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## Study on Flat Roofing Systems

### A B S T R A C T

In many buildings, the roof is a major element that gives the building its distinctive profile .The main purpose of a roof is to protect the building or the house in all types of weather with a minimum of maintenance .a roof must be strong to with stand snow and wind loads. Another consideration is appearance .a roof should add to the attractiveness of the building roof styles are used to create different architectural effects. This paper reports a study on flat roof systems include the layers of structural elements of the roof, types of finish used, flashing, roof edging, drainage, and other details associated with the roof.

## *Introduction*

The roof is a system that separates the building's top floor from the outdoor environment. A roof consists of a set of load-bearing and protective elements that intend to protect the interior of buildings from meteorological phenomena such as rain, heat, cold, wind and snow, sheltering the building's structure and ensuring high standards of living conditions. The rooftop is, by definition, the highest floor of the building and may be pitched or flat, with a structural and/or coating function. The roof of a building is undoubtedly the envelope element that most influences the performance of this type of construction, because it protects the interior from bad weather and solar radiation and guarantees thermal comfort inside the building. Flat roofs have had, over the last few years, a wide application in many countries, following the architectural evolution, the emergence of new materials, and the improvement in the performance of the existing ones. The success of this solution is related to it being quickly executed (in favorable weather) and providing a useful area for the building. [1,2]

Flat roofs are a key building element to ensure water tightness (water and steam) of the external envelope of buildings, and represent one of the areas where a significant part of thermal exchanges with the exterior occurs. Moreover, the behavior of an individual flat roof at the top floor of a building, and that of the whole building, is conditioned by the better or worse performance of this building assembly [3] .

## *Layers of Structural Elements*

Flat roofs can have various functional layers matched to each other. It is essential that the layer sequence provide adequate insulation against heat and noise. The moisture to which the structural layers are exposed [4,5].(e.g. trapped humidity, condensation build-up)

### *Under course*

The course below the waterproofing which deals with water is called the under course. It can be the load bearing structure, e.g. a concrete surface, or also boarding or the thermal insulation component. It is important that the waterproofing material match the under course, to avoid expansion cracks, for example.

### *Bonding course*

Bonding courses are installed to improve the adhesive properties of building component layers. These can be primers or prior applications of bitumen solutions and bitumen emulsions. Bonding courses are painted, rolled or sprayed on to a clean under course.

### *Leveling course*

If layers of components turn out to be uneven or rough, a leveling course may be needed. This compensates for component tolerances, creates a smooth surface and is supplied as bitumen roofing sheet, glass or plastic fleece, and as foam mats. It is laid loose or spot-glued.

### *Separating course*

Separating layers or courses are laid to insure that adjacent layers of structural elements with different expansions properties can move in relation to each other, or to accommodate other mechanical

movements. They can also be used if two materials are chemically incompatible.

### ***Vapor barrier***

Vapor barriers are used to regulate moisture transmission inside the building. They are not waterproof, but simply inhibit vapor diffusion. The inhabitation factor indicates how much moisture can diffuse through the vapor barrier. They can be bitumen roofing sheets, plastic vapor inhibiting sheets, elastomer roofing sheets, or compound foils. They can be laid loose or spot-glued. Points at which the individual sheets meet must be fully glued. The vapor barrier must extend to the top edge insulating course and be fixed there at roof edges and penetrations.

### ***Thermal insulation***

Thermal insulation protects the building from heat loss in summer, and prevents large thermal build-ups through insulation in summer (summer thermal insulation). Expanded polystyrene (EPS), extruded polystyrene (XPS), extruded polyurethane (PUR), mineral fiber insulating material (MF), foam glass (FG), cork, wood fiber insulation material, or expanded bituminized mineral infill may be used. The thermal insulation can also be used to create a roof drainage incline [6].

Sheet insulation should be laid with an offset and joints are as tight as possible. The insulation is glued to the surface below and the sheets are attached to each other according to the manufacturer's instructions.

### ***Vapor pressure compensation course***

A vapor pressure compensation course is fitted to distribute the water vapor pressure evenly in the roof water proofing material.

Such layers, like vapor barrier may consist of bitumen roof sheeting, plastic vapor barrier sheeting, elastomer roof sheeting or compound foils. They are laid loose or spot-glued

### ***Roof waterproofing***

The water-bearing course is created by the roof waterproofing. It is a closed, waterproof area and can be produced with bitumen roof sheeting, plastic or elastomer sheeting or fluid-applied waterproofing. The waterproofing must be at least 1.50 mm fit, at least 2.00 mm for used roofs.

### ***Filter course***

A protective or filter course is used to protect the waterproofing from mechanical influences. PVC, rubber or plastic granulate highly perforation-proof sheets, drainage mats, or sheets of extruded polystyrene foam are used.

