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The Role and Function of Thermal Insulation in Landscape Architecture

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Abstract

With the movement of cities toward a more industrial urban structure, they need of green environment is increasing. One of the solutions is creating the green roofs which the interest on them is increasing. However, having a green roof requires some technical guidelines to provide the desired environment. The technical guidelines for the instruction of green roof aim to provide an adapted, environmentally friendly and suitable material for offering the optimal operation. This focus of this document is mainly on the technical aspects of the material in need for insulation, roofing membranes and protection material, moisture-retention material and water proofing.

Keywords: Thermal isolation; Green roof; Landscape

Introduction

Human beings always try to reach the optimal situation in their living places. After mid- 1970s which modern green roof movement started in Germany and fast spreading of it through the world, environmental and energy benefits, structural material and its design have been received more concerns and attention from academic researchers. Nowadays, through the world and especially in Europe and North America the residents try to have some features of a green roof in their buildings.

Green roofs have many ecological advantages. They provide insulation and cooling. They reduce urban heat in cities. The provided shade by them has a significant cooling effect and decreases the temperature. Furthermore, the heat is not maintaining in the green roof the same as traditional roofs. On the other hand, they are effective in sound insulation of the buildings which is an important point in urban areas and enhance a wildlife habit. They improve the potential biodiversity in cites. Green roofs also clean the air and save energy. They have a significant role in storm water management, CSO control, and its impact on carbon dioxide reduction. Moreover, they are helpful in food production and aesthetic aspects.

The creation and maintenance of the green roofs need some especial facilities. The green roof can be built on the varieties of the roof, but in the majorities of cases, they are constructed on flat roofs. In addition to different kinds of roofs, they also have different styles of building systems and used materials. In fact, always there is a technique to construct a green roof on any kinds of the roof. However, the most common problem is the limitation of the weight carriage capacities of the roof. The most appropriate time for building a green roof is the time of a constructing a new building or when the roof of an existing building needs fix or to be replaced, which in both situations, a structural analyst should be hired for consultation, to determine the appropriate procedure that the rood needs to support a green roof.

Despite that the cost of the constructing of a green roof is more expensive than a conventional one, but its long-term benefits can be a simulating reason for the Choosing the green roof. The costs of a green roof can be different depending on the design, material, climate, and plants.

To utilize the positive points of green roofs, different issues should be concerned such as transfer of energy, moisture, air and heat. Even so the issue of water management has a critical role. However, besides of applying good strategies and material geographical and environmental issues should receive enough attention. In this article, we will investigate some of the materials and strategies which they have been used in the structures of a green roof.

Roofing Insulation

Green roofs are good roofing insulators that prevent heat flux through the roof [1]. They consist of insulation materials that are boards placed over the roof surface. These insulators are set below or above water proof and roofing materials. If it is placed above, it needs to be made of a material that is capable of exposing of a wet condition. On the other hand, sometimes we need a protective layer, since some insulation layers cannot resist to high temperature. Polyisocyanates, extruder polystyrene, expanded polystyrene and fresco boards are the most famous roof insulator materials.

Polyisocyanurate

It is also referred to as PIR, poly iso, or ISO, is essentially an improvement on polyurethane (PUR). It is the main roofing insulator and typically is informed of foam and used for rigid thermal insulation. It will install before roofing membrane. It should be kept dry, and its weight per inch of thickness is 0.2 to 0.3 lb/ft^2, (Figure 1). There is more detail in British standard BS 4841:2006.

Source: www.insulationireland.net

Figure 1: Polyisocyanurate rigid insulator.

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Extruded polystyrene

Polystyrene is a thermoplastic material, which is in a solid-state at room temperature, but flows if heated. Polystyrene foams are used as building insulation materials because they are good thermal insulators. Extruded polystyrene (PS) is economic polystyrene. It can be installed bellow or above a membrane. It is very resistant to absorbing water and its weight per inch of thickness: 0.25 lb/ft^2, (Figure 2). BSI standard number BS EN 14934 specifies the properties of this material (Figure 2) [2-5].

