



Aalto University
School of Engineering

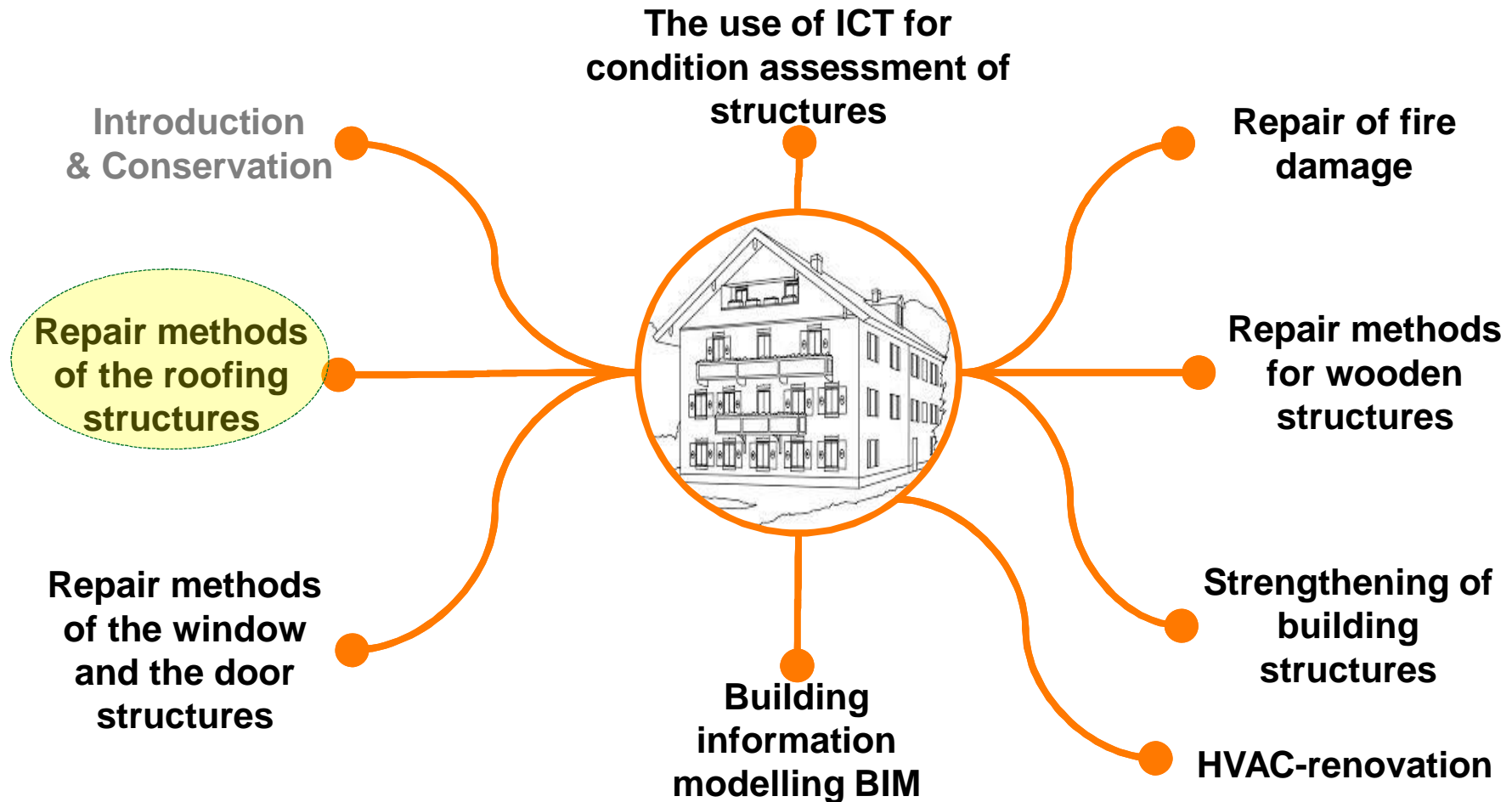
Rak-43.3313 Repair Methods of Structures, exercise
Esko Sistonen and Fahim Al-Neshawy



Repair methods of the roofing structures

Mon 29.02.2016

Course Content



Outlines

- Roof structure: types and examples
- Deterioration of roofs
- Roof repairing
- Green roof

Recommended readings

Kattoliitto, Roof systems manual.

Online at:

http://www.kattoliitto.fi/files/309/Roof_systems_manual.pdf

A guide to the repair of historic roofs.

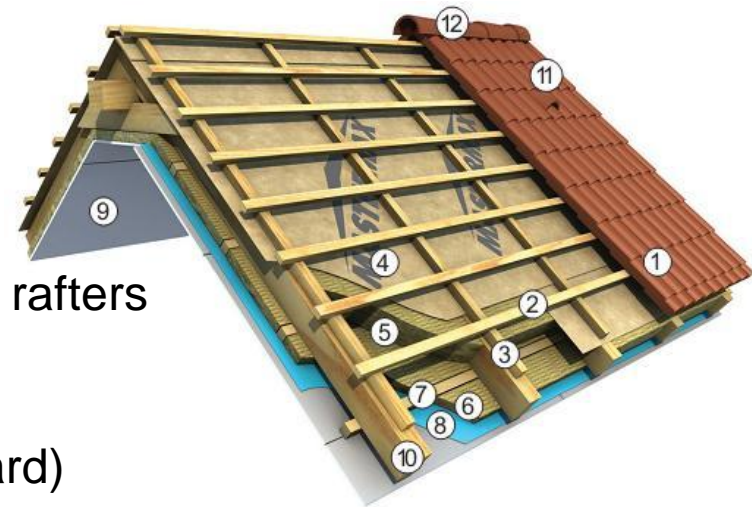
Online at:

<http://www.ahg.gov.ie/app/uploads/2015/07/Roofs-A-Guide-to-the-Repair-of-Historic-Roofs-2010.pdf>

Roof structures

Roof structure

- Roofs are one of a building's primary elements and play a major part in giving a building its character.
- The roof is a system that separates the building's top floor from the outdoor environment.
- Roof consists of functional parts, which have to work together:
 1. Roofing
 2. Tile batten
 3. Counter batten
 4. underlay
 5. Thermal insulation among the rafters
 6. Additional thermal insulation under the rafters
 7. Wooden or metal support
 8. Vapour control / vapour barrier layer
 9. Wall finishing (e.g., gypsum plasterboard)
 10. Rafter
 11. Ventilating tile and 12. Ridge tile

