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ANALYSIS OF WATER VAPOUR BARRIER LOCATION IN ROOF STRUCTURE

Summary. This thesis undertakes the question of the necessary thickness of thermal insulation and suitable location of vapour barrier which are needed for sloping roof design, including thermal transmittance of supporting structure. There will be used the method of the heat transfer in 2D. The results are presented in graphic form – temperature course, heat flow.

ANALIZA USYTUOWANIA IZOLACJI PAROSZCZELNEJ W KONSTRUKCJI DACHU

Streszczenie: W referacie poruszono problemy niezbędnej grubości materiału izolacyjnego oraz odpowiedniego usytuowania izolacji paroszczelnej, niezbędnej w konstrukcji dachów wraz ze zwróceniem uwagi na transmisyjność termiczną ich konstrukcji nośnej. Wykorzystana zostanie metoda dwuwymiarowego przepływu ciepła. Otrzymane wyniki przedstawione zostaną w formie graficznej.

1. Introduction

This article is aimed at the design composition of membrane slope roofing. The question number one in designing the thermal insulation of slope roof is the location of vapour barrier in this layers. We must focus on the correct choice of moisture stop.

As far as the chosen material is concerned, the main problem is usually its cost whereas others more important aspect are usually neglected. We would like to show the effect of vapour barrier position at slope roof. We established arguments of same construction such as thermal transfer or condensation of water vapour in roof. The quantity of water vapour condensation is affected by the location of moisture stop.

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2. Bases for physical design of roof structures

2.1. U-value

All building constructions must meet the requirements of U - value [$W.m^{-2}.K^{-1}$]. If we have calefactory with its relative humidity roof structures φi ≤ 60% have to meet the following requirement:

$$U \le U_N \tag{1}$$

where:

UN - is normative value by ČSN 730540-2:2002, Z1:2005.
U - is calculated value.

2.2. Condensed water vapour in roof structure and annual balance

If water vapour condensate in construction we have to avoid a failure in its function. ČSN 730540-2:2002 directs maximum quantities of annual condensed water vapour in construction $M_{c,a}$ [$kg.m^{-2}.a^{-1}$] :

$$M_{c,a} \le M_{ev,a} \tag{2}$$

where:
$M_{ev,a}$ - is maximum of evaporated water vapour in construction by year [$kg.m^{-2}.a^{-1}$].

$$M_{c,a} \le M_{c,a,N} \tag{3}$$

where:

$M_{c,a,N}$ - is the required value of condensated water vapour in construction by year, if a construction has strata with poor diffused lay near exterior so $M_{c,a,N} \le 0{,}1$, in other constructions $M_{c,a,N} \le 0{,}5$ [$kg.m^{-2}.a^{-1}$].

2.3. Location of vapour barrier

The aim of installing a vapour barrier is to prevent water vapour from permeating into membrane roofing where it can condensate. We often place vapour barrier near interior side. An alternative way where a vapour barrier may be situated is between two layers of thermal insulation. In such case we must check the correct functioning of roof cladding by means of thermal calculation.

There are a few possibilities of locating vapour barrier at roof construction:

- under thermal insulation on the interior side of the roof

Vapour barrier is most commonly placed between frame cover plasterboard and thermal insulation. Between plasterboard and vapour barrier there is not air space. This location of vapour barrie can lead to damage in vapour barrier and next non-performance its correct function.

- *between layers of thermal insulation*

Vapour barrier is situated between two layers of thermal insulation. Thermal insulation is located between rafter and under rafter. From bottom spar vapour barrier is applied and bottom this sheet next thermal insulation is located at the inside surface. So we can protect vapour barrier against damage. If we apply this method we must design the correct thickness of thermal insulation under and upper rafter. No correct rate evocate condensation water vapour inside construction.

2.4. Selection of vapour barrier

In our experiments we studied two types of materials of vapour barrier in different variants of composition. Coefficient of diffusion resistance:

With low coefficient of diffusion resistance μ= 400 000;

With high coefficient of diffusion resistance μ= 1 600 000.

3. The effects of selected vapour barrier location

The simulation of various types of complex of strata was made in computer programme Area 2005. We reasoned about boundary condition for interior θ_i = 20°C, φ_i = 50% + 5% = 55% (still settled room), for exterior θ_e = -15°C, φ_e = 84%. In the majority of cases the roof cladding meets the requirements of U-value. During simulations we kept same parameters of materials for all construction. We design thermal insulation form mineral fiber with U-value 0,043 $Wm^{-2}K^{-1}$, the width of rafter is 100 mm and the height is various in different examples.

In varieties **Var. 1 – Var. 4** we ratiocinated the ventilation air layer between upper face of thermal insulation and protective damp-proofing. In varieties **Var. 5 - Var. 6** protective damp-proofing overlies right on thermal insulation, this material can be contact with thermal insulation. It must be stressed that protective damp-insulation can act as vapour barrier at summer time.

Construction with vapour barrier situated closest to interior side was not simulated because in this case water vapour does not condensate inside construction.

We examine only typically structures of slope roofs.