### ***Surface protection***

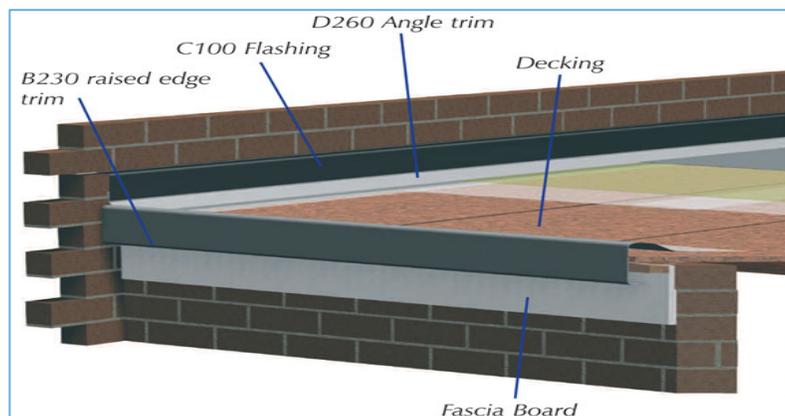
Modern foil roof are installed as single-layer waterproofing courses and attached to the course below with strips that are glued on subsequently, or spot-attached. They are usually made of light-colored materials, so that thermal expansion as result of sunlight is minimized. Because of their material properties they offer adequate protection from UV radiation. No additional surface protection need to be used for foil roofs. This saves weight, and the roof waterproofing does not provide adequate protection against UV radiation, wind upthrust or mechanical loads. A light surface protection is provided for bitumen sheets according to load. This can be achieved by applying sand, for example. Crushed slate is sprinkled into cold polymer bitumen compound and attached to the bitumen sheeting [7]

Gravel surface protection courses are known as heavy surface protection. The gravel later should be at least 50 mm thick when installed. The weight of the stones can prevent unfixed roof covering being lifted by wind suction. If the surface is protected with crushed stone or gravel, care should be taken that the grain size be sufficient by the material not to blow away in the wind. A sheet covering is preferable for surfaces exposed to strong winds.

### Accessible Coverings

Accessible coverings, i.e. coverings that can be walked on, can also be used to protect the surface. In such cases a compression-resistant thermal insulation course should be installed. The roof waterproofing must be adequately protected against mechanical influences. If the joints between the slabs are sealed, or the entire covering is closed, a slope of at least 1% must be created. Drainage is then maintained on the waterproofing, and it becomes the water-bearing course. The slabs chosen must be frost proof. Expansion joints should be provided to allow for thermal expansion.

Sufficient spacing should be maintained at the edges to prevent the raised waterproofing from damage. Accessible coverings can be laid in the form of small slabs in bed of mortar on a tufted mat or drainage course. The mortar should be approx. 4 cm thick. Spot bedding is recommended for larger slab coverings. Prefabricated height-adjustable elements can compensate for tolerance here. Compression-proof thermal insulation, such as foam glass, should be used to prevent the adjustable elements punching holes in the roof waterproofing. A more simple method is to lay the covering on little bags of mortar. For this, fresh mortar is packed into little plastic sacks, they can be leveled to compact the mortar completely. The cavity under the slabs maintained and the slabs are not bedded directly on they waterproofing, large slabs should be laid in a bed gravel for better weight distribution. Here the gravel bed is approx. 5 cm thick. The gravel selected should allow any accumulated precipitation water to drain off freely [7,8]



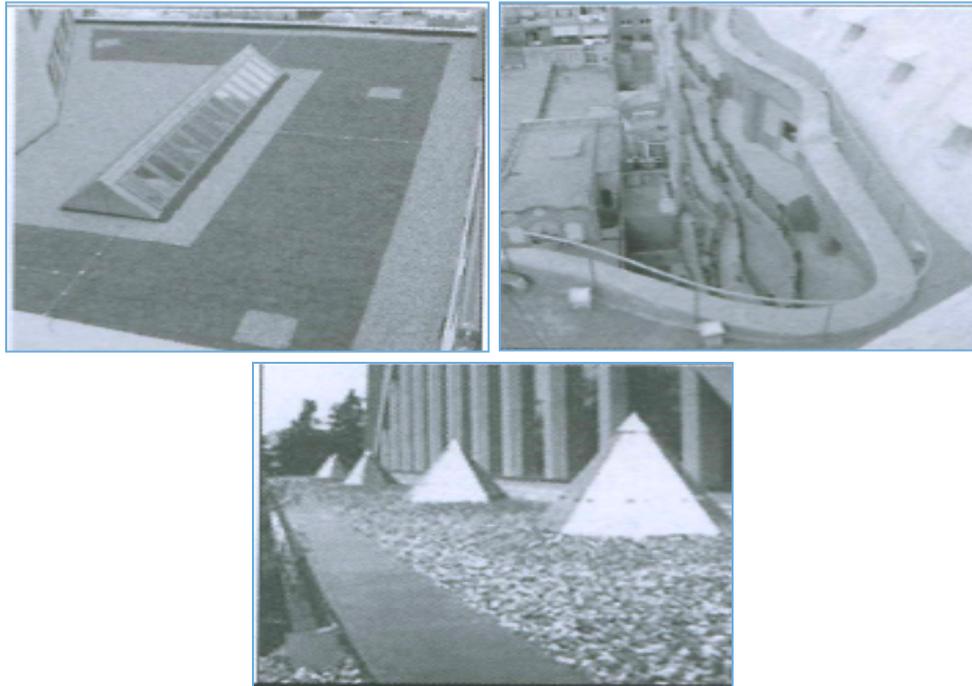


Fig .1 Accessible Coverings

### *Green Roof*

Plants can also be used to protect the surface. Here we distinguish, according to the thickness of the course and the plants chosen, between extensive and intensive planting. The additional load exerted on the roof should be considered at the structural calculation stage. Note also when choosing waterproofing that the roots must compromise it, or a special root course should

be installed. For extensive planting, the slope may be omitted to ensure that sufficient water is available for the plants, but care must be taken if damage does occur that water cannot seep through the whole set of courses, the individual waterproofing courses should be glued and divided into several fields by hulk head-styles barriers. These are places vertically, and split the roof into several areas that are then drained separately [9,10]

