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Citizens' knowledge of and perceptions of multi-storey wood buildings in seven European countries

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ABSTRACT

This study examined public attitudes towards multi-storey wood buildings (MSWBs) in seven European countries. A questionnaire was distributed to online panellists in Austria, Denmark, Finland, Germany, Norway, Sweden and the United Kingdom. Results from 7007 complete questionnaires indicate that respondents knew less about MSWBs in countries where brick, stone and concrete are the most commonly used house frame elements in construction (United Kingdom, Germany and Denmark) compared to countries with a stronger wood building tradition (Austria, Finland, Norway and Sweden). Respondents in Finland and Sweden had the most positive attitudes towards MSWB. The number of respondents, who considered a prospective apartment in an MSWB appealing, was approximately equal to the number that considered it an unappealing alternative. The factors most influencing the respondents' perception of MSWBs as a nice place to live were (i) vulnerability to fire, (ii) material solidity and durability, (iii) healthy indoor environment and (iv) vulnerability to moisture. The results from this study add new knowledge to the understanding of cross-country differences of preferences among the public for living in MSWBs. The results can be used to support the MSWB planning and marketing efforts in the countries involved.

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Timber construction; multi-storey wood buildings; consumer survey; consumer preferences

Introduction

In Europe, construction materials used in midrise and tall buildings (i.e. typically urban area constructions and three floors or more) are dominated by brick, steel and especially concrete. The main reason for this has been strong industrial traditions to use these materials in load-bearing in large structures, such as multi-storey buildings. This long-standing tradition in the European construction sector can act as an impediment for the uptake of new materials, technologies and business logics such as using wood beyond interior design and exterior cladding (e.g. Toppinen et al. 2019a).

During the 2010s, the market diffusion of multi-storey wood buildings (MSWBs, i.e. buildings with three floors or more) has been speeding up particularly in the Fenno-Scandic countries, but also in the Alpine region and in the United Kingdom (Hurmekoski et al. 2015). Thus, although MSWBs are yet a relatively small niche and most tall buildings are still constructed from steel and concrete, the prospects of future growth in the European MSWB market are strong, bringing new business opportunities also for European forestry and wood industries.

The state of academic and practical comprehension on the role of consumer engagement in construction is far more limited (e.g. Eriksson et al. 2015), especially regarding the public perceptions connected to the demand of MSWBs (e.g. Eriksson et al. 2015; Lähtinen et al. 2019). To the best of our knowledge, there has not been any multi-country studies allowing for comparison among countries. The drivers behind the market-diffusion of MSWB have been related to institutional factors affecting the supply side of the construction sector. Factors affecting the demand side, such as consumer perceptions and issues related to specification, are also important but have been given less attention.

There are three very important institutional factors that have impacted on the market diffusion of MSWB. The first and still the most important has been the change in building regulations across Europe since the late 1980s. As a result of progress from descriptive rules that prohibited wood-frame buildings of more than two stories towards functional criteria, new policies legalizing the construction of MSWBs started to emerge (Östman et al. 2011). Although there are still differences between and within countries on the interpretation

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of building norms and codes affecting MSWBs (e.g. Lähtinen et al. 2019), building regulations as an entity can no longer be considered as a barrier for the market diffusion of MSWB solutions, as also indicated by an earlier comparison between Austria and Finland (Vihemäki et al. 2019).

The second driver was the development in building technology. Technologies for bonding wood with adhesives to make large structures, such as beams, were patented more than 100 years ago (cf. Forest Products Laboratory 1999; Frihart 2015), and there are examples of structural use of glued laminated timber in the first half of the twentieth-century. Technologies for making large load-bearing structures from wood have developed considerably over the last 30 years. Modern wood construction utilizes engineered wood materials such as glued laminated timber, laminated veneer lumber and cross-laminated timber (Hurmekoski et al. 2015), and structural building systems such as platform, post-and-beam and pre-fabricated modular elements (Brege et al. 2014). Due to the technological development, wood-based building solutions enabled the substitution of concrete and steel-based construction methods in high-rise buildings enhancing the economic feasibility of the industrial wood-building processes. In all, enabling pre-fabrication and the industrial mass production of construction elements and modules, and thus decreasing the time spent in a building site, these solutions, may lead to improvements in cost effectiveness, productivity and revenue. This is in line with overall request for industrialization of the construction sector, which has been emphasized as crucial not only for the businesses but for the whole society. Thus, decreasing costs of supply is also a driver.

The third driver is the reduced environmental life-cycle impacts of MSWB solutions, mainly due to the building materials, compared with multi-storey buildings of concrete and steel (Sathre and Gustavsson 2009; Robertson et al. 2012; Milaj et al. 2017). Reducing the use of resources and generation of emissions in the building industry has become both a policy objective (European Commission 2011) and an objective within the industry. Along these lines, the inclusion of embodied energy in materials in life-cycle assessments and in public policies can further increase the interest for MSWB solutions. As a tool for decreasing the environmental footprint of construction and constructions, and to communicate this effort to property developers, investors and consumers, many actors choose to follow a number of voluntary environmental performance certification schemes (European Commission 2019). Examples of green standards for the building industry are BREEAM (BREEAM 2020) and LEED (US Green Building Council 2009). Such green standards may provide additional incentives for increasing the use of wood in multi-storey buildings. Overall due to perceived uncertainty to the uptake of innovations, new market entrants need to win the trust of the construction sector, even if the productivity gains and environmental attributes would make them appear more attractive.

There is need for a better understanding about how perceptions of wood as a load-bearing material influence the adaptation of MSWB in society, this can be addressed with conducting preference studies on topics related to MSWB. The MSWB business system is composed of external factors (e.g. regulatory framework and technological infrastructure) and internal factors (e.g. multiple supplier firms, on-site companies and customers), which all are connected to different actors and stakeholders affecting and being affected by the system (Toppinen et al. 2019a). The level of engagement by the different actors and stakeholders varies between countries (Roos et al. 2010). According to Nord et al. (2010), an individual construction process and hereunder the choice of materials is influenced by developers, consultants (i.e. engineers and architects), contractors and material suppliers. As end-users vote through their housing choices and willingness to pay, housing suppliers and developers have an incentive to consider the perceived end-user preferences. In addition, especially in Finland and Sweden, but also in other countries, urban planners have considerable power to make decisions on structural materials as a part of land use governance (Lähtinen et al. 2019). Although public decision-makers, that is, politicians, do not directly affect individual building projects, they are important players affecting public opinion on MSWB at a more general level (Roos et al. 2010). One reason for this is the construction sector's business traditions in multi-storey building processes, in which the existence of end-users as value-chain actors have been largely neglected (e.g. Brege et al. 2014). Another reason is business practices based on short-term sub-contracting agreements, which have made it challenging to develop business ecosystems that would enable profound consideration of end-user needs in project implementation (Toppinen et al. 2019a, 2019b).