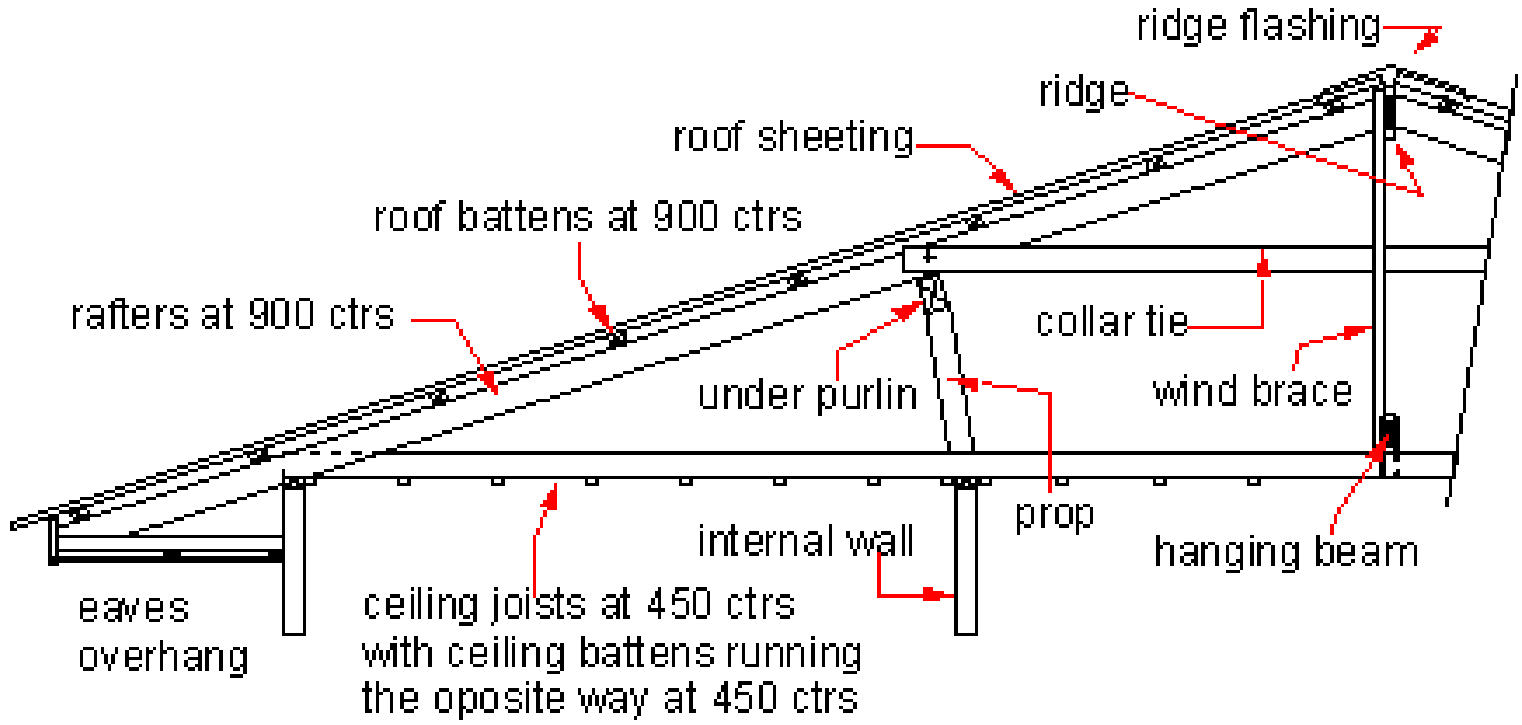


Roof structure

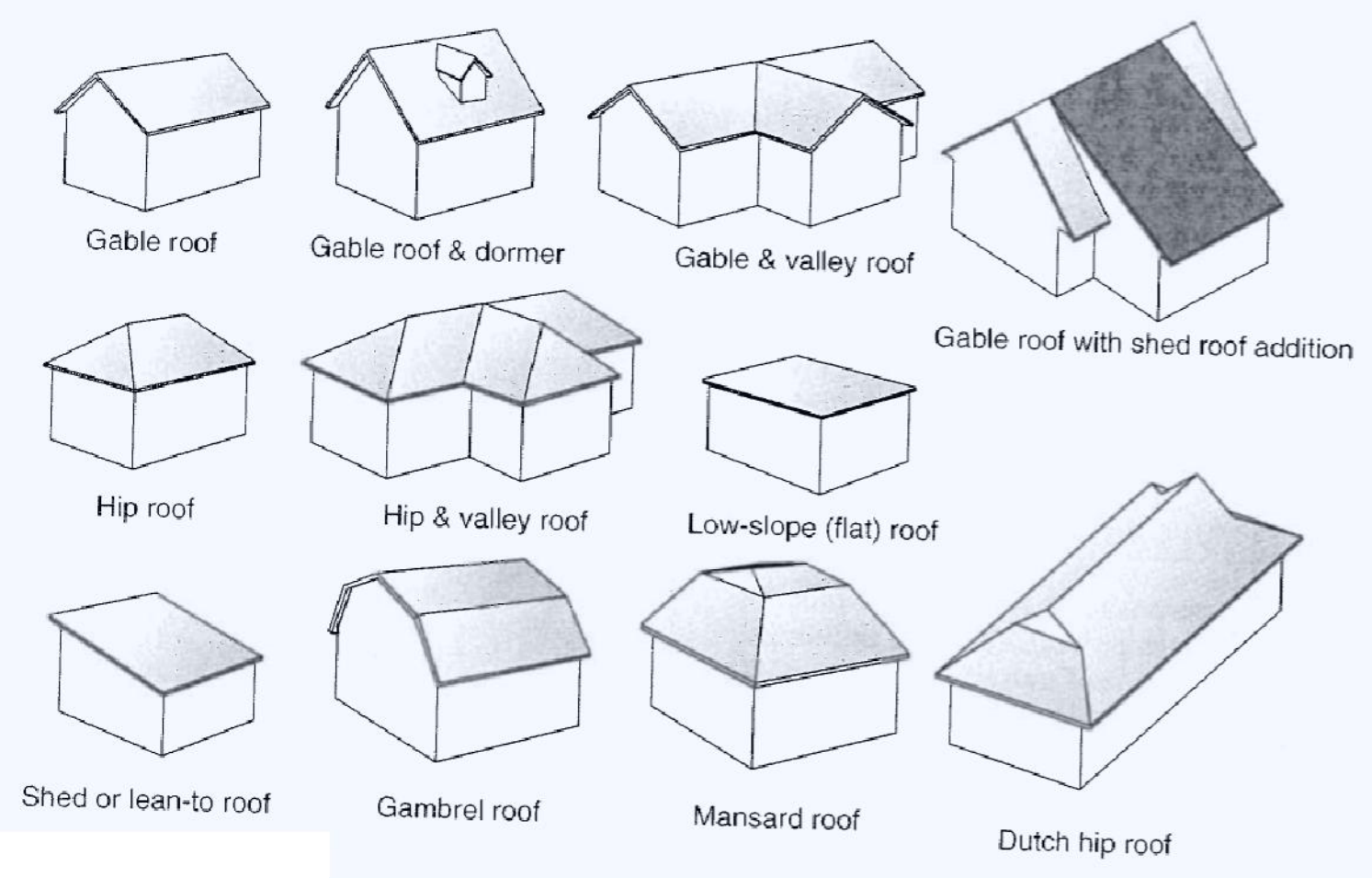
A roof must have the following qualities:

