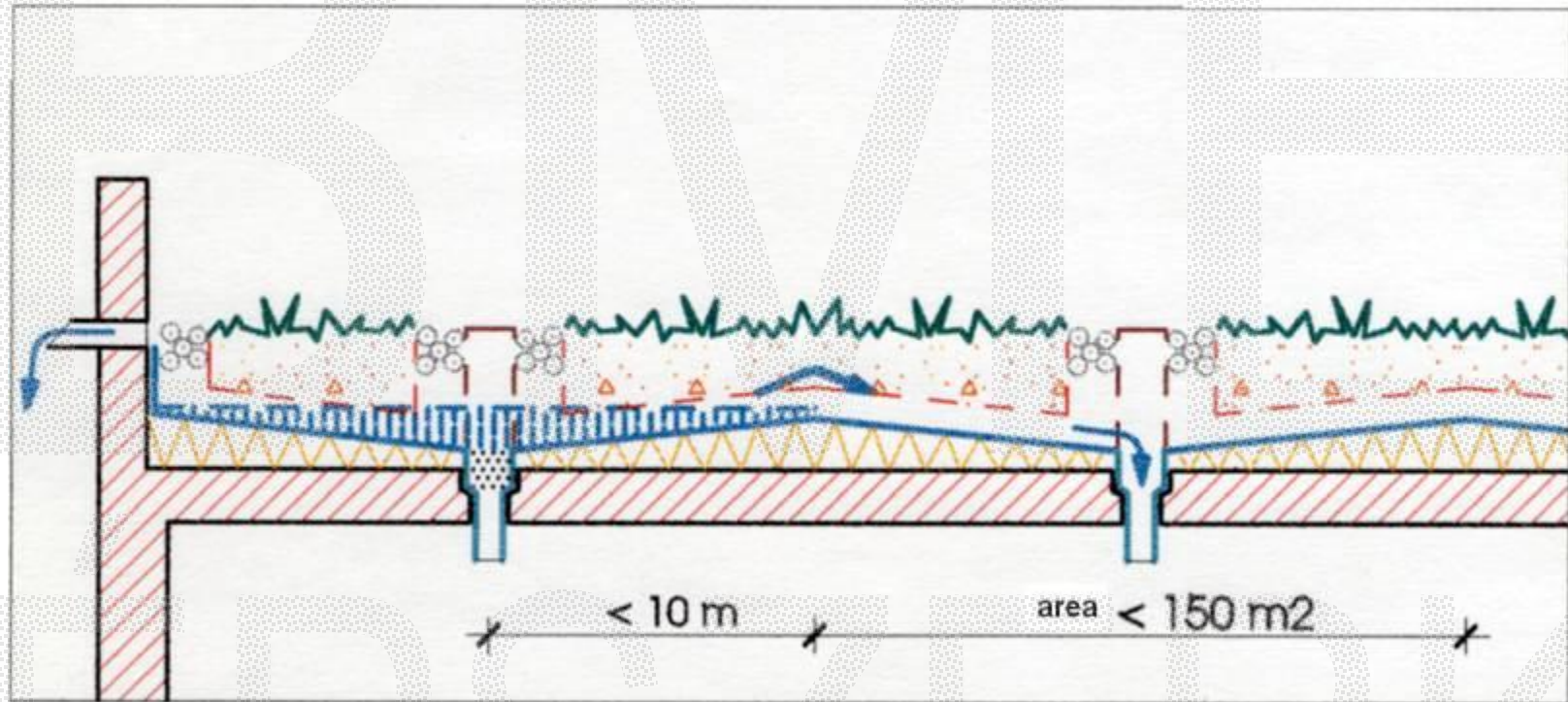
internal - **O.K.**





# GREEN ROOFS