Among the factors influencing end-users' preferences for building materials in general are the perceived durability, solidity and vulnerability of different materials – and by extension perceived maintenance costs (Mcmanus and Baxter 1981). Results from recent studies suggest that respondents tend to perceive wood as less durable than other materials. Larasatie et al. (2018) found that in the US Pacific Northwest people expect wood structures as to have shorter life spans and require more maintenance that other buildings, while in Norway Høibø et al. (2015) found that people who emphasize durability preferred brick and stone over wood. Preferences and attitudes towards materials used for outdoor cladding are in addition influenced by building traditions, by the culture of aesthetics, and often by municipal guidelines at district level. Inhabitants of Great Britain, for example, where masonry and brick have strong traditions, tend to regard the use of wood as outdoor cladding as inferior to these materials (e.g. Craig et al. 2002; Davies et al. 2002).

Results from studies that have concentrated on perceptions of wooden interiors (i.e. visible indoor surfaces, e.g. floor, walls, ceiling) in both residential and non-residential buildings, seem consistent in that wood is aesthetically pleasing, warm, natural and comfortable (e.g. Rametsteiner et al. 2007; Rice et al. 2007; Schauerte 2010). Gold and Rubik (2009) for example reported that 76% of their German respondents fully agreed that wood is cosy, while 68% fully agreed that wood is aesthetically pleasing. Nyrud and Bringslimark (2010) reviewed existing literature, and concluded that interiors with wood could have a psychologically positive effect, and several studies from North America, Asia and

Europe report that end-users associate wood with physically healthy indoor environment (e.g. Høibø et al. 2015; Larasatie et al. 2018).

Consumer preferences for load-bearing constructions in multi-storey or urban houses have been studied in single-country contexts, for example in Germany (Gold and Rubik 2009), Norway (Høibø et al. 2018), USA (Larasatie et al. 2018) and Finland (Lähtinen et al. 2019). Taken together, the results from these studies suggest that people tend to regard concrete and steel as more structurally sound than wood frames. Perceived vulnerability to fire, or perceived reduced fire safety in (tall) wood buildings compared to buildings constructed of other materials, is also a reoccurring theme. However, the combined results also suggest that preferences for load-bearing materials in urban houses depend on knowledge about, and experience with, building materials, and differences may appear across different country contexts. Thus, we hypothesized that background, and thus national culture, influence perceptions of wood as a building material in multi-storey buildings, making likely that cross-country differences in the citizens' perceptions for MSWBs depend on the building traditions within the country.

At least two studies have tested the effect of cultural background on preferences for materials in urban buildings. Høibø et al. (2018) compared two cultural groups, that is, respondents with an immigrant background and native Norwegian citizens, and found that there were little difference between the two groups. Schauerte (2010) studied differences between citizens from Sweden and Germany, and found that "national habitation" did have an impact on consumers' perceptions of wooden multi-storey buildings.

The main objectives of this study were to (i) provide a coherent description of the survey conducted during the Centre of Advanced Research NOFOBE, (ii) investigate the awareness (knowledge and experience) of MSWBs among citizens' from selected Northern and Central European countries and (iii) identify which factors influenced their expressed preference for multi-storey timber buildings. Further analyses have been applied on data from the questionnaire on more specific topics related to consumers´ views on load-bearing construction materials from wood: preferences for wood as a load-bearing material Aguilar et al. (2023); values and prejudices for load-bearing building materials Läthinen et al. (2021) and Viholainen et al. (2021); and wood as a construction material under extreme weather events Vehola et al. (2022).

Data and methods

The study focuses on the European market, it addresses three Fenno-Scandic countries (Finland, Norway, Sweden) and four large importers of Fenno-Scandic roundwood and wood products, such as structural timber (Denmark, Austria, Germany and the United Kingdom). Based on the latest trade flow data available from FAOSTAT (FAO 2023) these countries did in 2017 import 30% of the total export of sawnwood. Other large importers of Fenno-Scandic sawnwood are the USA (13% of total exports), China (8%) and countries in the Levant (Egypt, Algeria, Morocco and Saudi-Arabia, 9%, 7%, 4% and 3% respectively). The material of this study was gathered with an online questionnaire from 7007 respondents in December in 2018. The selected countries covered different building traditions, industrial background and market size, as well as geographical location. IPSOS (https://www.ipsos.com, 2019), a global market research and consulting company, administered the survey and collected the data. The data was collected from a pool of respondents administered by IPSOS, and the respondents were successively recruited to be representative for the demography of each surveyed country. The questionnaire was specifically designed for the survey and contained 35 questions. Ten questions addressed demographic background variables. The remaining 25 questions covered the respondents' environmental views, their perceptions on the use of wood for different purposes, their current living arrangement, affiliation with the forest-based or construction sector, and perceptions on the importance of several factors when choosing where and how to live, and finally, perceptions of living in an MSWB. In the questionnaire, perceptions are related to the respondents preference for MSWBs as a nice place to live. The respondents were asked to rate the *attractiveness* of living in MSWB, emphasizing the quality of MSWBs as a place to live not the aesthetic quality of such buildings.

Most of the questions used in this study were presented as statements. The scale used was a 9-point continuous interval Likert-type-scale. The perception of how nice it is to live in an MSWB was first addressed with a 9-point continuous interval Likert-type-scale, followed by a question asking respondents to rank selected factors whether they influenced the reported preference. This was done to force respondents to express the relative importance (trade-off) of the factors. The selection of factors was based on existing literature and our own research objectives. Where natural and to reduce potential measurement errors, an "I don't know"-alternative was included in order to avoid that respondents gave opinions when they had none. The co-authors with different background within forestry cooperated in formulating the questionnaire, undertaking several revisions. Much effort was made to consider and capture differences between the countries. Experts from IPSOS gave advice and assisted in finalizing and testing the questionnaire.