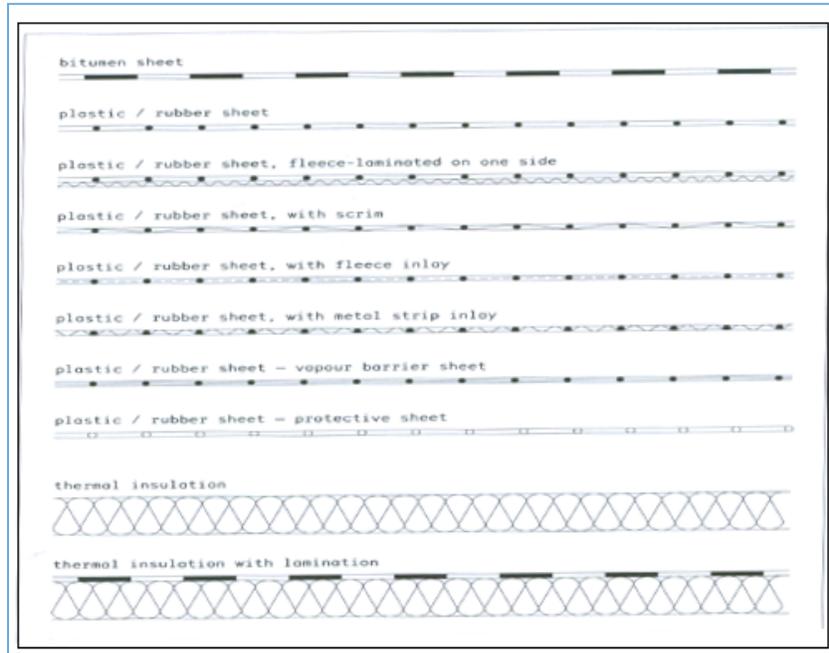


Fig: 2.A.Structural element courses according to the guidelines laid down by the zentroverband: flat roof guideline

