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CONSTRUCTION FOR PASSIVE HOUSES WITH BLOWEN CELLULOSE

OBVODOVÉ KONSTRUKCE PRO PASIVNÍ DOMY S FOUKANOU CELULOZOU

Abstract

Application of blown insulations in standard two-by-four insulations has one technological problem. This problem is connected with cutting through the board, which is time demanding. The new system should diminish amount of used timber and make application of blown insulations less difficult. The point of this paper is to describe new timber construction system dedicated for blown insulations and also thermal analysis of constructional details. The paper includes first experimental tests of application of blown cellulose insulation. There are benefits of new designed timber construction system in the conclusion of the paper.

Keywords

Wood construction, thermal insulation, cellulose

Abstrakt

Aplikace foukaných izolačních materiálů do standardních lehkých skeletů typu two-by-four má jeden technologický problém. Je nutné vyřezat do obvodové desky otvory, což je časově náročné. Nový nosný systém by měl snížit objem použitého řeziva a zároveň zjednodušit aplikaci foukaných izolací. Cílem této práce je popis nového dřevěného konstrukčního systému určeného pro foukané izolace a zároveň teplotní analýza některých detailů. Práce obsahuje také výsledky prvních testů aplikace foukané celulózové izolace. V závěru práce je přiřazeno zhodnocení a výhody nového konstrukčního systému.

Klíčová slova

Dřevěná konstrukce, tepelná izolace, celulóza

1. INTRODUCTION

Building materials used for filling gaps between load bearing members of walls framing are better insulates. Despite of many advantages of massive wall members they give off heat to exterior. This sets in heat bridges. This has negative effect on construction, which must be eliminated. Wood frames of current buildings can be filled with insulation board. Elimination of heat bridge is done by use of wooden I section. This section does not satisfy the need of easy application of blown insulation. Disadvantage of blown insulations is necessity of drilling a hole in sheeting. New wooden frame section is trying to eliminate both problems.

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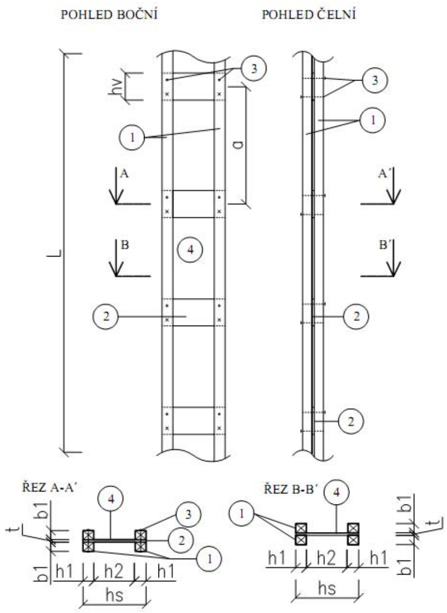
2. DESCRIPTION OF TECHNOLOGY

Nowadays application is done from exterior into the hollow part of wall through sheeting. If the construction is well prepared, it can be filled with insulation of higher density. Ideal density of insulation in walls is 60-70 kg/m3. This guarantees the volume stability of insulation.

3. MULTIPURPOSE WODEN LOAD BEARING MEMBER

- Built up load Bering member
- Web - OSB board, th.: 15mm
- Joints possibilities – screws, nails,
- Compression strength: 80 kN - 140 kN



Fog. 1: Load bearing member – sections and elevations

symbol	description
1	flange - wooden string C24
2	Web - OSB board
3	Joint- nail of screw
4	Plastic film (not steam barrier)
l	Member height
h	Web height
a	Web distance
h_l	Height of string section
h_2	Flange distance
b_l	Width of string section
t	Thickness of web
h_s	Wall thickness

Tab. 1: List of symbols

4. BENEFITS OF MULTIPURPOSE WODEN LOAD BEARING MEMBER

4.1 Subtile dimension

Nowadays constructions have bigger dimensions because of thickness of insulation. This has two outcomes:

A) Increased amount of timber

It is not only about load bearing construction (sticks). More insulation requires bigger horizontal strings.