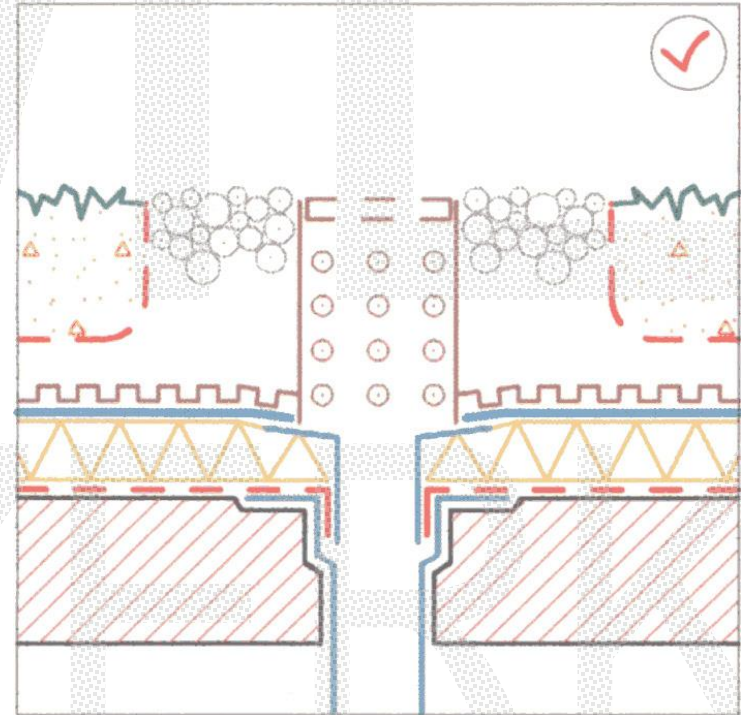
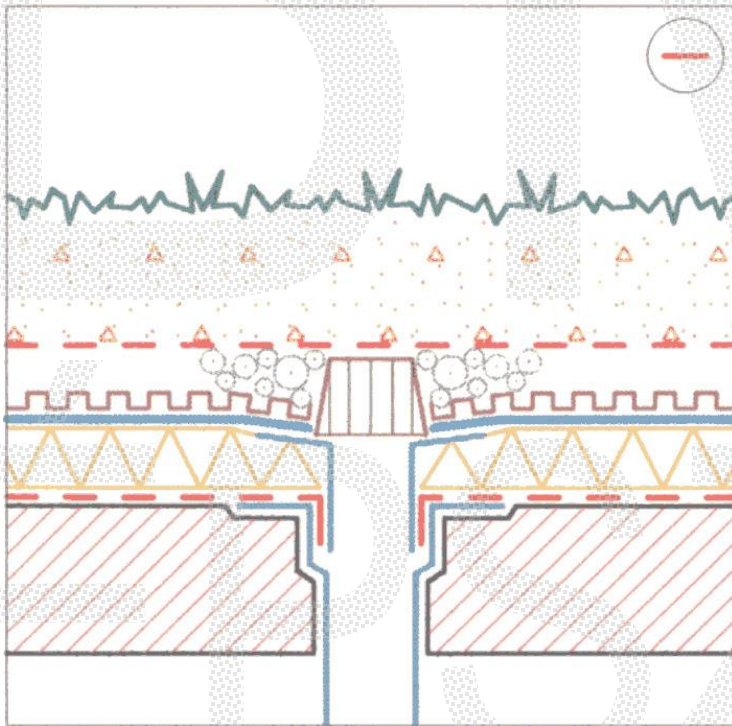
## DRAIN SYSTEM



