ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 2007
Seria: BUDOWNICTWO z. 112 Nr kol. 1763

Peter ŠPÁNIK*
STU Bratislava

LOAD CARRYING CAPACITY OF SANDWICH PANELS

Summary. The determination of the load carrying capacity of sandwich panels using different conditions: shear strength, buckling strength and deformations are presented. The influence of the quality of the core material (polyurethane foam) for the load carrying capacity is investigated.

OBCIĄŻENIA PRZENOSZONE PRZEZ PANELE

Streszczenie. W artykule przedstawiono różne sposoby obciążenia paneli. Zbadano wpływ jakości rdzenia (pianka poliuretanowa) na sposób przenoszenia obciążenia przez panel.

1. Introduction

Sandwich panels are often used in civil engineering structures. They represent the combination of two (or more) materials with totally different mechanical properties. Even if the producers present load carrying capacity of these panels, the responsible designer must be able to recognise the background. Presented article evaluates the ultimate load using different strength and deformation conditions.

2. Sandwich panel

Sandwich panels consist of external thin profiled face sheets (static, aesthetic function) and of thick core (thermal properties). For core material, are mostly used the polyurethane foam, the mineral foam and the polystyrene. It is necessary to arrange coupling effect between the internal core and the face sheets. The face sheets (steel, aluminium or fibre reinforced

* Opiekun naukowy: Prof. Ing. Ján Ravinger, DrSc.

plastics) carry the normal stresses and the core has a duty to carry the shear stresses. The core represents the elastic support for the face sheets as well.

The fabrication of the panels is the trade secret of the producers covered by patents. One possibility is to extrude and to fill up the core materials and face sheets in the form. Another way is to use the glue.

Fig. 1. The sandwich panel
Rys. 1. Panel

3. Computational model

Presented results are obtained using the finite strip method and the finite element method programs. Fragments of real roof panel are modelled like simple beams. The full stick between the steel face sheets and the polyurethane core has been assumed. The results have been arranged for different modulus of elasticity of the polyurethane core E_{PUR}: *20 MPa, 12 MPa and 5 MPa* (DIN 53 457) and related shear strength τ_{PUR}: *0,3 MPa, 0,15 MPa* (DIN 53 422). The steel face sheets have been assumed with modulus of elasticity E_{steel} = *210 GPa* and yield stress f_y =*235 MPa*.

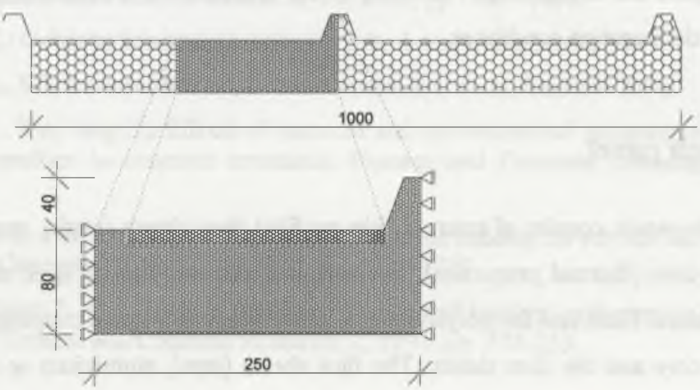

Fig. 2. The fragment of the calculated model
Rys. 2. Fragment obliczanego modelu

4. Conditions for determination of load carrying capacity

The first strength condition is exceeding of the design yield stress of the steel (S 235):

$$f_{y,d} = f_y / 1,1 = 235/1,1 = 213,6\ MPa \tag{1}$$

The strength of polyurethane core has been used as the second condition:

$$\tau_{max,d} = \tau_{PUR} / 2,5 \tag{2}$$

The maximum displacement in the middle of the panel has been taken as: L/200, L/250, L/300. The finite strip method and the finite element method automatically accept the normal and the shear stresses for the evaluation of the displacements. In the case of the sandwich panels the effect of the shear stresses is dominated for the displacement.

5. Results

The tables 1, 2 and 3 shows the load carrying capacity for different values of the modulus of the elasticity of the core (E_{PUR}) and related shear strength (τ_{PUR}) for different span of the panel. The minimum load carrying capacity is boldface. The load carrying capacities given by producers are presented as well.

Table 1

The load carrying capacity for $E_{PUR} = 20\ MPa$ and $\tau_{PUR}=0,3\ MPa$

q_{max}[kN/m^2]	1 m	2 m	3 m	4 m	5 m	6 m
L/300	**17,086**	**5,998**	**2,582**	**1,286**	**0,718**	**0,437**
L/250	20,503	7,197	**3,098**	**1,544**	**0,862**	**0,524**
L/200	25,629	8,997	**3,872**	**1,930**	**1,077**	**0,655**
f_{yd}=235MPa/1,1	22,070	**8,001**	4,197	2,537	1,682	1,193
$t_{PUR,d}$=0,3MPa/2,5	**19,608**	10,169	6,897	5,195	4,181	3,488
$q_{producer}$				1,945	1,1	

Table 2

The load carrying capacity for E_{PUR} = 12 MPa and $\tau_{PUR}=0,3\ MPa$

q_{max}[kN/m^2]	1 m	2 m	3 m	4 m	5 m	6 m
L/300	**11,193**	**4,494**	**2,119**	**1,121**	**0,650**	**0,406**
L/250	**13,432**	**5,393**	**2,543**	**1,346**	**0,781**	**0,487**
L/200	**16,790**	**6,742**	**3,179**	**1,682**	**0,976**	**0,609**
f_{yd}=235MPa/1,1	17,229	6,655	3,795	2,376	1,606	1,155
$t_{PUR,d}$=0,3MPa/2,5	19,967	10,435	7,018	5,263	4,211	3,509
$q_{producer}$				1,945	1,1	

Table 3

The load carrying capacity for E_{PUR} = 5 MPa and τ_{PUR}=0,15 MPa

q_{max}[kN/m^2]	1 m	2 m	3 m	4 m	5 m	6 m
L/300	**5,457**	**2,522**	**1,331**	**0,782**	**0,492**	**0,326**
L/250	**6,549**	**3,026**	**1,598**	**0,938**	**0,591**	**0,392**
L/200	**8,186**	**3,783**	**1,997**	**1,173**	**0,739**	**0,490**
f_{yd}=235MPa/1,1	11,069	4,333	2,807	1,960	1,406	1,047
$t_{PUR,d}$=0,15MPa/2,5	10,811	5,660	3,681	2,727	2,166	1,796
$q_{producer}$				1,945	1,1	

6. Conclusion

Presented results for the large span roof sandwich panel show that the limited condition for the load carrying capacity is the deformation. For the short span panels and the high quality of the core the load carrying capacity is determined by the shear strength of the core or the normal stresses of the steel face sheets. As the general conclusion we can say that the quality of the core material has the crucial effect for the ultimate load.

LITERATURE

1. Ravinger J.: COMPUTER PROGRAMS – Static, Stability and Dynamics of Building Structures. Alfa Bratislava 1990 (in Slovak).
2. Hohe J., Librescu L.: Advances in the Structural Modeling of Elastic Sandwich Panels. Taylor & Francis Inc., 2004.
3. http://www.skkkgroup.com/produkt.html

Recenzent: Prof. dr hab. inż. Andrzej Wawrzynek