Expanded polystyrene

It is usually in white color with low density and low thermal conductivity, which is another type of polystyrene that should be installed, bellows the roofing membrane. It is introduced in BSI standard number BS 3837. It also used for packaging industry. It should be kept dry and its weight per inch of thickness is 0.1 to 0.2 lb/ft^2, (Figure 3).

Fesco board

Fesco Board is a homogenous insulation board that is usually used as fire resistant. It can resist damages that come from construction and maintenance. It must be kept dry and its weight per inch of thickness is 0.77 lb/ft^2, (Figure 4). Fesco board meets the physical requirement of ASTM C 728 [6,7].

Roofing Membranes

Roofing membrane is a type of roofing system, which is used on flat or nearly flat roofs to prevent leaks and move water off the roof. Most of them are made from thermoplastic or synthetic rubber modified bitumen. They are replacement for asphalt roof systems. Most well-known membranes are EPDM (ethylene propylene diene Monomer (M-class) rubber), TPO (thermoplastic polyolefin), PVC (Poly vinyl chloride), BUR (Built-Up Roofing), Modified Bitumen and Liquid-Applied Membrane and Metal roofing.

EPDM

EPDM is an elastic material with a different kind of applications. Great heat, ozone and weather resistant, low cost, are important properties. Common thickness is: 45 mil (0.29 lb/ft^2), 60 mil (0.40 lb/ft^2) and 90 mil (0.63 lb/ft^2). It has an ability to retain in light color (Figure 5).

TPO and PVC membranes

TPO and PVC membranes are thermoplastic membranes with good chemical and oil resistant. The surfaces of them are in white color, and they are durable membranes. According to 45 mil, 60 mil and 80 mil thickness the weights are (0.232 lb/ft^2), (0.314 lb/ft^2), (0.42 lb/ft^2) (Figure 6).

Source: www.homeconstructionimprovement.com

Figure 2: Extruded polystyrene.

Source: www.homeconstructionimprovement.com

Figure 3: Expanded polystyrene.

Source: products.construction.com

Figure 4: Fesco board.

Source: http://en.wikipedia.org

Figure 5: EPDM membrane.

Source: www.arcat.com

Figure 6: Left: TPO membrane, Right: PVC membrane.

Source: www.partnersroofing.com

Figure 7: BUR membrane.

Built-up roofing

A built-up roof (BUR) system is a composed of three materials. The bitumen, felts and surfacing are the most-used materials in this membrane. There are two types of modified bitumen systems such as APP (Atactic Polypropylene) and SBS (Styrene Butadiene Styrene). These two differ in both installation processes, and they offer some specific advantageous [8].

It is low-cost and poor chemical and oil resistant. It has been low resistant to plant roots and there is needed the root barrier for the project to prevent growing the root in the roof (Figure 7).

Modified bitumen

Modified Bitumen is low cost membrane, and it is usually used for BUR systems. It has been poor resistant to chemical and oil. Common thickness weight is around 1 to 1.75 lb/ft^2 (Figure 8).

Applied membrane

Liquid applied membrane is becoming a popular choice for roofs, and it does not need flames or other heat sources. This kind of membranes is based on flexible thermo set resin systems such as polyester or polyurethane. Its weight with common thickness is 0.75 to 1.5 lb/ft^2 (Figure 9).

Metal roofing

Metal Roofing is an expensive membrane and cost much higher than other types of membranes but life time is more than 100 years, and this advantage makes it popular roofing membrane in most buildings. The weight according to the most common thickness is 1 to 1.5 lb/ft^2 (Figure 10).

Source: www.frazierroofing.com

Figure 8: Modified bitumen.

Source: www.basf-cc.com.sg

Figure 9: Liquid applied membrane.