- A roof must be **weather resistant** to rain, snow, wind and sun.
- The **durability** of a roof should be equal to or in excess of those materials used in the remainder of the building.
- A roof should have good **thermal insulation** properties.
- A roof should require a minimum of **maintenance**.
- A roof should retain structural stability when dead and imposed loads are applied to it :
 - dead loads is the weight of materials used to make the roof
 - imposed loads are loads created by wind, snow, etc.

Roof components



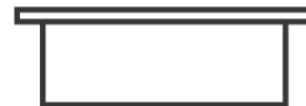
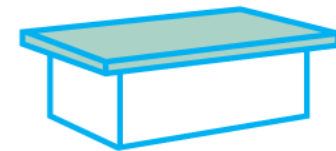
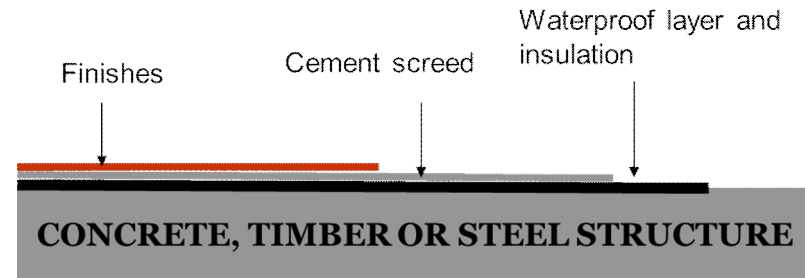
Types of roof structure



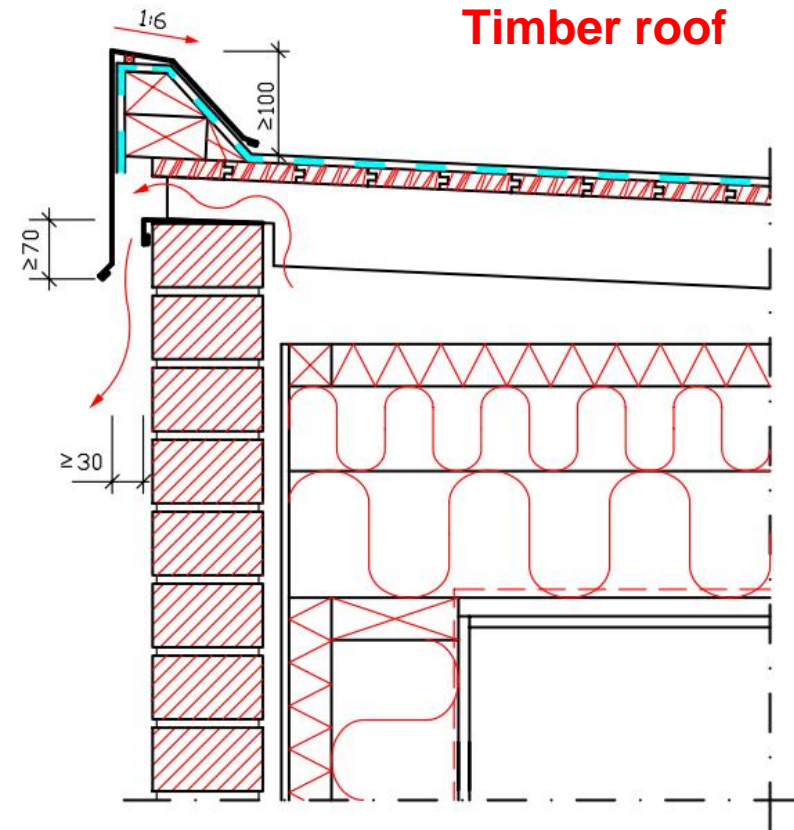
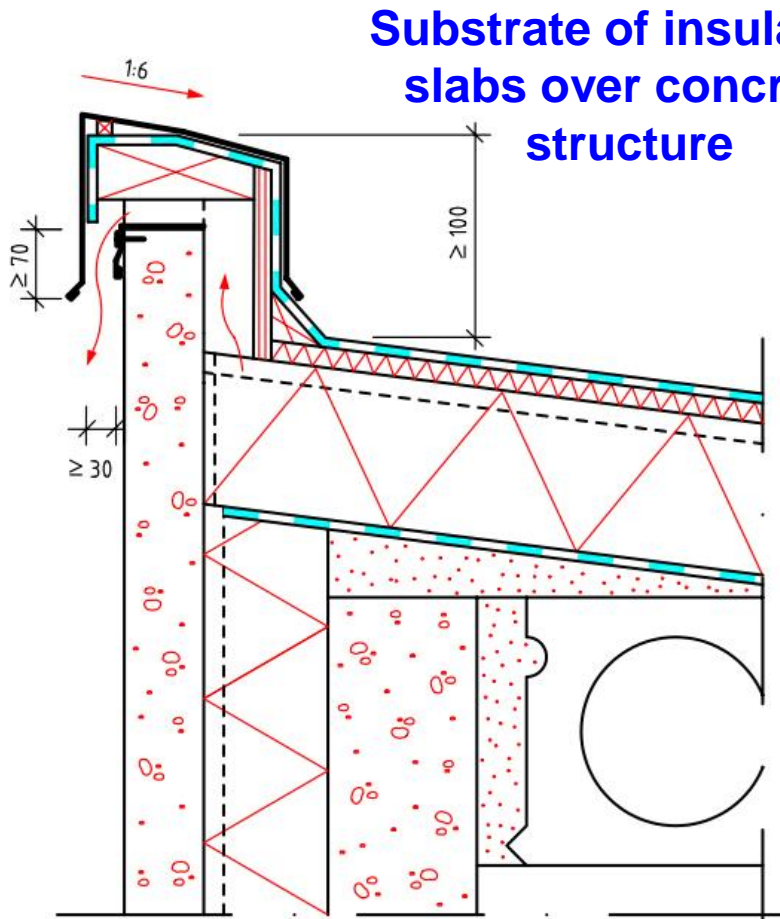
Types of roof structure