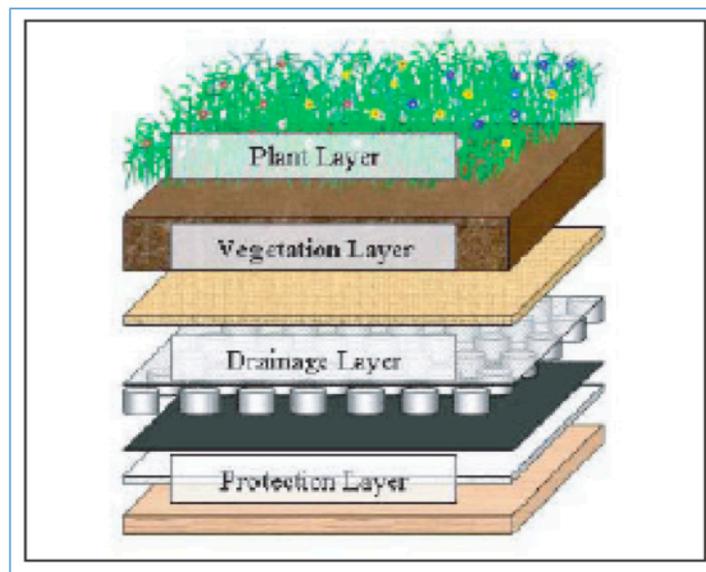


Fig: 2.b.Structural element: flat roof guideline

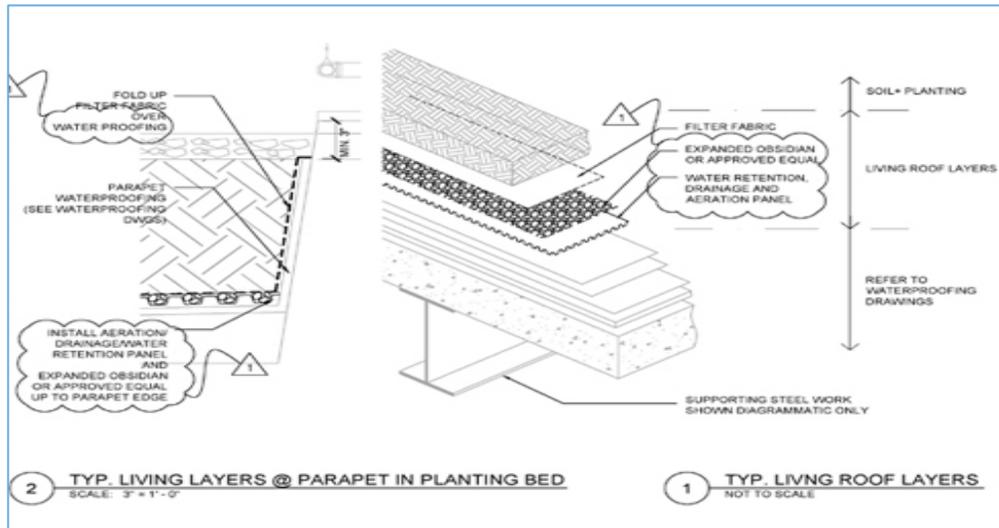


FIG.2.c: Planting Beds

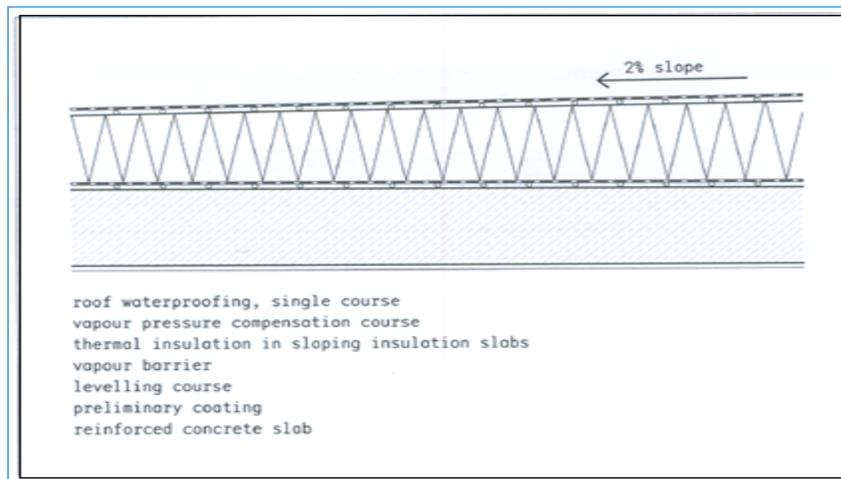
**Types of Finish**

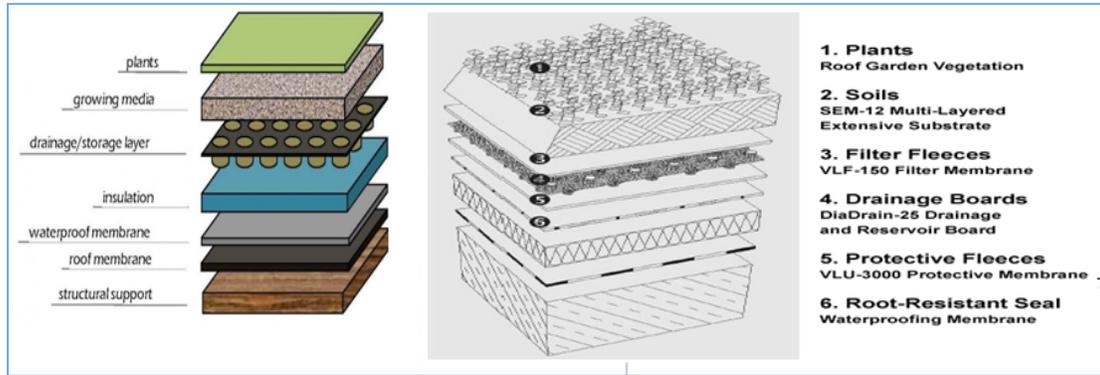
Three different principles for flat structures or course layers can be distinguished:-

**Unventilated roof**

An unventilated roof (warm roof) has its waterproofing course on the outside and so the thermal insulation is the sealed “warm area”. A typical structure for an unventilated roof involves applying a preparatory coating to prepare the surface of the roof structure, which may be in reinforced concrete roof, steel or wood. The leveling course and the

vapor barrier are laid on the surface. The insulation is made of hardwearing sloping slabs. Here great care must be taken that all areas of the roof drain towards the roof outlet or a gutter, with a slope of at least 2% (3% is better). A vapor pressure compensation course is laid on the insulation, and the waterproofing is applied to this; it can consist of one or more courses. Surface protection should be provided according to the product chosen [10,11,12]





Unventilated Roof Fig 2.d:

### Upside-down roof

The second approach to building up a layer structure is the upside-down roof. It is also called an IRMA roof (insulated roof membrane assembly). Here the thermal insulation course is above the waterproofing course, and must therefore be made of water-resistant insulation

material. For this structure, a sloping screed with an incline of at least 2% is placed on the roof support structure within a sequence of courses. The roof waterproofing is supported by a leveling course drained by the slope of the screed. The thermal insulation is also installed in the form of flat slabs. A filter course is placed on top to prevent elements of the surface protection material being washed into the insulation.