IPSOS distributed invitations to participate in the survey to members of their established online panels with respondents 18 years of age or older in Austria, Denmark, Finland, Germany, Norway, Sweden and the United Kingdom. A master questionnaire was designed in English and translated by a professional translation service into different languages, subsequently, native speakers among the authors from Denmark, Finland, Norway and Sweden checked the translation with emphasis on the professional (e.g. forestry, buildings and constructions) terms and phrases. In order to obtain representative samples in each country (with respect to age, gender and geography) the questionnaire was disclosed sequentially to segments of the IPSOS-panels as pre-determined quotas according to country demographics were reached. The full English version of the questionnaire is included in the online supplementary material. Table 1

Table 1. Details on questions used in the final questionnaire, including information given to the respondents prior to the questions, the question formulation and answer alternatives as presented in the questionnaire.

Question type	Information	Question formulation	Answer alternatives
Q16 – Multi answer	With a multi-storey WOOD BUILDING, we mean an apartment or office building of three storeys (floors) or more with a load-bearing construction made primarily of wood. *The respondents were furthermore shown 3 pictures of multi-storey wood buildings, these pictures are included in the online supplementary material*	Which of the following statements describes your level of knowledge regarding multi-storey wood buildings?	*Several answers were possible*. 1. I have never heard of them. 2. I have heard some discussions or read about them from a media (newspaper, internet, trade journal, radio/TV, social media). 3. I am interested in the subject and know something about it. 4. I am familiar with them through my studies/work. 5. I have visited a multi-storey wood building built in the 2000s. 6. I have lived in a multi-storey wood building built in the 2000s.
Q18 – 9 point scale		How attractive would it be for you to live in an apartment in a multi-storey wood building?	From 1 (Not attractive) to 9 (Very attractive) + Do not know
Q19 – Ranking numerical		Please rank the following factors or attributes for importance in deciding your response to the previous question regarding how attractive it would be for you to live in an apartment in a multi-storey wood building. Rank the alternatives, giving 1 to the most important factor or attribute and 2 to second most important and so forth. You may set zero to factors that are of no importance.	*Factors were presented in randomized order*. 1. Solidity and durability 2. Maintenance (frequencies and costs) 3. Vulnerability to moisture (decay and moulding) 4. Fire safety/Vulnerability to fire 5. Insulation regarding sound / Soundproofing 6. Healthy indoor environment (e.g. air quality) 7. Materials used in load-bearing construction (non-visible materials) 8. Indoor visible materials (floors, walls and ceilings) 9. Outdoor visible materials (outdoor cladding)

contains the information given to respondents in conjunction with the three questions, the framing of the questions and the answer alternatives, that were the basis for this article.

Results

The final sample included questionnaire data from 7007 respondents. Table 2 contains descriptive statistics related to the respondents´ place of residence, number of children in the household, gender- and age-distribution, and income-distribution in each country. There are, however, a lower proportion of children among Finnish respondents, as well as lower income levels among respondents in the UK and Germany. The Austrian and Norwegian samples contained the largest proportions of rural respondents, 46% and 36%, while the Finnish and Swedish samples were the most urban, 49% and 47% respectively.

The level of awareness about MSWBs varied between countries, see Figure 1.

In the full, population-weighted sample, 27% of the respondents confirmed to have read or heard media-discussions about MSWBs. There were also some respondents with higher level of awareness about MSWBs. Of the weighted sample, 10% reported having interest in, and knowledge about the subject, and 4% being familiar with MSWBs through studies or work. The proportion confirming such interest in MSWBs was lowest in Denmark and the UK (7%), followed by Germany (11%), while it was highest in Finland (18%). For being familiar with MSWBs, the variation between countries was small, ranging from 4% in Germany and United Kingdom to 7% in Finland. As expected, Germany, Denmark and United Kingdom were also the countries were the largest proportions of respondents (66–68%) reported never having heard about MSWBs, for the population-weighted full sample this figure was 61%.

The proportion of respondents that had any first-hand experience in terms of having lived in or visited an MSWB, were small in all countries. The proportions that had visited such a building varied from 8% in Norway and 7% in Finland to 1% in Germany, while the proportion in the population-weighted full sample was 3%. The group of Nordic countries (Finland, Norway and Sweden) differed statistically from the remaining countries (Kruskal Wallis ANOVA tests, Chi square = 20.9, df = 6, $p = .002$, due to non-normality in data a non-parametric test was used). As for having lived in an MSWB, the proportion in the population-weighted full sample was 1% while it varied between 5% in Norway to 1% in United Kingdom, Germany, Finland and Austria. Norway differed statistically from the remaining countries (Kruskal Wallis ANOVA tests, Chi square = 71.1, df = 6, $p = <.001$, due to non-normality in data a non-parametric test was used) (Figure 2).

Table 2. Descriptive statistics, populations from Eurostat (2019).

	Austria	Denmark	Finland	Germany	Norway	Sweden	United Kingdom	All
Population								
n (million)	8.8	5.8	5.5	82.8	5.3	10.1	66.3	184.6
% (of total sample)	5%	3%	3%	45%	3%	5%	36%	100%
Respondents								
n	1000	1000	1000	1001	1001	1003	1002	7007
Respondents age								
Mean	46.6	48.4	48.4	48.9	47.2	48.4	46.9	47.9
(SD)	(16.2)	(17.0)	(16.7)	(16.7)	(16.9)	(17.7)	(16.9)	(16.9)
Respondents gender								
Male	48%	49%	49%	49%	50%	49%	49%	49%
Female	52%	51%	51%	51%	50%	51%	51%	51%
Size of population in area where respondents live								
>1,000,000	23%	22%	22%	16%	13%	21%	15%	19%
100,000–1,000,000	13%	18%	27%	24%	22%	26%	23%	22%
10,000–100,000	23%	33%	32%	33%	29%	29%	38%	31%
Village < 10,000	26%	18%	9%	18%	20%	13%	20%	18%
Countryside	16%	9%	10%	8%	16%	11%	4%	11%
Respondents annual income								
Less than € 14.999	18%	9%	15%	15%	8%	10%	14%	13%
€ 15.000 – € 39.999	30%	31%	23%	31%	14%	26%	40%	28%
€ 40.000 – € 69.999	23%	23%	23%	23%	21%	30%	24%	24%
€ 70.000 – € 149.999	9%	17%	17%	14%	27%	17%	9%	16%
More than € 150.000	2%	1%	2%	1%	4%	1%	1%	2%
Do not want to answer	19%	19%	19%	15%	25%	16%	10%	18%
Children in household (<17 years)								
None	73%	75%	81%	74%	70%	74%	71%	74%
1 child	14%	12%	10%	14%	14%	11%	14%	13%
2 children or more	13%	13%	9%	12%	16%	15%	15%	13%