Low-slope (flat) roof

- A roof is designated as flat if its slope **is less than ten degrees.**
- Flat roofs have traditionally been used in hot climates **where water accumulation is not a problem.**
- They were generally unknown in northern climate before the end of the last century
 - Wood panels
 - steel decking
 - In-site cast concrete slab
 - Precast concrete slab



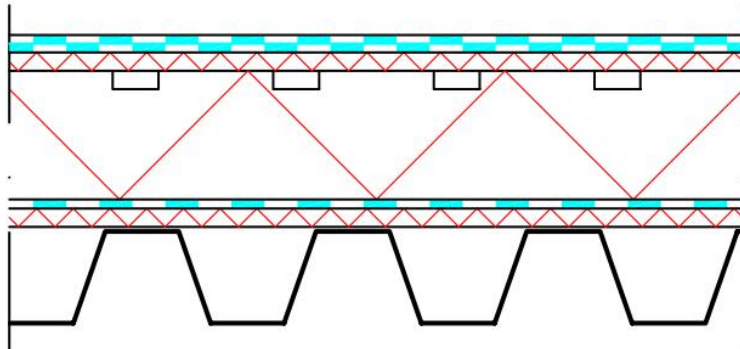
Examples of roof structure



http://www.kattoliitto.fi/files/309/Roof_systems_manual.pdf

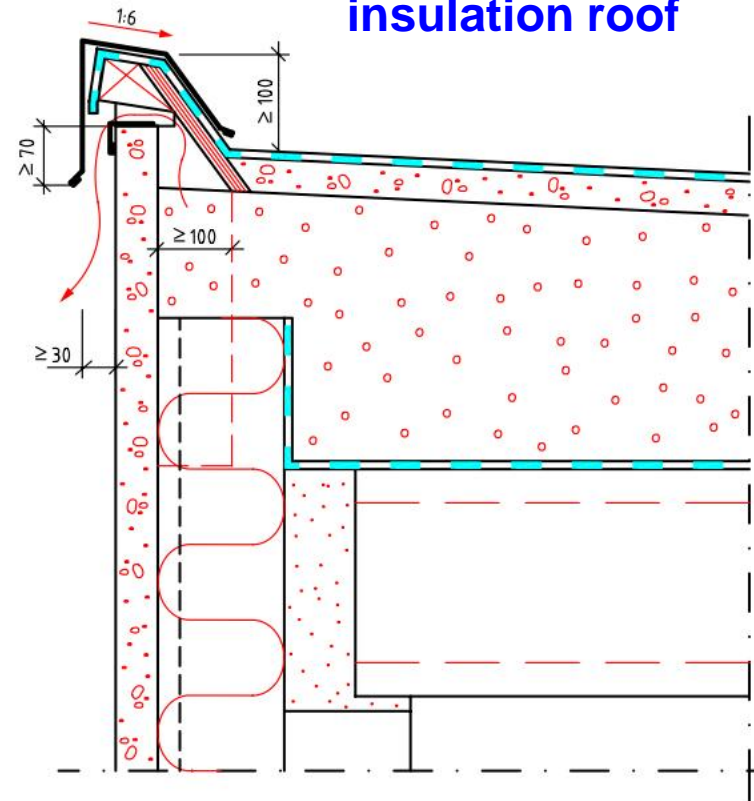
Examples of roof structure

Insulation slab substrate over corrugated sheeting, bitumen membrane and vapour barrier



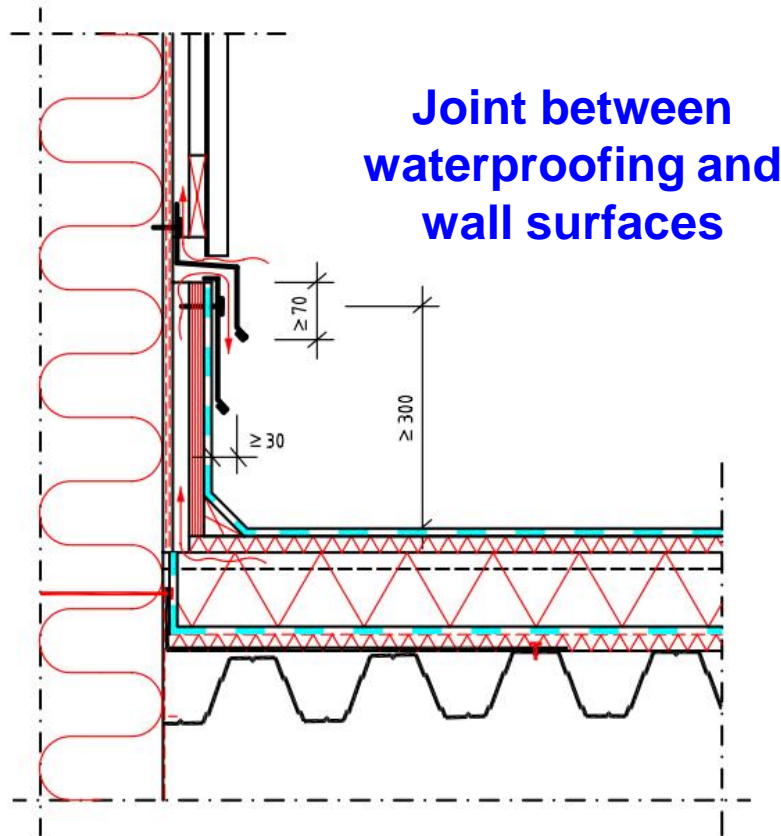
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Lightweight aggregate insulation roof



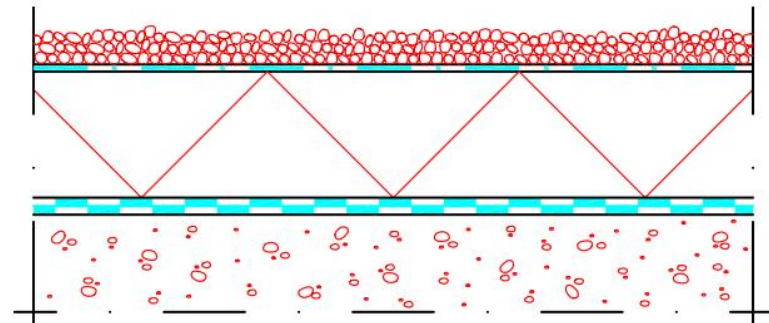
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Examples of roof structure



Inverted roof

- The falls required for the waterproofing are made in the loadbearing concrete structure.
- The waterproofing doubles as vapour barrier.