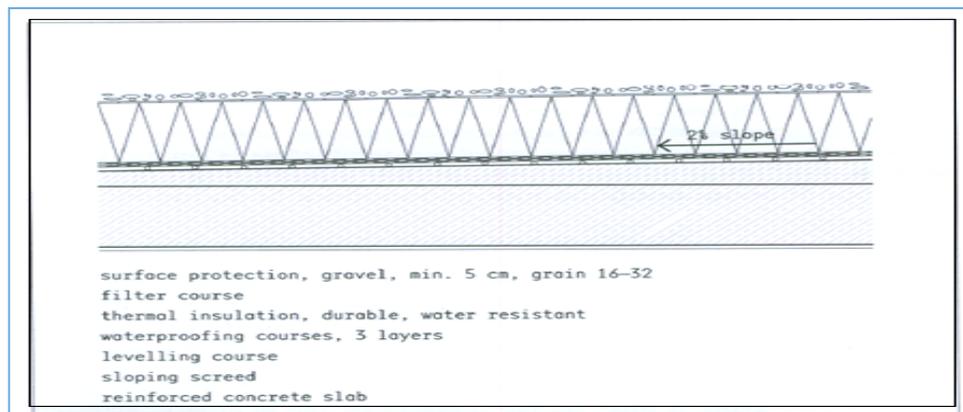


Fig3.a: Upside -down roof

### Ventilated roofs

The third construction available is the ventilated roof (formerly also known as cold roof). Ventilated roofs are often used for timber roof structure. The course structure is such that boarding, e.g. a sheet of plasterboard or chipboard, tops of the floor below. A vapor barrier runs under the rafters above it. The thermal insulation is between the rafters, and may consist of a

single layer. An air space of at least 15 cm must be adequate through ventilation. Boarding is fitted on top of the rafters; this can consist of chipboard, tongue-and-groove boarding or a similar material. The waterproofing layers are laid on leveling course. Surface can be protected when necessary.

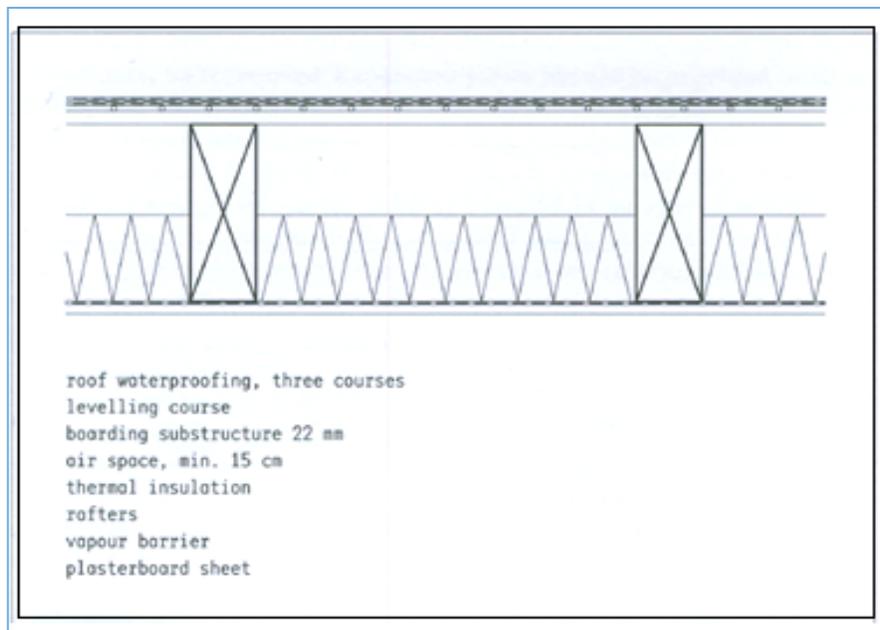


Fig 3.b:Ventilated roof

## Flashing

### *Rising structure elements*

To prevent spray or water that has accumulated on the roof from penetrating the structure the water proofing must be taken higher. Structural elements rising from the roof may include higher sections of the buildings, lift headgear, chimneys or service spaces. The same waterproofing principles apply to windows and doors. Given a flat roof pitch of up to 5 degrees the waterproofing must be continued and secured at least 15cm above the top edge of the roof covering on the rising structural element. The top edge of the roof covering is

not the waterproofing course, but maybe the gravel surface protection. If the roof pitch is greater than 5 degrees the waterproofing must be taken at least 10 cm up the rising structure elements.

### Door thresholds

Balcony and terrace doors present a particular difficulty. If the waterproofing is taken 15 cm above the working surface of the roof, there will inevitably be a step between the interior and the exterior. In most cases the shell height of the floor is the same inside and out, but the roof structure is much higher than the floor structure inside, because of the high protection of

waterproofing material. This requires an additional offset. But in order to make the roof area easily accessible, the flashing height can be reduced to 5 cm. this should insure that if water accumulates in snowy conditions it can not penetrate behind the waterproofing. If there is no roof outlet immediately outside the door, a grating or a gutter should be positioned there. Doors without thresholds may be essential when "barrier-free building" is required, e.g. in public buildings. This involves special construction methods such as protection against spray by canopies, heated gutters connected directly to the drainage system, or a roof structure with fully bonded courses [11,12].

The waterproofing, and where applicable the separating course, can be secured with clamping rails, which are pinned to the rising wall. Plastic waterproofing can be glued to composite metal sheeting. Joints should also be inserted in the rails at points where the buildings have expansion joints, to avoid tension. The upward run of waterproofing can be masked with canted metal sheets attached the rails to cover the waterproofing. These extended into the surface covering area. Care should be taken here that the sheet metals not cause mechanical damage to the waterproofing. For certain facades, the waterproofing should be taken behind the façade, although it is essential that the waterproofing be easily accessible in case of damage.