Protection Material

As mentioned earlier sometimes we need a protection layer to protect the insulation layer from heat and chemical attack during installing roofing membrane GYPSUM- BASED COVER BOARDS (DENS DECK OR DURABOARD), Fesco board, Extruded Polystyrene, Fabrics are different kind of protection materials. Only gypsum based cover boards is mentioned in the following, since others have been explained in previous sections.

Gypsum-based cover boards (Dens deck or dura board)

Gypsum-based cover board is a highly mold resistant roof panel and consists of a moisture-resistant, non-combustible core of specially treated gypsum with glass mat facings. It delivers the highest performance ratings for fire, strength and moisture resistance. It protects the insulator from heat and chemicals during adhering to the insulation layers. Because of applied weight over green roof beneath and fasteners it should be used to prevent damage to roof membrane. The three most common thicknesses are 1/4-inch (1.1 lb/ft^2), and 1/2-inch (1.95 lb/ft^2), and 3/4-inch (2.5 lb/ft^2) as shown in (Figure 11).

Moisture-Retention Material

Some kind of green roof component needs to be capable of exposing to moisture. These materials should absorb water when it is available. These products absorb several hundred times their volume in water and discharge the water slowly. Moisture- retention materials can remain wet for long periods. Most important moisture retention materials are geo textile fabrics, gel pack and particles and Dimpled Mats.

Geo textile fabrics

Geo textile fabrics are the moisture-retention products. Horticulturist's opinion is that water stored in these products is actually available to the plants when this material is positioned below

Source: www.metalroofingtips.com

Figure 10: Metal roofing.

Source: www.cannon-roof.com

Figure 11: Gypsum board.

root barrier and root plants intake water with contact. Example of this kind of materials is the rock-wool blankets, which holds an impressive amount of water. Although it depends on climate, it can be remaining wet for a long time, and it can take effect in drought-tolerant feature of the green roof system. It is very durable material which not only provides separation but also provides protective functions such as large elongation before the brake, high puncture resistant (Figures 12 and 13).

Gel packs and particles

Gel packs, and particles are packed in leaky pouches that are located near plant root zones, and it can be blended to the growth media. It can absorb water hundred times more than its volume and release the water slowly. It is useful for green roof plants but should not rely on it as an irrigation system. Plants should be kept watching because its rapid hydration can retain water from plants. The voids will be created in the soil after releasing the water. Calculating based on volume capacity should be done on its saturated weight [8-12].

Dimpled mats and filter fabrics

Its place is under of growth media, an array of holes, which can be placed of water. Although these are not heavy, for structural design process volume and weight of them should be calculated. Entering of green roof particles to the drainage system and stopping them from doing their work is a problem that can be solved by filter fabrics (Figure 14).

They are very lightweight and usually contain chemical that repel root growth. They can also act as root barriers [13].

Root Barrier

Root barrier is placed so that structures and plants may cohabit happily together. It provides protection from root penetration and usually does not increase the weight of green roof. Fabrics and Thermal Plastic are two common types of root barriers. Fabrics have mentioned in previous sections, thermal plastic is in next section.

Source: www.safwatco.com

Figure 12: Rock wool blankets.

Source: www.co.sheboygan.wi.us

Figure 13: Geo-textile fabrics.

Source: products.construction.com

Figure 14: Dimpled mats.

Thermal plastic

Thermal plastic is more expensive than the fabric root barrier, and it is usually used in intensive green roof projects, since it protects from root penetration. This material should be used under the drainage layer and above waterproofing system [14].

Waterproofing

Buildings need waterproofing especially when green roof is implemented. Concrete is not watertight on its own, so we need waterproofing materials. The conventional system of waterproofing involves "membranes." This relies on the application of one or more layers of membrane (available in various materials: e.g., bitumen, silicate, PVC, EPDM etc.) that act as a barrier between the water and the building structure and preventing the passage of water. There is a liquid-applied sealant in the market which has better adherence to a substrate [15].

