Tekst / Text: doc. dr. Iztok Šušteršič, InnoRenew CoE, Livade 6, 6310 Izola

DINAMIČNI ODZIV VISOKIH LESENIH ZGRADB PRI UPORABNI OBRATOVALNI OBTEŽBI

Gradbeni sektor je odgovoren za tretjino izpustov vsega ogljikovega dioksida, obenem pa porabi 40 odstotkov vseh surovin ter proizvede ravno toliko odpadkov. V prihodnje je zato nujno, da se panoga intenzivno preusmeri v bolj trajnostne vrste gradnje in v uporabo obnovljivih materialov. Les mora zato postati ključni dejavnik svetovnega gradbeništva. Lesene stavbe namreč predstavljajo enega izmed najboljših načinov skladiščenja ogljikovega dioksida v grajenem okolju. Naslavljajo poglavitne okoljske izzive in prispevajo h krožnemu gospodarstvu v sklopu gradbene industrije. Visoke lesene stavbe obenem ponujajo možnost stroškovno učinkovite izrabe prostora. Nivo razvoja materiala, tj. inženirskega lesa, je že razvit do stopnje, ki omogoča tudi resnično visoko leseno gradnjo. Trenutno najvišja lesena stavba na svetu, Mjøstårnet na Norveškem, v višino meri skoraj 90 m.

Ne razumemo pa še dobro vibracij, ki jih v tovrstnih zgradbah povzroča veter in posledično narekuje njihovo načrtovanje v okviru velikosti, oblike in teže, ki minimizirajo neugodno počutje. Potrebujemo več informacij o lastnih nihajnih časih in dušenju visokih zgradb, ki so dovzetne za resonanco z vibracijami vetra. Kljub povečevanju priljubljenosti visokih lesenih zgradb je trenutno na voljo relativno malo informacij in znanja v zvezi z dušenjem, porazdelitvijo mase in togosti pri nihanju tovrstnih konstrukcij. Na njihove dinamične lastnosti pa vplivata predvsem dušenje v lesenih spojih kot tudi vpliv nekonstrukcijskih elementov.

Rešitev problema načrtujemo v okviru projekta DynaTTB. V sklopu programa Forest Value ga sestavlja konzorcij mednarodnih partnerjev iz Norveške, Švedske, Anglije, Francije in tudi Slovenije. V okviru projekta bomo razvili nove, bolj natančne in z eksperimentalnimi preiskavami umerjene numerične modele, ki bodo omogočali bolj zanesljivo napovedovanje obnašanja visokih lesenih stavb pri obratovalni obtežbi vetra.

Metodologija projekta obsega izvedbo eksperimentalnih meritev komponent gradbenih konstrukcij (predvsem lesnih spojev) ter že izvedenih celotnih zgradb. Meritve bodo služile za verifikacijo numeričnih modelov. Tako bo možno bolj natančno ovrednotiti parametre, ki so trenutno podani predvsem kot ocene in niso dosledno znanstveno verificirani. Meritve bomo izvajali na že zgrajenih visokih lesenih zgradbah. Poleg prej omenjenega Mjøstårnet, še na drugih evropskih zgradbah, ki merijo 10 etaž ali več ter nekaterih nekoliko nižjih – med drugim tudi slovenski s štirimi etažami. Slovenski raziskovalci bomo eksperimentalne izsledke lahko kasneje koristno uporabili tudi pri načrtovanju modelov za protipotresno projektiranje takšnih zgradb.

VISOKE LESENE STAVBE OBENEM PONUJAJO MOŽNOST STROŠKOVNO UČINKOVITE IZRABE PROSTORA.

AT THE SAME TIME, TALL WOODEN BUILDINGS OFFER THE POSSIBILITY OF COST-EFFECTIVE USE OF SPACE.

Bolj natančni modeli bodo omogočili bolj zanesljivo načrtovanje visokih lesenih stavb, kar bo spodbudilo večjo uporabo visokih lesenih zgradb kot del urbanega razvoja z možnostjo povečanja rasti vrednosti in trga obnovljivih proizvodov gozdnega gospodarstva. Tako bomo lahko v prihodnje še povečevali delež lesene gradnje; poleg družinskih hiš bomo gradili tudi vse več pisarniških objektov, stanovanj in hotelov, ki bodo merili 10 etaž in več. Na podlagi novih spoznanj projekta bo takšna gradnja lahko bolj optimizirana ter cenovno dostopnejša.

