Course Name: Bioclimatic Architecture: Futureproofing with Simple and Advanced Passive Strategies

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Lecture 03

Cavity walls

Hello everyone. So, we are back again today to have a look at another advanced passive strategy and today we will look at the cavity walls. So, let us look at an advanced passive strategy called the cavity walls. So, what are cavity walls? A cavity wall is a form of masonry wall construction. It consists of two parallel layers like this. Layer 1 and layer 2, which are separated by a cavity.

So this is the cavity. Cavity walls may or may not include insulation within the cavity, whereas sometimes the cavity wall could have insulation in between that. So, the cavity itself acts like a natural barrier of moisture, and the insulation can be added for better thermal performance. The primary performance of this design is to enhance thermal efficiency and also reduce heat loss or gain from the building, as the case may be.

Proper insulation helps to reduce heat loss in cold climates and minimize heat gain in warm climates. Hence, proper insulation of the wall is important. Heat transfer across an air gap within a wall will take place through convection as is shown here. So when the surface of the outer wall says this is outside and this is the inside. When the surface of the outer wall gets warm and the wall becomes warm, the air closer to this wall becomes warm, and through convection, it becomes cool, and this cycle keeps on repeating itself based on the thermal capacity of what is in between these two walls.

This wall, the second wall, will get less warm or will get less cool, keeping the inside comfortable. Let us look at the working principle of cavity walls. Warm, lightweight air begins to move and heat the molecules of colder air. Warm air rises as a result of this, whereas cool air falls, creating a cyclical movement inside the cavity or the hollow wall. The heated exterior wall surface transfers heat to the air film on the second surface.

So, when solar radiation falls on this wall, there is gradual heating of the various layers of the wall. until the heat is passed on to the film of air adjacent to the outer wall, and that is the two that are called two. And here the convection starts because warm air begins to move up creating a low pressure area because of which the cool air descends and the loop continues. Through convection, the airflow within the cavity transfers heat from surface 2 to surface 3. As the air becomes warm, it transfers heat to the surface 3, and slowly the surface 3, which is actually the second wall, starts to warm up.

Reducing heat loss in the winter and maintaining a cool home in the summer is made possible by wall-insulated buildings because by the time this temperature reaches here, the outside begins to become cool and the direction of heat flow is towards the outside. The direction is towards the outside, and therefore, Constant temperature of about 28 degrees Celsius can be maintained when the external is 35 degrees Celsius. So, depending on the season, the insulated materials create a barrier between heated inside and cold outside or cool interior and hot exterior. They are named so because they are poor heat conductors. As a built-in insulator, the rat trap bond's hollow lowers the direct heat transmission through the wall.

This can be especially helpful in very warm areas where it is critical to regulate indoor temperature in order to enhance comfort. Until there is no more temperature difference, this movement of air will keep on happening, and by using insulation on the exterior wall, heat is retained and it becomes comfortable inside. In warm humid climate the rag-trap bond can be a very effective solution because this has a the brick bond itself has a built-in insulator and this can be helpful also in very warm areas because air acts like a air as an insulator. Now let us look at the types of insulation as well as the thermal properties. So if you look at how the insulation is filled, it can be filled in these three ways.

The first is the partial fill. In partial fill, what happens is even though there is adequate gap. The insulation is placed only partially and the remaining part is left as air as an insulator. So, in this 3- to 4-centimeter-wide cavity that is created between the two walls, a veneer between the insulation and the inner leaf is placed. kept to tighten the insulation layer against the second wall. Next is the full fill.

So, complete filling of insulation is the second type. So, if the proper insulation is selected and installed correctly, this fill must take over all cavity functions, leaving only a finger width gap between the veneer. Third is placing insulating blocks. Lightweight quick bricks, lightweight concrete blocks, or cellular concrete blocks are used to lay bricks on the inside leaf. In terms of insulation, if we look at the thermal properties, the thermal heat loss coefficient, also known as the U value, also known as air-to-air transmittance, represents the heat loss through the construction.

Because insulation works by preventing heat movement, which is quantified by the R value, the higher the air, the better the insulation. This is often utilized in walls, roofs, and floors. The type of insulation, the density of insulation and the thickness of the insulation, all of these affect the R value. Heat from the sun is dispersed in the cavity and vented through apertures in warm humid climate. What is the R value of insulation? It is the ability of a particular type of insulation to withstand heat flow, and that is called the R value.

These values are expressed per centimeter or per inch since thicker materials restrict heat transfer mode. The R value is obtained by multiplying the value by the thickness of the insulation. Let us quickly and briefly look at the insulation material. So, what are the types of insulation material? So, there are three types. First is the common species.

First is the common species. Second is state-of-the-art insulation material, and third is sustainable insulation material. So common species that are used very commonly or that are really not encouraged these days because they are not environmentally friendly. They comprise of organic insulation materials, fibrous, which is inorganic and cellular. They also comprise of inorganic insulation material, polystyrene, polyurethane, cork, and other fibrous or organic insulation material.

Whereas, state of the art insulation material can be innovative or advanced insulation. They could be transparent insulation materials, aerogels, closed-cell foam, vacuum insulation, or reflective insulation. Whereas, the sustainable insulation materials could be bio insulation material, agricultural waste materials, and recycled products insulation material. So materials from organic insulation include wood wool, flax or sheep wool, hemp, goat wool, and other renewable resources. Whereas non-renewable materials could be glass wool or mineral wool, and these are called inorganic insulating materials.

