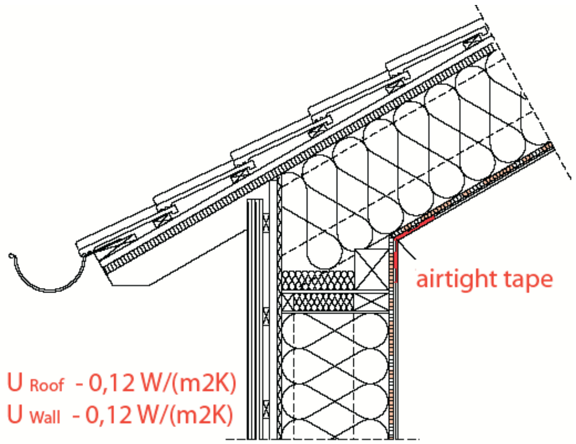
Construction of exterior walls in a Passive House

By Christian Bosselmann

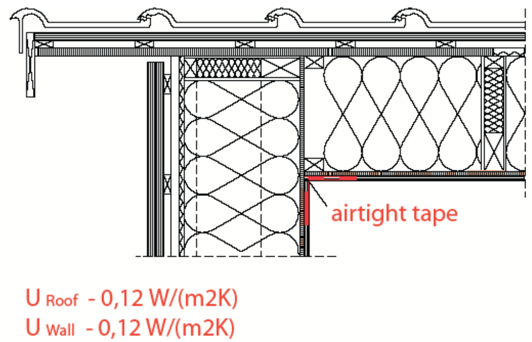
In order to build a passive house with primary heat consumption of less then 15 kWh/m2a, one has to meet the requirements defined by the PI (Passiv Haus Institut Darmstadt.)
In this article I would like focus on different construction methods of the walls.

Concept

Increasing the insulation is not enough. An **airtight construction** method without **cold bridges** is crucial for the energy performance of the building. Both massive (concrete, brick) or lightweight (wood) walls can be planned with the sufficient U value. According to the PI, opaque construction parts have to achieve an U-value of less then 0.15 W/(m2K). Transparent parts will do with less then 0.8 W/(m2K).
In general massive walls consists of the insulation towards the outside and the load bearing part on the inside. The conceptual advantage is the ability to store the passive solar energy in the massive part.
In lightweight constructions the insulation is placed between the load bearing posts, thus achieving less depth of the wall compared to massive ones. To use the passive solar power the lightweight construction can be combined with floors tiles and a thick layer of screed. One need to take in to account in which climate the house i build and what solar gains are to expect.
Cold bridgesnormally appear at the junction of the wall and floor slab, around windows and doors, on corners of the building and penetration of external construction parts. The `problem zones` have to be detailed carefully and monitored during the construction. To avoid cold bridges one should be able to draw a 25cm thick line around the whole house in section and plan, without having this line penetrated or interrupted at any point.
Carefully detailing and construction is also necessary for meeting the requirements to an **airtight construction**. The `problem zones` are similar to these of the cold bridges. In well planned massive construction the concrete can function as the vapour barrier as well as airtight layer. Lightweight construction mostly have a foil or the boards, such as oriented strand board OSB, functioning as the vapour barrier and airtight layer. Gaps and joints have to be sealed with licensed joint compound or tape.
Using the blower door test it is possible to determine how airtight a building is. A ventilator placed in the door generates a slight high or low pressure of 50 pascal within the house. At the same time the amount of necessary air to maintain the



IIII. 1, Eave line section



IIII. 2, Verge section

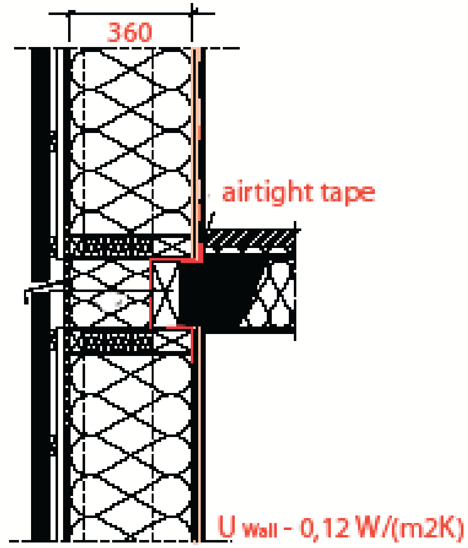
pressure difference for one hour is mesured. This amount indicates the leakages. Now relating the amount of air to the netto volume, you get the air change rate. According to the passive house standards it has to be less then 0.6 within on hour at a pressure difference of 50 pascal.