# GREEN ROOFS

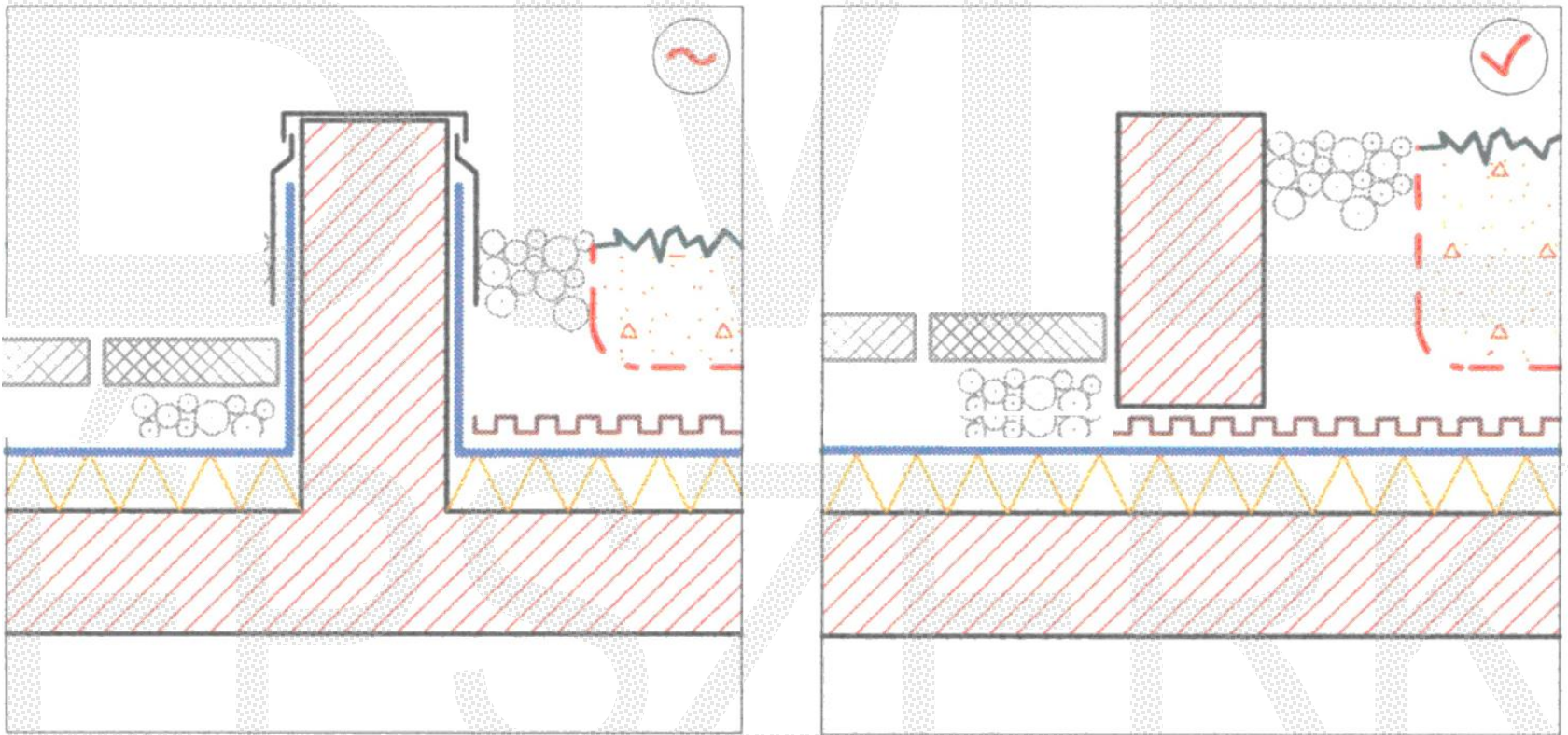
## DETAILS

### WATER OUTLET



# GREEN ROOFS DETAILS

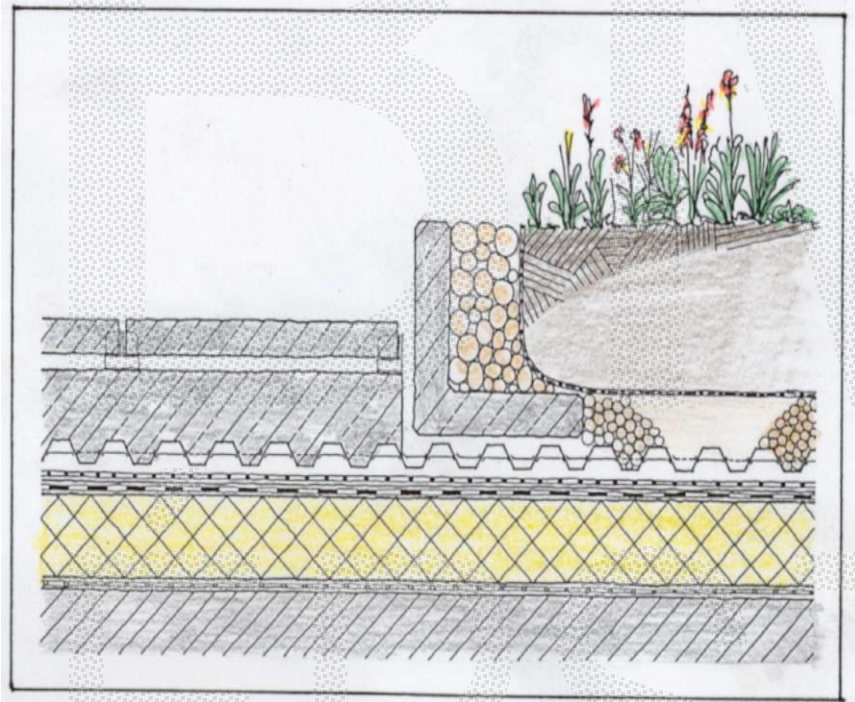
Separation of different functions