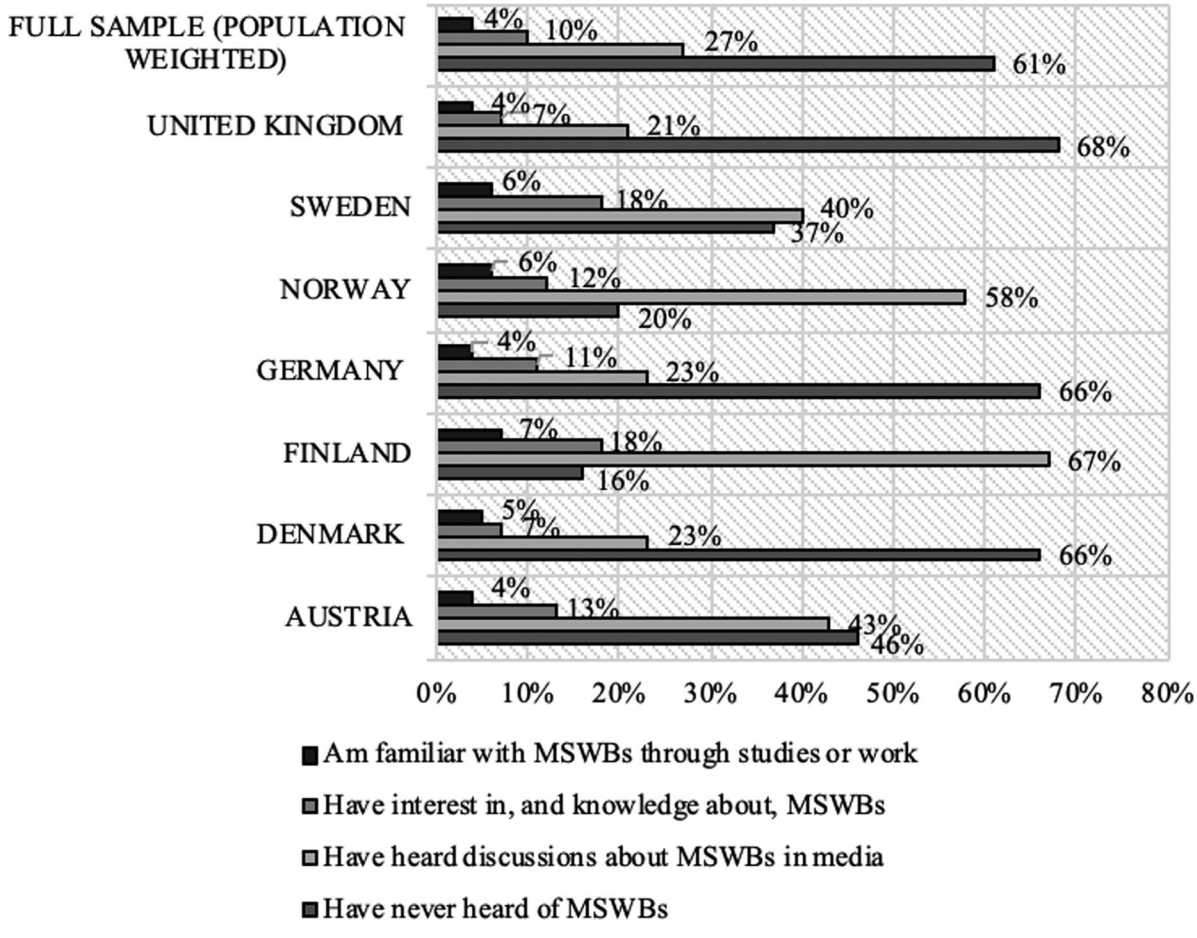

Figure 1. Reported level of awareness about MSWB within each country and in the full sample weighted for population sizes.

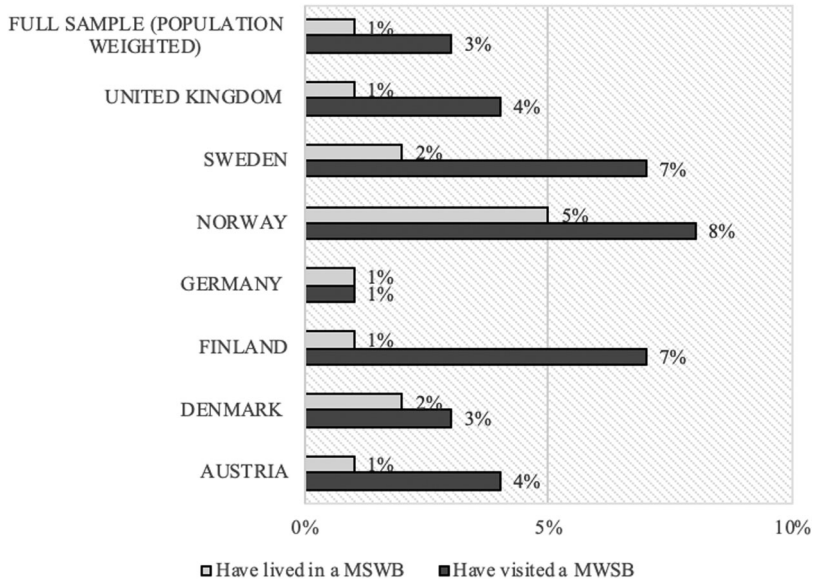

Figure 2. Proportions of respondents who reported they had visited and had lived in an MSWB built after year 2000 for each country, and for the population-weighted full sample.

When considering the perception of how nice it is to live in an MSWB, the respondents from Finland stood out. Nearly 60% of the Finnish sample considered it appealing to live in multi-storey wood buildings, and only 8% perceived this as unappealing. Within the other countries, the proportion that considered it nice to live in an MSWB varied between 33% and 42% while the proportion considering it unappealing ranged from 14% to 22% (cf. Figure 3). Among the Swedish respondents, a relatively low proportion of the respondents reported that they perceived that living in an MSWB to them was not a nice place to live. In the population-weighted full sample, the proportions that considered it nice to live in an MSWB and the proportions that considered it not appealing to live in an MSWB were close to equal. However, there was a clear difference in the extremes: the proportion considering living in MSWBs to be very unappealing (score = 1) was more than twice as large as the proportion considering living in such buildings to be very appealing (score = 9).