Construction methods (lightweight)

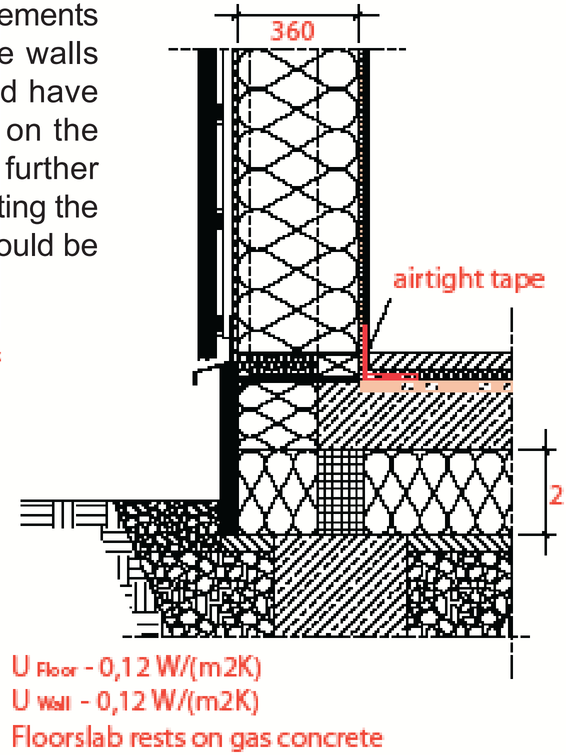
To achieve a great insulation depth in a single wall construction TGI or Box frames can be used. The percentage of wooden parts related to insulation in the walls i extremely low. Despite of the u value of wood, it is still a cold bridge when going all the way through.
The advantage of the single wall towards double wall construction also lies in the more efficient production. Some places it can be difficult to find contractors and engineers who have any experience in working with these products. In this case one can build the wall using customary wooden posts, as shown in the drawings further below.

Single wall construction

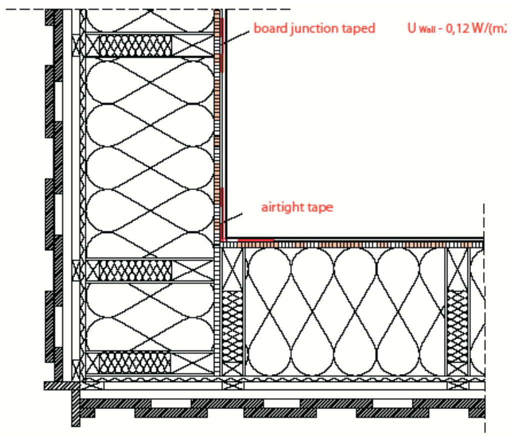
Illustration1-5 are downloaded from Informationsdienst Holz, DgfH Innovations- und Service GmbH, . On this site you will find very useful information concerning low energy and passive houses. In German thou.
The damp proof layer is made up by the OSB boards on the inside also bracing the structure. The joints with tongue and groove are sufficiently air and damp proof when placed and nailed directly above a post. Other junctions as you find them around windows, doors and between the slabs have to be sealed with a with licensed joint compound or tape. Junctions of the slabs are often very difficult to construct without leakages during the blower door test. To avoid these the junctions can be wrapped with a folie or wind paper, marked red on illustration 3. On the same illustration you can also see how the insulation depth is kept sufficiently thick along the floor slab. The base of the building often poses a problem in terms of cold bridges. The load bearing walls have to rest on the foundation, penetrating the insulation. The ground floor slab can rest on gas concrete (0.15 W/mk) or on foamglas (0.15 W/mK). The base point can be further improved by insulating the foundation on the outer side. Another possibility ist to insulate the ground floor slab on the inside, but loosing the benefit of the passive solar power gains.Illustration 4 shows the corner avoiding cold bridges by placing too many posts.
The illustrations 1-5 are optimized for the purpose of insulation. They have some weak points when it comes the erection of the building. On ill. 3 and 4 the wall projects from the slab resting on. They would have to be secured during the erection. Another problem poses the bolting of the different parts. In the case of prefabricated elements it would not be possible to bolt the walls inside the construction. They would have to be bolted from the outside and on the inside. To hide the bolts and make further installation possible without penetrating the vapour barriver a installation wall would be necessary.