# GREEN ROOFS DETAILS

Separation of different functions



PREFABRICATED R.C. ELEMENTS AT THE EDGE

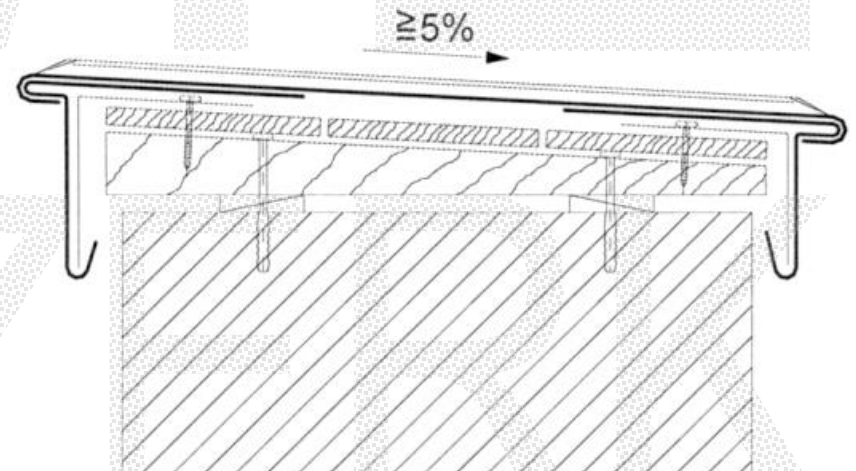
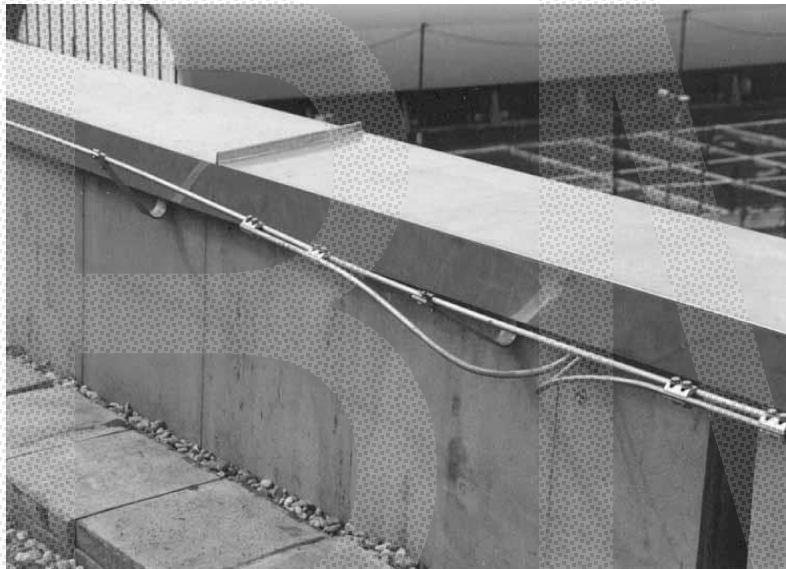