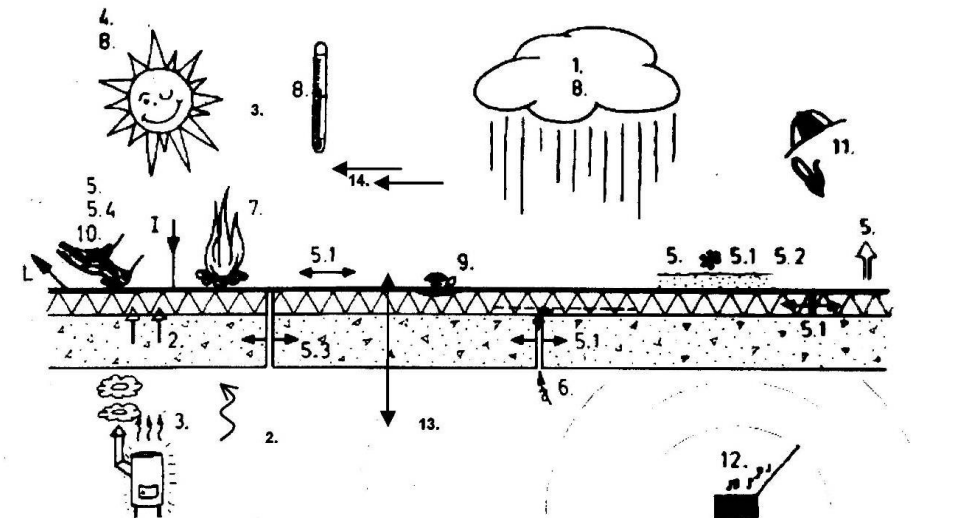


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Deterioration of roofs

Reasons behind deterioration of roof

- Internal / external moisture and temperature
- Radiation
- Static and dynamic stresses
- Wind / Air flow
- Fire
- Biological factors
- Etc.



- | | |
|--|--|
| 1. KOSTEUS ULKOPUOLELTA | 6. ILMAN LIIKE, ILMAVUODOT |
| 2. KOSTEUS SISÄPUOLELTA
(SISÄILMA, RAKENNUSKOSTEUS) | 7. TULIPALO |
| 3. LÄMMÖN LÄPIKULKU (SISÄ- JA
ULKOLÄMPÖTILA) | 8. ILMASTORASITUKSET |
| 4. AURINGON SÄTEILY I, VASTASÄTEILY L | 9. BIOLOGISET RASITUKSET
(KASVILLISUUS, MIKROBIT) |
| 5. STAATTISET JA DYNAAMISET RASITUKSET | 10. KATTEEN KULUMINEN |
| 5.1 KOSTEUS- JA LÄMPÖTILARIIPPUVAISET
LIIKKEET | 11. ULKONÄKÖSEIKAT |
| 5.2 JÄÄN JA LUMEN VAIKUTUS | 12. ÄÄNENERISTYS JA -ABSORPTIO |
| 5.3 LIIKKEET LIIKUNTASAUMOISSA | 13. PAINE-EROT |
| 5.3 PISTEKUORMITUS | 14. TUULI |

Reasons behind deterioration of roof

A roof system's performance is affected by numerous factors.:

- **Sun:**

- Heat and ultraviolet rays cause roofing materials to deteriorate over time.
- Deterioration can occur faster on the sides facing west or south.

- **Rain:**

- When water gets underneath roofing materials, it can work its way to the roof deck and cause the roof structure to rot.
- Extra moisture encourages mildew and rot elsewhere in a house, including walls, ceilings, insulation and electrical systems.

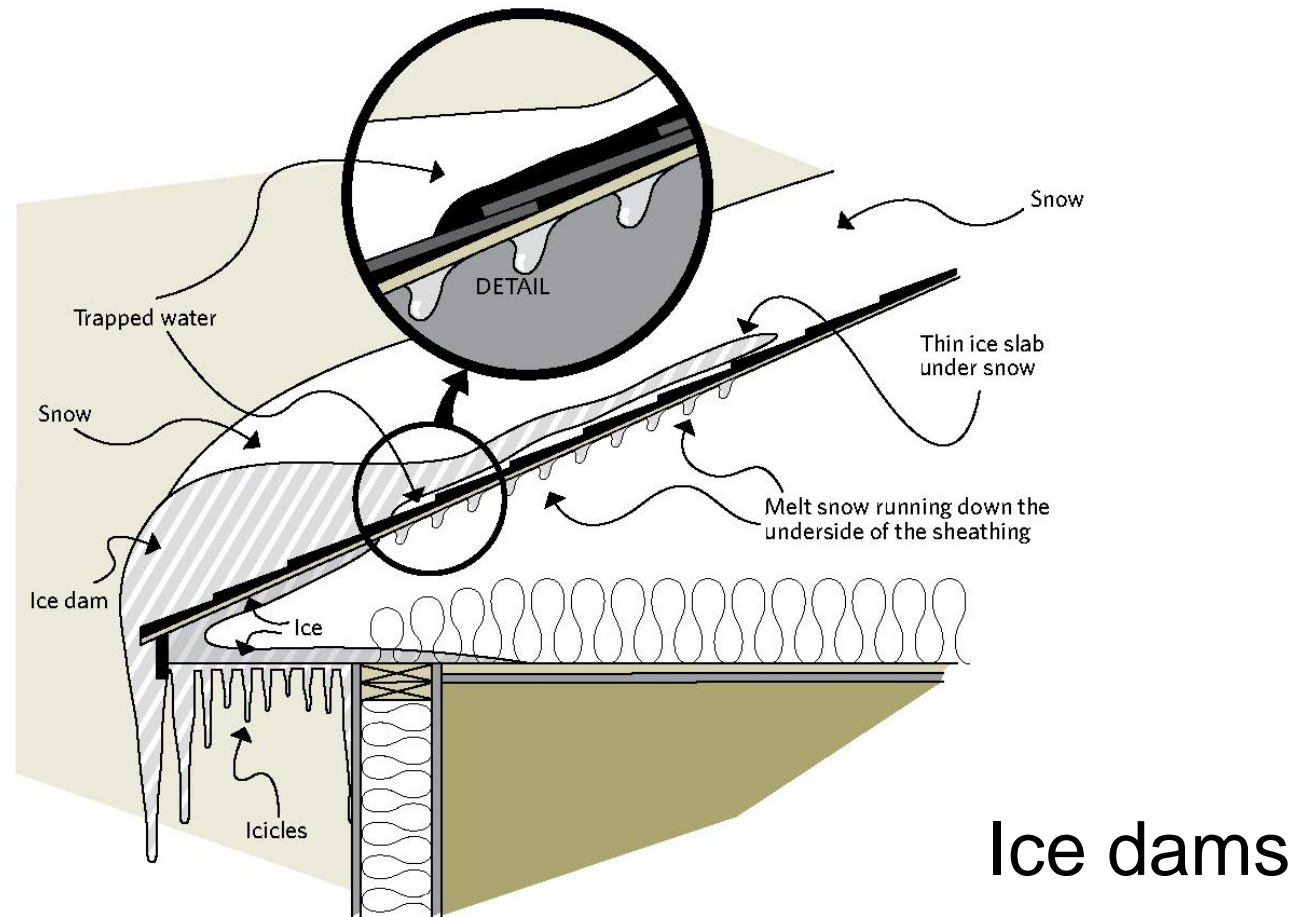
- **Wind:**

- High winds can lift shingles' edges (or other roofing materials) and force water and debris underneath them.
- Extremely high winds can cause extensive damage.