Ill. 3, Floor section



Ill. 4, Basepoint section



Ill. 5, Corner plan

Double wall construction

The illustrations 6 to 8 are modified details from the second prototype of the Watergy project, at the TU Berlin that the author has participated in. Start of of construction spring 2005

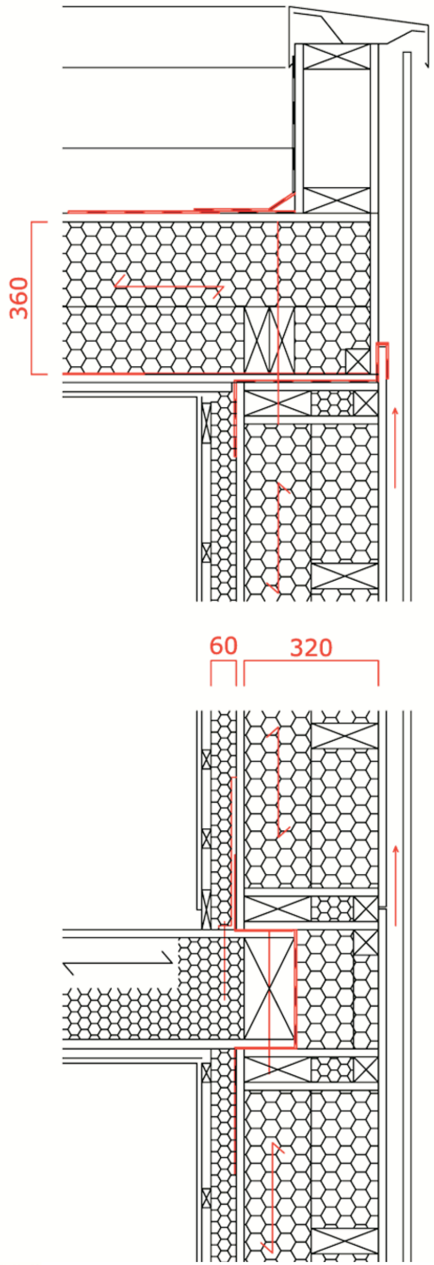
In order to use standard wooden post customary in trade and construction one would have to construct a double wall. The wall is made up by a layer of gypsum, 60 mm construction wall, OSB board (vapour barrier), vertical posts 60x160 (load bearing), horizontal posts 60x160 (not load bearing), DWD (diffusion open) and a ventilated facade. The walls are prefabricated which is why they are closed with a selfmade box frame on top and bottom. The bolting is hidden by the facade and construction wall. All construction parts do have a u value lower then 0.15. According to the loads one can change the construction grid from 62.5cm to 83.3 cm, thus optimizing the wood percentage related to insulation. Of course the insulation depth can be in.- or decreased using other posts.

As in the TGI or box frame system joints of the boards are nailed directly on the posts. Other joints and junctions are sealed with licensed joint compound or tape. The slab junctions are wrapped with folie or wind paper.