When assessing the results for the population-weighted full sample (Table 3), it was clear that fire safety/vulnerability to fire was the most important factor, followed by solidity and durability and vulnerability to moisture, with "healthy indoor environment" in close pursuit, but a more split verdict. Figure 4 provides a graphical display of how frequently each factor was ranked first, second or third, fourth to sixth, seventh to

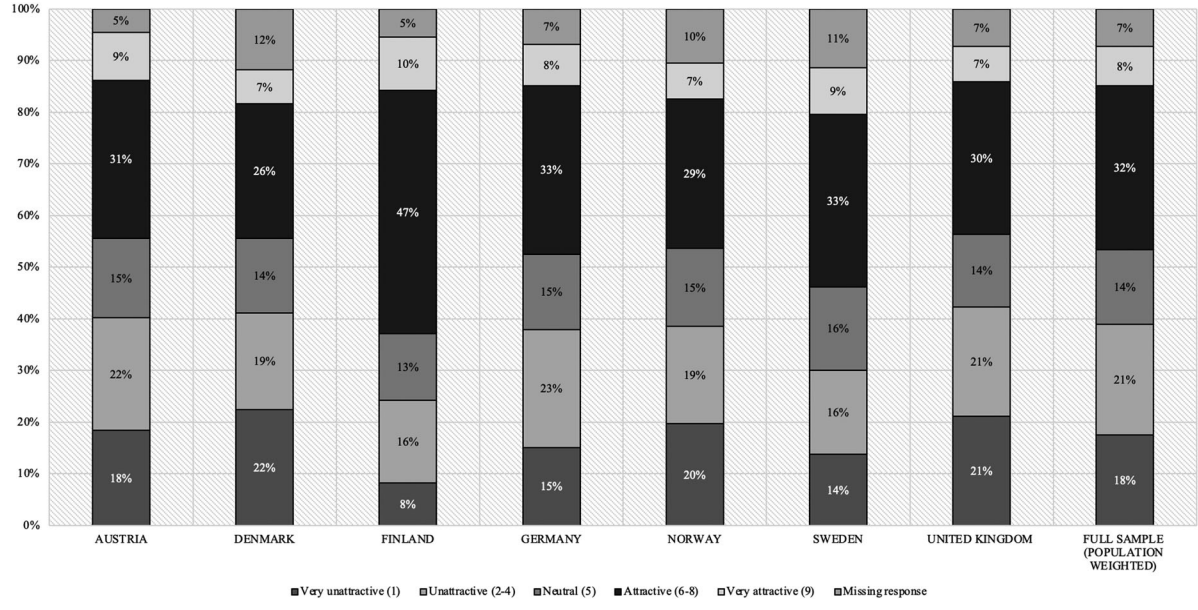

Figure 3. Perceived attractiveness of living in an MSWB on a scale from 1 (not attractive) to 9 (very attractive) for each country and for the full sample weighted for population sizes.

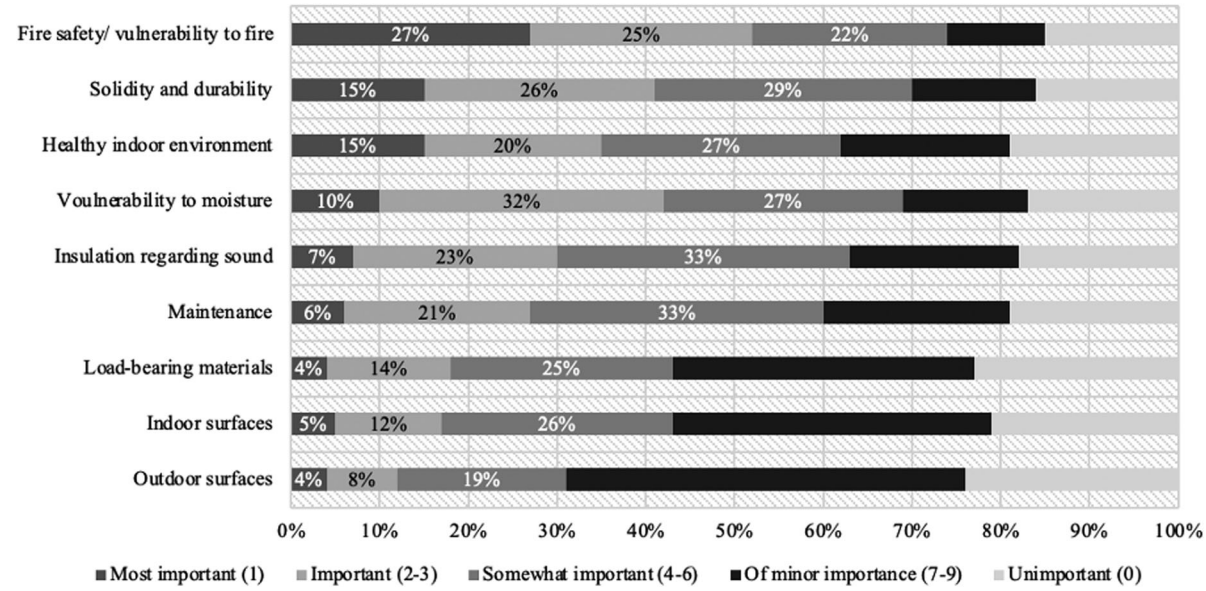

Figure 4. Importance of nine factors for the attractiveness of MSWB in the full population-weighted sample. In parentheses after each factor, the number n of respondents having ranked the factor.

Table 3. Weights assigned to each rank (Q19), dependent on the number of factors each respondent chose to rank.

	Factor rank										
	1	2	3	4	5	6	7	8	9		
Number of ranked factors	*Assigned weights to ranked factors*									SUM	*Number of respondents*
0										0	428
1	1									1	100
2	0.667	0.333								1	234
3	0.500	0.333	0.167							1	452
4	0.400	0.300	0.200	0.100						1	177
5	0.333	0.267	0.200	0.133	0.067					1	173
6	0.286	0.238	0.190	0.143	0.095	0.048				1	136
7	0.250	0.214	0.179	0.143	0.107	0.071	0.036			1	137
8	0.222	0.194	0.167	0.139	0.111	0.083	0.056	0.028		1	745
9	0.200	0.178	0.156	0.133	0.111	0.089	0.067	0.044	0.022	1	4425

Table 4. The three factors ranked as most important (lowest mean) to the attractiveness of living in a MSWB.