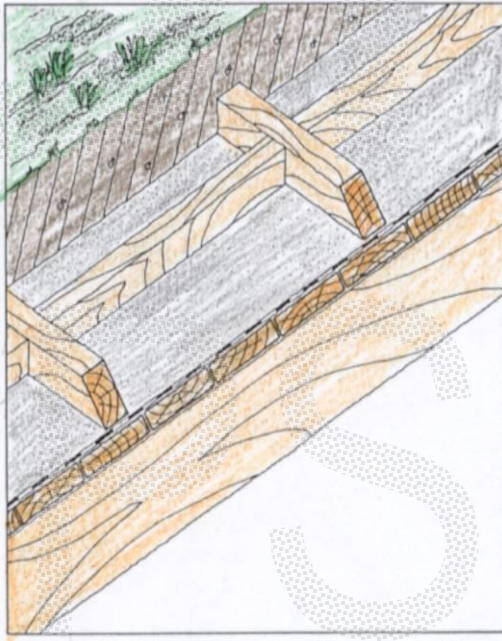
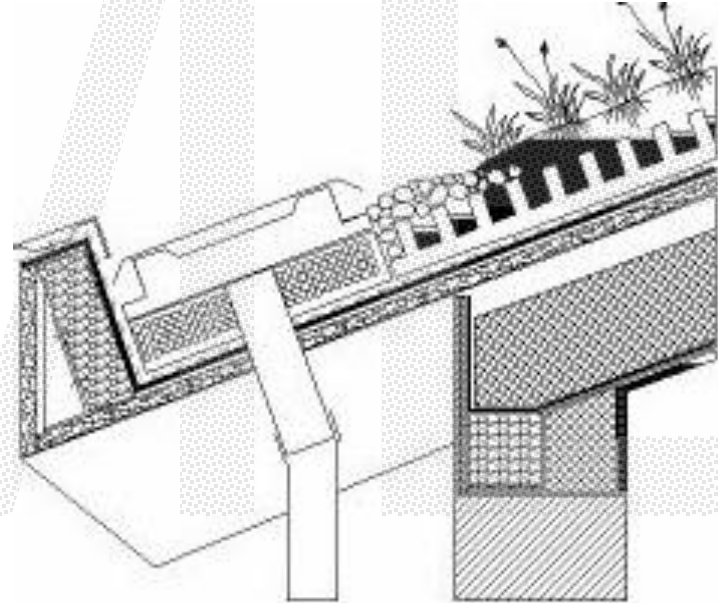
# GREEN ROOFS

## DETAILS

CAP OF PARAPET WALL  
example with zinc



# GREEN PITCHED ROOFS



Sliding protection above 25°

Irrigation- climate?







## PRINCIPLES – Passive Design Systems - Green roofs

A green roof also called “vegetated roof cover,” “living roof,” and “eco-roof” is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. It may also include additional layers such as a root barrier and drainage and irrigation systems. (The use of “green” refers to the growing trend of environmentalism and does not refer to roofs which are merely colored green, as with green roof tiles or roof shingles.)

Green roofs are known by many names and take many forms, but beneath each is an engineered roofing system that enables the growth of vegetation on conventional rooftops. Unlike traditional rooftop gardens that rely on individual containers and heavy planters, a green roof system allows extensive plant cultivation over a wide expanse of the roof.

Most green roof systems fall into two categories, extensive and intensive. This categorization is based on soil depth, but determines a variety of factors including weight, cost, maintenance, plant selection, and function.



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Knowledge base > Issues and Principles > Energy Management > Heating and Cooling > Passive Design > Green Roofs



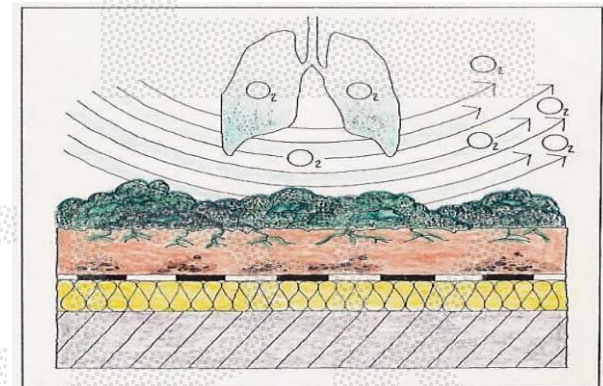
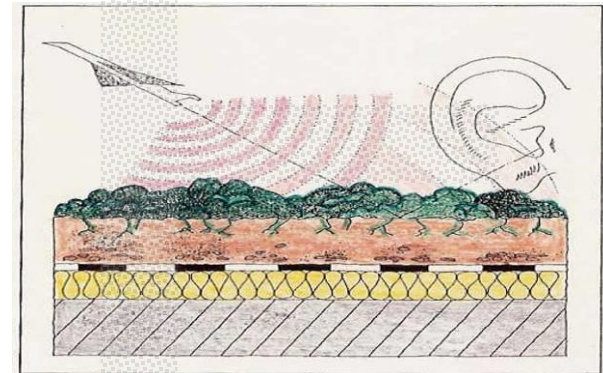
## Green roofs