- **Snow and ice:**

- Melting snow often refreezes at a roof's overhang where the surface is cooler, forming an ice dam
- This blocks proper drainage into the gutter
- Water backs up under the shingles (or other roofing materials) and seeps into the interior

Reasons behind deterioration of roof



Ice dams

Reasons behind deterioration of roof

- **Condensation:**

- Condensation can result from the buildup of relatively warm, moisture-laden air.
- Moisture in a poorly ventilated attic promotes decay of wood sheathing and rafters, possibly destroying a roof structure.
- Sufficient attic ventilation can be achieved by installing larger or additional vents and will help alleviate problems because the attic air temperature will be closer to the outside air temperature.

- **Moss, trees and bushes :**

- Moss can grow on moist wood shingles and shakes.
- Once it grows, moss holds even more moisture to a roof system's surface, causing rot.
- In addition, moss roots also can work their way into a wood deck and structure.
- trees and bushes should be trimmed away from homes and buildings to eliminate damp, shaded areas, and gutters should be kept clean to ensure good drainage.

Condensation / ventilation problem



Condensation/ventilation problem



Flat roof problems



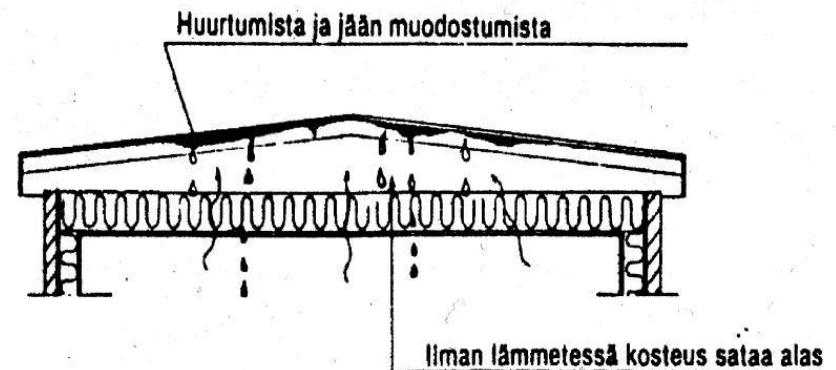
The most common roof damage

- Water leaks
- Roofing damage
- Chassis damage
- Heat-insulation layer wetting
- Water pooling at the roof surface and the formation of ice
- Follow-through and damage at related structures
- Eaves damage
- Supporting roof structure damage

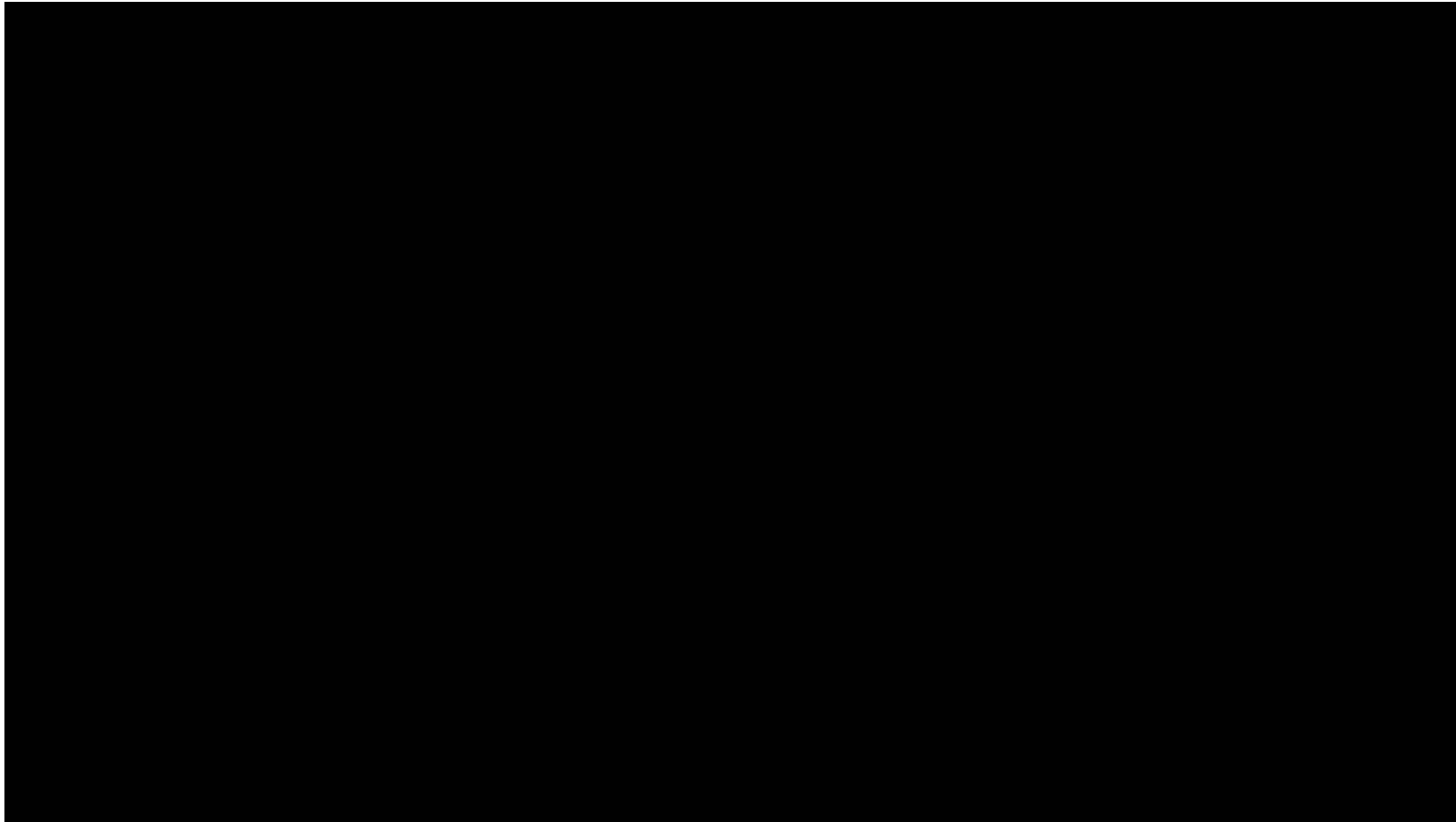


The most common roof damage

- Water vapour
- Ice dams
- Moisture in a poorly ventilated attic promotes decay of wood sheathing and rafters, possibly destroying a roof structure



