APEM journal

Advances in Production Engineering & Management
Volume 17 | Number 2 | June 2022 | pp 231–242
https://doi.org/10.14743/apem2022.2.433

ISSN 1854-6250
Journal home: apem-journal.org
Original scientific paper

Numerical study of racking resistance of timber-made double-skin façade elements

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A B S T R A C T

The use of a double-skin façade (DSF) is a quite new approach in the building renovation process, complementing conventional renovation strategies. A double-skin façade is an envelope wall construction that consists of two transparent surfaces separated by a cavity and can essentially improve the thermal and acoustic resistance of the building envelope. The main double-skin wall components are usually composed of a hardened external single glazing pane and a double or triple thermal insulating internal glass pane, which are connected to the frame structure. Recently, many studies have analysed the thermal and acoustic performance of DSF elements, but almost none in terms of structural behaviour, especially in terms of determining the racking resistance of such wall elements. Moreover, with a view to reduce the global warming potential, an eco-friendly timber frame instead of a commonly used steel, aluminium or plastic frame is studied in this analysis. However, structurally combining timber and glass to develop an appropriate load-bearing structural element is a very complex process involving a combination of two materials with different material properties, where the type of bonding can be selected as a crucial parameter affecting the racking resistance range. Since the costs of experiments performed on such full-scale DSF elements are very high and such experiments are time-consuming, it is crucial to develop special mathematical models for analysing the influence of the most important parameters. Therefore, the main goal of this paper is to develop the finite element mathematical model of the studied DSF structural elements with a highly ecological solution by using a timber frame. In the second step, the developed model is further implemented in the numerical analysis of racking stiffness and followed by a comprehensive parametric numerical study on different parameters influencing the horizontal load-bearing capacity of such DSF timber elements. The obtained results indicate that the new approach of the developed load-bearing prefabricated timber DSF elements can essentially improve racking resistance and stiffness compared with the widely studied timber-glass single-skin wall elements and can thus be fully recommended especially in the structural renovation process of old buildings.

A R T I C L E   I N F O

Keywords:
Timber;
Glass;
Double-skin façades;
Racking resistance;
Mathematical modelling;
Numerical analysis;
Finite Elements Methods (FEM)

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Article history:
Received 2 December 2021
Revised 12 August 2022
Accepted 19 August 2022

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APEM journal

Advances in Production Engineering & Management
Letnik 17 | Številka 2 | Junij 2022 | Strani 231–242
https://doi.org/10.14743/apem2022.2.433

ISSN 1854-6250
Spletna stran: apem-journal.org
Izvirni znanstveni članek

Numerična študija vodoravne odpornosti dvoslojnih fasadnih elementov iz lesa

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POVZETEK

Uporaba dvoslojne fasade (DSF) je precej nov pristop v procesu prenove stavb, ki dopolnjuje običajne strategije prenove. Dvoplastna fasada je ovojna stenska konstrukcija, ki je sestavljena iz dveh prozornih površin, ločenih z votlino, in lahko bistveno izboljša toplotno in zvočno odpornost ovoja stavbe. Glavne dvoslojne stenske komponente so običajno sestavljene iz utrjene zunanje enojne steklene plošče in dvojne ali trojne toplotnoizolacijske notranje steklene plošče, ki sta povezani s konstrukcijo okvirja. V zadnjem času so številne študije analizirale toplotno in zvočno učinkovitost elementov DSF, vendar skoraj nobena v smislu strukturnega obnašanja, zlasti v smislu določanja odpornosti na obremenitve takšnih stenskih elementov. Poleg tega je z namenom zmanjšanja potenciala globalnega segrevanja v tej analizi proučen okolju prijazen leseni okvir namesto običajno uporabljenega jeklenega, aluminijastega ali plastičnega okvirja. Vendar pa je strukturno združevanje lesa in stekla za razvoj ustreznega nosilnega konstrukcijskega elementa zelo zapleten proces, ki vključuje kombinacijo dveh materialov z različnimi lastnostmi, pri čemer je mogoče izbrati vrsto lepljenja kot ključni parameter, ki vpliva na razpon vodoravne odpornosti. Ker so stroški eksperimentov, ki se izvajajo na takšnih elementih DSF v naravni velikosti, zelo visoki in so takšni eksperimenti dolgotrajni, je ključnega pomena razviti matematične modele za analizo vpliva najpomembnejših parametrov. Zato je glavni cilj tega prispevka razviti matematični model z metodo končnih elementov za proučevanje strukturnih elementov DSF iz ekološkega lesenega okvirja. V drugem koraku se razviti model vključi v numerično analizo vodoravne togosti, nakar sledi celovita parametrična numerična študija različnih parametrov, ki vplivajo na vodoravno nosilnost lesenih elementov DSF. Rezultati kažejo, da lahko novi pristop razvitih nosilnih montažnih lesenih elementov DSF bistveno izboljša vodoravno odpornost in togost v primerjavi s široko raziskanimi leseno-steklenimi enoplastnimi stenskimi elementi in jih je zato mogoče v celoti priporočiti zlasti v procesu strukturne prenove starih stavb.

PODATKI O ČLANKU

Ključne besede:
Les;
Steklo;
Dvoslojne fasade;
Vodoravna odpornost;
Matematično modeliranje;
Numerična analiza;
Metoda končnih elementov (FEM)

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Zgodovina članka:
Prejet 2. decembra 2021
Popravljen 12. avgusta 2022
Sprejet 19. avgusta 2022