Country	Lowest	$\bar{x}$	2nd lowest	$\bar{x}$	3rd lowest	$\bar{x}$
Austria	Healthy indoor environment	3.46	Solidity and durability	3.91	Fire safety/ vulnerability to fire	3.92
Denmark	Healthy indoor environment	3.39	Fire safety/ vulnerability to fire	3.62	Vulnerability to moisture	3.80
Finland	Healthy indoor environment	2.94	Fire safety/ vulnerability to fire	3.78	Solidity and durability	4.01
Germany	Fire safety/ vulnerability to fire	3.65	Healthy indoor environment	3.82	Solidity and durability	3.96
Norway	Fire safety/ vulnerability to fire	3.27	Healthy indoor environment	3.59	Solidity and durability	4.07
Sweden	Fire safety/ vulnerability to fire	3.36	Solidity and durability	3.66	Healthy indoor environment	3.93
United Kingdom	Fire safety/ vulnerability to fire	2.77	Vulnerability to moisture	3.80	Solidity and durability	3.83
Full sample (population-weighted)	Fire safety/ vulnerability to fire	3.77	Solidity and durability	3.72	Vulnerability to moisture	3.77

ninth or not at all. It is worth noting that the factors that were seldom ranked high also were those most frequently not being ranked at all, and vice versa. The material used for load-bearing constructions, which in practice is the most important criterion for defining MSWBs, was of very low importance for how the respondents perceived living this kind of buildings.

Figures 5–8 and Tables 4–7 present relationships between respondents' perception of how nice it is to live in MSWBs (cf. relation to continuous interval Likert-type-scale in the figures) and the importance of factors influencing how nice it is to live in an MSWB. From the figures, it is apparent that the cases when living in an MSWB was perceived as unappealing often coincided with high importance of fire safety/vulnerability to fire (Figure 5). This pattern was consistent: the higher the respondents rated importance of fire safety/vulnerability to fire, the less appealing respondents perceived to live in a MSWB. Nevertheless, a considerable proportion (i.e. 18%) of those who considered it very nice to live in an MSWB had also ranked fire safety/vulnerability to fire as the most important factor suggesting that the respondents' perceptions of fire safety/vulnerability to fire in MSWB varied. There was a similar, clear, but opposite pattern between perceiving it appealing to live in an MSWB and the perception of

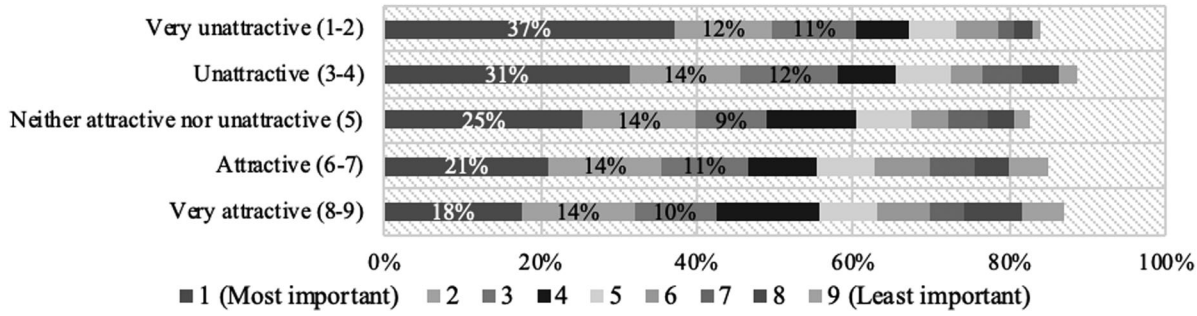

Figure 5. Ranked importance of fire safety/vulnerability to fire among respondents, organized after attractiveness for living in an MSWB. Results are based on the responses from the full population-weighted sample.

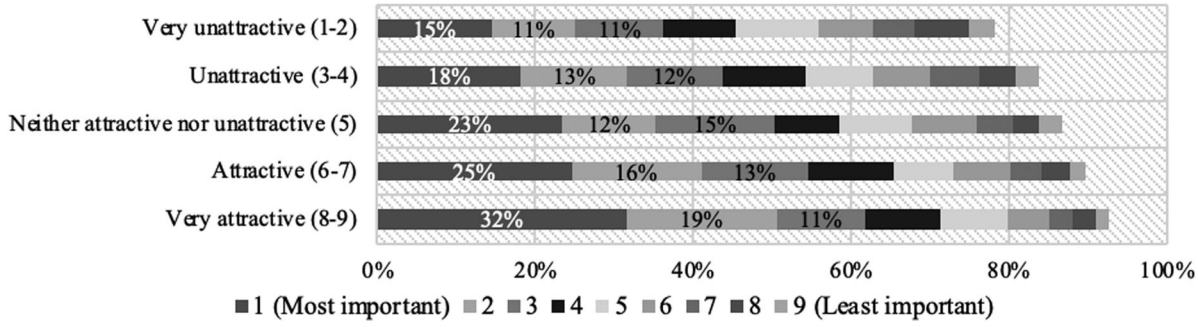

Figure 6. Ranked importance of healthy indoor environment among respondents, organized after attractiveness for living in an MSWB. Results are based on the responses from the full population-weighted sample.

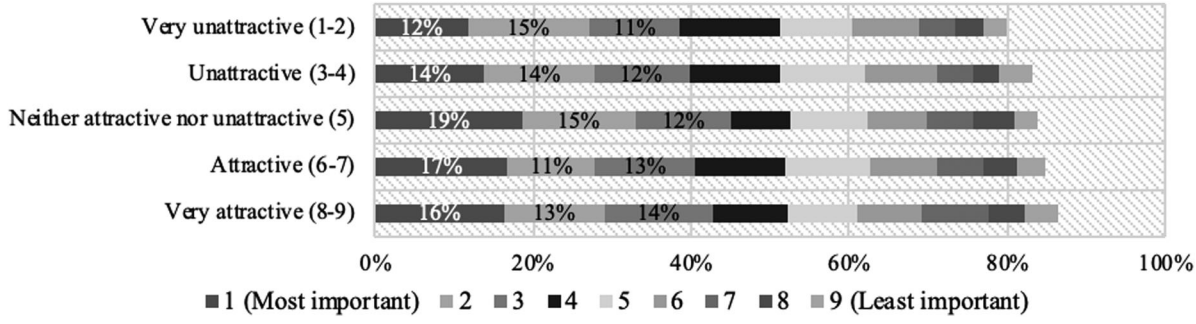

Figure 7. Ranked importance of solidity and durability among respondents, organized after attractiveness for living in an MSWB. Results are based on the responses from the full population-weighted sample.