Slovenski raziskovalci imamo v projektu pomembno vlogo. Zaradi bogatih preteklih izkušenj s področja dinamične potresne analize bomo prispevali obširno znanje o nelinearnem dinamičnem obnašanju konstrukcij, vnovčili pretekle eksperimentalne rezultate ter izkušnje z numeričnim modeliranjem takšnih zgradb. Zaupana pa nam je bila tudi naloga vodenja razvoja novih smernic za projektiranje visokih lesenih stavb na veter. Upamo, da bo dokument v prihodnje postal spremljevalec vseh načrtovalcev visokih lesenih stavb.

DYNAMIC RESPONSE OF TALL TIMBER BUILDINGS UNDER SERVICE LOAD

The construction sector is responsible for one-third of all carbon dioxide emissions, consuming 40 per cent of all raw materials and producing just as much waste. Therefore, it is imperative that in the future, the industry intensifies its focus on more sustainable construction and the use of renewable materials. Wood must, therefore, become a key factor in the construction sector around the world. Namely, wooden buildings represent one of the best ways to store carbon dioxide in the built environment. They address major environmental challenges and contribute to the circular economy within the construction industry. At the same time, tall wooden buildings offer the possibility of cost-effective use of space. The level of material development, i.e. engineered wood, has already been developed to such a degree that allows high timber construction. Currently, the tallest wooden building in the world, Mjøstårnet in Norway, measures almost 90 m in height.

However, we do not yet very well understand the vibrations caused by the wind in these buildings, which consequently dictates their design in terms of size, shape and weight that minimize the discomfort. We need more information about our swing times and the damping of tall buildings that are susceptible to resonance with wind vibrations. Despite the increasing popularity of tall wooden buildings, relatively little information and knowledge are currently available regarding the damping, mass distribution and stiffness in the swinging of such structures. Their dynamic properties are mainly influenced by the damping in wooden joints as well as by the influence of non-structural elements.

We are planning a solution to the problem within the DynaTTB project. Within the Forest Value program, it consists of a consortium of international partners from Norway, Sweden, England, France and Slovenia. Throughout the project, new, more accurate and experimental calibrated numerical models will be developed that will allow for a more reliable prediction of the behaviour of tall wooden buildings in wind load conditions.

The methodology of the project is to carry out experimental measurements of the components of building structures (especially timber joints) and of the already completed buildings. The measurements will serve to verify the numerical models. In this way, it will be possible to more accurately evaluate the parameters currently given primarily as estimates and not consistently scientifically verified. Measurements will be carried out on already built tall wooden buildings. In addition to the aforementioned Mjøstårnet, other European buildings measuring 10 or more floors and some slightly lower ones, including the four-storey Slovenian building will be examined. Slovenian researchers will later be able to use the experimental findings in the design of models for earthquake design of such buildings.

More accurate models will allow more reliable planning of tall timber buildings, which will encourage greater use of tall timber buildings as part of urban development, with the potential to increase the value growth and market for renewable forestry products. In this way, we will be able to further increase the share of timber construction; In addition to family houses, we will also be able to build more office buildings, apartments and hotels, measuring 10 floors and more. Based on new insights from the project, such construction will be more optimized and more affordable.

Slovenian researchers play an important role in the project. Due to extensive experience in the field of dynamic earthquake analysis, we will contribute extensive knowledge of nonlinear dynamic structural behaviour, realign past experimental results and experiences in numerical modelling of such structures. We were also entrusted with the task of leading the development of new guidelines for the design of tall wooden buildings in the wind. We hope that the document will in the future become the companion of all planners of tall wooden buildings.

Mjøstårnet, največja lesena zgradba na svetu, stoji v mestu Brumunddal na Norveškem, ima 18 etaž in v višino meri več kot 85 m, avtor fotografije: dr. Igor Gavrić

MJØSTÅRNET, the largest wooden building in the world. It is located in Brumunddal in Norway, has 18 floors and is more than 85 m high, author of photograph: Dr. Igor Gavrić

ZAHVALA / Acknowledgment: Evropska unija – ForestValue Research Programme in Ministrstvo za izobraževanje, znanost in šport Republike Slovenije in Okvirni program Evropske unije, Obzorje 2020 (H2020 WIDESPREAD-2-Teaming; #739574) ter Republika Slovenija. Investicijsko financiranje Republike Slovenije in Evropske unije iz Evropskega sklada za regionalni razvoj. / *European Union – ForestValue Research Programme and the Republic of Slovenia Ministry of Education, Science and Sport and Horizon 2020 Framework Programme of the European Union; H2020 WIDESPREAD-2-Teaming: #739574 and the Republic of Slovenia. Investment funding of the Republic of Slovenia and the European Union of the European Regional Development Fund.*