Liquid-Applied Membranes versus Roll Goods

Liquid-applied materials like a hot modified rubber and elastomeric urethanes cure to form a monolithic membrane with no seams [16]. In case of durability felt and fabrics can be used with them. It is applied directly and after curing, has a very good bonding to the concrete and this will prevent lateral movement of water between membrane and roof deck. Since it has been maximum bridging capacity, liquid material hasps problem is heavy penetration and cracks in the concrete. Roof penetration is one of most important problem for liquid-applied materials F and penetration should be kept to a minimum. If it is unavoidable, flushing must be installed. Water finds its way through concrete if the membrane damages. We should have a plan for building expansion to decrease the risk of cracks and tears, which comes by building movement. In the large project with large concrete structure liquid- materials are less expensive than roll goods. Roll goods are produced in various lengths and widths. These materials are installed by adhering, mechanically attaching, or loose-laying and ballasting in place over the roof surface, and each of this method has its advantage and disadvantages. Fully adhered membranes are typically more expensive due to the cost of labor and material for the adhering process. Mechanically attached roofing systems is a cost-saving alternative, but it is unsuitable or green roof projects because the screw is used in this method, and it can disturb the surface by green roof pressure on it. The last roofing configuration is loose-laid and ballasted membrane the roof assembly is simply laid over the roof surface and then weighted in place by ballast, in this case, the green roof system. This is the most cost-effective means of roof installation, eliminating the labor and materials associated with fully adhering or mechanically attached membranes (Figure 15).

In the case of a roof leak, loose-laid and ballasted roof installation has lateral migration of water, making the source of the leak difficult to trace and increasing the amount of water damage to the roof insulation and building interior.

Another drawback is that ballast is required over the entire roof area to secure the roofing system. However, in some cases we don't want to make all parts of the roof green, and this can make the installation strategy unsuitable.

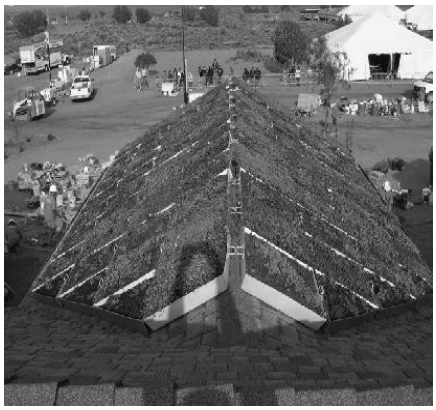

Figure 15: Final Slope Roof (Luckett, 2009).

Location of the Insulation

As a mentioned earlier insulation layer is part of every building structure project. It can be applied under or above roof materials. In many green roofs, projects are using polyisocyanurate which is rigid and must be kept dry. So it should be installed under the roof materials. If extruded polystyrene is used as insulation material, it can be used as impervious and water proof material. The walls and curbs can be covered with an insulation layer too.

Discussion and Conclusion

In the previous sections, we discuss the kinds of material applied to the green roof and some important issues, which should be concerned with the installation. Each of them has positive and negative points. In the case of the application according to kind of desirable use, we should choose the most suitable kind. The high quality, reasonable price, and availability are the priorities' characteristics. In choosing each of these materials so, many other issues should be kept in mind. In the case of physical issues, the material should be chosen according to geographical and environmental characteristics. For example, pesticide leakage from roof materials is one of the issues which recently receive more attention. The material should be tested to measure the amount of pesticide runoff to prevent from polluting the ground water. The kinds of materials should be select for foundations and pathways, which have no leach carbonates. So it is suggested to apply green roofing materials which have environmentally friendly standards.

Furthermore, the material should be chose and design in a way to prevent unwelcome wildlife problems. In the case of plants preferably the plants should be native but because the soils are not native soil (simply compacted, very heavy, etc.) it would limit the green roof plant palette so its environment will be more limited in bio- diversity. Therefore, in a green roof different aspect of material should be respected, and all the available verity should be considered to choose the best.

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