All components should satisfy the appropriate fireproofing criteria. Care should also be taken in the case of rising parts of the building that a fire could not spread to higher sections through apertures

in the roof, such as light cupolas. A gap of 5 m should be maintained to prevent possible flashover.

### Roof Edging

This could create tension at the connection points, which could cause cracks in the structure of the façade. This method is often used to provide existing listed buildings with thermal insulation subsequently, to maintain the appearance of the façade.

### Project Flat Roof

Flat roofs can be finished as projecting flat roofs at the point where they meet the facade, or with an up stand. Current practice is to finish the roof with a parapet or an edge trim. Projecting flat roofs present structural problems, as the waterproofing and insulating course in the roof and wall sections cannot easily be combined. If the external envelope is to be clad void-free thermal insulation material, to avoid thermal bridges, the projecting section of the roof must be completely covered with thermal insulation material. This, however, makes it look unduly thick as a structural element. The second possibility is to apply the thermal insulation to the inside of the roof slab, which is not in ideal solution, as it is impossible to make a direct connection with the insulating course in the wall element. This would also place the roof slab structure in the cold outside area, so it would behave differently in relation to temperature changes from the load bearing walls or columns below it [13,14]

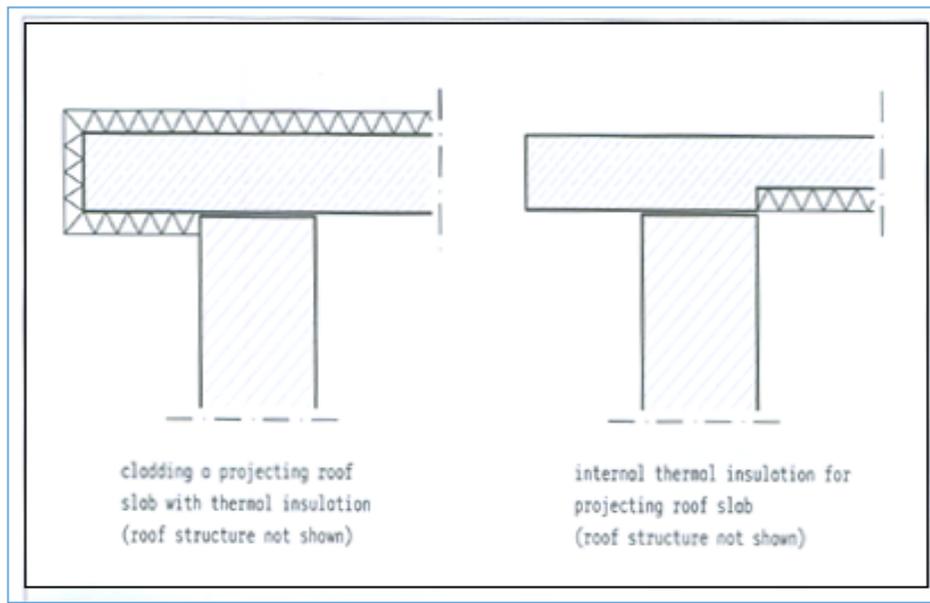


Fig4.a: Thermal insulation for projecting roof slab

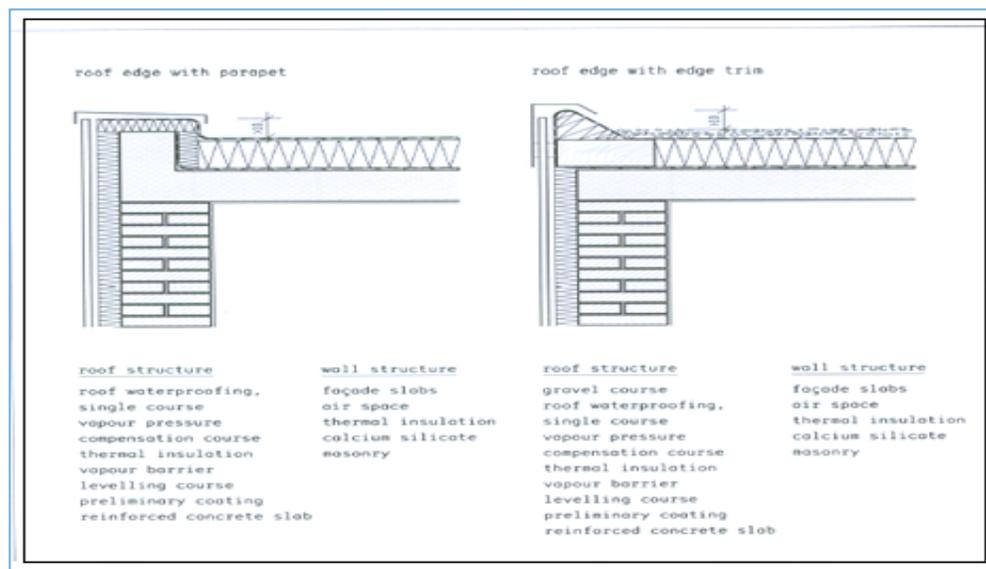


Fig4.b:-Roof edge with parapet and edge trim

### Roof Parapet, up stand

For roof edging with up stands the waterproofing layers can be continued upwards, as for the rising structural elements in the flat roof structure. Here, the topmost point should stand at least 10 cm above the roof. The reference level is the topmost layer – the foil, gravel or working surface. The up stands can be finished as a