Natural building materials are made from biomass, including wood, hemp, cotton, flax, agricultural residues, straw, husk, rice husk, cereal husk, or vegetable pith. Now, these insulation materials have a wide range of classifications, from bulky fiber materials such as fiberglass, rock wool, cellulose, and natural fibers to very rigid foam boards and sleek foils. The bulky fibers resist conductive heat flow in a building's cavity. Whereas rigid foam boards trap the air or any other gas in their cells to resist conductive heat flow. The third is reflective coils.

So, these are radiant barriers and reflective insulation systems. They reflect radiant heat flow, especially in the cool climates. Then next is the blanket, which can be batted and rolled. So, they come in the form of rolls. Then the fifth type is insulating concrete blocks.

Sixth is foam board insulation. Seventh is insulating concrete forms. And the eighth type is sprayed foam insulation. The insulation is applied like a spray. So, if we look at blankets, bats, and rolls, these are composed of fine glass fibers.

They are made up of silica sand, recycled glass, or any other inorganic materials. They are less dense and more flexible, and they are available as bats, blankets, or rolls. They provide good thermal insulation, and they reduce heat transfers considerably. These can be used in walls, ceilings, and floors, and also in HVAC systems as duct insulators. Then the mineral wool is comprised of two types.

One is the rock wool, and another is slag wool. They are generally denser, more rigid, and harder than fiberglass. These are again available as bats, blankets, and sometimes even loose fills and rigid boards. They have very good thermal performance, and they resist high temperatures. So, you can see how rigid foam boards can be an insulating material between the brickwork.

This is the brickwork, and this is the board. This is the insulating board, and this is the inner wall. So, there are polystyrene boards, which are rigid foam boards. They are made from expanded polystyrene beads. They are lightweight and easy to install, and they are effective thermal insulation.

Then the next type is - The fourth type is the insulating concrete blocks. So, concrete core is mixed with insulating material such as EPS beads or foams, and their combined thermal performance across the entire wall. So, that thermal performance is pretty much consistent. These are often used in exterior walls, providing both structural support as well as insulation. Here you can see self-insulating concrete blocks. The block itself has two layers of insulation.

This is the first layer, and this gap also acts as an insulant. Then sprayed foam is shown here, where the insulation is sprayed with a gun on the wall. And here you have another type, which is the reflective foil. Let us look at some case studies. The first case study we will take is by wall makers.

This site was a small plot that was being suffocated by other residential developments on all its sides. So, the idea of this residence was to have an inward-facing house with all its spaces opening into a funneling central courtyard. This house is aligned in the east and west directions, with openings facilitating maximum cross-ventilation. Each staggered wall has been tailor-made to suit the issue of deficiency in space that this residence posed. It aims to create larger volumes with also a feeling of privacy.

Here in this design, the rat-trap bond is used. The rag-trap bond is a brick masonry technique for building walls, and it reduces the overall volume of bricks needed and boosts thermal efficiency by placing bricks in a vertical orientation as opposed to the traditional horizontal orientation. Soon after completion, scaffolding pipes that were left over were used to create the grill work and the main staircase. So using rag trap bond over the regular course makes this house have a cavity wall. So, the idea was also to not throw away anything as waste. So, as you know, the parts of the flooring in the living spaces were composed of pieced-together wooden boards, which also acted as insulation. The next case study we will see is the Atal Akshaya, Urjabhavan, New Delhi. This is by the Ministry of New and Renewable Energy. It's their headquarters, and it's a net positive campus.

So this is India's first net positive energy government office building. This building is aimed to be iconic and is a landmark because it symbolizes energy-efficient renewable energy, which is integrated into the building. This will set an example of energy and environmental performance that achieves a net energy positive goal, thereby setting new standards for resource efficiency in design, construction, and operation. So, the Atal Akshaya Urjabhavan, which is a net positive energy campus, serves the MNRE Ministry of New and Renewable Energy Headquarters as it establishes a new standard for energy conscious development in the country. This building uses innovative ideas of combining passive methods with renewable energy systems and makes them accessible and educational to the general public.

It is India's first net-positive building, and it serves as a pattern for iconic net-positive energy buildings. This building uses a lot of techniques, not only cavity walls, but it also uses the solar roof. It uses the solar roof. The west facade has solid masses as the service areas are located on the western side. And that facade has punctures that are covered with GFRC jallies, which enable cross ventilation.

These jallies have the service cores placed along the west side for shielding the harsh sun. The building is cladded with Dholpur sandstone. Solar PV panels are installed in abundance. And the single mass in rectangle form is divided into two parts, the north wing and the south wing, which distribute the functions with a pivotal central spine. This acts as the entry for the building and collaborative spine connecting departments on each floor.

This building also uses radiant cooling, which we will see in the forthcoming classes. The east facade of the building is protected by thermal insulation by double walls. So, the walls are built with AAC, which is aerated cement concrete blocks used for the walls. And these have a cavity in between them that has glass wool, which is 200 mm thick. So the east facing has a continuous double glass unit.

And it also has a glazed facade to allow daylight into interior spaces when insulation is needed into interior spaces while insulating them from heat. So, it has aerated concrete walls. I am just showing the brick indication because it is the most accepted indication of a wall, and the insulation is glass wool. So, this building, which has to demonstrate itself as a net positive building, has used cavity walls, and as we saw, cavity walls function on the concept that having a plain cavity wall with just two walls, wall 1 and wall 2, with air space, transfers heat from wall 1 to wall 2 by conduction within the wall and convection between the walls. So, from point A to B, heat transfer happens by conduction, and between points B and C, heat transfer happens by convection, and between points C and D, heat transfer happens by conduction.

In order to improve the insulating capacity, insulation can be placed in between the walls. We also saw the different types of insulation that is used, and we briefly saw a couple of case studies where a cavity wall has been used for the masonry. With this, we will stop today's class and continue with yet another advanced passive technique. the forthcoming class. Thank you.