**Green roofs provide many ecological and aesthetic benefits, including:**

- Control storm water runoff, erosion and pollution,
- Improve water quality,
- Mitigate urban heat-island effects, cooling and cleaning the air,
- More than double the service life of the roof,
- Conserve energy, reduce heating
- Reduce cooling (by evaporative cooling)
- Reduce sound reflection and transmission,
- Create wildlife habitat,
- Improve the aesthetic environment in both work and home settings.
- Filter pollutants and heavy metals out of rainwater

### Disadvantages

- Higher initial and maintenance cost.
- Some existing buildings cannot be retrofitted with certain kinds of roof because of the weight load of the substrate and vegetation exceeds permitted static loading.
- Some kinds of green roofs also place higher demands on the waterproofing system of the structure both because water is retained on the roof and due to the possibility of roots penetrating the waterproof membrane.



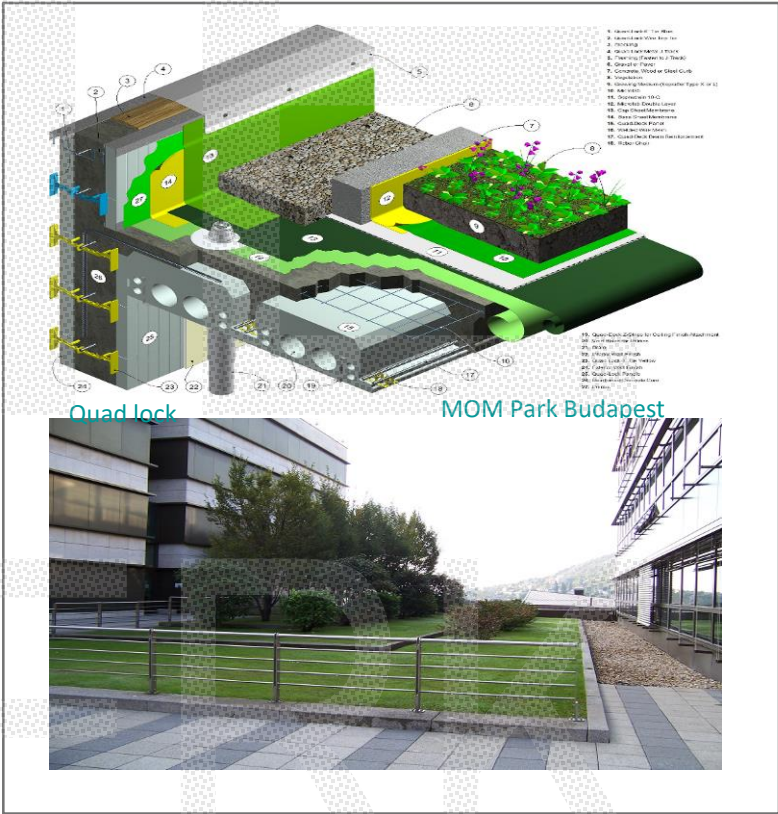
green



Green roofs

Green roofs can be categorized as intensive, "semi-intensive", or extensive, depending on the depth of planting medium and the amount of maintenance they need. Roof gardens, which require a reasonable depth of soil to grow large plants or conventional lawns, are considered "intensive" because they are labour-intensive, requiring irrigation, feeding and other maintenance. Intensive roofs are more park-like with easy access and may include anything from kitchen herbs to shrubs and small trees. "Extensive" green roofs, by contrast, are designed to be virtually self-sustaining and should require only a minimum of maintenance, perhaps a once-yearly weeding or an application of slow-release fertiliser to boost growth. Extensive roofs are usually only accessed for maintenance. They can be established on a very thin layer of "soil" (most use specially formulated composts): even a thin layer of rockwool laid directly onto a watertight roof can support a planting of Sedum species and mosses.

Another important distinction is between pitched green roofs and flat green roofs. Pitched sod roofs, a traditional feature of many Scandinavian buildings, tend to be of a simpler design than flat green roofs. This is because the pitch of the roof reduces the risk of water penetrating through the roof structure, allowing the use of fewer waterproofing and drainage layers.