roof parapet, e.g. in reinforced concrete or masonry, or with a roof edge trim mounted on an edging plank. The edging plank is usually a simple rectangular timber that can lie flat on the plane of the insulation. The

roof edge trim is shaped to run around the edge of the roof and overlap part of the façade. If a roof parapet is chosen, Meta

sheeting is usually employed to perform this function, but there are also prefabricated stone and concrete versions. According to the height of the building, different dimensional recommendations apply, as the wind situation becomes more critical with

increasing height. The parapet should project approx. 2 cm over the facade, to create a drip edge and prevent any rainwater that may accumulate from running behind the sheet metal.

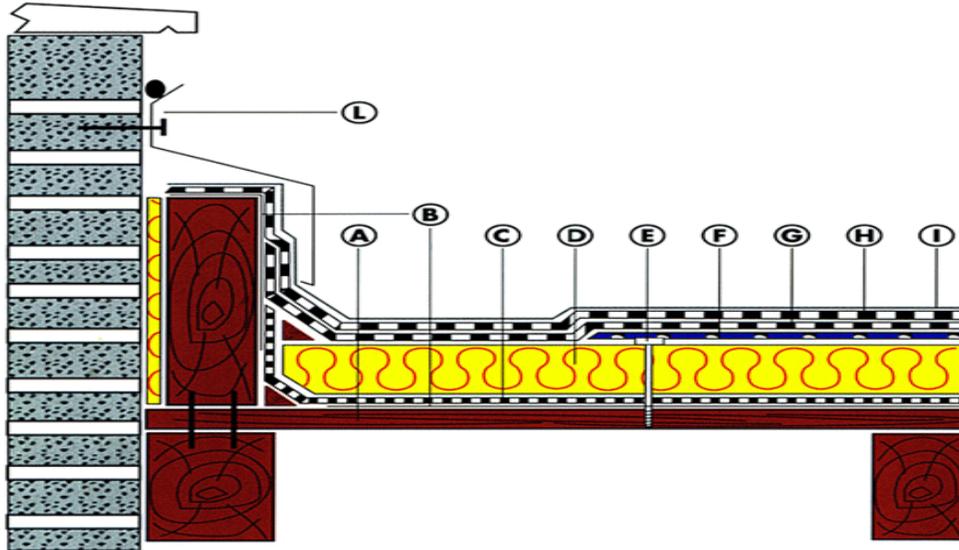


Fig.5 For roof edging with up stands the waterproofing

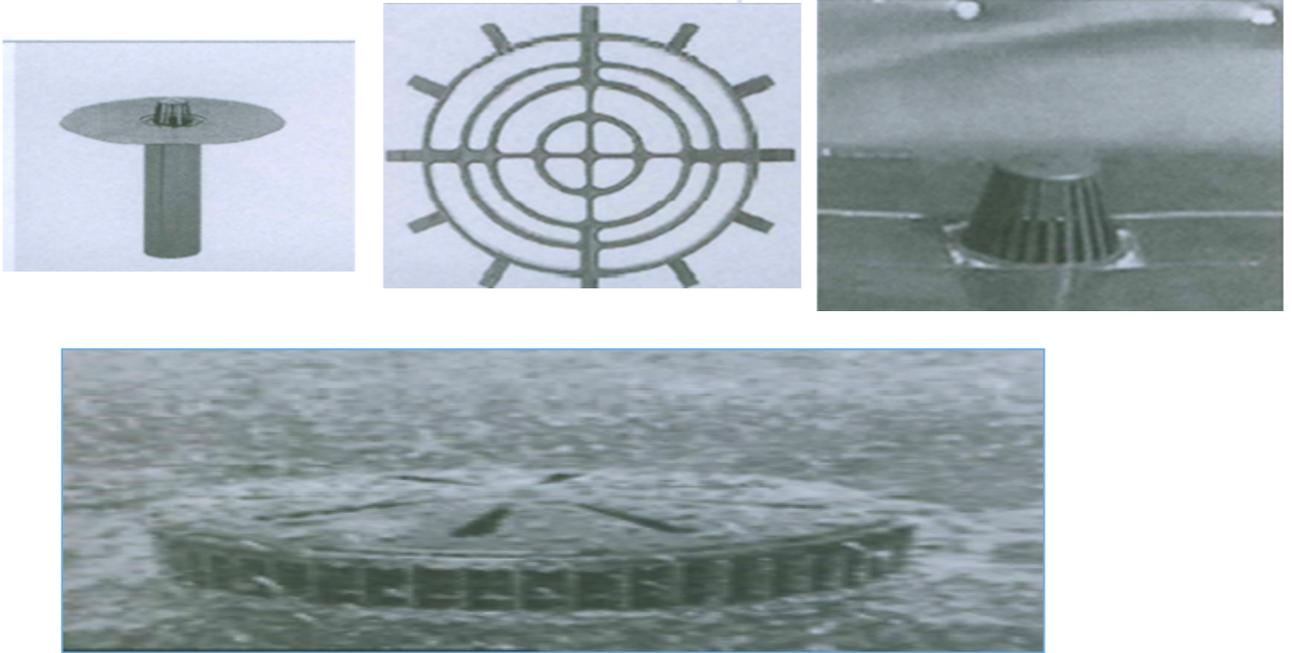
### Drainage

Flat roofs are usually drained internally, i.e. the downpipes run through the building to the drainage system in the foundations. Every roof must have at least one outlet plus an emergency outlet. The dimensions of the outlet pipes are established as for pitched roofs.