Deterioration: Video



Roof repairing

Roof repairing standards

- **SFS-EN 1296** (February 2001). Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roofing. Method of artificial ageing by long term exposure to elevated temperature.
- **SFS-EN 1297** (December 2004). Flexible sheets for waterproofing. Bitumen, plastic and rubber sheets for roof waterproofing. Method of artificial ageing by long term exposure to the combination of UV radiation, elevated temperature and water.
- **SFS-EN 491** (December 2011). Concrete roofing tiles and fittings for roof covering and wall cladding - Test methods .
- **SFS-EN 13693 + A1** (November 2009). Precast concrete products - Special roof elements.

Typical repair methods

Reroofing is categorized according to one of the following four methods

- roof repair
- roof restoration
- roof retrofit (recover)
- roof removal and replacement

- **Roof repair**

- is repair work of actual leaks and obvious deteriorated areas on an identified, localized basis

- **Roof restoration**

- is an intermediate step between repair and retrofit, and generally includes a repair procedure for all flashing and a new fluid-type liquid with an optional fabric or mat installed over an entire roof area
- This procedure can be very cost effective in the long term

Typical repair methods

Roof retrofit, or recover

- is refitting the existing roof system with a new membrane cover and all related flashing, over the top of the existing roof membrane.
- New insulation is generally used to separate the new membrane from the existing membrane
- Reroofing directly over an existing roof membrane is not recommended since defects in the old roofing system can be transferred to any new roof covering and there is always a high risk of trapping moisture from the existing roof under the new roof membrane.
- Complete roof removal eliminates these risks.

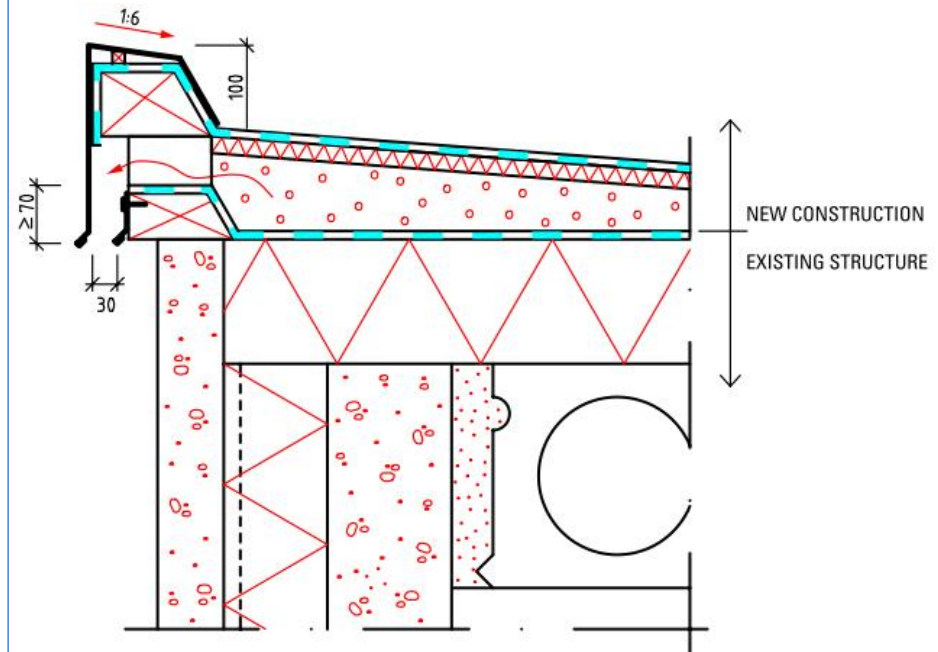
Roof Removal and Replacement

- is the installation of a new membrane system after complete removal of all roof components above the structural deck.
- this is generally considered the safest and surest method to guarantee long-term performance.

Roof repair examples

Alteration of roof pitch and heightening of eaves

- Applicable when renovating roofs, where added roof pitch is desirable.
- This solution can also be applied when repairing parts of roofs, e.g. at valleys or hips.
- Remove loose aggregate and any other dirt.
- The required pitch is created by applying light weight aggregate.
- Hard mineral wool slabs should be laid over the aggregate, avoiding the formation of a grid pattern

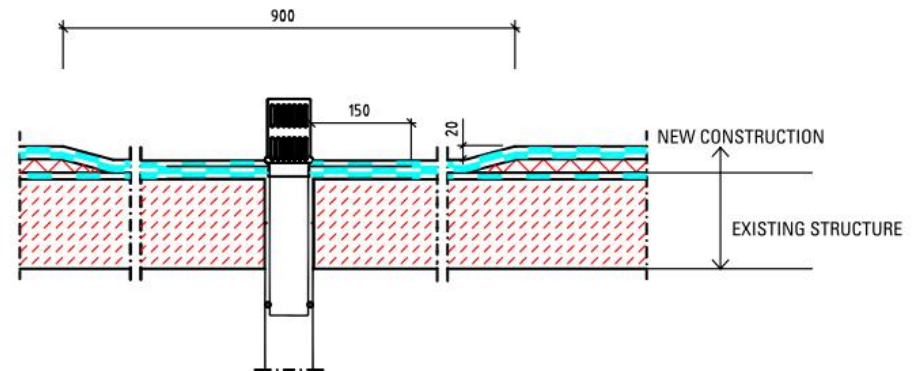


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Roof repair examples

Refurbishment roof drains

- When refurbishing a roof the roof drains are generally renewed.
- It is recommended that any roof drains with a diameter of less than 75 mm always be replaced with new ones.
- A refurbishment roof drain is installed inside the old one.
- A gasket mounted at the bottom end of the downpipe section ensures a good joint seal.
- The joined surfaces must be clean