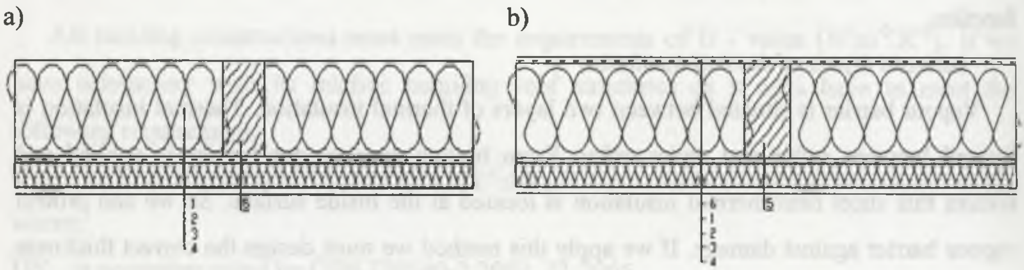

Fig. 1. Composition of roof construction: a) void of protected damp-proofing, b) with protected damp-proofing (1 – thermal insulation, 2 – moisture stop, 3 – thermal insulation, 4 – plasterboard, 5 – rafter, 6 – protected dam-proofing)

Rys. 1. Układ warstw w konstrukcji dachu: a) brak zabezpieczenia przeciwwilgociowego, b) z zabezpieczeniem przeciwwilgociowym (1 – izolacja cieplna, 2 – folia paroszczelna, 3 – izolacja cieplna, 4 – okładzina tynkowa, 5 – krokiew, 6 – zabezpieczenie przeciwwilgociowe)

Variant 1

In this case thermal insulation has thickness 160 mm, rafter has the same height and thickness as thermal insulation. Vapour barrier has factor of diffusion resistance μ= 400 000.

Variety 2

This variety is same as Var. 1 but we used vapour barrier with factor of diffusion resistance μ= 1 600 000.

Variety 3

Thermal insulation has thickness 140 mm, rafter has the same height and thickness as thermal insulation. Vapour barrier has factor of diffusion resistance μ= 400 000.

Variety 4

Construction of roof is same as Var. 3, factor of diffusion resistance μ= 1 600 000.

Variety 5

Here we used protective damp-insulation which is designed for direct contact with thermal insulation. Thickness of thermal insulation between rafter is 160 mm, vapour barrier factor of diffusion resistance μ= 400 000.

Variety 6

Composition of this construction is same as Var. 5, only we used vapour barrier factor of diffusion resistance μ= 1 600 000.

We made calculation for all varieties with different thickness of thermal insulation under rafter (see Fig. 1). We observed quantity change of condensed water vapour into construction and interior face temperature of roof construction.

Table 1

Record calculation for all variants (red color mark unsatisfactory values of parameters by ČSN 73 0540-2:200, Z1:2005)

Composition	Thickness TI under vapour barrier(mm)	Face temperature (°C)	Condensation of water vapour ($kg.m^{-2}$)	U-value ($W.m^{-2}.K^{-1}$)
Compos. 1-2	20	16,96	0	0,25
Compos 1-3	30	17,10	0	0,25
Compos 1-4	40	17,87	0,142	0,225
Compos 1-5	50	18,25	0,288	0,209
Compos 1-6	60	18,48	0,434	0,199
Compos 1-7	70	18,61	0,440	0,191
Compos 1-8	80	18,80	0,565	0,182
Compos 2-2	20	16,96	0	0,254
Compos 2-3	30	19,08	0	0,246
Compos 2-4	40	18,71	0,174	0,220
Compos 2-5	50	18,20	0,340	0,208
Compos 2-6	60	18,44	0,492	0,192
Compos 2-7	70	18,57	0,494	0,191
Compos 2-8	80	18,77	0,602	0,181
Compos 3-4	40	17,70	0,209	0,240
Compos 3-5	50	18,06	0,469	0,221
Compos 3-6	60	18,36	0,551	0,181
Compos 4-4	40	17,63	0,248	0,238
Compos 4-5	50	17,94	0,379	0,227
Compos 4-6	60	18,32	0,609	0,210
Compos 5-4	40	19,29	0,081	0,231
Compos 5-5	50	18,20	0,348	0,208
Compos 5-6	60	18,48	0,435	0,199
Compos 5-7	70	18,61	0,450	0,190
Compos 5-8	80	18,80	0,567	0,180
Compos 6-3	30	18,85	0	0,262
Compos 6-4	40	17,80	0,174	0,224
Compos 6-5	50	18,20	0,384	00,208

4. Conclusions

At simulation of Var. 1 is optimum ratio two layers of thermal insulation 1:4 to1:2,5. At this range U-value and quantity of condensation water vapour into construction are fulfilled. Demand on interior face temperature is fulfilled all cases.

The effect of devaporation is more expressive if we use vapour barrier with factor of diffusion resistance μ= 16000 000. At this case inside face temperature is lower.

If we use thermal insulation between rafter about thickness 140 mm (Var. 3), amount of condensed water vapour is approximately double compared to same composition with thickness of thermal insulation 140 mm.

No expressive variance at quantity of condensed water vapour is between Var. 3 and Var. 4.

The damp-insulation lying on thermal insulation made diffusion closed lay at exterior side. By ČSN 730540 we must exchange evaluative criterion for condensation water vapour inside construction. Direct location of protected damp-proof to thermal insulation has limited range of thermal insulation thickness under moisture stop.

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