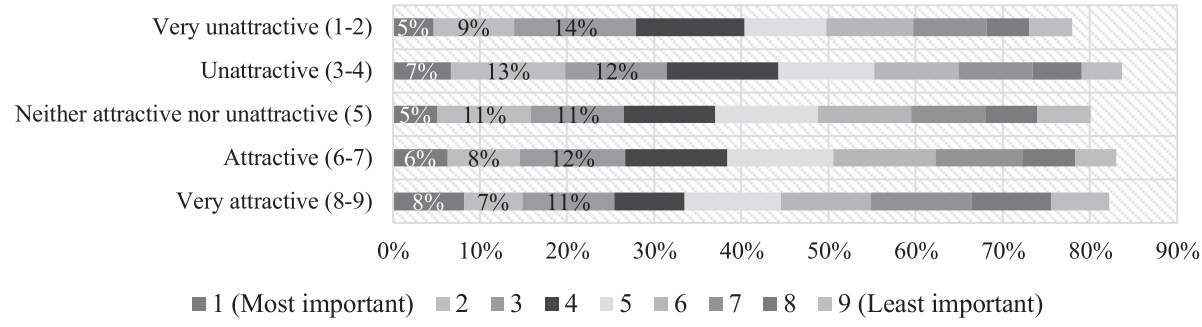

Figure 8. Ranked importance of the factor vulnerability to moisture among respondents, organized after attractiveness for living in an MSWB. Results are based on the responses from the full population-weighted sample.

Table 5. The three factors most frequently ranked as most important in each country and in the population-weighted full sample.

Country	1	%	2	%	3	%
Austria	Healthy indoor environment	25%	Fire safety/vulnerability to fire and solidity and durability	17%	Vulnerability to moisture	11%
Denmark	Healthy indoor environment	25%	Fire safety/ vulnerability to fire	20%	Vulnerability to moisture	10%
Finland	Healthy indoor environment	29%	Fire safety/ vulnerability to fire	19%	Vulnerability to moisture	17%
Germany	Fire safety/ vulnerability to fire	21%	Healthy indoor environment	19%	Solidity and durability	15%
Norway	Fire safety/ vulnerability to fire	27%	Healthy indoor environment	17%	Solidity and durability	12%
Sweden	Fire safety/ vulnerability to fire	26%	Solidity and durability	18%	Healthy indoor environment	16%
United Kingdom	Fire safety/vulnerability to fire	38%	Solidity and durability	15%	Vulnerability to moisture	10%
Full sample (population-weighted)	Fire safety/vulnerability to fire	27%	Healthy indoor environment and solidity and durability	15%	Vulnerability to moisture	10%

Table 6. Three factors most frequently ranked among the three most important to the attractiveness of living in an MSWB in each country and in the population-weighted full sample.

Country	1	%	2	%	3	%
Austria	Healthy indoor environment	50%	Fire safety/ vulnerability to fire	43%	Solidity and durability and insulation regarding sound	39%
Denmark	Healthy indoor environment	49%	Fire safety¨/ vulnerability to fire	46%	Vulnerability to moisture	43%
Finland	Healthy indoor environment	60%	Fire safety/ vulnerability to fire	47%	Vulnerability to moisture	42%
Germany	Fire safety/vulnerability to fire	45%	Healthy indoor environment and solidity and durability	40%	Vulnerability to moisture	39%
Norway	Fire safety/vulnerability to fire	51%	Healthy indoor environment	45%	Solidity and durability	38%
Sweden	Fire safety/vulnerability to fire	54%	Solidity and durability	47%	Healthy indoor environment	42%
United Kingdom	Fire safety/vulnerability to fire	64%	Vulnerability to moisture	47%	Solidity and durability	43%
Full sample (population-weighted)	Fire safety/vulnerability to fire	52%	Vulnerability to moisture	42%	Solidity and durability	41%

Table 7. The three factors with highest ranking in each country when weighted to account for the number of rankings assigned by each respondent.

Country	Highest ranked	SUM	2nd highest ranked	SUM	3rd highest ranked	Sum
Austria	Healthy indoor environment	144.66	Fire safety/ vulnerability to fire	130.47	Solidity and durability	123.09
Denmark	Healthy indoor environment	142.88	Fire safety/ vulnerability to fire	131.17	Vulnerability to moisture	122.11
Finland	Healthy indoor environment	157.24	Fire safety/ vulnerability to fire	133.82	Solidity and durability	125.47
Germany	Fire safety/vulnerability to fire	134.46	Healthy indoor environment	125.25	Solidity and durability	123.17
Norway	Fire safety/vulnerability to fire	150.81	Healthy indoor environment	135.87	Insulation regarding sound	117.52
Sweden	Fire safety/vulnerability to fire	152.29	Solidity and durability	135.11	Healthy indoor environment	124.93
United Kingdom	Fire safety/vulnerability to fire	163.60	Vulnerability to moisture	127.68	Solidity and durability	125.98
Full sample (population-weighted)	Fire safety/vulnerability to fire	153.27	Solidity and durability	118.60	Vulnerability to moisture	111.11

MSBs providing a healthy indoor environment (Figure 6), suggesting that respondents stressing a "healthy indoor environment" find MSWB to perhaps offer that. For solidity and durability (Figure 7) and for vulnerability to moisture (see Figure 8) there were no such distinct patterns.

Discussion

A large proportion of the respondents had heard about or had deeper knowledge about MSWBs, but the knowledge differed between countries and regions. Finland and Norway stood out with the highest levels of knowledge where 85–80% at least had heard about MSWB, Sweden and Austria took a mid-position (65–55%), while for Denmark, Germany and UK the knowledge was low as two out of three respondents had never heard about MSWBs. In comparison, 19% of the respondents in the US Pacific Northwest (Larasatie et al. 2018) were classified as familiar with MSWB. Thus, the level of knowledge within all the countries we studied was higher than in the US Pacific Northwest.