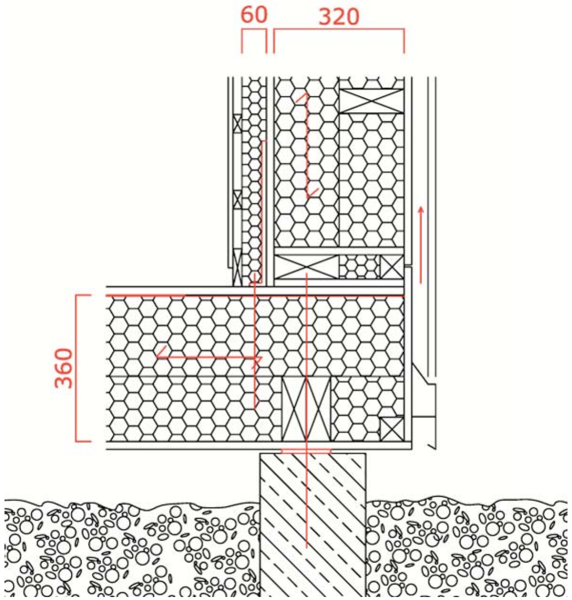
The building rests on a ringfoundation. Cold bridges are avoided by the crosswise arrangement of the beams.

Illustration 8 shows how to place the posts on the corner avoiding cold bridges and how the elements can be bolted with each another.

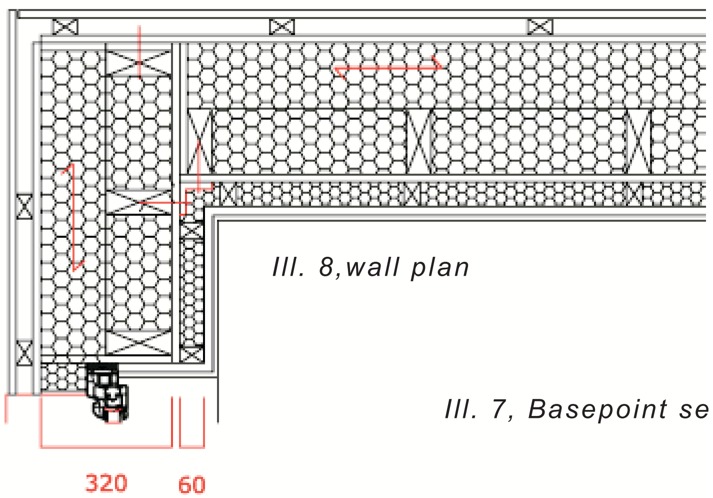
Windows and doors have to be insulated in front of their frame thus achieving the required U value of less then 0.8 W/(m2K) according to the PI