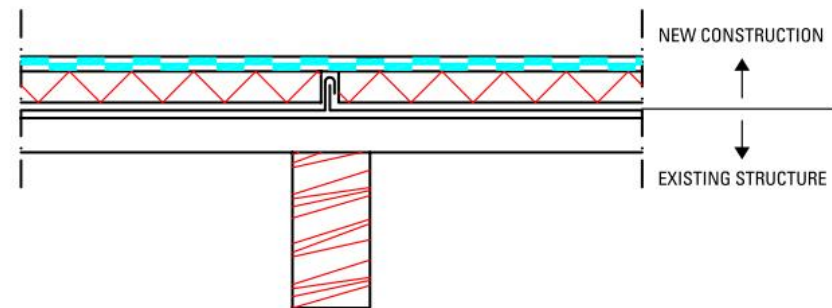


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Roof repair examples

Refurbishment of a low pitch sheet metal roof

- The roof surface is cleaned
- In standing seam sheet metal roofs the hard mineral wool slabs should be dimensioned to fill the space between the seams.
- The underlay membrane may additionally be bonded with bitumen over entire surface area.
- Cap membrane to be bonded over entire surface area by welding or gluing.



http://www.kattoliitto.fi/files/309/Roof_systems_manual.pdf

Floor repair: Video



Green roofs

<http://www.conservationtechnology.com/documents/GreenroofHandbook0116.pdf>

A green roof is:

- Green roofs are roofs that are covered with living plants
- Green roofs have been built for more than three thousand years, widespread acceptance has always been limited by the structural cost of supporting heavy soils and by the technical challenges of low-slope waterproofing.
- Recent advances in membrane waterproofing technology combined with the development of lightweight thin-profile green roofs have finally made green roofs practical for most new construction
- **Two main types: Extensive and Intensive green roofs**

Type 1: Extensive

- Shallow depth (typically 5 - 10 cm)
- Low growing, often broad leaved plants
- Plants with ability to withstand harsh weather conditions
- Extremely low maintenance
- Minimal weight load



Abby Roemer, Green roof technology:
<http://www.slideserve.com/oscar-bailey/green-roof-technology>

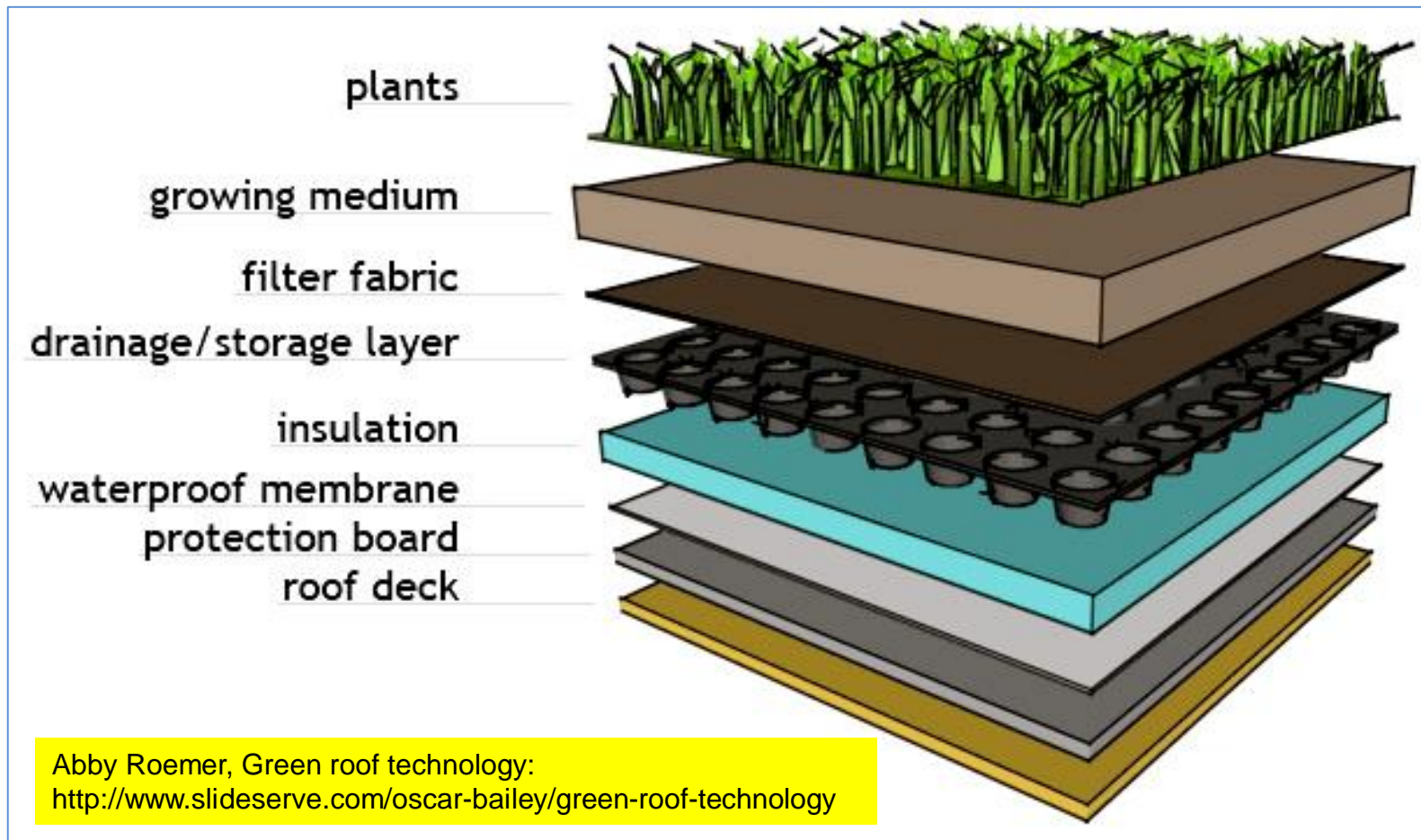
Type 2: Intensive

- Depth of 30 cm. or more
- Involve high maintenance plants such as trees and shrubs
- Irrigation system often necessary
- High maintenance
- Considerable weight load
- Less common
- Commonly accessible by public



Abby Roemer, Green roof technology:
<http://www.slideserve.com/oscar-bailey/green-roof-technology>

Basic green roof system layers



Environmental, Economic, & Psychological Benefits:

- Reduced rain water
 - Runoff = less chance of contaminated water or storm sewer flooding (a major issue)
- Cleaner air quality
- Improved insulation = lower heating and cooling costs
- Water purification
- Provides a habitat for various organisms

- Sound absorption
- Cooler air = less smog (urban heat island effect)
- Aesthetic appeal
- Extended roof life (by 20 years or more!)
- Recreational space
- Potential to recycle wastewater
- New jobs (horticulture specialists, manufacturers, installation experts, etc.)

Example of green roofs: Video



Summary

- **Lecture summary**

- Roof structure: types and examples
- Deterioration of roofs
- Roof repairing
- Green roof

- **Next Lecture:**

07.03.2016

Repair methods of the window and the door structures

- Window and door structures
- Identifying and assessing problems in windows and doors
- Typical repair methods for window and door structures