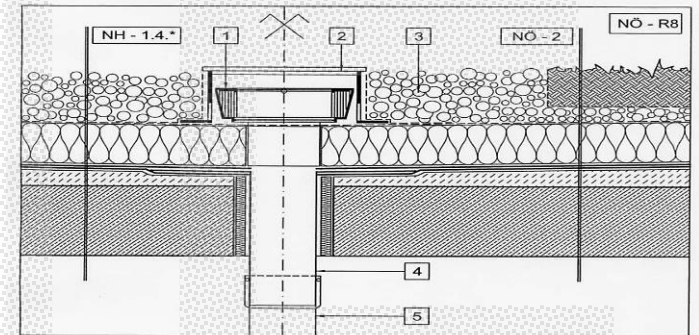


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## Green roofs

**IN DEPTH** Green roofs protect exterior roof membranes from ultraviolet radiation, extreme temperature fluctuations, punctures and other physical damage. They can significantly increase life expectancies of roof membranes, thereby diminishing the need for costly roof replacements and maintenance.

Many types of waterproofing are compatible with green roofs. World-wide, polyvinyl chloride (PVC) and polymer modified bituminous membranes are the most common. Many of these installations have now been in place for over 30 years and continue to perform as designed. PVC, EPDM and thermal polyolefin (TPO) are, in most cases, inherently root-resistant; other common waterproofing materials require a root barrier between the waterproofing materials and the vegetated cover.



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[Knowledge base](#) > [Issues and Principles](#) > [Energy Management](#) > [Heating and Cooling](#) > [Passive Design](#) > [Green Roofs](#)



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## Green roofs

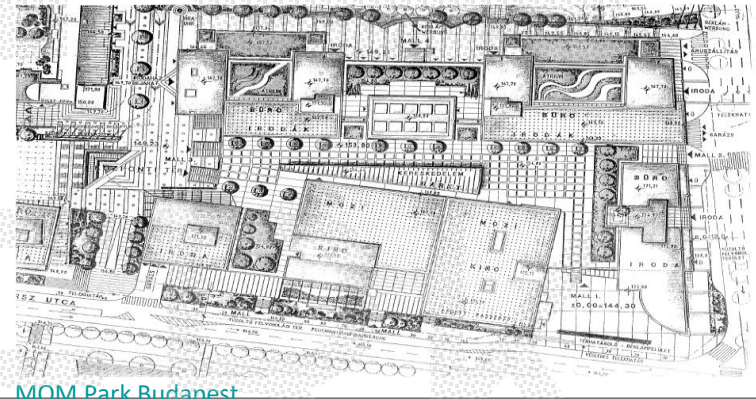
### APPLICATIONS –

What are the most important factors in designing a green roof?

- Climate, especially temperature and rainfall patterns
- Strength of the supporting structure
- Size, slope, height, and directional orientation of the roof
- Type of underlying waterproofing
- Drainage elements, such as drains, scuppers, and drainage conduits
- Accessibility and intended use
- Visibility, fit with architecture, and owner's aesthetic preferences
- Fit with other 'green' systems, such as solar panels
- Costs of materials and labor

Presently, the only widely-accepted, established standards for green roof construction are those developed in Germany by the *Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau. e.V.* ([FLL](#))

These standards and guidelines are comprehensive, and include industry standard tests for the weight, moisture, nutrient content, and grain-size distribution of growing media. FLL also certifies laboratories to conduct critical tests, such as the root penetration resistance of waterproofing membranes.



MOM Park Budapest





## Green roofs

### TEACHING RESOURCES –

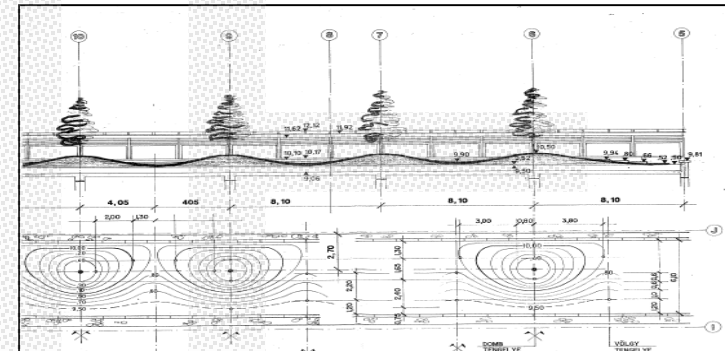
Green roofs are one of the most complex structural elements of the building. The architects has great difficulties as a single individual managing and systematizing such a diverse field.