Ill. 6, Roof and floor section



Ill. 7, Basepoint section

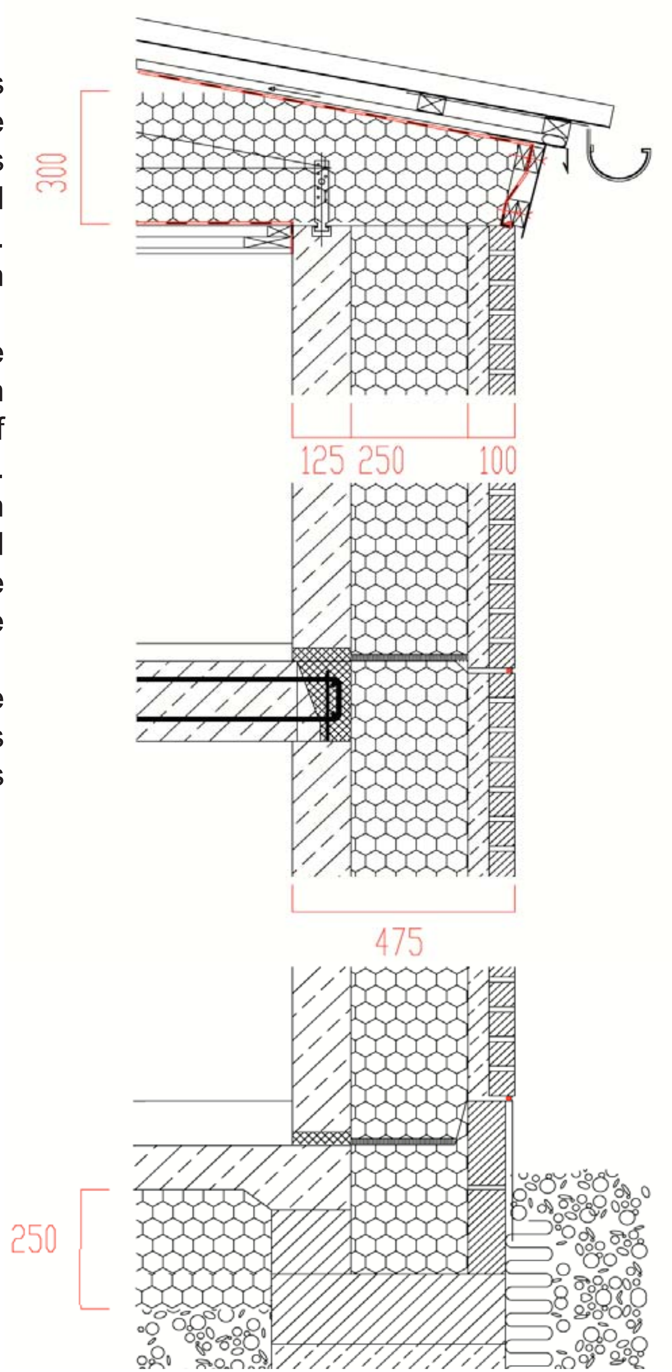


Ill. 8, wall plan

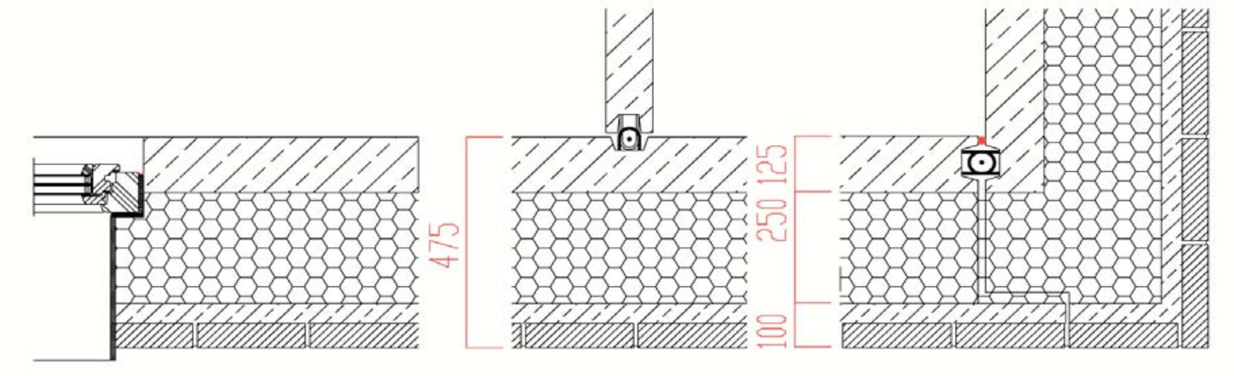
Construction methods (massive)

The illustrations 9 and 10 are from the first passive houses in Denmark, Næstved. (start of construction 02/2005) Architects, Suenson Tegnestue AS, consulting engineers Cernergia,
The author works as a technical advisor for Cenergia.

The walls are prefabricated with two walls of reinforced concrete and the insulation in between. Due to the face brick work facade the outer concrete wall is necessary. In cases of plastered facades a plaster base would be mounted. The walls have a U value of 0.15 W/(m2K).
The inner wall functions as vapour barrier and is airtight. The junctions are filled with concrete and should be airtight as well. To play it safe, the gaps in addition can be sealed using a licensed joint compound.
Due to the high heat conductance of concrete, avoiding cold bridges is of utmost importance. This makes the basepoint very difficult since the wall has to project its loads in to the foundation. Along with load bearing inner walls they have to be thermal separated. The walls and slabs can rest on a layer of gas concrete or even better foam glas. Illustration 7 shows how the potential cold bride of the wall and slab meeting the foundation is insulated. Further optimizing the basepoint the foundation is insulated as well.
The section between two floors does not pose a problem in general. The roof construction is made of wooden girders. The air proof vapour barrier has to be glued with the wall. The different pieces of the vapour barrier often being a PE folie have to be overlapped and taped. These junctions are placed along the girder and compressed by the substructure of the gypsum boards.
Illustration 8 shows how the corner and the connection to a inner load bearing wall is carried out. Also here the window frame is insulated on the front.



Ill. ,Roof, floor and basepoint section



Ill. 10,wall plan