construction	Wall thickness [mm]	Costs [Kč]	Frame dimension [mm]	Volume of timber for one frame [m3]	Compression strength [kN]	U [W/m2K]	Frame distance [m]
M.P. I sec.	160	810	4x40x40	0,02	81,33	0,14	0,6
W.F.		810	40x160	0,02	68,94	0,14	0,6
M.P. I sec.	180	810	4x40x40	0,02	81,33	0,13	0,6
W.F.		910	40x180	0,02	89,19	0,13	0,6
M.P. I sec.	200	1010	4x40x50	0,02	119,27	0,12	0,6
W.F.		1010	40x200	0,02	109,05	0,12	0,6
M.P. I sec.	240	1010	4x50x50	0,02	149,10	0,11	0,6
W.F.		1010	40x240	0,02	145,75	0,11	0,6
M.P. I sec.	300	1510	4x60x50	0,04	191,60	0,10	0,6
W.F.		2270	60x300	0,05	293,30	0,11	0,6
M.P. I sec.	350	1550	4x60x60	0,04	149,10	0,09	0,6
W.F.		-	-	-	-	-	-

Tab. 2: Comparation of Multipurpose wooden load bearing member with classic wooden frame

B) Lower relative deformation caused by drying

Wet timber used for building is going to lose its humidity. This causes lost of volume, which is followed by deformation. Total deformation is equal to dimensions of member. Dividing whole section into smaller regular parts decreases total deformation

4.2 Using build up columns has benefits in structural analysis:

A) Joints distances

While using nails for anchoring boards, we must meet requirements of Eurocode 5 for minimal distances between joints (viz. 8.3.1.2 [1])

Nails 60x2, 8mm has this minimal distances:

$$a_2 = 5d = 5.2{,}8 = 14mm$$

$$a_{3,t} = (10 + 5\cos\alpha)d = (10 + 5\cos 90)2{,}8 = 28mm$$

$$a_{3,c} = 10d = 10.2{,}8 = 28mm$$

It´s impossible to meet requirements for minimal distances between joint while using standard stick. If we use built up section, we have no problem with meeting requirements (pict 2).

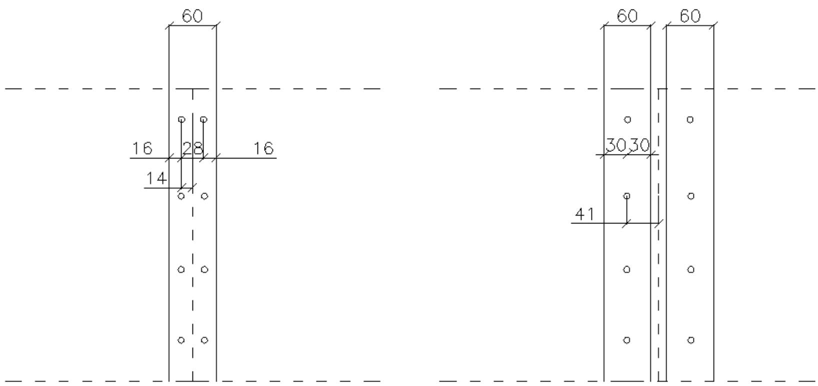


Fig. 2: Minimal joint distances (left – classic stick, right built up cross section).

B) Compression across the grain

For strings of wood frame is compression across the grain in horizontal members on the foundation. New I section allows us to use double horizontal member on foundation and tie stick from both sides. Result – no compression across the grain, no heat bridge.

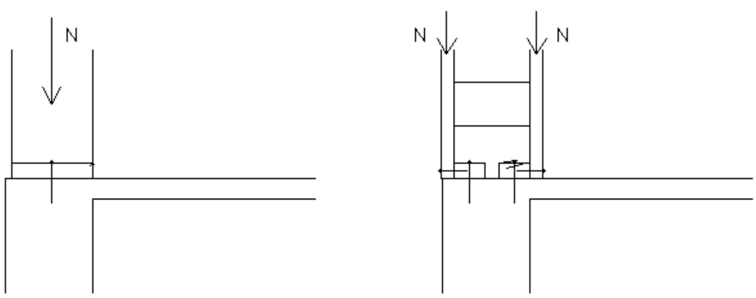


Fig. 3: left – classic foundation, right foundation with I section

5. THERMAL ANALYSIS

Thermal analysis was done according to standard [2]. The standard sets requirements for thermal moisture and air diffusion trough constructions . Main goal of thermal analysis is to ensure solid insulation around building. Thermal diffusion coefficient *U*, is described by thermal flow through whole constructions including thermal bridge effect. Relation between thermal diffusion coefficient *U* [W/(m^2.K)] and thermal resistivity *R* [(m^2.K)/W] is written below:

$$U = \frac{1}{R_T}\left[W/\left(m^2K\right)\right] \tag{1}$$

R_T thermal resistivity of construction [(m^2.K)/W]