The Finnish and Norwegian respondents stood out as the most familiar with MSWB. Both Finland and Norway have long traditions with using wood for structural applications, and wood is a well-known construction material for consumers in both countries (Strobel et al. 2017; Burnard et al. 2017). Another possible explanation for the higher awareness about MSWBs in the Finnish sample could be the importance of the forest-based sector in the Finnish economy and the consequent rather extensive public discussion on forest sector issues, use of wood in public buildings and indoor air quality and moisture issues.

The study confirms that only a small proportion of citizens in some of our target countries had personal experience of working or living in an MSWB. A larger portion, but still a small minority (i.e. around 3% for the full weighted sample and 7–8% for Finland, Norway and Sweden), responded that they had visited such a building. This is quite natural since few such buildings exist, with a modestly higher occurrence in the Fenno-Scandic countries and Austria (Hurmekoski et al. 2015).

The preference score, expressed the respondents´ perception of how nice it is to live in an MSWB, also differed among the countries. The Finns stood out as clearly least sceptical, with only 24% of the respondents stating a rank lower than the midpoint (score < 5), and 57% on stating a rank higher than the midpoint (score > 5). Swedes came second with 30% not stating a rank below the midpoint, and 42% higher than the midpoint. The respondents in Austria and Germany stated preferences very close to the Swedes (40% and 41% respectively considered living in an MSWB nice), but there was still a considerably larger proportion than within Sweden who stated that they regarded living in an MSWBs unappealing (i.e. 40% and 38%, respectively). Denmark, Norway and the United Kingdom exhibited scores similar to Austria and Germany, but a larger share considered wood less appealing: between 42% and 38% perceived it as not appealing, and 37–34% as appealing. The Danes and the respondents from United Kingdom were most sceptical towards living in MSWBs. The proportion of neutral responses varied between 13% and 16% in the seven countries. Thus, nearly two thirds of the respondents in the seven countries reported to be perceive it as nice or were neutral to living in an MSWB.

In the U.K., the 2017 Grenfell fire led to a ban on combustible materials including timber in wall construction in high-rise buildings above 18 metres. Fatal incidents such as the Grenfell Tower fire can have negatively impacted timber construction of multi-storey construction in the UK and it is likely that the fire also has affected UK perceptions of fire-safety in those buildings. Similar occurrences like the Grenfell Tower in the UK and the recent (2022) collapse of the Tretten wood bridge in Norway, and the way this has been presented in the news and the actions taken by authorities, have a large impact on how wood structures in are considered by the public. In our case, only the respondents from the UK had this effect because the Norwegian incident happened later.

Respondents' perception of how nice it is to live in an MSWBs was most influenced by fire safety/vulnerability to fire, healthy indoor living environments, solidity and durability and vulnerability to moisture. The effect of perceived fire safety/vulnerability to fire was particularly strong. This factor, together with perceived solidity and durability, have repeatedly been pointed to as influential for consumer-preferences of wood in earlier studies (e.g. Gold and Rubik 2009; Mahapatra and Gustavsson 2009; Larasatie et al. 2018). As could be expected from the literature, the stated importance of the factor vulnerability to fire was lowest for respondents that perceived MSWBs a nice place to live. However, 18% of those who considered living in an MSWB as a very nice place to live had ranked this factor as the most influential for their stance. This suggests that new research on fire risks in wooden buildings, that contradict old practices regarding wood as a building material, is known in at least some segments of the European population.

"Healthy indoor living" came out consistently as one of the top three most influential factors in all countries except the United Kingdom. Results from a few earlier studies have presented similar results. Health aspects were for example identified as an (very) important decisive aspect for Germans in relation to building structure (Gold and Rubik 2009), and well-being, which we interpret as a synonym for healthy indoor environment, was in a study from Finland (Lähtinen et al. 2019) shown to have a significant (although limited) influence on willingness to live in houses made of timber. Finally, Larasatie et al. (2018) found that their US respondents perceived wood buildings as more healthy than other buildings. Our findings thus add to and strengthen the evidence that healthy indoor environment is an important factor influencing people's preferences for building materials, and a preference element that tend to correlate with preferences for wooden buildings. Still, it should be noted that the public may not be able to distinguish between structural and non-structural parts of a multi-storey timber building, it is likely that the amount of visible wood can have a positive impact on perceptions of wood, including issues such as healthy indoor environment or fire safety.

The participants were in general citizens with low level of familiarity to MSWBs, therefore they may have difficulties assessing relevant factors/attributes, this is particularly relevant for aspects related to modern timber engineering. Furthermore, the preference structure is not subject to further analysis e.g. through the use of choices involving trade-offs given the open ranking procedure we decided on. To understand the full range of perceptions, and potential differences between countries towards multi-story wooden buildings, the results presented in this paper need to be complemented with future research.

Concluding remarks

The results from this study add new cross-country level knowledge to the preferences among the public for living in MSWBs and identify a list of factors influencing such preferences. The study describes a survey carried out in seven European countries and concludes that most European consumers are not familiar with MSWBs, and that very few have experience with multi-storey buildings where wood is a load-bearing material. There is some evidence that residents in Finland, Norway and Sweden have more knowledge of MSWBs and more experience from visits or from living in MSWBs (e.g. Viholainen 2021). This finding is most likely due to the strong tradition for using wood construction as well as the important role of the forest industries in these countries.

According to the study, major issues emerge, which must be addressed when designing and marketing new MSWBs. Fire properties of wood construction remain the most important concern among respondents. Accurate and reliable

communication of these risks and actions taken to mitigate them in MSWBs relative to alternatives needs to be communicated if the perceptions reflect inaccuracies, outdated information or possible bias. Furthermore, issues related to health and healthy indoor environments are important for the public, and the use of wood as a construction material is obviously perceived to contribute to improving residential buildings in this respect. The focus of the present study is on wood as a load-bearing material, and the wood is therefore not necessarily visible to the users. It is reason to believe that the relationship between the choice of construction material and residents' health is even more relevant when wood is used in visible surfaces in the interior. The structural properties of wood as a load-bearing material were, however, of less importance to the respondents that participated in the study. This is in stark contrast to the attention that is directed towards the structural properties of wood among engineers, architects and specifiers.

Finally, it must be acknowledged that there is a group of the public that does not have preference for, and that even might dislike wood construction, as found in experiments. This can be linked to lack of awareness or familiarity with wood construction, but it can also be due to a dislike for wood.

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