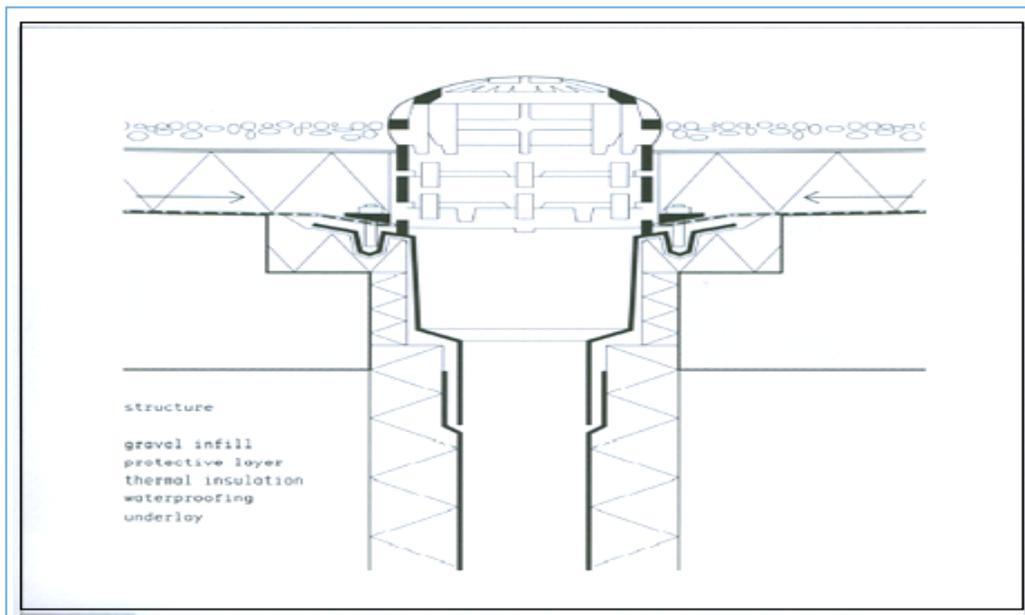
### Slope

The roof should slope by at least 2% to take the water to the outlets, as it impossible to construct a completely flat roof. The slope

prevents puddles from forming. It is created either with a sloping screed or sloping insulation. If the rooftop is to be accessible, accumulated precipitation water should be drained away on the surface as well as the insulation plane. Roof outlets or roof gullies should be arranged so that they are at least the lowest point on the roof, and freely accessible. It is possible to install inspection grids, for example, for used roof tops. These should be placed at least 30 cm away from rising structural elements or joints, so that the outlet can be cleanly waterproofed [15].



**Fig.6.a:Un ventilated roof as an example of roof derange**



**Fig.6.b :Un ventilated roof as an example of roof derange**

## Roof outlets

The roof gullies must have a locking waterproofing ring for foils or an adhesive flange, bonded securely with the waterproofing course, for bituminous seals. Gullies for flat roofs are available with both vertical and angled inlets. The vertical version is preferable in principle, as the water is taken directly into the downpipe, and any leaks can be located quickly. Angled flat roof gullies are used when large connected areas are overbuilt, for example, and it is impossible to drain the water of directly (e.g. column-free spaces).

Heating the roof outlets is recommended in areas with heavy snowfall, so that they do not freeze. This ensures drainage in winter as well.

## Emergency Overflow

To prevent water from accumulating on the roof, when an outlet is blocked with leaves, for example, an emergency overflow must be installed. Emergency overflows are waterspouts running through the roof edging (parapet). They must be placed at a low point of the slope, and be waterproofed and insulated on all sides. The projecting section of the tube must be long enough to prevent water from running down the façade. The water does not have to be direct into the drainage system as an emergency overflow is not a permanent drainage feature.

## Conclusions

Contrary to pitched roofs, the use of flat roofs has been growing, and most of buildings built during 21th century have flat roof especially in urban environment. A flat roof is a bit different from a pitched roof in that it lays horizontal across the top of the

building. Flat roofs are known for looking more modern and stylish.

Flat roofing is both economic and efficient, which saves the owner energy and money. Its construction involves considerably less labour and materials than its pitched roof counterpart and full replacement can often take just a day, and thus can be a really affordable way to create a great look for the building that is modern and convenient. With the low cost, it can be easily considered more affordable than traditional triangle roofing, which can save money and time in the long run. With a flat roof, store stuff on top is possible and installs solar panels in the space, or even a garden or an extra, outdoor living space is also possible.

From environmental concern flat roof can be the ideal canvas for an eco-friendly green roof.

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