In building with heating and air moisture φi < 60% all constructions must fulfill condition

$$U \leq U_N \tag{2}$$

U_N standard refuirement for thermal diffusion coefficient [W/(m^2.K)]

With suitable software it is possible to make more exact calculation of *U* coefficient. Taking into account L^{2D} [W/(m.K)], which determinate thermal diffusion in area of construction. Relation between *U* and L^{2D} is written below.

$$U = \frac{L^{2D}}{b} \tag{3}$$

b width of construction area [m]

L^{2D} thermal diffusion of construction in area [W/(m.K)]

There were found air gaps in the experimental sample after application of blown insulation. According to results a new model of construction was made. Values for model with air gaps are in the third column of table below.

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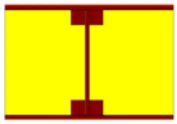
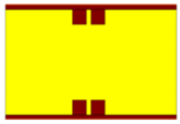
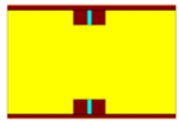
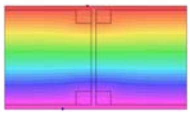
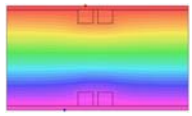
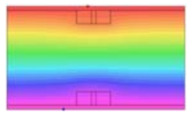
Part of construction	In point of heat bridge	Without heat bridge	Without heat bridge, with air gaps
Model			
Heat area of model			
$f_{Rsi,N}$ [-]	0,793	0,793	0,793
f_{Rsi} [-]	0,951	0,956	0,956
$f_{Rsi} \geq f_{Rsi,N}$	Satisfied	Satisfied	Satisfied
$U_{N,20}$ [W/(m2.K)]	0,30	0,30	0,30
U [W/(m2.K)]	$0{,}1454 \approx 0{,}15$	$0{,}1400 \approx 0{,}14$	$0{,}1402 \approx 0{,}14$
$U \leq U_N$	Satisfied	Satisfied	Satisfied

Tab. 3: Analysis of particular parts of I section

6. EXPERIMENTAL CHECK OF DESIGNED CONSTRUCTION

Main goal of experiments was to observe application of thermal insulation into timber construction of building. The experiment should show whether there are air gasp in isolation or not. Conclusion of experiments is included to next development of construction. Experiments were designed and performed in cooperation with company which is manufacturing cellulose insulations.

- Experiments has proven effectiveness of application of blown insulations
- Settlement of insulation will be proved in

There were three testing samples

- Segment of external wall
- Segment of wall corner
- Segment of external wall in position of window

All segments were tested for possibility of application of thermal insulation. Segment of external wall was tested for settlement of insulation. Sample was hanged up to 1m above concrete floor and it was cut loose. Its fall caused dynamic bump. Segment was opened after test. Test proved that there was no settlement in insulation. Density of insulation before test was 74,40 kg/m^3.

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Before application of insulation	Member filled with insulation	Plastic net solidity check
		

Tab. 4: Testing fazes

Application of blown insulation was tested especially at the wall corner segment. This point of building is meant to be problematic for application of insulation. Test sample was 1,2 m width in both directions and 1,0 m high. Sheeting of sample was made of OSB board of thickness 15 mm. There is small board of plexi glass in the sample so application progress can be seen.

Last segment with window is 2 m width 2,6 m high and 0,43 m thick. Standard timber element structure is sheeted with OSB boards. As other member this has 2 boards made of plexi glass to observe application especially in the place of window. Density of insulation in this sample was 65,8 kg/m^3.

New construction system is workable; it fulfills elementary condition of easy application of blown cellulose insulation.

7. CONCLUSION

Results of experimental test and theoretical modeling are good enough to dolare that multipurpose wooden load bearing member can be used in practice as equal substitute for clasic wood frame.

LITERATURE

ČSN 1995 -1-1 Navrhování dřevěných konstrukcí – obecné zásady

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