At first the university curricula could offer an introduction into green roof construction, installation and maintenance to teach students about green roof benefits and incentives, reviews of green roof products, waterproofing, roof membranes, and drainage. The elementary age students are learning about stormwater retention, urban heat island effect, plant growth and environmental benefits. The goal is not just to convey a great deal of theoretical knowledge, but to give the students a perspective, which allows them to solve real situations and problems in practice, to understand the interactions without calculating.

At a later time the students must be creative to develop their own course curriculum applying green roof concepts, such as soil composition, drought tolerant plant choices, landscape design, energy consumption, water utilization, sound insulation, effects on architectural design of energy conservation and the utilization of alternative energy sources in order to limit environmental pollution etc..

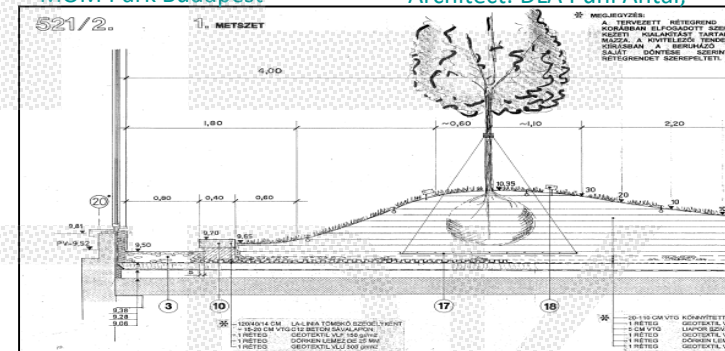
Other interesting teaching resources are at the following link:

[http://en.wikipedia.org/wiki/Green\\_roof](http://en.wikipedia.org/wiki/Green_roof)



MOM Park Budapest

Architect: DLA Puhl Antal,



Garden: Andor Anikó, Constructions: Dr Fülöp Zsuzsanna



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## Green roofs

### LEARNING RESOURCES –

The lecture courses analyse the main architectural issues and give the basic knowledge. In studios the students become acquainted with the design aspects. The representation, along with the basic "hands-on" training is concerning the expressive means of green roofs. Evaluation generally is via practical exercises and tests and a final exams.

Other learning resources:

Computer simulation is used as a teaching aid to clarify the physical processes in the building.

- Learning laboratories;
- Hands-on experience, As part of the building's "teaching tool" features, students in planning and discussions throughout the construction process.
- Monitoring/testing station for the building's "living green roof" and stormwater also serve as teaching tools to study stormwater quality and flow rate, and to conduct green roof technology research.
- Research papers, drafting an actual green roof.
- Websites of firm can offer an interesting and unique experience on the realities of the green roof marketplace.
- Supplying of a green roof demonstration garden. This gives the students a model for green roofs as well as learning new plants varieties.
- Case studies and further analysis of current projects to increase and assure the knowledge.



'extensive' green roof model, built at the Environmental Horticulture Department's ID Gardens, North Metro Technical College, Atlanta Georgia



students assisting with the installation of plants on Atlanta City Hall green roof.



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# Green roofs

Other interesting learning tools are those offered by Absorb Learning. Have a look at *(these links actually work, so you can click on them)*:

- ^ <http://www.efb-greenroof.eu>
- ^ [a b "Penn State Green Roof Research: About Green Roofs".  
http://hortweb.cas.psu.edu/research/greenroofcenter/history.html](http://hortweb.cas.psu.edu/research/greenroofcenter/history.html)
- ^ ["Plant-Covered Roofs Ease Urban Heat".](#)
- ^ ["Green roof case study - Barclays Bank HQ, Canary Wharf".  
http://www.livingroofs.org/livingpages/casebarclaysbank.html.](http://www.livingroofs.org/livingpages/casebarclaysbank.html)
- ^ ["Council approves stringent green-roof rules".  
http://www.theglobeandmail.com/news/national/council-approves-stringent-green-roof-rules/article1154619/.](http://www.theglobeandmail.com/news/national/council-approves-stringent-green-roof-rules/article1154619/)



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**THANK YOU FOR YOUR  
ATTENTION!**

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