Study of load-bearing timber-wall elements using experimental testing and mathematical modelling

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ABSTRACT

Combining timber and glass in the wall elements of the building envelope with the proper orientation of such transparent façade elements enables the utilization of solar energy for heating and internal illumination of the building. However, the asymmetrical layout of timber-glass wall elements in such buildings can result in problems with the horizontal stability of the structure, so their participation to load-bearing capacity of the structure is usually neglected. The study deals with solutions for such elements as horizontal load-bearing members with proper connection details. First, specifically developed timber-glass wall elements were experimentally tested under monotonic and cyclic horizontal point load, and further in combination with classical timber-framed wall elements implemented into special single and two-storey box-house models, which were further experimentally tested on the shaking table. In the second part as the main goal of the study, a quite simple mathematical model of the box-house prototypes is developed using a fictive diagonal element for simulating the racking stiffness of the bracing timber-glass wall element. The calculated results for the 1st vibration period are compared with the previously measured experimental results to prove an accuracy of the developed model. Finally, a linear time-history calculation is done as a sample presentation of the developed mathematical model using Landers acceleration spectrum. The developed mathematical model enables a simple and effective seismic response calculation of timber buildings considering the developed timber-glass wall elements as load-bearing bracing elements against horizontal load actions. The model can also be recommended for using in further parametric numerical academic studies analysing the influence of various parameters.

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Študija nosilnih lesenih zidnih elementov z uporabo eksperimentalnega testiranja in matematičnega modeliranja

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POVZETEK

Kombinacija lesa in stekla v stenskih elementih ovoja stavbe s pravilno orientacijo tovrstnih prosojnih fasadnih elementov omogoča izkoriščanje sončne energije za ogrevanje in notranjo osvetlitev objekta. Asimetrična postavitev leseno-steklenih stenskih elementov v takih objektih pa lahko povzroči probleme s horizontalno stabilnostjo konstrukcije, zato njihov vpliv na nosilnost konstrukcije običajno ni upoštevan. Študija obravnava rešitve za te elemente, kot so horizontalni nosilni elementi z ustreznimi povezavami. Najprej so bili posebej razviti leseno-stekleni stenski elementi eksperimentalno preizkušeni pod monotono in ciklično horizontalno točkovno obremenitvijo, nato pa v kombinaciji s klasičnimi leseno-okvirnimi stenskimi elementi implementirani v posebne eno- in dvonadstropne makete hiš, ki so bile nadalje eksperimentalno testirane na stresalni mizi. V drugem delu študije je bil kot glavni cilj raziskave razviti matematični model za opis prototipov maket hiš, v katerem za simulacijo togosti leseno-steklenega stenskega elementa uporabimo fiktivni diagonalni element. Izračunane rezultate za prvo nihajno periodo smo primerjali s predhodno izmerjenimi eksperimentalnimi rezultati, da smo potrdili točnost razvitega modela. Na koncu je s pomočjo razvitega matematičnega modela bil narejen linearni izračun časovne zgodovine z uporabo Landersovega spektra pospeškov. Razviti matematični model omogoča preprosto in učinkovito izračun potresne odzivnosti lesenih stavb ob upoštevanju razvitih leseno-steklenih stenskih elementov kot nosilnih opornih elementov za horizontalne obremenitve. Model se uporabi tudi v drugih parametričnih numeričnih akademskih študijah, ki analizirajo vpliv različnih parametrov.

PODATKI O ČLANKU

Ključne besede:

Stenski elementi;
Les;
Leseno-steklena zgradba;
Togost;
Vibracije;
Poskusi;
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